Arkansas Water Resources Center

2002 POLLUTANT LOADS
KINGS RIVER NEAR BERRYVILLE

Submitted to the
Arkansas Soil and Water Conservation Commission

By

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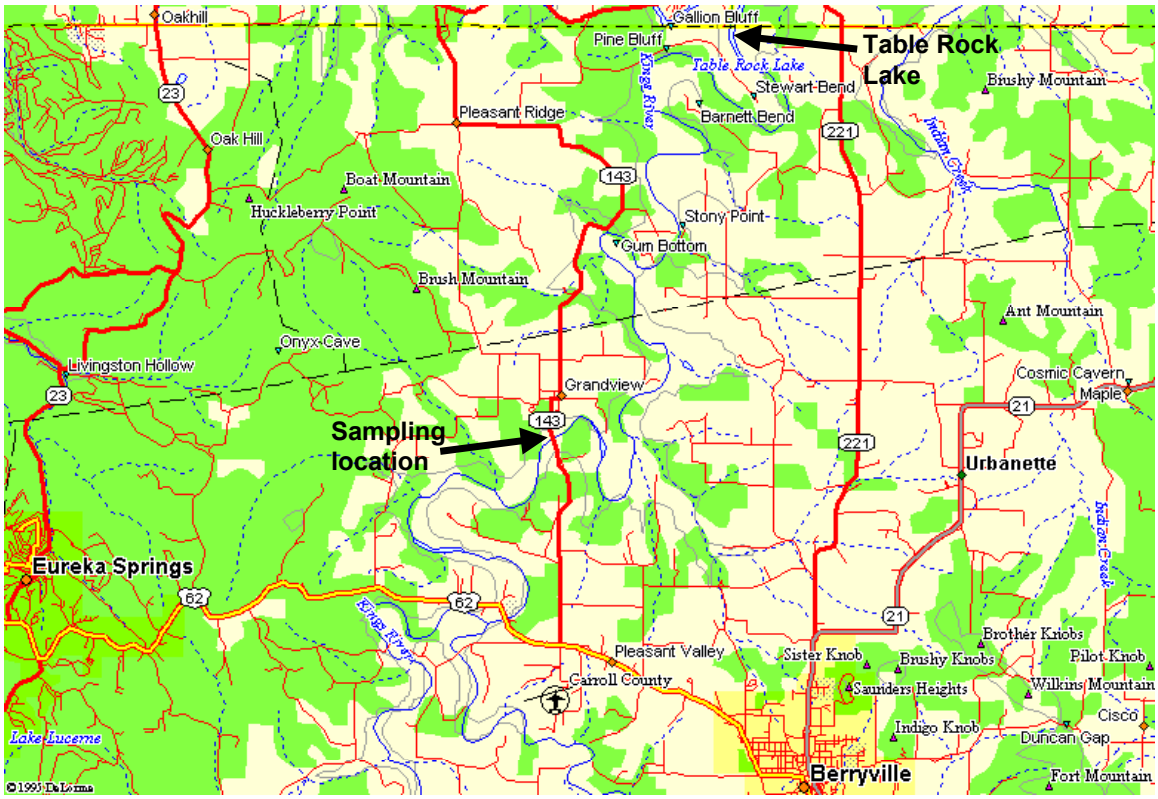
INTRODUCTION

An automatic sampler and a USGS gauging station were established in 1998 and water quality sampling was begun in 1999 on the Kings River near Berryville, Arkansas. Continuous stage and discharge measurements and frequent water quality sampling have been used to determine pollutant concentrations and loads in the river. This report presents the results from the sampling and analysis for January 1, 2002 to December 31, 2002.

BACKGROUND

In 1999, water quality sampling was begun at a new site established on the Kings River in the White River basin. The Kings River flows into Table Rock Lake at the Missouri border and the river basin contains forested and agricultural land and the wastewater from Berryville, Arkansas. USGS installed a stage gauge and developed a stage-discharge relationship for the site. The site is at "Lat 3625'36", long 9337'15", in SE1/4NE1/4 sec.3, T.20 N., R.25 W., Carroll County, Hydrologic Unit 11010001, on right bank at downstream side of bridge on State Highway 143, 1.5 mi downstream from Bee Creek, 2.5 mi upstream from Clabber Creek, 5.3 mi northwest of Berryville, and at mile 35.1" (from USGS web site). Figure 1 shows a map of the site.

