Arkansas Water Resources Center

WATER QUALITY SAMPLING, ANALYSIS AND ANNUAL LOAD DETERMINATIONS FOR NUTRIENTS AND SEDIMENT AT THE ARKANSAS HIGHWAY 45 BRIDGE ON THE WHITE RIVER JUST ABOVE BEAVER LAKE

Submitted to the
Arkansas Natural Resources Commission

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2005 ANNUAL REPORT

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SUMMARY

2005 loads and mean concentrations

	Mean concentrations (mg/l)	Annual Loads (kg)
Discharge (M3)	381.26	340,264,093
SO4+	12.01	4,084,897
Cl-	4.42	1,504,651
NO3-N	0.54	183,751
T-P	0.25	85,714
NH4	0.05	17,420
Total Nitrogen	0.90	306,791
PO4	0.01	3,368
TSS	175	59,619,604

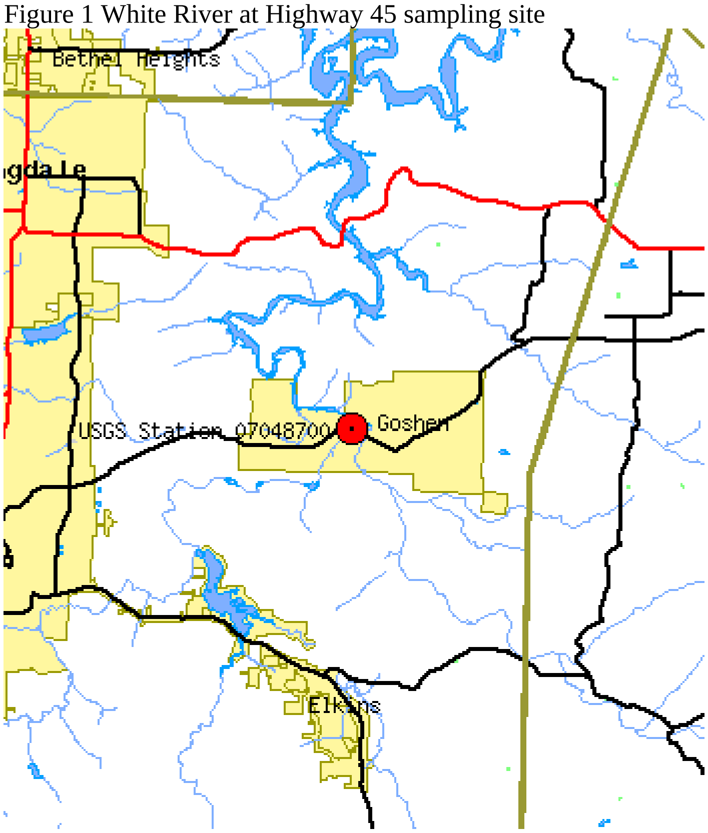
Storm flow loads, Base flow Loads and Mean Concentrations 2005.

	Storm Loads (kg)	Base Loads (kg)	Storm Concentrations (mg/l)	Base Concentrations (mg/l)
Discharge (M3)	137,150,337	203,113,756		
SO4+	1,117,852	2,967,046	8.15	14.61
Cl-	355,311	1,149,340	2.59	5.66
NO3-N	69,038	114,713	0.50	0.56
T-P	69,693	16,021	0.51	0.08
NH4	8,218	9,202	0.06	0.05
Total Nitrogen	142,130	164,661	1.04	0.81
PO4	2,110	1,259	0.02	0.01
TSS	54,559,431	5,060,173	398	25

INTRODUCTION

A water quality sampling station was installed at the Arkansas Highway 45 Bridge on the White River just above Beaver Lake in 2002. This station is coordinated with a USGS gauging station at the same location (see figure 1). This station is instrumented to collect samples at sufficient intervals across the hydrograph to accurately estimate the flux of total suspended solids, nitrogen and phosphorus into the upper end of Beaver Lake from the White River. The West Fork of the White River is listed on Arkansas' 1998 303d list as impaired from sediment. The Upper White was designated as the states highest priority watershed in the 1999 Unified Watershed Assessment. Accurate determination of stream nutrients and sediment is critical for future determinations of TMDLs, effectiveness of best management practices and trends in water quality.

Figure 1 White River at Highway 45 sampling site



SCOPE

This report is for water quality sampling, water sample analysis and annual pollutant load calculations at the Arkansas Highway 45 Bridge on the White River for calendar year 2005.

