

Prepared in cooperation with the Arkansas Department of Environmental Quality and the U.S. Environmental Protection Agency

Determination of Organic and Inorganic Percentages and Mass of Suspended Material at Four Sites in the Illinois River in Northwestern Arkansas and Northeastern Oklahoma, 2005–07

Scientific Investigations Report 2008–5136



Cover photographs: Illinois River downstream of bridge at County Road 631, May 2008 (photograph by Brian Haggard, University of Arkansas). Inset: Scanning electron microscope image of a diatom from a sample collected on the Illinois River at Savoy, Arkansas, August 2006.

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By Joel M. Galloway

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Conversion Factors and Datums

Multiply	By	To obtain
	Length	
inch (in.)	25.40	millimeter (mm)
inch (in.)	2.54×10^7	nanometer (nm)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi ²)	259.0	hectare (ha)
square mile (mi ²)	2.590	square kilometer (km ²)
	Flow rate	
cubic foot per second (ft ³ /s)	0.02832	cubic meter per second (m ³ /s)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows: °F = (1.8 x °C) + 32

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows: °C = (°F-32)/1.8

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD of 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Altitude, as used in this report, refers to distance above the vertical datum.

Determination of Organic and Inorganic Percentages and Mass of Suspended Material at Four Sites in the Illinois River in Northwestern Arkansas and Northeastern Oklahoma, 2005-07

By Joel M. Galloway

Abstract

The Illinois River located in northwestern Arkansas and northeastern Oklahoma is influenced by point and nonpoint sources of nutrient enrichment. This has led to increased algal growth within the stream, reducing water clarity. Also, sediment runoff from fields, pastures, construction sites, and other disturbed areas, in addition to frequent streambank failure, has increased sedimentation within the stream and decreased water clarity. A study was conducted by the U.S. Geological Survey in cooperation with the Arkansas Department of Environmental Quality and the U.S. Environmental Protection Agency to characterize the increased turbidity by determining the organic and inorganic composition and mass of suspended material in the Illinois River from August 2005 through July 2007. Water-quality samples were collected at four sites on the Illinois River (listed in downstream order): near Viney Grove, Arkansas; at Savoy, Arkansas; south of Siloam Springs, Arkansas; and near Tahlequah, Oklahoma.

In general, turbidity, total suspended solids, suspended-sediment concentration, organic material concentration (measured as volatile suspended solids and ash-free dry mass), and chlorophyll *a* concentration were the greatest in samples collected from the Illinois River at Savoy and the least in samples from the most upstream Illinois River site (near Viney Grove) and the most downstream site (near Tahlequah) from August 2005 through July 2007. For example, the suspended-sediment concentration at the Illinois River at Savoy had a median of 15 milligrams per liter, and the total suspended solids had a median of 12 milligrams per liter. The Illinois River near Tahlequah had the least suspended-sediment concentration with a median of 10 milligrams per liter and the least total suspended solids with a median of 6 milligrams per liter.

The turbidity, total suspended solids, suspended-sediment concentration, organic material concentration, and chlorophyll *a* concentration in samples collected during high-flow events were greater than in samples collected during base-flow conditions at the Illinois River at Savoy, south of Siloam Springs,

and near Tahlequah. For example, the median turbidity for the Illinois River at Savoy was 3 nephelometric turbidity ratio units during base-flow conditions and 52 nephelometric turbidity ratio units during high-flow conditions.

Organic material in the Illinois River generally composed between 13 and 47 percent of the total suspended material in samples collected from August 2005 through July 2007. Therefore, most of the suspended material in samples collected from the sites was inorganic material. Overall, the highest percentage of organic material was found at the Illinois River near Viney Grove and at the Illinois River near Tahlequah. The Illinois River south of Siloam Springs had the lowest percentage of organic material among the four sites. In general, the percentage of organic material was greater in samples collected during base-flow conditions compared to samples collected during high-flow conditions.

The mean seasonal concentrations and percentages of organic material were the least in the fall (September through November) in samples collected from August 2005 to July 2007 from the four Illinois River sites, while the greatest concentrations and percentages of organic material occurred at various times of the year depending on the site. The greatest concentrations of organic material occurred in the summer (June through August) in samples from sites on the Illinois River near Viney Grove, at Savoy and south of Siloam Springs, but in the spring (March through May) in samples from the Illinois River near Tahlequah. The greatest percentages of organic material (least percentages of inorganic material) occurred in the summer in samples from the site near Viney Grove, the winter and summer at the site at Savoy, in the spring, fall, and winter (December through February) at the site south of Siloam Springs, and in the winter at the site near Tahlequah.

Although a wide range of variability is evident in the data, several observations can be made about the suspended-material data collected from the four sites on the Illinois River from August 2005 through July 2007. Samples from the Illinois River near Savoy had the greatest turbidity, suspended-sediment concentration, total suspended solids, chlorophyll

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a, and organic material concentrations among the four sites, indicating that it may be the most affected by activities in the basin upstream from the site, causing increased suspended inorganic and organic material. Downstream from the Illinois River at Savoy, the data indicate that although a similar concentration of suspended material is being transported downstream, less organic material is being entrained, transported, or being added to the stream near the site south of Siloam Springs compared to the site upstream at Savoy. Even farther downstream at the Illinois River near Tahlequah, the data indicate that less of the suspended material, which was observed in samples from the two upstream sites, is being transported past the site near Tahlequah and the concentration of inorganic particles is less because of deposition upstream from the site, or the channel morphology may be more conducive for algal growth, increasing the effects of sources of organic material on the total mass of suspended material.

Introduction

The Illinois River located in northwestern Arkansas and northeastern Oklahoma is influenced by point and nonpoint sources of nutrient enrichment. This has led to increased algal growth within the stream, reducing water clarity. Also, sediment runoff from fields, pastures, construction sites, and other disturbed areas, in addition to frequent streambank failure, has increased sedimentation within the stream and decreased water clarity (Arkansas Department of Environmental Quality, 2008).

Water clarity in streams is often determined by measurements of turbidity. Turbidity is an expression of the optical properties of a sample that causes light rays to be scattered and absorbed (Gray and Glysson, 2003). Turbidity of water is caused by the presence of dissolved and suspended inorganic matter such as clay and silt; dissolved and suspended organic matter such as plankton, microscopic organisms, and small terrestrial organic material; organic acids; and water color. A study was conducted by the U.S. Geological Survey (USGS), in cooperation with the Arkansas Department of Environmental Quality (ADEQ) and the U.S. Environmental Protection Agency (USEPA), to determine the organic and inorganic percentages and mass of suspended material in the Illinois River from August 2005 through July 2007 to characterize the main causes of turbidity. Such data will provide water-resource managers with information that will be beneficial in the evaluation and refinement of current (2008) turbidity standards; in the development of nutrient criteria for rivers; and in the development of a total maximum daily load (TMDL), watershed plan, or any other instrument the States deem appropriate to protect the resource.

Study Area Description

The Illinois River Basin has a drainage area of 1,641 mi² at its confluence with the Arkansas River and is about equally

divided between northwestern Arkansas and northeastern Oklahoma (fig. 1). The basin is dominated by about equal proportions of agricultural (pasture and cropland) and forest land uses and is interspersed with minor amounts of commercial and residential land uses. Livestock production on pasture is the primary form of agriculture in the basin; about 48 percent of agricultural land use is pasture for cattle and horses. Numerous large-scale poultry and swine production facilities are in the basin and poultry and swine manures are used to fertilize pastures (Sims and Wolf, 1994). The upper basin is also one of the fastest-growing metropolitan statistical areas in the United States (Fayetteville-Springdale-Rogers, Arkansas) (U.S. Census Bureau, 2007).

Water-quality data collected at four sites in the Illinois River Basin are described in this report: the Illinois River near Viney Grove, Arkansas (USGS station number 07194760); Illinois River at Savoy, Arkansas (USGS station number 07194800); Illinois River south of Siloam Springs (USGS station number 07195430); and Illinois River near Tahlequah, Oklahoma (USGS station number 07196500) (fig. 1). The Illinois River near Viney Grove is the most upstream site with a drainage area of 80.7 mi². The drainage area contributing to the site does not contain any large point sources and the land use is about equally proportioned with agricultural (56 percent, mainly pasture) and forested (42 percent) land use. The Illinois River at Savoy has a drainage area of 167 mi² and is downstream from several wastewater-treatment plant discharges in its drainage area. Land use is mainly composed of agricultural land (approximately 60 percent, mainly pasture), and forest (approximately 30 percent). The Illinois River south of Siloam Springs, located near the Arkansas and Oklahoma State line, has a drainage area of 575 mi². The land use is also mainly pasture and forest and the site receives discharge from numerous wastewater-treatment plants in the drainage area. The Illinois River near Tahlequah, Oklahoma, is the most downstream site and has a drainage area of 959 mi², which is also mostly pasture (48 percent) and forested (37 percent) land uses.

Purpose and Scope

The primary purpose of this report is to describe the spatial and temporal variability of the organic and inorganic percentages and mass of suspended material at four sites in the Illinois River from August 2005 through July 2007. A secondary purpose of this report is to describe differences between methods used in the determination of the organic and inorganic percentages of suspended material. Water-quality samples were collected every 2 months and during four high-flow events at three sites on the Illinois River: at Savoy, Arkansas; south of Siloam Springs, Arkansas, near the Arkansas and Oklahoma State line; and near Tahlequah, Oklahoma (fig. 1). Water-quality samples also were collected every 2 months for the 2-year period at the Illinois River near

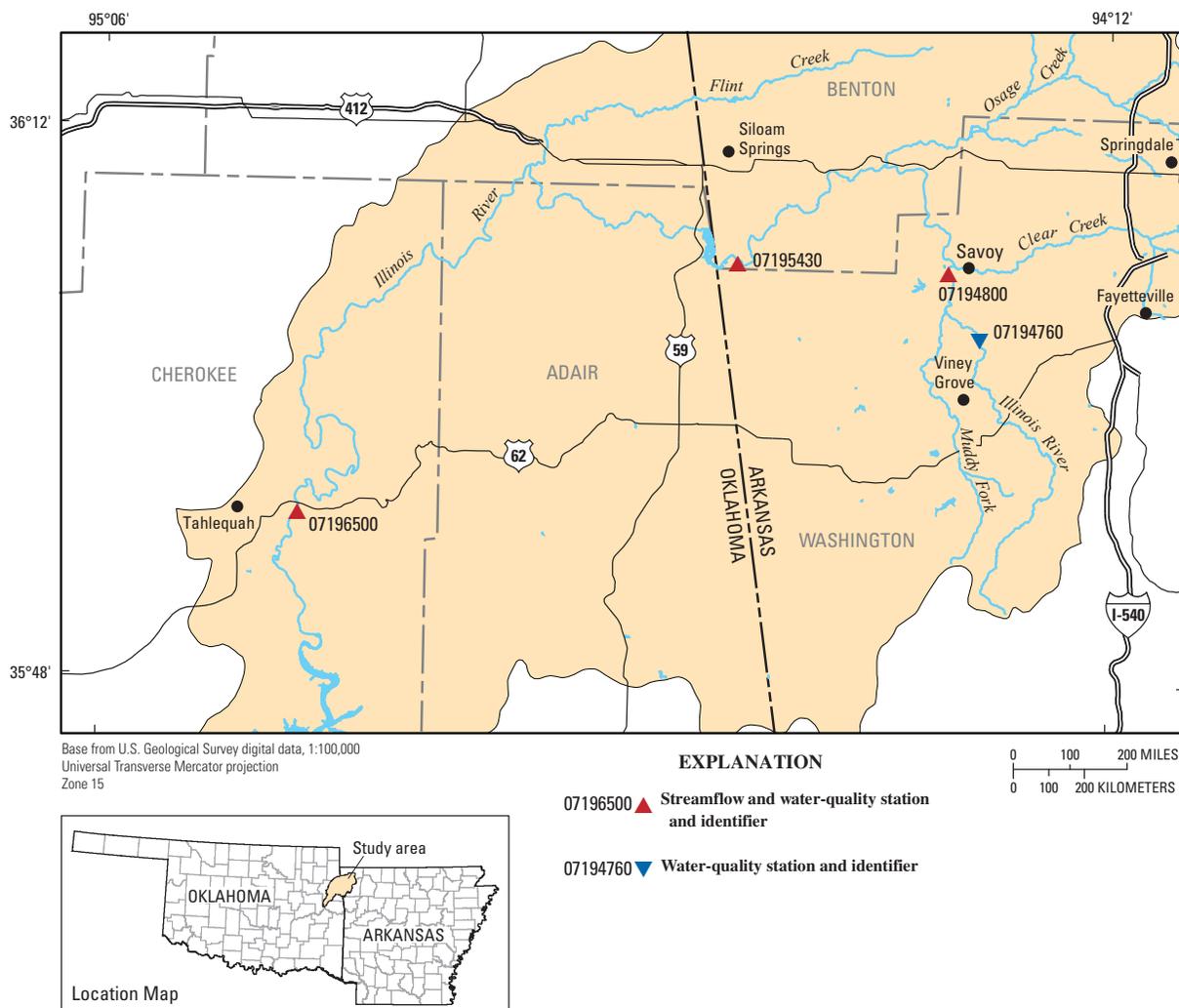


Figure 1. The Illinois River Basin study area.

Viney Grove, Arkansas, located upstream from all wastewater-treatment plant discharges in the Illinois River Basin.

Methods

Streamflow and water-quality data were collected at four sites on the Illinois River from August 2005 through July 2007. The following sections describe methods used for measurement of streamflow and the collection and analysis of water-quality samples and other water-quality data.

Data Collection

Stream stage was measured continuously at the Illinois River at Savoy, Arkansas (USGS station number 07194800), south of Siloam Springs, Arkansas (USGS station number 07195430) and near Tahlequah, Oklahoma (USGS station number 07196500) (fig. 1). Stage and instantaneous dis-

charge were measured to compute the continuous streamflow from stage-discharge rating curves using methods described in Rantz and others (1982). At the Illinois River near Viney Grove, Arkansas (USGS station number 07194760) only instantaneous discharge was measured when water-quality samples were collected.

