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Watershed Monitoring for the Lake Decatur Watershed, 2003-2006

by
Laura Keefer and Erin Bauer

Prepared for the
City of Decatur

June 2008

Illinois State Water Survey
Center for Watershed Science
Champaign, Illinois

A division of the Illinois Department of Natural Resources
and an affiliated agency of the University of Illinois

Watershed Monitoring for the Lake Decatur Watershed, 2003–2006

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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.

Lake Decatur has high concentrations of total dissolved solids and nitrates, and nitrate-nitrogen (nitrate-N) concentrations have exceeded drinking water standards in recent years. This has created a serious situation for the City of Decatur drinking water supply 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 2000, except from 1993 to 1995.

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 purpose of this initiative is to collect reliable hydrologic and water quality data throughout the watershed to assist city planners and resource managers in developing watershed management alternatives based on scientific data.

This report presents the annual data for 13 years of monitoring (May 1993–April 2006) and monthly data for project years (PY) 11, 12, and 13 (May 2003–April 2006). Based on the 13 years of data, it can be concluded that nitrate-N loads are relatively uniform throughout the entire watershed, but tend to be slightly higher at the tributary streams in the upper Sangamon River watershed than at the Sangamon River stations closer to the lake. Nitrate-N loads vary with concentration and streamflow and were the lowest in PY 7 and 13 due to low streamflows during those drought years. Flow-weighted nitrate-N concentrations at the Sangamon River station near Monticello (111) increased from 6.12 to 10.54 mg/L for PY 1 through PY 7 and fluctuated around 9.12 mg/L from PY 7 through PY 13. The highest nitrate-N concentrations during the entire monitoring period were observed at stations located at Long Creek (101) at Twin Bridge Road, Friends Creek (102) near Argenta, and Sangamon River near Monticello (111) in PY 7, 9, and 12.

Contents

List of Tables

List of Figures

Watershed Monitoring for the Lake Decatur Watershed, 2003–2006

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Introduction and Background

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 (mi^2). The dam was modified in 1956 to increase the maximum capacity of the lake to 28,000 acre-feet (9,125 million gallons). Water withdrawal from the lake at the water treatment plant has been averaging nearly 22 million gallons per day (mgd) and approximately 15 mgd are withdrawn by the Archer Daniels Midland Company. In the near future, the City of Decatur anticipates residential use to be stable and flat, whereas commercial and industrial use is expected to slowly increase.

The Sangamon River is a tributary to the Illinois River with a drainage area of 925 mi^2 at the Decatur dam. The watershed lies across seven counties in east-central Illinois: Champaign, Christian, Dewitt, Ford, Macon, McLean, and Piatt as shown in figure 1. The major urban areas within the watershed are Decatur, Monticello, Mahomet, Rantoul, and Gibson City. Figure 1 shows the watershed with sub-basins, monitoring stations, precipitation stations, and county borders. The predominant land use in the watershed is row crop agriculture comprising nearly 90 percent of the land area (Keefer and Bauer, 2005).

The Lake Decatur watershed is located in the humid, continental, climate region, typical for central Illinois. It lies in the Bloomington Ridged Plain of the Till Plains Section of the Central Lowland Province, characterized by broad, morainic ridges with intervening wide stretches of relatively flat or gently undulating ground moraine (Leighton et al., 1948). A more detailed description of the watershed physical characteristics is provided in Keefer and Bauer (2005).

Lake Decatur has experienced water quality problems for more than 30 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). Lake Decatur has had high total dissolved solid concentrations and high

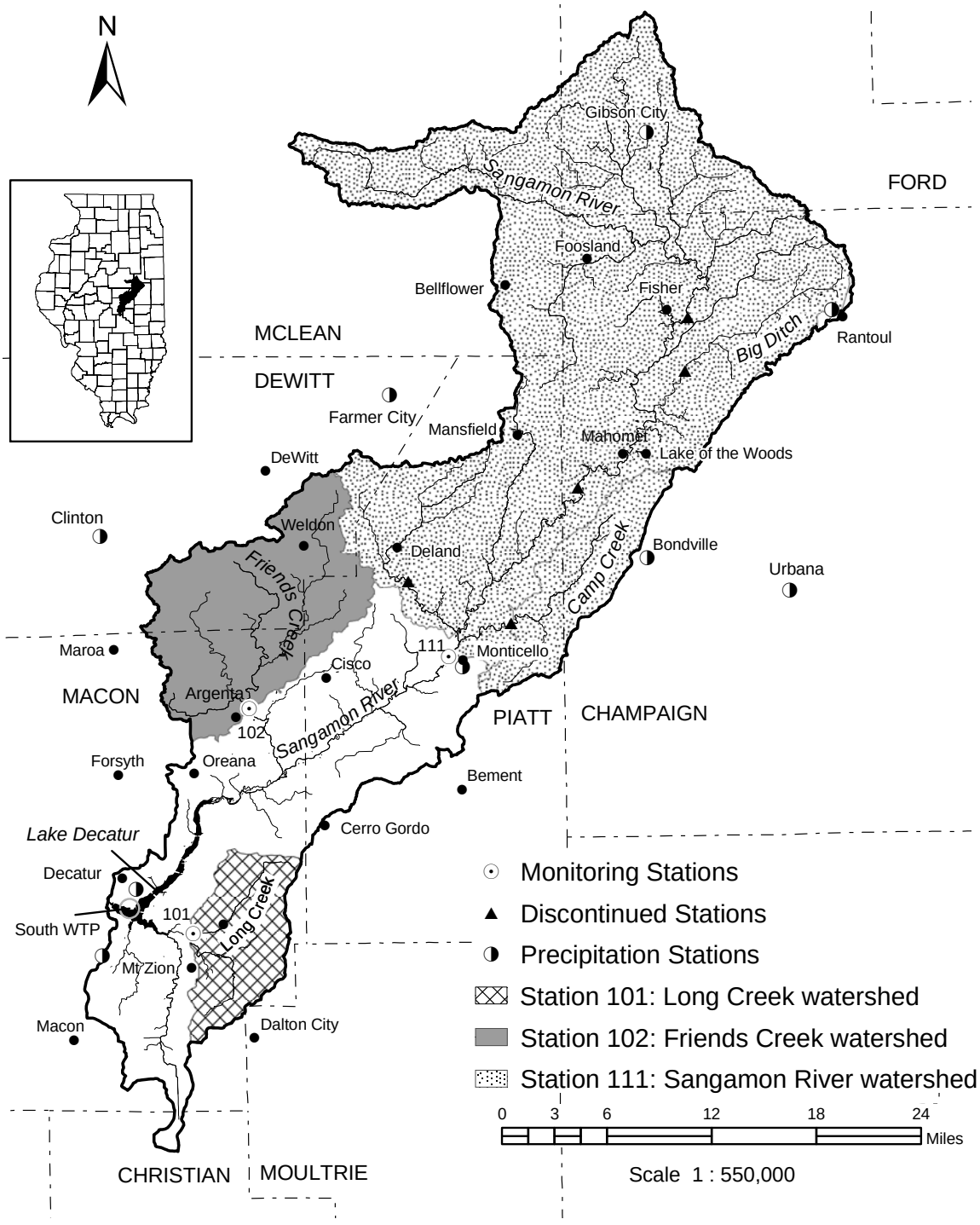

Figure 1. Lake Decatur watershed showing stream and precipitation monitoring stations and sub-watershed boundaries

nitrate-nitrogen (nitrate-N) concentrations that exceeded drinking water standards in recent years. Nitrate-N concentrations in Lake Decatur periodically exceeded the Illinois Environmental Protection Agency (IEPA) drinking water standard of 10 milligrams per liter (mg/L) between 1979 and 2002, except from 1993 to 1995, and 2000. Exceedances generally occurred on a seasonal basis (spring through mid-summer and late winter). Since 2000, nitrate-N excursions occurred during February-April 2001, February-June 2002, and May 2004. High nitrate-N concentrations 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.

Most of the water quality problems and high concentrations of nitrate-N are associated with nonpoint source pollution generated in the watershed of the Upper Sangamon River. 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 to better understand nitrate-N yields in the Lake Decatur watershed. The Illinois State Water Survey (ISWS) received a grant from the City of Decatur in 1993 to conduct the monitoring study and develop land-use management strategies that could assist the city in complying with IEPA drinking water standards. Demissie et al. (1996) presents the results of that two-year study.

To characterize and quantify the spatial and temporal distribution of nitrate-N yields in the Upper Sangamon, the City of Decatur supported the continuation of watershed monitoring through a grant to the ISWS. The purpose of this monitoring was to collect reliable hydrologic and water quality data throughout the watershed to assist city planners and resource managers in developing watershed management alternatives based on scientific data. The ISWS has published several reports presenting the results of watershed monitoring through 2003 (Demissie et al., 1996; Keefer and Demissie, 1996, 1999, 2000, 2002; Keefer et al., 1997; and Keefer and Bauer, 2005). Based on the monitoring data, the ISWS created a model to assist the city in forecasting weekly nitrate-N concentrations in Lake Decatur (Markus et al., 2003). 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. The watershed monitoring of nitrate-N data provided additional information to help determine the design capacity of this facility. The City of Decatur has continued funding watershed monitoring to assist in operating the facility as efficiently as possible.

This data report presents monthly data for PY 11, 12, and 13 for Long Creek (101), Friends Creek (102), and Sangamon River at Monticello (111) and annual data for 13 years of monitoring the watershed (May 1993-April 2006). The starting and ending dates of project years are provided in appendix A. The report is organized into two main sections: Introduction and Background and Hydrologic and Nitrate-N Monitoring. The Introduction and Background section is a condensed version of Keefer and Bauer (2005). The section on hydrologic and nitrate-N monitoring discusses the monitoring results of project years 11, 12, and 13 of data collection. A Summary and Discussion are also 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: 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 Illinois State Water Survey.

The authors wish to acknowledge the significant contributions of the following project staff toward the completion of this report. Field Technicians Josh Stevens, Kevin Rennels, and Louis Arighi were responsible for field data collection. Mary Richardson assisted with data entry and analysis. We gratefully acknowledge the following chemists who performed the nitrate-N analyses at the Illinois State Water Survey in Champaign: Daniel L. Webb, Loretta M. Skowron, Lauren F. Sievers, Sofia Lazovski, RuthAnn Nichols, and Kay Surratt. Becky Howard prepared the camera-ready version of the report, which was edited by Lisa Sheppard. Sara Nunnery provided expert advice on illustration layout.

Hydrologic and Nitrate-N Monitoring

A watershed monitoring network was established in 1993 to provide streamflow and water quality data for the Sangamon River and its tributaries. The network was originally comprised of eight sampling stations (see table 1 and figure 1) throughout the watershed upstream of Lake Decatur. Table 1 presents the station number, location, period of monitoring, and drainage area for each monitoring station. Currently, there are three active stations: Long Creek (101), Friends Creek (102), and Monticello on the Sangamon River (111). The data from these stations are presented and discussed in this report by month for PY 11–13 (May 2003–April 2006) and by project year for PY 1–13 (May 1993–April 2006).

Hydrologic Monitoring

Continuous hydrologic monitoring of the water level at each station facilitates the calculation of streamflow (discharge), which 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 station at Monticello (111). At each station, stage was recorded at 15-minute intervals, and discharge measurements were made periodically. Water levels were checked manually on a weekly basis, and mean daily streamflow data were obtained from the USGS for the Monticello (111) station. Detailed location descriptions and monitoring histories for each station are presented in Keefer and Bauer (2005).

Table 1. Station Number, Name and Location, Period of Monitoring, and Drainage Area of Lake Decatur Watershed Monitoring Stations

ISWS Station number	*Location*	*Period of ISWS monitoring (years)*	*Drainage area*	
			(mi^2)	*(acres)*
101	Long/Big 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
124	Camp Creek near White Heath: Downstream of Station 104	2001 - 2002	48.8	31,242
105	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	Lake Decatur Basin 1: Lost Bridge Road	2002 - 2004		
111	Sangamon River USGS Station #05572000 near Monticello, Piatt County	1993 - present	543.4	347,776
112	Sangamon River USGS Station #05570910 near Fisher, Champaign County	1993 - 2000	245.6	157,184

Precipitation

Precipitation data for selected locations around the watershed have been retrieved from the Midwestern Regional Climate Center database (http://mrcc.sws.uiuc.edu), which is operated by the ISWS. Figure 1 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 2 presents the 30-year (1971–2000) annual mean precipitation at these stations in the region. The 30-year average annual precipitation for the region is 38.94 inches. Table 3 presents the annual precipitation totals and the 13-year average annual precipitation (May 1993–April 2006) 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). The annual precipitation for the 13-year period of study (1993-2006) averaged 37.47 inches for the region. During PY 11–13, regional precipitation varied from 34.45 to 46.12 inches. Monthly precipitation for PY 11 (May 2003–April 2004), PY 12 (May 2004–April 2005), and PY 13 (May 2005–April 2006) is presented in figure 2 and annual precipitation for the entire monitoring period is presented in figure 3. Monthly and annual precipitation values for May 2003–April 2006 are presented in appendix B.

