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Water Quality Sampling, Analysis and Annual Load Determinations for TSS, Nitrogen and Phosphorus at the Wyman Road Bridge on the White River

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Final Report

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INTRODUCTION

A water quality sampling station was installed at the Wyman Road Bridge just below the confluence of the three main forks of the Upper White River in January 2000. This station is coordinated with the USGS gaging 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 Upper White River.

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 rises to ten percent over the prior base-flow. Trigger levels were evaluated and modified based on load calculation optimization techniques. 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 five feet. It took a discrete sample after a fixed volume of water has 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 Kjeldahl nitrogen, total phosphorus, dissolved reactive phosphorus and total suspended solids.

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 autosampler concentrations and cross-section concentrations. The USGS collected evenly weighted integrated (EWI) cross section samples at the same time AWRC collected discrete autosamples. All samples were transported and analyzed by the AWRC Water Quality Lab and the results used to determine correction factors for the autosample concentrations. Six routine bi-monthly samples and six storm flow samples were taken and compared during each year.

All samples taken and used for analysis will be done in accordance with an approved quality assurance project plan. This QAPP was prepared by the AWRC and submitted to the ASWCC for approval. The ASWCC reviewed the plan for conformance to it's Quality Management Plan and submitted the QAPP to EPA, Dallas for review and approval. The plan was approved on April 19, 2000.

RESULTS

Sampling began on April 19, 2000 and ended on December 31, 2001. Sampling was discontinued due to removal of the bridge where the sampling station was located and relocation of the USGS gaging station to a site downstream of where the new bridge construction was about to occur. It was determined that the location of the gaging station would not allow sampling that was comparable before, during and after construction.

During the first year, 220 individual samples were collected and analyzed. They include 17 base-flow grab samples, 190 discrete storm samples, 10 storm composite samples and 3 USGS cross-section samples. The stage for 2000 as well as the results from the samples is summarized in Figure 1 and Table 1.

Figure 1. Stage and measured concentrations 2000.

