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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

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Arkansas Water Resources Center

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

Submitted to the
Arkansas Natural Resources Commission

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2005 ANNUAL REPORT

Presented to the Arkansas Natural Resources Commission
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June 2006

SUMMARY

West Fork 2005 loads and mean concentrations.

parameter	Annual Loads (kg)	Flow-weighted Mean Concentrations (mg/l)
Discharge (m3)	84,315,555	2.67 (m3/s)
Nitrate-N	36,982	0.44
Total Phosphorus	14,413	0.17
Ammonia-N	4,699	0.06
TKN	64,884	0.77
Phosphate-P	1,455	0.02
TSS	7,503,125	88.99

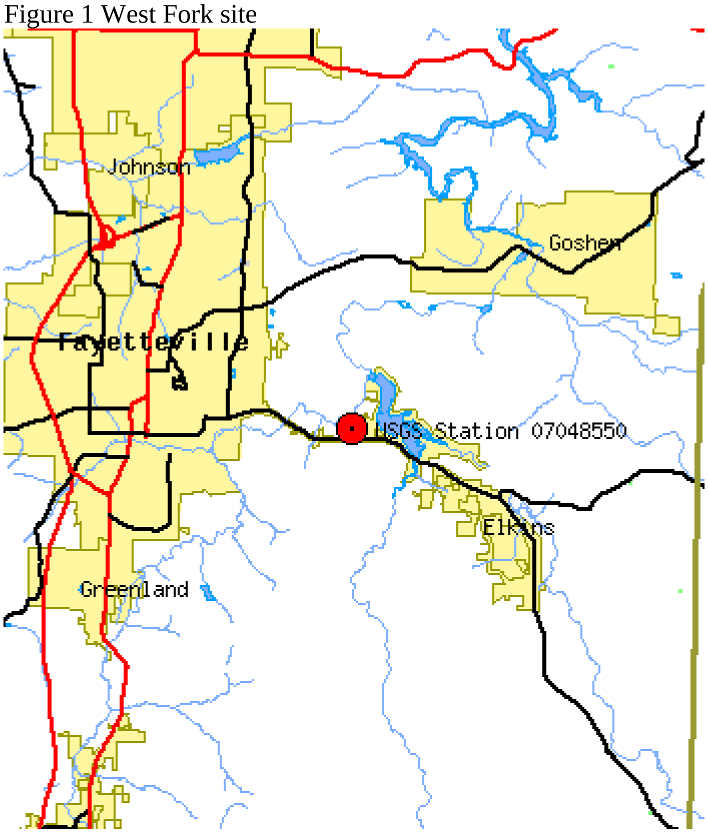
West Fork 2005 Storm-flow and Base-flow Loads and Mean Concentrations.

	Storm Loads (kg)	Base Loads (kg)	Storm Concentrations (mg/l)	Base Concentrations (mg/l)
Discharge (M3)	50,641,469	33,674,086	1.60583	1.067798
NO3-N	24,992	11,990	0.49	0.36
T-P	13,374	1,039	0.26	0.03
NH4	3,580	1,119	0.07	0.03
TKN	49,006	15,879	0.97	0.47
PO4	1,308	147	0.03	0.00
TSS	7,178,110	325,015	141.74	9.65

INTRODUCTION

A water quality sampling station was installed at the Washington County road 195 bridge on the West Fork of the White River just above the confluence of the three main forks of the Upper White River in December 2001. The Quality Assurance Project Plan (QAPP) was approved by EPA Region six on March 2002 and sampling was begun at that time. This station is coordinated with a USGS gauging station at the same location. This station was 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 West Fork of the White River. The West Fork 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 West Fork site



SCOPE

This report is for 2005 water quality sampling, water sample analysis and annual pollutant load calculations at the Washington County road 195 bridge on the West Fork of the White River. The parameters measured from collected samples were nitrate-nitrogen, ammonia-nitrogen, total nitrogen, total phosphorus, dissolved reactive phosphorus and total suspended solids. In addition turbidity, conductivity and temp were measured in-situ and recorded in thirty-minute intervals.

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. 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 three samples between each storm. 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.

After the initial phase, the sampler was reconfigured to take flow-weighted composite samples. The sampler began sampling after the stage exceeded a set trigger level of four feet. It took a discrete sample after a fixed volume of water had passed. The volume of water used for the flow weighted composite samples, i.e. sampling frequency, was 4 million cubic feet, as determined from the initial sampling phase. The discrete samples were composited by combining equal volumes of each into a single sample for analysis. Discrete samples were collected for compositing when all twenty-four bottles were filled or within forty-eight hours after the first sample. Storms were sampled in this manner for the period when the river stage was above the trigger level. Grab samples were taken every two weeks after the initial sampling phase. All samples were collected by AWRC Field Services 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 and total suspended solids.

