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Watershed Monitoring for the Lake Decatur Watershed, 2000–2003

by

Laura Keefer and Erin Bauer

Prepared for the City of Decatur

December 2005

Illinois State Water Survey
Center for Watershed Science
Champaign, Illinois

A Division of the Illinois Department of Natural Resources

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Prepared by:

Illinois State Water Survey
2204 Griffith Drive
Champaign, IL 61820-7495

Principal Investigator:

Laura Keefer
Hydrologist
Watershed Science Section

Project Staff:

Erin Bauer
Sandy Jones
Joshua Stevens

Prepared for:

City of Decatur
Keith Alexander, Project Manager

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Abstract

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 dam was modified in 1956 to increase the maximum capacity of the lake to 28,000 acre-feet. The drainage area of the Sangamon River upstream of Decatur is 925 square miles and includes portions of seven counties in east-central Illinois, which are primarily in agricultural production.

Lake Decatur has high concentrations of total dissolved solids and nitrates, and nitrate-nitrogen (nitrate-N) concentrations have been exceeding drinking water standards in recent years. This created a serious situation for the drinking water supply of the City of Decatur because nitrate-N cannot be removed from finished drinking water through regular water purification processes. Nitrate-N concentrations in Lake Decatur have exceeded the Illinois Environmental Protection Agency (IEPA) drinking water standard of 10 milligrams per liter (mg/L) on occasions each year between 1979 and 2002, except in 1993, 1994, 1995, and 2000. In June 2002, the City of Decatur activated a newly constructed nitrate-removal facility.

Since 1993, the Illinois State Water Survey has been monitoring the Lake Decatur watershed for trends in nitrate-N concentrations and loads and to identify any significant changes in the watershed. The continued purpose of the monitoring is to collect reliable hydrologic and water quality data throughout the watershed for use by city planners to efficiently operate the nitrate removal facility and by resource managers to develop watershed management alternatives based on scientific data. This report presents annual data for 10 years of monitoring (May 1993–April 2003) and monthly data for Project Years (PYs) 8–10 of monitoring (May 2000–April 2003). Based on these data, it can be concluded that the average unit nitrate-N loads are relatively uniform over the entire watershed, but tend to be slightly higher at the tributary stations than at the Sangamon River stations. There also can be considerable differences in loads at tributary stations from year to year. Nitrate-N loads vary with concentration and streamflow. Average annual runoff has varied from 4 to 14 inches over the monitoring period. Concentrations were lowest in PY 7 and highest in PY 1 due to extremely low and high streamflows, respectively. Flow-weighted nitrate-N concentrations have been increasing at the Monticello and Big Ditch stations during the study period. The highest nitrate-N concentrations during the monitoring period were observed in PY 6 and PY 7. Area-weighted annual nitrate-N yield into Lake Decatur has varied between 10 (1999) and 38 (1998) lb/acre during the 10-year monitoring period (1993–2003).

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Watershed Monitoring for the Lake Decatur Watershed, 2000–2003

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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 (6,518 million gallons) and a surface area of 4.4 square miles. The dam was modified in 1956 to increase the maximum capacity of the lake to 28,000 acre-feet (9,125 million gallons). Total water withdrawal from the lake averaged 39 million gallons per day (mgd) during the three-year study period. Drinking water withdrawal averaged 22 mgd for a population of 86,705.

The drainage area of the Sangamon River upstream of the Lake Decatur dam is 925 square miles. The watershed includes portions of seven counties in east-central Illinois as shown in figure 1. Agriculture comprises 80 percent of the land area in the watershed. Rural and urban grasses comprise 12 percent, and all other uses comprise the remaining 8 percent of land use (Luman et al., 1996). Major urban areas within the watershed are Decatur, Monticello, and Gibson City.

Lake Decatur has high concentrations of total dissolved solids. Nitrate-nitrogen (nitrate-N) concentrations have exceeded drinking water standards in recent years. This created a serious situation for the drinking water supply of the City of Decatur because nitrate-N cannot be removed from finished drinking water through regular water purification processes. Nitrate-N concentrations in Lake Decatur exceeded the Illinois Environmental Protection Agency (IEPA) drinking water standard of 10 milligrams per liter (mg/L) between 1979 and 2002, except in 1993, 1994, 1995, and 2000. Since 2000, nitrate-N excursions occurred during two periods, February–April 2001 and February–June 2002. A newly constructed ion-exchange facility to remove nitrate from the drinking water came online in June 2002. Periods of high nitrate-N concentration occur seasonally (late winter and spring–mid-summer).

On June 10, 1992, a Letter of Commitment (LOC) between the IEPA and the City of Decatur required the city to take several steps to reduce nitrate-N drinking water levels to acceptable concentrations within nine years. One of the steps required the city to conduct an initial, two-year monitoring study of the Lake Decatur watershed to better understand nitrate-N yields in the watershed. The Illinois State Water Survey (ISWS) received a grant from the City of Decatur in 1993 to conduct that monitoring study and develop land-use management strategies that could assist the city in complying with IEPA drinking water standards. Demissie and Keefer (1996) present the results of that study. The City of Decatur has continued to fund data collection to monitor the Lake Decatur watershed for trends in nitrate-N concentrations and loads. The purpose of the monitoring is to collect reliable hydrologic and water-quality data throughout the watershed for use by city planners and resource managers in developing watershed management alternatives based on scientific data. Keefer and Demissie (1996) present the monitoring results of Project Year (PY) 3, Keefer et al. (1997) present the monitoring results of PY 4, and Keefer and Demissie (1999, 2000, and 2002) present the monitoring results of PYs 5–7 in the context of longer term records. In July 2000, the City of Decatur and the State of Illinois agreed to a Consent Order to construct an ion-exchange facility to remove nitrate-N from the drinking water by July 1, 2002. That facility went online in June 2002.

This technical report presents the annual data for all 10 years of monitoring (May 1993–April 2003) and monthly data for PYs 8–10 of monitoring (May 2000–April 2003). The report is comprised of three main sections: Introduction, Background, and Hydrologic and Nitrate-N Monitoring. The latter section discusses the monitoring results of all ten years of data collection. A Summary and References also are included.

Acknowledgments

This work was supported by the City of Decatur. Keith Alexander, Water Management Director, served as project manager, and his cooperation and assistance are greatly appreciated. Several other city officials and staff also have been very cooperative and supportive: the Decatur City Council, Mayor Paul Osborne, City Manager Steve Garman, and Assistant City Manager for Public Services John Smith. The views expressed in this report are those of the authors and do not necessarily reflect the views of the sponsor or the ISWS.

The authors wish to acknowledge the significant contributions of the following project staff toward the completion of this report. Josh Stevens and Kevin Rennels, field technicians, were responsible for field data collection. Sandy Jones and Josh Stevens were responsible for processing and presenting data used in this report.

The authors gratefully acknowledge the sample analyses performed by the following chemists at the ISWS in Champaign: Loretta M. Skowron, Lauren F. Sievers, Sofia Lazovski, Ruth Ann Nichols, and Daniel L. Webb. William Bogner, Amy Russell, and Jim Slowikowski of the Center for Watershed Science provided assistance with fieldwork, data entry, and/or analysis. Patti Hill and Becky Howard prepared the camera-ready copy of the report, which was edited by Eva Kingston. Linda Hascall provided expert advice on illustration layout.

Background

Water Quality Problems in Lake Decatur

Lake Decatur has experienced water quality problems for more than 20 years. Past studies by the U.S. Environmental Protection Agency (USEPA) and the Illinois Environmental Protection Agency (IEPA) documented historical 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 suspended solids and nitrate-N. Currently, the most pressing water quality problem in Lake Decatur is a high concentration of nitrate-N. Nitrate-N cannot be removed from finished drinking water through regular water purification processes. An ion-exchange nitrate-removal facility began operation in June 2002.

The nitrate-N load that eventually reaches Lake Decatur originates in the watershed of the Upper Sangamon River (figure 1). To characterize and quantify the spatial and temporal distribution of nitrate-N yield in the Upper Sangamon River, the City of Decatur has continued to support further watershed monitoring through a grant to the ISWS. The purpose of the monitoring is to collect reliable hydrologic and water quality data throughout the watershed for use by city planners and resource managers in developing watershed management alternatives based on scientific data.

Watershed Physical Characteristics

The Upper Sangamon River watershed extends across seven counties in central Illinois: Champaign, Christian, Dewitt, Ford, Macon, McLean, and Piatt counties. The Sangamon River is a tributary to the Illinois River. The watershed lies in the humid, continental, climate region, typical for central Illinois. The 30-year (1971–2000) average annual precipitation for the region is 38.94 inches. The average annual precipitation for the ten-year period of study (1993–2003) was 37.13 inches for the region and varied from 35.65 to 39.82 inches. The Upper Sangamon watershed lies in the Bloomington Ridged Plain of the Till Plains Section of the Central Lowland Province (figure 2). The Till Plains section has broad, till plains in a youthful erosion stage. Low, broad, morainic ridges with intervening wide stretches of relatively flat or gently undulating ground moraine characterize the Bloomington Ridged Plain (Leighton et al., 1948).

Soil

There are 14 major soil association types in the watershed. Figures 3 and 4 show the distribution of the different soil associations and parent material, respectively. The percentage of watershed area of each soil association also is presented (table 1). The dominant soil associations in the Lake Decatur watershed consist of poorly drained Drummer and Sable silty clay loams and somewhat poorly drained Flanagan and Ipava silt loams (IL003, IL009, IL011, and IL012), which cover 74 percent of the watershed area. These very fertile soils, the most productive in the watershed, are very resistant to drought, and have a high organic content.

Figure 1. The Lake Decatur watershed

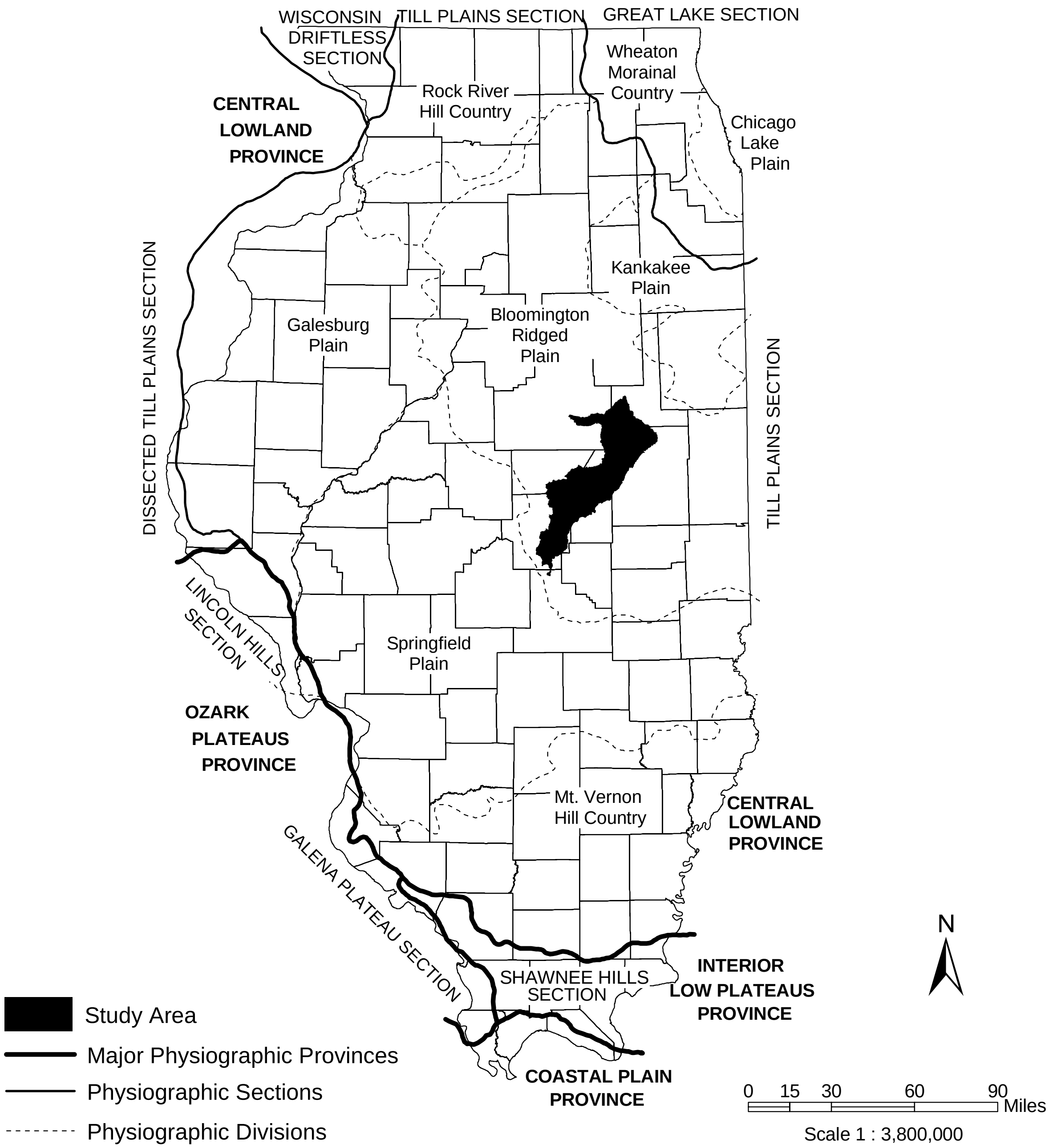

Figure 2. Location of the Lake Decatur watershed in the physiographic divisions of Illinois

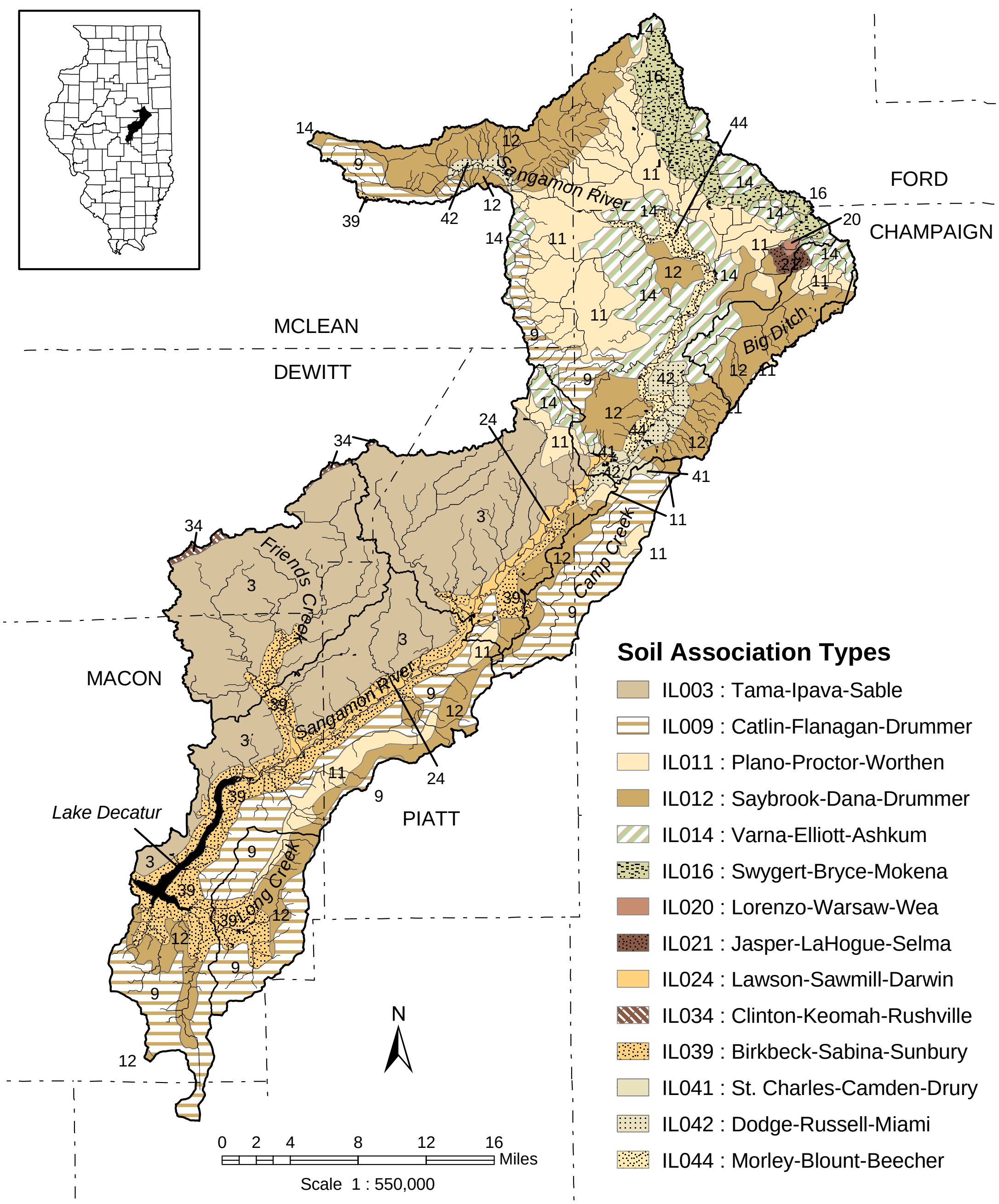

Figure 3. Map of soil associations in the Lake Decatur watershed

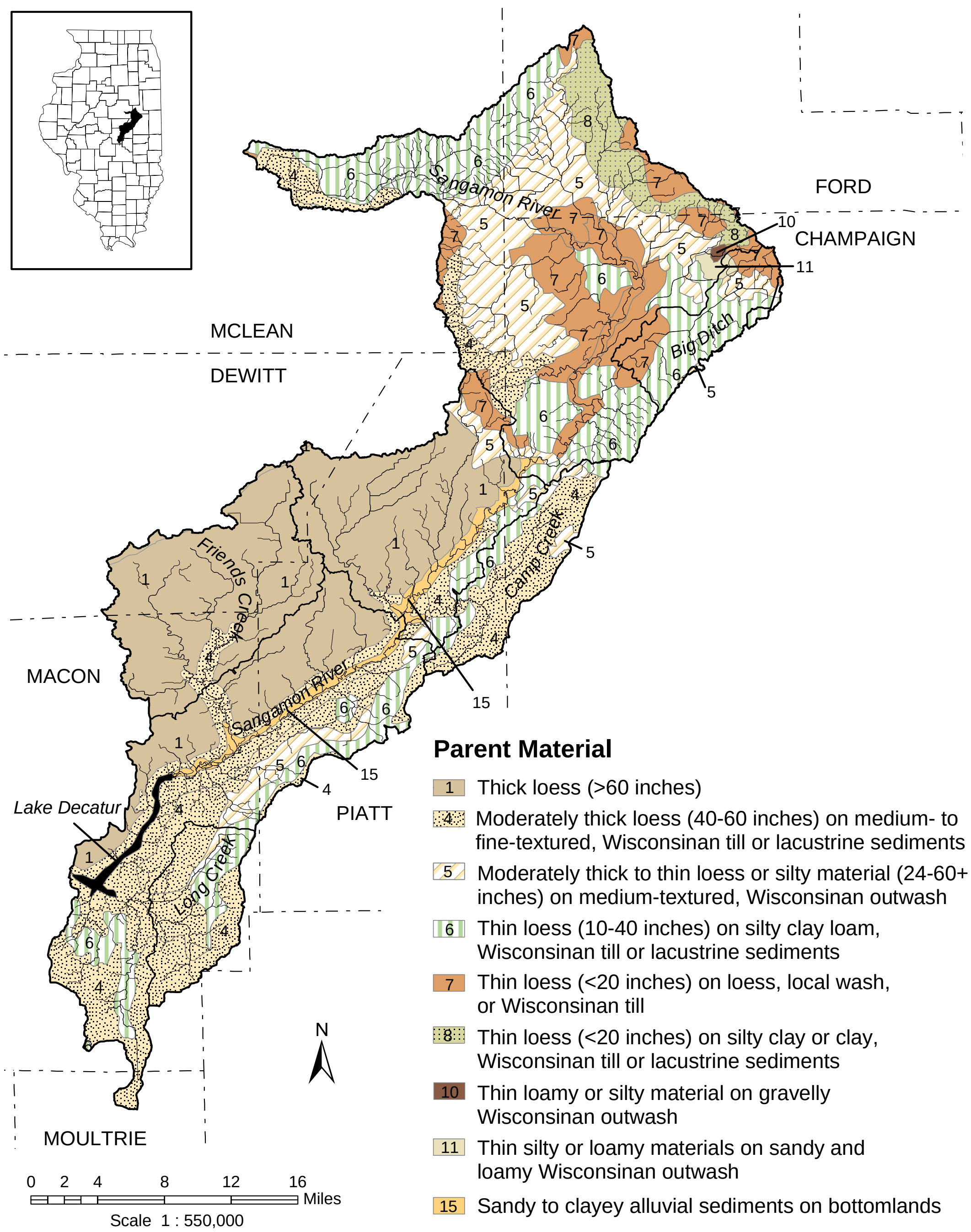

Figure 4. Map of soil parent material within the Lake Decatur watershed

Table 1. Percent Area of Soil Association within the Lake Decatur Watershed

Association code	*Association name*	*Percent watershed area*
IL003	Tama-Ipava-Sable	27.4
IL012	Saybrook-Dana-Drummer	17.7
IL009	Catlin-Flanagan-Drummer	15.4
IL011	Plano-Proctor-Worthen	13.4
IL014	Varna-Elliott-Ashkum	8.4
IL039	Birkbeck-Sabina-Sunbury	7.7
IL016	Swygert-Bryce-Mokena	3.3
IL024	Lawson-Sawmill-Darwin	1.9
IL044	Morley-Blount-Beecher	1.7
IL042	Dodge-Russell-Miami	1.6
IL041	St. Charles-Camden-Drury	0.3
IL021	Jasper-LaHogue-Selma	0.3
IL034	Clinton-Keomah-Rushville	0.2
IL020	Lorenzo-Warsaw-Wea	0.1
	Water	0.5

The watershed can be divided into three areas with respect to the drainage characteristics of the soil; these correspond closely with the distribution of the parent material (figure 4). One area is in the west-central portion of the watershed on the north side of the Sangamon River. The dominant soil association in this area is Tama-Ipava-Sable, which are “poorly drained to moderately well drained soils formed in loess, on uplands” (Martin, 1991). The second area is along the southeastern watershed boundary where the dominant soils are poorly drained to moderately well drained silty soils formed in loess on nearly level to moderately sloping terrain (Martin, 1991). The third area in the northeastern end of the watershed has two types of soil: poorly to moderately drained silty soils formed in loess, local wash, or glacial material on nearly level to gently sloping terrain, and moderately well to well drained silty soils formed in loess and the underlying glacial outwash on nearly level to moderately sloping ridges, outwash plains, or terraces (Fehrenbacher, 1990; NASS, 2003).