Water-quality samples were collected every 2 months and during four high-flow events at three sites on the Illinois River: at Savoy, south of Siloam Springs, and near Tahlequah (fig. 1) from August 2005 through July 2007. Water-quality samples also were collected every 2 months for the 2-year period at the Illinois River near Viney Grove. Samples were collected following equal-width increment methods using depth-integrated samplers and processed using protocols described in U.S. Geological Survey (variously dated). Samples were analyzed for suspended-sediment concentration (SSC), turbidity, chlorophyll *a*, ash-free dry mass, total suspended solids (TSS), and volatile suspended solids (VSS). Samples also were analyzed for nutrients (total ammonia plus organic nitrogen, dissolved nitrite plus nitrate, dissolved ammonia, total nitrogen, dis-

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solved orthophosphorus, and total phosphorus) and total dissolved solids (TDS), although the nutrient and TDS data are not described in this report. All water-quality data are presented in the appendix of the report. One sample collected during high-flow conditions and one sample collected during base-flow conditions also were analyzed for organic and inorganic composition using scanning electron microscopy (SEM). Field measurements, including water temperature, dissolved-oxygen concentration, pH, and specific conductance also were collected with each sample (Appendix) following protocols described in Wilde and Radke (1998).

Laboratory Analysis

Water-quality samples were analyzed for nutrients, TDS, SSC, turbidity, chlorophyll *a*, ash-free dry mass, TSS, and VSS. Nutrients, TDS, turbidity, chlorophyll *a*, and ash-free dry mass analyses were conducted by the USGS National Water Quality Laboratory in Lakewood, Colorado using methods described in Arar and Collins (1997), Fishman (1993), and the American Public Health Association and others (1995). SSC analyses were conducted by the USGS Missouri Water Science Center in Rolla, Missouri, following procedures described in Guy (1969). Analyses for TSS and VSS were conducted by the USGS Arkansas Water Science Center in Little Rock, Arkansas, following procedures in American Public Health Association and others (1995).

One sample collected at high-flow conditions and one sample collected at base-flow conditions at each site also were analyzed for the visual determination of organic and inorganic composition of the suspended material using scanning electron microscopy (SEM). Analysis by SEM was completed by the USGS Microbeam Laboratory in Denver, Colorado. For sample preparation, the samples were shaken vigorously for 2 minutes, and then 20 milliliters of water were filtered through 0.2-micron polycarbonate filters using a Millipore apparatus. Water was withdrawn from the sample bottles in 5-milliliter aliquots from four levels in the bottle (bottom, lower middle, upper middle, and top) to obtain a representative sampling in case of particle settling. The samples then were coated in a carbon evaporator with approximately 40 nanometers of carbon for conductivity. Carbon-coated filters were analyzed using a JEOL 5800LV scanning electron microscope operated at 15 kilovolts using a 0.5-3.0 nanoamp beam current. Energy dispersive x-ray spectroscopy (EDS) data were processed with the OXFORD ISIS standardless analysis software package (Isabelle Brownfield, U.S. Geological Survey, written commun., 2007). The low concentration of organic material in the sample collected during high-flow conditions required a different analysis procedure than was performed on the sample collected at base-flow conditions. The aliquots were filtered through a 0.4-micrometer pore filter using a Millipore apparatus. Afterwards, the filter was coated with gold. Gold-coated filters were analyzed using a JEOL 5800LV SEM operated at 10 kilovolts using a 0.5-3.0 nanoamp beam current. The sam-

ples were mapped at 1,000 times magnification for gold (to get total particulate coverage), carbon (organic fraction), and silicon (inorganic fraction) (Heather A. Lowers and Gregory P. Meeker, U.S. Geological Survey, written commun., 2007). The occurrence of diatoms was determined manually because they were identified as silicon by the SEM and was added to the organic fraction.

Quality Control and Quality Assurance

To maintain proper quality assurance and control (QA/QC) of water-quality data, protocols for instrument calibration (Wilde and Radke, 1998) and equipment cleaning (Wilde and others, 1998) were followed. Associated blank and replicate water-quality samples also were collected periodically by USGS personnel. Thirty-six blank samples and 57 replicate samples were collected at sites that were part of the USGS water-quality monitoring program in Arkansas from August 2005 through July 2007. Results indicated that cleaning procedures were adequate in preventing cross-contamination of samples and that the laboratory results were reproducible. QA/QC sample data were stored in the USGS National Water Information System (NWIS) database (<http://waterdata.usgs.gov/nwis>).

Laboratory QA/QC of water-quality sample analyses also were conducted by the respective laboratories. QA/QC procedures followed by the USGS National Water Quality Laboratory in Lakewood, Colorado, are presented in Maloney (2005). The USGS Arkansas Water Science Center laboratory in Little Rock, Arkansas, followed similar procedures. Analytical balances were used for accurate weighing of samples, reagents, and calibration standards. Prior to each use, balances were checked with Class I weights in the expected-use range that were certified by a National Institute of Standards and Technology (NIST) or a NIST-certified entity. The balances were cleaned and certified once a year by a contract service technician. The calibration, maintenance, and use were documented in a log book. Balances that failed calibration checks were not used until repaired and recertified by a contract service technician. A laboratory blank sample analysis also was conducted for each set of samples that was processed.

Data Analysis

Streamflow recorded at the Illinois River at Savoy, south of Siloam Springs, and near Tahlequah was separated using the Base-Flow Index (BFI) hydrograph separation computer program to identify the base-flow and surface-runoff components of streamflow (Wahl and Wahl, 1995). The BFI program uses the Institute of Hydrology method of base-flow separation, which divides the water year into increments and identifies the minimum flow for each increment. Minimums are compared to adjacent minimums to determine turning points on the base-flow hydrograph. If 90 percent of a given minimum is less than both adjacent minimums, then that minimum

is a turning point. Straight lines are drawn between the turning points to define the base-flow hydrograph (Wahl and Wahl, 1995). The area beneath the hydrograph is the estimate of the volume of base flow for the period. The ratio of the base-flow volume to total-flow volume is the base-flow index.

Water-quality samples collected from the Illinois River sites near Savoy, south of Siloam Springs, and near Tahlequah were separated into those collected under base-flow or high-flow conditions. Base-flow water-quality samples were collected on days when the estimated base flow was greater than or equal to 70 percent of the total daily mean flow. High-flow samples were defined as water-quality samples collected on days when the surface-runoff component was greater than 30 percent of total daily mean flow.

The resulting streamflow and water-quality data were analyzed or summarized using several statistical and graphical techniques. Boxplots were used to compare concentrations of selected water-quality constituents. Concentrations reported as less than a laboratory reporting level were converted to one-half the laboratory reporting level for preparation of boxplots and statistical analyses.

The percentages of organic and inorganic material in water-quality samples were determined using three different methods. The VSS, or the matter that is removed when the dried material from a sample is ignited at 550°C (American Public Health Association and others, 1995), provides an estimate of the mass of the total suspended solids that is organic. The inorganic suspended solids (ISS) were determined by subtracting the VSS from the TSS (referred to as the TSS method in this report). Another method used to determine the organic and inorganic material in each sample used the analyses for ash-free dry mass and for SSC. The ash-free dry mass represents the organic fraction and the SSC represents the total suspended material in the sample. Therefore, the inorganic suspended solids were determined by subtracting the ash-free dry mass from the SSC (referred to as the SSC method in this report). SEM analysis also was used to visually determine the percentages of organic and inorganic material by counting the different particle types from an aliquot of the sample. This analysis was conducted on only two samples from each site (one collected at base-flow conditions and one collected at high-flow conditions) and is referred to as the SEM method.

Hydrologic and Water-Quality Conditions

Streamflow increased substantially from the most upstream site (with continuous streamflow data) on the Illinois River (at Savoy) to the most downstream site (near Tahlequah) from August 2005 through July 2007 (fig. 2). Also, the mean annual streamflow was considerably less from August 2005 through July 2007 compared to the long-term mean annual streamflow recorded at each site. The streamflow for the Illinois River near Viney Grove was collected only when samples

were collected and was not recorded continuously as it was at the other three sites. Measured streamflow for the site near Viney Grove ranged from 4.0 to 199 ft³/s. The daily mean streamflow at the Illinois River at Savoy ranged from 5.3 to 5,690 ft³/s with mean of 105 ft³/s for the period (August 2005 through July 2007). The mean annual streamflow for the entire period of record (July 1979 to October 2007) was 147 ft³/s (U.S. Geological Survey, 2008). The Illinois River south of Siloam Springs had daily mean streamflows ranging from 50.0 to 8,620 ft³/s with a mean daily streamflow of 338 ft³/s for the period. The mean annual streamflow for the Illinois River south of Siloam Springs for the entire period of record (August 1995 through October 2007) was 540 ft³/s. The daily mean streamflow for the Illinois River near Tahlequah ranged from 86.0 to 11,300 ft³/s from August 2005 through July 2007. The mean daily streamflow was 530 ft³/s compared to the annual mean of 930 ft³/s for the entire period of record (October 1935 to October 2007).

In general, turbidity was greatest in samples collected from the Illinois River at Savoy and least in samples from the most upstream Illinois River site (near Viney Grove) and the most downstream site (near Tahlequah) from August 2005 through July 2007 (fig. 3). Samples from the Illinois River at Savoy had a median turbidity of 6 nephelometric turbidity ratio units (NTRU) and a maximum turbidity of 930 NTRU. In comparison, the median and maximum turbidities for samples from the Illinois River near Tahlequah were 5 and 79 NTRU, respectively. Samples from the Illinois River south of Siloam Springs had a median turbidity of 6 NTRU and a maximum turbidity of 180 NTRU. The Illinois River near Viney Grove, that did not have any high-flow event samples collected, had a median turbidity of 5 NTRU, and a maximum turbidity of 13 NTRU.

The turbidity in samples collected during high-flow events was considerably greater than in samples collected during base-flow conditions at the Illinois River sites at Savoy, south of Siloam Springs, and near Tahlequah from August 2005 through July 2007 (fig. 3). The median turbidity for samples from the Illinois River at Savoy was 3 NTRU during base-flow conditions and 52 NTRU during high-flow conditions. Similarly, samples from the Illinois River sites south of Siloam Springs and near Tahlequah had median turbidities of 1 and 3 NTRU, respectively, in samples collected during base-flow conditions, and 17 and 6 NTRU, respectively, in samples collected during high-flow conditions.

TSS and SSC commonly are used to quantify concentrations of suspended solid-phase material in surface water. However, the analytical methods differ and the two may not be equivalent when solid-phase material, especially sand, becomes more concentrated (Gray and others, 2000). SSC analytical methods measure all the sediment and the mass of the entire water-sediment mixture of the original sample; TSS methods only use an aliquot of the original sample for subsequent analysis.

Samples from the Illinois River at Savoy had the greatest TSS and SSC among the four sampling sites in the Illinois

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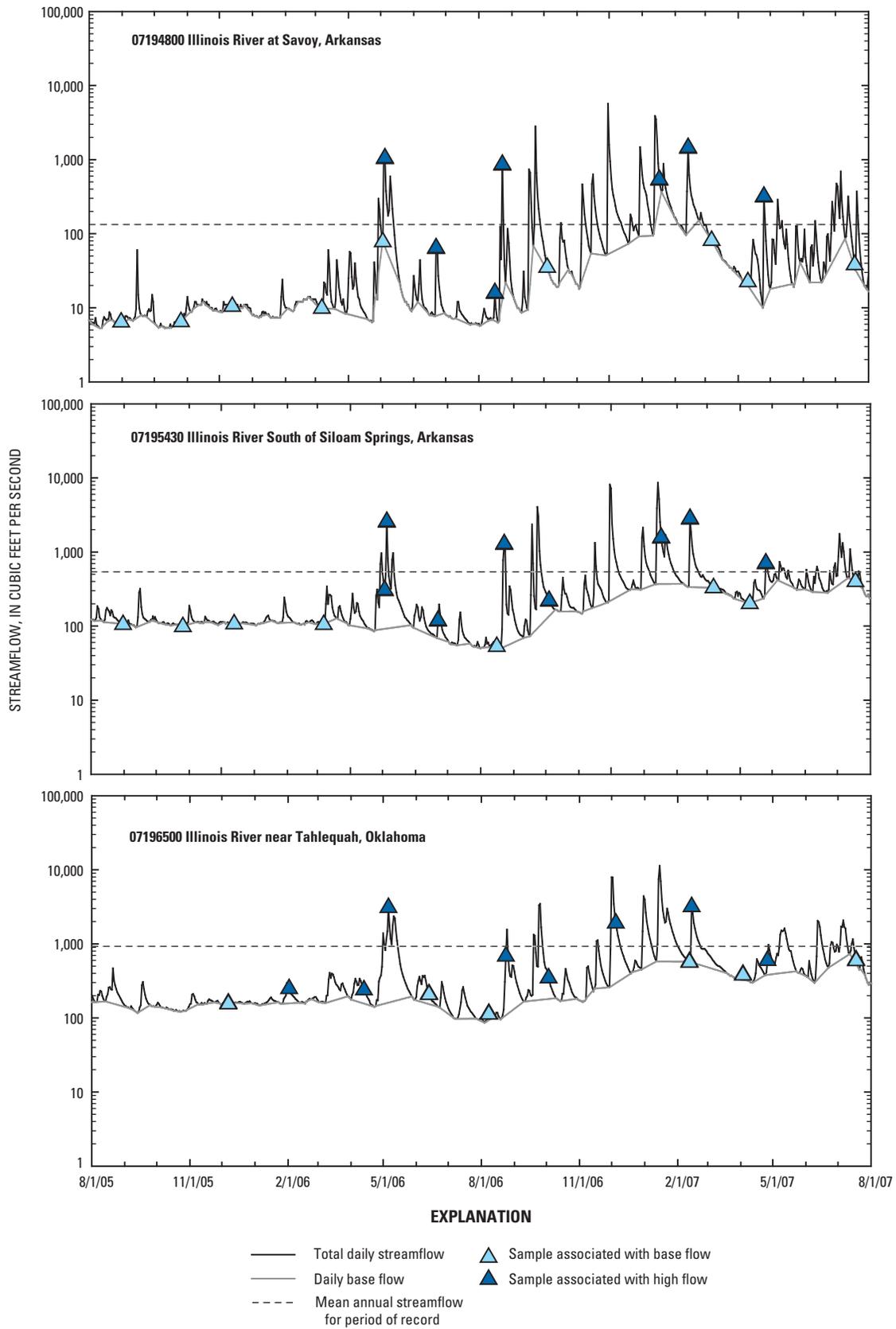


Figure 2. Daily base flow and total daily mean streamflow and water-quality sample times from August 2005 to July 2007 for the Illinois River sites at Savoy, Arkansas; south of Siloam Springs, Arkansas; and near Tahlequah, Oklahoma.

