12-1-2013

Water Quality Monitoring for Selected Priority Watersheds in Arkansas, Upper Saline, Poteau and Strawberry Rivers

L. B. Massey
University of Arkansas, Fayetteville

J.A. McCarty
University of Arkansas, Fayetteville

M.D. Matlock
University of Arkansas, Fayetteville

A.N. Sharpley
University of Arkansas, Fayetteville

B.E. Haggard
University of Arkansas, Fayetteville

Citation

Massey, L. B.; McCarty, J.A.; Matlock, M.D.; Sharpley, A.N.; and Haggard, B.E.. 2013. Water Quality Monitoring for Selected Priority Watersheds in Arkansas, Upper Saline, Poteau and Strawberry Rivers. Arkansas Water Resource Center, Fayetteville, AR. MSC369. 81
https://scholarworks.uark.edu/awrctr/16

December 2013

Water Quality Monitoring for Selected Priority Watersheds in Arkansas, Upper Saline, Poteau and Strawberry Rivers

Project 11-800 Final Report

Funded by Arkansas Natural Resources Commission
MSC Publication 369 | Arkansas Water Resources Center

FUNDED BY ARKANSAS NATURAL RESOURCES COMMISSION
MSC PUBLICATION 369 | ARKANSAS WATER RESOURCES CENTER

Water Quality Monitoring for Selected Priority Watersheds in Arkansas, Upper Saline, Poteau and Strawberry Rivers

L.B. Massey[1], J.A. McCarty[2], M.D. Matlock[2], A.N. Sharpley[3], and B.E. Haggard[1],

[1]Arkansas Water Resources Center, UA Division of Agriculture; [2]Center for Agricultural and Rural Sustainability, UA Division of Agriculture; [3]Department of Crop, Soil and Environmental Science, UA Division of Agriculture

Arkansas Natural Resources Commission has identified three priority hydrological unit code (HUC) 8 watersheds, the Upper Saline (HUC 08040203), Poteau (HUC 11110105), and Strawberry Watersheds (HUC 11010012). SWAT models have been developed to estimate nutrient and sediment loads in these watersheds where limited water-quality data was available. The purpose of this project was to collect additional water samples across these HUC 8 watersheds to better understand how water quality changes across subwatershed with differing land use mixes, as well as estimate nitrate-nitrogen (NO_3-N), total phosphorus (TP), and total suspended sediment (TSS) loads. Water samples were collected at twenty sites near HUC 12 outlets or other desired locations within each of the three selected watersheds. These sites included seven existing USGS stage and discharge monitoring stations. The sites were sampled monthly from October 2011 through September 2012, and storm samples were collected through March 2013. Constituent loads were estimated for calendar year 2011 and 2012 at the seven sites where the USGS records discharge data and compared with SWAT model output. We also ranked the subwatersheds based on mean concentrations of NO_3-N, TP, and TSS and calculated a Spearman rank coefficient (ρ). The knowledge attained from this project helped validate the SWAT modeling output, and improved the level of confidence that we had in the subwatershed prioritizations based on the SWAT output.

We were able to develop statistically significant regression models to estimate NO_3-N, TP and TSS loads based on the monitoring data, using simple log-log regression with discharge. The watershed model show relatively good agreement overall; however, we observed a few differences between the loads estimated from monitoring data and SWAT output. For example, the watershed model tends to over-predict TP and TSS loads at the lower discharges in the Strawberry Watershed, and sediment loads predicted by the SWAT model are less than that predicted by the regression method on the low end of monthly discharge. However, the overall comparisons increase our confidence in the SWAT model's ability to predict loads at the sties used in hydrological calibration within these watersheds.

We also compared mean concentrations during base flow conditions at the selected HUC 12 level, and there were some interesting relations between the monitoring data and the SWAT output. We observed significant relations in the ranks of the sites within the Poteau and Upper Saline Watersheds for NO3-N and TP, but not TSS. The monitoring data and SWAT output were not related at the Strawberry Watershed.

In summary, the load comparisons were favorable across all three watersheds; whereas, the concentration comparisons were only significant within the Poteau and Upper Saline Watersheds. These results increase our confidence in the subwatershed prioritization by the SWAT model for the Poteau and Upper Saline Watersheds, but not necessarily for the Strawberry Watershed. This is not a limitation of the modeling efforts given the lack of calibration data, but shows the importance of the monitoring data to calibrate hydrology and constituent transport.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Nonpoint source pollution is the leading remaining cause of water quality problems in US waterways, and agriculture is the leading contributor to water quality impairments on surveyed rivers and lakes (US EPA, 2000). The most common nonpoint source pollutants are sediment and nutrients which result from agricultural and urban runoff as well as stream channel modifications from increased flows. Effectively managing the landscape is necessary to reduce local pollution and prevent sediment and nutrients from being transported downstream.

Water-quality monitoring can be utilized to better understand the relationship between land use and in-stream nutrient and sediment concentrations and loads. A monitoring program is the most reliable way to identify specific areas of concern that are contributing to nonpoint source pollution in a watershed; however, there is not always the luxury of time, human capital and funding necessary to collect the needed data. Therefore, agencies responsible for addressing nonpoint source pollution often employ the use of watershed models and other assessment tools to estimate nutrient and sediment loads (Gassman et al., 2007). These models come with limitations, because watershed data input into models is often not collected at a high frequency (Gassman et al., 2007; Santhi et al., 2001) and may not reflect a range of representative flow conditions including seasonal base flow and storm events. In addition, models often use equations with parameters that are not directly measured using data (e.g., curve number equation; Gassman et al., 2007; Gupta et al., 1998; Santhi et al., 2001). Nonetheless, models are useful tools to estimate sediment and nutrient loads in the absence of monitoring data across the watershed and to prioritize where to target best management practices and program resources.

The goal of the Arkansas Natural Resources Commission (ANRC) 319 program is to fund nonpoint source projects that will achieve the best possible results in addressing nonpoint source pollution. Therefore, ANRC 319 Program funds are targeted toward priority watersheds where there are known impairments or significant threats to water quality from present and future activities. To cost effectively manage sources and causes of nonpoint source pollution, implementation of mitigation efforts at the subwatershed scale within selected priority watersheds is needed. The soil water assessment tool (SWAT) model has previously been used to prioritize [relatively] data rich subwatersheds in Arkansas by ANRC (because of past ANRC 319 Program monitoring projects). However, recent water-quality data for three priority hydrological unit code (HUC) 8 watersheds (i.e., Upper Saline, Poteau and Strawberry) was more limited, and the purpose of this project was to collect additional water samples across these HUC 8 watersheds to:

1. better understand how water quality changes across headwater subwatersheds draining different land use mixes, and
2. estimate nitrogen (N), phosphorus (P), and sediment loads at select sites where active USGS stage and discharge monitoring stations exist.

The knowledge attained from this project helped validate the SWAT modeling output, and improved the level of confidence that we had in the subwatershed prioritizations based on the SWAT output.

STUDY SITE DESCRIPTIONS

The focus of this project was three priority HUC 8 level watersheds in Arkansas, the Upper Saline (HUC 08040203), Poteau (HUC 11110105), and Strawberry Watersheds (HUC 11010012). The Poteau Watershed (HUC 11110105) is a 1432 km^2 watershed that lies in western Arkansas crossing into Oklahoma. The watershed is primarily forested (56.3%) and 19.0% is grassland, 19.0% is transitional, 2.9% is suburban/urban, and 0.7% is water (Arkansaswater.org, 2011). The major streams within the watershed include Hawes Creek, Jones Creek, Poteau River, Riddle Creek and Ross Creek. The portion of the Poteau Watershed that lies in Arkansas is divided into 28 HUC-12s, and we monitored sites within 19 of these HUC-12s (Table 1, Figure 1) including HUC-12 outlets, and upstream and downstream of the Waldron wastewater treatment plant (WWTP). Other NPDES permitted sites within the watershed include Bonanza WWTP, James Fork WWTP and Waldron Poultry Processing Plant. There are two active USGS monitoring sites in the Poteau Watershed which are located on the Poteau River at Cauthron, AR and the James Fork near Hackett, AR. Segments on the Poteau River are currently listed on 303(d) list (ADEQ, 2012) as impaired by total dissolved solids and dissolved oxygen.

Table 1. Monitoring site locations, catchment area, and land use in the Poteau Watershed.

Site ID	Lat N	Long W	Area (Acres)	%F[1]	%U[2]	%AG[3]	HUC_12_NAME	HUC_12
POT-12A	34 53.769	94 03.975	9,569	51%	5%	39%	Headwaters Poteau River	111101050102
POT-13	34 55.666	94 10.124	50,827	54%	7%	36%	Bull Creek-Poteau River	111101050107
POT-15B	35 01.177	94 25.285	1,686	90%	2%	8%	Upper Sugar Loaf Creek	111101050605
POT-16	35 01.984	94 19.315	9,461	86%	1%	10%	Headwaters James Fork	111101050801
POT-17	35 02.820	94 20.302	11,113	68%	5%	26%	West Creek-James Fork	111101050802
POT-1A	35 01.379	94 16.985	3,478	85%	1%	12%	Cherokee Creek-Brazil Creek	111101050803
POT-1C	35 04.839	94 16.013	14,872	45%	6%	47%	Cherokee Creek-Brazil Creek	111101050803
POT-2	35 04.953	94 26.077	887	83%	3%	13%	Gap Creek	111101050610
POT-21	34 51.647	94 11.910	18,910	75%	4%	18%	Ross Creek	111101050103
POT-22	34 51.895	94 12.835	20,658	87%	3%	4%	Upper Jones Creek	111101050104
POT-24A	34 55.711	94 10.313	109,217	63%	6%	28%	Lower Jones Creek	111101050105
POT-28A	34 42.970	94 33.006	14,867	92%	0%	1%	Big Creek	111101050201
POT-29C	34 46.428	94 30.748	60,432	91%	3%	5%	Upper Black Fork	111101050202
POT-3	35 05.964	94 21.021	69,887	52%	5%	41%	School House Branch-James	111101050805
POT-30A	34 47.257	94 30.924	15,292	95%	2%	3%	Haws Creek	111101050203
POT-5	35 05.709	94 17.776	17,080	23%	5%	70%	Prairie Creek	111101050804
POT-8	35 14.569	94 25.345	1,132	31%	6%	60%	Wells Creek-Poteau River	111101050903
POT-9	35 22.078	94 25.563	7,043	10%	85%	5%	Cedar Creek-Poteau River	111101050904
POT-P1[4]	34 55.129	94 17.918	129,745	66%	5%	26%	Cross Creek-Poteau River	111101050301
POT-P2[4]	35 09.755	94 24.424	90,887	51%	5%	42%	Big Branch-James Fork	111101050807

[1] Forest; Includes deciduous, evergreen and mixed forest; [2] Urban; Includes barren, developed-open space, low, medium, and high intensity development; [3] Agriculture; Includes crops, grassland and pasture; and[4] Indicates USGS stage and discharge station

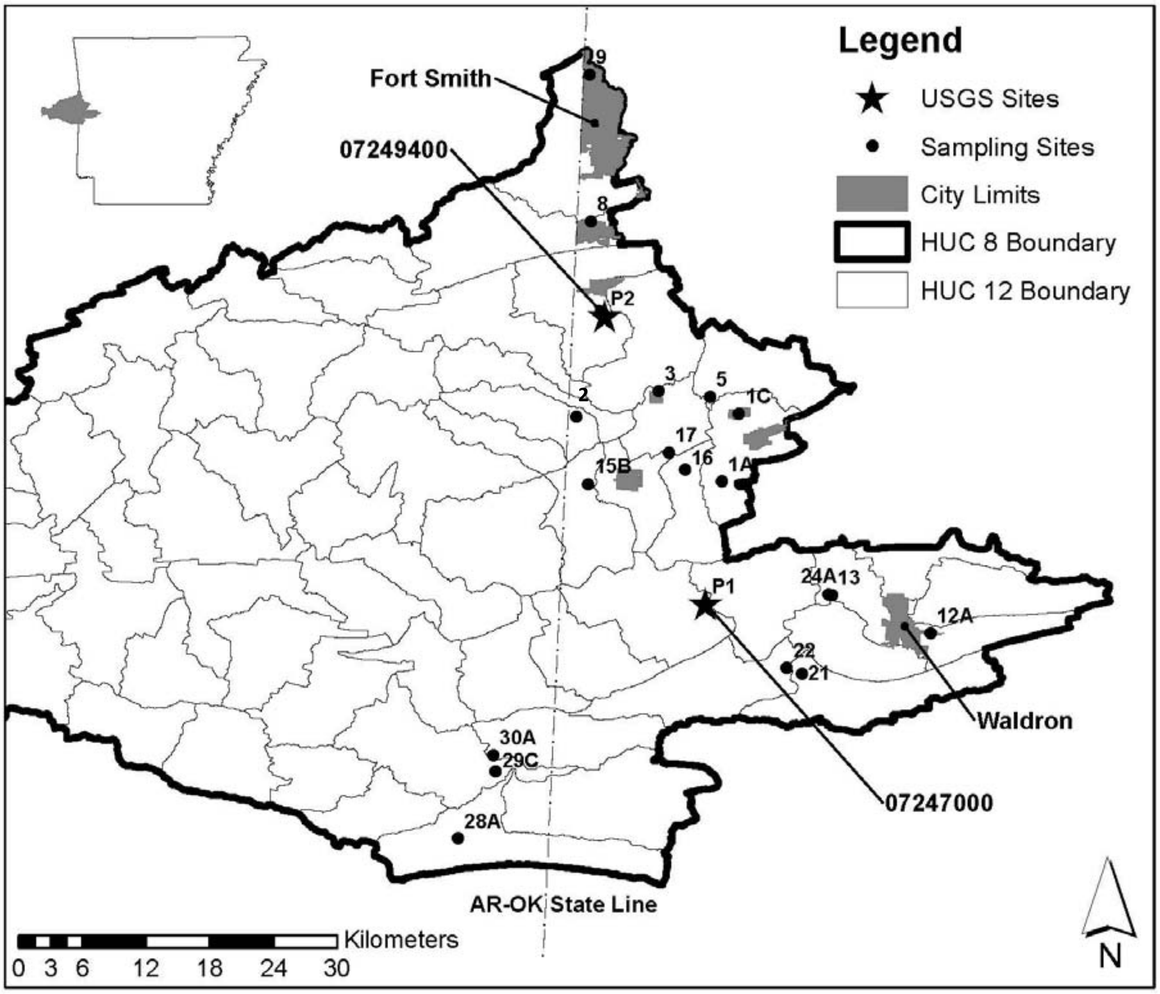

Figure 1. HUC 12 watershed boundaries, sampling sites and numbers, and USGS gaging sites in the Poteau Watershed, Arkansas .

The Strawberry Watershed (HUC 11010012) lies within the White River Basin in northern Arkansas and drains a 1992 km^2 area of which 56.5% is forest, 35.2% is grassland, 4.2% is transitional, 1.8% is cropland, 3.2% is suburban/urban and 0.4% is water (Arkansaswater.org, 2011). The main tributaries to the Strawberry River include Caney Creek, Coopers Creek, Little Strawberry River, North Big Creek, Piney Fork, Reeds Creek, and South Big Creek; the Strawberry River and its tributaries flow into the Lower Black Watershed. The Strawberry Watershed is divided into 27 HUC-12s, and we selected 20 of these HUC-12s to monitor (Table 2, Figure 2). The catchment land use of the selected sites were a mix of forested (45%-87%) and agricultural (25%-47%) land, and urban land use made up 10% or less of any given drainage area. Both the Highland WWTP and Horseshoe bend WWTP are permitted to discharge into the Strawberry Watershed. Reaches on the Strawberry River, Little Strawberry River and South Big Creek were identified as impaired on the 2008 303(d) list, but these reaches have been removed from the 2012 draft 303(d) list (ADEQ, 2008). The USGS operates a stage monitoring gage at the Strawberry River near Poughkeepsie, Arkansas, with the data from this gage presented on the web.

Table 2. Monitoring site locations, catchment area, and land use in the Strawberry Watershed.

Site ID	Lat N	Long W	Area (Acres)	%F[1]	%U[2]	%AG[3]	HUC_12_NAME	HUC_12
STR-1	35 58.976	91 20.191	22,348	63%	4%	33%	Reeds Creek-Strawberry River	110100120405
STR-10	36 01.661	91 19.536	342,657	61%	5%	33%	Clayton Creek-Strawberry River	110100120307
STR-11	36 05.787	91 28.586	241,669	58%	6%	36%	Whaley Creek-Strawberry River	110100120304
STR-12	36 06.339	91 46.996	17,728	49%	4%	47%	Philadelphia Creek-Piney Fork	110100120101
STR-13	36 06.436	91 34.499	143,158	57%	6%	36%	Lave Creek-Strawberry River	110100120207
STR-16	36 07.209	91 24.209	15,031	87%	3%	10%	Mill Creek-Strawberry River	110100120305
STR-17	35 53.447	91 14.131	14,622	54%	4%	40%	Caney Creek-Strawberry Creek	110100120503
STR-2	35 55.631	91 15.139	467,961	61%	5%	33%	Sleep Bank Creek-Strawberry	110100120504
STR-20	36 14.030	91 47.405	25,322	51%	7%	42%	Little Strawberry River	110100120203
STR-22	36 08.288	91 30.220	47,816	59%	7%	34%	Barnes Branch-North Big Creek	110100120303
STR-23	36 07.848	91 40.448	126,923	56%	7%	37%	Hars Creek-Strawberry River	110100120206
STR-24A	36 11.069	91 32.104	6,097	69%	3%	28%	Little Creek-North Big Creek	110100120302
STR-26	36 12.008	91 45.596	87,985	54%	5%	40%	Bullpen Creek-Strawberry River	110100120204
STR-27	36 13.270	91 33.574	22,856	45%	10%	45%	Hackney Creek-North Big Creek	110100120301
STR-5	36 01.200	91 20.164	46,568	67%	5%	27%	Mill Creek-South Big Creek	110100120403
STR-6	36 04.170	91 40.357	57,227	51%	4%	44%	Mays Branch-Piney Fork	110100120103
STR-7	36 04.840	91 46.646	63,839	52%	4%	44%	Mill Creek-Piney Fork	110100120104
STR-8	36 04.402	91 44.108	38,424	50%	5%	45%	Caney Creek-Piney Fork	110100120102
STR-9	36 02.022	91 18.441	29,784	70%	4%	25%	Cooper Creek	110100120502
STR-S1[4]	36 06.619	91 26.982	302,376	59%	6%	35%	Meeks Branch-Strawberry River	110100120306

[1] Forest; Includes deciduous, evergreen and mixed forest; [2] Urban; Includes barren, developed-open space, low, medium, and high intensity development; [3] Agriculture; Includes crops, grassland and pasture; and [4] Indicates USGS stage and discharge station

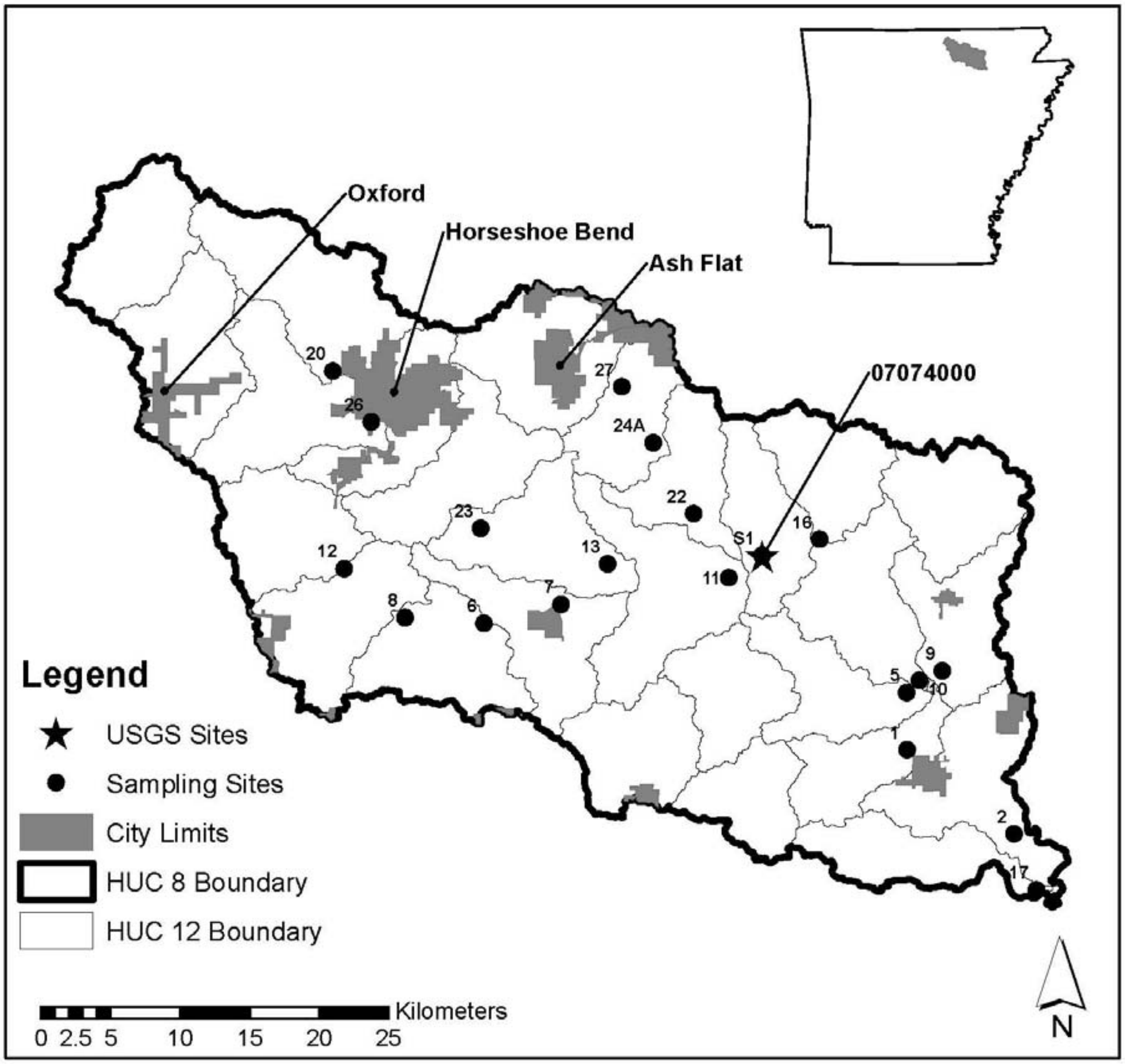

Figure 2. HUC 12 watershed boundaries, sampling sites and numbers, and USGS gaging site in the Strawberry Watershed, Arkansas.

The Upper Saline Watershed (HUC 08040203) in central Arkansas drains a 4426 km^2 area of which 78.6% is forest, 9.8% is grassland, 7.3% is transitional, 3.1% is suburban/urban and 1.0% is water (Arkansaswater.org, 2011). The Upper Saline Watershed lies within the Ouachita River Basin; the Saline River flows south and into the Lower Saline Watershed. The main tributaries to the Saline River include Cedar Creek, Derrieuseaux Creek, Francois Creek, Hurricane Creek, Huskey Creek, Lost Creek, and Simpson Creek. The Upper Saline Watershed is divided into 40 HUC-12s, and we selected 19 HUCs to monitor water quality (Table 3, Figure 3). The catchment land use of the selected sites was primarily forested (48-96%) while urban and agriculture made up 3%-22% and 0-21% of the drainage areas. NPDES permitted dischargers include WWTP in Benton, Cedar Creek, Harmony Grove and Leola. Reaches on the Saline River and Big Creek have been identified as impaired on the 2012 draft 303(d) list for total dissolved solids and turbidity from resource extraction (i.e., natural gas), surface erosion and other unknown sources (ADEQ, 2012). The USGS operates five stage and discharge monitoring gages within the watershed, and these data are available on the web.

Table 3. Monitoring site locations, catchment area, and land use in the Upper Saline Watershed.

