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2005 Nutrient and Sediment Monitoring Report Kings River Near Berryville, Arkansas

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2005 NUTRIENT AND SEDIMENT MONITORING REPORT KINGS RIVER NEAR BERRYVILLE, ARKANSAS

Submitted to the
Arkansas Natural Resources Commission

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SUMMARY

. Kings River near Berryville 2005 Loads and Mean Concentrations

Parameter	Total Load (kg/yr)	Mean concentration (mg/L)
Discharge	279,456,255 (m^3/yr)	8.9 (m^3/s)
SO^4	1,660,837	5.94
Cl-	1,278,605	4.58
$N0_3$-N	216,851	0.78
TP	51,244	0.18
NH_4^+-N	6,819	0.02
TN	290,911	1.04
PO_4^{2-}-P	9,790	0.04
TSS	32,090,774	114.83

Kings River near Berryville 2005 Storm and base-flow Loads and Mean Concentrations

Parameter	Storm Load (kg/yr)	Base Load (kg/yr)	Storm Mean concentration (mg/L)	Base Mean concentration (mg/L)
Discharge (m^3/yr)	99,044,847	180,411,408		
SO^4	434,128	1,226,709	4.38	6.80
Cl-	380,224	898,381	3.84	4.98
$N0_3$-N	111,452	105,399	1.13	0.58
TP	42,365	8,879	0.43	0.05
NH_4^+-N	2,701	4,118	0.03	0.02
TN	157,567	133,344	1.59	0.74
PO_4^{2-}-P	4,775	5,016	0.05	0.03
TSS	31,120,504	970,270	314.21	5.38

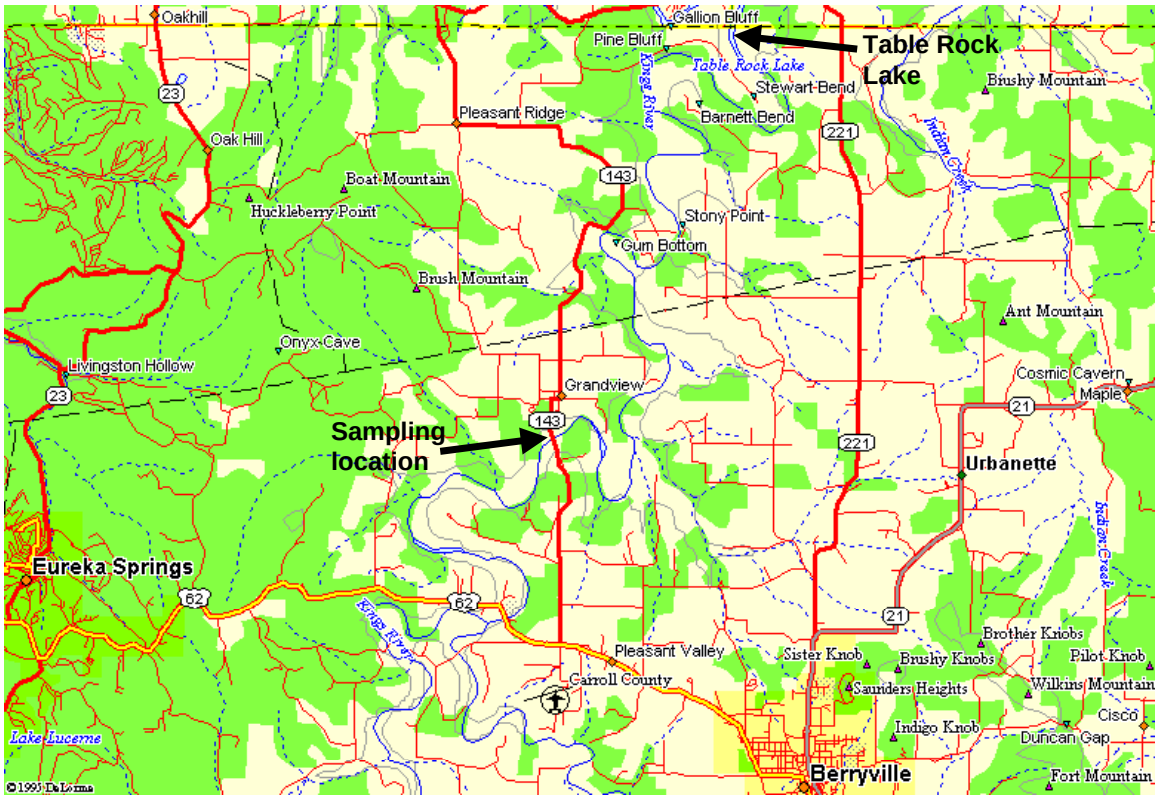
INTRODUCTION

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, 2005 to December 31, 2005.