Figure 1. Map of Kings River Sampling site



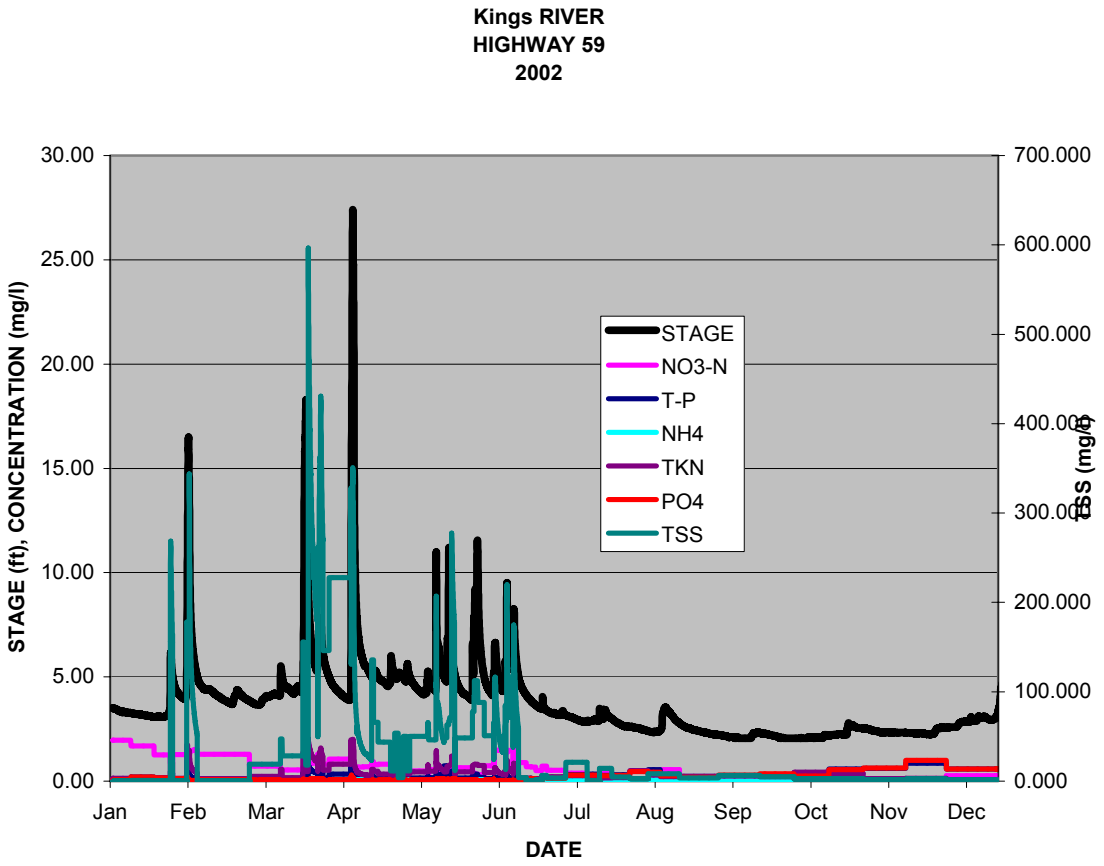
METHODS

The sampler was configured to take flow-weighted composite samples. The sampler was set to begin sampling when the stage rose above a set trigger level of five feet. It took a discrete sample after a fixed volume of water (8,000,000 cubic feet) passed. The discrete samples were composited by combining equal volumes of each into a single composite sample for analysis. The discrete samples were collected for compositing within forty-eight hours after the first sample. All storms were sampled in this manner as long as the stage was above the trigger level. Grab samples were taken every two weeks. The data collected at this site was used to calculate total pollutant loads and mean concentrations for the year. All samples were analyzed for Nitrate Nitrogen (NO3-N), Ammonia Nitrogen (NH4-N), Total Kjeldahl Nitrogen (TKN), Total Phosphorus (TP), Soluble Reactive Phosphate (SRP), Sulfate (SO4), Chloride (Cl), and Total Suspended Solids (TSS). AWRC Field Services personnel collected all samples and all samples were analyzed by the AWRC Water Quality Lab using standard field and laboratory QA/QC procedures.

Pollutant loads and mean concentrations were calculated by multiplying the concentration for each 30 minute period times the discharge during that period. Pollutant concentrations were assigned to each time period by taking the measured concentration and applying it from half way to the previous sample to half way to the subsequent sample. The yearly load is the sum of all the loads for all the time periods. The yearly mean concentrations were calculated by dividing the yearly load by the yearly discharge.

A total of 73 grab samples and 21 storm composite samples were collected, analyzed and used for load determination at this site in calendar year 2002. In addition, 4 field blanks, 4 field duplicates and 5 USGS/AWRC paired samples were collected, analyzed and used for QA/QC. The stage and determined concentrations are illustrated in figure 2.

Figure 2. 2002 Stage and Concentrations.