Channel Gradient

Channel gradient (slope) is an indicator of erosion and stream velocity. Figure 5 shows the channel profiles for the Upper Sangamon River and selected tributaries with respect to the monitoring station locations and elevations. Each tributary is plotted relative to other tributaries and Lake Decatur. Data were retrieved from the Illinois Streams Information System (Day, 1999), version 3.0 from May 2003. Table 2 presents the mean percent slope of each tributary and the river. The mean slope of the Sangamon River upstream of Lake Decatur Dam is 0.059 percent. The greatest slopes are found on the upper reach of Big Ditch (0.538%), Big Creek, a tributary to Long Creek (0.296%), and Long Creek upstream of Station 101 at Twin Bridges Road bridge (0.223%).

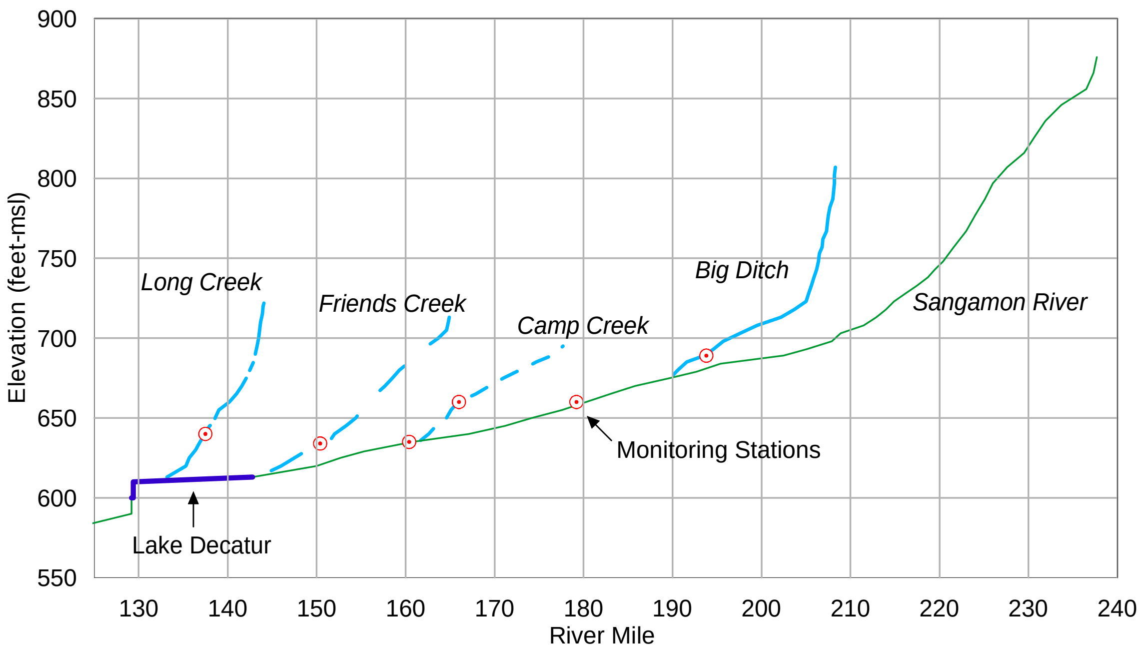

Figure 5. Stream profiles of the Upper Sangamon River and selected tributaries in the Lake Decatur watershed

Table 2. Mean Stream Slope of the Sangamon River and Selected Tributaries

Location	*Mean slope (percent)*
Sangamon River	
Upstream of Lake Decatur Dam	0.059
Long Creek	0.223
Long Creek upstream of Station 101	0.223
Big Creek #1 tributary	0.199
Big Creek #2 tributary	0.296
Friends Creek	0.095
Friends Creek upstream of Station 102	0.106
Sangamon River upstream of Station 111	0.068
Camp Creek	0.069
Camp Creek upstream of Station 104	0.057
Sangamon River upstream of Station 105	0.082
Big Ditch	0.141
Big Ditch upstream of Station 106	0.154
Big Ditch upper reach	0.538

Lake Sedimentation History

Soil erosion in the Lake Decatur watershed is recognized as a long-term problem to be controlled so that Lake Decatur can provide adequate water supply to the City of Decatur (Demissie and Keefer, 1996). The ISWS has conducted eight sedimentation surveys in Lake Decatur (1931–1932, 1936, 1946, 1956, 1966, 1983, 2000, and 2001). A report by Fitzpatrick et al. (1987) summarizes the surveys from 1931–1932 through 1983. Bogner (2001, 2002) summarizes the 2000 and 2001 surveys.

From 1922 until 1983, the lake capacity loss rate for Lake Decatur averaged 149 acre-feet (ac-ft) per year. Total lake storage capacity dropped from 27,900 to 18,800 ac-ft, a loss of one-third of the original capacity in 61 years. Volume loss rate for 1956–1983 was 0.42 percent, lower than the long-term average. The total sediment delivered to the lake, 1922–1983, was 21.4 tons of soil per acre of watershed for an average sediment trap efficiency of 77 percent. The annual rate of sediment accumulation in the lake is 0.27 tons per acre. Table 3 shows the sources of sediment to the lake. Sediment composition of samples taken in 1983 was 57 percent clay, 36 percent silt, and 7 percent sand (Bogner 2001, 2002; Fitzpatrick et al., 1987).

Sedimentation surveys conducted in 2000 and 2001 focused on three basins of Lake Decatur: the basin at the headwater of the main lake body (Basin 6) and the basin areas of the Sand Creek and Big/Long Creek tributaries at the southern end of the lake (Bogner, 2001, 2002). The capacity of Basin 6 decreased from 2,797 ac-ft in 1922 to 1,451 ac-ft in 2000, a loss of 48.1 percent. Annual sedimentation rates for Basin 6 decreased over time. The most recent rate, 8.3 ac-ft, occurred in 1983–2000 (Bogner, 2001). The capacity of the Big/Long Creek Basin decreased from 2,754 ac-ft in 1922 to 1,512 ac-ft in 2001, a loss of 54.9 percent. Annual sedimentation rates for the basin were 9.9 ac-ft. Sediment consolidation was not as apparent in the deeper Big/Long Creek basin as in the shallower Basin 6 (Bogner, 2002).

Land-Use Trends

Agriculture is the dominant land use in the Lake Decatur watershed. The following crop data are from Illinois Agricultural Statistics Service (NASS, 2003). Figure 6 shows changes in acreage for different crops in the watershed, 1925–2002. Agricultural land use increased from 415,827 acres (70%) in 1925 to 484,838 acres (82%) in 2002. Since 1925, the percentage of land in agricultural use within the watershed was lowest in 1934 (62%) and highest (90%) in 1980. Corn and soybeans, the dominant crops, comprised 82 percent of the watershed in 2002. Row crop (corn and soybeans) agriculture more than doubled from 1925 (221,020 acres) to 2002 (485,110 acres). Corn acreage has increased slightly over the last 77 years, averaging 224,228 acres and ranging between 163,470 acres in 1934 and 289,513 acres in 1976. Corn acreage has varied only slightly over the last 14 years, averaging 245,615 acres. The gradual increase in soybean acreage was concurrent with the decrease in acreages of small grains such as wheat, oats, hay, and sorghum. Acreage for small grain crops began a steady decline from almost 33 percent of the watershed area in 1952 to less than 5 percent in 1971. Since 1989, combined corn and soybean acreage has averaged 488,701 acres, and agricultural acreage has averaged 494,114 acres or 83.5 percent of the watershed area. Small grains have comprised little more than 0.1 percent of the watershed area each year since 1999.

Table 3. Sources of Sediment to Lake Decatur: Estimated Proportion of Total Lake Sediment and Sediment Yield by Source Area (Fitzpatrick et al., 1987)

Source	*Lake watershed area (percent)*	*Total lake sediment (percent)*	*Yield to lake (tons/acre/year)*
All sources	100	100	0.27
Sangamon River above Monticello	59	22	0.10
Sangamon River below Monticello and above the lake	25	27	0.29
Bluff watersheds	6	29	1.25
Big/Long and Sand Creeks	9	19	0.56
Lakeshore erosion	–	2	–

Note:
– indicates incomplete data or no data available.

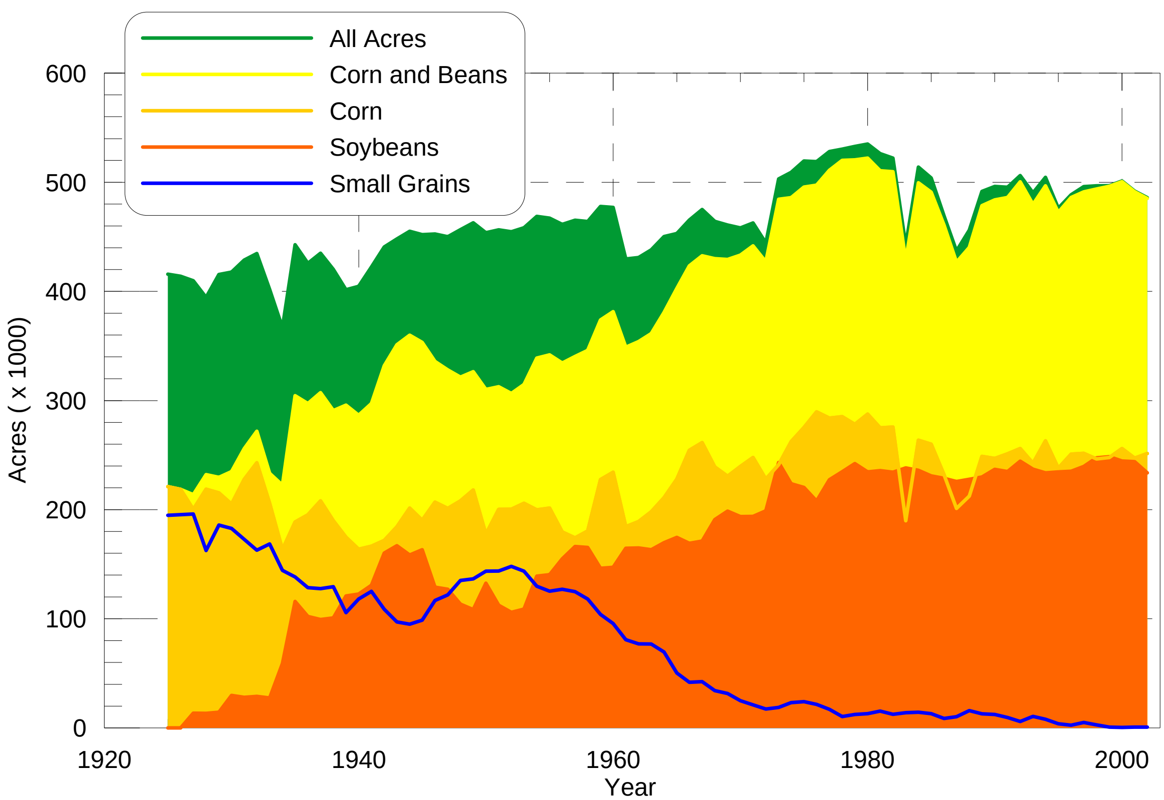

Figure 6. Row crop acreage harvested in the Lake Decatur watershed, 1925–2002

The sharp drop of corn acreage in 1983 (figure 6) was attributed to the federal government's "Payment-in-kind Program," a program enacted to reduce surplus grain inventories (Green, 1990). The cool, wet spring of 1983, which delayed spring planting, also may have contributed to the reduction in acres planted (IDOA and USDA, 1984). The government issued further crop reductions in 1986, 1987, and 1988 to reduce grain inventories (Green, 1990).

The 1995 Illinois land cover/land-use database from Illinois Department of Natural Resources is derived from 1991–1995 satellite imagery. This database indicates that 80 percent of the Lake Decatur watershed area was agricultural land, which is similar to the 82 percent reported by the Illinois Agricultural Statistics Service (NASS, 2003). The remaining acreage is grassland (11.8%), forest (2.8%), wetlands/marsh (1.4%), urban/transportation (2.9%), and water (0.7%) [Luman et al., 1996].

Hydrologic and Nitrate-N Monitoring

A watershed monitoring network was established in 1993 to provide streamflow and water-quality data for the Upper Sangamon River and its tributaries. The network originally had eight sampling stations (figure 7) throughout the watershed upstream of Lake Decatur. Table 4 presents the station number, name and location, period of monitoring, and drainage areas for the monitoring stations.

Hydrologic Monitoring

Continuous hydrologic monitoring of the water level at each station facilitates the calculation of streamflow (discharge). This is essential for establishing the nitrate-N contribution to Lake Decatur from the Upper Sangamon River and its tributaries. The ISWS installed streamgages at all monitoring sites, except the U.S. Geological Survey (USGS) streamgaging stations at Monticello (111) and Fisher (112). At each station, stage was recorded at 15-minute intervals, and discharge measurements were made periodically. Water samples collected weekly from each station were analyzed for nitrate-N. Efforts were made to sample during storm events. Water levels were checked manually on a weekly basis, and mean daily streamflow data were obtained from the USGS for the Monticello (111) and Fisher (112) stations. Detailed location descriptions and monitoring histories for each station are presented later in this report.

Precipitation

Precipitation data for selected locations around the study area were retrieved from the Midwestern Regional Climate Center database, which is operated by the ISWS. Figure 2 shows the locations of the six precipitation monitoring stations selected from within and around the Lake Decatur watershed: Clinton, Decatur, Gibson City, Rantoul, Monticello, and Urbana. Table 5 presents the annual precipitation totals and the 10-year average annual precipitation (May 1993–April 2003) for the study period at each station in order from north to south in the watershed. The Gibson City station is the closest to the northern (upstream) end of the watershed, and the Decatur station is the farthest south (downstream). Monthly and annual 30-year (1971–2000) mean precipitation for the six stations are shown (table 6). Previous reports compared data from PY 1–PY 7 (May 1993–April 2000) with the 1961–1990 30-year mean. This report discusses the monthly precipitation for PY 8–PY 10 and annual precipitation for all 10 years at each station relative to the monthly and annual percentile ranking within the 1971–2000 30-year mean precipitation data (Jim Angel, Illinois State Climatologist, ISWS, Personal Communication, 2003). Monthly precipitation data are discussed separately for the period May 2000–April 2003 followed by a 10-year summary of annual precipitation. Figure 8 presents the monthly precipitation totals for PY 8 (May 2000–April 2001), PY 9 (May 2001–April 2002), and PY 10 (May 2002–April 2003). Monthly and annual precipitation values for this period are presented in Appendix A.

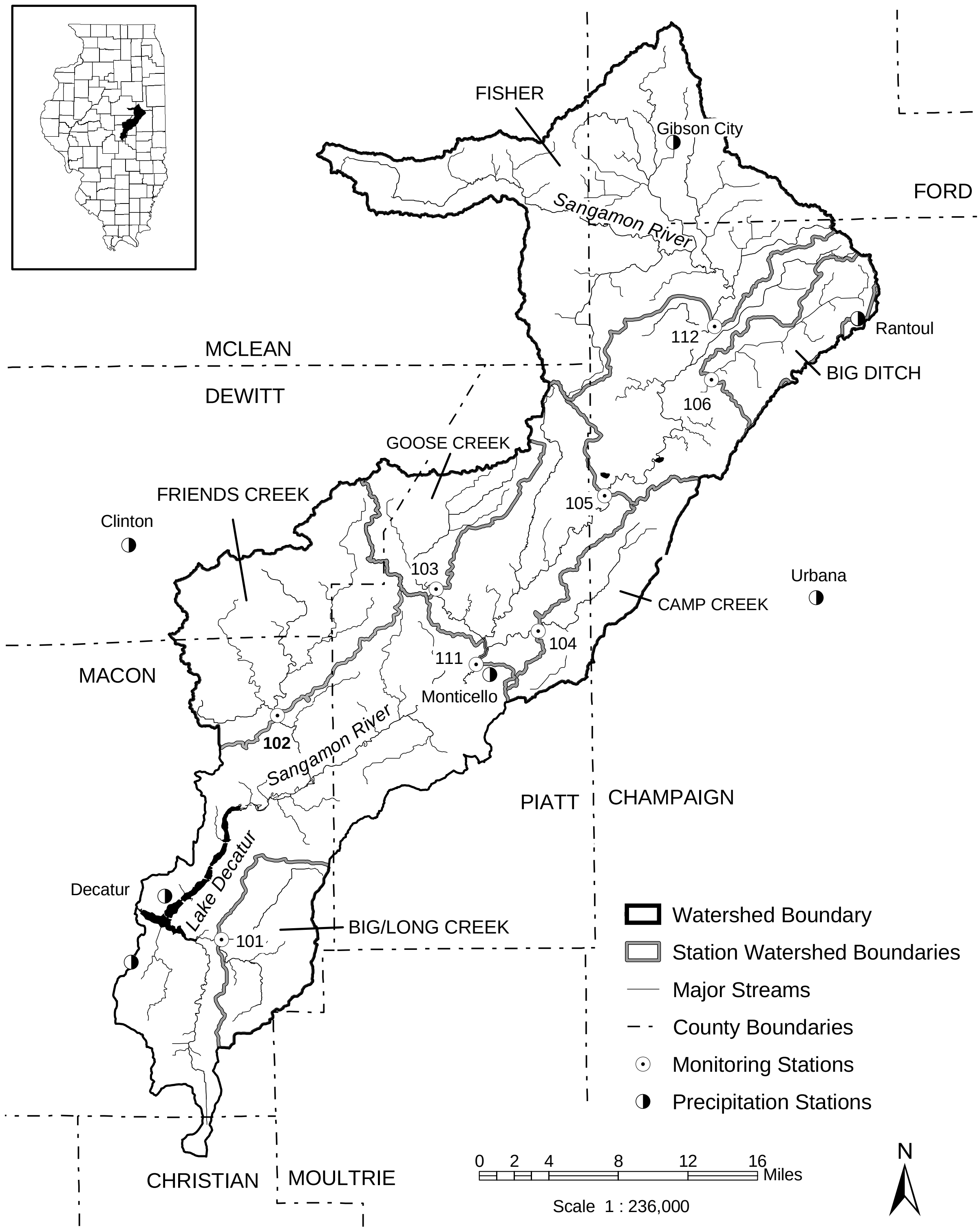

Figure 7. Location of the Lake Decatur sub-basin boundaries,
and stream and precipitation monitoring stations

Table 4. Station Number, Name and Location, Period of Monitoring, and Drainage Area, Lake Decatur Watershed Monitoring Stations

Station	*Name: Location*	*Period of ISWS monitoring (years)*	*Drainage area (mi²)*	*Drainage area (acres)*
101	Long Creek: at Twin Bridge Road	1993 – present	46.2	29,568
102	Friends Creek: at Route 48 near Argenta	1993 – present	111.9	71,616
103	Goose Creek: near Deland	1993 – 2000	45.1	28,864
104	Camp Creek: near White Heath	1993 – 2002	47.2	30,208
105	Mahomet: Sangamon River at Shively Bridge near Mahomet	1993 – 2003	368.2	235,648
106	Big Ditch: at Champaign County Road 700 East near Fisher	1993 – 2003	38.2	24,448
107	Lost Bridge: Lake Decatur Basin 1 at Lost Bridge Road	2002 – present		
111	Monticello: Sangamon River USGS Station (#05572000) near Monticello	1993 – present	543.4	347,776
112	Fisher: Sangamon River USGS Station (#05570910) near Fisher	1993 – 2000	245.6	157,184
Ungaged stations				
107	Lost Bridge: Lake Decatur Basin 1 at Lost Bridge Road	2002 – present		
201	Lake Decatur	1993 – 1995		
202	Lake Decatur	1993 – 1995		
203	Lake Decatur	1993 – 1995		

Table 5. Annual Precipitation for Selected Stations for the Ten-Year Study Period (May 1993–April 2003)