METHODS

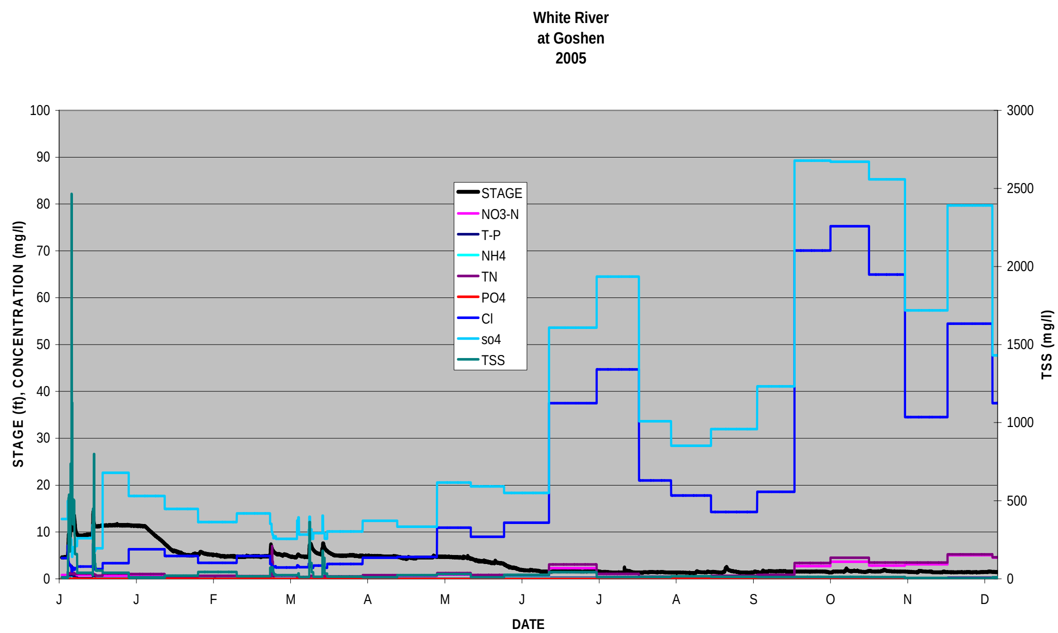
Initially the sampler was operated in a discrete mode taking samples at thirty-minute intervals for the first twenty-four samples and sixty-minute intervals for the next twenty-four samples of each storm event. The sampler was set to begin taking samples when the stage rose to ten percent over the prior base flow. Discrete samples were collected when all twenty-four bottles were filled or within forty-eight hours after the first sample. Grab samples were taken often enough to have a minimum of one sample between each storm event. The sampler was operated using this protocol until three storms were adequately sampled. The results from this initial sampling phase were used to determine the sampling start (trigger) and frequency for flow-weighted composite sampling. In addition, the results were used to develop rating curves to predict pollutant concentrations as a function of discharge in order to calculate loads for inadequately sampled storm events.

The trigger level for storm sampling has not been set for this site. The site is in the upper portion of Beaver Lake when lake elevations exceed approximately 1120 feet above MSL. That means a variable trigger level must be used. In addition, discharge rating curve development by the USGS has not been possible due to variable velocities and discharges at a given elevation. That has meant that flow-weighted composite sampling has not been possible at this site to date. Storm flows have been sampled at this site by manually triggering an automatic sampler to collect samples every 4 hours when the stage makes a significant rise. In addition, grab samples were collected every two weeks. All samples were collected by AWRC Personnel and transported to the AWRC Water quality Laboratory for analysis. All samples were analyzed for nitrate-nitrogen, ammonia-nitrogen, total nitrogen, total phosphorus, dissolved reactive phosphorus, sulfate, chloride and total suspended solids.

RESULTS

There were a total of 81 individual samples collected and analyzed for this project during the year. They include 26 grab samples, 44 discrete storm samples, 4 duplicate samples 3 bank replicate samples and 4 blank samples. The measured stage and concentrations are illustrated in figure 2.

Figure 2. 2005 Stage and measured concentrations



USGS stage and discharge data was not available for the time periods of 5/17 to 5/24 and 6/19 to 7/22. Discharge was estimated for these time periods by interpolation.

A small part of one small storm event was not sampled during the year. Concentrations for this time period was estimated by interpolation. If a larger portion had been missed, regression coefficients from discrete storm sampling would have been used. Table 1 lists the regression equations and R^2 value for each parameter.