BACKGROUND

In 1999, water quality sampling was begun at a new site established on the Kings River in the White River sub-basin. The Kings River flows into Table Rock Lake at the Missouri border and the sub-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

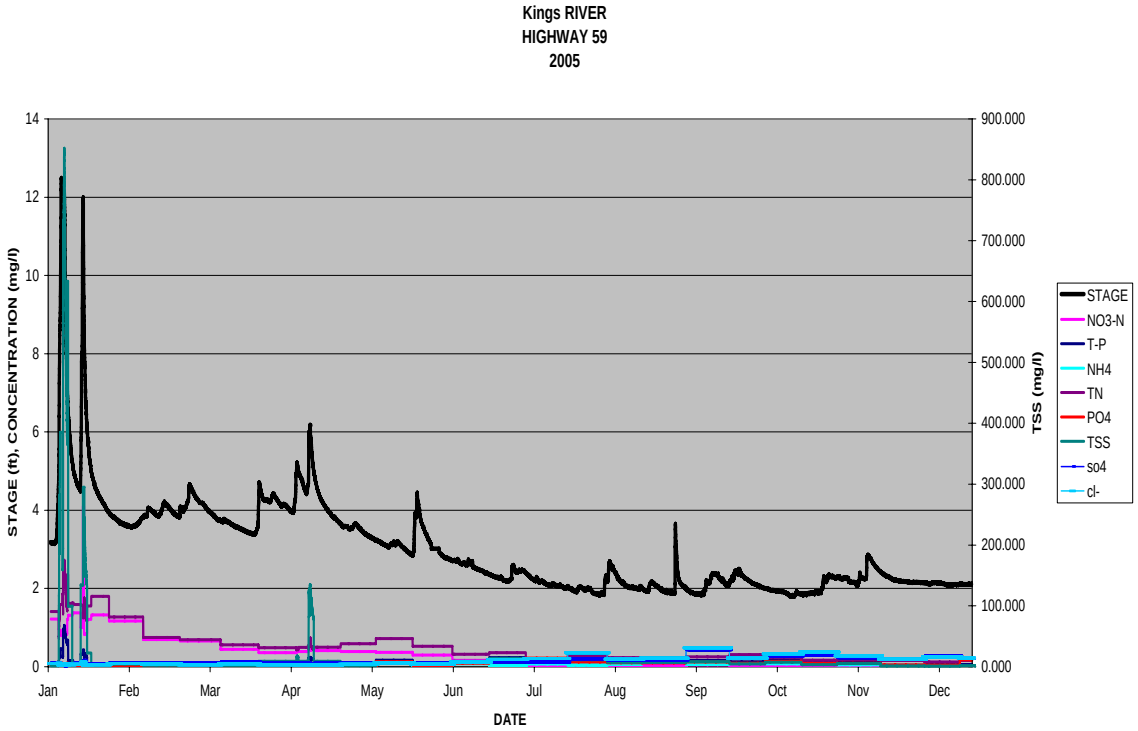
The sampler was configured to take flow-weighted composite samples. The sampler was set to begin sampling when the stage rose above a set trigger level of five feet. It took a discrete sample after a fixed volume of water (8,000,000 cubic feet) passed. The discrete samples were composited by combining 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. In a couple of cases, the sampler was not triggered correctly due to USGS DCP malfunction. In these cases, a grab sample was collected and concentrations for those time periods were estimated using the stage/ concentration relationships developed earlier in the project.