Project year	*Mean precipitation (inches)*					
	Gibson City	*Rantoul*	*Urbana*	*Clinton*	*Monticello*	*Decatur*
PY 1	48.78	54.39	56.94	51.73	46.47	42.29
PY 2	37.22	33.07	33.37	36.91	31.90	37.32
PY 3	33.90	31.34	36.64	32.87	36.94	34.83
PY 4	36.61	37.15	39.20	36.17	38.11	39.22
PY 5	39.01	38.45	41.86	42.62	38.40	29.85
PY 6	35.09	41.83	44.41	38.58	41.00	36.28
PY 7	25.36	26.03	34.00	35.21	29.29	28.91
PY 8	32.46	31.33	36.41	36.25	32.16	36.50
PY 9	38.95	39.91	42.28	40.75	33.70	46.90
PY 10	29.07	26.94	33.08	31.97	32.37	33.38
10-year mean	35.65	36.04	39.82	38.31	36.03	36.55

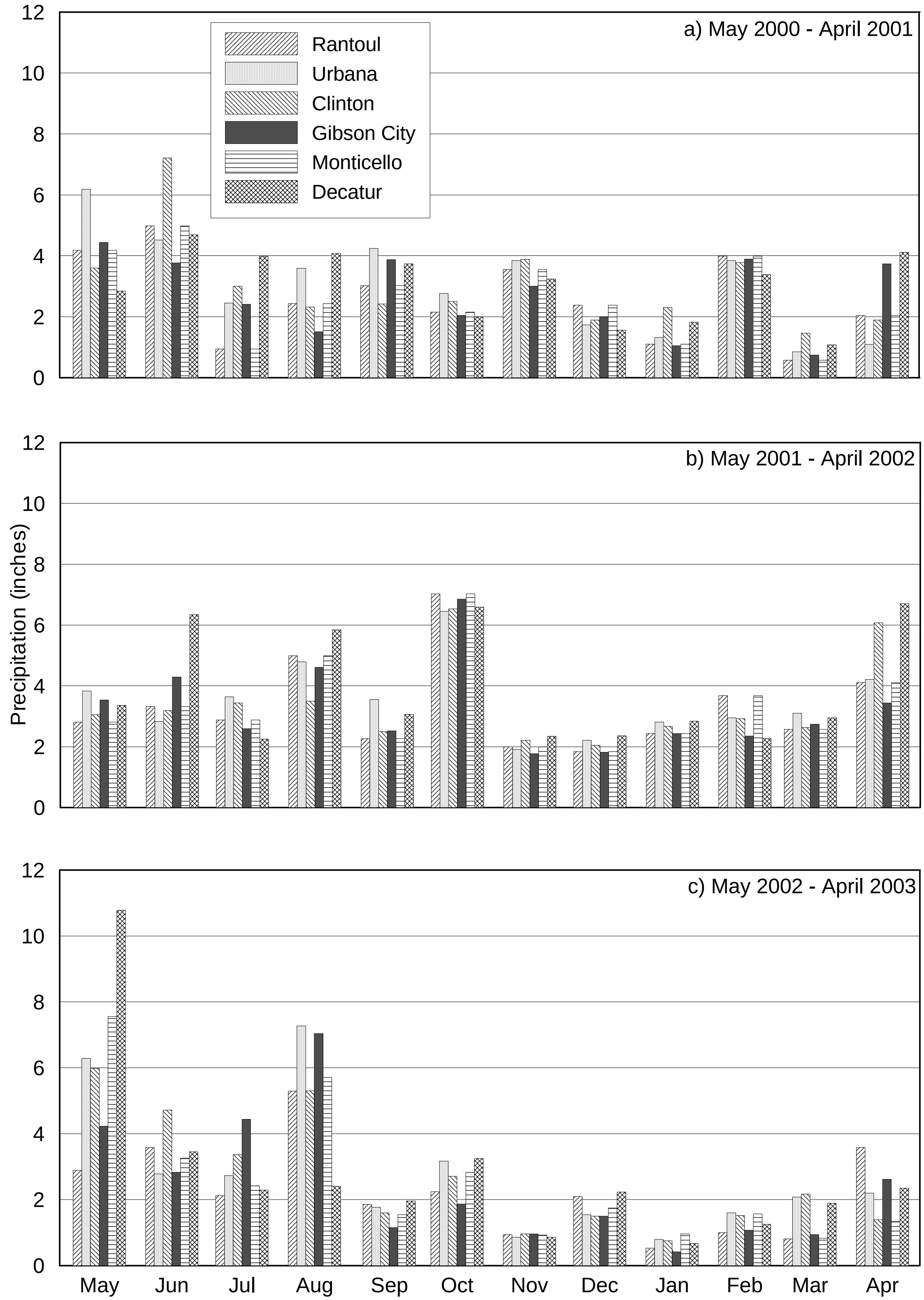

Figure 8. Monthly precipitation at six locations around the Lake Decatur watershed: a) May 2000–April 2001, b) May 2001–April 2002, and c) May 2002–April 2003

Table 6. Monthly and Annual 30-Year (1971–2000) Mean Precipitation for Selected Stations

	Mean precipitation (inches)					
Month	*Gibson City*	*Rantoul*	*Urbana*	*Clinton*	*Monticello*	*Decatur*
May	4.07	3.99	4.80	4.28	4.41	4.50
June	4.04	3.97	4.21	4.06	3.97	3.79
July	3.74	3.95	4.67	4.34	4.57	0.60
August	3.91	3.50	4.37	3.93	4.15	4.10
September	2.83	3.03	3.22	2.81	2.79	2.98
October	2.66	2.89	2.81	3.16	2.77	2.76
November	3.01	2.80	3.45	3.28	3.38	3.16
December	2.54	2.38	2.76	2.85	2.86	2.86
January	1.60	1.94	1.89	1.84	1.98	2.11
February	1.59	1.94	2.01	1.93	1.93	1.94
March	2.99	2.96	3.21	3.43	3.12	3.25
April	3.30	3.84	3.65	4.03	3.75	3.63
Annual	36.28	37.01	41.05	39.94	39.66	39.68

Project Year 8 (May 2000–April 2001)

The two highest monthly precipitation values during PY 8 occurred at the Clinton station in June 2000 (7.21 inches), ranking near the 90th percentile, and at the Urbana station in May 2000 (6.18 inches), ranking in the 75th percentile. February 2001 precipitation was well above normal, with all stations (except Decatur) ranking above the 90th percentile for the month. The lowest monthly rainfall occurred in March 2001, with all stations receiving well below normal precipitation (< 10th percentile). During PY 8, average annual precipitation across the region was below normal, ranking slightly less than the 25th percentile for the region.

Project Year 9 (May 2001–April 2002)

The two highest monthly precipitation values occurred in October 2001 at Monticello and Rantoul (7.02 inches each), ranking near the 99th and 97th percentiles, respectively. All stations posted highest monthly precipitation for PY 9 during October 2001 (5.53–7.02 inches), ranking between the 95th and 99th percentiles. The lowest monthly precipitation at all of the stations occurred during December 2001, with values ranging from 1.55 to 2.36 inches; this was normal precipitation, ranking between the 25th and 50th percentiles. Precipitation was well above normal in February 2002, ranking above the 90th percentile at all stations, except Decatur (~ 85th percentile) and Clinton (~ 80th percentile). For PY 9, the Decatur station had above normal precipitation (~80th percentile). All other stations had near normal annual precipitation. Across the watershed, annual precipitation for PY 9 was normal, ranking near the 70th percentile for the region.

Project Year 10 (May 2002–April 2003)

The highest monthly precipitation occurred at the Decatur station in May 2002, with 10.78 inches of precipitation, normal precipitation ranking near the 50th percentile for the station. In August 2002, above to well above normal precipitation fell at the Urbana and Gibson City stations, ~88th and ~91st percentiles, respectively. The lowest precipitation occurred in January 2003 at the Gibson City station (0.42 inches), ranking near the 10th percentile. All stations had well below normal precipitation during November 2002, each ranking below the 10th percentile. Monticello, Rantoul, and Gibson City had well below normal precipitation during March 2003, as did Clinton in April 2003 (all below the 10th percentile). All stations posted below to well below normal annual precipitation (below the 25th percentile) at each station for PY 10. Annual precipitation at the Rantoul station ranked below the 5th percentile.

Ten-Year Summary of Annual Precipitation (May 1993–April 2003)

Annual precipitation data, May 1993–April 2003, are presented in table 5. For comparison, monthly and annual 30-year mean precipitation data are shown in table 6 and annual 30-year precipitation percentiles in table 7.

During the first year of watershed monitoring (May 1993–April 1994), the Midwest experienced widespread flooding. Annual precipitation at stations in the Upper Sangamon River watershed averaged well above normal, ranking above the 95th percentile. The exception was Decatur, which posted normal precipitation during PY 1.

Over the last 10 years, the region experienced two years of moderate drought conditions, defined as a 12-month period with precipitation levels between 70 and 80 percent of the 30-year mean annual precipitation (Changnon, 1987). These drought years occurred in PY 7 (May 1999–April 2000) and PY 10 (May 2002–April 2003) with 30-year ratios of 76 percent and 79 percent, respectively. Precipitation during PY 7 ranked well below normal, less than 10th percentile in relation to the 30-year annual mean precipitation data. During PY 7, precipitation ranked less

Table 7. Annual 30-Year (1971–2000) Mean Precipitation Percentiles for Selected Stations

Percentile	*Gibson City*	*Rantoul*	*Urbana*	*Clinton*	*Monticello*	*Decatur*	*Average*
1	20.72	23.74	27.71	26.60	23.75	23.31	24.50
5	25.09	27.55	31.17	29.90	28.39	27.42	28.42
10	27.70	29.74	33.13	31.78	31.15	29.81	30.70
25	31.13	33.66	36.59	35.08	34.80	34.10	34.25
50	35.25	38.41	40.71	39.02	39.18	39.33	38.51
75	39.72	43.59	45.13	43.24	43.92	45.08	43.12
90	44.06	48.62	49.37	47.29	48.49	50.70	47.57
95	46.79	51.81	52.03	49.83	51.38	54.28	50.37
99	52.22	58.15	57.26	54.81	57.08	61.41	55.90

than the 5th percentile at Monticello and Rantoul, less than the 10th percentile at Gibson City and Decatur, and below normal between the 10th and 25th percentiles at Urbana and Clinton. The drought year of PY 10 ranked slightly greater than the 10th percentile compared to PY 7. Precipitation during the remaining seven years (PYs 2–6, 8, and 9) was on the low side of normal.

Precipitation at all stations was normal across the watershed during PY 5 and PY 9, except at the Decatur station, which posted well below normal precipitation (< 10th percentile) and above normal precipitation (~80th percentile), respectively. The Decatur station is near the southwestern end of the watershed (figure 7). This variation in precipitation may be attributed to the long north-south dimension of the watershed. As weather patterns generally move west to east across Illinois, isolated storms may cause precipitation over a small portion of the Lake Decatur watershed and leave the rest of the watershed dry.

Stream Stage

The "stage" of a stream is the measurement of the water surface elevation from an arbitrary datum. The stage is recorded at 15-minute intervals and makes it possible to calculate the volume of water flowing past a gaging station (Demissie et al., 2001).

Monitoring Equipment. Each ISWS streamgaging site has a water-level recorder that continuously monitors and records the stage of the stream every 15 minutes. Water level was measured with a float and pulley system enclosed within a 6-inch polyvinyl chloride pipe (PVC) stilling well. The stage was recorded using a Leupold & Stevens data encoder powered by a 12-volt battery (figure 9a and 9b). The data were stored by a Leupold & Stevens data logger or by a Campbell Scientific CR10X data logger/controller connected to an SM192 storage module. Each station houses stage recording equipment in an ISWS-designed security shelter for protection from weather and vandalism.

Figure 9. Streamgaging equipment: (a) Leupold & Stevens data logger and (b) CR10X data logger

Station Site Descriptions. A detailed description of the location and record period for each station follows. Figure 7 shows the locations of each station within the watershed. Figure 10 shows downstream and upstream views from each monitoring station.

Long/Big Creek near Twin Bridge Road, Long Creek, IL (Station 101). The ISWS started monitoring this station in May 1993. The gage is located on Long Creek at Twin Bridge Road approximately 1.5 miles southeast of Long Creek, Illinois. The shelter and stilling well are located on the downstream bridge rail on the southernmost bridge pier, left descending bank. The station has a drainage area of 46.2 square miles.

Friends Creek at Rt. 48 near Argenta, IL (Station 102). The USGS monitored Friends Creek from October 1966 through October 1982 with a graphic water-stage recorder (USGS #05572450). A Type A wire-weight gage also was installed. The graphic stage recorder was replaced with a digital water-stage recorder in July 1971. The USGS streamflow data are available online (http://waterdata.usgs.gov/nwis/discharge/?site_no=05572450). In May 1993, the ISWS began monitoring the same gage site, using the existing USGS steel stilling well, oil tube, and wire-weight gage. The gage on Friends Creek at Illinois Route 48 is approximately 0.5 miles east-northeast of Argenta, Illinois. The shelter and stilling well are located on the upstream bridge rail, right descending bank. The station has a drainage area of 111.9 square miles.

Goose Creek near Deland, IL (Station 103). The Goose Creek station was a USGS gage from May 1951 through September 1959 (USGS #05571500), and those data are available online (http://waterdata.usgs.gov/il/nwis/uv?05571500). The ISWS conducted monitoring from May 1993 through September 2000. The ISWS gage was located on Goose Creek at Piatt County Road 600 East, approximately two miles southeast of DeLand, Illinois. The shelter and stilling well were located on the downstream bridge rail, right descending bank. The station had a drainage area of 45.1 square miles.

Camp Creek near White Heath, IL (Station 104). The ISWS monitored the Camp Creek station from April 1993 through July 2002. The station was located on Camp Creek at Piatt County Road 1200 East, approximately two miles south of White Heath, Illinois. The shelter and stilling well were located on the downstream side of the bridge on the northern bridge pylon near the right descending bank. The station had a drainage area of 47.2 square miles.

Sangamon River at Shively Bridge near Mahomet, IL (Station 105). The ISWS began monitoring at the Mahomet station in May 1993. The station is located on the Sangamon River at Champaign County Road 2000 North, approximately 2.5 miles southwest of Mahomet, Illinois. The shelter and stilling well are located on the downstream side of the bridge on the pylon nearest the right descending bank. Biweekly sampling for non-volatile oxygen concentration (NVOC), acidity, temperature, arsenic, boron, and sulfur began in May 2002. The station has a drainage area of 368.2 square miles.

Big Ditch near Fisher, IL (Station 106). The ISWS began monitoring at Big Ditch in April 1993. The station is located on Big Ditch at Champaign County Road 700 East, approximately 3.5 miles south-southeast of Fisher, Illinois. The shelter and stilling well are

Station 101: Long Creek at Twin Bridges Road in the town of Long Creek

Station 102: Friends Creek near Argenta

Station 103: Goose Creek near Deland

Figure 10. Downstream (left) and upstream (right) views from stations in the study area

Station 104: Camp Creek near White Heath

Station 105: Sangamon River southwest of Mahomet

Station 106: Big Ditch near Fisher

Figure 10. Continued

Station 111: Sangamon River near Monticello

Station 112: Sangamon River near Fisher

Figure 10. Concluded

located on the downstream side of the bridge in line with the pylon nearest the left descending bank. The station has a drainage area of 38.2 square miles.

Sangamon River at Monticello, IL (Station 111). The USGS began streamflow monitoring at the Monticello station (USGS #05572000) in February 1908. The ISWS began monitoring water quality at this station in May 1993. The USGS streamflow data are available online (http://waterdata.usgs.gov/il/nwis/uv?05572000). The station is located on the Sangamon River at Bridge Street, west of Monticello, Illinois. Suspended sediment samples are collected by the ISWS using the single vertical method with a bridge-mounted DH-59 (depth-integrated sampler). Biweekly sampling for NVOC, acidity, temperature, arsenic, boron, and sulfur began in May 2002. The station has a drainage area of 543.4 square miles.

Sangamon River at Fisher, IL (Station 112). The USGS began streamflow monitoring at the Fisher station (USGS #05570910) in September 1978. The ISWS monitored water quality at this station from April 1993 through July 2000. The USGS streamflow data are available online through September 2001 (http://waterdata.usgs.gov/il/nwis/uv?05570910). The station is located on the Sangamon River at U.S. Route 136 in Champaign County, east of Fisher, Illinois. The station has a drainage area of 245.6 square miles.

Lake Decatur Basin 1: Lake Decatur, IL (Station 107). The ISWS began biweekly sampling for NVOC, acidity, temperature, arsenic, boron, and sulfur in May 2002. Samples are taken from Lake Decatur at the Lost Bridge Road bridge.

Streamflow

Streamflow data (discharge) are generated from the 15-minute stage record collected at a gaging station. Stage data are converted to discharge by applying a stage-discharge rating curve. The rating curve relationship is developed by taking detailed discharge measurements at various known stages. Each measurement is plotted against the corresponding stage at which the discharge measurement occurred. A curve is developed to express the relationship between stage and discharge. Using this stage-discharge (rating) curve, the stage data are converted to discharge. Discharge data then are used to calculate load. Methods used in this study to determine stream discharge followed established USGS procedures as outlined by Rantz (1982a, 1982b).

During a monitoring period, the rating curve may require recalibration due to changes in the channel cross section caused by extreme streamflow events or human modifications. In these cases, the stage-discharge curve is adjusted and applied only to the portion of the stage record affected by the disturbance. Discharge data from the streamgaging station at Monticello (111) and Fisher (112) were obtained from the USGS.

Streamflow Data. The following section presents total monthly streamflow data for the May 2000 through April 2003 period. Data for PYs 8–10 are discussed separately. Figure 11 displays monthly discharge data for the stations located on tributaries of the Sangamon River (stations 101, 102, 104, and 106), and figure 12 displays the monthly discharge data for stations on the Sangamon River (stations 105 and 111). Total annual streamflow data also are presented (table 8).

Project Year 8 (May 2000–April 2001)

All stations recorded highest monthly discharges in February 2001 (PY 8). For most months, Friends Creek (102) had the highest discharge rate due to its larger drainage area (figure 11). Long Creek (101) and Friends Creek (102) experienced low-flow conditions, from August–October 2000. Camp Creek (104) and Big Ditch (106) had a much longer period of low flow, July–December 2000.

For 51 days, January 1, 2000–February 20, 2000, groundwater was pumped from the Dewitt pumping fields into Friends Creek (upstream of station 102). The average pumping rate was 6,684,794 gallons per day or 10.34 cubic feet per second (cfs). Total pumpage was 340,924,478 gallons for the period, an average of 6.5 percent of the streamflow measured at Friends Creek (102) during that time.

