



# Arkansas Water Resources Center

## ILLINOIS RIVER 2001 POLLUTANT LOADS AT ARKANSAS HIGHWAY 59 BRIDGE

Submitted to the  
Arkansas Soil and Water Conservation Commission

By

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## SUMMARY

Results for Illinois River at AR59 for Calendar Year **2001**

Pollutant	Total Discharge (m <sup>3</sup> /yr)	Total Load (kg/yr)	Average Discharge (m <sup>3</sup> /s)	Mean Concentrations (mg/l)
	532,000,000		16.9	
N03-N		1,520,000		2.86
TKN		447,000		0.84
TP		256,000		0.48
TSS		70,800,000		133

- Comparison between the loads and discharge calculated for 1999 to those in 2000 indicate decreases in discharge, nitrates, TKN and TSS but an increase in total phosphorus.

Comparison between 1997, 1998, 1999, 2000 and 2001 **loads**

Parameter	<b>1997</b> Loads	<b>1998</b> Loads	<b>1999</b> Loads	<b>2000</b> Loads	<b>2001</b> Loads
Discharge (m <sup>3</sup> )	458,460,000	588,000,000	635,000,000	536,000,000	532,000,000
N03-N (kg/yr)	1,020,000	1,390,000	1,560,000	1,100,000	1,520,000
TKN (kg/yr)	301,000	481,000	514,000	462,000	447,000
TP (kg/yr)	127,000	232,000	267,000	283,000	256,000
TSS (kg/yr)	18,400,000	72,600,000	77,100,000	63,600,000	70,800,000

- Comparison between flow-weighted mean concentrations for 1997, 1998, 1999, 2000 and 2001 indicate increasing concentrations for all parameters except a slight decrease in TKN and TP concentrations between 2000 and 2001.

Comparison between 1997, 1998, 1999, 2000 and 2001 **flow-weighted mean concentrations**

Parameter	<b>1997</b> Mean Concentrations (mg/l)	<b>1998</b> Mean Concentrations (mg/l)	<b>1999</b> Mean Concentrations (mg/l)	<b>2000</b> Mean Concentrations (mg/l)	<b>2001</b> Mean Concentrations (mg/l)
N03-N	2.24	2.37	2.45	2.06	2.86
TKN	0.66	0.82	0.81	0.86	0.84
TP	0.28	0.39	0.42	0.53	0.48
TSS	40	123	121	118	133

- A total of 49 water samples were collected and analyzed in 2001.
- All significant storm events were sampled during the year.

## INTRODUCTION

Automatic water samplers and a U. S. Geological Survey gauging station were established in 1995 on the main stem of the Illinois River at the Arkansas Highway 59 Bridge. Since that time, continuous stage and discharge measurements and water quality sampling have been used to determine pollutant concentrations and loads in the Arkansas portion of the Illinois River. This report represents the results from the measurement and sampling for January 1, 2001 to December 31, 2001.

## PREVIOUS RESULTS

In the fall of 1995, a gauge was installed at the Highway 59 bridge by the USGS and automatic sampling equipment was installed by the Arkansas Water Resource Center. In September 1995, sampling was begun on the Illinois River. Grab samples were taken every week and storms were sampled using an automatic sampler set to take samples every 4 hours. During the period from September 13, 1995 to September 15, 1996 one hundred thirty seven grab samples and discrete storm samples were collected and analyzed. Table 1 summarizes the results from that study (Parker et al, 1997).

Table 1. Results from **1996** study period (Parker et al, 1997)

Nutrients	Total Discharge (m <sup>3</sup> /yr)	Total Load (kg/yr)	Average Discharge (m <sup>3</sup> /s)	Average Flow Weighted Concentrations (mg/l)
	300,775,680		9.5	
N03-N		550,000		2.0
NH3-N		8,530		0.031
TKN		201,000		0.74
TP		89,900		0.29
TSS		27,000,000		89
TOC		1,130,000		4.2

Sampling was discontinued on September 15, 1996 and no water quality samples were taken between September 15, 1996 and November 1, 1996. Stage and discharge was still recorded for this period, however, no loads were calculated. Water quality sampling was resumed on November 1, 1996. The sampling protocol was changed to collection of grab samples every two weeks and flow-weighted storm composite samples. Between November 1, 1996 and December 31, 1996 a total of four grab samples and one storm composite sample were collected and analyzed. Stage and discharge were recorded.