Site ID	Lat N	Long W	Area (Acres)	%F[1]	%U[2]	%AG[3]	HUC_12_NAME	HUC_12
SAL-3	34 18.858	92 38.417	20,540	70%	6%	4%	Thunder Branch-Big Creek	80402030603
SAL-5	34 21.156	92 37.936	42,864	64%	5%	10%	Big Creek-Francois Creek	80402030604
SAL-8	34 21.110	92 20.430	90,425	53%	10%	12%	Mud Creek-Hurricane Creek	80402030404
SAL-11	34 19.157	92 35.196	441,535	74%	8%	7%	Jordan Creek-Saline Rive	80402030704
SAL-13	34 24.493	92 37.706	3,143	71%	4%	2%	Trace Creek-Saline River	80402030703
SAL-14	34 25.710	92 21.729	62,365	48%	13%	15%	Logan Creek-Hurricane Creek	80402030402
SAL-16	34 29.930	92 34.294	372,352	79%	8%	7%	Saline River	80402030702
SAL-30A	34 36.963	92 44.934	76,252	88%	4%	3%	Big Creek-Saline River	80402030305
SAL-31	34 36.327	92 37.115	84,950	86%	3%	7%	Lower North Fork Saline River	80402030103
SAL-32	34 40.377	92 47.940	57,988	88%	4%	2%	Tailwaters Alum Fork Saline River	80402030303
SAL-34A	34 55.114	92 38.801	246,876	81%	7%	7%	Moccasin Creek-Saline River	80402030701
SAL-35	34 36.859	92 53.579	10,512	60%	22%	4%	Cedar Creek-South Fork Saline River	80402030201
SAL-36	34 30.669	92 24.892	41,318	44%	17%	21%	Little Hurricane -Hurricane Creek	80402030401
SAL-37	34 35.849	92 44.580	68,159	80%	9%	5%	Tailwaters Middle Fork Saline River	80402030304
SAL-39	34 42.023	92 39.686	53,462	89%	3%	5%	Middle North Fork Saline River	80402030102
SAL-U1[4]	34 47.727	93 00.433	3,404	95%	4%	1%	Headwaters Alum Fork Saline River	80402030302
SAL-U2[4]	34 47.840	92 56.012	17,183	96%	3%	0%	Headwaters Alum Fork Saline River	80402030302
SAL-U3A[4]	34 33.767	92 36.926	352,173	82%	7%	7%	Depot Creek-Saline River	80402030702
SAL-U4[4]	34 13.720	92 22.354	158,777	57%	9%	8%	Ray Creek-Hurricane Creek	80402030405
SAL-U6[4]	34 47.704	92 50.631	28,331	92%	3%	0%	Headwaters Alum Fork Saline River	80402030302

[1] Forest; Includes deciduous, evergreen and mixed forest; [2] Urban; Includes barren, developed-open space, low, medium, and high intensity development; [3] Agriculture; Includes crops, grassland and pasture; and [4] Indicates USGS stage and discharge station

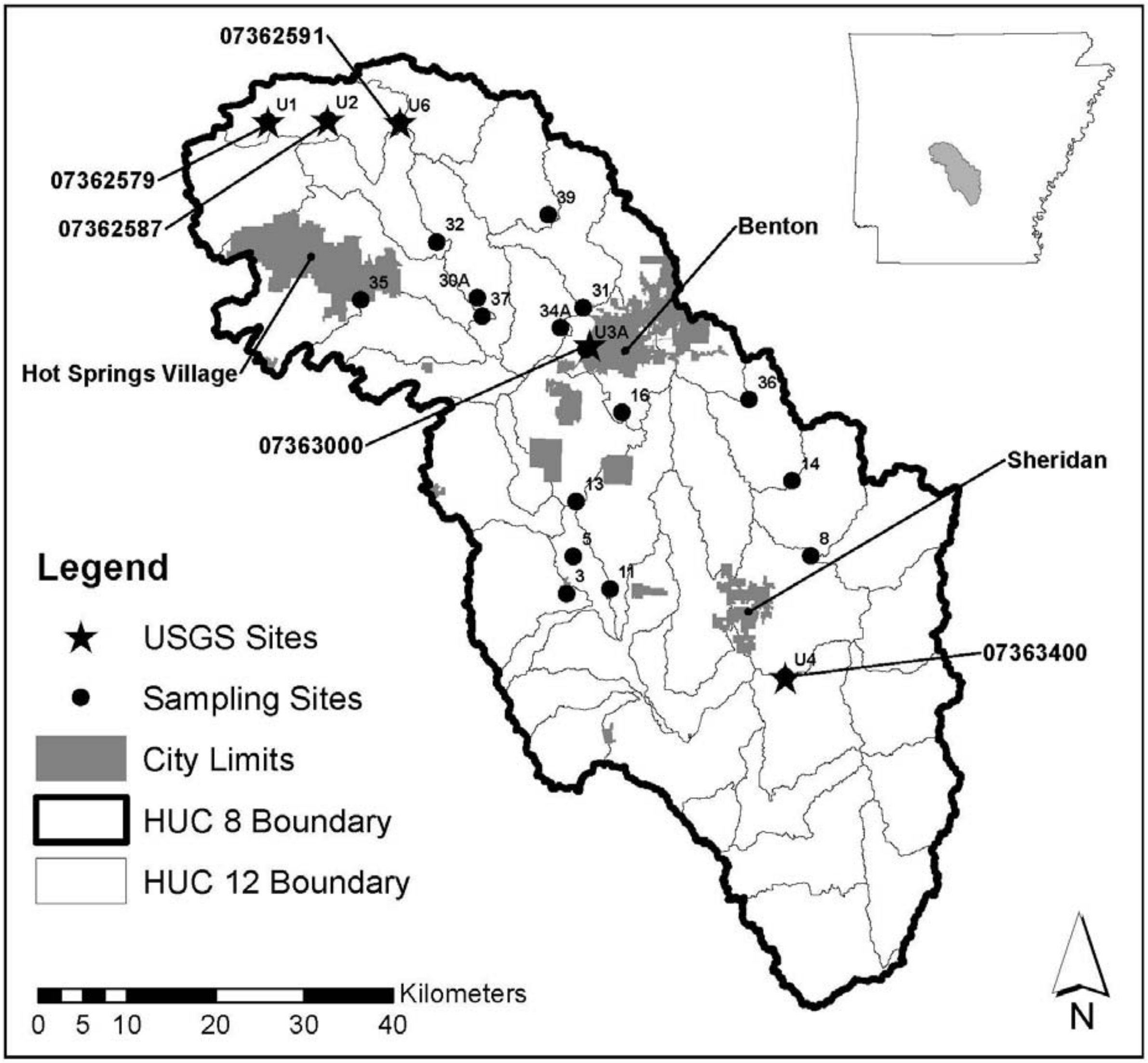

Figure 3. HUC 12 watershed boundaries, sampling sites and numbers, and USGS gaging sites in the Upper Saline Watershed, Arkansas

METHODS

Sample Collection and Analysis

Water samples were collected at twenty sites near HUC 12 outlets or other desired locations within each of the three selected watershed (i.e., Upper Saline, Poteau and Strawberry; Tables 1-3; Figures 1-3). These sixty sampling sites include seven existing USGS stage and discharge monitoring stations within these same watersheds. The sites were sampled monthly from October 2011 through September 2012 (n=720 samples), and additional water samples were collected across a range of stream flows including seasonal base flow to storm event conditions at the seven existing USGS sites (n=168 samples) from October 2011 through March 2013.

Water samples were collected from the vertical centroid of flow where the water was actively moving and well-mixed either by hand (grab sample), or by an Alpha style horizontal sampler or swing arm pole sampler. Field duplicates were collected at a frequency of 10%, and field blanks were collected quarterly throughout the duration of the project. Field duplicates and blanks were collected following the same methods as the environmental water samples. The collected water samples, blanks and field duplicates were stored on ice and delivered to the Water Quality Laboratory.

Laboratory Analysis

The collected water samples, field duplicates and blanks were analyzed at the AWRC Water Quality Laboratory for soluble reactive phosphorus (SRP), total phosphorus (TP), nitrate-nitrogen (NO_3-N), total nitrogen (TN), total suspended solids (TSS), turbidity and conductivity. The samples were handled and analyzed following the EPA-approved quality assurance project plan (QAPP) developed for this project. The analytical techniques, practical quantitation limits and method detection limits are provided in Table 4, and the equipment used to measure constituent concentrations are available on the web (http://www.uark.edu/depts/awrc/waterqualitylab.html).

Table 4. Analytical methods utilized at the Arkansas Water Resources Center Water Quality Lab.

Parameter	Source/Method	Units	PQL[1]	MDL[2]
Nitrate-Nitrogen	EPA/300.0	mg/L	0.01	0.003
Soluble Reactive Phosphorus	EPA/365.1	mg/L	0.11	0.04
Total Phosphorus	APHA 4500PJ	mg/L	0.02	0.01
Total Nitrogen	APHA 4500PJ	mg/L	0.05	0.02
Total Suspended Solids	EPA/160.2	mg/L	7	2
Turbidity	EPA 180.1	NTU	--	--
Conductivity	EPA 120.1	µS/cm	--	--

[1]practical quantitation limit; and [2]method detection limit

Load Estimations

Constituent loads were estimated for calendar year 2011 and 2012 at the seven sites where the USGS records discharge data (i.e., POT-P1, POT-P2, STR-S1, SAL-U1, SAL-U2, SAL-U3A, SAL-U4, SAL-U6). Daily discharge (Q_d) for each site was downloaded from the USGS Arkansas Water Science Center website for January 2011 through December 2012, except at STR-S1 where only river stage was available. Therefore, we developed a rating curve based on the available stage-discharge measurements taken by the USGS from 1980-2012 ($Q=2.243 \bullet stage+1.525$; $r^2=0.976$). We then used the developed rating curve to estimate discharge based on the stage level that was recorded in 15 minute increments. The 15 minute incremental discharge values were averaged over 24 hours to estimate daily discharge at STR-S1.

Daily measured loads were calculated by multiplying Q_d by a corresponding constituent concentration. The measured loads were plotted as a function of Q_d and then linear regression was used to develop an equation that describes daily constituent loads (L_d) at each site as a function of measured discharge. The basic log-log linear regression model for L_d can be expressed solely as a function of discharge.

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

where ln represents the natural logarithm function, β_0 is a constant, β_1 is the coefficient for discharge and Q_d is the daily mean discharge (cfs). Log-log regression often results in bias when transforming the log values, where the values are often underestimated. Therefore, a non-parametric bias correction factor (BCF; Helsel and Hirsh, 2002) was calculated and used when transforming the logarithmic results back to actual daily loads. BCF for natural logarithmic transformation is

$$BCF = \frac{\sum e^{e_i}}{n}$$

where n is the number of samples and e_i is the residual or difference between measured and estimated loads in natural log units. This factor was multiplied by the re-transformed value to account for any bias. Therefore, daily loads were estimated based on the log-log equation for the discharge record, multiplied by the corresponding BCF, and then summed into monthly and annual loads.

Monthly and annual loads were also estimated using the USGS Load Estimator Program (LOADEST; MOD36, 2004). Daily stream discharge and constituent concentrations were input into LOADEST, and the program developed a regression model for the estimation of constituent loads based on two equations. The calibration and estimation procedures within LOADEST were based on adjusted maximum likelihood estimation (AMLE). Equation 1 AMLE is similar to the simple log-log approach we used in spreadsheets, and only differs in how the daily loads are corrected for bias in re-transformation.

$$\ln (L) = \beta_0 + \beta_1 \ln (Q)$$

where ln represents the natural logarithm function, β_0 is a constant, β_1 is the coefficient for discharge and Q is discharge (cfs). LOADEST also estimated loads based on Equation 4 AMLE which includes sin and cos variables which account for seasonal variations in constituent loads.

$$\ln (L) = \beta_0 + \beta_1 \ln (Q) + \beta_2 \sin (2\pi dtime) + \beta_3 \cos(2\pi dtime)$$

where β_2 and β_3 are the coefficients for seasonal variation and dtime represents decimal time. We employed the use of LOADEST for two reasons – first, we wanted to compare Equation 1 AMLE to the simple log-log regression plus BCF approach we use in spreadsheet, and then we also wanted to see how Fourier's equation (i.e., sine and cosine factors) might influence nutrient loads (e.g., comparing Equation 1 AMLE and Equation 4 AMLE).

Monitoring and Modeling Comparisons

The daily loads were summed into monthly and annual loads for all three estimation techniques for calendar years 2011 and 2012. This required loads to be projected beyond our monitoring program (i.e., October 2011 through March 2012) for all active USGS discharge or stage monitoring sites. Monthly loads for Poteau, Strawberry and Upper Saline Watersheds were estimated for TSS, TP and NO_3-N for three years using SWAT model (Saraswat et al., 2013). However, the modeling period did not overlap with the water-quality monitoring program as Saraswat et al. (2013) had to limit the period through 2010 in order to complete the contracted watershed modeling. Therefore, we were not able to directly compare loads between that estimated from the monitoring data and that predicted by the SWAT model. Instead, we used a novel, innovative technique comparing the relation between monthly discharge and loads at sites where monitoring and modeling overlapped. If the estimated TSS, TP and NO_3-N loads from the monitoring data and watershed modeling follow the same general pattern with discharge, then that increases the confidence that we have in the model output and how it might be used to conduct subwatershed prioritization for the ANRC 319 Program.

The monthly load comparisons were limited to the sites used in hydrologic calibration, providing an opportunity to evaluate how the model predicted nutrient and sediment loads at sites where discharge was available. However, this comparison does not evaluate the models ability to predict nutrient and sediment loads across the subwatersheds (i.e., HUC 12s) within the Poteau, Strawberry and Upper Saline Watersheds. We were also limited in where we could estimate nutrient and sediment loads through the water-quality monitoring program, because load estimation requires a discharge record and it was not feasible to have stage-discharge monitoring sites established across the many HUC 12s in each of these watersheds. Therefore, we compared mean concentrations from the monitoring data to that predicted by the model at the subwatershed level (Sarswat et al., 2013). The SWAT model output represented cumulative loads at the subwatershed level, and base flow was calculated using the base flow filter by dividing the daily flow into base and surface flow fractions. We used the model output representing chemical concentrations during base flow conditions to estimate a mean concentration for TSS, TP and NO_3-N which would be representative of three years within the modeling period. The model estimated concentrations and loads at the HUC 12 outlets, whereas the monitoring program selected sites near the HUC outlet that provided public access. We ranked the subwatersheds based on mean concentration and calculated a Spearman rank coefficient (ρ) because the ultimate goal was prioritization, not absolute predictions.

RESULTS AND DISCUSSION

Since the SWAT model focused on prioritizing the subwatersheds based on TSS, TP and NO_3-N loads, we limited our discussion of results within this report to those constituents. All other data summaries are provided in the appendix, as well as detailed monthly loads from the three load estimation techniques.

Poteau Watershed

Base Flow Concentrations

The focus of this report is not on the variations in the monitoring data across the Poteau Watershed, but how the monitoring data compares with the SWAT model developed to provide subwatershed prioritization. The concentrations of NO_3-N, TP and TSS were variable across the watershed (Table 5), reflecting the spatial variability in local and watershed-level influences on water quality. The mean concentrations ranged from less than 0.10 to over 1.00 mg/L for NO_3-N, from 0.02 to over 0.35 mg/L for TP, and then less than 5 to approximately 15 mg/L for TSS. The general trends were that TP was elevated at sites where either NO_3-N or TSS was also relatively elevated, suggesting a nutrient source or that P was tied to particulates in the water column. There was substantial variability in nutrient concentrations at individual sites, where the coefficient of variation was near or even exceeded 100%.

Table 5. Mean nitrate-N, total phosphorus and total suspended solids concentration and standard deviation (StDev) from sites monitored in the Poteau Watershed.

Site ID	Nitrate-N (mg/L)		Total Phosphorus (mg/L)		Total Suspended Solids (mg/L)	
	Mean	± StDev	Mean	± StDev	Mean	± StDev
POT-12A	0.665	1.060	0.083	0.081	10.4	15.0
POT-13	0.890	1.100	0.355	0.259	8.3	7.5
POT-15B	0.179	0.193	0.061	0.056	12.4	22.1
POT-16	0.114	0.103	0.029	0.025	3.9	5.3
POT-17	0.337	0.465	0.033	0.013	5.4	4.7
POT-1A	0.063	0.070	0.057	0.064	8.5	11.8
POT-1C	0.980	1.191	0.186	0.205	10.9	16.8
POT-2	1.062	1.261	0.066	0.069	9.0	13.8
POT-21	0.349	0.437	0.037	0.031	4.5	4.0
POT-22	0.101	0.100	0.070	0.085	6.0	4.2
POT-24A	0.481	0.460	0.207	0.166	11.0	7.9
POT-28A	0.192	0.187	0.020	0.020	1.9	2.5
POT-29C	0.194	0.225	0.024	0.016	2.6	1.8
POT-3	0.215	0.302	0.033	0.024	5.5	4.1
POT-30A	0.120	0.122	0.026	0.017	2.3	1.3
POT-5	0.367	0.567	0.046	0.045	3.3	3.1
POT-8	0.116	0.157	0.107	0.071	15.5	12.2
POT-9	0.386	0.418	0.079	0.094	9.0	7.5
POT-P1	0.356	0.460	0.086	0.077	8.3	7.3
POT-P2	0.250	0.348	0.053	0.030	12.4	13.8

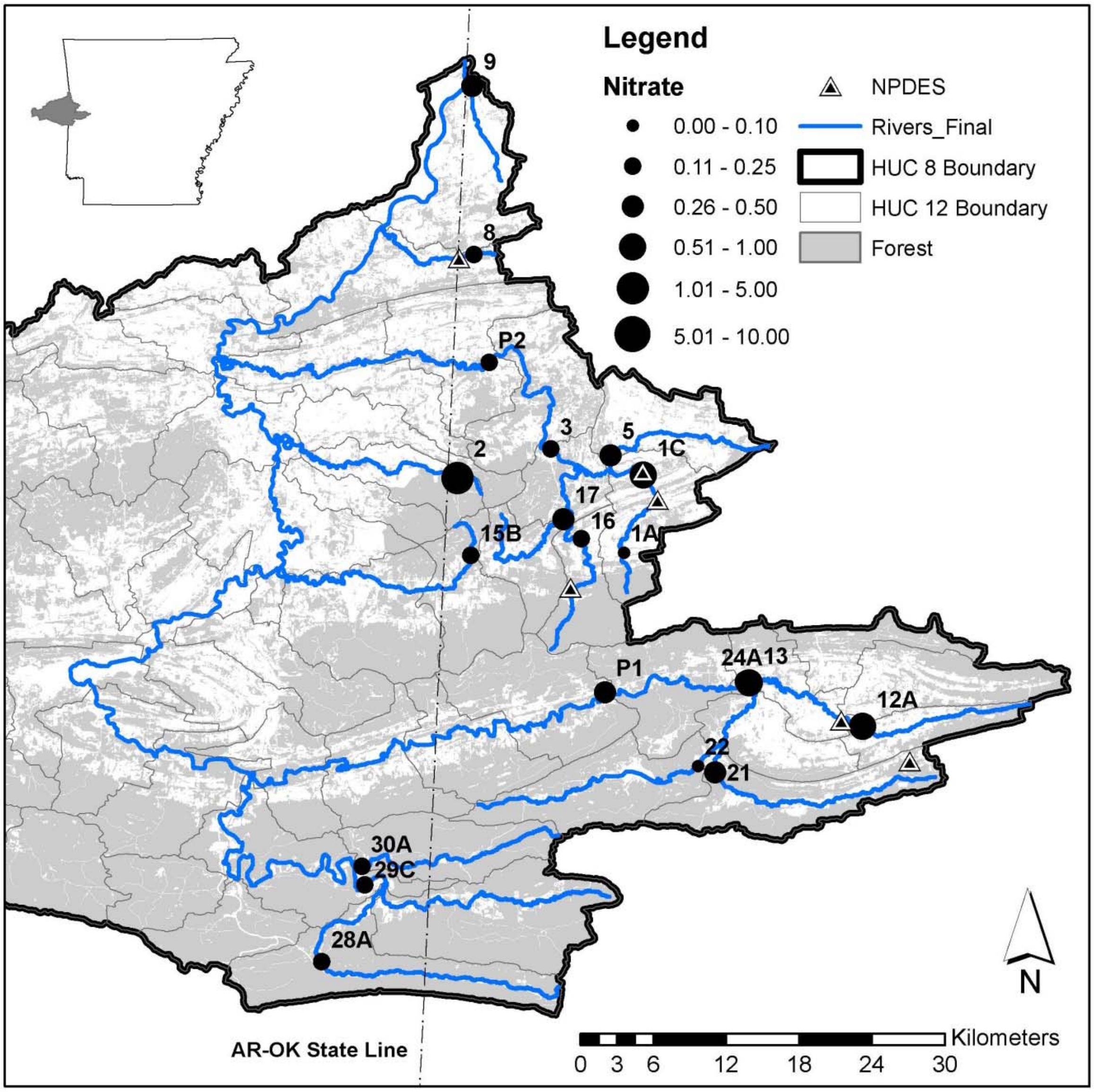

Figure 4. Nitrate-N concentrations (mg/L) at select monitoring locations in the Poteau watershed.

Nitrate-N concentrations were highly variable across the monitoring sites within the selected HUC 12s (Figure 4). The sites with elevated NO_3-N concentrations (i.e., larger symbols) contained permitted discharges upstream and also drained relatively developed catchments. Site 2 (Gap Creek HUC 12) was somewhat of an outlier, where this stream had NO_3-N concentrations on average of 1 mg/L but drained a catchment that was 83% forested. Nitrate-N concentrations are influenced broadly by catchment and riparian land use, where NO_3-N generally increases as forested area transitions into urban development and pasture (i.e., agriculture).

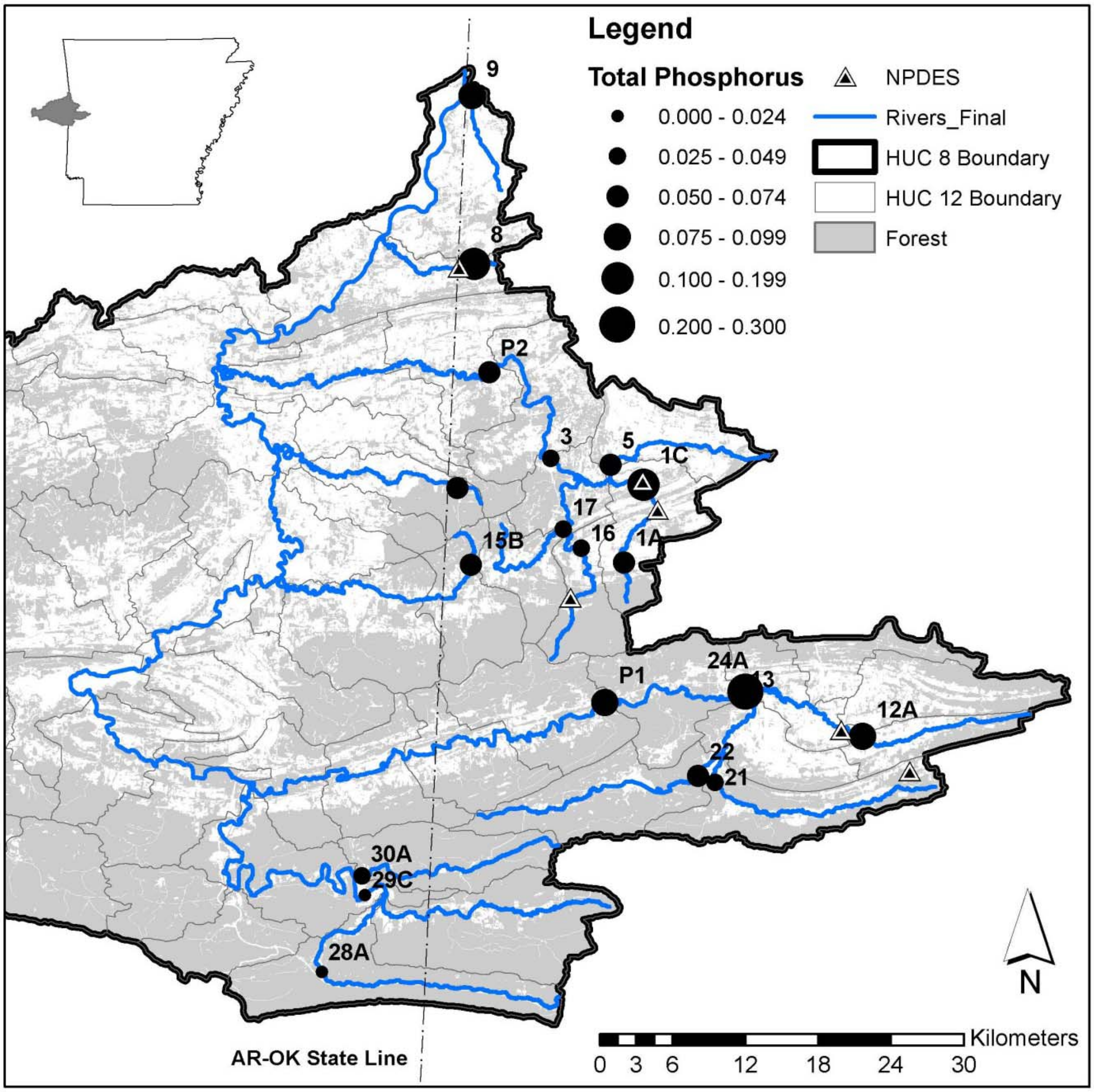

Figure 5. Total phosphorus concentrations (mg/L) at select monitoring locations in the Poteau watershed.

Total P concentrations were also variable across these sites (Figure 5), where TP was generally elevated within the HUC 12s that had permitted discharges. The permitted discharges also occur in the municipal areas of urban development, which are surrounded by and have pasture land use in the catchment. Phosphorus concentrations are broadly influenced by catchment and riparian land use, but effluent discharges often have a more profound influence on in-stream concentrations.

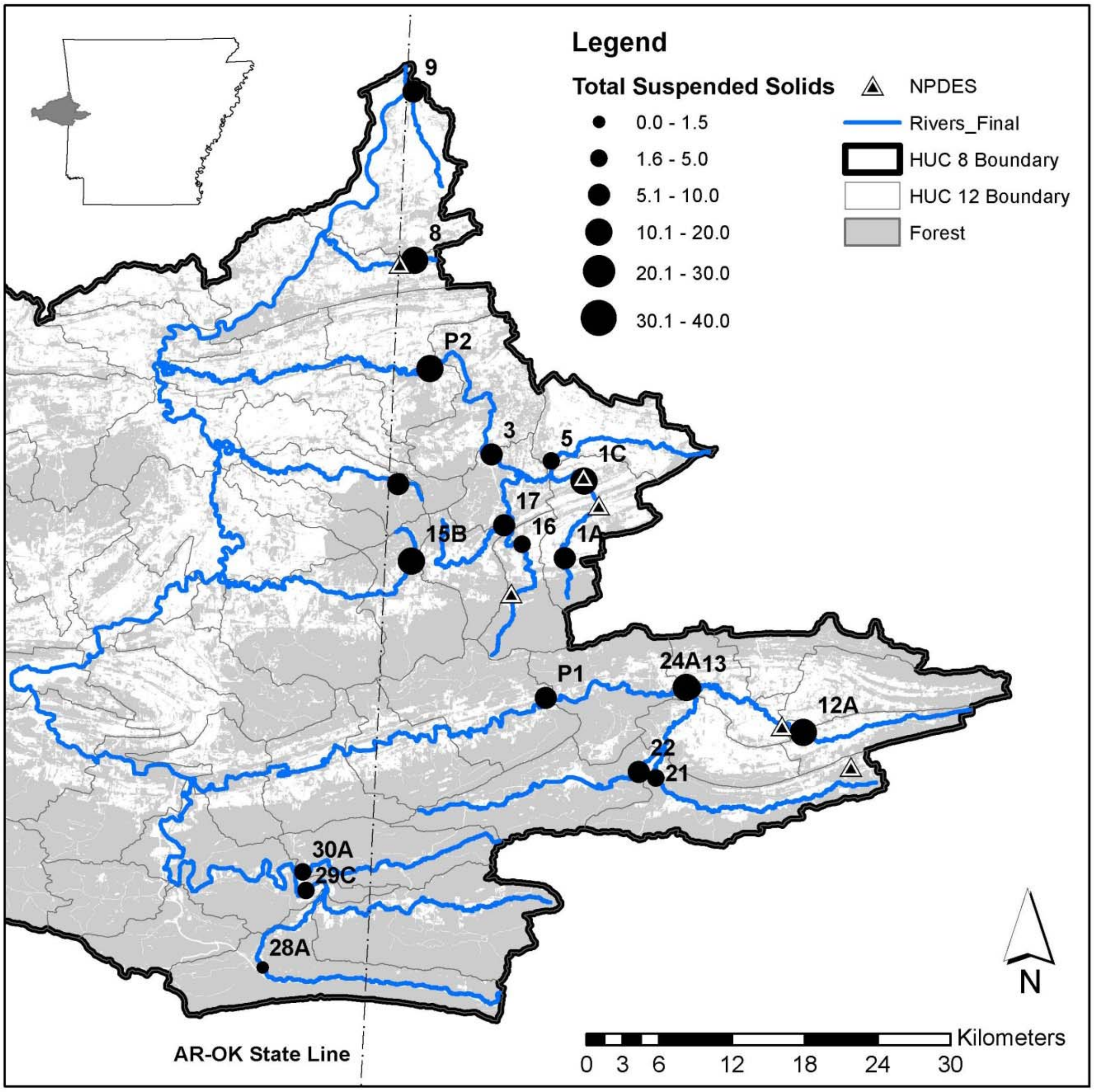

Figure 6. Total suspended sediment concentrations (mg/L) at select monitoring locations in the Poteau watershed.