Project Year 11 (May 2003–April 2004)

The two highest monthly precipitation values during PY 11 occurred at Rantoul in July 2003 (8.73 inches), ranking just above the 90th percentile, and at Urbana in March 2004 (7.74 inches), ranking well above the 95th percentile. Regionally, precipitation in July, August, September, and November 2003 and March 2004 was well above the 30-year mean, while precipitation in October 2003 and February and April 2004 was well below 30-year mean precipitation amounts. The lowest monthly rainfall occurred in February 2004 when the region received 0.49 inches or 27 percent of the 30-year mean rainfall, while October 2003 received 1.55 inches, the 28th driest October in the past 109 years (55 percent of 30-year mean). Regional precipitation amounts were averaged and compared with the 30-year mean. Precipitation data collection at the Monticello station was discontinued in October 2003.

Project Year 12 (May 2004–April 2005)

The highest monthly precipitation during PY 12 occurred at Gibson City in May 2004 (8.21 inches). The next highest monthly precipitation occurred at Rantoul in August 2004 (6.94 inches). Regionally, the highest monthly precipitation occurred in January 2005, averaging 6.69 inches or 3.58 times the 30-year mean. Most stations recorded the least amount of rainfall for PY 12 in September 2004 for a regional average of 0.14 inches or 24 percent of the 30-year mean. Rainfall amounts in March and April 2005 were also low at 51 and 81 percent of the 30-year mean, respectively. Overall, precipitation in PY 12 was slightly above normal for the region compared to the 30-year mean.

Table 2. Monthly and Annual 30-Year (1971-2000) Mean Precipitation for Selected Stations, 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	4.60
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	1.76	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

Note: Regional annual average: 38.94

Table 3. Annual Precipitation for Selected Stations for the 13-Year Study Period (May 1993–April 2006)

Project year	*Mean precipitation (inches)*						*Regional mean*
	Gibson City	*Rantoul*	*Urbana*	*Clinton*	*Monticello*	*Decatur*	
PY 1	48.78	54.39	56.94	51.73	54.39	42.29	51.42
PY 2	37.22	33.07	33.37	36.91	33.07	37.32	35.16
PY 3	33.90	31.34	36.64	32.87	31.34	34.83	33.49
PY 4	36.61	37.15	39.20	36.17	37.15	39.22	37.58
PY 5	39.01	38.45	41.86	42.62	38.45	29.85	38.37
PY 6	35.09	41.83	44.41	38.58	41.83	36.28	39.67
PY 7	25.36	26.03	34.00	35.21	26.03	28.91	29.26
PY 8	32.46	31.33	36.41	36.25	31.33	36.50	34.05
PY 9	38.95	39.91	42.28	40.75	39.91	46.90	41.45
PY 10	29.07	26.94	33.08	31.97	30.71	33.38	30.86
PY 11	38.93	45.00	45.67	39.00	*4.71	38.21	35.25
PY 12	44.61	47.98	44.46	48.06	*	45.51	46.12
PY 13	32.43	36.97	32.64	32.98	*	37.21	34.45
13-year mean	36.34	37.72	40.07	38.70	33.54	37.42	37.47

Note: * incomplete data

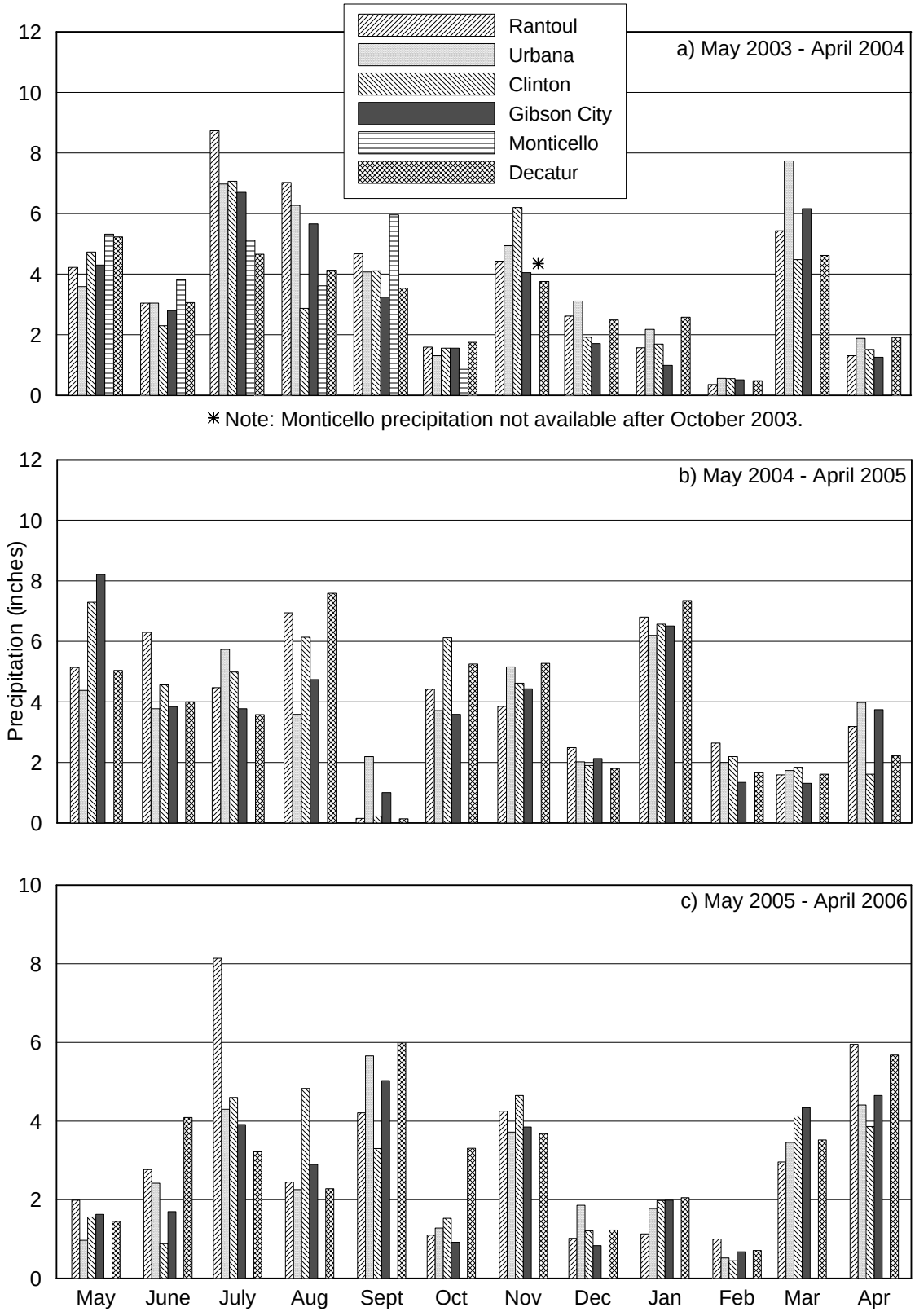

Figure 2. Monthly precipitation at six locations around the Lake Decatur watershed: a) May 2003–April 2004, b) May 2004–April 2005, and c) May 2005–April 2006

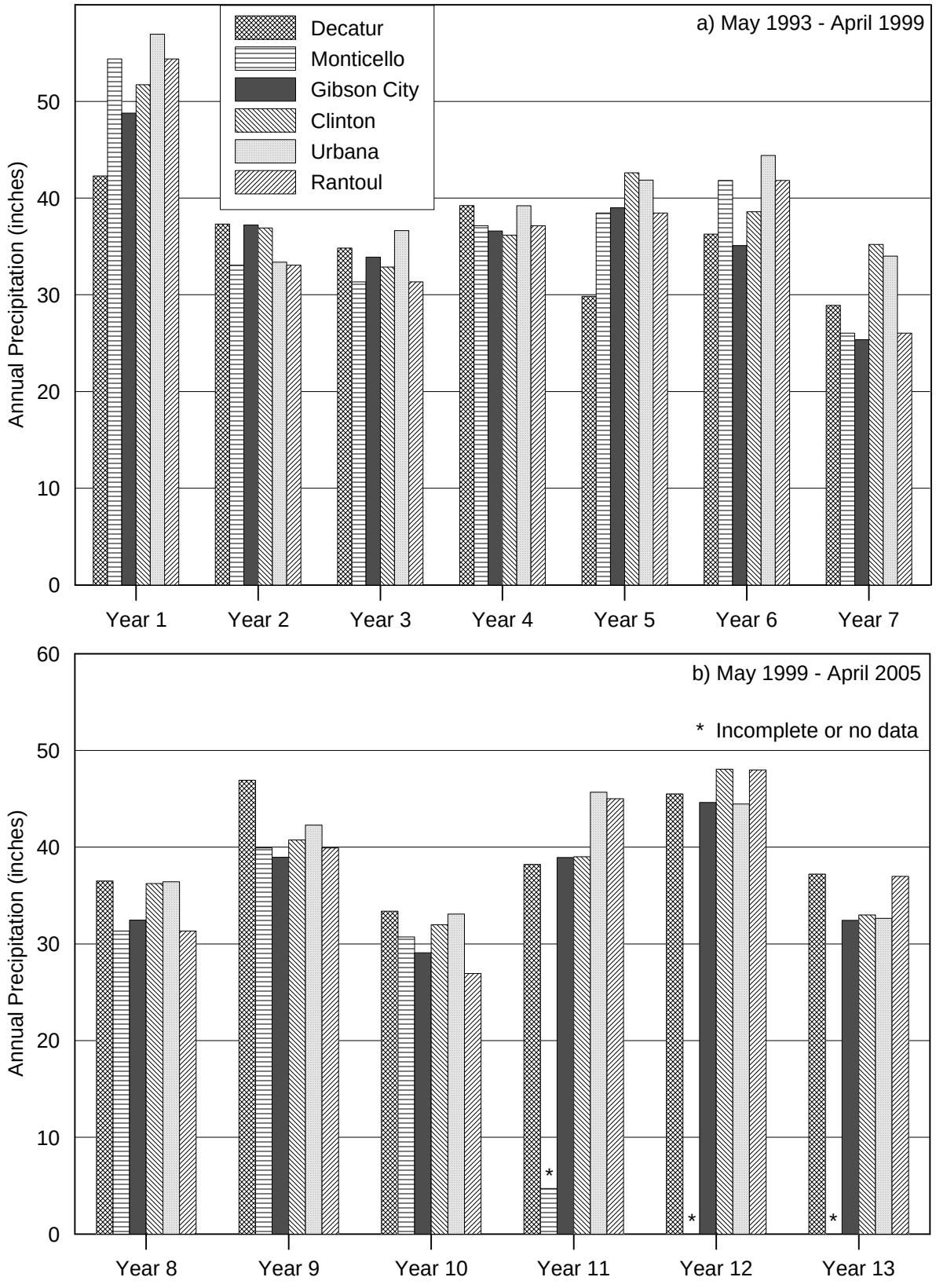

Figure 3. Annual precipitation during study period: a) May 1993–April 2000 and b) May 2000–April 2006

Project Year 13 (May 2005–April 2006)

The highest monthly precipitation was at Rantoul in July 2005 (8.14 inches), which was more than 2 times the 30-year mean for that station. Regionally, September 2005 and April 2006 received slightly above normal rainfall compared to the 30-year mean. The lowest rainfall was recorded in February 2006 for all stations, for a regional average of 0.67 inches or 37 percent of the 30-year mean. Low rainfall amounts compared to the 30-year mean occurred in May, June, August, October, and December 2005 resulting in below normal rainfall amounts of 34.45 inches or 89 percent of the 30-year mean for the region.

Precipitation amounts in PY 11 and PY 12 were near to slightly above normal (107 percent and 119 percent of the 30-year mean, respectively) despite the large monthly variations (figure 2) compared to the 30-year mean. It is normal to have this amount of month-to-month variation compared to the 30-year mean (per Jim Angel, state climatologist, ISWS). PY 13 was below normal (89 percent of the 30-year mean) and would be comparable with PY 8 with respect to the 30-year mean.

Streamflow

Streamflow data (discharge) are generated from the 15-minute stage record collected at each gaging station. 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, and 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 nitrate-N 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) were obtained from the USGS.

Streamflow Data. The following section presents monthly streamflow data for the May 2003 through April 2006 period. Figure 4 presents monthly discharge data from PY 11–13 for stations at Long Creek (101), Friends Creek (102), and Monticello (111).

Project Year 11 (May 2003–April 2004)

Discharges on the tributary stations Friends Creek (102) and Long Creek (101) stayed below 5,000 cubic feet per second (cfs) for most of the year except during March 2004 when Friends Creek (102) had a discharge of 7,280 cfs and Long Creek (101) experienced its highest discharge for the project year of 2,684 cfs. Discharge at Monticello (111) ranged between 1,397 cfs and 2,334 cfs from May–July 2003 and November 2003–January 2004. Discharges in August–October 2003 were slightly higher than normal for the season.