During the period from January 1, 1997 to October 15, 1997, there were twenty-six grab samples and twenty-five storm composite samples collected and analyzed using the same protocol. During the period from October 15, 1997 to December 31, 1997, the sampling protocol was changed to taking grab samples every two or three days and taking discrete storm samples every thirty or sixty minutes. In this period, there were twenty-four grab samples and one hundred and forty storm discrete samples collected and analyzed. The loads and mean concentrations for 1997 calculated using these samples are summarized in Table 2.

Table 2. Results from **1997**-study period (Nelson and Soerens, 1998).

Pollutant	Total Discharge (m <sup>3</sup> /yr)	Total Load (kg/yr)	Average Discharge (m <sup>3</sup> /s)	Mean Concentrations (mg/l)
	458,460,000		14.5	
N03-N		1,020,000		2.24
TKN		301,000		0.66
TP		127,000		0.28
TSS		18,400,000		40.2

In the periods from January 1, 1998 to May 15, 1998 and November 1, 1998 to December 31, 1998, the Illinois River sampling was supplemented by sampling from another research project. That project, sponsored by the USGS Water Resource Institute Program, was titled “Investigation of Optimum Sample Interval for Determining Storm Water Pollutant Loads” by Marc Nelson, Thomas Soerens and Jean Spooner. The sampling protocol for that project consisted of taking grab samples every two days and discrete storm water samples at thirty-minute intervals on the rising limb and sixty-minute intervals on the falling limb of storm hydrographs. Storm water sampling was begun at a variable trigger level set to the current stage plus ten percent and adjusted every two days. After the first thirty-six hours of each storm, sample times were increased to from four to twenty-four hours until the stage fell below the initial trigger. All samples were collected within twenty-four hours. All samples were analyzed for nitrate nitrogen (NO<sub>3</sub>-N), ammonia nitrogen (NH<sub>4</sub>-N), total Kjeldahl nitrogen (TKN), total phosphorus (TP), ortho phosphate (O-P) 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.

In the period from May 16, 1998 to October 31, 1998, the sampling protocol was changed back to the collection of grab samples every two weeks and flow-weighted composite samples during storms. Storms were defined as all flows above a five-foot trigger level. Once stage had risen above the trigger, a USGS programmable data logger began summing the volume of water discharged. Once a determined amount of water had been discharged, the data logger sent a signal to an automatic water sampler that filled one of twenty-four one-liter bottles. The total was then reset to zero and discharge was again summed for the next sample. In this fashion up to twenty-four samples, each representing an equal volume of storm water was collected. The volume of water represented by each individual sample was eight million cubic feet. These samples were retrieved before all twenty-four bottles were filled, or within 48 hours after being taken. The individual samples were composited into a flow-weighted composite storm sample by combining equal volumes of each. Samples were taken as long as the stage remained above the trigger level. All samples were analyzed for nitrate nitrogen (NO<sub>3</sub>-N), total Kjeldahl nitrogen (TKN), total phosphorus (TP) 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.

In the period from January 1, 1998 to December 31, 1998, there were four hundred and forty nine samples collected and analyzed. These results are summarized in Table 3.

Table 3. Results from **1998**-study period (Nelson and Soerens, 1999).

Pollutant	Total Discharge (m <sup>3</sup> /yr)	Total Load (kg/yr)	Average Discharge (m <sup>3</sup> /s)	Mean Concentrations (mg/l)
	588,000,000		18.6	
NO <sub>3</sub> -N		1,390,000		2.37
TKN		481,000		0.82
TP		232,000		0.39
TSS		72,600,000		123.5

In the period from January 1, 1999 to December 31, 1999, there were three hundred and sixty nine samples collected and analyzed. These results are summarized in Table 4.

Table 4. Results from the **1999** study period (Nelson and Soerens, 2000)

Pollutant	Total Discharge (m <sup>3</sup> /yr)	Total Load (kg/yr)	Average Discharge (m <sup>3</sup> /s)	Mean Concentrations (mg/l)
	635,000,000		20.0	
N03-N		1,560,000		2.45
TKN		514,000		0.81
TP		267,000		0.42
TSS		77,100,000		121

In the period from January 1, 2000 to December 31, 2000, there were fifty-one samples collected and analyzed. These results are summarized in Table 5.

Table 5. Results for Illinois River at AR59 for Calendar Year **2000** (Nelson and Soerens, 2001).

