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Constituent Loads and Trends in the Upper Illinois River Watershed and Upper White River Basin: 2015 October through 2018 September

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EXECUTIVE SUMMARY

The Arkansas Natural Resources Commission (ANRC) identified two priority hydrologic unit code (HUC) 8 watersheds, the Upper White River Basin (UWRB; HUC 11010001) and the Upper Illinois River Watershed (UIRW; 11110103), in northwest Arkansas. Nonpoint source (NPS) pollution is a concern in these watersheds, such as excess nutrients from agriculture and sediment from changes in land uses. Several NPS pollution projects have been funded by ANRC, including streambank restoration on Sager Creek and best management practices (BMP) to control urban sediment in Fayetteville. The purpose of this project was to collect water samples at 15 sites in the UWRB and UIRW to estimate constituent loads and understand how water quality has been changing in these priority watersheds over time.

Sampling sites were selected because of their location within the watershed (representing a variety of land use characteristics and including important tributaries to the main stems of the Illinois and White Rivers) and most were at existing U.S. Geological Survey (USGS) stream gaging stations. Approximately 46 water samples were collected during each project year (July 1 through June 30) at each site during base-flow and surface runoff conditions, ranging from small to large storm events. Water samples were analyzed for nitrate-nitrogen nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), chloride (Cl), sulfate (SO_4), and total suspended solids (TSS). Constituent concentrations were paired with daily discharge and loads were estimated using the software program LOADEST. Trends in water quality also were evaluated, as monotonic changes in flow-adjusted constituent concentrations over time.

Constituent loads at the sample sites in the UWRB and UIRW were highly variable, especially for TSS, but generally followed changes in discharge, where increasing discharge drove increasing loads. Constituent loads also were positively related to watershed area across the sampling sites. At the majority of sites, trends in nutrients, sediments, and ions generally indicated improvements in water quality (decreasing trends) or no change in water quality. In fact, TP decreased by approximately 20%, give or take, at Richland Creek, Town Branch, and Mud Creek. However, there were some instances of increasing trends in N, P, TSS, or ions, especially at Richland Creek, Town Branch, Baron Creek, Osage Creek, and Mud Creek.

Long-term water-quality monitoring data are often needed to identify changes in water quality because of the lag time between the implementation of BMPs or landscape disturbances and the water-quality response. This report reflects up to ten years of data at most sites and at least three full years of data at a few sites. These data can be used to evaluate the effectiveness of NPS projects aimed to reduce nutrient and sediment loads and to help calibrate and validate models that can be used for future planning. This information also can provide insight in to where additional resources should be targeted, or identify potential emerging water-quality problems.

INTRODUCTION

Water chemistry can greatly influence the quality of surface waters and affect the ability for streams and rivers to meet their designated use(s). In Arkansas, many streams and rivers were placed on the draft 2018 303(d) list of impaired water bodies due to excess levels of nutrients, chlorides, sulfates, and sediments (ADEQ, 2018). The Arkansas Non-Point Source (NPS) Management Program wants to reduce pollutant loading from the landscape and improve water quality, where funding for projects is targeted to priority watersheds throughout the State.

The Arkansas Natural Resources Commission (ANRC) funds projects associated with reducing NPS pollution in priority watersheds. Projects include the implementation of best management practices (BMPs), technical assistance to land-owners, education outreach, and water-quality monitoring. Monitoring the water quality in priority watersheds is designed to provide information related to water-quality changes resulting from the implementation of NPS projects, state regulations, and other watershed management activities that may have occurred. The NPS Management Program also uses water-quality monitoring data to help calibrate and validate models that can be used for future planning, BMP scenarios, and potential assessment of NPS projects aimed to reduce nutrient and sediment loads. Long-term monitoring data are often needed to identify water-quality improvements from NPS projects because of the lag time between the implementation of management practices and the water-quality response. For example, lag time can vary considerably by site and by pollutant, where it could take years, decades, or more to observe a change in water quality after watershed management activities are implemented (Meals et al., 2010).

The Upper Illinois River Watershed (UIRW) and the Upper White River Basin (UWRB) in northwest Arkansas are listed as priority watersheds. One of the major NPS concerns in these watersheds is excess nutrients, particularly phosphorus from animal agriculture (ANRC, 2018). Excess sediment is another major issue in these watersheds due to changes in land use, where there have been and continue to be increases in residential, commercial, and industrial development (ANRC, 2018). Many NPS projects have been or are currently being completed in the UIRW and UWRB, including streambank restoration on Sager Creek (project 07-900) and best management practices to control urban sediment in Fayetteville (07-600). There are efforts outside the ANRC NPS program as well, including streambank restoration and BMPs in both priority watersheds, especially along the West Fork of the White River by the Beaver Watershed Alliance, Illinois River Watershed Partnership, and the Watershed Conservation Resource Center. The objectives of the current study were (1) to collect water samples at various sites in the UIRW and UWRB that add to the long-term records of water-quality data; (2) to estimate constituent loads at sites where the U.S. Geological Survey (USGS) or the Arkansas Water Resources Center (AWRC) records streamflow; and (3) to evaluate trends in water quality to help document the effects of NPS projects on downstream water quality.

METHODS

Water Sample Collection

Water samples were collected manually from bridge access locations at the 15 sites within the Upper White River Basin and Upper Illinois River Watershed. An alpha-style horizontal sampler or a Kemmerer type vertical sampler was used to collect the sample at a single point representative of the stream (i.e., near the vertical centroid of flow where water velocity is greatest). Samples were collected at a near-weekly frequency with approximately 46 samples per site being collected during a project year (i.e., July through June). The monitoring program was adjusted to ensure that a sufficient fraction of water samples represented surface runoff conditions (or storm events) resulting from episodic rainfall events, including small and large storm events. Thus, water samples captured potential seasonal variation in constituent concentrations as well as variation in flow. All samples were collected according to an approved quality assurance project plan (QAPP; QMP # 15-020), which was updated annually to reflect any changes during the project time period.

Lab Analysis

All water samples were delivered to the Arkansas Water Resources Center Water Quality Lab (AWRC

WQL) and analyzed for nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) using standard analytical procedures for the analysis of water and wastewater. The AWRC WQL is certified by the Arkansas Department of Environmental Quality (ADEQ) for the analysis of water samples, including all parameters included in this water-quality monitoring project. The laboratory used standard quality assurance and quality control (QA/QC) practices during analyses, such as blanks, duplicates, and spikes. All water physico-chemical data was collected and analyzed following the approved QAPP and standard methods for the analysis of water samples.

Flow Measurement

The U.S. Geological Survey (USGS) operates multiple stream gaging station in northwest Arkansas, which coincided with the sampling locations used in this project. Daily mean flow values (cfs), or discharge, were available through the USGS National Water Information Systems (NWIS; USGS, 2018) at all sites that had operating gages. Daily discharge was downloaded for each site at the end of the project period for use in loads and trends analysis.

Daily discharge at Sager Creek was estimated using a stage monitoring station operated by the AWRC. Discharge (daily mean streamflow) and stage were measured at least once a month using an acoustic Doppler current meter during base flow or wadeable conditions and also during storm events using an instream acoustic Doppler current profiler. These measurements were used to develop a stage-discharge relationship for Sager Creek during the current project period of October 2015 through September 2018 (Figure 1). Daily discharged for the time period prior to this project was estimated using these same methods, and those discharge values were used in the loads and trends analysis here (Scott et al., 2015). A typical parametric model would not fit the data for the entire domain of stage sufficiently. Instead, the full range in stage was divided into low, moderate, and high ranges. Linear models relating discharge and stage were used for the low and high ranges, and a locally weighted regression (LOESS) curve was used for the moderate domain to better fit the curvilinear relationship. Any projections outside the range of paired stage and discharge values were based on the linear models for the low and high ranges. The respective models were then applied to the entire continuous stage measurement record to generate daily discharge values at Sager Creek. Any missing pieces of the stage record due to inclement weather, equipment malfunctions, or personnel errors were not estimated nor included in the final calculations for loads or trends.

Load Estimation

Constituent loads (kg/d) were estimated at each site for the entire record of available streamflow data using LOADEST, a FORTRAN program developed by USGS (Runkel et al., 2004). LOADEST calculates observed loads (constituent concentration times daily discharge) for a given calibration data set; this represents all the sampling dates where water samples were collected and we have both concentration and discharge available. LOADEST then models observed loads with various parameters (described below), then applies the model to an estimation data set containing continuous date and discharge of a desired estimation period to estimate daily loads. Water-quality data (e.g., concentrations, discharge and loads) are often not normally distributed, so LOADEST uses log-transformation of observed loads and discharge to meet the normality requirements of regression modeling.

LOADEST has 11 built-in regression models which vary in the use of discharge (Q, cfs), decimal time (t, years), and a user defined period (per, not used in this report) to explain the variation in observed loads and then predict loads for the time and discharge record. The time parameter is used to model seasonal variation in loads (basically using Fourier's equation) that occur throughout the year and trends in loads (i.e., concentrations) over time. The available models are given in Table 1, where these equations vary from a simple linear regression model between log-transformed loads and discharge to very complex regression models. LOADEST can automatically pick the "best" model (model 0, Table 1) by comparing Akaike Information Criterion (AIC, a statistic representing the model's overall goodness of fit and simplicity) values for each model where the lowest AIC is considered the best. To select the most appropriate model, we employed a stepwise process that com-

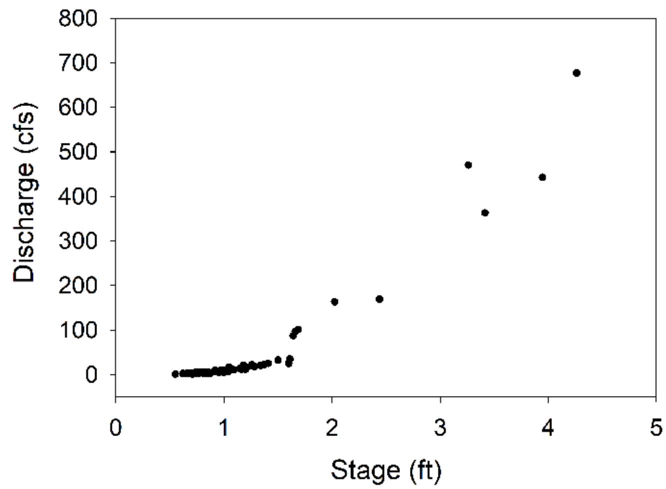

Figure 1. Scatterplot of stage vs discharge at Sager Creek. Stage and discharge were measured manually from October 2015 through September 2018 during wadeable conditions and via an acoustic Doppler current profiler during greater flows.

Table 1. Summary of available predefined regression models in LOADEST (Runkel et al., 2004). Where a_n are model coefficients; ln is natural logartithm; Q is mean daily stream flow; lnQ = ln(streamflow) – center of ln(streamflow); t = decimal time - center of decimal time; and per is period, 1 or 0, depending on user-defined period.

Specified value	Regression model
0	Automatically select best model from models 1-9
1	$a_0 + a_1 lnQ$
2	$a_0 + a_1 lnQ + a_2 lnQ^2$
3	$a_0 + a_1 lnQ + a_2 t$
4	$a_0 + a_1 lnQ + a_2 \sin(2\pi t) + a_3 \cos(2\pi t)$
5	$a_0 + a_1 lnQ + a_2 lnQ^2 + a_3 t$
6	$a_0 + a_1 lnQ + a_2 lnQ^2 + a_3 \sin(2\pi t) + a_4 \cos(2\pi t)$
7	$a_0 + a_1 lnQ + a_2 \sin(2\pi t) + a_3 \cos(2\pi t) + a_4 t$
8	$a_0 + a_1 lnQ + a_2 lnQ^2 + a_3 \sin(2\pi t) + a_4 \cos(2\pi t) + a_5 t$
9	$a_0 + a_1 lnQ + a_2 lnQ^2 + a_3 \sin(2\pi t) + a_4 \cos(2\pi t) + a_5 t + a_6 t^2$
10	$a_0 + a_1 per + a_2 lnQ + a_3 lnQ\ per$
11	$a_0 + a_1 per + a_2 lnQ + a_3 lnQ\ per + a_4 Q^2 + a_5 lnQ^2 per$

pares models by terms of statistical output and considered hydrological-biogeochemical relationships in the streams.

First, LOADEST was executed with model 0 to compare AIC values between all of the predefined models. The most complex models (models 8 and 9) were often selected at this step; however, the simpler models often had comparable AIC values and possibly even better values for other relevant relationship statistics. To determine if a simpler model should be used, models with comparable AIC values were evaluated for load estimation bias percentage (BP) and Nash-Sutcliffe Efficiency (E). BP is a standard metric indicating the reliability of the resulting load estimations where ±25% BP is desired. E is a metric that describes the ability of the model to predict loads where E=1 is a perfect match of load estimates to load observations, E=0 indicates that the predicted loads are as accurate an estimate as using the observed mean, E<0 indicates that the observed mean is a better estimate than the regression model. Generally, BP decreased as E increased. Simpler models with slightly greater AIC values (slightly worse fit) than a complex model were chosen when the simpler model had greater E and lower BP.

Constituent loads (i.e., concentrations) might change over time where using datasets that covers several years, such as the case in this project. Several of the regression models in LOADEST have the ability to account for long-term increases or decreases in constituent loads; models 1, 2, 4, and 6 in LOADEST have a related counterpart model which includes this time parameter (models 3, 5, 7 and 8, respectively). So the last step in model selection was ensure that the time parameter, if included in the equation, was congruent with any statistically significant trend in the flow-adjusted concentrations.

Trend Analysis

Monotonic changes in constituent concentrations over time (increasing, decreasing, or unchanging), e.g. trends, were evaluated for each constituent at each site across the entire sampling period. The statistical program R (Version 3.5.1) was used to evaluate trends. Trend analysis involved a three step process:

First, constituent concentrations (C) and daily discharge (Q) were log-transformed (logC and logQ, respectively) to account for the log-normal distribution typically seen in water quality data. This transformation also reduced the influence of outliers.

Second, a LOESS curve was fitted to the logC vs. logQ data in order to correct for variation in concentrations due to flow. This smoothing technique accounted for intricacies in the logC vs logQ relationship.

Third, the residuals from the LOESS regression, termed here as flow-adjusted concentrations (FACs), were plotted over time. Two methods were used to evaluate trends through time: (1) linear regression of FACs vs time identified monotonic linear changes in water quality, and (2) Seasonal Kendall analysis of FACs vs time identified monotonic trends that might not be linear, as they might be influenced by seasonal variability over time. Trends were significant at $\alpha \leq 0.05$ (e.g. the trend was "extremely likely") and marginally significant at $0.05 < \alpha \leq 0.10$ (e.g. the trend was "likely").

If there was a significant trend, the slope from the linear regression was converted to percent change in constituent concentration per year (% change/year) using the following equation:

$$\%\ \text{change/year} = e^{\text{slope}} - 1$$

The R code used in this study is based off that described in Simpson and Haggard (2018). The three step process is a common approach to looking at monotonic changes in FACs over time (see White et al., 2004 for more details if desired). This technique has been used to evaluate trends in FACs for many streams and rivers, (e.g., Haggard, 2010; Scott et al., 2011, Simpson and Haggard, 2018), where the trends in FACs could be attributed to changes in the watershed such as improvements in effluent nutrient concentrations

RESULTS

Upper White River Basin

The Upper White River Basin (UWRB; HUC 11010001) is a 5747 km2 watershed that lies in northwest Arkansas and flow north into Missouri. The UWRB has headwaters in the Boston Mountains ecoregion, which then flow north into the Ozark Highlands ecoregion. Parts or all of several counties in Arkansas are covered by the UWRB, including Benton, Boone, Carroll, Crawford, Franklin, Johnson, Madison, Newton and Washington counties. The White River is impounded to form Beaver Lake, which serves as the drinking water source for over 400,000 people, as well as providing recreational, tourism industrial, and aquatic life uses. War Eagle Creek and Richland Creek are the other main tributary inflows into Beaver Lake, while Kings River is a major tributary to the White River downstream of Beaver Lake.

Forest land cover (61%) dominates the UWRB, 32% is pasture, and 5% is urban (ANRC, 2018). In addition to the forest land cover, this watershed has typically been characterized by its agricultural activities including pasture land, cattle grazing and poultry operations. But, in recent decades, land use conversion from forest and pasture to urban development has occurred, especially in the downstream portions approaching Beaver Lake. The human population and subsequent urban development is expected to continue to increase, which will have an effect on the hydrology and water quality of streams and lakes in the watershed.

The UWRB has been identified by the Arkansas Natural Resources Commission as a 319 Nonpoint Source (NPS) Pollution priority catchment (ANRC, 2018). The major water-quality concerns in this watershed are nutrients, sediments, chlorides, sulfates and total dissolved solids (ANRC, 2018). There are several 319 and other program projects in the UWRB, ranging from streambank restoration to landowner education, in an effort to reduce pollutant loads from land uses that are likely to influence water quality. Measuring the success of these projects depends on the availability of long-term water quality data that can be paired with discharge data.

Most sampling occurred at sites where USGS stream gaging stations exist and daily discharge data were available. Streams that were selected for water-quality sampling also varied in catchment area and land use. For example, Town Branch is a small watershed draining 50% urban land cover (Table 2). On the other hand, Kings River (Kings) and the White River near Fayetteville (Wyman) drain large watersheds with almost 70% forested land cover. The White River, the West Fork of the White River (WFWR), and Town Branch (TB) are on the draft 2018 303(d) list of impaired water bodies for chloride, sulfate and or total dissolved solids. War Eagle Creek (WEC) and Richland Creek (Richland) drain a mixture of forest and pasture land cover with little urban development.

Table 2. Select study sites (Site ID), USGS station number, site coordinates, drainage area and land cover as percentages of total drainage area for sites in the Upper White River Basin (HUC 11010001). All water samples were collected in Arkansas at the following locations: the Kings River near Berryville (Kings); the White River near Fayetteville (Wyman); War Eagle Creek near Hindsville (WEC); the West Fork of the White River east of Fayetteville (WFWR); Richland Creek near Goshen (Richland); and Town Branch in Fayetteville (TB).

Site ID	USGS Station	Latitude	Longitude	Area (km^2)	Percent of Land Use*					
					Urban	Forest	Grassland	Pasture	Wetlands	Water
Kings	07050500	36°25'38"N	93°37'15"W	1369	4.2	67.0	2.4	26.0	0.3	0.1
Wyman	07048600	36°04'23"N	94°04'52"W	1032	6.5	69.3	2.7	20.6	0.7	0.2
WEC	07049000	36°12'00"N	93°51'18"W	686	4.8	57.6	2.3	34.9	0.3	<0.05
WFWR	07048550	36°03'14"N	94°04'59"W	317	13.2	59.7	2.5	23.7	0.7	0.2
Richland	07048780	36°02'55"N	93°58'27"W	310	3.7	60.2	2.5	33.2	0.3	<0.05
TB	07048495	36°02'36"N	94°08'10"W	31	50	33.8	1.1	14.7	0.2	0.1

*Land use was determined by the University of Arkansas Center for Advanced Spatial Technology (CAST) using the 2011 National Land Cover Dataset for most sites. Richland and TB were new sites and land use was determined using Model My Watershed, an application of WikiWatershed by the Stroud Water Research Center (https://modelmywatershed.org/).

KINGS RIVER NEAR BERRYVILLE, ARKANSAS (KINGS)

The Kings River (Kings) was sampled at the USGS stream gaging station near Berryville, Arkansas (USGS 07050500), where approximately 320 water samples were collected and analyzed for constituents from July 2011 through September 2018. The Kings River Watershed is 1370 km2, draining 67% forested lands, 28% pasture and grasslands, and 4% urban development. The Kings River is a tributary to the White River within the Upper White River Basin, flowing into Table Rock Lake in Missouri.

The constituent concentrations were paired with mean daily discharge and then used in the software program LOADEST to estimate constituent loads. The regression models for constituents at this site were complex, including mean daily discharge (Q), Q^2, and time (t); the regression models also included coefficients to account for seasonal variations in the observed daily loads. The various statistics and specific equations used in constituent load estimation are presented in Table 3. The mean daily loads were variable across constituents, and show that nitrate-nitrogen (NO_3-N), on average, made up over 75% of total nitrogen (TN) loads, whereas soluble reactive phosphorus (SRP) loads were less than 30% of the total phosphorus (TP) loads.

Table 3. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for the Kings River near Berryville, AR (Kings; USGS 07050500) from July 2011 through September 2018, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression Equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	6.4346 + 1.4456lnQ - 0.1431lnQ² - 0.4463sin(2πt) + 0.2966cos(2πt) - 0.0883t	1.85	15	0.78	1770 (1530-2040)
TN	6.4238 + 1.2964lnQ - 0.0360lnQ² - 0.1934sin(2πt) + 0.2317cos(2πt) - 0.0621t	0.97	10	0.89	2320 (2060-2600)
SRP	2.0978 + 1.4092lnQ - 0.4079sin(2πt) - 0.8070cos(2πt)	2.87	-10	0.69	60 (40-90)
TP	3.2681 + 1.4667lnQ - 0.2169sin(2πt) - 0.7447cos(2πt)	2.58	-24	0.76	210 (145-230)
TSS	8.1758 + 1.7598lnQ + 0.1830sin(2πt) - 0.9259cos(2πt)	2.95	-60	0.43	96500 (52500-163000)
Cl	8.2194 + 0.6979lnQ + 0.0277lnQ² - 0.1633sin(2πt) - 0.0164cos(2πt) - 0.0146t	-0.07	5	0.82	5380 (5140-5640)
SO_4	8.5699 + 0.8130lnQ + 0.0295lnQ² - 0.1416sin(2πt) + 0.0622cos(2πt)	0.11	5	0.87	9450 (8920-10000)

The mean daily loads were summed into annual loads (Table 4), which varied annually and generally increased with increasing annual discharge. However, the change in constituent loads between years does reflect the use of log-transformed values and re-transformation, as well as discharge exponents used in the equations. For example, annual discharge was similar between project years 2014 and 2016 but the change in constituent loads was not necessarily proportional to the differences in annual discharge. The annual loads were dependent upon how constituent concentrations changed over time and how discharge varied across project years, reflecting the importance of hydrology in understanding constituent transport at the Kings River.

Table 4. Summary of annual discharge volume (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Kings River near Berryville, AR (Kings; USGS 07050500) for project years 2011-2018 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2011	421,000,000	782,000	802,000	12,500	38,600	11,300,000	1,770,000	2,890,000
2012	303,000,000	405,000	423,000	5,300	19,500	5,810,000	1,250,000	1,980,000
2013	452,000,000	607,000	643,000	13,600	43,500	12,900,000	1,830,000	2,960,000
2014	634,000,000	652,000	837,000	20,900	78,400	33,500,000	2,150,000	3,790,000
2015	616,000,000	655,000	931,000	31,600	100,500	38,800,000	2,240,000	4,110,000
2016	647,000,000	415,000	774,000	22,000	92,500	50,400,000	1,960,000	3,820,000
2017	471,000,000	387,000	590,000	12,100	45,400	17,000,000	1,560,000	2,960,000
2018*	18,000,000	5,260	8,240	584	1,560	302,000	122,000	151,000

*Project Year 2018 included July 1-September 30, 2018.

Many of the constituents showed that flow-adjusted concentrations changed over time at the Kings River (Table 5) when we look at monotonic trends both linearly (linear regression) and accounting for seasonality (Seasonal Kendall test).

- NO_3-N and TN concentrations were extremely likely decreasing throughout the study period
- SRP and TP concentrations were also extremely likely decreasing
- Chloride concentrations were either extremely likely or likely decreasing throughout the study period, depending on if seasonal influences are considered
- Sulfate concentrations were likely decreasing, when seasonal influences are considered

The directional changes in flow-adjusted concentrations were congruent with the relationship with time in the load estimation equations.

Table 5. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Kings River near Berryville, AR (Kings; USGS 07050500) from July 2011 through September 2018, with statistics showing the coefficient of determination (R^2) and p-value of the overall F-test (p-value) for linear regression analysis, and the p-value for the Seasonal Kendall analysis. Percent change per year (% Change/year) is reported for significant trends (p-value<0.05) and marginally significant trends (0.05≤p≤0.10).

	Linear Regression			Seasonal Kendall	
Constituent	p-value	R^2	% Change/year	p-value	% Change/year
NO_3-N	<0.01	0.05	-8.3	<0.01	-7.1
TN	<0.01	0.07	-5.5	<0.01	-4.6
SRP	<0.01	0.09	-14.7	<0.01	-9.0
TP	<0.01	0.1	-12.5	<0.01	-7.0
TSS	0.27	0	-	0.37	-
Cl	0.01	0.02	-1.7	0.05*	-1.0
SO_4	0.21	0.01	-	0.07*	-0.9

*The trend was marginally significant (0.05≤p≤0.10).

WHITE RIVER NEAR FAYETTEVILLE, ARKANSAS (WYMAN)

The White River was sampled at the USGS stream gaging station on Wyman Road near Fayetteville, Arkansas (USGS 07048600), where approximately 440 water samples were collected and analyzed for constituents from July 2009 through September 2018. The White River at this site drains a large watershed (1032 km2) with land use representing 69% forested area, 23% pasture and grasslands, 7% urban development, and almost 1% wetlands. This site is just upstream of the wastewater effluent discharge from the Paul Noland Treatment Facility east of Fayetteville.

The constituent concentrations were paired with mean daily discharge and then used in the software program LOADEST to estimate constituent loads. The regression models for constituent loads at this site were complex and included multiple discharge factors (Q and Q^2), seasonal coefficients (sin and cos) and or time (t). The regression models and associated statistics used in load estimation are presented in Table 6. The mean daily loads were variable across constituents, and show that nitrate-nitrogen (NO_3-N) loads made up 64% of total nitrogen (TN) loads, whereas soluble reactive phosphorus (SRP) loads made up less than 10% of total phosphorus (TP) loads.

Table 6. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for the White River near Fayetteville, AR (Wyman; USGS 07048600) from July 2009 through September 2018, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	**Regression Equation**	**AIC**	**BP** (%)	**E**	**Mean Daily Load** (kg/d)
NO_3-N	$4.0108 + 1.1371 \ln Q - 0.0046 \ln Q^2 - 0.0264 \sin(2\pi t) + 0.3989 \cos(2\pi t) - 0.0508t$	1.64	27	0.61	640 (567-720)
TN	$4.5630 + 1.1045 \ln Q + 0.0152 \ln Q^2 - 0.1229 \sin(2\pi t) + 0.1031 \cos(2\pi t)$	0.74	10	0.67	1210 (1110-1310)
SRP	$-0.2150 + 1.2524 \ln Q + 0.0386 \ln Q^2 - 0.2794 \sin(2\pi t) - 0.2131 \cos(2\pi t)$	2.11	14	0.23	28 (22-37)
TP	$1.8016 + 1.2941 \ln Q + 0.0455 \ln Q^2 - 0.2998 \sin(2\pi t) - 0.4002 \cos(2\pi t) + 0.0105t$	1.92	20	0.13	298 (229-381)
TSS	$7.5059 + 1.4807 \ln Q - 1.4807 \sin(2\pi t) - 0.63102 \cos(2\pi t)$	2.76	-45	0.55	107000 (76800-146000)
Cl	$6.6680 + 0.8900 \ln Q - 0.0095 \ln Q^2 - 0.0051 \sin(2\pi t) + 0.2040 \cos(2\pi t) - 0.0136t$	0.85	3	0.80	3720 (3500-3940)
SO_4	$8.0132 + 0.8933 \ln Q - 0.0115 \ln Q^2 - 0.1269 \sin(2\pi t) + 0.0781 \cos(2\pi t)$	1.01	1	0.87	13400 (12600-14300)

The mean daily loads for each constituent were summed into annual loads for each project year (Table 7). Loads varied between project years and generally reflected changes in discharge. However, this variation was not necessarily proportional to the changes in discharge, which is a result of the log-log transformations and discharge exponents used in the regression models. For example, annual discharge volume in 2016 was approximately 29% less than that in 2015, but annual TP and SRP loads in 2016 were 50-60% less than the loads in 2015. Overall, annual loads were positively related to annual discharge across project years, demonstrating the importance of hydrology in understanding constituent transport at the White River near Fayetteville.

WHITE RIVER NEAR FAYETTEVILLE, ARKANSAS (WYMAN)

Table 7. Summary of annual discharge volume (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for White River near Fayetteville, AR (Wyman; USGS 07048600) for project years 2009-2018 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2009	631,000,000	352,000	557,000	14,600	149,000	53,300,000	1,860,000	6,660,000
2010	686,000,000	347,000	657,000	19,600	235,000	79,600,000	1,630,000	5,570,000
2011	358,000,000	215,000	313,000	5,490	45,100	16,200,000	1,140,000	3,900,000
2012	322,000,000	142,000	226,000	3,410	31,900	15,100,000	956,000	3,280,000
2013	366,000,000	166,000	277,000	4,500	40,200	16,900,000	1,120,000	4,020,000
2014	714,000,000	273,000	576,000	12,900	147,000	63,700,000	1,780,000	6,690,000
2015	634,000,000	304,000	662,000	19,000	186,000	52,000,000	1,620,000	6,130,000
2016	446,000,000	155,000	358,000	7,790	89,500	34,700,000	1,090,000	4,060,000
2017	505,000,000	207,000	439,000	8,400	82,200	29,200,000	1,300,000	4,750,000
2018*	22,700,000	4,460	13,400	242	2,600	1,310,000	63,300	308,000

*Project Year 2018 included July 1-September 30, 2018.

At the White River near Fayetteville, only NO3-N and chloride showed a statistically significant trend in flow-adjusted concentrations over the sampling period (Table 8).

- NO_3-N was extremely likely decreasing during the study period
- Chloride was also extremely likely decreasing during the study period

The directional changes in the flow-adjusted concentrations as identified by the trend analysis were congruent with the equations used to estimate loads, so that loads were reflective of any changes that occurred through time.

Table 8. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for the White River near Fayetteville, AR (Wyman; USGS 07048600) from July 2009 through September 2018, with statistics showing the coefficient of determination (R^2) and p-value of the overall F-test (p-value) for linear regression analysis, and the p-value for the Seasonal Kendall analysis. Percent change per year (% Change/year) is reported for significant trends (p-value<0.05) and marginally significant trends (0.05≤p≤0.10).

