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Water Quality Monitoring and Constituent Load Estimation in the Upper Illinois River Watershed, 2009

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The Arkansas Water Resources Center (AWRC) monitored water quality at eight sites in the Upper Illinois River Watershed (UIRW) during base flow conditions and storm events from July 1, 2009 through June 30, 2010. Water samples were collected manually with an alpha or Kemmerer style sampler and analyzed for nitrate-nitrogen (NO_3-N), sulfate (SO_4), chloride (Cl), soluble reactive phosphorus (SRP), total phosphorus (TP), dissolved ammonia (NH_3-N), total N (TN), total suspended solids (TSS), and turbidity. Physico-chemical parameters were measured in the field including pH, conductivity, water temperature, and dissolved oxygen concentration. The selected sites were at established discharge monitoring stations maintained by the US Geological Survey or AWRC, and constituent loads were determined using regression models between constituent concentrations, discharge, and seasonal factors to estimate daily loads, which were then summed to produce monthly and annual load estimates. The constituent loads and annual flow-weighted concentrations for the 2009 calendar year are summarized in the tables below, using the data collected in this study. The regression models were applied throughout the discharge record of the entire calendar year to estimate loads.

Summary of calculated total loads (kg) for each parameter at the sampled sites in the Upper Illinois River Watershed for the period, January through December 2009.

Site	Cl	SO_4	NH_3-N	NO_3-N	SRP	TN	TP	TSS
Ballard Creek	461,000	767,000	5,300	119,000	21,000	139,000	29,000	6,492,000
Baron Fork	258,000	748,000	2,800	81,000	6,100	117,000	9,800	1,290,000
Flint Creek (W. Siloam)	521,000	1,201,000	1,300	116,000	2,400	130,000	5,300	1,852,000
Flint Creek (Springtown)	101,000	92,000	1,300	56,000	1,700	62,000	2,600	447,000
Illinois River (AR59)	8,011,000	9,546,000	31,000	1,740,000	82,000	1,970,000	236,000	111,961,000
Illinois River (Savoy, AR)	1,656,000	3,144,000	21,000	392,000	39,000	530,000	72,000	20,556,000
Illinois River (Watts, OK)	7,694,000	9,434,000	38,300	1,861,000	85,500	2,194,000	241,000	77,038,000
Mud Creek Tributary	14,000	18,000	100	900	60	1,600	300	1,342,000
Osage Creek	3,200,000	3,310,000	16,500	607,000	15,300	670,000	40,700	24,900,000

Summary of calculated flow weighted concentrations (FWC, mg L^{-1}) for each parameter at the sampled sites in the Upper Illinois River Watershed for the period, January through December 2009.

Site	Cl	SO_4	NH_3-N	NO_3-N	SRP	TN	TP	TSS
Ballard Creek	7.61	12.67	0.09	1.97	0.34	2.29	0.49	107
Baron Fork	4.63	13.45	0.05	1.46	0.11	2.10	0.18	23
Flint Creek (W. Siloam)	9.56	21.93	0.02	2.12	0.04	2.37	0.10	34
Flint Creek (Springtown)	5.76	5.21	0.07	3.18	0.10	3.52	0.15	322
Illinois River (AR59)	10.93	13.02	0.04	2.37	0.11	2.69	0.32	153
Illinois River (Savoy, AR)	6.97	13.24	0.09	1.65	0.16	2.23	0.30	87
Illinois River (Watts, OK)	9.41	11.54	0.05	2.28	0.10	2.68	0.30	94
Mud Creek Tributary	8.53	11.14	0.07	0.56	0.04	0.95	0.16	824
Osage Creek	16.25	16.81	0.08	3.08	0.08	3.40	0.21	126

ABBREVIATIONS: Chloride (Cl), Sulfate (SO_4), Ammonia-Nitrogen (NH_3-N), Nitrate-Nitrogen (NO_3-N), Soluble Reactive Phosphorus (SRP), Total Nitrogen (TN), Total Phosphorus (TP), Total Suspended Solids (TSS), Upper Illinois River Watershed (UIRW), Arkansas Water Resources Center (AWRC), Arkansas Natural Resources Commission (ANRC), Arkansas Department of Environmental Quality (ADEQ)

INTRODUCTION

The headwaters of the Illinois River originate near Hogeye in northwest Arkansas, and the river flows northwesterly through the Ozarks, into Oklahoma and eventually into Lake Tenkiller Ferry. The main tributaries to the Illinois River in northwest Arkansas include Osage Creek, Clear Creek, Flint Creek, Baron Fork and Muddy Fork. The Illinois River and its tributaries drain 1960 km^2 that are forest (41%) and agricultural lands (i.e., primarily pasture and forages; 46%); however, over the past decade increases in residential, commercial and industrial development have been observed (i.e., urban land use has increased to 13%). The Illinois River is used for recreation, aquatic life and refuge, and agricultural, industrial and residential water supply by some communities in northwest Arkansas and northeast Oklahoma. The Illinois River and its tributaries also provide the ecological service of wastewater treatment as several headwater tributaries receive treated effluent from wastewater treatment plants.

Because of the Illinois River's varying designnated uses in Arkansas and Oklahoma, the river is center to many political, scientific and legal debates. Several stream reaches within the Illinois River and its tributaries (including Muddy Fork, Clear Creek, Osage Creek, Spring Creek and Little Osage Creek) were either included on Arkansas Department of Environmental Quality's (ADEQ) 2008 303d list (ADEQ, 2008) or added to the list by the U.S. Environmental Protection Agency (USEPA); the Arkansas Natural Resources Commission (ANRC) has also listed the Illinois River drainage area as a priority 319 watershed. Therefore, monitoring water quality at multiple sites spanning the Upper Illinois River Watershed (UIRW) is important, and the catchments of the selected sites need to represent a myriad of land uses from mostly residential development to that dominated by pasture.

The focus within the UIRW has primarily been on phosphorus (P), but stream reaches on ADEQ's 303(d) list in 2008 also identified pathogens, sediment and nitrate as the pollutants of concern. However, much of the monitoring and scientific investigations have addressed P sources, concentrations and loads within this catchment. The long term monitoring of the Illinois River in northwest Arkansas has shown that flow-adjusted P loads were decreasing from 2002 through 2008 (Haggard, 2010). Massey et al. (2009) showed that the transport of P and other constituents was clearly related to the amount of water flowing past a site.

Water quality monitoring within the UIRW is critical to understanding the contribution from different land uses and how water quality is changing over time. Eight sites were selected within the UIRW in July 2009, where these sites drained catchments representing urban, pasture and mixed land uses. The selected sites have been historically monitored for water quality by the ADEQ, Arkansas Water Resources Center (AWRC) and or the US Geological Survey (USGS). Continuous discharge (i.e., daily discharge records) was available at the selected sites through the AWRC or USGS. This report presents the annual loads and flow-weighted concentrations (FWC) of select constituents at this site for the 2009 calendar year. Semi-annual loads from 1 January to 30 June 2010 are also presented for all sampled sites in the appendix.

STUDY SITE DESCRIPTIONS

The selected sites encompass the UIRW and includ sites on the Illinois River and its tributaries, Ballard Creek, Baron Fork, Flint Creek, and Osage Creek. These sites are representative of various geographic positions in the UIRW and land uses, including catchments dominated by urban development (Mud Creek Tributary), pasture (Ballard Creek and Flint

Creek), and mixed land uses. Many of these sites are downstream from effluent discharges, which have been shown to change water chemistry in streams during base flow conditions (Ekka et al., 2006).

Ballard Creek (AWRC Discharge and Water Quality Monitoring Station)

Ballard Creek lies in the south-central and western portion of the UIRW and flows northwesterly into Oklahoma. Ballard Creek drains approximately 62 km^2 in Arkansas of which 36% is forest, 59% is pasture and 4% is urban land use. A sampling station was installed in 2001 at the Washington County Road 76 Bridge over Ballard Creek to monitor water quality and discharge. Since July 2002, continuous stage and discharge measurements and water quality samples have been used to determine loads and flow-weighted concentrations (FWC) from Ballard Creek. Average annual discharge at this site over the past decade has ranged from 0.9 m^3 s^{-1} in 2006 to 1.8 m^3 s^{-1} in 2008.

Baron Fork at Dutch Mills (USGS Station No. 07196900)

Baron Fork lies in the southern portion of the UIRW and drains a 105 km^2 area; land use distribution is 57% forest, 40% pasture and 3% urban within the drainage area. The USGS began monitoring discharge at Baron Fork (near Dutch Mills, AR) in 1954. Average annual discharge at this site has ranged from 0.4 to 2.4 m^3 s^{-1} over the past decade.

Flint Creek at Springtown (USGS Station No. 07195800)

Flint Creek lies in the northern portion of the UIRW flowing southwesterly into Oklahoma. At this site, Flint Creek drains a 104 km^2 of which 39% is forest, 53% is pasture and 8% is urban. The USGS began monitoring discharge at Flint Creek (near Springtown, AR) in 1962. Average annual discharge at this site over the past decade ranged from 0.3 m^3 s^{-1} in 2006 to 2.1 m^3 s^{-1} in 2008.

Flint Creek near West Siloam Springs (USGS Station No. 07195855)

Flint Creek near West Siloam Springs, Oklahoma lies just across the state border. At this site, Flint Creek drains 180 km^2 of which 30% is forest, 57% is pasture and 13% is urban. The USGS began monitoring discharge at Flint Creak (near West Siloam Springs, OK) in 1979. Average annual discharge at this site over the past decade ranged from 0.1 m^3 s^{-1} in 2006 to 0.7 m^3 s^{-1} in 2008. This site is upstream of the influence of the effluent discharge from the City of Siloam Springs into Sager Creek, which is a tributary to Flint Creek.

Illinois River at Highway 59 (USGS Station No. 07195430)

The Illinois River at Highway 59 (AR59, South of Siloam Springs, Arkansas) is the outlet of the Illinois River drainage area in the UIRW. At this point, the Illinois River drains 1490 km^2 of which 41% is forest, 46% is pasture and 13% is urban. The USGS began monitoring discharge at this site in 1995, and the AWRC has monitored this site since 1997. Average annual discharge over the past decade has ranged from 5.2 m^3 s^{-1} in 2006 to 30 m^3 s^{-1} in 2008. The water quality at this site is influenced by upstream tributaries in the watershed including Osage Creek, Clear Creek, and the Muddy Fork. Treated wastewater effluent from the Cites of Rogers, Springdale, and Fayetteville, along with other smaller cities are discharged into tributaries to the Illinois River upstream of this site.

Illinois River at Savoy (USGS Station No. 07194800).

The Illinois River at Savoy drains 433 km^2 of which 70% is forest, 28% is pasture and 2% is urban. The USGS began monitoring discharge at this site in 1979; average annual discharge over the past decade has ranged from 1.3 m^3 s^{-1} in 2006 to 7.9 ft^3 s^{-1} in 2008. The Illinois River at Savoy is downstream of the convergence of Goose Creek and the Illinois River; Goose Creek receives the treated wastewater effluent from the City of Fayetteville's Westside facility.

Illinois River near Watts, Oklahoma (USGS Station No.07195500)

The Illinois River at Watts, Oklahoma drains 1530 km^2 of mixed forest, pasture and urban land use. The USGS began monitoring discharge at this site in 1956; average annual discharge over the past decade has ranged from 6.5 m^3 s^{-1} in 2006 to 32.5 ft^3 s^{-1} in 2008. The Illinois River at Watts, Oklahoma lies downstream of Lake Frances in the northeastern portion of the Lower Illinois River Watershed (LIRW).

Mud Creek Tributary (USGS Station No. 07194809)

Niokaska Creek, a tributary to Mud Creek, originates in the western portion of the UIRW, within the City of Fayetteville, and drains a 3 km^2 which is 25% forest, 14% pasture and 61% urban. The USGS began monitoring discharge at Niokaska Creek (at Township Street in Fayetteville, AR) in 1996. Average annual discharge at this site over the past decade ranged from 0.01 m^3 s^{-1} in 2005 to 0.1 m^3 s^{-1} in 2008.

Osage Creek near Elm Springs (USGS Station No. 07195000)

Osage Creek, originates in the northwestern portion of the UIRW, and drains a 337 km^2 which is 20% forest, 36% pasture and 44% urban; the Cities of Rogers and Springdale lie within this drainage area. The USGS began monitoring discharge at Osage Creek (near Elm Springs, AR) in 1951. Average annual discharge at this site over the past decade ranged from 2.2 m^3 s^{-1} in 2006 to 8.5 m^3 s^{-1} in 2008. The treated effluent from the municipalities in Rogers and Springdale are discharged into Osage Creek upstream from this monitoring site.

METHODS

Sample Collection

Storm and base flow events in the Illinois River Drainage Area were sampled from July 1, 2009 through June 30, 2010 at eight locations on selected streams, including Mud Creek tributary, Baron Fork, Flint Creek, Osage Creek, Ballard Creek and the Illinois River just upstream of the Arkansas-Oklahoma border. The water samples were collected at the bridges on the Mud Creek tributary at Township Road, on Osage Creek near Elm Springs, on Ballard Creek at County Road 76, on the Baron Fork near Dutch Mills, on Flint Creek near West Siloam Springs and at Springtown, on the Illinois River at Arkansas Highway 59 and at Savoy. Water samples were collected using an Alpha style horizontal sampler or a Kemmerer type vertical sampler near the vertical centroid of flow (i.e., middle of the channel where water is actively moving). Water samples were collected every 168 hours, on average, at each site where up to 25% of the collected samples represented storm event or surface runoff conditions following episodic rainfall events, including small and large storm events.

Physico-chemical parameters including pH, conductivity, temperature, and dissolved oxygen concentration were measured on site. All water samples were delivered to the AWRC Water Quality Laboratory (WQL) and analyzed for nitrate-nitrogen (NO_3-N), sulfate (SO_4), chloride (Cl), soluble reactive phosphate (SRP), total phosphorus (TP), dissolved ammonia (NH_3-N), total nitrogen (TN), total suspended solids (TSS), and turbidity. Duplicate samples were collected at a frequency of 10% throughout the duration of the project for quality assurance and quality control purposes. All water samples were analyzed following analytical procedures as outlined in the quality assurance project plan.

Load Determination and Mean Concentrations

Constituent loads (L) were calculated at all sites using the constituent concentration data from the collected samples and average daily discharge data (Q_d) from the USGS from desired time periods. Daily measured loads were calculated by multiplying Q_d by a corresponding constituent concentration. The measured loads were plotted as a function of Q_d and then linear regression was used to develop an equation that describes daily constituent loads (L_d) at each site as a function of measured discharge. The basic log-log linear regression model for L_d can be expressed solely as a function of discharge:

$$\ln(L_d) = \beta_0 + \beta_1 \ln(Q_d) \qquad (1)$$

where ln represents the natural logarithm function, β_o is a constant, β_1 is the coefficient for discharge and Q_d is the daily mean discharge (cfs). Regression models were also developed to consider seasonal influences:

$$\ln(L_d) = \beta_0 + \beta_1 \ln(Q_d) + \beta_2 \sin(2\pi T) + \beta_3 \sin(2\pi T) \qquad (2)$$

where β_2 and β_3 are the coefficients for seasonal variation and T is decimal time.

Log-log regression often results in bias when transforming the log values where the values are often under-estimated. Therefore, a non-parametric bias correction factor (BCF; Helsel and Hirsh, 2002) was calculated and used when transforming the logarithmic results back to actual daily loads. BCF for natural logarithmic transformation is:

$$\text{BCF}= \frac{\sum e^{e}{}_{i}}{n} \qquad (3)$$

where n is the number of samples and e_i is the residual or difference between measured and estimated loads in natural log units. This factor was multiplied by the re-transformed value to account for any bias.

Daily loads often show two distinct relations with Q_d representing different flow regimes (e.g., base flow conditions and storm events). Thus, load estimation using regression models can be complex requiring the model developer to really get to know the data. This project evaluated whether all the data could be used to develop regression models, or whether the data needed to be split at some breakpoint separating the data into flow regimes. Then, separate regression models would be developed based on the breakpoint. The appropriate regression model (i.e., equation 1 or 2) was selected based upon the coefficient of determination (R^2), calculated BCFs, and visual observation of any breakpoints in the relations between L_d and Q_d. Seasonal factors were included in the regression models (i.e., Equation 2) for all data or data representing the low flow regimes, when the regression coefficients were both significant and or when the regression model with seasonal factors explained an additional 5% of the variation in L_d. Whereas, only equation 1 was used with the data representing the high flow regime or storm event conditions.

The selected regression model was then used to estimate L_d. The estimated loads were multiplied by the calculated BCF and summed into annual loads during the calendar year. The annual FWC (mg L^{-1}) was determined by dividing the total load (kg) by the annual discharge volume (m^3).

Table 1. Minimum, Maximum and geometric mean of physico-chemical parameters at the Illinois River at AR59 from 1 July 2009 to 30 June 2010.

Parameter	Minimum	Maximum	Geometric Mean
pH	7.7	8.9	8.0
Conductivity (µS cm^{-1})	182	343	296
Dissolved Oxygen (mg L^{-1})	5.8	16.6	8.9
Temperature (^oC)	1.7	26.4	11.1

RESULTS

Illinois River at Highway 59

Physico-chemical parameters were measured on-site during this project period (i.e., from 1 July 2009 to 30 June 2010). Physico-chemical parameters varied seasonally and with episodic rainfall events; a summary of the parameters measured at Illinois River at AR59 are provided in Table 1. The physico-chemical properties of the Illinois River at this site were within the expected range, relative to a stream influenced by effluent discharges in the headwaters and mixed land uses.

Discharge and constituent concentrations were variable throughout the year showing the effects of episodic rainfall events and seasonal influences. Average daily flow during 2009 at the Illinois River at the AR59 bridge was 1,986,000 m^3, but was as great as 50,077,440 m^3 during storm events. Total annual discharge was 733,084,000 m^3 which is approximately 75% of that observed during 2008. A total of 49 samples collected during the study period at Illinois River at AR59 were used in linear regression with flow to estimate annual loads for 2009; two data points were not used, because corresponding flow data was not available from the USGS. Five parameters (i.e., NO_3-N, SO_4, Cl, TN, and NH_3-N) were adequately described by one equation for all flow regimes, while three parameters (i.e., SRP, TP, and TSS) required separate equations for low flow and high flow regimes. The amount of variation in the dependent variable explained by the selected linear regression models ranged from 70% to 98% for all equations (P<0.001). A summary of the regression equations used and statistical significance of the selected models is provided in Table 2.

Table 2. Regression equations and statistics of linear regression model(s) used to estimate constituent loads at Illinois River at AR59 Bridge during calendar year 2009.

Parameter	Regression Equation	Flow Regime	R^2	P
NO_3-N	$\ln(L_d) = 2.35 + 0.92\ln(Q_d) + 0.13\sin(2\pi T) + 0.83\cos(2\pi T)$	All	0.98	<0.001
SO_4	$\ln(L_d) = 3.96 + 0.93\ln(Q_d)$	All	0.98	<0.001
Cl	$\ln(L_d) = 4.40 + 0.85\ln(Q_d)$	All	0.95	<0.001
SRP	$\ln(L_d) = -3.33 + 1.13\ln(Q_d) - 0.71\sin(2\pi T) - 0.67\cos(2\pi T)$	Low	0.79	<0.001
	$\ln(L_d) = -8.04 + 1.81\ln(Q_d)$	High	0.96	<0.001
TP	$\ln(L_d) = -4.78 + 1.47\ln(Q_d) - 0.51\sin(2\pi T) - 0.61\cos(2\pi T)$	Low	0.87	<0.001
	$\ln(L_d) = -10.12 + 2.17\ln(Q_d)$	High	0.95	<0.001
TN	$\ln(L_d) = 2.08 + 0.97\ln(Q_d) - 0.08\sin(2\pi T) - 0.09\cos(2\pi T)$	All	0.99	<0.001
NH_3-N	$\ln(L_d) = -4.85 + 1.28\ln(Q_d) - 0.33\sin(2\pi T) - 0.34\cos(2\pi T)$	All	0.70	<0.001
TSS	$\ln(L_d) = -1.28 + 1.64\ln(Q_d) - 0.34\sin(2\pi T) - 0.69\cos(2\pi T)$	Low	0.88	<0.001
	$\ln(L_d) = -9.75 + 2.79\ln(Q_d)$	High	0.92	<0.001

Table 3. Bias Correction Factors (BCF), annual loads (kg) and flow-weighted concentrations (FWC) for each constituent at Illinois River at AR59 during 2009.

Parameter	BCF			Total Load	FWC
	All Flows	Low Flow	High Flow	(kg)	($mg\ L^{-1}$)
Cl	1.02	--	--	8,011,000	10.93
SO_4	1.01	--	--	9,546,000	13.02
NH_3-N	1.39	--	--	31,000	0.04
NO_3-N	1.01	--	--	1,740,000	2.37
SRP	--	1.08	1.03	82,000	0.11
TN	1.00	--	--	1,970,000	2.69
TP	--	1.05	1.04	236,000	0.32
TSS	--	1.06	1.13	111,961,000	153

The calculated BCFs ranged from 1.00 (for TN across all flows) to 1.39 (for NH_3-N across all flows) for the selected parameters at Illinois River at AR59. Illinois River at AR59 exhibited the highest parameter loads of all monitored sites, because this site drains the largest catchment area and is the watershed outlet. However, the calculated loads at this site for calendar year 2009 were less than those observed in 2008 [as expected], because total discharge volume in 2009 was less than that observed in 2008. FWC decreased or remained constant for most parameters, except for Cl and SO_4, for which FWC increased 27% and 22%, respectively. The BCF, total loads and FWC during 2009 are shown in Table 3.

Daily loads are presented in Figure 1, and this figure shows the order of magnitude difference between daily constituent loads and flow regimes at the Illinois River at Highway 59. The daily constituent loads clearly show the influence of episodic storm events which re-suspend materials from within the fluvial channel and transport these materials from the landscape to tributary streams. Daily loads were summed to produce monthly loads, which were also influenced by the frequency and intensity of storm events. Higher loads were observed during the rainy seasons of spring and fall, and the highest loads observed during May and October. Loads were least during summer and winter months. A summary of the monthly loads from CY 2009 are presented in Table 4. Semi-annual and monthly loads were also summed through June 2010 and are presented in Appendices 4 and 5.

Table 4. Summary of estimated monthly loads (kg) for each constituent at the Illinois River at Arkansas AR59 for Calendar Year 2009.

Month	Cl	SO_4	NH_3-N	NO_3-N	SRP	TN	TP	TSS
January	441,000	489,000	700	99,400	1,390	108,000	2,570	414,000
February	796,000	932,000	1,540	193,000	3,450	212,000	6,580	1,150,000
March	603,000	690,000	1,170	142,000	2,310	151,400	4,220	666,000
April	1,104,000	1,330,000	3,170	262,000	7,330	287,600	15,860	3,830,000
May	1,699,000	2,144,000	7,470	395,000	18,900	450,000	46,500	13,800,000
June	547,000	607,000	1,610	105,000	2,140	112,000	3,820	416,000
July	300,000	312,000	730	51,000	1,530	53,600	2,190	197,000
August	273,000	282,000	690	44,500	1,590	47,600	2,090	172,000
September	459,000	512,000	1,710	80,200	2,880	91,900	4,750	650,000
October	1,304,000	1,745,000	11,400	275,400	39,000	356,000	146,000	90,500,000
November	214,000	223,000	410	38,900	590	42,000	820	87,000
December	273,000	281,000	330	54,400	370	57,500	590	45,800

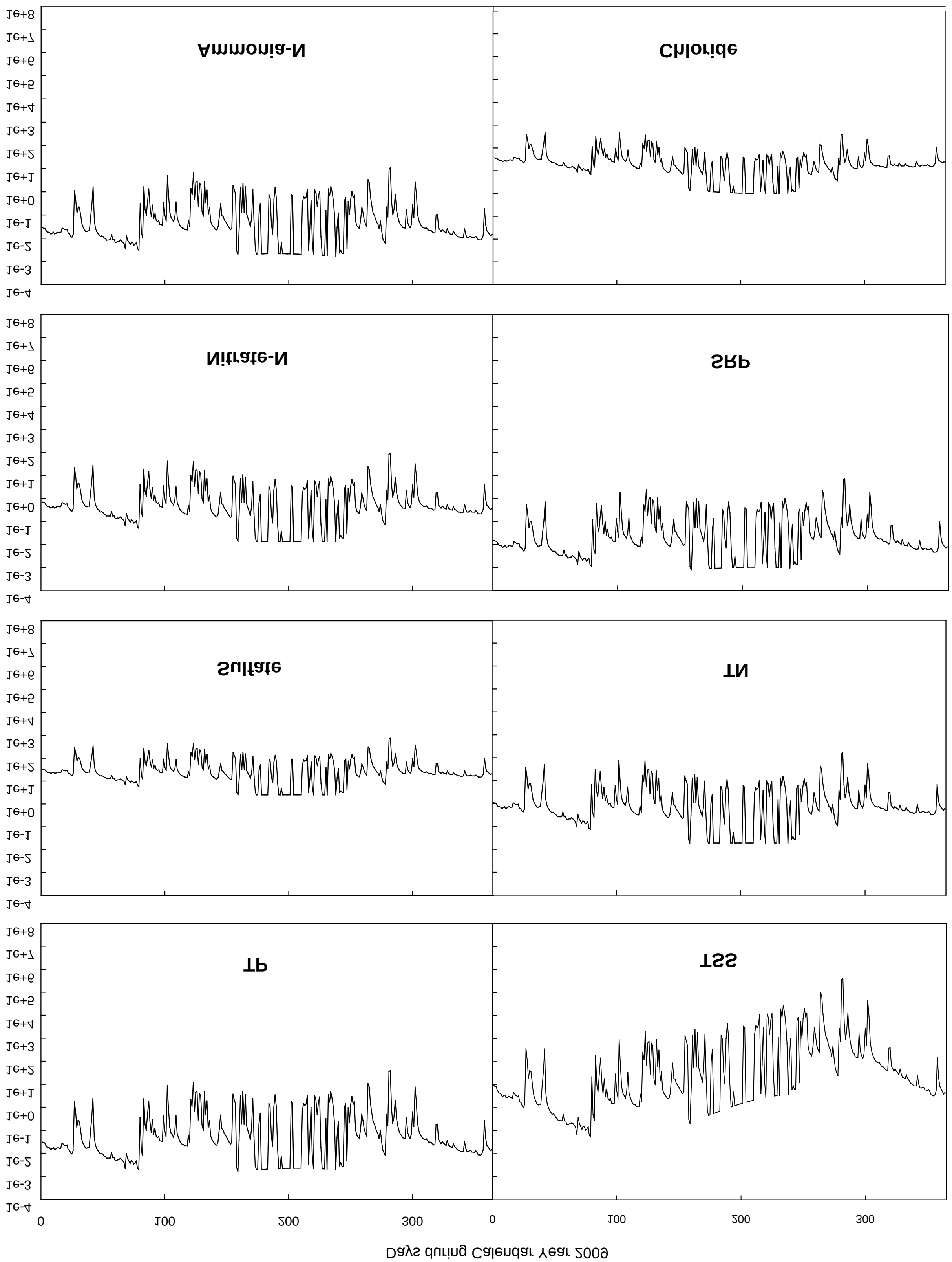

Figure 1. Daily constituent loads (kg d^{-1}) as a function of time (d) at the Illinois River at AR59 during 2009.