Table 1. Regression equations determined from discrete storm samples 2004

parameter	Regression equation	Regression coefficient
Sulfate	y=-0.0059x + 10.392	R^2 = 0.1287
Chloride	y= -0.0026x + 3.8073	R^2 = 0.05
Nitrate-N	y = -0.0004x + 0.6507	R^2 = 0.0812
Total Phosphorus	y = 0.0011x + 0.2517	R^2 = 0.6308
Ammonia-N	y = -7E-05x + 0.0899	R^2 = 0.0438
TKN	y = 0.0015x + 0.6703	R^2 = 0.4325
Phosphate-P	y = 3E-06x + 0.026	R^2= 0.0036
TSS	y = 0.5304x + 140.54	R^2 = 0.4435

Total annual loads and flow-weighted mean concentrations were calculated for 2005 and listed in table 2. Flow-weighted mean concentrations were calculated by dividing the annual load by the annual discharge.

Table 2. 2005 loads and mean concentrations

	Mean concentrations (mg/l)	**Annual Loads (kg)**
Discharge (M3)	381.26	340,264,093
SO4+	12.01	4,084,897
Cl-	4.42	1,504,651
NO3-N	0.54	183,751
T-P	0.25	85,714
NH4	0.05	17,420
Total Nitrogen	0.90	306,791
PO4	0.01	3,368
TSS	175	59,619,604

The loads can be segregated into storm and base-flow loads by defining storm flows as anything above 50 m^3 /s at this site. The segregated loads and mean concentrations are listed in table 3.

Table 3. Storm flow loads, Base flow Loads and Mean Concentrations 2005.

	Storm Loads (kg)	Base Loads (kg)	Storm Concentrations (mg/l)	Base Concentrations (mg/l)
Discharge (M3)	137,150,337	203,113,756		
SO4+	1,117,852	2,967,046	8.15	14.61
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NO3-N	69,038	114,713	0.50	0.56
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NH4	8,218	9,202	0.06	0.05
Total Nitrogen	142,130	164,661	1.04	0.81
PO4	2,110	1,259	0.02	0.01
TSS	54,559,431	5,060,173	398	25

Table 4 lists the storm and base-flow segregated results for 2004.

Table 4 Results from previous year (2004)

	Storm Loads (kg)	Base Loads (kg)	Storm Concentrations (mg/l)	Base Concentrations (mg/l)
Discharge (M3)	389,319,217	337,082,721		
NO3-N	145,241	201,146	0.37	0.60
T-P	349,293	40,561	0.90	0.12
NH4	23,372	15,948	0.06	0.05
Total Nitrogen	554,619	171,591	1.42	0.51
PO4	9,221	3,418	0.02	0.01
TSS	171,947,037	16,093,716	441	48

DISCUSSION

The White River @ 45 Bridge during 2005 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 5 and Figure 3. 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 White River watershed had very high TSS loads compared to the other watersheds during both base-flows and storm-flows. Most of the TSS was transported during storm events. The P load for the White River was higher than the other watersheds in the white River basin with values comparable to the Illinois River basin. Total nitrogen loads per hectare were similar to other White River sub-basin watersheds which are lower than the Illinois River sub-basin watersheds.