Sediment concentrations in the water column were also variable (Figure 6), but TSS concentrations were generally low during base flow across the Poteau Watershed. The majority of the sites across the watershed had TSS concentrations less than the PQL, i.e. 7 mg/L. While the Poteau Watershed and Lake Wister in Oklahoma are often thought of as more turbid systems, the upper portion of the watershed in Arkansas has relatively clear waters (as suggested by low TSS). However, there are sites with greater than 10 mg/L of TSS in the water column on average, and these sites also tended to have greater TP concentrations as well.

Load Estimations

We were able to develop regression models to estimate nutrient and sediment loads based on the monitoring data, and the statistical models were significant (Table 6, P<0.001) for all three techniques at both sites in the Poteau Watershed where the USGS has active discharge monitoring stations (POT-P1 and POT-P2). The simple log-log regression technique estimated annual loads very similar to that predicted by the LOADEST Equation 1 AMLE, suggesting that the simple approach used in a spreadsheet provides sufficient information on nutrient and sediment loads (Table 7). When we compared monthly loads between these similar regression techniques (Figure 7), we found that monthly loads were highly correlated (R^2>0.99, P<0.001) with slopes near one. This result was not surprising, because the only real difference between the two approaches is how bias in re-transformation is corrected – but, it does provide evidence that our spreadsheet regression technique provides similar estimated NO_3-N, TP and TSS loads to that predicted using the USGS software program, LOADEST. This is significant because we have used the spreadsheet regression techniques to estimate loads for the ANRC 319 Program at water-quality monitoring sites across northwest Arkansas.

Table 6. Regression statistics including R^2, bias correction factor (BCF) and p-value for models used to estimate nutrient and sediment loads at POT-P1 and POT-P2 in the Poteau Watershed, Arkansas.

		POT-P1			POT-P2		
Constituent	Statistic	Regression	Equation 1	Equation 4	Regression	Equation 1	Equation 4
NO_3-N	R^2	0.92	0.92	0.98	0.92	0.92	0.97
	BCF	1.37	-	-	1.59	-	-
	P-value	<0.001	<0.001	<0.001[1]	<0.001	<0.001	<0.001[1]
SRP	R^2	0.92	0.92	0.94	0.95	0.95	0.97
	BCF	1.68	-	-	1.40	-	-
	P-value	<0.001	<0.001	<0.001[1]	<0.001	<0.001	<0.001[1]
TN	R^2	0.97	0.97	0.99	0.99	0.99	0.99
	BCF	1.11	-	-	1.05	-	-
	P-value	<0.001	<0.001	<0.001[1]	<0.001	<0.001	<0.001[1]
TP	R^2	0.93	0.93	0.95	0.94	0.94	0.97
	BCF	1.36	-	-	1.28	-	-
	P-value	<0.001	<0.001	<0.001[1]	<0.001	<0.001	<0.001[1]
TSS	R^2	0.90	0.90	0.93	0.90	0.90	0.92
	BCF	1.62	-	-	1.79	-	-
	P-value	<0.001	<0.001	<0.001[1]	<0.001	<0.001	<0.001[1]

[1] P-value based on discharge coefficient

The LOADEST Equation 4 AMLE, which included the sine and cosine factors to account for seasonal variations, was also comparable to the other load estimation techniques, especially during 2012 (Table 7). The amount of data used to estimate loads were constrained by the period of the monitoring program (i.e., one year), where most of the time we would ideally have multiple years of data collected at a regular frequency to have a better understanding of seasonal variations. None-the-less, the statistical significance of LOADEST Equation 4 AMLE and at times the sine and cosine functions suggest that seasonal variation might exist in the constituents. This is further supported by the large variations in constituent concentrations at individual sites, where the standard deviation was almost as or greater than the mean concentration. The seasonal variations in constituent concentrations are often present downstream from effluent discharges, or in constituents like NO_3-N that are strongly influence by biogeochemical processes.

However, we did not select LOADEST Equation 4 AMLE for comparisons with the model output, primarily because we thought that we needed data over a larger temporal scale (i.e., multiple years) to account for seasonal variation during load estimation. There were some cases where LOADEST Equation 1 and 4 differed by a factor of two to three, particularly at POT-P2 where NO_3-N loads were substantially less with Equation 4 during 2011 and 2012 as well as TP and TSS loads which were substantially more with Equation 4 during the wetter 2011. This suggests that caution should be used when using data collected over a limited time (e.g., one year) to estimate loads with regression models that consider sine and cosine functions to address seasonal variations.

Without multiple years of data, we thought the simple regression model based on variations in discharge was the best way to evaluate the predictions and performance of watershed modeling efforts, especially when modeling and monitoring periods do not overlap. Figure 8 shows the scatter plots of monthly NO_3-N, TP and TSS loads as a function of monthly discharge for the Poteau Watershed, where the monitoring data used the simple regression model based on discharge and the SWAT model output was provided by Saraswat et al. (2013). We want to see the loads estimated by the regression method and the watershed model following the same general trend.

Table 7. Annual nutrient and sediment loads for calendar year 2011 and 2014 at POT-P1 and POT-P2 in the Poteau Watershed calculated based on regression and USGS LOADEST Equations 1 and 4 AMLE.

	Nitrate-N (kg)		Total Phosphorus (kg)		Total Suspended Solids (kg)	
	2011	2012	2011	2012	2011	2012
POT-P1						
Regression	143,600	68,700	110,300	49,400	33,200,000	13,600,000
Equation 1	143,300	68,800	113,300	51,000	36,700,000	15,150,000
Equation 4	132,600	45,100	104,600	35,800	30,700,000	10,900,000
POT-P2						
Regression	79,000	45,600	26,800	16,300	14,840,000	8,700,000
Equation 1	77,100	44,700	26,800	16,300	14,200,000	8,350,000
Equation 4	22,000	29,300	68,700	17,720	40,300,000	9,810,000

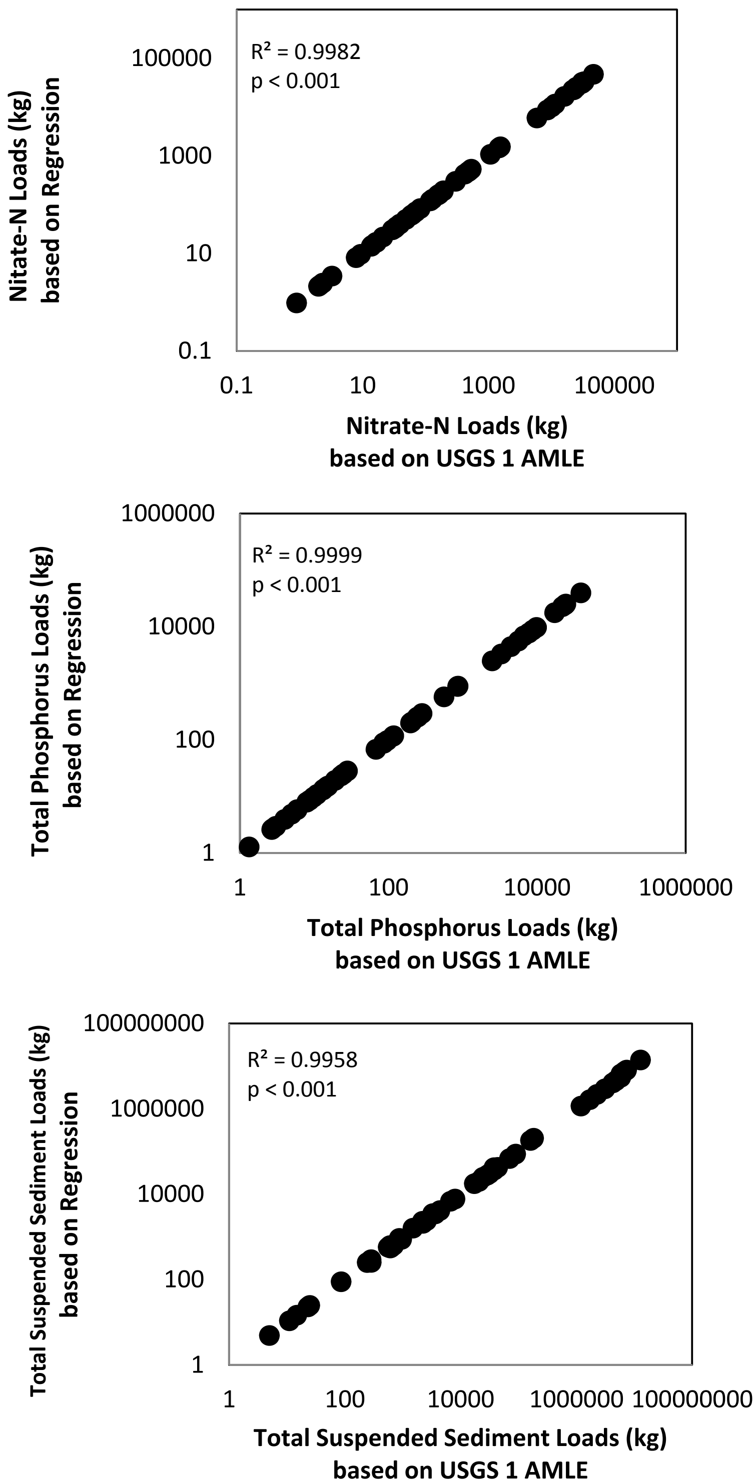

Figure 7. Relation between nutrient and sediment loads estimated using USGS LOADEST Equation 1 AMLE and loads estimated using simple regression with bias correction factor.

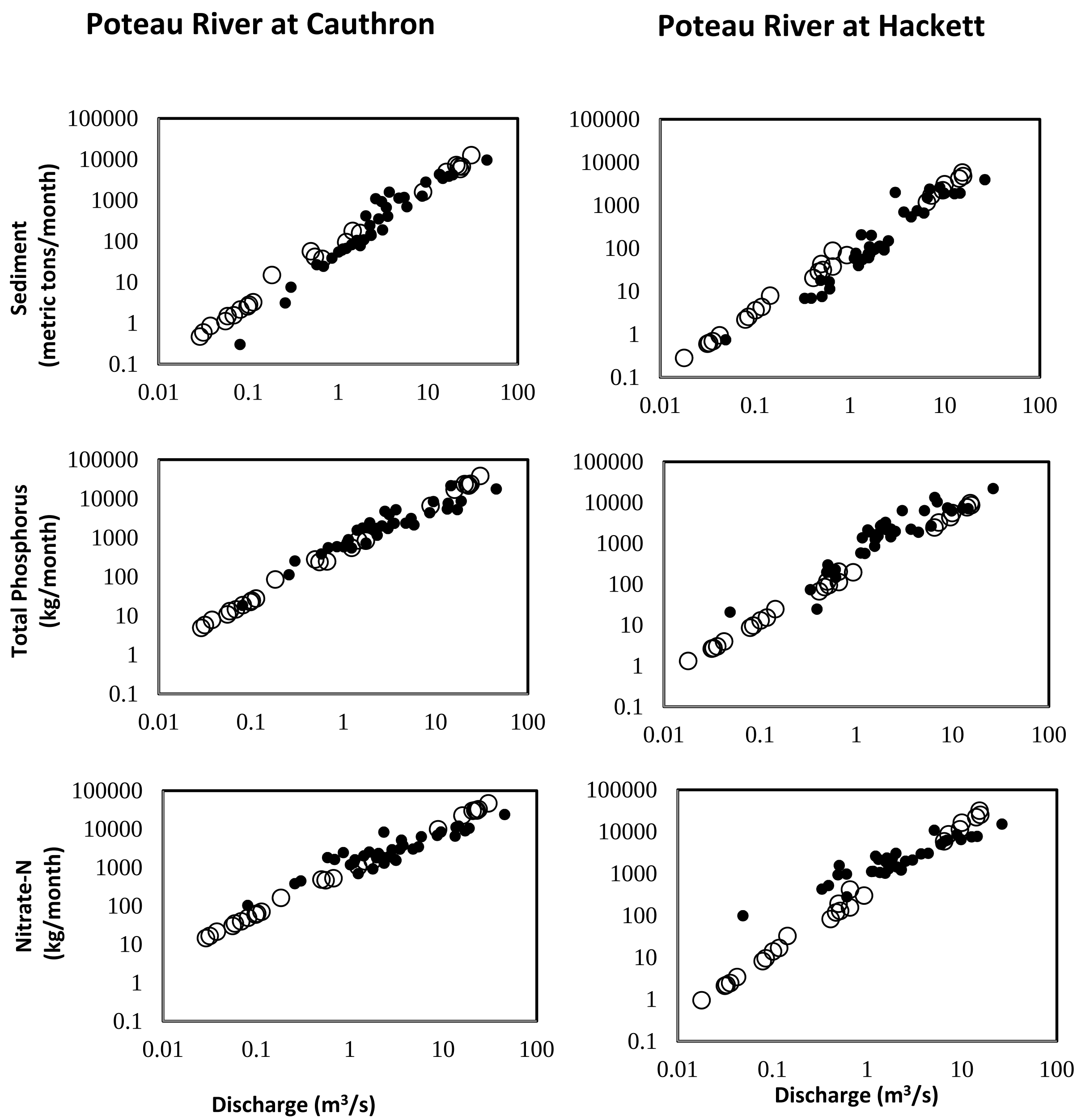

Figure 8. Relation between discharge and sediment and nutrient loads at Poteau River at Cauthron (POT-P1) and James Fork near Hackett (POT-P2) estimated by simple regression with bias correction factor (open) and SWAT model (closed).

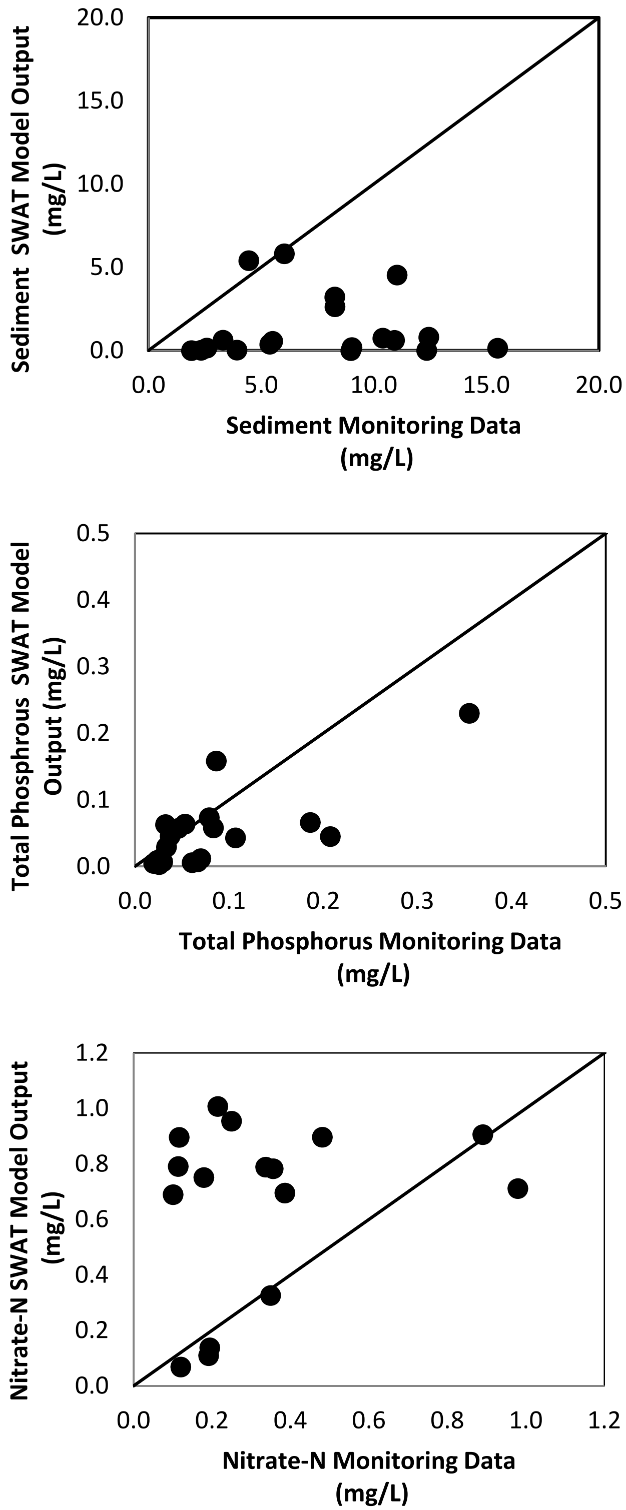

Figure 9. Relation between nutrient and sediment concentrations observed in monitoring data, 2011-2012 and SWAT model output, 2008-2010 at Poteau Watershed HUC-12s.

The loads of NO_3-N, TP and TSS predicted by the regression method and the watershed model show relatively good agreement overall. In general, we would like to see these symbols show a close relation over the range in monthly flow which happens across the two sites in the Poteau Watershed, with two minor discussion points (Figure 8). First, the sediment loads at the Poteau River near Cauthron (POT-P1) tend to be under-predicted by the watershed model relative to the load estimated by the regression method. However, the majority of sediment transport occurs during storm events (i.e., high flows) and the symbols overlap on that end suggesting good agreement. Second, the NO_3-N loads tend to be over-predicted by the watershed model relative to the load estimated by the regression method. Nitrate-N loads are greater with increased discharge, but these data (i.e., monthly NO_3-N loads) tend to fall on separate relations with discharge. We need to expand our analysis to evaluate possible statistical differences in these relationships, but for the purposes of this study – the watershed model output compared favorably with the estimated loads from the monitoring data. This favorable comparison might not be surprising, because Saraswat et al. (2013) did have some available nutrient and sediment loading data available to calibrate the watershed model. This is actually a benefit for this project, because it shows that comparing the relations between monthly loads and discharge is a good way to evaluate model performance in the absence of monitoring data collected during the modeling period.

The second way we compared monitoring data to the watershed model output was through the mean concentrations measured and predicted, respectively, at the selected HUC 12s across the Poteau watershed (Figure 9). We compared mean concentrations during base flow conditions for the SWAT model and monitoring data. Monitoring and modeling periods did not overlap in time, so watershed changes during the time difference may have influenced nutrient and sediment concentrations and affected the watershed monitoring and model relationship. We observed significant relations between the monitoring data and the model output for NO_3-N and TP, but not TSS (Table 8). The slopes of the linear relation are not really close to one, which would mean equality in predictions. However, the most important aspect is that the monitoring data and watershed model output suggest that the same sites are high or low – thus, the observation that the Spearman rank coefficient is significant shows the ranks from low to high are in good agreement between the data and model output. This is important because it shows that the watershed model does provide the ability to prioritize subwatersheds, and the significant relations increase our confidence.

Table 8. Summary of regression statics describing the relation between monitoring data collected from HUC-12s and SWAT model output at the Poteau Watershed.

Total Suspended Solids (mg/L)			Total Phosphorus (mg/L)			Nitrate-N (mg/L)		
	Regression			*Regression*			*Regression*	
slope	r	P-value	slope	r	P-value	slope	r	P-value
-0.007	0.032	0.989	0.500	0.728	<0.001	0.796	0.438	0.060
	Spearman's Rank Coefficient			*Spearman's Rank Coefficient*			*Spearman's Rank Coefficient*	
n	ρ	P-value	n	ρ	P-value	n	ρ	P-value
19	0.198	0.414	19	0.616	0.006	19	0.454	0.051

Strawberry Watershed

Baseflow Concentrations

The focus of this project was to help validate the SWAT model (Saraswat et al., 2013) being used to prioritize the subwatersheds within the Strawberry Watershed. Therefore, we will not provide a detailed discussion about spatial and temporal variability in nutrient and sediment concentrations for the monitoring sites. The concentrations of NO_3-N, TP, and TSS were variable but relatively low across the watershed (Table 9), and the spatial variability was not closely related to catchment land uses (data not shown). The mean concentrations ranged from <0.10 mg/L to 0.50 mg/L for NO_3-N, from 0.02 mg/L to approximately 0.30 mg/L for TP, and <5 mg/L to over 35 mg/L for TSS. There was a considerable amount of variability in constituent concentrations within individual sites, where the coefficient of variation often exceeded 100%

Table 9. Mean nitrate-N, total phosphorus and total suspended solids concentration and standard deviation (StDev) from sites monitored in the Poteau Watershed.

Site ID	Nitrate-N (mg/L)		Total Phosphorus (mg/L)		Total Suspended Solids (mg/L)	
	Mean	± StDev	Mean	± StDev	Mean	± StDev
STR-1	0.496	0.135	0.028	0.026	9.6	8.5
STR-10	0.150	0.182	0.026	0.016	14.8	7.4
STR-11	0.173	0.145	0.016	0.011	5.7	2.7
STR-12	0.165	0.175	0.021	0.022	2.4	2.2
STR-13	0.138	0.178	0.020	0.014	6.3	3.8
STR-16	0.047	0.049	0.011	0.007	1.8	1.5
STR-17	0.035	0.040	0.294	0.185	35.1	72.0
STR-2	0.185	0.149	0.049	0.031	26.1	14.0
STR-20	0.205	0.198	0.017	0.011	3.2	2.4
STR-22	0.153	0.188	0.016	0.013	2.3	2.1
STR-23	0.141	0.178	0.022	0.015	4.4	4.9
STR-24A	0.104	0.086	0.012	0.012	0.9	0.5
STR-26	0.182	0.199	0.028	0.018	6.0	3.2
STR-27	0.303	0.188	0.026	0.018	3.8	4.4
STR-5	0.198	0.119	0.023	0.015	6.5	4.7
STR-6	0.185	0.161	0.022	0.028	5.7	10.8
STR-7	0.179	0.161	0.021	0.014	4.1	4.5
STR-8	0.159	0.123	0.019	0.023	3.6	5.3
STR-9	0.098	0.067	0.041	0.023	7.0	3.4
STR-S1	0.162	0.167	0.016	0.010	7.7	5.1

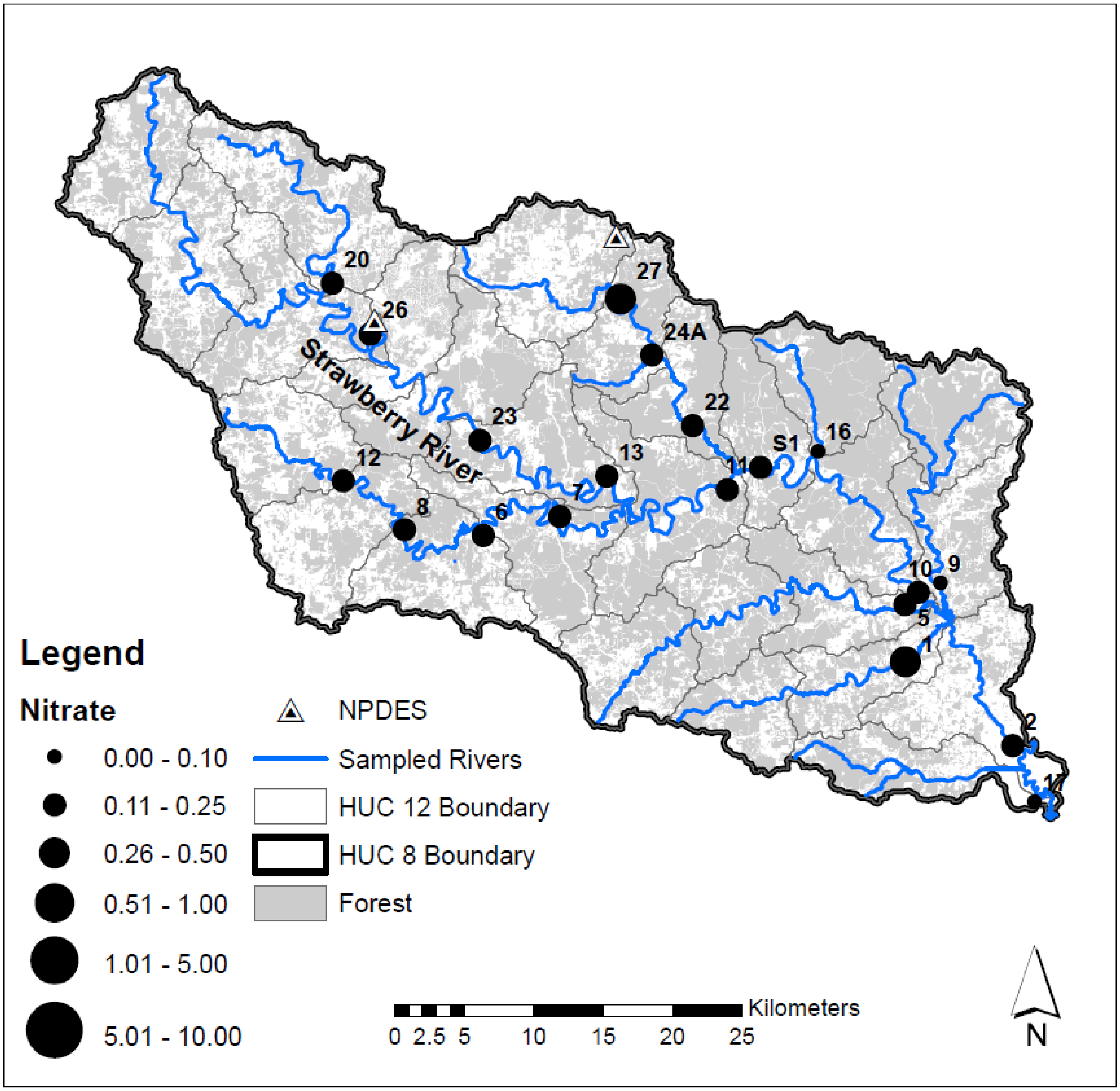

Figure 10. Nitrate-N concentration (mg/L) at select monitoring locations in the Strawberry watershed.

While the range in NO_3-N concentration was up to 0.50 mg/L (Table 9), all sites but one (STR-1) had concentrations less than or equal to 0.30 mg/L on average (Figure 10). Nitrate-N concentrations within the Strawberry Watershed were low. Nitrate-N was not significantly related to land use characteristics across the sites, with the exception of STR-27 which was below a WWTP. Concentration, as well as land use variability between the sites was small.Elevated NO_3-N during base flow conditions does not seem to be a primary concern within this particular watershed, based on the sites monitored.

