Arkansas Water Resources Center

2004 POLLUTANT LOADS
KINGS RIVER NEAR BERRYVILLE, ARKANSAS

Submitted to the
Arkansas Soil and Water Conservation Commission

By
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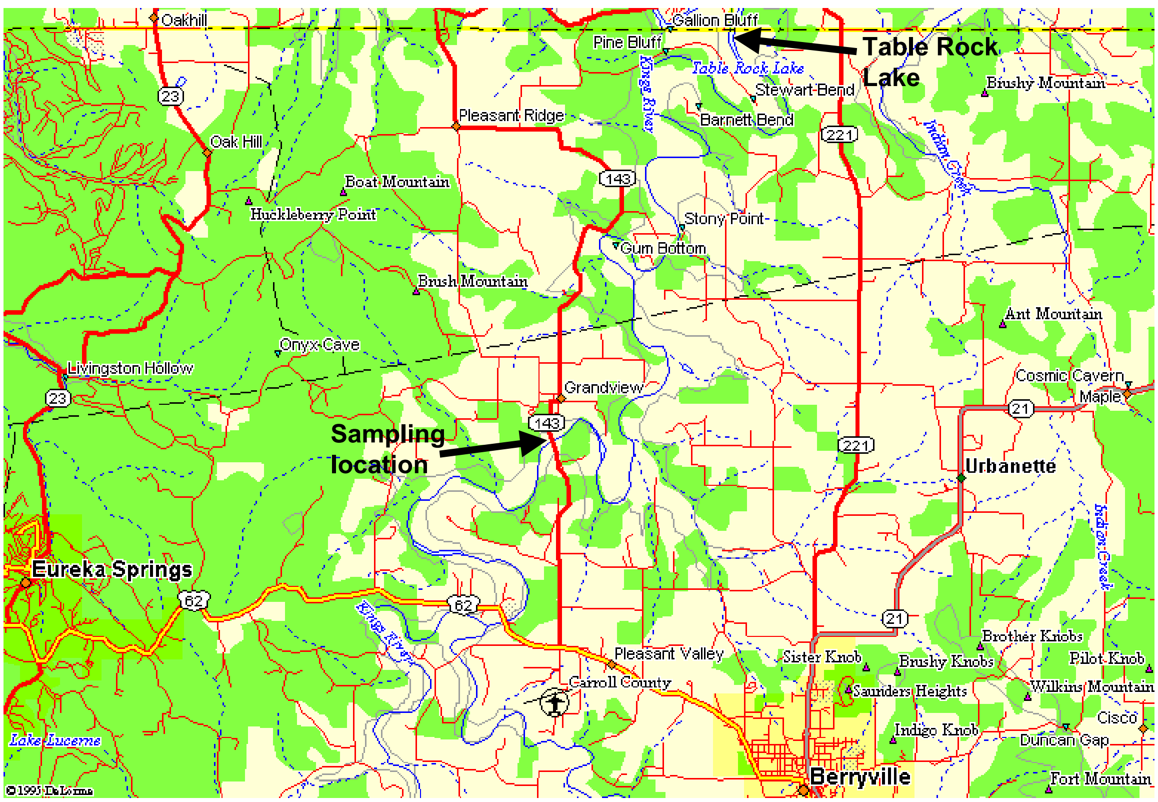
INTRODUCTION

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, 2004 to December 31, 2004.