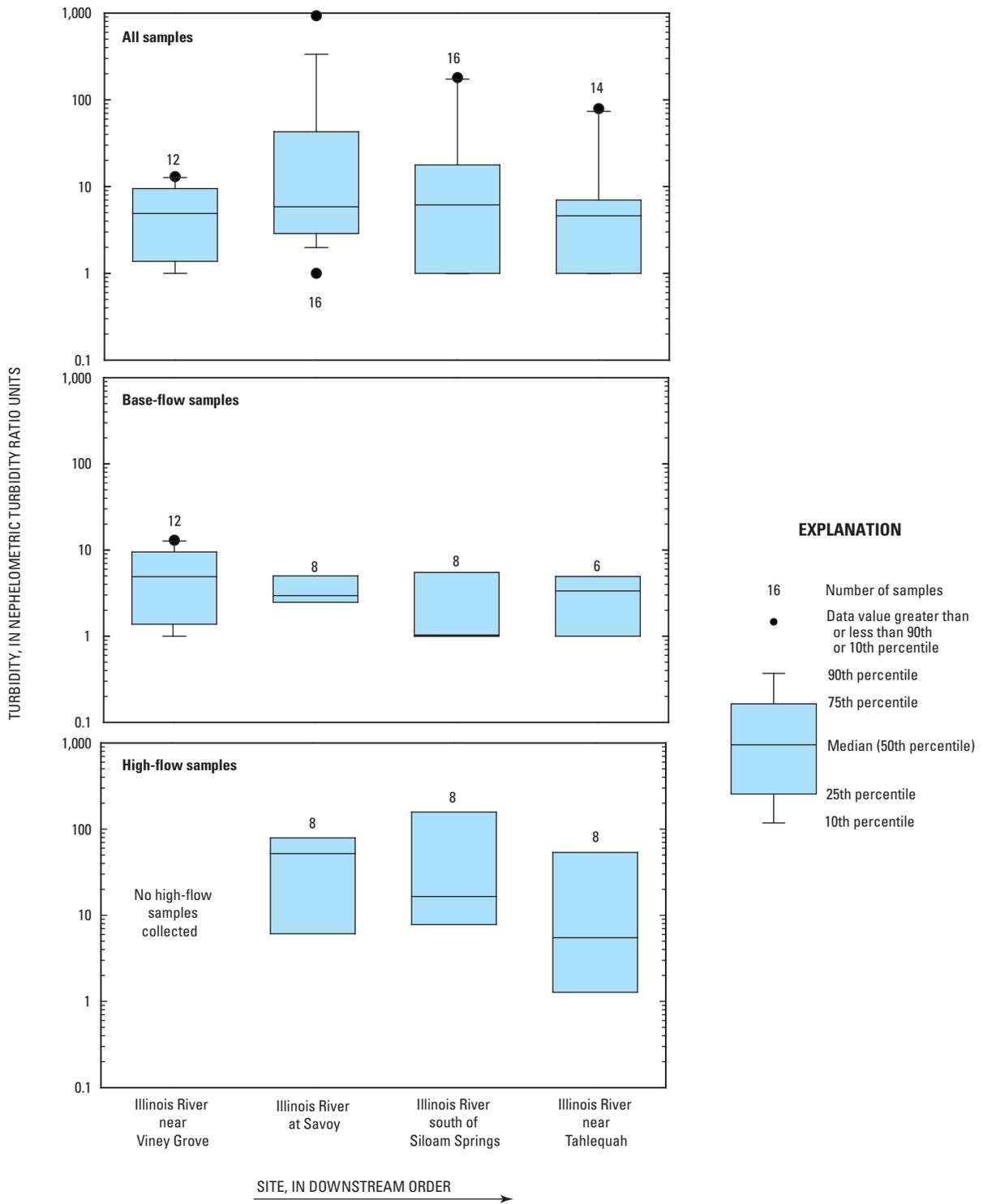


Figure 3. Distribution of turbidity in water samples collected from August 2005 to July 2007 for the Illinois River sites near Viney Grove, Arkansas; at Savoy, Arkansas; south of Siloam Springs, Arkansas; and near Tahlequah, Oklahoma.

River from August 2005 through July 2007 (fig. 4). The TSS in samples from the Illinois River at Savoy ranged from less than 1 to 1,240 mg/L with a median of 12 mg/L and the SSC ranged from 6 to 1,480 milligrams per liter (mg/L) with a median of 15 mg/L. Samples from the Illinois River near Tahlequah had the least TSS, ranging from less than 1 to 124 mg/L with a median of 6 mg/L and the least SSC, ranging from 2 to 140 mg/L with a median of 10 mg/L. Although no high-flow samples were collected at the Illinois River near Viney Grove, samples had similar values of TSS (ranging from 2 to 13 mg/L, with a median of 8 mg/L) and SSC (ranging from 4 to 123 mg/L, with a median of 15 mg/L) as measured at the Illinois River near Tahlequah. Similar to turbidity, TSS and SSC were greatest in samples collected during high-flow conditions compared to samples collected at base-flow conditions.

Organic matter in stream ecosystems can originate from many sources within the stream (autochthonous) and from outside the stream channel (allochthonous). Autochthonous sources of organic matter include primary production by periphyton, macrophytes, and phytoplankton, while allochthonous sources can include terrestrial plant litter and soil particulates (Allen, 1995).

Concentrations of suspended organic material (measured as VSS and ash-free dry mass) measured in samples from the Illinois River at Savoy were greater than in samples from the three other sites in the Illinois River from August 2005 through July 2007 (fig. 5). The VSS and ash-free dry mass in samples from the Illinois River at Savoy had median values of 3.1 and 4.3 mg/L, respectively. The VSS ranged from less than 1.0 to 130.0 mg/L and the ash-free dry mass ranged from less than 2.0 to 143.8 mg/L. Samples from the Illinois River south of Siloam Springs had similar median values of VSS (2.2 mg/L) and ash-free dry mass (3.4 mg/L) but did not have as great a range of values of VSS (less than 1.0 to 30.0 mg/L) and ash-free dry mass (less than 3.2 to 41.4 mg/L) as the site at Savoy. Samples from the Illinois River sites near Viney Grove and near Tahlequah had median VSS values of 2.0 and 1.8 mg/L, respectively, and had median ash-free dry mass values of 3.2 and 1.9 mg/L, respectively.

Organic material concentrations in samples collected during high-flow conditions generally were greater than concentrations in samples collected during base-flow conditions (fig. 5). For example, samples from the Illinois River at Savoy had median VSS and ash-free dry mass concentrations of 1.0 and 2.5 mg/L, respectively, during base-flow conditions, compared to median VSS and ash-free dry mass concentrations of 10.0 and 12.7 mg/L, respectively, during high-flow conditions. The greater concentrations of organic material during high-flow conditions may reflect an increase in allochthonous sources such as plant litter and soil that are washed into the stream channel or scouring of the periphyton (benthic algae) from the streambed as velocities in the stream increased.

Chlorophyll *a* is a photosynthetic pigment found in algae and other green plants. The concentration of chlorophyll *a*, from samples collected in open water, commonly is used as a measure of the density of the algae.

Chlorophyll *a* concentrations were greatest in samples from the Illinois River at Savoy compared to the other three sites in samples collected from August 2005 through July 2007 (fig. 6). Chlorophyll *a* concentrations in samples from the Illinois River at Savoy ranged from 0.7 to 29.1 micrograms per liter ($\mu\text{g/L}$) with a median of 3.2 $\mu\text{g/L}$. In comparison, samples from the Illinois River south of Siloam Springs had the least median concentration (1.6 $\mu\text{g/L}$). Chlorophyll *a* concentrations ranged from 0.3 to 14.1 $\mu\text{g/L}$ in samples from the Illinois River south of Siloam Springs. Samples from the Illinois River near Tahlequah had chlorophyll *a* concentrations ranging from 0.8 to 12.3 $\mu\text{g/L}$ with a median of 2.5 $\mu\text{g/L}$.

Chlorophyll *a* concentrations in samples collected during high-flow conditions generally were greater than concentrations in samples collected during base-flow conditions at most of the sites (fig. 6). The median chlorophyll *a* concentration increased from 1.4 $\mu\text{g/L}$ in samples collected during base-flow conditions to 5.5 $\mu\text{g/L}$ in samples collected during high-flow conditions at the Illinois River at Savoy and from 1.6 $\mu\text{g/L}$ during base-flow conditions to 3.2 $\mu\text{g/L}$ during high-flow conditions in samples from the Illinois River south of Siloam Springs. However, the median concentration in samples from the Illinois River near Tahlequah was slightly less during high-flow conditions (2.5 $\mu\text{g/L}$) than during base-flow conditions (2.7 $\mu\text{g/L}$). The greater concentrations during high-flow conditions at the Illinois River sites at Savoy and south of Siloam Spring may be the result of scouring of the periphyton (benthic algae) from the streambed as velocities in the stream increased. The concentrations in samples from the Illinois River near Tahlequah during high-flow conditions possibly did not increase because of greater dilution effects (greater volume of streamflow than the upstream sites) or because habitat in the stream channel and water chemistry upstream from the site was not as conducive for algal growth as at the other sites. There are other factors that may have had an influence on the measured chlorophyll *a* concentrations, such as the time of the year the sample was collected and whether the sample was collected on the rise, peak, or fall of the streamflow hydrograph during high-flow conditions.

Comparison of Suspended Material Method Results

To determine the organic and inorganic composition of the suspended material at the four sites in the Illinois River, three different methods were used (TSS method, SSC method, and SEM method) for comparison. The mass of the suspended organic material was determined by analysis of ash-free dry mass and an analysis of VSS from the samples collected at the four sites. Likewise, the mass of the total suspended material was determined by two different analyses, including SSC and TSS analyses from the samples collected at the four sites.

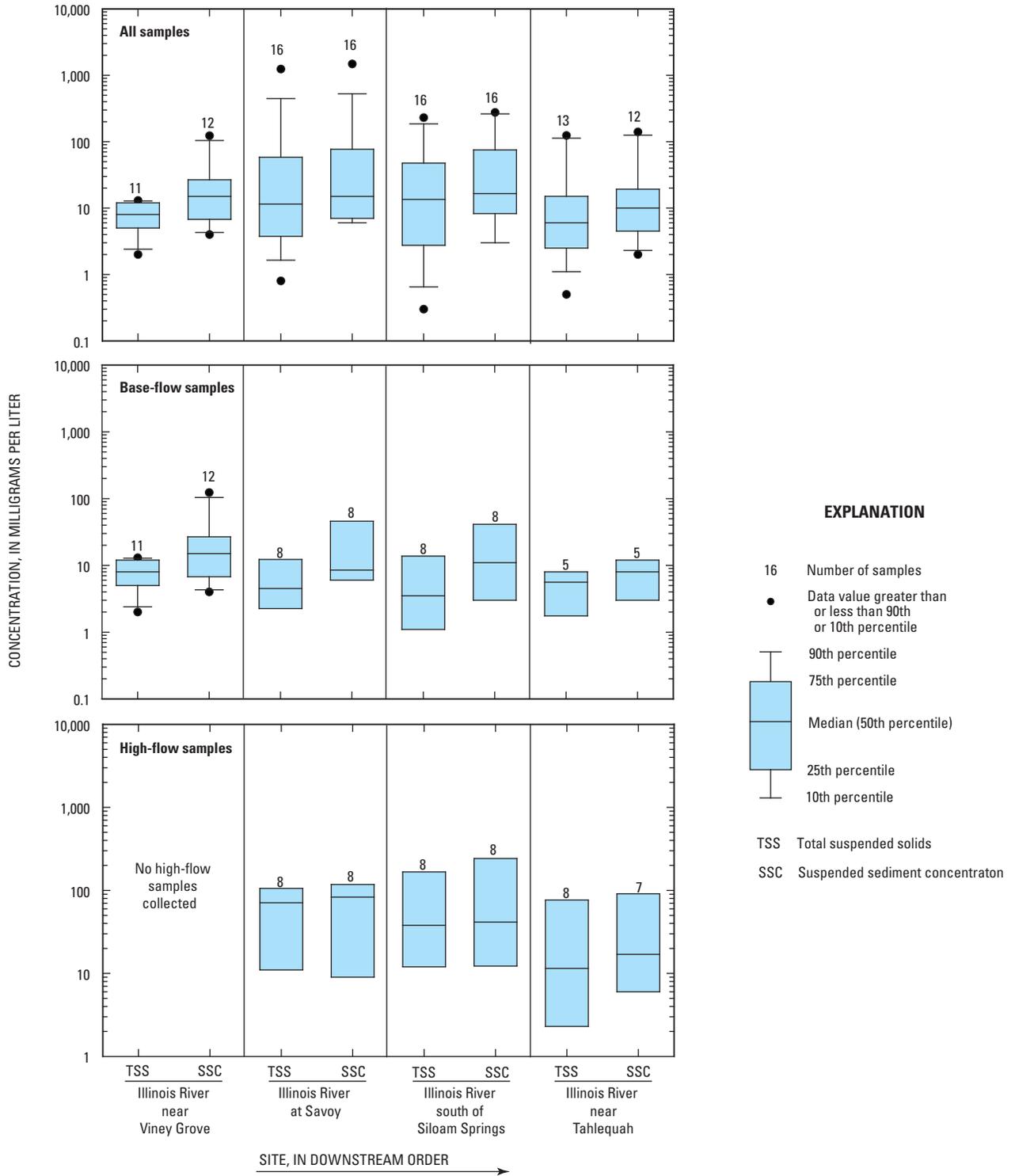


Figure 4. Distribution of suspended-sediment concentrations and total suspended solids in water samples collected from August 2005 to July 2007 for the Illinois River sites near Viney Grove, Arkansas; at Savoy, Arkansas; south of Siloam Springs, Arkansas; and near Tahlequah, Oklahoma.