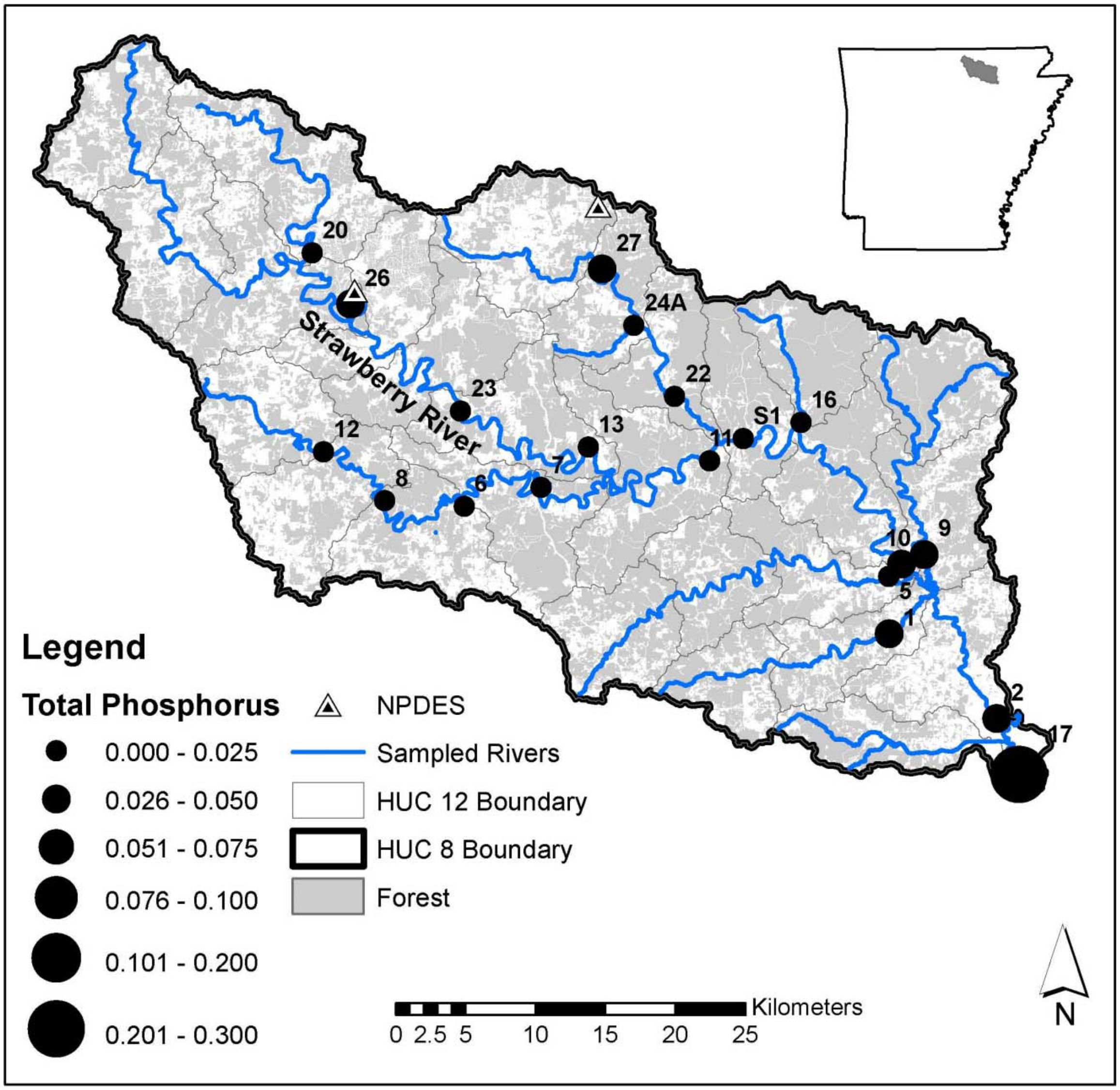

Figure 11. Total phosphorus concentration (mg/L) at select monitoring locations in the Strawberry watershed.

Total P was relatively similar across the sites monitored in the Strawberry Watershed (Figure 11), where only three sites had TP concentrations greater than 0.03 mg/L. The greatest TP concentration occurred at the site STR 17 (Caney Creek), which is a small, mostly stagnant agricultural drainage tributary that flows into the Strawberry River. This site has 40% agricultural land use in its catchment, but several other sites have similar land use characteristics and TP concentrations with an order of magnitude less. Phosphorus concentrations in the selected sites were not significantly related to land uses nor traced to permitted discharge.

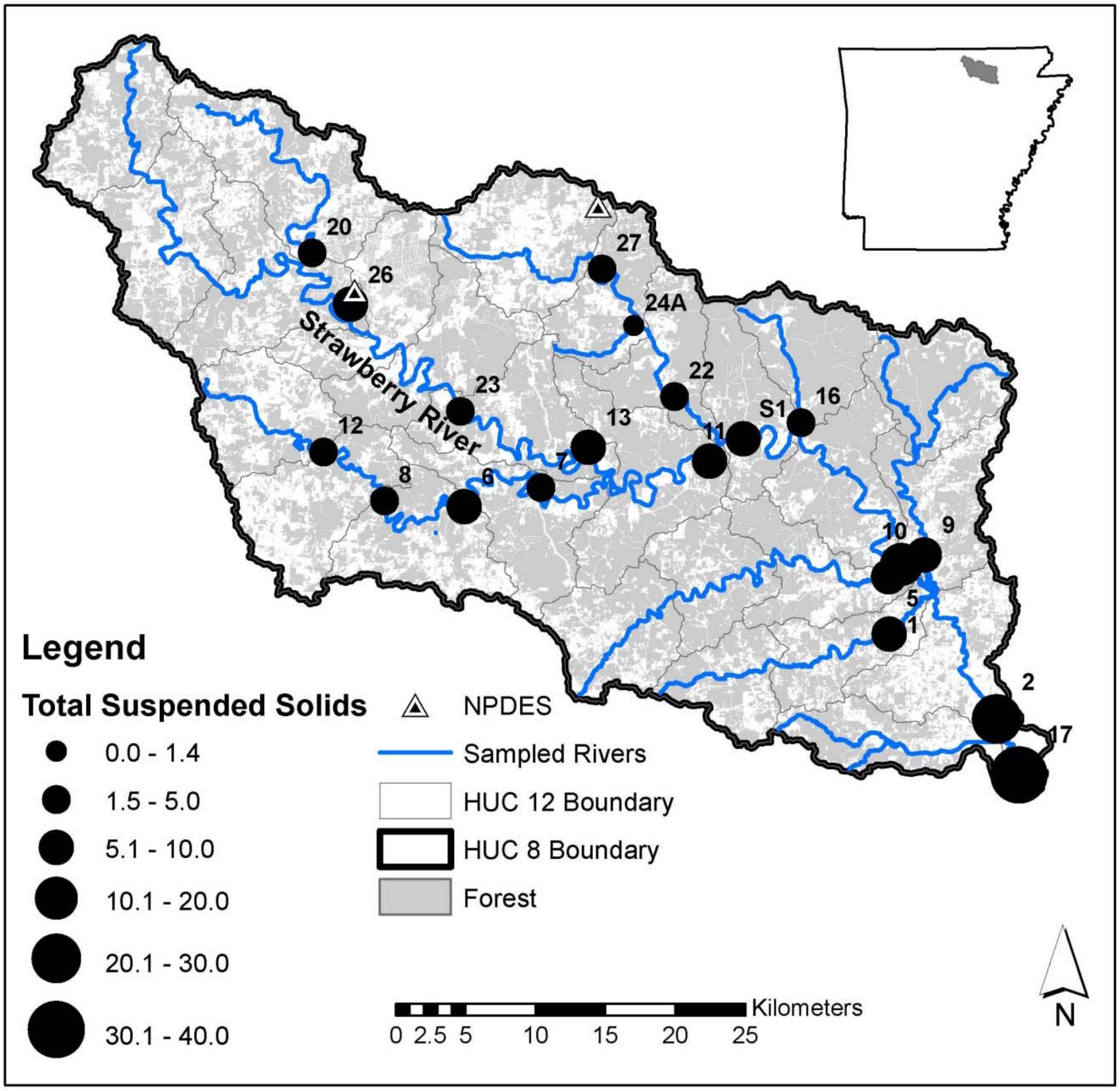

Figure 12. Total suspended solids concentration (mg/L) at select monitoring locations in the Strawberry watershed.

Sediment concentrations were more variable spatially across the selected sites within the Strawberry Watershed (Figure 12). However, only six sites had mean TSS concentrations which exceeded the PQL of 7 mg/L. The two sites with the greatest TSS concentrations on average occurred near the watershed outlet, i.e., the Strawberry River (Site 2) and Caney Creek (Site 17). This tributary to Strawberry River deserves additional attention, because it has the highest TSS and TP concentrations but NO_3-N less than 0.1 mg/L.

Load Estimations

We were able to develop regression modeled to estimate nutrient loads based on the monitoring data, and the statistical models were significant (Table 10; P<0.001) for all three techniques at the Strawberry River. The simple log-log regression technique estimated annual loads very close to that estimated by LOADEST Equation 1 (Table 11), again suggesting congruence between these two techniques. The monthly loads between these two techniques were highly correlated (R^2>0.99, p<0.001, data not shown). We wanted to test or compare the loads estimated by these regression methods at this watershed also, and our spreadsheet regression technique estimates loads very similarly to that calculated by LOADEST when using the same equation but different bias correction.

Table 10. Regression statistics including R^2, bias correction factor (BCF) and p-value for models used to estimate nutrient and sediment loads at STR-S1 in the Strawberry Watershed, Arkansas.

Constituent	Statistic	Regression	Equation 1	Equation 4
NO_3-N	R^2	0.94	0.94	0.96
	BCF	1.27	-	-
	P-value	<0.001	<0.001	<0.001[1]
SRP	R^2	0.90	0.898	0.92
	BCF	1.22	-	-
	P-value	<0.001	<0.001	<0.001[1]
TN	R^2	0.98	0.984	0.99
	BCF	1.04	-	-
	P-value	<0.001	<0.001	<0.001[1]
TP	R^2	0.85	0.85	0.93
	BCF	1.38	-	-
	P-value	<0.001	<0.001	<0.001[1]
TSS	R^2	0.91	0.91	0.96
	BCF	1.33	-	-
	P-value	<0.001	<0.001	<0.001[1]

[1] P-value based on discharge coefficient

The LOADEST Equation 4 AMLE which accounts for seasonal variations in constituent concentrations and loads was relatively comparable during the low flow year (2012). However, the results were not comparable during the high flow year (2011) across all the constituents. Nitrate-N loads were almost four times less, whereas TP and TSS loads were an order of magnitude more when compared to the regression models only using discharge (Table 7). This further suggests that caution should be used when including sine and cosine factors in load estimation, especially when you have a limited amount of information about seasonal variability. Again, we selected the regression model based on variation in discharge to evaluate the predictions and performance of the SWAT modeling of the Strawberry Watershed.

The best approach to evaluating watershed model predictions and performance is qualitatively assessing the relation between monthly load and discharge. We want to see the loads estimated by regression methods and watershed modeling at the Strawberry River following the same pattern. Figure 13 shows the scatter plots of monthly NO_3-N, TP and TSS loads as a function of monthly discharge, where the monitoring data used the simple regression model based on discharge and the SWAT model output was provided by Saraswat et al. (2013).

Table 11. Annual nutrient and sediment loads for calendar year 2011 and 2012 at STR-S1 in the Strawberry Watershed calculated based on regression and USGS LOADEST Equations 1 and 4 AMLE.

	Nitrate-N (kg)		Total Phosphorus (kg)		TSS (kg)	
	2011	2012	2011	2012	2011	2012
Regression	630,000	62,191	277,286	19,710	198,615,425	11,030,491
Equation 1	567,000	57,500	300,000	23,060	194,000,000	11,300,000
Equation 4	173,000	50,700	4,340,000	30,130	4,560,000,000	22,300,000

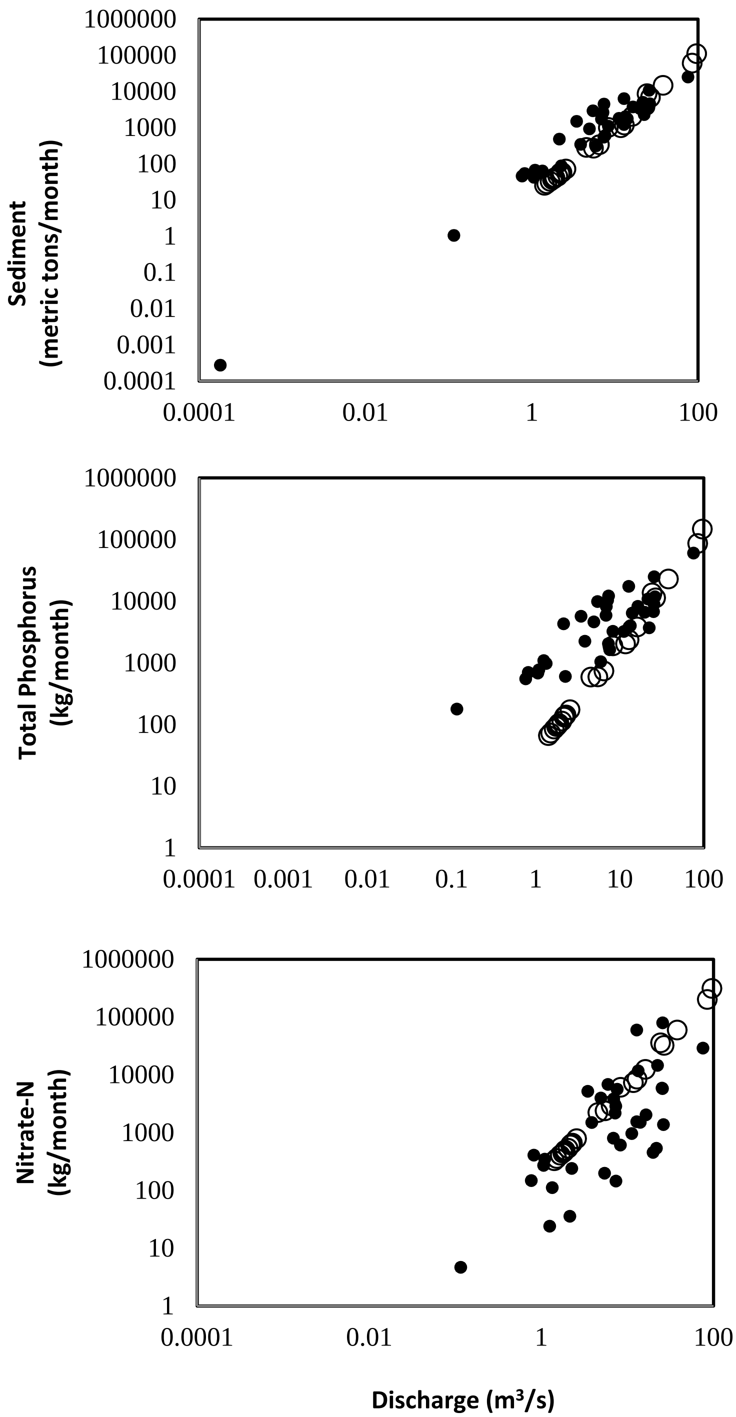

Figure 13. Relation between discharge and sediment and nutrient loads at Strawberry River at Poughkeepsie (STR-S1) estimated by simple regression with bias correction factor (open) and SWAT model (closed).

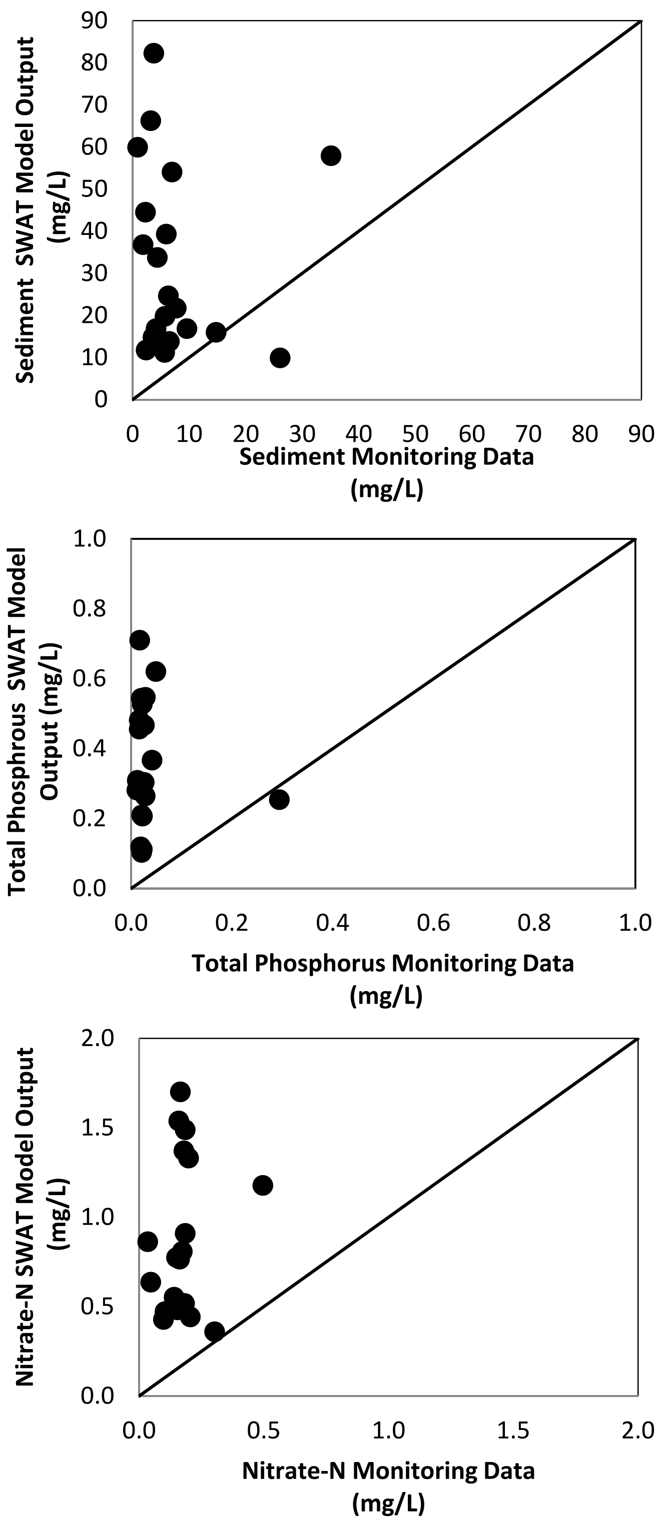

Figure 14. Relation between nutrient and sediment concentrations observed in monitoring data, 2011-2012 and SWAT model output, 2008-2010 at Strawberry Watershed HUC-12s.

The monthly loads of NO_3-N, TP and TSS predicted by the regression method and the watershed model both increase with monthly discharge, showing relatively good agreement (Figure 13). We would like to see the symbols representing the watershed model output fall in close proximity above and below the symbols representing the regression method. This generally occurs for NO_3-N at the Strawberry River, but the watershed model tends to over-predict TP and TSS loads at the lower discharges. However, the majority of the sediment and P transport occurs during storm events (i.e., high flows) and the symbols tend to overlap on that end. These results suggest relatively good agreement which increases our confidence in the watershed modeling output. This is especially important because Saraswat et al. 2013 did not have any nutrient or sediment loadings for use in model calibration. The relative agreement and overlap of the symbols in Figure 13, suggest that the regionalization approach used to calibrate the SWAT model was successful at this site (i.e., the Strawberry River) within the Strawberry Watershed.

The second way we evaluated the SWAT model output for the Strawberry Watershed was through comparing the mean concentrations measured and predicted at the selected HUC 12s. The focus was on comparing constituent concentrations during base flow. We also need to keep in mind that the monitoring periods and modeling periods do not overlap, so landscape changes within the watershed can influence nutrient and sediment concentrations. We did not observe any significant correlations ($r<0.20$, $P\geq0.10$; Table 12) between the monitoring data and the watershed model output (Figure 14). Furthermore, the Spearman rank coefficients between the measured and predicted mean concentration were not significant ($P>0.20$; Table 12) for NO_3-N, TP and or TSS. This was an unfortunate observation, because this limits our confidence in the watershed model and its ability to prioritize the subwatersheds within the Strawberry Watershed. This is not the fault of the modeling effort by Saraswat et al. (2013), but it is a reflection of modeling watershed processes when you have limited data available on nutrient and sediment loads spatially.

Table 12. Summary of regression statics describing the relation between monitoring data collected from HUC-12s and SWAT model output at the Strawberry Watershed.

Total Suspended Solids (mg/L)			Total Phosphorus (mg/L)			Nitrate-N (mg/L)		
	Regression			*Regression*			*Regression*	
slope	r	P-value	slope	r	P-value	slope	r	P-value
-0.134	0.055	0.825	-0.294	0.100	0.100	0.858	0.192	0.419
	Spearman's Rank Coefficient			*Spearman's Rank Coefficient*			*Spearman's Rank Coefficient*	
n	ρ	P-value	n	ρ	P-value	n	ρ	P-value
20	-0.293	0.209	20	0.0692	0.767	20	0.211	0.368

Upper Saline Watershed

Baseflow Concentrations

The focus of this report is not on the magnitude or variations in the monitoring data across the Upper Saline Watershed, but how it compares with the SWAT model developed and used to provide subwatershed prioritization. The constituent concentrations were variable across this watershed, ranging from less than 0.10 to over 8.00 mg/L for NO_3-N, from less than 0.20 to 0.22 mg/L for TP, and from less than 5 to almost 13 mg/L for TSS during baseflow conditions (Table 13). There was substantial variability in nutrient and sediment concentrations at individual sites, as the coefficient of variation was often near or even exceeded 100%. The variability within individual sites likely reflects seasonal changes in constituent concentrations across the monitoring period.

Table 13. Average nitrate-N, total phosphorus and total suspended solids concentration and standard deviation from sites monitored in the Upper Saline Watershed.

Site ID	Nitrate-N (mg/L)		Total Phosphorus (mg/L)		Total Suspended Solids (mg/L)	
	Mean	± StDev	Mean	± StDev	Mean	± StDev
SAL-11	0.170	0.136	0.072	0.052	12.7	13.0
SAL-13	0.248	0.186	0.043	0.023	10.3	9.0
SAL-14	0.166	0.115	0.052	0.026	7.9	7.5
SAL-16	0.496	0.536	0.081	0.072	7.7	5.5
SAL-3	0.008	0.009	0.043	0.024	8.0	4.6
SAL-30A	0.079	0.126	0.020	0.013	2.2	1.3
SAL-31	0.042	0.046	0.017	0.014	2.3	1.9
SAL-32	0.043	0.045	0.015	0.007	2.1	1.0
SAL-34A	0.070	0.084	0.022	0.012	6.0	6.9
SAL-35	8.813	5.426	0.220	0.152	1.4	0.8
SAL-36	0.399	0.228	0.147	0.154	6.9	4.0
SAL-37	0.097	0.113	0.020	0.006	2.2	0.8
SAL-39	0.025	0.037	0.023	0.022	10.2	17.0
SAL-5	0.036	0.039	0.042	0.025	7.1	4.5
SAL-8	0.106	0.081	0.051	0.022	9.3	8.7
SAL-U1	0.003	0.002	0.025	0.029	3.5	5.3
SAL-U2	0.043	0.107	0.017	0.012	2.4	2.8
SAL-U3A	0.083	0.077	0.025	0.017	4.3	3.1
SAL-U4	0.091	0.076	0.069	0.038	9.9	6.1
SAL-U6	0.023	0.020	0.014	0.011	2.5	1.3

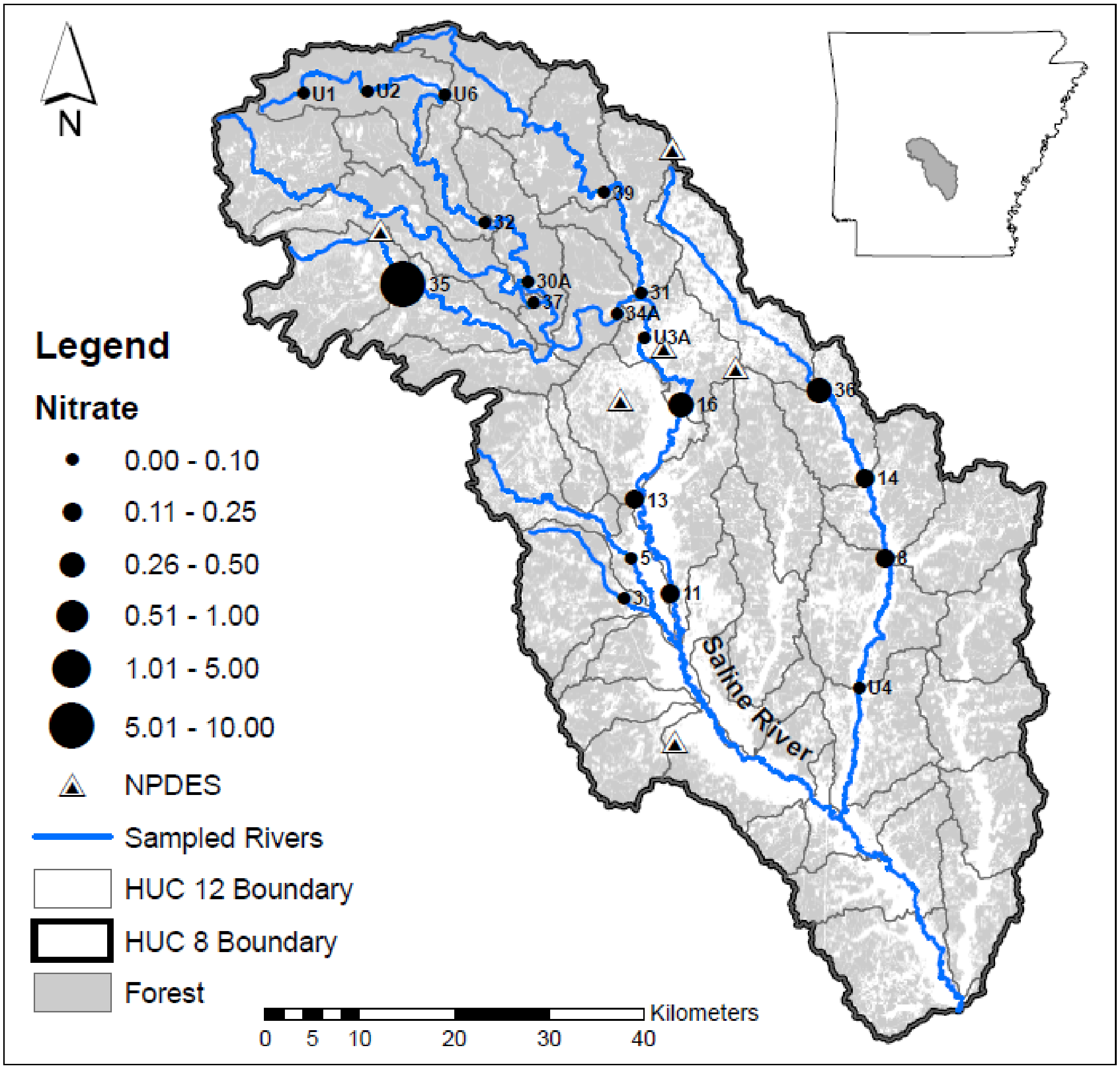

Figure 15. Nitrate-N concentration (mg/L) at select monitoring locations in the Upper Saline watershed.