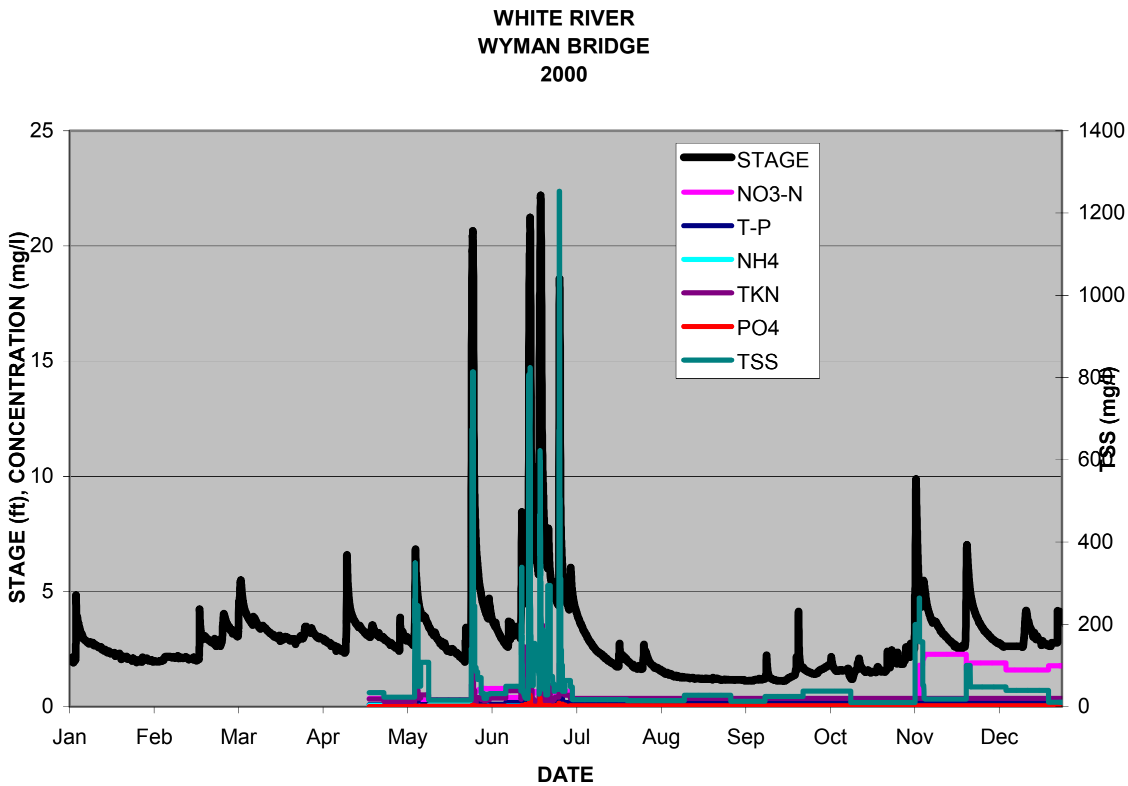


Table 1. 2000 partial year loads and mean concentrations.

parameter	Loads (kg)	Mean Concentrations (mg/l)
Nitrate-N	215,937	0.63
Total Phosphorus	174,636	0.51
Ammonia-N	12,437	0.04
TKN	372,651	1.09
Phosphate-P	18,806	0.05
TSS	85,914,146	250.51

In 2001, 54 individual samples were collected and analyzed. They include 26 base-flow grab samples, 22 storm composite samples, and 6 USGS cross-section samples. The stage for 2001 as well as the results from the samples is summarized in Figure 2 and Table 2.

Figure 2. Stage and measured concentrations 2001.

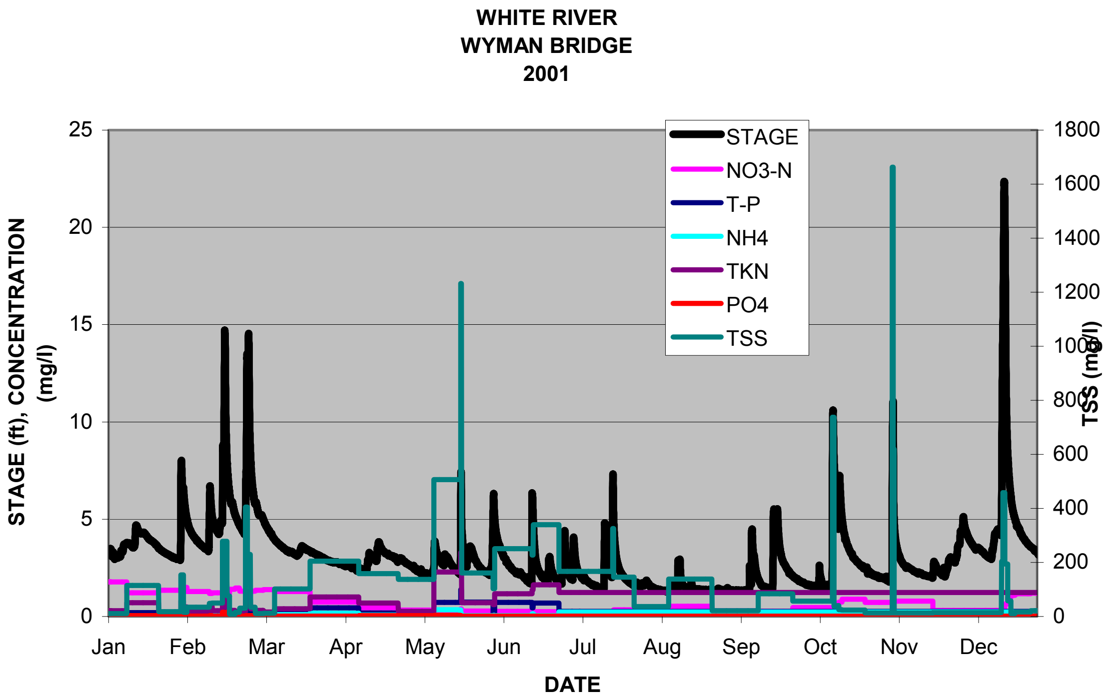


Table 2. 2001 annual loads and mean concentrations.