10 Organic and Inorganic Percentages and Mass of Suspended Material at Four Sites in the Illinois River

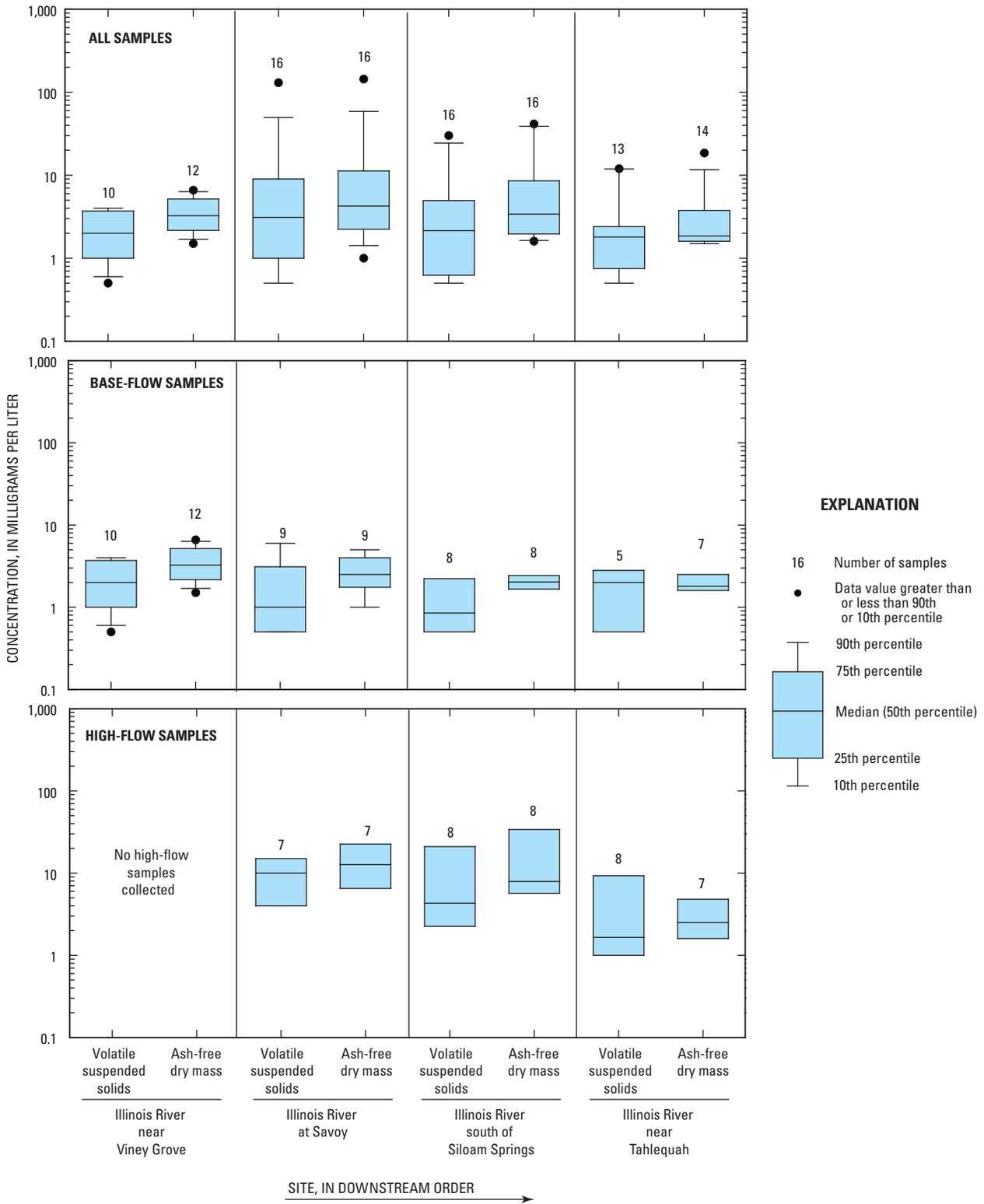


Figure 5. Distribution of volatile suspended solids and ash-free dry mass in water samples collected from August 2005 to July 2007 for the Illinois River sites near Viney Grove, Arkansas; at Savoy, Arkansas; south of Siloam Springs, Arkansas; and near Tahlequah, Oklahoma.

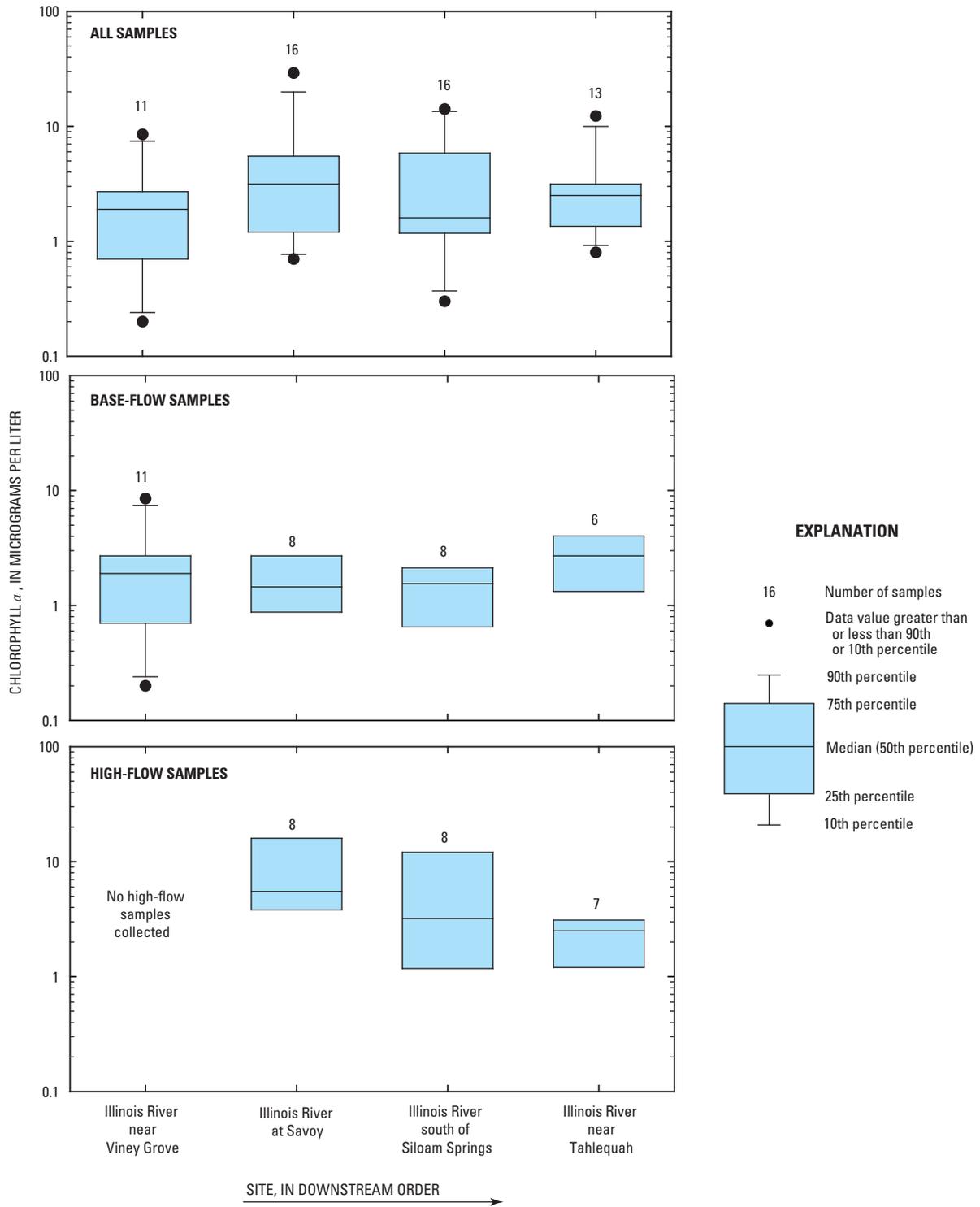


Figure 6. Distribution of chlorophyll *a* in water samples collected from August 2005 to July 2007 for the Illinois River sites near Viney Grove, Arkansas; at Savoy, Arkansas; south of Siloam Springs, Arkansas; and near Tahlequah, Oklahoma.

12 Organic and Inorganic Percentages and Mass of Suspended Material at Four Sites in the Illinois River

VSS and ash-free dry mass data compared relatively well at VSS concentrations greater than 3.0 mg/L (fig. 7). At lower concentrations, ash-free dry mass was consistently greater than VSS. Some of the differences in the values at the lower concentrations may be explained by measurement errors in the laboratory analysis. As the mass of material decreases, the measurement of mass is more affected by accuracy of the laboratory balances, thus increasing the uncertainty in the measurement.

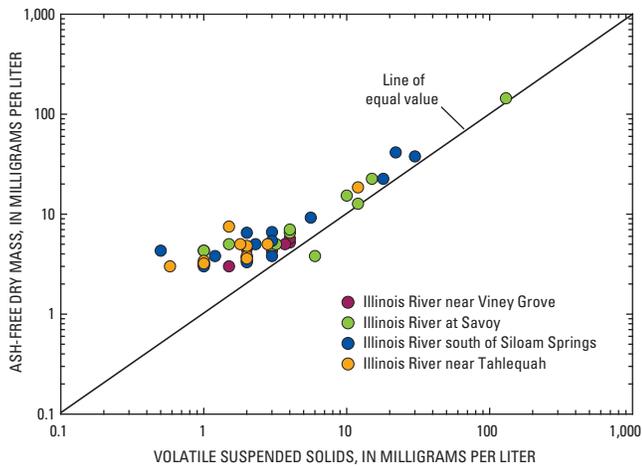


Figure 7. Comparison of volatile suspended solids and ash-free dry mass in water samples collected from August 2005 to July 2007 for the Illinois River sites near Viney Grove, Arkansas; at Savoy, Arkansas; south of Siloam Springs, Arkansas; and near Tahlequah, Oklahoma.

Similar to the comparison of VSS and ash-free dry mass, the TSS and SSC data compared relatively well at TSS concentrations greater than 3 mg/L, although the differences between values were more variable at most concentrations (fig. 8). Some of the differences in the values at the lower concentrations also may be explained by measurement errors in the laboratory analysis. In addition, as mentioned earlier, the analytical methods differ and the two methods may not be equivalent when solid-phase material, especially sand, becomes more concentrated (Gray and others, 2000).

The results of the three methods used to determine the organic and inorganic portions of the suspended material were widely variable among the different methods. Comparisons between the TSS method and the SSC method showed that differences between percentages calculated using the two methods generally increased as the percentage of organic material increased (fig. 9). Much of the differences between the results of the TSS and SSC methods may be attributed to the sample processing methods. In the analysis of TSS and VSS, the two constituents were determined from the same volume of water from the same sample container (American Public Health

Association and others, 1995). However, the ash-free dry mass was analyzed by a separate laboratory and from a different sample container than the SSC analysis. Although the samples in each container should have the same composition among the containers because they were split from the composite sample collected from the stream, differences in results could arise from different instrument and measurement accuracies among the laboratories and particle distributions can change within the different containers because of adhesion to the container walls and from settling.

The SEM method also showed variable results from the TSS and SSC methods (table 1). In general, the SEM method yielded greater percentages of organic material than the other methods in samples collected during base-flow conditions when concentrations of TSS were relatively small, except for the sample collected at the Illinois River near Tahlequah where the SEM value was similar to the SSC method value and less than the TSS method value. In samples collected during high-flow conditions when TSS concentrations were usually greater, the SEM results were similar to results from the other two methods, except in the sample from the Illinois River near Tahlequah, where the SEM yielded a much smaller percentage of organic material than the other two methods. The greatest difference between the SEM method and the two other methods is that the SEM method determines the percentage of organic material from the area that the inorganic and organic particles occupy on the sample and the other two methods determine the percentages from the mass of the particles in the sample. The SEM method may show a higher percentage

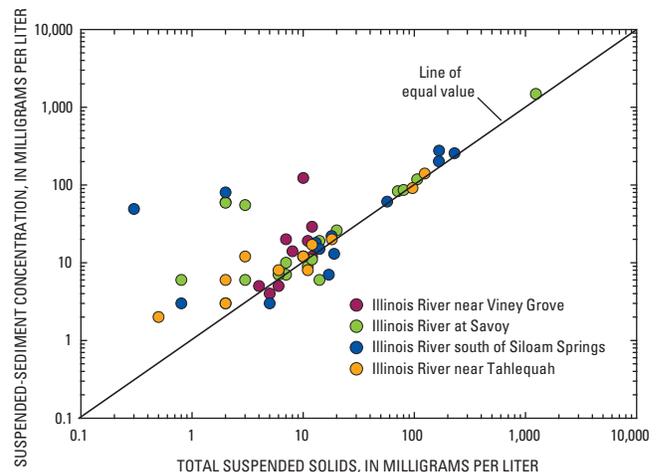


Figure 8. Comparison of suspended-sediment concentrations and total suspended solids in water samples collected from August 2005 to July 2007 for the Illinois River sites near Viney Grove, Arkansas; at Savoy, Arkansas; south of Siloam Springs, Arkansas; and near Tahlequah, Oklahoma.

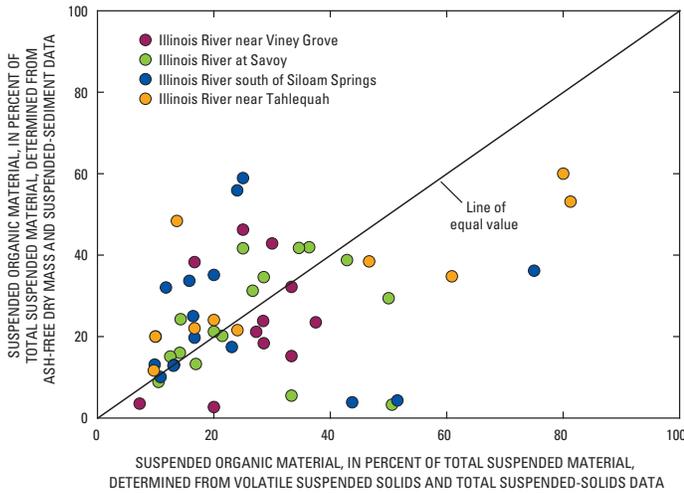


Figure 9. Comparison of the percentages of inorganic material in water samples collected from August 2005 to July 2007 for the Illinois River sites near Viney Grove, Arkansas; at Savoy, Arkansas; south of Siloam Springs, Arkansas; and near Tahlequah, Oklahoma using two different methods.

of organic particles than the other two methods when flow conditions are lower and TSS concentrations are less because stream velocities also would be less, so inorganic particles entrained in the water column would probably have less mass (silt and clay-sized particles). Likewise, when flow conditions are higher (greater stream velocities), inorganic particles with greater mass (sand-size particles), but not necessarily occupying greater space, would be entrained in the water column, resulting in lower or similar percentages of organic material from the SEM method compared to the other two methods that use mass to measure the amount of material.