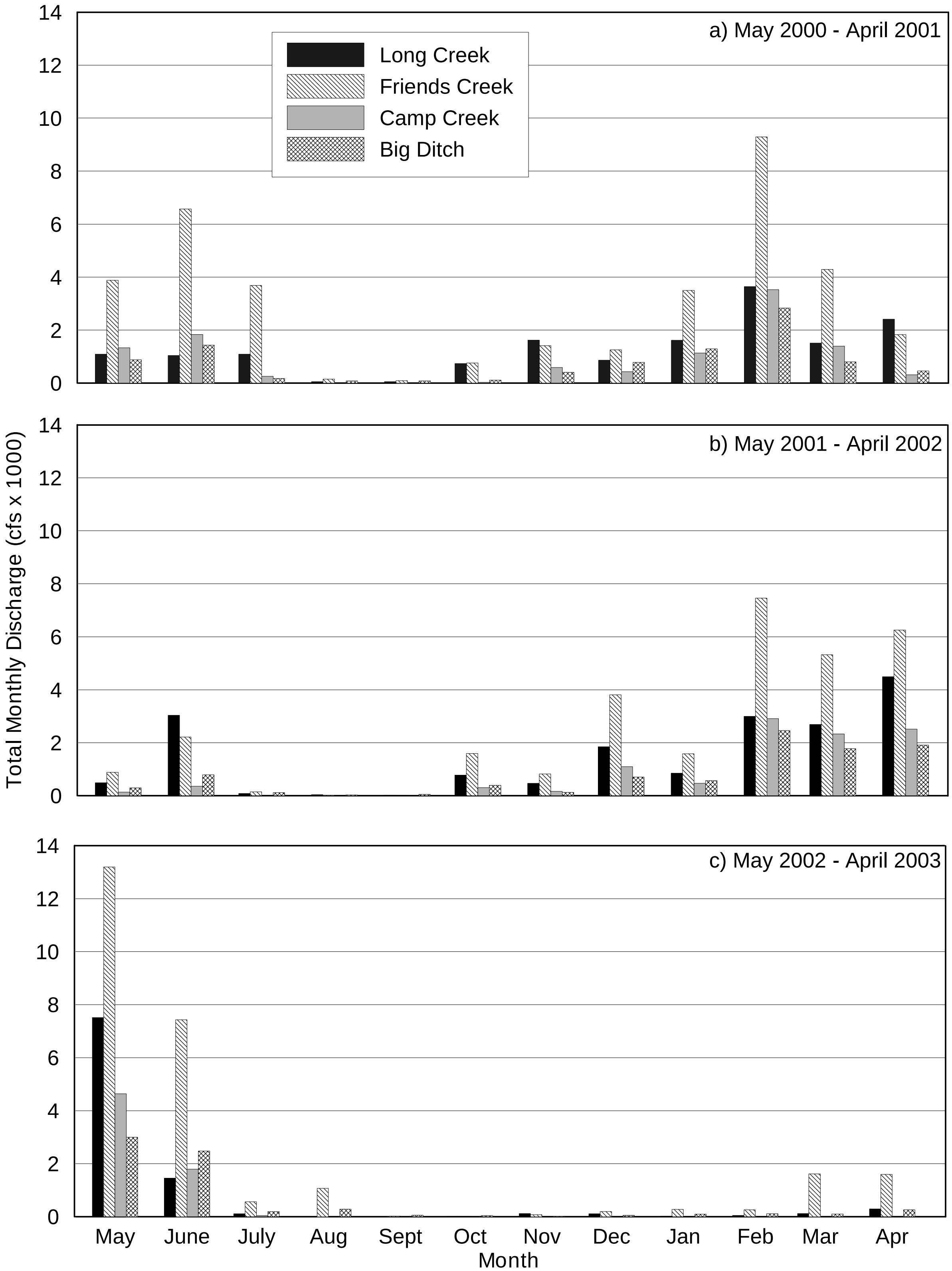

Figure 11. Monthly discharge for tributary stations: a) May 2000–April 2001, b) May 2001–April 2002, and c) May 2002–April 2003

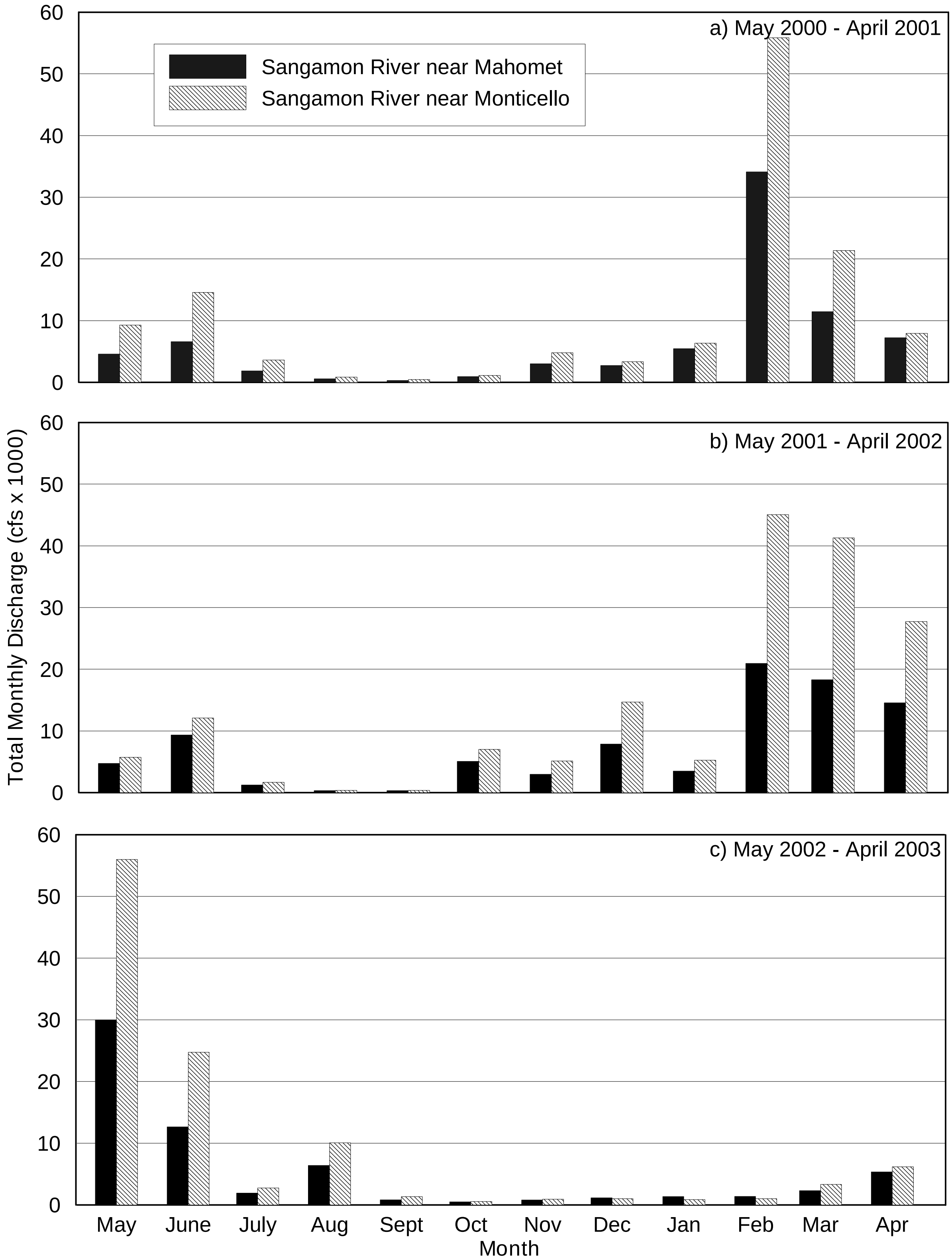

Figure 12. Monthly discharge for Sangamon River stations: a) May 2000–April 2001, b) May 2001–April 2002, and c) May 2002–April 2003

Table 8. Annual Streamflow for the Ten-Year Study Period (May 1993–April 2003)

	Annual streamflow (cfs x 1000)							
Project year	*Station 101*	*Station 102*	*Station 103*	*Station 104*	*Station 105*	*Station 106*	*Station 111*	*Station 112*
1	21.3	60.2	22.9	25.3	234.8	25.2	351.3	161.8
2	5.9	18.9	8.9	6.0	77.6	6.9	118.6	53.4
3	7.9	26.3	9.8	9.6	85.2	11.9	133.3	66.3
4	14.7	34.0	10.0	11.1	114.1	16.7	166.6	46.3
5	10.9	32.0	11.2	15.7	98.6	11.5	171.3	76.3
6	25.9	37.9	12.7	17.8	133.3	18.3	202.1	78.5
7	7.0	19.3	4.6	3.9	29.9	1.9	50.1	22.1
8	15.7	36.7	–	10.8	78.8	9.3	129.5	52.6
9	17.8	30.1	–	10.3	89.2	9.2	166.4	
10	9.8	26.3	–	–	64.6	6.7	108.7	

Note:
– Incomplete data or no data available.

The Sangamon River stations show the same trends as the tributary stations (figure 12). Discharges were highest in February 2000, 55,832 cfs at Monticello (111). The period of low flow (below 2,500 cfs) was July–October 2000 for Mahomet (105) and August–October 2000 for Monticello (111).

Project Year 9 (May 2001–April 2002)

All stations recorded highest monthly discharges in February 2002 during PY 9, except Long Creek (101). That station showed its highest discharge in April 2002.

For the tributary stations, October 2001–April 2002 discharge rates were highest at Friends Creek (102), with highest rates occurring in the spring. The duration of low flow for each station varied. Big Ditch (106) had the longest period of low flow, May 2001–January 2002. Low flow also occurred at Camp Creek (104), May–November 2001; Friends Creek (102), July–September 2001; and Long Creek (101), July–November 2001.

Discharge on the river was highest in February, March, and April 2002. The highest discharges were 45,057 cfs at Monticello (111) and 20,961 cfs at Mahomet. For all stations, the lowest discharges occurred July–September 2001.

Project Year 10 (May 2002–2003)

The highest monthly discharges at all stations occurred in May 2002; the second highest discharges occurred in June 2002. In July 2002, a period of low flow began at all stations and lasted through April 2003 (end of the project year). There were no late winter and early spring storms (February–April) during PY 10.

Discharge at all tributary stations was higher in May 2002 than in February–April 2002. Discharge rates declined in June 2002, and all stations posted low-flow conditions by July 2002. The period of low flow lasted through April 2003 for most stations.

The highest monthly discharge at river stations occurred in May 2002: 55,986 cfs at Monticello (111) and 29,969 cfs at Mahomet (105). The period of low flow (below 2,500 cfs) lasted from September 2002 through February 2003.

Runoff. For the purpose of comparing streamflow between stations, discharge was converted to runoff (inches per unit watershed area) by dividing monthly discharge by the drainage area upstream of the streamgaging station and then converting to inches. Runoff is a normalized streamflow per unit watershed area, which allows the comparison of streamflow and precipitation records between stations. Runoff varies between stations due to the spatial variability of precipitation patterns across the watershed and drainage characteristics. Monthly runoff data for May 2000–April 2003 are presented, and PYs 8–10 are discussed separately, followed by a summary discussion of annual runoff over the 10-year period. Figures 13 and 14 show monthly runoff in inches for PYs 8–10 for tributary and river stations, respectively. Annual runoff data for the 10-year study period are presented (table 9). Figures 15 and 16 present annual runoff in inches for the tributary and river stations, respectively.

Project Year 8 (May 2000–April 2001)

The highest monthly runoff at tributary stations, 3.11 inches, occurred at Friends Creek (102) in February 2001. That station had consistently higher runoff than the other stations during May–July 2000, while Long Creek (101) values were generally greater than those at other stations during October 2000–January 2001 and in April 2001. Monthly runoff in July–October 2000 was less than 0.5 inches at most stations. Exceptions occurred in July 2000 at Long Creek (101) and Friends Creek (102), 0.84 and 1.24 inches, respectively, and in October 2000 at Long Creek (101), 0.60 inches. Long Creek (101) also had unusually high runoff, 1.96 inches in April 2001, due to isolated storms that did not affect the rest of the watershed. Runoff at the other three stations averaged 0.45 inches in April 2001.

The greatest runoff at river stations occurred in February 2001: 3.85 inches at Monticello (111) and 3.47 inches at Mahomet (105). Both stations had runoff of less than an inch during May 2000–January 2001 and April 2001.

Project Year 9 (May 2001–April 2002)

The highest runoff at the tributary stations occurred in February 2002, except at Long Creek (101). Monthly runoff averaged less than 0.5 inches at all stations during July–November 2001. Monthly runoff was consistently higher at Long Creek (101) than at other tributary stations throughout PY 9 except during May 2001 and February 2002. Due to isolated storms in the Decatur area, Long Creek (101) had unusually high monthly runoff in June 2001 (2.47 inches) and April 2002 (3.65 inches) compared to the average runoff at the other three stations during those months, 0.60 and 1.99 inches, respectively.

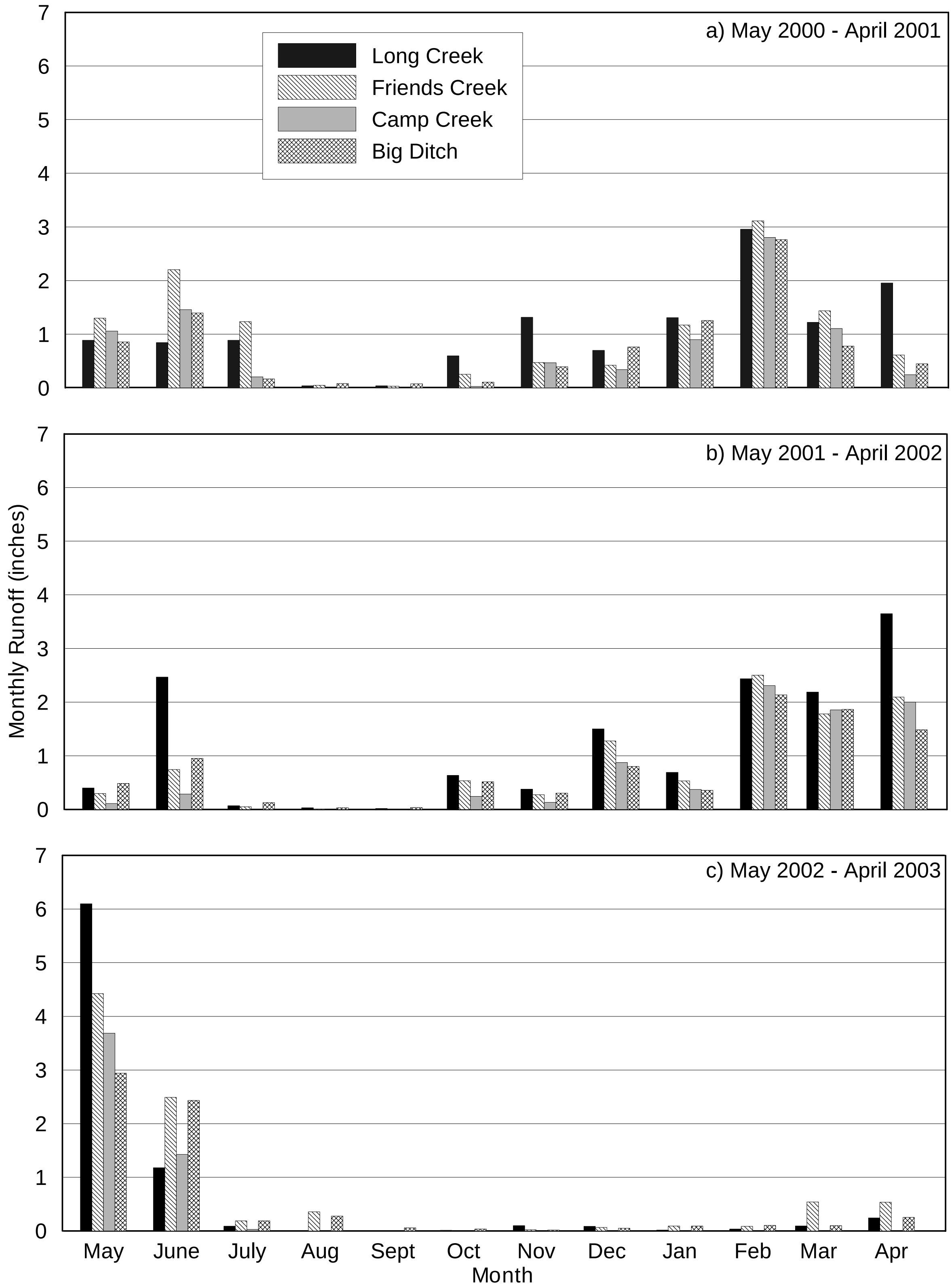

Figure 13. Monthly runoff for tributary stations: a) May 2000–April 2001,
b) May 2001–April 2002, and c) May 2002–April 2003

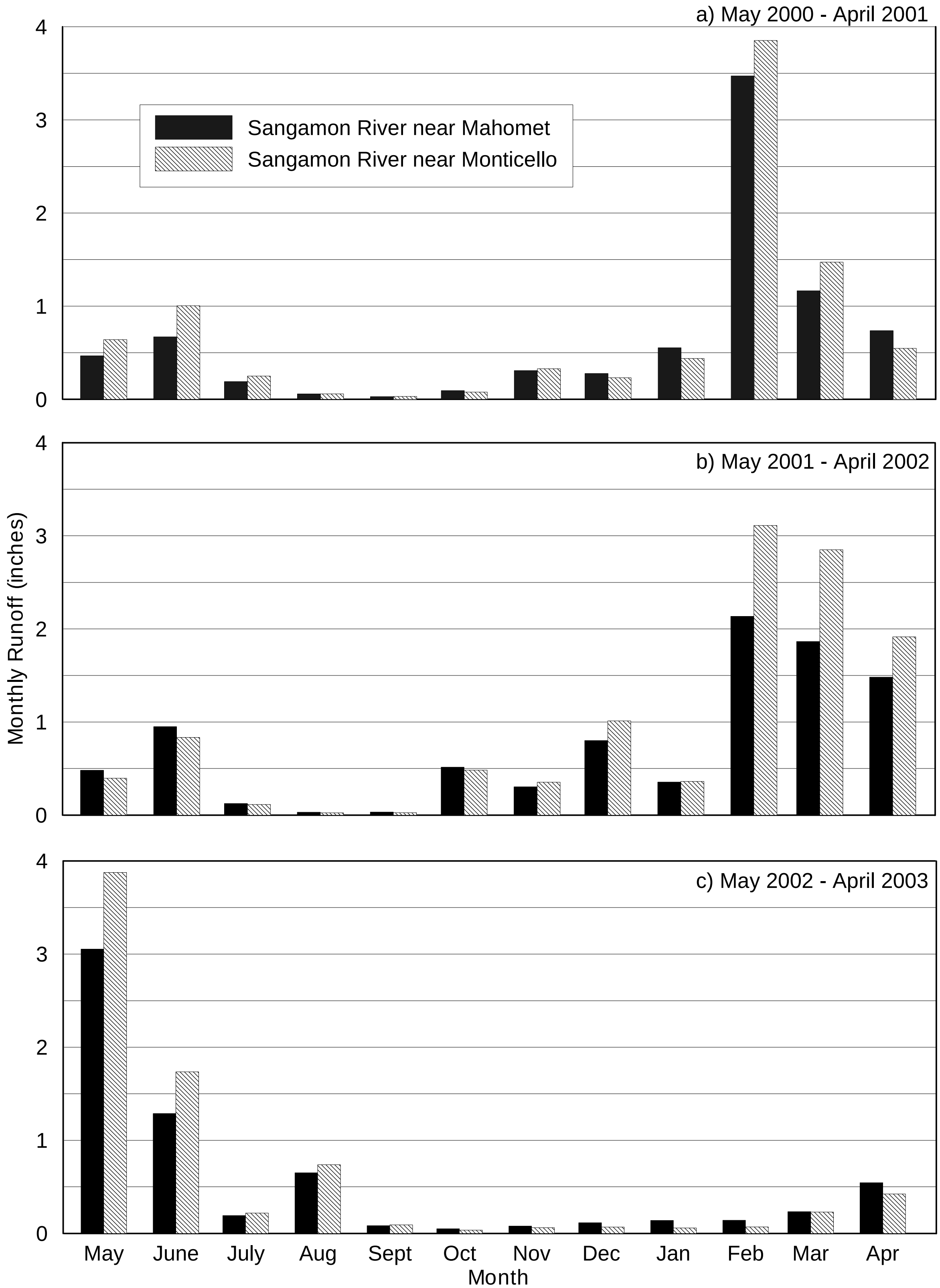

Figure 14. Monthly runoff for Sangamon River stations: a) May 2000–April 2001, b) May 2001–April 2002, and c) May 2002–April 2003

Table 9. Annual Runoff for the Ten-Year Study Period (May 1993–April 2003)

	Runoff (inches)										
Station	*Year 1*	*Year 2*	*Year 3*	*Year 4*	*Year 5*	*Year 6*	*Year 7*	*Year 8*	*Year 9*	*Year 10*	*Mean*
Tributary stations											
Long Creek (101)	17	5	6	12	9	21	6	13	14	8	11
Friends Creek (102)	20	6	9	11	11	13	6	12	10	9	11
Goose Creek (103)	19	7	8	8	9	11	4	–	–	–	9
Camp Creek (104)	20	5	8	9	12	14	3	9	8	–	10
Big Ditch (106)	25	7	12	16	11	18	2	9	9	7	12
Annual average	20	6	9	11	11	15	4	11	10	8	
Sangamon River stations											
Mahomet (105)	24	8	9	12	10	14	3	8	9	7	10
Monticello (111)	24	8	9	12	12	14	3	9	11	8	11
Fisher (112)	25	8	10	12	12	12	3	8	–	–	11
Annual average	24	8	9	12	11	13	3	8	10	7	
All stations											
Yearly average	22	7	9	12	11	14	4	10	10	8	

Note:
– Incomplete data or no data available.

The highest runoff at river stations was 3.11 inches at Monticello (111) in February 2002. During May 2000–January 2001, monthly runoff was less than an inch at both stations and less than 0.5 inches for seven of those months. During February and March 2002, runoff at Monticello (111) was approximately an inch greater than at Mahomet (105).

Project Year 10 (May 2002–April 2003)

Monthly runoff for all stations was highest in May and June 2002. Average runoff during those two months was 4.01 and 1.76 inches, respectively.

Among tributary stations, Long Creek (101) had the highest monthly runoff, 6.10 inches in May 2002, due to isolated storms. Runoff values varied greatly in May 2002: 6.10 inches at Long Creek (101), 4.42 inches at Friends Creek (102), 3.69 inches at Camp Creek (104), and 2.94 inches at Big Ditch (106). Runoff values were below 0.5 inches for 10 consecutive months, July 2002–April 2003.

Among river stations, the highest runoff occurred in May 2002: 3.88 inches at Monticello (111) and 3.05 inches at Mahomet (105). Runoff values averaged below 0.5 inches for the rest of the project year (July 2002–April 2003), except in August 2002.