Table 5. Minimum, Maximum and geometric mean of physico-chemical parameters at Ballard Creek from 1 July 2009 to 30 June 2010.

Parameter	Minimum	Maximum	Geometric Mean
pH	7.4	8.4	7.9
Conductivity (µS cm^{-1})	99	384	285
Dissolved Oxygen (mg L^{-1})	2.6	16.6	8.5
Temperature (^oC)	0.6	26.0	8.8

Ballard Creek

Physico-chemical parameters were measured on-site during this project period (i.e., from 1 July 2009 to 30 June 2010). A summary of the physico-chemical parameters at Ballard Creek is provided in Table 5. The physico-chemical properties of this site were within the expected range, relative to a stream influenced by sample collection timing, variable hydrology, local geology, climatic conditions, and pasture land use within the catchment.

Average daily flow during 2009 at Ballard Creek was 150,000 m^3 and total annual discharge was 60,545,000 m^3; annual discharge was similar to that observed during 2008. From the period July 1 to December 30, 2009, a total of 54 samples were collected at Ballard Creek, analyzed, and used in linear regression with flow to estimate annual loads for 2009.

Chloride, NH_3-N and TSS were adequately described by one equation for all flow regimes, while the other parameters required separate equations for low flow and high flow regimes. Select constituents were better represented when seasonal influences were considered, including NH_3-N, SRP, TP and SO_4. The amount of variation in the dependent variable explained by the selected linear regression equations ranged from 53% to 96% for all equations ($P \leq 0.002$). A summary of the regression equations used and statistical significance of the selected models is provided in Table 6.

The calculated BCFs ranged from 1.00 (SO_4) to 2.03 (TSS) for the selected parameters at Ballard Creek. Calculated loads at this site for calendar year 2009 were less than those observed in 2008, for all parameters except SRP, TP and TSS which increased by 44%, 9%, and 24%, respectively. However, flow at Ballard

Table 6. Regression equation and statistics of linear regression model used to estimate constituent loads at Ballard Creek during calendar year 2009.

Parameter	Regression Equation	Flow Regime	R^2	P
NO_3-N	$\ln(L_d) = -0.44 + 1.64 \ln(Q_d)$	Low	0.71	<0.001
	$\ln(L_d) = 1.47 + 0.91 \ln(Q_d)$	High	0.76	0.002
SO_4	$\ln(L_d) = 3.43 + 1.07 \ln(Q_d) + 0.17\sin(2\pi T) + 0.29\cos(2\pi T)$	Low	0.96	<0.001
	$\ln(L_d) = 0.93 + 0.92 \ln(Q_d)$	High	0.93	<0.001
Cl	$\ln(L_d) = 4.45 + 0.67 \ln(Q_d)$	All	0.93	<0.001
SRP	$\ln(L_d) = -8.94 + 2.90 \ln(Q_d) + 0.63\sin(2\pi T) + 1.26\cos(2\pi T)$	Low	0.62	<0.001
	$\ln(L_d) = -1.66 + 1.28 \ln(Q_d)$	High	0.92	<0.001
TP	$\ln(L_d) = -6.46 + 2.36 \ln(Q_d) - 0.53\sin(2\pi T) - 0.98\cos(2\pi T)$	Low	0.53	<0.001
	$\ln(L_d) = -0.65 + 1.18 \ln(Q_d)$	High	0.82	<0.001
TN	$\ln(L_d) = 0.27 + 1.47 \ln(Q_d)$	Low	0.75	<0.001
	$\ln(L_d) = 2.12 + 0.89 \ln(Q_d)$	High	0.95	<0.001
NH_3-N	$\ln(L_d) = -3.61 + 1.30 \ln(Q_d) - 0.16\sin(2\pi T) - 0.95\cos(2\pi T)$	All	0.68	<0.001
TSS	$\ln(L_d) = -1.10 + 1.91 \ln(Q_d) - 0.08\sin(2\pi T) - 0.95\cos(2\pi T)$	All	0.75	<0.001

Table 7. Bias correction factors (BCF), calculated annual loads (kg) and flow-weighted concentrations (FWC) for each constituent at Ballard Creek during 2009.

Parameter	BCF			Total Load	FWC
	All Flows	Low Flow	High Flow	(kg)	(mg L^{-1})
Cl	1.01	--	--	461,000	7.61
SO_4	--	1.00	1.02	767,000	12.67
NH_3-N	1.37	--	--	5,300	0.09
NO_3-N	--	1.03	1.19	119,000	1.97
SRP	--	1.15	1.11	21,000	0.34
TN	--	1.02	1.03	139,000	2.29
TP	--	1.14	1.27	29,000	0.49
TSS	2.03	--	--	6,492,000	107

Creek increased 10% compared to 2008, and observed loads are often closely tied to annual flow volume. FWC for SRP and TSS also increased 30 and 15%, respectively, but remained similar for TP. The BCF, total loads and FWC for each parameter during 2009 are presented in Table 7.

The daily loads are depicted in Figure 2, showing the variability in loads associated with seasonal precipitation patterns (i.e., rainy spring and fall) typical for this region. The hydrologic nature of Ballard Creek is very flashy during spring and fall, while relatively buffered during summer and winter. Daily loads were summed to produce monthly loads, and the same flashy nature of Ballard Creek was observed in monthly loads. Higher loads were observed during the rainy seasons of spring and fall with the highest loads observed in October. Loads were least during the drier summer and winter. A summary of the monthly loads from CY 2009 are presented in Table 8. Semi-annual loads and monthly were also summed through June 2010 and are presented in Appendices 4 and 5.

Baron Fork at Dutch Mills

Physico-chemical parameters were measured on-site during this project period (i.e., from 1 July 2009 to 30 June 2010). A summary of the physico-chemical parameters at Baron Fork is provided in Table 9. The physico-chemical properties of this site were within the expected range, relative to a stream influenced by sample collection timing, variable hydrology, local geology, climatic conditions and mixed land uses.

Table 8. Summary of estimated monthly loads (kg) for each constituent at Ballard Creek near Fayetteville for Calendar Year 2009.

Month	Cl	SO_4	NH_3-N	NO_3-N	SRP	TN	TP	TSS
January	33,900	67,600	65	7,420	370	9,040	660	14,200
February	47,700	94,600	170	9,190	1,700	13,800	2,890	63,500
March	43,900	89,200	190	12,200	950	13,400	1,630	55,600
April	40,700	73,600	290	12,100	950	12,700	1,530	109,000
May	51,900	85,500	1,030	13,400	3,070	16,700	4,550	846,000
June	22,200	22,300	170	4,270	130	4,350	220	21,800
July	21,500	18,800	170	3,740	140	3,870	240	19,500
August	21,700	19,000	140	3,820	140	3,950	240	16,200
September	39,300	57,400	500	10,000	1,640	11,600	2,460	259,000
October	75,600	129,000	2,400	24,000	11,400	31,400	14,600	5,070,000
November	31,600	52,800	81	10,000	150	9,350	260	13,500
December	30,600	57,400	53	8,820	60	8,370	130	8,610

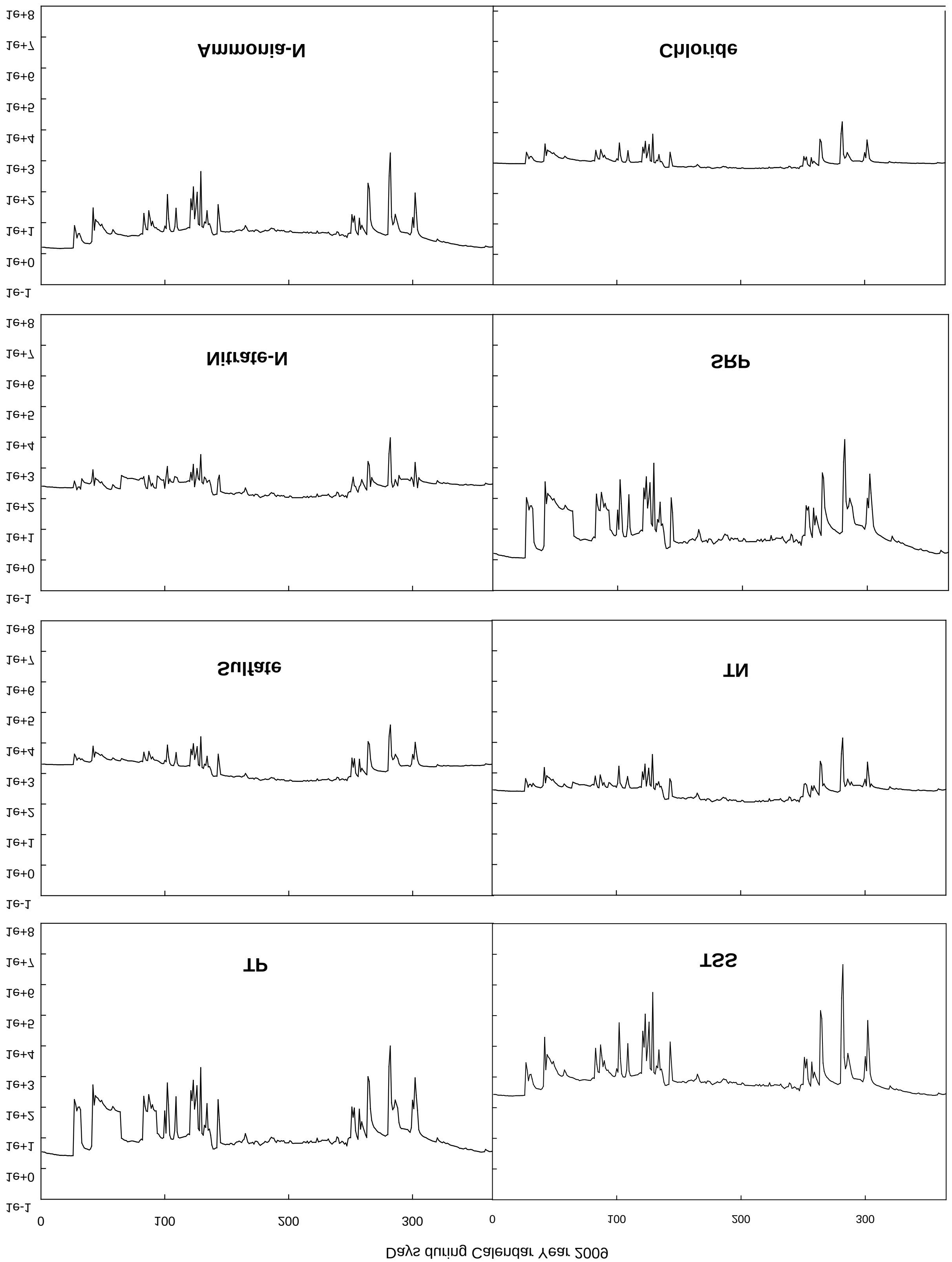

Figure 2. Daily constituent loads (kg d^{-1}) as a function of time (d) at Ballard Creek during 2009.

Table 9. Minimum, Maximum and geometric mean of physico-chemical parameters at Baron Fork at Dutch Mills from 1 July 2009 to 30 June 2010.

Parameter	Minimum	Maximum	Geometric Mean
pH	7.7	8.5	7.9
Conductivity (µS cm^{-1})	129	334	274
Dissolved Oxygen (mg L^{-1})	4.6	16.6	8.8
Temperature (^oC)	0.70	27.2	9.3

Average daily flow during 2009 at Baron Fork was 151,000 m^3 and total annual discharge was 60,545,000 m^3. From the period July 1 to December 30, 2009, a total of 55 samples were collected at Baron Fork, analyzed, and used in linear regression with flow to estimate annual loads for 2009. Most parameters (6 of 8) were adequately described by one equation for all flow regimes, while NO_3-N and TN were better described by separate equations for low flow and high flow regimes. Several constituents used regression models to estimate loads that included seasonal influences, except NO_3-N and TN which relied solely on the relation between L_d and Q_d. The amount of variation in the dependent variable explained by the selected linear regression equations ranged from 69% to 99% for all equations (P≤0.006). A summary of the regression equations used and statistical significance of the selected regression models is provided in Table 10.

The calculated BCFs ranged from 0.77 to 1.27 for the selected parameters at Baron Fork, and the BCFs, total loads and FWC for each parameter during 2009 are presented in Table 11. These are the first load estimates and annual FWCs available at the Baron Fork, which had not been previously monitored by the AWRC. This information is vital to future watershed modeling efforts in the Illinois River drainage area in northwest Arkansas, because little information is available about constituent transport in the southern portion of this watershed. The southern portion of this watershed likely has different soils, topography, and landscape influences compared to the parts of the watershed that have been historically monitored by the AWRC.

Daily loads are presented in Figure 3, showing order of magnitude differences in L_d between flow regimes at the Baron Fork. This load graph

Table 10. Regression equations and statistics of linear regression models used to estimate constituent loads at Baron Fork at Dutch Mills during calendar year 2009.

Parameter	Regression Equation	Flow Regime	R^2	P
NO_3-N	$\ln(L_d) = 0.08 + 1.42 \ln(Q_d)$	Low	0.94	<0.001
	$\ln(L_d) = 2.00 + 0.85 \ln(Q_d)$	High	0.69	0.006
SO_4	$\ln(L_d) = 4.05 + 0.88 \ln(Q_d) - 0.17\sin(2\pi T) + 0.25\cos(2\pi T)$	All	0.99	<0.001
Cl	$\ln(L_d) = 3.58 + 0.76 \ln(Q_d) + 0.07\sin(2\pi T) + 0.11\cos(2\pi T)$	All	0.98	<0.001
SRP	$\ln(L_d) = -3.64 + 1.39 \ln(Q_d) - 0.45\sin(2\pi T) - 0.68\cos(2\pi T)$	All	0.98	<0.001
TP	$\ln(L_d) = -3.36 + 1.42 \ln(Q_d) - 0.47\sin(2\pi T) - 0.93\cos(2\pi T)$	All	0.96	<0.001
TN	$\ln(L_d) = 0.47 + 1.34 \ln(Q_d)$	Low	0.76	<0.001
	$\ln(L_d) = 1.91 + 0.93 \ln(Q_d)$	High	0.89	<0.001
NH_3-N	$\ln(L_d) = -3.47 + 1.19 \ln(Q_d) - 0.43\sin(2\pi T) - 1.08\cos(2\pi T)$	All	0.84	<0.001
TSS	$\ln(L_d) = -0.02 + 1.60 \ln(Q_d) - 0.47\sin(2\pi T) - 1.61\cos(2\pi T)$	All	0.87	<0.001

Table 11. Bias correction factors (BCF), calculated annual loads (kg) and flow-weighted concentrations (FWC) for each constituent at Baron Fork at Dutch Mills during 2009.

Parameter	BCF			Total Load	FWC
	All Flows	Low Flow	High Flow	(kg)	(mg L^{-1})
Cl	1.01	--	--	258,000	4.63
SO_4	1.01	--	--	748,000	13.45
NH_3-N	1.27	--	--	2,800	0.05
NO_3-N	--	1.07	0.82	81,000	1.46
SRP	1.06	--	--	6,100	0.11
TN	--	1.04	0.77	117,000	2.10
TP	1.08	--	--	9,800	0.18
TSS	1.53	--	--	1,290,000	23

also shows differences in hydrologic response during the summer season, where some variation in L_d occurs; this contrasts the observations at Ballard Creek. Daily loads clearly show the influence of episodic storm events on constituent transport. Daily loads were summed to produce monthly loads, where higher loads were generally observed during spring and fall and lower loads were typically observed during the drier summer months of June, July and August. A summary of the monthly loads from CY 2009 are presented in Table 12. Semi-annual and monthly loads were also summed through June 2010 and are presented in Appendices 4 and 5.

Flint Creek at Springtown

Physico-chemical parameters were measured on-site during this project period (i.e., from 1 July 2009 to 30 June 2010). A summary of the physico-chemical parameters at Baron Fork is provided in Table 13. The physico-chemical properties of this site were within the expected range, relative to a stream influenced by sample collection timing, variable hydrology, local geology, climatic conditions and pasture land use within the drainage area.

Average daily flow during 2009 at Flint Creek at Springtown was 48,000 m^3 and total annual discharge was 17,575,000 m^3. From the period July 1 to December 30, 2009, a total of 54 samples were collected at Flint Creek, analyzed, and used in linear regression with flow to estimate annual loads for 2009. All parameters, except TSS, were adequately described by one equation for all flow regimes, while TSS was better described by separate equations for low flow and high flow regimes. Several regression

Table 12. Summary of estimated monthly loads (kg) for each constituent at Baron Fork for Calendar Year 2009.

Month	Cl	SO_4	NH_3-N	NO_3-N	SRP	TN	TP	TSS
January	17,500	56,600	41	4,450	120	5,860	150	8,570
February	24,600	78,200	54	8,600	130	9,750	170	9,940
March	20,200	59,900	72	6,420	130	7,460	190	17,400
April	33,200	101,000	230	13,600	420	16,200	670	81,600
May	42,900	130,000	680	13,900	1,160	22,600	2,080	366,000
June	8,670	18,100	90	1,720	79	2,510	150	19,400
July	2,720	4,450	20	200	13	330	23	2,340
August	2,900	4,930	23	300	19	470	33	3,120
September	26,800	71,800	660	9,020	1,440	14,600	2,430	345,000
October	48,700	148,000	830	15,700	2,390	27,100	3,680	426,000
November	16,900	43,100	61	4,870	120	6,710	160	8,540
December	12,400	32,100	19	2,230	36	3,240	40	1,570

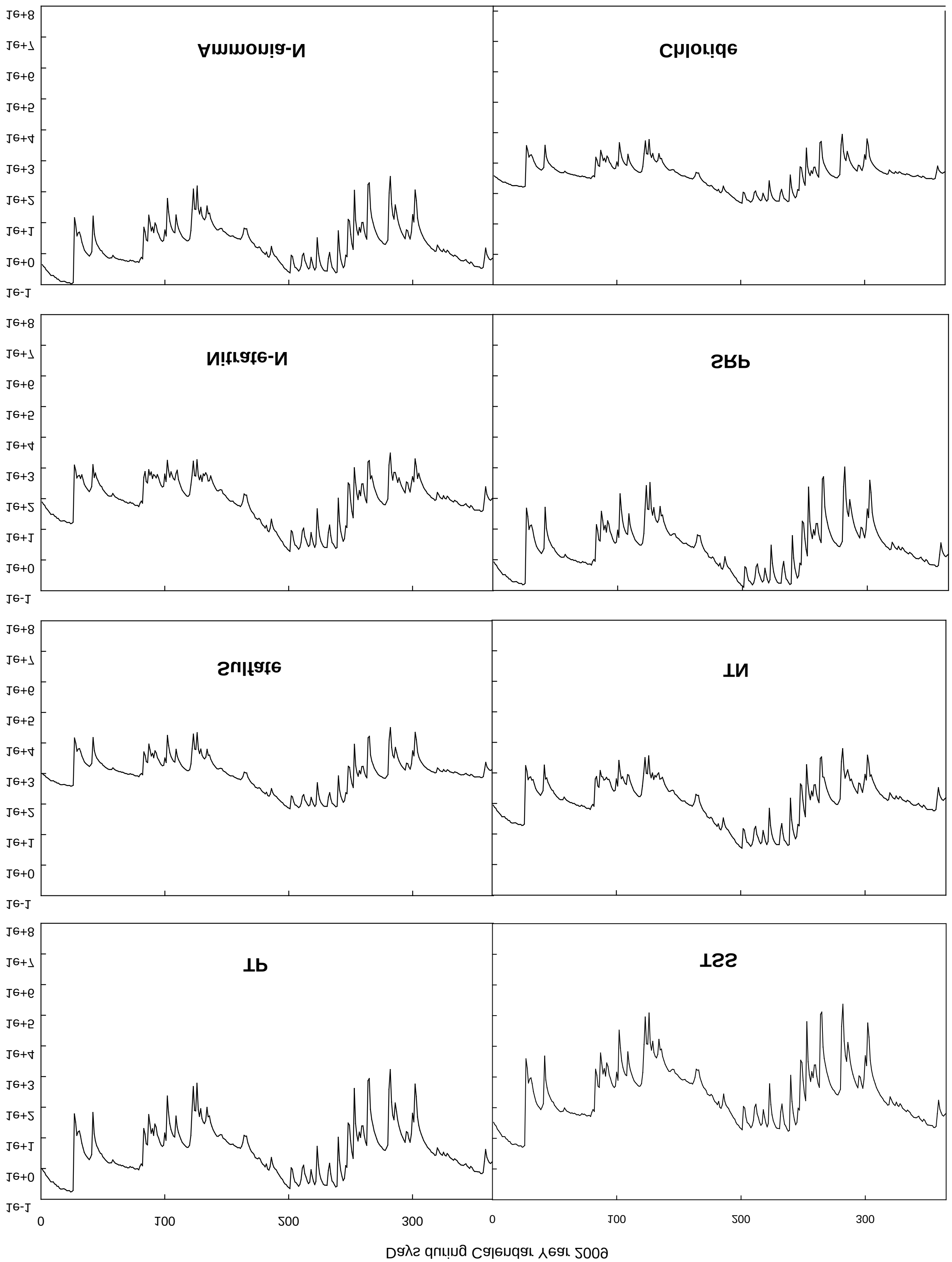

Figure 3. Daily constituent loads (kg d^{-1}) as a function of time (d) at the Baron fork during 2009.

Table 13. Minimum, Maximum and geometric mean of physico-chemical parameters at Flint Creek at Springtown from 1 July 2009 to 30 June 2010.

Parameter	Minimum	Maximum	Geometric Mean
pH	7.5	8.1	7.8
Conductivity (µS cm^{-1})	132	238	211
Dissolved Oxygen (mg L^{-1})	7.8	13.3	9.7
Temperature (^oC)	6.8	19.1	11.9

models utilized seasonal factors to estimate L_d, including those developed for NO_3-N, TN, SRP, TP, and TSS. The amount of variation in the dependent variable explained by the selected linear regression equations ranged from 64% to 99% for all equations (P≤0.002). A summary of the regression equation used and statistical significance of the selected models is provided in Table 14.

The calculated BCFs ranged from 1.01 to 2.81 for the selected parameters at Flint Creek at Springtown, and the BCF, total loads and FWC for each parameter during 2009 are presented in Table 15. These are the first load estimates and annual FWCs available at Flint Creek at Springtown, which has not been previously monitored by the AWRC. These loading data will assist in future modeling efforts with the Illinois River drainage area in northwest Arkansas, providing load estimates for a relatively small watershed the has unique hydrology and geology. This catchment is split between forested and pasture land uses, which is typical of many subwatersheds within the UIRW.

Daily loads are presented in Figure 4, showing the influence of local hydrology and precipitation patterns. This graph shows the influence of episodic storm events on the transport of constituents at Flint Creek at Springtown, reflecting the re-suspension of materials from within the fluvial channel during high flows and the hydrologic connection to the landscape. Constituent transport at this site is unique, and it shows the importance of having a water quality monitoring program target multiple sites within a larger watershed such as the UIRW. Daily loads were summed to produce monthly loads, and the monthly loads also exhibited variation consistent with seasonal rainfall patterns. Higher loads were generally observed during spring and fall, and lower loads were observed during the summer and winter. A summary of the monthly loads from CY 2009 are presented in Table 16. Semi-annual loads and monthly loads were also summed

Table 14. Regression equations and statistics of linear regression models used to estimate constituent loads at Flint Creek at Springtown during calendar year 2009.