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



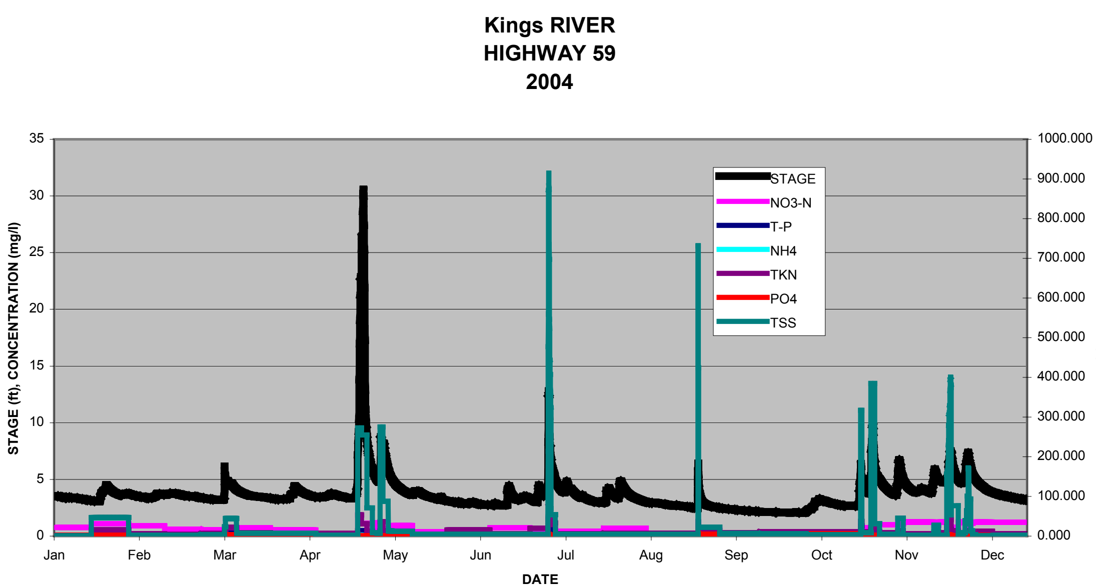
METHODS

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 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 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 26 grab samples and 7 storm composite samples were collected, analyzed and used for load determination at this site in calendar year 2004. In addition, 4 field blanks, 4 field duplicates and 3 USGS/AWRC paired samples were collected, analyzed and used for QA/QC. The stage and determined concentrations are illustrated in figure 2.

Figure 2. 2004 Stage and Concentrations.



RESULTS

The 2004 calculated loads and flow-weighted mean concentrations are shown in Table 1.

Table 1. Kings River near Berryville 2004 Loads and Mean Concentrations

Parameter	Total Load (kg/yr)	Mean concentration (mg/L)
Discharge (m^3/yr)	535,880,146	600 (cfs)
SO^4	3,167,502	5.91
Cl-	3,196,705	5.97
$N0_3$-N	336,492	0.63
TP	132,436	0.25
NH_4^+-N	14,537	0.03
TKN	373,566	0.70
PO_4^{2-}-P	25,171	0.05
TSS	65,666,970	123

Table 2. 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 3 Flow-weighted Mean concentrations.

Parameter	**1999** mean concentrations	**2000** mean concentrations	**2001** mean concentrations	**2002** mean concentrations	**2003** mean concentrations	**2004** mean concentrations
Discharge (cfs)	535	320	372	653	239	600
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 4 storm events that were not sampled due to equipment malfunctions. The concentrations during this period were estimated using the stage / concentration regression relationships for two storms and average values from grabs for the other two storms. 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

Phosphorus concentrations have decreased significantly in the watershed since monitoring began. The base-flow concentration has decreased consistently from a high of 0.29 mg/l to the 2004 value of 0.09 mg/l as shown in figure 4. This improvement may be the result of improved phosphorus removal by the Berryville WWTP. Storm loads closely track the total annual discharge and don't exhibit any significant trends as shown in figure 5.

Figure 4 Base-flow concentration trends.