parameter	Loads (kg)	Mean Concentrations (mg/l)
Nitrate-N	343,991	0.82
Total Phosphorus	160,880	0.38
Ammonia-N	20,765	0.05
TKN	337,974	0.81
Phosphate-P	14,775	0.04
TSS	74,920,331	178.77

Discrete storm samples were collected on 5 storms in 2000 using 190 individual samples. The results from three of these storms are illustrated in Figure 3. 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 3. Although these relationships were determined, they were not used to model any of the storm events during the project since all storms were sampled adequately.

Figure 3. Discrete storm samples.

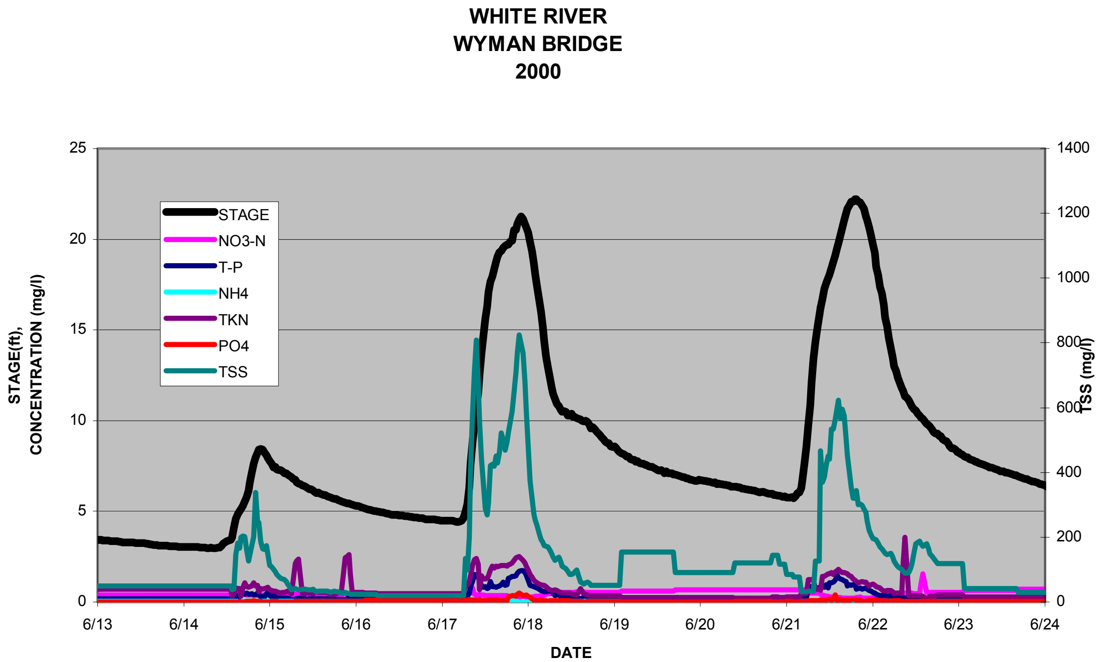


Table 3. Regression equations determined from discrete storm samples.

parameter	Regression equation	Regression coefficient
Nitrate-N	y = -0.0122x + 0.5391	R^2 = 0.1892
Total Phosphorus	y = 0.0524x - 0.05	R^2 = 0.5886
Ammonia-N	y = -0.0002x + 0.0281	R^2 = 0.006
TKN	y = 0.0648x + 0.3034	R^2 = 0.3052
Phosphate-P	y = 0.0076x - 0.0203	R^2= 0.3903
TSS	y = 23.385x - 15.124	R^2 = 0.4458

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 5 feet, the segregated loads and mean concentrations for 2001 are shown in Table 4.