Parameter	Regression Equation	Flow Regime	R^2	P
NO_3-N	$\ln(L_d) = 2.14 + 0.97 \ln(Q_d) + 0.10\sin(2\pi T) + 0.08\cos(2\pi T)$	All	0.98	<0.001
SO_4	$\ln(L_d) = 2.13 + 1.11 \ln(Q_d)$	All	0.98	<0.001
Cl	$\ln(L_d) = 3.23 + 0.83 \ln(Q_d)$	All	0.98	<0.001
SRP	$\ln(L_d) = -3.21 + 1.40 \ln(Q_d) - 0.31\sin(2\pi T) - 0.23\cos(2\pi T)$	All	0.93	<0.001
TP	$\ln(L_d) = -3.13 + 1.45 \ln(Q_d) - 0.37\sin(2\pi T) - 0.22\cos(2\pi T)$	All	0.90	<0.001
TN	$\ln(L_d) = 2.04 + 1.03 \ln(Q_d) + 0.07\sin(2\pi T) + 0.07\cos(2\pi T)$	All	0.99	<0.001
NH_3-N	$\ln(L_d) = -3.78 + 1.26 \ln(Q_d)$	All	0.64	<0.001
TSS	$\ln(L_d) = 0.54 + 0.98 \ln(Q_d) + 0.33\sin(2\pi T) - 0.68\cos(2\pi T)$	Low	0.65	<0.001
	$\ln(L_d) = -9.20 + 3.59 \ln(Q_d)$	High	0.71	0.002

Table 15. Bias correction factors (BCF), calculated annual loads (kg) and flow-weighted concentrations (FWC) for each constituent at Flint Creek at Springtown during 2009.

Parameter	BCF			Total Load	FWC
	All Flows	Low Flow	High Flow	(kg)	(mg L^{-1})
Cl	1.01	--	--	101,000	5.76
SO_4	1.02	--	--	92,000	5.21
NH_3-N	2.81	--	--	1,300	0.07
NO_3-N	1.01	--	--	56,000	3.18
SRP	1.10	--	--	1,700	0.10
TN	1.01	--	--	62,000	3.52
TP	1.18	--	--	2,600	0.15
TSS	--	1.23	2.56	447,000	322

through June 2010 and are presented in Appendices 4 and 5.

Flint Creek near West Siloam Springs

Physico-chemical parameters were measured on-site during this project period (i.e., from 1 July 2009 to 30 June 2010). A summary of the physico-chemical parameters at Flint Creek near West Siloam Springs is provided in Table 17. The physico-chemical properties of this site were within the expected range, relative to a stream influenced by sample collection timing, variable hydrology, local geology, climatic conditions and pasture land use within the catchment.

Average daily flow during 2009 at Flint Creek near West Siloam Springs was 148,000 m^3 and total annual discharge was 54,764,000 m^3. From the period July 1 to December 30, 2009, a total of 54 samples were collected at Flint Creek West Siloam Springs, analyzed, and used in linear regression with flow to estimate annual loads for 2009. Cl and NH_3-N were sufficiently described by one equation for all flow regimes, while the other parameters were better described by separate equations for low flow and high flow regimes. All regression models representing the low flow regime included seasonal factors, whereas the only the regression model for Cl based on all data included seasonal factors. The amount of var-iation in the dependent variable explained

Table 16. Summary of estimated monthly loads (kg) for each constituent at Flint Creek at Springtown for Calendar Year 2009.

Month	Cl	SO_4	NH_3	NO_3-N	SRP	TN	TP	TSS
January	3,540	1,960	19	1,700	13	1,670	16	220
February	7,960	6,300	77	4,700	59	4,920	78	1,310
March	5,410	3,620	40	2,890	29	2,920	37	780
April	10,300	8,440	100	5,930	91	6,260	120	2,240
May	14,600	14,080	190	8,670	210	9,570	290	21,800
June	6,040	4,080	45	2,780	52	2,900	68	1,530
July	4,260	2,460	25	1,730	31	1,790	41	850
August	3,690	2,060	20	1,430	27	1,470	35	520
September	4,430	2,680	28	1,800	37	1,890	52	440
October	26,270	33,600	540	16,400	960	19,900	1,540	401,000
November	10,200	9,560	130	5,590	190	6,320	290	15,930
December	4,580	2,740	28	2,190	23	2,210	30	250

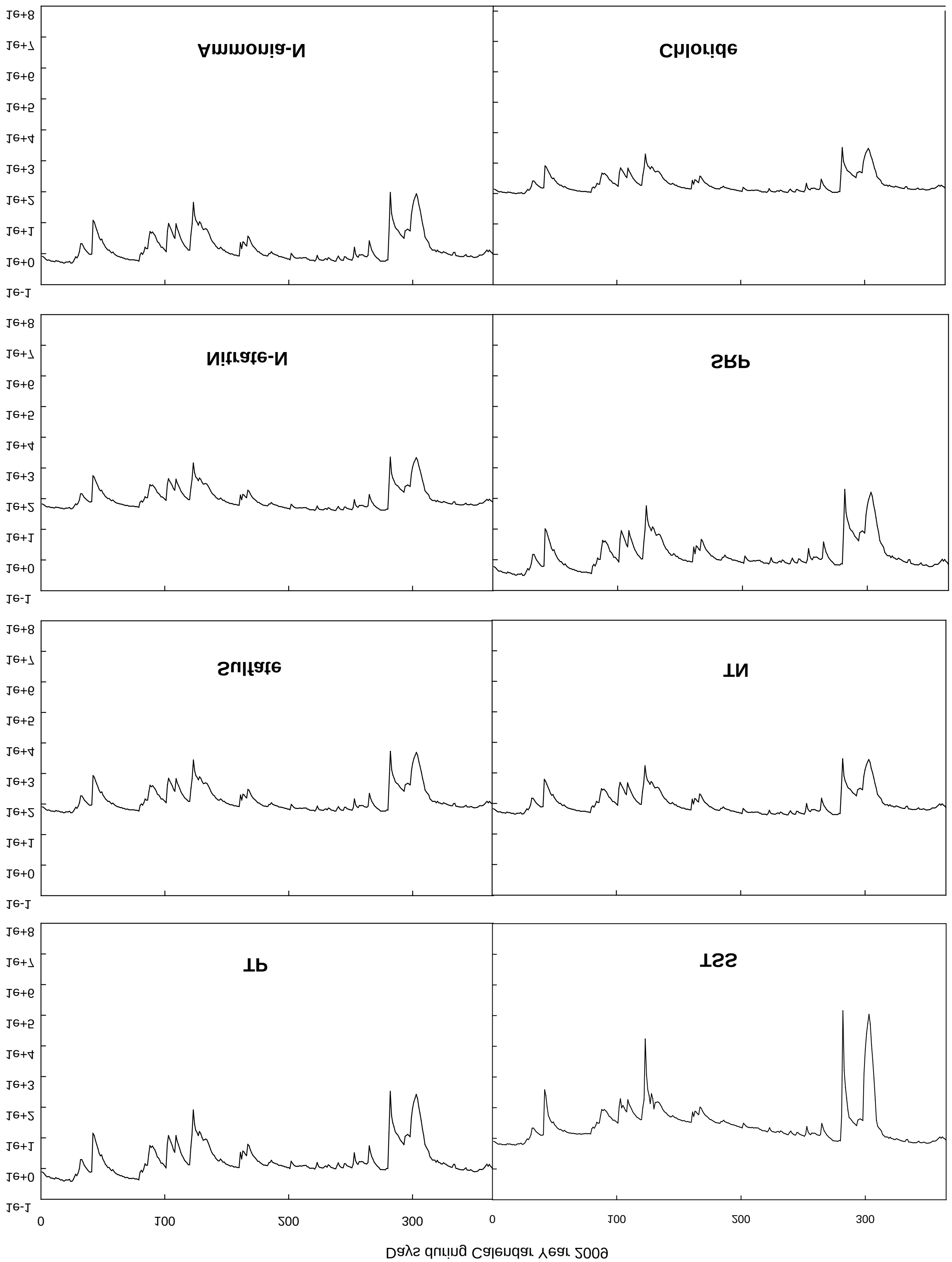

Figure 4. Daily constituent loads (kg d^{-1}) as a function of time (d) at Flint Creek at Springtown during 2009.

Table 17. Minimum, Maximum and geometric mean of physico-chemical parameters at Flint Creek near West Siloam Springs from 1 July 2009 to 30 June 2010.

Parameter	Minimum	Maximum	Geometric Mean
pH	7.7	8.7	7.9
Conductivity ($\mu S\ cm^{-1}$)	206	332	292
Dissolved Oxygen ($mg\ L^{-1}$)	6.4	14.0	9.0
Temperature (^oC)	5.3	25.2	12.4

by the selected linear regression equations ranged from 66% to 99% for all equations ($P \leq 0.001$). A summary of the regression equations used and statistical significance of the selected models is provided in Table 18.

The calculated BCFs ranged from 1.00 to 1.34 for the selected parameters at Flint Creek near West Siloam Springs, and the BCFs, total loads and FWC for each parameter during 2009 are presented in Table 19. This site is downstream from Flint Creek at Springtown, and all constituent loads increased relative to that measured upstream. There was about a three-fold increase in total water volume from upstream to downstream sites on Flint Creek, and if loads were simply tied to hydrology then loads would show similar increases. However, loads generally increased less than three-fold, except for Cl, SO_4 and TSS which showed much larger increases downstream relative to upstream.

Daily loads are depicted below in Figure 5 and show some differences relative to the upstream site on Flint Creek at Springtown; this graph of L_d shows the importance of episodic storm events. Daily loads were summed to produce monthly loads, where monthly loads at this site showed some variation consistent with seasonal rainfall patterns. The highest monthly loads were observed during May and October and the lower loads were observed during the summer and winter months. A summary of the monthly loads from CY 2009 are presented in Table 20. Semi-annual and monthly loads were also summed through June 2010 and are presented in Appendices 4 and 5.

Table 18. Regression equations and coefficients of linear regression models used to estimate constituent loads at Flint Creek near West Siloam Springs during calendar year 2009.

Parameter	Regression Equation	Flow Regime	R^2	P
NO_3-N	$\ln(L_d) = -0.71 + 1.57 \ln(Q_d) + 0.02\sin(2\pi T) + 0.31\cos(2\pi T)$	Low	0.91	<0.001
	$\ln(L_d) = 2.57 + 0.86 \ln(Q_d)$	High	0.99	<0.001
SO_4	$\ln(L_d) = 4.71 + 0.84 \ln(Q_d) + 0.22\sin(2\pi T) + 0.10\cos(2\pi T)$	Low	0.62	<0.001
	$\ln(L_d) = 6.25 + 0.51 \ln(Q_d)$	High	0.98	0.001
Cl	$\ln(L_d) = 4.11 + 0.78 \ln(Q_d) - 0.09\sin(2\pi T) - 0.59\cos(2\pi T)$	All	0.98	<0.001
SRP	$\ln(L_d) = -4.13 + 1.32 \ln(Q_d) - 0.39\sin(2\pi T) - 0.40\cos(2\pi T)$	Low	0.81	<0.001
	$\ln(L_d) = -7.07 + 1.90 \ln(Q_d)$	High	0.99	<0.001
TP	$\ln(L_d) = -3.59 + 1.30 \ln(Q_d) - 0.29\sin(2\pi T) - 0.47\cos(2\pi T)$	Low	0.74	<0.001
	$\ln(L_d) = -9.06 + 2.34 \ln(Q_d)$	High	0.99	<0.001
TN	$\ln(L_d) = -0.59 + 1.56 \ln(Q_d) - 0.00\sin(2\pi T) - 0.26\cos(2\pi T)$	Low	0.91	<0.001
	$\ln(L_d) = 2.09 + 0.97 \ln(Q_d)$	High	0.95	<0.001
NH_3-N	$\ln(L_d) = -3.49 + 1.07 \ln(Q_d)$	All	0.66	<0.001
TSS	$\ln(L_d) = -0.64 + 1.65 \ln(Q_d) + 0.03\sin(2\pi T) - 0.86\cos(2\pi T)$	Low	0.72	<0.001
	$\ln(L_d) = -8.36 + 1.05 \ln(Q_d)$	High	0.99	<0.001

Table 19. Bias correction factors (BCF), annual loads (kg) and flow-weighted concentrations (FWC) for each constituent at Flint Creek near West Siloam Springs during 2009.

Parameter	BCF			Total Load	FWC
	All Flows	Low Flow	High Flow	(kg)	(mg L^{-1})
Cl	1.01	--	--	521,000	5.76
SO_4	--	1.04	1.00	1,201,000	5.21
NH_3-N	1.34	--	--	1,300	0.07
NO_3-N	--	1.03	1.00	116,000	3.18
SRP	--	1.02	1.01	2,400	0.10
TN	--	1.03	1.00	130,000	3.52
TP	--	1.03	1.01	5,300	0.15
TSS	--	1.12	1.06	1,852,000	322

Illinois River at Savoy

Physico-chemical parameters were measured on-site during this project period (i.e., from 1 July 2009 to 30 June 2010). A summary of the physico-chemical parameters at the Illinois River at Savoy is provided in Table 21. The physico-chemical properties of this site were within the expected range, relative to a stream influenced by sample collection timing, variable hydrology, local geology, climatic conditions, effluent discharges in the headwaters and mixed land uses.

Average daily flow during 2009 at the Illinois River at Savoy was 644,000 m^3 and total annual discharge was 237,547,000 m^3. From the period July 1 to December 30, 2009, a total of 56 samples were collected at Illinois River at Savoy, analyzed, and used in linear regression with flow to estimate annual loads for 2009. All parameters were described by one equation for all flow regimes, but select constituents (i.e., SRP, TP and TSS) included seasonal factors in these regression models. The amount of variation in the dependent variable explained by the selected linear regression equations ranged from 77% to 97% for all equations (P<0.001), and the explanation of variability in the data was similar between the Illinois River at Highway 59 and at Savoy. However, separate regression equations were needed for low and

Table 20. Summary of estimated monthly loads (kg) for each constituent at Flint Creek near West Siloam Springs for Calendar Year 2009.

Month	Cl	SO_4	NH_3	NO_3-N	SRP	TN	TP	TSS
January	29,000	71,100	48	4,300	27	4,490	42	2,210
February	46,000	119,000	94	10,900	69	11,300	100	8,610
March	46,000	123,000	88	8,600	59	9,200	100	11,000
April	61,100	156,000	140	14,000	130	15,400	210	27,600
May	75,600	173,000	200	20,000	290	21,900	450	70,100
June	36,600	85,000	79	4,960	110	5,840	190	25,080
July	22,500	47,100	42	1,900	60	2,270	100	9,190
August	19,600	38,900	36	1,640	54	1,930	87	5,790
September	20,900	41,000	40	2,250	58	2,600	87	4,660
October	89,900	174,000	350	30,900	1,390	36,500	3,670	1,660,000
November	44,600	98,900	110	11,270	150	12,300	210	22,600
December	31,800	73,600	58	5,520	43	5,920	63	2,900

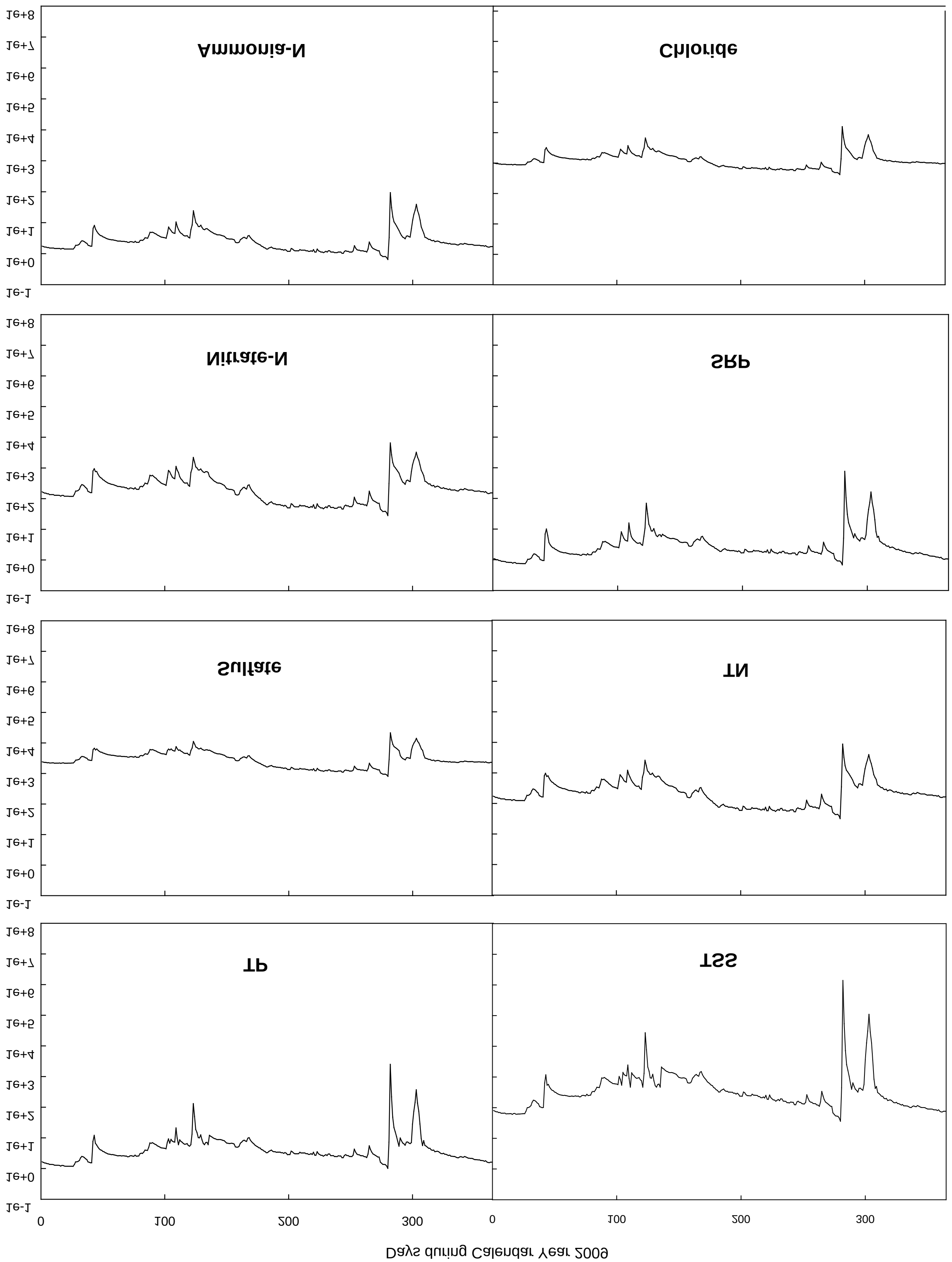

Figure 5. Daily constituent loads (kg d^{-1}) as a function of time (d) at Flint Creek near West Siloam Springs in 2009.

Table 21. Minimum, Maximum and geometric mean of physico-chemical parameters at the Illinois River at Savoy from 1 July 2009 to 30 June 2010.

Parameter	Minimum	Maximum	Geometric Mean
pH	7.4	8.5	7.9
Conductivity (µS cm^{-1})	134	364	266
Dissolved Oxygen (mg L^{-1})	5.8	15.3	8.9
Temperature (^oC)	1.0	26.7	9.9

high flow regimes at the Illinois River at Highway 59. A summary of the regression equation used and statistical significance of the selected model is provided in Table 22.

The calculated BCFs ranged from 1.02 to 1.55 for the selected parameters at Illinois River at Savoy, and the BCF, total loads and FWC for each parameter during 2009 are presented in Table 23. This site is upstream from the Illinois River at AR59, and it had about one third of the total discharge that was observed downstream near the Arkansas-Oklahoma border. The constituent loads were generally one third or less at the Illinois River at Savoy compared to that observed downstream at AR59, except for SRP. The annual SRP load at Illinois River at Savoy was about half that observed at AR59, whereas the annual TP load was much closer to one third that observed downstream. This shows the importance of SRP storage within the reaches downstream from Savoy along the Illinois River, as well as within tributary inflows along this section.

Daily loads are depicted in Figure 6 below, showing the influence of episodic storm events on constituent transport in the Illinois River at Savoy. The graphs of L_d show some similarities between sites along the Illinois River (i.e., AR59 and Savoy), but also some differences. These differences likely reflect variation in the relation between L_d and Q_d, as well as differences in catchment land use and other constituent sources such as effluent discharges. The calculated daily loads were summed to produce monthly loads, where monthly loads at this site showed some variation consistent with seasonal rainfall patterns. The higher monthly loads were observed during the rainier spring and fall months while lower loads were observed during the summer winter months. A summary of the monthly loads from CY 2009 are presented in Table 24. Semi-annual and monthly loads were also summed through June 2010 and are presented in Appendices 4 and 5.

Table 22. Regression equations and coefficients of linear regression models used to estimate constituent loads at Illinois River at Savoy during calendar year 2009.

Parameter	Regression Equation	Flow Regime	R^2	P
NO_3-N	$\ln(L_d) = 2.44 + 0.83 \ln(Q_d)$	All	0.95	<0.001
SO_4	$\ln(L_d) = 4.43 + 0.85 \ln(Q_d)$	All	0.97	<0.001
Cl	$\ln(L_d) = 4.63 + 0.71 \ln(Q_d)$	All	0.96	<0.001
SRP	$\ln(L_d) = -4.03 + 1.37 \ln(Q_d) - 0.84\sin(2\pi T) - 0.71\cos(2\pi T)$	All	0.86	<0.001
TP	$\ln(L_d) = -3.46 + 1.40 \ln(Q_d) - 0.55\sin(2\pi T) - 0.65\cos(2\pi T)$	All	0.91	<0.001
TN	$\ln(L_d) = 2.26 + 0.91 \ln(Q_d)$	All	0.97	<0.001
NH_3-N	$\ln(L_d) = -3.85 + 1.28 \ln(Q_d)$	All	0.77	<0.001
TSS	$\ln(L_d) = 0.005 + 1.64 \ln(Q_d) - 0.48\sin(2\pi T) - 1.12\cos(2\pi T)$	All	0.85	<0.001

Table 23. Bias correction factors (BCF), annual loads (kg) and flow-weighted concentrations (FWC) for each constituent at Illinois River at Savoy during 2009.

Parameter	BCF			Total Load	FWC
	All Flows	Low Flow	High Flow	(kg)	(mg L^{-1})
Cl	1.02	--	--	1,656,000	6.97
SO_4	1.02	--	--	3,144,000	13.24
NH_3-N	1.45	--	--	21,000	0.09
NO_3-N	1.03	--	--	392,000	1.65
SRP	1.28	--	--	39,000	0.16
TN	1.02	--	--	530,000	2.23
TP	1.19	--	--	72,000	0.30
TSS	1.55	--	--	20,556,000	87

Illinois River near Watts, Oklahoma

Physico-chemical parameters were measured on-site during this project period (i.e., from 1 July 2009 to 30 June 2010). A summary of the physico-chemical parameters measured at the Illinois River near Watts, Oklahoma is provided in Table 25. The physico-chemical properties of this site were within the expected range, relative to a stream influenced by sample collection timing, variable hydrology, local geology, climatic conditions, effluent discharges in the head-waters and mixed land uses.

Average daily flow during 2009 at the Illinois River near Watts, Oklahoma was 2,122,000 m^3 and total annual discharge was 807,303,000 m^3. From the period July 1 to December 30, 2009, a total of 60 samples were collected at Illinois River near Watts, Oklahoma, analyzed, and used in linear regression with flow to estimate annual loads for 2009. Most parameters were described by one equation for all flow regimes, but select constituents (i.e., SRP, TP and TSS) were better described using separate equations for low flow and high flow regimes. Seasonal factors were also included in regressions for several constituents (i.e., NO_3-N, SRP low flow, TP low flow, TN, NH_3-N and TSS low flow). The amount of variation in the dependent variable explained by the selected linear regression equations ranged from 74% to 97% for all

Table 24. Summary of estimated monthly loads (kg) for each constituent at Illinois River at Savoy for Calendar Year 2009.