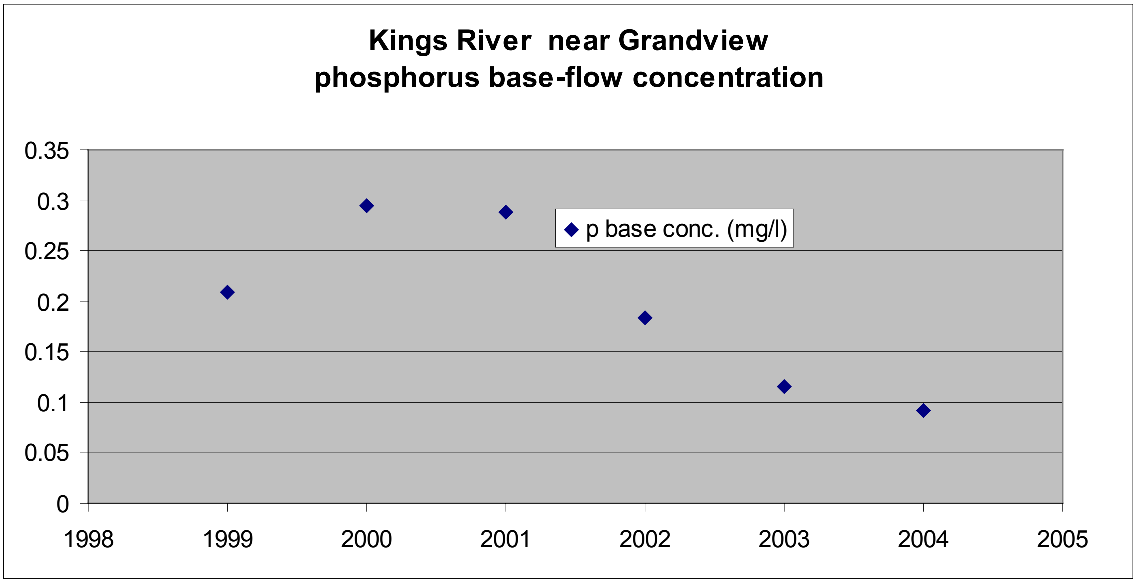
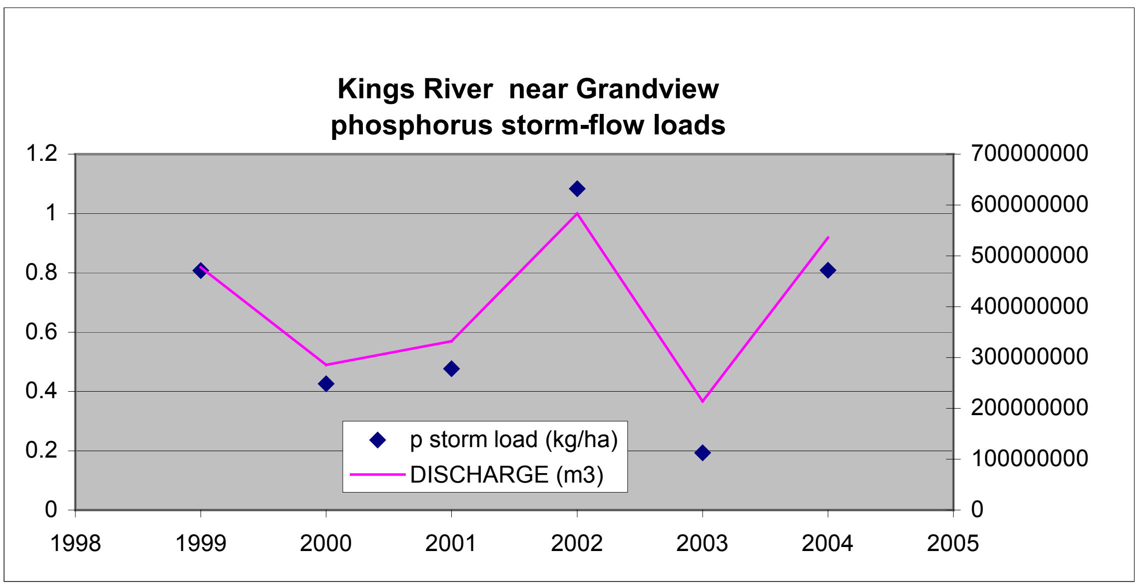