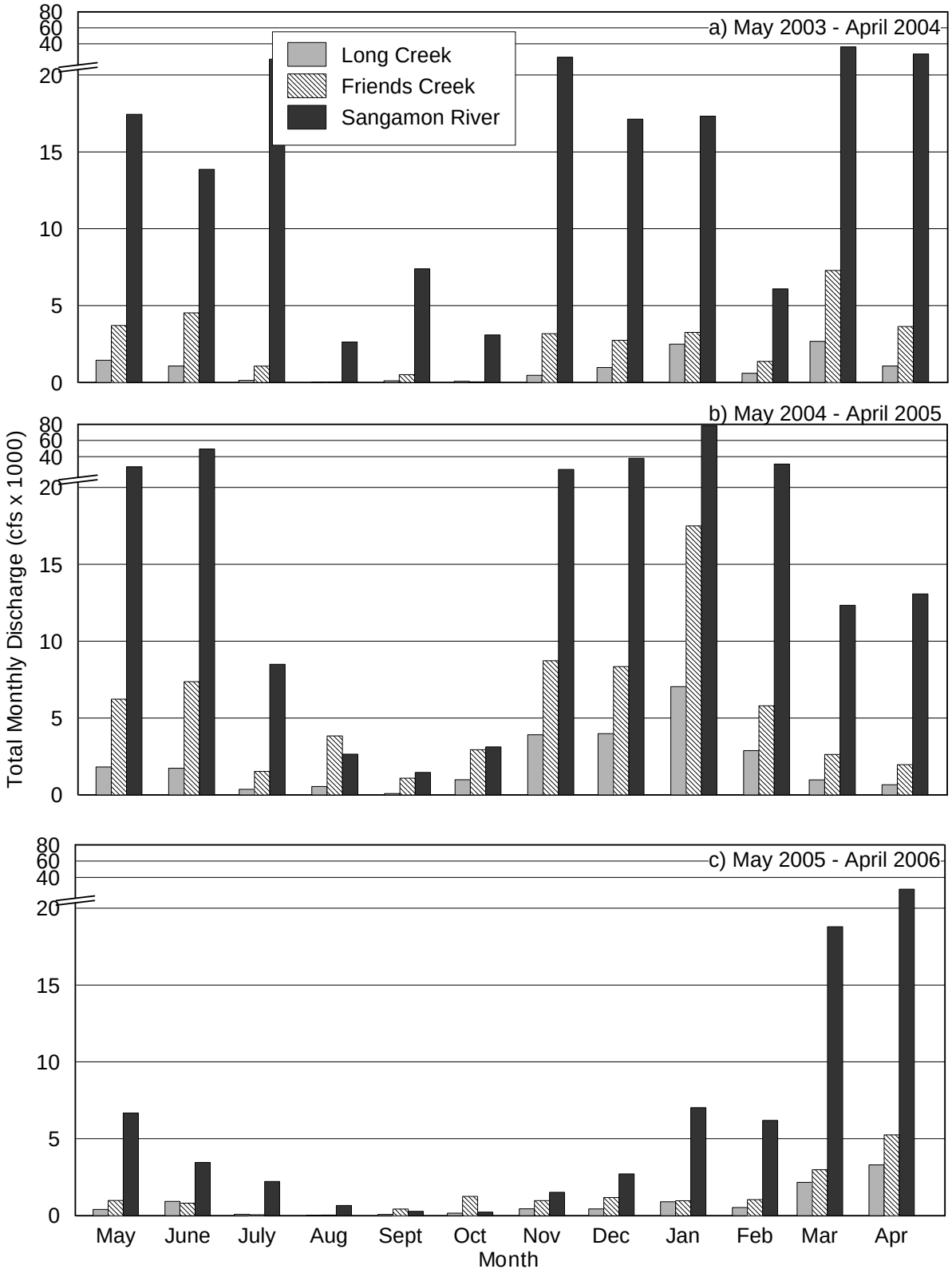

Figure 4. Monthly discharge: a) May 2003–April 2004, b) May 2004–April 2005, and c) May 2005–April 2006

Project Year 12 (May 2004–April 2005)

All stations recorded the highest monthly discharges in January 2005 during PY 12. Friends Creek (102) discharge rates were greater than 5,000 cfs for May, June, November, and December 2004, and January and February 2005. Long Creek (101) discharge rates were typically lower than 5,000 cfs for PY 12, except for January 2005. For this project year, discharge rates increased each month from May through June and then dropped to relatively low rates for the summer months. Discharge rates increased each month in November 2004–January 2005. March and April 2005 experienced moderate discharge rates at all three stations.

Project Year 13 (May 2005–April 2006)

The highest discharge for each tributary occurred in April 2006. From May 2005 through February 2006, the highest discharge of 1,250 cfs occurred in October 2005 at Friends Creek (102). In March 2005, a period of low flow began at all stations and lasted through February 2006. There were no significant storms in May 2005–February 2006 during PY13.

For 63 days, September 2, 2005 through November 4, 2005, 15 cfs per day of groundwater was pumped from the Dewitt pumping fields into Friends Creek (upstream of station 102).

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 2003–April 2006 are presented in figure 5.

Project Year 11 (May 2003–April 2004)

All stations had the highest runoff during March 2004. Runoff at all stations was less than 1.56 inches from May 2003 through February 2004, except for Long Creek (101) in January 2004 (2.02 inches). The runoff at Long Creek (101) during January 2004 was much greater than at Friends Creek (102) and Monticello (111), 1.09 and 1.17 inches, respectively. In July 2003, the Sangamon River watershed at Monticello (111) had significantly higher runoff (1.4 inches) than that of the tributary stations, 0.11 and 0.36 inches for Long Creek (101) and Friends Creek (102), respectively.

Project Year 12 (May 2004–April 2005)

All stations had the highest runoff during January 2005; Long Creek (101) had the greatest runoff of 5.72 inches followed by Monticello (111) at 5.28 inches and Friends Creek (102) at 4.46 inches. For the tributary stations, Friends Creek (102) had consistently higher runoff than Long Creek (101) from May through October 2004. Then, from November 2004 through February 2005, Long Creek (101) had consistently higher runoff than Friends Creek

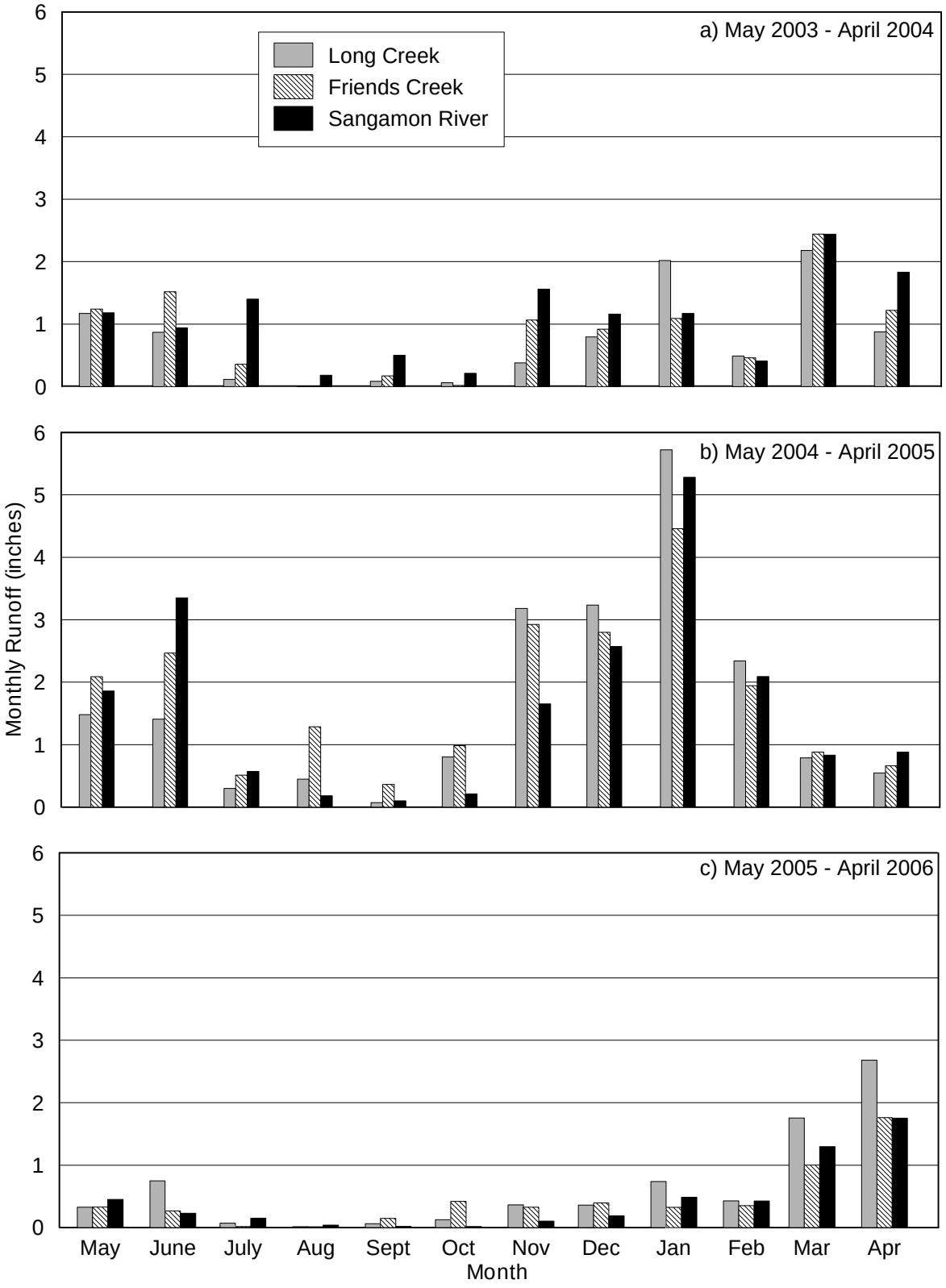

Figure 5. Monthly runoff: a) May 2003–April 2004, b) May 2004–April 2005, and c) May 2005–April 2006

(102) and Monticello (111). In June 2004, runoff rates varied among the three stations from 1.41 inches at Long Creek (101) to 2.47 inches at Friends Creek (102), to 3.35 inches at Monticello (111). Runoff was consistently higher (>1.65 inches) from November 2004 through February 2005 at all stations.

Project Year 13 (May 2005–April 2006)

The highest runoff for PY 13 was in April 2006 at Long Creek (101) (2.68 inches), compared to Friends Creek (102) (1.76 inches) and Monticello (111) (1.75 inches). Runoff values for all stations averaged 0.26 inches for the period May 2005 through February 2006. The two highest runoff values during that period were at Long Creek (101), 0.75 inches in June 2005 and 0.74 inches in January 2006. Long Creek (101) also had the highest runoff in March and April 2006, 1.75 and 2.68 inches, respectively.

Summary of Annual Runoff (May 1993–April 2006)

Annual runoff data for the 13-year study period are presented in figure 6. The tributary stations experienced highest runoff rates of the 13-year study period during PY 12, due to precipitation amounts in November 2004 and January 2005. Runoff rates were very low during PY 13, close to rates seen during the drought in PY 7 even though precipitation rates were not severely low.

Nitrate-N Monitoring

Nitrate-N samples were collected at Long Creek (101), Friends Creek (102), and Monticello (111) stations for all 13 years of this monitoring project. Nitrate-N samples were collected manually by the 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. Water temperature and acidity of each bulk sample were recorded. Nitrate-N concentration data for PY 1–10 of the monitoring study are presented in Keefer and Bauer (2005), Keefer and Demissie (1996, 1999, 2000, and 2002), Keefer et al. (1997), and Demissie et al. (1994 and 1996). Temperature, acidity, and non-volatile organic carbon (NVOC) data for May 2003 through April 2006 are presented in appendix C. Minimum, maximum, and mean nitrate-N concentrations for this period are presented in appendix D. Those data were collected for use by City of Decatur resource managers and are not discussed further in this report.

Nitrate-N Concentrations

Figure 7 presents PY 11–13 nitrate-N concentration data from the monitoring stations on Long Creek (101), Friends Creek (102), Sangamon River at Monticello (111), and daily data from the South Water Treatment Plant (SWTP) provided by the City of Decatur for use in this study. Figure 7 shows the seasonal variation of nitrate-N concentrations observed for PY 11–13. Seasonal variation of nitrate-N concentrations has been observed in previous years and presented in previous reports (Demissie et al., 1996; Keefer et al., 1997; Keefer and Demissie, 1999, 2000; Keefer and Bauer, 2005).