In addition to the above sampling for load determination, the AWRC in conjunction with the USGS conducted cross-section sampling to determine the relationship between auto-sampler concentrations and cross-section concentrations. The USGS collected evenly weighted integrated (EWI) cross section samples at the same time AWRC collected discrete auto-samples. All samples were transported and analyzed by the AWRC Water Quality Lab. Five storm-flow paired samples were taken and compared during the year. Regressions of log USGS vs. log AWRC concentrations for total P and TSS from the beginning of the project are shown in figures 3 and 4.

Figure 3.

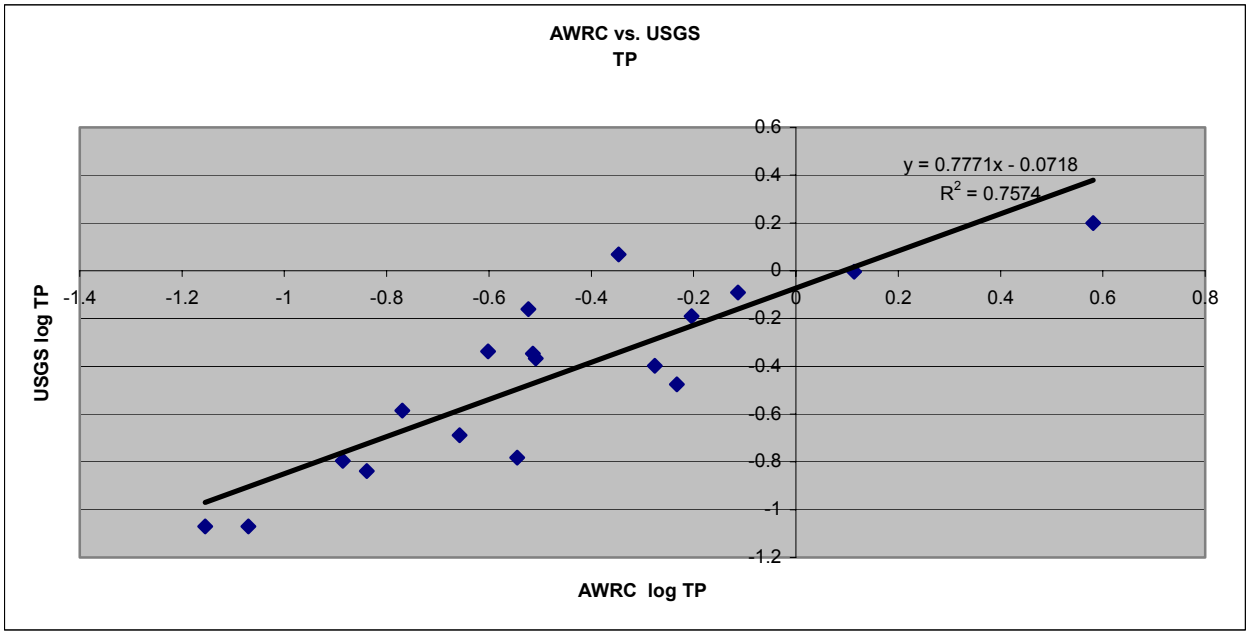
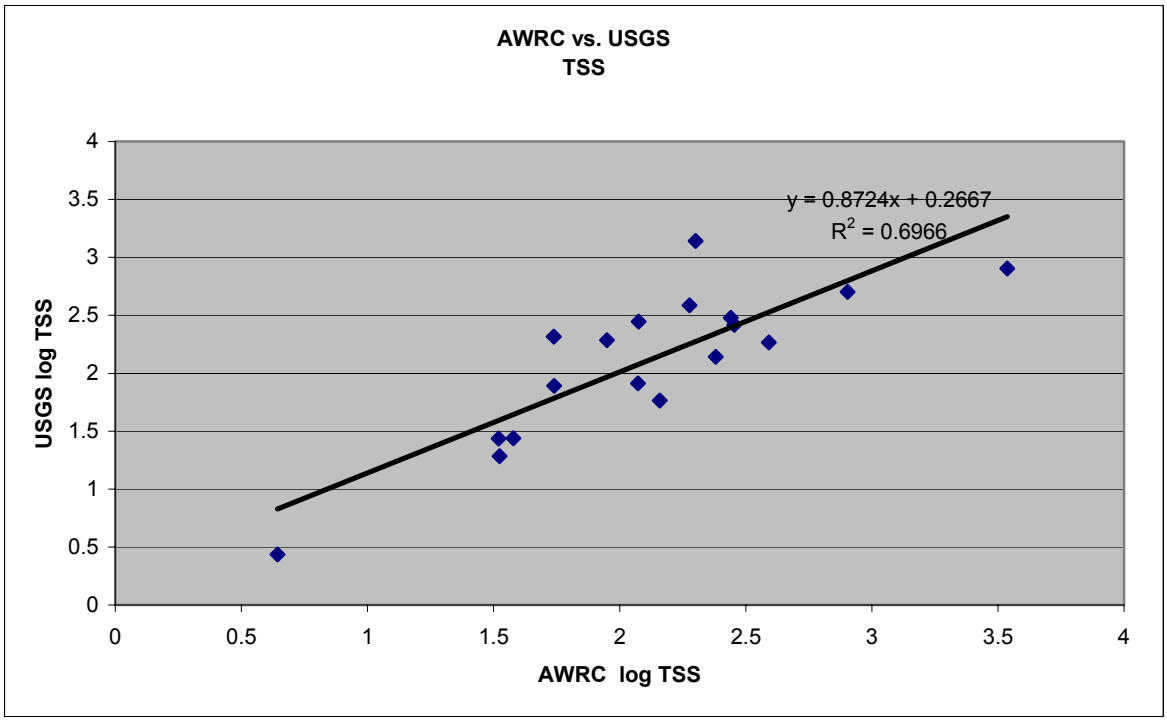