Pollutant	Total Discharge (m <sup>3</sup> /yr)	Total Load (kg/yr)	Average Discharge (m <sup>3</sup> /s)	Mean Concentrations (mg/l)
	536,000,000		17	
N03-N		1,100,000		2.06
TKN		462,000		0.86
TP		283,000		0.53
TSS		63,600,000		118

## METHODS

In the period from January 1, 2001 to December 31, 2001, the Illinois River sampling followed the following protocol. Base flow grab samples were taken every two weeks using the automatic sampler. Storm flow-weighted composite samples were taken during all storm events. Sampling was initiated when the river stage exceeded the trigger level of 5 feet. Flow-weighted composite samples were taken by causing the sampler to collect a single discrete sample for every four million cubic feet of water that passed the bridge. These discrete samples were collected once per day and composited by taking equal volumes from each discrete and combining them to form a single sample. Flow-weighted composite samples were taken from trigger level to trigger level of all storm events where the river stage was above the trigger for at least twelve hours. All samples were collected within twenty-four hours of being taken. All samples were analyzed for nitrate nitrogen (NO<sub>3</sub>-N), ammonia nitrogen (NH<sub>4</sub>-N), total Kjeldahl nitrogen (TKN), total phosphorus (TP), ortho-phosphate (O-P) 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.

Calendar year pollutants loads and mean concentrations were calculated from the collected data. USGS stage and discharge data in thirty-minute intervals was used to calculate thirty-minute total volumes. Each volume was assigned a pollutant concentration. The pollutant concentrations were assigned by applying the results of grab samples between storm trigger levels and the results of storm water samples above trigger levels. All concentration data were assigned to the time periods from half way to the previous sample to half way to the subsequent sample except the first and last of a storm or base flow period which were assigned to the start or end of the period. Thirty-minute loads were calculated by multiplying thirty-minute volumes by their assigned concentrations. The yearly loads were calculated by summing the thirty-minute loads during the calendar year. Yearly mean concentrations were calculated by dividing the yearly load by the yearly volume.

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 auto-sampler concentrations and cross-section concentrations. The USGS collected evenly weighted integrated (EWI) cross section samples at the same time AWRC collected discrete auto-samples. All samples were transported and analyzed by the AWRC Water Quality Lab. Five storm-flow paired samples were taken and compared during the year.

**RESULTS**

In the period from January 1, 2001 to December 31, 2001, there twenty-five composite storm samples and twenty-six base-flow grab samples collected, analyzed and used to calculate loads. These results are summarized in Table 5 and Figure 1.

Table 6. Results for Illinois River at AR59 for Calendar Year **2001**

Pollutant	Total Discharge (m <sup>3</sup> /yr)	Total Load (kg/yr)	Average Discharge (m <sup>3</sup> /s)	Mean Concentrations (mg/l)
	532,000,000		16.9	
N03-N		1,520,000		2.86
TKN		447,000		0.84
TP		256,000		0.48
TSS		70,800,000		133