In addition, 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 Nitrogen (TN), 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 30minute 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 26 grab samples and 12 storm samples were collected, analyzed and used for load determination at this site in calendar year 2005. In addition, 4 field blanks, 4 field duplicates and 4 field replicate samples were collected, analyzed and used for QA/QC. The stage and determined concentrations are illustrated in figure 2 and tables 1 and 2.

Figure 2. 2005 Stage and Concentrations.



RESULTS

The 2005 calculated loads and flow-weighted mean concentrations are shown in Tables 1 and 2.

Table 1. Kings River near Berryville 2005 Loads and Mean Concentrations

Parameter	Total Load (kg/yr)	Mean concentration (mg/L)
Discharge	279,456,255 (m^3/yr)	8.9 (m^3/s)
SO^4	1,660,837	5.94
Cl-	1,278,605	4.58
$N0_3$-N	216,851	0.78
TP	51,244	0.18
NH_4^+-N	6,819	0.02
TN	290,911	1.04
PO_4^{2-}-P	9,790	0.04
TSS	32,090,774	114.83

Table 2. Kings River near Berryville 2005 Storm and base-flow Loads and Mean Concentrations

Parameter	Storm Load (kg/yr)	Base Load (kg/yr)	Storm Mean concentration (mg/L)	Base Mean concentration (mg/L)
Discharge (m^3/yr)	99,044,847	180,411,408		
SO^4	434,128	1,226,709	4.38	6.80
Cl-	380,224	898,381	3.84	4.98
$N0_3$-N	111,452	105,399	1.13	0.58
TP	42,365	8,879	0.43	0.05
NH_4^+-N	2,701	4,118	0.03	0.02
TN	157,567	133,344	1.59	0.74
PO_4^{2-}-P	4,775	5,016	0.05	0.03
TSS	31,120,504	970,270	314.21	5.38

Table 3. Past Loads for all parameters

Parameter	**1999** Loads	**2000** Loads	**2001** Loads	**2002** Loads	**2003** Loads	**2004** Loads
Discharge (m^3)	477,590,619	285,535,630	332,293,424	582,849,012	213,724,326	535,880,146
N03-N (kg/yr)	401,729	250,132	479,272	432,143	154,168	336,492
TP (kg/yr)	153,786	102,332	108,473	180,203	40,230	132,436
NH_4^+-N (kg/yr)	12,997	10,968	17,316	20,936	3,927	14,537
TKN (kg/yr)	348,376	210,601	226,891	401,495	106,926	373,566
PO_4 P (kg/yr)	47,914	47,106	34,984	44,767	13,383	25,171
TSS (kg/yr)	79,598,491	35,645,367	36,818,561	63,146,716	13,840,392	65,666,970
SO_4 (kg/yr)	1,804,599	1,737,722	2,100,924	4,960,436	1,307,889	3,167,502
Cl^- (kg/yr)	2,608,416	1,464,226	1,791,831	2,383,729	1,025,241	3,196,705

Table 4 Past Flow-weighted Mean concentrations.

Parameter	**1999** mean concen-trations	**2000** mean concen-trations	**2001** mean concen-trations	**2002** mean concen-trations	**2003** mean concen-trations	**2004** mean concen-trations
Average Discharge (M^3/s)	15	9	10	18	7	17
N03-N (mg/l)	0.84	0.88	1.44	0.74	0.72	0.63
TP (mg/l)	0.32	0.36	0.33	0.31	0.19	0.25
NH_4^+-N (mg/l)	0.03	0.04	0.05	0.04	0.02	0.03
TKN (mg/l)	0.73	0.74	0.68	0.69	0.50	0.70
PO_4 P (mg/l)	0.10	0.16	0.11	0.08	0.06	0.05
TSS (mg/l)	167	125	111	108	64.76	123
SO_4 (mg/l)	3.78	6.09	6.32	8.51	6.12	5.91
Cl^- (mg/l)	5.46	5.13	5.39	4.09	4.80	5.97

During the year, there were portions of 5 storm events that were not sampled due to equipment malfunctions. The concentrations during this period 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 5.