Table 4. Storm-flow and Base-flow loads and Mean Concentrations 2001.

	Storm Loads (kg)	Base Loads (kg)	Storm Concentrations (mg/l)	Base Concentrations (mg/l)
VOLUME (M3)	210,542,386	208,549,795		
NO3-N	169,761	174,229	0.81	0.84
T-P	116,730	44,150	0.55	0.21
NH4	8,360	12,405	0.04	0.06
TKN	221,202	116,772	1.05	0.56
PO4	10,719	4,056	0.05	0.02
TSS	55,311,385	19,608,946	262.71	94.03

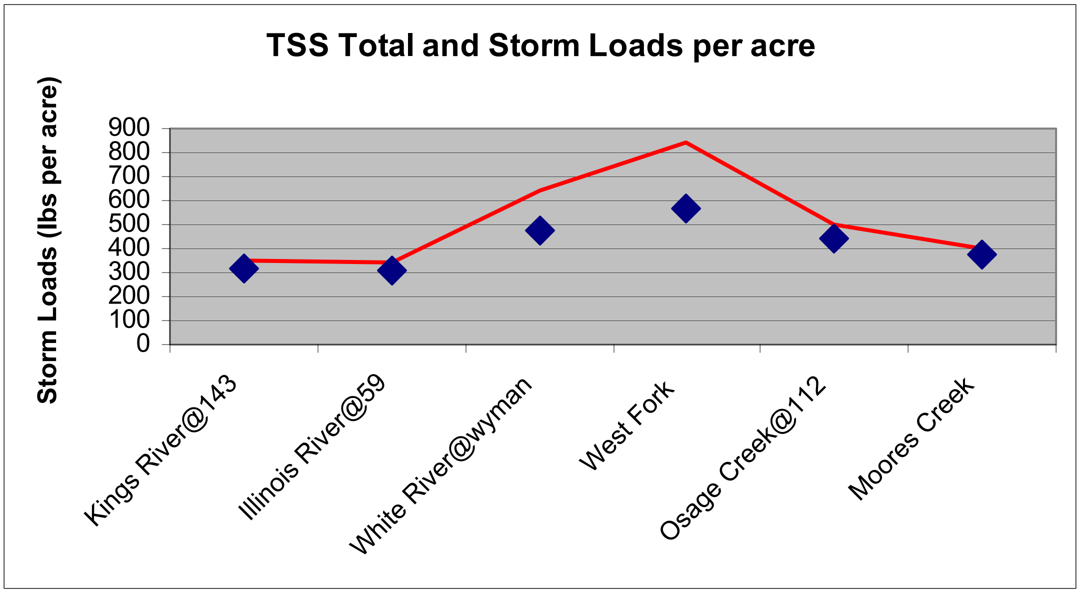
The results for this White River @ Wyman Bridge site during 2001 can be compared to results from other Northwest Arkansas watersheds that were investigated using the same sampling and load calculation protocols. Table 5 lists the results for TSS, phosphorus and discharge from 5 watersheds. TSS and phosphorus are shown as total annual loads per acre; annual storm loads per acre, and annual mean base-flow concentrations. Total loads in pounds per acre represents the total mass of a constituent that would be transported to a receiving water body. Storm loads in pounds per acre is a way to represent the total quantities that are washed from the surface of the watershed during storm events (non-point source pollution). Base-flow concentrations represent the concentration of a constituent that the biological community in the stream would face during most of the year. These values do not necessarily represent actual base and storm flows, but rather represent comparable values for determining the relative impacts in similar watershed.