Nitrate-N concentrations were relatively small across the majority of the Upper Saline Watershed (Figure 15) with the exception of a few sites that could be traced back to permitted discharges, especially SAL-35 (a tributary of Cedar Creek which flows into the South Fork of the Saline River). This particular site had the greatest NO_3-N concentrations (8.81 mg/L) on average, whereas the other sites across the watershed had NO_3-N less than 0.50 mg/L on average. The SAL-35 sampling location was directly below the Hotsprings Village WWTP effluent discharge. The stream at the sampling site had a small wetted width (<6 ft) and depth (<1 ft) and so it is not uncharacteristic to assume that a very large portion of the stream was waste water effluent. The low NO_3-N concentrations in the remainder of the watershed suggest that this species of dissolved inorganic N might not be the dominant form of TN. Thus, it might be better to focus on TN in this watershed and the other two monitored in this project.

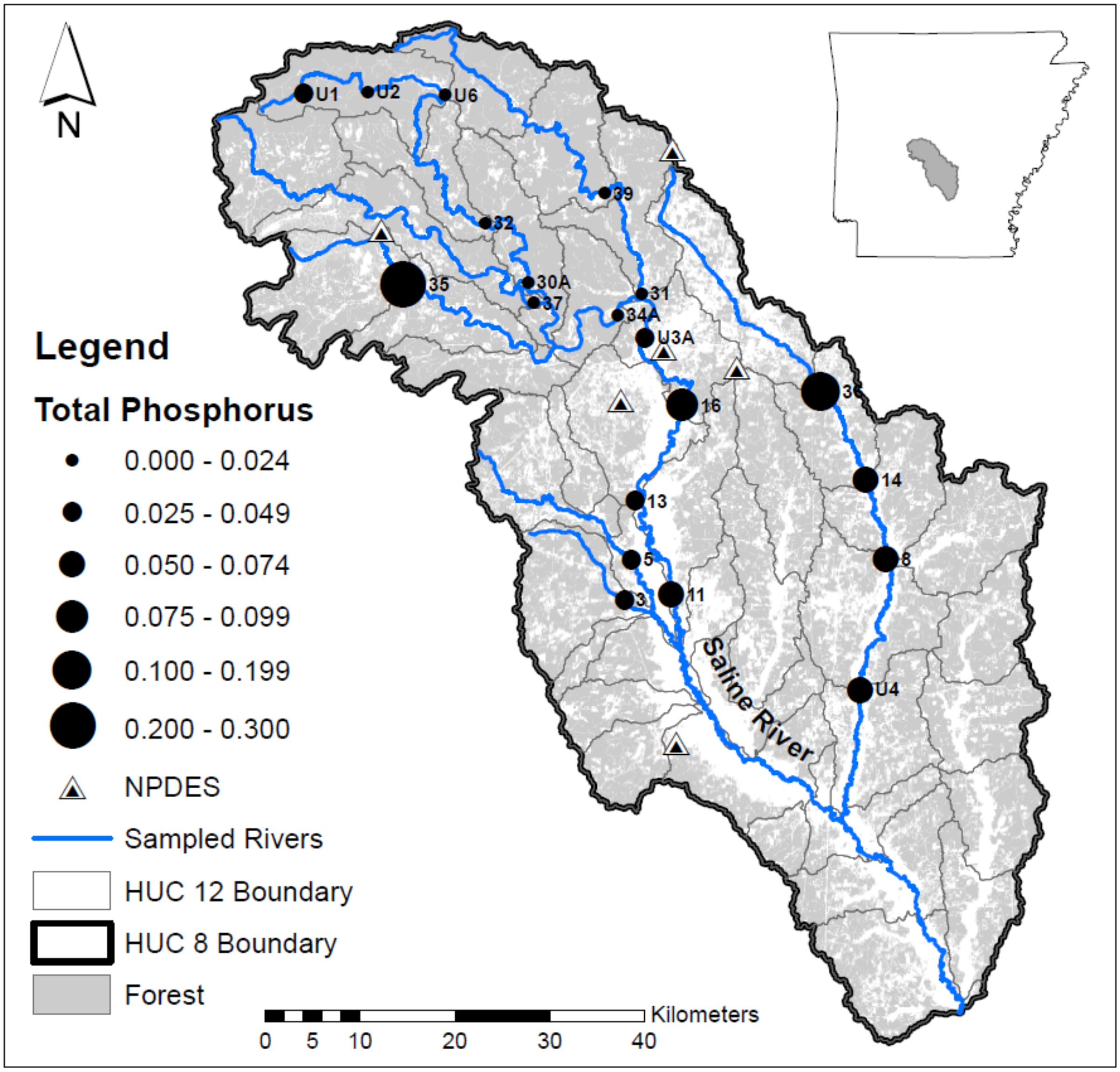

Figure 16. Total phosphorus concentration (mg/L) at select monitoring locations in the Upper Saline watershed.

Total P concentrations averaged across the entire watershed were less than those of the Poteau but greater than the Strawberry. Sampling sites below permitted discharges exhibited the highest Total P concentrations. Four sites exceeded 0.07 mg/l with SAL-35 and SAL-36 being the highest at 0.220 and 0.147 mg/l, respectively. SAL-35, as discussed before, is a small, wastewater dominated feeder creek. SAL-36 was also a site sampled below a permitted discharge facility but also had the second highest urban land use in the Upper Saline watershed at 16% (Figure 16). Phosphorus in streams is broadly influenced by catchment land use, but at times local, riparian influence might be even more important. The majority of sites within the Upper Saline Watershed had mean TP concentrations less than 0.04 mg/L.

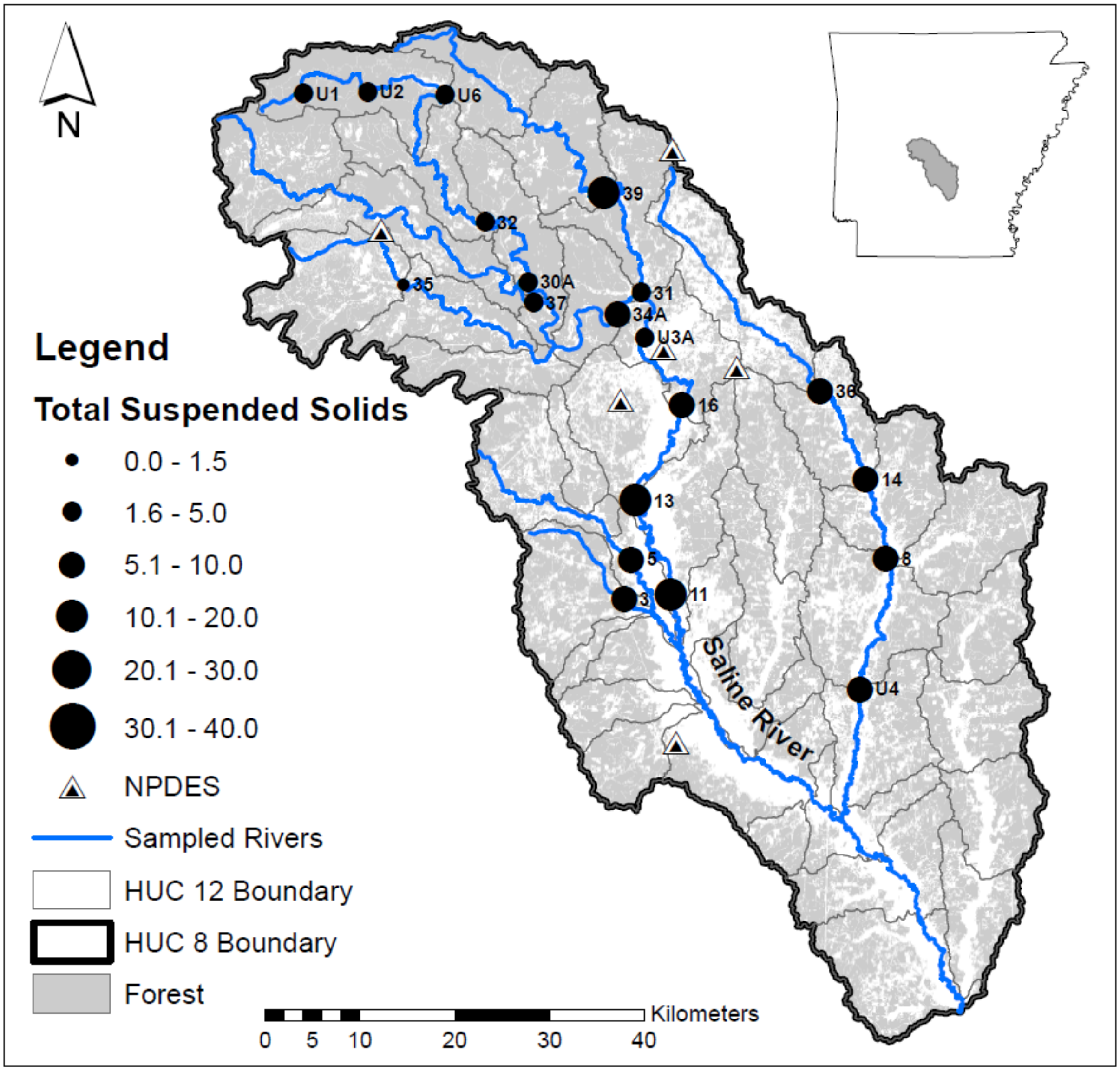

Figure 17. Total suspended solids concentration (mg/L) at select monitoring locations in the Upper Saline watershed.

Sediment concentrations in the water column were also spatially variable, but TSS concentrations were generally low during baseflow across the Upper Saline Watershed. Sites with the lowest concentrations tended to be in the upper bounds of the watershed where percent forest land use was highest and watershed slopes were the greatest. The majority of sites had mean TSS concentrations less than PQL (i.e., 7 mg/L; Figure 17), but nine sites did have mean concentrations that exceeded this concentration. There were three sites where the mean TSS concentration exceeded 10 mg/L but it was observed that the lowest TSS concentration (1.4 mg/L) corresponded to the site that had the greatest NO_3-N and TP concentrations (i.e., SAL-35 the tributary to Cedar Creek).

Load Estimations

We were able to develop regression models to estimate nutrient and sediment loads based on the monitoring data, and the statistical models were significant (Table 14, P<0.001) for all three techniques al all four sites within the Upper Saline Watershed. The simple log-log regression technique used in spreadsheets provided annual nutrient and sediment loads very similar to that estimated by Equation 1 AMLE of the USGS Loadest software (Table 14). When we compared monthly loads (data not shown), the two regression methods were significantly related (R2>0.99, P<0.001). These results from this watershed plus the other two watersheds show that the spreadsheet method we have used for the ANRC 319 program to estimate constituent loads is an effective tool.

Table 14. Regression statistics including R^2, bias correction factor (BCF) and p-value for models used to estimate nutrient and sediment loads SAL-U1, SAL-U2, SAL-U3A and SAL-U4 in the Upper Saline Watershed, Arkansas.

	NO_3-N			SRP			TN			TP			TSS		
Load Model	R^2	BCF	P-Value	R^2	BCF	P-Value	R^2	BCF	P-Value	R^2	BCF	P-Value	R^2	BCF	P-Value
SAL-U1															
Regression	0.85	2.73	<0.001	0.95	1.31	<0.001	0.92	1.75	<0.001	0.92	1.48	<0.001	0.91	1.73	<0.001
Equation 1	0.85	-	<0.001	0.95	-	<0.001	0.92	-	<0.001[1]	0.92	-	<0.001	0.91	-	<0.001
Equation 4	0.86	-	<0.001[1]	0.96	-	<0.001[1]	0.94	-	<0.001[1]	0.94	-	<0.001[1]	0.94	-	<0.001[1]
SAL-U2															
Regression	0.89	1.91	<0.001	0.93	1.55	<0.001	0.91	1.55	<0.001	0.95	1.35	<0.001	0.92	1.86	<0.001
Equation 1	0.89	-	<0.001[1]	0.93	-	<0.001	0.91	-	<0.001	0.95	-	<0.001	0.92	-	<0.001
Equation 4	0.91	-	<0.001[1]	0.94	-	<0.001[1]	0.94	-	<0.001[1]	0.96	-	<0.001[1]	0.92	-	<0.001[1]
SAL-U3A															
Regression	0.85	1.63	<0.001	0.92	1.24	<0.001	0.95	1.16	<0.001	0.89	1.35	<0.001	0.88	1.72	<0.001
Equation 1	0.85	-	<0.001	0.92	-	<0.001	0.95	-	<0.001	0.89	-	<0.001	0.88	-	<0.001
Equation 4	0.88	-	<0.001[1]	0.95	-	<0.001[1]	0.97	-	<0.001[1]	0.93	-	<0.001[1]	0.89	-	<0.001[1]
SAL-U4															
Regression	0.87	1.39	<0.001	0.93	1.18	<0.001	0.98	1.05	<0.001	0.94	1.12	<0.001	0.94	1.19	<0.001
Equation 1	0.87	-	<0.001	0.93	-	<0.001	0.98	-	<0.001	0.94	-	<0.001	0.94	-	<0.001
Equation 4	0.91	-	<0.001[1]	0.95	-	<0.001[1]	0.99	-	<0.001[1]	0.97	-	<0.001[1]	0.94	-	<0.001[1]

[1] P-value based on discharge coefficient

The loads predicted by LOADEST Equation 4 AMLE (Table 15), which accounts for seasonal variation using sine and cosine functions, was at times comparable to the loads predicted by the regression models based solely on discharge. The data used to estimate loads was collected over one year during base flow, whereas storm event sampling occurred over an extended period because of relatively dry conditions. Coefficients of the sine and cosine function in regression models were at times significant, but it would be advantageous to have multiple years of data to help define seasonal variations.

Again, we did not select LOADEST Equation 4 AMLE for comparisons with the SWAT modeling efforts of Saraswat et al. (2013), because we only had one year of data to define seasonal fluctuations. There were some cases where the inclusion of seasonal factors predicted loads that diverged from that estimated when the regression models were based solely on discharge. Without sufficient data to account for seasonal variation, we focused on comparing the simple regression models based on discharge to the SWAT model output. Figure 18 shows the scatter plots of monthly NO_3-N, TP and TSS loads as a function of monthly discharge, where the monitoring data used the simple regression model based on discharge and the SWAT model output was provided by Saraswat et al., (2013). The key is that loads from the regression and watershed model should follow the same general pattern with discharge.

Table 15. Annual nutrient and sediment loads for calendar year 2011 and 2014 at SAL U1, SAL U2, SAL U3A and SALU4 in the Upper Saline Watershed calculated based on regression and USGS LOADEST Equations 1 and 4 AMLE.

	Nitrate-N (kg)		Total Phosphorus (kg)		TSS (kg)	
	2011	2012	2011	2012	2011	2012
SAL-U1						
Regression	170	74	167	72	45,700	19,200
Equation 1	150	67	177	77	44,500	18,800
Equation 4	160	56	428	108	47,000	26,900
SAL-U2						
Regression	6,430	1,520	3,980	706	1,730,000	221,000
Equation 1	5,950	1,430	4,040	723	1,840,000	239,000
Equation 4	8,250	1,460	14,700	958	5,780,000	294,000
SAL-U3A						
Regression	211,000	75,700	94,710	34,000	62,500,000	16,400,000
Equation 1	206,000	75,230	97,300	35,400	61,900,000	16,600,000
Equation 4	276,000	67,900	193,000	34,600	115,000,000	18,800,000
SAL-U4						
Regression	36,000	26,300	18,000	13,200	5,300,000	3,860,000
Equation 1	37,900	27,600	18,020	13,270	5,360,000	3,900,000
Equation 4	44,900	23,000	20,500	12,100	5,780,000	3,750,000

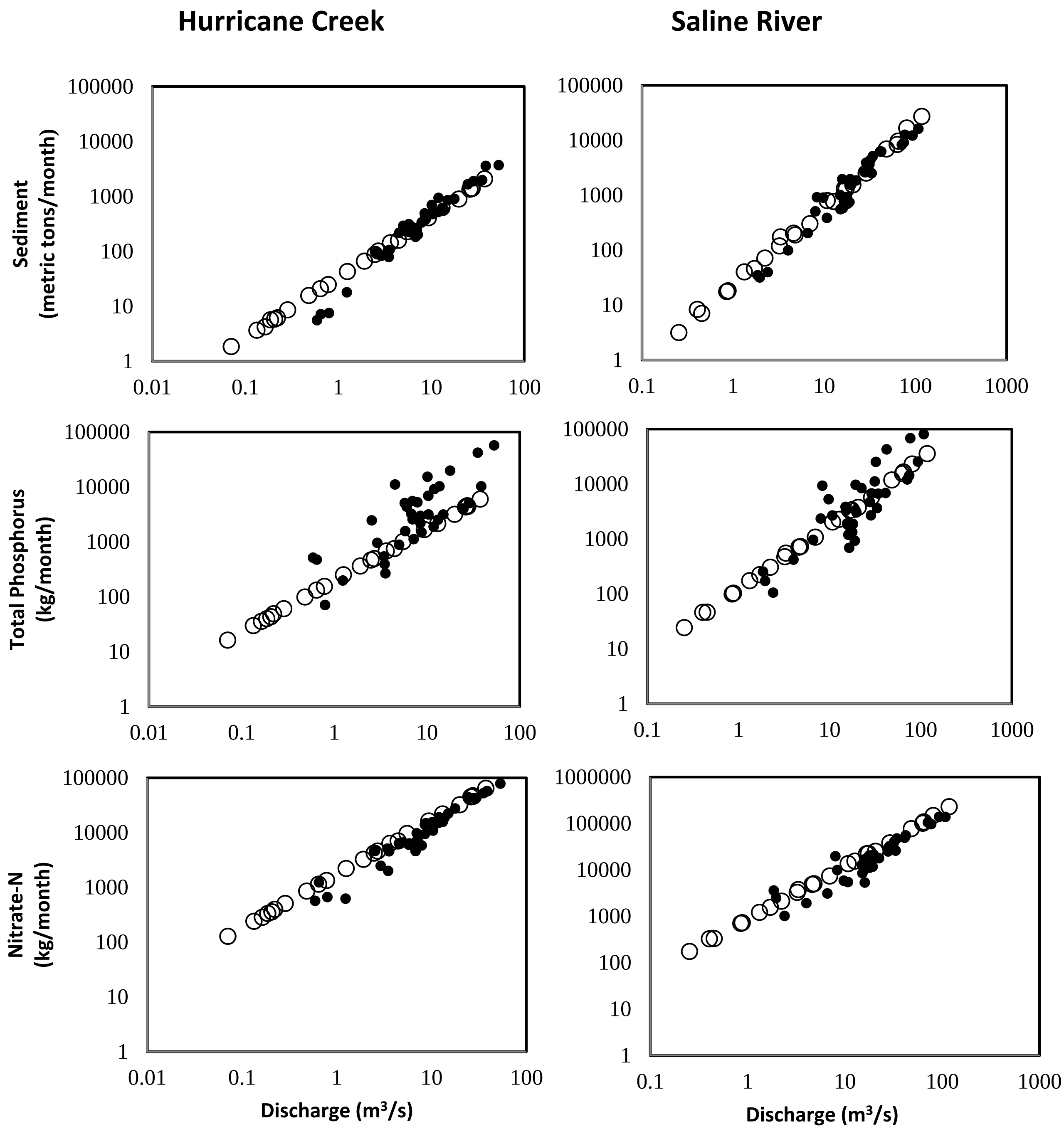

Figure 18. Relation between discharge and sediment and nutrient loads at Hurricane Creek (SAL-U1) and Saline River at Benton (SAL-U3A) estimated by simple regression with bias correction factor (open) and SWAT model (closed).

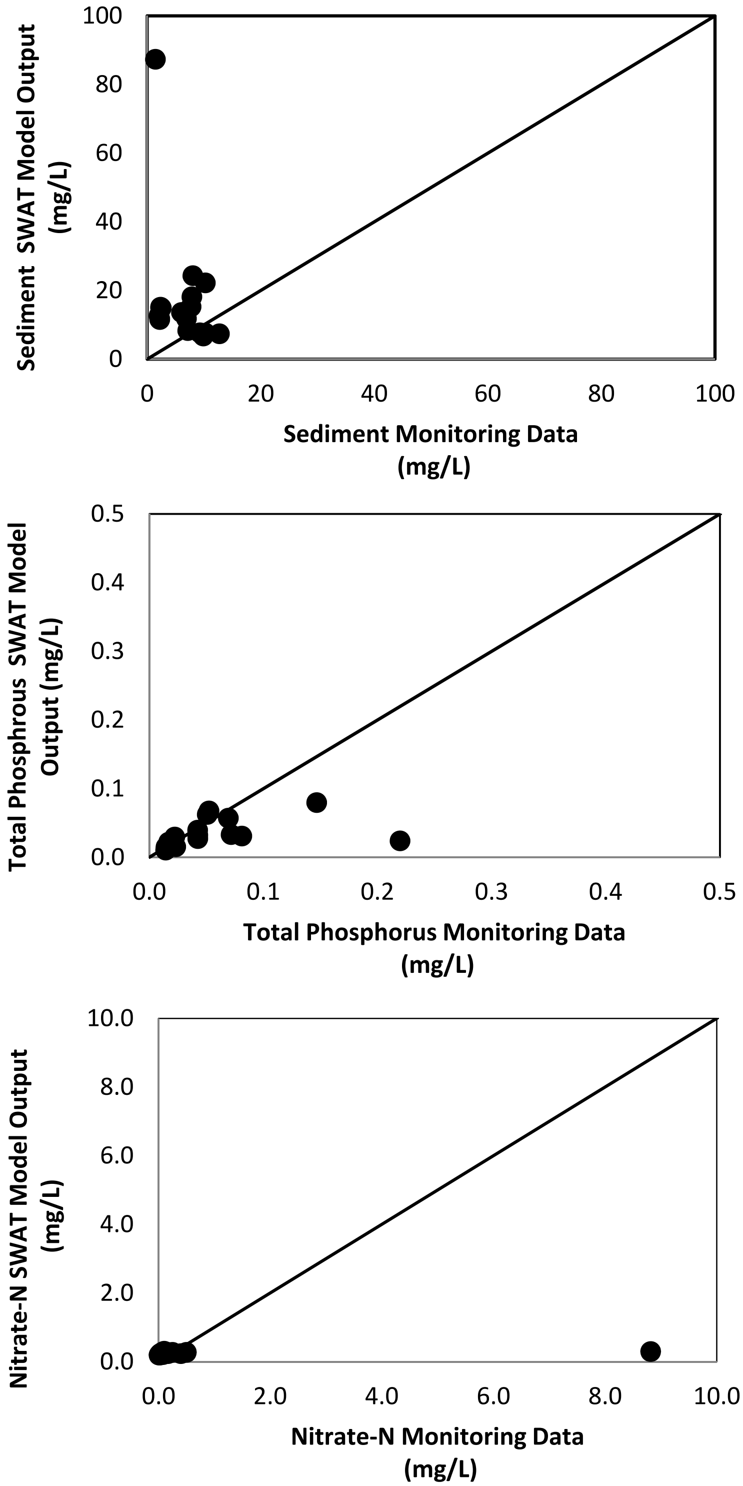

Figure 19. Relation between nutrient and sediment concentrations observed in monitoring data, 2011-2012 and SWAT model output, 2008-2010 at Upper Saline Watershed HUC-12s.

The loads of NO_3-N, TP and TSS predicted by the regression method and the watershed model show relatively good agreement overall at the two sites (SAL-U1 and SAL-U3A) provided by Saraswat et al. (2013; Figure 19). [The other two sites were not used in the watershed modeling effort]. In general, we want to see these symbols in Figure 18 show a close relation over the range of monthly discharge which generally occurs across both sites used in hydrologic calibration of the SWAT model. There are a few points worth discussing, where the sediment loads predicted by the SWAT model are less than that predicted by the regression method on the low end of monthly discharge. However, we need to keep in mind that the majority of sediment is transported during high flows where we have good overlap in the estimated loads. In contrast, the TP loads follow similar patterns at the low flow but the SWAT model output tends to be slightly higher at the higher flows. We would conclude that there is good general agreement for TP across the range of monthly discharge. The results for NO_3-N were very nice, and these comparisons should increase our confidence in the SWAT modeling effort (Saraswat et al., 2013), especially considering that nutrient and sediment loads were not available in the Upper Saline Watershed for calibration.

The second way we evaluated the SWAT model was to compare mean constituent concentrations during base flow, which allows us to evaluate the watershed model spatially (i.e., across the HUC 12s of the watershed). Here, we compared mean concentrations for the water samples collected at the selected sites to that predicted by the SWAT model. There was not a significant correlation between the monitoring data and the SWAT model output ($r<0.40$, $P>0.10$; Table 16), suggesting that the magnitude of the base flow concentration were not well represented in the SWAT model. However, the ranks of the data from low to high based on Spearman's rank coefficient showed that there was a significant relation ($P<0.01$) between the monitoring data and the model output. In these comparisons, we need to keep in mind that the monitoring period and modeling period did not overlap and that the monitoring sites within a HUC 12 were not always close to the subwatershed outlet (where the SWAT model output was based geospatially). Thus, the significant relation with ranks from low to high for NO_3-N and TP increases our confidence in the subwatershed prioritization for the Upper Saline Watershed conducted by Saraswat et al. (2013).

Table 16. Summary of regression statics describing the relation between monitoring data collected from HUC-12s and SWAT model output at the Upper Saline Watershed.

Total Suspended Solids (mg/L)			Total Phosphorus (mg/L)			Nitrate-N (mg/L)		
	Regression			*Regression*			*Regression*	
slope	r	P-value	slope	r	P-value	slope	r	P-value
-1.959	0.377	0.136	0.141	0.373	0.140	0.006	0.386	0.127
	Spearman's Rank Coefficient			*Spearman's Rank Coefficient*			*Spearman's Rank Coefficient*	
n	ρ	P-value	n	ρ	P-value	n	ρ	P-value
17	-0.348	0.171	17	0.722	0.002	17	0.660	0.005

REFERENCES

Gassman, P.W., M.R. Reyes, C.H. Green, and J.G. Arnold. 2007. The Soil and Water Assessment Tool: Historical Development, Applications, and Future Research Directions. Transactions of the ASABE. 504: 1211-1250.