	Linear Regression			Seasonal Kendall	
Constituent	p-value	R^2	% Change/year	p-value	% Change/year
NO_3-N	<0.01	0.05	-5.3	<0.01	-4.8
TN	0.69	<0.01	-	0.28	-
SRP	0.89	<0.01	-	0.94	-
TP	0.66	<0.01	-	0.52	-
TSS	0.15	<0.01	-	0.17	-
Cl	0.04	0.01	-1.4	0.02	-1.3
SO_4	0.34	<0.01	-	0.75	-

WAR EAGLE CREEK NEAR HINDSVILLE, ARKANSAS (WEC)

The War Eagle Creek (WEC) was sampled at the USGS stream gaging station near Hindsville, AR (USGS 07049000), where approximately 430 water samples were collected and analyzed for constituents from July 2009 through September 2018. The WEC watershed is approximately 690 km2, draining 57% forest, 38% pasture and grasslands, and 5% urban. War Eagle Creek receives the treated waste-water effluent from the city of Huntsville, Arkansas and it flows directly into Beaver Lake, the first large impoundment of the White River.

The constituent concentrations were paired with mean daily discharge, which were used to compute daily loads in the software program LOADEST. The regression equations used to estimate daily loads were complex and included multiple discharge factors (Q and Q^2), seasonal coefficients (sin and cos) and or time (t). The regression models and associated statistics used in load estimation are presented in Table 9. The mean daily loads were variable across constituents, and showed that nitrate-nitrogen (NO_3-N) loads made up the majority of total nitrogen (TN) loads (approximately 75%), whereas soluble reactive phosphorus (SRP) loads were only 17% of total phosphorus (TP) loads.

Table 9. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for War Eagle Creek near Hindsville, AR (WEC; USGS 07049000) from July 2009 through September 2018, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression Equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$6.6357 + 0.9387\ln Q - 0.0290\ln Q^2 - 0.0807\sin(2\pi t) + 0.1376\cos(2\pi t) - 0.0103t$	0.89	-6	0.85	980 (920-1040)
TN	$6.7676 + 0.9968\ln Q - 0.0079\ln Q^2 - 0.0835\sin(2\pi t) + 0.0932\cos(2\pi t)$	0.53	-1	0.94	1310 (1240-1400)
SRP	$1.7537 + 1.4347\ln Q - 0.3280\sin(2\pi t) - 0.2028\cos(2\pi t) - 0.0104t$	1.86	1	0.93	24 (19-30)
TP	$3.1849 + 1.5211\ln Q - 0.2131\sin(2\pi t) - 0.4520\cos(2\pi t)$	1.97	-24	0.70	138 (108-175)
TSS	$8.5652 + 1.7586\ln Q - 0.1304\sin(2\pi t) - 0.7885\cos(2\pi t)$	2.48	-17	0.75	74500 (49400-108000)
Cl	$8.2858 + 0.7197\ln Q - 0.0099\ln Q^2 - 0.1952\sin(2\pi t) + 0.0554\cos(2\pi t)$	0.63	1	0.85	4000 (3820-4190)
SO_4	$8.2878 + 0.9392\ln Q - 0.0263\ln Q^2 - 0.0710\sin(2\pi t) + 0.1761\cos(2\pi t) + 0.0195t$	-0.19	0	0.94	4980 (4800-5160)

The mean daily loads were summed to calculate annual loads (Table 10), which varied between project years, generally following changes in annual discharge. But, this variation in constituent loads was not necessarily proportional to changes in discharge, which reflects the use of log-log transformations and discharge exponents used in the regression models. For example, while total annual discharge in 2017 was approximately one-third less than what it was in 2015, SRP loads in 2017 were 60% less than those in 2015. Annual loads were generally strongly linked to annual discharge across project years, reflecting the importance of hydrology in understanding the transport of various constituents at War Eagle Creek.

WAR EAGLE CREEK NEAR HINDSVILLE, ARKANSAS (WEC)

Table 10. Summary of annual discharge volume (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for War Eagle Creek near Hindsville, AR (WEC; USGS 07049000) for project years 2009-2018 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2009	344,000,000	464,000	574,000	11,500	58,900	29,400,000	1,880,000	2,080,000
2010	414,000,000	416,000	599,000	15,800	106,000	74,900,000	1,560,000	1,930,000
2011	261,000,000	357,000	445,000	6,290	29,300	11,000,000	1,470,000	1,720,000
2012	193,000,000	255,000	308,000	3,180	16,600	6,450,000	1,080,000	1,260,000
2013	270,000,000	360,000	446,000	5,480	27,700	10,700,000	1,540,000	1,820,000
2014	285,000,000	335,000	443,000	6,840	41,600	22,000,000	1,390,000	1,750,000
2015	426,000,000	480,000	701,000	17,000	88,500	42,500,000	1,920,000	2,620,000
2016	329,000,000	334,000	485,000	9,170	61,700	37,600,000	1,360,000	1,860,000
2017	275,000,000	301,000	430,000	6,490	37,300	17,100,000	1,230,000	1,740,000
2018*	6,190,000	8,260	9,750	48	220	50,000	82,900	45,900

*Project Year 2018 included July 1-September 30, 2018.

At War Eagle Creek, only NO_3-N and sulfate showed a statistically significant trend in flow-adjusted concentrations over the sampling period when we look at monotonic trends both linearly (linear regression) and accounting for seasonality (Seasonal Kendall test; Table 11).

- NO_3-N concentrations were extremely likely decreasing during the study period, when we look at linear trends
- Sulfate concentrations were extremely likely increasing at this site, when look at both linear trends and when we account for seasonal influences

The directional changes in the flow-adjusted concentrations as identified by the trend analysis were congruent with the equations used to estimate loads, so that loads were reflective of any changes that occurred through time.

Table 11. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for War Eagle Creek near Hindsville, AR (WEC; USGS 07049000) from July 2009 through September 2018, with statistics showing the coefficient of determination (R^2) and p-value of the overall F-test (p-value) for linear regression analysis, and the p-value for the Seasonal Kendall analysis. Percent change per year (% Change/year) is reported for significant trends (p-value<0.05) and marginally significant trends (0.05≤p≤0.10).

	Linear Regression			Seasonal Kendall	
Constituent	p-value	R^2	% Change/year	p-value	% Change/year
NO_3-N	<0.01	0.02	-2	0.12	-
TN	0.26	<0.01	-	0.79	-
SRP	0.12	0.01	-	0.23	-
TP	0.16	<0.01	-	0.68	-
TSS	0.74	<0.01	-	0.68	-
Cl	0.15	<0.01	-	0.76	-
SO_4	<0.01	0.03	1.5	<0.01	1.6

WEST FORK OF THE WHITE RIVER EAST OF FAYETTEVILLE, ARKANSAS (WFWR)

The West Fork of the White River (WFWR) was sampled at the USGS stream gaging station east of Fayetteville (USGS 07048550), where approximately 440 water samples were collected and analyzed for constituents from July 2009 through September 2018. The WFWR watershed is 317 km2, draining 60% forested area, 26% pasture and grasslands, 13% urban, and almost 1% wetlands. The WFWR receives the Town Branch stream in southeast Fayetteville and then flows into the White River just downstream of Lake Sequoyah.

The constituent concentrations were paired with mean daily discharge and used to estimate loads using the software program LOADEST. The regression models for constituent loads at this site ranged from relatively simple models with discharge and time, to more complex models with multiple discharge factors (Q and Q^2), seasonal coefficients (sin and cos) and or time (t). The regression models and associated statistics used in load estimation are presented in Table 12. The mean daily loads were variable across constituents, showing that nitrate-nitrogen (NO_3-N) loads made up 59% of total nitrogen (TN) loads, whereas soluble reactive phosphorus (SRP) loads made up less than 10% of total phosphorus (TP) loads.

Table 12. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for West Fork White River east of Fayetteville, AR (WFWR; USGS 07048550) from July 2009 through September 2018, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$3.2670 + 1.2268 \ln Q - 0.0311 \ln Q^2 - 0.0622 \sin(2\pi t) + 0.2226 \cos(2\pi t) - 0.0709t$	2.53	41	0.64	235 (194-281)
TN	$4.0020 + 1.1295 \ln Q - 0.0113t$	1.20	0	0.80	400 (365-437)
SRP	$-0.4418 + 1.2027 \ln Q - 0.0219t$	2.30	-22	0.63	7 (6-8)
TP	$1.4775 + 1.3752 \ln Q - 0.3410 \sin(2\pi t) - 0.6205 \cos(2\pi t)$	2.44	-28	0.56	84 (67-105)
TSS	$7.0425 + 1.5722 \ln Q - 0.3082 \sin(2\pi t) - 0.9722 \cos(2\pi t)$	2.84	-27	0.56	57800 (40700-79700)
Cl	$6.5879 + 0.8568 \ln Q - 0.0177 \ln Q^2 + 0.0448 \sin(2\pi t) + 0.3143 \cos(2\pi t) - 0.0039t$	1.08	0	0.60	2000 (1880-2130)
SO_4	$8.1646 + 0.8607 \ln Q - 0.0224 \ln Q^2 - 0.1062 \sin(2\pi t) + 0.1309 \cos(2\pi t)$	0.80	3	0.84	8560 (8110-9030)

The mean daily loads were summed into annual loads for each project year (Table 13). Loads varied between project years, which generally reflected changes in discharge. When constituent loads did vary between years with changes in discharge, the differences were not necessarily proportional, which is a result of the log-log transformations and discharge exponents used in the regression models. For example, annual discharge volume in 2017 was approximately half of the total discharge in 2015, but the annual TSS load in 2017 was approximately 67% of that in 2015. Many annual load estimations were positively related to annual discharge across project years, while others were less strongly related. This suggests that hydrology and other potential factors are important in understanding constituent transport in the WFWR.

WEST FORK OF THE WHITE RIVER EAST OF FAYETTEVILLE, ARKANSAS (WFWR)

Table 13. Summary of annual discharge (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for West Fork White River east of Fayetteville, AR (WFWR; USGS 07048550) for project years 2009-2018 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2009	173,000,000	120,000	150,000	2,650	32,400	20,300,000	841,000	3,700,000
2010	187,000,000	109,000	175,000	3,230	41,200	33,200,000	732,000	3,070,000
2011	125,000,000	83,200	106,000	1,850	15,100	7,300,000	661,000	2,690,000
2012	106,000,000	53,300	86,800	1,460	15,000	9,400,000	489,000	2,060,000
2013	132,000,000	69,700	105,000	1,730	14,300	6,950,000	700,000	2,920,000
2014	236,000,000	105,000	203,000	3,500	51,300	39,200,000	924,000	4,080,000
2015	265,000,000	126,000	245,000	4,440	57,700	38,600,000	1,040,000	4,490,000
2016	185,000,000	69,300	157,000	2,660	35,900	26,600,000	723,000	3,160,000
2017	141,000,000	54,000	117,000	1,950	20,400	12,600,000	613,000	2,530,000
2018*	9,460,000	2,640	6,340	94	2,040	1,200,000	39,600	238,000

*Project Year 2018 included July 1-September 30, 2018.

In the WFWR, only NO_3-N and TN showed changes in flow-adjusted concentrations over the sampling period when we look at monotonic trends both linearly (linear regression) and accounting for seasonality (Seasonal Kendall test; Table 14).

- NO_3-N concentrations were extremely likely decreasing during the study period, when we look at both linear trends and when we consider seasonal influences
- TN concentrations were likely decreasing when we look at both linear trends and when we consider seasonal influences

The directional changes in flow-adjusted concentrations from the trend analysis were congruent with the load estimation equations, such that loads were reflective of changes that occurred through time.

Table 14. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for West Fork White River east of Fayetteville, AR (WFWR; USGS 07048550) from July 2009 through September 2018, with statistics showing the coefficient of determination (R^2) and p-value of the overall F-test (p-value) for linear regression analysis, and the p-value for the Seasonal Kendall analysis. Percent change per year (% Change/year) is reported for significant trends (p-value<0.05) and marginally significant trends (0.05≤p≤0.10).

	Linear Regression			Seasonal Kendall	
Constituent	p-value	R^2	% Change/year	p-value	% Change/year
NO_3-N	<0.01	0.07	-7.5	<0.01	-7.2
TN	0.06*	0.01	-1.5	0.07*	-1.4
SRP	0.97	<0.01	-	0.97	-
TP	0.71	<0.01	-	0.50	-
TSS	0.70	<0.01	-	0.26	-
Cl	0.54	<0.01	-	0.76	-
SO_4	0.53	<0.01	-	0.25	-

*The trend was marginally significant (0.05≤p≤0.10).

RICHLAND CREEK AT TUTTLE ROAD NEAR GOSHEN, ARKANSAS (RICHLAND)

Richland Creek (Richland) was sampled at the USGS stream gaging station on Tuttle Road in Goshen, Arkansas (USGS 07048780), where 136 water samples were collected and analyzed for constituents from October 2015 through September 2018. Richland Creek at this site drains a 310 km2 watershed, slightly smaller than the WFWR watershed. The Richland watershed is predominantly forest (60%), with 33% pasture, 4% urban, 3% grassland, and less than 1% wetland. Richland Creek is one of the major tributaries of the White River with the confluence near the headwaters of Beaver Lake.

The constituent concentrations were paired with mean daily discharge and then used to estimate daily loads using the software program LOADEST. The regression equations used to predict daily loads were generally complex and included multiple discharge factors (Q and Q^2), seasonal coefficients (sin and cos) and or time (t). The regression models and associated statistics used in load estimation are presented in Table 15. Mean daily loads varied across constituents, where nitrate-nitrogen (NO_3-N) made up half of total nitrogen (TN) loads, and soluble reactive phosphorus (SRP) loads only made up approximately 23% of total phosphorus (TP) loads.

Table 15. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Richland Creek at Tuttle Road in Goshen, AR (Richland; USGS 07048780) from October 2015 through September 2018, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$4.0200 + 0.9023\ln Q - 0.0148\ln Q^2 - 0.1522\sin(2\pi t) - 0.1669\cos(2\pi t) + 0.1319t$	0.96	4	0.92	230 (200-260)
TN	$4.0617 + 0.9606\ln Q + 0.0099\ln Q^2 + 0.1086t$	0.69	-8	0.70	456 (393-526)
SRP	$-0.7794 + 1.2367\ln Q - 0.0930\sin(2\pi t) - 0.4350\cos(2\pi t)$	2.11	-26	0.83	10 (6-15)
TP	$0.1294 + 1.3244\ln Q - 0.0973\sin(2\pi t) - 0.4609\cos(2\pi t)$	2.75	-24	-0.21	44 (19-87)
TSS	$5.0048 + 1.5150\ln Q + 0.1910\sin(2\pi t) - 0.5867\cos(2\pi t)$	3.77	-71	0.28	26100 (2640-106000)
Cl	$5.2700 + 0.8659\ln Q - 0.0099\ln Q^2 - 0.1609\sin(2\pi t) + 0.0261\cos(2\pi t)$	-0.48	2	0.93	810 (760-860)
SO_4	$6.0507 + 0.9232\ln Q - 0.1274\sin(2\pi t) + 0.0035\cos(2\pi t)$	0.22	-3	0.92	2490 (2260-2740)

Mean daily loads for each constituent were summed to calculate annual loads (Table 16), which varied between project years. Annual loads varied with annual discharge, but this variation was not necessarily proportional, which reflects the use of log-transformation and discharge exponents in the regression models. For example, annual discharge in 2016 was 23% greater than in 2017, while TSS was almost two times greater in 2016 compared to 2017. In addition to variations in total discharge, there may be other important factors influencing constituent transport in Richland Creek.

RICHLAND CREEK AT TUTTLE ROAD NEAR GOSHEN, ARKANSAS (RICHLAND)

Table 16. Summary of annual discharge volume (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Richland Creek near Goshen, AR (Richland; USGS 07048490) for project years 2015-2018 (e.g., project year 2016 is July 1, 2016 - June 30, 2017).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2015*	136,000,000	91,100	175,000	5,560	26,600	15,900,000	348,000	1,090,000
2016	119,000,000	74,200	171,000	2,850	12,400	8,170,000	269,000	851,000
2017	97,000,000	82,000	151,000	2,170	9,040	4,490,000	263,000	774,000
2018*	1,520,000	2,410	2,520	27	86	35,900	5,960	13,900

*Project Year 2015 began in October rather than July 2015, and Project Year 2018 was from July 1-September 30, 2018.

Many of the constituents that were evaluated showed changes in flow-adjusted concentrations over time when we look at monotonic trends both linearly (linear regression) and accounting for seasonality (Seasonal Kendall test; Table 17).

- NO_3-N and TN concentrations were extremely likely increasing during the study period
- Interestingly, TP concentrations were extremely likely decreasing during the study period, by 17-25%, depending on if seasonality is considered
- Chloride and sulfate concentrations were extremely likely increasing, when seasonal influences are considered

The directional changes in flow-adjusted constituent concentrations identified by trend analysis were congruent with the regression models that were used to estimate constituent loads, so that loads were reflective of temporal trends.

Table 17. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Richland Creek, (Richland; USGS 07048490) from October 1, 2015 through September 2018, with statistics showing the coefficient of determination (R^2) and p-value of the overall F-test (p-value) for linear regression analysis, and the p-value for the Seasonal Kendall analysis. Percent change per year (% Change/year) is reported for significant trends (p-value<0.05) and marginally significant trends (0.05≤p≤0.10).

	Linear Regression			Seasonal Kendall	
Constituent	p-value	R^2	% Change/year	p-value	% Change/year
NO_3-N	0.03	0.04	8.6	0.02	9.5
TN	<0.01	0.06	9.4	<0.01	13.4
SRP	0.69	<0.01	-	0.12	-
TP	<0.01	0.09	-25.1	0.01	-17.2
TSS	0.54	<0.01	-	0.46	-
Cl	0.36	0.01	-	0.02	5.5
SO_4	0.52	<0.01	-	0.01	6.3

TOWN BRANCH ON ARMSTRONG IN FAYETTEVILLE (TB)

Town Branch (TB) was sampled at the USGS stream gaging station on Armstrong Avenue in Fayetteville, Arkansas (USGS 07048495), where 143 water samples were collected and analyzed for constituents from October 2015 through September 2018. This stream drains much of south Fayetteville with land use representing 50% urban development, 34% forest, and 15% pasture. Town Branch flows into the West Fork of the White River, a tributary to the White River that forms Beaver Lake.

The constituent concentrations were paired with mean daily discharge and then used to compute daily loads in the software program LOADEST. The regression equations used to predict daily loads were generally complex and included multiple discharge factors (Q and Q^2), seasonal coefficients (sin and cos) and or time (t). The various statistics and regression models used in constituent load estimation are presented in Table 18. The mean daily loads were highly variable for some constituents, shown by large bias percentages (BP). Nitrate-nitrogen (NO_3-N) loads were 33% of the total nitrogen (TN) loads at this site, whereas soluble reactive phosphorus (SRP) loads were 13% of the total phosphorus (TP) loads.

Table 18. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Town Branch at Armstrong Avenue in Fayetteville (TB; USGS 07048495) from October 2015 through September 2018, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$3.5354 + 0.8994\ln Q - 0.0166\ln Q^2 + 0.0035\sin(2\pi t) + 0.2264\cos(2\pi t)$	1.49	8	0.91	29 (24-35)
TN	$4.3358 + 1.0801\ln Q - 0.0138\ln Q^2 + 0.1040t$	0.93	7	0.84	87 (72-105)
SRP	$0.5363 + 1.3388\ln Q - 0.0102\ln Q^2 + 0.2077\sin(2\pi t) + 0.3931\cos(2\pi t)$	1.59	35	0.33	4 (3-6)
TP	$1.7675 + 1.4624\ln Q - 0.0085\ln Q^2$	2.42	74	-0.93	31 (16-56)
TSS	$7.3030 + 1.8728\ln Q - 0.0096\ln Q^2 + 0.6134\sin(2\pi t) - 0.0901\cos(2\pi t)$	2.86	111	-2.28	33500 (12000-75200)
Cl	$6.3921 + 0.7073\ln Q - 0.0200\ln Q^2 - 0.3351\sin(2\pi t) + 0.1423\cos(2\pi t)$	0.55	-5	0.87	361 (329-395)
SO_4	$8.0341 + 0.7410\ln Q - 0.0274\ln Q^2 - 0.2605\sin(2\pi t) + 0.1678\cos(2\pi t)$	0.11	-3	0.87	1797 (1667-1934)

The mean daily loads for all constituents were summed into annual loads for each project year (Table 19), which varied between project years. The variation in annual constituent loads between years was not necessarily proportional to the changes in discharge, reflecting the use of log-transformations and discharge exponents in the regression models. For example, the annual discharge in 2016 was 16% greater than in 2017, while TSS loads were over one and a half times greater in 2016 compared to 2017. There are likely additional factors that influence loads at Town Branch, other than hydrology.

Table 19. Summary of calculated annual discharge volume (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Town Branch at Armstrong Avenue in Fayetteville(TB; USGS 07048495) for project years 2015-2018 (e.g., project year 2016 is July 1, 2016 - June 30, 2017).

Project Year	Annual Q	NO_3-N	TN	SRP	TP	TSS	Cl	SO_4
2015*	31,000,000	9,800	31,400	2,070	14,700	14,000,000	132,000	639,000
2016	27,400,000	11,500	31,500	1,240	10,400	14,000,000	127,000	648,000
2017	23,600,000	9,660	29,800	1,000	8,710	8,600,000	122,000	609,000
2018*	2,180,000	1,010	2,610	81	246	165,000	14,300	72,900

*Project Year 2015 began in October rather than July 2015, and Project Year 2018 was from July 1-September 30, 2018.

Several of the constituents showed significant changes over time (Table 20), when we look at monotonic trends both linearly (linear regression) and accounting for seasonality (Seasonal Kendall test).

- NO_3-N extremely likely increased when we look at linear trends during the study period
- TN concentrations extremely likely increased when we look at both linear trends and when we consider seasonal influences
- Interestingly, TP concentrations extremely likely decreased by approximately 20-25%, depending on if seasonal influences are considered
- Chloride concentrations likely increased when we consider seasonal influences
- Sulfate concentrations extremely likely decreased when we look at linear trends through time

The directional changes in constituent concentrations were congruent with the regression models used to estimate constituent loads, so that loads were reflective of temporal trends.

Table 20. Trend analyses of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Town Branch (TB; USGS 07048495) from October 2015 through September 2018, with statistics showing the coefficient of determination (R^2) and p-value of the overall F-test (p-value) for linear regression analysis, and the p-value for the Seasonal Kendall analysis. Percent change per year (% Change/year) is reported for significant trends (p-value<0.05) and marginally significant trends (0.05≤p≤0.10).

	Linear Regression			Seasonal Kendall	
Constituent	p-value	R^2	% Change/year	p-value	% Change/year
NO_3-N	0.03	0.04	13.3	0.12	-
TN	<0.01	0.06	11.2	0.01	9.3
SRP	0.26	0.01	-	0.36	-
TP	<0.01	0.09	-24.8	<0.01	-21.6
TSS	0.26	0.01	-	0.79	-
Cl	0.73	<0.01	-	0.08*	5.0
SO_4	0.03	0.03	-6.3	0.84	-

*The trend was marginally significant (0.05≤p≤0.10).

Upper Illinois River Watershed

The Upper Illinois River Watershed (UIRW; HUC 11110103) is a 1952 km2 watershed that lies in northwest Arkansas and flows west into Oklahoma. The UIRW has headwaters in the Boston Mountains ecoregion, which then flows north into the Ozark Highlands ecoregion before entering Oklahoma and flowing into Lake Tenkiller. This watershed includes two primary counties in Arkansas: Benton and Washington counties. The Illinois River is used for recreation, aquatic life, and the water supply for residential communities, agriculture and industry. In Arkansas, the Illinois River is designated as an ecologically sensitive water body (ESW) due to the presence of the Neosho Mucket mussel and a Scenic River in Oklahoma.

Approximately 53% of the UIRW is pasture, 31% is forest, and 16% is urban land use (ANRC, 2018). This watershed is largely characterized by agricultural activities including pasture land, cattle grazing and poultry operations, where poultry litter is often land applied. These agricultural activities are associated with nutrient additions, particularly phosphorus (P), to the landscape. Not only can excess nutrients be transported to surface waters via overland flow from runoff events in the short-term, “legacy” P has become an issue as well. Legacy P describes the portion that gets stored in the soils or streambed sediments. Despite the implementation of best management practices (BMPs), this legacy P can be a long-term source of P to waterbodies. Also, in recent decades, there have been increases in residential, industrial and commercial development, which will have an effect on the hydrology and water quality of streams and lakes in the watershed.

The UIRW has been identified by the Arkansas Natural Resources Commission as a 319 Nonpoint Source (NPS) Pollution priority catchment (ANRC, 2018). The major water-quality concerns in this watershed are nutrients (especially from pasture land use due to the application of poultry litter as fertilizer) and sediments (ANRC, 2018). There are several 319 projects in the UIRW, ranging from streambank restoration to landowner education, in an effort to reduce pollutant loads from land uses that are likely to influence water quality. Measuring the success of these 319 projects and others depends on the availability of long-term water quality data that can be paired with discharge data.

Most sampling occurred at sites where USGS stream gaging stations exist and daily discharge data was available. At Sager Creek, a USGS stream gaging station wasn’t available, so AWRC operated their own. Streams that were selected for water-quality sampling varied in location within the watershed, catchment area, and land use (Table 21). For example, Spring Creek (Spring), Osage Creek (OC112), Mud Creek (Mud), and Sager Creek (Sager) are relatively small watersheds (<100 km2) that drain largely urban areas (38-62%), although these sites also drain substantial pasture land use (21-58%). The Illinois River is the only river in this watershed that is on the draft 2018 303(d) list of impaired waterbodies, due to chloride and sulfate. Osage Creek, Spring Creek, and Sager Creek should be considered successes, as those streams were previously listed as impaired due to phosphorus, nitrogen and or sediments. Three sampling sites were on the Illinois River, where Savoy is the most upstream, the site at Highway 59 is in Arkansas near the border of Oklahoma, and the site at Watts is in Oklahoma, downstream from Lake Francis (a small impoundment).

Table 21. Select study sites (Site ID), USGS station number, site coordinates, drainage area and land cover as percentages of total drainage area for sites in the Upper Illinois River Watershed (HUC 11110103). All water samples were collected in Arkansas (except the site at Watts) at the following locations: the Illinois River near Watts, OK (Watts); the Illinois River at Highway 59 (IR59); the Illinois River at Savoy (Savoy); Osage Creek near Elm Springs (Osage); Baron Fork at Dutch Mills (Baron); Spring Creek near Springdale (Spring); Osage Creek near Cave Springs (OC112); Mud Creek near Johnson (Mud); and Sager Creek at Siloam Springs.

					Percent of Land Use*					
Site ID	**USGS Station**	**Latitude**	**Longitude**	**Area (km^2)**	**Urban**	**Forest**	**Grassland**	**Pasture**	**Wetlands**	**Water**
Watts	07195500	36°07'47"N	94°34'18"W	1633.5	17.6	28.9	1.3	51.4	0.5	0.3
IR59	07195430	36°06'33"N	94°32'04"W	1473.2	18.6	28.5	1.2	50.9	0.4	0.3
Savoy	07194800	36°06'10"N	94°20'39"W	435.4	8.2	36.7	1.4	52.8	0.4	0.4
Osage	07195000	36°13'20"N	94°17'14"W	336.7	37.3	11.6	0.4	50.4	0.1	0.1
Baron	07196900	35°52'48"N	94°29'11"W	106.4	4.3	45.5	1.8	48.2	0.1	<0.05
Spring	07194933	36°14'37"N	94°14'19"W	91.8	45.2	12.1	0.2	42.3	0.1	0.1
OC112	07194880	36°16'53"N	94°13'40"W	89.0	61.7	6.2	0.3	31.2	0.2	.01
Mud	07194809	36°07'22"N	94°09'45"W	43.0	62.2	16.8	0.2	20.6	0.1	0.2
Sager	N/A	36°11'42"N	94°33'49"W	35.0	38.0	3.7	<0.05	58.1	0.1	0.1

*Land use was determined by the University of Arkansas Center for Advanced Spatial Technology (CAST) using the 2011 National Land Cover Dataset for most sites. OC112 and Mud were new sites and land use was determined using Model My Watershed, an application of WikiWatershed by the Stroud Water Research Center (https://modelmywatershed.org/).

ILLINOIS RIVER NEAR WATTS, OKLAHOMA (WATTS)

The Illinois River near Watts, Oklahoma (Watts) was sampled at the USGS gaging station near Watts, Oklahoma (USGS 07195500), where approximately 420 water samples were collected and analyzed for constituents from July 2009 through September 2018. The Watts watershed is 1,634 km2 in area, draining 29% forested lands, 53% pasture and grasslands, and 18% urban development. Watts is an important site since the Illinois River has been a focal point for phosphorus management in the past. The Illinois River was also sampled at two locations upstream (see Illinois River south of Siloam Springs, Arkansas and Illinois River at Savoy, Arkansas). One important distinction between Watts and the site south of Siloam Springs is the remnant of Lake Francis (located between the two sites), which can behave like a small impoundment of the river.

The constituent concentrations were paired with mean daily discharge (Q) and then used in the software program LOADEST to estimate constituent loads. The regression models for constituent loads at this site were relatively simple for some constituents (Q and t coefficients only), while other constituent models were more complex (Q, Q^2, t, and sin and cos coefficients to account for seasonal variations in the observed daily loads). The specific equations used in constituent load estimation and their respective regression statistics are presented in Table 22. The mean daily loads were variable across constituents, showing that nitrate-nitrogen (NO_3-N) made up nearly 80% of the total nitrogen (TN) loads whereas soluble reactive phosphorus (SRP) loads were 30% of the total phosphorus (TP) loads.

Table 22. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Illinois River near Watts, OK (Watts; USGS 07195500) July 2009 through September 2018, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$8.7760 + 0.9188\ln Q - 0.0812\ln Q^2 - 0.0065\sin(2\pi t) + 0.2078\cos(2\pi t)$	-0.27	-3	0.80	3490 (3390-3590)
TN	$8.9416 + 1.0121\ln Q - 0.0523\ln Q^2 + 0.0010\sin(2\pi t) + 0.1656\cos(2\pi t) - 0.0057t$	-0.86	-4	0.91	4420 (4300-4540)
SRP	$5.1172 + 1.3680\ln Q - 0.0099t$	1.92	8	0.84	205 (160-260)
TP	$5.8992 + 1.5651\ln Q - 0.0125t$	1.82	7	0.88	675 (490-910)
TSS	$11.1019 + 1.9390\ln Q + 0.0302t$	2.60	83	-1.31	448400 (210200-843400)
Cl	$10.2939 + 0.6545\ln Q - 0.0223\ln Q^2 - 0.0643\sin(2\pi t) + 0.0288\cos(2\pi t)$	1.19	5	0.84	19100 (18200-20200)
SO_4	$10.5660 + 0.7690\ln Q - 0.0103\ln Q^2 - 0.0413\sin(2\pi t) + 0.0964\cos(2\pi t) + 0.0205t$	-0.43	1	0.93	23700 (23000-24300)

The mean daily loads were summed into annual loads for each project year (Table 23), which varied between project years but generally followed the pattern in annual Q. The discrepancy in constituent loads between years, however, does reflect the use of log-transformation and re-transformation of values, as well as discharge exponents in the estimation equations. This influence was most profound in total suspended solids (TSS), where the change in annual load was not necessarily proportional to the change in annual Q; TSS loads were highly variable, which is reflected in the regression statistics. Project year 2016 had around 18% more discharge than 2014, but the 2016 TSS load was nearly seven times the 2014 load. Annual loads were dependent upon how discharge varied between project years, reflecting the importance of hydrology in understanding constituent transport at IR59.