Figure 4.



RESULTS

The 2002 calculated loads and flow-weighted mean concentrations are shown in Table 1.

Table 1. Kings River near Berryville 2002 Loads and Mean Concentrations

Parameter	Total Load (kg/yr)	Mean concentration (mg/L)
Discharge (m^3/yr)	582,849,012	653 (cfs)
$N0_3$-N	432,143	0.74
TP	180,203	0.31
NH_4^+-N	20,936	0.04
TKN	401,495	0.69
PO_4^{2-}-P	44,767	0.08
TSS	63,146,716	108.34
SO_4	4,960,436	8.51
Cl^-	2,383,729	4.09

Table 2. Loads for all parameters

Parameter	**1999** Loads	**2000** Loads	**2001** Loads	**2002** Loads
Discharge (m^3)	477,590,619	285,535,630	332,293,424	582,849,012
N03-N (kg/yr)	401,729	250,132	479,272	432,143
TP (kg/yr)	153,786	102,332	108,473	180,203
NH_4^+-N (kg/yr)	12,997	10,968	17,316	20,936
TKN (kg/yr)	348,376	210,601	226,891	401,495
PO_4 P (kg/yr)	47,914	47,106	34,984	44,767
TSS (kg/yr)	79,598,491	35,645,367	36,818,561	63,146,716
SO_4 (kg/yr)	1,804,599	1,737,722	2,100,924	4,960,436
Cl^- (kg/yr)	2,608,416	1,464,226	1,791,831	2,383,729

Table 3. Flow-weighted Mean concentrations.

Parameter	**1999** mean concentrations	**2000** mean concentrations	**2001** mean concentrations	**2002** mean concentrations
Discharge (cfs)	535	320	372	653
N03-N (mg/l)	0.84	0.88	1.44	0.74
TP (mg/l)	0.32	0.36	0.33	0.31
NH_4^+-N (mg/l)	0.03	0.04	0.05	0.04
TKN (mg/l)	0.73	0.74	0.68	0.69
PO_4 P (mg/l)	0.10	0.16	0.11	0.08
TSS (mg/l)	167	125	111	108
SO_4 (mg/l)	3.78	6.09	6.32	8.51
Cl^- (mg/l)	5.46	5.13	5.39	4.09

During the year, there were 7 portions of storm events that were not sampled due to equipment malfunctions. The concentrations during those periods were estimated using the stage / concentration regression relationships. These relationships were determined from intensive discrete storm sampling in 1999 and 2000. The equations used are listed in table 4.

Table 4. Regression equations determined from discrete storm samples

Parameter	Regression equation	Regression coefficient
Nitrate-N	y = -0.0139x + 0.9438	$R^2 = 0.0109$
Total Phosphorus	y = 0.0965x - 0.1158	$R^2 = 0.2415$
Ammonia-N	y = -0.0004x + 0.0275	$R^2 = 0.0011$
TKN	y = 0.26x - 0.4359	$R^2 = 0.2962$
Phosphate-P	y = 0.0116x + 0.1771	$R^2 = 0.1433$
TSS	y = 97.54x – 333.16	$R^2 = 0.4361$
SO4	y = -0.2865 + 4.9888	$R^2 = 0.4551$
Cl-	y = - 0.1864 + 6.8752	$R^2 = 0.3082$

DISCUSSION

The loads and concentrations developed for the Kings River can be compared to loads and concentrations developed in other watersheds in Northwest Arkansas. Five other watersheds have been monitored using the same monitoring and load calculation protocols. The only differences between the protocols are that trigger levels and storm composite sample volumes are different for each site. This means that the distinction between storm and base flows (defined here as the trigger level) may be relatively different at each site.