Organic and Inorganic Percentages of Suspended Material

The percentage of organic material in the Illinois River varied spatially, with flow conditions, and seasonally in samples collected at four sites from August 2005 through July 2007. Organic material in the Illinois River generally composed between 13 and 47 percent (based on 25th and 75th percentiles of samples collected at all of the sites using both TSS and SSC methods for determining percentages) of the total

Table 1. Comparison of results of three methods for determining the organic and inorganic composition of suspended material in samples collected at the Illinois River sites near Viney Grove, Arkansas; at Savoy, Arkansas; south of Siloam Springs, Arkansas; and near Tahlequah, Oklahoma.

[mg/L, milligrams per liter; <, less than]

Site number (fig. 1)	Site name	Sample date	Flow condition	Total suspended solids concentration (mg/L)	Percent of total suspended material that is organic		
					Total suspended solids method	Suspended sediment concentration method	Scanning electron microscope method
07194760	Illinois River near Viney Grove	10/26/2005	Base flow	7	20	27	63
07194800	Illinois River at Savoy	10/26/2005	Base flow	3	33	6	67
07195430	Illinois River south of Siloam Springs	10/26/2005	Base flow	2	44	38	56
07196500	Illinois River near Tahlequah	12/7/2005	Base flow	<1	80	60	57
07194800	Illinois River at Savoy	8/23/2006	High flow	1,240	10	9	9
07195430	Illinois River south of Siloam Springs	8/23/2006	High flow	230	13	13	6
07196500	Illinois River near Tahlequah	8/24/2006	High flow	12	17	22	1

suspended material in samples collected from August 2005 through July 2007. Therefore, most of the suspended material in samples collected from the sites was inorganic material. In general, the percentage of organic material in samples collected during base-flow conditions was greater than in samples collected during high-flow conditions. Organic material composed the greatest percentage of the total suspended material in samples from the Illinois River in the winter (December through February) and summer (June through August) at Savoy; in the spring (March through May), fall (September through November), and winter south of Siloam Springs; in the winter near Tahlequah; and in the summer near Viney Grove.

Spatial Variability

Overall, the greatest percentage of organic material determined from the TSS method was found in samples from the Illinois River near Viney Grove compared to the other three sites from August 2005 through July 2007 (fig. 10). The percentage of organic suspended material in samples from the Illinois River near Viney Grove ranged from 7 to 38 percent of the suspended material with a median of 28 percent. Because high-flow events were not sampled at the Illinois River near Viney Grove, the concentrations of inorganic material were probably low and effects of biological processes such as algal growth would be more prevalent, increasing the percentage of organic material in samples. Samples from the Illinois River south of Siloam Springs had the least median percentage of organic material (16 percent) compared to the other three sites and had percentages ranging from 10 to 75 percent of the total suspended material. The Illinois River near Tahlequah had the greatest range of percentages of organic material, ranging from 10 to 81 percent of the total suspended material. The Illinois River at Savoy had organic material that composed 10 to 50 percent of the total suspended material with a median of 26 percent organic material.

Using the SSC method for determining the percentage of organic material, the greatest median percentage of organic material was found in samples from the Illinois River near Tahlequah from August 2005 through July 2007 (fig. 10). The median percentage of organic material in samples from the Illinois River near Tahlequah was 35 percent and the range was 12 to 60 percent of the total suspended material. The median percentage of organic material using the SSC method in samples from Illinois River sites near Viney Grove and at Savoy were 24 and 23 percent, respectively, slightly less than was determined using the TSS method. Similar to the results from the TSS method, the lowest median percentages of organic material were found in samples from the Illinois River south of Siloam Springs.

The SEM method showed different results than the other two methods, with the greatest percentage of organic material among the four sites in samples from the Illinois River at Savoy and the least in samples from the Illinois River near

Tahlequah (table 2). However, only two samples (one collected during base-flow conditions and one collected during high-flow conditions) were analyzed for each site except for the Illinois River near Viney Grove that had only one sample collected during base-flow conditions. One reason that the SEM may show a difference from the TSS and SSC methods may be related to the size and mass of the organic and inorganic particles in samples collected from the sites. The particle-size distribution in samples from the Illinois River at Savoy was mostly silt and clay-sized (90 percent of the particles in the base-flow sample and 93 percent in the high-flow sample had diameters less than 0.063 millimeters, see appendix) compared to the particle size distribution in samples from the Illinois River near Tahlequah (56 percent of the particles in the base-flow sample and 71 percent in the high-flow sample had diameters less than 0.063 millimeters, see appendix).

Hydrologic Variability

In general, organic material (determined from the TSS method) composed a smaller percentage of the suspended material in samples collected during high-flow conditions compared to samples collected during base-flow conditions (fig. 10). For example, the organic material composed 23 percent of the total suspended material (median value) in samples collected during base-flow conditions and 13 percent in samples collected during high-flow conditions at the Illinois River south of Siloam Springs. Samples from the Illinois River near Tahlequah had the greatest median percentage of organic material (36 percent) during base-flow conditions compared to the median percentages in samples from sites on the Illinois River near Viney Grove (28 percent), at Savoy (29 percent) and south of Siloam Springs (23 percent). However, during high-flow conditions, the organic material composed the greatest median percentage of suspended material in samples collected from the Illinois River at Savoy (17 percent) compared to the sites on the Illinois River south of Siloam Springs (13 percent) and near Tahlequah (15 percent) (fig. 10). Samples were not collected during high-flow conditions at the Illinois River near Viney Grove. The Illinois River south of Siloam Springs had the least percentage of organic material during high-flow conditions, or conversely, the greatest percentage of inorganic material. The greater percentage of inorganic material during high-flow conditions can result from streambank failure, streambed scouring, and terrestrial sources, including activities that may increase the erosion of soil material such as row-crop agriculture, animal grazing, timber harvesting, mining, road construction and maintenance, and urbanization (Guy, 1970).

Similar to the results of the TSS method, the results from the SSC method also showed the least median percentages of organic material in samples collected during high-flow conditions (highest percentage of inorganic material) and the greatest median percentages of organic material in samples collected during base-flow conditions (fig. 10). However, the

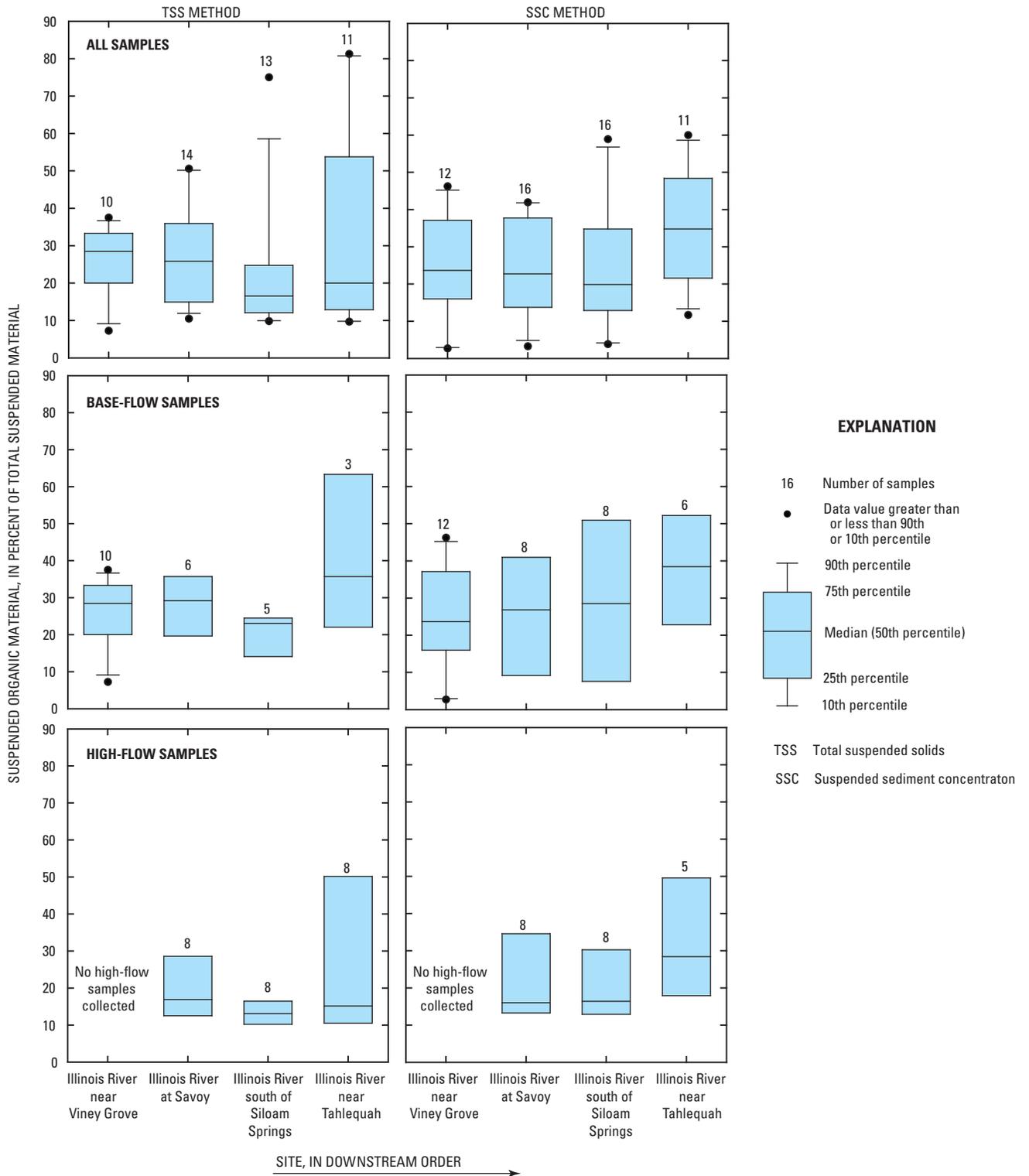


Figure 10. Distribution of organic material in water samples collected from August 2005 to July 2007 for the Illinois River sites near Viney Grove, Arkansas; at Savoy, Arkansas; south of Siloam Springs, Arkansas; and near Tahlequah, Oklahoma.

Table 2. Results of scanning electron microscopy analysis of samples collected at the Illinois River sites near Viney Grove, Arkansas; at Savoy Arkansas; south of Siloam Springs, Arkansas; and near Tahlequah, Oklahoma.

Site number (fig. 1)	Site name	Sample date	Flow condition	Common minerals identified, in decreasing abundance	Organic material identified	Organic material (percent of total suspended material)
07194760	Illinois River near Viney Grove	10/26/2005	Base flow	Quartz, kaolinite, potassium feldspar, plagioclase	Diatoms and small carbon particulate	63
07194800	Illinois River at Savoy	10/26/2005	Base flow	Kaolinite, quartz, potassium feldspar	Long filament algae (coated with clay minerals and manganese), diatoms, and small carbon particulate	67
07195430	Illinois River south of Siloam Springs	10/26/2005	Base flow	Quartz, kaolinite, potassium feldspar, plagioclase, titanium oxide, iron oxide	Diatoms and small carbon particulate	56
07196500	Illinois River near Tahlequah	12/07/2005	Base flow	Quartz, kaolinite, potassium feldspar, plagioclase, apatite	Diatoms and small carbon particulate	57
07194800	Illinois River at Savoy	8/23/2006	High flow	Quartz, kaolinite, potassium feldspar	Diatoms and small carbon particulate	9
07195430	Illinois River south of Siloam Springs	8/23/2006	High flow	Quartz, kaolinite, potassium feldspar, albite	Diatoms and small carbon particulate	6
07196500	Illinois River near Tahlequah	8/24/2006	High flow	Quartz, kaolinite, potassium feldspar, calcite, iron oxide	Diatoms and small carbon particulate	1

distribution of percentages of organic material in samples collected at high-flow and base-flow conditions at individual sites was more variable when values were calculated using the SSC method for sites on the Illinois River. For example, in samples collected during base-flow conditions at the Illinois River south of Siloam Springs, the percentage of organic material ranged from 4 to 59 percent of the total suspended material compared to percentages determined by the TSS methods, which ranged from 12 to 23 percent of the total suspended material.

The results from the SEM method showed that in the samples collected during base-flow conditions (one sample at each site), organic material particles composed 56 to 67 percent of the total suspended material particles and in the samples collected at high-flow conditions (one sample at each site except for the Illinois River near Viney Grove), the material was mostly (more than 90 percent) inorganic particles (table 2). Most of the organic material identified during high-flow and base-flow conditions was composed of diatoms and small carbon particulate matter (table 2 and fig. 11). However, some filamentous algae also were identified in samples collected from the Illinois River at Savoy during base-flow conditions. Most of the inorganic material at the four sites was composed of quartz, kaolinite (a clay-forming mineral), and potassium feldspar (table 2 and fig. 11).

Seasonal Variability

The mean seasonal concentrations and percentages of organic material (determined from the TSS method) were the least in samples collected in the fall from August 2005 to July 2007 from the four Illinois River sites, while the greatest concentrations and percentages of organic material occurred at various times of the year depending on the site (fig. 12). The greatest concentrations of organic material occurred in the summer (June through August) in samples from sites on the Illinois River near Viney Grove, at Savoy, and south of Siloam Springs, but in the spring (March through May) in samples from the Illinois River near Tahlequah. The greatest percentages of organic material (least percentages of inorganic material) occurred in the summer in samples from the site near Viney Grove, the winter and summer at the site at Savoy, in the spring, fall (September through November), and winter (December through February) at the site south of Siloam Springs, and in the winter at the site near Tahlequah. In samples collected during high-flow conditions, the greatest concentrations and percentages of organic material occurred in the summer at the Illinois River sites at Savoy and south of Siloam Springs and in the winter at the site near Tahlequah. No high-flow samples were collected at the Illinois River near Viney Grove for comparison. In samples collected during base-flow conditions, the greatest concentrations also occurred in the summer at the sites at Savoy, south of Siloam Springs, and near Viney Grove, and during the spring at the site near Tahlequah. However, the greatest percentage of

organic material (least percentage of inorganic material) in samples collected during base-flow conditions occurred in the winter at the Illinois River sites at Savoy, south of Siloam Springs, and near Tahlequah, and in the summer at the site near Viney Grove. Variability in organic material during different seasons at the four sites could reflect different sources of inorganic and organic material. Greater organic mass can occur in the spring and summer when water temperatures are greater, more sunlight occurs, and base-flow conditions are more dominant (lower stream velocities); conditions more conducive for increased algal growth in the stream. However, some algal groups, such as diatoms, can grow at lower water temperatures, such as in the late winter and spring, and also can increase the biomass in the stream (Stevenson and others, 1996). Greater percentages of organic material in the winter also may be because the concentration of total suspended solids is the least, and even small amounts of organic material could compose a large percentage of the total material. The winter months also are dominated by greater base-flow conditions with greater streamflow rates than the other seasons (fig. 2) with larger inputs of ground water that generally has little inorganic suspended material. In the spring and summer months, the suspended material also could be more dominated by allochthonous sources of organic and inorganic material because of the greater occurrence of storm-runoff events and more activities in the watershed, such as agriculture and urban construction.