Table 5. 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 = -0.2865x + 4.9888	R^2 = 0.4551
Cl-	y = - 0.1864x + 6.8752	R^2 = 0.3082

DISCUSSION

Phosphorus concentrations during base-flow have decreased significantly in the watershed since monitoring began. The base-flow concentration has decreased consistently from a high of 0.29 mg/l in 2000 to the 2005 value of 0.05 mg/l as shown in figure 3. This improvement may be the result of reduced phosphorus discharge by the Berryville WWTP. Verbal communications with the WWTP manager confirm a significant reduction in P discharge, which was attributed to reductions by a Tyson poultry processing plant. Communications with Tysons confirms reduced P discharges due to elimination of “killing” operations at the plant. Storm loads closely track the total annual discharge and don’t exhibit any significant trends as shown in figure 4. Annual discharge and storm loads were lower than average in 2005

Figure 3 Base-flow concentration trends.

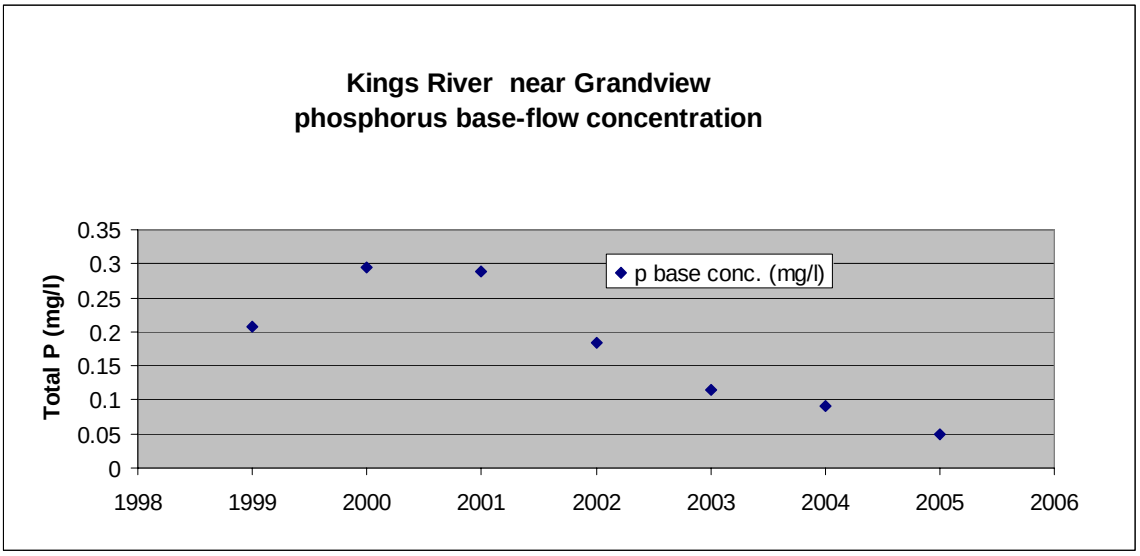
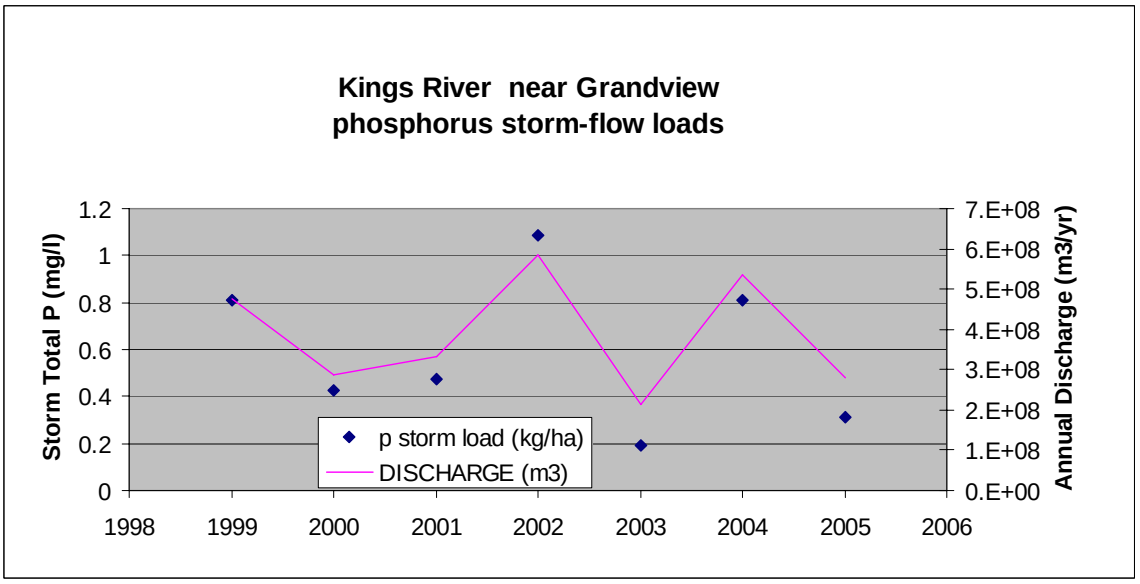