RESULTS

During 2004, 60 individual samples were collected and analyzed. They include 26 base-flow grab samples, 22 composite storm samples, 4 field blanks, 4 sampler duplicates and 4 bank replicates. The stage for 2005 as well as the concentration results from the samples are summarized in Figure 2 and Table 1.

Figure 2. 2005 Stage and Concentrations

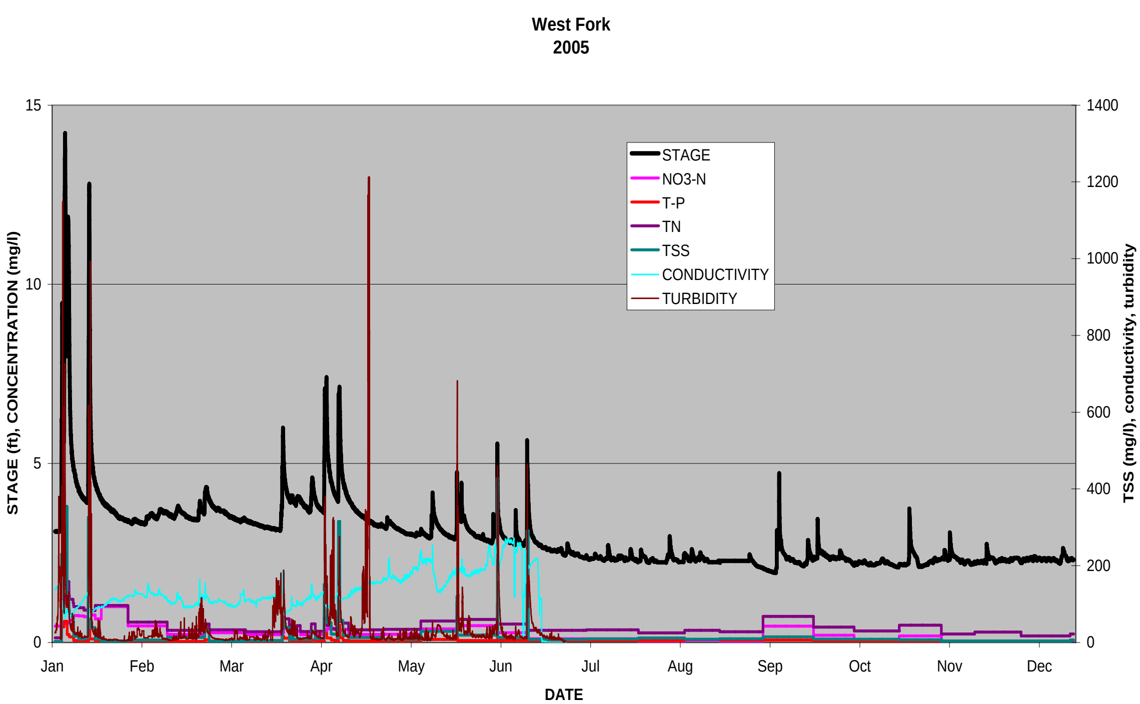


Table 1. 2005 loads and mean concentrations.

parameter	Annual Loads (kg)	Flow-weighted Mean Concentrations (mg/l)
Discharge (m3)	84,315,555	2.67 (m3/s)
Nitrate-N	36,982	0.44
Total Phosphorus	14,413	0.17
Ammonia-N	4,699	0.06
TKN	64,884	0.77
Phosphate-P	1,455	0.02
TSS	7,503,125	88.99

Discrete storm samples were collected on 5 storms in 2002 using 190 individual samples. These results were modeled using least-squares linear regressions to determine a relationship between concentrations and stage. These relationships can be used to predict concentrations of the different constituents as a function of stage during storm events if actual measured values are unavailable due to equipment failure. The relationships determined are summarized in Table 2. These relationships were not used in 2005 to predict missing storm event concentrations. Only a small part of one storm event was not sampled adequately. That data was filled in by interpolation.