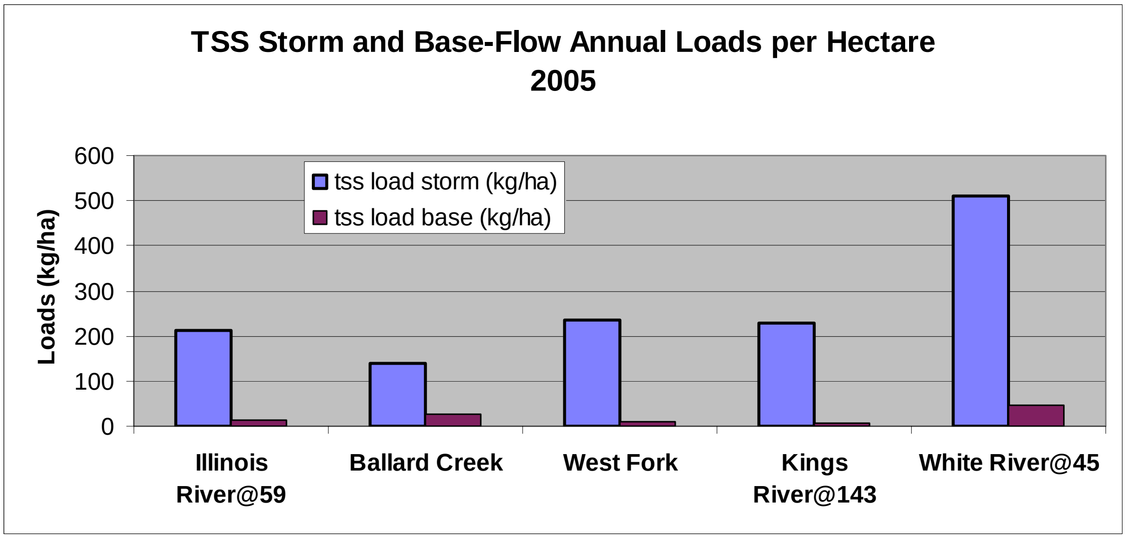
The base-flow concentrations show relative levels of TSS, T-P and TN that are impacting in-stream biological activity during most of the year. These are the values that are of greatest interest for determining impacts to in-stream biological habitat and nuisance algae production. The base-flow concentration of TSS was very high, much higher than the values measured at the upstream tributary the West Fork. The T-P concentration was highest in the White basin, but lower than the Illinois Basin. The nitrate concentration was low considering there is a point source discharge into the river (Fayetteville WWTP).

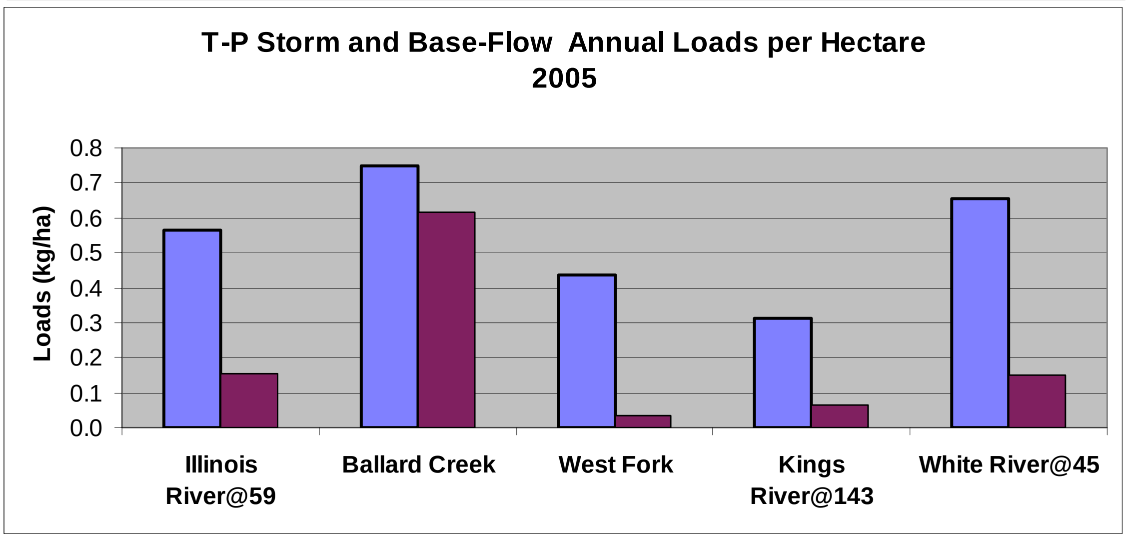
Figure 2 shows that there are significant levels of sulfate and chloride in the White River. These concentrations peak in late summer when the flow is at its lowest. This indicates a relatively constant source that is diluted at higher flows. The source of these constituents is unproven. However, chlorides and sulfate are often associated with wastewater from WWTPs or septic tanks. Data obtained from the Fayetteville WWTP shows that in December 2005 their average discharge was 6.8 cfs and contained an average of 98 mg/l sulfate and 87 mg/l sulfate. The river averaged 7.07 cfs and contained 69 mg/l sulfate and 46 mg/l chloride during that same time period. This suggests the impact the WWTP discharges may be having on the river, particularly at low base-flows.