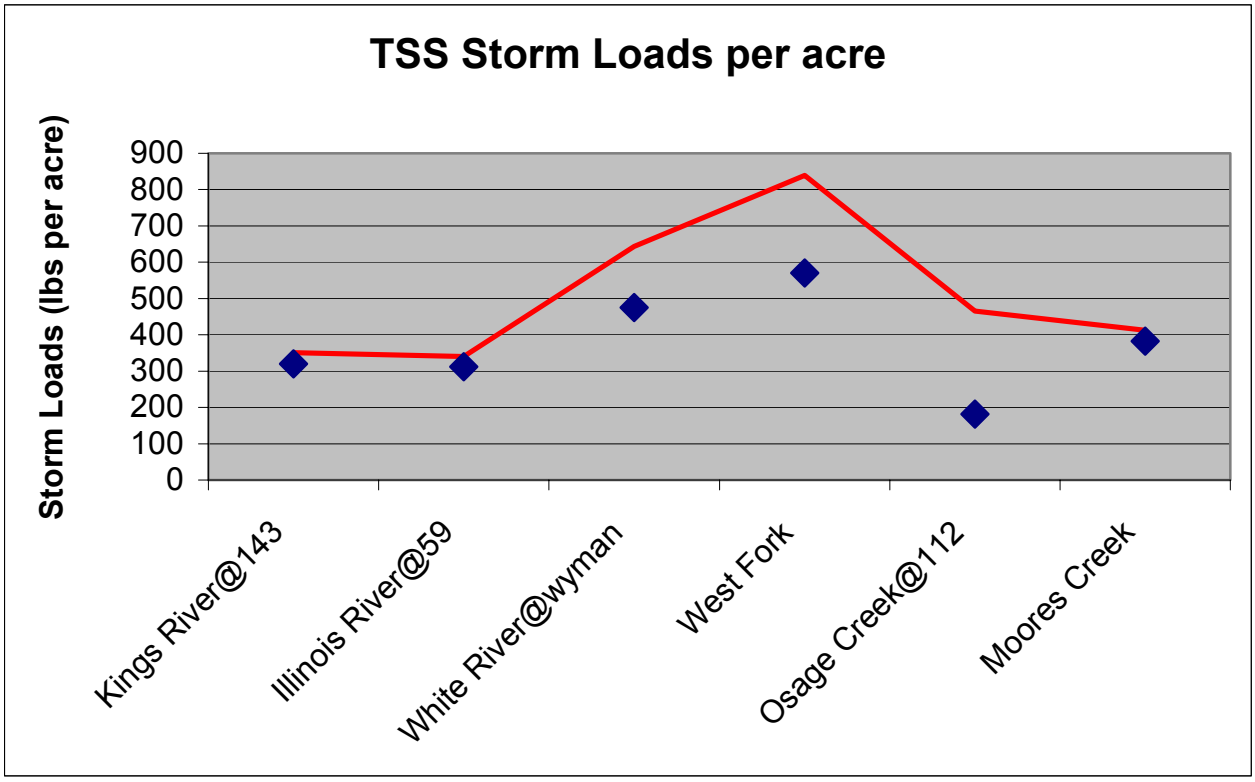
The results for the six watersheds are summarized in Table 5 and Figure 5. The table and figure show TSS and phosphorus as total annual loads per watershed acre, as storm loads per watershed acre and as base-flow concentrations. Normalizing total and storm loads to a per acre basis allows comparison between watersheds of differing sizes. The total loads indicate the mass of TSS or P that are being transported to a receiving water body. Storm loads per acre may be used to represent relative impacts from non-point sources. In Figure 8, a red line represents the total loads and blue diamonds represents the storm loads. The Kings River watershed has relatively low total TSS compared to the others and most of the TSS is transported during storm events. The P load for the Kings is significantly lower than the other watersheds with the primary difference during storm events.