ILLINOIS RIVER NEAR WATTS, OKLAHOMA (WATTS)

Table 23. Summary of annual discharge volume (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Illinois River near Watts, OK (Watts; USGS 07195500) for project years 2009-2018 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2009	687,000,000	1,530,000	1,870,000	61,400	159,000	49,800,000	8,130,000	9,070,000
2010	951,000,000	1,400,000	2,040,000	159,000	611,000	414,000,000	7,510,000	9,300,000
2011	439,000,000	1,070,000	1,230,000	30,900	69,400	17,400,000	6,140,000	6,880,000
2012	429,000,000	926,000	1,120,000	34,300	84,400	27,400,000	5,400,000	6,250,000
2013	460,000,000	1,100,000	1,250,000	29,900	63,300	15,100,000	6,490,000	7,480,000
2014	658,000,000	1,370,000	1,680,000	58,400	152,000	59,600,000	7,390,000	9,180,000
2015	988,000,000	1,770,000	2,330,000	141,000	522,000	434,000,000	8,920,000	12,100,000
2016	783,000,000	1,210,000	1,660,000	117,000	441,000	401,000,000	6,690,000	9,140,000
2017	633,000,000	1,290,000	1,600,000	61,600	176,000	96,200,000	6,870,000	9,230,000
2018*	66,100,000	126,000	140,000	3,160	5,690	1,210,000	1,130,000	1,250,000

*Project Year 2018 included July 1-September 30, 2018.

Almost all constituents showed that flow-adjusted concentrations changed over time at Watts (Table 24) when we look at monotonic trends both linearly (linear regression) and accounting for seasonality (Seasonal Kendall test).

- NO_3-N and TN concentrations were extremely likely decreasing throughout the study period
- SRP concentrations were extremely likely decreasing when seasonal influences are considered
- TP concentrations were likely decreasing linearly throughout the study period, and extremely likely decreasing when seasonality is considered
- TSS concentrations were likely increasing linearly throughout the study, and were extremely likely increasing when seasonal influences are considered
- Sulfate concentrations were extremely likely increasing during the study

The directional changes in flow-adjusted concentrations were congruent with the relationship with time in the load estimation equations.

Table 24. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Illinois River near Watts, OK (Watts; USGS 07195500) from July 2009 through September 2018, with statistics showing the coefficient of determination (R^2) and p-value of the overall F-test (p-value) for linear regression analysis, and the p-value for the Seasonal Kendall analysis. Percent change per year (% Change/year) is reported for significant trends (p-value<0.05) and marginally significant trends (0.05≤p≤0.10).

	Linear Regression			Seasonal Kendall	
Constituent	p-value	R^2	% Change/year	p-value	% Change/year
NO_3-N	<0.01	0.03	-1.4	<0.01	-1.3
TN	0.01	0.02	-0.8	0.01	-0.7
SRP	0.30	<0.01	-	0.03	-1.4
TP	0.08*	0.01	-1.6	0.02	-1.4
TSS	0.05*	0.01	2.7	0.02	2.1
Cl	0.67	<0.01	-	0.24	-
SO_4	<0.01	0.06	1.7	<0.01	2.2

*The trend was marginally significant (0.05≤p≤0.10).

ILLINOIS RIVER SOUTH OF SILOAM SPRINGS, ARKANSAS (IR59)

The Illinois River south of Siloam Springs (IR59) was sampled at the USGS gaging station near Siloam Springs, Arkansas on Hwy 59 (USGS 07194530), where approximately 430 water samples were collected and analyzed for constituents from July 2009 through September 2018. The IR59 watershed is 1,473 km2 in area, draining 29% forested lands, 52% pasture and grasslands, and 19% urban development. Aside from being the main stream in the Illinois River Watershed, IR59 is an important site due to the focus of past watershed management on reducing phosphorus concentrations and loads in this river. The Illinois River was also sampled at other sites downstream (see Illinois River near Watts, Oklahoma) and upstream (see Illinois River at Savoy, Arkansas).

The constituent concentrations were paired with mean daily discharge (Q) and then used in the software program LOADEST to estimate constituent loads. The regression models for constituent loads at this site were generally complex in the use of Q and time (t); the models also used sin and cos coefficients to account for seasonal variations in the observed daily loads. The specific equations used in constituent load estimation and their respective regression statistics are presented in Table 25. The mean daily loads were variable across constituents, showing that nitrate-nitrogen (NO_3-N) makes up a large percentage of the total nitrogen (TN) loads whereas soluble reactive phosphorus (SRP) loads were about 34% of the total phosphorus (TP) loads.

Table 25. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Illinois River south of Siloam Springs, AR (IR59; USGS 07195430) July 2009 to September 2018, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	**Regression equation**	**AIC**	**BP** (%)	**E**	**Mean Daily Load** (kg/d)
NO_3-N	$8.7380 + 0.8991 \ln Q - 0.0744 \ln Q^2 - 0.0115 \sin(2\pi t) + 0.1607 \cos(2\pi t) - 0.0160t$	0.49	-0.3	0.88	3560 (3380 - 3740)
TN	$8.9081 + 0.9874 \ln Q - 0.0444 \ln Q^2 + 0.0039 \sin(2\pi t) + 0.1601 \cos(2\pi t) - 0.0096t$	-0.51	-3	0.94	4450 (4300 - 4610)
SRP	$5.1811 + 1.4476 \ln Q - 0.2742 \sin(2\pi t) - 0.5271 \cos(2\pi t)$	1.30	16	0.82	180 (150 - 220)
TP	$5.8218 + 1.5743 \ln Q - 0.0086t$	1.89	-4	0.97	530 (380 - 720)
TSS	$10.9238 + 2.2022 \ln Q - 0.0140 \ln Q^2 + 0.0640 \sin(2\pi t) - 0.7967 \cos(2\pi t)$	2.42	165	-7.1	590000 (261000 - 1160000)
Cl	$10.3132 + 0.6453 \ln Q - 0.0285 \ln Q^2 - 0.0588 \sin(2\pi t) + 0.0509 \cos(2\pi t)$	-0.21	-1	0.86	18700 (18200 - 19300)
SO_4	$10.5674 + 0.7680 \ln Q - 0.0119 \ln Q^2 - 0.0595 \sin(2\pi t) + 0.0947 \cos(2\pi t) + 0.0197t$	-0.62	4	0.88	23300 (22700 - 24000)

The mean daily loads were summed into annual loads for each project year (Table 26), which varied between project years but generally followed the pattern in annual Q. The discrepancy in constituent loads between years, however, does reflect the use of log-transformation and re-transformation of values, and the discharge exponents. This influence was most profound in TSS, where the change in annual load was not proportional to the change in annual Q. TSS loads were highly variable, which is reflected in the regression statistics. For example, project year 2016 had around 15% more discharge than 2014, but over six times more TSS load.

ILLINOIS RIVER SOUTH OF SILOAM SPRINGS, ARKANSAS (IR59)

Table 26. Summary of annual discharge volume (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Illinois River south of Siloam Springs, AR (IR59; USGS 07195430) for project years 2009-2018 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2009	734,000,000	1,730,000	2,040,000	80,900	176,000	96,200,000	8,240,000	9,720,000
2010	971,000,000	1,530,000	2,150,000	166,000	570,000	752,000,000	7,380,000	9,620,000
2011	446,000,000	1,110,000	1,280,000	28,600	75,500	17,800,000	6,030,000	7,060,000
2012	449,000,000	981,000	1,190,000	34,000	96,100	52,200,000	5,400,000	6,520,000
2013	438,000,000	1,050,000	1,200,000	29,900	60,800	17,400,000	6,110,000	7,280,000
2014	687,000,000	1,440,000	1,780,000	66,800	149,000	97,000,000	7,490,000	9,720,000
2015	943,000,000	1,720,000	2,280,000	133,000	439,000	297,000,000	8,670,000	12,200,000
2016	791,000,000	1,250,000	1,730,000	117,000	411,000	611,000,000	6,820,000	9,610,000
2017	581,000,000	1,160,000	1,490,000	45,200	137,000	51,200,000	6,550,000	8,950,000
2018*	62,000,000	119,000	135,000	5,090	5,230	1,540,000	1,030,000	1,210,000

*Project Year 2018 included July 1-September 30, 2018.

Many of the constituents showed that flow-adjusted concentrations changed over time at IR59 (Table 27) when we look at monotonic trends both linearly (linear regression) and accounting for seasonality (Seasonal Kendall test).

- NO_3-N and TN concentrations were extremely likely decreasing during the study period, when we look at both linear trends and when we account for seasonal influences
- SRP and TP concentrations extremely likely decreased, when we consider seasonal influences
- TSS concentrations likely increased linearly throughout the study period
- Sulfate concentrations extremely likely increased during the study period

The directional changes in the flow-adjusted concentrations as identified by the trend analysis were congruent with the equations used to estimate loads, so that loads were reflective of any changes that occurred through time.

Table 27. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Illinois River south of Siloam Springs, AR (IR59; USGS 07195430) from July 2009 through September 2018, with statistics showing the coefficient of determination (R^2) and p-value of the overall F-test (p-value) for linear regression analysis, and the p-value for the Seasonal Kendall analysis. Percent change per year (% Change/year) is reported for significant trends (p-value<0.05) and marginally significant trends (0.05≤p≤0.10).

	Linear Regression			Seasonal Kendall	
Constituent	p-value	R^2	% Change/year	p-value	% Change/year
NO_3-N	<0.01	0.03	-1.8	<0.01	-1.4
TN	<0.01	0.02	-1.2	<0.01	-1.1
SRP	0.30	<0.01	-	0.02	-1.3
TP	0.26	<0.01	-	0.01	-1.6
TSS	0.10*	0.01	2.7	0.18	-
Cl	0.23	<0.01	-	0.18	-
SO_4	<0.01	0.05	1.6	<0.01	2.1

*The trend was marginally significant (0.05≤p≤0.10).

ILLINOIS RIVER AT SAVOY, ARKANSAS (SAVOY)

The Illinois River (Savoy) was sampled at the USGS gaging station at Savoy, Arkansas (USGS 07194800), where approximately 420 water samples were collected and analyzed for constituents from July 2009 to September 2018. The Savoy watershed is 435 km2 in area, draining 37% forested lands, 54% pasture and grasslands, and 8% urban development. Savoy is the most upstream Illinois River site sampled in this study, with two other sites located downstream (see Illinois River south of Siloam Springs, Arkansas and Illinois River near Watts, Oklahoma).

The constituent concentrations were paired with mean daily discharge (Q) and then used in the software program LOADEST to estimate constituent loads. The regression models for constituent loads at this site were relatively simple for some constituents (Q and t coefficients only), while other constituent models were more complex (Q, Q^2, t, and sin and cos coefficients to account for seasonal variations in the observed daily loads). The specific equations used in constituent load estimation and their respective regression statistics are presented in Table 28. The mean daily loads were variable across constituents, showing that nitrate-nitrogen (NO_3-N) makes up 64% of the total nitrogen (TN) loads whereas soluble reactive phosphorus (SRP) loads were 40% of the total phosphorus (TP) loads.

Table 28. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Illinois River at Savoy, AR (Savoy; USGS 07194800) July 2009 through September 2018, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$6.8342 + 0.7803\ln Q - 0.0269\ln Q^2 - 0.0337\sin(2\pi t) + 0.1172\cos(2\pi t) - 0.0368t$	0.74	-6	0.75	680 (645-715)
TN	$7.1006 + 0.9200\ln Q - 0.0323\sin(2\pi t) + 0.0668\cos(2\pi t) - 0.0202t$	0.11	3	0.91	1070 (1010-1120)
SRP	$3.2941 + 1.4089\ln Q - 0.0005t$	2.34	16	0.51	80 (55-115)
TP	$4.1033 + 1.4677\ln Q - 0.0004t$	1.97	12	0.71	200 (145-270)
TSS	$9.0858 + 1.8470\ln Q - 0.0164\sin(2\pi t) - 0.8137\cos(2\pi t)$	2.55	95	-5.50	117000 (64300-195000)
Cl	$8.4248 + 0.6477\ln Q - 0.0850\sin(2\pi t) + 0.0529\cos(2\pi t) - 0.0051t$	0.04	-1	0.88	3260 (3160-3370)
SO_4	$9.0167 + 0.8202\ln Q - 0.0184\ln Q^2 + 0.0108\sin(2\pi t) + 0.1682\cos(2\pi t)$	-0.45	-1	0.93	6160 (5980-6360)

The mean daily loads were summed into annual loads for each project year (Table 29), which varied between project years but generally followed the pattern in annual Q. The discrepancy in constituent loads between years, however, does reflect the use of log-transformation and re-transformation of values, and discharge exponents. For example, annual discharge volume was nearly equal between 2014 and 2016, but the nitrate-nitrogen (NO3-N) load was 27% less and the total suspended solids (TSS) load was 165% greater in 2016 compared to 2014. Annual loads were dependent on the flow regime, reflecting the importance of hydrology in understanding constituent loads.

Table 29. Summary of annual discharge volume (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Illinois River at Savoy, AR (Savoy; USGS 07194800) for project years 2009-2018 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2009	232,000,000	423,000	598,000	33,600	78,000	37,900,000	1,720,000	3,290,000
2010	261,000,000	305,000	570,000	71,400	182,000	154,000,000	1,330,000	2,640,000
2011	105,000,000	224,000	285,000	10,600	23,300	4,500,000	1,040,000	1,850,000
2012	95,000,000	175,000	236,000	10,200	22,700	8,200,000	859,000	1,510,000
2013	83,700,000	182,000	223,000	6,500	13,700	2,200,000	942,000	1,570,000
2014	174,000,000	265,000	398,000	22,500	51,000	27,900,000	1,290,000	2,480,000
2015	271,000,000	329,000	592,000	60,100	150,000	68,200,000	1,640,000	3,280,000
2016	182,000,000	194,000	365,000	41,000	102,000	74,000,000	1,040,000	2,050,000
2017	143,000,000	186,000	308,000	22,300	52,400	16,900,000	1,020,000	1,990,000
2018*	10,300,000	19,000	24,900	597	1,210	435,000	145,000	177,000

*Project Year 2018 included July 1-September 30, 2018.

Many of the constituents showed that flow-adjusted concentrations changed over time at Savoy (Table 30) when we look at monotonic trends both linearly (linear regression) and accounting for seasonality (Seasonal Kendall test).

- NO_3-N and TN concentrations were extremely likely decreasing during the study period
- TSS concentrations were likely increasing during the study period, when we look at linear trends
- Chloride was likely decreasing during the study period, when we look at linear trends
- Sulfate concentrations were extremely likely increasing during the study period, when seasonal influences are considered

The directional changes in the flow-adjusted concentrations as identified by the trend analysis were congruent with the equations used to estimate loads, so that loads were reflective of changes that occurred through time.

Table 30. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Illinois River at Savoy, AR (Savoy; USGS 07194800) from July 2009 through September 2018, with statistics showing the coefficient of determination (R^2) and p-value of the overall F-test (p-value) for linear regression analysis, and the p-value for the Seasonal Kendall analysis. Percent change per year (% Change/year) is reported for significant trends (p-value<0.05) and marginally significant trends (0.05≤p≤0.10).

	Linear Regression			Seasonal Kendall	
Constituent	p-value	R^2	% Change/year	p-value	% Change/year
NO_3-N	<0.01	0.08	-3.8	<0.01	-2.9
TN	<0.01	0.05	-2.1	<0.01	-1.7
SRP	0.38	<0.01	-	0.20	-
TP	0.45	<0.01	-	0.24	-
TSS	0.06*	0.01	3.1	0.28	-
Cl	0.08*	0.01	-0.8	0.93	-
SO_4	0.32	<0.01	-	0.01	1.0

*The trend was marginally significant (0.05≤p≤0.10).

OSAGE CREEK NEAR ELM SPRINGS, ARKANSAS (OSAGE)

Osage Creek (Osage) was sampled at the USGS stream gaging station near Elm Springs, Arkansas (USGS 07195000), where approximately 420 water samples were collected and analyzed for constituents from July 2009 through September 2018. The Osage Creek Watershed is 337 km2 in area, draining 12% forested lands, 51% pasture and grasslands, and 37% urban development. Osage Creek is a tributary to the Illinois River within the Illinois River Watershed. Osage Creek at this location was sampled downstream of the confluence with Spring Creek, and there are three wastewater facilities with effluent discharge that influence Osage including the City of Rogers, City of Springdale (via Spring Creek), as well as Northwest Arkansas Conservation Authority's regional waste water treatment plant.

The constituent concentrations were paired with mean daily discharge (Q) and then used in the software program LOADEST to estimate constituent loads. The regression models for constituent loads at this site were generally complex in the use of Q and time (t); the models also used coefficients to account for seasonal variations in the observed daily loads. The specific equations used in constituent load estimation and their respective regression statistics are presented in Table 31. The mean daily loads were variable across constituents, showing that nitrate-nitrogen (NO_3-N) made up almost 85% of the total nitrogen (TN) loads whereas soluble reactive phosphorus (SRP) loads were just 59% of the total phosphorus (TP) loads.

Table 31. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Osage Creek near Elm Springs, AR (Osage; USGS 07195000) July 2009 through September 2018, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	7.6328 + 0.6284lnQ + 0.0048sin(2πt) + 0.1516cos(2πt) - 0.0177t	1.01	-3	0.71	1260 (1210-1320)
TN	7.9521 + 0.7982lnQ + 0.0010sin(2πt) + 0.1370cos(2πt) - 0.0100t	0.00	-3	0.92	1500 (1460-1550)
SRP	4.2824 + 1.2964lnQ + 0.1074lnQ^2 - 0.1258sin(2πt) - 0.3379cos(2πt)	0.64	23	0.51	67 (54-83)
TP	5.0572 + 1.5112lnQ - 0.1235sin(2πt) - 0.2252cos(2πt)	1.32	-7	0.94	113 (91-139)
TSS	9.9079 + 2.5511lnQ - 0.0686lnQ^2 + 0.0850sin(2πt) - 0.4123cos(2πt)	2.94	252	-62	163000 (36600-475000)
Cl	9.4532 + 0.3897lnQ - 0.0311sin(2πt) + 0.0618cos(2πt)	0.16	-1	0.64	8930 (8690-9180)
SO_4	9.5935 + 0.4432lnQ + 0.0369lnQ^2 + 0.0236t	0.26	-1	0.78	10500 (10200-10800)

The mean daily loads were summed into annual loads for each project year (Table 32), which varied between project years but generally followed the pattern in annual Q. The discrepancy in constituent loads between years, however, does reflect the use of log-transformation and re-transformation of values, as well as discharge exponents. This influence was most profound in total suspended solids (TSS) loads, where the change in annual load was not necessarily proportional to the change in annual Q; TSS loads were highly variable, which is reflected in the regression statistics. Annual discharge volume was nearly equal between 2015 and 2016, as were most of the constituents, except for TSS loads which were almost 70% greater in 2016 compared to 2015. Annual loads were dependent on the flow regime, reflecting the importance of hydrology in understanding constituent loads.

Table 32. Summary of annual discharge volume (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Osage Creek near Elm Springs, AR (Osage; USGS 07195000) for project years 2009-2018 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2009	168,000,000	523,000	596,000	16,600	32,100	17,400,000	3,420,000	3,570,000
2010	226,000,000	504,000	641,000	61,500	94,600	231,000,000	3,200,000	3,630,000
2011	121,000,000	427,000	464,000	9,250	16,200	3,440,000	3,100,000	3,380,000
2012	125,000,000	396,000	444,000	13,500	24,300	28,600,000	2,930,000	3,340,000
2013	136,000,000	437,000	492,000	11,300	20,400	6,240,000	3,220,000	3,690,000
2014	163,000,000	470,000	553,000	14,400	28,000	13,300,000	3,380,000	3,990,000
2015	202,000,000	503,000	628,000	39,000	63,500	85,100,000	3,510,000	4,270,000
2016	200,000,000	458,000	583,000	42,200	65,400	143,000,000	3,310,000	4,210,000
2017	184,000,000	471,000	590,000	17,200	35,300	23,500,000	3,430,000	4,370,000
2018*	24,300,000	72,200	80,300	2,280	3,220	336,000	682,000	924,000

*Project Year 2018 included July 1-September 30, 2018.

All of the constituents except chloride showed that flow-adjusted concentrations changed over time at Osage (Table 33) when we look at monotonic trends both linearly (linear regression) and accounting for seasonality (Seasonal Kendall test).

- NO_3-N and TN concentrations were extremely likely decreasing throughout the study period
- SRP and TP concentrations were extremely likely or likely changing during the study period, depending on if seasonal influences are considered
- TSS concentrations were likely decreasing during the study period
- Sulfate concentrations were extremely likely increasing during the study period

The directional changes in flow-adjusted concentrations were congruent with the relationship with time in the load estimation equations.

Table 33. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Osage Creek near Elm Springs, AR (Osage; USGS 07195000) from July 2009 through September 2018, with statistics showing the coefficient of determination (R^2) and p-value of the overall F-test (p-value) for linear regression analysis, and the p-value for the Seasonal Kendall analysis. Percent change per year (% Change/year) is reported for significant trends (p-value<0.05) and marginally significant trends (0.05≤p≤0.10).

	Linear Regression			Seasonal Kendall	
Constituent	p-value	R^2	% Change/year	p-value	% Change/year
NO_3-N	0.01	0.02	-1.9	<0.01	-2.2
TN	0.01	0.02	-1.1	<0.01	-1.5
SRP	0.01	0.02	-1.9	<0.01	-1.8
TP	0.02	0.01	-1.9	0.05*	-1.3
TSS	0.07*	0.01	-3.2	0.06*	-2.4
Cl	0.42	<0.01	-	0.14	-
SO_4	<0.01	0.05	2.1	<0.01	2.5

*The trend was marginally significant (0.05≤p≤0.10).

BARON FORK AT DUTCH MILLS, ARKANSAS (BARON)

Baron Fork (Baron) was sampled at the USGS gaging station at Dutch Mills, Arkansas (USGS 07196900), where approximately 420 water samples were collected and analyzed for constituents from July 2009 through September 2018. The Baron watershed is 106 km2 in area, draining 46% forested lands, 50% pasture and grasslands, and 4% urban development. The Baron Fork is a large tributary to the Illinois River, where the confluence of the two streams is just upstream of Lake Tenkiller in Oklahoma. Baron is a unique site for the Illinois River Watershed since it has relatively little urban development in its catchment.

The constituent concentrations were paired with mean daily discharge and then used in the software program LOADEST to estimate constituent loads. The regression models for constituents at this site were generally complex, including mean daily discharge (Q), Q^2, time (t), and even t2; the regression models also included coefficients to account for seasonal variations in the observed daily loads. The various statistics and specific equations used in constituent load estimation are presented in Table 34. The mean daily loads were variable across constituents, showing that nitrate-nitrogen (NO_3-N) made up nearly 80% of the total nitrogen (TN) loads while soluble reactive phosphorus (SRP) made up less than 60% of the total phosphorus (TP) loads.

Table 34. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Baron Fork at Dutch Mills, AR (Baron; USGS 07196900) July 2009 through September 2018, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$4.1505 + 1.1037\ln Q - 0.0466\ln Q^2 + 0.0866\sin(2\pi t) + 0.7412\cos(2\pi t)$	2.35	30	0.63	205 (175-245)
TN	$4.1526 + 1.1259\ln Q - 0.0237\ln Q^2 + 0.0366\sin(2\pi t) + 0.5239\cos(2\pi t) + 0.0080t + 0.0187t^2$	1.51	22	0.65	260 (225-295)
SRP	$0.2661 + 1.3656\ln Q + 0.0055t$	2.14	12	0.50	13 (10-18)
TP	$0.9058 + 1.3560\ln Q - 0.1073\sin(2\pi t) - 0.3291\cos(2\pi t)$	1.99	-34	0.74	23 (18-30)
TSS	$5.1260 + 1.4822\ln Q - 0.1521\sin(2\pi t) - 0.7416\cos(2\pi t)$	3.32	-63	0.42	4600 (2040-9015)
Cl	$5.7420 + 0.8115\ln Q - 0.0248\ln Q^2 - 0.0657\sin(2\pi t) + 0.1456\cos(2\pi t) - 0.0065t$	-0.47	-4	0.85	440 (425-450)
SO_4	$6.6751 + 0.8895\ln Q - 0.0260\ln Q^2 + 0.0273\sin(2\pi t) + 0.2865\cos(2\pi t)$	-0.07	-2	0.90	1350 (1295-1400)

The mean daily loads were summed into annual loads for each project year (Table 35), which varied between project years but generally followed the pattern in annual Q. The discrepancy in constituent loads between years, however, does reflect the use of log-transformation and re-transformation of values, as well as discharge exponents. Annual discharge volumes were nearly equal in 2011 and 2016, but in 2016 total nitrogen (TN) loads were 20% less, total phosphorus loads were over twice as high, and total suspended solids (TSS) loads were over three times greater than respective loads in 2011. TSS loads were especially variable, which is reflected in the regression statistics. Annual loads were dependent on the flow regime, reflecting the importance of hydrology in understanding constituent loads at Baron.

BARON FORK AT DUTCH MILLS, ARKANSAS (BARON)

Table 35. Summary of annual discharge volume (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Baron Fork at Dutch Mills, AR (Baron; USGS 07196900) for project years 2009-2018 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2009	54,600,000	124,000	159,000	5,120	9,970	1,860,000	270,000	794,000
2010	52,000,000	80,600	113,000	8,900	15,700	3,380,000	175,000	545,000
2011	27,600,000	81,400	77,800	2,220	3,470	458,000	160,000	485,000
2012	21,900,000	51,000	49,200	1,780	3,010	474,000	116,000	353,000
2013	14,500,000	33,400	30,700	841	1,410	185,000	92,200	259,000
2014	45,100,000	83,300	91,000	4,790	9,270	1,930,000	191,000	589,000
2015	69,500,000	123,000	161,000	11,900	20,600	4,390,000	237,000	749,000
2016	27,000,000	35,800	60,400	4,360	7,530	1,570,000	84,900	269,000
2017	38,700,000	86,100	132,000	4,930	7,630	1,310,000	152,000	503,000
2018*	620,000	456	804	15	40	6,200	5,160	10,300

*Project Year 2018 included July 1-September 30, 2018.

Several of the constituents showed that flow-adjusted concentrations changed over time at Baron (Table 36) when we look at monotonic trends both linearly (linear regression) and accounting for seasonality (Seasonal Kendall test).

- NO_3-N and TN concentrations were likely increasing during the study period, when we look at linear trends
- TP concentrations were extremely likely decreasing during the study period
- TSS concentrations were extremely likely decreasing, when we look at seasonal influences
- Chloride concentrations were extremely likely decreasing during the study period

The directional changes in the flow-adjusted concentrations as identified by the trend analysis were congruent with the equations used to estimate loads, so that loads were reflective of changes that occurred through time.

Table 36. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Baron Fork at Dutch Mills, AR (Baron; USGS 07196900) from July 2009 through September 2018, with statistics showing the coefficient of determination (R^2) and p-value of the overall F-test (p-value) for linear regression analysis, and the p-value for the Seasonal Kendall analysis. Percent change per year (% Change/year) is reported for significant trends (p-value<0.05) and marginally significant trends (0.05≤p≤0.10).

	Linear Regression			Seasonal Kendall	
Constituent	p-value	R^2	% Change/year	p-value	% Change/year
NO_3-N	0.08*	0.01	3.2	0.13	-
TN	0.07*	0.01	1.8	0.11	-
SRP	0.52	<0.01	-	0.37	-
TP	0.02	0.01	-2.4	<0.01	-3.0
TSS	0.27	<0.01	-	0.03	-3.9
Cl	0.02	0.01	-0.9	0.04	-0.6
SO_4	0.50	<0.01	-	0.27	-

*The trend was marginally significant (0.05≤p≤0.10).

SPRING CREEK AT HWY 112 NEAR SPRINGDALE, ARKANSAS (SPRING)

Spring Creek (Spring) was sampled at the USGS stream gaging station near Springdale, Arkansas (USGS 07194933), where approximately 290 water samples were collected and analyzed for constituents from February 2012 through September 2018. The Spring Creek Watershed is 91.8 km2 in area, draining 12% forested lands, 42.5% pasture and grasslands, and 45% urban development. Spring Creek is a tributary to Osage Creek which later flows into the Illinois River. Spring has interesting potential water quality impacts due to relatively high urban land use within the catchment in addition to Springdale's waste water treatment plant which discharges effluent into Spring Creek upstream from this study site.

The constituent concentrations were paired with mean daily discharge (Q) and then used in the software program LOADEST to estimate constituent loads. The regression models for constituent loads at this site were generally complex and included mean daily discharge (Q) and time (t); the regression models also included coefficients to account for seasonal variations in the observed daily loads. Regression statistics and models used are reported in Table 37. The mean daily loads were variable across constituents, showing that nitrate-nitrogen (NO_3-N) loads made up over 80% of total nitrogen (TN) loads while soluble reactive phosphorus (SRP) loads made up 55% of total phosphorus (TP) loads.

Table 37. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Spring Creek at Hwy 112 near Springdale, AR (Spring; USGS 07194933) February 2012 through September 2018, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	6.4630 + 0.6151lnQ - 0.1429sin(2πt) - 0.0620cos(2πt)	0.75	-2	0.73	394 (376-412)
TN	6.8212 + 0.8030lnQ - 0.1193sin(2πt) - 0.0524cos(2πt) - 0.0151t	-0.18	-6	0.85	486 (471-5001)
SRP	3.7169 + 1.1073lnQ + 0.3540sin(2πt) - 0.0089cos(2πt) - 0.0819t	1.14	-16	0.88	21 (19-23)
TP	4.2129 + 1.3430lnQ + 0.3070sin(2πt) - 0.0181cos(2πt) - 0.0868t	1.38	-23	0.78	38 (32-46)
TSS	8.4531 + 2.4146lnQ + 0.2705sin(2πt) + 0.3194cos(2πt)	3.13	172	-27	61700 (8140-227000)
Cl	8.7559 + 0.3156lnQ - 0.0005sin(2πt) - 0.0652cos(2πt)	0.60	0	0.56	4860 (4670-5070)
SO_4	9.1253 + 0.3496lnQ + 0.0666sin(2πt) - 0.0664cos(2πt)	0.70	0	0.61	6840 (6550-7140)

The mean daily loads were summed into annual loads for each project year (Table 38), which varied between project years. This variation was not necessarily proportional to the changes in discharge, which is a result of log-log relationships and discharge exponents used in the regression models. For example, annual discharge volumes were similar in project years 2013 and 2014 yet the total suspended solids (TSS) load in 2013 was more than twice the load for 2014. Several annual load estimations were highly dependent on the flow regime for the project year. The annual loads in project year 2011 were not complete since data collection began in February 2012.