Figure 4 Storm-flow load trends



The loads and concentrations developed for the Kings River can be compared to loads and concentrations developed in other watersheds in Northwest Arkansas for 2005. Four 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.

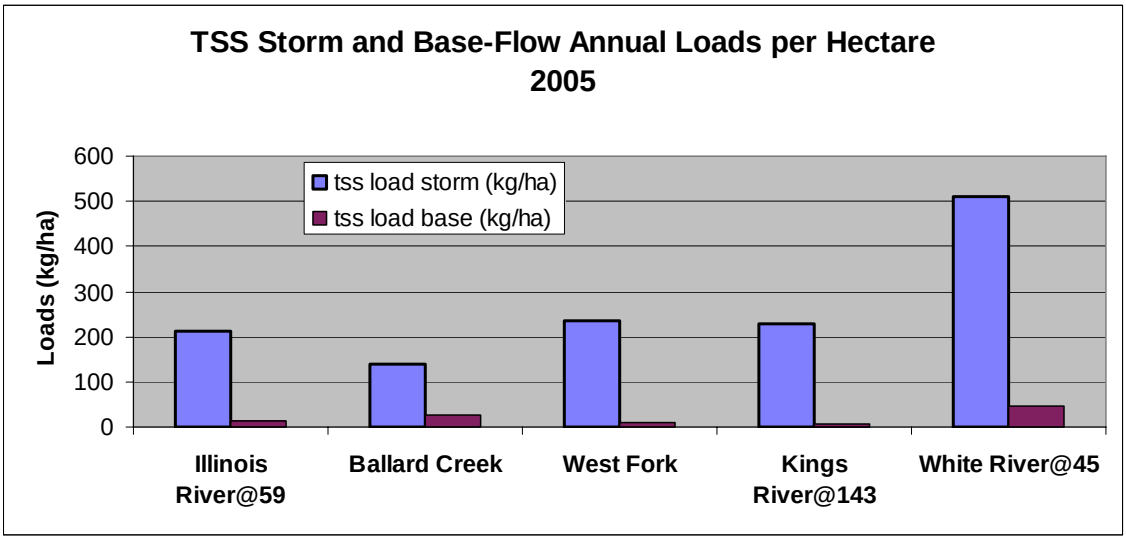
The results for the five watersheds are summarized in Table 6 and Figure 5. The table and figure show TSS, total phosphorus and total nitrogen as total annual storm-flow loads per watershed hectare, as base-flow loads per watershed hectare and as base-flow concentrations. Normalizing storm and base-flow loads to a per hectare 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 hectare may be used to represent relative impacts from non-point sources. The Kings River watershed had average TSS loads compared to the others and most of the TSS was transported during storm events. The P load for the Kings was significantly lower than the other watersheds with the primary transport occurring during storm events. Total nitrogen loads per hectare were similar to other White River sub-basin watersheds, which are lower than the Illinois River sub-basin watersheds.