Figure 5 Storm-flow load trends



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

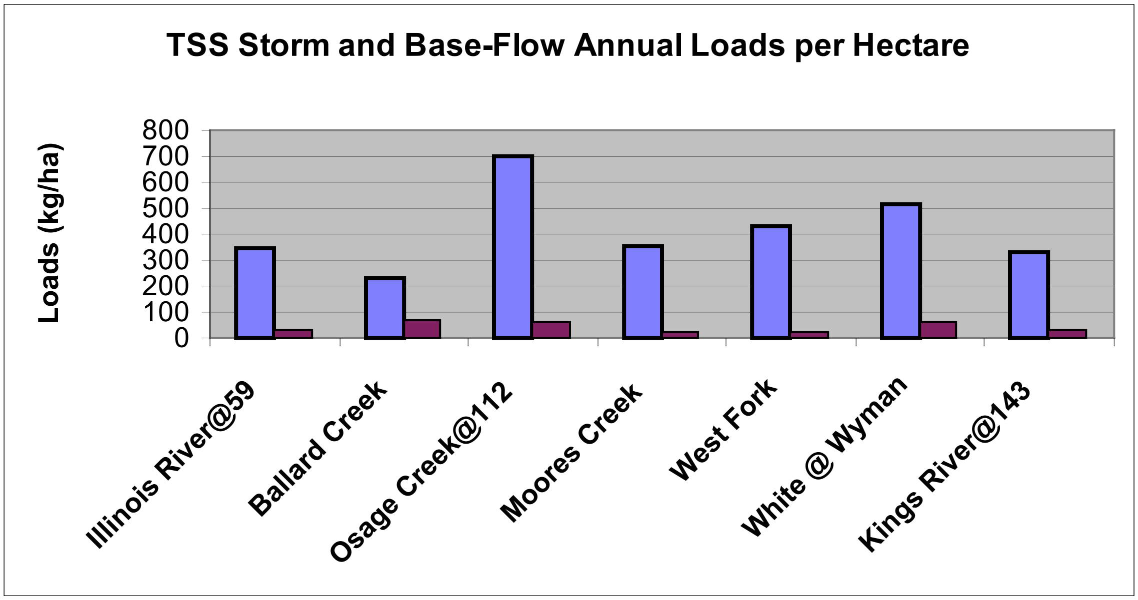
The results for the seven watersheds are summarized in Table 5 and Figure 6. The table and figure show TSS and phosphorus total annual storm-flow loads per watershed acre, as base-flow loads per watershed acre and as base-flow concentrations. Normalizing storm and base-flow loads to a per acre basis 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. The Kings River watershed has average TSS loads 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.

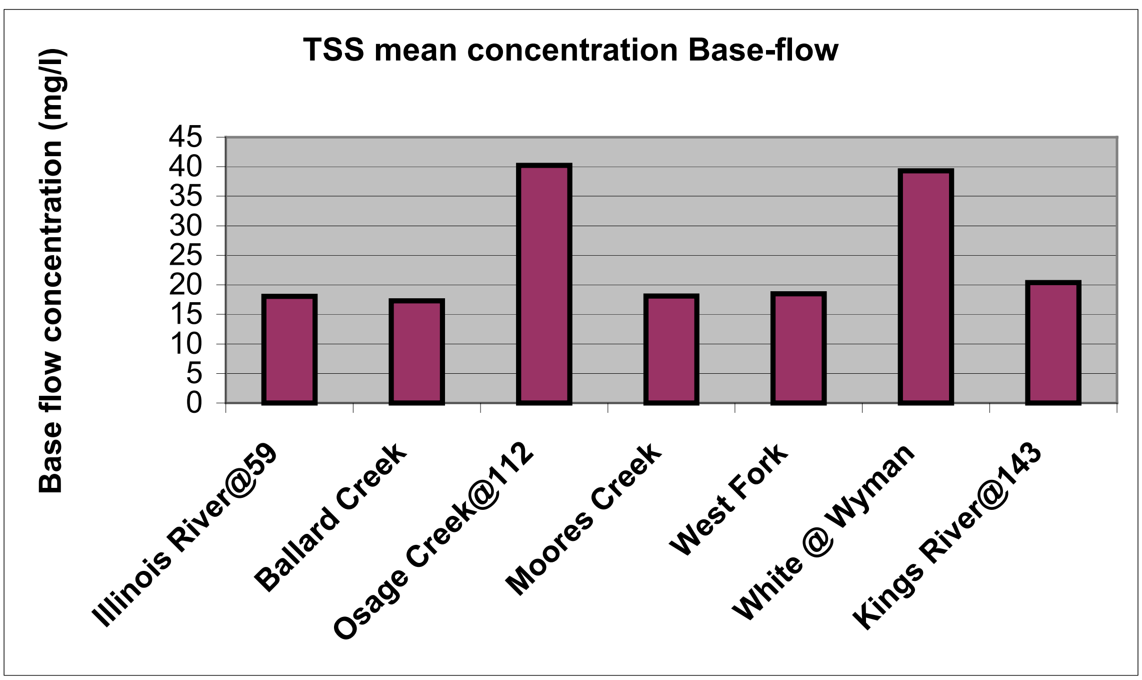
The base-flow concentrations show relative levels of TSS and P that are impacting in-stream biological activity during most of the year. These are the values that are of greatest interest for determining impacts to in-stream macro invertebrate habitat and nuisance algae production. The base-flow concentration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