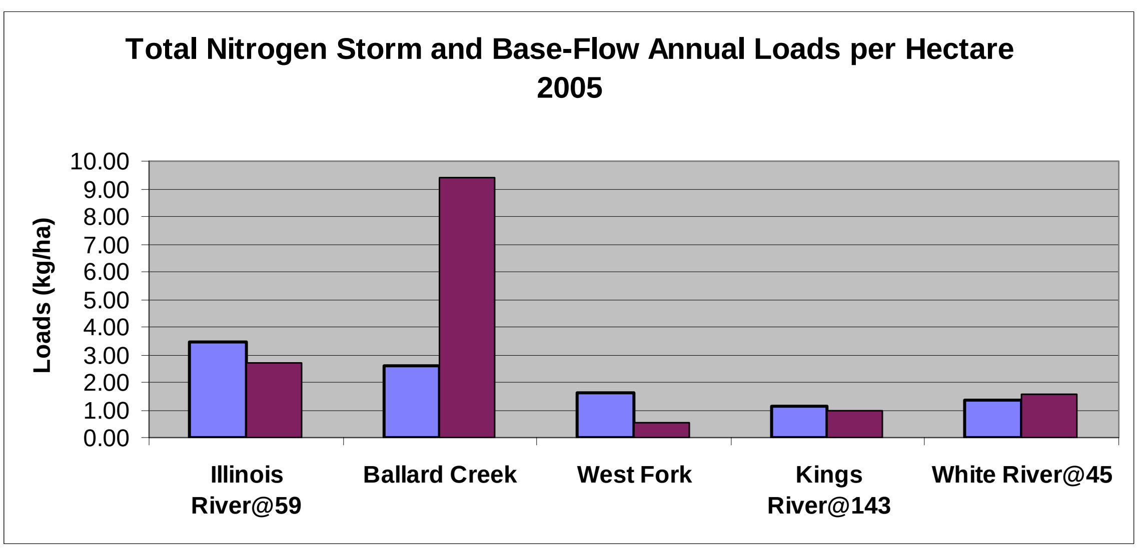
Table 5 Comparison of five northwest Arkansas watersheds

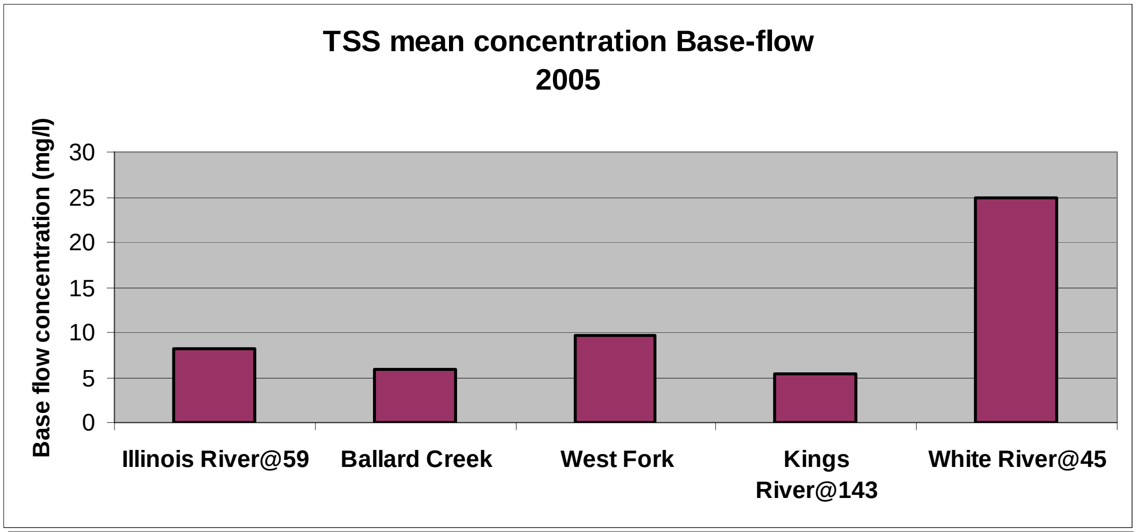
2005	Illinois River@59	Ballard Creek	West Fork	Kings River@143	White River@45
Hectares	**148,930**	**7,106**	**30,563**	**136,497**	**106,711**
YEARS of data	**2005**	**2005**	**2005**	**2005**	**2005**
tss load (kg/ha)	**225**	**165**	**245**	**235**	**559**
tss load storm (kg/ha)	**212**	**140**	**235**	**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**	**2.87**
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)	**390,894,159**	**37,191,537**	**84,315,555**	**279,456,255**	**340,264,093**
DISCHARGE/AREA (m^3/ha)	**2,625**	**5,234**	**2,759**	**2,047**	**3,189**