Table 2. Corrected Regression equations determined from discrete storm samples 2002

parameter	Regression equation	Regression coefficient
Nitrate-N	$y = -0.054x + 0.416$	$R^2 = 0.0379$
Total Phosphorus	$y = 0.0299x + 0.1626$	$R^2 = 0.377$
Ammonia-N	$y = 0.003x + 0.0361$	$R^2 = 0.1248$
TKN	$y = 0.0424x + 0.4855$	$R^2 = 0.224$
Phosphate-P	$y = 0.002x + 0.0035$	$R^2= 0.2611$
TSS	$y = 16.008x + 53.214$	$R^2 = 0.443$

The loads and mean concentrations can be segregated into storm-flow and base-flow using the trigger level as an arbitrary distinction between flow regimes. Using the trigger level value of 4 feet, the segregated loads and mean concentrations for 2004 are shown in Table 4.

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

	Storm Loads (kg)	Base Loads (kg)	Storm Concentrations (mg/l)	Base Concentrations (mg/l)
Discharge (m^3/yr)	50,641,469	33,674,086	1.6 (m^3/s)	1.1 (m^3/s)
NO3-N	24,992	11,990	0.49	0.36
T-P	13,374	1,039	0.26	0.03
NH4	3,580	1,119	0.07	0.03
TKN	49,006	15,879	0.97	0.47
PO4	1,308	147	0.03	0.00
TSS	7,178,110	325,015	141.74	9.65

In addition to measuring TSS, turbidity was measured and recorded every fifteen minutes during the project. Figure 3 shows the stage TSS and turbidity measured during the year. After June, the turbidity and conductivity measurements were inoperable due to low water levels.

Figure 3 2005 Stage, TSS and Turbidity measurements

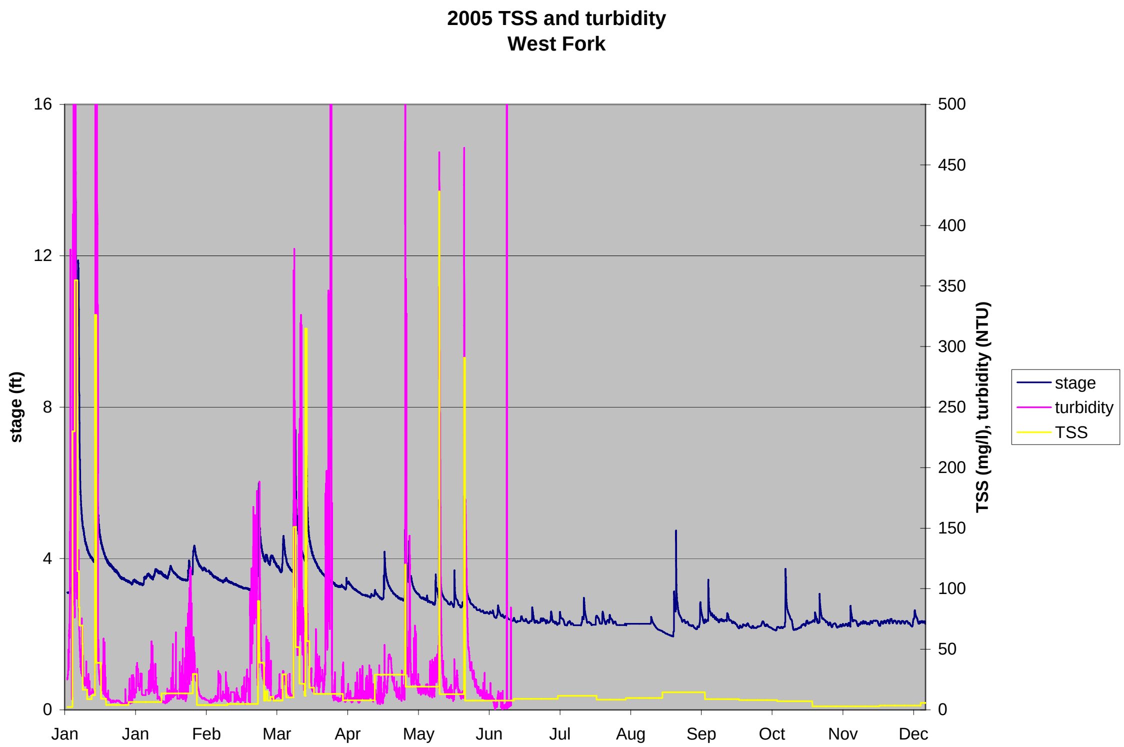
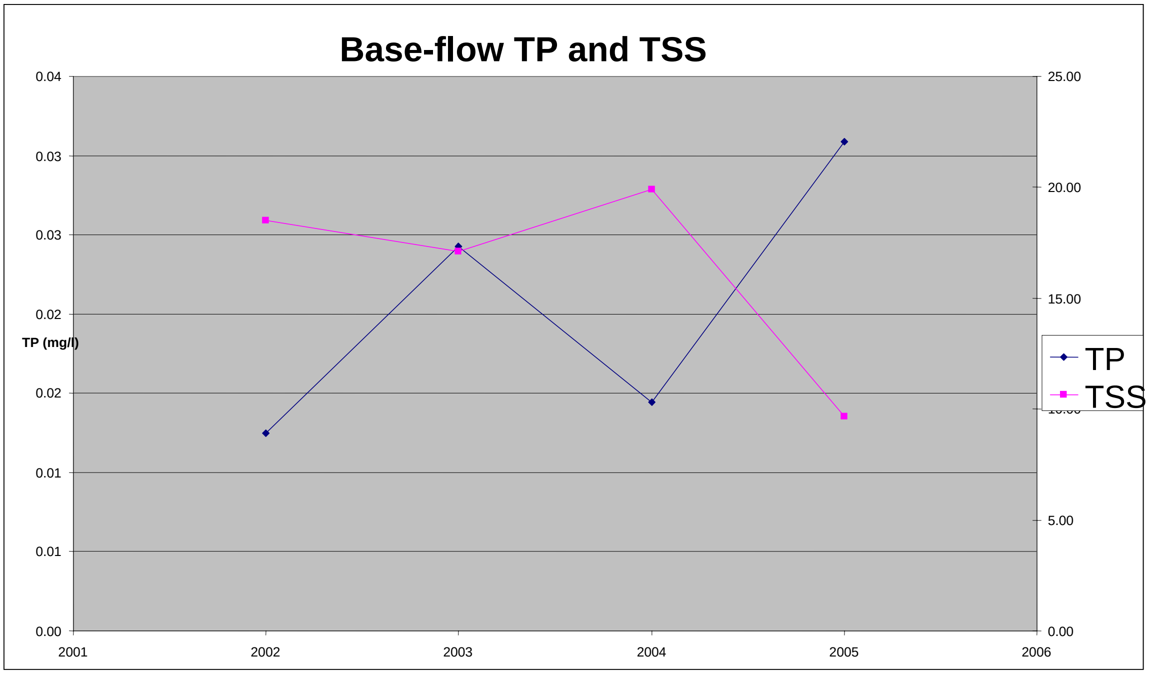