SPRING CREEK AT HWY 112 NEAR SPRINGDALE, ARKANSAS (SPRING)

Table 38. Summary of annual discharge volume (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Spring Creek at Hwy 112 near Springdale, AR (Spring; USGS 07194933) for project years 2011-2018 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2011*	17,300,000	56,100	67,300	2,190	3,350	270,000	678,000	904,000
2012	42,500,000	125,000	151,000	6,440	9,580	1,320,000	1,660,000	2,320,000
2013	53,200,000	142,000	176,000	8,480	14,300	5,770,000	1,790,000	2,520,000
2014	51,200,000	142,000	171,000	6,980	10,600	2,170,000	1,800,000	2,530,000
2015	78,400,000	169,000	222,000	11,100	25,400	55,900,000	1,930,000	2,750,000
2016	71,200,000	151,000	194,000	8,270	18,700	79,600,000	1,790,000	2,520,000
2017	54,100,000	142,000	167,000	5,640	9,190	4,810,000	1,760,000	2,480,000
2018*	11,900,000	29,900	34,200	1,550	2,120	304,000	433,000	642,000

*Data collection at Spring Creek began in February 2012; project year 2018 was from July 1-September 30, 2018.

Several of the constituents showed that flow-adjusted concentrations changed over time at Spring (Table 39) when we look at monotonic trends both linearly (linear regression) and accounting for seasonality (Seasonal Kendall test).

- NO_3-N and TN concentrations were extremely likely decreasing during the study period
- SRP and TP concentrations also were extremely likely decreasing during the study period
- TSS concentrations were extremely likely increasing when we look at seasonal influences
- Chloride concentrations also were extremely likely increasing when we look at seasonality

The directional changes in flow-adjusted concentrations were congruent with the relationship with time in the load estimation equations. These decreasing trends were likely from changes in the effluent discharge, where the City of Springdale's facility made changes to reduce nutrient inputs in Spring Creek.

Table 39. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Spring Creek at Hwy 112 near Springdale, AR (Spring; USGS 07194933) from February 2012 through September 2018, with statistics showing the coefficient of determination (R^2) and p-value of the overall F-test (p-value) for linear regression analysis, and the p-value for the Seasonal Kendall analysis. Percent change per year (% Change/year) is reported for significant trends (p-value<0.05) and marginally significant trends (0.05≤p≤0.10).

	Linear Regression			Seasonal Kendall	
Constituent	p-value	R^2	% Change/year	p-value	% Change/year
NO_3-N	0.02	0.02	-2.4	<0.01	-2.3
TN	0.01	0.03	-1.9	<0.01	-1.6
SRP	<0.01	0.04	-4.7	<0.01	-4.4
TP	<0.01	0.03	-4.4	<0.01	-4.4
TSS	0.16	0.01	-	0.03	5.2
Cl	0.26	<0.01	-	0.02	-1.7
SO_4	0.14	0.01	-	0.33	-

OSAGE CREEK AT HWY 112 NEAR CAVE SPRINGS, ARKANSAS (OC112)

Osage Creek (OC112) was sampled at the USGS stream gaging station near Cave Springs, Arkansas (USGS 07194880) where approximately 140 water samples were collected and analyzed for constituents from October 2015 through September 2018. The OC112 watershed is 89 km2 and drains predominantly urban land use (61.7%) with 31.2% pasture and 6.2% forest land cover in the watershed. Osage Creek at this site receives wastewater treatment plant effluent from the City of Rogers. Water quality monitoring for this project also took place at a site on Osage Creek downstream from this site (see Osage).

The constituent concentrations were paired with mean daily discharge (Q) and then used in the software program LOADEST to estimate constituent loads. The regression models for constituent loads at this site were generally complex in the use of Q and time (t); the models also used coefficients to account for seasonal variations in the observed daily loads. The specific equations used in constituent load estimation and their respective regression statistics are presented in Table 40. The mean daily loads were variable across constituents, showing that nitrate-nitrogen (NO_3-N) made up 78% of the total nitrogen (TN) loads and soluble reactive phosphorus (SRP) loads were 42% of the total phosphorus (TP) loads.

Table 40. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Osage Creek near Cave Springs, AR (OC112; USGS 07194880) October 2015 through September 2018, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$6.1903 + 0.4845\ln Q - 0.1354\sin(2\pi t) + 0.0611\cos(2\pi t) - 0.0827t$	0.67	-6	0.61	312 (292-332)
TN	$6.5750 + 0.6849\ln Q + 0.0157\ln Q^2 - 0.1162\sin(2\pi t) + 0.0475\cos(2\pi t)$	0.06	-6	0.86	399 (378-420)
SRP	$3.0774 + 1.2292\ln Q + 0.2041\sin(2\pi t) - 0.2276\cos(2\pi t)$	1.55	-11	0.96	13 (10-16)
TP	$3.7251 + 1.3977\ln Q + 0.1209\sin(2\pi t) - 0.1684\cos(2\pi t)$	1.64	-4	0.88	31 (21-42)
TSS	$8.4749 + 2.2534\ln Q - 0.0274\ln Q^2 + 0.1877t$	2.60	104	-5.70	23800 (4360-69100)
Cl	$8.1395 + 0.3647\ln Q + 0.0478\ln Q^2 - 0.0605\sin(2\pi t) - 0.0145\cos(2\pi t)$	0.29	-1	0.83	2600 (2470-2730)
SO_4	$8.2201 + 0.4566\ln Q + 0.0607\ln Q^2 - 0.0542\sin(2\pi t) - 0.0870\cos(2\pi t)$	0.47	-1	0.91	2670 (2520-2830)

The mean daily loads were summed into annual loads for each project year (Table 41), which varied between project years. This variation was not necessarily proportional to the changes in discharge, which is a result of log-log relationships and discharge exponents used in the regression models. For example, annual discharge volume in 2016 was 36% greater than discharge volume in 2017 yet the total suspended solids (TSS) load in 2016 was over three and a half times the load in 2017. Annual load estimations were related to discharge volume, suggesting the importance of hydrology in understanding constituent transport in Osage Creek at this site. TSS loads were highly variable, which is reflected in the regression statistics.

OSAGE CREEK AT HWY 112 NEAR CAVE SPRINGS, ARKANSAS (OC112)

Table 41. Summary of annual discharge volume (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Osage Creek near Cave Springs, AR (OC112; USGS 07194880) for project years 2015-2018 (e.g., project year 2011 is July 1, 2015 - June 30, 2016).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2015*	50,800,000	99,700	118,700	4,020	11,000	10,300,000	734,000	757,000
2016	72,600,000	120,000	157,000	6,000	14,390	12,288,000	977,000	1,014,000
2017	53,200,000	104,000	138,000	3,560	7,200	3,400,000	930,000	950,000
2018*	7,890,000	17,700	22,900	590	910	100,000	204,000	209,000

*Project Year 2015 began in October rather than July 2015, and Project Year 2018 was from July 1-September 30, 2018.

Only two of the constituents showed that flow-adjusted concentrations changed over time at OC112 (Table 42) when we look at monotonic trends both linearly (linear regression) and accounting for seasonality (Seasonal Kendall test).

- NO_3-N concentrations extremely likely decreased by almost 10% during the study period, when we look at both linear trends and when we account for seasonal influences
- TSS concentrations likely increased by approximately 15% when we look at linear trends throughout the study period

The directional changes in the flow-adjusted concentrations as identified by the trend analysis were congruent with the equations used to estimate loads, so that loads were reflective of changes that occurred through time.

Table 42. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Osage Creek near Cave Springs, AR (OC112; USGS 07194880) from October 2015 through September 2018, with statistics showing the coefficient of determination (R^2) and p-value of the overall F-test (p-value) for linear regression analysis, and the p-value for the Seasonal Kendall analysis. Percent change per year (% Change/year) is reported for significant trends (p-value<0.05) and marginally significant trends (0.05≤p≤0.10).

	Linear Regression			Seasonal Kendall	
Constituent	p-value	R^2	% Change/year	p-value	% Change/year
NO_3-N	<0.01	0.07	-9.3	<0.01	-8.1
TN	0.52	<0.01	-	0.88	-
SRP	0.64	<0.01	-	0.65	-
TP	0.54	<0.01	-	0.38	-
TSS	0.05*	0.03	15.5	0.31	-
Cl	0.20	0.01	-	0.51	-
SO_4	0.67	<0.01	-	1.00	-

*The trend was marginally significant (0.05≤p≤0.10).

MUD CREEK ON GREGG AVENUE NEAR JOHNSON, ARKANSAS (MUD)

Mud Creek (Mud) was sampled at the USGS stream gaging station on Gregg Avenue near Johnson, Arkansas (USGS 07194809), where 140 water samples were collected and analyzed for constituents from October 2015 through September 2018. The Mud watershed is 43 km2 in area, draining a largely urban watershed (62%), with 20% pasture and 17% forest land cover. Mud Creek flows into Clear Creek, a tributary to the Illinois River.

The constituent concentrations were paired with mean daily discharge (Q) and then used in the software program LOADEST to estimate constituent loads. The regression models for constituent loads at this site were similar in the use of Q and time (t), reflecting similar hydrological relationships, seasonal effects, and trends in loads. Regression statistics and models used are reported in Table 43. The mean daily loads were variable across constituents, showing that nitrate-nitrogen (NO_3-N) made up 41% of total nitrogen (TN) loads whereas soluble reactive phosphorus (SRP) loads were 21% greater than total phosphorus (TP) loads.

Table 43. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Mud Creek near Johnson, AR (Mud; USGS 07194809) October 2015 through September 2018, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$3.5478 + 0.9939\ln Q + 0.2054\sin(2\pi t) + 0.2821\cos(2\pi t)$	1.36	4	0.70	36 (29-44)
TN	$4.3436 + 1.1428\ln Q - 0.0102\ln Q^2 + 0.2559\sin(2\pi t) + 0.1411\cos(2\pi t)$	0.96	1	0.97	88 (71-107)
SRP	$0.5564 + 1.4456\ln Q + 0.4661\sin(2\pi t) - 0.5118\cos(2\pi t)$	1.53	25	0.50	4 (3-5)
TP	$1.6876 + 1.5422\ln Q + 0.2616\sin(2\pi t) - 0.4558\cos(2\pi t)$	2.42	70	-0.58	19 (9-37)
TSS	$6.9822 + 1.9467\ln Q + 0.5619\sin(2\pi t) - 0.2238\cos(2\pi t)$	2.75	104	-0.97	19700 (4850-54800)
Cl	$6.5084 + 0.7061\ln Q - 0.0136\ln Q^2 - 0.2704\sin(2\pi t) + 0.1848\cos(2\pi t)$	-0.07	-6	0.90	426 (401-451)
SO_4	$7.3719 + 0.7327\ln Q - 0.1883\sin(2\pi t) + 0.1538\cos(2\pi t)$	0.25	-2	0.91	1070 (996-1160)

The mean daily loads were summed into annual loads (Table 44), which varied between project years. Constituent loads generally followed the pattern in discharge, although this relationship was not necessarily proportional to the changes in discharge, which is a result of log-log relationships and discharge exponents used in the regression models. For example, discharge volume in 2016 was almost twice as high as it was in 2017, yet SRP and TP were over three times higher and TSS was over seven times higher in 2016 compared to 2017. Annual loads were likely dependent upon how discharge and other factors varied within project years, reflecting the importance of inter-annual variability in hydrology when estimating constituent loads.

MUD CREEK ON GREGG AVENUE NEAR JOHNSON, ARKANSAS (MUD)

Table 44. Summary of annual discharge volume (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Mud Creek near Johnson, AR (Mud; USGS 07194809) for project years 2015-2018 (e.g., project year 2016 is July 1, 2016 - June 30, 2017).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2015*	23,200,000	8,870	22,000	1,190	7,110	5,090,000	137,000	338,000
2016	34,400,000	18,700	47,300	2,040	9,920	14,000,000	170,000	441,000
2017	19,500,000	9,370	21,200	631	2,920	1,830,000	133,000	326,000
2018*	3,180,000	1,340	3,460	185	630	241,000	16,400	43,900

*Project Year 2015 began in October rather than July 2015, and Project Year 2018 was from July 1-September 30, 2018.

Some of the constituents showed that flow-adjusted concentrations changed over time at Mud (Table 45) when we look at monotonic trends both linearly (linear regression) and accounting for seasonality (Seasonal Kendall test).

- TN concentrations were likely decreasing when we look at linear trends throughout the study
- TP concentrations were extremely likely decreasing by over 25% when we look at both linear trends and when we account for seasonal influences
- Chloride concentrations were likely decreasing when we look at linear trends
- Sulfate concentrations were extremely likely increasing during the study period when we consider seasonal influences

The directional changes in the flow-adjusted concentrations as identified by the trend analysis were congruent with the equations used to estimate loads, so that loads were reflective of changes that occurred through time.

Table 45. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Mud Creek (Mud; USGS 07194809) from October 2015 through September 2018, with statistics showing the coefficient of determination (R^2) and p-value of the overall F-test (p-value) for linear regression analysis, and the p-value for the Seasonal Kendall analysis. Percent change per year (% Change/year) is reported for significant trends (p-value<0.05) and marginally significant trends (0.05≤p≤0.10).

	Linear Regression			Seasonal Kendall	
Constituent	p-value	R^2	% Change/year	p-value	% Change/year
NO_3-N	0.16	0.02	-	0.49	-
TN	0.05*	0.03	7.6	0.79	-
SRP	0.88	<0.01	-	0.22	-
TP	<0.01	0.09	-27.1	<0.01	-25.9
TSS	0.50	<0.01	-	0.98	-
Cl	0.09*	0.02	-5.0	0.82	-
SO_4	0.70	<0.01	-	0.02	4.4

*The trend was marginally significant (0.05≤p≤0.10).

SAGER CREEK AT SILOAM SPRINGS, ARKANSAS (SAGER)

Sager Creek at Siloam Springs, Arkansas (Sager) was sampled from the bridge access behind (but upstream from) the City of Siloam Springs wastewater treatment plant, where approximately 315 water samples were collected and analyzed for constituents from July 2011 through September 2018. The Sager Creek Watershed is 35 km2 in area, draining 4% forested lands, 58% pasture and grasslands, and 38% urban development. Sager Creek is a tributary to Flint Creek, which is major tributary to the Illinois River in the Illinois River Watershed. Sager represents a unique site due to a relatively large urban influence, in which the City of Siloam Springs has taken significant measures to improve the quality of the stream.

The constituent concentrations were paired with mean daily discharge (Q) and then used in the software program LOADEST to estimate constituent loads. The regression models for constituent loads at this site were similar in their use of Q and time (t), reflecting similar hydrological relationships, seasonal effects, and trends in loads. Regression statistics and models used are reported in Table 46. The mean daily loads were variable across constituents, showing that, on average, nitrate-nitrogen (NO_3-N) loads made up 60% of total nitrogen (TN) loads while soluble reactive phosphorus (SRP) loads also made up 60% of total phosphorus (TP) loads.

Table 46. Regression models used for load estimations of nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Sager Creek at Siloam Springs, AR (Sager; not gaged by USGS) July 2011 through September 2018, with respective Akaike Information Criterion (AIC), load bias percentages (BP), Nash-Sutcliffe Efficiency index (E), and mean daily load for the estimation period with lower and upper values of the 95% confidence intervals (CI) in parentheses.

Constituent	Regression equation	AIC	BP (%)	E	Mean Daily Load (kg/d)
NO_3-N	$4.6885 + 0.7764\ln Q - 0.0610\ln Q^2 - 0.0697\sin(2\pi t) + 0.1512\cos(2\pi t)$	0.73	-4	0.67	51 (48-54)
TN	$4.8976 + 0.9530\ln Q - 0.0216\sin(2\pi t) + 0.1322\cos(2\pi t)$	0.03	9	0.90	84 (78-89)
SRP	$1.5442 + 1.4825\ln Q + 0.2422\sin(2\pi t) - 0.6258\cos(2\pi t)$	1.93	1	0.76	9 (6-12)
TP	$2.0495 + 1.5072\ln Q + 0.2589\sin(2\pi t) - 0.4735\cos(2\pi t)$	1.67	15	0.57	15 (11-20)
TSS	$5.7645 + 1.7839\ln Q + 0.3357\sin(2\pi t) - 0.1601\cos(2\pi t)$	2.58	9	-0.53	1940 (885-3720)
Cl	$6.2348 + 0.8007\ln Q - 0.1533\sin(2\pi t) + 0.0940\cos(2\pi t)$	1.33	4	0.45	311 (282-341)
SO_4	$6.4127 + 0.8859\ln Q - 0.1925\sin(2\pi t) + 0.1044\cos(2\pi t)$	5.15	4	0.79	367 (340-394)

The mean daily loads were summed into annual loads for each project year (Table 47), which varied between project years. This variation was not necessarily proportional to the changes in discharge, which is a result of log-log relationships used in the regression models. For example, annual discharge volume in 2014 was nearly 50% greater than discharge volume in 2012 yet the total suspended solids (TSS) load in 2012 was still greater than the load for 2014. Several annual load estimations were highly dependent on the flow regime for the project year, reflecting the importance of hydrology in understanding constituent transport in Sager Creek.

Table 47. Summary of annual discharge volume (Q, m^3) and annual loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total P (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Sager Creek at Siloam Springs, AR (Sager; not gaged by USGS) for project years 2011-2018 (e.g., project year 2011 is July 1, 2011 - June 30, 2012).

Project Year	Annual Q (m^3)	NO_3-N (kg)	TN (kg)	SRP (kg)	TP (kg)	TSS (kg)	Cl (kg)	SO_4 (kg)
2011	5,480,000	9,170	11,800	503	805	56,500	55,500	59,900
2012	11,100,000	15,900	22,800	1,550	2,700	272,000	90,100	100,000
2013	11,300,000	17,600	22,600	2,010	3,040	221,000	98,600	108,000
2014	15,700,000	21,700	31,500	2,810	4,670	444,000	123,000	140,000
2015	27,200,000	26,600	52,600	6,840	11,900	1,610,000	183,000	237,000
2016	22,300,000	22,300	43,300	6,310	11,600	1,770,000	140,000	169,000
2017	15,200,000	17,600	31,500	2,500	4,740	684,000	111,000	133,000
2018*	1,490,000	2,150	2,770	248	350	17,000	12,900	13,200

*Project Year 2018 included July 1-September 30, 2018.

Many of the constituents showed that flow-adjusted concentrations changed over time at Sager (Table 48) when we look at monotonic trends both linearly (linear regression) and accounting for seasonality (Seasonal Kendall test).

- NO_3-N concentrations were extremely likely decreasing during the study period when we seasonal influences are considered
- TN concentrations were extremely likely decreasing when we look at linear trends as well as when we account for seasonality
- TSS concentrations were extremely likely decreasing when we look at linear trends through time
- Chloride concentrations were likely decreasing when we account for seasonal influences
- Sulfate concentrations were extremely likely decreasing throughout the study period

The directional changes in flow-adjusted concentrations were congruent with the relationship with time in the load estimation equations.

Table 48. Trends in flow-adjusted concentrations of nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for Sager Creek at Siloam Springs, AR (Sager; not gauged by USGS) from July 2011 through September 2018, with statistics showing the coefficient of determination (R^2) and p-value of the overall F-test (p-value) for linear regression analysis, and the p-value for the Seasonal Kendall analysis. Percent change per year (% Change/year) is reported for significant trends (p-value<0.05) and marginally significant trends (0.05≤p≤0.10).

	Linear Regression			Seasonal Kendall	
Constituent	p-value	R^2	% Change/year	p-value	% Change/year
NO_3-N	0.11	0.01	-	0.03	-1.4
TN	0.03	0.02	-1.5	0.01	-1.7
SRP	0.25	<0.01	-	0.20	-
TP	0.77	<0.01	-	0.40	-
TSS	0.03	0.02	-5.0	0.18	-
Cl	0.15	0.01	-	0.05*	-1.6
SO_4	<0.01	0.03	-2.7	<0.01	-2.6

*The trend was marginally significant (0.05≤p≤0.10).

SUMMARY AND CONSIDERATIONS

Water samples were successfully collected at all the sites included in this project focused on water-quality in the UIRW and UWRB. The complexities of sampling 15 sites across two HUC 8 watersheds surfaced when storm events needed to be sampled. For example, the two small urban streams (TB and Mud) were very flashy streams responding to episodic rainfall events in a matter of hours; the field services unit had to be flexible to sample these sites outside of normal business hours. The remaining sites had a little bit longer lag time before the runoff hydrograph peaked during storm events, but these sites had highly variable times to peak. The lag time to peak was dependent upon many hydrologic and meteorological factors, such as antecedent moisture conditions, rainfall intensity and duration, and even the direction the weather front moved into the watersheds. Despite these complexities, the streams were sampled across the range of discharge observed during the project period – this is one of the most important aspects of this study.

The water samples were delivered to the AWRC WQL and analyzed following standard methods and the approved QAPP. The concentration data from the WQL was paired with mean daily discharge and then used to develop regression models to estimate daily constituent loads based on discharge and time. The regression models used to estimate constituent loads varied in complexity, ranging from a simple log-log regression between load and discharge to models that included multiple discharge factors, seasonal coefficients, and trends over time. The regression statistics (AIC, BP, and E) were generally very good across all constituents, except TSS which always showed high variability, so TSS loads should be considered with this in mind. The loads across all the sites followed the general patterns typical of watersheds, such as:

- Annual loads generally increased with increasing annual discharge within and across sites.
- Annual loads increased with increasing watershed area.

The unit area loads (loads divided by watershed area) did not necessarily follow the decreasing pattern often seen with watershed area, likely because these watersheds had land uses across the spectrum – that is, the watersheds varied from highly urbanized to forested to pasture and grassland. The watersheds also varied in topography, underlying geologic influence, and soils. The loading data from these sites will be useful in the calibration and validation of future watershed modeling efforts.

The most important use of the concentration and discharge data was estimating trends, based on the three step process: (1) log-transform data, (2) plot LOESS line, and (3) evaluate residuals or flow-adjusted concentrations over time. The constituent trends observed were variable across these sites, but some commonalities did appear across these sites. The intent of this part of the project was to understand how constituent concentrations are changing over time and whether these changes were from changes in watershed management, such as reduced nutrient inputs from effluent discharges, state regulations, or even the implementation of best management practices and educational programs by the ANRC 319 NPS Management Program. The following bullets highlight potential changes in water quality from watershed activities or that have potentially important implications in these HUC 8 watersheds.

- The influence of municipal effluent discharges on stream water chemistry are profound (Haggard et al., 2001, 2005) and these effects are often measureable for many river km downstream, e.g. the City of Springdale's municipal facility (Haggard, 2010). The effluent discharge from Springdale's facility made some changes during the period of record for this dataset (January 2012 to June 2015) which have resulted in decreasing trends in Spring Creek for NO_3-N, TN, SRP, and TP concentrations. Spring Creek also was listed as impaired due to TP concentrations, but has been removed from the State's 303(d) list (ADEQ, 2018). These changes in TP can be seen in our trends analysis. The positive impact that changes in effluent discharge had on Spring Creek are also seen further downstream in Osage Creek, where nutrients also decreased during the period of record.
- Osage Creek (at OC112) is located downstream from the Rogers WWTP, and NO_3-N

decreased during this period of record. TN, SRP, and TP showed no statistically significant changes during this study.

- Osage Creek (Osage) further downstream receives discharge from the NACA WWTP, the Rogers WWTP, and the Springdale WWTP by way of Spring Creek. Osage showed decreasing trends in NO_3-N, TN, SRP, and TP concentrations during the period of record. These improvements in water quality also resulted in the removal of Osage Creek from the State's 303(d) list, for which it was impaired due to TP concentrations.
- All three sites on the Illinois River (Savoy, IR59, and Watts) showed decreasing trends or no change in nutrient concentrations, especially when seasonal influences were considered. The decreases in nutrient concentrations are likely driven by improvements in point source discharges, and potentially by other water-quality improvement activities addressing non-point sources in these watersheds.
- Beaver Lake did not meet its recent numeric criteria for chlorophyll-a and Secchi transparency depth according to the draft 2018 303(d) list (ADEQ, 2018). Algae, measured as chlorophyll-a concentrations, have been increasing in Beaver Lake (Scott and Haggard, 2015). The reason for these increases might be tied to changes in watershed inputs, climate, or even lake management (i.e., changes in lake levels and releases). However, Beaver Lake is listed as a Category 4b, meaning a TMDL does not need to be created since there are alternative management activities in place that are expected to result in attainment of the water quality standard. In fact, the trends in nutrients in two of the major tributaries to Beaver Lake (White River and War Eagle Creek) appear to be leveling off or decreasing, especially in the case of NO_3-N.
- Richland Creek, the other major tributary to Beaver Lake, is interesting in that data show a large increasing trend for NO_3-N and TN (approximately 10% per year), but a very large decreasing trend in TP (approximately 20% per year). The trends in flow-adjusted nutrient concentrations in Richland Creek also highlight the importance of long-term monitoring data to identify changes in water quality. For example, when analyzing data between 2009 and 2014 (at a sampling location further downstream), trends showed increasing nitrogen and phosphorus (see Scott et al., 2015). However, upon a closer inspection of that data, there appeared to be a shift toward decreasing flow-adjusted concentrations toward the end of that sampling period. Thus, it is critically important to keep collecting these data to understand how inputs into the drinking water supply, i.e. Beaver Lake, are changing over time.
- Changes in water quality resulting from watershed improvements are generally difficult to see at the large watershed scale, but may be visible at smaller scales. Our study site on Sager Creek is a likely example of visible improvements in water quality due to the implementation of best management practices and restoration activities, as it is situated upstream from the Siloam Springs WWTP. Sager has been listed as impaired due to NO_3-N, but is no longer on the 303(d) list (ADEQ, 2018). In fact, our data show that Sager has seen decreasing trends in NO_3-N, TN, TSS, and even chloride and sulfate during this period of record. The removal of small dams, channel restoration just upstream of the sampling site, as well as channel and wetland restoration further upstream have likely had positive impacts on water quality at this site. These projects were funded by the ANRC 319 NPS Management Program and the City of Siloam Springs, and this would be a water-quality success story which would not have been recorded without data post-watershed activities.

The data collected in this project are critical to understanding nutrient sources within these two watersheds, as well as how water-quality (i.e., flow-adjusted concentration of various constituents) is changing over time. The ability to detect trends in water quality requires a commitment to long-term monitoring, and the ANRC 319 NPS Management Program has been funding these efforts for decades.

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Appendix 1. Summary of monthly discharge volume (Q, m^3) and monthly loads (kg) for nitrate-N (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), chloride (Cl), and sulfate (SO_4) for each project site.