Implications

In addition to variability among the different methods used to determine the amount of organic material, sources of variability in organic material concentrations and percentages among sites during different flow conditions and seasons can be difficult to quantify because of the complexities of algal dynamics in the streams and the processes that occur in the basin that affect the terrestrial sources of organic material. Algal biomass can be affected by many factors including nutrient concentrations, stream substrate, light availability (stream channel shading), flow velocities, channel structure (pools, riffles, runs), and other aquatic fauna (Stevenson and others, 1996). Terrestrial sources of organic material can be affected by season (for example, greater amounts of leaf litter in the fall), the location and timing of activities that may increase the erosion of soil material (row-crop agriculture, animal grazing, timber harvesting, mining, road construction and maintenance, and urbanization), and differences in organic material content in disturbed soils (Guy, 1970).

Although a wide range of variability is evident in the data, several observations can be made about the suspended material data collected from the four sites on the Illinois River from August 2005 through July 2007. Samples from the Illinois River near Savoy had the greatest turbidity, TSS, SSC, chlorophyll *a*, and organic material concentrations among the

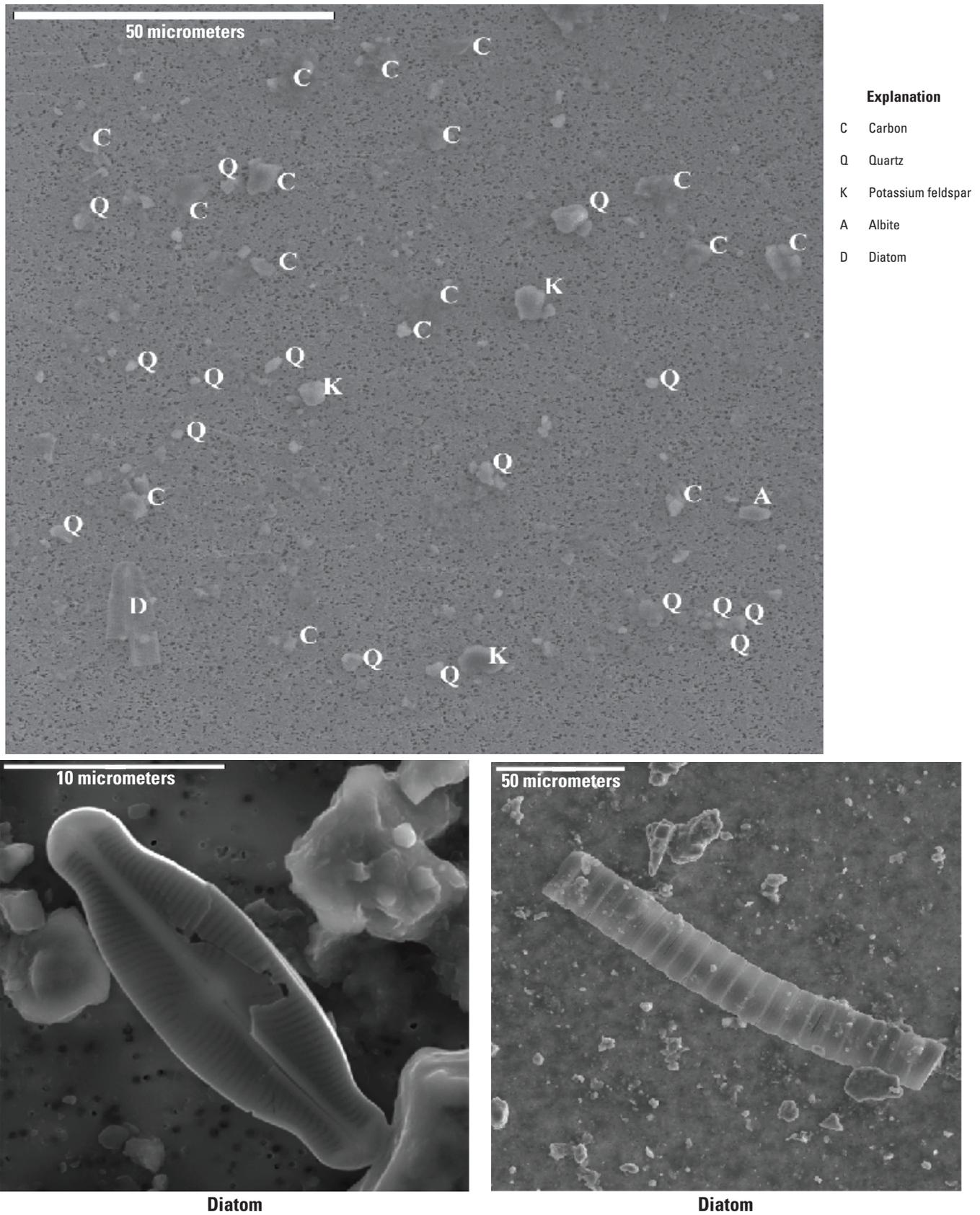


Figure 11. Images of suspended material from a scanning electron microscopy analysis of a sample collected during high-flow conditions on August 23, 2006, from the Illinois River at Savoy, Arkansas.

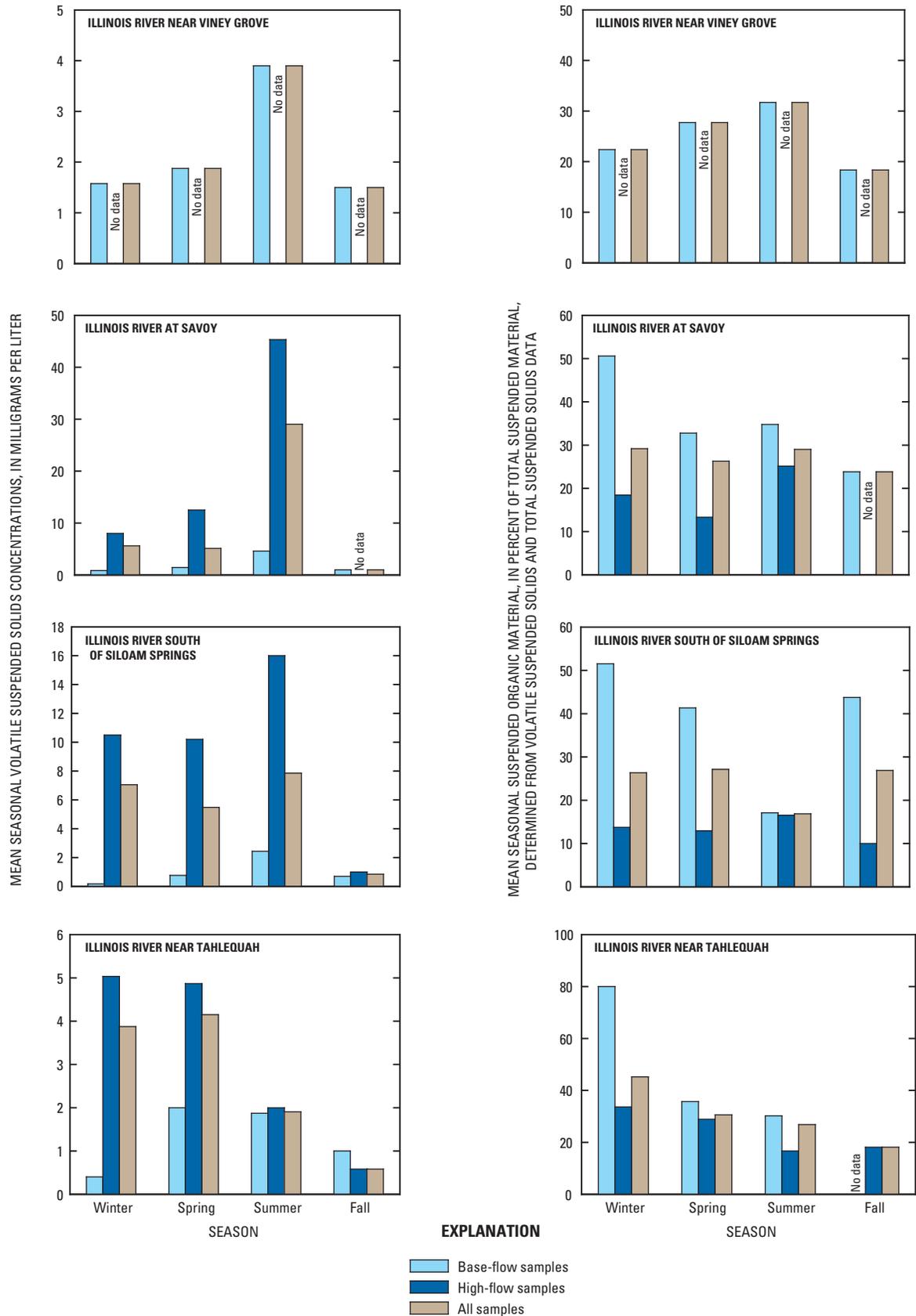


Figure 12. Seasonal concentrations and percentages of organic material in water samples collected from August 2005 to July 2007 for the Illinois River sites near Viney Grove, Arkansas; at Savoy, Arkansas; south of Siloam Springs, Arkansas; and near Tahlequah, Oklahoma.

four sites, indicating that it may be the most affected by activities in the basin upstream from the site, causing increased suspended inorganic and organic material. Sources of organic material can include primary production by periphyton, macrophytes, and phytoplankton; terrestrial plant litter; and soil particulates. The greater chlorophyll *a* concentrations indicate the stream habitat and nutrient concentrations (appendix) are more conducive for algal growth than at the other sites. Downstream from the Illinois River at Savoy, at the site south of Siloam Springs, samples had the least chlorophyll *a* concentrations, the least percentage of organic material (greatest percentage of inorganic material), and similar concentrations of TSS and SSC as the site at Savoy. This would indicate that although a similar concentration of suspended material is being transported downstream, less organic material is being entrained, transported, or being added to the stream near the site south of Siloam Springs compared to the site upstream at Savoy. The lesser chlorophyll *a* concentrations in samples from the Illinois River south of Siloam Springs would indicate that the stream habitat or chemistry might not be as favorable for algal growth (a source of organic material) as observed upstream at the site at Savoy. Even farther downstream at the Illinois River near Tahlequah, samples had the least turbidity, TSS and SSC, and organic material concentrations among the four sites, yet had the greatest percentage of organic material (determined from the SSC method). The lesser concentrations of TSS and SSC and lesser turbidity values would indicate that less of the suspended material that was observed in samples from the two upstream sites is being transported past the site near Tahlequah. The greater percentage of organic material in samples from the Illinois River near Tahlequah may be because the concentration of inorganic particles is less because of deposition upstream from the site, increasing the effects of sources of organic material on the total mass of suspended material. Also, the channel morphology may be more conducive for algal growth, such as the presence of longer, wider pools with less stream velocities.

Summary

The Illinois River located in northwestern Arkansas and northeastern Oklahoma is influenced by point and nonpoint sources of nutrient enrichment. This has led to increased algal growth within the stream, reducing water clarity. Also, sediment runoff from fields, pastures, construction sites, and other disturbed areas, in addition to frequent streambank failure, has increased sedimentation within the stream and decreased water clarity. A study was conducted by the U.S. Geological Survey, in cooperation with the Arkansas Department of Environmental Quality and the U.S. Environmental Protection Agency, to characterize the increased turbidity by determining the organic and inorganic percentages and mass of suspended material in the Illinois River from August 2005 through July 2007. Water-quality samples were collected every 2 months and during four

high-flow events at three sites on the Illinois River: at Savoy, Arkansas; south of Siloam Springs, Arkansas; and near Tahlequah, Oklahoma. Water-quality samples also were collected every 2 months for the 2-year period at the Illinois River near Viney Grove, Arkansas, located upstream from all wastewater-treatment plant discharges in the Illinois River.

Streamflow increased substantially from the most upstream site on the Illinois River (with continuous streamflow data) at Savoy to the most downstream site near Tahlequah from August 2005 through July 2007. Also, the mean annual streamflow was considerably less from August 2005 through July 2007 compared to the long-term mean annual streamflow recorded at each site.

In general, turbidity, total suspended solids (TSS), suspended-sediment concentration (SSC), organic material concentration (measured as volatile suspended solids and ash-free dry mass), and chlorophyll *a* concentration were the greatest in samples collected from the Illinois River at Savoy and the least in samples from the most upstream Illinois River site (near Viney Grove) and the most downstream site (near Tahlequah) from August 2005 through July 2007. For example, the TSS at the Illinois River at Savoy had a median of 12 milligrams per liter (mg/L), and the SSC had a median of 15 mg/L. The Illinois River near Tahlequah had the least TSS with a median of 6 mg/L and the least SSC with a median of 10 mg/L.

The turbidity, TSS, SSC, organic material concentration, and chlorophyll *a* concentration in samples collected during high-flow events were greater than in samples collected during base-flow conditions at the Illinois River at Savoy, south of Siloam Springs, and near Tahlequah. For example, the median turbidity for the Illinois River at Savoy was 3 nephelometric turbidity ratio units (NTRU) during base-flow conditions and 52 NTRU during high-flow conditions. The median VSS and ash-free dry mass concentrations were 1.0 and 2.5 mg/L, respectively during base-flow conditions, compared to median VSS and ash-free dry mass concentrations of 10.0 and 12.7 mg/L, respectively, during high-flow conditions.

The results of the three methods used to determine the organic and inorganic percentages of the suspended material were widely variable among the different methods. Comparisons between the TSS method and the SSC method showed that differences between percentages calculated using the two methods generally increased as the percentage of organic material increased. Much of the differences between the results of the TSS and SSC methods may be attributed to the sample processing methods. In general, the SEM method yielded greater percentages of organic material than the other methods in samples collected during base-flow conditions when concentrations of TSS were relatively small, except for the sample collected at the Illinois River near Tahlequah where the SEM value was similar to the SSC method value and less than the TSS method value.