Figure 4 Base-flow TSS and TP Trends



DISCUSSION

The loads and concentrations developed for the West Fork @ 195 Bridge 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 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 West Fork watershed had average TSS loads compared to the others and most of the TSS was transported during storm events. The P load for the West Fork was lower than the other watersheds (except the Kings) 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 higher than the other watersheds (except the White). However, it appears to be decreasing (see figure 4) The T-P concentration was very low, but increasing. The nitrate concentration was low considering there is a small point source discharge into the river (West Fork WWTP).

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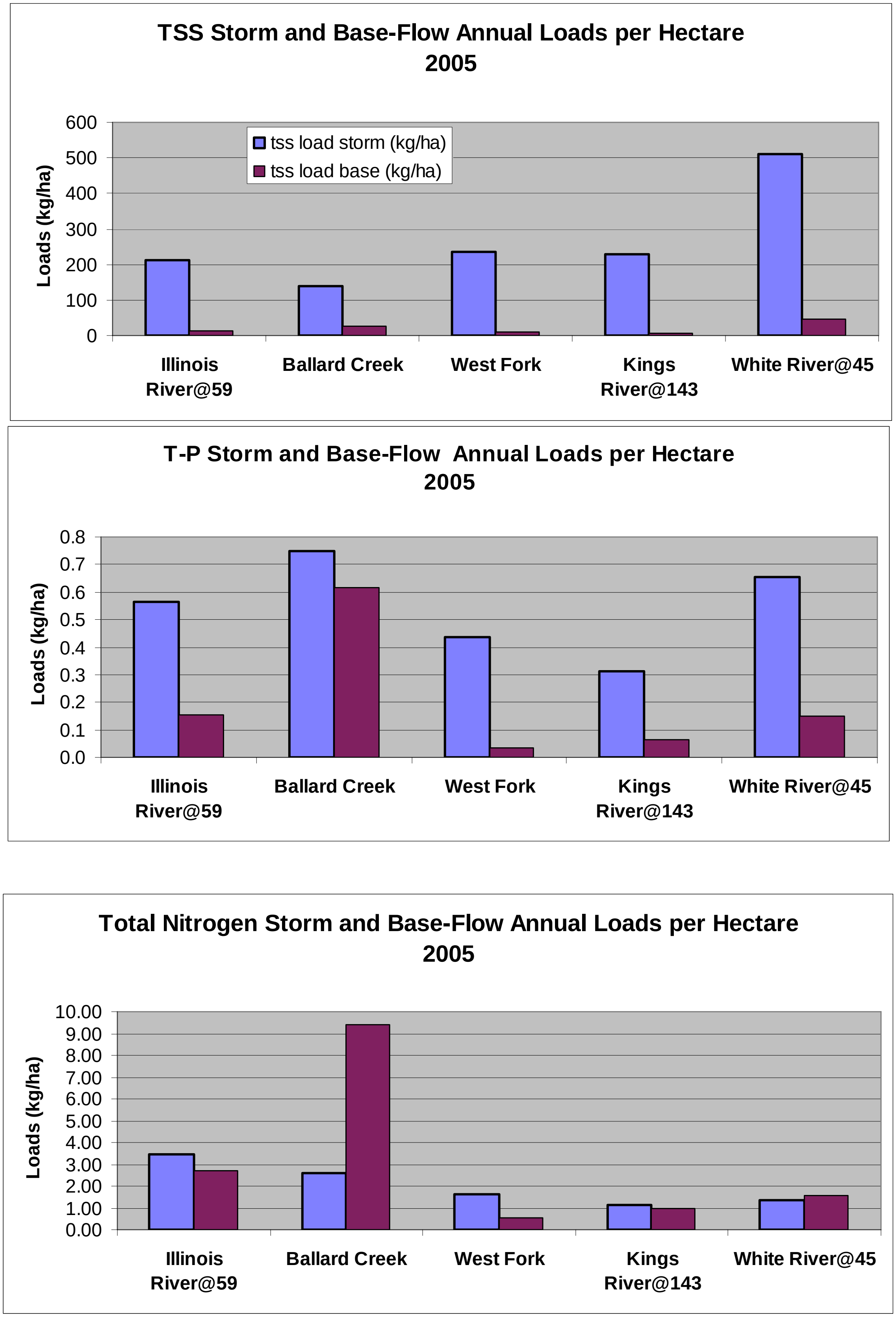
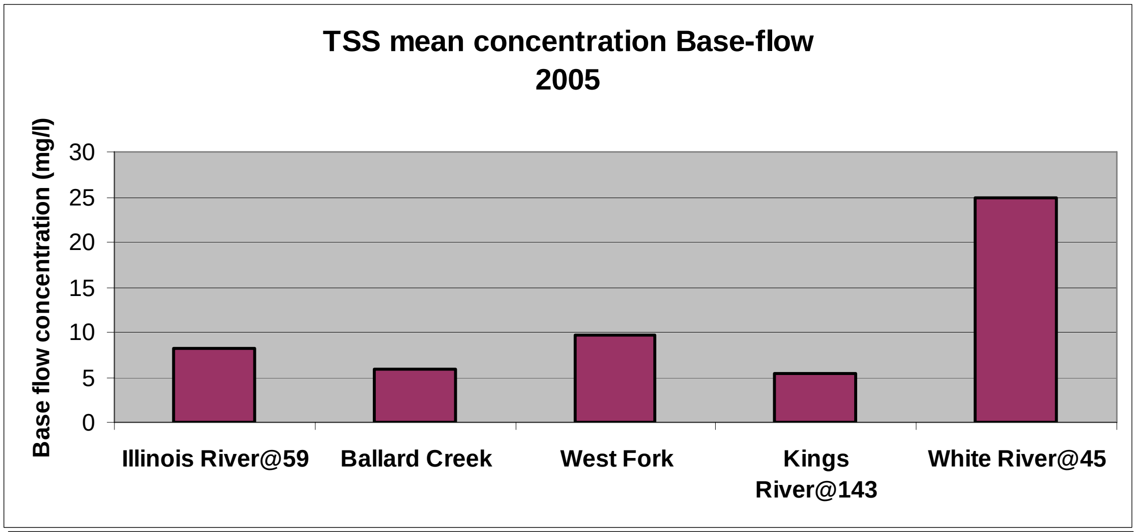
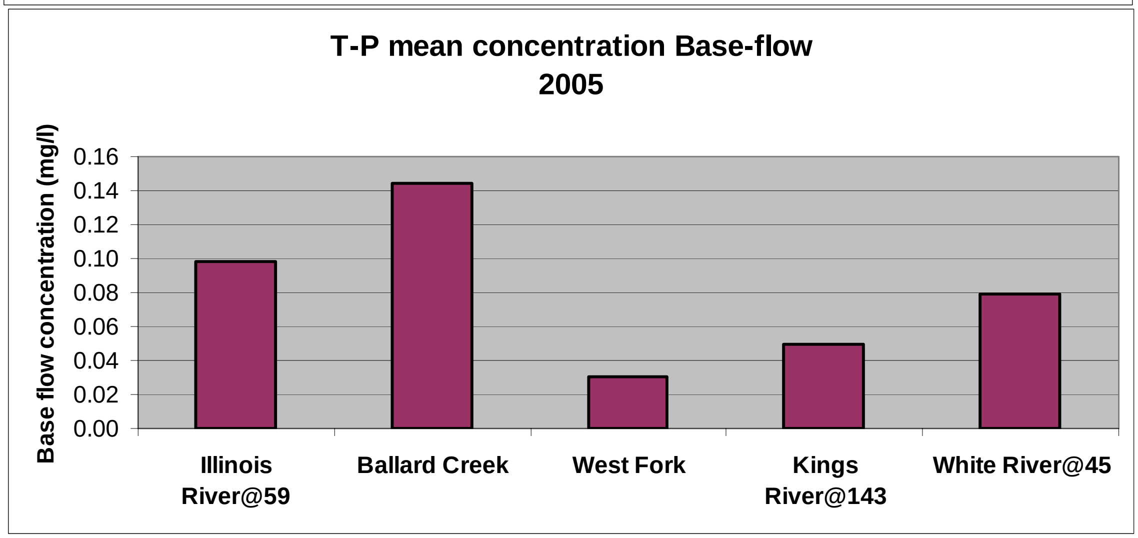
Table 5 Comparison of five northwest Arkansas watersheds