KINGS RIVER NEAR BERRYVILLE, ARKANSAS (KINGS)

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
July	**2011**	2,730,000	419	1,090	32	90	11,000	27,800	29,000
Aug.	**2011**	5,120,000	2,030	3,070	132	343	52,100	41,800	45,500
Sep.	**2011**	5,600,000	3,580	4,270	186	431	59,400	46,200	50,800
Oct.	**2011**	5,080,000	2,640	3,590	120	254	25,800	50,700	54,300
Nov.	**2011**	61,900,000	131,000	119,000	3,830	9,720	2,270,000	269,000	418,000
Dec.	**2011**	66,100,000	168,000	131,000	2,230	5,740	1,070,000	303,000	472,000
Jan.	**2012**	57,300,000	127,000	125,000	1,450	4,510	1,180,000	237,000	404,000
Feb.	**2012**	49,000,000	114,000	91,500	699	2,160	413,000	214,000	349,000
Mar.	**2012**	149,000,000	214,000	302,000	3,680	14,800	6,110,000	440,000	880,000
Apr.	**2012**	17,900,000	18,800	19,500	144	504	89,700	90,000	131,000
May	**2012**	4,210,000	1,250	2,330	24	80	10,500	34,200	41,000
June	**2012**	1,390,000	98	407	8	24	2,390	17,900	18,400
July	**2012**	573,000	11	98	4	9	711	12,000	10,700
Aug.	**2012**	572,000	17	110	6	13	897	12,700	11,000
Sep.	**2012**	1,790,000	242	663	31	67	5,840	24,900	24,000
Oct.	**2012**	3,780,000	1,810	2,470	87	185	18,700	40,200	42,700
Nov.	**2012**	1,780,000	313	817	19	36	2,160	28,300	28,100
Dec.	**2012**	3,180,000	1,250	2,110	27	57	3,790	39,800	43,800
Jan.	**2013**	22,400,000	42,400	41,400	445	1,370	317,000	111,000	174,000
Feb.	**2013**	35,900,000	70,200	57,400	415	1,290	223,000	166,000	264,000
Mar.	**2013**	48,400,000	80,300	73,700	555	1,940	419,000	195,000	324,000
Apr.	**2013**	79,100,000	101,000	113,000	1,330	5,250	1,670,000	258,000	455,000
May	**2013**	84,200,000	88,200	108,000	1,810	7,180	2,480,000	262,000	456,000
June	**2013**	24,800,000	19,300	24,500	563	2,110	664,000	97,000	146,000
July	**2013**	2,840,000	444	1,070	41	111	14,400	27,400	29,500
Aug.	**2013**	59,900,000	50,300	66,100	4,710	14,700	5,290,000	209,000	324,000
Sep.	**2013**	3,030,000	544	1,260	61	135	13,100	33,600	34,700
Oct.	**2013**	8,010,000	5,610	6,360	272	618	88,100	62,800	73,600
Nov.	**2013**	15,000,000	18,700	16,600	402	906	114,000	101,000	130,000
Dec.	**2013**	71,700,000	145,000	137,000	2,810	7,670	1,790,000	295,000	501,000
Jan.	**2014**	41,700,000	85,300	68,300	752	2,070	346,000	200,000	316,000
Feb.	**2014**	11,700,000	12,300	12,200	80	226	25,300	76,300	107,000
Mar.	**2014**	87,400,000	129,000	145,000	1,500	5,650	1,750,000	289,000	538,000
Apr.	**2014**	84,900,000	106,000	122,000	1,400	5,470	1,700,000	270,000	493,000
May	**2014**	26,900,000	20,200	24,000	347	1,270	295,000	112,000	171,000
June	**2014**	44,500,000	32,800	42,600	1,240	4,600	1,520,000	154,000	246,000
July	**2014**	7,580,000	2,280	3,870	138	413	70,200	49,400	60,200

KINGS RIVER NEAR BERRYVILLE, ARKANSAS (KINGS) Continued

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
Aug.	**2014**	3,410,000	533	1,270	64	159	18,800	32,800	35,300
Sep.	**2014**	2,210,000	266	756	40	86	7,600	27,600	27,900
Oct.	**2014**	30,900,000	37,100	37,900	2,190	5,470	1,280,000	144,000	209,000
Nov.	**2014**	8,690,000	6,390	7,070	187	402	41,100	70,400	86,100
Dec.	**2014**	23,700,000	37,300	30,600	479	1,160	154,000	137,000	198,000
Jan.	**2015**	34,000,000	60,600	52,600	718	1,970	367,000	165,000	262,000
Feb.	**2015**	14,100,000	16,800	15,900	115	348	49,500	81,500	121,000
Mar.	**2015**	164,000,000	232,000	272,000	3,130	11,900	3,780,000	486,000	969,000
Apr.	**2015**	45,100,000	48,000	50,300	514	1,890	428,000	169,000	283,000
May	**2015**	174,000,000	128,000	216,000	6,140	25,800	12,300,000	440,000	877,000
June	**2015**	134,000,000	82,000	148,000	7,200	28,900	15,000,000	348,000	660,000
July	**2015**	87,200,000	53,600	87,300	5,520	20,100	9,200,000	256,000	443,000
Aug.	**2015**	5,630,000	1,300	2,450	132	336	45,900	43,900	50,600
Sep.	**2015**	8,020,000	4,350	5,440	346	870	166,000	53,700	65,400
Oct.	**2015**	2,250,000	310	826	35	70	5,120	30,100	31,100
Nov.	**2015**	49,000,000	75,600	75,000	2,720	6,920	1,550,000	206,000	338,000
Dec.	**2015**	242,000,000	239,000	471,000	19,200	59,700	24,800,000	742,000	1,640,000
Jan.	**2016**	56,200,000	103,000	86,100	1,190	3,270	572,000	245,000	411,000
Feb.	**2016**	12,100,000	10,900	11,300	84	241	28,100	76,000	110,000
Mar.	**2016**	85,700,000	113,000	126,000	1,370	4,990	1,380,000	283,000	535,000
Apr.	**2016**	26,200,000	21,900	24,900	273	1,000	230,000	110,000	177,000
May	**2016**	38,900,000	28,000	35,900	670	2,560	759,000	138,000	230,000
June	**2016**	10,100,000	3,690	5,610	135	458	89,900	53,800	73,400
July	**2016**	13,200,000	5,000	7,450	341	1,060	234,000	67,900	91,000
Aug.	**2016**	11,800,000	4,400	6,410	382	1,030	186,000	68,200	87,100
Sep.	**2016**	11,400,000	6,180	7,990	579	1,490	336,000	67,100	86,500
Oct.	**2016**	11,400,000	7,840	8,680	439	1,010	153,000	75,500	96,700
Nov.	**2016**	3,330,000	824	1,590	46	92	6,730	38,200	43,100
Dec.	**2016**	4,610,000	2,090	2,920	45	99	7,630	46,200	56,400
Jan.	**2017**	14,200,000	15,700	14,500	147	390	46,500	88,000	129,000
Feb.	**2017**	11,200,000	9,220	9,860	77	224	26,600	69,500	102,000
Mar.	**2017**	85,500,000	91,700	116,000	1,510	5,820	1,870,000	264,000	518,000
Apr.	**2017**	316,000,000	158,000	416,000	13,600	61,700	39,300,000	705,000	1,700,000
May	**2017**	148,000,000	102,000	165,000	4,230	17,600	7,570,000	382,000	768,000
June	**2017**	23,900,000	12,200	17,500	539	2,000	619,000	91,500	144,000
July	**2017**	14,600,000	6,210	9,010	435	1,440	391,000	67,000	94,900
Aug.	**2017**	18,900,000	9,950	13,800	1,160	3,400	1,010,000	84,200	121,000
Sep.	**2017**	2,240,000	220	648	41	91	8,520	26,300	28,000
Oct.	**2017**	2,110,000	254	689	32	64	4,600	28,100	29,800

KINGS RIVER NEAR BERRYVILLE, ARKANSAS (KINGS) Continued

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
Nov.	**2017**	2,450,000	407	963	29	58	3,790	31,500	34,900
Dec.	**2017**	3,970,000	1,550	2,290	37	80	6,050	41,300	50,400
Jan.	**2018**	15,000,000	17,800	16,700	200	562	88,800	83,900	129,000
Feb.	**2018**	120,000,000	122,000	194,000	3,310	12,100	4,240,000	335,000	742,000
Mar.	**2018**	137,000,000	118,000	190,000	3,350	13,500	5,560,000	373,000	808,000
Apr.	**2018**	64,100,000	55,300	66,400	931	3,560	983,000	205,000	381,000
May	**2018**	90,600,000	53,400	92,900	2,480	10,400	4,710,000	246,000	489,000
June	**2018**	6,000,000	1,250	2,410	63	207	33,900	37,900	50,100
July	**2018**	2,840,000	240	741	36	99	12,200	25,900	29,900
Aug.	**2018**	11,800,000	4,580	6,450	480	1,310	274,000	63,600	85,000
Sep.	**2018**	3,250,000	440	1,050	69	152	14,900	32,500	36,500

WHITE RIVER NEAR FAYETTEVILLE, ARKANSAS (WYMAN)

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
July	**2009**	2,010,000	463	870	10	93	44,400	7,420	30,300
Aug.	**2009**	5,650,000	1,590	3,000	47	436	235,000	18,900	81,800
Sep.	**2009**	57,300,000	26,100	54,200	1,870	20,400	8,010,000	144,000	616,000
Oct.	**2009**	160,000,000	93,300	190,000	7,840	84,900	25,800,000	381,000	1,550,000
Nov.	**2009**	38,200,000	21,100	29,500	467	3,420	1,430,000	139,000	539,000
Dec.	**2009**	35,000,000	23,800	28,900	410	2,780	1,020,000	135,000	467,000
Jan.	**2010**	44,400,000	30,900	34,300	401	2,600	1,000,000	175,000	565,000
Feb.	**2010**	65,100,000	45,600	51,300	630	4,330	1,710,000	236,000	734,000
Mar.	**2010**	69,200,000	41,500	52,800	752	6,160	2,660,000	218,000	676,000
Apr.	**2010**	37,900,000	18,200	23,500	277	2,250	1,120,000	126,000	406,000
May	**2010**	107,000,000	46,900	83,700	1,870	20,800	9,990,000	252,000	880,000
June	**2010**	9,090,000	2,520	4,270	50	469	263,000	30,300	116,000
July	**2010**	26,000,000	8,570	18,500	483	5,770	3,110,000	62,300	258,000
Aug.	**2010**	427,000	74	175	2	16	4,570	1,810	7,740
Sep.	**2010**	22,400,000	8,200	16,200	361	3,550	1,800,000	64,000	281,000
Oct.	**2010**	1,920,000	574	992	11	73	21,800	9,010	37,600
Nov.	**2010**	6,120,000	3,030	4,150	50	327	123,000	26,300	100,000
Dec.	**2010**	7,260,000	3,660	4,590	45	274	96,000	34,400	124,000
Jan.	**2011**	9,790,000	5,440	6,250	57	342	122,000	46,200	154,000
Feb.	**2011**	43,700,000	27,400	32,100	363	2,520	1,020,000	162,000	509,000
Mar.	**2011**	41,500,000	22,500	27,100	281	2,030	902,000	152,000	478,000
Apr.	**2011**	295,000,000	165,000	342,000	12,200	151,000	43,900,000	575,000	1,870,000
May	**2011**	222,000,000	99,000	200,000	5,660	68,500	28,100,000	462,000	1,620,000
June	**2011**	10,700,000	2,980	5,280	66	632	360,000	33,800	129,000
July	**2011**	322,000	49	122	1	11	2,480	1,370	5,570
Aug.	**2011**	1,530,000	346	738	10	93	44,300	5,440	24,000
Sep.	**2011**	813,000	204	414	5	41	15,400	3,330	14,700
Oct.	**2011**	753,000	203	385	4	27	7,360	3,640	15,200
Nov.	**2011**	55,500,000	32,400	54,600	1,250	10,400	3,690,000	168,000	653,000
Dec.	**2011**	64,600,000	40,600	57,000	919	6,620	2,390,000	225,000	814,000
Jan.	**2012**	52,100,000	35,300	46,200	689	4,990	1,720,000	182,000	597,000
Feb.	**2012**	46,400,000	28,500	35,000	410	2,840	1,090,000	172,000	549,000
Mar.	**2012**	119,000,000	70,900	110,000	2,120	19,500	6,950,000	320,000	1,010,000
Apr.	**2012**	14,600,000	5,610	7,750	72	554	262,000	54,300	180,000
May	**2012**	1,490,000	359	608	5	38	14,000	6,250	22,000
June	**2012**	601,000	118	239	2	19	7,380	2,370	9,060
July	**2012**	203,000	32	80	1	7	2,180	817	3,400
Aug.	**2012**	508,000	109	249	3	30	13,200	1,860	8,330
Sep.	**2012**	194,000	35	89	1	8	2,150	847	3,750

WHITE RIVER NEAR FAYETTEVILLE, ARKANSAS (WYMAN) Continued

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
Oct.	**2012**	1,390,000	381	730	8	56	17,100	6,330	27,000
Nov.	**2012**	590,000	157	297	2	15	2,720	3,260	12,900
Dec.	**2012**	1,140,000	406	607	5	26	5,870	6,390	23,100
Jan.	**2013**	24,000,000	15,300	21,400	334	2,520	827,000	83,900	278,000
Feb.	**2013**	36,600,000	20,100	25,300	258	1,750	701,000	139,000	452,000
Mar.	**2013**	61,500,000	31,300	44,200	559	4,480	1,910,000	198,000	640,000
Apr.	**2013**	77,900,000	33,300	52,900	727	6,530	3,170,000	224,000	754,000
May	**2013**	88,500,000	31,700	62,300	1,200	13,100	6,580,000	216,000	789,000
June	**2013**	29,100,000	8,740	17,900	310	3,350	1,880,000	74,900	291,000
July	**2013**	683,000	105	271	3	26	8,170	2,690	11,600
Aug.	**2013**	32,700,000	9,640	24,500	662	7,800	4,010,000	75,700	342,000
Sep.	**2013**	496,000	121	269	4	31	13,000	1,850	8,400
Oct.	**2013**	4,930,000	1,540	2,970	40	308	125,000	19,000	83,200
Nov.	**2013**	16,500,000	6,990	11,700	162	1,190	466,000	62,600	255,000
Dec.	**2013**	52,100,000	31,100	48,900	853	6,440	2,120,000	173,000	628,000
Jan.	**2014**	37,200,000	21,100	29,100	356	2,430	871,000	140,000	483,000
Feb.	**2014**	9,670,000	4,260	5,500	42	261	93,500	43,800	144,000
Mar.	**2014**	82,100,000	42,900	69,800	1,200	10,700	3,870,000	233,000	760,000
Apr.	**2014**	77,100,000	32,800	54,500	782	7,070	3,220,000	217,000	737,000
May	**2014**	37,700,000	11,700	22,100	309	3,060	1,650,000	106,000	392,000
June	**2014**	14,400,000	3,320	7,030	89	892	498,000	43,500	177,000
July	**2014**	4,370,000	813	1,930	23	226	108,000	14,600	63,900
Aug.	**2014**	8,720,000	2,070	5,190	100	1,080	581,000	24,500	113,000
Sep.	**2014**	3,640,000	814	1,900	26	226	95,700	13,200	61,300
Oct.	**2014**	47,600,000	19,000	43,300	1,110	10,700	4,250,000	126,000	558,000
Nov.	**2014**	14,600,000	5,670	9,950	129	938	361,000	56,200	233,000
Dec.	**2014**	31,600,000	15,700	23,900	295	2,000	730,000	120,000	450,000
Jan.	**2015**	33,100,000	17,600	25,700	314	2,150	767,000	125,000	438,000
Feb.	**2015**	15,200,000	6,760	9,240	78	518	197,000	63,000	210,000
Mar.	**2015**	111,000,000	55,100	89,700	1,330	11,300	4,420,000	321,000	1,060,000
Apr.	**2015**	41,200,000	14,700	24,800	286	2,480	1,210,000	127,000	443,000
May	**2015**	249,000,000	89,100	219,000	5,790	70,900	30,400,000	485,000	1,810,000
June	**2015**	153,000,000	45,300	121,000	3,380	44,000	20,600,000	306,000	1,250,000
July	**2015**	78,200,000	20,600	56,600	1,440	18,000	9,490,000	167,000	737,000
Aug.	**2015**	7,790,000	1,590	4,030	60	587	289,000	24,500	115,000
Sep.	**2015**	4,290,000	952	2,340	34	310	138,000	14,700	69,200
Oct.	**2015**	652,000	135	324	3	23	4,970	3,080	13,600
Nov.	**2015**	64,400,000	33,000	67,800	1,590	13,700	4,450,000	176,000	713,000
Dec.	**2015**	244,000,000	162,000	369,000	13,400	129,000	26,400,000	549,000	2,010,000

WHITE RIVER NEAR FAYETTEVILLE, ARKANSAS (WYMAN) Continued

Month	Year	Monthly Q	NO_3-N	TN	SRP	TP	TSS	Cl	SO_4
		m3	kg	kg	kg	kg	kg	kg	kg
Jan.	**2016**	27,500,000	13,200	19,600	206	1,360	488,000	109,000	387,000
Feb.	**2016**	9,570,000	3,780	5,430	42	267	94,300	42,100	142,000
Mar.	**2016**	65,200,000	29,600	49,000	654	5,430	2,150,000	198,000	666,000
Apr.	**2016**	30,300,000	10,300	19,100	259	2,480	1,140,000	91,000	321,000
May	**2016**	75,800,000	22,900	53,000	1,030	11,800	5,780,000	178,000	681,000
June	**2016**	27,000,000	6,660	16,000	267	2,970	1,610,000	68,800	281,000
July	**2016**	20,700,000	4,400	11,700	207	2,310	1,300,000	54,200	246,000
Aug.	**2016**	9,840,000	1,930	5,110	76	758	376,000	30,100	143,000
Sep.	**2016**	2,370,000	440	1,160	14	122	43,500	8,920	42,400
Oct.	**2016**	1,080,000	216	539	6	42	10,900	4,780	21,700
Nov.	**2016**	638,000	145	324	3	17	3,050	3,330	13,800
Dec.	**2016**	2,870,000	935	1,610	13	78	20,600	14,200	54,300
Jan.	**2017**	9,720,000	4,020	6,120	53	336	115,000	41,900	149,000
Feb.	**2017**	11,100,000	4,410	6,700	57	380	140,000	45,600	156,000
Mar.	**2017**	63,800,000	26,500	47,500	652	5,700	2,300,000	187,000	639,000
Apr.	**2017**	187,000,000	72,000	178,000	4,650	55,400	19,400,000	384,000	1,370,000
May	**2017**	108,000,000	33,000	81,700	1,780	21,200	9,240,000	241,000	922,000
June	**2017**	28,800,000	6,690	16,900	282	3,170	1,700,000	72,700	302,000
July	**2017**	12,100,000	2,330	6,300	96	1,050	580,000	33,200	150,000
Aug.	**2017**	28,700,000	6,730	20,300	498	5,850	2,920,000	67,500	325,000
Sep.	**2017**	1,980,000	335	950	11	101	34,800	7,410	35,700
Oct.	**2017**	2,850,000	683	1,600	19	143	47,800	11,400	52,200
Nov.	**2017**	1,840,000	454	982	9	59	14,400	8,700	37,100
Dec.	**2017**	5,680,000	2,080	3,600	34	217	69,800	24,700	95,300
Jan.	**2018**	29,900,000	14,300	24,400	319	2,350	800,000	102,000	364,000
Feb.	**2018**	133,000,000	70,800	147,000	3,160	29,200	8,320,000	320,000	1,080,000
Mar.	**2018**	148,000,000	64,800	134,000	2,530	24,700	8,490,000	371,000	1,280,000
Apr.	**2018**	71,700,000	23,700	47,600	622	5,730	2,650,000	197,000	711,000
May	**2018**	66,800,000	20,300	51,400	1,090	12,700	5,190,000	152,000	578,000
June	**2018**	2,650,000	407	1,080	11	100	40,200	9,150	38,700
July	**2018**	1,840,000	252	776	9	88	34,800	6,240	29,000
Aug.	**2018**	17,800,000	3,650	11,000	213	2,330	1,210,000	46,100	226,000
Sep.	**2018**	3,070,000	562	1,580	20	177	66,200	11,000	53,300

WAR EAGLE CREEK NEAR HINDSVILLE, ARKANSAS (WEC)

Month	Year	Monthly Q	NO_3-N	TN	SRP	TP	TSS	Cl	SO_4
		m3	kg	kg	kg	kg	kg	kg	kg
July	**2009**	3,290,000	4,610	4,940	28	129	32,400	36,000	19,400
Aug.	**2009**	1,630,000	2,330	2,520	11	46	9,000	23,500	9,880
Sep.	**2009**	18,700,000	25,600	31,400	684	3,420	1,480,000	127,000	110,000
Oct.	**2009**	97,400,000	111,000	163,000	6,670	35,200	19,800,000	426,000	493,000
Nov.	**2009**	25,500,000	43,600	47,700	519	1,960	475,000	205,000	193,000
Dec.	**2009**	17,800,000	31,600	33,600	257	896	184,000	148,000	143,000
Jan.	**2010**	21,600,000	37,200	39,700	271	973	203,000	157,000	171,000
Feb.	**2010**	46,200,000	69,300	80,500	775	3,170	861,000	238,000	319,000
Mar.	**2010**	39,600,000	51,900	63,200	710	3,510	1,280,000	179,000	238,000
Apr.	**2010**	21,500,000	30,000	33,700	261	1,260	389,000	120,000	135,000
May	**2010**	48,000,000	52,100	69,000	1,300	8,230	4,670,000	188,000	232,000
June	**2010**	3,150,000	4,280	4,610	22	105	26,500	30,600	18,700
July	**2010**	22,000,000	26,300	32,900	629	3,840	1,980,000	122,000	114,000
Aug.	**2010**	2,610,000	3,770	4,070	23	99	22,400	32,900	16,400
Sep.	**2010**	12,800,000	19,000	21,600	293	1,390	469,000	108,000	83,100
Oct.	**2010**	2,310,000	3,910	4,090	18	59	8,830	35,800	17,600
Nov.	**2010**	3,460,000	6,250	6,480	34	110	18,100	44,000	28,800
Dec.	**2010**	2,640,000	4,860	4,940	17	51	6,650	36,900	22,700
Jan.	**2011**	3,000,000	5,470	5,510	17	50	6,380	37,700	25,900
Feb.	**2011**	21,300,000	33,400	36,900	259	1,050	256,000	131,000	158,000
Mar.	**2011**	24,200,000	36,400	40,300	272	1,160	296,000	143,000	171,000
Apr.	**2011**	176,000,000	139,000	240,000	8,940	61,700	46,900,000	399,000	660,000
May	**2011**	134,000,000	125,000	187,000	5,170	35,600	24,700,000	396,000	576,000
June	**2011**	10,400,000	13,700	15,400	122	660	223,000	73,200	61,400
July	**2011**	2,380,000	3,220	3,530	16	74	16,600	28,400	14,400
Aug.	**2011**	10,300,000	14,300	16,400	197	1,020	358,000	84,900	63,900
Sep.	**2011**	4,130,000	6,530	7,070	52	213	48,400	49,000	29,600
Oct.	**2011**	2,280,000	3,820	4,040	17	56	8,240	35,500	17,800
Nov.	**2011**	50,200,000	71,500	91,400	1,760	7,590	2,590,000	290,000	340,000
Dec.	**2011**	43,000,000	68,100	80,200	956	3,710	974,000	275,000	328,000
Jan.	**2012**	32,800,000	47,400	58,200	695	2,930	900,000	180,000	233,000
Feb.	**2012**	25,700,000	40,300	45,300	334	1,330	320,000	158,000	197,000
Mar.	**2012**	78,200,000	84,900	120,000	2,180	12,000	5,720,000	266,000	417,000
Apr.	**2012**	8,220,000	12,000	12,900	60	269	62,800	61,300	57,300
May	**2012**	2,190,000	2,970	3,230	10	44	8,600	23,100	14,000
June	**2012**	1,260,000	1,600	1,800	5	24	4,650	15,800	7,480
July	**2012**	810,000	996	1,160	3	14	2,430	12,500	4,660
Aug.	**2012**	816,000	1,070	1,230	4	15	2,410	14,000	5,000
Sep.	**2012**	2,410,000	3,660	4,030	26	106	23,900	32,000	17,100

WAR EAGLE CREEK NEAR HINDSVILLE, ARKANSAS (WEC) Continued

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
Oct.	**2012**	5,140,000	8,490	9,280	75	291	65,400	58,000	40,400
Nov.	**2012**	1,140,000	1,900	2,040	5	16	1,690	20,800	9,360
Dec.	**2012**	1,990,000	3,550	3,690	10	30	3,350	30,400	17,700
Jan.	**2013**	21,900,000	29,900	38,200	523	2,340	816,000	121,000	151,000
Feb.	**2013**	22,600,000	35,600	39,600	253	1,010	229,000	144,000	178,000
Mar.	**2013**	32,000,000	44,700	52,400	423	1,970	589,000	169,000	223,000
Apr.	**2013**	47,100,000	58,800	72,300	747	4,050	1,530,000	213,000	289,000
May	**2013**	45,900,000	52,600	67,400	932	5,710	2,750,000	201,000	255,000
June	**2013**	11,300,000	13,800	16,600	178	1,050	436,000	67,400	65,800
July	**2013**	1,090,000	1,390	1,600	7	30	6,360	14,900	6,630
Aug.	**2013**	32,700,000	38,500	50,700	1,130	6,810	3,470,000	181,000	183,000
Sep.	**2013**	1,790,000	2,670	2,960	13	48	8,020	27,700	12,900
Oct.	**2013**	7,280,000	11,800	13,100	113	459	111,000	78,000	57,700
Nov.	**2013**	11,100,000	19,100	20,900	159	581	118,000	109,000	95,800
Dec.	**2013**	44,800,000	64,300	82,000	1,190	4,990	1,530,000	252,000	331,000
Jan.	**2014**	27,400,000	44,200	50,500	400	1,530	351,000	185,000	228,000
Feb.	**2014**	6,930,000	11,700	12,200	44	156	25,100	62,900	60,300
Mar.	**2014**	54,500,000	67,200	87,100	1,030	5,300	2,000,000	230,000	347,000
Apr.	**2014**	53,600,000	63,000	82,000	1,000	5,560	2,270,000	221,000	321,000
May	**2014**	17,800,000	22,300	26,600	239	1,360	513,000	101,000	111,000
June	**2014**	11,100,000	13,900	16,400	153	888	344,000	74,600	68,100
July	**2014**	1,110,000	1,380	1,610	5	24	4,630	15,600	6,830
Aug.	**2014**	2,180,000	2,950	3,440	28	138	41,400	25,000	14,500
Sep.	**2014**	1,080,000	1,530	1,750	6	23	3,400	18,800	7,670
Oct.	**2014**	20,300,000	28,700	36,000	604	2,810	954,000	145,000	145,000
Nov.	**2014**	5,030,000	8,550	9,370	62	226	44,700	58,300	43,900
Dec.	**2014**	10,500,000	18,100	19,900	126	447	84,700	97,100	95,400
Jan.	**2015**	15,400,000	24,200	28,400	247	971	237,000	109,000	129,000
Feb.	**2015**	5,300,000	8,320	9,160	42	165	34,100	44,200	44,300
Mar.	**2015**	68,800,000	84,800	111,000	1,260	6,440	2,340,000	287,000	451,000
Apr.	**2015**	16,600,000	22,700	26,000	158	781	218,000	103,000	118,000
May	**2015**	96,300,000	90,200	136,000	3,090	21,400	13,200,000	307,000	468,000
June	**2015**	42,100,000	43,400	60,400	1,210	8,260	4,840,000	178,000	221,000
July	**2015**	40,500,000	42,500	59,200	1,320	8,920	5,160,000	187,000	215,000
Aug.	**2015**	3,880,000	5,360	6,190	48	235	67,500	42,500	27,000
Sep.	**2015**	3,520,000	5,240	5,930	40	175	41,400	43,500	26,700
Oct.	**2015**	1,690,000	2,680	2,980	10	35	4,730	28,500	14,100
Nov.	**2015**	38,600,000	52,600	70,400	1,230	5,420	1,740,000	222,000	284,000
Dec.	**2015**	195,000,000	183,000	323,000	12,200	62,600	31,500,000	602,000	1,030,000

WAR EAGLE CREEK NEAR HINDSVILLE, ARKANSAS (WEC) Continued

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
Jan.	**2016**	27,800,000	44,500	51,600	391	1,510	330,000	191,000	243,000
Feb.	**2016**	7,630,000	12,400	13,400	51	193	34,100	66,500	67,900
Mar.	**2016**	51,200,000	63,900	82,800	882	4,470	1,560,000	227,000	350,000
Apr.	**2016**	16,900,000	21,400	26,100	222	1,240	479,000	94,300	115,000
May	**2016**	28,400,000	33,100	42,000	469	2,870	1,250,000	142,000	175,000
June	**2016**	11,400,000	14,200	16,900	141	817	294,000	76,900	73,700
July	**2016**	13,000,000	15,900	19,600	226	1,350	550,000	90,800	82,300
Aug.	**2016**	5,890,000	8,090	9,370	72	361	102,000	60,200	41,900
Sep.	**2016**	1,840,000	2,670	3,050	13	50	8,380	28,400	14,100
Oct.	**2016**	2,350,000	3,760	4,180	18	62	9,550	36,000	20,200
Nov.	**2016**	1,530,000	2,520	2,790	8	24	2,720	26,300	14,000
Dec.	**2016**	2,220,000	3,820	4,120	11	33	3,740	33,100	21,500
Jan.	**2017**	6,450,000	10,700	11,800	53	192	34,600	60,700	60,500
Feb.	**2017**	6,110,000	9,710	10,700	41	160	29,100	53,500	54,900
Mar.	**2017**	43,900,000	53,700	70,200	737	3,910	1,430,000	195,000	302,000
Apr.	**2017**	141,000,000	119,000	199,000	5,200	36,200	23,700,000	376,000	672,000
May	**2017**	83,700,000	81,300	120,000	2,390	16,700	10,400,000	293,000	447,000
June	**2017**	21,000,000	23,400	30,600	407	2,660	1,310,000	111,000	126,000
July	**2017**	5,790,000	7,410	8,730	61	335	103,000	52,500	39,400
Aug.	**2017**	13,100,000	16,700	21,000	286	1,610	622,000	99,100	89,500
Sep.	**2017**	1,920,000	2,760	3,170	13	53	9,100	29,300	15,000
Oct.	**2017**	1,810,000	2,820	3,190	11	39	5,320	29,900	15,700
Nov.	**2017**	1,750,000	2,890	3,210	9	29	3,440	29,200	16,400
Dec.	**2017**	2,640,000	4,510	4,920	15	47	6,070	36,700	26,100
Jan.	**2018**	12,600,000	18,700	22,700	178	743	186,000	86,100	109,000
Feb.	**2018**	78,700,000	79,600	126,000	2,380	12,800	5,480,000	252,000	474,000
Mar.	**2018**	74,300,000	76,200	114,000	1,930	11,500	5,560,000	255,000	447,000
Apr.	**2018**	39,000,000	47,400	60,300	539	2,980	1,040,000	186,000	271,000
May	**2018**	41,100,000	40,100	59,200	1,060	7,170	4,040,000	155,000	229,000
June	**2018**	1,890,000	2,320	2,730	9	44	9,100	21,800	12,900
July	**2018**	1,470,000	1,800	2,160	8	35	6,870	19,900	9,990
Aug.	**2018**	3,010,000	4,040	4,770	29	141	35,600	36,100	22,300
Sep.	**2018**	1,700,000	2,420	2,820	11	44	7,120	26,900	13,600

WEST FORK WHITE RIVER EAST OF FAYETTEVILLE, ARKANSAS (WFWR)

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
July	2009	937,000	321	535	7	90	36,500	5,210	29,200
Aug.	2009	3,300,000	1,630	2,300	36	590	312,000	15,300	89,800
Sep.	2009	16,500,000	10,900	14,500	259	4,990	3,250,000	62,700	352,000
Oct.	2009	44,700,000	33,800	43,700	830	14,500	9,710,000	160,000	817,000
Nov.	2009	9,220,000	6,660	6,710	107	868	291,000	60,900	290,000
Dec.	2009	7,090,000	5,330	5,140	82	438	131,000	54,200	224,000
Jan.	2010	12,800,000	10,200	9,970	165	796	262,000	91,600	346,000
Feb.	2010	17,400,000	13,600	13,900	234	1,130	401,000	115,000	421,000
Mar.	2010	21,900,000	15,300	19,000	336	2,230	1,130,000	111,000	413,000
Apr.	2010	9,570,000	5,500	7,040	113	710	303,000	55,700	225,000
May	2010	28,400,000	16,300	25,700	464	5,960	4,430,000	100,000	448,000
June	2010	1,660,000	604	1,010	14	146	63,800	9,140	46,400
July	2010	11,900,000	6,260	10,600	190	4,260	3,580,000	36,200	201,000
Aug.	2010	143,000	29	65	1	8	2,200	914	5,160
Sep.	2010	5,230,000	2,890	3,960	65	1,120	607,000	23,600	136,000
Oct.	2010	580,000	244	322	4	32	8,020	4,590	23,500
Nov.	2010	2,040,000	1,160	1,290	19	116	30,800	16,500	76,100
Dec.	2010	1,940,000	1,280	1,380	22	121	38,400	15,100	61,800
Jan.	2011	5,480,000	3,710	3,840	60	283	82,000	44,700	174,000
Feb.	2011	18,400,000	13,300	14,800	249	1,270	483,000	116,000	426,000
Mar.	2011	12,700,000	8,060	9,660	157	812	310,000	81,500	305,000
Apr.	2011	67,800,000	39,000	70,900	1,380	17,100	14,600,000	203,000	806,000
May	2011	58,300,000	31,600	56,300	1,050	15,800	13,300,000	175,000	783,000
June	2011	2,930,000	1,150	1,920	29	310	151,000	14,900	74,600
July	2011	109,000	16	46	1	4	1,130	710	3,770
Aug.	2011	2,600,000	1,210	1,900	30	566	326,000	10,900	64,100
Sep.	2011	1,370,000	676	942	14	211	92,700	7,130	40,600
Oct.	2011	1,520,000	718	940	14	131	42,500	10,500	54,900
Nov.	2011	23,000,000	16,600	20,600	368	4,200	2,060,000	108,000	498,000
Dec.	2011	25,600,000	19,200	21,600	371	2,810	1,100,000	146,000	610,000
Jan.	2012	16,700,000	12,100	14,000	240	1,380	538,000	103,000	385,000
Feb.	2012	14,100,000	9,430	11,000	182	936	345,000	93,600	345,000
Mar.	2012	34,600,000	21,400	32,300	588	4,590	2,690,000	148,000	549,000
Apr.	2012	3,300,000	1,340	2,040	29	158	53,100	23,000	93,900
May	2012	795,000	218	420	6	33	10,400	5,550	24,700
June	2012	980,000	328	599	9	89	41,000	5,250	26,300
July	2012	718,000	209	410	6	74	32,900	3,820	21,500
Aug.	2012	1,120,000	451	751	12	199	102,000	5,260	30,900
Sep.	2012	338,000	110	190	3	33	12,000	2,050	11,800