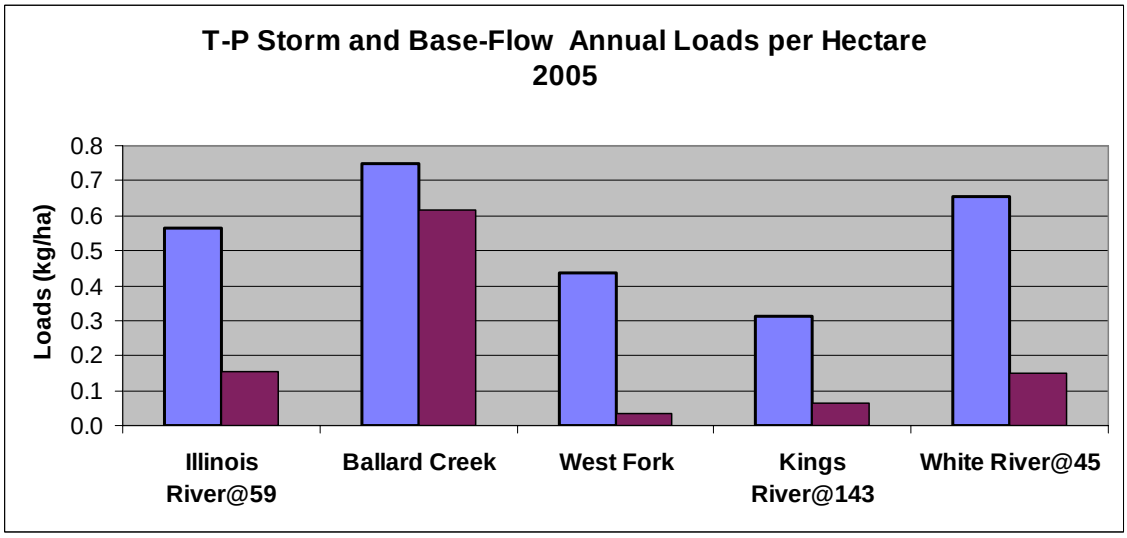
The base-flow concentrations show relative levels of TSS, T-P and TN that are impacting in-stream biological activity during most of the year. These are the values that are of greatest interest for determining impacts to in-stream biological habitat and nuisance algae production. The base-flow concentration of TSS was in the mid range of the other watersheds (except the White). The T-P concentration was low and as mentioned earlier, falling. The nitrate concentration was very low considering there is a point source discharge into the river.

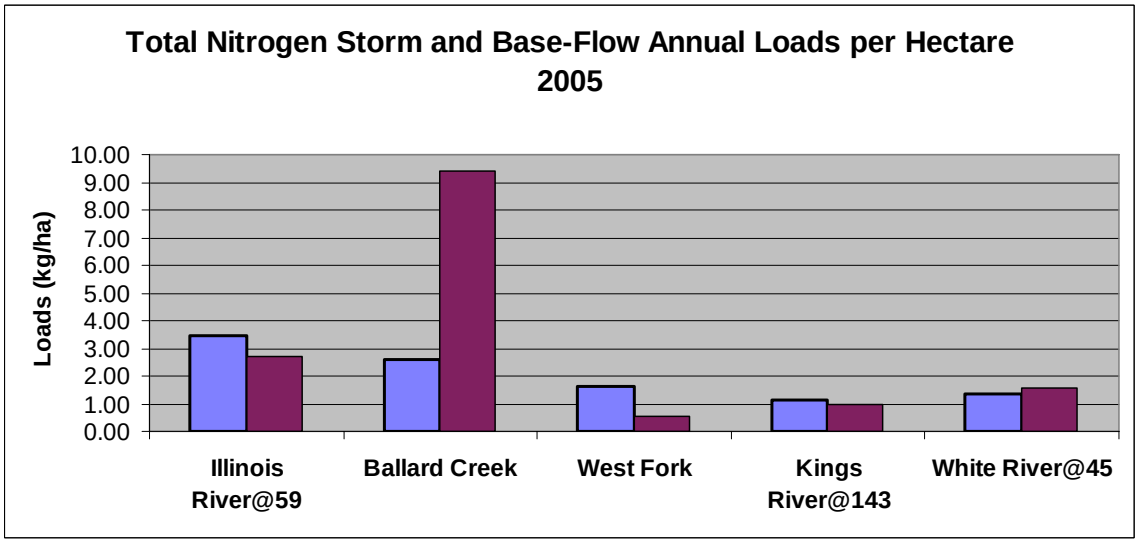
Table 6 Comparison of five northwest Arkansas watersheds 2005 data