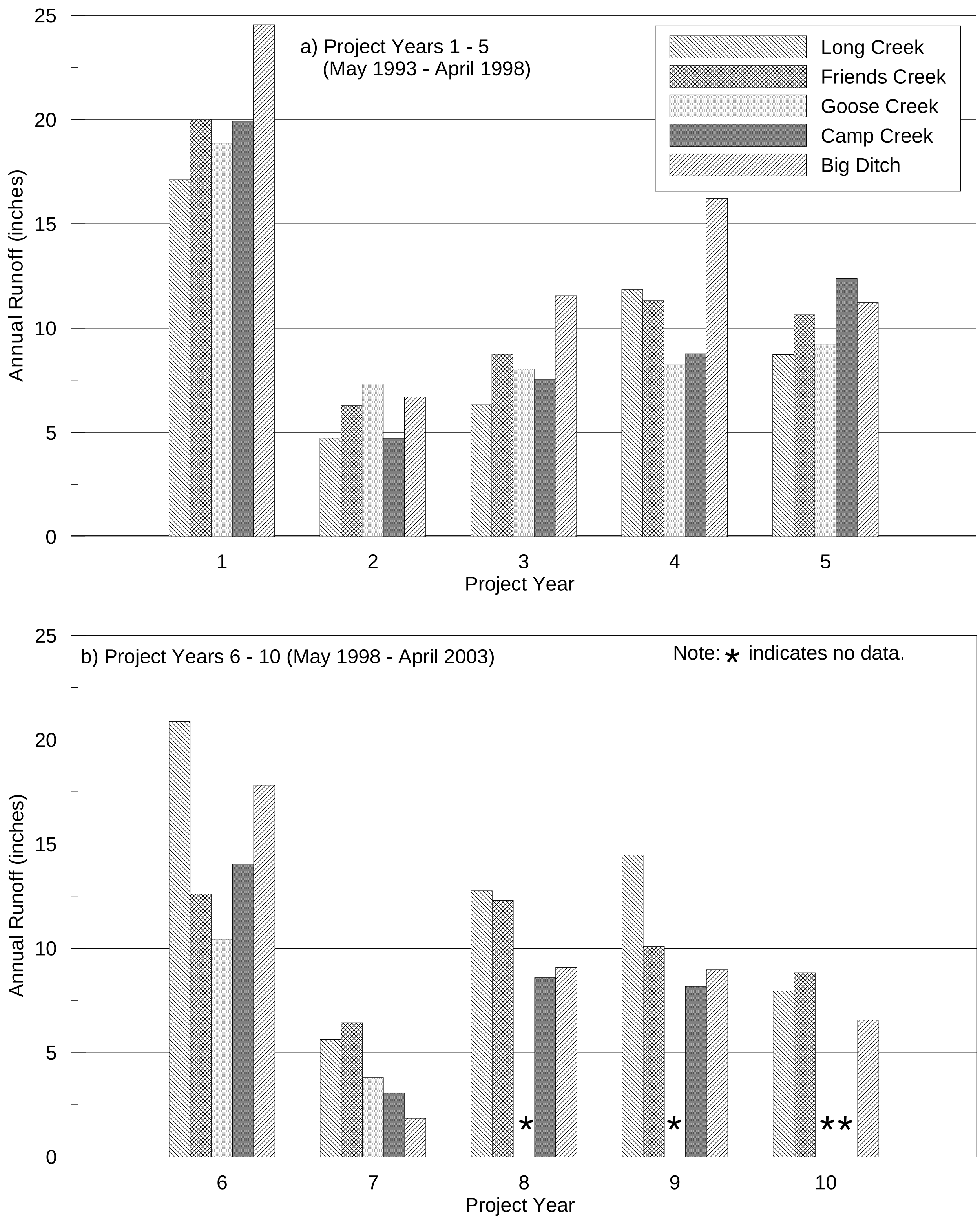

Figure 15. Annual runoff for tributary stations: a) Project Years 1–5 (May 1993–April 1998) and b) Project Years 6–10 (May 1998–April 2003)

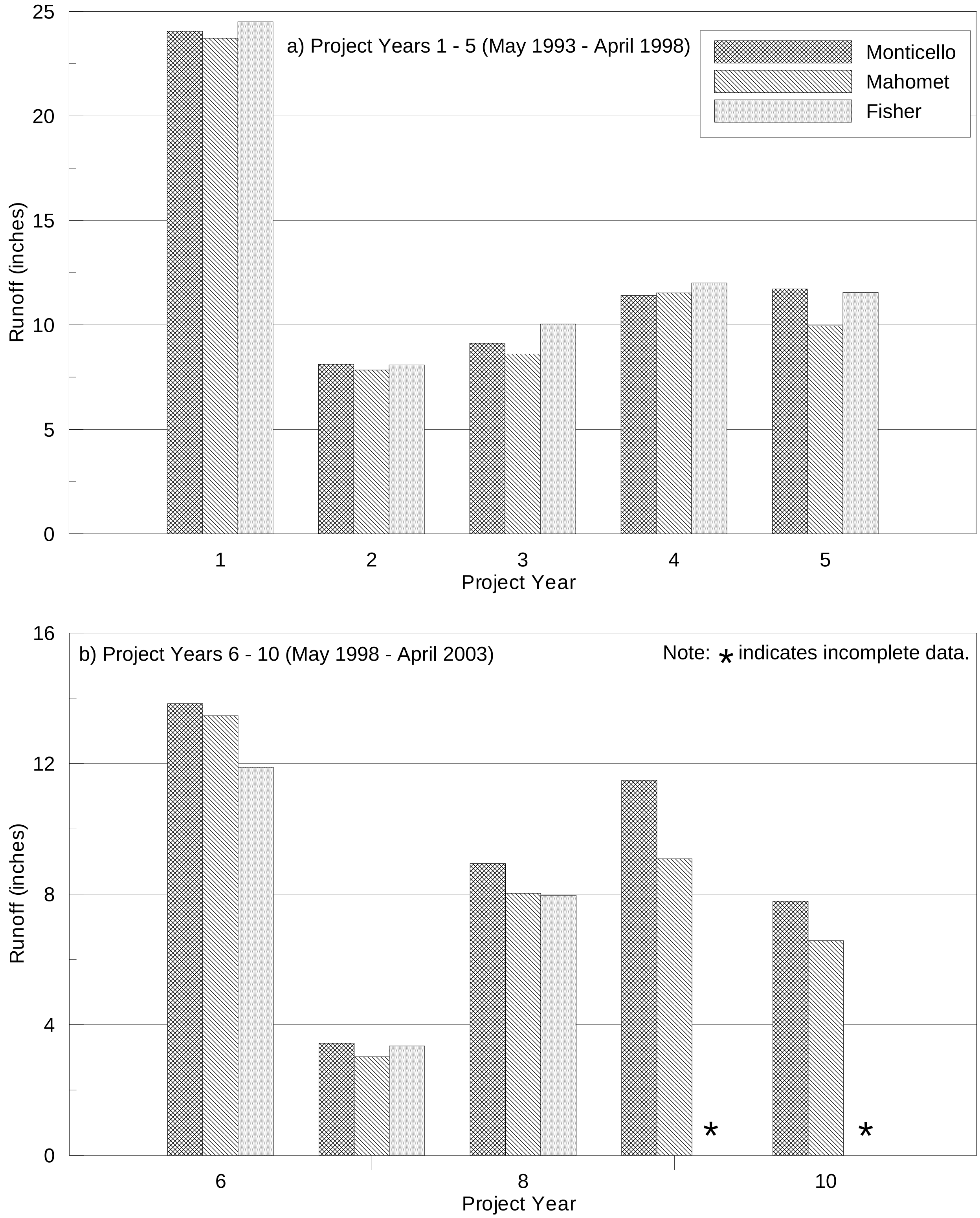

Figure 16. Annual runoff for Sangamon River stations: a) Project Years 1–5 (May 1993–April 1998) and b) Project Years 6–10 (May 1998–April 2003)

Ten-Year Summary of Annual Runoff (May 1993–April 2003)

Figures 15 and 16 show annual runoff, May 1993–April 2003, for tributary and river stations, respectively. All stations had their highest annual runoff in PY 1, except Long Creek (101), which had its highest annual runoff in PY 6. Second highest runoff for all stations occurred in PY 6.

Among tributary stations, the highest runoff occurred in PY 1 (20.1 inches) and PY 6 (15.2 inches). The lowest runoff occurred in PYs 2 and 7, 6.0 and 4.2 inches, respectively. Average runoff for each station over the entire project period ranged from 9.7 inches at Camp Creek (104) to 11.5 inches at Big Ditch (106). The difference in annual runoff between sub-watersheds for a particular year ranged from 2.3 inches in PY 10 to 10.5 inches in PY 6. The high variation in runoff is attributed to the longer north-south dimension of the watershed and sub-watersheds. Big Ditch (106) is at the northern end of the watershed, and Long Creek (101) is at the extreme southern end of the watershed. As weather patterns generally move west to east across Illinois, isolated storms can cause more precipitation over small portions of the entire watershed while leaving the rest of the watershed dry.

Among river stations, the highest runoff occurred in PY 1 (24.1 inches) and PY 6 (13.1 inches). The lowest average annual runoff occurred in PY 7 and PY 2, 3.3 and 8.0 inches, respectively. Runoff for Monticello (111) over the 10-year project period averaged 11 inches.

Water Quality Monitoring

Nitrate-N samples were collected at all stations during May 1993–April 2003. Water temperature of the bulk sample was recorded. Total Kjeldahl nitrogen and ammonium were sampled during PYs 1 and 2, May 1993–April 1995 (Demissie et al., 1996). During November 2000–April 2003, an automatic pump sampler at Big Ditch (106) collected storm samples. Acidity, NVOC, arsenic (As), boron (B), and sulfur (S) were sampled biweekly at Mahomet (105) and Monticello (111), March 2001–April 2003. Sampling for NVOC at Long Creek (101), Friends Creek (102), and Lost Bridge (107) was added in May 2002. Minimum, maximum and mean temperature, acidity, and NVOC values are presented in appendix B. Metals (As, B, and S), NVOC, temperature, and acidity data are presented in appendix C. Those data were collected for use by City of Decatur resource managers and are not discussed further in this report.

Nitrate-N

Nitrate-N samples were collected manually by weighted bottle method. Water samples were stored at 4°C and transported to the ISWS laboratory for analysis. Weekly samples were collected unless the stream was pooled or ice-covered. Efforts were made to visit sites more often during storm events.

Nitrate-N Concentration. Figures 17 and 18 present the nitrate-N concentrations for PYs 8–10 at tributary, river, and lake stations, respectively. Table 10 shows maximum, mean, and

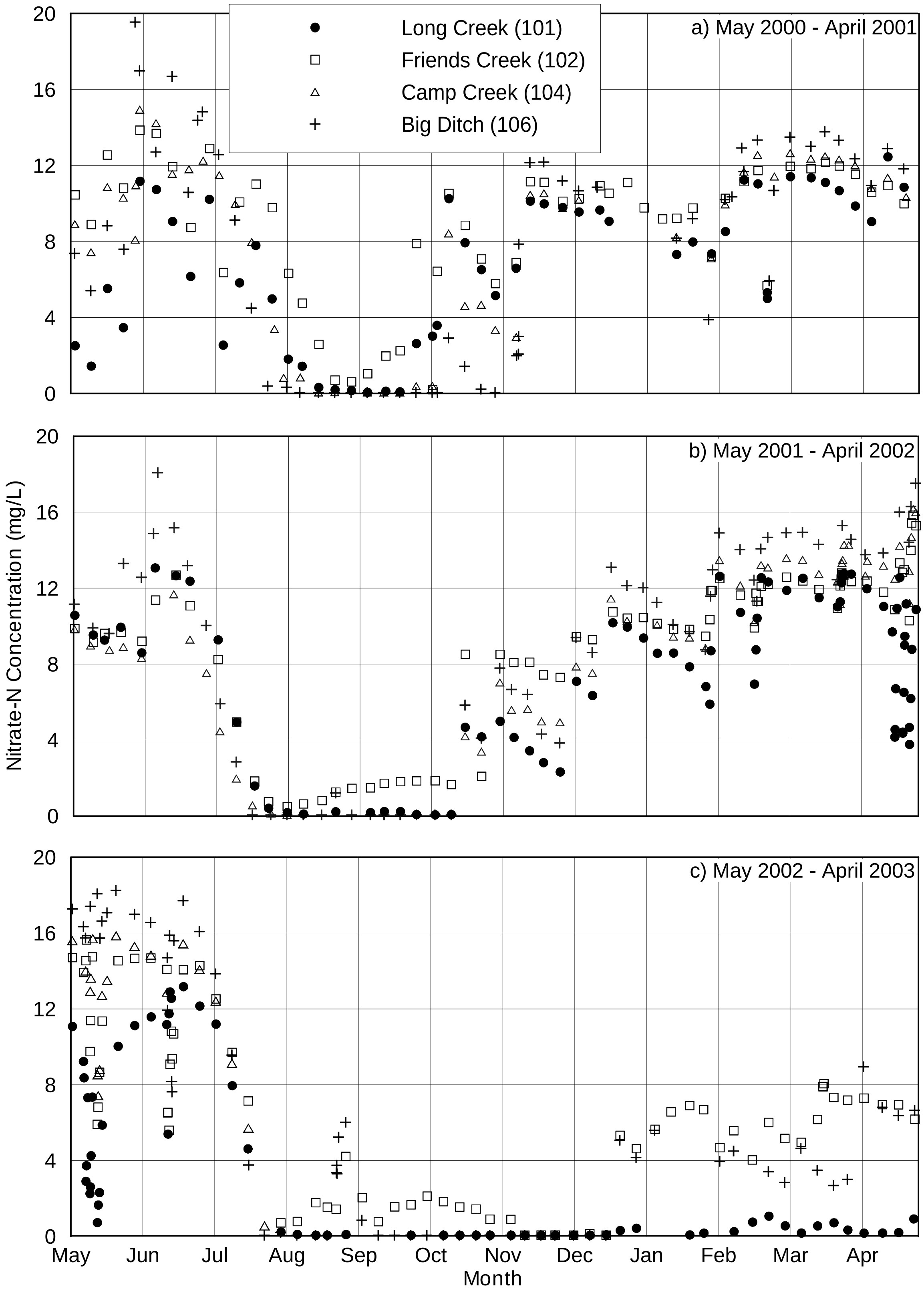

Figure 17. Nitrate-N Concentrations for tributary stations: a) May 2000–April 2001, b) May 2001–April 2002, and c) May 2002–April 2003

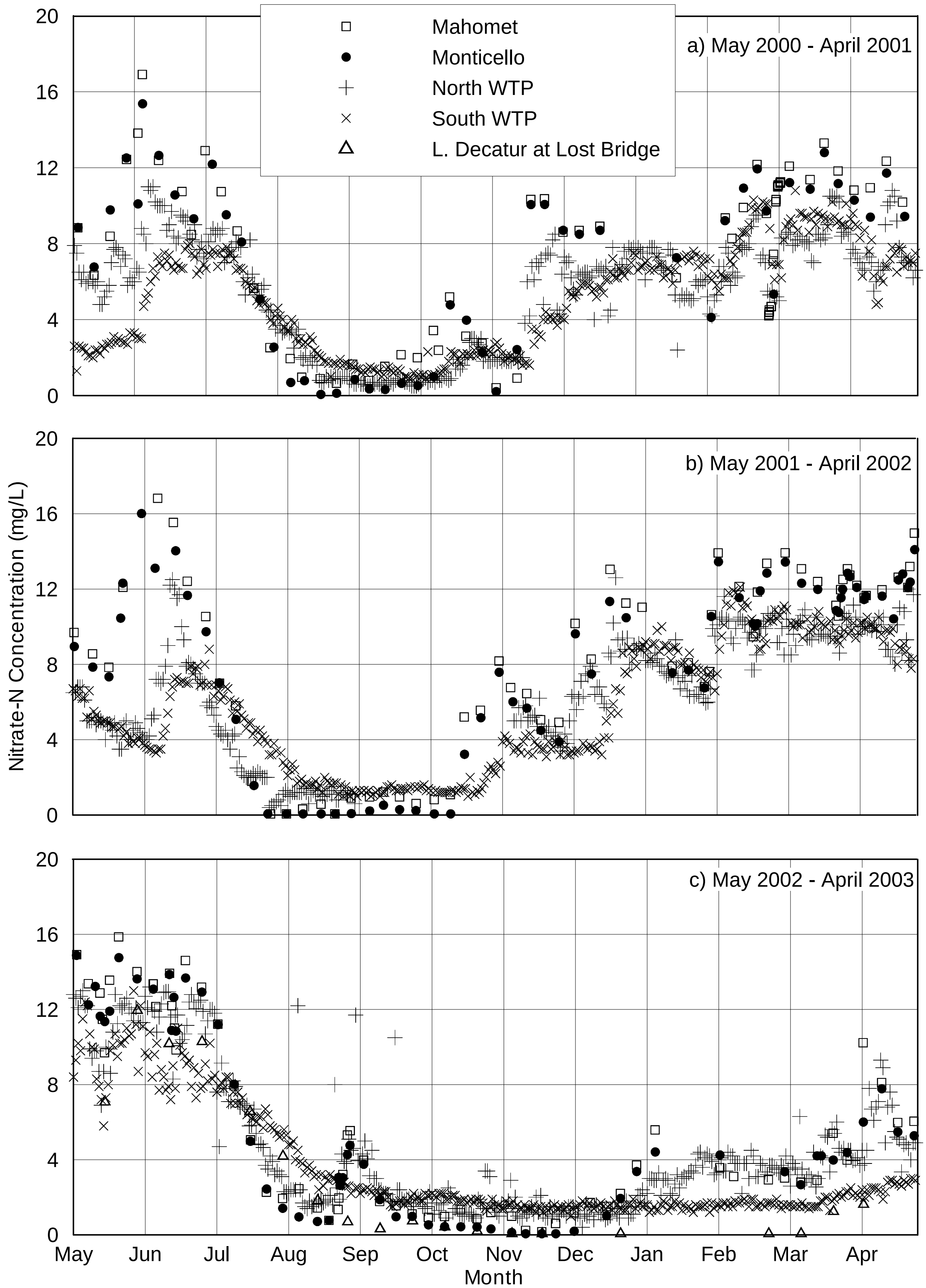

Figure 18. Nitrate-N concentrations for Sangamon River stations: a) May 2000–April 2001, b) May 2001–April 2002, and c) May 2002–April 2003

Table 10. Maximum, Mean, and Minimum Nitrate-N Concentrations during Project Years 8–10 (May 2000–April 2003)

	Nitrate-N concentration (mg/L)								
	Project Year 8			*Project Year 9*			*Project Year 10*		
Station	*Max*	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*	*Mean*	*Min*
Tributary									
Long Creek (101)	12.45	6.66	0.06	13.06	7.47	0.06	13.17	3.66	0.06
Friends Creek (102)	13.85	8.78	0.21	15.84	9.07	0.49	15.64	6.56	0.06
Camp Creek (104)	15.30	9.31	0.06	16.17	9.79	0.06	15.86*	11.96	0.56
Big Ditch (106)	19.54	7.37	0.06	19.53	12.08	0.06	18.33	11.32	0.06
River/Lake									
Mahomet (105)	16.91	7.74	0.41	16.81	8.49	0.06	15.87	5.71	0.16
Monticello (111)	15.37	7.01	0.06	16.00	8.24	0.06	14.88	5.44	0.06
NWTP	11.00	5.49	0.50	12.60	6.54	0.40	13.20	4.60	0.40
SWTP	10.80	5.06	0.80	12.10	5.57	1.00	13.00	3.60	1.00
Lost Bridge (107)		–	–	–	–	–	11.95	3.05	0.06

Notes:
* Partial year of data.
– No data available.

minimum nitrate-N concentrations at all stations for May 2000–April 2003 (PYs 8–10). In the following section, PYs 8–10 are discussed here separately. The data for project years 1–10 can be found in Appendix D. Overall, the nitrate-N concentration data exhibit a seasonal cycle: highest concentrations during the spring months, decreases to near zero during the summer, rises again during the fall, and then relatively steady concentrations through the winter. In general, concentrations tend to be highest in the tributaries then decrease downstream from the Sangamon River through Lake Decatur.

Project Year 8 (May 2000–April 2001)

Among tributary stations, Big Ditch (106) and Camp Creek (104) had the highest concentrations, 19.54 and 14.94 mg/L, respectively, in May 2000. The lowest concentrations were below the minimum detectable limit (MDL) of 0.06 mg/L at Long Creek (101), Camp Creek (104), and Big Ditch (106) during August and September 2000. Friends Creek (102) had the highest annual mean concentration, 8.78 mg/L. Long Creek (101) had the lowest annual mean concentration, 6.66 mg/L. Long Creek (101) also had consistently lower concentration values than other stations throughout the year, except during late September 2000.

During the spring and early summer, all stations, except Long Creek (101), had their highest annual concentrations in May 2000. During this season, Long Creek (101) concentrations were consistently lower than those at Big Ditch (106), Camp Creek (104), and Friends Creek (102). Large variations in concentrations were observed. For example, Camp Creek (104) and Big Ditch (106) had the largest difference in nitrate concentrations, 8.10 and 19.54 mg/L, respectively, on May 28, 2000. By mid-August 2000, nitrate-N concentrations at most stations were approaching the nitrate MDL. The period of low nitrate concentration lasted about two months (August–September 2000). Friends Creek concentrations were first to increase in early September 2000, almost a month before other stations.

Nitrate-N concentrations increased in early October 2000 followed by a slow decrease in early November 2000. Friends Creek (102) concentrations were consistently higher, and Big Ditch (106) concentrations were consistently lower than those at other stations during this period. All station concentrations increased to an average of 11 mg/L in mid-November 2000, then slowly decreased through January 2001.

In February 2001, concentrations increased at all stations. During February–April 2001, Big Ditch (106) had the highest concentration, 13.77 mg/L. The mean concentration at all stations during this period was 10.38 mg/L. Big Ditch (106) concentrations were consistently higher, and Long Creek (101) concentrations were consistently lower than those at other stations, during February–April 2001.