Month	Cl	SO_4	NH_3	NO_3-N	SRP	TN	TP	TSS
January	92,800	164,000	840	20,600	410	26,800	1,000	152,000
February	148,000	270,000	1,400	33,900	630	44,500	1,610	261,000
March	121,000	211,000	960	26,600	490	34,200	1,330	265,000
April	194,000	366,000	2,000	45,800	1,380	61,000	3,670	954,000
May	307,000	640,000	4,870	79,100	5,430	112,000	13,700	5,020,000
June	63,600	94,200	230	12,200	390	14,100	750	155,000
July	35,600	46,200	72	6,070	180	6,510	280	42,500
August	43,200	59,900	130	7,790	400	8,720	600	105,000
September	117,000	213,000	1,240	26,700	4,380	35,300	6,800	1,730,000
October	342,000	769,000	8,080	93,900	23,800	140,000	39,800	11,700,000
November	118,000	196,000	680	24,900	990	30,800	1,600	186,000
December	75,900	115,000	300	14,800	200	17,400	380	31,700

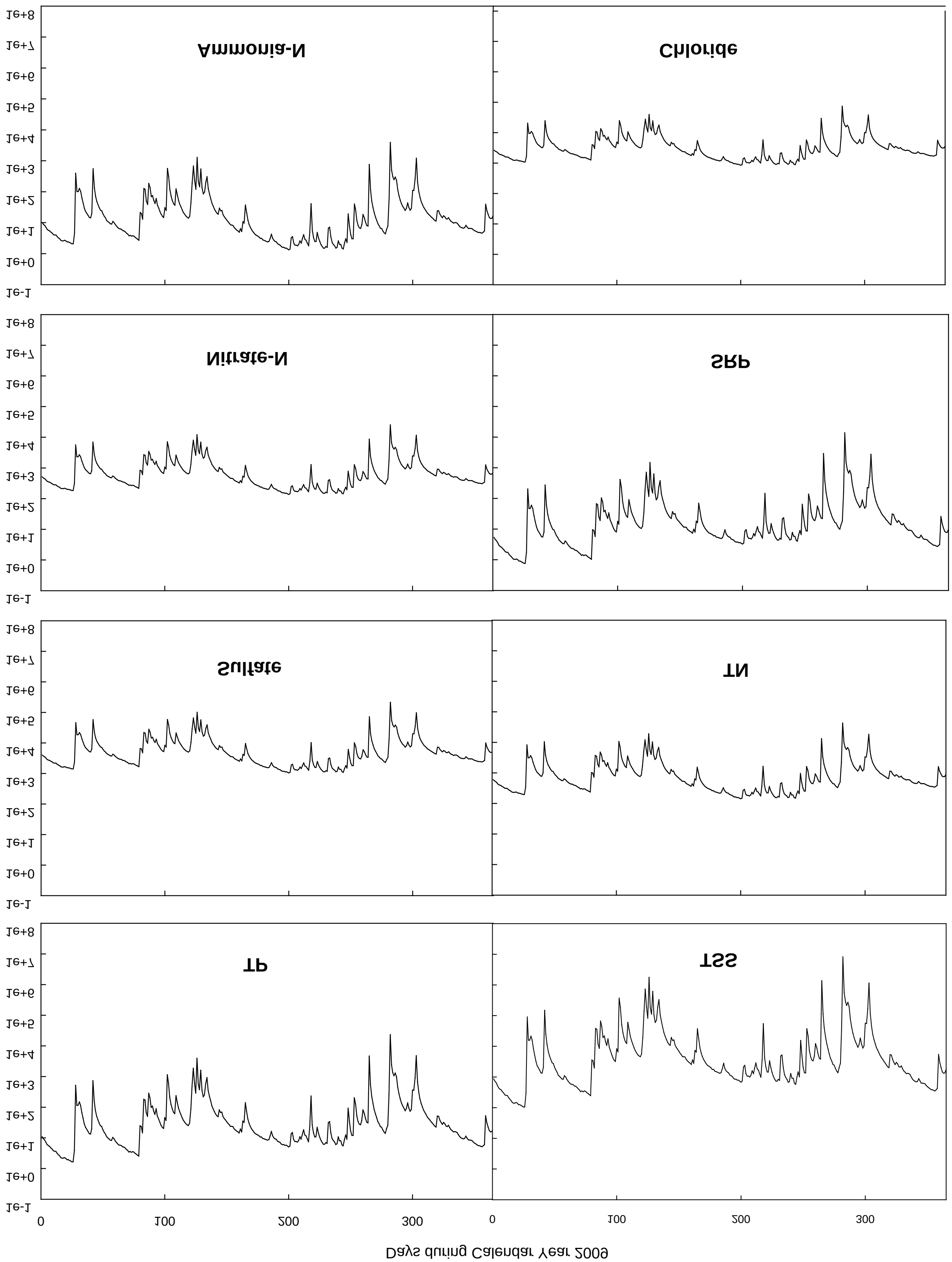

Figure 6. Daily constituent loads (kg d^{-1}) as a function of time (d) at the Illinois River at Savoy during 2009.

Table 25. Minimum, Maximum and geometric mean of physico-chemical parameters at the Illinois River near Watts, Oklahoma from 1 July 2009 to 30 June 2010.

Parameter	Minimum	Maximum	Geometric Mean
pH	7.8	8.5	8.1
Conductivity (µS cm^{-1})	180	336	292
Dissolved Oxygen (mg L^{-1})	6.6	15.3	9.8
Temperature (^{o}C)	2.0	28.6	11.2

equations (P<0.001), and the explanation of variability in the data was similar between the Illinois River at Highway 59 and near Watts, Oklahoma. Separate regression equations were also needed for low and high flow regimes at the Illinois River at Highway 59. A summary of the regression equation used and statistical significance of the selected model is provided in Table 26.

The calculated BCFs ranged from 1.01 to 1.22 for the selected parameters at Illinois River near Watts, OK, and the BCF, total loads and FWC for each parameter during 2009 are presented in Table 27. This site is downstream from the Illinois River at AR59, and total annual discharge was about 10% greater at this site compared to that observed near the state line. The constituent loads, however were not necessarily 10% greater at the Illinois River near Watts, OK compared to that observed upstream at AR59. In fact, TP only increased by 2% and TSS decreased by 45%, likely because small impoundments, like Lake Frances, have the potential to accumulate (and release) sediment and sediment associated nutrients, such as phosphorus.

Daily loads are depicted in Figure 6 below, showing the influence of episodic storm events on constituent transport in the Illinois River near Watts, OK. The graphs of L_d show some similarities between sites along the Illinois River (i.e., AR59, Savoy, and Watts), but also some differences. These differences likely reflect variation in the relation between L_d and Q_d, as well as differences in catchment land use, constituent sources such as effluent discharges and the effects of Lake Frances. The calculated daily loads were summed to produce monthly loads, where monthly loads at this site showed some variation consistent with seasonal rainfall patterns. The higher monthly loads were observed during the rainier spring and fall months

Table 26. Regression equations and coefficients of linear regression models used to estimate constituent loads at Illinois River near Watts, OK during calendar year 2009.

Parameter	Regression Equation	Flow Regime	R^2	P
NO_3-N	$\ln(L_d) = 2.37 + 0.91 \ln(Q_d) - 0.13 \sin(2\pi T) - 0.15 \cos(2\pi T)$	All	0.95	<0.001
SO_4	$\ln(L_d) = 4.69 + 0.81 \ln(Q_d)$	All	0.97	<0.001
Cl	$\ln(L_d) = 5.45 + 0.68 \ln(Q_d)$	All	0.94	<0.001
SRP	$\ln(L_d) = -7.46 + 1.83 \ln(Q_d) - 0.70\sin(2\pi T) - 0.79\cos(2\pi T)$	Low	0.79	<0.001
	$\ln(L_d) = -6.72 + 1.67 \ln(Q_d)$	High	0.88	<0.001
TP	$\ln(L_d) = -6.32 + 1.73 \ln(Q_d) - 0.49\sin(2\pi T) - 0.76\cos(2\pi T)$	Low	0.80	<0.001
	$\ln(L_d) = -9.42 + 2.10 \ln(Q_d)$	High	0.92	<0.001
TN	$\ln(L_d) = 2.03 + 0.98 \ln(Q_d) + 0.10 \sin(2\pi T) - 0.10\cos(2\pi T)$	All	0.97	<0.001
NH_3-N	$\ln(L_d) = -5.41 + 1.39 \ln(Q_d) - 0.09\sin(2\pi T) - 0.52\cos(2\pi T)$	All	0.74	<0.001
TSS	$\ln(L_d) = -3.06 + 1.94 \ln(Q_d) - 0.35\sin(2\pi T) - 1.20\cos(2\pi T)$	Low	0.85	<0.001
	$\ln(L_d) = -8.97 + 2.69 \ln(Q_d)$	High	0.92	<0.001

Table 27. Bias correction factors (BCF), annual loads (kg) and flow-weighted concentrations (FWC) for each constituent at Illinois River near Watts, OK during 2009.

Parameter	BCF			Total Load	FWC
	All Flows	Low Flow	High Flow	(kg)	(mg L^{-1})
Cl	1.02	--	--	38,300	9.41
SO_4	1.01	--	--	7,694,000	11.54
NH_3-N	1.21	--	--	1,861,000	0.05
NO_3-N	1.01	--	--	85,500	2.28
SRP	--	1.05	1.15	9,434,000	0.10
TN	1.02	--	--	2,194,000	2.68
TP	--	1.04	1.14	241,000	0.30
TSS	--	1.12	1.22	77,038,000	94

while lower loads were observed during the summer winter months. A summary of the monthly loads from CY 2009 are presented in Table 28. Semi-annual and monthly loads were also summed through June 2010 and are presented in Appendices 4 and 5.

Mud Creek Tributary

Physico-chemical parameters were measured on-site during this project period (i.e., from 1 July 2009 to 30 June 2010). Physico-chemical parameters varied seasonally and with episodic rainfall events. A summary of the physico-chemical parameters at Mud Creek Tributary is provided in Table 29. The physico-chemical properties of this site were within the expected range, relative to a smaller catchment with predominantly urban land use.

Average daily flow during 2009 at Mud Creek Tributary was 4,400 m^3 and total annual discharge was 1,629,000 m^3; this is the smallest catchment monitored within the UIRW and the only one that is primarily urban development. From the period July 1 to December 30, 2009, a total of 56 samples were collected at Mud Creek Tributary, analyzed, and used in linear regression with flow to estimate annual loads for 2009. All parameters were adequately

Table 28. Summary of estimated monthly loads (kg) for each constituent at Illinois River at Savoy for Calendar Year 2009.

Month	Cl	SO_4	NH_3	NO_3-N	SRP	TN	TP	TSS
January	770	448,000	110,000	1,930	504,000	118,000	3,760	551,000
February	1,880	726,000	211,000	4,650	896,000	233,000	9,380	1,500,000
March	1,460	555,000	139,000	2,500	643,000	152,000	4,720	655,000
April	4,400	881,000	240,000	8,070	1,120,000	280,000	18,100	3,610,000
May	12,000	1,315,000	375,000	21,600	1,800,000	467,000	54,800	12,900,000
June	1,880	510,000	91,700	3,110	569,000	106,000	5,370	886,000
July	770	337,000	47,700	1,520	341,000	53,500	2,560	363,000
August	660	324,000	44,500	1,590	326,000	50,000	2,480	297,000
September	1,460	460,000	78,800	3,560	514,000	93,000	5,830	756,000
October	11,300	1,140,000	316,000	33,500	1,610,000	413,000	129,000	55,000,000
November	1,270	592,000	126,000	2,910	683,000	142,000	4,610	457,000
December	410	403,000	81,400	540	423,000	84,700	950	60,800

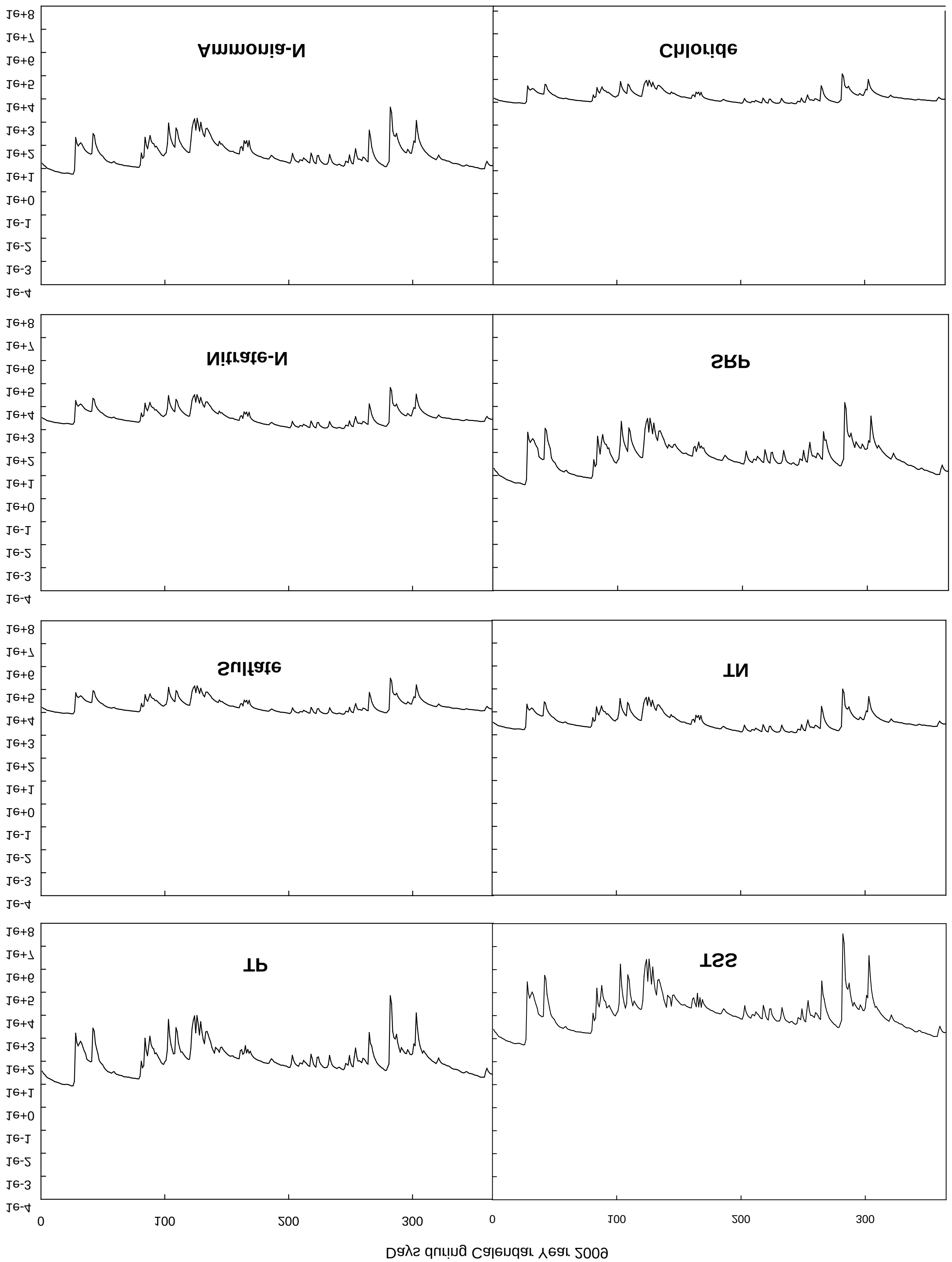

Figure 6. Daily constituent loads (kg d^{-1}) as a function of time (d) at the Illinois River near Watts, OK during 2009.

Table 29. Minimum, Maximum and geometric mean of physico-chemical parameters Mud Creek Tributary from 1 July 2009 to 30 June 2010.

Parameter	Minimum	Maximum	Geometric Mean
pH	7.7	8.3	8.1
Conductivity (µS cm^{-1})	68	453	355
Dissolved Oxygen (mg L^{-1})	4.2	15.4	10.0
Temperature (^oC)	0.8	25.2	8.0

described by one equation for all flow regimes where variation in the dependent variable explained by the selected linear regression equations ranged from 86% to 94% for all equations (P <0.001). The regression models also included seasonal factors when estimating constituent loads, except NO_3-N, TN and SO_4. A summary of the regression equation(s) used and statistical significance of the selected model(s) is provided in Table 30.

The calculated BCFs ranged from 1.10 to 6.48 for the selected parameters at Mud Creek Tributary, and the BCF, total loads and FWC for each parameter during 2009 are presented in Table 31. The largest BCF was observed for TSS, suggesting that some [relatively] larger differences were observed between measured and predicted L_d for TSS. This site is extremely important, because it is the only site which truly reflects constituent transport from an urban catchment; all the other monitoring stations within the UIRW generally drain mixed land uses, whereas this catchment is totally within the City of Fayetteville. The data from this site should be extremely useful in future watershed modeling efforts, as it provides the ability to calibrate watershed models to estimate constituent loads from well-established urban catchments.

Daily loads are shown in Figure 8, and the lines on these graphs clearly show the influence of flashy hydrology typical of urban streams on constituent transport. This shows that every rainfall event results in runoff, and the regression models predict episodic, sharp increases in constituent transport based on the changes in hydrology. The flashy nature of these streams make sampling more difficult, but it is critically important to sample storm events on the rising, peak and falling limbs of the hydrograph. Daily loads were summed to produce monthly loads, where monthly loads at this site showed some variation consistent with seasonal rainfall patterns. The higher monthly loads were observed during the rainier spring and fall months while lower loads were observed during the summer and winter months. A summary of the monthly loads from CY 2009

Table 30. Regression equations and coefficients of linear regression models used to estimate constituent loads at Mud Creek Tributary during calendar year 2009.

Parameter	Regression Equation	Flow Regime	R^2	P
NO_3-N	$\ln(L_d) = -0.27 + 1.20 \ln(Q_d)$	All	0.88	<0.001
SO_4	$\ln(L_d) = 3.55 + 0.78 \ln(Q_d)$	All	0.86	<0.001
Cl	$\ln(L_d) = 3.23 + 0.78 \ln(Q_d) + 0.41\sin(2\pi T) + 0.44\cos(2\pi T)$	All	0.88	<0.001
SRP	$\ln(L_d) = -3.37 + 1.44 \ln(Q_d) - 0.45\sin(2\pi T) - 0.99\cos(2\pi T)$	All	0.86	<0.001
TP	$\ln(L_d) = -2.52 + 1.40 \ln(Q_d) - 0.55\sin(2\pi T) - 0.65\cos(2\pi T)$	All	0.91	<0.001
TN	$\ln(L_d) = 0.28 + 1.24 \ln(Q_d)$	All	0.94	<0.001
NH_3-N	$\ln(L_d) = -2.77 + 1.28 \ln(Q_d) - 0.09\sin(2\pi T) - 0.79\cos(2\pi T)$	All	0.87	<0.001
TSS	$\ln(L_d) = 2.19 + 1.66 \ln(Q_d) - 0.28\sin(2\pi T) - 1.38\cos(2\pi T)$	All	0.81	<0.001

Table 31. Bias Correction Factors (BCF), annual loads (kg) and flow-weighted concentrations (FWC) for each constituent at Mud Creek Tributary during 2009.

Parameter	BCF			Total Load	FWC
	All Flows	Low Flow	High Flow	(kg)	(mg L^{-1})
Cl	1.35	--	--	14,000	8.53
SO_4	1.10	--	--	18,000	11.14
NH_3-N	1.21	--	--	100	0.07
NO_3-N	1.65	--	--	900	0.56
SRP	1.09	--	--	60	0.04
TN	1.11	--	--	1,600	0.95
TP	1.45	--	--	300	0.16
TSS	6.48	--	--	1,342,000	824

is presented in Table 32. Both semi-annual and monthly loads were also summed through June 2010 and are presented in Appendices 4 and 5.

Osage Creek at Elm Springs

Physico-chemical parameters were measured on-site during this project period (i.e., from 1 July 2009 to 30 June 2010). Physico-chemical parameters varied seasonally and with episodic rainfall events. A summary of the physico-chemical parameters at Osage Creek is provided in Table 33. The physico-chemical properties of this site were within the expected range, relative to a stream influenced by multiple factors including sample collection timing, variable hydrology, local geology, climatic conditions, effluent discharge from the Cities of Springdale and Rogers and mixed land use.

Average daily flow during 2009 at the Osage Creek was 534,000 m^3 and total annual discharge was 196,999,000 m^3; annual discharge was approximately 75% of that observed during 2008. From the period July 1 to December 30, 2009, a total of 54 samples were collected at Osage Creek, analyzed, and used in linear regression with flow to estimate annual loads for 2009. All parameters were adequately described by one equation for all flow regimes, and the amount of variation in the dependent variable explained by the selected linear regres-

Table 32. Summary of estimated monthly loads (kg) for each constituent at Mud Creek Tributary for Calendar Year 2009.

Month	Cl	SO_4	NH_3	NO_3-N	SRP	TN	TP	TSS
January	92,800	164,000	840	20,600	410	26,800	1,000	152,000
February	148,000	270,000	1,400	33,900	630	44,500	1,610	261,000
March	121,000	211,000	960	26,600	490	34,200	1,330	265,000
April	194,000	366,000	2,000	45,800	1,380	61,000	3,670	954,000
May	307,000	640,000	4,870	79,100	5,430	112,000	13,700	5,020,000
June	63,600	94,200	230	12,200	390	14,100	750	155,000
July	35,600	46,200	72	6,070	180	6,510	280	42,500
August	43,200	59,900	130	7,790	400	8,720	600	105,000
September	117,000	213,000	1,240	26,700	4,380	35,300	6,800	1,730,000
October	342,000	769,000	8,080	93,900	23,800	140,000	39,800	11,700,000
November	118,000	196,000	680	24,900	990	30,800	1,600	186,000
December	75,900	115,000	300	14,800	200	17,400	380	31,700

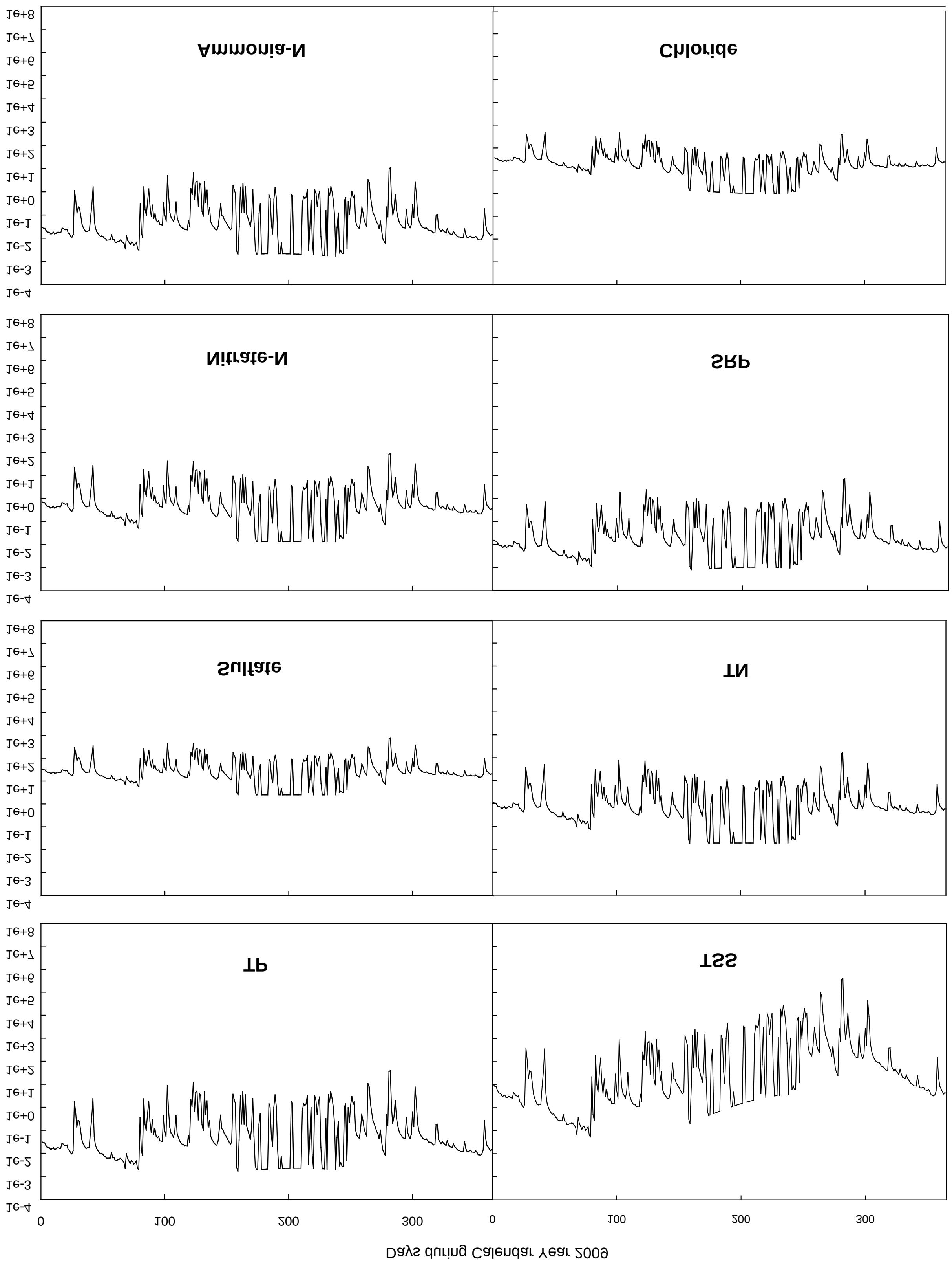

Figure 8. Daily constituent loads (kg d^{-1}) as a function of time (d) at Mud Creek Tributary during 2009.

Table 33. Minimum, Maximum and geometric mean of physico-chemical parameters at Osage Creek at Elm Springs from 1 July 2009 to 30 June 2010.

Parameter	Minimum	Maximum	Geometric Mean
pH	7.9	8.6	8.1
Conductivity ($\mu S\ cm^{-1}$)	154	447	356
Dissolved Oxygen ($mg\ L^{-1}$)	7.6	15.1	9.9
Temperature (^oC)	4.7	23.8	12.1

sion equations ranged from 71% to 93% for all equations ($P<0.001$). The regression models for SO_4, SRP, TP and TSS included seasonal components, whereas the other regression models were solely based on Q_d. A summary of the regression models used and statistical significance of the selected models is provided in Table 34.

The BCFs ranged from 1.01 (Cl, SO_4 and TN) to 1.38 (TSS) and the BCF, total loads and FWC for each parameter during 2009 are presented in Table 35. This site lies downstream from the input of treated wastewater effluent from the Cities of Springdale and Rogers, Arkansas. Monitoring loads and constituent concentrations at this site provides important data for modeling efforts where urban systems influence watershed hydrology.

Daily loads are shown below in Figure 9, reflecting the hydrologic nature of Osage Creek. This graph shoes the influence of episodic storm events on the transport of constituents at Osage Creek, reflecting the re-suspension of materials from within the fluvial channel during high flows and the hydrologic connection to the landscape. This graph clearly shows the influence of local hydrology and precipitation patterns at Osage Creek typical for this region. Daily loads were summed to produce monthly loads, where monthly loads at this site showed some variation consistent with seasonal rainfall patterns. The higher monthly loads were observed during the rainier spring and fall months while lower loads were observed during the summer winter months. A summary of the monthly loads from CY 2009 are presented in Table 36. Semi-annual and monthly loads were also summed through June 2010 and are presented in Appendices 4 and 5.

DISCUSSION

This project successfully estimated constituent loads in calendar year 2009 using water samples collected during this project at eight sites in the UIRW. Historical constituent loads at the Illinois

Table 34. Regression equations and coefficients of linear regression models used to estimate constituent loads at Osage Creek at Elm Springs during calendar year 2009.