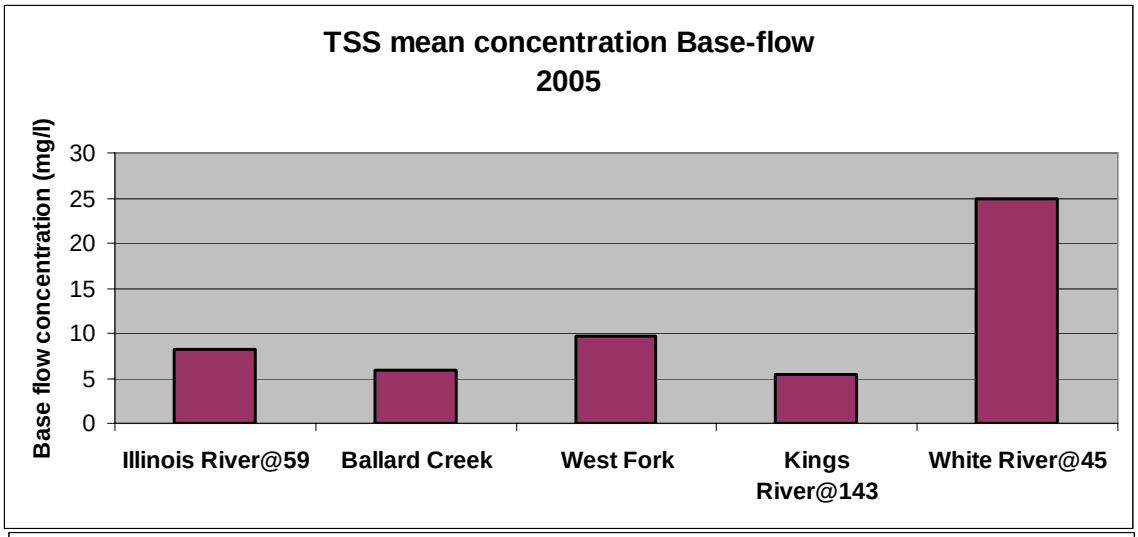
2005	Illinois River@59	Ballard Creek	West Fork	Kings River@143	White River@45
Hectares	148,930	7,106	30,563	136,497	106,711
YEARS of data	2005	2,005	2,005	2,005	2005
tss load (kg/ha)	225	165	245	235	559
tss load storm (kg/ha)	212	140	235	228	511
tss load base (kg/ha)	13	25	11	7	47
tss conc. base (mg/l)	8	6	10	5	25
p load (kg/ha)	0.72	1.36	0.47	0.38	0.80
p storm load (kg/ha)	0.56	0.75	0.44	0.31	0.65
p load base (kg/ha)	0.15	0.62	0.03	0.07	0.15
p base conc. (mg/l)	0.10	0.14	0.03	0.05	0.08
Total Nitrogen load (kg/ha)	7.86	12.00	2.12	2.13	6.80
Total Nitrogen storm load(kg/ha)	3.48	2.60	1.60	1.15	1.33
Total Nitrogen base load (kg/ha)	2.69	9.40	0.52	0.98	1.54
NO3-N base conc. (mg/l)	2.57	1.85	0.36	0.20	0.56
DISCHARGE ($m^{3/}$yr)	390,894,159	37,191,537	84,315,555	279,456,255	340,264,093
DISCHARGE/AC (m^3/ha/yr)	2,625	5,234	2,759	2,047	3,189