Table 5 Comparison of seven northwest Arkansas watersheds

	Illinois River@ 59	Ballard Creek	Osage Creek@ 112	Moores Creek	West Fork	White @ Wyman	Kings River@ 143
Hectares	148,930	7,106	8,988	1,000	30,563	103,603	136,497
YEARS of data	8	2	3	4	3	2	6
tss load (kg/ha)	374	303	764	838	454	576	360
tss load storm (kg/ha)	345	232	702	781	433	514	333
tss load base (kg/ha)	29	72	62	57	22	62	27
tss conc. base (mg/l)	18	17	40	18	19	39	20
p load (kg/ha)	1.45	1.69	1.54	2.80	1.06	1.69	0.88
p storm load (kg/ha)	1.06	1.04	1.23	2.22	1.04	1.26	0.63
p load base (kg/ha)	0.39	0.66	0.30	0.58	0.02	0.44	0.24
p base conc. (mg/l)	0.23	0.16	0.19	0.17	0.02	0.24	0.20
Total Nitrogen load (kg/ha)	10.80	17.54	19.54	7.72	3.89	4.62	4.54
NO3-N base conc. (mg/l)	2.43	2.62	3.59	2.20	0.34	0.55	0.85
DISCHARGE (m^3/ha)	3,465	5,583	5,130	3,011	4,303	4,009	2,964

Figure 6 Comparison of seven watersheds





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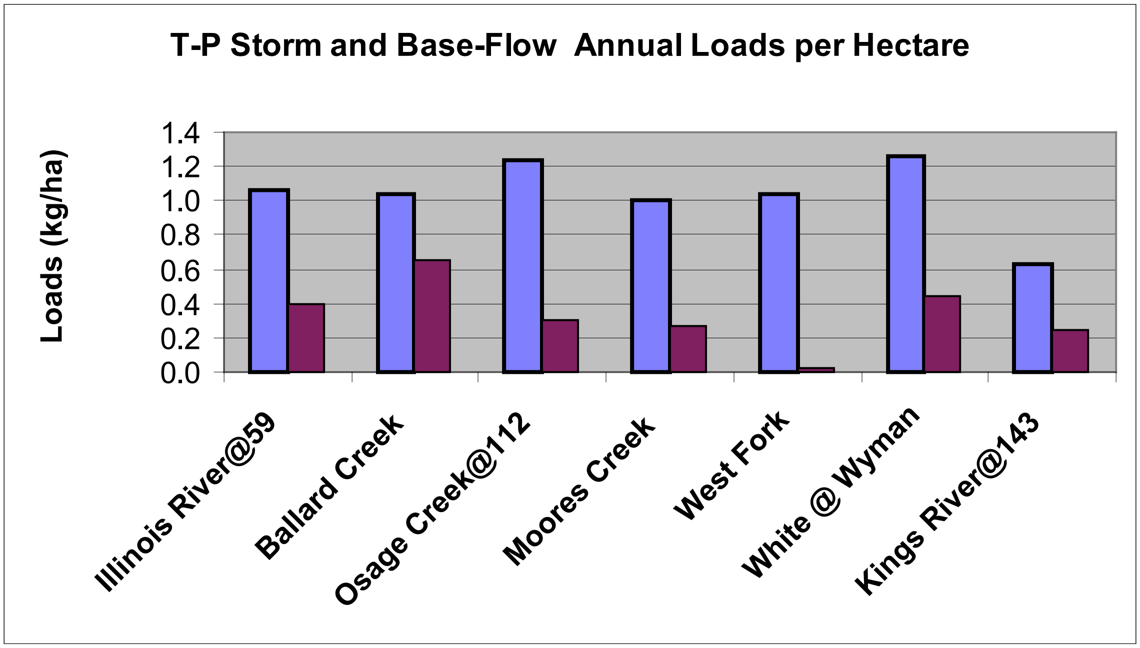