Parameter	Regression Equation	Flow Regime	R^2	P
NO_3-N	$\ln(L_d) = -9.75 + 2.79 \ln(Q_d)$	All	0.76	<0.001
SO_4	$\ln(L_d) = 6.00 + 0.59 \ln(Q_d) - 0.34\sin(2\pi T) - 0.07\cos(2\pi T)$	All	0.84	<0.001
Cl	$\ln(L_d) = 6.30 + 0.53 \ln(Q_d)$	All	0.78	<0.001
SRP	$\ln(L_d) = -2.79 + 1.18 \ln(Q_d) - 0.39\sin(2\pi T) - 0.40\cos(2\pi T)$	All	0.93	<0.001
TP	$\ln(L_d) = -3.98 + 1.50 \ln(Q_d) - 0.27\sin(2\pi T) - 0.41\cos(2\pi T)$	All	0.80	<0.001
TN	$\ln(L_d) = 3.53 + 0.75 \ln(Q_d)$	All	0.87	<0.001
NH_3-N	$\ln(L_d) = -7.38 + 1.86 \ln(Q_d)$	All	0.71	<0.001
TSS	$\ln(L_d) = -5.65 + 2.58 \ln(Q_d) - 0.18\sin(2\pi T) - 0.52\cos(2\pi T)$	All	0.83	<0.001

Table 35. Bias Correction Factors (BCF), annual loads (kg) and flow-weighted concentrations (FWC) for each constituent at Osage Creek during 2009.

Parameter	BCF			Total Load	FWC
	All Flows	Low Flow	High Flow	(kg)	(mg L^{-1})
Cl	1.01	--	--	3,200,000	16.25
SO_4	1.01	--	--	3,310,000	16.81
NH_3-N	1.26	--	--	16,500	0.08
NO_3-N	1.02	--	--	607,000	3.08
SRP	1.02	--	--	15,300	0.08
TN	1.01	--	--	670,000	3.40
TP	1.19	--	--	40,700	0.21
TSS	1.37	--	--	24,900,000	126

River generally follow the same pattern as annual discharge, and loads in 2009 were less than the previous year because annual discharge was only 75% of that observed in 2008 (Figure 10). Discharge increased, however, at Ballard Creek between years, as well as TP and TSS annual loads (Figure 11). Since constituent loading is so closely tied to hydrology, loads should be evaluated over time using a statistical technique to remove the influence of discharge to accurately determine trends in water quality.

Historically, annual constituent loads have been estimated at two sites in the UIRW, Illinois River at AR59 and Ballard Creek, using an auto-sampler. However, 2009 annual loads were estimated using regression models that were developed from a weekly monitoring program that specifically targeted storm events. This method of load estimation was cheaper, evaluated more sites (n=8), and easily est-imated loads backwards or forwards [in time] during data gaps. Using the autosampler method i.e., the historical method, required that concentrations be applied to the annual hydrograph during data gaps, i.e., the time in between sample collection. So, using the regression model method took the bias out of applying observed concentrations to time periods when data was not available. The auto-sampler method did, however, provide event

Table 36. Summary of estimated monthly loads (kg) for each constituent at Osage Creek for Calendar Year 2009.

Month	Cl	SO_4	NH_3-	NO_3-N	SRP	TN	TP	TSS
January	175,000	153,000	110	29,000	220	29,200	350	12,100
February	244,000	216,000	560	45,300	520	49,100	1,190	167,000
March	236,000	206,000	440	42,700	500	45,600	1,140	138,000
April	339,000	321,000	2,300	68,100	1,480	77,900	4,700	2,440,000
May	449,000	462,000	4,540	95,600	3,110	113,000	10,400	6,060,000
June	292,000	312,000	840	55,900	1,610	61,700	3,750	640,000
July	223,000	246,000	210	39,100	950	40,600	1,570	80,800
August	191,000	216,000	130	32,200	730	32,600	1,040	38,200
September	217,000	253,000	280	38,400	990	40,200	1,600	118,000
October	383,000	463,000	6,560	80,300	4,000	95,100	13,000	15,100,000
November	259,000	278,000	420	47,600	900	51,100	1,590	108,000
December	194,000	185,000	130	32,900	330	33,400	480	13,700

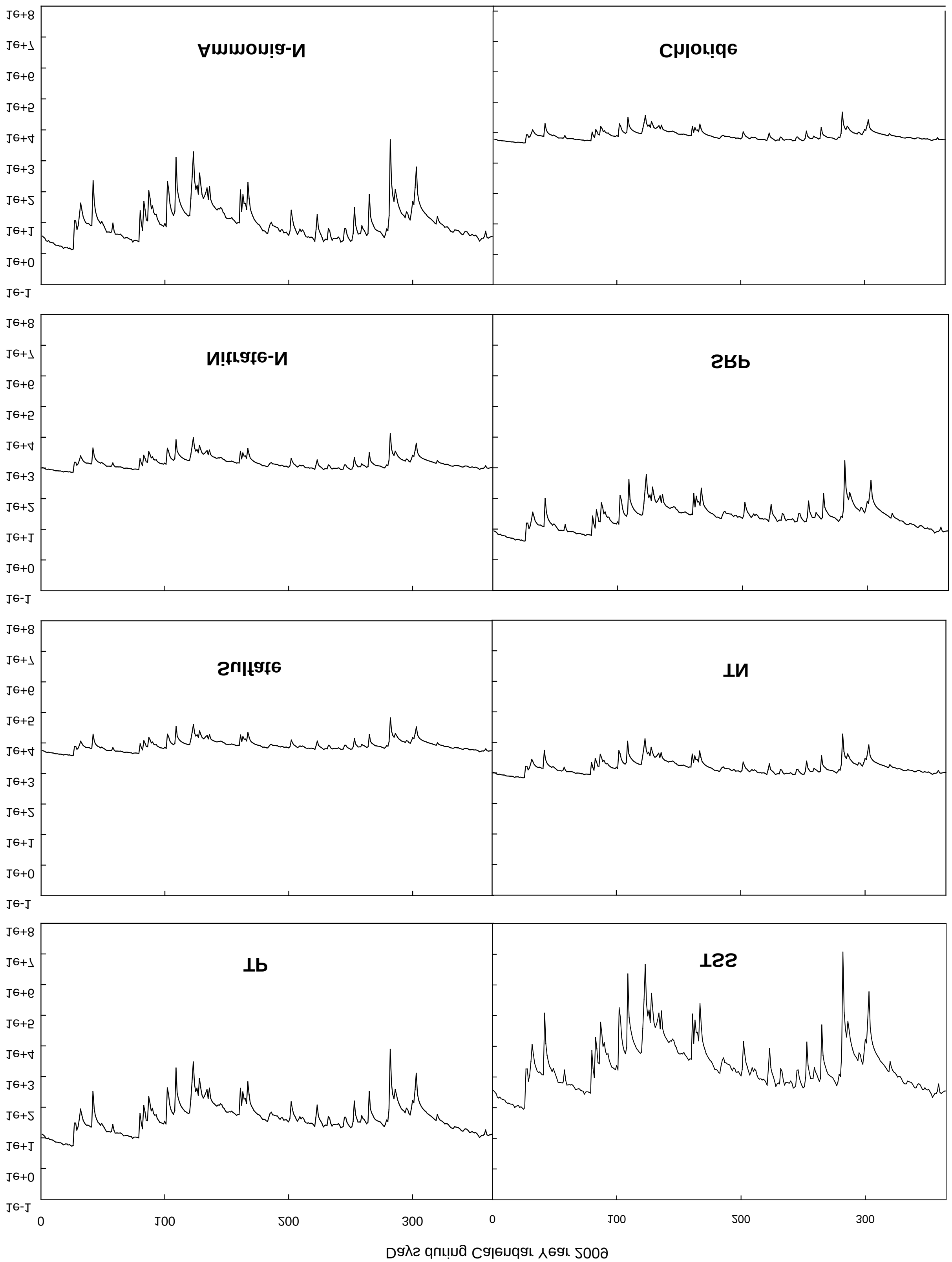

Figure 9. Daily constituent loads (kg d^{-1}) as a function of time (d) at Osage Creek during 2009.

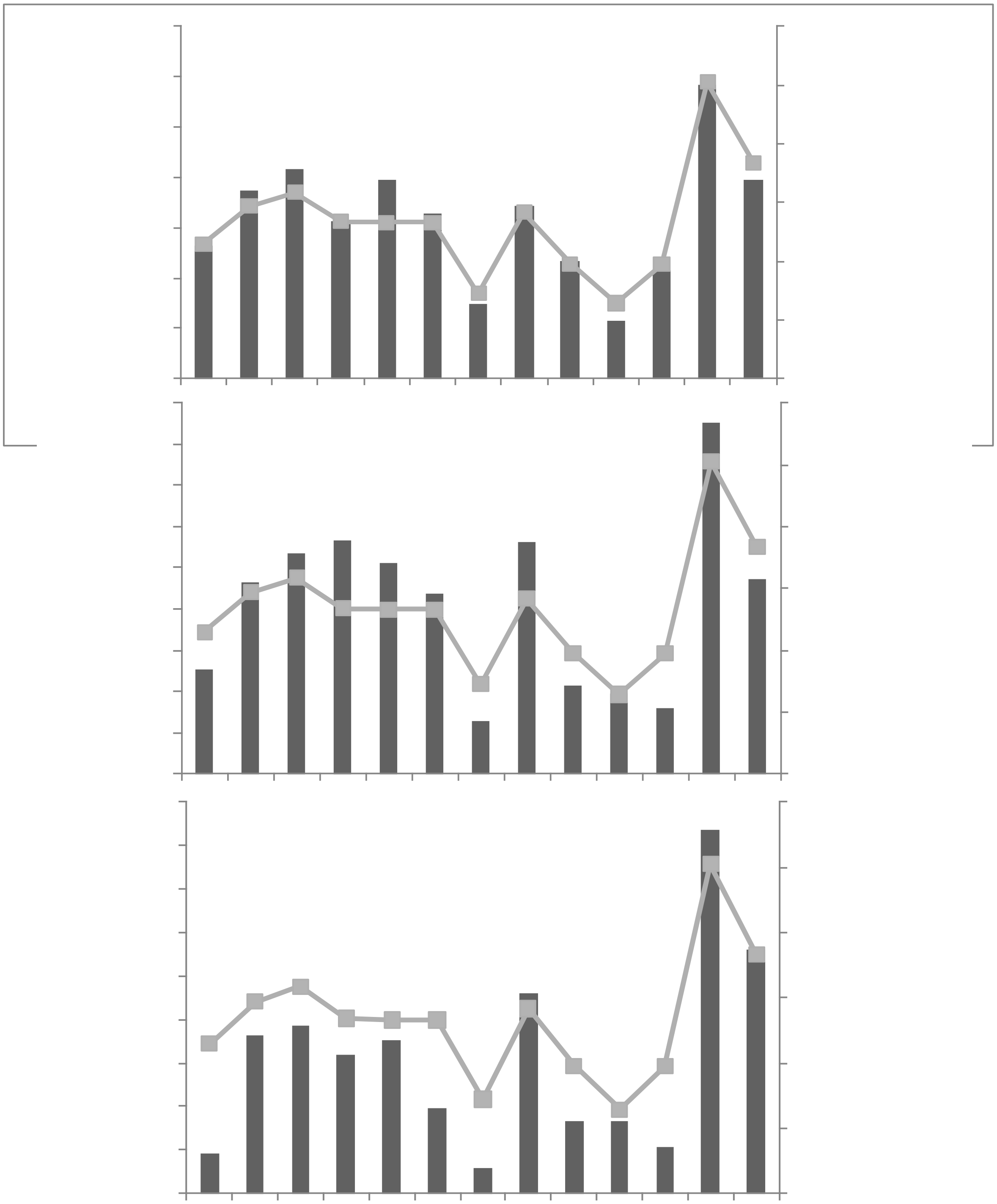

Figure 10. Total nitrogen (TN), total phosphorus (TP) and total suspended solids (TSS) annual loads and discharge at the Illinois River at Arkansas Highway 59 Bridge from 1997 to 2009.

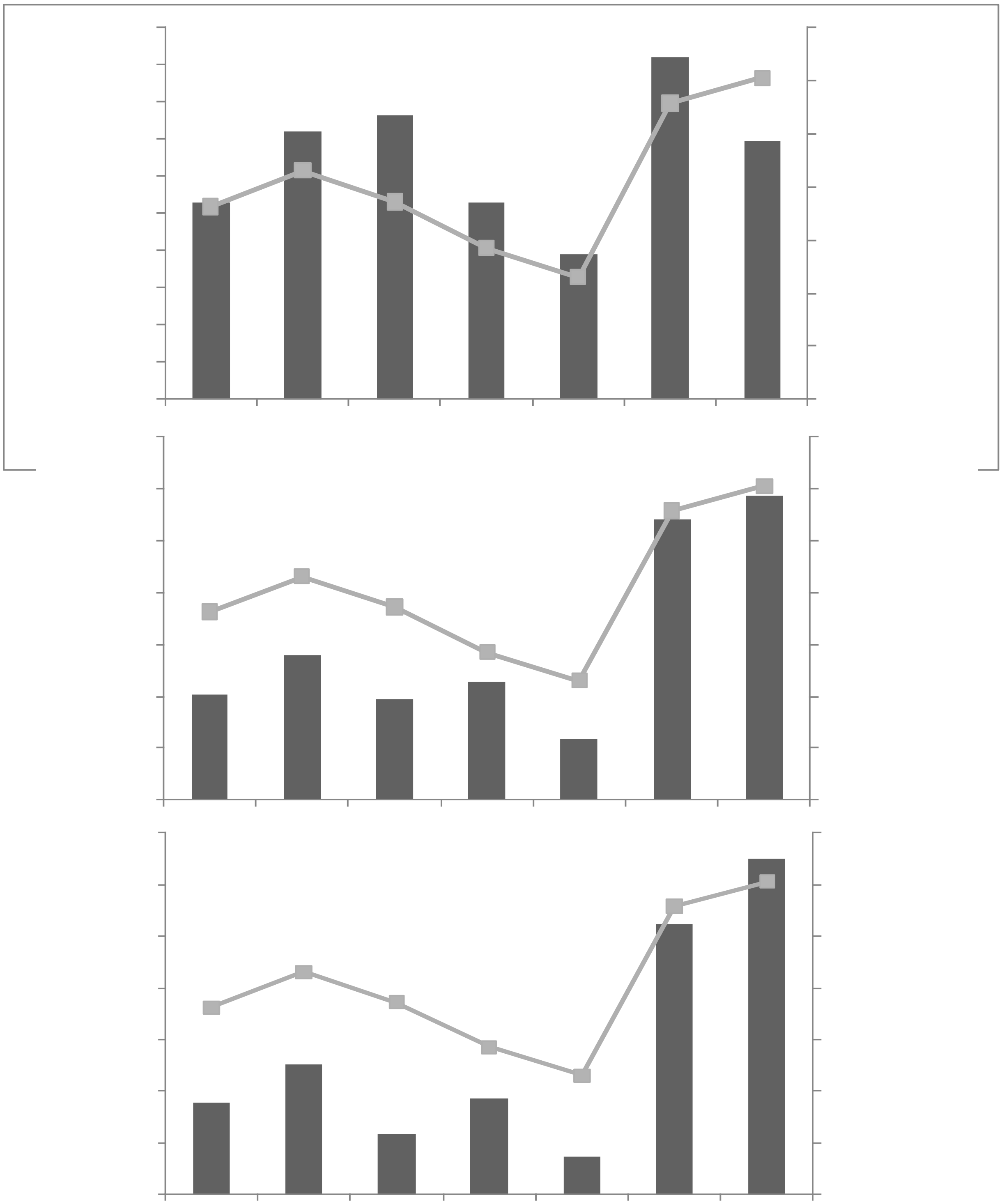

Figure 11. Total nitrogen (TN), total phosphorus (TP) and total suspended solids (TSS) annual loads and discharge at Ballard Creek from 2003 to 2009.

based information that the current monitoring program does not, because auto-samplers collect flow composite samples which represent the rising and falling limb of individual storm events. Therefore, it is important to target storm events in weekly monitoring programs so that loads are accurately estimated when using regression models. While both load estimation methods have their advantages, ANRC should have confidence that switching monitoring programs provided data that is comparable to that collected with auto-samplers. In addition, estimating annual loads at additional sites in the UIRW provides valuable loading information for prioritizing restoration needs and future modeling efforts.

When estimating constituent loads using statistical models, multiple factors including flow regimes and seasonal variations need to be considered so that the selected model best describes the relationship between load and discharge at a site. To estimate loads at in the UIRW during 2009, some constituents required different models for low and high flow (e.g., SRP, TP, and TSS at Illinois River at AR Hwy 59), and some constituents required a seasonal component be included in the model (e.g., NO_3-N, SRP, TP, TN and TSS low flow at Flint Creek at Springtown). Most often, the model with the best statistics (e.g., lowest BCF and highest R^2 value) was chosen to predict loads; however, this model might not always be the best descriptor of the true relation between L_d and Q_d. For example, two models were developed to estimate annual TSS loads at Illinois River at AR59. One model considered all flow regimes (BCF: 1.11; R^2: 0.93), and the other model considered both low flow (BCF: 1.06 R^2: 0.88) and high flow (BCF: 1.13; R^2: 0.92) regimes. While the all flows model exhibited a higher R^2, a pattern in the residuals was observed when comparing predicted and observed daily loads that influenced load estimations for the all flows model. Therefore, the split hydrograph model was selected to estimate loads for TSS, and this example highlights the need to closely examine predicted versus observed data. In other cases, the annual loads predicted with certain regression models were not comparable to that previously measured. For example, the Ballard Creek regression model with SRP and TP using all data had a higher R^2, whereas the split hydrograph method predicted loads that were more comparable to that historically measured. The statistic R^2 varies in significance with the number of observations used in the regression model development. The regression model with lower BCF and or higher R^2 may or may not represent daily loads in the selected stream, and it is critical that the data be closely investigated to determine the most appropriate regression model.

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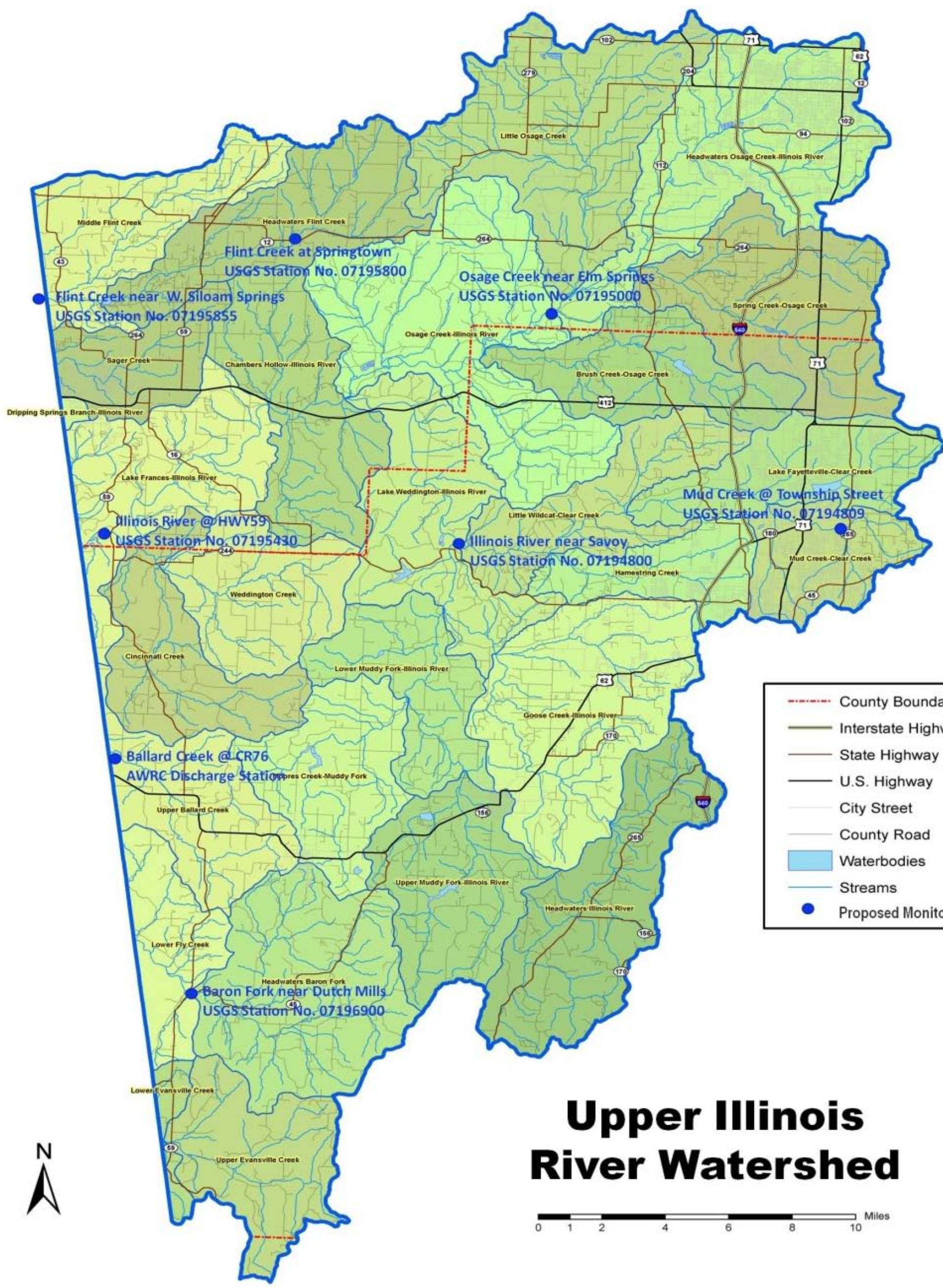
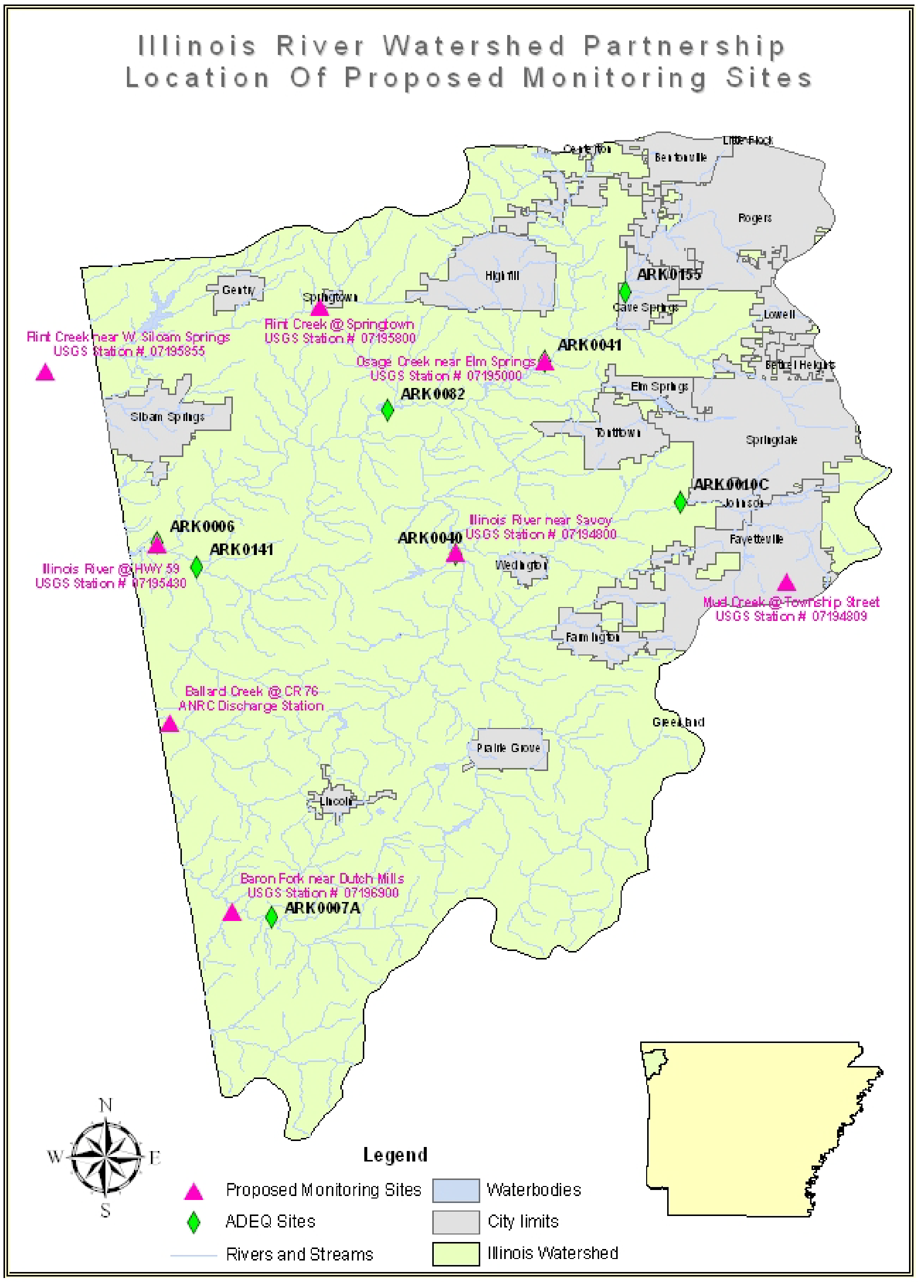
APPENDIX 1. Location of the sampling stations In the Illinois River Watershed, northwest Arkansas.



APPENDIX 2. Location of the sampling stations In the Illinois River Watershed, northwest Arkansas and location of ADEQ monitoring sites in the Illinois River Watershed, northwest Arkansas.



APPENDIX 3. Sample collection record and constituent concentrations[A] at select sites within the Upper Illinois River Watershed from 1 July 2009 to 30 June 2010.