Gupta, H.V., S. Sorooshian, and P.O. Yapo. 1998. Toward improved calibration of hydrologic models: Multiple and noncommensurable measures of information. Water Resources Research 34:” 751-763.

Santhi, C. J.G. Arnold, J.R. Williams, W.A. Dugas, R. Srinivasan and L.Mm Hauck 2001. Validation of the SWAT Model on a Large River Basin with Point and Nonpoint sources. JAWRA. 37: 1169-1188

Saraswat, D., N. Pai., M. Daniels, and T. Riley. 2013. Development of Comprehensive Watershed Modeling for 12-digit HUCs in Selected Priority Watersheds in Arkansas- Phase III.

US Environmental Protection Agency (EPA). 2000. National Water Quality Inventory. EPA-841-R-02-001.

APPENDIX

Table A1. Frequency distribution of constituent concentrations during base flow conditions among selected sampling sites in the Poteau Watershed, Arkansas, October 2011- September 2012.

Conductivity (µS/cm)

Site ID	MIN	10th	25th	Median	75th	90th	Max	Mean	Geomean	StDev
POT-12A	58	59	65	86	169	230	230	119	105	66
POT-13	61	63	86	187	877	1178	1232	420	238	438
POT-15B	85	86	103	158	220	331	372	171	155	82
POT-16	73	73	84	113	152	293	336	133	120	74
POT-17	110	111	123	133	179	195	198	145	142	30
POT-1A	51	52	64	82	137	426	500	133	102	128
POT-1C	80	82	90	210	407	547	576	253	195	178
POT-2	66	66	69	103	126	174	177	106	100	38
POT-21	46	47	51	62	86	101	106	67	65	19
POT-22	33	33	34	40	52	56	56	43	42	9
POT-24A	49	49	59	82	487	901	1003	238	133	303
POT-28A	20	20	21	24	34	57	60	28	27	12
POT-29C	25	25	27	29	49	60	61	37	35	13
POT-3	148	148	166	274	376	410	416	278	259	102
POT-30A	28	29	33	39	72	100	101	52	47	26
POT-5	96	97	110	161	273	300	308	185	168	82
POT-8	95	97	107	168	323	437	464	220	188	129
POT-9	119	120	169	235	264	289	296	214	206	58
POT-P1	5	17	49	81	192	438	464	140	85	142
POT-P2	141	144	179	248	334	397	397	257	243	91
POT-12A	58	59	65	86	169	230	230	119	105	66

Nitrate (NO_3-N; mg/L)

Site ID	MIN	10th	25th	Median	75th	90th	Max	Mean	Geomean	StDev
POT-12A	0.001	0.001	0.001	0.150	1.329	3.029	3.416	0.665	0.038	1.060
POT-13	0.034	0.044	0.133	0.531	1.314	3.265	3.703	0.890	0.412	1.100
POT-15B	0.001	0.001	0.014	0.103	0.304	0.556	0.629	0.179	0.048	0.193
POT-16	0.001	0.008	0.025	0.092	0.179	0.307	0.329	0.114	0.059	0.103
POT-17	0.001	0.003	0.011	0.051	0.634	1.267	1.334	0.337	0.073	0.465
POT-1A	0.001	0.001	0.002	0.034	0.125	0.191	0.202	0.063	0.020	0.070
POT-1C	0.001	0.001	0.114	0.517	1.522	3.516	4.149	0.980	0.202	1.191
POT-2	0.017	0.048	0.164	0.601	1.888	3.518	3.619	1.062	0.472	1.261
POT-21	0.007	0.009	0.026	0.124	0.585	1.231	1.352	0.349	0.119	0.437
POT-22	0.001	0.001	0.012	0.081	0.153	0.297	0.354	0.101	0.034	0.100
POT-24A	0.001	0.001	0.047	0.411	0.911	1.270	1.291	0.481	0.138	0.460
POT-28A	0.001	0.001	0.024	0.138	0.418	0.449	0.449	0.192	0.063	0.187
POT-29C	0.001	0.001	0.015	0.131	0.362	0.633	0.691	0.194	0.049	0.225
POT-3	0.001	0.001	0.001	0.052	0.385	0.816	0.861	0.215	0.028	0.302
POT-30A	0.001	0.005	0.032	0.059	0.204	0.338	0.340	0.120	0.057	0.122
POT-5	0.001	0.001	0.001	0.018	0.836	1.481	1.708	0.367	0.029	0.567
POT-8	0.001	0.001	0.001	0.047	0.215	0.440	0.489	0.116	0.023	0.157
POT-9	0.005	0.008	0.035	0.087	0.878	0.902	0.909	0.386	0.132	0.418
POT-P1	0.001	0.001	0.015	0.232	0.414	1.361	1.538	0.356	0.073	0.460
POT-P2	0.001	0.001	0.004	0.049	0.526	0.910	0.969	0.250	0.037	0.348
POT-12A	0.001	0.001	0.001	0.150	1.329	3.029	3.416	0.665	0.038	1.060

Soluble Reactive Phosphorus (SRP; mg/L)

Site ID	MIN	10th	25th	Median	75th	90th	Max	Mean	Geomean	StDev
POT-12A	0.001	0.001	0.002	0.009	0.016	0.168	0.204	0.027	0.007	0.059
POT-13	0.024	0.033	0.056	0.204	0.455	0.673	0.743	0.258	0.156	0.234
POT-15B	0.001	0.001	0.001	0.003	0.006	0.011	0.012	0.004	0.003	0.004
POT-16	0.001	0.001	0.001	0.002	0.004	0.007	0.007	0.003	0.002	0.002
POT-17	0.001	0.001	0.001	0.001	0.005	0.008	0.008	0.003	0.002	0.003
POT-1A	0.001	0.001	0.001	0.003	0.006	0.011	0.011	0.004	0.003	0.003
POT-1C	0.002	0.002	0.011	0.051	0.142	0.424	0.507	0.104	0.039	0.144
POT-2	0.001	0.001	0.004	0.005	0.010	0.015	0.016	0.007	0.005	0.004
POT-21	0.001	0.001	0.001	0.003	0.006	0.022	0.027	0.005	0.003	0.007
POT-22	0.001	0.001	0.001	0.003	0.004	0.007	0.008	0.003	0.003	0.002
POT-24A	0.017	0.017	0.022	0.098	0.184	0.328	0.353	0.114	0.067	0.110
POT-28A	0.001	0.001	0.001	0.002	0.003	0.006	0.006	0.002	0.002	0.002
POT-29C	0.001	0.001	0.001	0.001	0.002	0.005	0.005	0.002	0.001	0.001
POT-3	0.001	0.001	0.001	0.003	0.005	0.013	0.016	0.004	0.003	0.004
POT-30A	0.001	0.001	0.001	0.001	0.003	0.005	0.005	0.002	0.002	0.001
POT-5	0.001	0.001	0.002	0.006	0.017	0.054	0.067	0.013	0.006	0.018
POT-8	0.001	0.001	0.005	0.007	0.009	0.081	0.092	0.017	0.007	0.028
POT-9	0.001	0.001	0.001	0.004	0.008	0.020	0.020	0.006	0.003	0.007
POT-P1	0.001	0.001	0.002	0.012	0.022	0.126	0.145	0.027	0.009	0.043
POT-P2	0.001	0.001	0.002	0.005	0.008	0.030	0.036	0.008	0.005	0.010
POT-12A	0.001	0.001	0.002	0.009	0.016	0.168	0.204	0.027	0.007	0.059

Total Nitrogen (TN; mg/L)

Site ID	MIN	10th	25th	Median	75th	90th	Max	Mean	Geomean	StDev
POT-12A	0.31	0.36	0.60	1.10	1.59	3.35	3.68	1.27	1.01	0.96
POT-13	0.69	0.72	1.00	1.26	2.70	4.26	4.75	1.79	1.50	1.22
POT-15B	0.16	0.17	0.26	0.47	0.69	1.17	1.36	0.52	0.43	0.33
POT-16	0.14	0.15	0.19	0.35	0.46	1.27	1.55	0.43	0.34	0.38
POT-17	0.25	0.25	0.33	0.46	0.79	1.51	1.60	0.61	0.52	0.42
POT-1A	0.12	0.14	0.22	0.35	0.55	2.09	2.59	0.56	0.38	0.68
POT-1C	0.72	0.73	0.89	1.00	1.66	4.36	5.31	1.50	1.24	1.27
POT-2	0.32	0.41	0.69	1.37	2.48	5.30	5.68	1.89	1.38	1.63
POT-21	0.23	0.23	0.34	0.48	0.97	1.53	1.64	0.65	0.54	0.45
POT-22	0.33	0.35	0.41	0.50	0.60	0.75	0.75	0.52	0.51	0.13
POT-24A	0.63	0.63	0.71	1.03	1.79	2.20	2.24	1.17	1.06	0.58
POT-28A	0.14	0.14	0.15	0.32	0.47	0.57	0.58	0.33	0.29	0.16
POT-29C	0.18	0.18	0.32	0.45	0.50	0.75	0.80	0.42	0.39	0.17
POT-3	0.17	0.19	0.25	0.36	0.57	1.16	1.23	0.48	0.40	0.33
POT-30A	0.15	0.15	0.17	0.35	0.50	0.58	0.59	0.35	0.31	0.16
POT-5	0.23	0.23	0.24	0.32	1.08	1.98	2.06	0.69	0.48	0.65
POT-8	0.61	0.63	0.69	0.86	1.49	1.70	1.78	1.04	0.97	0.41
POT-9	0.48	0.51	0.65	0.86	1.12	1.30	1.35	0.88	0.84	0.27
POT-P1	0.49	0.49	0.53	0.61	0.78	2.13	2.38	0.83	0.73	0.56
POT-P2	0.39	0.39	0.42	0.56	0.74	1.14	1.15	0.64	0.59	0.27
POT-12A	0.31	0.36	0.60	1.10	1.59	3.35	3.68	1.27	1.01	0.96

Total Phosphorus (TP; mg/L)

Site ID	MIN	10th	25th	Median	75th	90th	Max	Mean	Geomean	StDev
POT-12A	0.022	0.022	0.036	0.054	0.102	0.268	0.296	0.083	0.060	0.081
POT-13	0.098	0.102	0.113	0.296	0.571	0.768	0.802	0.355	0.265	0.259
POT-15B	0.014	0.016	0.025	0.042	0.089	0.178	0.214	0.061	0.045	0.056
POT-16	0.008	0.009	0.013	0.022	0.037	0.084	0.098	0.029	0.023	0.025
POT-17	0.016	0.017	0.020	0.032	0.046	0.056	0.058	0.033	0.031	0.013
POT-1A	0.012	0.014	0.019	0.026	0.067	0.194	0.202	0.057	0.037	0.064
POT-1C	0.064	0.067	0.079	0.111	0.190	0.657	0.786	0.186	0.136	0.205
POT-2	0.018	0.018	0.023	0.042	0.091	0.216	0.264	0.066	0.046	0.069
POT-21	0.012	0.012	0.019	0.030	0.036	0.105	0.112	0.037	0.029	0.031
POT-22	0.026	0.027	0.029	0.039	0.070	0.259	0.332	0.070	0.050	0.085
POT-24A	0.026	0.030	0.056	0.194	0.350	0.469	0.482	0.207	0.137	0.166
POT-28A	0.004	0.004	0.008	0.012	0.028	0.058	0.058	0.020	0.014	0.020
POT-29C	0.004	0.004	0.010	0.020	0.034	0.054	0.058	0.024	0.018	0.016
POT-3	0.012	0.013	0.017	0.027	0.035	0.085	0.098	0.033	0.027	0.024
POT-30A	0.004	0.005	0.014	0.020	0.034	0.059	0.064	0.026	0.021	0.017
POT-5	0.014	0.016	0.025	0.033	0.050	0.143	0.182	0.046	0.036	0.045
POT-8	0.036	0.037	0.054	0.075	0.176	0.231	0.242	0.107	0.087	0.071
POT-9	0.018	0.019	0.026	0.047	0.086	0.287	0.360	0.079	0.053	0.094
POT-P1	0.030	0.031	0.043	0.058	0.089	0.258	0.278	0.086	0.067	0.077
POT-P2	0.016	0.019	0.032	0.042	0.086	0.104	0.108	0.053	0.046	0.030
POT-12A	0.022	0.022	0.036	0.054	0.102	0.268	0.296	0.083	0.060	0.081

Total Suspended Solids (TSS; mg/L)

Site ID	MIN	10th	25th	Median	75th	90th	Max	Mean	Geomean	StDev
POT-12A	1.3	1.4	1.9	4.3	10.6	46.0	53.3	10.4	5.6	15.0
POT-13	1.9	2.2	4.0	6.2	10.3	24.4	30.2	8.3	6.4	7.5
POT-15B	1.2	1.3	1.6	4.9	12.2	62.0	80.0	12.4	5.2	22.1
POT-16	0.7	0.8	1.1	2.1	4.5	15.8	20.0	3.9	2.4	5.3
POT-17	1.7	1.8	2.1	3.7	6.0	16.2	17.8	5.4	4.2	4.7
POT-1A	0.8	1.0	1.6	3.9	9.5	35.4	41.1	8.5	4.3	11.8
POT-1C	2.8	2.8	3.1	4.9	11.3	48.6	62.5	10.9	6.4	16.8
POT-2	0.5	0.6	1.5	3.7	10.5	39.7	50.2	9.0	4.0	13.8
POT-21	1.9	2.0	2.4	3.3	4.7	13.3	16.5	4.5	3.6	4.0
POT-22	1.7	2.2	3.4	4.5	8.4	14.8	16.7	6.0	5.0	4.2
POT-24A	3.9	3.9	6.7	7.7	17.7	27.3	29.3	11.0	9.1	7.9
POT-28A	0.3	0.3	0.8	1.4	1.6	8.2	8.9	1.9	1.3	2.5
POT-29C	0.1	0.2	1.1	2.5	3.9	5.8	6.1	2.6	1.7	1.8
POT-3	1.8	2.2	3.5	4.3	6.1	14.5	17.9	5.5	4.7	4.1
POT-30A	0.1	0.1	1.5	2.4	3.5	4.2	4.3	2.3	1.6	1.3
POT-5	0.9	1.0	1.8	2.3	3.7	10.2	12.7	3.3	2.6	3.1
POT-8	2.6	3.4	6.1	12.6	23.8	39.1	41.5	15.5	11.6	12.2
POT-9	1.7	1.9	2.6	5.8	14.3	21.9	21.9	9.0	6.3	7.5
POT-P1	4.2	4.2	4.9	6.3	8.2	24.4	30.9	8.3	6.9	7.3
POT-P2	3.2	3.6	4.6	7.5	14.0	43.0	53.7	12.4	8.9	13.8
POT-12A	1.3	1.4	1.9	4.3	10.6	46.0	53.3	10.4	5.6	15.0

Turbidity (NTU)

Site ID	MIN	10th	25th	Median	75th	90th	Max	Mean	Geomean	StDev
POT-12A	2.5	2.7	4.5	9.9	21.4	41.0	43.0	15.0	10.6	13.0
POT-13	1.3	1.9	4.9	9.4	21.2	60.4	71.3	16.7	9.8	19.7
POT-15B	9.3	10.7	16.3	21.1	68.8	113.0	127.0	40.2	28.7	36.7
POT-16	2.5	2.6	2.9	6.3	13.6	20.0	21.6	8.4	6.5	6.2
POT-17	4.3	4.5	5.5	16.0	18.2	34.8	35.8	14.9	11.7	10.6
POT-1A	8.1	8.3	10.3	12.9	17.3	79.2	102.0	20.7	15.0	26.1
POT-1C	3.0	3.7	7.5	9.4	16.6	25.9	29.1	12.2	10.3	7.2
POT-2	9.5	9.7	11.6	15.0	21.3	44.0	50.9	18.5	16.4	11.5
POT-21	4.3	4.5	5.2	6.9	12.0	37.6	45.4	11.5	8.8	11.5
POT-22	2.2	2.8	4.8	8.5	10.1	15.9	18.3	8.2	7.2	4.1
POT-24A	6.1	6.4	7.5	12.1	26.4	61.3	66.6	19.8	14.7	18.5
POT-28A	2.7	2.7	3.1	4.2	7.3	11.2	11.5	5.3	4.7	2.9
POT-29C	2.9	3.0	3.8	4.8	5.7	15.9	18.3	5.9	5.2	4.2
POT-3	3.7	3.9	5.5	7.7	16.0	35.7	43.3	11.9	9.2	11.0
POT-30A	2.4	2.8	4.9	7.3	8.3	12.2	13.1	6.9	6.4	2.8
POT-5	1.5	1.8	2.8	4.1	12.5	39.1	50.4	9.5	5.6	13.5
POT-8	6.9	8.0	12.4	26.6	46.1	57.7	60.0	29.4	23.9	18.0
POT-9	3.3	3.3	6.5	15.2	32.8	60.0	62.2	22.0	14.6	19.7
POT-P1	5.4	5.4	7.0	10.0	22.0	47.8	57.7	15.6	11.8	14.9
POT-P2	6.3	7.3	9.7	16.5	24.9	42.5	47.3	19.0	16.3	11.5
POT-12A	2.5	2.7	4.5	9.9	21.4	41.0	43.0	15.0	10.6	13.0

Table A2. Annual and monthly nutrient and sediment loads at POT-P1 in Poteau Watershed, Arkansas, estimated using simple linear regression with bias correction factor, 2011-2012.

		NO_3-N (kg)	SRP (kg)	Total N (kg)	Total P (kg)	TSS (kg)
2011	Annual	143,600	57,500	371,600	110,300	33,200,000
	January	22	1	85	8	870
	February	1,540	210	4,780	850	161,200
	March	540	41	1,810	250	37,700
	April	30,300	12,800	77,300	23,900	7,350,000
	May	31,500	11,300	82,400	23,500	6,760,000
	June	1,460	250	4,390	860	181,400
	July	72	3	270	28	3,280
	August	50	2	190	19	2,180
	September	17	1	67	6	600
	October	36	1	140	13	1,500
	November	47,200	23,500	117,400	38,900	12,830,000
	December	30,900	9,370	82,900	22,000	5,880,000
2012	Annual	68,700	22,100	184,000	49,400	13,600,000
	January	22,900	8,400	59,900	17,200	4,990,000
	February	10,100	2,440	28,200	6,640	1,620,000
	March	33,300	11,000	88,200	24,300	6,740,000
	April	1,080	120	3,450	560	96,500
	May	64	3	240	25	2,850
	June	15	0	60	5	480
	July	170	18	530	86	15,200
	August	60	2	230	23	2,590
	September	470	51	1,520	240	42,100
	October	490	77	1,510	280	57,500
	November	31	1	120	11	1,140
	December	40	1	160	15	1,580

Table A3. Annual and monthly nutrient and sediment loads at POT-P1 in Poteau Watershed, Arkansas, estimated using USGS LOADEST 1 Equation AMLE, 2011-2012.

		NO_3-N (kg)	SRP (kg)	Total N (kg)	Total P (kg)	TSS (kg)
2011	Annual	143,300	58,300	372,000	113,300	36,700,000
	January	21	1	84	8	920
	February	1,550	210	4,800	890	182,100
	March	530	42	1,810	260	42,000
	April	30,200	13,000	77,300	24,500	8,120,000
	May	31,400	11,500	82,500	24,200	7,520,000
	June	1,470	260	4,410	900	205,000
	July	70	3	270	28	3,530
	August	49	2	190	19	2340
	September	16	0	66	6	630
	October	35	1	140	13	1,610
	November	46,900	23,600	117,300	39,700	14,030,000
	December	31,000	9,630	83,200	22,700	6,590,000
2012	Annual	68,800	22,600	184,500	51,000	15,150,000
	January	22,900	8,570	60,000	17,700	5,540,000
	February	10,110	2,510	28,300	6,890	1,820,000
	March	33,400	11,200	88,400	25,200	7,530,000
	April	1,080	120	3,460	580	108,700
	May	63	3	240	25	3,070
	June	14	0	59	5	490
	July	170	19	530	89	17,100
	August	59	2	230	23	2,780
	September	470	52	1,530	250	47,400
	October	500	80	1,510	290	65,000
	November	30	1	120	11	1,200
	December	39	1	160	15	1,700

Table A4. Annual and monthly nutrient and sediment loads at POT-P1 in Poteau Watershed, Arkansas, estimated using USGS LOADEST Equation 4 AMLE, 2011-2012.

		NO_3-N (kg)	SRP (kg)	Total N (kg)	Total P (kg)	TSS (kg)
2011	Annual	132,600	45,800	353,900	104,600	30,700,000
	January	55	3	120	9	1,010
	February	1,460	212	4,370	680	147,900
	March	330	34	1,360	190	37,600
	April	5,390	2,210	38,700	13,500	5,540,000
	May	5,180	1,970	41,000	14,100	5,530,000
	June	310	71	2,600	730	217,100
	July	31	3	210	35	6,230
	August	38	3	200	31	4,800
	September	27	2	94	12	1,410
	October	95	6	227	26	2,960
	November	68,600	27,300	155,500	48,900	13,110,000
	December	51,100	14,000	109,500	26,400	6,140,000
2012	Annual	45,100	12,700	147,000	35,800	10,900,000
	January	22,600	6,690	58,700	14,200	4,010,000
	February	8,730	1,990	25,500	5,230	1,360,000
	March	11,800	3,730	55,300	14,900	5,180,000
	April	380	56	2,140	380	96,300
	May	21	2	150	20	3,860
	June	5	0	42	5	840
	July	63	11	420	110	24,600
	August	49	4	250	38	5,780
	September	510	80	1,910	420	77,400
	October	770	140	2,150	480	91,700
	November	100	5	210	19	1930
	December	130	6	250	20	2110

Table A5. Annual and monthly nutrient and sediment loads at POT-P2 in Poteau Watershed, Arkansas, estimated using simple linear regression with bias correction factor, 2011-2012.

		NO_3-N (kg)	SRP (kg)	Total N (kg)	Total P (kg)	TSS (kg)
2011	Annual	79,000	6,480	129,300	26,800	14,840,000
	January	1	0	16	1	280
	February	160	15	900	120	37,800
	March	130	12	770	97	31,500
	April	32,200	2,600	43,500	9,800	5,850,000
	May	25,600	2,110	41,800	8,720	4,820,00
	June	120	11	680	87	28,700
	July	8	1	88	9	2,220
	August	10	1	97	10	2,570
	September	420	37	1,260	210	89,000
	October	14	1	120	13	3,650
	November	8770	731	17,000	3,300	1,700,000
	December	11,600	970	23,100	4,440	2,270,000
2012	Annual	45,600	3,770	81,300	16,300	8,700,000
	January	16,500	1,360	26,700	5,600	3,110,000
	February	5,980	510	13,700	2,480	1,200,000
	March	22,400	1,850	37,500	7,750	4,240,000
	April	300	27	1,460	200	70,000
	May	83	8	570	68	20,700
	June	17	2	140	15	4,360
	July	190	17	840	120	43,700
	August	2	0	31	3	610
	September	2	0	31	3	640
	October	33	3	200	25	7,970
	November	2	0	34	3	700
	December	3	0	43	4	1,000

Table A6. Annual and monthly nutrient and sediment loads at POT-P2 in Poteau Watershed, Arkansas, estimated using USGS LOADEST Equation 1 AMLE, 2011-2012.

		NO_3-N (kg)	SRP (kg)	Total N (kg)	Total P (kg)	TSS (kg)
2011	Annual	77,100	6,110	129,300	26,800	14,200,000
	January	1	0	16	1	250
	February	160	14	900	120	37,000
	March	130	11	770	97	30,700
	April	31,100	2,440	43,500	9,760	5,520,000
	May	25,000	1,990	41,700	8,730	4,613,000
	June	120	11	680	87	28,000
	July	8	1	88	9	2,080
	August	9	1	97	10	2,420
	September	420	35	1,260	210	87,300
	October	14	1	120	13	3,480
	November	8,640	690	17,000	3,320	1,640,000
	December	11,450	920	23,100	4,470	2,190,000
2012	Annual	44,700	3,570	81,300	16,300	8,350,000
	January	16,200	1,280	26,700	5,600	2,970,000
	February	5,930	482	13,700	2,500	1,160,000
	March	22,000	1,750	37,500	7,770	4,070,000
	April	300	26	1,460	200	68,740
	May	82	7	570	68	20,100
	June	17	2	140	15	4,170
	July	190	17	840	120	42,900
	August	2	0	30	3	550
	September	2	0	31	3	580
	October	33	3	200	25	7,750
	November	2	0	34	3	640
	December	3	0	43	4	880

Table A7. Annual and monthly nutrient and sediment loads at POT-P2 in Poteau Watershed, Arkansas, estimated using USGS LOADEST Equation 4 AMLE, 2011-2012.

		NO_3-N (kg)	SRP (kg)	Total N (kg)	Total P (kg)	TSS (kg)
2011	Annual	22,000	17,200	123,000	68,700	40,300,000
	January	10	0	17	0	20
	February	390	4	940	33	10,500
	March	200	4	800	33	11,000
	April	2,530	7,580	40,600	28,200	18,400,000
	May	1,660	6,820	38,600	28,000	16,900,000
	June	16	18	650	150	59,200
	July	2	1	85	13	3,630
	August	3	2	94	16	4,330
	September	72	140	1,170	760	267,000
	October	23	1	130	10	2,190
	November	5,770	1,340	16,600	5,830	2,320,000
	December	11,300	1,270	22,900	5,710	2,340,000
2012	Annual	29,300	4,020	81,000	17,720	9,810,000
	January	15,300	1,250	26,800	5,290	2,700,000
	February	6,700	340	14,000	1,720	820,000
	March	7,090	2,330	36,900	10,000	6,040,000
	April	160	16	1,470	130	54,100
	May	22	7	560	68	25,100
	June	3	2	140	19	6,390
	July	15	66	770	430	162,000
	August	1	0	30	3	730
	September	2	0	31	3	530
	October	28	4	200	31	8,440
	November	12	0	36	1	160
	December	26	0	46	1	120

Table A8. Frequency distribution of constituent concentrations during base flow conditions among selected sampling sites in the Poteau Watershed, Arkansas, October 2011- September 2012.