Figure 1. Recorded stage and measured concentration for 2001

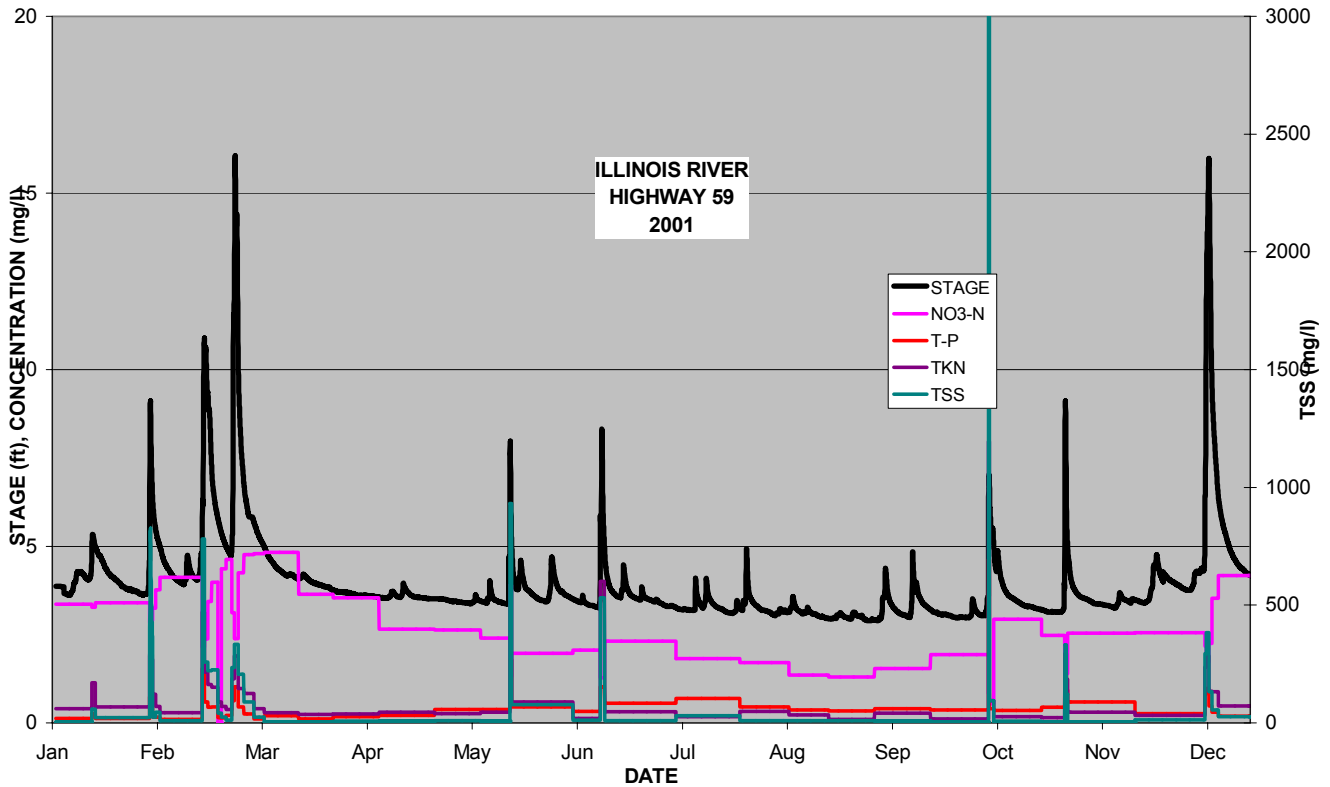


Figure 2. Trends in mean discharge and mean concentrations

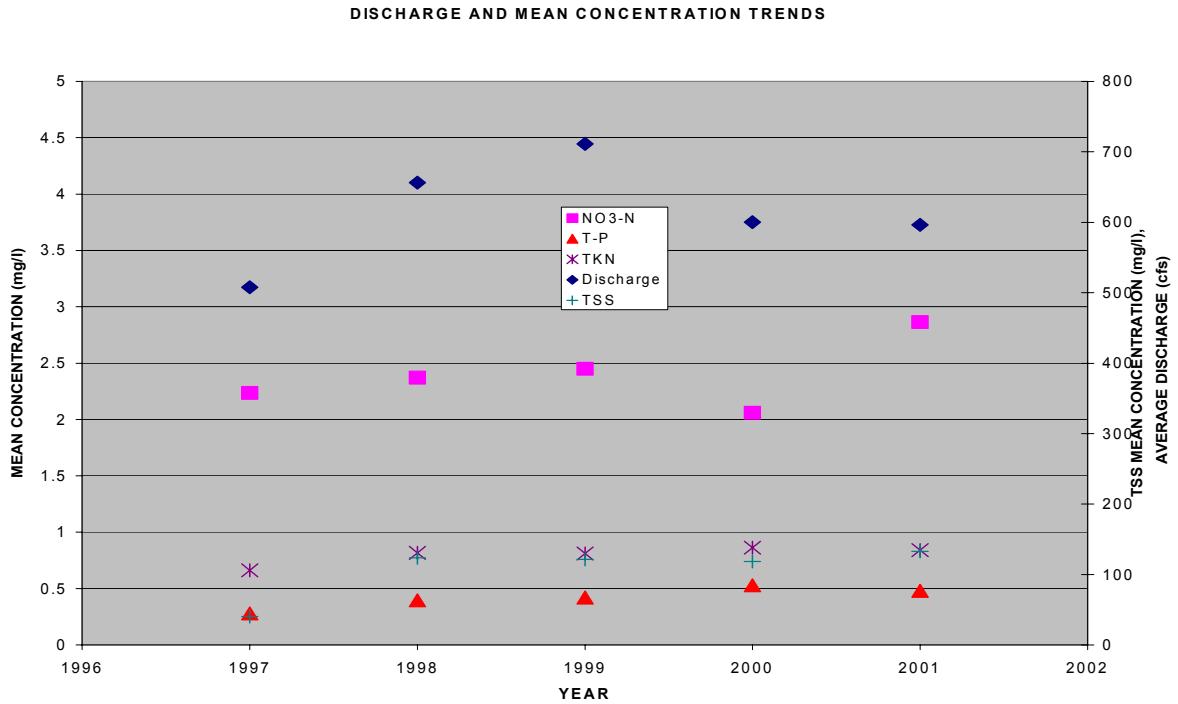


Figure 3. Comparison of auto-sampler concentrations to EWI cross-section concentrations of TSS