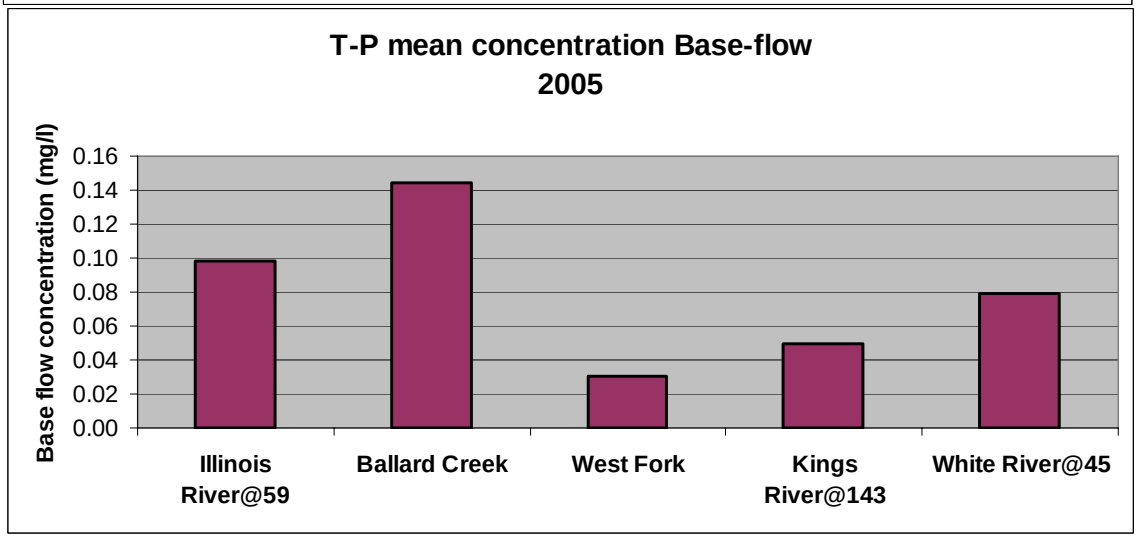
Figure 5 Comparison of five watersheds

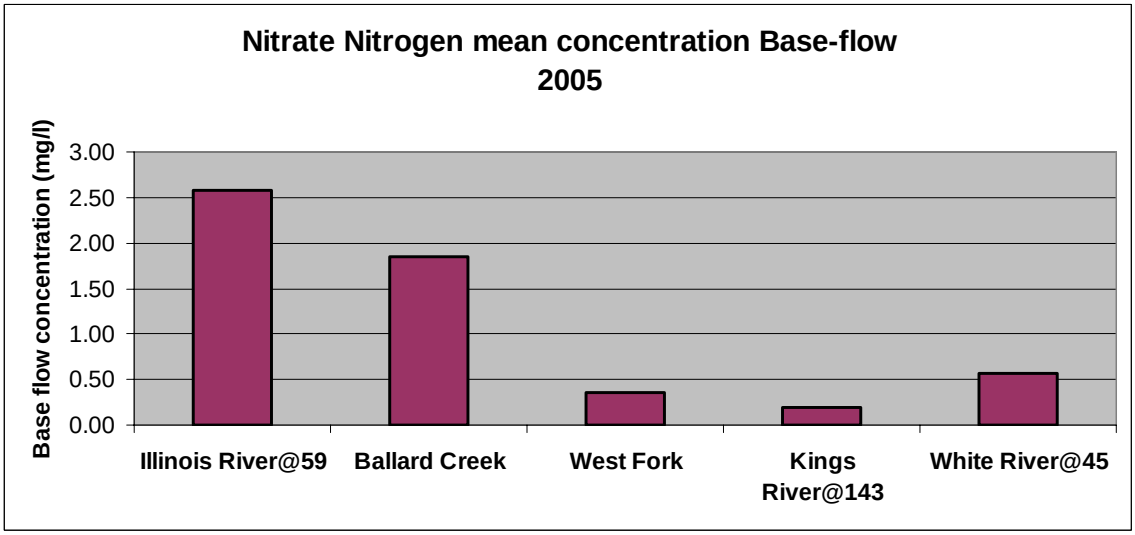







TSS mean concentration Base-flow
2005
Base flow concentration (mg/l)
30
25
20
15
10
5
0
Illinois River@59
Ballard Creek
West Fork
Kings River@143
White River@45


T-P mean concentration Base-flow
2005
Base flow concentration (mg/l)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Illinois River@59
Ballard Creek
West Fork
Kings River@143
White River@45


Nitrate Nitrogen mean concentration Base-flow
2005
Base flow concentration (mg/l)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Illinois River@59
Ballard Creek
West Fork
Kings River@143
White River@45

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Verbal communication with Derrel Back, Berryville WWTP Manager. April 2006.

Verbal communications with Christy Smith, Tysons Berryville Plant Environmental Manager and Jimmie Mardis, Tysons Corporate Environmental Manager. April 2006.