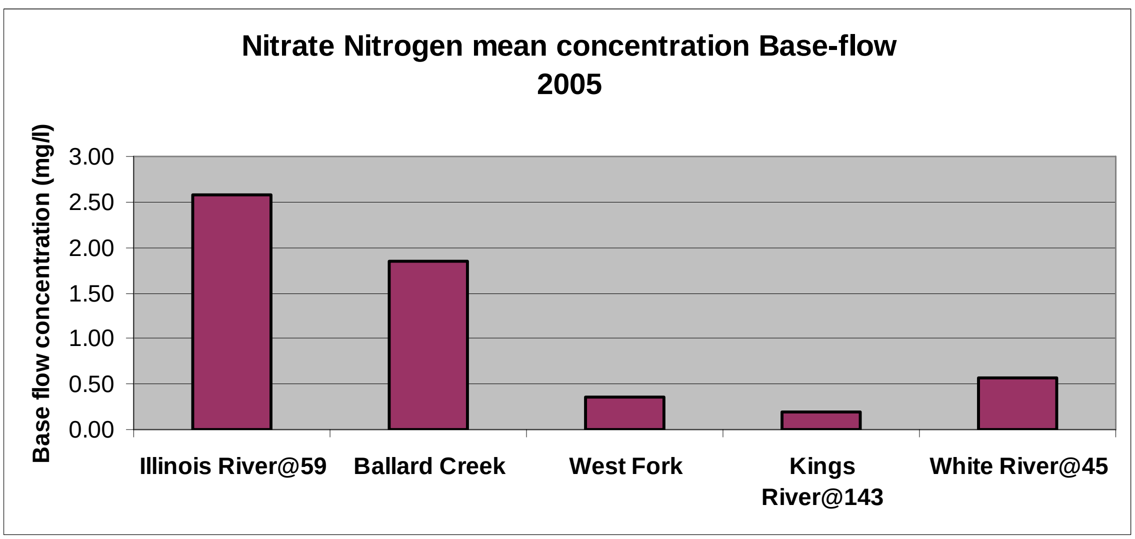
2005	Illinois River@59	Ballard Creek	West Fork	Kings River@143	White River@45
Hectares	148,930	7,106	30,563	136,497	106,711
YEARS of data	2005	2005	2005	2005	2005
tss load (kg/ha)	225	165	245	235	559
tss load storm (kg/ha)	212	140	235	228	511
tss load base (kg/ha)	13	25	11	7	47
tss conc. base (mg/l)	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 ($m^{3/}yr$)	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 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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