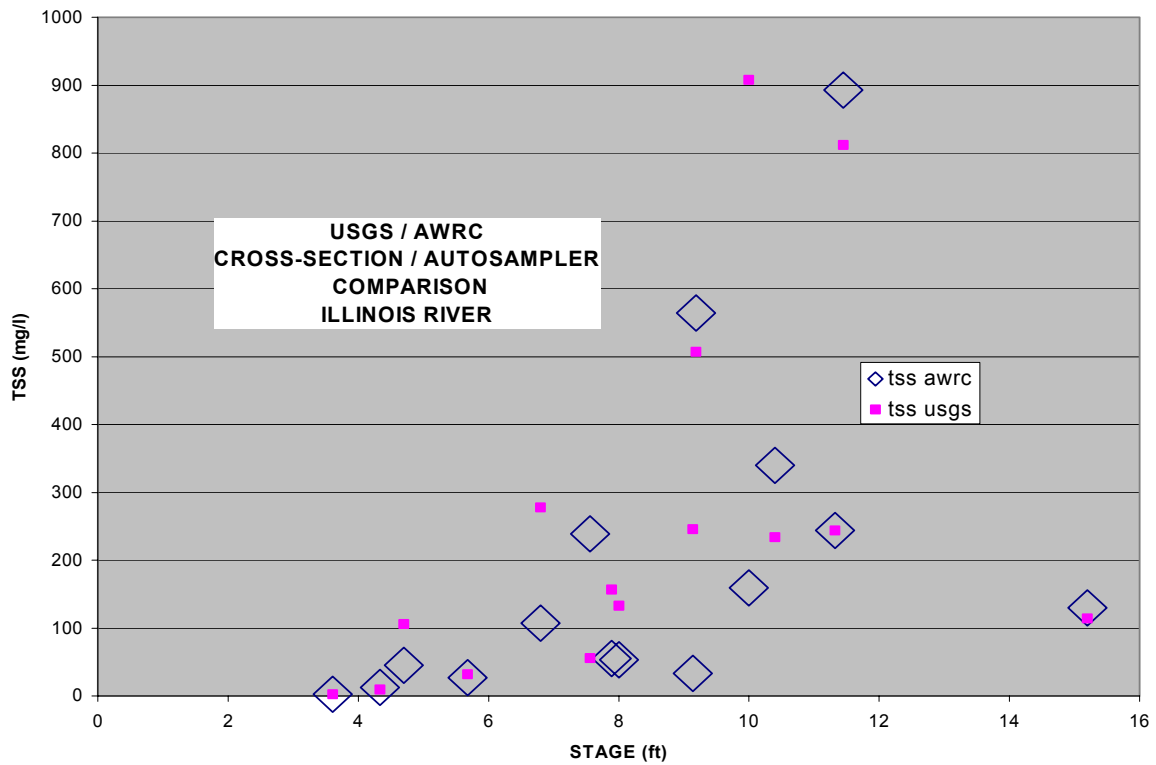




Figure 4. Regression of log TSS concentrations AWRC vs. USGS.