Organic material in the Illinois River generally composed between 13 and 47 percent of the total suspended material in samples collected from August 2005 through July 2007. Therefore, most of the suspended material in samples

collected from the sites was inorganic material. Overall, the highest percentage of organic material was found at the Illinois River near Viney Grove using the TSS method and at the Illinois River near Tahlequah using the SSC method. The Illinois River south of Siloam Springs had the lowest percentage of organic material among the four sites for both methods. In general, the percentage of organic material was greater in samples collected during base-flow conditions compared to samples collected during high-flow conditions. For example, organic material at the Illinois River at Savoy composed 29 percent of the suspended material (median value) during base-flow conditions and 17 percent of the suspended material (median value) during high-flow conditions (TSS method).

The mean seasonal concentrations and percentages of organic material (from the TSS method) were the least in samples collected in the fall from August 2005 to July 2007 from the four Illinois River sites, while the greatest concentrations and percentages of organic material occurred at various times of the year depending on the site. The greatest concentrations of organic material occurred in the summer (June through August) in samples from sites on the Illinois River near Viney Grove, at Savoy, and south of Siloam Springs, but in the spring (March through May) in samples from the Illinois River near Tahlequah. The greatest percentages of organic material (least percentages of inorganic material) occurred in the summer in samples from the site near Viney Grove, the winter and summer at the site at Savoy, in the spring, fall, and winter (December through February) at the site south of Siloam Springs, and in the winter at the site near Tahlequah.

Although a wide range of variability is evident in the data, several observations can be made about the suspended material data collected from the four sites on the Illinois River from August 2005 through July 2007. Samples from the Illinois River near Savoy had the greatest turbidity, TSS, SSC, chlorophyll *a*, and organic material concentrations among the four sites, indicating that it may be the most affected by activities in the basin upstream from the site, causing increased suspended inorganic and organic material. Downstream from the Illinois River at Savoy, at the site south of Siloam Springs, samples had the least chlorophyll *a* concentrations, the least percentage of organic material (greatest percentage of inorganic material), and similar concentrations of TSS and SSC as the site at Savoy. This would indicate that although a similar concentration of suspended material is being transported downstream, less organic material is being entrained, transported, or being added to the stream near the site south of Siloam Springs compared to the site upstream at Savoy. Even farther downstream at the Illinois River near Tahlequah, samples had the least turbidity, SSC and TSS, and organic material concentrations among the four sites, yet had the greatest percentage of organic material (determined from the SSC method). This would suggest that less of the suspended material that was observed in samples from the two upstream sites is being transported past the site near Tahlequah and the concentration of inorganic particles is less because of deposi-

tion upstream from the site, or the channel morphology may be more conducive for algal growth, increasing the effects of sources of organic material on the total mass of suspended material.

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APPENDIX

Appendix - Water-quality data from August 2005 to July 2007 for the Illinois River sites near Viney Grove, Arkansas; at Savoy, Arkansas; south of Siloam Springs, Arkansas; and near Tahlequah, Oklahoma.

[ft³/s, cubic feet per second; nm, nanometers; NTRU, nephelometric turbidity ratio units; mg/L, milligrams per liter; °C, degrees Celsius; µs/cm, microsiemens per centimeter; N, nitrogen; P, phosphorus; µg/L, micrograms per liter; <, less than; E, estimated; nm, nanometers; mm, millimeters]

Sample date	Sample time	Dis-charge, instan-taneous (ft ³ /s) (00061)	Turbidity, unfiltered, broad band light source (400-680 nm), detectors at multiple angles including 90 and 30 degrees, ratiometric correction (NTRU) (63676)	Dissolved oxygen (mg/L) (00300)	pH (standard units) (00400)	Specific conduc-tance (µs/cm at 25°C) (00095)	Water temper-ature (°C) (00010)	Total dissolved solids (mg/L) (70300)	Residue, fixed non-filterable (mg/L) (00540)	Total sus-pended solids (mg/L) (00530)	Volatile sus-pended solids (mg/L) (00535)	Ammonia plus organic nitrogen, unfiltered (mg/L as N) (00625)	Ammonia, filtered (mg/L as N) (00608)
08/31/05	1430	--	3.9	6.3	7.8	358	23.6	207	69	--	--	0.21	<0.04
10/26/05	1300	--	E2.5	6.8	8.0	380	11.0	215	8	10	2.0	0.20	<0.04
12/13/05	1300	--	<2.0	11.5	7.7	385	4.6	183	2	2	<1.0	0.21	<0.04
03/07/06	0850	4	5.1	7.9	7.7	351	10.6	204	5	7	2.0	0.32	E0.02
05/03/06	0900	40	13.0	6.0	7.2	254	19.5	151	9	11	3.0	0.42	E0.04
06/22/06	0930	--	12.0	4.5	7.6	366	24.0	207	8	12	4.0	0.32	0.06
08/16/06	0900	--	8.1	3.3	7.5	353	24.5	201	8	12	4.0	0.69	0.22
10/04/06	1000	--	4.7	6.1	7.6	347	19.7	214	5	6	1.0	0.24	E0.02
01/17/07	1145	199	8.3	11.8	7.4	207	3.7	139	5	8	3.0	0.21	E0.01
03/07/07	1405	38	<2.0	15.6	8.5	269	12.3	167	3	5	1.5	0.22	<0.02
04/10/07	1045	14.4	<2.0	8.6	7.9	336	10.5	185	2	4	1.0	0.20	<0.02
07/19/07	0700	19.8	9.9	5.2	8.1	315	24.2	179	10	13	3.7	0.29	0.02

Illinois River near Viney Grove, Arkansas (07194760)

Appendix - Water-quality data from August 2005 to July 2007 for the Illinois River sites near Viney Grove, Arkansas; at Savoy, Arkansas; south of Siloam Springs, Arkansas; and near Tahlequah, Oklahoma.—Continued

[ft³/s, cubic feet per second; mm, nanometers; NTRU, nephelometric turbidity ratio units; mg/L, milligrams per liter; °C, degrees Celsius; µs/cm, microsiemens per centimeter; N, nitrogen; P, phosphorus; µg/L, micrograms per liter; <, less than; E, estimated; nm, nanometers; mm, millimeters]

Sample date	Sample time	Discharge, instantaneous (ft ³ /s) (00061)	Turbidity, unfiltered, broad band light source (400-680 nm), detectors at multiple angles including 90 and 30 degrees, radiometric correction (NTRU) (63676)	Dissolved oxygen (mg/L) (00300)	pH (standard units) (00400)	Specific conductance (µs/cm at 25°C) (00095)	Water temperature (°C) (00010)	Total dissolved solids (mg/L) (70300)	Residue, fixed non-filterable (mg/L) (00540)	Total suspended solids (mg/L) (00530)	Volatile suspended solids (mg/L) (00535)	Ammonia plus organic nitrogen, unfiltered (mg/L as N) (00625)	Ammonia, filtered (mg/L as N) (00608)
Illinois River at Savoy, Arkansas (07194800)													
08/31/05	1245	7	3.2	5.4	7.8	305	25.0	184	8	14	6.0	0.26	<0.04
10/26/05	1400	7	E2.4	7.8	8.1	334	12.5	191	2	3	1.0	0.24	<0.04
12/13/05	1215	11	2.7	13	8.0	350	3.1	201	<1	2	<1.0	0.24	<0.04
03/07/06	0950	10	3.1	8.6	7.7	303	10.2	178	<1	<1	<1.0	0.42	0.07
05/03/06	0715	88	12.0	6.6	7.5	249	19.8	149	10	14	3.0	0.54	0.05
05/05/06	0715	1,190	79.0	7.3	7.8	141	16.8	104	91	106	15.0	1.10	0.04
06/22/06	0840	7	4.5	5.7	7.6	329	24.4	189	5	7	2.0	0.38	0.03
08/16/06	0800	15	6.1	3.9	7.5	306	25.4	182	7	11	4.0	0.54	0.04
08/23/06	1610	1,840	930.0	4.2	7.7	202	23.8	122	1,110	1,240	130.0	4.70	0.11
10/04/06	0910	37	5.6	5.9	7.6	332	20.7	195	6	7	1.0	0.30	0.02
01/17/07	0930	549	15.0	11.3	7.2	212	4.3	131	16	20	4.0	0.42	0.03
02/13/07	1600	1,320	52.0	11.7	7.4	151	5.4	105	59	71	12.0	0.84	0.05
03/07/07	1245	84	2.8	14.3	8.3	277	11.4	161	5	6	1.5	0.21	<0.02
04/10/07	1145	22	<2.0	10.2	8.0	322	11.2	186	2	3	<1.0	0.30	E0.02
04/25/07	1230	426	60.0	9.2	7.7	238	18.5	195	70	80	10.0	1.20	E0.02
07/19/07	0815	41	6.4	6.2	7.9	297	25.4	171	8	12	3.2	0.33	0.02

Appendix - Water-quality data from August 2005 to July 2007 for the Illinois River sites near Viney Grove, Arkansas; at Savoy, Arkansas; south of Siloam Springs, Arkansas; and near Tahlequah, Oklahoma.—Continued

[ft³/s, cubic feet per second; nm, nanometers; NTRU, nephelometric turbidity ratio units; mg/L, milligrams per liter; °C, degrees Celsius; μs/cm, microsiemens per centimeter; N, nitrogen; P, phosphorus; μg/L, micrograms per liter; <, less than; E, estimated; nm, nanometers; mm, millimeters]

Sample date	Sample time	Dis-charge, instan-taneous (ft ³ /s) (00061)	Flow condition	Turbidity, unfiltered, broad band light source (400-680 nm), detectors at multiple angles including 90 and 30 degrees, ratiometric correction (NTRU) (63676)	Dissolved oxygen (mg/L) (00300)	pH (standard units) (00400)	Specific conduc-tance (μs/cm at 25°C) (00095)	Water temper-ature (°C) (00010)	Total dissolved solids (mg/L) (70300)	Residue, fixed non-filterable (mg/L) (00540)	Total sus-pended solids (mg/L) (00530)	Volatile sus-pended solids (mg/L) (00535)	Ammonia plus organic nitrogen, unfiltered (mg/L as N) (00625)	Ammonia, filtered (mg/L as N) (00608)
08/31/05	0820	107	Base flow	4	6.3	7.9	400	24.5	239	14	17	2.0	0.20	<0.04
10/26/05	0900	100	Base flow	E1.0	8.0	8.2	444	11.8	253	<1	2	<1.0	0.19	<0.04
12/13/05	0915	108	Base flow	<2.0	12.5	8.3	450	3.7	258	<1	<1	<1.0	0.26	<0.04
03/07/06	1115	106	Base flow	<2.0	12.3	7.9	428	11.9	246	<1	<1	<1.0	0.33	<0.04
05/03/06	1115	309	High flow	14.0	7.2	7.5	324	20.0	193	16	19	3.0	0.40	<0.04
05/05/06	0730	3,660	High flow	180.0	6.6	7.0	192	17.4	134	145	167	22.0	1.50	E0.03
06/22/06	0740	67	High flow	5.7	5.8	7.6	420	25.2	242	8	10	2.0	0.28	0.01
08/16/06	0710	54	Base flow	6.0	4.3	7.8	429	26.8	254	10	13	3.0	0.31	0.02
08/23/06	1655	1,670	High flow	170.0	5.5	7.5	240	24.7	144	200	230	30.0	1.30	0.02
10/04/06	0810	221	High flow	6.4	7.2	7.6	370	20.7	218	8	10	1.0	0.20	E0.01
01/17/07	1430	1,490	High flow	12.0	10.4	7.3	245	5.5	147	15	18	3.0	0.36	E0.02
02/13/07	1700	3,770	High flow	120.0	10.1	7.6	211	6.6	130	149	166	18.0	1.20	0.06
03/07/07	1045	338	Base flow	<2.0	12.9	8.1	334	9.7	190	4	5	1.2	0.20	<0.02
04/10/07	0920	202	Base flow	<2.0	9.3	7.9	368	10.8	202	1	2	<1.0	0.25	<0.02
04/25/07	1500	1,120	High flow	19.0	12.7	7.6	354	19.5	216	52	57	5.6	0.73	E0.01
07/18/07	1000	409	Base flow	6.3	7.4	8.1	342	25.2	193	12	14	2.3	0.28	<0.02

Illinois River south of Siloam Springs, Arkansas (07195430)

Appendix - Water-quality data from August 2005 to July 2007 for the Illinois River sites near Viney Grove, Arkansas; at Savoy, Arkansas; south of Siloam Springs, Arkansas; and near Tahlequah, Oklahoma.—Continued

[ft³/s, cubic feet per second; nm, nanometers; NTRU, nephelometric turbidity ratio units; mg/L, milligrams per liter; °C, degrees Celsius; µs/cm, microsiemens per centimeter; N, nitrogen; P, phosphorus; µg/L, micrograms per liter; <, less than; E, estimated; nm, nanometers; mm, millimeters]

Sample date	Sample time	Dis-charge, instan-taneous (ft ³ /s) (00061)	Flow condition	Turbidity, unfiltered, broad band light source (400-680 nm), detectors at multiple angles including 90 and 30 degrees, ratiometric correction (NTRU) (63676)	Dissolved oxygen (mg/L) (00300)	pH (standard units) (00400)	Specific conduc-tance (µs/cm at 25°C) (00095)	Water temper-ature (°C) (00010)	Total dissolved solids (mg/L) (70300)	Residue, fixed non-filterable (mg/L) (00540)	Total sus-pended solids (mg/L) (00530)	Volatile sus-pended solids (mg/L) (00535)	Ammonia plus organic nitrogen, unfiltered (mg/L as N) (00625)	Ammonia, filtered (mg/L as N) (00608)
Illinois River near Tahlequah, Oklahoma (07196500)														
12/07/05	1100	159	Base flow	<2.0	14.1	8.1	341	6.4	195	<1	<1	<1.0	E0.08	E0.01
02/02/06	1400	247	High flow	<2.0	15.2	8.5	360	11.6	208	1	2	1.0	0.19	0.02
04/13/06	1245	240	High flow	<2.0	12.5	8.4	321	20.3	184	1	2	1.0	0.26	<0.05
05/06/06	1100	3,260	High flow	68.0	7.4	7.2	244	18.3	156	85	96	11.7	0.88	0.03
06/13/06	1215	208	Base flow	4.7	9.6	8.0	299	25.7	181	3	3	--	0.16	0.02
08/08/06	1145	116	Base flow	5.6	12.1	7.9	335	29.1	188	8	10	2.0	0.17	0.01
08/24/06	1015	565	High flow	6.0	5.0	8.0	355	27.1	210	10	12	2.0	0.35	<0.01
10/03/06	1215	344	High flow	5.0	8.5	7.8	323	22.6	185	3	3	<1.0	0.11	<0.02
12/05/06	1030	1,850	High flow	10.0	11.0	7.8	261	7.6	158	16	18	1.8	0.26	<0.02
02/12/07	1215	487	Base flow	<2.0	12.7	7.8	279	6.5	157	--	--	--	0.10	<0.02
02/14/07	1115	3,740	High flow	79.0	11.1	7.5	286	4.7	163	112	124	12	0.89	0.03
04/03/07	1030	236	Base flow	2.2	9.0	8.0	297	19.2	167	4	6	2.0	0.20	<0.02
04/26/07	0930	460	High flow	2.1	9.1	7.6	297	17.1	185	9	11	1.5	0.26	<0.02
06/07/07	0945	363	Base flow	4.3	6.6	7.9	290	23.5	174	--	--	--	0.19	<0.02
07/18/07	0800	615	Base flow	4.5	6.4	8.1	291	24.6	164	4	6	2.8	0.19	E0.01