River and lake nitrate-N concentrations showed the same seasonal trends as tributary stations. Concentrations at the river stations were not as variable as tributary stations, and those at water treatment plants in Lake Decatur were even less variable. Mahomet (105) had the highest concentration, 16.91 mg/L, and the highest mean concentration for the year, 7.71 mg/L, compared to the lowest concentration at the South Water Treatment plant (SWTP) intake in Lake Decatur, which had a 10.80 mg/L maximum value and a 5.06 mg/L average value. From mid-June 2000 through April 2001, Mahomet (105) showed consistently higher concentrations than those at other stations downstream. The annual minimum concentration at all locations was below 0.8 mg/L.

Project Year 9 (May 2001–April 2002)

For tributary stations, the highest nitrate-N concentration was at Big Ditch (106), 18.07 mg/L. The lowest nitrate-N concentrations were near or below the MDL at Long Creek (101), Camp Creek (104) and Big Ditch (106), August–October 2001. Friends Creek (102) had higher concentrations than other stations, mid-July–December 2001. In general, Big Ditch (106) had higher concentrations than other stations, mid-December 2001–April 2002. Annual mean concentrations were highest at Big Ditch (106), 12.08 mg/L, and lowest at Long Creek (101), 7.47 mg/L.

During May and June 2001, concentrations did not vary significantly between stations. Nitrate-N concentrations decreased steadily to the MDL by mid-July 2001. The mean concentration at all stations during May and June 2001 was 11.05 mg/L.

Nitrate-N concentrations were near the MDL at all stations except Friends Creek (102), mid-July–mid-October 2001. Friends Creek (102) concentrations increased very slowly from a low of 0.49 mg/L to a high of 1.86 mg/L during the season. Nitrate-N concentrations had a stairstep pattern of sharp increases and slow declines, mid-October–April 2001. These peak concentrations occurred in mid-October [Friends Creek (102), 8.51 mg/L], mid-December [Big

Ditch (106), 13.09 mg/L], February 2002 [Big Ditch (106), 14.90 mg/L], and late April 2002 [Big Ditch (106), 17.52 mg/L]. During February–April 2002, concentrations fluctuated at all stations. Over the study period, it has been observed that nitrate-N concentrations fluctuated dramatically during storm events. Concentrations usually increase at the beginning of a storm event and decrease near the peak discharge of the event. As discharge levels stabilize, nitrate-N levels return to near previous levels.

River and lake stations showed the same trends as tributary stations. Mahomet (105) had the highest concentration, 16.81 mg/L, and the highest mean concentration, 8.49 mg/L. Monticello (111) had a high concentration of 16.00 mg/L and a mean concentration of 8.24 mg/L. Mahomet (105) had consistently higher concentrations than Monticello (111), June 2001–April 2002. Nitrate-N concentrations increased abruptly at the beginning of February 2002 for an early spring high of 13.91 mg/L. Concentrations were steady at approximately 12 mg/L, February–April 2002. Maximum and mean concentrations at both treatment plants were approximately 4 and 2 mg/L less than those at Monticello (111) and Mahomet (105) (table 10).

Project Year 10 (May 2002–April 2003)

For tributary stations, Big Ditch (106) had the highest concentration for the year, 18.25 mg/L, and Long Creek (101) had the lowest concentration, at the MDL. Monitoring at Camp Creek (104) was discontinued in July 2002.

Sharp increases and decreases in nitrate-N concentrations were observed during May and June 2002. Over the study period, nitrate-N concentrations fluctuated dramatically during storm events.

In mid-June 2002, concentrations at all stations began a steady decrease, approaching the MDL in mid-July 2002. Mid-July–late December concentrations remained low. During these six months of low flow conditions, Big Ditch (106) and Friends Creek (102) had the highest concentrations, 6.03 and 4.22 mg/L, respectively. These high concentrations were coincident with a small storm event in late August 2002. At some point during this period, concentrations were below the MDL at each of the stations. Friends Creek (102) concentrations were generally higher than those at other stations, August–October 2002.

In mid-December, nitrate-N concentrations at Friends Creek (102) and Big Ditch (106) increased from below the MDL to approximately 5 mg/L and remained between 3 and 9 mg/L through the end of the project year. The highest concentration was 9.00 mg/L at Big Ditch (106), and the lowest was 0.08 mg/L at Long Creek (101). Nitrate-N concentrations at Long Creek (101) did not increase significantly during this period. The highest concentration measured at Long Creek (101) was 1.07 mg/L, September 2002–April 2003. In general, October 2002–April 2003 nitrate-N concentrations were significantly lower than those in any other project year.

River and lake stations showed the same seasonal trends as the Big Ditch (106) and Friends Creek (102) stations. In May 2002, Mahomet (105) had the highest mean concentration and highest maximum concentration, 5.72 and 15.87 mg/L, respectively. The lowest concentrations, below the MDL, occurred at Monticello (111) and Lost Bridge (107). Lost

Bridge (107) had the lowest mean concentration, 3.05 mg/L. Mahomet (105) had consistently higher concentrations than the four other stations. Lost Bridge (107) concentrations were always less than those at other stations, except during late July and August 2002.

Nitrate-N Load. Nitrate-N load is used to compare the relative contribution of nitrate-N from different areas being monitored over time. Nitrate-N load is calculated as the product of nitrate-N concentration and discharge. This load is converted to pounds of nitrate-N per year and normalized per unit area (acres) to determine the relative contribution of nitrate-N per acre from the watershed above each monitoring station (Keefer, 2003).

Monthly nitrate-N loads (pounds or lb/acre/month) for tributary and river stations are presented in figures 19 and 20, respectively. Each year of monthly nitrate-N load data for the period May 2000–April 2003 (PYs 8–10) is discussed separately, followed by discussion of annual loads (lb/acre/year) for the 10-year project period (May 1993–April 2003), with data presented in table 11. Annual nitrate-N load data for all stations for the entire monitoring period are shown in figures 21 and 22.

Table 11. Annual Nitrate-N Loads in the Sangamon River Basin for the Ten-Year Study Period (May 1993–April 2003)

	Annual nitrate-N load (lb/acre)										
Station	*Year 1*	*Year 2*	*Year 3*	*Year 4*	*Year 5*	*Year 6*	*Year 7*	*Year 8*	*Year 9*	*Year 10*	*Mean*
Tributary											
Long Creek (101)	28	9	13	25	18	50	11	23	34	16	23
Friends Creek (102)	35	12	20	28	25	35	16	23	24	19	24
Goose Creek (103)	36	16	18	20	21	28	12	–	–	–	22
Camp Creek (104)	39	11	18	24	28	37	9	19	19	–	23
Big Ditch (106)	49	15	17	26	27	43	5	21	22	19	24
Annual average	37	13	17	25	24	39	11	21	25	18	
Sangamon River											
Fisher (112)	40	15	21	26	27	32	8	–	–	–	24
Mahomet (105)	37	14	17	25	22	31	7	15	22	15	21
Monticello (111)	34	14	16	24	25	33	8	17	26	18	21
Annual average	37	14	18	25	25	32	8	16	24	16	
Weighted annual yield into Lake Decatur*	32	12	16	25	23	38	10	19	28	17	22

Notes:
– No data available.
* Area-weighted using Long Creek, Friends Creek, and Monticello stations.

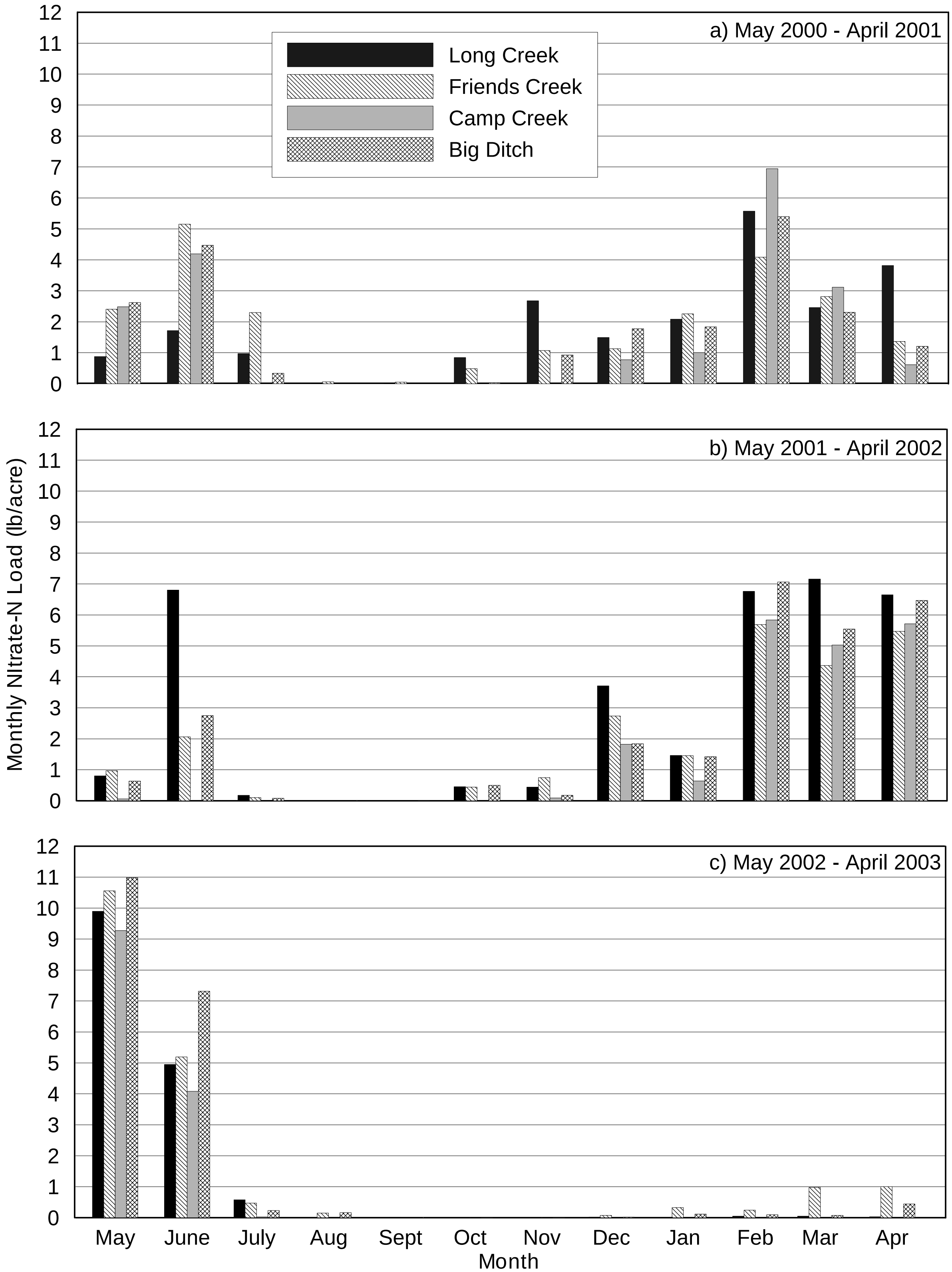

Figure 19. Monthly nitrate-N loads for tributary stations: a) May 2000–April 2001, b) May 2001–April 2002, and c) May 2002–April 2003

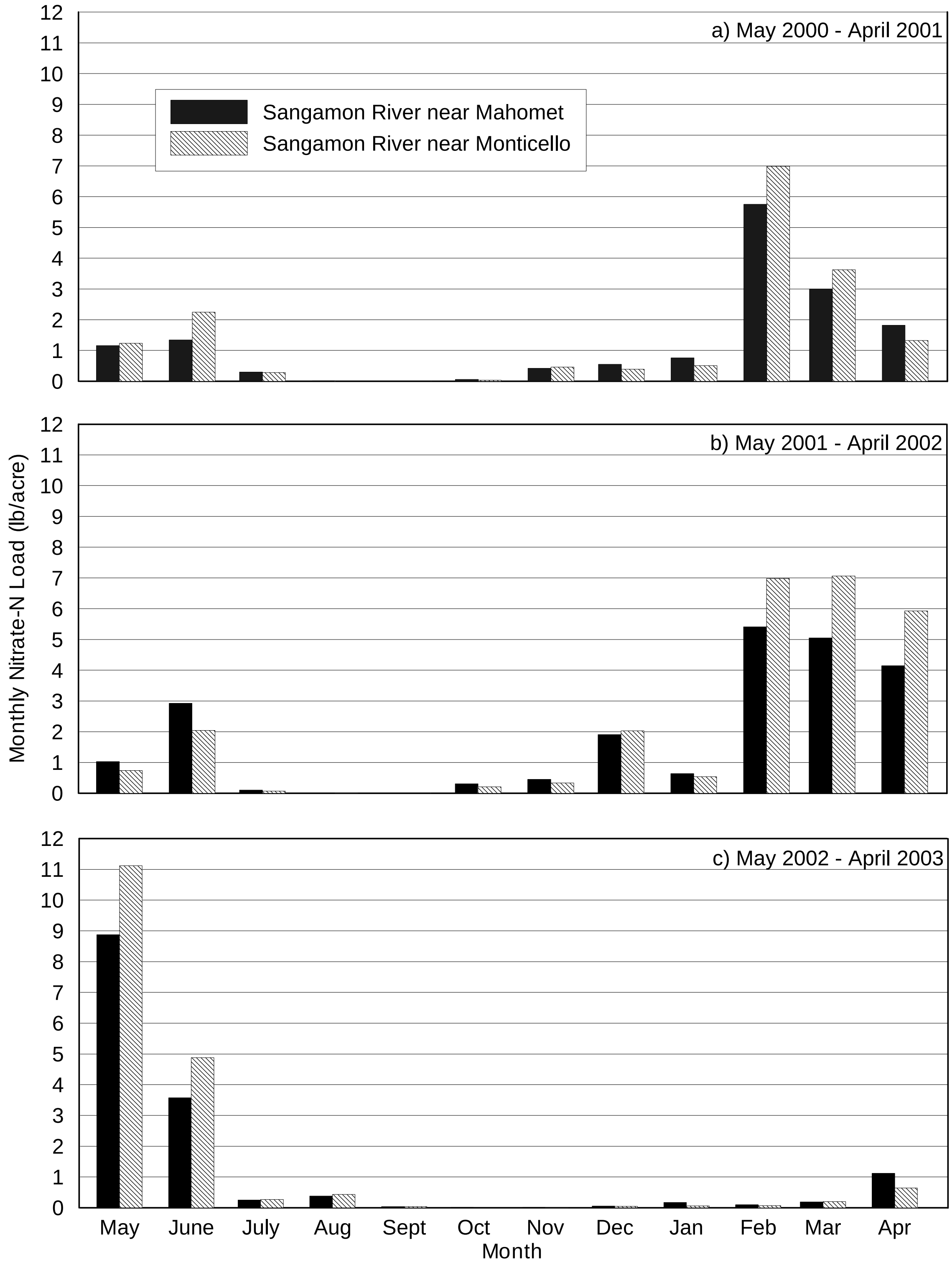

Figure 20. Monthly nitrate-N loads for Sangamon River stations: a) May 2000–April 2001, b) May 2001–April 2002, and c) May 2002–April 2003

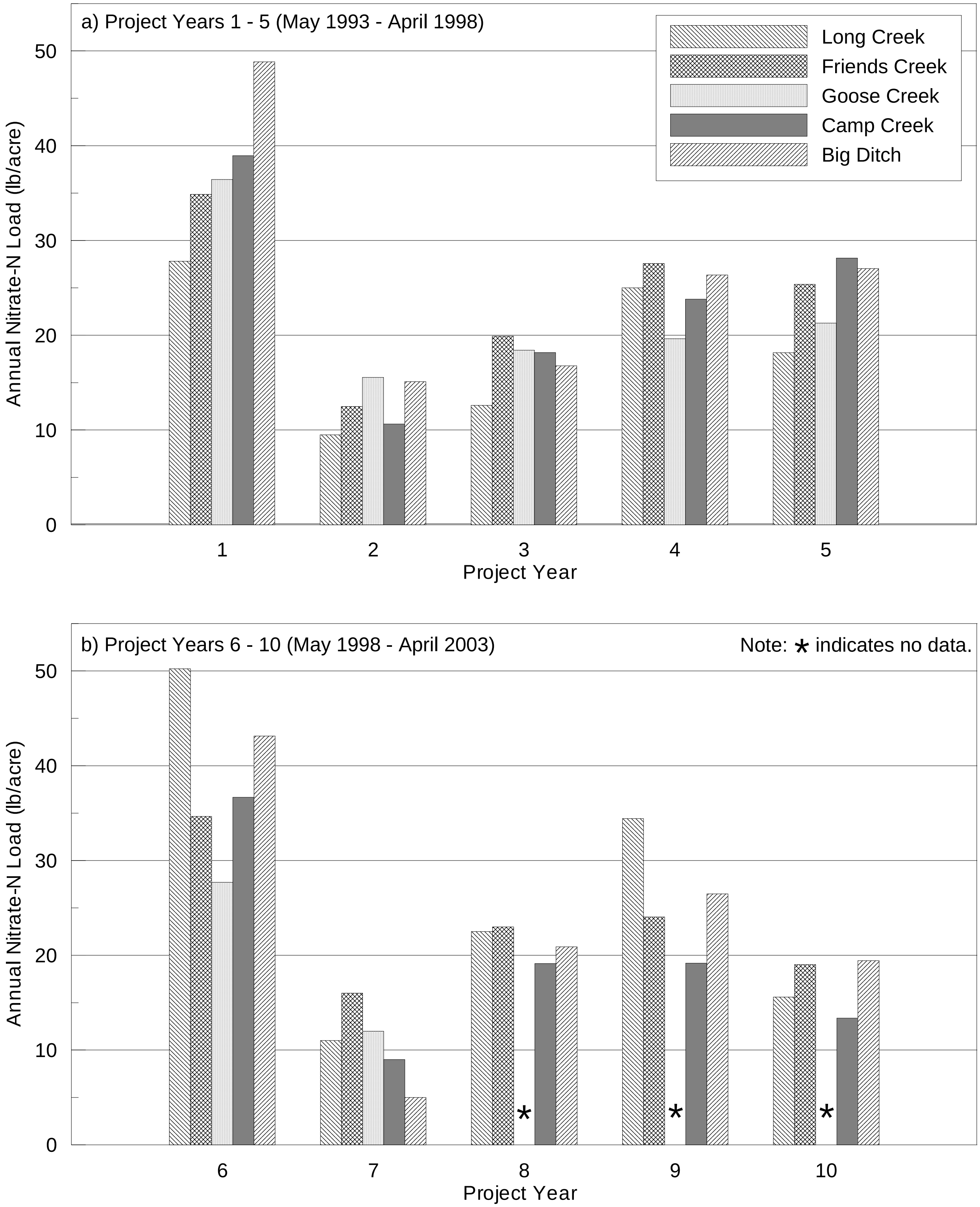

Figure 21. Annual nitrate-N loads for tributary stations: a) Project Years 1–5 (May 1993–April 1998) and b) Project Years 6–10 (May 1998–April 2003)

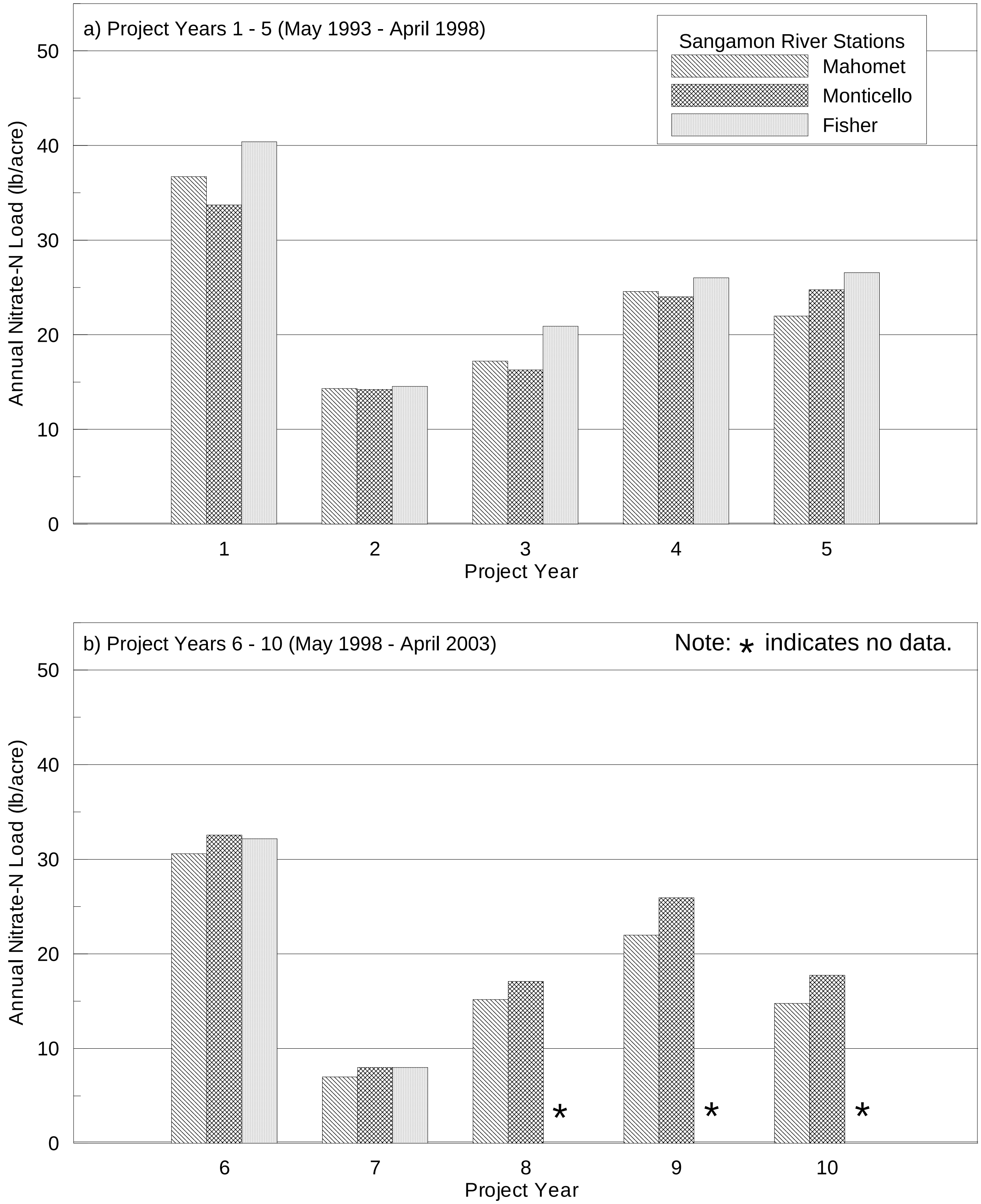

Figure 22. Annual nitrate-N loads for Sangamon River stations: a) Project Years 1–5 (May 1993–April 1998) and b) Project Years 6–10 (May 1998–April 2003)

Project Year 8 (May 2000–April 2001)

For tributary stations, Camp Creek (104) had the highest monthly nitrate-N load for the year in February 2001, 6.9 lb/acre. The lowest monthly load was zero pounds at Big Ditch (106) in September and October 2000 and at Camp Creek (104), July–November 2000. Monthly loads were below one lb/acre at all stations, August–October 2000. Monthly loads gradually increased, November 2000–February 2001. Loads decreased in March and April 2001. The average monthly load for all stations was 2.0 lb/acre.