Conductivity (µS/cm)

Site ID	MIN	10th	25th	Median	75th	90th	Max	Mean	Geomean	StDev
STR-1	203	211	272	355	364	374	376	321	315	60
STR-10	287	288	313	359	392	408	412	353	351	44
STR-11	261	266	292	347	371	390	392	334	331	45
STR-12	181	196	271	349	402	417	420	328	319	79
STR-13	220	228	284	358	418	451	455	347	339	79
STR-16	298	306	390	460	482	500	504	433	427	68
STR-17	86	89	116	149	246	370	371	185	166	98
STR-2	235	247	306	358	391	397	398	343	339	55
STR-20	160	168	229	320	419	442	446	315	299	101
STR-22	4	87	303	446	474	506	506	381	276	142
STR-23	214	214	276	389	471	488	491	366	351	106
STR-24A	302	322	411	480	497	517	518	449	444	66
STR-26	179	182	231	352	410	433	438	323	309	94
STR-27	192	213	331	394	435	462	467	373	363	81
STR-5	250	256	295	360	376	384	385	337	333	48
STR-6	198	214	257	335	368	390	393	315	309	63
STR-7	235	236	263	321	364	386	390	316	312	55
STR-8	175	193	260	328	377	395	400	313	305	70
STR-9	205	208	245	322	420	460	470	333	321	91
STR-S1	271	275	310	363	385	405	410	350	347	47
STR-1	203	211	272	355	364	374	376	321	315	60

Nitrate (NO_3-N; mg/L)

Site ID	MIN	10th	25th	Median	75th	90th	Max	Mean	Geomean	StDev
STR-1	0.340	0.351	0.405	0.493	0.520	0.776	0.868	0.496	0.482	0.135
STR-10	0.010	0.010	0.012	0.085	0.199	0.547	0.620	0.150	0.069	0.182
STR-11	0.057	0.060	0.073	0.101	0.248	0.472	0.504	0.173	0.133	0.145
STR-12	0.010	0.010	0.015	0.104	0.275	0.502	0.579	0.165	0.077	0.175
STR-13	0.005	0.007	0.012	0.057	0.207	0.515	0.561	0.138	0.057	0.178
STR-16	0.010	0.010	0.014	0.039	0.058	0.153	0.191	0.047	0.032	0.049
STR-17	0.010	0.010	0.010	0.021	0.037	0.125	0.150	0.035	0.022	0.040
STR-2	0.040	0.043	0.067	0.156	0.221	0.503	0.560	0.185	0.140	0.149
STR-20	0.010	0.010	0.030	0.156	0.289	0.606	0.697	0.205	0.104	0.198
STR-22	0.010	0.014	0.030	0.089	0.187	0.568	0.653	0.153	0.079	0.188
STR-23	0.010	0.010	0.014	0.066	0.214	0.525	0.569	0.141	0.063	0.178
STR-24A	0.010	0.019	0.040	0.065	0.158	0.270	0.298	0.104	0.073	0.086
STR-26	0.010	0.010	0.014	0.127	0.248	0.587	0.618	0.182	0.085	0.199
STR-27	0.020	0.021	0.154	0.319	0.488	0.566	0.573	0.303	0.209	0.188
STR-5	0.070	0.075	0.119	0.172	0.254	0.443	0.512	0.198	0.172	0.119
STR-6	0.002	0.004	0.022	0.167	0.332	0.446	0.465	0.185	0.085	0.161
STR-7	0.008	0.009	0.020	0.174	0.273	0.459	0.465	0.179	0.090	0.161
STR-8	0.030	0.031	0.064	0.123	0.216	0.404	0.441	0.159	0.118	0.123
STR-9	0.020	0.026	0.045	0.074	0.152	0.224	0.244	0.098	0.078	0.067
STR-S1	0.031	0.032	0.052	0.090	0.229	0.522	0.594	0.162	0.107	0.167
STR-1	0.340	0.351	0.405	0.493	0.520	0.776	0.868	0.496	0.482	0.135

Soluble Reactive Phosphorus (SRP; mg/L)

Site ID	MIN	10th	25th	Median	75th	90th	Max	Mean	Geomean	StDev
STR-1	0.001	0.001	0.002	0.008	0.016	0.042	0.046	0.012	0.006	0.014
STR-10	0.001	0.001	0.001	0.005	0.009	0.018	0.021	0.006	0.004	0.006
STR-11	0.001	0.001	0.001	0.005	0.009	0.012	0.012	0.005	0.003	0.004
STR-12	0.001	0.001	0.001	0.005	0.012	0.029	0.035	0.008	0.004	0.010
STR-13	0.001	0.001	0.001	0.005	0.010	0.016	0.017	0.006	0.004	0.005
STR-16	0.001	0.001	0.001	0.004	0.006	0.011	0.011	0.004	0.003	0.004
STR-17	0.005	0.006	0.019	0.035	0.055	0.130	0.148	0.045	0.032	0.039
STR-2	0.001	0.001	0.003	0.009	0.013	0.026	0.030	0.009	0.006	0.008
STR-20	0.001	0.001	0.001	0.005	0.009	0.016	0.018	0.006	0.003	0.005
STR-22	0.001	0.001	0.001	0.006	0.010	0.014	0.015	0.006	0.003	0.005
STR-23	0.001	0.001	0.001	0.005	0.008	0.018	0.020	0.006	0.003	0.006
STR-24A	0.001	0.001	0.001	0.004	0.006	0.009	0.009	0.004	0.003	0.003
STR-26	0.001	0.001	0.001	0.011	0.012	0.016	0.016	0.008	0.005	0.006
STR-27	0.001	0.001	0.004	0.008	0.015	0.022	0.022	0.010	0.007	0.007
STR-5	0.001	0.001	0.002	0.006	0.009	0.023	0.025	0.008	0.005	0.007
STR-6	0.001	0.001	0.001	0.005	0.015	0.032	0.036	0.009	0.004	0.011
STR-7	0.001	0.001	0.002	0.005	0.011	0.018	0.019	0.006	0.004	0.006
STR-8	0.001	0.001	0.001	0.005	0.008	0.022	0.025	0.006	0.004	0.007
STR-9	0.001	0.001	0.002	0.009	0.011	0.035	0.038	0.011	0.006	0.011
STR-S1	0.001	0.001	0.002	0.005	0.008	0.011	0.012	0.005	0.004	0.004

Total Nitrogen (TN; mg/L)

Site ID	MIN	10th	25th	Median	75th	90th	Max	Mean	Geomean	StDev
STR-1	0.41	0.44	0.53	0.63	0.68	0.98	1.02	0.64	0.62	0.17
STR-10	0.08	0.08	0.20	0.26	0.41	0.70	0.73	0.31	0.26	0.20
STR-11	0.09	0.11	0.18	0.25	0.46	0.68	0.74	0.31	0.26	0.19
STR-12	0.08	0.08	0.17	0.28	0.48	0.76	0.82	0.33	0.27	0.22
STR-13	0.15	0.16	0.18	0.23	0.50	0.74	0.80	0.32	0.27	0.21
STR-16	0.06	0.06	0.09	0.14	0.20	0.26	0.27	0.15	0.13	0.07
STR-17	0.53	0.53	0.69	1.14	1.42	2.55	2.96	1.18	1.05	0.66
STR-2	0.14	0.16	0.24	0.36	0.46	0.73	0.75	0.39	0.35	0.18
STR-20	0.10	0.14	0.30	0.35	0.49	0.83	0.92	0.40	0.35	0.21
STR-22	0.09	0.10	0.15	0.20	0.35	0.67	0.74	0.27	0.22	0.19
STR-23	0.09	0.11	0.20	0.24	0.50	0.74	0.77	0.33	0.28	0.21
STR-24A	0.11	0.11	0.15	0.18	0.26	0.38	0.41	0.21	0.20	0.09
STR-26	0.13	0.14	0.22	0.37	0.55	0.87	0.93	0.40	0.35	0.23
STR-27	0.19	0.24	0.36	0.50	0.59	0.73	0.74	0.48	0.46	0.16
STR-5	0.19	0.21	0.26	0.28	0.47	0.61	0.65	0.35	0.33	0.14
STR-6	0.09	0.11	0.22	0.29	0.52	0.69	0.70	0.35	0.30	0.19
STR-7	0.11	0.13	0.21	0.37	0.52	0.70	0.73	0.38	0.33	0.19
STR-8	0.11	0.13	0.19	0.25	0.40	0.65	0.66	0.31	0.28	0.18
STR-9	0.09	0.10	0.27	0.36	0.52	1.29	1.36	0.47	0.36	0.39
STR-S1	0.12	0.14	0.19	0.23	0.40	0.63	0.70	0.29	0.26	0.17
STR-1	0.41	0.44	0.53	0.63	0.68	0.98	1.02	0.64	0.62	0.17

Total Phosphorus (TP; mg/L)

Site ID	MIN	10th	25th	Median	75th	90th	Max	Mean	Geomean	StDev
STR-1	0.002	0.004	0.015	0.024	0.030	0.084	0.106	0.028	0.020	0.026
STR-10	0.002	0.002	0.012	0.031	0.038	0.049	0.054	0.026	0.018	0.016
STR-11	0.002	0.002	0.010	0.016	0.018	0.036	0.036	0.016	0.012	0.011
STR-12	0.002	0.003	0.008	0.016	0.026	0.069	0.086	0.021	0.014	0.022
STR-13	0.002	0.003	0.009	0.020	0.026	0.047	0.052	0.020	0.015	0.014
STR-16	0.002	0.003	0.005	0.011	0.016	0.023	0.024	0.011	0.009	0.007
STR-17	0.142	0.146	0.173	0.212	0.384	0.688	0.770	0.294	0.256	0.185
STR-2	0.014	0.015	0.019	0.056	0.060	0.103	0.104	0.049	0.040	0.031
STR-20	0.002	0.004	0.008	0.018	0.023	0.038	0.042	0.017	0.014	0.011
STR-22	0.002	0.002	0.004	0.014	0.023	0.040	0.046	0.016	0.011	0.013
STR-23	0.008	0.008	0.010	0.016	0.024	0.054	0.058	0.022	0.019	0.015
STR-24A	0.002	0.002	0.005	0.011	0.014	0.038	0.048	0.012	0.009	0.012
STR-26	0.004	0.005	0.016	0.028	0.034	0.064	0.070	0.028	0.022	0.018
STR-27	0.002	0.003	0.011	0.025	0.037	0.056	0.060	0.026	0.019	0.018
STR-5	0.002	0.003	0.012	0.023	0.030	0.051	0.060	0.023	0.017	0.015
STR-6	0.002	0.002	0.004	0.016	0.026	0.084	0.104	0.022	0.012	0.028
STR-7	0.002	0.003	0.009	0.021	0.036	0.043	0.044	0.021	0.016	0.014
STR-8	0.002	0.002	0.004	0.012	0.027	0.069	0.086	0.019	0.011	0.023
STR-9	0.002	0.003	0.030	0.040	0.065	0.069	0.070	0.041	0.030	0.023
STR-S1	0.002	0.002	0.006	0.018	0.025	0.029	0.030	0.016	0.012	0.010
STR-1	0.002	0.004	0.015	0.024	0.030	0.084	0.106	0.028	0.020	0.026

Total Suspended Solids (TSS; mg/L)

Site ID	MIN	10th	25th	Median	75th	90th	Max	Mean	Geomean	StDev
STR-1	1.2	2.1	4.7	6.2	13.6	27.9	32.7	9.6	7.1	8.5
STR-10	3.8	4.2	7.7	15.7	20.1	25.9	26.1	14.8	12.7	7.4
STR-11	2.4	2.5	3.1	5.4	8.5	10.0	10.4	5.7	5.1	2.7
STR-12	0.3	0.4	1.6	2.1	2.4	7.1	9.0	2.4	1.8	2.2
STR-13	1.8	2.2	3.9	5.2	9.0	13.5	14.0	6.3	5.4	3.8
STR-16	0.9	0.9	0.9	1.2	2.7	4.9	5.4	1.8	1.5	1.5
STR-17	6.9	7.1	10.2	13.6	18.9	193.3	262.8	35.1	17.0	72.0
STR-2	8.8	9.0	14.4	23.0	38.7	49.7	52.5	26.1	22.6	14.0
STR-20	0.9	1.0	1.5	2.3	4.7	8.0	8.7	3.2	2.6	2.4
STR-22	0.7	0.8	1.0	1.9	2.6	6.9	8.7	2.3	1.8	2.1
STR-23	0.1	0.3	2.1	3.1	4.3	15.9	18.6	4.4	2.6	4.9
STR-24A	0.1	0.2	0.7	0.7	1.3	1.7	1.8	0.9	0.7	0.5
STR-26	2.4	2.4	2.9	5.5	7.6	12.2	13.1	6.0	5.2	3.2
STR-27	0.1	0.3	0.7	1.6	5.4	13.0	14.5	3.8	1.8	4.4
STR-5	2.1	2.1	4.0	5.8	7.4	16.6	20.3	6.5	5.5	4.7
STR-6	0.5	0.7	1.5	2.1	4.2	29.7	39.5	5.7	2.7	10.8
STR-7	0.9	1.0	1.5	2.6	4.6	14.3	17.3	4.1	2.9	4.5
STR-8	0.2	0.4	1.9	2.3	3.2	15.1	20.1	3.6	2.1	5.3
STR-9	3.9	3.9	4.2	6.1	8.4	14.0	15.2	7.0	6.4	3.4
STR-S1	2.9	3.0	4.0	7.2	8.7	18.4	22.3	7.7	6.6	5.1
STR-1	1.2	2.1	4.7	6.2	13.6	27.9	32.7	9.6	7.1	8.5

Turbidity (NTU)

Site ID	MIN	10th	25th	Median	75th	90th	Max	Mean	Geomean	StDev
STR-1	2.6	3.0	4.0	6.5	7.9	32.0	42.1	8.8	6.4	10.7
STR-10	3.3	3.4	7.0	13.8	18.2	27.5	29.9	13.5	11.3	7.8
STR-11	1.6	2.0	3.7	6.2	8.7	16.0	16.6	7.0	5.7	4.6
STR-12	1.7	1.8	2.2	2.7	6.5	17.7	21.7	5.0	3.6	5.7
STR-13	2.9	3.2	4.1	4.7	9.7	21.4	24.8	7.5	6.0	6.3
STR-16	0.8	0.8	1.3	2.5	4.3	8.6	9.7	3.2	2.5	2.6
STR-17	5.9	8.2	17.0	22.9	34.0	56.1	57.9	27.1	23.1	15.4
STR-2	6.3	6.5	8.4	15.6	29.4	41.5	45.0	19.0	15.6	12.4
STR-20	1.2	1.4	2.3	3.5	8.2	16.9	20.3	5.8	4.2	5.4
STR-22	1.1	1.2	1.6	2.2	5.1	14.0	17.2	3.9	2.7	4.5
STR-23	2.7	2.7	2.8	3.7	9.7	27.5	29.2	7.9	5.3	8.8
STR-24A	0.6	0.7	0.9	1.4	2.3	8.7	11.2	2.3	1.6	2.9
STR-26	3.2	3.3	4.6	6.0	13.4	21.0	21.7	8.7	7.1	6.3
STR-27	1.2	1.2	1.7	3.6	6.9	20.5	21.4	6.1	3.8	6.8
STR-5	2.7	2.9	3.5	4.9	8.8	15.3	17.9	6.5	5.6	4.3
STR-6	1.6	1.8	2.2	2.6	8.0	39.9	52.5	8.2	4.3	14.2
STR-7	1.0	1.3	2.1	3.1	12.5	17.2	17.9	6.4	4.2	6.1
STR-8	1.3	1.5	2.0	2.4	8.1	26.6	34.3	6.3	3.7	9.2
STR-9	3.2	3.3	6.0	7.7	11.3	17.1	19.3	8.6	7.6	4.4
STR-S1	2.5	2.6	3.9	6.5	12.3	16.0	16.8	7.7	6.5	4.8
STR-1	2.6	3.0	4.0	6.5	7.9	32.0	42.1	8.8	6.4	10.7

Table A9. Annual and monthly nutrient and sediment loads at STR-S1 in Strawberry Watershed, Arkansas, estimated using simple linear regression with bias correction factor, 2011-2012.

		NO_3-N (kg)	SRP (kg)	Total N (kg)	Total P (kg)	TSS (kg)
2011	Annual	630,000	29,961	1,260,451	277,286	198,615,425
	January	500	23	1096	104	41360
	February	6,100	290	12822	1890	1024582
	March	7,360	349	15691	2036	1004805
	April	314,000	14945	621344	148670	111604353
	May	202,000	9593	404525	86928	60985475
	June	2387	113	5164	596	271403
	July	661	31	1460	143	58403
	August	494	23	1095	104	41348
	September	444	21	985	93	37141
	October	409	19	910	85	33150
	November	36025	1712	73561	13674	8710348
	December	59741	2840	121800	22963	14803058
2012	Annual	62,191	2,954	130,413	19,710	11,030,491
	January	8472	402	18029	2377	1185999
	February	12481	593	26242	3837	2069351
	March	32349	1537	66781	11368	6828348
	April	2934	139	6337	739	339021
	May	2233	106	4796	592	285569
	June	630	30	1387	138	56880
	July	358	17	796	73	28373
	August	327	15	728	66	25537
	September	467	22	1035	98	39252
	October	615	29	1359	133	53897
	November	538	26	1191	115	45987
	December	787	37	1733	174	72277

Table A10. Annual and monthly nutrient and sediment loads at STR-S1 in Strawberry Watershed, Arkansas, estimated using USGS LOADEST Equation 1 AMLE, 2011-2012.

		NO_3-N (kg)	SRP (kg)	Total N (kg)	Total P (kg)	TSS (kg)
2011	Annual	567,000	30,500	1,250,000	300,000	194,000,000
	January	460	25	1,100	120	43,100
	February	5,660	310	12,800	2,240	1,060,00
	March	6,850	376	15,700	2,440	1,052,000
	April	281,000	15,000	617,000	157,000	107,000,000
	May	182,000	9,800	403,000	94,900	59,900,000
	June	2,220	120	5,180	720	285,000
	July	610	34	1,460	170	61,000
	August	460	25	1,100	120	43,100
	September	410	23	1,000	110	38,700
	October	380	21	910	100	34,500
	November	32,900	1,790	73,500	15,510	8,780,000
	December	54,600	2,960	122,000	25,920	14,900,000
2012	Annual	57,500	3,140	131,000	23,060	11,300,000
	January	7,880	430	18,100	2,850	1,240,000
	February	11,570	630	26,300	4,540	2,150,000
	March	29,800	1,620	66,800	13,120	6,960,000
	April	2,730	150	6,360	890	356,000
	May	2,080	110	4,800	710	298,000
	June	590	32	1,390	170	59,400
	July	330	18	800	86	29,500
	August	300	17	730	78	26,500
	September	430	24	1,040	120	40,900
	October	570	31	1,360	160	56,200
	November	500	27	1,190	140	47,900
	December	730	40	1,740	210	75,500

Table A11. Annual and monthly nutrient and sediment loads at STR-S1 in Strawberry Watershed, Arkansas, estimated using USGS LOADEST Equation 4 AMLE, 2011-2012.

		NO_3-N (kg)	SRP (kg)	Total N (kg)	Total P (kg)	TSS (kg)
2011	Annual	173,000	108,000	1,650,000	4,340,000	4,560,000,000
	January	1,160	6	820	7	2,620
	February	5,710	240	12,100	1,370	814,000
	March	6,810	200	13,900	680	418,000
	April	51,600	58,000	834,000	2,590,000	2,990,000,000
	May	35,900	33,600	530,000	1,260,000	1,390,000,000
	June	980	144	5,440	930	643,000
	July	340	41	1,540	230	115,000
	August	320	35	1,190	210	77,400
	September	420	29	1,050	170	49,200
	October	580	19	900	75	18,900
	November	23,700	6,490	96,750	215,000	77,000,000
	December	45,000	8,920	152,000	269,000	102,000,000
2012	Annual	50,700	3,190	130,000	30,130	22,300,000
	January	11,900	290	16,700	1,180	471,000
	February	13,200	500	24,900	3,090	1,560,000
	March	17,600	2,050	69,900	24,200	19,200,000
	April	2,140	77	5,590	220	158,000
	May	1,080	110	4,740	690	555,000
	June	330	27	1,350	110	69,100
	July	210	19	810	83	39,900
	August	230	20	770	100	38,100
	September	430	31	1,110	180	54,900
	October	810	33	1,390	160	41,100
	November	1,020	18	1,100	52	12,900
	December	1,690	18	1,470	40	11,500

Table A12. Frequency distribution of constituent concentrations during base flow conditions among selected sampling sites in the Upper Saline Watershed, Arkansas, October 2011- September 2012.

Conductivity (µS/cm)

Site ID	MIN	10th	25th	Median	75th	90th	Max	Mean	Geomean	StDev
SAL-11	82	86	107	133	153	168	171	129	126	27
SAL-13	85	93	125	139	163	168	169	140	137	25
SAL-14	127	147	280	358	719	939	943	485	410	279
SAL-16	32	49	128	152	180	189	192	145	133	46
SAL-3	22	23	27	29	46	126	159	43	36	37
SAL-30A	40	47	88	116	146	162	164	113	105	39
SAL-31	63	69	95	117	139	161	165	115	112	30
SAL-32	27	29	55	67	145	182	187	98	83	55
SAL-34A	57	65	104	120	138	248	294	129	120	58
SAL-35	42	47	219	283	400	428	432	280	233	131
SAL-36	177	199	277	407	636	967	1009	474	419	256
SAL-37	68	78	112	142	163	173	177	136	131	34
SAL-39	40	43	64	77	102	113	114	80	77	23
SAL-5	34	36	42	56	65	675	936	127	66	255
SAL-8	80	104	178	274	526	652	659	336	284	195
SAL-U1	13	13	15	18	21	36	37	20	19	8
SAL-U2	14	15	19	23	52	184	230	46	31	61
SAL-U3A	59	69	96	116	147	153	154	119	115	29
SAL-U4	71	82	140	210	382	527	540	255	217	152
SAL-U6	18	19	22	24	26	155	208	39	28	53
SAL-11	82	86	107	133	153	168	171	129	126	27

Nitrate (NO_3-N; mg/L)

Site ID	MIN	10th	25th	Median	75th	90th	Max	Mean	Geomean	StDev
SAL-11	0.003	0.003	0.028	0.167	0.248	0.398	0.402	0.170	0.071	0.136
SAL-13	0.003	0.003	0.105	0.233	0.392	0.538	0.542	0.248	0.121	0.186
SAL-14	0.003	0.003	0.045	0.182	0.254	0.340	0.369	0.166	0.086	0.115
SAL-16	0.010	0.029	0.144	0.274	0.776	1.549	1.565	0.496	0.260	0.536
SAL-3	0.003	0.003	0.003	0.003	0.017	0.023	0.023	0.008	0.005	0.009
SAL-30A	0.003	0.003	0.012	0.031	0.090	0.367	0.440	0.079	0.030	0.126
SAL-31	0.003	0.003	0.003	0.030	0.065	0.136	0.152	0.042	0.020	0.046
SAL-32	0.003	0.003	0.003	0.021	0.085	0.131	0.142	0.043	0.021	0.045
SAL-34A	0.003	0.003	0.003	0.044	0.122	0.240	0.281	0.070	0.025	0.084
SAL-35	0.157	0.217	5.654	9.810	12.359	17.488	18.800	8.813	5.291	5.426
SAL-36	0.003	0.063	0.265	0.341	0.547	0.808	0.867	0.399	0.265	0.228
SAL-37	0.003	0.003	0.003	0.053	0.171	0.304	0.306	0.097	0.032	0.113
SAL-39	0.003	0.003	0.003	0.003	0.024	0.103	0.107	0.025	0.009	0.037
SAL-5	0.003	0.003	0.003	0.026	0.060	0.115	0.133	0.036	0.017	0.039
SAL-8	0.003	0.003	0.016	0.109	0.181	0.227	0.239	0.106	0.053	0.081
SAL-U1	0.003	0.003	0.003	0.003	0.003	0.007	0.008	0.003	0.003	0.002
SAL-U2	0.003	0.003	0.003	0.007	0.032	0.278	0.381	0.043	0.010	0.107
SAL-U3A	0.003	0.004	0.015	0.074	0.126	0.232	0.266	0.083	0.044	0.077
SAL-U4	0.003	0.003	0.021	0.096	0.139	0.231	0.266	0.091	0.048	0.076
SAL-U6	0.003	0.003	0.004	0.022	0.034	0.061	0.069	0.023	0.014	0.020
SAL-11	0.003	0.003	0.028	0.167	0.248	0.398	0.402	0.170	0.071	0.136

Soluble Reactive Phosphorus (SRP; mg/L)

Site ID	MIN	10th	25th	Median	75th	90th	Max	Mean	Geomean	StDev
SAL-11	0.003	0.004	0.005	0.011	0.024	0.043	0.048	0.015	0.011	0.013
SAL-13	0.004	0.004	0.006	0.009	0.020	0.059	0.069	0.017	0.011	0.019
SAL-14	0.003	0.003	0.005	0.013	0.015	0.018	0.018	0.011	0.010	0.005
SAL-16	0.003	0.003	0.007	0.017	0.062	0.118	0.136	0.038	0.020	0.041
SAL-3	0.001	0.001	0.003	0.006	0.009	0.010	0.011	0.006	0.005	0.003
SAL-30A	0.001	0.001	0.001	0.004	0.006	0.047	0.062	0.009	0.004	0.017
SAL-31	0.001	0.001	0.001	0.005	0.008	0.009	0.010	0.005	0.003	0.003
SAL-32	0.001	0.001	0.001	0.004	0.007	0.066	0.080	0.011	0.004	0.023
SAL-34A	0.001	0.001	0.001	0.007	0.009	0.010	0.010	0.006	0.004	0.004
SAL-35	0.001	0.003	0.023	0.115	0.325	0.334	0.335	0.160	0.069	0.140
SAL-36	0.003	0.003	0.010	0.019	0.075	0.280	0.356	0.058	0.022	0.099
SAL-37	0.001	0.001	0.001	0.007	0.010	0.011	0.011	0.006	0.004	0.004
SAL-39	0.001	0.001	0.002	0.004	0.006	0.009	0.010	0.004	0.004	0.003
SAL-5	0.001	0.001	0.002	0.005	0.008	0.010	0.010	0.005	0.004	0.003
SAL-8	0.002	0.002	0.002	0.008	0.013	0.026	0.030	0.009	0.007	0.008
SAL-U1	0.001	0.001	0.001	0.002	0.009	0.012	0.013	0.004	0.003	0.004
SAL-U2	0.001	0.001	0.001	0.002	0.009	0.022	0.024	0.006	0.003	0.007
SAL-U3A	0.001	0.001	0.001	0.006	0.008	0.010	0.010	0.005	0.004	0.003
SAL-U4	0.004	0.004	0.009	0.013	0.019	0.029	0.031	0.014	0.012	0.008
SAL-U6	0.001	0.001	0.001	0.004	0.006	0.008	0.008	0.004	0.003	0.003

Total Nitrogen (TN; mg/L)