WEST FORK WHITE RIVER EAST OF FAYETTEVILLE, ARKANSAS (WFWR) continued

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
Oct.	2012	1,040,000	466	653	10	104	36,800	6,680	35,600
Nov.	2012	457,000	136	221	3	14	2,650	4,400	20,500
Dec.	2012	983,000	426	553	7	36	8,080	9,380	39,600
Jan.	2013	4,390,000	2,720	3,360	55	294	107,000	30,600	115,000
Feb.	2013	5,130,000	2,700	3,410	51	216	63,400	41,100	153,000
Mar.	2013	19,100,000	10,900	16,100	274	1,900	951,000	97,200	366,000
Apr.	2013	29,900,000	15,500	24,900	422	3,660	2,060,000	132,000	535,000
May	2013	34,900,000	16,200	30,000	520	7,080	5,110,000	123,000	562,000
June	2013	8,270,000	3,430	6,320	102	1,440	916,000	32,900	164,000
July	2013	440,000	100	226	3	37	14,200	2,510	14,200
Aug.	2013	4,270,000	1,720	3,070	48	959	570,000	17,400	103,000
Sep.	2013	886,000	372	597	9	143	66,300	4,560	26,000
Oct.	2013	4,440,000	2,100	3,050	47	609	258,000	25,300	136,000
Nov.	2013	5,900,000	3,180	4,070	62	510	167,000	39,800	189,000
Dec.	2013	20,200,000	13,200	16,800	285	2,130	846,000	116,000	478,000
Jan.	2014	16,500,000	10,300	12,800	210	1,220	430,000	108,000	419,000
Feb.	2014	3,640,000	1,630	2,220	31	120	29,500	32,200	121,000
Mar.	2014	34,200,000	18,600	29,600	513	3,780	2,010,000	161,000	604,000
Apr.	2014	26,300,000	12,800	21,300	353	2,890	1,520,000	122,000	493,000
May	2014	11,000,000	4,370	8,080	128	1,400	799,000	49,600	229,000
June	2014	4,150,000	1,340	2,650	39	474	236,000	20,300	105,000
July	2014	483,000	100	244	3	37	14,000	2,770	15,500
Aug.	2014	725,000	181	389	5	71	27,400	4,090	24,200
Sep.	2014	3,040,000	1,140	1,990	29	476	219,000	15,500	90,800
Oct.	2014	14,600,000	7,670	12,400	211	3,630	2,000,000	58,700	313,000
Nov.	2014	3,240,000	1,470	2,070	30	254	79,200	23,200	113,000
Dec.	2014	11,600,000	6,560	8,500	133	897	297,000	78,600	332,000
Jan.	2015	8,880,000	4,990	6,600	105	629	217,000	61,600	242,000
Feb.	2015	3,390,000	1,470	2,140	31	134	38,600	28,000	105,000
Mar.	2015	45,000,000	23,400	38,200	650	4,680	2,340,000	214,000	801,000
Apr.	2015	13,400,000	5,590	9,730	151	1,160	539,000	71,500	296,000
May	2015	83,000,000	34,400	77,800	1,400	22,800	18,800,000	232,000	1,050,000
June	2015	48,200,000	18,500	43,100	756	16,600	14,700,000	134,000	691,000
July	2015	32,400,000	12,400	28,900	504	12,900	11,400,000	87,000	482,000
Aug.	2015	1,760,000	577	1,140	17	309	157,000	8,070	48,500
Sep.	2015	4,750,000	1,820	3,320	51	935	480,000	21,800	128,000
Oct.	2015	750,000	246	420	6	53	15,500	5,370	28,200
Nov.	2015	28,700,000	16,100	25,200	437	5,060	2,410,000	127,000	581,000
Dec.	2015	108,000,000	58,200	118,000	2,310	26,300	16,600,000	356,000	1,400,000

WEST FORK WHITE RIVER EAST OF FAYETTEVILLE, ARKANSAS (WFWR) continued

Month	Year	Monthly Q	NO_3-N	TN	SRP	TP	TSS	Cl	SO_4
		m3	kg	kg	kg	kg	kg	kg	kg
Jan.	2016	12,700,000	6,610	9,010	138	770	238,000	91,200	359,000
Feb.	2016	2,270,000	804	1,290	17	67	16,000	20,800	78,300
Mar.	2016	24,000,000	11,400	19,200	316	2,150	1,000,000	126,000	474,000
Apr.	2016	8,890,000	3,300	6,790	110	1,160	741,000	42,700	179,000
May	2016	26,500,000	9,840	21,600	357	5,250	3,730,000	95,800	446,000
June	2016	14,500,000	4,940	10,900	173	2,790	1,850,000	54,100	278,000
July	2016	15,100,000	5,110	11,300	179	3,920	2,650,000	53,100	306,000
Aug.	2016	2,720,000	735	1,630	23	386	181,000	13,300	80,300
Sep.	2016	2,130,000	692	1,330	19	300	126,000	11,300	66,000
Oct.	2016	1,350,000	423	778	11	124	41,900	8,790	48,200
Nov.	2016	375,000	90	177	2	11	2,210	3,560	16,500
Dec.	2016	2,240,000	914	1,380	20	104	27,500	18,900	78,800
Jan.	2017	6,680,000	3,000	4,450	65	333	97,200	51,800	202,000
Feb.	2017	3,860,000	1,500	2,430	34	159	46,300	31,000	117,000
Mar.	2017	29,000,000	12,600	23,400	383	2,910	1,450,000	142,000	542,000
Apr.	2017	74,200,000	28,100	71,700	1,310	18,500	15,400,000	219,000	893,000
May	2017	36,400,000	12,800	30,000	497	7,190	5,210,000	129,000	590,000
June	2017	10,800,000	3,340	7,920	123	1,990	1,310,000	41,800	215,000
July	2017	2,930,000	747	1,810	25	424	223,000	13,300	75,800
Aug.	2017	7,140,000	2,290	5,210	81	1,910	1,230,000	26,700	161,000
Sep.	2017	444,000	84	213	3	31	9,440	2,910	16,900
Oct.	2017	1,370,000	435	815	12	130	45,100	8,930	47,800
Nov.	2017	564,000	129	266	3	18	3,560	5,230	24,800
Dec.	2017	2,200,000	820	1,320	18	101	26,300	18,600	78,300
Jan.	2018	6,100,000	2,630	4,280	65	378	130,000	43,500	168,000
Feb.	2018	37,600,000	17,000	34,400	604	4,860	2,620,000	158,000	574,000
Mar.	2018	35,200,000	14,200	30,800	529	4,860	2,950,000	146,000	554,000
Apr.	2018	16,300,000	5,690	11,700	178	1,440	673,000	83,500	346,000
May	2018	29,600,000	9,760	25,200	427	6,130	4,640,000	100,000	450,000
June	2018	1,100,000	194	560	7	74	27,300	6,400	33,500
July	2018	1,400,000	284	772	10	163	74,200	7,090	41,500
Aug.	2018	7,190,000	2,140	5,080	77	1,780	1,080,000	27,600	167,000
Sep.	2018	868,000	212	490	7	101	40,500	4,970	29,100

RICHLAND CREEK AT TUTTLE ROAD NEAR GOSHEN, ARKANSAS (RICHLAND)

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
Oct.	2015	224,000	320	283	4	10	2,710	1,120	2,430
Nov.	2015	10,100,000	8,970	12,100	428	1,800	868,000	29,500	86,400
Dec.	2015	66,600,000	36,100	89,900	3,980	20,400	13,200,000	130,000	500,000
Jan.	2016	11,400,000	11,100	13,600	291	1,120	381,000	41,700	109,000
Feb.	2016	1,890,000	2,160	2,310	23	73	16,300	9,270	20,400
Mar.	2016	21,900,000	15,300	26,800	432	1,720	710,000	65,200	184,000
Apr.	2016	8,320,000	5,900	10,300	139	535	257,000	25,500	68,300
May	2016	10,800,000	7,580	13,300	176	650	319,000	31,000	83,900
June	2016	4,960,000	3,740	6,220	84	304	160,000	14,500	38,400
July	2016	2,770,000	2,670	3,520	49	165	80,100	9,090	22,600
Aug.	2016	909,000	1,140	1,210	13	39	13,800	3,720	8,450
Sep.	2016	258,000	390	367	4	10	2,740	1,240	2,700
Oct.	2016	7,950	14	15	0	0	22	52	109
Nov.	2016	73	0	0	0	0	0	1	2
Dec.	2016	161,000	270	229	2	6	1,190	933	1,950
Jan.	2017	967,000	1,480	1,340	12	37	7,420	5,300	11,200
Feb.	2017	664,000	952	943	6	19	3,440	3,710	7,710
Mar.	2017	9,450,000	7,830	12,900	168	654	270,000	29,700	80,400
Apr.	2017	53,100,000	27,100	78,900	1,460	6,680	4,660,000	101,000	361,000
May	2017	38,300,000	23,900	54,600	863	3,620	2,340,000	85,600	270,000
June	2017	12,100,000	8,420	17,300	277	1,140	791,000	28,300	85,200
July	2017	1,590,000	1,810	2,270	23	73	31,100	5,650	13,500
Aug.	2017	2,000,000	2,490	2,870	45	153	74,400	6,720	16,800
Sep.	2017	211,000	364	340	3	8	2,100	1,030	2,240
Oct.	2017	136,000	268	220	2	6	1,330	734	1,570
Nov.	2017	405,000	814	642	6	18	3,920	2,240	4,730
Dec.	2017	124,000	258	215	1	3	496	820	1,660
Jan.	2018	3,000,000	3,640	4,500	70	274	95,800	11,000	28,600
Feb.	2018	25,600,000	20,100	40,300	724	3,200	1,530,000	64,500	206,000
Mar.	2018	25,100,000	19,900	39,200	563	2,380	1,190,000	65,900	199,000
Apr.	2018	17,900,000	16,300	27,200	292	1,090	452,000	53,700	146,000
May	2018	20,400,000	15,200	32,300	435	1,820	1,110,000	48,400	148,000
June	2018	589,000	798	969	5	15	4,340	2,530	5,560
July	2018	86,500	142	165	1	2	394	435	928
Aug.	2018	1,220,000	1,830	1,970	24	76	33,500	4,440	10,700
Sep.	2018	215,000	438	387	3	8	2,020	1,080	2,320

TOWN BRANCH AT ARMSTRONG IN FAYETTEVILLE, ARKANSAS (TB)

Month	Year	Monthly Q	NO_3-N	TN	SRP	TP	TSS	Cl	SO_4
		m3	kg	kg	kg	kg	kg	kg	kg
Oct.	2015	234,000	105	182	5	13	2,750	2,700	12,000
Nov.	2015	5,190,000	1,470	5,340	384	1,950	1,520,000	20,500	98,500
Dec.	2015	18,200,000	4,290	18,500	1,470	11,400	11,500,000	49,700	234,000
Jan.	2016	765,000	410	666	12	55	6,870	11,400	51,300
Feb.	2016	236,000	153	181	2	10	929	4,660	20,300
Mar.	2016	2,390,000	1,210	2,440	68	562	283,000	18,600	92,600
Apr.	2016	1,160,000	638	1,190	33	234	161,000	8,140	41,900
May	2016	2,210,000	1,140	2,330	78	475	421,000	11,800	63,600
June	2016	669,000	382	650	18	85	56,000	4,720	24,900
July	2016	1,070,000	542	1,060	36	127	86,700	6,430	34,400
Aug.	2016	364,000	178	325	10	26	12,100	2,960	14,500
Sep.	2016	668,000	269	675	31	89	55,000	4,190	20,700
Oct.	2016	317,000	138	289	9	24	7,400	3,140	14,300
Nov.	2016	180,000	86	144	3	7	709	2,820	11,900
Dec.	2016	313,000	152	292	6	25	4,460	4,520	19,500
Jan.	2017	686,000	346	705	15	84	19,200	8,590	38,900
Feb.	2017	295,000	183	270	3	19	2,590	5,140	22,800
Mar.	2017	2,690,000	1,430	3,080	69	539	240,000	21,000	106,000
Apr.	2017	16,000,000	5,790	19,100	880	8,210	12,100,000	43,100	231,000
May	2017	3,510,000	1,690	4,090	144	1,010	1,290,000	17,100	92,400
June	2017	1,280,000	699	1,440	39	188	135,000	7,770	42,100
July	2017	403,000	218	427	11	40	22,400	2,780	14,600
Aug.	2017	827,000	361	935	37	114	87,700	4,510	23,600
Sep.	2017	236,000	106	233	7	17	6,990	2,090	9,760
Oct.	2017	590,000	233	657	24	75	33,600	4,550	21,400
Nov.	2017	330,000	153	323	6	18	2,660	4,350	19,100
Dec.	2017	447,000	215	480	9	38	6,370	5,990	26,500
Jan.	2018	455,000	246	482	7	36	5,500	6,980	30,900
Feb.	2018	8,260,000	3,060	10,700	368	3,520	2,610,000	36,900	183,000
Mar.	2018	6,100,000	2,480	7,990	258	2,490	2,240,000	26,700	136,000
Apr.	2018	550,000	381	591	7	36	6,900	7,160	35,200
May	2018	5,070,000	2,020	6,590	261	2,300	3,570,000	17,500	93,800
June	2018	307,000	190	328	6	21	8,550	2,860	14,500
July	2018	612,000	319	714	18	56	30,300	4,240	22,100
Aug.	2018	1,110,000	492	1,370	48	147	114,000	6,390	33,200
Sep.	2018	458,000	199	527	16	43	20,600	3,670	17,600

ILLINOIS RIVER AT NEAR WATTS, OKLAHOMA (WATTS)

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
July	2009	21,900,000	41,300	48,000	1,030	1,720	193,000	379,000	347,000
Aug.	2009	20,800,000	39,200	45,100	961	1,600	181,000	377,000	340,000
Sep.	2009	38,600,000	78,700	93,700	2,650	5,700	1,130,000	559,000	552,000
Oct.	2009	171,000,000	282,000	403,000	24,200	77,800	32,800,000	1,340,000	1,660,000
Nov.	2009	52,800,000	135,000	153,000	3,630	7,580	1,350,000	754,000	806,000
Dec.	2009	28,600,000	79,900	85,300	1,470	2,580	325,000	509,000	528,000
Jan.	2010	39,700,000	117,000	128,000	2,430	4,770	759,000	604,000	670,000
Feb.	2010	69,400,000	201,000	231,000	5,290	11,600	2,280,000	837,000	1,000,000
Mar.	2010	84,300,000	207,000	257,000	7,720	19,200	4,970,000	869,000	1,060,000
Apr.	2010	51,200,000	129,000	151,000	3,440	7,070	1,240,000	654,000	731,000
May	2010	83,200,000	171,000	220,000	7,290	17,600	4,250,000	844,000	970,000
June	2010	25,600,000	51,900	60,300	1,290	2,250	288,000	409,000	398,000
July	2010	77,300,000	130,000	176,000	7,670	20,300	6,020,000	763,000	840,000
Aug.	2010	14,600,000	25,900	29,600	587	910	93,300	291,000	262,000
Sep.	2010	31,600,000	65,200	75,300	1,860	3,630	605,000	500,000	490,000
Oct.	2010	14,400,000	30,100	32,800	570	875	88,200	310,000	289,000
Nov.	2010	16,400,000	39,400	42,300	730	1,220	151,000	331,000	328,000
Dec.	2010	16,400,000	42,400	44,600	679	1,070	114,000	342,000	347,000
Jan.	2011	16,500,000	44,500	46,800	689	1,090	120,000	333,000	348,000
Feb.	2011	32,200,000	91,900	101,000	1,950	3,840	669,000	484,000	549,000
Mar.	2011	39,600,000	110,000	122,000	2,350	4,540	736,000	571,000	648,000
Apr.	2011	388,000,000	351,000	682,000	96,700	418,000	319,000,000	1,430,000	2,410,000
May	2011	262,000,000	377,000	578,000	42,500	151,000	85,400,000	1,580,000	2,190,000
June	2011	42,500,000	88,600	105,000	2,580	5,010	827,000	577,000	602,000
July	2011	20,700,000	38,800	44,600	935	1,540	186,000	364,000	345,000
Aug.	2011	19,400,000	36,300	41,300	877	1,460	182,000	355,000	333,000
Sep.	2011	19,100,000	38,300	43,100	928	1,640	235,000	350,000	336,000
Oct.	2011	14,900,000	31,400	34,000	596	925	101,000	316,000	302,000
Nov.	2011	68,200,000	160,000	192,000	6,060	15,200	4,450,000	811,000	956,000
Dec.	2011	60,900,000	170,000	190,000	4,300	9,200	1,910,000	829,000	974,000
Jan.	2012	42,700,000	123,000	136,000	2,810	5,880	1,210,000	619,000	726,000
Feb.	2012	43,100,000	125,000	138,000	2,740	5,520	1,030,000	609,000	721,000
Mar.	2012	86,800,000	201,000	255,000	8,600	22,700	7,380,000	843,000	1,090,000
Apr.	2012	33,100,000	83,100	93,100	1,810	3,320	511,000	491,000	546,000
May	2012	17,300,000	36,200	40,700	737	1,190	143,000	308,000	313,000
June	2012	12,800,000	23,200	26,600	495	758	83,900	246,000	237,000
July	2012	7,310,000	10,700	12,500	221	296	25,000	168,000	152,000
Aug.	2012	9,240,000	15,100	17,200	331	497	55,100	202,000	185,000
Sep.	2012	12,600,000	23,400	25,900	481	729	79,400	269,000	253,000

ILLINOIS RIVER AT NEAR WATTS, OKLAHOMA (WATTS) continued

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
Oct.	2012	14,800,000	31,100	33,800	621	1,010	130,000	306,000	300,000
Nov.	2012	9,840,000	21,000	22,200	335	477	46,200	234,000	230,000
Dec.	2012	11,000,000	26,000	27,300	396	587	62,900	251,000	259,000
Jan.	2013	16,900,000	44,500	48,600	908	1,780	356,000	306,000	342,000
Feb.	2013	22,800,000	64,700	68,500	1,100	1,890	267,000	394,000	448,000
Mar.	2013	51,400,000	136,000	157,000	3,610	7,840	1,810,000	651,000	797,000
Apr.	2013	101,000,000	226,000	284,000	9,260	23,400	7,330,000	975,000	1,260,000
May	2013	135,000,000	249,000	336,000	14,700	41,600	16,400,000	1,120,000	1,460,000
June	2013	37,900,000	78,000	91,600	2,260	4,440	833,000	520,000	563,000
July	2013	18,400,000	33,400	38,300	828	1,410	207,000	326,000	321,000
Aug.	2013	59,500,000	110,000	136,000	4,690	11,000	3,030,000	710,000	787,000
Sep.	2013	17,500,000	34,600	38,200	769	1,280	177,000	337,000	332,000
Oct.	2013	27,000,000	60,200	66,400	1,450	2,740	507,000	465,000	489,000
Nov.	2013	27,100,000	68,900	73,200	1,360	2,400	370,000	483,000	526,000
Dec.	2013	59,100,000	160,000	181,000	4,540	10,400	2,760,000	760,000	948,000
Jan.	2014	45,900,000	134,000	145,000	2,920	5,950	1,260,000	666,000	814,000
Feb.	2014	20,900,000	58,900	61,600	949	1,580	219,000	374,000	430,000
Mar.	2014	69,600,000	176,000	209,000	5,700	13,700	4,090,000	777,000	1,010,000
Apr.	2014	47,800,000	121,000	137,000	2,990	5,980	1,200,000	625,000	752,000
May	2014	36,400,000	80,900	92,900	2,090	4,010	759,000	510,000	577,000
June	2014	30,800,000	62,800	71,900	1,610	2,920	487,000	462,000	496,000
July	2014	14,400,000	25,200	28,500	552	845	102,000	278,000	273,000
Aug.	2014	14,500,000	25,800	28,900	570	886	111,000	288,000	281,000
Sep.	2014	15,600,000	30,100	33,100	647	1,040	141,000	311,000	310,000
Oct.	2014	47,800,000	102,000	121,000	3,700	8,640	2,490,000	624,000	728,000
Nov.	2014	18,900,000	46,200	48,400	820	1,340	188,000	375,000	404,000
Dec.	2014	37,500,000	106,000	113,000	2,140	4,080	778,000	598,000	712,000
Jan.	2015	30,700,000	89,300	93,400	1,600	2,900	506,000	513,000	614,000
Feb.	2015	21,600,000	60,900	63,700	1,000	1,700	259,000	379,000	447,000
Mar.	2015	92,100,000	240,000	282,000	7,450	17,300	4,870,000	982,000	1,330,000
Apr.	2015	39,600,000	100,000	111,000	2,220	4,170	769,000	557,000	669,000
May	2015	185,000,000	318,000	444,000	21,600	61,700	26,600,000	1,350,000	1,920,000
June	2015	140,000,000	229,000	314,000	16,100	47,500	22,800,000	1,130,000	1,500,000
July	2015	131,000,000	212,000	288,000	14,000	38,800	16,200,000	1,120,000	1,440,000
Aug.	2015	35,000,000	69,200	78,600	1,910	3,570	675,000	537,000	576,000
Sep.	2015	21,200,000	42,700	46,700	948	1,580	240,000	390,000	405,000
Oct.	2015	15,900,000	33,800	35,800	621	959	125,000	332,000	346,000
Nov.	2015	84,400,000	183,000	228,000	8,700	23,900	9,890,000	862,000	1,160,000
Dec.	2015	421,000,000	513,000	847,000	96,800	415,000	397,000,000	1,970,000	3,530,000
Jan.	2016	87,100,000	246,000	277,000	6,800	15,500	4,390,000	1,020,000	1,390,000

ILLINOIS RIVER AT NEAR WATTS, OKLAHOMA (WATTS) continued

Month	Year	Monthly Q	NO_3-N	TN	SRP	TP	TSS	Cl	SO_4
		m3	kg	kg	kg	kg	kg	kg	kg
Feb.	2016	31,900,000	93,500	97,900	1,640	2,940	514,000	509,000	631,000
Mar.	2016	52,900,000	144,000	160,000	3,460	7,220	1,770,000	685,000	888,000
Apr.	2016	30,600,000	74,400	82,100	1,610	2,980	586,000	459,000	548,000
May	2016	50,900,000	109,000	129,000	3,460	7,460	1,990,000	622,000	761,000
June	2016	26,100,000	52,800	59,400	1,250	2,180	369,000	412,000	454,000
July	2016	37,600,000	73,600	84,600	2,110	4,010	823,000	542,000	603,000
Aug.	2016	17,300,000	31,700	35,000	693	1,090	153,000	331,000	340,000
Sep.	2016	15,500,000	29,800	32,200	610	956	134,000	311,000	322,000
Oct.	2016	16,100,000	34,400	36,200	637	1,000	143,000	332,000	354,000
Nov.	2016	11,300,000	25,000	25,800	389	562	67,700	260,000	280,000
Dec.	2016	12,200,000	29,800	30,400	428	627	77,400	276,000	310,000
Jan.	2017	19,100,000	52,900	54,200	819	1,350	214,000	364,000	436,000
Feb.	2017	13,700,000	36,000	37,000	520	797	108,000	275,000	325,000
Mar.	2017	37,600,000	96,600	109,000	2,430	5,140	1,380,000	505,000	655,000
Apr.	2017	362,000,000	348,000	629,000	83,800	360,000	369,000,000	1,410,000	2,620,000
May	2017	182,000,000	330,000	445,000	20,200	56,900	26,400,000	1,390,000	2,040,000
June	2017	58,500,000	118,000	140,000	4,040	8,740	2,450,000	692,000	851,000
July	2017	29,800,000	57,900	65,400	1,510	2,730	526,000	461,000	513,000
Aug.	2017	48,500,000	93,400	109,000	3,220	6,860	1,890,000	640,000	749,000
Sep.	2017	17,000,000	33,300	35,700	677	1,060	156,000	336,000	357,000
Oct.	2017	19,500,000	42,900	45,200	836	1,390	233,000	378,000	419,000
Nov.	2017	15,000,000	35,200	36,200	572	882	127,000	318,000	358,000
Dec.	2017	17,600,000	46,100	46,800	708	1,130	173,000	356,000	420,000
Jan.	2018	17,300,000	47,300	47,900	691	1,090	166,000	345,000	417,000
Feb.	2018	153,000,000	261,000	384,000	23,600	80,600	55,200,000	946,000	1,640,000
Mar.	2018	141,000,000	296,000	384,000	16,000	46,800	24,400,000	1,130,000	1,770,000
Apr.	2018	61,200,000	153,000	174,000	4,060	8,500	2,260,000	736,000	988,000
May	2018	93,700,000	183,000	232,000	8,880	23,700	10,800,000	879,000	1,220,000
June	2018	19,600,000	38,300	42,200	814	1,310	209,000	339,000	379,000
July	2018	19,200,000	35,500	39,300	809	1,320	223,000	341,000	372,000
Aug.	2018	31,900,000	61,500	69,700	1,780	3,480	855,000	483,000	553,000
Sep.	2018	15,000,000	28,700	30,700	571	885	135,000	304,000	327,000

ILLINOIS RIVER SOUTH OF SILOAM SPRINGS, ARKANSAS (IR59)

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
July	2009	21,200,000	47,300	50,200	1,340	1,540	268,000	358,000	347,000
Aug.	2009	19,100,000	42,300	44,500	1,350	1,360	233,000	339,000	327,000
Sep.	2009	37,100,000	85,200	93,400	4,270	5,370	1,890,000	518,000	552,000
Oct.	2009	185,000,000	318,000	431,000	45,500	86,500	74,000,000	1,320,000	1,820,000
Nov.	2009	52,900,000	146,000	157,000	4,070	7,270	1,090,000	744,000	843,000
Dec.	2009	27,300,000	82,000	85,400	995	2,260	111,000	493,000	530,000
Jan.	2010	40,200,000	124,000	134,000	1,430	4,650	306,000	613,000	698,000
Feb.	2010	72,600,000	214,000	245,000	3,130	12,000	1,200,000	867,000	1,060,000
Mar.	2010	95,600,000	239,000	294,000	5,690	22,800	5,450,000	938,000	1,190,000
Apr.	2010	54,100,000	146,000	165,000	2,350	7,250	1,010,000	680,000	776,000
May	2010	97,500,000	211,000	260,000	8,880	22,200	10,100,000	907,000	1,100,000
June	2010	31,500,000	73,700	80,400	1,850	2,910	555,000	462,000	478,000
July	2010	99,400,000	171,000	222,000	19,900	32,400	37,400,000	823,000	1,010,000
Aug.	2010	16,000,000	34,300	36,200	1,020	984	138,000	301,000	292,000
Sep.	2010	34,700,000	80,300	86,800	3,570	4,110	1,180,000	512,000	547,000
Oct.	2010	15,300,000	36,800	38,100	766	898	62,400	315,000	316,000
Nov.	2010	16,500,000	43,700	45,600	679	1,130	66,300	331,000	345,000
Dec.	2010	14,700,000	40,700	42,500	410	846	28,000	315,000	330,000
Jan.	2011	15,000,000	42,900	45,400	336	890	26,600	314,000	333,000
Feb.	2011	33,100,000	97,100	108,000	1,090	3,950	344,000	493,000	569,000
Mar.	2011	35,800,000	103,000	114,000	1,080	3,680	271,000	538,000	609,000
Apr.	2011	375,000,000	377,000	700,000	84,200	364,000	502,000,000	1,350,000	2,400,000
May	2011	276,000,000	413,000	614,000	50,500	153,000	209,000,000	1,550,000	2,290,000
June	2011	39,300,000	90,600	101,000	2,580	4,270	1,000,000	533,000	576,000
July	2011	18,700,000	39,800	42,800	1,100	1,230	196,000	327,000	326,000
Aug.	2011	18,300,000	39,100	41,700	1,280	1,270	217,000	328,000	329,000
Sep.	2011	18,900,000	42,800	45,500	1,420	1,530	253,000	337,000	348,000
Oct.	2011	16,100,000	38,400	40,100	833	981	73,500	326,000	335,000
Nov.	2011	74,200,000	172,000	206,000	8,630	18,200	5,990,000	817,000	1,040,000
Dec.	2011	59,000,000	167,000	186,000	3,380	8,770	1,000,000	804,000	981,000
Jan.	2012	41,200,000	119,000	134,000	1,630	5,500	509,000	604,000	723,000
Feb.	2012	41,600,000	122,000	137,000	1,430	5,080	403,000	600,000	716,000
Mar.	2012	97,000,000	216,000	282,000	6,730	28,200	8,720,000	875,000	1,180,000
Apr.	2012	31,400,000	82,600	91,900	1,050	2,900	276,000	473,000	529,000
May	2012	17,400,000	40,200	44,200	576	1,120	105,000	306,000	318,000
June	2012	12,700,000	26,200	28,800	504	705	80,200	237,000	238,000
July	2012	7,930,000	14,200	15,700	321	315	27,600	172,000	166,000
Aug.	2012	10,800,000	21,000	22,700	628	583	79,700	218,000	217,000
Sep.	2012	12,000,000	25,100	26,700	673	635	61,600	250,000	252,000