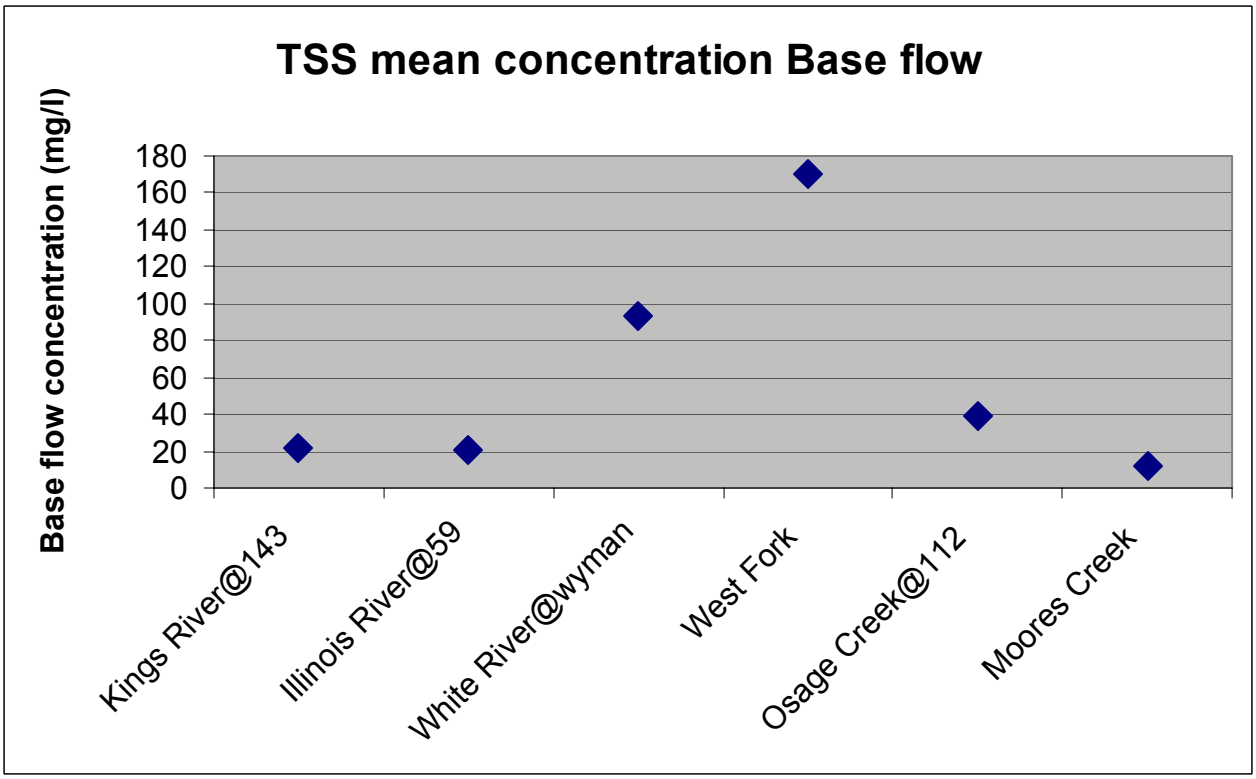
The base-flow concentrations show relative levels of TSS and P that are impacting in-stream biological activity during most of the year. These are the values that are of greatest interest for determining impacts to in-stream macro invertebrate habitat and nuisance algae production. The base-flow concentration of T-P is consistent with the other watersheds that have point-source discharges by WWTPs (all except Moores Creek).