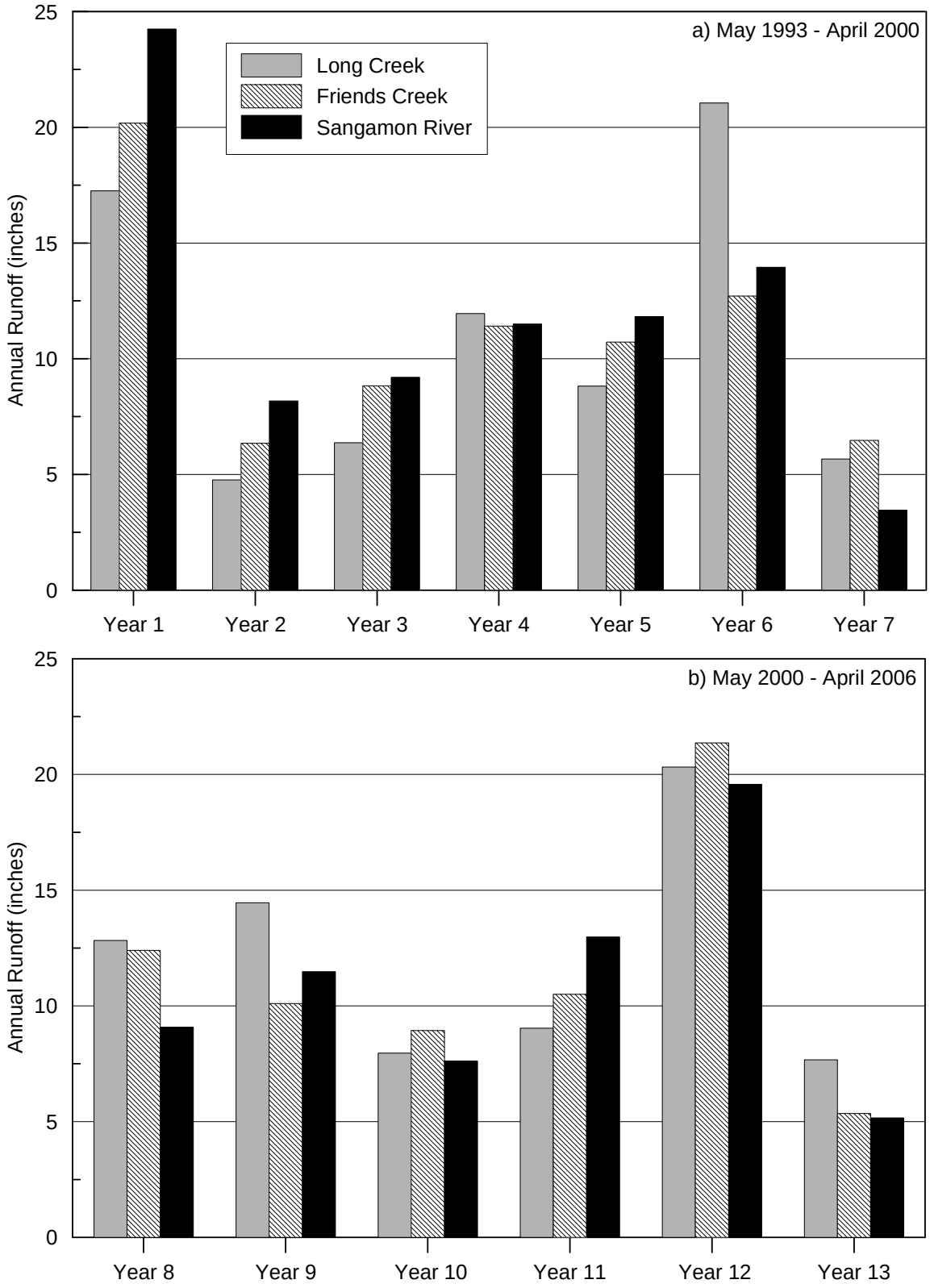

Figure 6. Annual runoff during study period: a) May 1993–April 2000 and b) May 2000–April 2006

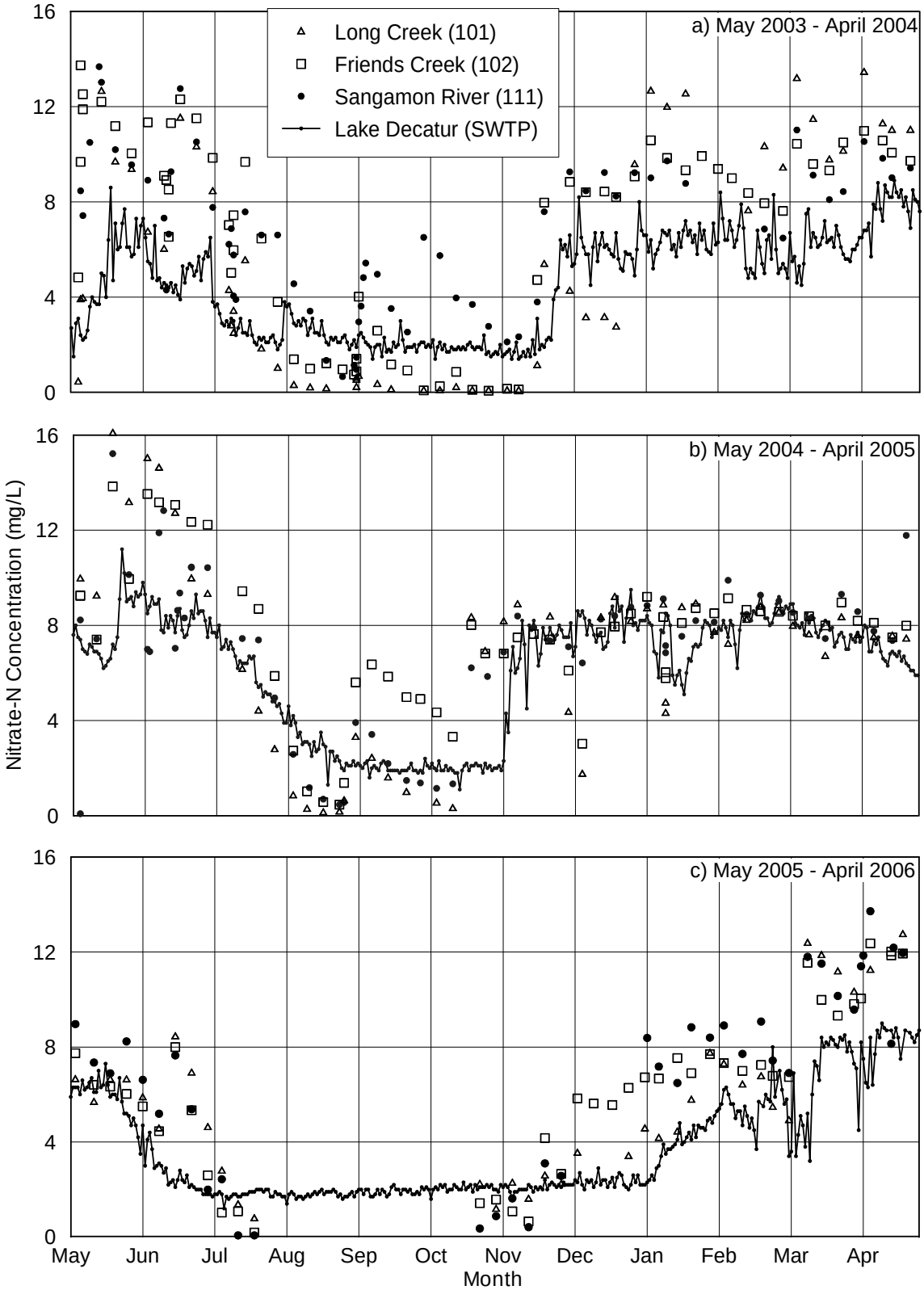

Figure 7. Nitrate-N concentrations for monitored stations and daily values from Lake Decatur at the South Water Treatment Plant: a) May 2003–April 2004, b) May 2004–April 2005, and c) May 2005–April 2006

Project Year 11 (May 2003–April 2004)

Concentrations in May and June 2003 ranged from 0.43 to 13.74 mg/L and occurred during the first week of May (figure 7a). During these months, concentrations varied greatly week to week. In July, concentrations decreased and remained low through mid-November. Monticello (111) concentrations were consistently higher than those at the tributary stations from the beginning of August through mid-November 2004. Concentrations increased sharply in mid-November and remained above 8 mg/L through the end of April 2004, except during the last part of February 2004. Long Creek (101) nitrate concentrations were much higher than concentrations at Friends Creek (102) and Monticello (111) in January, March, and April 2004.

SWTP concentrations followed the same pattern, yet were generally lower than those at the river and tributary stations, except from mid-July through mid-November 2004.

Project Year 12 (May 2004–April 2005)

The highest nitrate-N concentrations for PY 11–13 occurred in May and June 2004 at Long Creek (101). During these two months, concentrations ranged from 6.90 to 16.07 mg/L, with the tributary stations showing concentrations consistently higher than at the Monticello (111) river station (figure 7b). Concentrations at all stations began decreasing in July 2004. During August–September 2004, Long Creek (101) and Monticello (111) station concentrations remained below 4 mg/L, while Friends Creek (102) concentrations increased to 6.36 mg/L in early September. Friends Creek (102) concentrations decreased throughout September and early October 2004. Concentrations at all stations increased sharply in mid-October, ranging between 5.85 and 9.89 mg/L through the end of the project year, except for some isolated events: two weeks at the end of November and beginning of December 2004, one week in January 2005, and at the end of April 2005. From February through the end of April 2005 concentration values between stations remained very steady, averaging around 8 mg/L.

SWTP concentrations followed the same pattern as the monitoring stations, with concentrations close in value to the tributaries and river concentrations from November 2004 through April 2005.

Project Year 13 (May 2005–April 2006)

Figure 7c shows that concentrations at all stations gradually decreased from May through July 2005 with the exception of an increase in the middle of June 2005. In mid-July, the stream stage levels were below the point of zero flow (pzf) where stream water was ponded and not flowing; therefore samples were not collected during this time. Streamflow returned in mid-October 2005. Nitrate-N concentrations increased gradually from October 2005 through April 2006, reaching a peak concentration of 13.72 mg/L at Monticello (111). Monticello (111) had consistently higher concentrations in January and February 2006 than those at the tributary stations. In December 2005 the Sangamon River at Monticello (111) was ice-covered, so no samples were collected.

SWTP concentrations followed the same pattern as the station concentrations, yet were generally lower than concentrations at the river and tributary stations, except during the summer

and fall months, July through November 2006. Lake concentration levels did not begin to increase until January 2006 and leveled off in March 2006 at slightly more than 8 mg/L. Keefer and Bauer (2005) observed similar seasonal patterns in nitrate-N concentrations.

Annual Maximum, Minimum, and Mean Concentrations (1993 –2006)

Table 4 shows the maximum, mean, and minimum nitrate-N concentrations for PY 11–13. Figure 8 shows the maximum, minimum, and mean annual nitrate-N concentrations for the 13-year study period at Long Creek (101), Friends Creek (102), and Monticello (111). The maximum nitrate-N concentration levels at each station did not occur in the same year. For the 13-year study period, the maximum nitrate-N concentration at Long Creek (101) of 16.07 mg/L occurred in PY 12, at Friends Creek of 16.82 mg/L in PY 7, and at Monticello (111) of 16.00 mg/L in PY 9. Annual mean concentrations varied from 6.03 to 9.07 mg/L during the 13-year study. Long Creek (101) mean nitrate-N concentrations were the lowest, varying between 6.03 to 7.59 mg/L, while Friends Creek (102) had the highest mean concentrations ranging from 7.30 to 9.07 mg/L. Minimum concentrations were below 1.0 mg/L except for Monticello (111) during PY 1.

Nitrate-N Loads

Nitrate-N load is used to compare the relative contribution of nitrate-N from different areas being monitored over time. Nitrate-N concentrations are used for regulatory purposes but are not sufficient to determine the relative contribution of nitrate-N from different areas. 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). Figure 9 presents the monthly nitrate-N loads (lb/acre/month) during PY 11–13, and figure 10 presents the annual nitrate-N loads for all 13 project years.