River stations showed the same trends as tributary stations. Monticello (111) had the highest monthly load, 7.0 lb/acre in February 2001. Nitrate-N load was low (< 1 lb/acre), July 2000–January 2001. Loads increased sharply in February 2001, averaging 6.4 lb/acre before decreasing in March and April 2001.

Project Year 9 (May 2001–April 2002)

For tributary stations, Long Creek (101) had the highest monthly load, 7.2 lb/acre in March 2002, with the next highest value, 6.8 lb/acre in June 2001. Monthly nitrate-N loads were below one lb/acre at all stations, May 2001 and July–November 2001. All tributary stations had zero or near zero load (<0.01 lb/acre) during August and September 2001. Monthly loads increased from an average of 0.5 lb/acre in October 2001 to 6.3 lb/acre in February 2002. Long Creek (101) had an isolated high monthly load, 6.8 lb/acre in June 2001, due to an isolated storm that did not occur at other tributary stations. Long Creek (101) and Big Ditch (106) had the highest monthly nitrate-N loads, February–April 2002.

River stations showed the same trends as tributary stations. Monticello (111) had the highest monthly load, 7.1 lb/acre in March 2002. Monthly loads at Monticello (111) were more than 3 lb/acre greater than monthly loads at Mahomet (105), February–April 2002.

Project Year 10 (May 2002–April 2003)

For tributary stations, Big Ditch (106) had the highest load for the project year, 11 lb/acre in May 2002. All stations had their highest monthly loads for the year during May 2002, and those values were the highest recorded since May 1998 (PY 7). July 2002–April 2003 monthly nitrate-N loads were less than one lb/acre at all stations. In June 2002, nitrate-N load at Big Ditch (106) was 2 lb/acre greater than at other tributary stations.

Monthly loads at river stations increased from 5.0 lb/acre in April 2002 to 10.00 lb/acre in May 2002. During May and June 2002, loads at Monticello (111) were 2.2 and 1.3 lb/acre greater than at Mahomet (105), respectively. Both river stations had zero to near zero load (<0.01 lb/acre) in October and November 2002. Monthly loads were approximately one lb/acre or less, July 2002–April 2003.

Ten-Year Summary of Annual Load (May 1993–April 2003)

Table 11 summarizes annual nitrate-N load data for tributary and river stations during the entire study period. Figures 21 and 22 also show those data.

Annual nitrate-N loads for tributary stations ranged from a low of 5 lb/acre at Big Ditch (106) in PY 7 to a high of 50 lb/acre at Long Creek (101) in PY 6. Big Ditch (106) had the second highest annual load, 49 lb/acre in PY 1. The average annual load for tributary stations decreased from 37 lb/acre in PY 1 to 13 lb/acre in PY 2, and increased from 17 lb/acre in PY 3 to 39 lb/acre in PY 6. In PY 7, average annual loads decreased to 11 lb/acre. Gradual increases in average annual load occurred from 21 lb/acre in PY 8 to 25 lb/acre in PY 9. Long Creek (101) had an unusually high load, 34 lb/acre in PY 9, due to higher discharge. Average annual load increased slightly in PY 10 to 18 lb/acre.

River stations showed the same annual trends as tributary stations. Monticello (111), had the highest annual loads, 34 and 33 lb/acre/yr, respectively, in PYs 1 and 6. Annual loads were lowest in PYs 2 and 7, 14 and 8 lb/acre/yr, respectively. Upstream at Mahomet (105), the highest annual load was 37 lb/acre in PY 1, and the lowest annual load was 7 lb/acre in PY 7. The annual nitrate-N load ranged from a low of 7 lb/acre at Mahomet (105) in PY 7 to a high of 40 lb/acre at Fisher (112) in PY 1. During the first four project years (May 1993–April 1997), Mahomet (105) had slightly higher nitrate-N loads than Monticello (111), a situation that reversed in the last six project years (May 1997–April 2003).

The 10-year mean annual nitrate-N load for all stations showed little variability, ranging from 21 to 24 lb/acre (table 11). Average annual loads varied from 11 lb/acre (PY 7) to 39 lb/acre (PY 6) for tributary stations and from 10 lb/acre (PY 7) to 38 lb/acre (PY 6) for river stations. Weighted annual nitrate-N yields to Lake Decatur ranged from lows of 10 lb/acre (PY 7) and 12 lb/acre (PY 2) to highs of 38 lb/acre (PY 6) and 32 lb/acre (PY 1). The 10-year average annual yield was 22 lb/acre.

Table 12 and figure 23 present annual average data for rainfall, streamflow, flow-weighted nitrate-N concentration, and nitrate-N loads for the 10-year monitoring period for the Sangamon River station at Monticello (111). The Monticello (111) station monitors a 543.4-square-mile drainage area, which represents approximately 60 percent of the Lake Decatur watershed. The flow-weighted nitrate-N concentration was determined by summing the product of the monthly average nitrate-N concentrations and the monthly total streamflow, and then dividing that value by the total annual streamflow.

The Monticello (111) station has a 95-year streamflow record (1908–2003) and long-term mean annual streamflow of 417 cfs (table 12). Streamflow during PY 1, the greatest streamflow during the study period, was 961 cfs, twice the long-term mean. The PY 1 streamflow was surpassed only twice since 1908 for the Monticello (111) station (Demissie et al., 1996). During PY 7, the driest during the study period, that station had the ninth lowest annual mean streamflow for the 95-year (1908–2003) period of record. Between PY 1 and PY 10, the flow-weighted nitrate-N concentrations at Monticello (111) increased from 6.17 to 10.49 mg/L. The annual average streamflow, flow-weighted nitrate-N concentration, and nitrate-N loads for all stations during the entire monitoring period are presented in appendix E.

Table 12. Rainfall, Streamflow, Flow-Weighted Nitrate-N Concentration, and Load for the Sangamon River at Monticello (111) for the Ten-Year Study Period (May 1993–April 2003)

Monitoring year	*Average rainfall* (inches)*	*Average streamflow (cfs)*	*Flow-weighted nitrate-N concentration (mg/L)*	*Nitrate-N load (lb/acre/yr)*
(May – April)				
PY 1: 1993–1994	51.7	961	6.17	34
PY 2: 1994–1995	34.5	323	7.72	14
PY 3: 1995–1996	34.3	362	7.88	16
PY 4: 1996–1997	37.4	460	9.29	24
PY 5: 1997–1998	40.0	469	9.32	25
PY 6: 1998–1999	40.3	556	10.39	33
PY 7: 1999–2000	30.0	138	10.54	8
PY 8: 2000–2001	33.6	367	8.51	17
PY 9: 2001–2002	39.1	464	10.66	26
PY 10: 2002–2003	28.9	295	10.49	18
Long-term mean (1908–2003)	–	417	–	–
10-year mean (1993–2003)	37.0	440	9.10	22

Notes:
– Incomplete data or no data available.
* Average of annual precipitation from Monticello, Gibson City, Urbana, Clinton, and Rantoul weather stations.

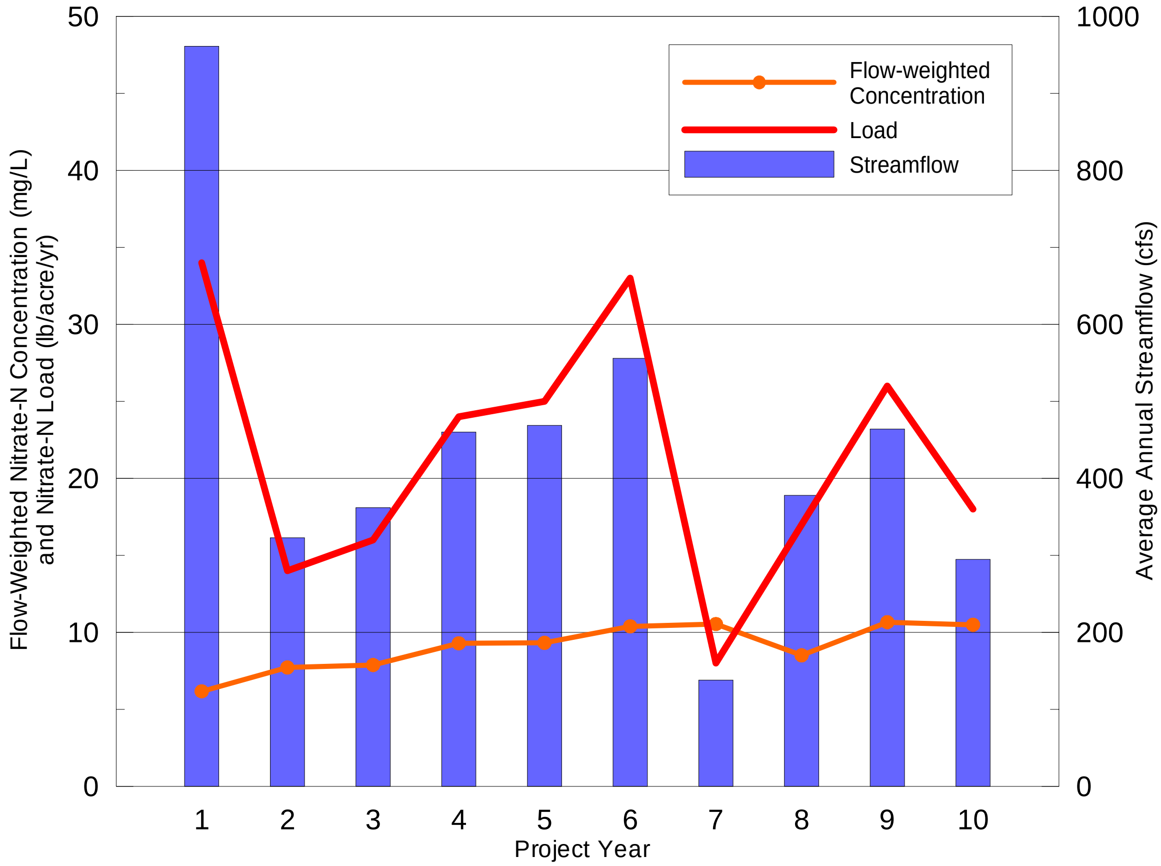

Figure 23. Mean annual streamflow, load, and flow-weighted nitrate-N concentrations of the Sangamon River at Monticello (111), May 1993–April 2003

Summary

The Illinois State Water Survey monitored streamflow and collected nitrate-N samples in the Lake Decatur watershed during 1993–2003. This report presents the monthly data collected for six stations during 2000–2003 and annual data for the entire monitoring period.

Over the 10-year monitoring period, precipitation throughout the entire watershed varied from widespread flood conditions in one year to two years of moderate drought. Precipitation varied across the watershed within any given year. Runoff data also reflected this.

The only long-term streamflow station in the watershed is on the Sangamon River at Monticello (111) and has a 95-year record. Long-term mean streamflow for that station is 417 cfs, and the 10-year mean streamflow is 5 percent greater than the long-term record. Therefore, the annual streamflow for the 10-year monitoring period appears to be consistent with the long-term record.

Nitrate-N concentrations during Project Years 8–10 had maximum values above 10 mg/L at all stations. Mean concentrations were generally higher at tributary stations; concentrations decreased at river and lake stations as drainage areas increase. Flow weighted nitrate-N concentrations have increased by approximately 4 mg/L over the 10-year study period at the Monticellow (111) station (table 12).

Annual nitrate-N loads varied from year to year for all stations and generally corresponded with variation in runoff. The 10-year mean annual nitrate-N loads at each station varied little, ranging from 21 to 24 lb/acre, with a weighted annual yield to Lake Decatur of 22 lb/acre and a range of 10–32 lb/acre.

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Appendix A. Monthly Precipitation for Project Years 8–10 (May 2000–April 2003) at Selected Stations

Appendix A. Monthly Precipitations for Project Years 8–10
(May 2000–April 2003)

Date	*Gibson City*	*Rantoul*	*Urbana*	*Clinton*	*Monticello*	*Decatur*
Year 8						
May-00	4.44	4.18	6.18	3.60	4.04	2.84
Jun-00	3.77	4.98	4.52	7.21	6.01	4.69
Jul-00	2.41	0.94	2.45	3.00	2.47	3.98
Aug-00	1.51	2.43	3.59	2.32	3.54	4.07
Sep-00	3.87	3.02	4.24	2.42	3.67	3.74
Oct-00	2.04	2.15	2.76	2.50	2.17	1.99
Nov-00	3.00	3.55	3.84	3.88	3.42	3.24
Dec-00	2.00	2.38	1.73	1.89	1.81	1.56
Jan-01	1.05	1.10	1.32	2.30	0.93	1.82
Feb-01	3.89	3.99	3.84	3.78	2.99	3.38
Mar-01	0.74	0.57	0.85	1.46	0.80	1.08
Apr-01	3.74	2.04	1.09	1.89	0.31	4.11
Annual	*32.46*	*31.33*	*36.41*	*36.25*	*32.16*	*36.50*
Year 9						
May-01	3.54	2.81	3.83	3.05	2.23	3.36
Jun-01	4.29	3.32	2.83	3.19	2.48	6.34
Jul-01	2.59	2.88	3.64	3.44	4.80	2.25
Aug-01	4.61	4.99	4.79	3.50	2.36	5.84
Sep-01	2.52	2.26	3.55	2.49	1.08	3.06
Oct-01	6.85	7.02	6.45	6.53	5.53	6.59
Nov-01	1.77	2.00	1.91	2.21	1.91	2.34
Dec-01	1.82	1.84	2.21	2.05	1.55	2.36
Jan-02	2.43	2.43	2.81	2.67	2.21	2.84
Feb-02	2.35	3.68	2.95	2.92	2.33	2.27
Mar-02	2.74	2.57	3.10	2.63	2.86	2.95
Apr-02	3.44	4.11	4.21	6.07	4.36	6.70
Annual	*38.95*	*39.91*	*42.28*	*40.75*	*33.70*	*46.90*
Year 10						
May-02	4.23	2.89	6.29	5.98	7.56	10.78
Jun-02	2.83	3.58	2.78	4.72	3.26	3.45
Jul-02	4.44	2.12	2.73	3.37	2.42	2.29
Aug-02	7.04	5.29	7.27	5.30	5.71	2.40
Sep-02	1.15	1.86	1.77	1.60	1.54	1.96
Oct-02	1.87	2.24	3.17	2.71	2.83	3.25
Nov-02	0.96	0.94	0.86	0.96	0.93	0.86
Dec-02	1.50	2.10	1.54	1.50	1.75	2.23
Jan-03	0.42	0.53	0.79	0.75	0.96	0.67
Feb-03	1.07	1.00	1.60	1.52	1.57	1.25
Mar-03	0.94	0.81	2.08	2.17	1.58	1.89
Apr-03	2.62	3.58	2.20	1.39	2.26	2.35
Annual	*29.07*	*26.94*	*33.08*	*31.97*	*32.37*	*33.38*

Appendix B. Maximum, Minimum, and Mean Acidity, Temperature, and Non-volatile Organic Carbon (NOVC) for Project Years 8–10 (May 2000–April 2003)

Table B-1. Maximum, Minimum, and Mean Acidity, Temperature, and Non-volatile Organic Carbon (NVOC) for Project Years 8–10 (May 2000–April 2003)

Temperature (ºF)

Station	*Project Year 8*			*Project Year 9*			*Project Year 10*		
number	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*
101	57	32	82	54	33	82	57	32	81
102	56	32	80	55	35	83	56	32	81
104	58	33	80	53	33	81	65*	53*	82*
105	51	32	78	55	33	81	58	34	80
106	55	32	86	54	33	81	57	34	89
107	–	–	–	–	–	–	64	34	89
111	57	32	83	56	33	85	60	33	81

Acidity (pH)

Station	*Project Year 8*			*Project Year 9*			*Project Year 10*		
number	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*
101	8.00	7.90	8.20	8.03	7.48	8.37	7.79	7.23	8.18
102	8.03	7.86	8.10	8.07	7.24	8.48	7.87	7.35	8.29
104	7.90	7.75	8.07	8.08	7.62	8.93	7.89	7.39	8.40*
105	7.98	7.81	8.15	8.08	7.27	8.44	7.80	7.29	8.23
106	8.01	7.83	8.28	8.06	6.36	8.45	7.88	7.27	8.89
107	–	–	–	–	–	–	8.45	7.49	9.03
111	7.96	7.85	8.05	8.11	7.59	8.61	7.95	7.47	8.32

NVOC (mg/L)

Station	*Project Year 8*			*Project Year 9*			*Project Year 10*		
number	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*
101	–	–	–	–	–	–	4.82	2.20	8.90
102	–	–	–	–	–	–	4.30	1.70	15.70
105	2.86	1.60	5.80	3.49	2.00	9.10	3.93	1.80	8.80
106	4.98*	1.70*	8.60*	–	–	–	–	–	–
107	–	–	–	–	–	–	4.03	2.80	5.40
111	2.99	1.40	6.50	3.88	1.90	8.40	3.67	1.90	6.40

Notes:
– Incomplete data or no data available.
* Partial year of data.

Appendix C. Temperature, Acidity, Non-volatile Organic Carbon (NVOC), Arsenic, Boron, and Sulfur Data (December 2000–April 2003)

Appendix C-1. Temperature, Acidity, and Non-volatile Organic Carbon (NVOC), Long Creek (Station 101), 05/01/2002–04/30/2003

Date	*Time (CST)*	*Water temp (ºF)*	*Acidity (pH)*	*NVOC*
5/14/2002	13:28	57	7.33	4.3
5/28/2002	13:28	64	8.04	2.2
6/11/2002	7:51	70	8.07	2.3
6/25/2002	13:29	74	8.18	2.2
7/16/2002	7:37	70	8.15	3.3
7/30/2002	13:04	80	7.94	4.8
8/14/2002	13:13	73	8.05	4.3
8/27/2002	12:48	76	8.06	4.6
9/24/2002	13:14	66	7.86	5.2
10/8/2002	13:30	61	7.75	6.5
10/22/2002	13:57	50	7.66	7.3
11/6/2002	15:00	45	7.59	5.7
11/19/2002	14:15	46	7.63	8.9
12/10/2002	14:39	40	7.44	5.3
12/23/2002	14:39	37	7.83	5.9
1/28/2003	15:07	38	7.23	6.1
2/10/2003	14:30	38	7.53	4.1
2/25/2003	14:46	39	7.57	4.7
3/11/2003	14:43	41	7.87	3.7
3/25/2003	15:09	57	8.14	3.9
4/7/2003	13:54	48	7.58	5.1
4/22/2003	12:28	59	–	5.6

Note:
– Incomplete data or no data available.