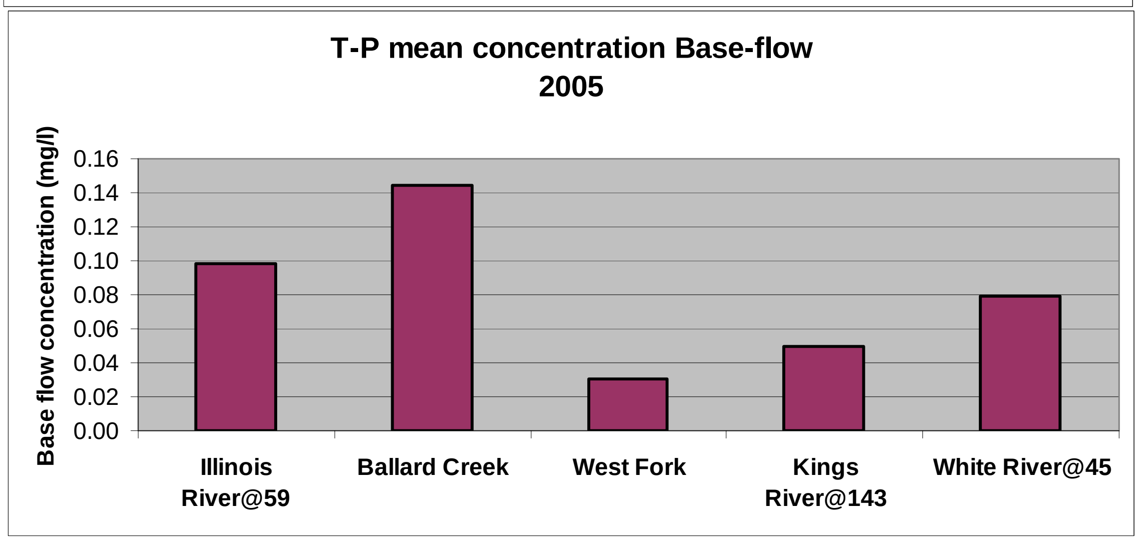
Figure 3 Comparison of five watersheds

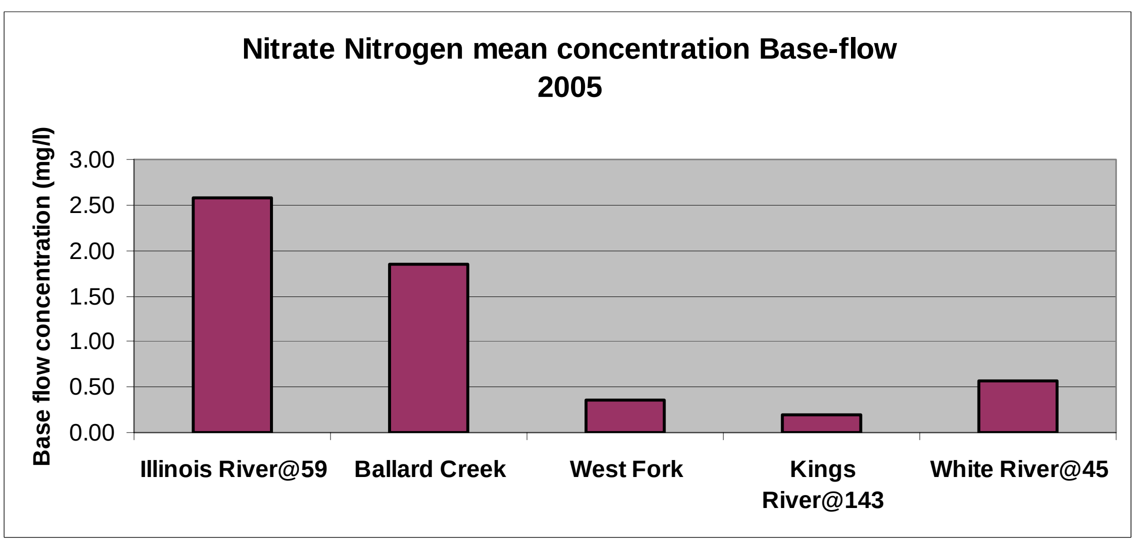







TSS mean concentration Base-flow
2005
Base flow concentration (mg/l)
30
25
20
15
10
5
0
Illinois River@59
Ballard Creek
West Fork
Kings River@143
White River@45


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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Written communications from Mike Lawrence, Superintendent of Rogers WWTP who collected the discharge information for all WWTPs in the Illinois and White River watersheds. May 2006.