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Determination of Nutrient Loads in Upper Moores Creek 2000

Submitted to the
Washington County Conservation District and
Arkansas Soil and Water Conservation Commission

By

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March, 2001

Publication No. MSC-290

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WASHINGTON COUNTY CONSERVATION DISTRICT

ARKANSAS SOIL & WATER CONSERVATION COMMISSION

INTRODUCTION

In Northwest Arkansas, nutrients transported by surface water are a major concern. These nutrients are implicated in causing water quality impairment of lakes in Northwest Arkansas and eastern Oklahoma. The nutrients of concern are nitrogen and phosphorus. Nitrogen and phosphorus stimulate algae production in water bodies and can cause water quality degradation. Problems associated with algae growth are aesthetic impairment, objectionable taste and odor of potable water, interference with recreation activities, and fish kills in some hyper-eutrophic cases. The sources of these nutrients are primarily from land application of confined animal wastes as soil amendments to pastures.

In 1990, the University of Arkansas Cooperative Extension Service (CES) and U. S. Department of Agriculture Natural Resources Conservation Service (NRCS) initiated a program in the Muddy Fork watershed of the Illinois River. This program focused on implementing best management practices (BMP) in the watershed that would reduce nutrient losses from pastures. Education, technical assistance, and cost sharing were the approaches used by these agencies to encourage BMP implementation. The predominant BMPs implemented were nutrient management, pasture and hay-land management, waste utilization, dead poultry composting, and waste storage structures.

In 1991, the Arkansas Soil and Water Conservation Commission (ASWCC) and the U. S. Environmental Protection Agency (EPA) sponsored a monitoring project in the Lincoln Lake Basin (see Figure 1). The Lincoln Lake Basin, part of the Muddy Fork watershed, received appreciable BMP implementation by the CES and NRCS. The objective of this monitoring project was to demonstrate the effectiveness of the implemented BMPs in reducing nutrient transport from the pastures in this intensively managed area.

Nutrient and sediment transport was monitored from September 1991 until April 1994 in Moores Creek and Beatty Branch, the two streams that feed Lincoln Lake, (Edwards *et al*., 1996 and 1997). The monitoring protocol consisted of grab samples every two weeks and flow-weighted composite samples taken with autosamplers during storm events. Total nutrient and sediment loads were calculated for each site. Monitoring was discontinued in May 1994.

In January 1995, water quality monitoring stations were re-established at the same Moores Creek and Beatty Branch sites in the watershed. These sites were monitored using the same monitoring protocol as the previous study. In July 1996, a third monitoring site was added to the monitoring network on the Moores Creek basin. This site was located just above an 800-acre parcel of land surrounding the creek that was selectively logged beginning in the fall of 1995. Since the lower Moores Creek sampler was located toward the lower end of this parcel, the upper Moores Creek sampler was added to help continue trends analysis in the creek without the effects of the logging on water quality. These sites were monitored until December 1998. Total nutrient and sediment loads were calculated for all three sites (Vendrell, et al., 1999)

Beginning in January 1999, the upper Moores Creek site was used to monitor water quality as a part of a research project investigating sampling techniques (Nelson, et al., 2000). The other two sites were not part of this project and no monitoring occurred there. The monitoring protocol consisted of grab samples every two days and discrete storm samples taken every 30 minutes during the first twelve hours of a storm event and every 60 minutes during the next 24 hours of each storm event. Although most storm events were monitored and numerous grab samples were taken, total yearly loads were not calculated for nutrient and sediment transport in 1999.

In January 2000 monitoring began for this project at the upper Moores Creek site.

OBJECTIVES

The objectives of the continued water quality monitoring of Moores Creek were to 1) determine nutrient and sediment concentrations and yearly loads at the upper Moores Creek site, 2) compare the 2000 loads to past loads to identify trends in water quality.

METHODS

In January 2000, automatic water sampling equipment was re-installed in the upper Moores Creek site. A programmable datalogger was used in conjunction with a pressure transducer to measure and record water depth (stage). It converted the stage to discharge using a stage/discharge-rating curve developed in previous years. The datalogger initiated sampling by triggering the autosampler as soon as the stage had reached a depth of 26 inches. This trigger level was chosen initially in previous years to cause the upper sampler to begin taking samples at the same point in a storm hydrograph as the lower sampler. Once sampling had been initiated, the datalogger began calculating discharge and summing the total volume passing the sampler. Each time ten thousand cubic meters had passed, the sampler took a discrete sample, until it had taken 24 samples, or samples were retrieved. Once per day during storm events samples were retrieved from the sampler and it was reset to continue sampling until the stage had fallen below the trigger level. Each time samples were collected, equal volumes from each discrete sample were combined into one sample for analysis. These flow-weighted composite samples gave an accurate picture of the average concentrations for the entire storm event. In addition to sampling all storm events where the stage exceeds the trigger level for more than six hours, grab samplers were taken manually every two weeks during the year.