Appendix C-2. Temperature, Acidity, and Non-volatile Organic Carbon (NVOC), Friends Creek (Station 102), 05/02/2002–04/30/2003

Date	*Time (CST)*	*Water temp (ºF)*	*Acidity (pH)*	*NVOC*
5/14/2002	12:44	58.00	7.35	5.1
5/28/2002	12:37	65.00	8.15	1.8
6/11/2002	10:00	67.00	8.14	2.2
6/25/2002	12:41	73.00	8.23	1.7
7/16/2002	9:14	72.00	8.27	3.0
7/30/2002	11:28	80.00	8.05	4.6
8/14/2002	11:56	70.00	7.67	10.0
8/27/2002	11:00	75.00	8.29	3.1
9/10/2002	10:36	79.00	8.18	4.1
9/24/2002	12:15	63.00	7.97	5.0
10/8/2002	11:44	57.00	7.72	7.0
10/22/2002	11:47	50.00	7.69	6.4
11/6/2002	12:13	48.00	7.58	6.1
11/19/2002	12:33	49.00	7.36	15.7
12/10/2002	12:29	39.00	7.88	5.9
12/23/2002	12:14	37.00	7.91	2.5
1/14/2003	11:44	32.90	7.95	2.4
1/28/2003	11:54	37.40	7.43	2.7
2/10/2003	12:26	34.90	7.80	2.3
2/25/2003	13:47	35.40	7.59	2.7
3/11/2003	12:35	37.40	7.95	2.4
3/25/2003	12:45	55.76	8.03	1.8
4/7/2003	13:06	44.42	7.91	2.0
4/22/2003	10:31	51.80	–	2.1

Note:
– Incomplete data or no data available.

Appendix C-3. Temperature, Acidity, Non-volatile Organic Carbon (NVOC), Arsenic, Boron, Sulfur, and Sulfate, Sangamon River near Mahomet (Station 105), 02/27/2001–04/30/2003

Date	*Time (CST)*	*Water temp (ºF)*	*Acidity (pH)*	*NVOC*	*Arsenic (µg/L)*	*Boron (mg/L)*	*Sulfur (mg/L)*	*Sulfate (mg/L)*
2/27/2001	14:45	39	8.10	5.8	3.043	0.040	7.217	21.624
3/21/2001	11:44	45	7.81	1.6	<0.580	0.030	14.583	43.695
3/27/2001	11:49	40	8.15	1.8	<0.580	0.033	15.756	47.211
4/17/2001	15:53	52	–	2.4	<0.580	0.034	14.489	43.413
4/24/2001	10:38	61	7.90	2.7	0.849	0.039	16.389	49.105
5/9/2001	10:40	65	7.27	3	–	–	–	–
5/22/2001	14:35	64	8.22	2.3	0.792	0.043	15.364	46.034
6/6/2001	14:35	64	7.92	2.7	<0.580	0.038	11.650	34.908
6/19/2001	10:30	76	8.18	2.7	0.814	0.043	16.765	50.234
7/10/2001	10:12	80	8.18	3.1	1.434	0.062	19.180	57.468
7/25/2001	11:40	81	8.34	9.1	2.761	0.091	23.463	70.303
8/8/2001	10:31	81	8.14	4.7	4.707	0.125	21.241	63.645
8/29/2001	9:56	72	8.32	5.6	2.392	0.158	31.515	94.427
9/12/2001	9:54	67	8.10	5.3	2.081	0.086	11.526	34.536
9/26/2001	13:27	60	8.18	5.5	1.650	0.121	20.510	61.456
10/11/2001	10:05	60	8.44	5.2	1.411	0.139	22.250	66.668
10/24/2001	10:11	64	7.96	3	0.756	0.061	19.951	59.779
11/6/2001	12:02	47	8.11	2.9	<0.580	0.051	19.300	57.828
11/19/2001	11:42	54	7.92	2.6	<0.580	0.066	22.113	66.256
12/4/2001	10:31	49	8.05	2.4	<0.580	0.044	15.738	47.155
12/26/2001	10:56	33	8.09	2.1	<0.580	0.034	16.098	48.234
1/15/2002	10:35	34	8.26	2	<0.580	0.047	20.543	61.554
1/29/2002	10:13	44	8.13	2.1	<0.580	0.055	21.927	65.701
2/13/2002	10:31	40	8.14	2	1.433	0.023	16.998	50.932
2/25/2002	10:23	46	7.90	2.4	1.391	0.028	14.322	42.914
3/12/2002	10:44	43	7.94	3.8	1.236	0.026	12.629	37.841
3/27/2002	10:09	38	8.23	2.1	1.168	0.026	16.303	48.848
4/16/2002	9:11	66	8.07	2	<0.580	0.032	14.558	43.619
4/30/2002	9:33	54	7.72	5.2	<0.580	0.030	8.229	24.656
5/14/2002	10:14	58	7.37	6.4	5.483	0.055	4.801	14.385
5/28/2002	10:06	64	8.11	2.1	0.867	0.031	14.112	42.283
6/11/2002	12:15	71	8.02	1.8	0.918	0.044	13.229	39.638
6/25/2002	8:49	75	8.14	2	<0.580	0.043	14.055	42.113
7/16/2002	12:37	77	8.23	3.2	1.217	0.065	19.623	58.797
7/30/2002	9:24	79	8.00	3.6	1.938	0.066	17.511	52.468
8/14/2002	9:50	73	8.07	4	1.997	0.102	20.209	60.551
8/27/2002	9:22	75	8.01	3.7	1.472	0.057	10.774	32.282

Appendix C-3. Concluded

Date	*Time (CST)*	*Water temp (ºF)*	*Acidity (pH)*	*NVOC*	*Arsenic (µg/L)*	*Boron (mg/L)*	*Sulfur (mg/L)*	*Sulfate (mg/L)*
9/10/2002	9:13	77	8.15	3.4	1.988	0.079	16.799	50.334
9/24/2002	9:27	61	8.12	3.3	1.023	0.098	23.493	70.393
10/8/2002	9:43	56	7.77	3.6	1.592	0.104	23.344	69.945
10/22/2002	10:01	49	7.72	4	1.520	0.104	24.588	73.673
11/6/2002	10:23	45	7.57	–	0.711	0.117	27.512	82.433
11/19/2002	10:59	46	7.37	6.8	2.562	0.124	25.214	75.548
12/10/2002	10:53	36	7.54	3.8	1.504	0.159	29.958	89.763
12/23/2002	10:31	38	7.71	3.6	0.933	0.081	27.888	83.560
2/10/2003	10:37	35	7.58	3	<0.580	0.088	23.165	69.409
2/25/2003	10:47	35	7.29	8.8	0.850	0.077	18.049	54.080
3/11/2003	10:29	35	7.57	6.1	0.871	0.057	15.024	45.018
3/25/2003	10:30	57	7.86	3.2	1.031	0.038	16.075	48.166
4/7/2003	9:29	44	7.54	3.4	0.746	0.040	11.697	35.048
4/22/2003	8:58	55	–	2.7	1.151	0.048	15.836	47.448

Note:
– Incomplete data or no data available.

Appendix C-4. Temperature, Acidity, and Non-volatile Organic Carbon (NVOC), Arsenic, Boron, Sulfur, and Sulfate, Sangamon River near Monticello (Station 111), 12/14/2000–04/30/2003

Date	*Time (CST)*	*Water temp (ºF)*	*Acidity (pH)*	*NVOC*	*Arsenic (ug/L)*	*Boron (mg/L)*	*Sulfur (mg/L)*	*Sulfate (mg/L)*
12/14/2000	12:15	32.00	–	–	–	0.027	14.052	42.105
1/16/2001	14:15	33.00	–	4	<0.580	0.035	14.630	43.835
1/31/2001	14:20	34.00	–	–	1.524	0.023	6.587	19.737
2/14/2001	14:52	40.00	7.85	2.2	0.704	0.028	12.876	38.580
2/27/2001	15:43	40.00	8.02	6.5	3.496	0.050	5.019	15.039
3/21/2001	14:46	48.00	7.87	1.7	<0.580	0.030	13.379	40.087
3/27/2001	16:50	42.00	8.05	1.4	<0.580	0.029	14.518	43.500
4/17/2001	12:48	53.00	7.93	2.5	0.824	0.029	14.174	42.470
4/25/2001	9:19	57.00	7.92	2.6	0.856	0.040	14.938	44.759
5/9/2001	13:02	70.00	7.59	3	0.658	0.044	15.966	47.840
5/22/2001	12:58	64.00	8.28	2.9	<0.580	0.038	12.901	38.655
6/5/2001	12:25	61.00	8.12	2.8	0.684	0.034	12.924	38.725
6/19/2001	13:19	79.00	8.27	3.2	0.605	0.043	15.019	45.002
7/10/2001	13:14	82.00	8.33	3.3	1.357	0.060	15.746	47.179
7/24/2001	8:47	82.00	8.25	6.6	2.649	0.075	19.221	57.592
8/8/2001	14:42	80.00	8.16	4.9	3.949	0.090	16.999	50.935
8/29/2001	12:58	77.00	7.92	6.2	2.954	0.117	16.824	50.409
9/12/2001	10:59	70.00	8.53	5	2.158	0.082	12.041	36.078
9/26/2001	11:48	62.00	8.22	5.2	1.680	0.090	14.806	44.364
10/11/2001	13:19	60.00	8.61	4.9	1.671	0.102	17.419	52.192
10/24/2001	15:03	58.00	7.76	4.8	0.982	0.065	17.395	52.121
11/7/2001	12:20	55.00	8.24	3.8	–	– –	– –	–
11/7/2001	12:42	55.00	8.24	–	0.801	0.049	18.638	55.845
11/19/2001	14:32	53.00	8	3	<0.580	0.057	21.441	64.244
12/4/2001	13:29	52.00	8.07	2.9	<0.580	0.042	14.939	44.761
12/26/2001	13:22	33.00	8.51	2.2	<0.580	0.033	15.100	45.245
1/15/2002	13:54	34.00	8.16	2	<0.580	0.033	17.205	51.551
1/29/2002	11:52	44.60	8.05	2.2	1.568	0.045	20.238	60.638
2/13/2002	12:09	39.92	8.14	1.9	1.114	0.021	15.542	46.567
2/25/2002	12:04	45.50	7.77	8.4	1.174	0.022	12.518	37.506
3/12/2002	13:22	42.00	7.75	4.3	2.848	0.032	10.480	31.403
3/27/2002	12:47	40.00	7.95	2	1.020	0.022	15.081	45.187
4/16/2002	10:41	67.00	8.05	2	0.757	0.028	13.235	39.656
4/30/2002	12:31	56.00	7.69	5.6	1.074	0.036	8.116	24.318
5/14/2002	11:56	58.00	7.51	6.4	2.227	0.051	5.995	17.962
5/28/2002	11:45	65.00	8.02	2.1	<0.580	0.033	12.468	37.359

Appendix C-4. Concluded

Date	*Time (CST)*	*Water temp (ºF)*	*Acidity (pH)*	*NVOC*	*Arsenic (ug/L)*	*Boron (mg/L)*	*Sulfur (mg/L)*	*Sulfate (mg/L)*
6/11/2002	10:37	70.00	8.13	2	1.234	0.041	11.802	35.364
6/25/2002	11:58	77.00	8.18	1.9	1.554	0.042	12.690	38.023
7/16/2002	10:56	77.00	8.21	3.1	0.623	0.052	16.814	50.380
7/30/2002	10:39	80.00	8.08	3.3	2.278	0.066	17.708	53.058
8/14/2002	10:53	73.00	8.04	4	2.271	0.075	16.167	48.442
8/27/2002	10:13	75.00	7.91	4.5	1.102	0.056	7.711	23.103
9/10/2002	10:07	80.00	8.24	3.4	1.573	0.072	16.253	48.700
9/24/2002	10:29	63.00	8.32	3	1.746	0.085	19.247	57.669
10/8/2002	10:48	57.00	8.15	3.9	1.929	0.093	19.451	58.280
10/22/2002	10:56	49.00	7.98	4	1.708	0.094	21.397	64.111
11/6/2002	11:21	45.00	7.67	4.8	1.465	0.102	22.287	66.778
11/19/2002	11:48	46.00	7.47	5.6	2.612	0.107	22.981	68.859
12/23/2002	11:29	37.00	7.8	3.7	0.887	0.086	26.799	80.297
3/11/2003	11:29	37.58	7.89	4.3	0.754	0.047	15.602	46.749
3/25/2003	12:08	57.92	7.95	3	0.844	0.041	14.903	44.655
4/7/2003	12:20	46.76	7.55	4.2	1.280	0.044	13.045	39.088
4/22/2003	9:47	55.40	–	2.6	1.049	0.040	14.152	42.403

Note:
– Incomplete data or no data available.

Appendix C-5: Temperature, Acidity, and Non-volatile Organic Carbon (NVOC), Arsenic, Boron, Sulfur, and Sulfate, Lake Decatur: Lost Bridge Road (Station 107), 05/1/2002–04/30/2003

Date	*Time (CST)*	*Water temp (ºF)*	*Acidity (pH)*	*NVOC*	*Arsenic (ug/L)*	*Boron (mg/L)*	*Sulfur (mg/L)*	*Sulfate (mg/L)*
5/14/2002	13:59	62	7.49	5.4	3.470	0.041	5.595	16.764
5/28/2002	14:18	72	8.65	2.8	<0.580	0.034	9.766	29.261
6/11/2002	7:14	76	8.27	2.8	1.384	0.041	10.958	32.833
6/25/2002	14:02	84	8.77	3.2	<0.580	0.041	8.351	25.022
7/16/2002	7:00	79	8.74	3.9	1.641	0.040	9.607	28.786
7/30/2002	14:15	89	8.87	3.6	2.726	0.045	10.181	30.505
8/14/2002	14:10	77	8.3	3.7	4.442	0.048	10.451	31.314
8/27/2002	13:33	81	8.41	4.3	3.165	0.065	10.625	31.835
9/10/2002	13:46	86	9.03	4.5	4.381	0.051	8.086	24.227
9/24/2002	13:48	72	8.4	4.1	6.325	0.055	7.682	23.018
10/8/2002	14:05	66	8.32	4.2	5.809	0.054	7.784	23.323
10/22/2002	13:08	54	8.53	5.1	4.688	0.050	7.800	23.371
11/6/2002	14:19	46	8.67	4.4	5.784	0.052	7.910	23.701
11/19/2002	15:15	48	8.5	4.6	5.649	0.049	7.828	23.455
12/23/2002	14:00	38	8.38	4.8	4.432	0.061	8.527	25.549
2/25/2003	15:21	34	8.22	4.7	2.604	0.061	11.986	35.913
3/11/2003	14:04	41	8.4	4.3	2.638	0.058	11.577	34.688
3/25/2003	14:20	57	8.37	3.5	1.304	0.059	12.772	38.267
4/7/2003	14:28	51	8.2	3.5	1.897	0.044	12.067	36.156
4/22/2003	11:43	59	–	3.1	1.510	0.035	12.123	36.325

Notes:
– Incomplete data or no data available.

Appendix D. Mean, Minimum, and Maximum Nitrate Concentrations, Project Years 1–10 (May 1993–April 2003)

Appendix D. Mean, Minimum, and Maximum Nitrate Concentrations, Project Years 1–10 (May 1993–April 2003)

Station No.	*Project Year 1*			*Project Year 2*			*Project Year 3*			*Project Year 4*			*Project Year 5*		
	Mean	*Min*	*Max*	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*
101	7.19	0.74	13.50	5.60	0.02	11.57	5.70	0.02	13.89	6.15	0.02	13.47	6.30	0.04	14.41
102	7.40	0.22	11.40	6.50	0.02	12.54	6.55	0.57	13.47	7.85	0.11	14.58	7.80	0.04	14.78
103	8.25	5.24	14.10	7.55	0.02	10.97	5.62	0.02	16.06	8.58	0.02	14.74	7.67	0.08	14.66
104	8.61	3.84	13.69	7.75	0.02	11.75	6.82	0.02	16.26	9.08	0.02	15.99	8.45	0.07	16.36
105	6.26	0.02	11.90	7.36	0.02	11.36	5.64	0.02	11.45	6.43	0.08	14.14	6.69	0.22	15.05
106	8.31	2.81	15.28	7.04	0.02	13.04	6.98	0.02	15.13	7.47	0.02	16.50	7.93	0.04	16.31
111	5.88	0.02	11.27	4.55	0.02	9.54	3.97	0.02	19.56	6.11	0.02	13.21	6.46	0.04	14.01
112	7.16	1.33	13.90	5.95	0.02	11.19	5.95	0.02	12.22	6.60	0.02	13.94	6.82	0.04	15.21

Station No.	*Project Year 6*			*Project Year 7*			*Project Year 8*			*Project Year 9*			*Project Year 10*		
	Mean	*Min*	*Max*	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*
101	7.59	0.09	14.53	3.40	0.11	13.30	6.66	0.06	12.45	7.47	0.06	13.06	3.66	0.06	13.17
102	7.32	0.09	15.37	6.14	0.13	16.82	8.78	0.21	13.85	9.07	0.49	15.84	6.56	0.06	15.64
103	8.09	0.09	16.14	7.65	0.11	17.97	*	0.25	15.54	–	–	–	–	–	–
104	7.31	0.09	16.96	6.46	0.11	17.51	7.87	0.06	14.94	9.79	0.06	16.17	*	0.56	15.86
105	7.33	0.09	15.59	5.79	0.11	14.96	7.71	0.41	16.91	8.49	0.06	16.81	6.34	0.16	15.87
106	9.05	0.09	15.67	5.89	0.11	18.80	7.67	0.06	19.54	9.18	0.06	18.07	6.62	0.06	18.25
111	6.08	0.09	14.54	4.33	0.11	14.50	7.01	0.06	15.37	8.24	0.06	16.00	5.44	0.06	14.88
112	7.71	0.13	16.32	6.45	0.11	15.47	*	2.18	16.86	–	–	–	–	–	–

Notes:

– Incomplete or no data available.

* Partial year of data.

Appendix E. Annual Average Runoff, Streamflow, Flow-Weighted Nitrate-N Concentration, and Nitrate-N Loads (May 1993–April 2003)

Appendix E. Annual Average Runoff, Streamflow, Flow-Weighted Nitrate-N Concentration, and Nitrate-N Loads (May 1993–April 2003)

Station no.	*Monitoring year (May–April)*	*Average streamflow (cfs)*	*Flow-weighted nitrate-N concentration (mg/L)*	*Nitrate-N load (lb/acre/yr)*
101	1993-1994	58.12	6.79	26
	1994–1995	16.00	8.84	9
	1995–1996	21.30	8.80	13
	1996–1997	40.20	9.31	25
	1997–1998	29.78	9.16	18
	1998–1999	71.63	10.61	50
	1999–2000	19.12	8.35	11
	2000–2001	44.01	8.59	25
	2001–2002	49.50	10.08	33
	2002–2003	109.02	6.80	12
102	1993-1994	164.20	7.69	35
	1994–1995	51.43	8.74	12
	1995–1996	71.34	10.03	20
	1996–1997	93.91	10.75	28
	1997–1998	87.68	10.57	25
	1998–1999	104.60	12.13	35
	1999–2000	53.03	11.31	16
	2000–2001	103.03	10.38	29
	2001–2002	83.97	11.20	25
	2002–2003	71.61	10.88	22
103	1993-1994	62.52	8.52	36
	1994–1995	24.27	9.38	16
	1995–1996	26.47	10.15	18
	1996–1997	27.65	10.50	20
	1997–1998	30.68	10.17	21
	1998–1999	34.79	12.23	29
	1999–2000	12.73	14.28	12
	2000–2001	11.82	12.68	10
	2001–2002	9.08	8.98	11
	2002–2003	6.58	6.55	8
104	1993-1994	68.83	8.63	9
	1994–1995	16.28	9.93	7
	1995–1996	25.85	10.63	6
	1996–1997	30.80	11.97	8
	1997–1998	43.08	10.03	8
	1998–1999	48.97	11.84	7
	1999–2000	10.70	12.33	6
	2000–2001	30.65	10.93	8
	2001–2002	–	–	–
	2002–2003	–	–	–

Appendix E. Concluded

Station no.	*Monitoring year (May–April)*	*Average streamflow (cfs)*	*Flow-weighted nitrate-N noncentration (mg/L)*	*Nitrate-N load (lb/acre/yr)*
105	1993-1994	642.55	6.81	7
	1994–1995	211.52	8.06	5
	1995–1996	231.39	8.92	6
	1996–1997	315.45	9.41	6
	1997–1998	269.49	9.74	6
	1998–1999	367.50	10.47	7
	1999–2000	82.01	10.20	5
	2000–2001	223.10	9.03	7
	2001–2002	262.24	9.14	7
	2002–2003	–	10.07	5
106	1993-1994	45.23	9.30	49
	1994–1995	27.36	9.89	15
	1995–1996	33.85	10.22	17
	1996–1997	44.79	9.98	26
	1997–1998	31.05	11.09	27
	1998–1999	40.32	11.39	43
	1999–2000	8.90	10.77	5
	2000–2001	22.87	9.80	21
	2001–2002	24.95	13.01	22
	2002–2003	21.74	13.29	19
111	1993-1994	961	6.17	34
	1994–1995	323	7.72	14
	1995–1996	362	7.88	16
	1996–1997	460	9.29	24
	1997–1998	469	9.32	25
	1998–1999	556	10.39	33
	1999–2000	138	10.54	8
	2000–2001	378	8.51	17
	2001–2002	464	10.66	26
	2002–2003	295	10.49	18
112	1993-1994	443.00	7.26	40
	1994–1995	145.47	7.94	15
	1995–1996	180.08	9.25	21
	1996–1997	219.26	9.56	26
	1997–1998	208.61	10.15	27
	1998–1999	248.35	11.51	31
	1999–2000	60.74	11.47	9
	2000–2001	149.51	–	–
	2001–2002	–	–	–
	2002–2003	–	–	–

Note:

– Incomplete or no data available.