[A]All concentrations are reported to three decimal places to provide raw data, except for TSS which is reported as a whole number; the PQLs of thes constituents are 0.90 mg L^{-1} NH_3-N, 0.16 mg L^{-1} Cl, 0.003 mg L^{-1} NO_3-N, 0.01 mg L^{-1} SRP, 0.02 mg L^{-1} SO_4, 0.05 mg L^{-1} TN, 0.02 mg L^{-1} TP, and 7 mg L^{-1} TSS.

3A. Illinois River at AR59

Date	Time	Collector	NH_3-N ($mg\ L^{-1}$)	Cl ($mg\ L^{-1}$)	NO_3-N ($mg\ L^{-1}$)	SRP ($mg\ L^{-1}$)	SO4 ($mg\ L^{-1}$)	TN ($mg\ L^{-1}$)	TP ($mg\ L^{-1}$)	TSS ($mg\ L^{-1}$)	Turbidity (NTU)
07-Jul-09	630	AWRC, Wade Cash	0.02	13.337	2.490	0.061	11.921	2.64	0.080	6	5.5
14-Jul-09	630	AWRC, Wade Cash	0.03	15.050	2.506	0.067	14.396	2.73	0.088	9	8.7
21-Jul-09	700	AWRC, Wade Cash	0.01	15.837	2.320	0.056	14.883	2.50	0.086	10	7.2
28-Jul-09	600	AWRC, Wade Cash	0.03	15.827	2.343	0.062	14.908	2.52	0.102	9	9.4
04-Aug-09	730	AWRC, Wade Cash	0.03	15.642	2.210	0.058	15.196	2.31	0.084	7	7.0
11-Aug-09	700	AWRC, Wade Cash	0.03	14.608	2.048	0.079	14.354	2.28	0.130	15	15
18-Aug-09	630	AWRC, Wade Cash	0.06	16.631	2.095	0.066	15.608	2.19	0.096	8	7.9
25-Aug-09	630	AWRC, Wade Cash	0.01	16.343	2.001	0.065	16.877	2.19	0.092	6	5.6
01-Sep-09	800	AWRC, Wade Cash	0.02	19.408	2.249	0.059	17.787	2.44	0.080	6	5.8
08-Sep-09	630	AWRC, Wade Cash	0.33	14.499	1.937	0.072	15.516	2.15	0.112	10	8.5
15-Sep-09	630	AWRC, Wade Cash	0.01	14.771	2.183	0.073	15.005	2.32	0.106	7	7.3
22-Sep-09	630	AWRC, Wade Cash	0.01	12.525	2.159	0.132	13.839	2.34	0.204	22	23
29-Sep-09	630	AWRC, Wade Cash	0.01	13.393	2.409	0.067	15.773	2.60	0.058	6	6.9
06-Oct-09	630	AWRC, Wade Cash	0.02	16.114	2.622	0.058	16.790	2.86	0.096	4	4.7
13-Oct-09	800	AWRC, Wade Cash	0.06	7.131	2.618	0.099	11.023	2.81	0.168	24	25
30-Oct-09	630	AWRC, Wade Cash	0.05	5.737	1.365	0.202	9.228	2.44	0.853	489	357
03-Nov-09	800	AWRC, Wade Cash	0.02	7.546	2.913	0.058	10.929	3.05	0.076	6	9.4
10-Nov-09	630	AWRC, Wade Cash	0.01	10.756	3.175	0.053	12.654	3.23	0.010	3	3.5
17-Nov-09	630	AWRC, Wade Cash	0.03	11.803	2.853	0.035	13.638	3.00	0.062	3	2.9
23-Nov-09	800	AWRC, Wade Cash	0.01	12.380	2.952	0.035	14.100	3.12	0.052	2	2.5
01-Dec-09	1430	AWRC, Wade Cash	0.01	12.606	2.883	0.024	12.770	3.02	0.032	2	1.5
08-Dec-09	630	AWRC, Wade Cash	0.01	14.462	3.120	0.014	14.680	3.26	0.028	1	1.2
15-Dec-09	700	AWRC, Wade Cash	0.01	14.793	3.066	0.010	15.205	3.18	0.016	2	3.3
21-Dec-09	730	AWRC, Wade Cash	0.01	16.362	3.125	0.009	16.825	3.26	0.016	2	1.2
29-Dec-09	1030	AWRC, Wade Cash	0.01	13.097	2.445	0.017	15.045	2.58	0.034	2	2.9
05-Jan-10	1530	AWRC, Wade Cash	0.01	13.677	2.534	0.019	14.993	2.65	0.028	1	3.7
12-Jan-10	700	AWRC, Wade Cash	0.01	16.413	3.079	0.012	16.611	3.17	0.016	1	1.9
19-Jan-10	800	AWRC, Wade Cash	0.01	17.258	2.802	0.013	16.784	3.10	0.034	3	3.7
03-Feb-10	630	AWRC, Wade Cash	0.05	16.316	2.432	0.032	17.061	2.57	0.054	9	9.1
10-Feb-10	800	AWRC, Wade Cash	0.01	12.006	2.836	0.043	13.821	3.00	0.064	5	8.7
16-Feb-10	730	AWRC, Wade Cash	0.01	12.066	2.971	0.033	14.725	3.04	0.038	3	5.5
23-Feb-10	730	AWRC, Wade Cash	0.01	13.709	2.410	0.036	15.994	2.59	0.068	7	11
02-Mar-10	730	AWRC, Wade Cash	0.01	12.830	3.013	0.010	14.277	3.15	0.028	4	4.2
08-Mar-10	630	AWRC, Wade Cash	0.01	13.527	3.000	0.010	15.202	3.17	0.034	5	4.9
16-Mar-10	730	AWRC, Wade Cash	0.02	14.272	3.049	0.035	14.814	3.30	0.050	3	3.6
22-Mar-10	730	AWRC, Wade Cash	0.05	12.109	1.986	0.049	16.175	2.27	0.110	16	21
30-Mar-10	1530	AWRC, Wade Cash	0.01	8.335	3.121	0.041	11.997	3.30	0.052	10	10
07-Apr-10	800	AWRC, Wade Cash	0.02	10.068	2.789	0.035	11.884	2.97	0.064	9	10
13-Apr-10	630	AWRC, Wade Cash	0.01	11.261	2.718	0.005	12.230	2.84	0.036	8	6.9
20-Apr-10	700	AWRC, Wade Cash	0.01	12.076	2.960	0.022	12.334	3.19	0.044	6	4.5
27-Apr-10	730	AWRC, Wade Cash	0.05	12.006	2.480	0.042	13.305	2.56	0.066	6	7.0
04-May-10	800	AWRC, Wade Cash	0.03	13.383	2.494	0.017	13.680	2.74	0.048	7	6.5
11-May-10	700	AWRC, Wade Cash	0.04	14.102	2.657	0.047	14.842	2.92	0.076	13	12
14-May-10	730	AWRC, Wade Cash	0.09	13.908	2.618	0.058	14.965	2.76	0.112	28	19
26-May-10	1230	AWRC, Wade Cash	0.01	9.217	2.645	0.057	11.040	2.84	0.102	18	16
01-Jun-10	800	AWRC, Wade Cash	0.01	10.445	2.814	0.058	12.181	2.85	0.088	11	11
08-Jun-10	630	AWRC, Wade Cash	0.01	11.856	2.699	0.049	12.486	2.84	0.086	14	11
15-Jun-10	630	AWRC, Wade Cash	0.05	12.726	2.531	0.060	13.183	2.70	0.086	9	9.8
23-Jun-10	700	AWRC, Wade Cash	0.01	14.955	2.342	0.058	13.975	2.41	0.118	2	8.6

3B. Ballard Creek

Date	Time	Collector	NH_3-N (mg L^{-1})	Cl (mg L^{-1})	NO_3-N (mg L^{-1})	SRP (mg L^{-1})	SO4 (mg L^{-1})	TN (mg L^{-1})	TP (mg L^{-1})	TSS (mg L^{-1})	Turbidity (NTU)
07-Jul-09	9:10	AWRC, Wade Cash	0.07	13.112	2.566	0.055	12.136	2.87	0.082	3	2.1
14-Jul-09	7:10	AWRC, Wade Cash	0.06	12.916	2.245	0.061	11.170	2.65	0.098	3	3.9
21-Jul-09	8:00	AWRC, Wade Cash	0.06	11.404	1.445	0.074	9.512	1.85	0.136	9	8.3
28-Jul-09	7:20	AWRC, Wade Cash	0.05	12.660	2.049	0.073	10.200	2.28	0.100	2	3.7
04-Aug-09	7:15	AWRC, Wade Cash	0.03	12.329	1.758	0.077	10.110	2.17	0.170	5	5.6
11-Aug-09	7:30	AWRC, Wade Cash	0.10	11.044	1.262	0.210	10.542	1.90	0.306	11	12
18-Aug-09	7:30	AWRC, Wade Cash	0.17	12.375	1.913	0.098	10.373	2.19	0.152	3	3.4
25-Aug-09	8:15	AWRC, Wade Cash	0.04	11.849	1.902	0.091	11.018	2.24	0.130	3	4.1
01-Sep-09	7:45	AWRC, Wade Cash	0.07	12.132	1.518	0.125	12.279	1.89	0.176	5	5.4
08-Sep-09	7:30	AWRC, Wade Cash	0.35	10.582	2.505	0.162	17.413	3.04	0.234	7	11
10-Sep-09	8:45	AWRC, Wade Cash	0.24	6.987	0.362	0.379	14.465	1.45	1.048	214	195
15-Sep-09	7:30	AWRC, Wade Cash	0.09	9.328	1.968	0.294	14.138	2.62	0.432	11	18
22-Sep-09	7:00	AWRC, Wade Cash	0.01	4.966	1.267	0.770	7.911	2.15	1.024	33	39
29-Sep-09	7:45	AWRC, Wade Cash	0.01	10.356	4.696	0.075	14.392	5.21	0.100	1	3.5
06-Oct-09	7:15	AWRC, Wade Cash	0.02	11.029	4.561	0.064	14.398	4.71	0.136	25	24
09-Oct-09	9:30	AWRC, Wade Cash	0.09	1.922	0.708	0.631	3.952	1.29	0.872	62	68
13-Oct-09	8:00	AWRC, Wade Cash	0.04	7.638	2.659	0.203	14.513	3.09	0.280	7	14
20-Oct-09	8:00	AWRC, Wade Cash	0.02	9.284	4.114	0.064	14.480	4.21	0.084	2	3.6
27-Oct-09	7:15	AWRC, Wade Cash	0.13	9.162	0.903	0.376	16.621	1.62	0.524	23	30
03-Nov-09	7:30	AWRC, Wade Cash	0.02	8.033	3.265	0.062	13.843	3.44	0.082	2	6.5
10-Nov-09	7:15	AWRC, Wade Cash	0.03	10.025	3.682	0.045	14.906	3.79	0.046	1	2.6
17-Nov-09	7:30	AWRC, Wade Cash	0.05	10.233	2.071	0.051	17.516	2.41	0.102	4	9.5
23-Nov-09	7:15	AWRC, Wade Cash	0.03	10.084	2.256	0.024	18.241	2.50	0.050	2	4.0
01-Dec-09	8:00	AWRC, Wade Cash	0.01	11.101	2.384	0.020	19.502	2.54	0.032	2	2.5
08-Dec-09	7:30	AWRC, Wade Cash	0.01	10.737	2.866	0.010	18.939	2.98	0.120	1	1.6
15-Dec-09	8:00	AWRC, Wade Cash	0.01	11.109	2.293	0.007	21.383	2.43	0.020	1	2.4
21-Dec-09	7:15	AWRC, Wade Cash	0.01	11.559	2.758	0.005	21.014	2.94	0.008	1	2.7
29-Dec-09	15:15	AWRC, Wade Cash	0.01	11.878	1.887	0.009	26.050	2.10	0.026	2	3.3
05-Jan-10	14:30	AWRC, Wade Cash	0.01	12.417	2.309	0.018	26.728	2.60	0.030	1	3.5
12-Jan-10	7:45	AWRC, Wade Cash	0.01	12.192	3.122	0.017	24.164	3.24	0.024	1	2.4
19-Jan-10	7:45	AWRC, Wade Cash	0.01	11.608	2.145	0.014	24.023	2.51	0.052	5	2.1
26-Jan-10	7:45	AWRC, Wade Cash	0.01	10.735	2.302	0.048	21.310	2.59	0.074	3	10
03-Feb-10	7:30	AWRC, Wade Cash	0.07	12.296	1.884	0.176	20.136	2.27	0.244	5	15
10-Feb-10	7:45	AWRC, Wade Cash	0.01	12.092	2.782	0.053	19.028	3.02	0.084	2	8.2
16-Feb-10	7:30	AWRC, Wade Cash	0.02	11.177	2.838	0.028	20.125	2.94	0.038	2	5.0
23-Feb-10	7:30	AWRC, Wade Cash	0.03	11.104	2.173	0.053	20.659	2.37	0.098	4	8.5
02-Mar-10	7:30	AWRC, Wade Cash	0.01	11.393	2.913	0.016	20.643	3.11	0.032	3	4.5
08-Mar-10	7:45	AWRC, Wade Cash	0.01	11.711	2.921	0.022	20.826	3.06	0.044	2	3.0
16-Mar-10	7:45	AWRC, Wade Cash	0.08	12.126	2.316	0.039	22.777	2.68	0.066	4	4.7
22-Mar-10	11:24	AWRC, Wade Cash	0.12	10.860	1.361	0.167	18.774	1.89	0.262	12	24
30-Mar-10	7:45	AWRC, Wade Cash	0.02	8.321	3.226	0.061	15.999	3.47	0.080	4	9.9
07-Apr-10	16:30	AWRC, Wade Cash	0.02	8.686	2.579	0.045	16.312	2.85	0.078	5	7.9
13-Apr-10	7:30	AWRC, Wade Cash	0.01	10.146	3.156	0.018	16.072	3.31	0.040	3	3.9
20-Apr-10	7:30	AWRC, Wade Cash	0.01	10.797	3.108	0.015	16.450	3.37	0.026	2	2.5
27-Apr-10	7:20	AWRC, Wade Cash	0.06	10.591	2.745	0.026	19.009	2.87	0.054	2	5.0
04-May-10	7:30	AWRC, Wade Cash	0.07	11.427	3.202	0.033	16.435	3.45	0.056	3	3.6
11-May-10	7:45	AWRC, Wade Cash	0.08	11.316	3.192	0.028	15.108	3.43	0.050	3	3.4
14-May-10	13:15	AWRC, Wade Cash	0.38	5.421	0.597	0.478	10.256	1.78	1.528	367	335
18-May-10	7:15	AWRC, Wade Cash	0.04	7.294	1.393	0.115	17.512	1.79	0.194	11	19
25-May-10	11:30	AWRC, Wade Cash	0.03	9.515	2.820	0.089	15.909	3.12	0.130	5	6.4
01-Jun-10	7:30	AWRC, Wade Cash	0.05	11.125	3.029	0.092	14.965	3.20	0.118	4	4.3
08-Jun-10	7:30	AWRC, Wade Cash	0.10	10.073	2.680	0.170	13.350	3.09	0.260	10	13
15-Jun-10	7:15	AWRC, Wade Cash	0.07	10.783	2.654	0.178	12.931	3.04	0.234	8	9.3
23-Jun-10	7:30	AWRC, Wade Cash	0.08	11.979	2.442	0.106	12.801	2.79	0.182	6	3.7

3C. Baron Fork

Date	Time	Collector	NH_3-N ($mg\ L^{-1}$)	Cl ($mg\ L^{-1}$)	NO_3-N ($mg\ L^{-1}$)	SRP ($mg\ L^{-1}$)	SO4 ($mg\ L^{-1}$)	TN ($mg\ L^{-1}$)	TP ($mg\ L^{-1}$)	TSS ($mg\ L^{-1}$)	Turbidity (NTU)
07-Jul-09	8:15	AWRC, Wade Cash	0.06	9.798	1.017	0.040	15.363	1.23	0.062	2	2.6
14-Jul-09	6:40	AWRC, Wade Cash	0.07	10.008	0.443	0.029	13.325	0.78	0.052	5	6.4
21-Jul-09	8:45	AWRC, Wade Cash	0.15	9.646	0.329	0.031	12.248	0.52	0.072	14	16
28-Jul-09	6:50	AWRC, Wade Cash	0.10	10.670	0.451	0.027	13.970	0.65	0.054	4	5.9
04-Aug-09	6:45	AWRC, Wade Cash	0.04	10.751	0.650	0.034	14.314	0.84	0.060	5	5.1
11-Aug-09	7:15	AWRC, Wade Cash	0.08	9.343	0.855	0.080	11.856	1.22	0.140	7	11
18-Aug-09	7:00	AWRC, Wade Cash	0.12	9.899	0.449	0.033	16.294	0.73	0.076	5	6.9
25-Aug-09	7:45	AWRC, Wade Cash	0.01	10.149	0.527	0.035	15.462	0.78	0.063	6	5.9
01-Sep-09	7:30	AWRC, Wade Cash	0.06	9.191	0.853	0.047	16.760	1.07	0.080	6	5.7
05-Sep-09	12:00	AWRC, Wade Cash	0.19	3.185	0.862	0.477	7.375	2.17	0.550	175	183
08-Sep-09	7:00	AWRC, Wade Cash	0.14	6.383	1.906	0.089	17.914	2.24	0.110	7	7.6
10-Sep-09	9:00	AWRC, Wade Cash	0.08	2.642	0.907	0.284	8.743	1.47	0.566	82	114
15-Sep-09	7:00	AWRC, Wade Cash	0.03	6.374	1.890	0.087	18.023	2.15	0.116	7	9.1
22-Sep-09	6:30	AWRC, Wade Cash	0.11	2.973	1.537	0.206	8.686	2.16	0.314	34	52
29-Sep-09	7:00	AWRC, Wade Cash	0.01	7.002	3.428	0.060	15.225	3.59	0.074	1	2.4
06-Oct-09	6:45	AWRC, Wade Cash	0.02	7.825	3.160	0.047	15.137	3.37	0.062	1	1.4
09-Oct-09	10:00	AWRC, Wade Cash	0.11	1.726	0.975	0.272	5.149	1.47	0.494	71	97
13-Oct-09	7:30	AWRC, Wade Cash	0.02	5.478	3.104	0.066	13.761	3.30	0.084	3	4.8
20-Oct-09	7:30	AWRC, Wade Cash	0.01	6.147	3.417	0.058	16.334	3.51	0.056	1	2.0
27-Oct-09	7:00	AWRC, Wade Cash	0.03	5.245	1.428	0.059	15.087	1.68	0.076	4	6.8
03-Nov-09	7:15	AWRC, Wade Cash	0.01	5.189	2.683	0.047	13.362	2.83	0.050	2	3.1
10-Nov-09	6:45	AWRC, Wade Cash	0.05	6.297	2.967	0.039	18.069	3.10	0.048	3	3.1
17-Nov-09	7:00	AWRC, Wade Cash	0.01	6.460	2.370	0.031	17.794	2.50	0.044	2	2.0
23-Nov-09	6:45	AWRC, Wade Cash	0.01	6.474	2.060	0.023	16.091	2.19	0.040	1	1.7
01-Dec-09	7:30	AWRC, Wade Cash	0.01	6.689	2.120	0.025	18.394	2.22	0.040	7	3.4
08-Dec-09	7:15	AWRC, Wade Cash	0.01	6.754	2.346	0.017	16.528	2.48	0.042	0	1.5
15-Dec-09	7:30	AWRC, Wade Cash	0.01	7.278	2.168	0.022	17.934	2.27	0.016	1	2.9
21-Dec-09	7:00	AWRC, Wade Cash	0.01	8.009	2.406	0.014	18.288	2.53	0.016	0	3.3
29-Dec-09	14:45	AWRC, Wade Cash	0.01	6.928	1.732	0.025	20.331	1.83	0.022	1	2.0
05-Jan-10	14:00	AWRC, Wade Cash	0.01	6.843	1.867	0.019	20.046	1.99	0.024	0	1.8
12-Jan-10	7:15	AWRC, Wade Cash	0.01	7.572	2.370	0.017	19.638	2.51	0.020	1	1.6
26-Jan-10	7:30	AWRC, Wade Cash	0.01	5.809	1.859	0.030	18.683	2.03	0.026	1	3.6
03-Feb-10	7:00	AWRC, Wade Cash	0.02	6.148	1.722	0.033	18.711	1.90	0.046	1	7.4
10-Feb-10	7:15	AWRC, Wade Cash	0.01	6.125	2.364	0.032	17.211	2.54	0.038	2	3.1
16-Feb-10	7:00	AWRC, Wade Cash	0.01	6.576	2.342	0.028	17.992	2.48	0.032	1	4.2
23-Feb-10	7:00	AWRC, Wade Cash	0.01	6.335	1.936	0.031	19.516	1.98	0.038	1	3.1
02-Mar-10	7:00	AWRC, Wade Cash	0.01	6.925	2.382	0.025	20.166	2.51	0.038	2	3.3
08-Mar-10	7:00	AWRC, Wade Cash	0.01	7.326	2.317	0.027	19.621	2.42	0.032	3	2.5
16-Mar-10	7:15	AWRC, Wade Cash	0.02	7.228	2.016	0.031	20.991	2.27	0.050	3	3.3
22-Mar-10	11:02	AWRC, Wade Cash	0.04	5.345	1.432	0.045	18.564	1.68	0.088	4	14
30-Mar-10	7:00	AWRC, Wade Cash	0.01	5.336	3.693	0.040	15.342	3.03	0.036	3	6.0
07-Apr-10	16:15	AWRC, Wade Cash	0.01	5.499	2.044	0.037	16.063	2.24	0.048	2	2.6
13-Apr-10	6:45	AWRC, Wade Cash	0.01	6.298	2.244	0.029	16.117	2.36	0.036	3	2.3
20-Apr-10	7:00	AWRC, Wade Cash	0.02	7.157	2.247	0.028	16.202	2.48	0.032	2	2.1
27-Apr-10	6:45	AWRC, Wade Cash	0.01	6.235	1.737	0.029	17.232	1.80	0.038	2	2.7
04-May-10	7:00	AWRC, Wade Cash	0.07	6.678	1.672	0.032	17.345	1.91	0.054	3	2.9
11-May-10	7:15	AWRC, Wade Cash	0.06	5.234	1.391	0.059	17.815	1.86	0.122	12	27
13-May-10	21:30	AWRC, Wade Cash	0.28	3.420	0.917	0.098	11.620	1.79	0.264	44	84
14-May-10	12:45	AWRC, Wade Cash	0.15	2.678	0.636	0.199	8.110	1.45	0.800	270	272
18-May-10	7:00	AWRC, Wade Cash	0.01	4.326	1.433	0.049	14.565	1.64	0.072	5	8.4
25-May-10	11:00	AWRC, Wade Cash	0.01	6.000	2.114	0.048	14.613	2.29	0.066	4	4.2
01-Jun-10	7:00	AWRC, Wade Cash	0.03	6.798	2.238	0.047	14.929	2.33	0.064	3	3.7
08-Jun-10	7:00	AWRC, Wade Cash	0.03	6.439	1.988	0.060	15.336	2.20	0.082	4	5.0
15-Jun-10	7:00	AWRC, Wade Cash	0.04	7.272	1.682	0.051	14.316	1.89	0.074	4	4.6
23-Jun-10	7:00	AWRC, Wade Cash	0.05	8.334	0.861	0.038	14.108	1.02	0.084	6	4.0