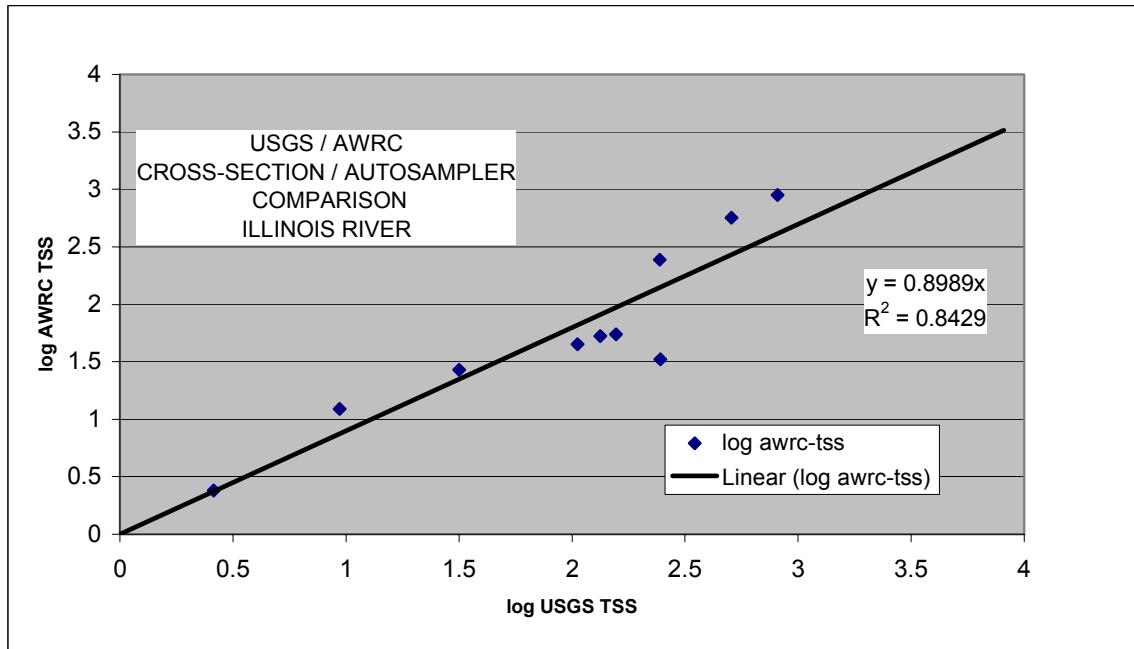


Figure 5. Comparison of auto-sampler concentrations to EWI cross-section