All samples were taken immediately upon collection to the AWRC- Water Quality Lab and analyzed for nitrate (NO_3-N), ammonia (NH_3-N), total Kjeldahl Nitrogen (TKN), total phosphorus TP, ortho-phosphate (PO4-P), and total suspended solids (TSS). All samples were analyzed using approved and certified methods, and all laboratory and field sampling procedures adhered to the laboratory quality management plan. In addition, field blanks and duplicates were used as field sampling quality control.

Stage, time and discharge data was downloaded from the dataloggers once per month. This data was combined with the analytical results for the samples in a spreadsheet and used to calculate total nutrient and solids loads for the year. Loads were calculated by assigning a concentration to every thirty-minute time interval, multiplying the concentration by the volume passing during the time interval, and summing each thirty-minute load over the year. Flow-weighted mean concentrations were calculated by dividing the year's total load for each parameter by the year's total discharge.

RESULTS

There were a total of twenty grab samples taken at approximate two-week intervals during the year. Grab samples were not taken during a three month period in the summer and early fall when the creek dried up completely. There were only five storm events during the year and all were sampled using flow-weighted composite samples. These results are summarized in Figure 2, Figure 3, Table 1 and Table 2.

Table 1. 2000 discharge and flow-weighted mean concentrations.

Volume (M^3)	NO3-N (mg/l)	TP (mg/l)	NH3-N (mg/l)	TKN (mg/l)	PO4-P (mg/l)	TSS (mg/l)
2,184, 249	2.00	0.66	0.10	1.44	0.28	208.69

Table 2. 2000 total nutrient and sediment loads.

	NO3-N (kg)	TP (kg)	NH3-N (kg)	TKN (kg)	PO4-P (kg)	TSS (kg)
	4370	1452	227	3136	612	45582 2

DISCUSSION

The first objective of this project was to accurately determine the nutrient and sediment loads in the upper Moores Creek. It was an unusual year in that the normal stormy periods of early spring and late fall were without major runoff events. The most significant runoff events occurred in June. There were only five runoff events (above trigger level for 6 hours). The average number of events is closer to twelve. Even though the number of events was small, the sediment and nutrient transport that occurred during these events was a large percentage of the year's totals (except for nitrates).

Table 3. Total loads, storm loads and storm loads percent of total.

	NO3 kg	T-P kg	NH3 kg	TKN kg	Ortho-P kg	TSS kg
total	4364	1452	227	3136	613	455827
storm	862	1266	182	2638	509	425493
storm %	20%	87%	80%	84%	83%	93%

One of the striking results from this year's sampling was the nitrate concentration. Nitrates are highly soluble and tend to leach into the groundwater. During the summer, the groundwater is the major component of total flow in the creek. During storm events, surface runoff is the major component of flow in the creek. This leads to the normal situation where nitrate concentrations peak during the summer and are diluted by runoff during wet times of the year. Moores Creek nitrate concentrations have shown an increasingly unusual pattern. The nitrate concentrations in the base flow samples were at their lowest level in the spring and summer, then peaked in November (Figure 2.). These nitrates do not appear to be associated with surface runoff, since the storm percentage was only 20%, and do not appear to be associated with groundwater, since the concentrations were low during low flow periods. Another option is that they were transported to the creek in shallow groundwater that percolated into the ground and then flowed directly into the creek without reaching the groundwater table. This means that the time between litter application (for instance) and when the nitrates reached the creek was fairly short. The implication is that there appeared to have been a significant input of nitrates into the Moores Creek basin in the fall that was lost into the creek. Since a study of Lincoln Lake in 1991 showed that nitrates were the limiting factor for algae growth (Trost, 1997), the increased input of nitrates to the lake may have a significant impact on water quality. In addition, since nutrients lost to the creek are nutrients unavailable for growth of forage, management practices that mitigate this effect could be both ecologically and economically valuable.