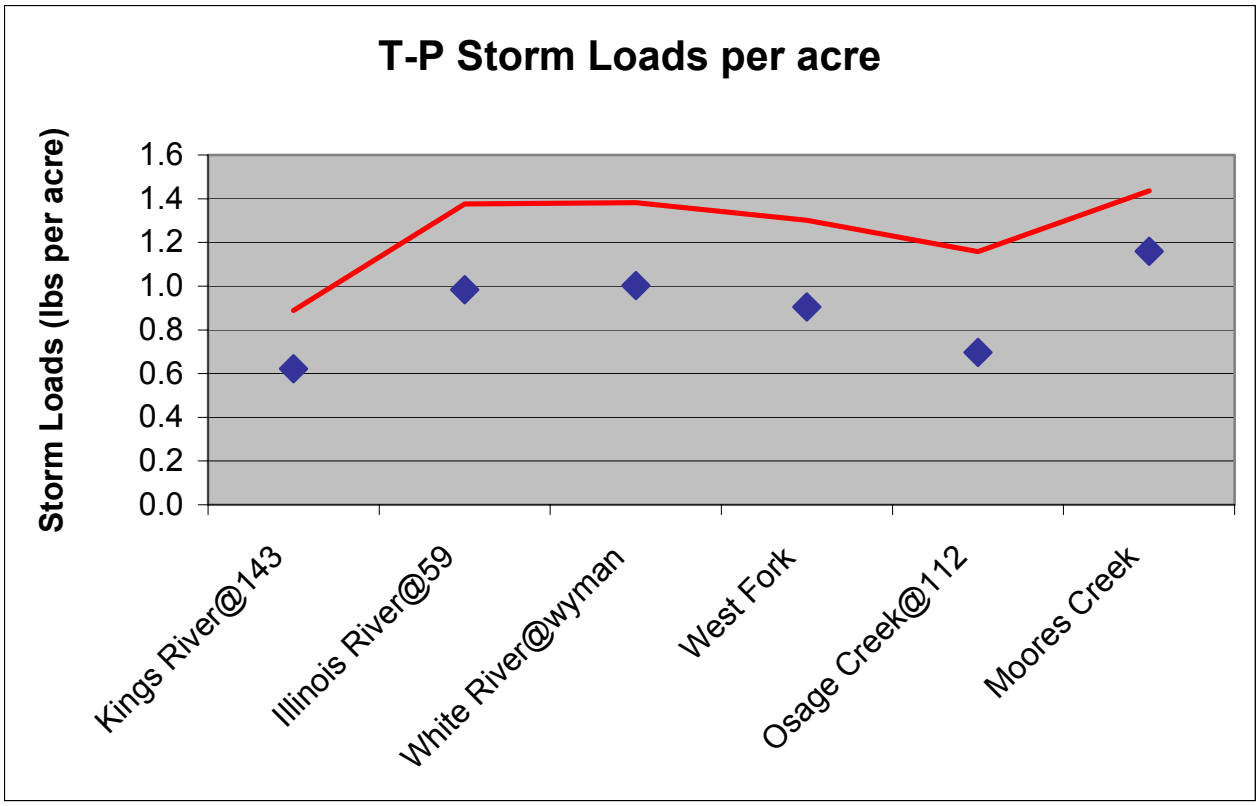
Table 5. Comparison of six watersheds

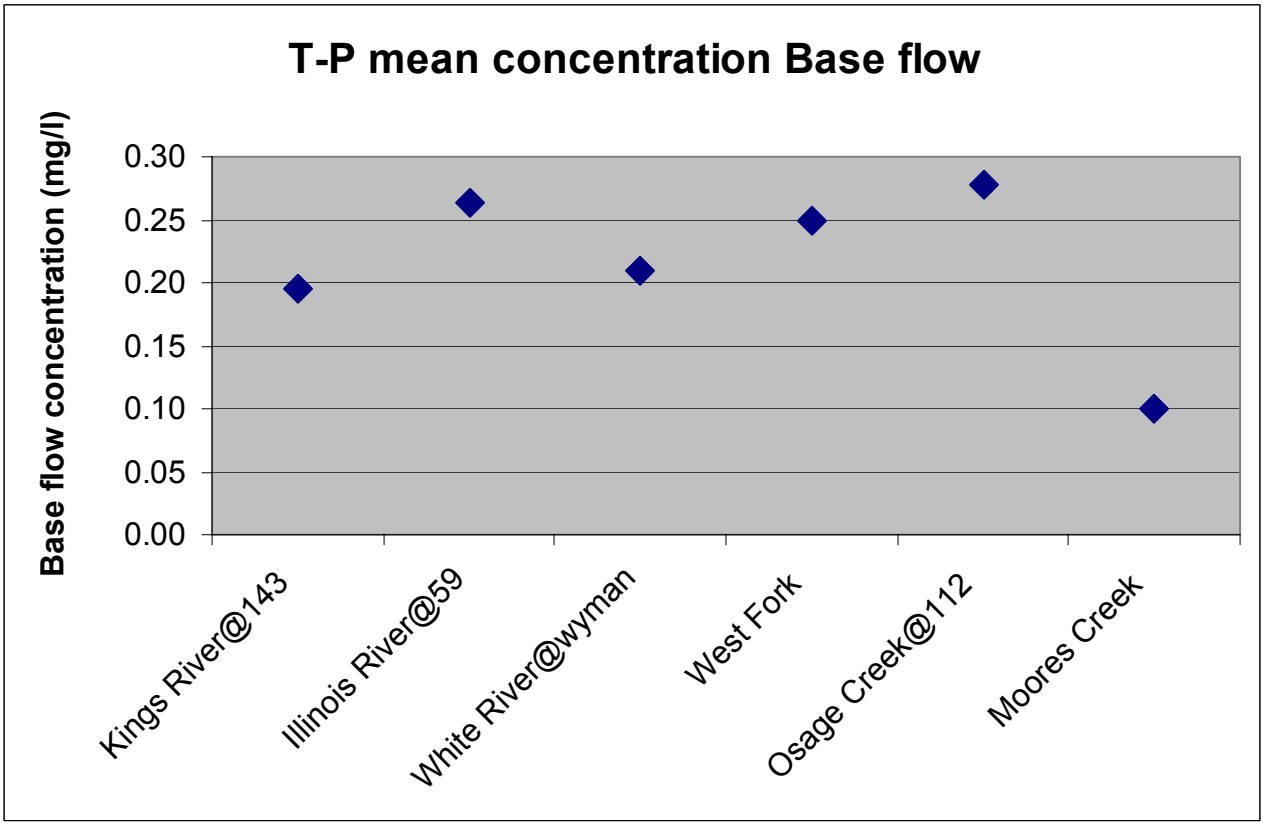
	Kings River@143	Illinois River@59	White River@wyman	West Fork	Osage Creek@112	Moores Creek
ACRES	337,280	368,000	256,000	65,920	22,208	2,200
YEARS of data	4	6	1	1	1	2
TSS load (#/acre)	351	340	644	839	466	413
TSS load storm (#/acre)	320	312	475	570	182	382
TSS conc. base (mg/l)	27	20	93	170	39	12
P load (#/acre)	0.89	1.38	1.38	1.30	1.16	1.44
P storm load (#/acre)	0.62	0.98	1.00	0.91	0.70	1.16
P base conc. (mg/l)	0.24	0.26	0.21	0.25	0.28	0.10
DISCHARGE (ft3)	1.5E+10	1.9E+10	1.5E+10	3.5E+09	1.2E+09	8.6E+07
DISCHARGE/AC (ft3/acre)	44,161	52,625	57,847	53,419	55,475	38,987