Table 4. Maximum, Mean, and Minimum Nitrate-N Concentrations during Project Years 11 - 13 (May 2003 - April 2006)

	Nitrate-N Concentration (mg/L)								
	Project Year 11			*Project Year 12*			*Project Year 13*		
Station	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*
Tributary									
Long Creek (101)	5.33	0.07	13.44	6.77	0.12	16.07	6.24	0.77	12.74
Friends Creek (102)	6.93	0.07	13.74	7.49	0.47	13.84	6.13	0.19	11.54
River/Lake									
Monticello (111)	6.70	0.66	13.68	7.01	0.08	15.22	6.88	0.07	13.72
SWTP	4.46	1.40	8.90	6.15	1.10	11.20	3.60	1.20	9.00

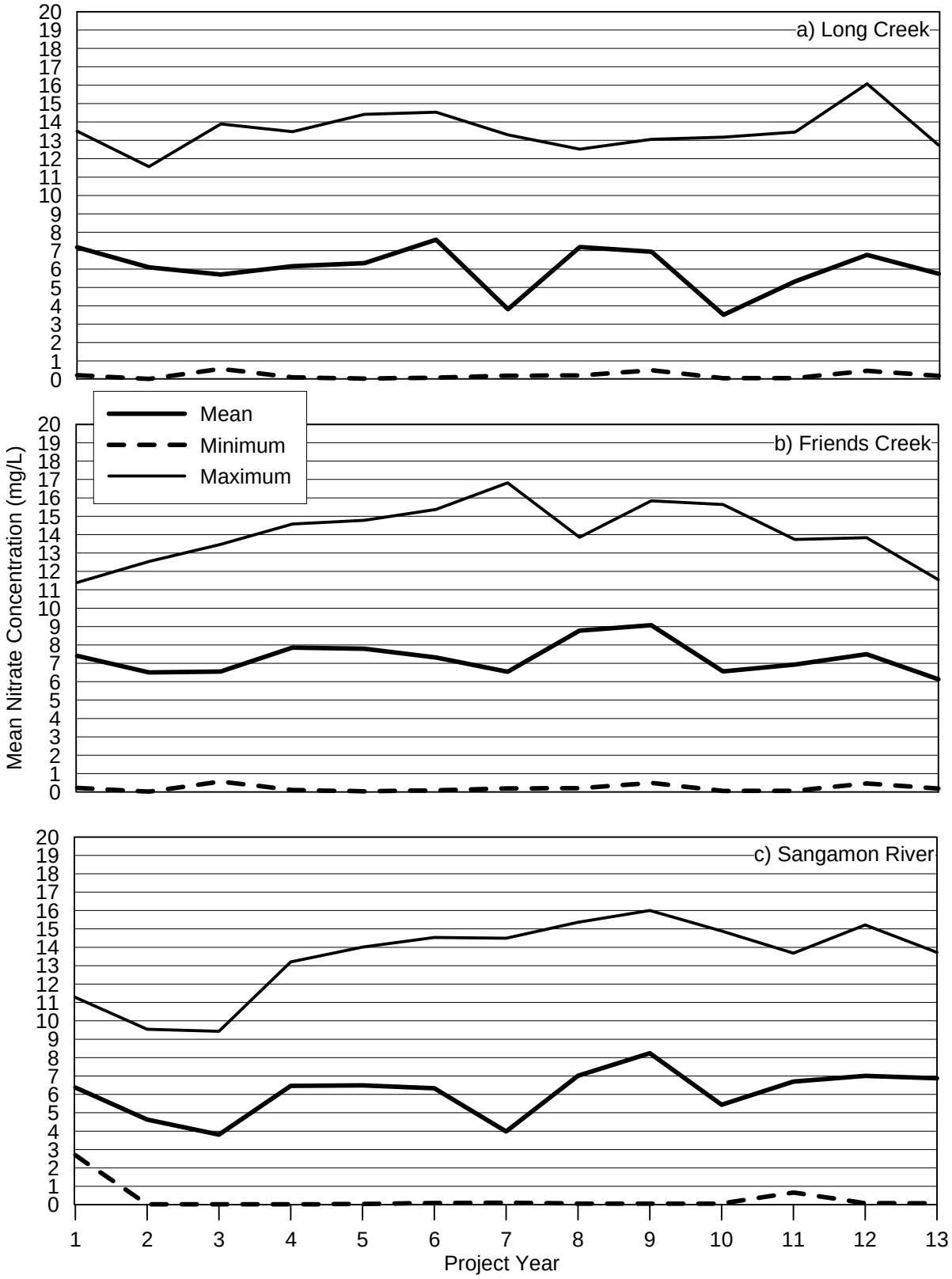

Figure 8. Mean, minimum, and maximum annual nitrate-N concentrations during study period: a) Long Creek (101), b) Friends Creek (102), and c) Sangamon River at Monticello (111)

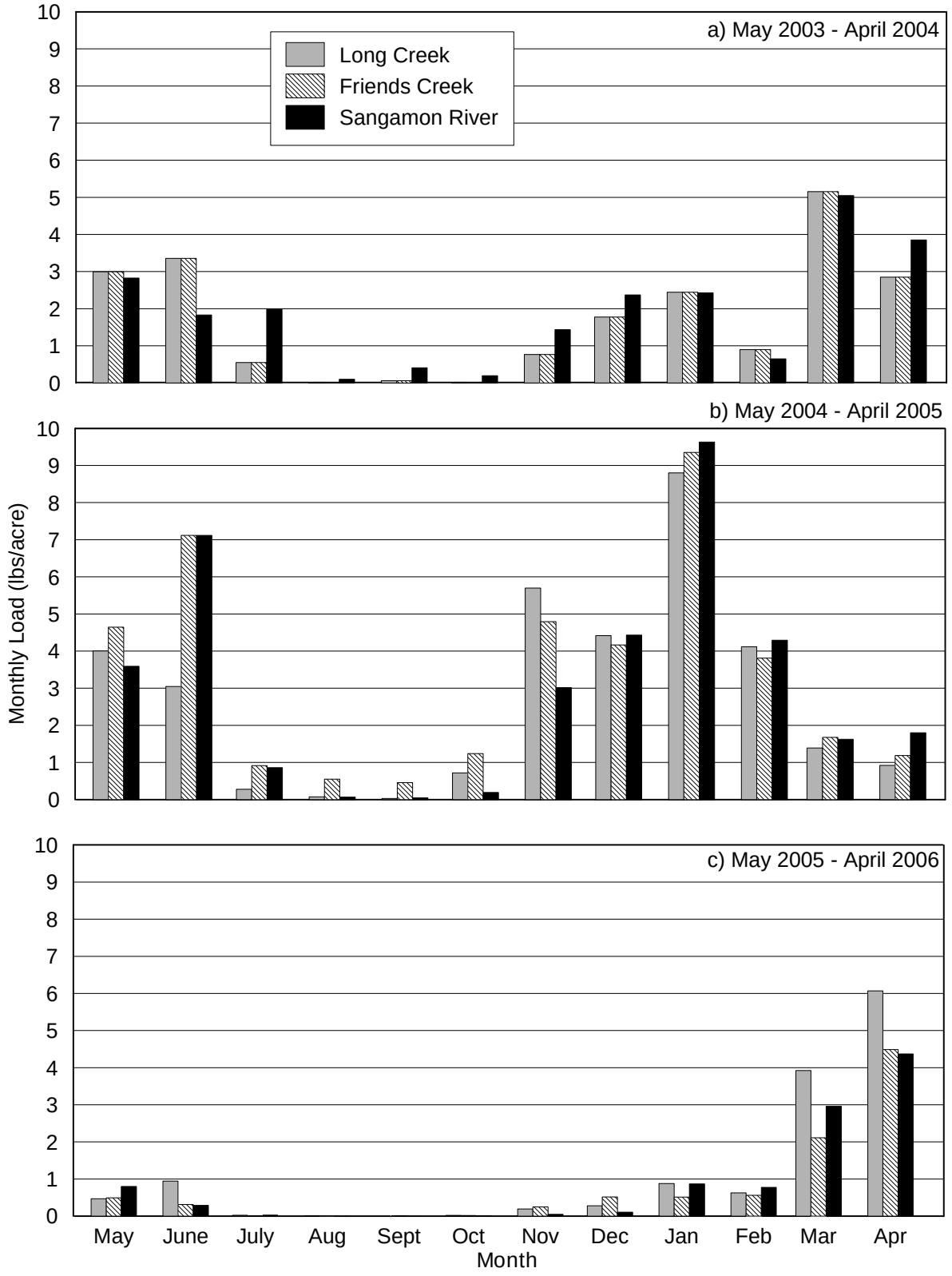

Figure 9. Monthly nitrate-N load: a) May 2003–April 2004, b) May 2004–April 2005, and c) May 2005–April 2006

As can be seen in figure 9, highest monthly nitrate-N loads for each project year occurred in different months. In PY 11, monthly nitrate-N loads were highest during March 2004; for PY 12, the highest loads occurred in January 2005; and for PY 13, the highest loads occurred in April 2006. Monthly nitrate-N loads for PY 13 were very low due to the drought conditions that lasted 13 months beginning in March 2005 (PY 12). Drought conditions ended in April 2006 (the last month of PY 13).

Annual Nitrate-N Loads. Figure 10 presents the annual nitrate-N loads of Long Creek (101), Friends Creek (102), and Monticello (111) for the 13-year monitoring period. Table 5 presents the annual nitrate-N loads for the all monitored stations in the watershed during the 13-year study period.

During the entire monitoring period for the three monitoring stations, the annual nitrate-N load ranged from a low of 8 lb/acre in PY 7 from the Sangamon River at Monticello (111) to a high of 50.2 lb/acre for Long Creek (101) in PY 6. The total nitrate-N load delivered to Lake Decatur was determined by using the Long Creek (101), Friends Creek (102), and Monticello (111) station mean annual loads and watershed areas to calculate area-weighted mean annual yields. The largest nitrate-N load of 39 lb/acre was delivered to the lake in PY 6, and the lowest load of 11 lb/acre occurred in PY 13. The 13-year mean annual load for Friends Creek (102) and Long Creek (101) stations was 23 lb/acre. The 13-year mean annual load for Monticello (111) was 21.9 lb/acre. The mean annual nitrate-N load delivered from the Lake Decatur watershed for the 13-year study period was 22.7.

Based on the data (figures 9 and 10 and table 5), it can be concluded that nitrate-N loads are relatively uniform over the entire watershed, but tend to be slightly higher in the tributary streams in the upper Sangamon River watershed than in the river. Nitrate-N loads vary from monitoring station to station and change significantly from year to year.

The annual average data for rainfall, streamflow, flow-weighted nitrate-N concentrations, and nitrate-N loads for the 13-year monitoring period at Monticello (111) are presented in table 6 and are plotted in figure 11. 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 98-year streamflow record (1908–2006) and long-term mean annual streamflow of 456 cfs (table 6). The greatest annual streamflow during the monitoring study was 961 cfs, which is twice the long-term mean. PY 1 streamflow was the third highest recorded streamflow since 1908 (Demissie et al., 1996). The lowest streamflow during the monitoring period was in PY 7 (138 cfs), which is the ninth lowest annual mean streamflow for 1908 to 2006. Between PY 1 and PY 10, the flow-weighted nitrate-N concentrations at Monticello (111) increased from 6.17 to 10.49 mg/L, then decreased to 7.33 mg/L from PY 10 to PY 12 with a slight increase in PY 13 to 8.83 mg/L. Flow-weighted nitrate-N concentrations fluctuated around 9.12 mg/L from PY 7–13. The 13-year mean annual flow-weighted nitrate-N concentration is 8.84 mg/L. The annual average streamflow, flow-weighted nitrate-N concentration, and nitrate-N loads for the Long Creek (101), Friends Creek (102), and Monticello (111) stations during the entire 13-year monitoring period are presented in appendix E.

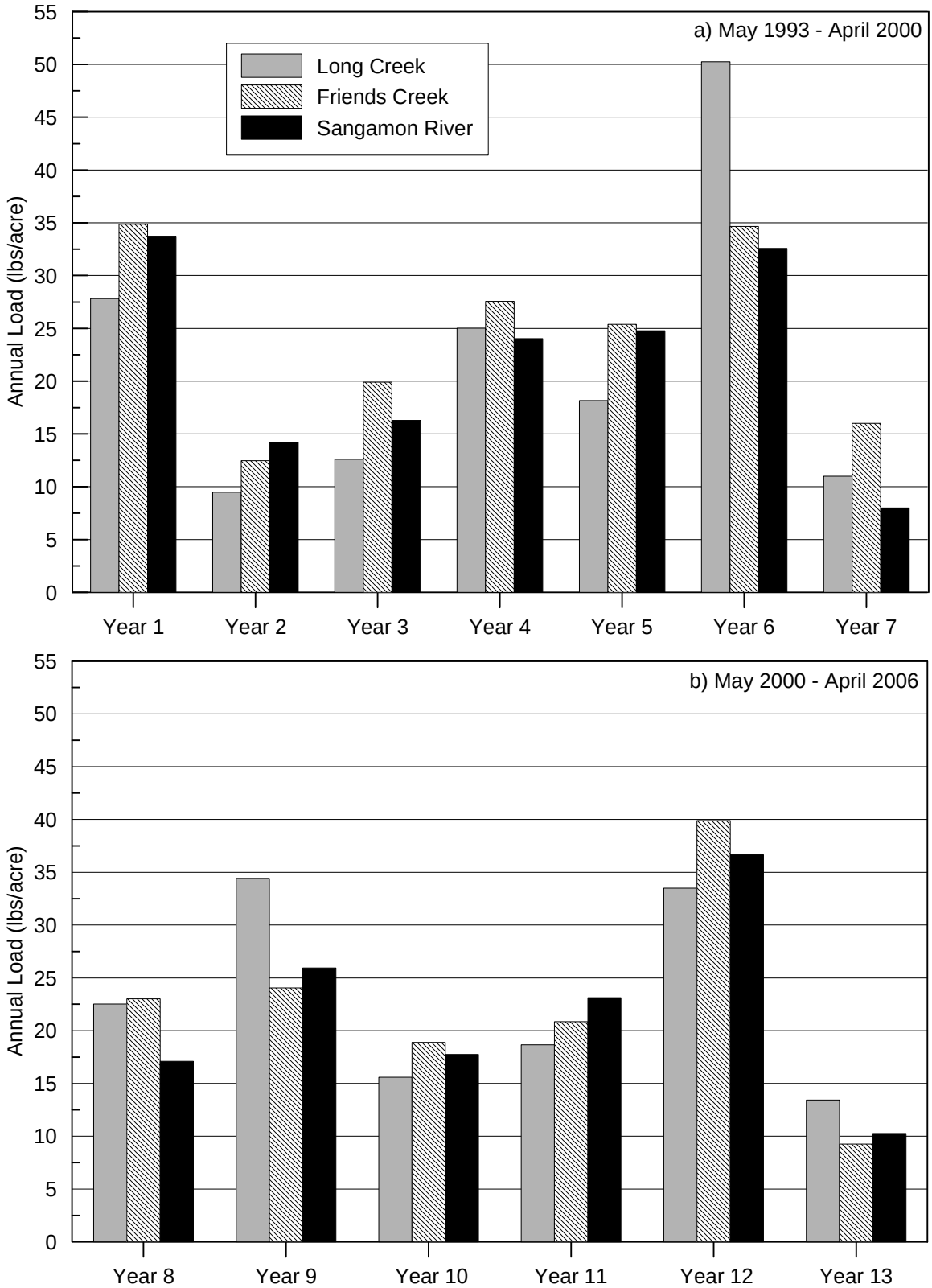

Figure 10. Annual nitrate-N load during study period: a) May 1993–April 2000 and b) May 2000–April 2006