Site ID	MIN	10th	25th	Median	75th	90th	Max	Mean	Geomean	StDev
SAL-11	0.33	0.34	0.36	0.48	0.59	0.73	0.76	0.49	0.47	0.13
SAL-13	0.25	0.25	0.37	0.53	0.69	0.83	0.87	0.53	0.49	0.19
SAL-14	0.17	0.21	0.44	0.60	0.65	0.72	0.74	0.53	0.50	0.17
SAL-16	0.27	0.29	0.35	0.51	1.15	2.16	2.18	0.83	0.64	0.68
SAL-3	0.09	0.18	0.46	0.60	0.76	0.79	0.79	0.57	0.51	0.20
SAL-30A	0.08	0.08	0.15	0.24	0.34	0.69	0.78	0.28	0.23	0.19
SAL-31	0.06	0.07	0.09	0.19	0.24	0.27	0.28	0.17	0.16	0.07
SAL-32	0.07	0.08	0.14	0.18	0.26	0.30	0.31	0.19	0.18	0.07
SAL-34A	0.07	0.09	0.18	0.25	0.30	0.43	0.44	0.25	0.23	0.11
SAL-35	0.35	0.40	5.99	9.00	14.55	23.72	27.18	10.07	6.32	7.27
SAL-36	0.45	0.50	0.64	0.76	1.06	1.33	1.42	0.83	0.79	0.27
SAL-37	0.16	0.17	0.20	0.24	0.30	0.46	0.47	0.27	0.26	0.09
SAL-39	0.06	0.06	0.11	0.15	0.37	0.39	0.39	0.19	0.16	0.13
SAL-5	0.28	0.29	0.33	0.52	0.83	1.02	1.04	0.58	0.53	0.26
SAL-8	0.19	0.24	0.42	0.52	0.64	0.66	0.67	0.51	0.48	0.14
SAL-U1	0.01	0.02	0.04	0.08	0.21	1.07	1.12	0.25	0.11	0.38
SAL-U2	0.01	0.02	0.05	0.09	0.31	0.97	1.11	0.24	0.11	0.33
SAL-U3A	0.09	0.10	0.13	0.28	0.36	0.42	0.42	0.26	0.23	0.12
SAL-U4	0.25	0.30	0.45	0.56	0.73	0.83	0.84	0.57	0.55	0.18
SAL-U6	0.15	0.15	0.16	0.17	0.18	0.28	0.30	0.18	0.18	0.04
SAL-11	0.33	0.34	0.36	0.48	0.59	0.73	0.76	0.49	0.47	0.13

Total Phosphorus (TP; mg/L)

Site ID	MIN	10th	25th	Median	75th	90th	Max	Mean	Geomean	StDev
SAL-11	0.018	0.021	0.034	0.061	0.097	0.179	0.200	0.072	0.057	0.052
SAL-13	0.018	0.019	0.028	0.035	0.048	0.092	0.098	0.043	0.038	0.023
SAL-14	0.020	0.021	0.031	0.046	0.070	0.097	0.102	0.052	0.047	0.026
SAL-16	0.012	0.014	0.025	0.048	0.137	0.215	0.242	0.081	0.054	0.072
SAL-3	0.006	0.011	0.024	0.033	0.068	0.078	0.078	0.043	0.035	0.024
SAL-30A	0.006	0.007	0.012	0.015	0.025	0.048	0.056	0.020	0.017	0.013
SAL-31	0.004	0.004	0.007	0.013	0.023	0.047	0.052	0.017	0.013	0.014
SAL-32	0.004	0.005	0.008	0.016	0.020	0.028	0.030	0.015	0.013	0.007
SAL-34A	0.010	0.011	0.016	0.019	0.022	0.048	0.052	0.022	0.020	0.012
SAL-35	0.012	0.016	0.082	0.212	0.373	0.398	0.402	0.220	0.144	0.152
SAL-36	0.052	0.054	0.067	0.089	0.164	0.496	0.599	0.147	0.109	0.154
SAL-37	0.008	0.009	0.015	0.022	0.024	0.027	0.028	0.020	0.018	0.006
SAL-39	0.004	0.004	0.008	0.012	0.038	0.064	0.064	0.023	0.015	0.022
SAL-5	0.014	0.016	0.021	0.031	0.066	0.084	0.088	0.042	0.036	0.025
SAL-8	0.014	0.015	0.036	0.050	0.071	0.081	0.082	0.051	0.045	0.022
SAL-U1	0.004	0.004	0.006	0.010	0.044	0.082	0.084	0.025	0.014	0.029
SAL-U2	0.004	0.004	0.006	0.015	0.026	0.039	0.044	0.017	0.012	0.012
SAL-U3A	0.004	0.005	0.014	0.020	0.035	0.057	0.058	0.025	0.020	0.017
SAL-U4	0.028	0.030	0.039	0.053	0.106	0.138	0.148	0.069	0.061	0.038
SAL-U6	0.004	0.005	0.008	0.011	0.016	0.038	0.046	0.014	0.012	0.011
SAL-11	0.018	0.021	0.034	0.061	0.097	0.179	0.200	0.072	0.057	0.052

Total Suspended Solids (TSS; mg/L)

Site ID	MIN	10th	25th	Median	75th	90th	Max	Mean	Geomean	StDev
SAL-11	2.7	3.0	4.4	7.7	14.7	41.0	44.4	12.7	8.8	13.0
SAL-13	2.1	2.6	4.9	5.8	12.3	28.6	29.2	10.3	7.6	9.0
SAL-14	1.5	1.7	2.5	6.1	10.1	24.1	27.8	7.9	5.6	7.5
SAL-16	2.8	3.2	4.4	6.0	7.7	20.0	21.9	7.7	6.5	5.5
SAL-3	1.0	1.8	4.7	7.5	9.6	17.0	19.2	8.0	6.6	4.6
SAL-30A	0.9	1.0	1.2	2.0	2.4	4.9	5.1	2.2	1.9	1.3
SAL-31	0.9	0.9	1.1	1.7	3.0	6.6	7.8	2.3	1.9	1.9
SAL-32	0.7	0.8	1.3	2.2	2.8	4.0	4.3	2.1	1.9	1.0
SAL-34A	0.9	1.3	2.4	3.9	5.2	22.0	25.3	6.0	4.1	6.9
SAL-35	0.5	0.6	1.0	1.3	1.7	3.0	3.6	1.4	1.3	0.8
SAL-36	1.5	2.0	3.3	6.2	10.3	13.6	14.1	6.9	5.8	4.0
SAL-37	1.1	1.2	1.7	2.1	2.7	3.7	4.1	2.2	2.1	0.8
SAL-39	0.9	0.9	1.2	2.1	13.5	49.5	54.7	10.2	3.7	17.0
SAL-5	1.8	2.0	3.2	6.0	11.3	15.1	16.5	7.1	5.8	4.5
SAL-8	2.4	2.8	4.5	7.1	9.9	29.0	34.3	9.3	7.1	8.7
SAL-U1	0.4	0.5	0.7	1.1	2.6	15.0	15.7	3.5	1.7	5.3
SAL-U2	0.3	0.4	0.6	1.0	3.2	8.0	8.1	2.4	1.4	2.8
SAL-U3A	2.1	2.2	2.5	3.8	4.4	11.1	13.6	4.3	3.8	3.1
SAL-U4	1.7	2.5	5.5	8.8	12.6	22.0	25.3	9.9	8.2	6.1
SAL-U6	0.7	0.9	1.7	2.2	3.4	4.9	5.5	2.5	2.2	1.3
SAL-11	2.7	3.0	4.4	7.7	14.7	41.0	44.4	12.7	8.8	13.0

Turbidity (NTU)

Site ID	MIN	10th	25th	Median	75th	90th	Max	Mean	Geomean	StDev
SAL-11	4.4	4.7	5.9	14.1	19.1	59.6	69.6	18.4	13.1	18.4
SAL-13	5.0	5.1	6.1	10.7	14.9	28.5	34.2	12.1	10.3	8.0
SAL-14	3.3	3.7	4.6	11.4	15.5	31.8	37.6	11.9	9.3	9.5
SAL-16	3.5	4.1	6.0	7.0	10.7	31.9	33.9	11.0	8.7	9.5
SAL-3	1.1	3.2	8.3	12.1	16.1	19.7	19.8	12.0	10.2	5.3
SAL-30A	1.7	1.7	2.2	3.1	5.4	5.9	5.9	3.6	3.3	1.6
SAL-31	1.2	1.3	2.0	3.8	5.2	11.3	11.3	4.6	3.6	3.4
SAL-32	2.0	2.0	2.6	3.5	4.6	4.7	4.7	3.3	3.2	1.0
SAL-34A	1.5	1.8	3.4	5.1	7.5	18.0	18.1	6.8	5.4	5.4
SAL-35	0.7	0.8	1.8	2.4	3.6	4.1	4.2	2.5	2.3	1.1
SAL-36	3.8	4.0	5.7	9.9	16.5	22.6	25.1	11.3	9.7	6.4
SAL-37	1.4	1.5	2.0	3.3	5.0	6.2	6.5	3.5	3.2	1.6
SAL-39	2.0	2.1	2.7	4.2	21.8	34.2	36.7	10.6	6.3	11.7
SAL-5	3.7	5.1	8.8	9.8	13.5	19.1	21.0	10.9	10.1	4.3
SAL-8	5.6	5.8	8.3	11.1	15.7	27.9	29.4	13.0	11.5	7.2
SAL-U1	2.7	2.7	3.2	3.8	7.2	16.5	17.0	6.0	4.8	5.0
SAL-U2	1.6	1.8	2.7	3.9	5.1	10.8	13.0	4.4	3.8	2.9
SAL-U3A	2.1	2.4	3.6	6.7	9.0	18.6	21.9	7.3	6.1	5.3
SAL-U4	6.7	7.7	13.0	16.3	20.0	58.1	72.9	20.3	16.8	17.2
SAL-U6	2.3	2.4	3.5	4.3	5.8	6.9	7.1	4.5	4.3	1.5
SAL-11	4.4	4.7	5.9	14.1	19.1	59.6	69.6	18.4	13.1	18.4

Table A13. Annual and monthly nutrient and sediment loads at SAL-U1 in Upper Saline Watershed, Arkansas, estimated using simple linear regression with bias correction factor, 2011-2012.

		NO_3-N (kg)	SRP (kg)	Total N (kg)	Total P (kg)	TSS (kg)
2011	Annual	170	26	3,110	167	45,700
	January	1	0	8	1	157
	February	5	1	82	5	1,360
	March	5	1	73	5	1,300
	April	47	7	906	47	13,000
	May	44	7	863	44	12,200
	June	1	0	9	1	170
	July	0	0	0	0	7
	August	1	0	14	1	264
	September	0	0	3	0	55
	October	0	0	0	0	7
	November	31	5	595	31	8,550
	December	32	5	560	32	8,590
2012	Annual	74	11	1,210	72	19,200
	January	10	2	161	10	2,660
	February	12	2	196	12	3,160
	March	33	5	583	32	8,780
	April	4	1	53	4	954
	May	1	0	9	1	182
	June	0	0	0	0	6
	July	0	0	0	0	7
	August	0	0	0	0	7
	September		1	113	7	1,800
	October	3	0	40	3	710
	November	1	0	13	1	245
	December	3	0	39	3	696

Table A14. Annual and monthly nutrient and sediment loads at SAL-U1 in Upper Saline Watershed, Arkansas, estimated using USGS LOADEST Equation 1 AMLE, 2011-2012.

		NO_3-N (kg)	SRP (kg)	Total N (kg)	Total P (kg)	TSS (kg)
2011	Annual	150	26	3,020	177	44,500
	January	1	0	8	1	153
	February	5	1	80	6	1,330
	March	5	1	72	5	1,280
	April	42	7	878	50	12,700
	May	39	7	834	47	11,900
	June	1	0	9	1	167
	July	0	0	0	0	6
	August	1	0	14	1	259
	September	0	0	3	0	53
	October	0	0	0	0	6
	November	28	5	576	33	8,300
	December	29	5	547	34	8,400
2012	Annual	67	11	1,180	77	18,800
	January	9	2	158	11	2,620
	February	11	2	192	13	3,110
	March	29	5	568	34	8,570
	April	4	1	52	4	940
	May	1	0	9	1	179
	June	0	0	0	0	6
	July	0	0	0	0	6
	August	0	0	0	0	6
	September	6	1	110	7	1,770
	October	3	0	39	3	698
	November	1	0	12	1	240
	December	3	0	38	3	685

Table A15. Annual and monthly nutrient and sediment loads at SAL-U1 in Upper Saline Watershed, Arkansas, estimated using USGS LOADEST Equation 4 AMLE, 2011-2012.

		NO_3-N (kg)	SRP (kg)	Total N (kg)	Total P (kg)	TSS (kg)
2011	Annual	163	29	7,840	428	47,000
	January	0	0	2	0	26
	February	3	1	44	2	722
	March	2	0	38	2	732
	April	34	7	2,670	125	53,100
	May	34	7	3,370	167	69,400
	June	1	0	21	1	533
	July	0	0	0	0	11
	August	2	0	58	6	1,250
	September	0	0	5	1	95
	October	0	0	0	0	2
	November	50	8	1,100	86	14,110
	December	37	6	543	39	7,140
2012	Annual	56	10	1,570	108	26,900
	January	6	1	78	5	1,150
	February	7	1	109	6	1,670
	March	21	4	698	32	12,200
	April	2	0	54	3	1,180
	May	0	0	12	1	289
	June	0	0	0	0	8
	July	0	0	0	0	11
	August	0	0	0	0	9
	September	12	2	509	51	8,760
	October	5	1	80	8	1,270
	November	1	0	9	1	139
	December	2	0	17	1	251

Table A16. Annual and monthly nutrient and sediment loads at SAL-U2 in Upper Saline Watershed, Arkansas, estimated using simple linear regression with bias correction factor, 2011-2012.

		NO_3-N (kg)	SRP (kg)	Total N (kg)	Total P (kg)	TSS (kg)
2011	Annual	6,430	382	44,200	3,980	1,730,000
	January	9	0	37	2	450
	February	244	14	1,390	112	34,100
	March	118	7	607	46	11,500
	April	2,210	132	16,100	1,500	712,000
	May	2,540	151	18,000	1,640	733,000
	June	208	12	1,220	100	32,800
	July	0	0	0	0	2
	August	104	6	622	52	17,400
	September	6	0	24	2	279
	October	4	0	14	1	139
	November	500	30	3,250	282	108,000
	December	487	29	2,930	243	81,100
2012	Annual	1,520	90	8,720	706	221,000
	January	162	9	887	70	20,000
	February	242	14	1,370	110	32,800
	March	531	31	3,280	277	97,200
	April	81	5	411	31	7,610
	May	14	1	59	4	750
	June	1	0	4	0	35
	July	0	0	0	0	2
	August	0	0	1	0	11
	September	152	9	877	71	22,600
	October	79	5	418	32	8,800
	November	55	3	272	20	4,870
	December	207	12	1,150	91	25,900

Table A17. Annual and monthly nutrient and sediment loads at SAL-U2 in Upper Saline Watershed, Arkansas, estimated using USGS LOADEST Equation 1 AMLE, 2011-2012.

		NO_3-N (kg)	SRP (kg)	Total N (kg)	Total P (kg)	TSS (kg)
2011	Annual	5,950	351	47,700	4,040	1,840,000
	January	8	0	40	3	484
	February	229	13	1,530	115	37,200
	March	111	6	667	47	12,600
	April	2,030	120	17,300	1,520	750,000
	May	2,350	139	19,400	1,660	777,000
	June	196	11	1,336	103	35,500
	July	0	0	0	0	1
	August	98	6	679	53	18,780
	September	5	0	26	2	300
	October	3	0	15	1	148
	November	467	27	3,530	287	116,000
	December	457	27	3,200	249	87,900
2012	Annual	1,430	83	9,550	723	239,000
	January	152	9	974	72	21,700
	February	228	13	1,500	112	35,700
	March	498	29	3,580	283	105,000
	April	76	4	451	32	8,300
	May	13	1	64	4	810
	June	1	0	4	0	37
	July	0	0	0	0	1
	August	0	0	1	0	12
	September	142	8	960	73	24,500
	October	74	4	459	33	9,590
	November	51	3	298	21	5,310
	December	195	11	1,260	93	28,300

Table A18. Annual and monthly nutrient and sediment loads at SAL-U2 in Upper Saline Watershed, Arkansas, estimated using USGS LOADEST Equation 4 AMLE, 2011-2012.

		NO_3-N (kg)	SRP (kg)	Total N (kg)	Total P (kg)	TSS (kg)
2011	Annual	8,250	351	236,000	14,700	5,780,000
	January	2	0	5	1	118
	February	117	9	631	62	25,700
	March	46	4	262	25	9,470
	April	2,540	108	83,100	5,530	2,490,000
	May	3,340	132	119,000	7,280	2,820,000
	June	357	13	11,800	588	139,000
	July	0	0	0	0	1
	August	317	9	9,640	416	70,200
	September	10	0	60	3	438
	October	4	0	11	1	97
	November	970	43	8,600	558	160,000
	December	542	31	3,160	245	76,800
2012	Annual	1,460	77	15,400	958	294,000
	January	82	7	341	34	12,100
	February	115	9	583	58	23,300
	March	328	21	3,460	299	144,000
	April	43	3	388	31	11,100
	May	8	0	60	4	1,130
	June	1	0	4	0	55
	July	0	0	0	0	1
	August	0	0	3	0	19
	September	473	15	8,100	373	65,500
	October	174	7	1,460	79	15,300
	November	65	4	282	20	4,180
	December	168	11	698	60	17,700

Table A19. Annual and monthly nutrient and sediment loads at SAL-U3A in Upper Saline Watershed, Arkansas, estimated using simple linear regression with bias correction factor, 2011-2012.

		NO_3-N (kg)	SRP (kg)	Total N (kg)	Total P (kg)	TSS (kg)
2011	Annual	211,000	10,100	613,000	94,710	62,500,000
	January	1,630	112	5,060	735	191,000
	February	8,440	483	25,300	3,790	1,550,000
	March	5112	315	15,500	2,300	772,000
	April	26,600	1,320	77,900	11,900	7,000,000
	May	80,300	3,580	231,000	36,000	27,400,000
	June	684	49	2,130	307	72,400
	July	230	18	733	104	18,300
	August	1,240	80	3,800	557	175,000
	September	104	9	334	47	7,100
	October	223	18	709	100	17,700
	November	51,900	2,350	149,000	23,300	16,900,000
	December	34,700	1,770	102,000	15,600	8,460,000
2012	Annual	75,700	4,120	225,000	34,000	16,400,000
	January	7,570	445	22,800	3,400	1,300,000
	February	12,900	716	38,500	5,790	2,550,000
	March	37,200	1,840	109,000	16,700	9,690,000
	April	2,420	160	7,450	1,090	304,000
	May	499	38	1,570	225	46,400
	June	390	28	1,220	176	40,400
	July	54	5	176	24	3,180
	August	103	8	329	46	8,390
	September	--	267	13,700	2,050	801,000
	October	1,060	74	3,300	478	120,000
	November	1,590	106	4,900	715	205,000
	December	7,430	430	22,300	3,340	1,330,000

Table A20. Annual and monthly nutrient and sediment loads at SAL-U3A in Upper Saline Watershed, Arkansas, estimated using USGS LOADEST Equation 1 AMLE, 2011-2012.

		NO_3-N (kg)	SRP (kg)	Total N (kg)	Total P (kg)	TSS (kg)
2011	Annual	206,000	10,000	607,000	97,300	61,900,000
	January	1,630	112	5,040	768	196,000
	February	8,450	484	25,200	4,000	1,590,000
	March	5,130	316	15,500	2,410	795,100
	April	26229	1,310	77,300	12,400	7,030,000
	May	77,500	3,520	227,000	36,700	26,800,000
	June	680	49	2,120	320	73,900
	July	225	18	725	107	18,300
	August	1,240	80	3,780	583	180,000
	September	100	9	329	48	6,990
	October	217	18	701	103	17,660
	November	50,300	2,320	147,000	23,800	16,600,000
	December	34,300	1,760	101,000	16,200	8,550,000
2012	Annual	75,230	4,110	224,000	35,400	16,600,000
	January	7,590	445	22,800	3,560	1,340,000
	February	12,880	716	38,200	6,050	2,600,000
	March	36,600	1,830	108,000	17,300	9,750,000
	April	2,420	160	7,420	1,140	313,000
	May	494	37	1560	233	47,000
	June	386	28	1210	182	41,100
	July	51	5	173	25	3,060
	August	100	8	325	48	8,390
	September	4,570	267	13,700	2,150	823,000
	October	1,060	74	3,290	500	123,000
	November	1,590	105	4,880	748	211,000
	December	7,440	430	22,300	3,490	1,360,000

Table A21. Annual and monthly nutrient and sediment loads at SAL-U3A in Upper Saline Watershed, Arkansas, estimated using USGS LOADEST Equation 4 AMLE, 2011-2012.

		NO_3-N (kg)	SRP (kg)	Total N (kg)	Total P (kg)	TSS (kg)
2011	Annual	276,000	14,300	978,000	193,000	115,000,000
	January	1,120	69	2,650	283	79,700
	February	6,260	336	17,100	2,230	1,090,000
	March	2,730	169	8,990	1,130	605,000
	April	19,400	1,200	97,100	18,500	14,400,000
	May	68,600	4,210	392,000	84,600	70,400,000
	June	420	36	2,050	327	120,000
	July	184	17	800	128	27,800
	August	1,840	137	7,650	1,580	369,000
	September	121	10	350	49	6,100
	October	275	20	673	88	11,300
	November	119,000	5,460	315,000	62,500	20,400,000
	December	56,100	2,650	134,000	22,000	7,410,000
2012	Annual	67,900	3,790	216,000	34,600	18,800,000
	January	6,430	344	15,800	2,010	804,000
	February	9,950	522	27,500	3,700	1,910,000
	March	27,100	1,460	102,000	16,800	13,100,000
	April	1,130	81	4,560	600	308,000
	May	218	19	990	131	51,800
	June	244	21	1,200	195	69,500
	July	35	4	150	21	3,710
	August	121	10	420	69	11,050
	September	9,200	591	31,800	6,680	1,440,000
	October	1,670	108	4,180	639	103,000
	November	2,300	135	5,220	745	143,000
	December	9,510	490	21,600	3,060	896,000

Table A22. Annual and monthly nutrient and sediment loads at SAL-U4 in Upper Saline Watershed, Arkansas, estimated using simple linear regression with bias correction factor, 2011-2012.

		NO_3-N (kg)	SRP (kg)	Total N (kg)	Total P (kg)	TSS (kg)
2011	Annual	36,000	3,320	184,000	18,000	5,300,000
	January	358	48	2,230	253	43,300
	February	1,230	142	7,090	758	160,000
	March	1,720	191	9,710	1,020	229,000
	April	9,360	817	46,400	4,440	1,410,000
	May	9,090	801	45,300	4,350	1,360,000
	June	212	30	1,350	156	25,000
	July	57	9	400	49	6,210
	August	179	25	1,150	133	21,100
	September	40	7	286	36	4,260
	October	34	6	242	30	3,700
	November	4,300	400	22,100	2,160	629,000
	December	9,430	844	47,400	4,580	1,400,000
2012	Annual	26,300	2,450	134,000	13,200	3,860,000
	January	3,000	314	16,400	1,690	411,000
	February	6,260	593	32,400	3,210	903,000
	March	13,500	1,110	64,800	6,060	2,110,000
	April	710	89	4,270	471	88,800
	May	77	12	513	61	8,680
	June	53	8	360	44	5,880
	July	18	3	128	16	1,870
	August	50	8	336	40	5,710
	September	793	94	4,630	500	102,000
	October	134	19	863	100	15,800
	November	539	69	3,290	366	66,700
	December	1,110	129	6,420	688	145,000

Table A23. Annual and monthly nutrient and sediment loads at SAL-U4 in Upper Saline Watershed, Arkansas, estimated using USGS LOADEST Equation 1 AMLE, 2011-2012.

		NO_3-N (kg)	SRP (kg)	Total N (kg)	Total P (kg)	TSS (kg)
2011	Annual	37,900	3,280	184,000	18,020	5,360,000
	January	378	47	2,240	254	43,900
	February	1,310	141	7120	762	163,000
	March	1,830	189	9,740	1,030	233,000
	April	9,830	806	46,500	4,450	1,420,000
	May	9,560	791	45,400	4,360	1,380,000
	June	222	29	1,350	156	25,300
	July	59	9	400	49	6,230
	August	188	25	1,150	133	21,400
	September	41	7	286	36	4,260
	October	35	6	241	30	3,700
	November	4,540	395	22,120	2,170	638,000
	December	9,920	834	47,490	4,590	1,420,000
2012	Annual	27,600	2,420	135,000	13,270	3,900,000
	January	3,180	312	16,500	1,700	418,000
	February	6,610	587	32,500	3,220	916,000
	March	14,100	1,100	64,900	6,060	2,120,000
	April	752	88	4,280	473	90,200
	May	80	12	513	61	8,760
	June	55	8	361	44	5,920
	July	18	3	128	16	1,860
	August	52	8	336	40	5,760
	September	840	93	4,650	503	104,000
	October	141	19	864	100	16,000
	November	571	68	3,300	367	67,700
	December	1,180	128	6,440	691	147,000

Table A24. Annual and monthly nutrient and sediment loads at SAL-U4 in Upper Saline Watershed, Arkansas, estimated using USGS LOADEST Equation 4 AMLE, 2011-2012.

		NO_3-N (kg)	SRP (kg)	Total N (kg)	Total P (kg)	TSS (kg)
2011	Annual	44,900	3,970	213,000	20,500	5,780,000
	January	324	33	1,780	222	39,400
	February	875	96	5,530	561	139,000
	March	988	127	7,490	656	189,000
	April	5,990	819	47,900	3,340	1,300,000
	May	6,200	897	50,500	3,510	1,300,000
	June	131	27	1,310	113	22,600
	July	49	10	429	45	6,230
	August	288	41	1,630	193	26931
	September	65	9	357	51	5,200
	October	59	7	274	44	4,400
	November	10,600	675	32,500	4,150	893,000
	December	19,400	1,230	62,800	7,570	1,850,000
2012	Annual	23,000	2,320	132,000	12,100	3,750,000
	January	3,190	274	15,200	1,690	414,000
	February	5,440	498	29,400	2,780	867,000
	March	9,540	1,020	63,000	4,710	1,970,000
	April	328	57	3,240	264	69,100
	May	32	7	375	32	6,490
	June	30	7	326	30	5,090
	July	15	3	133	14	1,850
	August	77	11	453	55	7,110
	September	1,780	188	7,660	941	147,000
	October	279	27	1,120	167	20,700
	November	1,060	89	4,010	582	84,200
	December	1,580	129	6,570	853	160,000