ILLINOIS RIVER SOUTH OF SILOAM SPRINGS, ARKANSAS (IR59) continued

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
Oct.	2012	13,500,000	30,800	32,600	710	841	76,500	277,000	289,000
Nov.	2012	9,620,000	22,500	23,900	302	434	15,200	226,000	235,000
Dec.	2012	11,800,000	30,400	32,400	314	621	21,200	265,000	285,000
Jan.	2013	19,300,000	51,400	58,300	663	2,250	226,000	332,000	385,000
Feb.	2013	24,600,000	71,500	78,000	624	2,010	94,500	422,000	487,000
Mar.	2013	53,000,000	139,000	164,000	2,240	8,220	1,190,000	662,000	823,000
Apr.	2013	109,000,000	237,000	303,000	8,180	27,600	10,800,000	989,000	1,330,000
May	2013	142,000,000	257,000	347,000	17,000	48,700	38,700,000	1,100,000	1,500,000
June	2013	36,000,000	79,700	90,200	2,340	3,900	976,000	492,000	552,000
July	2013	19,200,000	39,300	43,200	1,330	1,480	367,000	325,000	340,000
Aug.	2013	64,600,000	124,000	148,000	10,300	13,000	9,540,000	701,000	849,000
Sep.	2013	17,600,000	38,300	40,900	1,210	1,220	171,000	327,000	347,000
Oct.	2013	24,500,000	57,300	62,000	1,860	2,350	427,000	419,000	469,000
Nov.	2013	23,400,000	61,000	64,700	1,140	1,820	132,000	432,000	488,000
Dec.	2013	55,700,000	145,000	169,000	3,510	9,880	1,460,000	715,000	924,000
Jan.	2014	39,600,000	113,000	126,000	1,530	4,750	399,000	601,000	741,000
Feb.	2014	17,300,000	48,200	52,600	370	1,130	39,900	331,000	378,000
Mar.	2014	67,600,000	164,000	202,000	3,550	13,800	3,060,000	742,000	978,000
Apr.	2014	44,500,000	114,000	130,000	1,760	5,110	640,000	597,000	721,000
May	2014	36,100,000	83,500	95,500	1,790	3,830	739,000	502,000	581,000
June	2014	27,900,000	60,700	67,700	1,620	2,370	471,000	423,000	468,000
July	2014	14,500,000	28,500	31,200	766	810	111,000	271,000	282,000
Aug.	2014	13,800,000	27,100	29,400	823	757	101,000	269,000	280,000
Sep.	2014	15,000,000	31,200	33,600	958	925	123,000	291,000	310,000
Oct.	2014	50,700,000	109,000	128,000	6,400	9,490	3,390,000	622,000	786,000
Nov.	2014	19,800,000	50,200	53,400	887	1,380	88,800	383,000	436,000
Dec.	2014	39,500,000	109,000	121,000	1,810	4,390	350,000	615,000	763,000
Jan.	2015	29,000,000	81,900	90,000	937	2,640	154,000	494,000	599,000
Feb.	2015	20,200,000	55,800	61,600	478	1,500	68,600	364,000	430,000
Mar.	2015	99,200,000	246,000	303,000	5,010	18,700	3,190,000	1,030,000	1,420,000
Apr.	2015	45,000,000	113,000	130,000	1,770	4,960	619,000	607,000	746,000
May	2015	185,000,000	324,000	446,000	22,600	56,900	39,500,000	1,340,000	1,970,000
June	2015	155,000,000	265,000	354,000	24,400	47,000	49,200,000	1,210,000	1,700,000
July	2015	136,000,000	231,000	302,000	24,200	37,400	37,200,000	1,130,000	1,540,000
Aug.	2015	37,400,000	77,900	86,800	3,690	3,870	1,140,000	541,000	625,000
Sep.	2015	21,800,000	46,800	50,600	1,630	1,620	256,000	385,000	430,000
Oct.	2015	14,900,000	33,000	35,400	735	831	58,600	309,000	342,000
Nov.	2015	76,500,000	162,000	205,000	8,490	19,800	5,650,000	792,000	1,120,000
Dec.	2015	371,000,000	458,000	767,000	79,800	337,000	247,000,000	1,790,000	3,340,000

ILLINOIS RIVER SOUTH OF SILOAM SPRINGS, ARKANSAS (IR59) continued

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
Jan.	2016	90,400,000	239,000	285,000	4,890	15,600	1,800,000	1,060,000	1,480,000
Feb.	2016	30,800,000	86,500	96,500	845	2,700	141,000	503,000	626,000
Mar.	2016	58,100,000	149,000	177,000	2,340	8,280	1,070,000	729,000	962,000
Apr.	2016	28,500,000	68,100	78,400	1,060	2,750	434,000	431,000	519,000
May	2016	50,700,000	108,000	130,000	3,460	7,410	2,550,000	603,000	761,000
June	2016	26,700,000	56,000	63,500	1,510	2,270	459,000	404,000	465,000
July	2016	46,100,000	92,700	107,000	4,470	5,550	2,130,000	596,000	718,000
Aug.	2016	18,000,000	35,400	38,800	1,210	1,130	183,000	327,000	360,000
Sep.	2016	16,600,000	34,000	37,000	1,110	1,080	151,000	313,000	350,000
Oct.	2016	17,500,000	39,000	42,100	980	1,160	109,000	340,000	390,000
Nov.	2016	11,700,000	26,600	28,800	400	567	23,600	262,000	298,000
Dec.	2016	12,100,000	29,300	32,000	303	590	17,700	271,000	316,000
Jan.	2017	21,900,000	59,100	65,700	604	1,720	84,100	398,000	493,000
Feb.	2017	15,400,000	40,200	44,800	316	931	33,300	301,000	363,000
Mar.	2017	45,200,000	110,000	133,000	1,910	6,540	1,050,000	577,000	767,000
Apr.	2017	349,000,000	342,000	625,000	81,900	334,000	574,000,000	1,380,000	2,620,000
May	2017	174,000,000	314,000	427,000	18,300	48,100	28,400,000	1,350,000	2,020,000
June	2017	63,500,000	127,000	154,000	5,550	9,740	4,130,000	710,000	918,000
July	2017	33,100,000	66,000	75,300	2,660	3,210	951,000	475,000	565,000
Aug.	2017	55,500,000	107,000	126,000	7,230	8,100	3,930,000	676,000	858,000
Sep.	2017	17,500,000	35,700	38,900	1,150	1,090	138,000	331,000	378,000
Oct.	2017	20,000,000	44,300	48,400	1,210	1,450	161,000	373,000	442,000
Nov.	2017	14,300,000	33,300	36,200	550	819	43,600	302,000	356,000
Dec.	2017	17,800,000	45,200	49,500	548	1,130	49,100	358,000	437,000
Jan.	2018	17,500,000	45,600	50,500	411	1,080	38,800	349,000	429,000
Feb.	2018	129,000,000	216,000	330,000	12,400	58,300	23,200,000	864,000	1,490,000
Mar.	2018	117,000,000	234,000	320,000	8,620	34,200	12,100,000	999,000	1,550,000
Apr.	2018	59,000,000	139,000	167,000	2,670	7,860	1,250,000	717,000	968,000
May	2018	83,100,000	159,000	207,000	6,930	18,500	9,210,000	805,000	1,130,000
June	2018	17,300,000	34,000	38,600	779	1,050	143,000	302,000	348,000
July	2018	18,500,000	34,900	39,500	1,200	1,270	275,000	317,000	365,000
Aug.	2018	30,100,000	58,000	66,600	3,080	3,220	1,170,000	441,000	538,000
Sep.	2018	13,400,000	26,000	28,700	803	745	86,800	269,000	309,000

ILLINOIS RIVER AT SAVOY, ARKANSAS (SAVOY)

Month	Year	Monthly Q	NO_3-N	TN	SRP	TP	TSS	Cl	SO_4
		m3	kg	kg	kg	kg	kg	kg	kg
July	2009	2,210,000	6,430	6,730	77	140	26,300	40,000	42,400
Aug.	2009	3,120,000	8,430	9,220	150	292	85,200	49,600	55,500
Sep.	2009	15,400,000	27,600	39,500	2,100	4,800	2,800,000	126,000	197,000
Oct.	2009	69,000,000	86,300	163,000	16,100	39,600	27,300,000	345,000	683,000
Nov.	2009	12,300,000	31,400	36,300	931	1,920	283,000	138,000	225,000
Dec.	2009	6,530,000	19,800	20,800	372	735	52,100	92,200	145,000
Jan.	2010	16,100,000	38,100	46,300	1,520	3,240	328,000	148,000	300,000
Feb.	2010	29,800,000	62,300	81,500	3,240	7,020	817,000	221,000	506,000
Mar.	2010	33,500,000	60,400	85,700	4,430	9,960	2,150,000	216,000	499,000
Apr.	2010	11,400,000	26,700	31,400	877	1,810	277,000	109,000	206,000
May	2010	28,200,000	45,100	67,200	3,650	8,160	3,620,000	175,000	358,000
June	2010	3,970,000	10,300	11,300	187	360	74,500	54,700	72,800
July	2010	24,000,000	31,700	53,900	4,190	9,870	9,790,000	139,000	245,000
Aug.	2010	2,270,000	6,450	6,870	81	149	28,000	42,200	43,600
Sep.	2010	4,570,000	11,300	13,000	287	583	177,000	63,100	78,200
Oct.	2010	1,580,000	5,240	5,300	48	85	6,860	37,000	36,200
Nov.	2010	2,320,000	7,580	7,680	91	171	11,800	46,200	54,500
Dec.	2010	2,210,000	7,650	7,530	79	146	6,860	45,800	56,500
Jan.	2011	3,200,000	10,700	10,600	131	245	11,100	56,900	81,500
Feb.	2011	12,000,000	27,600	33,400	1,110	2,370	293,000	113,000	227,000
Mar.	2011	11,100,000	27,200	31,300	801	1,640	163,000	113,000	219,000
Apr.	2011	134,000,000	92,800	261,000	51,500	135,000	119,000,000	360,000	934,000
May	2011	59,300,000	66,200	127,000	12,800	31,000	24,200,000	256,000	582,000
June	2011	4,400,000	10,900	12,200	211	406	84,700	58,800	80,100
July	2011	2,010,000	5,510	5,930	66	120	21,300	37,400	39,100
Aug.	2011	1,800,000	5,080	5,450	57	104	17,100	36,400	35,600
Sep.	2011	1,750,000	5,170	5,470	57	104	13,300	37,000	36,400
Oct.	2011	1,990,000	6,200	6,410	65	119	10,300	42,700	44,500
Nov.	2011	16,000,000	32,200	42,900	1,750	3,840	849,000	145,000	257,000
Dec.	2011	18,000,000	40,200	50,300	1,680	3,590	450,000	173,000	328,000
Jan.	2012	12,800,000	30,400	36,300	1,080	2,280	223,000	131,000	253,000
Feb.	2012	11,000,000	26,500	31,100	871	1,820	171,000	113,000	222,000
Mar.	2012	29,400,000	45,700	70,700	4,510	10,400	2,590,000	178,000	412,000
Apr.	2012	6,250,000	15,600	17,400	342	671	74,900	74,800	127,000
May	2012	2,920,000	7,810	8,400	112	209	25,800	45,800	60,700
June	2012	1,510,000	4,040	4,400	51	93	14,700	28,400	30,600
July	2012	808,000	2,320	2,520	18	32	3,940	20,700	17,100
Aug.	2012	906,000	2,620	2,840	22	39	4,930	23,200	19,000
Sep.	2012	1,030,000	3,100	3,300	26	46	4,760	26,400	22,600

ILLINOIS RIVER AT SAVOY, ARKANSAS (SAVOY) continued

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
Oct.	2012	1,500,000	4,640	4,850	45	81	6,490	35,200	34,500
Nov.	2012	1,550,000	5,030	5,130	46	83	4,420	36,500	38,500
Dec.	2012	1,610,000	5,400	5,410	48	87	3,390	37,500	42,800
Jan.	2013	3,200,000	8,760	9,660	196	399	32,600	49,200	73,900
Feb.	2013	3,670,000	10,700	11,200	165	314	16,400	56,500	89,800
Mar.	2013	13,600,000	27,900	35,500	1,230	2,610	366,000	120,000	247,000
Apr.	2013	25,900,000	42,800	61,600	3,080	6,850	1,980,000	176,000	383,000
May	2013	34,100,000	47,300	75,900	4,940	11,300	5,620,000	199,000	423,000
June	2013	7,050,000	14,900	18,000	417	827	210,000	78,400	119,000
July	2013	4,290,000	9,880	11,500	195	372	90,400	60,500	76,000
Aug.	2013	3,170,000	7,060	8,470	176	351	125,000	46,600	54,200
Sep.	2013	1,910,000	5,060	5,640	73	136	22,100	37,600	38,500
Oct.	2013	3,270,000	8,700	9,630	141	269	35,000	57,000	67,600
Nov.	2013	3,370,000	9,580	10,300	141	267	19,500	59,700	76,800
Dec.	2013	12,400,000	26,100	33,600	1,190	2,570	330,000	124,000	229,000
Jan.	2014	10,300,000	24,400	28,800	745	1,530	126,000	115,000	215,000
Feb.	2014	5,090,000	13,700	14,900	255	493	27,600	70,300	120,000
Mar.	2014	19,900,000	34,700	48,800	2,360	5,250	1,050,000	149,000	325,000
Apr.	2014	10,000,000	20,900	25,700	711	1,450	203,000	98,200	186,000
May	2014	5,630,000	12,300	14,600	309	608	111,000	67,200	105,000
June	2014	4,220,000	9,300	11,000	203	391	90,900	56,000	76,200
July	2014	1,310,000	3,350	3,760	37	65	9,930	27,800	26,500
Aug.	2014	1,470,000	3,760	4,240	45	81	13,100	31,000	29,400
Sep.	2014	1,630,000	4,140	4,710	61	115	22,300	33,000	32,600
Oct.	2014	8,140,000	15,500	20,800	740	1,580	443,000	86,900	131,000
Nov.	2014	3,460,000	9,330	10,300	152	289	23,900	59,700	77,600
Dec.	2014	10,200,000	23,000	28,000	748	1,540	144,000	116,000	205,000
Jan.	2015	7,970,000	18,600	22,100	566	1,160	100,000	94,900	169,000
Feb.	2015	3,820,000	10,200	11,100	176	338	18,400	57,100	92,700
Mar.	2015	30,200,000	48,600	71,500	3,560	7,850	1,410,000	205,000	477,000
Apr.	2015	9,590,000	19,800	24,300	622	1,250	168,000	97,400	182,000
May	2015	54,100,000	61,900	112,000	8,500	19,500	10,200,000	268,000	610,000
June	2015	42,400,000	46,700	85,800	7,310	17,200	15,400,000	218,000	445,000
July	2015	49,200,000	52,100	98,900	8,460	19,800	18,100,000	249,000	491,000
Aug.	2015	9,430,000	17,200	22,800	669	1,370	514,000	100,000	145,000
Sep.	2015	4,900,000	10,300	12,700	277	550	139,000	66,900	85,700
Oct.	2015	1,800,000	4,910	5,410	57	103	8,700	39,300	40,800
Nov.	2015	25,200,000	34,600	58,500	3,910	9,000	2,170,000	168,000	338,000
Dec.	2015	116,000,000	92,400	235,000	40,800	107,000	44,400,000	420,000	1,040,000

ILLINOIS RIVER AT SAVOY, ARKANSAS (SAVOY) continued

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
Jan.	2016	20,300,000	37,400	51,400	2,070	4,460	514,000	173,000	366,000
Feb.	2016	4,080,000	10,600	11,700	185	352	18,000	60,800	99,500
Mar.	2016	14,400,000	26,400	35,300	1,300	2,780	372,000	124,000	261,000
Apr.	2016	5,910,000	11,400	14,600	460	971	248,000	63,600	108,000
May	2016	15,700,000	22,900	34,500	1,710	3,750	1,590,000	114,000	220,000
June	2016	4,490,000	8,990	11,100	232	452	102,000	56,300	80,000
July	2016	4,530,000	8,810	11,100	245	483	152,000	58,300	76,300
Aug.	2016	2,320,000	5,250	6,200	84	156	30,300	41,400	44,300
Sep.	2016	1,420,000	3,580	4,090	41	73	8,450	31,800	30,200
Oct.	2016	1,650,000	4,370	4,890	50	91	7,520	36,900	37,700
Nov.	2016	1,510,000	4,240	4,630	45	80	4,220	35,100	37,700
Dec.	2016	1,480,000	4,330	4,630	43	77	2,930	34,800	39,800
Jan.	2017	1,810,000	5,070	5,480	64	118	4,780	36,800	48,400
Feb.	2017	1,680,000	4,680	5,030	54	99	3,800	33,400	45,200
Mar.	2017	9,670,000	17,400	23,300	837	1,770	270,000	89,200	177,000
Apr.	2017	99,300,000	64,800	177,000	32,100	82,400	65,900,000	299,000	783,000
May	2017	43,200,000	50,400	88,100	6,200	14,100	6,600,000	234,000	528,000
June	2017	13,800,000	20,700	30,200	1,230	2,620	1,050,000	112,000	199,000
July	2017	4,960,000	9,200	11,800	272	538	162,000	61,300	83,200
Aug.	2017	11,000,000	16,000	24,200	1,080	2,340	1,310,000	97,100	149,000
Sep.	2017	1,540,000	3,710	4,310	46	83	10,300	33,200	32,400
Oct.	2017	2,190,000	5,240	6,120	86	161	18,500	42,400	47,100
Nov.	2017	1,380,000	3,760	4,160	39	70	3,660	32,800	34,600
Dec.	2017	1,820,000	4,970	5,460	60	110	4,690	38,900	47,600
Jan.	2018	2,130,000	5,640	6,230	79	148	6,440	40,800	55,900
Feb.	2018	42,300,000	39,100	85,000	10,000	24,600	7,150,000	177,000	474,000
Mar.	2018	35,500,000	41,800	74,300	5,890	13,700	3,930,000	194,000	475,000
Apr.	2018	13,100,000	22,400	30,400	1,010	2,090	320,000	115,000	233,000
May	2018	24,400,000	28,700	49,500	3,630	8,390	3,970,000	146,000	309,000
June	2018	2,430,000	5,080	6,130	88	164	26,800	39,000	47,900
July	2018	2,040,000	4,300	5,220	70	128	24,100	36,200	39,400
Aug.	2018	6,070,000	9,950	13,900	444	923	386,000	67,900	93,500
Sep.	2018	2,190,000	4,790	5,790	83	155	24,500	40,500	43,800

OSAGE CREEK NEAR ELM SPRINGS, ARKANSAS (OSAGE)

Month	Year	Monthly Q	NO_3-N	TN	SRP	TP	TSS	Cl	SO_4
		m3	kg	kg	kg	kg	kg	kg	kg
July	2009	9,690,000	32,500	34,700	836	1,210	101,000	247,000	270,000
Aug.	2009	7,240,000	26,600	26,900	679	850	47,600	222,000	244,000
Sep.	2009	9,880,000	32,200	34,600	970	1,520	165,000	248,000	264,000
Oct.	2009	34,900,000	68,100	92,400	7,210	14,600	14,200,000	385,000	418,000
Nov.	2009	13,400,000	44,900	49,800	1,050	1,990	173,000	302,000	300,000
Dec.	2009	7,430,000	34,200	33,900	447	666	21,400	254,000	249,000
Jan.	2010	8,500,000	38,400	39,100	441	760	42,400	265,000	259,000
Feb.	2010	13,100,000	49,600	55,200	654	1,390	126,000	294,000	287,000
Mar.	2010	16,700,000	55,100	64,200	976	2,270	565,000	317,000	324,000
Apr.	2010	14,000,000	48,700	55,000	763	1,520	186,000	296,000	308,000
May	2010	22,000,000	57,300	71,100	1,800	3,990	1,660,000	331,000	365,000
June	2010	10,800,000	35,800	39,200	800	1,280	130,000	254,000	282,000
July	2010	12,100,000	34,100	38,900	1,240	2,230	758,000	248,000	285,000
Aug.	2010	3,690,000	16,900	15,400	365	322	9,250	169,000	201,000
Sep.	2010	10,400,000	31,300	34,600	1,150	1,990	495,000	244,000	269,000
Oct.	2010	5,520,000	24,000	23,100	469	537	14,500	213,000	230,000
Nov.	2010	7,750,000	31,600	32,200	561	836	36,300	246,000	252,000
Dec.	2010	5,840,000	28,800	27,700	353	464	11,600	231,000	235,000
Jan.	2011	6,250,000	31,600	30,600	321	454	12,100	239,000	241,000
Feb.	2011	6,680,000	31,900	31,900	314	497	20,600	226,000	230,000
Mar.	2011	7,310,000	34,400	34,500	342	522	21,900	245,000	255,000
Apr.	2011	86,900,000	102,000	180,000	42,400	59,900	181,000,000	408,000	558,000
May	2011	57,300,000	92,300	140,000	12,700	24,600	47,700,000	436,000	537,000
June	2011	15,900,000	44,800	52,700	1,230	2,260	325,000	296,000	335,000
July	2011	10,300,000	32,600	35,700	892	1,350	130,000	251,000	289,000
Aug.	2011	9,190,000	29,500	31,700	882	1,270	113,000	241,000	276,000
Sep.	2011	8,200,000	27,700	29,300	787	1,130	89,100	231,000	260,000
Oct.	2011	8,010,000	29,800	30,800	682	955	43,600	246,000	266,000
Nov.	2011	17,800,000	47,200	57,200	2,110	4,600	2,250,000	310,000	330,000
Dec.	2011	11,400,000	42,800	46,400	703	1,300	80,400	298,000	303,000
Jan.	2012	8,520,000	37,300	38,500	442	755	41,800	266,000	272,000
Feb.	2012	8,800,000	37,800	39,700	420	751	44,300	258,000	265,000
Mar.	2012	14,700,000	48,500	56,400	859	1,960	497,000	298,000	321,000
Apr.	2012	10,100,000	38,600	41,800	529	915	68,700	263,000	288,000
May	2012	7,480,000	29,700	30,700	454	646	42,300	229,000	263,000
June	2012	6,730,000	25,600	26,200	489	623	33,700	211,000	250,000
July	2012	4,260,000	18,500	17,500	374	345	9,390	180,000	222,000
Aug.	2012	5,870,000	21,600	21,700	575	701	59,700	200,000	241,000
Sep.	2012	6,720,000	24,300	24,900	630	789	36,400	217,000	251,000

OSAGE CREEK NEAR ELM SPRINGS, ARKANSAS (OSAGE) continued

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
Oct.	2012	6,900,000	26,100	26,600	603	831	50,700	227,000	256,000
Nov.	2012	4,930,000	23,000	22,100	361	415	8,760	207,000	228,000
Dec.	2012	5,440,000	26,400	25,400	334	433	12,500	223,000	240,000
Jan.	2013	7,510,000	32,700	33,600	409	720	72,300	246,000	261,000
Feb.	2013	6,560,000	30,700	31,000	306	473	16,900	226,000	241,000
Mar.	2013	11,300,000	41,900	46,400	589	1,190	199,000	279,000	304,000
Apr.	2013	23,300,000	56,600	73,300	2,430	5,460	5,580,000	326,000	378,000
May	2013	32,000,000	61,600	85,600	6,160	11,700	22,400,000	348,000	428,000
June	2013	10,200,000	32,500	36,200	746	1,170	116,000	247,000	295,000
July	2013	8,240,000	26,400	28,400	764	1,130	171,000	224,000	274,000
Aug.	2013	23,000,000	46,500	60,800	3,480	6,990	4,890,000	318,000	391,000
Sep.	2013	9,610,000	29,900	32,800	916	1,370	107,000	249,000	290,000
Oct.	2013	11,800,000	35,900	40,400	1,080	1,860	208,000	281,000	317,000
Nov.	2013	9,610,000	34,100	36,800	717	1,180	66,500	267,000	292,000
Dec.	2013	12,300,000	42,200	47,500	798	1,600	174,000	298,000	320,000
Jan.	2014	10,500,000	41,100	44,600	553	1,030	63,700	290,000	308,000
Feb.	2014	6,180,000	29,100	29,300	288	430	13,800	222,000	242,000
Mar.	2014	12,300,000	43,500	49,200	632	1,300	182,000	289,000	322,000
Apr.	2014	10,300,000	37,700	41,500	533	927	68,800	265,000	303,000
May	2014	12,100,000	38,500	43,900	765	1,360	173,000	274,000	326,000
June	2014	10,400,000	32,300	36,300	774	1,220	120,000	250,000	305,000
July	2014	7,080,000	24,500	25,700	602	745	40,100	219,000	273,000
Aug.	2014	6,810,000	23,500	24,500	635	760	35,300	218,000	270,000
Sep.	2014	9,370,000	28,900	31,800	893	1,320	98,000	246,000	294,000
Oct.	2014	19,000,000	43,800	55,100	2,470	5,200	2,280,000	313,000	371,000
Nov.	2014	8,450,000	31,100	33,200	613	942	40,700	255,000	286,000
Dec.	2014	10,500,000	38,600	42,300	638	1,130	60,500	289,000	316,000
Jan.	2015	8,810,000	36,500	38,700	454	765	31,700	273,000	298,000
Feb.	2015	7,400,000	31,900	33,400	347	571	24,600	237,000	263,000
Mar.	2015	15,700,000	50,900	60,200	823	1,790	270,000	324,000	368,000
Apr.	2015	12,900,000	42,500	49,000	692	1,330	143,000	288,000	337,000
May	2015	28,000,000	61,700	82,600	2,400	5,500	2,380,000	367,000	459,000
June	2015	28,800,000	56,300	77,000	3,830	7,950	7,900,000	349,000	450,000
July	2015	19,900,000	45,000	57,000	1,990	3,850	1,030,000	319,000	405,000
Aug.	2015	13,300,000	34,700	40,900	1,350	2,260	338,000	279,000	348,000
Sep.	2015	8,550,000	26,900	29,300	806	1,130	68,500	239,000	293,000
Oct.	2015	6,960,000	25,500	26,500	588	762	27,200	233,000	280,000
Nov.	2015	18,100,000	45,200	56,800	1,760	3,990	1,130,000	313,000	367,000
Dec.	2015	67,400,000	93,300	153,000	28,600	44,400	81,900,000	461,000	599,000

OSAGE CREEK NEAR ELM SPRINGS, ARKANSAS (OSAGE) continued

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
Jan.	2016	18,400,000	56,600	68,400	1,050	2,380	246,000	362,000	402,000
Feb.	2016	10,200,000	39,000	43,200	485	904	51,100	275,000	310,000
Mar.	2016	11,900,000	42,700	48,300	576	1,110	88,000	295,000	341,000
Apr.	2016	8,770,000	32,700	35,600	460	750	54,100	248,000	300,000
May	2016	9,610,000	32,300	35,900	599	959	92,800	252,000	316,000
June	2016	9,280,000	29,000	32,500	686	1,040	99,600	238,000	306,000
July	2016	17,600,000	40,100	50,500	1,820	3,480	1,170,000	299,000	390,000
Aug.	2016	8,940,000	27,000	29,900	835	1,140	70,600	243,000	311,000
Sep.	2016	8,730,000	26,300	29,200	848	1,250	121,000	237,000	299,000
Oct.	2016	8,370,000	27,600	30,000	733	1,100	83,600	247,000	301,000
Nov.	2016	5,230,000	22,300	22,200	381	451	10,100	212,000	256,000
Dec.	2016	5,040,000	23,700	23,200	305	366	7,050	219,000	259,000
Jan.	2017	7,860,000	32,400	34,300	405	668	31,200	258,000	298,000
Feb.	2017	6,330,000	28,000	29,000	296	449	15,600	223,000	261,000
Mar.	2017	13,000,000	42,100	49,400	698	1,480	267,000	292,000	350,000
Apr.	2017	71,300,000	86,400	149,000	31,100	44,900	134,000,000	412,000	609,000
May	2017	34,000,000	66,500	93,600	3,750	8,370	7,720,000	392,000	520,000
June	2017	13,400,000	36,000	43,200	1,020	1,800	257,000	275,000	359,000
July	2017	13,300,000	33,900	40,700	1,220	2,090	382,000	274,000	363,000
Aug.	2017	16,600,000	38,300	47,700	1,760	3,200	607,000	302,000	397,000
Sep.	2017	8,110,000	25,200	27,700	759	1,030	53,700	235,000	302,000
Oct.	2017	6,990,000	24,200	25,700	607	830	51,400	230,000	291,000
Nov.	2017	6,100,000	23,800	24,600	444	599	24,400	222,000	273,000
Dec.	2017	8,630,000	32,500	35,200	520	842	36,200	268,000	316,000
Jan.	2018	8,050,000	32,700	34,900	411	664	25,500	264,000	310,000
Feb.	2018	31,200,000	58,900	86,600	4,710	10,500	13,200,000	329,000	426,000
Mar.	2018	33,800,000	71,000	100,000	3,250	8,000	6,690,000	400,000	512,000
Apr.	2018	25,700,000	62,400	82,900	1,570	3,710	772,000	378,000	481,000
May	2018	17,800,000	43,600	55,600	1,430	3,050	1,570,000	304,000	402,000
June	2018	7,710,000	25,100	27,600	558	765	50,900	223,000	301,000
July	2018	8,820,000	25,800	29,000	782	1,130	118,000	235,000	320,000
Aug.	2018	9,680,000	26,600	30,500	961	1,460	193,000	243,000	329,000
Sep.	2018	5,760,000	19,900	20,800	542	628	25,600	204,000	274,000

BARON FORK AT DUTCH MILLS, ARKANSAS (BARON)