Table 5. Annual Nitrate-N Loads in the Sangamon River Basin for the 13-Year Study Period, May 1993-April 2006

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

Table 6. Summary of Rainfall, Flow, Flow-Weighted Nitrate-N Concentration and Load for the Sangamon River at Monticello (111) for the Duration of the Monitoring Period, 1993-2006

Project year	*Monitoring year (May–April)*	*Total rainfall* (inches)*	*Average streamflow (cfs)*	*Flow-weighted nitrate-N concentration (mg/L)*	*Nitrate-N load (lb/acre/yr)*
1	1993-1994	53.0	961	6.17	34
2	1994-1995	35.1	323	7.72	14
3	1995-1996	33.7	362	7.88	16
4	1996-1997	37.3	460	9.29	24
5	1997-1998	40.5	469	9.32	25
6	1998-1999	40.0	556	10.39	33
7	1999-2000	30.2	138	10.54	8
8	2000-2001	34.1	378	8.51	17
9	2001-2002	40.5	464	10.66	26
10	2002-2003	30.3	295	10.49	18
11	2003-2004	42.2	524	7.77	23
12	2004-2005	46.3	795	7.33	37
13	2005-2006	33.8	207	8.83	10
	13-year mean (1993-2006)	-	456	8.84	22.7

Notes:
- Incomplete data.
* Average of annual precipitation from Gibson City, Urbana, Clinton, and Rantoul weather stations.

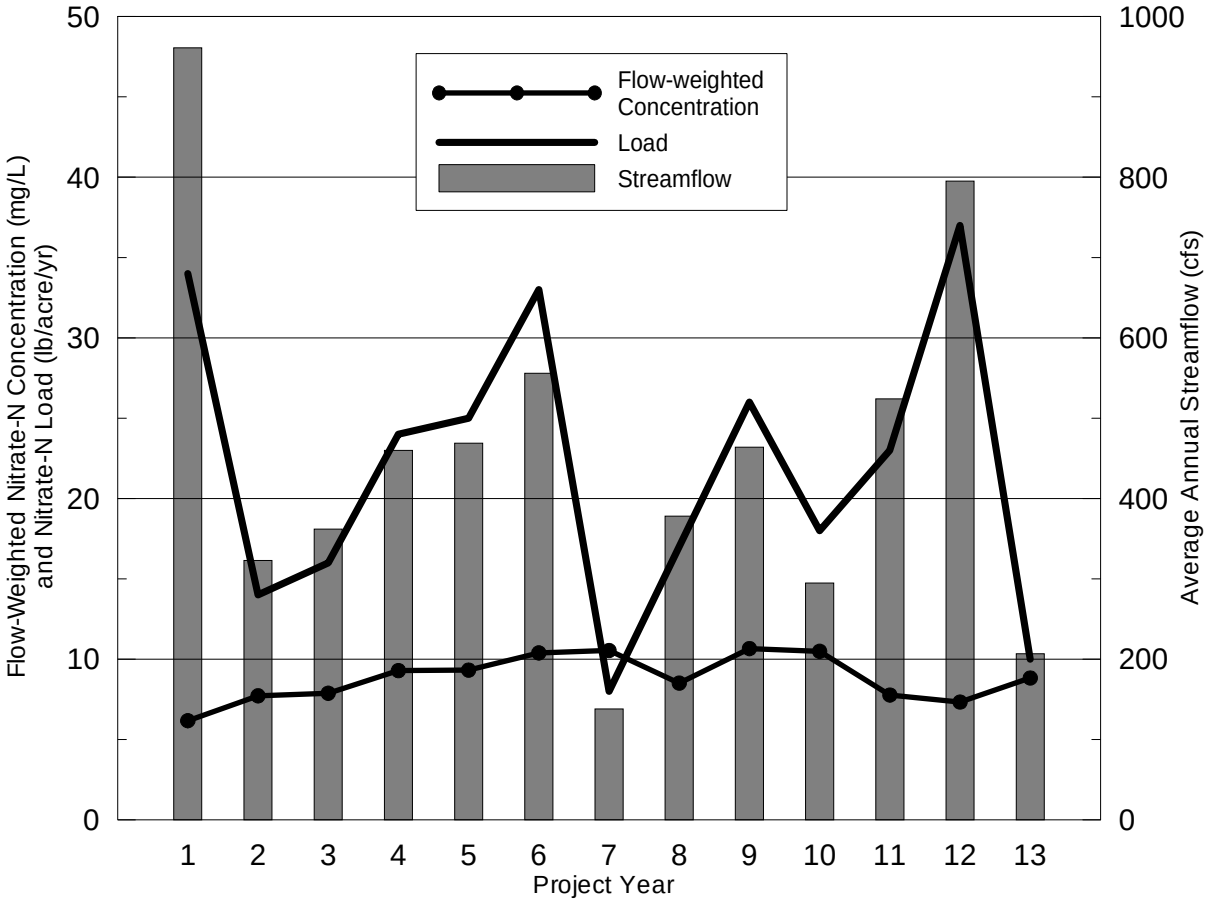

Figure 11. Mean annual streamflow, load, and flow-weighted mean nitrate-N concentrations from the Sangamon River at Monticello (111) during study period, May 1993–April 2006

Summary

The Illinois State Water Survey monitored streamflow and collected nitrate-N samples in the Lake Decatur Watershed during 1993–2006. This report presents the monthly data for Long Creek (101), Friends Creek (102), and Monticello (111) for May 2003–April 2006 and the annual data of all tributary and river monitored stations for May 1993–April 2006.

Nitrate-N concentrations during PY 11–13 (2003–2006) had maximum values ranging from 11.5 to 16.0 mg/L. The highest maximum values were during PY 12. Mean concentrations varied between 5.3 and 7.5 mg/L with an overall average of 6.6 mg/L for all three stations during PY 11–13. Minimum concentrations ranged from 0.07 to 0.8 mg/L. Flow-weighed nitrate-N concentrations increased by approximately 4.22 mg/L from PY 1 (6.17 mg/L) to PY 7 (10.54 mg/L) and decreased by approximately 1.8 mg/L in PY 13 (8.83 mg/L) at the Monticello (111) station (table 6).

Annual nitrate-N loads varied greatly from year to year during the 13-year period of study. The highest weighted annual yields into Lake Decatur occurred during PY 6 with 39 lb/acre and PY 12 with 37 lb/acre, and the lowest weighted annual yields occurred in PY 13 (11 lb/acre) and PY 2 and PY 7 (each 12 lb/acre). The 13-year mean weighted annual yield to Lake Decatur was 22.7 lb/acre.

Based on the data (figures 9 and 10 and table 5), it can be concluded that nitrate-N loads are relatively uniform over the entire watershed, but tend to be slightly higher in the tributary streams in the upper Sangamon River watershed than in the river. Nitrate-N loads vary from monitoring station to station and change significantly from year to year.

Monthly and annual streamflow and water quality data for May 1993–April 2003 are presented in the following reports: Keefer and Bauer (2005), Keefer and Demissie (1996, 1999, 2000, and 2002), Keefer et al. (1997), and Demissie et al. (1996 and 1994).

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Appendix A. Starting and Ending Dates for Project Years 1-13

	Year	
Project Year	*Starting May 1*	*Ending April 30*
PY 1	1993	1994
PY 2	1994	1995
PY 3	1995	1996
PY 4	1996	1997
PY 5	1997	1998
PY 6	1998	1999
PY 7	1999	2000
PY 8	2000	2001
PY 9	2001	2002
PY 10	2002	2003
PY 11	2003	2004
PY 12	2004	2005
PY 13	2005	2006

Appendix B. Monthly Precipitation for Project Years 11-13 (May 2003–April 2006) at Selected Stations

Date	*Gibson City*	*Rantoul*	*Urbana*	*Clinton*	*Monticello*	*Decatur*
Year 11						
May-03	4.3	4.22	3.59	4.73	5.32	5.23
Jun-03	2.79	3.04	3.04	2.3	3.81	3.06
Jul-03	6.7	8.73	6.98	7.07	5.12	4.66
Aug-03	5.66	7.03	6.27	2.87	3.62	4.13
Sep-03	3.24	4.67	4.07	4.11	5.96	3.54
Oct-03	1.56	1.59	1.31	1.56	0.86	1.75
Nov-03	4.05	4.43	4.94	6.2	end of	3.76
Dec-03	1.71	2.62	3.11	1.92	final data	2.49
Jan-04	0.99	1.57	2.18	1.69		2.58
Feb-04	0.51	0.36	0.56	0.55		0.48
Mar-04	6.16	5.43	7.74	4.48		4.62
Apr-04	1.26	1.31	1.88	1.52		1.91
Annual	*38.93*	*45*	*45.67*	*39*	*	*38.21*
Year 12						
May-04	8.21	5.14	4.38	7.29		5.04
Jun-04	3.84	6.3	3.77	4.56		4
Jul-04	3.77	4.47	5.73	4.99		3.58
Aug-04	4.74	6.94	3.59	6.14		7.59
Sep-04	1	0.15	2.19	0.23		0.14
Oct-04	3.59	4.42	3.71	6.12		5.25
Nov-04	4.43	3.85	5.16	4.62		5.27
Dec-04	2.13	2.49	2.02	1.9		1.8
Jan-05	6.51	6.8	6.2	6.57		7.35
Feb-05	1.34	2.64	2	2.19		1.66
Mar-05	1.31	1.59	1.73	1.84		1.61
Apr-05	3.74	3.19	3.98	1.61		2.22
Annual	*44.61*	*47.98*	*44.46*	*48.06*		*45.51*
Year 13						
May-05	1.63	1.99	0.97	1.56		1.45
Jun-05	1.7	2.77	2.42	0.88		4.09
Jul-05	3.91	8.14	4.3	4.6		3.22
Aug-05	2.9	2.45	2.26	4.83		2.28
Sep-05	5.03	4.21	5.66	3.3		5.99
Oct-05	0.92	1.1	1.28	1.53		3.31
Nov-05	3.85	4.25	3.72	4.65		3.68
Dec-05	0.83	1.02	1.86	1.21		1.23
Jan-06	1.99	1.13	1.78	1.98		2.05
Feb-06	0.68	1	0.52	0.45		0.71
Mar-06	4.34	2.96	3.46	4.13		3.52
Apr-06	4.65	5.95	4.41	3.86		5.68
Annual	*32.43*	*36.97*	*32.64*	*32.98*		*37.21*

Appendix C. Temperature, Acidity, Non-volatile Organic Carbon (NVOC) for Project Years 11-13 (May 2003–April 2006)

Appendix C-1. Temperature, Acidity, Non-volatile Organic Carbon (NVOC), Long Creek (Station 101), 5/1/2003–4/30/2006

Date	*Time (CST)*	*Water temp* (F)	*Acidity (pH)*	*NVOC*
5/5/2003	13:02	60.80	-	-
5/6/2003	12:46	62.60	-	4.6
5/14/2003	11:00	60.00	-	-
5/20/2003	13:24	65.12	7.87	3.4
5/27/2003	13:58	63.00	-	-
6/3/2003	13:33	57.20	-	-
6/10/2003	13:36	70.88	7.92	3.6
6/17/2003	14:30	68.00	-	-
6/24/2003	13:22	75.74	8.06	-
7/1/2003	13:13	75.00	-	-
7/8/2003	12:51	84.02	8.02	-
7/9/2003	21:56	77.00	-	-
7/10/2003	6:44	70.70	-	-
7/10/2003	11:07	71.60	-	-
7/15/2003	10:55	75.20	-	-
7/22/2003	12:19	74.66	8.04	-
7/29/2003	12:50	74.30	8.06	-
8/5/2003	13:09	71.60	-	-
8/12/2003	12:10	71.42	7.91	-
8/19/2003	12:16	77.00	-	-
9/1/2003	6:41	66.20	-	-
9/1/2003	13:36	68.00	-	-
9/1/2003	16:48	68.00	-	-
9/2/2003	7:15	68.00	-	-
9/10/2003	11:12	69.00	8.00	-
9/16/2003	11:20	66.20	-	-
9/30/2003	13:18	55.40	-	-
10/7/2003	10:13	57.38	7.69	-
10/14/2003	10:12	55.40	-	-
10/21/2003	12:06	60.26	7.45	-
10/28/2003	10:46	50.00	-	-
11/5/2003	12:40	54.50	7.38	-
11/10/2003	10:35	42.08	7.32	-
11/18/2003	12:50	56.66	7.68	-
12/2/2003	13:05	41.36	7.83	-
12/17/2003	12:05	-	8.115	-
12/30/2003	12:00	-	8.08	-
1/13/2004	11:40	-	8.00	-
2/24/2004	12:10	40.46	7.85	-
3/9/2004	12:30	44.60	7.49	-
3/23/2004	12:07	47.48	7.87	-