concentrations of T-P

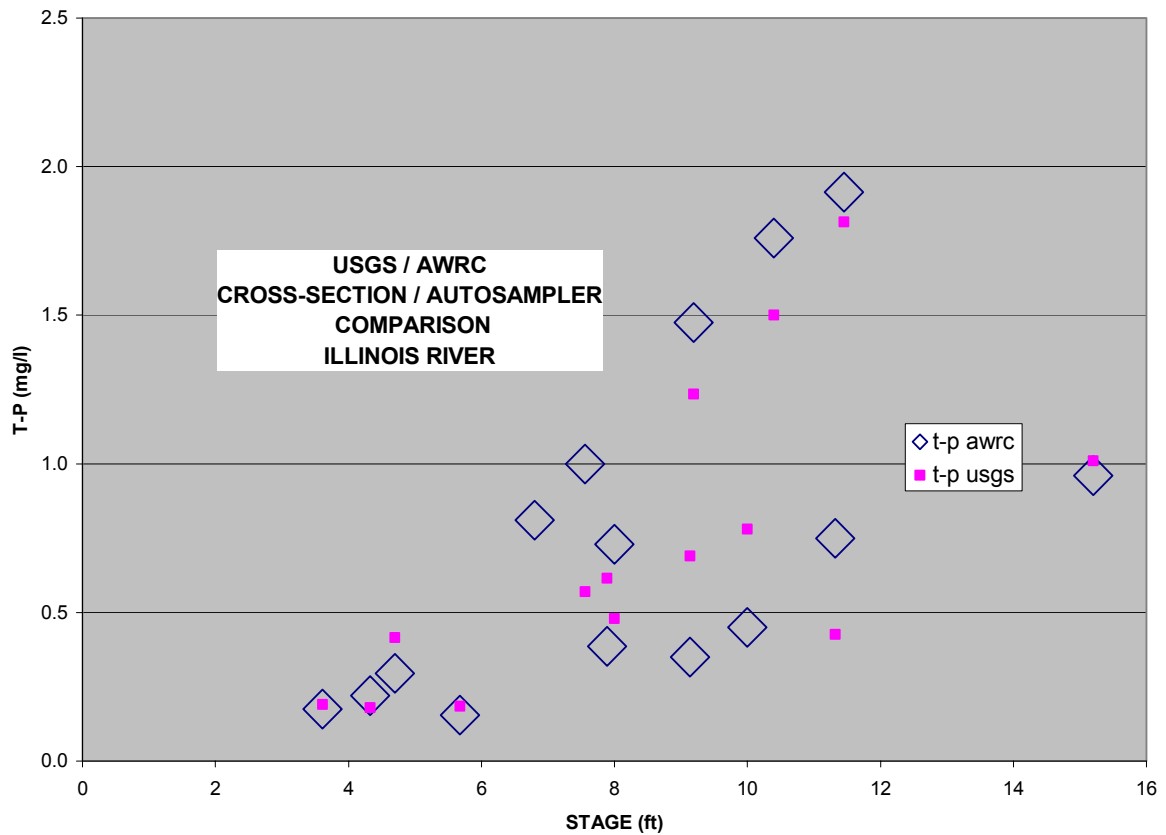
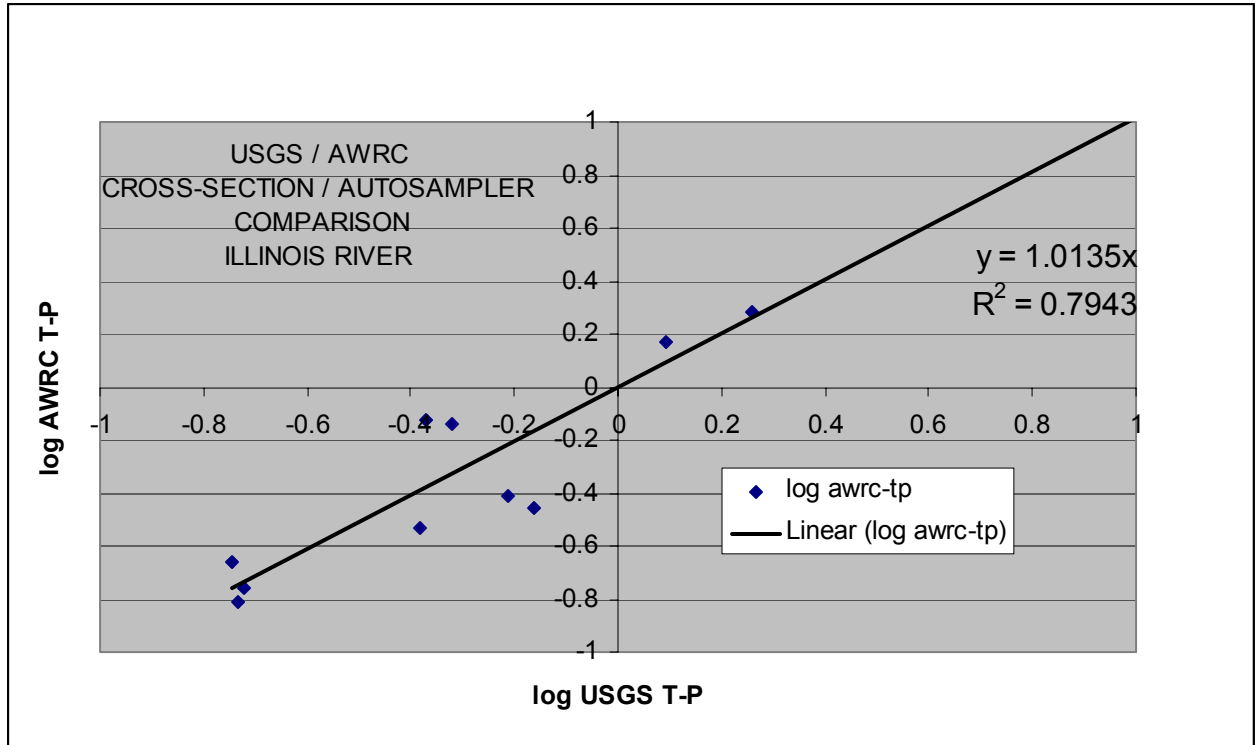