Month	Year	Monthly Q	NO_3-N	TN	SRP	TP	TSS	Cl	SO_4
		m3	kg	kg	kg	kg	kg	kg	kg
July	2009	293,000	218	356	7	18	2,690	2,440	4,820
Aug.	2009	343,000	274	436	10	27	4,390	2,820	5,480
Sep.	2009	7,200,000	7,550	13,800	803	2,000	475,000	28,600	72,100
Oct.	2009	13,900,000	19,200	33,100	1,810	3,960	847,000	51,500	142,000
Nov.	2009	2,700,000	6,460	7,700	142	275	35,500	19,800	50,800
Dec.	2009	1,620,000	5,480	5,640	68	109	10,200	14,100	38,100
Jan.	2010	3,620,000	15,000	15,500	230	320	31,100	24,600	77,300
Feb.	2010	6,190,000	25,300	26,900	455	620	63,000	36,000	121,000
Mar.	2010	8,730,000	25,600	31,500	861	1,260	166,000	39,000	134,000
Apr.	2010	3,160,000	8,090	9,260	181	293	35,000	18,900	57,600
May	2010	6,190,000	9,660	13,700	530	1,040	185,000	26,700	79,400
June	2010	699,000	767	1,010	22	52	7,650	5,120	11,800
July	2010	723,000	650	908	26	67	11,800	5,080	11,000
Aug.	2010	67,200	34	52	1	3	372	638	1,100
Sep.	2010	1,890,000	1,940	2,940	164	420	97,400	9,400	22,000
Oct.	2010	409,000	571	646	11	24	2,800	3,990	8,310
Nov.	2010	963,000	2,330	2,340	39	71	7,830	8,400	20,600
Dec.	2010	508,000	1,490	1,370	17	26	2,300	5,080	12,800
Jan.	2011	546,000	1,880	1,630	17	24	1,880	5,560	14,900
Feb.	2011	3,130,000	12,600	11,500	194	266	25,800	20,400	66,400
Mar.	2011	3,000,000	10,500	9,690	164	236	23,600	19,900	63,200
Apr.	2011	24,600,000	29,200	52,500	5,850	9,760	2,120,000	47,700	174,000
May	2011	15,100,000	18,200	28,400	2,390	4,670	1,080,000	41,900	135,000
June	2011	990,000	1,150	1,360	37	84	12,900	6,730	16,100
July	2011	214,000	146	189	4	12	1,630	1,830	3,570
Aug.	2011	428,000	349	434	12	34	5,530	3,430	6,830
Sep.	2011	315,000	316	364	9	22	3,190	2,790	5,540
Oct.	2011	503,000	747	759	14	31	3,740	4,750	10,100
Nov.	2011	4,360,000	9,300	10,300	439	820	136,000	22,500	62,800
Dec.	2011	5,170,000	16,600	15,600	413	651	79,400	30,800	92,700
Jan.	2012	3,560,000	14,000	12,300	269	368	38,800	22,500	71,700
Feb.	2012	3,490,000	14,200	12,000	230	311	30,800	22,500	73,600
Mar.	2012	7,090,000	20,600	21,000	723	1,040	137,000	31,700	109,000
Apr.	2012	1,600,000	3,930	3,570	69	113	12,300	11,200	32,600
May	2012	553,000	825	825	16	32	3,710	4,340	10,800
June	2012	344,000	407	471	18	39	6,670	2,050	5,080
July	2012	40,600	15	22	0	1	138	384	649
Aug.	2012	18,200	5	8	0	0	45	180	275
Sep.	2012	66,400	39	48	1	2	264	695	1,200

BARON FORK AT DUTCH MILLS, ARKANSAS (BARON) continued

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
Oct.	2012	223,000	268	269	5	11	1,270	2,270	4,570
Nov.	2012	321,000	612	535	8	14	1,300	3,430	7,650
Dec.	2012	381,000	1,020	809	9	15	1,170	4,160	10,200
Jan.	2013	1,080,000	4,180	3,350	62	84	8,080	8,180	24,600
Feb.	2013	1,480,000	5,870	4,440	64	88	7,470	11,900	36,500
Mar.	2013	3,740,000	12,300	10,700	268	378	42,600	21,400	70,600
Apr.	2013	7,360,000	16,300	17,000	740	1,190	186,000	31,500	104,000
May	2013	6,100,000	9,150	10,600	581	1,120	211,000	24,900	75,500
June	2013	1,080,000	1,290	1,370	43	97	15,100	7,040	17,300
July	2013	514,000	419	477	15	39	6,310	3,910	8,200
Aug.	2013	740,000	645	724	24	65	11,000	5,550	11,600
Sep.	2013	488,000	503	528	14	36	5,200	4,170	8,540
Oct.	2013	374,000	486	478	11	26	3,390	3,410	7,200
Nov.	2013	646,000	1,400	1,190	20	38	3,930	6,140	14,600
Dec.	2013	1,090,000	3,530	2,960	67	101	11,000	8,040	22,800
Jan.	2014	562,000	2,120	1,650	28	40	3,670	4,530	13,200
Feb.	2014	50,100	89	78	1	1	47	604	1,420
Mar.	2014	3,730,000	11,400	10,500	315	448	54,200	18,600	63,300
Apr.	2014	2,970,000	7,590	6,790	165	263	30,900	17,900	55,300
May	2014	2,550,000	4,250	4,380	152	290	44,600	13,900	39,700
June	2014	801,000	879	948	29	67	10,500	5,470	13,000
July	2014	206,000	139	165	4	11	1,640	1,730	3,420
Aug.	2014	74,900	39	50	1	3	448	687	1,230
Sep.	2014	65,900	38	46	1	3	304	662	1,160
Oct.	2014	1,700,000	2,540	2,850	140	306	57,000	9,290	23,400
Nov.	2014	639,000	1,400	1,210	21	39	4,110	5,950	14,300
Dec.	2014	2,550,000	8,780	7,260	147	225	23,600	18,500	54,100
Jan.	2015	1,840,000	7,250	5,670	94	132	12,200	14,300	43,400
Feb.	2015	786,000	2,920	2,220	27	37	2,830	7,080	20,900
Mar.	2015	6,590,000	21,400	19,900	550	770	90,900	33,000	114,000
Apr.	2015	2,210,000	5,430	4,970	109	176	20,400	14,100	42,800
May	2015	17,500,000	22,500	31,200	2,370	4,570	971,000	50,900	167,000
June	2015	10,900,000	10,800	15,600	1,330	3,010	743,000	35,200	103,000
July	2015	15,300,000	10,400	18,700	2,750	6,670	2,030,000	35,900	104,000
Aug.	2015	1,390,000	1,330	1,620	66	174	33,900	8,800	19,700
Sep.	2015	1,320,000	1,440	1,730	74	188	36,800	8,160	18,700
Oct.	2015	204,000	261	269	4	10	1,040	2,060	4,260
Nov.	2015	6,030,000	13,100	15,800	780	1,330	212,000	23,700	74,000
Dec.	2015	26,800,000	51,800	77,500	6,720	9,510	1,600,000	61,400	227,000

BARON FORK AT DUTCH MILLS, ARKANSAS (BARON) continued

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
Jan.	2016	3,350,000	13,700	11,600	197	275	26,300	23,400	74,200
Feb.	2016	1,020,000	3,910	3,170	38	51	4,000	8,820	26,700
Mar.	2016	3,270,000	11,100	10,300	208	289	30,500	19,700	65,400
Apr.	2016	2,150,000	4,460	4,910	154	262	39,400	11,600	35,600
May	2016	7,160,000	9,290	13,200	832	1,650	347,000	24,500	76,700
June	2016	1,540,000	1,900	2,340	78	169	28,400	8,850	23,000
July	2016	653,000	567	736	22	58	9,890	4,570	10,100
Aug.	2016	213,000	149	200	5	13	1,940	1,810	3,510
Sep.	2016	107,000	73	98	2	5	601	1,050	1,930
Oct.	2016	112,000	104	128	2	4	419	1,200	2,320
Nov.	2016	93,500	131	143	1	3	210	1,090	2,270
Dec.	2016	86,800	150	156	1	2	140	1,050	2,330
Jan.	2017	96,200	221	215	2	2	129	1,140	2,790
Feb.	2017	226,000	654	611	5	7	448	2,380	6,470
Mar.	2017	545,000	1,590	1,580	21	29	2,720	4,460	13,100
Apr.	2017	14,600,000	17,700	34,800	3,180	5,270	1,120,000	26,600	103,000
May	2017	8,760,000	12,700	19,300	1,040	1,940	396,000	31,200	99,400
June	2017	1,520,000	1,740	2,490	86	196	37,600	8,420	21,800
July	2017	1,310,000	1,260	1,870	62	154	29,100	7,830	18,600
Aug.	2017	4,350,000	3,520	6,630	521	1,330	366,000	15,500	40,000
Sep.	2017	81,000	52	80	1	3	370	806	1,470
Oct.	2017	230,000	281	366	5	11	1,250	2,280	4,750
Nov.	2017	1,180,000	2,880	3,290	48	87	9,500	9,790	25,300
Dec.	2017	398,000	1,060	1,140	11	18	1,490	4,050	10,300
Jan.	2018	38,400	88	99	1	1	63	433	1,050
Feb.	2018	12,200,000	33,200	53,400	2,190	2,810	398,000	33,100	134,000
Mar.	2018	9,800,000	26,600	38,700	1,220	1,710	245,000	37,400	137,000
Apr.	2018	3,630,000	9,270	12,000	217	340	40,900	20,400	65,700
May	2018	5,050,000	7,480	13,600	653	1,130	214,000	17,600	56,800
June	2018	431,000	427	676	12	26	3,620	3,250	7,540
July	2018	175,000	111	199	3	9	1,190	1,470	2,930
Aug.	2018	295,000	233	411	9	24	4,140	2,250	4,630
Sep.	2018	151,000	112	195	3	7	866	1,440	2,750

SPRING CREEK NEAR SPRINGDALE, ARKANSAS (SPRING)

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
Feb.	2012	3,560,000	12,300	14,600	450	674	30,100	144,000	192,000
Mar.	2012	6,450,000	17,100	22,800	819	1,480	198,000	167,000	223,000
Apr.	2012	3,430,000	11,700	13,800	407	578	25,500	138,000	183,000
May	2012	2,230,000	8,480	9,250	279	348	10,600	121,000	160,000
June	2012	1,650,000	6,480	6,780	238	268	5,560	107,000	146,000
July	2012	1,280,000	5,230	5,230	213	219	3,200	101,000	142,000
Aug.	2012	3,280,000	8,490	10,400	722	1,030	99,500	133,000	196,000
Sep.	2012	3,290,000	8,870	10,700	735	966	40,200	139,000	208,000
Oct.	2012	2,910,000	8,640	10,100	618	807	29,400	140,000	207,000
Nov.	2012	1,710,000	6,850	7,140	298	334	3,780	122,000	173,000
Dec.	2012	1,890,000	7,850	8,200	281	337	5,590	128,000	177,000
Jan.	2013	2,500,000	9,710	10,600	315	435	17,700	136,000	182,000
Feb.	2013	2,400,000	9,740	10,600	262	346	7,950	127,000	166,000
Mar.	2013	4,030,000	13,200	15,800	445	698	58,700	149,000	196,000
Apr.	2013	7,120,000	17,000	23,100	886	1,710	650,000	164,000	221,000
May	2013	7,990,000	18,200	25,000	1,080	1,870	357,000	178,000	247,000
June	2013	4,080,000	11,300	13,800	590	820	49,300	142,000	200,000
July	2013	4,190,000	10,300	12,800	773	1,200	247,000	141,000	205,000
Aug.	2013	9,000,000	13,500	20,700	2,120	4,740	4,710,000	159,000	241,000
Sep.	2013	2,060,000	6,350	7,040	417	538	33,600	115,000	170,000
Oct.	2013	3,960,000	10,100	12,400	825	1,250	168,000	151,000	224,000
Nov.	2013	3,310,000	10,200	11,900	573	752	20,600	150,000	217,000
Dec.	2013	6,100,000	15,100	19,800	963	1,720	292,000	175,000	249,000
Jan.	2014	4,320,000	14,000	16,600	533	781	31,000	166,000	228,000
Feb.	2014	2,630,000	10,400	11,300	268	355	8,700	131,000	173,000
Mar.	2014	4,840,000	14,900	18,100	501	815	98,300	159,000	210,000
Apr.	2014	4,120,000	13,200	15,600	422	619	38,500	147,000	196,000
May	2014	4,600,000	13,200	16,000	532	788	69,400	151,000	206,000
June	2014	4,090,000	11,300	13,600	555	775	57,700	142,000	200,000
July	2014	2,650,000	8,260	9,170	401	483	17,200	128,000	184,000
Aug.	2014	2,670,000	8,010	8,960	463	553	18,500	131,000	193,000
Sep.	2014	2,780,000	8,140	9,220	513	624	20,100	134,000	200,000
Oct.	2014	5,660,000	12,100	15,900	1,150	1,970	443,000	164,000	246,000
Nov.	2014	2,860,000	9,370	10,400	449	563	13,600	143,000	208,000
Dec.	2014	3,360,000	11,300	12,800	445	590	16,100	156,000	219,000
Jan.	2015	2,950,000	11,200	12,200	320	419	10,000	149,000	201,000
Feb.	2015	2,520,000	10,100	10,800	235	308	8,010	129,000	170,000
Mar.	2015	4,620,000	15,000	17,600	429	644	41,600	161,000	213,000
Apr.	2015	4,450,000	13,800	16,300	426	636	53,000	151,000	201,000

SPRING CREEK NEAR SPRINGDALE, ARKANSAS (SPRING) continued

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
May	2015	8,050,000	18,300	24,400	926	1,580	293,000	178,000	247,000
June	2015	8,640,000	16,700	23,200	1,220	2,280	1,240,000	171,000	246,000
July	2015	6,330,000	13,600	17,700	987	1,550	321,000	164,000	241,000
Aug.	2015	4,070,000	10,300	12,300	686	913	60,500	149,000	223,000
Sep.	2015	2,950,000	8,480	9,560	504	614	21,300	137,000	205,000
Oct.	2015	2,660,000	8,490	9,230	428	509	12,400	140,000	207,000
Nov.	2015	5,810,000	13,500	17,300	922	1,550	250,000	168,000	247,000
Dec.	2015	27,800,000	30,000	55,300	4,700	15,900	54,800,000	227,000	336,000
Jan.	2016	7,580,000	19,500	25,000	868	1,470	144,000	196,000	274,000
Feb.	2016	3,400,000	12,300	13,600	301	417	15,400	146,000	193,000
Mar.	2016	5,020,000	15,700	18,500	434	664	52,200	165,000	219,000
Apr.	2016	4,090,000	13,100	15,000	358	515	38,600	147,000	196,000
May	2016	4,360,000	12,900	14,900	427	605	49,700	150,000	205,000
June	2016	4,280,000	11,600	13,700	493	692	67,500	144,000	203,000
July	2016	4,420,000	10,600	12,800	621	932	181,000	142,000	207,000
Aug.	2016	2,880,000	8,430	9,270	428	512	20,800	135,000	199,000
Sep.	2016	2,550,000	7,780	8,390	395	461	14,200	131,000	195,000
Oct.	2016	3,130,000	9,240	10,300	478	604	25,700	146,000	216,000
Nov.	2016	2,280,000	8,210	8,490	295	345	7,210	134,000	193,000
Dec.	2016	2,300,000	9,040	9,160	247	294	5,820	139,000	193,000
Jan.	2017	2,660,000	10,500	10,800	241	306	8,300	144,000	193,000
Feb.	2017	2,190,000	9,260	9,310	171	214	5,680	124,000	162,000
Mar.	2017	4,470,000	13,900	16,000	361	579	94,700	153,000	202,000
Apr.	2017	28,000,000	30,200	54,600	3,310	11,300	77,200,000	201,000	281,000
May	2017	11,200,000	21,500	29,900	1,170	2,350	1,980,000	191,000	268,000
June	2017	5,140,000	12,800	15,500	552	821	130,000	151,000	213,000
July	2017	3,850,000	10,300	11,800	474	618	47,000	144,000	208,000
Aug.	2017	5,820,000	12,700	15,800	871	1,270	172,000	165,000	249,000
Sep.	2017	3,010,000	8,590	9,430	438	532	22,800	138,000	206,000
Oct.	2017	3,170,000	9,240	10,100	445	569	32,500	146,000	216,000
Nov.	2017	2,550,000	8,670	9,050	308	376	12,400	137,000	198,000
Dec.	2017	2,660,000	9,770	10,100	270	337	10,300	144,000	201,000
Jan.	2018	1,490,000	7,330	6,690	118	131	2,090	119,000	158,000
Feb.	2018	9,090,000	15,600	22,900	862	2,260	3,500,000	138,000	185,000
Mar.	2018	8,350,000	20,000	25,600	674	1,300	613,000	183,000	246,000
Apr.	2018	5,320,000	15,500	18,100	401	606	62,700	160,000	215,000
May	2018	6,020,000	15,000	18,300	521	872	315,000	160,000	219,000
June	2018	2,790,000	8,990	9,460	260	320	18,800	127,000	176,000
July	2018	4,000,000	10,100	11,600	480	689	143,000	140,000	204,000

SPRING CREEK NEAR SPRINGDALE, ARKANSAS (SPRING) continued

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
Aug.	2018	4,610,000	10,900	12,800	621	866	119,000	153,000	229,000
Sep.	2018	3,270,000	8,920	9,830	446	567	41,200	140,000	210,000

OSAGE CREEK NEAR CAVE SPRINGS, ARKANSAS (OC112)

Month	Year	Monthly Q	NO_3-N	TN	SRP	TP	TSS	Cl	SO_4
		m3	kg	kg	kg	kg	kg	kg	kg
Oct.	2015	1,600,000	6,840	6,360	91	123	2,320	66,800	68,900
Nov.	2015	5,810,000	11,300	13,500	472	1,040	278,000	84,600	92,900
Dec.	2015	21,900,000	18,900	31,600	2,390	7,970	9,860,000	126,000	157,000
Jan.	2016	4,900,000	13,800	15,200	238	445	31,800	90,100	90,900
Feb.	2016	2,620,000	9,900	9,920	103	176	7,640	71,700	67,500
Mar.	2016	3,770,000	11,600	12,300	162	291	19,400	79,800	75,000
Apr.	2016	3,010,000	9,450	9,910	138	233	14,100	71,100	65,900
May	2016	3,610,000	9,530	10,500	202	339	28,800	73,900	70,300
June	2016	3,520,000	8,440	9,490	231	384	38,300	70,200	68,800
July	2016	8,010,000	11,200	15,000	789	1,570	420,000	87,800	95,000
Aug.	2016	2,090,000	6,600	6,900	139	185	4,600	66,300	67,700
Sep.	2016	4,640,000	8,630	10,600	439	802	144,000	76,800	84,100
Oct.	2016	4,140,000	9,210	10,900	331	604	106,000	80,100	87,000
Nov.	2016	1,930,000	7,300	7,560	100	146	4,080	69,400	71,000
Dec.	2016	1,810,000	7,670	7,790	78	118	3,420	71,300	70,300
Jan.	2017	3,310,000	10,000	11,300	154	288	31,500	79,500	78,000
Feb.	2017	1,840,000	7,510	7,800	68	110	4,620	64,400	59,600
Mar.	2017	5,330,000	10,900	13,800	296	655	202,000	82,700	79,600
Apr.	2017	22,800,000	16,700	31,000	2,360	7,280	10,300,000	118,000	136,000
May	2017	12,500,000	15,300	23,300	981	2,200	1,010,000	106,000	112,000
June	2017	4,150,000	8,700	10,900	269	437	38,100	74,300	73,600
July	2017	5,670,000	9,200	12,400	480	844	137,000	81,000	85,000
Aug.	2017	5,950,000	9,630	13,100	534	898	115,000	85,000	92,800
Sep.	2017	2,150,000	6,240	7,180	144	197	6,370	67,000	70,000
Oct.	2017	2,970,000	7,500	9,090	208	338	36,300	75,000	79,700
Nov.	2017	2,560,000	7,450	8,810	147	240	21,100	72,800	75,600
Dec.	2017	2,600,000	8,240	9,640	125	206	13,800	76,400	76,800
Jan.	2018	2,320,000	8,080	9,270	95	159	10,400	74,300	71,500
Feb.	2018	9,740,000	11,700	19,100	691	1,930	1,960,000	90,100	94,600
Mar.	2018	8,370,000	12,500	18,700	530	1,310	888,000	94,300	94,500
Apr.	2018	4,110,000	9,400	12,300	197	348	36,200	77,300	73,100
May	2018	5,000,000	8,970	12,400	314	621	207,000	78,700	76,400
June	2018	1,760,000	5,370	6,330	93	126	4,510	61,100	57,700
July	2018	2,730,000	6,200	7,950	191	282	21,100	68,200	68,300
Aug.	2018	3,580,000	6,720	9,160	299	484	68,200	73,000	76,800
Sep.	2018	1,580,000	4,780	5,740	103	141	7,720	62,400	64,200

MUD CREEK NEAR JOHNSON, ARKANSAS (MUD)

Month	Year	Monthly Q	NO_3-N	TN	SRP	TP	TSS	Cl	SO_4
		m3	kg	kg	kg	kg	kg	kg	kg
Oct.	2015	321,000	99	195	7	23	3,130	3,230	8,010
Nov.	2015	3,410,000	1,020	2,810	163	806	271,000	18,700	46,100
Dec.	2015	11,600,000	3,750	11,100	871	5,680	4,550,000	43,300	115,000
Jan.	2016	1,430,000	514	954	16	73	11,500	16,600	36,300
Feb.	2016	430,000	191	269	2	9	1,030	7,180	15,800
Mar.	2016	2,640,000	1,330	2,670	46	220	95,400	22,700	52,500
Apr.	2016	1,300,000	768	1,570	31	125	68,500	10,100	24,800
May	2016	1,480,000	883	1,840	41	154	84,100	10,500	26,400
June	2016	544,000	313	556	10	28	6,910	4,860	12,400
July	2016	2,720,000	1,360	3,600	180	631	364,000	11,800	32,400
Aug.	2016	604,000	244	543	24	76	20,600	4,200	11,100
Sep.	2016	893,000	311	801	47	168	48,200	5,240	13,700
Oct.	2016	566,000	178	391	16	58	9,960	4,760	11,800
Nov.	2016	218,000	67	104	2	7	490	3,160	7,500
Dec.	2016	545,000	178	320	6	27	4,200	6,990	15,800
Jan.	2017	1,160,000	433	833	16	75	16,900	12,900	28,600
Feb.	2017	492,000	218	332	3	15	2,500	7,470	16,500
Mar.	2017	2,850,000	1,500	3,080	55	257	124,000	22,700	53,400
Apr.	2017	16,800,000	9,750	27,000	1,400	7,470	12,600,000	49,600	145,000
May	2017	5,680,000	3,380	7,960	226	924	711,000	29,500	76,500
June	2017	1,840,000	1,060	2,330	61	209	101,000	11,300	29,300
July	2017	726,000	375	792	24	72	25,200	5,020	13,200
Aug.	2017	1,840,000	763	2,010	110	368	136,000	9,060	24,200
Sep.	2017	211,000	74	146	5	17	2,840	1,930	5,030
Oct.	2017	896,000	277	682	37	148	37,600	6,250	15,600
Nov.	2017	319,000	98	168	4	14	1,440	4,110	9,690
Dec.	2017	617,000	201	375	8	34	4,930	7,440	16,800
Jan.	2018	630,000	235	384	5	22	2,960	9,050	19,900
Feb.	2018	5,860,000	2,650	6,370	182	1,040	675,000	33,200	81,800
Mar.	2018	4,320,000	2,280	5,260	133	685	516,000	26,400	64,900
Apr.	2018	1,180,000	683	1,150	13	47	12,000	12,600	29,300
May	2018	2,610,000	1,550	3,590	104	463	411,000	14,500	37,600
June	2018	314,000	179	298	5	15	3,420	3,100	8,070
July	2018	955,000	465	1,090	42	133	50,200	5,570	14,800
Aug.	2018	1,730,000	710	1,920	114	391	159,000	8,070	21,700
Sep.	2018	501,000	170	450	29	106	31,800	2,810	7,340

SAGER CREEK AT SILOAM SPRINGS, ARKANSAS (SAGER)

Month	Year	Monthly Q	NO_3-N	TN	SRP	TP	TSS	Cl	SO_4
		m3	kg	kg	kg	kg	kg	kg	kg
Aug.	2011	257,000	395	490	30	41	1,520	2,560	2,470
Sep.	2011	440,000	591	808	77	107	5,200	3,900	4,200
Oct.	2011	230,000	426	475	13	17	509	3,000	2,910
Nov.	2011	1,350,000	1,770	2,610	206	317	21,500	11,600	14,000
Dec.	2011	521,000	1,130	1,180	20	31	1,260	6,700	7,090
Jan.	2012	431,000	887	1,030	17	30	2,090	5,360	5,690
Feb.	2012	309,000	733	777	7	12	566	4,240	4,240
Mar.	2012	1,340,000	1,970	2,980	115	221	22,800	10,700	12,600
Apr.	2012	291,000	649	709	8	13	515	3,540	3,340
May	2012	199,000	395	463	7	11	427	2,360	2,140
June	2012	119,000	214	265	4	6	139	1,500	1,280
July	2012	121,000	206	256	5	6	127	1,540	1,320
Aug.	2012	404,000	648	764	45	61	2,090	3,870	3,850
Sep.	2012	398,000	696	769	33	44	1,290	4,270	4,240
Oct.	2012	1,190,000	1,820	2,250	146	207	8,930	10,700	12,200
Nov.	2012	256,000	541	565	8	12	305	3,680	3,610
Dec.	2012	236,000	542	562	5	8	218	3,680	3,590
Jan.	2013	353,000	814	865	9	16	761	4,870	4,970
Feb.	2013	286,000	704	729	5	9	358	4,070	4,000
Mar.	2013	1,020,000	1,800	2,350	64	120	10,400	9,320	10,400
Apr.	2013	2,360,000	2,930	4,960	360	684	86,800	16,000	19,100
May	2013	3,680,000	3,820	7,160	801	1,430	156,000	21,500	26,000
June	2013	774,000	1,350	1,580	65	103	4,870	6,610	6,690
July	2013	777,000	1,110	1,450	134	193	9,670	6,140	6,390
Aug.	2013	2,650,000	2,410	4,460	1,200	1,780	148,000	15,400	18,600
Sep.	2013	548,000	935	1,040	53	71	2,310	5,530	5,670
Oct.	2013	791,000	1,290	1,530	82	117	5,220	7,830	8,590
Nov.	2013	607,000	1,210	1,270	34	49	1,680	7,190	7,630
Dec.	2013	1,050,000	1,960	2,290	63	103	6,010	11,300	12,900
Jan.	2014	883,000	1,800	2,040	40	69	4,380	9,960	11,100
Feb.	2014	315,000	779	800	6	10	404	4,420	4,380
Mar.	2014	931,000	1,730	2,170	53	100	8,760	8,900	9,770
Apr.	2014	454,000	1,010	1,090	14	25	1,130	5,070	4,970
May	2014	452,000	912	1,010	20	33	1,400	4,630	4,460
June	2014	1,790,000	2,430	3,430	307	489	32,400	12,200	13,500
July	2014	388,000	694	774	28	39	1,140	3,850	3,650
Aug.	2014	683,000	994	1,260	113	159	7,430	5,730	5,940
Sep.	2014	514,000	835	971	62	83	3,170	5,050	5,170
Oct.	2014	2,190,000	2,110	3,830	655	961	68,900	15,000	18,800

SAGER CREEK AT SILOAM SPRINGS, ARKANSAS (SAGER) continued

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
Nov.	2014	498,000	1,050	1,070	22	31	962	6,290	6,530
Dec.	2014	878,000	1,760	1,940	45	73	3,780	10,000	11,100
Jan.	2015	783,000	1,620	1,810	35	59	3,490	9,050	10,000
Feb.	2015	463,000	1,080	1,150	13	22	1,240	5,810	6,000
Mar.	2015	1,890,000	3,270	4,310	126	238	21,400	16,200	18,700
Apr.	2015	738,000	1,530	1,710	33	58	3,340	7,330	7,520
May	2015	5,360,000	5,170	10,200	1,420	2,510	297,000	29,600	36,600
June	2015	1,300,000	1,610	2,470	269	434	32,700	8,710	9,660
July	2015	4,090,000	4,000	7,180	1,280	1,970	146,000	23,000	27,600
Aug.	2015	784,000	1,150	1,430	129	179	7,810	6,520	6,850
Sep.	2015	336,000	584	653	28	37	1,100	3,700	3,630
Oct.	2015	258,000	491	535	13	18	490	3,360	3,290
Nov.	2015	3,620,000	3,300	6,780	775	1,250	111,000	24,900	33,600
Dec.	2015	13,100,000	7,060	24,400	4,300	7,860	1,310,000	70,800	108,000
Jan.	2016	1,180,000	2,540	2,740	47	80	4,210	13,300	14,900
Feb.	2016	537,000	1,300	1,330	13	22	1,040	6,820	7,050
Mar.	2016	1,290,000	2,600	3,030	59	109	7,580	12,500	13,800
Apr.	2016	710,000	1,390	1,620	40	71	4,620	6,800	7,010
May	2016	985,000	1,490	2,040	129	221	18,200	7,660	8,170
June	2016	391,000	742	827	22	33	1,100	3,930	3,710
July	2016	1,980,000	1,880	3,470	756	1,180	106,000	11,500	13,500
Aug.	2016	398,000	640	757	45	61	2,210	3,880	3,830
Sep.	2016	517,000	807	969	67	91	3,630	4,960	5,150
Oct.	2016	622,000	1,000	1,210	70	99	4,640	6,290	6,800
Nov.	2016	207,000	439	464	6	8	184	3,140	3,020
Dec.	2016	280,000	637	661	7	11	368	4,150	4,140
Jan.	2017	1,140,000	2,030	2,590	68	122	9,620	11,500	13,400
Feb.	2017	403,000	970	1,010	9	16	773	5,280	5,370
Mar.	2017	554,000	1,270	1,360	16	29	1,470	6,430	6,530
Apr.	2017	9,430,000	5,180	17,700	3,720	7,240	1,360,000	42,200	59,000
May	2017	4,430,000	5,360	8,820	757	1,340	130,000	27,500	32,800
June	2017	2,340,000	2,070	4,290	788	1,360	159,000	12,800	15,500
July	2017	295,000	532	599	18	25	650	3,120	2,880
Aug.	2017	742,000	1,090	1,360	117	164	6,920	6,110	6,400
Sep.	2017	180,000	325	365	8	11	211	2,350	2,160
Oct.	2017	534,000	850	1,040	60	85	4,040	5,490	5,880
Nov.	2017	277,000	585	612	9	14	394	3,910	3,880
Dec.	2017	313,000	700	732	9	14	523	4,470	4,530
Jan.	2018	385,000	870	935	11	19	980	5,170	5,340

SAGER CREEK AT SILOAM SPRINGS, ARKANSAS (SAGER) continued

Month	Year	Monthly Q m3	NO_3-N kg	TN kg	SRP kg	TP kg	TSS kg	Cl kg	SO_4 kg
Feb.	2018	4,980,000	4,110	10,400	873	1,740	285,000	30,200	41,800
Mar.	2018	3,180,000	3,490	6,750	488	961	140,000	21,100	26,600
Apr.	2018	1,190,000	2,260	2,700	70	127	8,650	10,600	11,400
May	2018	2,880,000	2,350	5,570	831	1,570	236,000	15,500	19,600
June	2018	225,000	424	487	10	15	421	2,510	2,260
July	2018	542,000	815	1,020	78	111	4,870	4,540	4,610
Aug.	2018	758,000	996	1,360	161	227	11,800	5,930	6,350
Sep.	2018	188,000	338	380	10	13	265	2,400	2,220