Appendix C-1. Continued

Date	*Time (CST)*	*Water temp* (F)	*Acidity (pH)*	*NVOC*
4/7/2004	14:18	66.73	8.11	-
5/18/2004	12:18	67.10	8.02	-
5/25/2004	11:26	66.02	8.07	-
6/14/2004	10:38	73.00	-	-
6/21/2004	9:45	64.00	-	-
6/28/2004	9:21	66.00	-	-
7/13/2004	10:59	78.80	7.94	-
7/20/2004	10:05	71.60	8.14	-
7/27/2004	10:22	67.10	8.71	-
8/4/2004	9:28	74.30	7.91	-
8/17/2004	9:53	20.20	7.93	-
8/24/2004	10:03	22.20	7.81	-
8/26/2004	9:42	21.10	7.74	-
8/31/2004	11:33	20.60	7.95	-
9/7/2004	11:08	21.10	8.16	-
9/14/2004	10:05	21.00	8.05	-
9/22/2004	11:28	18.60	7.93	-
10/5/2004	10:50	12.20	8.06	-
10/12/2004	10:02	13.00	7.75	-
10/20/2004	11:00	14.20	7.76	-
10/26/2004	15:01	16.40	7.66	-
11/3/2004	13:40	13.40	8.00	-
11/9/2004	11:30	11.80	8.01	-
11/23/2004	11:10	52.00	8.12	-
12/1/2004	11:25	41.00	7.93	-
12/7/2004	13:00	49.00	7.29	-
12/15/2004	11:38	38.00	8.57	-
12/21/2004	11:20	36.00	7.89	-
12/28/2004	11:45	35.00	8.89	-
1/4/2005	11:56	43.00	6.46	-
1/11/2005	12:05	42.00	7.61	-
1/12/2005	13:40	43.00	7.37	-
1/12/2005	15:18	43.00	7.39	-
1/19/2005	12:25	37.00	7.67	-
1/25/2005	13:05	39.00	7.91	-
2/2/2005	11:49	31.00	7.85	-
2/8/2005	11:12	39.00	7.6	-
2/16/2005	12:55	42.00	7.61	-
2/22/2005	11:42	40.00	7.77	-
3/2/2005	10:56	36.00	7.77	-
3/8/2005	11:50	41.00	7.78	-
3/15/2005	11:06	38.00	7.49	-

Appendix C-1. Continued

Date	*Time (CST)*	*Water temp* (F)	*Acidity (pH)*	*NVOC*
3/22/2005	11:36	42.00	6.81	-
3/29/2005	12:55	52.00	8.09	-
4/5/2005	10:20	57.00	7.99	-
4/12/2005	13:15	59.00	8.14	-
4/20/2005	10:33	64.50	8.07	-
4/26/2005	10:13	54.00	8.38	-
5/3/2005	10:33	50.00	8.23	-
5/11/2005	10:40	72.00	7.91	-
5/18/2005	10:50	63.00	7.92	-
5/25/2005	9:57	63.00	7.92	-
6/1/2005	9:55	66.00	7.93	-
6/8/2005	11:27	76.00	7.95	-
6/15/2005	9:38	68.00	7.74	-
6/22/2005	12:04	72.50	8.01	-
6/29/2005	10:30	77.00	7.99	-
7/5/2005	11:45	74.00	7.95	-
7/12/2005	11:15	71.00	8.03	-
7/19/2005	11:43	77.00	7.76	-
7/27/2005	12:30	76.00	7.91	-
8/2/2005	11:21	78.00	7.85	-
8/9/2005	11:52	77.00	7.78	-
8/23/2005	14:27	76.00	7.83	-
8/30/2005	12:21	72.00	7.74	-
9/20/2005	12:00	71.00	7.78	-
9/26/2005	10:50	69.00	7.5	-
10/3/2005	12:09	70.00	8.08	-
10/11/2005	11:16	57.00	7.89	-
10/17/2005	10:35	55.00	7.84	-
10/24/2005	13:03	50.00	8.1	-
10/31/2005	12:25	52.00	7.91	-
11/7/2005	12:45	54.00	7.87	-
11/14/2005	12:17	48.00	7.90	-
11/21/2005	16:34	44.00	7.91	-
11/28/2005	13:28	50.00	7.7	-
12/5/2005	12:45	32.00	8.06	-
12/27/2005	13:15	39.00	7.73	-
1/3/2006	16:45	44.00	8.05	-
1/9/2006	13:59	41.00	7.93	-
1/17/2006	13:13	38.00	7.86	-
1/23/2006	12:49	39.00	7.90	-
1/31/2006	12:57	41.00	7.91	-

Appendix C-1. Concluded

Date	*Time (CST)*	*Water temp* (F)	*Acidity (pH)*	*NVOC*
2/6/2006	14:20	36.00	7.79	-
2/14/2006	14:23	39.00	8.10	-
2/22/2006	14:00	36.00	7.69	-
2/27/2006	12:46	40.00	8.11	-
3/6/2006	14:04	40.00	8.04	-
3/14/2006	15:16	45.00	7.71	-
3/20/2006	12:45	42.00	7.78	-
3/27/2006	13:16	43.00	7.89	-
4/3/2006	14:11	47.00	7.64	-
4/10/2006	13:23	53.00	7.50	-
4/24/2006	13:20	60.00	7.98	-

Appendix C-2. Temperature, Acidity, Non-volatile Organic Carbon (NVOC), Friends Creek (Station 102), 5/1/2003–4/30/2006

Date	*Time (CST)*	*Water temp* (F)	*Acidity (pH)*	*NVOC*
5/5/2003	14:25	59	-	-
5/6/2003	11:00	59	-	2.1
5/14/2003	10:20	59	-	-
5/20/2003	12:31	64	8.11	2
5/27/2003	12:50	62	-	-
6/3/2003	12:35	55	-	-
6/10/2003	11:00	69	8.18	2.2
6/11/2003	23:20	68	-	-
6/12/2003	8:25	64	-	-
6/17/2003	13:30	66	-	-
6/24/2003	11:54	75	8.2	-
7/1/2003	12:35	75	-	-
7/8/2003	12:03	84	8.19	-
7/9/2003	21:15	75	-	-
7/10/2003	7:28	70	-	-
7/10/2003	13:50	72	-	-
7/15/2003	9:43	73	-	-
7/22/2003	9:34	74	8.28	-
7/29/2003	9:40	73	8.22	-
8/5/2003	9:16	72	-	-
8/12/2003	9:18	71	7.86	-
8/19/2003	10:02	75	-	-
8/26/2003	9:46	79	7.94	-
9/1/2003	5:50	66	-	-
9/1/2003	14:22	66	-	-
9/2/2003	9:20	66	-	-
9/10/2003	12:17	71	8.37	-
9/16/2003	10:41	68	-	-
9/23/2003	12:40	66	8.15	-
9/30/2003	11:03	55	-	-
10/7/2003	12:58	65	8.06	-
10/14/2003	9:26	57	-	-
10/21/2003	12:46	62	7.38	-
10/28/2003	10:03	50	-	-
11/5/2003	13:15	53	7.06	-
11/10/2003	10:00	42	7.26	-
11/18/2003	13:25	57	7.59	-
12/2/2003	10:42	42	8.1	-
12/17/2003	12:45	-	8.277	-
12/30/2003	13:00	-	7.85	-

Appendix C-2. Continued

Date	*Time (CST)*	*Water temp* (F)	*Acidity (pH)*	*NVOC*
1/13/2004	12:10	-	8.28	-
2/24/2004	12:45	42	7.81	-
3/9/2004	13:00	47	7.90	-
3/23/2004	12:50	50	8.35	-
4/7/2004	15:24	62	7.98	-
5/18/2004	11:36	67	7.91	-
5/25/2004	10:44	70	7.56	-
6/14/2004	10:08	68	-	-
6/21/2004	9:10	64	-	-
6/28/2004	10:05	67	-	-
7/13/2004	9:52	77	8.19	-
7/20/2004	9:22	72	8.33	-
7/27/2004	11:09	69	8.69	-
8/4/2004	10:15	77	8.05	-
8/17/2004	9:00	20	7.91	-
8/24/2004	10:45	22	7.69	-
8/26/2004	9:00	23	7.44	-
8/31/2004	10:25	23	8.00	-
9/7/2004	10:05	21	8.38	-
9/14/2004	11:45	22	8.28	-
9/22/2004	9:36	20	8.26	-
9/28/2004	9:51	16	8.45	-
10/5/2004	10:02	12	8.90	-
10/12/2004	9:14	13	8.04	-
10/20/2004	10:07	14	7.33	-
10/26/2004	15:50	16	7.86	-
11/3/2004	12:59	14	7.54	-
11/9/2004	10:33	12	8.6	-
11/16/2004	11:12	52	7.58	-
11/23/2004	12:02	52	8.04	-
12/1/2004	12:30	45	-	-
12/7/2004	12:10	49	7.68	-
12/15/2004	10:57	40	7.54	-
12/21/2004	10:34	37	8.66	-
12/28/2004	10:38	35	8.48	-
1/4/2005	11:00	44	7.78	-
1/11/2005	11:16	43	7.58	-
1/12/2005	10:08	43	7.44	-
1/12/2005	12:15	43	7.37	-
1/19/2005	11:31	37	8.00	-
1/25/2005	11:52	40	7.73	-

Appendix C-2. Continued

Date	*Time (CST)*	*Water temp* (F)	*Acidity (pH)*	*NVOC*
2/2/2005	10:51	35	7.90	-
2/8/2005	10:24	41	7.39	-
2/16/2005	12:09	42	7.68	-
2/22/2005	10:38	40	7.75	-
3/2/2005	11:43	37	8.01	-
3/8/2005	10:56	41	8.67	-
3/15/2005	10:22	38	8.35	-
3/22/2005	10:55	42	8.15	-
3/29/2005	10:30	52	8.09	-
4/5/2005	9:39	55	8.05	-
4/12/2005	9:40	58	8.09	-
4/20/2005	9:35	65	8.11	-
4/26/2005	9:31	53	8.09	-
5/3/2005	9:35	47	8.08	-
5/11/2005	9:58	72	8.13	-
5/18/2005	9:54	65	8.04	-
5/25/2005	10:34	65	8.12	-
6/1/2005	9:05	69	8.06	-
6/8/2005	9:35	76	8.13	-
6/15/2005	11:08	72	8.05	-
6/22/2005	10:02	77	7.78	-
6/29/2005	8:43	78	8.1	-
7/5/2005	10:00	75	7.98	-
7/12/2005	9:15	70	7.73	-
7/19/2005	10:00	79	7.73	-
7/27/2005	9:32	74	7.63	-
8/9/2005	10:25	79	7.78	-
8/20/2005	13:08	79	7.92	-
8/23/2005	10:21	71	7.58	-
8/30/2005	9:55	71	7.62	-
9/6/2005	13:11	69	8.07	-
9/12/2005	9:18	69	8.02	-
9/20/2005	9:59	68	8.15	-
9/26/2005	8:51	65	7.9	-
10/3/2005	10:09	67	8.03	-
10/11/2005	9:26	57	8.02	-
10/17/2005	8:54	54	8.03	-
10/24/2005	9:45	49	7.97	-
10/31/2005	10:36	52	7.97	-
11/7/2005	11:04	53	7.72	-

Appendix C-2. Concluded

Date	*Time (CST)*	*Water temp* (F)	*Acidity (pH)*	*NVOC*
11/14/2005	10:45	46	7.82	-
11/21/2005	14:29	44	7.96	-
11/28/2005	10:53	50	7.88	-
12/5/2005	10:42	31	8.32	-
12/12/2005	12:57	31	7.91	-
12/20/2005	12:15	32	7.97	-
12/27/2005	10:35	-	8.08	-
1/3/2006	14:09	45	8.04	-
1/9/2006	11:07	40	8.16	-
1/17/2006	10:55	40	8.05	-
1/23/2006	10:21	37	7.71	-
1/31/2006	10:27	42	8.00	-
2/6/2006	10:30	33	7.85	-
2/14/2006	11:59	36	8.13	-
2/22/2006	10:26	36	8.07	-
2/27/2006	10:16	38	7.98	-
3/6/2006	10:26	39	7.95	-
3/14/2006	13:48	44	7.67	-
3/20/2006	10:09	41	7.61	-
3/27/2006	10:31	43	7.90	-
4/3/2006	10:00	48	7.86	-
4/6/2006	14:25	51	-	-
4/10/2006	10:29	50	7.83	-
4/19/2006	10:08	59	7.52	-
4/19/2006	12:13	59	7.53	-
4/24/2006	9:55	57	7.97	-