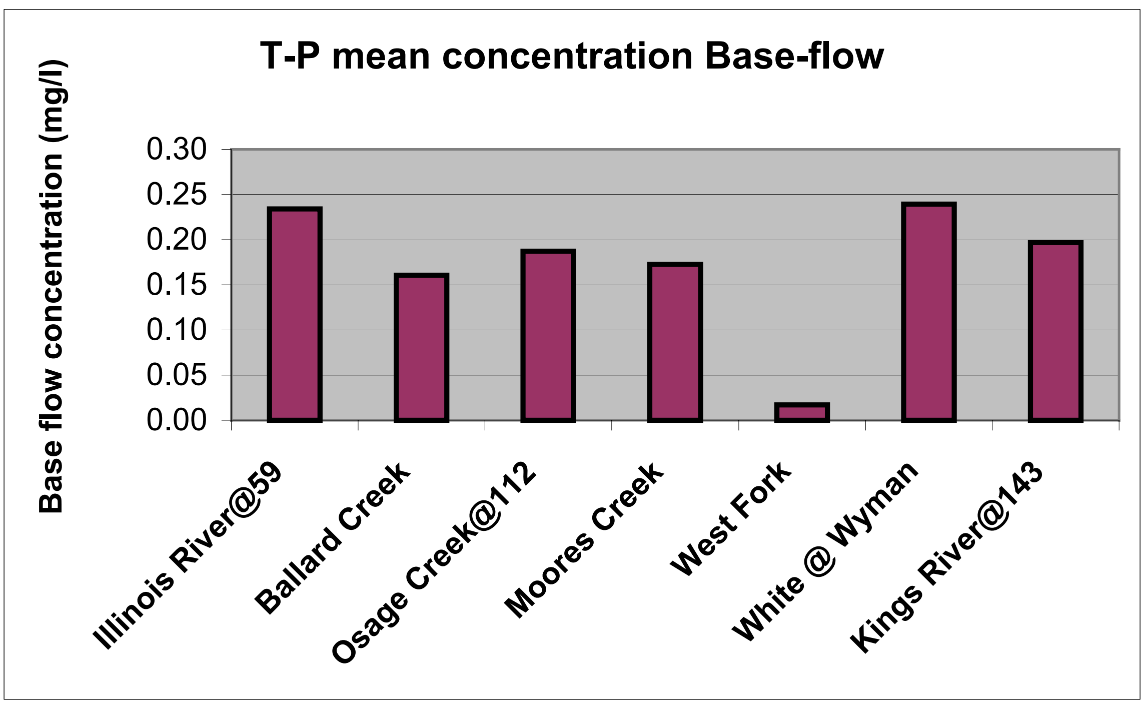

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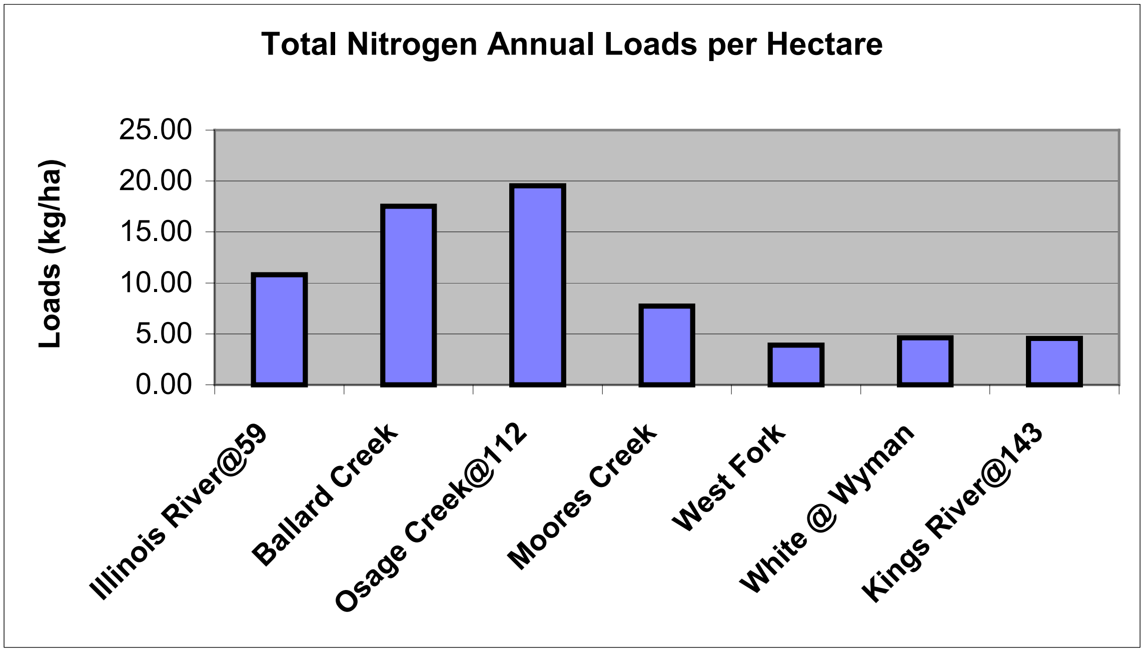