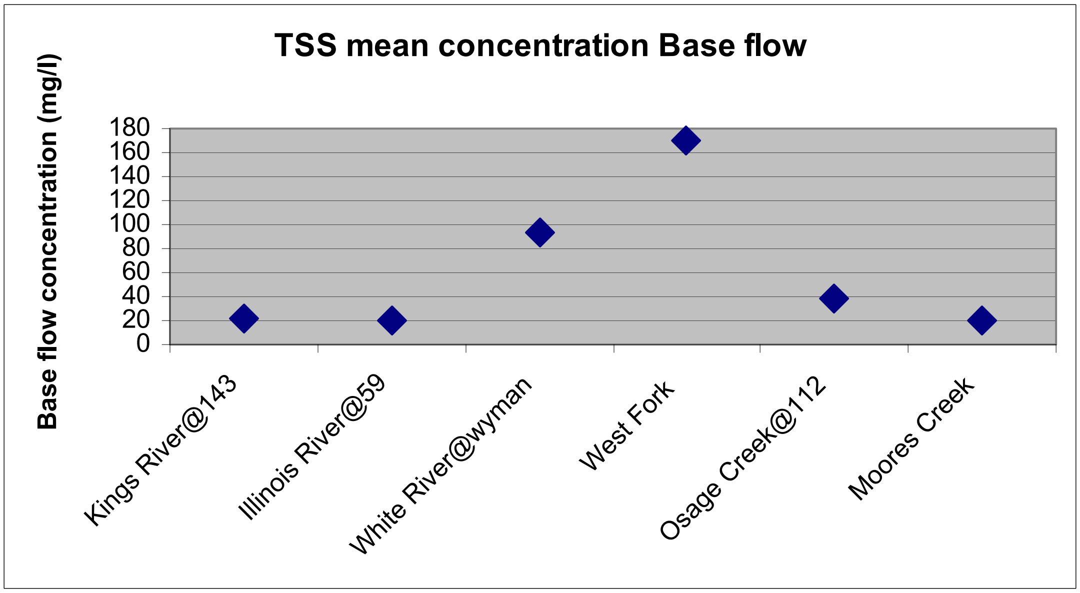
Table 5. Comparison of results to other Northwest Arkansas Watersheds.

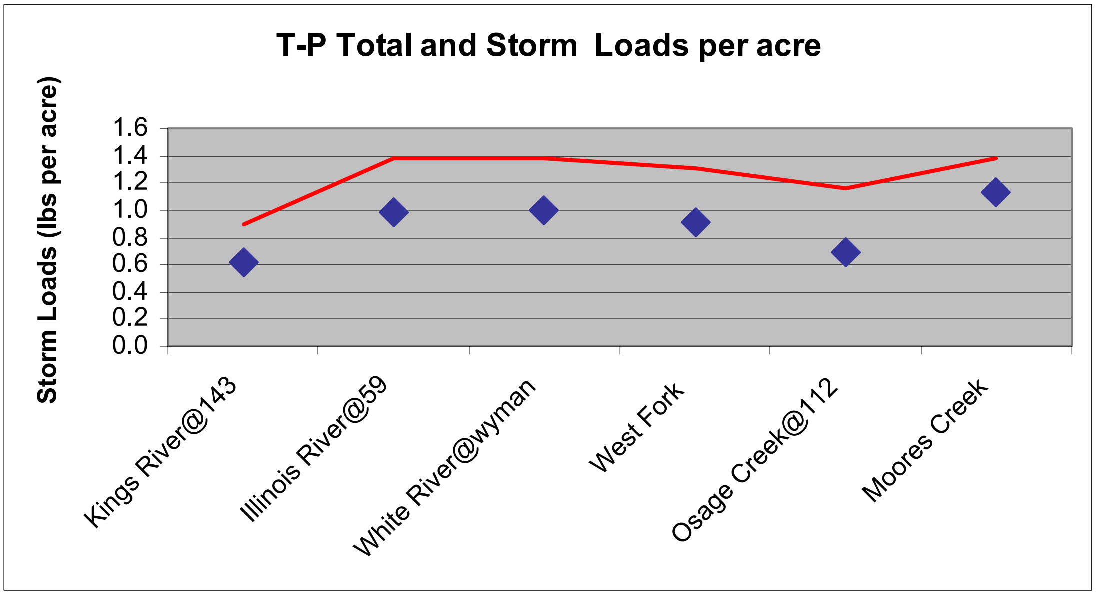
Comparison of the numbers shown can lead to the following conclusions about the White River at the Wyman Bridge in 2001. Storms are washing significantly greater masses of TSS per acre and high levels of phosphorus per acre when compared to the others. Base-flows contain very high levels of TSS but medium levels of phosphorus. Runoff is greater than in the other watersheds possibly indicating greater urbanization.