Appendix C-3. Temperature, Acidity, Non-volatile Organic Carbon (NVOC), Sangamon River at Monticello (Station 111), 5/1/2003–4/30/2006

Date	*Time (CST)*	*Water temp* (F)	*Acidity (pH)*	*NVOC*
5/5/2003	12:13	59	-	-
5/6/2003	10:17	63	-	3.3
5/9/2003	6:34	64	-	-
5/13/2003	14:40	61	-	-
5/14/2003	9:37	62	-	-
5/20/2003	9:59	63	7.9	2.8
5/27/2003	12:06	65	-	-
6/3/2003	11:42	59	-	-
6/10/2003	10:15	69	8.15	2.2
6/11/2003	23:58	68	-	-
6/24/2003	11:11	77	8.08	-
7/1/2003	11:45	78	-	-
7/8/2003	11:19	81	7.73	-
7/9/2003	20:23	77	-	-
7/10/2003	8:02	73	-	-
7/10/2003	14:27	73	-	-
7/11/2003	6:56	73	-	-
7/15/2003	9:10	73	-	-
7/22/2003	8:58	74	7.97	-
7/29/2003	14:03	76	8.13	-
8/5/2003	8:37	73	-	-
8/12/2003	13:15	75	8.21	-
8/19/2003	9:11	75	-	-
8/26/2003	9:07	77	8.23	-
9/1/2003	5:15	68	-	-
9/1/2003	14:45	66	-	-
9/2/2003	10:57	66	-	-
9/10/2003	12:55	71	8.25	-
9/16/2003	10:00	68	-	-
9/23/2003	13:23	69	7.92	-
9/30/2003	10:17	55	-	-
10/7/2003	8:28	57	8.14	-
10/14/2003	8:51	57	-	-
10/21/2003	13:15	59	7.7	-
10/28/2003	9:25	50	-	-
11/5/2003	10:07	56	7.57	-
11/10/2003	9:30	43	7.76	-
11/18/2003	9:53	55	7.87	-
12/2/2003	10:16	42	7.87	-
12/17/2003	9:36	-	8.199	-
12/30/2003	8:50	-	7.98	-
1/13/2004	8:50	-	8.07	-

Appendix C-3. Continued

Date	*Time (CST)*	*Water temp* (F)	*Acidity (pH)*	*NVOC*
2/24/2004	10:10	39	7.11	-
3/9/2004	13:30	45	7.47	-
3/23/2004	10:15	48	8.05	-
5/18/2004	10:55	70	7.90	-
5/25/2004	10:12	67	7.89	-
6/14/2004	9:30	76	-	-
6/15/2004	8:52	75	-	-
6/16/2004	13:50	73	-	-
6/21/2004	8:45	62	-	-
6/21/2004	9:00	62	-	-
6/28/2004	10:25	68	-	-
7/13/2004	9:09	78	8.06	-
7/20/2004	8:48	74	8.45	-
7/27/2004	9:25	69	8.19	-
8/4/2004	8:38	77	7.91	-
8/11/2004	9:32	20	-	-
8/17/2004	10:32	-	7.99	-
8/24/2004	11:40	24	8.16	-
8/26/2004	8:30	22	8.00	-
8/31/2004	9:55	22	8.12	-
9/7/2004	9:26	22	8.47	-
9/14/2004	9:11	23	8.39	-
9/22/2004	8:58	20	8.23	-
9/28/2004	9:15	17	8.14	-
10/5/2004	9:28	13	8.31	-
10/12/2004	8:42	13	7.98	-
10/20/2004	9:38	13	7.97	-
10/27/2004	11:55	15	7.72	-
11/3/2004	12:10	14	7.41	-
11/9/2004	10:03	11	8.16	-
11/16/2004	10:30	48	7.38	-
11/23/2004	10:22	51	7.91	-
12/1/2004	10:23	42	8.15	-
12/7/2004	11:30	49	7.49	-
12/15/2004	10:12	36	7.66	-
12/21/2004	9:47	33	8.49	-
12/28/2004	9:55	32	8.69	-
1/4/2005	10:12	42	8.32	-
1/11/2005	10:41	40	7.80	-
1/12/2005	9:37	45	7.66	-
1/12/2005	16:10	45	7.62	-
1/19/2005	10:26	33	6.97	-

Appendix C-3. Continued

Date	*Time (CST)*	*Water temp* (F)	*Acidity (pH)*	*NVOC*
1/25/2005	11:06	35	7.28	-
2/2/2005	10:16	33	7.78	-
2/8/2005	9:37	40	7.96	-
2/16/2005	11:17	41	7.77	-
2/22/2005	9:59	40	7.83	-
3/2/2005	9:18	35	7.75	-
3/8/2005	9:58	41	8.08	-
3/15/2005	9:40	38	8.12	-
3/22/2005	10:03	44	8.42	-
3/29/2005	9:49	48	8.21	-
4/5/2005	8:55	56	7.99	-
4/12/2005	9:07	61	8.03	-
4/20/2005	8:56	66	8.06	-
4/26/2005	8:51	55	8.03	-
5/3/2005	8:50	49	8.05	-
5/11/2005	9:21	70	8.03	-
5/18/2005	9:20	65	7.97	-
5/25/2005	9:03	64	8.03	-
6/1/2005	8:30	69	8.07	-
6/8/2005	9:08	76	8.12	-
6/15/2005	12:05	74	8.08	-
6/22/2005	13:05	77	8.21	-
6/29/2005	8:15	81	8.24	-
7/5/2005	9:29	77	8.12	-
7/12/2005	8:37	74	8.46	-
7/19/2005	9:26	80	8.13	-
7/27/2005	8:52	78	7.8	-
8/2/2005	9:15	80	7.83	-
8/9/2005	9:23	79	8.57	-
8/23/2005	9:28	79	7.74	-
8/30/2005	13:41	74	7.65	-
9/6/2005	13:55	78	8.06	-
9/12/2005	12:00	78	7.89	-
9/20/2005	9:00	71	7.88	-
9/26/2005	11:56	71	7.88	-
10/3/2005	13:20	70	7.71	-
10/11/2005	12:18	59	7.76	-
10/17/2005	11:40	61	7.95	-
10/24/2005	8:39	49	7.74	-
10/31/2005	9:51	55	8.07	-
11/7/2005	10:08	53	7.53	-
11/14/2005	10:05	46	7.74	-

Appendix C-3. Concluded

Date	*Time (CST)*	*Water temp* (F)	*Acidity (pH)*	*NVOC*
11/21/2005	13:45	42	7.95	-
11/28/2005	10:16	47	7.94	-
1/4/2006	10:52	42	8.06	-
1/9/2006	10:18	39	8.05	-
1/17/2006	10:05	36	8.13	-
1/23/2006	9:40	37	8.07	-
1/31/2006	9:27	41	7.95	-
2/6/2006	9:31	35	8.04	-
2/14/2006	11:07	35	8.26	-
2/22/2006	9:36	34	7.99	-
2/27/2006	9:17	38	7.96	-
3/6/2006	9:36	38	8.11	-
3/14/2006	13:03	47	8.06	-
3/20/2006	9:26	43	8.12	-
3/27/2006	9:48	43	7.95	-
4/3/2006	9:13	50	8.02	-
4/5/2006	9:21	50	7.90	-
4/7/2006	12:52	55	7.61	-
4/10/2006	9:40	51	7.77	-
4/19/2006	9:15	60	7.80	-
4/20/2006	14:15	60	7.64	-
4/24/2006	9:05	60	8.08	-

Appendix D. Mean, Minimum, and Maximum Nitrate Concentrations in mg/L, Project Years 1-13 (May 1993–April 2006)

	Project Year 1			*Project Year 2*			*Project Year 3*		
Station no.	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*
101	7.19	0.74	13.50	6.09	0.02	11.57	5.70	0.02	13.89
102	7.40	0.22	11.40	6.50	0.02	12.54	6.55	0.57	13.47
103	8.25	5.24	14.10	7.55	0.02	10.97	5.62	0.02	16.06
104	8.61	3.84	13.69	7.75	0.02	11.75	6.82	0.02	16.26
124	-	-	-	-	-	-	-	-	-
105	6.26	0.02	11.90	7.36	0.02	11.36	5.64	0.02	11.45
106	8.31	2.81	15.28	7.04	0.02	13.04	6.98	0.02	15.13
111	6.37	2.69	11.27	4.63	0.02	9.54	3.81	0.02	9.43
112	7.16	1.33	13.90	5.95	0.02	11.19	5.95	0.02	12.22

	Project Year 4			*Project Year 5*			*Project Year 6*		
Station no.	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*
101	6.15	0.02	13.47	6.32	0.04	14.41	7.59	0.09	14.53
102	7.85	0.11	14.58	7.80	0.04	14.78	7.32	0.09	15.37
103	8.58	0.02	14.74	7.67	0.08	14.66	8.09	0.09	16.14
104	9.08	0.02	15.99	8.45	0.07	16.36	7.31	0.09	16.96
124	-	-	-	-	-	-	-	-	-
105	6.43	0.08	14.14	6.69	0.22	15.05	7.33	0.09	15.59
106	7.47	0.02	16.50	7.93	0.04	16.31	9.05	0.09	15.67
111	6.46	0.02	13.21	6.49	0.04	14.01	6.33	0.09	14.54
112	6.60	0.02	13.94	6.82	0.04	15.21	7.71	0.13	16.32

	Project Year 7			*Project Year 8*			*Project Year 9*		
Station no.	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*
101	3.81	0.11	13.30	7.20	0.06	12.52	6.94	0.06	13.06
102	6.53	0.20	16.82	8.78	0.21	13.85	9.07	0.49	15.84
103	7.65	0.11	17.97	*	0.25	15.54	-	-	-
104	6.46	0.11	17.51	7.87	0.06	14.94	9.79	0.06	16.17
124	-	-	-	-	-	-	10.04	0.06	16.08
105	5.79	0.11	14.96	7.71	0.41	16.91	8.49	0.06	16.81
106	5.89	0.11	18.80	7.67	0.06	19.54	9.18	0.06	18.07
111	3.98	0.11	14.50	7.01	0.06	15.37	8.24	0.06	16.00
112	6.45	0.11	15.47	*	2.18	16.86	-	-	-

Appendix D. Concluded

	Project Year 10			*Project Year 11*			*Project Year 12*		
Station no.	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*	*Mean*	*Min*	*Max*
101	3.51	0.06	13.17	5.33	0.07	13.44	6.77	0.12	16.07
102	6.56	0.06	15.64	6.93	0.07	13.74	7.49	0.47	13.84
103	-	-	-	-	-	-	-	-	-
104	*	0.56	15.86	-	-	-	-	-	-
124	11.89	0.85	16.03	-	-	-	-	-	-
105	6.34	0.16	15.87	-	-	-	-	-	-
106	6.62	0.06	18.25						
111	5.44	0.06	14.88	6.70	0.66	13.68	7.01	0.08	15.22
112	-	-	-	-	-	-	-	-	-

	Project Year 13		
Station no.	*Mean*	*Min*	*Max*
101	6.24	0.77	12.74
102	6.13	0.19	11.54
103			
104			
124			
105			
106			
111	6.88	0.07	13.72
112			

Appendix E. Annual Average Streamflow, Flow-Weighted Nitrate-N Concentration, and Nitrate-N Loads (May 1993–April 2006)

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	6.79	26
	1994–1995	16	8.84	9
	1995–1996	21	8.80	13
	1996–1997	40	9.31	25
	1997–1998	30	9.16	18
	1998–1999	72	10.61	50
	1999–2000	19	8.35	11
	2000–2001	44	8.59	25
	2001–2002	50	10.08	33
	2002–2003	27	6.80	12
	2003–2004	58	9.29	19
	2004–2005	16	7.98	36
	2005–2006	21	8.34	14
102	1993–1994	164	7.69	35
	1994–1995	51	8.74	12
	1995–1996	71	10.03	20
	1996–1997	94	10.75	28
	1997–1998	88	10.57	25
	1998–1999	105	12.13	35
	1999–2000	53	11.31	16
	2000–2001	103	10.38	29
	2001- 2002	84	11.20	25
	2002–2003	72	10.88	22
	2003–2004	86	9.00	21
	2004–2005	186	8.06	41
	2005–2006	44	7.66	9

Appendix E. Concluded

	Monitoring year (May–April)	*Average streamflow (cfs)*	*Flow-weighted nitrate-N concentration (mg/L)*	*Nitrate-N load (lb/acre/yr)*
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
	2003–2004	524	7.77	23
	2004–2005	795	8.11	36
	2005–2006	207	8.83	10

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