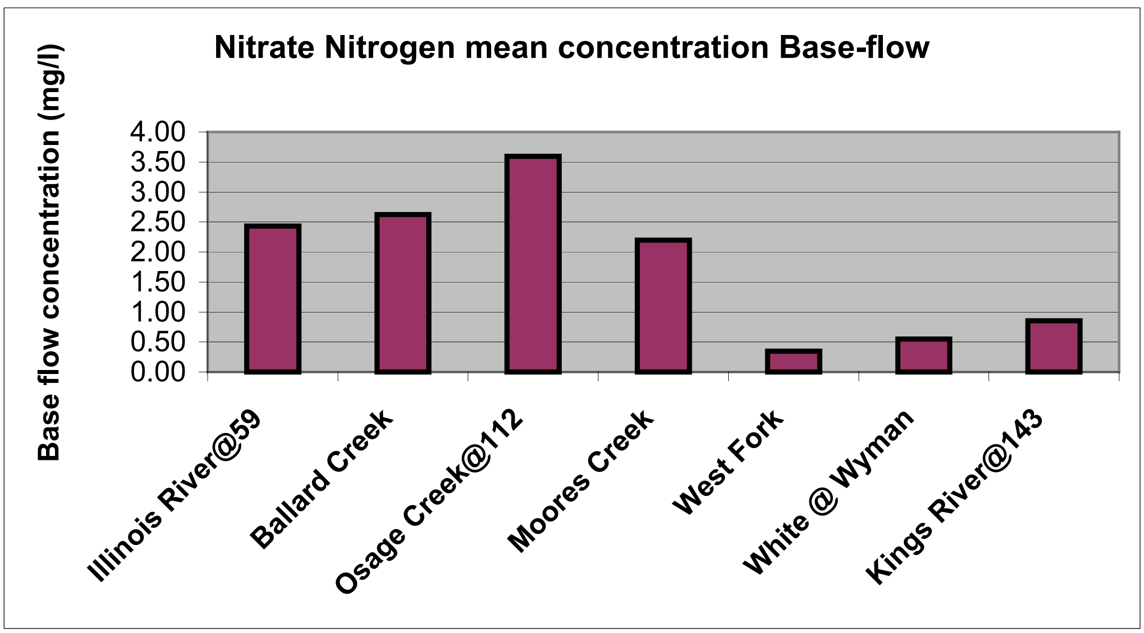

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