3D. Flint Creek at Springtown

Date	Time	Collector	NH_3-N (mg L^{-1})	Cl (mg L^{-1})	NO_3-N (mg L^{-1})	SRP (mg L^{-1})	SO4 (mg L^{-1})	TN (mg L^{-1})	TP (mg L^{-1})	TSS (mg L^{-1})	Turbidity (NTU)
07-Jul-09	0:45	AWRC, Wade Cash	0.01	7.32	3.15	0.05	4.57	3.25	0.06	1	1.70
14-Jul-09	9:15	AWRC, Wade Cash	0.02	7.17	3.17	0.06	4.11	3.34	0.06	1	1.30
21-Jul-09	10:45	AWRC, Wade Cash	0.01	6.82	3.00	0.05	3.80	2.99	0.07	2	4.70
28-Jul-09	9:15	AWRC, Wade Cash	0.03	7.30	3.05	0.05	4.09	3.11	0.05	1	1.20
04-Aug-09	9:15	AWRC, Wade Cash	1.02	7.25	2.98	0.05	3.73	3.02	0.06	1	1.20
11-Aug-09	9:30	AWRC, Wade Cash	0.01	7.12	2.84	0.05	3.54	3.04	0.08	1	1.60
18-Aug-09	9:30	AWRC, Wade Cash	0.01	7.18	2.92	0.05	3.60	2.93	0.06	0	1.60
25-Aug-09	10:15	AWRC, Wade Cash	0.01	7.34	2.93	0.08	3.57	3.18	0.07	1	1.40
01-Sep-09	10:00	AWRC, Wade Cash	0.04	7.42	2.89	0.04	3.55	3.05	0.06	2	1.10
15-Sep-09	9:30	AWRC, Wade Cash	0.01	7.53	2.65	0.05	3.80	2.71	0.06	1	1.40
06-Oct-09	9:15	AWRC, Wade Cash	0.03	7.41	2.82	0.05	3.68	2.99	0.05	0	0.80
09-Oct-09	8:00	AWRC, Wade Cash	0.20	2.61	2.29	0.73	4.37	3.47	1.66	561	378
27-Oct-09	9:00	AWRC, Wade Cash	0.01	5.78	3.25	0.06	6.62	3.44	0.07	2	2.80
03-Nov-09	9:30	AWRC, Wade Cash	0.02	5.57	3.94	0.06	7.55	4.04	0.06	1	2.20
10-Nov-09	9:15	AWRC, Wade Cash	0.01	6.09	3.48	0.05	6.02	3.51	0.06	0	2.20
17-Nov-09	9:30	AWRC, Wade Cash	0.01	6.55	3.33	0.04	5.08	3.44	0.06	1	0.80
23-Nov-09	9:30	AWRC, Wade Cash	0.01	6.76	3.23	0.04	4.66	3.36	0.05	0	1.30
01-Dec-09	10:00	AWRC, Wade Cash	0.01	6.88	3.28	0.02	4.35	3.32	0.05	1	0.60
08-Dec-09	9:15	AWRC, Wade Cash	0.01	6.93	3.36	0.04	4.08	3.43	0.05	0	0.70
15-Dec-09	9:45	AWRC, Wade Cash	0.01	7.12	3.32	0.04	4.02	3.38	0.04	1	1.80
21-Dec-09	9:15	AWRC, Wade Cash	0.01	7.56	3.41	0.03	4.09	3.43	0.04	0	1.70
29-Dec-09	17:15	AWRC, Wade Cash	0.01	7.22	3.27	0.03	4.22	3.38	0.04	1	0.80
05-Jan-10	17:00	AWRC, Wade Cash	0.01	7.05	3.41	0.03	4.74	3.42	0.04	0	1.80
12-Jan-10	9:45	AWRC, Wade Cash	0.01	7.12	3.50	0.03	4.43	3.46	0.04	0	2.40
19-Jan-10	9:45	AWRC, Wade Cash	0.01	7.31	3.29	0.03	4.21	3.45	0.04	1	1.00
03-Feb-10	9:30	AWRC, Wade Cash	0.07	7.19	3.46	0.04	5.43	3.56	0.05	0	2.60
10-Feb-10	9:45	AWRC, Wade Cash	0.01	6.26	4.34	0.04	7.14	4.72	0.05	0	2.70
16-Feb-10	9:30	AWRC, Wade Cash	0.03	6.43	4.07	0.04	6.26	4.42	0.04	0	2.60
02-Mar-10	9:30	AWRC, Wade Cash	0.01	7.01	3.93	0.03	5.43	3.92	0.04	1	2.00
16-Mar-10	9:30	AWRC, Wade Cash	0.01	7.04	3.43	0.04	4.49	3.58	0.04	1	1.40
30-Mar-10	9:30	AWRC, Wade Cash	0.01	5.35	5.00	0.05	7.44	5.36	0.05	2	3.60
07-Apr-10	18:15	AWRC, Wade Cash	0.01	6.02	3.93	0.05	5.84	3.93	0.05	2	1.80
13-Apr-10	9:15	AWRC, Wade Cash	0.02	6.32	3.67	0.04	5.07	3.67	0.05	1	1.30
20-Apr-10	9:30	AWRC, Wade Cash	0.01	6.62	3.42	0.04	4.45	3.53	0.04	1	1.50
27-Apr-10	9:30	AWRC, Wade Cash	0.10	6.68	3.27	0.04	4.34	3.22	0.05	1	1.50
04-May-10	9:15	AWRC, Wade Cash	0.05	6.71	3.21	0.04	4.17	3.31	0.05	1	1.60
11-May-10	9:45	AWRC, Wade Cash	0.06	6.68	3.15	0.05	4.00	3.26	0.06	1	1.40
14-May-10	14:00	AWRC, Wade Cash	0.19	5.01	1.99	0.29	3.45	2.49	0.45	33	44
18-May-10	9:30	AWRC, Wade Cash	0.01	5.94	3.65	0.06	6.26	3.75	0.08	2	2.60
20-May-10	7:15	AWRC, Wade Cash	0.11	2.65	1.82	0.38	4.37	2.47	0.73	162	127
26-May-10	13:30	AWRC, Wade Cash	0.01	5.42	3.74	0.06	6.75	3.82	0.08	3	2.70
01-Jun-10	9:15	AWRC, Wade Cash	0.01	5.23	3.33	0.06	6.39	5.41	0.07	2	2.20
08-Jun-10	9:30	AWRC, Wade Cash	0.05	5.73	3.17	0.06	5.37	3.24	0.07	2	1.40
15-Jun-10	9:15	AWRC, Wade Cash	0.03	6.19	3.07	0.06	4.36	3.20	0.07	2	2.60
23-Jun-10	9:30	AWRC, Wade Cash	0.03	6.62	3.33	0.06	4.60	3.40	0.14	6	1.60

3E. Flint Creek near West Siloam Springs

Time	Collector	NH_3-N (mg L^{-1})	Cl (mg L^{-1})	NO_3-N (mg L^{-1})	SRP (mg L^{-1})	SO4 (mg L^{-1})	TN (mg L^{-1})	TP (mg L^{-1})	TSS (mg L^{-1})	Turbidity (NTU)
11:45	AWRC, Wade Cash	0.03	11.77	1.07	0.03	25.04	1.23	0.04	4	2.90
8:45	AWRC, Wade Cash	0.02	11.93	0.97	0.03	26.47	1.14	0.06	3	4.20
10:15	AWRC, Wade Cash	0.01	11.52	0.86	0.03	25.98	1.01	0.05	6	5.70
8:45	AWRC, Wade Cash	0.01	11.81	0.87	0.03	25.50	1.01	0.05	4	2.20
9:00	AWRC, Wade Cash	0.01	11.04	0.83	0.03	21.98	1.01	0.06	5	5.60
9:00	AWRC, Wade Cash	0.01	11.86	0.74	0.03	24.95	0.85	0.05	3	4.20
9:45	AWRC, Wade Cash	0.01	11.79	0.73	0.03	24.52	0.84	0.04	3	3.90
9:30	AWRC, Wade Cash	0.03	12.26	0.71	0.03	26.39	0.84	0.04	3	2.60
9:00	AWRC, Wade Cash	0.03	7.01	2.83	0.04	3.52	2.95	0.06	1	0.90
8:30	AWRC, Wade Cash	0.01	10.31	1.50	0.04	15.71	1.63	0.06	10	9.30
9:00	AWRC, Wade Cash	0.17	11.10	1.36	0.03	21.05	1.51	0.04	1	1.60
8:45	AWRC, Wade Cash	0.01	11.43	1.28	0.02	23.03	1.47	0.03	2	2.20
8:45	AWRC, Wade Cash	0.07	4.06	1.78	0.28	6.19	2.51	0.65	245	165
9:30	AWRC, Wade Cash	0.01	9.24	2.79	0.04	20.35	2.95	0.04	1	1.90
8:30	AWRC, Wade Cash	0.01	8.34	2.57	0.04	16.50	2.74	0.05	7	6.00
9:00	AWRC, Wade Cash	0.04	8.85	2.80	0.03	17.98	2.93	0.03	2	2.40
8:30	AWRC, Wade Cash	0.02	10.66	2.40	0.03	23.99	2.66	0.04	1	1.80
9:00	AWRC, Wade Cash	0.02	11.40	2.14	0.02	28.06	2.26	0.03	2	1.70
9:00	AWRC, Wade Cash	0.01	11.80	1.91	0.02	30.24	2.05	0.03	1	1.60
9:30	AWRC, Wade Cash	0.01	12.44	1.70	0.02	33.42	1.83	0.02	1	1.60
8:45	AWRC, Wade Cash	0.01	12.05	1.94	0.02	30.53	2.02	0.02	1	0.90
9:15	AWRC, Wade Cash	0.01	12.06	1.95	0.02	30.98	1.99	0.03	1	1.40
8:45	AWRC, Wade Cash	0.01	12.38	1.88	0.01	32.46	1.97	0.01	1	1.30
16:45	AWRC, Wade Cash	0.04	12.40	1.66	0.01	33.94	1.77	0.02	1	1.20
16:55	AWRC, Wade Cash	0.01	12.48	1.75	0.02	33.35	1.86	0.04	1	2.00
9:15	AWRC, Wade Cash	0.01	12.05	2.29	0.01	28.75	2.26	0.02	1	2.10
9:15	AWRC, Wade Cash	0.01	12.75	1.61	0.01	34.81	1.76	0.02	2	1.50
9:00	AWRC, Wade Cash	0.01	11.49	2.39	0.02	24.39	2.56	0.01	1	3.00
9:00	AWRC, Wade Cash	0.03	11.55	2.27	0.01	25.41	2.41	0.02	2	1.90
9:15	AWRC, Wade Cash	0.01	10.42	3.09	0.02	18.49	3.15	0.03	2	3.10
9:00	AWRC, Wade Cash	0.01	10.98	2.70	0.02	22.33	2.88	0.03	1	2.90
8:45	AWRC, Wade Cash	0.01	10.94	2.70	0.01	23.08	2.76	0.02	2	2.10
9:00	AWRC, Wade Cash	0.01	11.40	2.44	0.01	26.85	2.56	0.02	2	1.60
9:00	AWRC, Wade Cash	0.03	12.01	1.96	0.02	30.56	2.18	0.03	3	2.00
8:45	AWRC, Wade Cash	0.01	11.43	1.75	0.02	29.34	1.93	0.02	3	2.60
8:45	AWRC, Wade Cash	0.03	11.74	1.70	0.02	29.48	1.75	0.03	4	3.60
8:45	AWRC, Wade Cash	0.04	11.61	1.51	0.02	30.77	1.68	0.04	4	4.30
9:15	AWRC, Wade Cash	0.02	11.61	1.43	0.02	30.34	1.60	0.03	3	3.00
7:45	AWRC, Wade Cash	0.01	5.75	2.39	0.12	7.28	2.75	0.49	255	166
13:00	AWRC, Wade Cash	0.01	8.28	2.46	0.04	17.69	2.60	0.06	8	6.10
8:30	AWRC, Wade Cash	0.02	9.57	1.82	0.03	22.20	2.34	0.06	20	3.50
9:00	AWRC, Wade Cash	0.03	10.46	1.40	0.03	26.91	1.69	0.05	5	3.20
8:45	AWRC, Wade Cash	0.04	10.24	1.31	0.03	25.06	1.47	0.05	9	6.30
9:00	AWRC, Wade Cash	0.02	11.48	0.92	0.03	30.24	1.00	0.06	2	3.60

3F. Illinois River at Savoy

Date	Time	Collector	NH_3-N (mg L^{-1})	Cl (mg L^{-1})	NO_3-N (mg L^{-1})	SRP (mg L^{-1})	SO4 (mg L^{-1})	TN (mg L^{-1})	TP (mg L^{-1})	TSS (mg L^{-1})	Turbidity (NTU)
07-Jul-09	6:25	AWRC, Wade Cash	0.06	14.883	2.298	0.094	18.153	2.65	0.122	10	8.7
14-Jul-09	6:00	AWRC, Wade Cash	0.04	17.384	2.426	0.072	23.538	2.91	0.104	14	11.6
21-Jul-09	0:15	AWRC, Wade Cash	0.07	17.887	2.795	0.063	27.060	2.94	0.112	11	9.3
28-Jul-09	6:00	AWRC, Wade Cash	0.06	16.250	2.592	0.075	23.096	3.14	0.122	15	15
04-Aug-09	6:00	AWRC, Wade Cash	0.04	15.309	2.147	0.064	23.573	2.47	0.136	42	27
11-Aug-09	6:30	AWRC, Wade Cash	0.10	12.937	2.269	0.083	18.130	2.71	0.140	19	19
18-Aug-09	6:30	AWRC, Wade Cash	0.02	15.577	2.052	0.061	18.506	2.55	0.104	9	9.4
20-Aug-09	18:30	AWRC, Wade Cash	0.04	17.951	2.165	0.070	18.226	2.48	0.132	27	25
25-Aug-09	7:15	AWRC, Wade Cash	0.01	17.283	1.891	0.065	19.143	2.36	0.134	9	9.8
01-Sep-09	6:45	AWRC, Wade Cash	0.03	18.026	2.456	0.071	18.467	2.71	0.102	9	8.9
05-Sep-09	17:00	AWRC, Wade Cash	0.12	11.553	2.030	0.274	14.081	3.02	0.290	79	95
08-Sep-09	6:15	AWRC, Wade Cash	0.07	14.009	2.448	0.112	19.165	2.85	0.140	15	19
10-Sep-09	12:15	AWRC, Wade Cash	0.01	15.812	3.086	0.144	21.518	3.58	0.262	48	37
15-Sep-09	6:15	AWRC, Wade Cash	0.03	12.346	2.247	0.080	16.292	2.49	0.114	9	10
22-Sep-09	5:45	AWRC, Wade Cash	0.28	3.068	0.785	0.345	6.526	2.08	1.018	351	347
29-Sep-09	6:15	AWRC, Wade Cash	0.03	9.864	2.568	0.066	16.237	2.89	0.100	4	6.8
06-Oct-09	6:00	AWRC, Wade Cash	0.01	13.287	3.135	0.050	17.345	3.42	0.068	4	4.0
09-Oct-09	17:15	AWRC, Wade Cash	0.11	2.601	1.012	0.384	6.240	1.54	0.622	99	117
13-Oct-09	7:00	AWRC, Wade Cash	0.15	5.253	1.763	0.138	10.466	2.40	0.238	27	28
20-Oct-09	7:00	AWRC, Wade Cash	0.04	8.686	2.940	0.054	13.810	3.34	0.094	5	7.3
27-Oct-09	6:15	AWRC, Wade Cash	0.04	8.215	2.078	0.059	14.377	2.47	0.082	7	6.3
03-Nov-09	6:30	AWRC, Wade Cash	0.02	6.776	2.356	0.049	13.160	2.52	0.072	7	11
10-Nov-09	6:15	AWRC, Wade Cash	0.04	8.991	2.529	0.036	13.882	2.82	0.054	3	5.0
17-Nov-09	6:15	AWRC, Wade Cash	0.02	9.275	1.893	0.043	17.640	2.35	0.084	4	5.8
23-Nov-09	6:15	AWRC, Wade Cash	0.04	9.111	2.000	0.025	15.873	2.25	0.050	3	4.5
01-Dec-09	6:45	AWRC, Wade Cash	0.01	10.758	2.233	0.016	16.636	2.36	0.030	3	2.2
08-Dec-09	6:30	AWRC, Wade Cash	0.01	11.833	2.641	0.007	17.345	2.81	0.022	2	1.9
15-Dec-09	6:45	AWRC, Wade Cash	0.01	12.075	2.578	0.006	18.987	2.85	0.022	1	2.5
21-Dec-09	6:15	AWRC, Wade Cash	0.01	12.027	2.401	0.003	18.428	2.68	0.018	1	2.9
29-Dec-09	14:15	AWRC, Wade Cash	0.01	10.992	1.635	0.014	18.875	1.97	0.036	2	6.0
05-Jan-10	22:15	AWRC, Wade Cash	0.02	10.331	1.640	0.018	19.591	1.90	0.034	1	3.2
12-Jan-10	6:30	AWRC, Wade Cash	0.05	13.532	2.715	0.025	20.303	2.95	0.040	1	3.2
19-Jan-10	6:30	AWRC, Wade Cash	0.05	12.457	2.151	0.034	20.949	2.51	0.070	3	2.8
26-Jan-10	6:45	AWRC, Wade Cash	0.05	7.955	1.564	0.032	17.482	1.82	0.056	5	10
03-Feb-10	6:15	AWRC, Wade Cash	0.18	9.891	1.182	0.156	20.345	1.83	0.254	22	26
10-Feb-10	6:45	AWRC, Wade Cash	0.06	9.063	2.158	0.038	16.946	2.41	0.068	4	9.7
16-Feb-10	6:30	AWRC, Wade Cash	0.04	9.433	2.293	0.020	17.406	2.60	0.038	3	5.7
23-Feb-10	6:15	AWRC, Wade Cash	0.05	9.107	1.672	0.035	17.708	2.10	0.080	7	14
02-Mar-10	6:30	AWRC, Wade Cash	0.01	10.141	2.303	0.006	17.951	2.49	0.030	4	4.9
08-Mar-10	6:30	AWRC, Wade Cash	0.01	10.738	2.424	0.005	18.225	2.79	0.032	8	7.2
16-Mar-10	6:30	AWRC, Wade Cash	0.01	11.675	2.311	0.016	19.204	2.77	0.044	5	5.5
30-Mar-10	6:30	AWRC, Wade Cash	0.01	7.000	2.579	0.032	14.825	2.90	0.056	10	12
07-Apr-10	19:15	AWRC, Wade Cash	0.01	8.105	2.220	0.029	15.412	2.48	0.066	12	14
13-Apr-10	6:15	AWRC, Wade Cash	0.02	9.569	2.415	0.008	14.829	2.66	0.038	9	6.9
20-Apr-10	6:30	AWRC, Wade Cash	0.01	11.625	2.829	0.020	15.105	3.27	0.046	6	5.3
27-Apr-10	6:15	AWRC, Wade Cash	0.06	9.772	1.838	0.035	16.831	2.16	0.068	7	9.0
04-May-10	6:15	AWRC, Wade Cash	0.05	11.421	2.403	0.026	17.572	2.61	0.062	9	8.3
11-May-10	6:45	AWRC, Wade Cash	0.07	11.607	2.333	0.044	18.102	2.78	0.094	16	15
14-May-10	6:45	AWRC, Wade Cash	0.45	6.879	0.928	0.057	17.585	1.52	0.224	68	79
14-May-10	19:00	AWRC, Wade Cash	0.14	3.356	0.593	0.119	8.847	1.45	0.873	443	399
18-May-10	6:15	AWRC, Wade Cash	0.01	5.721	1.172	0.048	13.542	1.54	0.114	22	24
25-May-10	10:30	AWRC, Wade Cash	0.07	7.965	2.036	0.040	14.057	2.42	0.084	20	15
01-Jun-10	6:15	AWRC, Wade Cash	0.01	9.521	3.075	0.042	14.801	5.38	0.074	9	10
08-Jun-10	6:30	AWRC, Wade Cash	0.07	9.955	2.345	0.172	13.875	3.02	0.296	27	28
15-Jun-10	6:15	AWRC, Wade Cash	0.07	13.646	2.550	0.053	15.253	2.87	0.094	15	13
23-Jun-10	6:30	AWRC, Wade Cash	0.04	17.695	2.429	0.050	18.296	2.62	0.084	1	8.8

3G. Illinois River near Watts, Oklahoma

Date	Time	Collector	NH_3-N	Cl	NO_3-N	SRP	SO_4	TN	TP	TSS	Turbidity
07-Jul-09	10:45	AWRC, W. Cash	0.02	13.612	2.423	0.062	12.123	2.61	0.058	14	12
14-Jul-09	8:15	AWRC, W. Cash	0.06	15.549	2.275	0.060	14.414	2.49	0.090	11	12
21-Jul-09	9:45	AWRC, W. Cash	0.02	16.752	2.116	0.054	15.359	2.24	0.090	12	12
28-Jul-09	8:15	AWRC, W. Cash	0.02	15.986	2.096	0.059	15.152	2.27	0.098	12	12
04-Aug-09	8:15	AWRC, W. Cash	0.02	15.138	1.970	0.057	14.839	2.14	0.096	10	9.4
11-Aug-09	8:30	AWRC, W. Cash	0.02	15.409	1.886	0.067	15.761	2.11	0.120	15	14
18-Aug-09	8:30	AWRC, W. Cash	0.05	16.771	1.869	0.060	15.515	2.02	0.108	11	13
25-Aug-09	9:15	AWRC, W. Cash	0.03	15.989	1.826	0.061	16.734	2.02	0.096	10	11
01-Sep-09	9:00	AWRC, W. Cash	0.01	19.429	2.026	0.057	17.658	2.20	0.092	12	11
08-Sep-09	8:30	AWRC, W. Cash	0.03	13.528	1.712	0.077	14.684	2.17	0.134	15	13
08-Sep-09	8:30	AWRC, W. Cash	0.04	13.530	1.703	0.078	14.676	1.95	0.122	15	13
10-Sep-09	7:00	AWRC, W. Cash	0.03	15.277	2.159	0.090	16.123	2.45	0.156	25	20
15-Sep-09	8:30	AWRC, W. Cash	0.04	12.791	1.789	0.138	13.927	2.03	0.202	16	16
22-Sep-09	8:00	AWRC, W. Cash	0.20	7.259	1.312	0.484	8.919	2.07	0.954	167	159
29-Sep-09	8:30	AWRC, W. Cash	0.02	12.893	2.342	0.069	15.512	2.52	0.108	14	13
06-Oct-09	8:15	AWRC, W. Cash	0.04	16.005	2.474	0.060	17.018	2.74	0.088	12	10
09-Oct-09	18:30	AWRC, W. Cash	0.38	2.963	0.884	0.266	4.804	1.61	1.098	346	398
13-Oct-09	8:45	AWRC, W. Cash	0.05	6.863	2.637	0.101	10.895	2.89	0.168	23	25
20-Oct-09	9:00	AWRC, W. Cash	0.01	9.353	3.187	0.071	12.047	3.32	0.090	7	7.0
27-Oct-09	8:15	AWRC, W. Cash	0.01	10.370	2.905	0.063	12.530	3.11	0.082	5	4.4
30-Oct-09	7:45	AWRC, W. Cash	0.02	6.257	1.737	0.144	9.923	2.32	0.730	324	212
03-Nov-09	8:30	AWRC, W. Cash	0.03	7.583	2.858	0.060	10.913	3.01	0.092	6	9.4
03-Nov-09	8:30	AWRC, W. Cash	0.01	7.568	2.860	0.061	10.895	3.01	0.088	6	9.7
10-Nov-09	8:00	AWRC, W. Cash	0.02	10.362	3.151	0.053	12.300	3.61	0.084	4	4.9
17-Nov-09	8:30	AWRC, W. Cash	0.01	11.330	3.064	0.039	12.606	3.23	0.064	3	4.5
23-Nov-09	8:30	AWRC, W. Cash	0.01	12.327	2.905	0.034	13.923	3.07	0.050	3	3.1
01-Dec-09	9:00	AWRC, W. Cash	0.01	12.570	2.776	0.025	12.782	2.89	0.034	2	2.0
08-Dec-09	8:15	AWRC, W. Cash	0.01	14.153	2.938	0.013	14.508	3.07	0.022	1	1.5
15-Dec-09	8:45	AWRC, W. Cash	0.01	14.606	2.933	0.008	14.824	3.04	0.016	2	2.2
21-Dec-09	8:15	AWRC, W. Cash	0.01	16.330	2.972	0.007	16.408	3.13	0.016	1	2.3
29-Dec-09	16:15	AWRC, W. Cash	0.01	12.527	2.410	0.014	15.149	2.55	0.028	2	3.8
05-Jan-10	15:45	AWRC, W. Cash	0.01	13.741	2.487	0.015	15.106	2.61	0.026	1	3.2
05-Jan-10	15:45	AWRC, W. Cash	0.01	13.569	2.499	0.014	15.125	2.61	0.024	1	4.0
12-Jan-10	8:45	AWRC, W. Cash	0.01	16.203	2.941	0.012	16.670	3.05	0.016	1	1.8
19-Jan-10	8:45	AWRC, W. Cash	0.01	17.466	2.716	0.014	16.446	2.99	0.056	1	2.1
26-Jan-10	8:45	AWRC, W. Cash	0.02	12.345	2.152	0.047	16.174	2.42	0.066	5	9.6
03-Feb-10	8:15	AWRC, W. Cash	0.03	15.635	2.416	0.034	17.162	2.53	0.064	6	7.4
10-Feb-10	8:45	AWRC, W. Cash	0.03	11.681	2.802	0.044	13.926	2.98	0.064	5	8.0
16-Feb-10	8:30	AWRC, W. Cash	0.01	11.861	2.921	0.030	14.689	2.99	0.042	2	6.7
23-Feb-10	8:15	AWRC, W. Cash	0.04	13.791	2.398	0.037	16.321	2.56	0.070	7	12
02-Mar-10	8:30	AWRC, W. Cash	0.01	12.464	2.936	0.013	14.144	3.10	0.026	4	3.9
08-Mar-10	8:30	AWRC, W. Cash	0.02	13.328	2.911	0.011	15.052	3.05	0.024	4	4.5
08-Mar-10	8:30	AWRC, W. Cash	0.01	13.320	2.916	0.010	15.063	3.02	0.022	5	4.9
16-Mar-10	8:30	AWRC, W. Cash	0.04	14.136	2.980	0.037	14.867	3.26	0.058	5	4.1
30-Mar-10	8:30	AWRC, W. Cash	0.02	8.246	3.114	0.042	12.048	3.29	0.060	12	12
07-Apr-10	17:30	AWRC, W. Cash	0.02	9.701	2.736	0.043	11.700	2.94	0.094	14	12
13-Apr-10	8:15	AWRC, W. Cash	0.01	10.845	2.555	0.008	11.873	2.74	0.032	10	8.8
20-Apr-10	8:30	AWRC, W. Cash	0.02	12.146	2.868	0.021	12.542	3.08	0.044	7	7.1
25-Apr-10	9:00	AWRC, W. Cash	0.10	15.074	3.020	0.036	15.201	3.11	0.094	22	17
27-Apr-10	8:15	AWRC, W. Cash	0.05	11.779	2.438	0.042	13.076	2.53	0.074	10	9.9
04-May-10	8:15	AWRC, W. Cash	0.06	13.279	2.382	0.025	13.614	2.61	0.064	13	11
11-May-10	8:45	AWRC, W. Cash	0.07	14.477	2.784	0.043	14.420	3.03	0.080	15	13
14-May-10	18:15	AWRC, W. Cash	0.09	10.085	1.994	0.080	11.626	2.23	0.200	45	42
18-May-10	8:15	AWRC, W. Cash	0.01	7.429	1.856	0.066	10.709	2.09	0.134	30	28
26-May-10	12:30	AWRC, W. Cash	0.01	8.957	2.538	0.058	11.074	2.68	0.104	21	19
01-Jun-10	8:15	AWRC, W. Cash	0.01	10.362	2.730	0.057	11.913	3.50	0.108	18	16
01-Jun-10	8:15	AWRC, W. Cash	0.02	10.305	2.729	0.058	11.976	4.65	0.100	1	17
08-Jun-10	8:30	AWRC, W. Cash	0.06	12.057	2.590	0.049	12.120	2.71	0.086	17	14
15-Jun-10	8:15	AWRC, W. Cash	0.03	12.633	2.345	0.055	13.229	2.47	0.094	17	15
23-Jun-10	8:30	AWRC, W. Cash	0.01	14.253	2.149	0.057	13.185	2.23	0.094	2	9.8