Figure 5. Comparisons between 6 watersheds.






T-P Storm Loads per acre
Storm Loads (lbs per acre)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Kings River@143
Illinois River@59
White River@wyman
West Fork
Osage Creek@112
Moores Creek


T-P mean concentration Base flow
Base flow concentration (mg/l)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Kings River@143
Illinois River@59
White River@wyman
West Fork
Osage Creek@112
Moores Creek

REFERENCES

Nelson, M.A., T.S. Soerens, J. Spooner "Results of Investigation of Optimum Sample Interval for Determining Storm Water Pollutant Loads", Proceedings of the Water Environment Federation WEFTEK Conference, New Orleans, LA, 1999.

Nelson, M.A., T.S. Soerens "1997 Pollutant Loads At. Arkansas Highway 59 Bridge" Presented at Arkansas-Oklahoma Arkansas River Compact Commission Meeting, September 1998.

Nelson, M.A., T.S. Soerens "1998 Pollutant Loads At. Arkansas Highway 59 Bridge" Arkansas Water resources Center Publication, 1999.

Nelson, M.A., T.S. Soerens "1999 Pollutant Loads At. Arkansas Highway 59 Bridge" Arkansas Water resources Center Publication, 2000.

Nelson, M.A., T.S. Soerens "2000 Pollutant Loads At. Arkansas Highway 59 Bridge" Arkansas Water resources Center Publication, 2001.

Nelson, M.A., T.S. Soerens "2001 Pollutant Loads At. Arkansas Highway 59 Bridge" Arkansas Water resources Center Publication, 2002.

Nelson, M.A., T.S. Soerens, J. Spooner " Preliminary Results of Investigation of Optimum Sample Interval for Determining Storm Water Pollutant Loads", Presented at ASCE Watershed Management Conference, Memphis, TN, 1998.

Nelson, M.A., T.S. Soerens and D.G. Parker "Phosphorus Transport in the Illinois River: Preliminary Results of Intensive Sampling" Proceedings of the Arkansas Water Resource Center Annual Conference, 1998.

Parker, D.G., R. Williams and E. Teague "Illinois River Water Quality Automatic Sampler Installation" Arkansas Water Resource Center Miscellaneous Publication 0227, 1997.

Nelson, M.A., T.S. Soerens, J. Spooner "Investigation of Optimum Sample Number and Timing for Determining Storm Water Pollutant Loads Year [1998 and 1999}", Arkansas Water Resources Center Annual Report 1999-2000, August 2001.

Nelson, M.A., L.W. Cash "Water Quality Sampling, Analysis And Annual Load Determinations For TSS, Nitrogen And Phosphorus At The Wyman Road Bridge On The White River, Final Report" Arkansas Water Resources Center Publication, 2003.

Nelson, M.A., L.W. Cash "Water Quality Sampling, Analysis And Annual Load Determinations For TSS, Nitrogen And Phosphorus At The Washington County Road 195 Bridge On The West Fork Of The White River, 2002 Annual Report" Arkansas Water Resources Center Publication, 2003.

Nelson, M.A., L.W. Cash "Water Quality Sampling, Analysis And Annual Load Determinations For TSS, Nitrogen And Phosphorus At The 143 Bridge On The Kings River, 2002 Annual Report" Arkansas Water Resources Center Publication, 2003.

Nelson, M.A., S. L. Diffin "Water Quality Sampling, Analysis And Annual Load Determinations For TSS, Nitrogen And Phosphorus At The 112 Bridge On The Osage Creek, Final Report" Arkansas Water Resources Center Publication, 2003.

Nelson, M.A., L.W. Cash "Water Quality Sampling, Analysis And Annual Load Determinations For TSS, Nitrogen And Phosphorus On Moores Creek, 2002 Annual Report" Arkansas Water Resources Center Publication, 2003.