The second objective of this project was to begin to identify trends in the water quality data. This basin has been studied and sampled since 1991 and a great deal of data has been generated. The initial project from 1991 to 1994 sampled at the lower Moores Creek site. Those investigators concluded that for the three years studied, mean concentrations decreased for NH_4-N, TKN, and COD during base flow and for NO_3-N, NH_4-N, TKN, and COD during storm flow at the lower Moores Creek site (Edwards *et al.*1996 and 1997).

The second project, "The Continuation of Monitoring of the Moores Creek Basin"(Vendrell et al. 1999), lasted from 1995 through 1998. These investigators concluded that the mean concentrations of NH4, TKN and TOC decreased during storm flow and NH4 decreased during base flow at the lower Moores Creek site. Both of these studies used modeling techniques to try to predict trends in monthly mean concentrations. A model that incorporates the typical pattern of higher sediment related nutrient concentrations in the spring and fall (the opposite of dissolved nutrient concentrations) was "fit" to the data by minimizing the differences between the model and the data. The model that "best fit" the data was used to determine the trend (up, down or none) in the concentrations. This type of modeling is usually only applied to long periods of time (5 years minimum) to minimize the errors involved. If the errors involved in determining the annual loads are for example +/- 10%, a 5 % change in those annual loads is indistinguishable. In both of the previous studies, the trends determined were less in magnitude than the errors involved in the modeling.

The upper Moores Creek sampling site that was used in this sampling project has been sampled since 1997. Mean concentrations for each calendar year since then except 1999 are displayed in figure 4. The figure shows that from 1997 to 1998, the mean concentrations for NO_3-N and T-P increased, and from 1998 to 2000 all mean concentrations increased. Mean concentrations, which are the yearly total loads divided by the yearly discharge, are used for comparison because they help reduce the variability that results from changes in runoff for the year. The uncertainties of weather add to the difficulty of determination of trends in water quality, because years with more storm events have higher discharge and higher total loads even if the watershed remains the same. Mean concentrations do not completely remove the effect of weather variation between years because more runoff usually means more storm events with corresponding higher mean concentrations for non-soluble parameters and lower mean concentrations for soluble parameters. These factors illustrate the difficulties in interpreting water quality data over short periods. The fact that nitrates and total phosphorus increased over the four year period despite the fact that total discharge went up and down, probably points to changing conditions in the watershed rather than hydrological variability. However, it is to soon to identify these increases as a significant trend.

FUTURE WORK

A proposal has been submitted to Arkansas Soil and Water Conservation Commission for funding to continue water quality monitoring at the upper Moores Creek site. This project will attempt to determine the effectiveness of the BMPs implemented in the basin and relate those BMPs to changes in water quality in both Moores Creek and in Lincoln Lake. The upper Moores Creek site will have been accurately monitored for five years. Five years is considered by statisticians to be the minimum length of time to determine trends. Lincoln Lake will again be assessed to determine if nitrates are still limiting the algae growth and to assess the changes in water quality that have occurred in the lake in the last ten years. All of this information will be used to help landowners, producers and local officials to make informed decisions about the best ways to maintain or improve the Lincoln Lake watershed while supporting businesses, family farms and the citizens of Lincoln and Washington County.

REFERENCES

Edwards, D. R., T. C. Daniel, J. F. Murdock, P. F. Vendrell, and D. J. Nichols, The Moores Creek monitoring project, Final Report, Arkansas Water Resources Center, University of Arkansas, Fayetteville, Arkansas, 1994.

Edwards, D. R., T. C. Daniel, H. D. Scott, P. A. Moore, Jr., J. F. Murdock, and P. F. Vendrell, Effect of BMP implementation on storm flow quality of two Northwest Arkansas streams, ASAE, (in review), 1997.

Edwards, D. R., T. C. Daniel, H. D. Scott, J. F. Murdock, M. J. Habiger, and H. M. Burks, Stream quality impacts of best management practices in a Northwest Arkansas basin, Water Resources Bulletin, 32(3), 499-509, 1996.

Nelson, M.A., T.S. Soerens, J. Spooner, Optimum Sampling Intervals for Calculating Nutrient Loads in Streams, Proceedings of the 2000 AWRC Conference, April 2000.

Trost, G. K., Nitrate-N Interaction on Phytoplankton Community Structure in Three Reservoirs. Masters of Science Thesis University of Arkansas, May 1997.