Figure 6. Regression of log T-P concentrations AWRC vs. USGS.

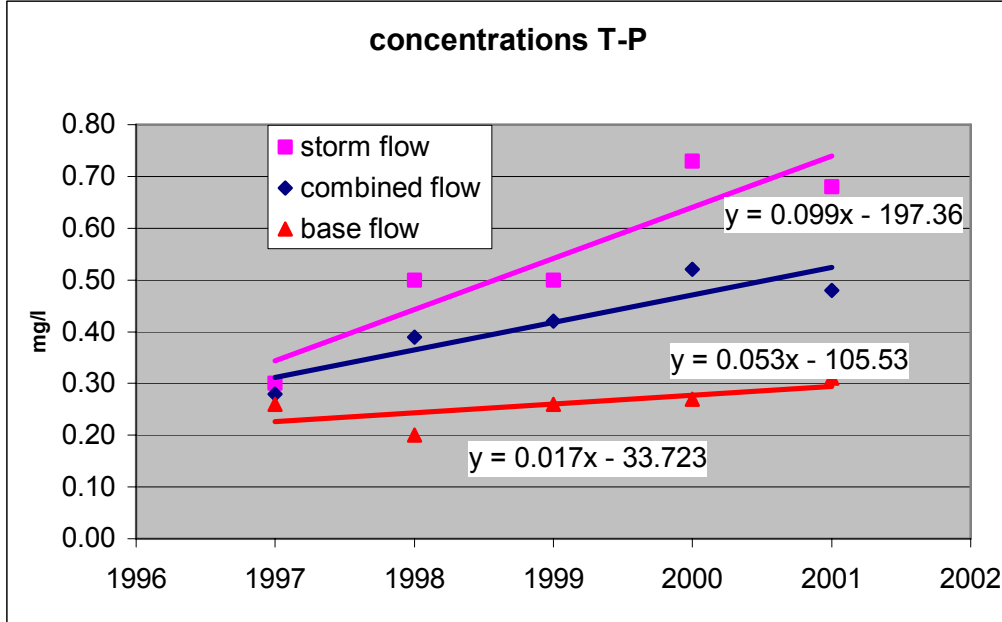


## DISCUSSION

The loads that were calculated for the year 2001 should be considered a very reliable estimate of the actual loads in the Illinois River in Arkansas. There were no gaps in the discharge data and all storm events were sampled adequately.

Results from five years water quality monitoring for total phosphorus are summarized as mean concentrations in figure 7. The mean concentrations were determined by dividing the annual load by the annual discharge. Shown are the base flow, storm flow and combined concentrations. Base flow concentrations represent the phosphorus load determined when the river stage was below five feet divided by the total discharge that occurred when the river stage was below five feet. Storm flow concentrations are loads divided by discharge above five feet. The combined flow concentration is the total load divided by the total discharge. Shown also in figure 7 are the linear regression trends of the mean concentrations. These results show an increasing trend in base flow and storm flow concentrations. The regressions indicate that base flow concentrations are increasing 0.02 mg/l per year and that storm flow concentrations are increasing 0.1mg/l per year. This indicates that non-point source contributions to phosphorus in the watershed may be increasing at a much faster rate than are point source contributions.

Figure 7. Trends in mean T-P concentrations for base flow and storm flow.



A source of error in the use of automatic samplers to collect samples is that the sampler may take samples that are not representative of the cross-section. In an effort to determine the possible error, beginning in 1998, the USGS began taking samples that represent the entire cross-section (EWI samples) at the same time the autosampler was taking samples. Results from those samples indicate that the auto samples may be overestimating TSS by 10% and underestimating concentrations of total phosphorus by 1% (see Figure 4 and 6). Figures 3 and 5 indicate that this relationship is not consistent at all flows with the low and high stages showing similar results and intermediate stages showing greater variation. This may be a result of not sampling at exactly the same time during a period when concentrations are changing rapidly. With this noted inconsistency, it is not recommended that concentrations from autosampler samples be adjusted using the determined relationships.

## REFERENCES

- Nelson, M.A., T.S. Soerens, J. Spooner "Results of Investigation of Optimum Sample Interval for Determining Storm Water Pollutant Loads", Proceedings of the Water Environment Federation WEFTEK Conference, New Orleans, LA, 1999
- Nelson, M.A., T.S. Soerens "1997 Pollutant Loads At. Arkansas Highway 59 Bridge" Presented at Arkansas-Oklahoma Arkansas River Compact Commission Meeting, September 1998.
- Nelson, M.A., T.S. Soerens "1998 Pollutant Loads At. Arkansas Highway 59 Bridge" Arkansas Water resources Center Publication, 1999.
- Nelson, M.A., T.S. Soerens "1999 Pollutant Loads At. Arkansas Highway 59 Bridge" Arkansas Water resources Center Publication, 2000.
- Nelson, M.A., T.S. Soerens "2000 Pollutant Loads At. Arkansas Highway 59 Bridge" Arkansas Water resources Center Publication, 2001.
- Nelson, M.A., T.S. Soerens, J. Spooner " Preliminary Results of Investigation of Optimum Sample Interval for Determining Storm Water Pollutant Loads", Presented at ASCE Watershed Management Conference, Memphis, TN, 1998.
- Nelson, M.A., T.S. Soerens and D.G. Parker "Phosphorus Transport in the Illinois River: Preliminary Results of Intensive Sampling" Proceedings of the Arkansas Water Resource Center Annual Conference, 1998.
- Parker, D.G., R. Williams and E. Teague "Illinois River Water Quality Automatic Sampler Installation" Arkansas Water Resource Center Miscellaneous publication 0227, 1997.
- Nelson, M.A., T.S. Soerens, J. Spooner "Investigation of Optimum Sample Number and Timing for Determining Storm Water Pollutant Loads Year [1998 and 1999}", Arkansas Water Resources Center Annual Report 1999-2000, August 2001.