Appendix - Water-quality data from August 2005 to July 2007 for the Illinois River sites near Viney Grove, Arkansas; at Savoy, Arkansas; south of Siloam Springs, Arkansas; and near Tahlequah, Oklahoma.—Continued

[ft³/s, cubic feet per second; mm, nanometers; NTRU, nephelometric turbidity ratio units; mg/L, milligrams per liter; °C, degrees Celsius; µs/cm, microsiemens per centimeter; N, nitrogen; P, phosphorus; µg/L, micrograms per liter; <, less than; E, estimated; nm, nanometers; mm, millimeters]

Sample date	Sample time	Nitrite plus nitrate, filtered (mg/L as N) (00631)	Total nitrogen, unfiltered (mg/L as N) (00600)	Ortho-phosphorus, filtered (mg/L as P) (00671)	Phosphorus, filtered (mg/L as P) (00666)	Phosphorus, unfiltered (mg/L as P) (00665)	Biomass, phytoplankton, ash-free dry mass (mg/L) (49953)	Biomass, plankton, ash weight (mg/L) (81533)	Biomass, plankton, dry weight (mg/L) (81354)	Chlorophyll <i>a</i> , plankton, chromatographic-fluorometric method (µg/L) (70953)	Pheophytin <i>a</i> , phytoplankton (µg/L) (62360)	Suspended sediment, diameter (percent smaller than 0.063 mm) (70331)	Suspended sediment concentration (mg/L) (80154)
Illinois River near Viney Grove, Arkansas (07194760)													
08/31/05	1430	2.14	2.4	E0.010	E0.03	0.05	6.6	329	336	--	--	75	13
10/26/05	1300	2.48	2.7	0.020	E0.03	E0.04	3.4	151	155	0.2	0.5	50	123
12/13/05	1300	2.46	2.7	E0.010	<0.04	E0.03	2.2	89.3	91.5	2.7	1.1	73	60
03/07/06	0850	1.71	2.0	<0.020	<0.04	E0.03	4.5	180	185	8.5	4.6	75	20
05/03/06	0900	1.16	1.6	0.020	E0.03	0.05	5.1	176	182	1.5	4.4	90	19
06/22/06	0930	1.66	2.0	0.031	E0.04	0.07	5.2	236	241	E1.9	E2.3	80	29
08/16/06	0900	1.30	2.0	0.028	E0.02	0.08	5.7	266	271	2.2	3.7	84	12
10/04/06	1000	3.85	4.1	0.035	E0.03	0.06	3.1	146	150	0.7	1.3	87	5
01/17/07	1145	3.42	3.6	0.036	E0.02	0.07	<4.3	194	198	0.4	0.4	84	14
03/07/07	1405	2.49	2.7	E0.004	<0.04	<0.04	<3.0	136	139	3.1	2.2	80	4
04/10/07	1045	2.74	2.9	0.010	<0.04	E0.03	<4.3	191	195	2.0	1.8	73	5
07/19/07	0700	2.02	2.3	0.036	0.04	0.07	<5.0	231	236	1.0	2.3	96	16

Appendix - Water-quality data from August 2005 to July 2007 for the Illinois River sites near Viney Grove, Arkansas; at Savoy, Arkansas; south of Siloam Springs, Arkansas; and near Tahlequah, Oklahoma.—Continued

[ft³/s, cubic feet per second; nm, nanometers; NTRU, nephelometric turbidity ratio units; mg/L, milligrams per liter; °C, degrees Celsius; μs/cm, microsiemens per centimeter; N, nitrogen; P, phosphorus; μg/L, micrograms per liter; <, less than; E, estimated; nm, nanometers; mm, millimeters]

Sample date	Sample time	Nitrite plus nitrate, filtered (mg/L as N) (00631)	Total nitrogen, unfiltered (mg/L as N) (00600)	Ortho-phosphorus, filtered (mg/L as P) (00671)	Phosphorus, filtered (mg/L as P) (00666)	Phosphorus, unfiltered (mg/L as P) (00665)	Biomass, phytoplankton, ash-free dry mass (mg/L) (49953)	Biomass, plankton, ash weight (mg/L) (81533)	Biomass, plankton, dry weight (mg/L) (81354)	Chlorophyll <i>a</i> , phytoplankton, chromatographic, fluorometric method (μg/L) (70953)	Pheophytin <i>a</i> , phytoplankton (μg/L) (62360)	Suspended sediment, sieve diameter (percent smaller than 0.063 mm) (70331)	Suspended sediment concentration (mg/L) (80154)
Illinois River at Savoy, Arkansas (07194800)													
08/31/05	1245	0.41	0.7	0.020	0.04	0.06	<3.8	164	168	1.2	--	92	6
10/26/05	1400	0.59	0.8	E0.010	E0.03	0.05	<3.2	138	140	0.7	0.7	90	55
12/13/05	1215	1.23	1.5	<0.020	<0.04	E0.03	<2.0	88	90	0.8	0.9	86	59
03/07/06	0950	0.52	0.9	E0.010	E0.03	0.05	2.5	95	97	3.0	3.4	82	6
05/03/06	0715	1.27	1.8	0.070	0.09	0.14	4.8	172	177	1.8	4.6	80	19
05/05/06	0715	0.90	2.0	0.100	0.13	0.31	22.5	733	755	5.5	9	85	118
06/22/06	0840	0.71	1.1	0.059	0.07	0.10	3.7	168	172	E3.8	E5.6	76	7
08/16/06	0800	0.14	0.7	0.051	0.05	0.11	6.5	267	273	16.0	7.5	70	9
08/23/06	1610	0.95	5.7	0.051	0.08	1.61	143.8	3,920	4,070	29.1	56.8	93	1,480
10/04/06	0910	3.00	3.3	0.053	0.07	0.09	3.2	145	148	1.7	1.3	87	10
01/17/07	0930	3.19	3.6	0.077	0.07	0.14	7.0	222	229	1.2	1.0	88	26
02/13/07	1600	1.16	2.0	0.165	0.19	0.28	12.7	511	524	5.5	3.7	82	83
03/07/07	1245	2.29	2.5	0.009	<0.04	E0.02	<5.0	225	230	3.7	2.8	74	7
04/10/07	1145	1.97	2.3	0.017	E0.03	0.05	<4.3	190	193	1.1	1.1	80	6
04/25/07	1230	1.57	2.8	0.066	0.08	0.25	15.3	484	499	10.3	16.4	94	86
07/19/07	0815	1.56	1.9	0.057	0.05	0.09	5.0	230	234	3.3	2.5	96	11

Appendix - Water-quality data from August 2005 to July 2007 for the Illinois River sites near Viney Grove, Arkansas; at Savoy, Arkansas; south of Siloam Springs, Arkansas; and near Tahlequah, Oklahoma.—Continued

[ft³/s, cubic feet per second; mm, nanometers; NTRU, nephelometric turbidity ratio units; mg/L, milligrams per liter; °C, degrees Celsius; μs/cm, microsiemens per centimeter; N, nitrogen; P, phosphorus; μg/L, micrograms per liter; <, less than; E, estimated; nm, nanometers; mm, millimeters]

Sample date	Sample time	Nitrite plus nitrate, filtered (mg/L as N) (00631)	Total nitrogen, unfiltered (mg/L as N) (00600)	Ortho-phosphorus, filtered (mg/L as P) (00671)	Phosphorus, filtered (mg/L as P) (00666)	Phosphorus, unfiltered (mg/L as P) (00665)	Biomass, phytoplankton, ash-free dry mass (mg/L) (49953)	Biomass, plankton, ash weight (mg/L) (81533)	Biomass, plankton, dry weight (mg/L) (81354)	Chlorophyll <i>a</i> , plankton, chromatographic-fluorometric method (μg/L) (70953)	Pheo-phytin <i>a</i> , phytoplankton (μg/L) (62360)	Suspended sediment, sieve diameter (percent smaller than 0.063 mm) (70331)	Suspended sediment concentration (mg/L) (80154)
Illinois River south of Siloam Springs, Arkansas (07195430)													
08/31/05	0820	1.32	1.5	0.120	0.12	0.14	<3.3	144	148	0.4	--	87	7
10/26/05	0900	2.03	2.2	0.090	0.10	0.11	<3.2	143	145	0.3	0.6	99	80
12/13/05	0915	2.32	2.6	0.140	0.14	0.14	2.2	89	91	1.5	0.9	94	49
03/07/06	1115	1.59	1.9	0.070	0.08	0.08	1.7	73	75	2.2	3.0	67	3
05/03/06	1115	1.79	2.2	0.090	0.11	0.14	6.6	274	281	1.6	4.1	97	13
05/05/06	0730	1.06	2.5	0.130	0.15	0.48	41.4	1,550	1,590	8.6	18.3	92	276
06/22/06	0740	1.38	1.7	0.110	0.12	0.13	6.5	301	308	E1.4	E3.5	72	12
08/16/06	0710	0.79	1.1	0.138	0.14	0.15	3.8	172	176	1.6	3.6	66	18
08/23/06	1655	1.49	2.8	0.250	0.29	0.54	37.7	1,520	1,560	4.8	11.0	94	256
10/04/06	0810	2.75	3.0	0.094	0.11	0.22	3.0	143	146	0.8	0.9	92	12
01/17/07	1430	3.87	4.2	0.081	0.07	0.13	5.4	196	202	1.1	0.8	91	22
02/13/07	1700	1.67	2.8	0.145	0.16	0.34	22.5	834	856	14.1	9.1	92	201
03/07/07	1045	3.14	3.3	0.018	<0.04	0.04	<3.8	168	171	6.2	2.9	79	3
04/10/07	0920	2.53	2.8	0.042	0.05	0.06	<4.3	190	193	1.4	1.3	82	3
04/25/07	1500	2.14	2.9	0.059	0.07	0.16	9.2	323	332	13.2	19.1	91	61
07/18/07	1000	2.11	2.4	0.080	0.09	0.10	<5.0	233	238	1.9	2.0	79	15

Appendix - Water-quality data from August 2005 to July 2007 for the Illinois River sites near Viney Grove, Arkansas; at Savoy, Arkansas; south of Siloam Springs, Arkansas; and near Tahlequah, Oklahoma.—Continued

[ft³/s, cubic feet per second; mm, nanometers; NTRU, nephelometric turbidity ratio units; mg/L, milligrams per liter; °C, degrees Celsius; μs/cm, microsiemens per centimeter; N, nitrogen; P, phosphorus; μg/L, micrograms per liter; <, less than; E, estimated; nm, nanometers; mm, millimeters]

Sample date	Sample time	Nitrite plus nitrate, filtered (mg/L as N) (00631)	Total nitrogen, unfiltered (mg/L as N) (00600)	Ortho-phosphorus, filtered (mg/L as P) (00671)	Phosphorus, filtered (mg/L as P) (00666)	Phosphorus, unfiltered (mg/L as P) (00665)	Biomass, phytoplankton, ash-free dry mass (mg/L) (49953)		Biomass, plankton, ash weight (mg/L) (81533)	Biomass, plankton, dry weight (mg/L) (81354)	Chlorophyll <i>a</i> , phytoplankton, chromatographic, fluorometric method (μg/L) (70953)		Pheytin <i>a</i> , phytoplankton (μg/L) (62360)	Sus-pended sediment, sieve diameter (percent smaller than 0.063 mm) (70331)	Sus-pended sediment concentration (mg/L) (80154)
							ton, weight	dry mass			μg/L	μg/L			
Illinois River near Tahlequah, Oklahoma (07196500)															
12/07/05	1100	0.55	0.63	0.014	0.03	0.03	<3.0	127	129	0.8	0.8	0.9	56	2	
02/02/06	1400	1.20	1.39	0.023	0.04	0.04	<3.4	149	152	2.5	2.5	2.7	58	3	
04/13/06	1245	0.24	0.50	E0.028	0.03	0.04	<3.2	138	140	3.1	3.1	3.0	48	6	
05/06/06	1100	1.45	2.33	0.104	0.12	0.23	--	--	--	--	--	--	93	91	
06/13/06	1215	0.70	0.86	0.060	0.07	0.08	<3.3	153	155	2.4	2.4	3.2	73	12	
08/08/06	1145	0.09	0.26	0.069	0.07	0.09	3.8	163	167	3.0	3.0	2.5	86	12	
08/24/06	1015	0.69	1.04	0.091	0.11	0.14	4.8	185	190	2.5	2.5	3.0	71	17	
10/03/06	1215	1.81	1.92	0.078	0.09	0.09	<3.0	136	139	1.2	1.2	0.8	--	--	
12/05/06	1030	3.23	3.49	0.085	0.10	0.12	<5.0	233	237	1.1	1.1	1.0	84	20	
02/12/07	1215	3.17	3.27	0.034	0.04	0.05	<3.2	141	144	1.5	1.5	0.4	87	4	
02/14/07	1115	2.55	3.44	0.088	0.10	0.22	18.5	746	764	12.3	12.3	7.4	84	140	
04/03/07	1030	1.80	2.00	0.038	0.05	0.06	<3.6	159	162	6.5	6.5	4.0	--	--	
04/26/07	0930	1.50	1.76	0.046	0.05	0.07	<7.5	338	343	2.8	2.8	5.5	77	8	
06/07/07	0945	0.98	1.17	0.056	0.06	0.07	<3.8	165	168	3.4	3.4	3.5	--	--	
07/18/07	0800	1.03	1.22	0.062	0.07	0.07	<5.0	226	230	3.2	3.2	2.6	84	8	

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