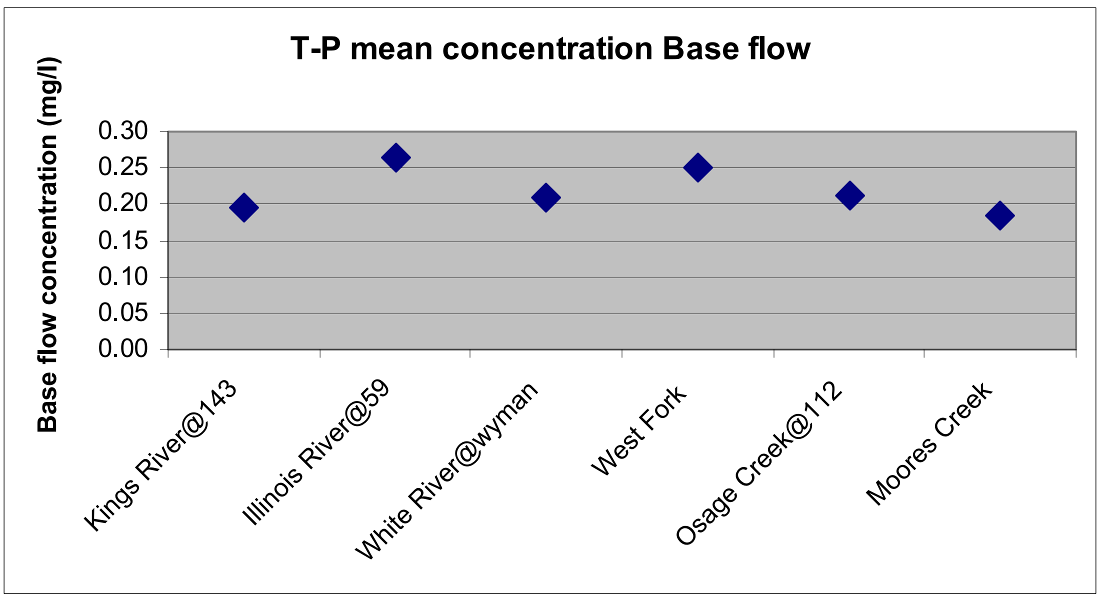
	Kings River@143	Illinois River@59	White River@wyman	West Fork	Osage Creek@112	Moores Creek
ACRES	337,280	368,000	256,000	65920	22,208	2,200
YEARS of data	4	6	1	1	2	3
tss load (#/acre)	351	340	644	839	501	401
tss load storm (#/acre)	320	312	475	570	442	377
tss conc. base (mg/l)	21	20	93	170	39	20
p load (#/acre)	0.89	1.38	1.38	1.30	1.16	1.38
p storm load (#/acre)	0.62	0.98	1.00	0.91	0.70	1.13
p base conc. (mg/l)	0.19	0.26	0.21	0.25	0.21	0.19
DISCHARGE (ft3)	1.0E+10	1.9E+10	1.5E+10	3.5E+09	1.4E+09	9.6E+07
DISCHARGE/AC (ft3/acre)	29,528	52,625	57,847	53,419	62,066	43,804

Figure 5. Comparisons between 6 watersheds.






T-P Total and 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

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