3H. Mud Creek Tributary

Date	Time	Collector	NH_3-N ($mg\ L^{-1}$)	Cl ($mg\ L^{-1}$)	NO_3-N ($mg\ L^{-1}$)	SRP ($mg\ L^{-1}$)	SO4 ($mg\ L^{-1}$)	TN ($mg\ L^{-1}$)	TP ($mg\ L^{-1}$)	TSS ($mg\ L^{-1}$)	Turbidity (NTU)
07-Jul-09	14:00	AWRC, Wade Cash	0.07	11.496	0.184	0.017	18.001	0.41	0.032	2	3.3
14-Jul-09	10:20	AWRC, Wade Cash	0.03	13.376	0.150	0.014	20.277	0.20	0.030	5	7.1
21-Jul-09	7:15	AWRC, Wade Cash	0.12	4.341	0.500	0.061	7.078	0.97	0.320	156	157
22-Jul-09	10:15	AWRC, Wade Cash	0.02	8.316	0.256	0.019	19.193	0.35	0.046	6	5.5
28-Jul-09	10:30	AWRC, Wade Cash	0.02	12.814	0.129	0.009	21.070	0.24	0.036	2	3.7
30-Jul-09	14:50	AWRC, Wade Cash	0.13	2.184	0.399	0.052	3.423	0.67	0.212	71	76
04-Aug-09	10:30	AWRC, Wade Cash	0.02	10.356	0.172	0.006	18.686	0.25	0.032	4	4.3
10-Aug-09	18:30	AWRC, Wade Cash	0.40	1.052	0.281	0.069	2.197	1.92	0.713	647	352
11-Aug-09	10:30	AWRC, Wade Cash	0.01	5.028	0.305	0.023	11.318	0.55	0.060	5	11
18-Aug-09	10:30	AWRC, Wade Cash	0.05	11.530	0.109	0.014	20.598	0.23	0.048	3	4.2
20-Aug-09	8:10	AWRC, Wade Cash	0.07	3.871	0.313	0.042	7.061	0.57	0.114	18	24
20-Aug-09	10:30	AWRC, Wade Cash	0.12	1.187	0.389	0.091	2.550	0.85	0.454	200	197
25-Aug-09	11:30	AWRC, Wade Cash	0.01	10.305	0.108	0.016	19.427	0.25	0.048	3	3.4
01-Sep-09	11:00	AWRC, Wade Cash	0.02	12.842	0.083	0.011	23.688	0.23	0.028	3	3.7
08-Sep-09	10:30	AWRC, Wade Cash	0.06	9.160	0.134	0.015	17.010	0.32	0.046	3	3.3
15-Sep-09	10:30	AWRC, Wade Cash	0.02	10.181	0.190	0.018	18.287	0.32	0.030	2	2.7
22-Sep-09	10:15	AWRC, Wade Cash	0.04	8.652	1.304	0.035	16.485	1.51	0.064	6	9.5
29-Sep-09	10:30	AWRC, Wade Cash	0.01	10.711	0.251	0.019	20.750	0.40	0.030	1	1.7
06-Oct-09	10:15	AWRC, Wade Cash	0.12	3.012	0.424	0.091	5.787	0.94	0.326	90	146
13-Oct-09	11:00	AWRC, Wade Cash	0.10	4.605	0.490	0.036	9.820	0.76	0.106	29	35
20-Oct-09	11:00	AWRC, Wade Cash	0.05	9.669	0.425	0.017	18.625	0.64	0.016	1	2.7
27-Oct-09	10:15	AWRC, Wade Cash	0.01	6.472	0.312	0.047	12.747	0.52	0.066	5	8.0
03-Nov-09	10:30	AWRC, Wade Cash	0.02	9.149	0.590	0.017	17.145	0.77	0.018	0	2.4
10-Nov-09	10:00	AWRC, Wade Cash	0.01	10.134	0.141	0.015	17.924	0.23	0.024	1	2.4
17-Nov-09	10:30	AWRC, Wade Cash	0.01	10.017	0.197	0.014	18.633	0.36	0.032	2	1.9
23-Nov-09	10:30	AWRC, Wade Cash	0.01	11.016	0.187	0.008	19.530	0.33	0.030	1	2.2
01-Dec-09	11:00	AWRC, Wade Cash	0.01	11.036	0.147	0.012	20.094	0.26	0.020	2	1.8
08-Dec-09	10:25	AWRC, Wade Cash	0.03	15.013	0.263	0.028	28.084	0.30	0.050	8	10.7
15-Dec-09	11:05	AWRC, Wade Cash	0.01	12.416	0.049	0.004	21.897	0.15	0.008	1	2.4
21-Dec-09	10:10	AWRC, Wade Cash	0.01	12.341	0.048	0.002	22.711	0.18	0.004	1	4.8
29-Dec-09	18:15	AWRC, Wade Cash	0.01	21.585	0.435	0.004	21.365	0.53	0.014	0	2.1
12-Jan-10	10:45	AWRC, Wade Cash	0.01	18.267	0.348	0.006	22.540	0.42	0.010	1	1.7
19-Jan-10	10:40	AWRC, Wade Cash	0.01	18.933	0.129	0.004	22.732	0.27	0.016	1	1.2
26-Jan-10	10:38	AWRC, Wade Cash	0.01	17.028	0.910	0.008	20.113	1.04	0.001	1	4.0
03-Feb-10	10:30	AWRC, Wade Cash	0.02	39.654	0.770	0.001	20.581	0.90	0.014	0	2.8
10-Feb-10	10:45	AWRC, Wade Cash	0.01	35.433	0.852	0.005	19.901	0.97	0.010	1	4.0
16-Feb-10	10:25	AWRC, Wade Cash	0.01	21.930	0.674	0.005	20.706	0.82	0.010	1	2.9
23-Feb-10	10:28	AWRC, Wade Cash	0.01	22.476	0.688	0.004	21.214	0.85	0.006	1	1.7
02-Mar-10	10:30	AWRC, Wade Cash	0.01	19.438	0.442	0.004	22.303	0.66	0.008	1	1.3
08-Mar-10	10:40	AWRC, Wade Cash	0.01	18.769	0.178	0.004	23.153	0.30	0.001	1	2.8
16-Mar-10	10:25	AWRC, Wade Cash	0.02	18.489	0.088	0.005	23.726	0.27	0.012	2	1.7
22-Mar-10	11:04	AWRC, Wade Cash	0.02	19.941	0.644	0.011	15.892	0.91	0.138	95	77
30-Mar-10	10:25	AWRC, Wade Cash	0.01	16.010	0.717	0.007	19.313	0.89	0.002	1	3.1
07-Apr-10	11:05	AWRC, Wade Cash	0.01	15.242	0.521	0.008	18.324	0.68	0.050	2	2.1
13-Apr-10	10:15	AWRC, Wade Cash	0.01	15.345	0.274	0.008	19.976	0.44	0.014	2	1.8
20-Apr-10	10:00	AWRC, Wade Cash	0.02	15.543	0.167	0.008	21.143	0.32	0.012	1	1.5
27-Apr-10	10:25	AWRC, Wade Cash	0.06	15.124	0.414	0.013	19.222	0.55	0.016	1	2.4
04-May-10	10:15	AWRC, Wade Cash	0.07	15.319	0.278	0.014	19.692	0.45	0.034	1	2.1
11-May-10	10:40	AWRC, Wade Cash	0.06	13.381	0.350	0.020	17.796	0.54	0.036	2	3.5
14-May-10	10:00	AWRC, Wade Cash	0.57	1.960	0.379	0.099	2.480	1.60	1.579	994	567
18-May-10	10:30	AWRC, Wade Cash	0.01	12.117	0.837	0.020	16.874	1.01	0.034	3	3.2
26-May-10	14:30	AWRC, Wade Cash	0.02	12.827	0.504	0.025	17.570	0.65	0.044	4	5.0
01-Jun-10	10:05	AWRC, Wade Cash	0.06	13.570	0.425	0.023	17.722	0.52	0.040	4	3.9
08-Jun-10	10:30	AWRC, Wade Cash	0.02	10.952	0.349	0.026	14.674	0.50	0.042	4	3.9
15-Jun-10	10:25	AWRC, Wade Cash	0.02	12.991	0.272	0.025	16.115	0.44	0.042	4	4.3
23-Jun-10	10:30	AWRC, Wade Cash	0.07	15.021	0.219	0.021	22.446	0.34	0.038	5	5.0

3I. Osage Creek at Elm Springs

Date	Time	Collector	NH_3-N ($mg\ L^{-1}$)	Cl ($mg\ L^{-1}$)	NO_3-N ($mg\ L^{-1}$)	SRP ($mg\ L^{-1}$)	SO4 ($mg\ L^{-1}$)	TN ($mg\ L^{-1}$)	TP ($mg\ L^{-1}$)	TSS ($mg\ L^{-1}$)	Turbidity (NTU)
07-Jul-09	0:20	AWRC, Wade Cash	0.03	19.685	4.065	0.092	17.649	4.20	0.106	3	2.7
14-Jul-09	9:40	AWRC, Wade Cash	0.01	24.114	3.963	0.094	26.263	4.03	0.110	4	3.8
21-Jul-09	11:30	AWRC, Wade Cash	0.03	24.125	3.704	0.101	26.665	3.80	0.146	18	9.8
28-Jul-09	9:45	AWRC, Wade Cash	0.01	24.342	3.707	0.104	26.869	3.91	0.142	4	4.2
04-Aug-09	9:30	AWRC, Wade Cash	0.04	25.340	3.805	0.087	27.063	3.82	0.130	5	5.1
11-Aug-09	10:00	AWRC, Wade Cash	0.06	19.417	2.788	0.113	23.554	3.22	0.196	24	27
18-Aug-09	9:45	AWRC, Wade Cash	0.01	27.855	3.884	0.106	32.867	3.93	0.136	5	5.6
25-Aug-09	10:45	AWRC, Wade Cash	0.01	28.418	3.607	0.101	32.259	3.91	0.120	3	3.3
01-Sep-09	10:15	AWRC, Wade Cash	0.02	31.927	3.883	0.104	34.208	4.16	0.120	2	2.4
08-Sep-09	10:00	AWRC, Wade Cash	0.05	26.273	3.526	0.086	26.828	3.78	0.124	3	3.4
10-Sep-09	7:30	AWRC, Wade Cash	0.06	15.770	2.174	0.167	15.550	2.57	0.374	84	95
15-Sep-09	10:00	AWRC, Wade Cash	0.01	27.082	3.779	0.104	30.906	3.94	0.130	3	3.8
22-Sep-09	9:30	AWRC, Wade Cash	0.11	10.354	1.527	0.125	12.838	1.90	0.260	48	51
29-Sep-09	10:00	AWRC, Wade Cash	0.01	26.530	3.809	0.112	31.906	4.00	0.142	2	2.2
06-Oct-09	9:45	AWRC, Wade Cash	0.06	31.450	4.332	0.108	33.478	4.50	0.137	3	3.0
13-Oct-09	10:15	AWRC, Wade Cash	0.06	13.883	3.738	0.139	19.944	3.93	0.230	57	36
20-Oct-09	10:30	AWRC, Wade Cash	0.01	17.014	4.372	0.072	21.090	4.71	0.092	6	6.4
27-Oct-09	9:30	AWRC, Wade Cash	0.04	17.139	3.479	0.063	18.572	3.69	0.088	5	4.4
03-Nov-09	10:00	AWRC, Wade Cash	0.01	13.899	4.174	0.057	14.959	4.22	0.084	8	12
10-Nov-09	9:30	AWRC, Wade Cash	0.04	17.117	4.449	0.053	19.300	4.50	0.070	2	2.5
17-Nov-09	9:45	AWRC, Wade Cash	0.01	21.717	4.392	0.048	19.592	4.67	0.076	1	1.7
23-Nov-09	9:45	AWRC, Wade Cash	0.01	20.018	4.286	0.047	22.232	4.46	0.062	1	1.7
01-Dec-09	10:30	AWRC, Wade Cash	0.01	21.587	4.737	0.053	17.111	4.75	0.066	2	2.5
08-Dec-09	9:45	AWRC, Wade Cash	0.01	25.240	4.747	0.051	25.565	5.12	0.068	2	2.0
15-Dec-09	10:15	AWRC, Wade Cash	0.01	25.333	4.545	0.049	27.172	4.90	0.086	13	14
21-Dec-09	9:30	AWRC, Wade Cash	0.01	25.182	4.524	0.042	25.845	4.81	0.056	1	1.8
29-Dec-09	17:45	AWRC, Wade Cash	0.01	23.180	4.585	0.043	19.210	4.63	0.066	2	2.4
05-Jan-10	17:15	AWRC, Wade Cash	0.01	25.535	4.354	0.044	21.078	4.59	0.056	1	2.8
12-Jan-10	10:00	AWRC, Wade Cash	0.01	27.900	4.054	0.041	26.787	4.05	0.048	1	2.1
19-Jan-10	10:00	AWRC, Wade Cash	0.01	32.291	3.615	0.041	28.373	3.90	0.058	2	2.4
26-Jan-10	10:00	AWRC, Wade Cash	0.01	20.899	3.633	0.043	18.674	3.79	0.044	2	4.0
03-Feb-10	9:45	AWRC, Wade Cash	0.05	31.679	3.438	0.027	18.833	3.65	0.054	4	4.8
10-Feb-10	10:00	AWRC, Wade Cash	0.03	20.684	4.104	0.033	16.643	4.28	0.050	2	3.2
16-Feb-10	9:45	AWRC, Wade Cash	0.01	20.042	4.288	0.030	17.180	4.68	0.044	2	4.7
23-Feb-10	9:45	AWRC, Wade Cash	0.01	21.938	3.684	0.031	16.903	3.79	0.048	2	3.7
02-Mar-10	9:45	AWRC, Wade Cash	0.01	21.242	4.427	0.029	19.365	4.87	0.050	2	2.1
08-Mar-10	10:00	AWRC, Wade Cash	0.01	22.132	4.280	0.028	21.350	4.52	0.044	2	2.6
16-Mar-10	10:00	AWRC, Wade Cash	0.02	23.790	4.187	0.031	21.850	4.57	0.052	4	2.9
22-Mar-10	13:33	AWRC, Wade Cash	0.03	17.899	2.142	0.035	15.194	2.46	0.086	10	13
30-Mar-10	9:45	AWRC, Wade Cash	0.01	13.314	4.198	0.046	16.217	4.42	0.052	5	5.0
07-Apr-10	18:45	AWRC, Wade Cash	0.04	18.327	4.095	0.052	15.684	4.38	0.060	6	3.9
13-Apr-10	9:45	AWRC, Wade Cash	0.03	18.953	4.197	0.047	19.182	4.52	0.722	3	2.8
20-Apr-10	9:45	AWRC, Wade Cash	0.01	22.320	4.314	0.057	23.435	4.62	0.070	2	2.5
24-Apr-10	19:30	AWRC, Wade Cash	0.07	12.102	1.912	0.063	11.618	2.12	0.158	35	33
27-Apr-10	9:45	AWRC, Wade Cash	0.05	17.816	3.736	0.057	16.532	3.80	0.076	3	3.8
04-May-10	9:45	AWRC, Wade Cash	0.04	22.365	3.888	0.057	24.103	4.15	0.078	4	4.1
11-May-10	10:00	AWRC, Wade Cash	0.07	19.573	3.429	0.063	21.135	3.69	0.100	7	6.3
14-May-10	14:15	AWRC, Wade Cash	0.21	5.750	0.978	0.139	6.384	1.89	1.225	659	516
18-May-10	9:45	AWRC, Wade Cash	0.03	12.683	3.320	0.075	14.951	3.53	0.110	11	8.8
26-May-10	13:45	AWRC, Wade Cash	0.03	13.933	3.814	0.062	15.368	3.89	0.088	9	6.7
01-Jun-10	9:30	AWRC, Wade Cash	0.01	16.559	4.005	0.059	17.093	3.92	0.076	5	4.3
08-Jun-10	9:45	AWRC, Wade Cash	0.05	20.209	4.011	0.070	24.130	4.04	0.090	6	5.2
15-Jun-10	9:45	AWRC, Wade Cash	0.01	20.708	3.810	0.085	20.978	4.04	0.108	7	4.9
23-Jun-10	9:45	AWRC, Wade Cash	0.01	23.409	3.498	0.074	27.415	3.72	0.126	6	3.6

APPENDIX 4. Summary of estimated semi-annual loads and flow-weighted concentrations for each constituent at each sampled site in the Upper Illinois River Watershed from 1 January through 30 June 2010; the data are provisional as the US Geological Survey has not finalized its discharge record for this period.

4A. Summary of estimated semi-annual loads (kg) for each consistent at each sampled site in the Upper Illinois River Watershed for the period, 1 January through 30 June 2010.

Site	Cl	SO_4	NH_3-N	NO_3-N	SRP	TN	TP	TSS
Ballard Creek	205,000	363,000	1,100	55,000	3,000	59,000	4,900	290,000
Baron Fork	155,000	472,000	942	56,000	1,600	68,000	2,600	339,000
Flint Creek (W. Siloam)	303,000	724,000	700	66,700	1,100	73,000	2,200	586,000
Flint Creek (Springtown)	82,000	78,000	1,100	49,000	1,100	54,200	1,600	115,000
Illinois River (AR59)	4,344,000	5,031,000	10,000	989,000	19,400	1,074,000	37,000	6,571,000
Illinois River (Savoy)	948,000	1,747,000	8,900	219,000	6,400	289,000	16,000	3,985,000
Illinois River (Watts)	3,687,000	4,367,000	12,400	908,000	21,000	1,019,000	42,700	7,070,000
Mud Creek Tributary	8,000	7,800	50	400	20	700	80	17,000
Osage Creek	1,550,000	1,460,000	3,720	288,000	4,760	313,000	11,300	2,090,000

4B. Summary of calculated flow weighted concentrations (FWC, mg L^{-1}) for each constituent at the sampled sites in the Upper Illinois River Watershed for the period, 1 January through 30 June 2010.

Site	Cl	SO_4	NH_3-N	NO_3-N	SRP	TN	TP	TSS
Ballard Creek	9.68	17.11	0.05	2.59	0.14	2.76	0.23	14
Baron Fork	5.24	15.97	0.03	1.88	0.06	2.30	0.09	11
Flint Creek (W. Siloam)	10.05	24.02	0.02	2.21	0.04	2.43	0.07	19
Flint Creek (Springtown)	5.51	5.28	0.07	3.34	0.08	3.66	0.11	8
Illinois River (AR59)	11.57	13.40	0.03	2.63	0.05	2.86	0.10	18
Illinois River (Savoy)	7.64	14.07	0.07	1.76	0.05	2.32	0.13	32
Illinois River (Watts)	10.43	12.35	0.04	2.57	0.06	2.88	0.12	20
Mud Creek Tributary	11.54	11.28	0.07	0.56	0.03	0.95	0.12	25
Osage Creek	18.23	17.10	0.04	3.39	0.06	3.67	0.13	24

Appendix 5. Summary of estimated monthly loads (kg) for each constituent at the Upper Illinois River Watershed; the data are provisional as the US Geological Survey has not finalized its discharge record for this period.

5A. Summary of estimated monthly loads (kg) for each constituent at the Illinois River at AR59, Arkansas from 1 January 2010 to 30 June 2010.

Month	Cl	SO_4	NH_3-N	NO_3-N	SRP	TN	TP	TSS
January	515,400	572,000	780	116,000	1,240	126,000	1,870	195,000
February	846,700	988,000	1,580	204,000	3,210	224,000	5,290	710,000
March	942,800	1,120,000	2,250	230,000	5,650	252,000	12,200	2,680,000
April	667,000	756,000	1,330	151,000	1,870	159,000	3,340	402,000
May	974,000	1,160,000	3,490	212,000	5,930	234,000	11,900	2,290,000
June	399,000	428,000	960	75,000	1,530	78,000	2,780	292,000

5B. Summary of estimated monthly loads (kg) for each constituent at Ballard Creek from 1 January 2010 to 30 June 2010.

Month	Cl	SO_4	NH_3-N	NO_3-N	SRP	TN	TP	TSS
January	33,500	69,300	61	8,270	220	9,460	410	12,100
February	33,800	72,200	79	8,810	360	10,200	650	17,100
March	44,200	85,300	260	11,700	1,340	13,300	2,140	124,000
April	32,300	54,700	160	9,310	290	9,160	490	33,200
May	33,500	49,400	280	9,330	490	9,350	750	61,800
June	28,000	31,900	260	7,430	360	7,150	490	41,600

5C. Summary of estimated monthly loads (kg) for each constituent at Baron Fork at Dutch Mills, Arkansas from 1 January 2010 to 30 June 2010.

Month	Cl	SO_4	NH_3-N	NO_3-N	SRP	TN	TP	TSS
January	22,700	69,600	41	8,200	99	8,950	120	5,700
February	34,400	113,000	82	14,800	200	16,500	250	14,000
March	40,700	136,300	220	15,000	490	18,600	730	76,400
April	19,900	54,800	93	6,840	130	7,980	200	19,500
May	30,400	84,900	450	9,660	680	15,000	1,230	213,000
June	6,600	13,100	58	1,000	47	1,500	85	10,000

5D. Summary of estimated monthly loads (kg) for each constituent at Flint Creek at Springtown from 1 January 2010 to 30 June 2010.

Month	Cl	SO_4	NH_3-N	NO_3-N	SRP	TN	TP	TSS
January	5,510	3,500	38	2,870	27	2,900	35	380
February	8,750	6,800	82	5,150	61	5,360	80	890
March	14,500	14,700	210	9,560	190	10,500	260	19,600
April	16,000	14,700	190	9,780	180	10,600	230	3,920
May	26,200	29,400	430	16,600	560	18,900	780	87,600
June	10,600	9,030	110	5,560	140	6,060	190	2,950

5E. Summary of estimated monthly loads (kg) for each constituent at Flint Creek near West Siloam Springs, Arkansas from 1 January 2010 to 30 June 2010.

Month	Cl	SO_4	NH_3-N	NO_3-N	SRP	TN	TP	TSS
January	33,500	83,200	59	5,820	35	6,060	54	3,070
February	48,100	128,000	97	11,900	63	12,400	100	8,540
March	64,300	148,000	150	15,700	190	16,600	280	36,400
April	47,400	125,000	97	8,760	79	9,720	140	18,600
May	75,000	159,000	220	20,200	640	23,400	1,470	497,000
June	34,800	80,700	73	4,450	97	5,240	170	22,200

5F. Summary of estimated monthly loads (kg) for each constituent Illinois River at Savoy, Arkansas from 1 January 2010 to 30 June 2010.

Month	Cl	SO_4	NH_3-N	NO_3-N	SRP	TN	TP	TSS
January	145,000	256,000	1,100	32,300	530	41,400	1,240	150,000
February	218,000	413,000	2,110	51,700	930	68,800	2,360	341,000
March	228,000	445,000	2,690	55,400	1,430	75,200	3,940	911,000
April	110,000	183,000	640	23,200	370	28,700	960	176,000
May	194,000	375,700	2,240	46,800	2,920	63,400	6,920	2,320,000
June	53,600	74,900	160	9,720	250	11,010	490	91,100

5G. Summary of estimated monthly loads (kg) for each constituent at Illinois River near Watts, Oklahoma from 1 January 2010 to 30 June 2010.

Month	Cl	SO_4	NH_3-N	NO_3-N	SRP	TN	TP	TSS
January	1,310	1,040	2	35	1	58	2	440
February	1,680	1,270	2	42	1	68	2	260
March	2,230	1,870	9	110	4	190	13	1,110
April	800	810	3	26	1	42	4	310
May	1,780	2,460	31	170	12	300	60	14,300
June	210	380	1	7	1	11	2	670

5H. Summary of estimated monthly loads (kg) for each constituent at Mud Creek Tributary at Fayetteville, Arkansas from 1 January 2010 to 30 June 2010.

Month	Cl	SO_4	NH_3-N	NO_3-N	SRP	TN	TP	TSS
January	1,310	1,040	2	35	1	58	2	440
February	1,680	1,270	2	42	1	68	2	260
March	2,230	1,870	9	110	4	190	13	1,110
April	800	810	3	26	1	42	4	310
May	1,780	2,460	31	170	12	300	60	14,300
June	210	380	1	7	1	11	2	670

5I. Summary of estimated monthly loads (kg) for each constituent at Osage Creek, Arkansas from 1 January 2010 to 30 June 2010.

Month	Cl	SO_4	NH_3-N	NO_3-N	SRP	TN	TP	TSS
January	205,000	182,000	190	35,320	310	36,400	540	25,900
February	248,000	219,000	420	45,900	490	49,500	1,040	76,800
March	279,000	248,000	890	52,900	750	58,300	1,980	391,000
April	265,000	241,000	450	49,000	683	52,800	1,510	130,000
May	324,000	325,000	1,490	64,000	1,650	71,800	4,590	1,360,000
June	233,000	241,000	270	41,600	880	43,800	1,630	103,000