Vendrell, P. F., M. A. Nelson, W. L. Cash, K. F. Steele, K. A. Teague, and D. R. Edwards, Nutrient transport by streams in the Lincoln Lake basin, Arkansas Water Resources Center, Publication No. MSC-210, 45-51, 1997.

Acknowledgements

The authors would like to thank the staff of the Arkansas Water Resources Center Water Quality Lab for their hard work and dedication to the highest quality analytical results, without which this project would have been impossible.

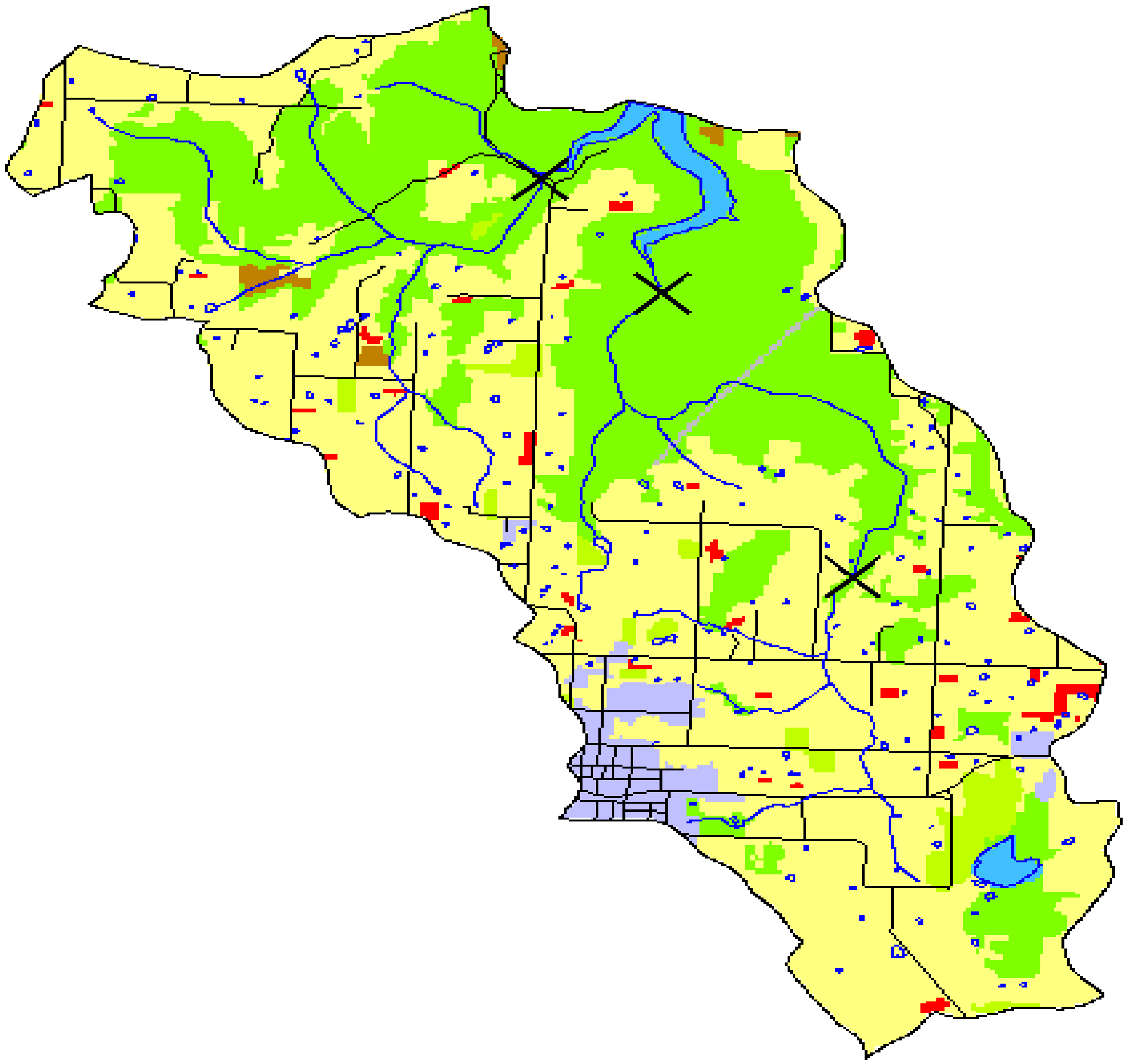

Figure 1. Location of sampling sites.

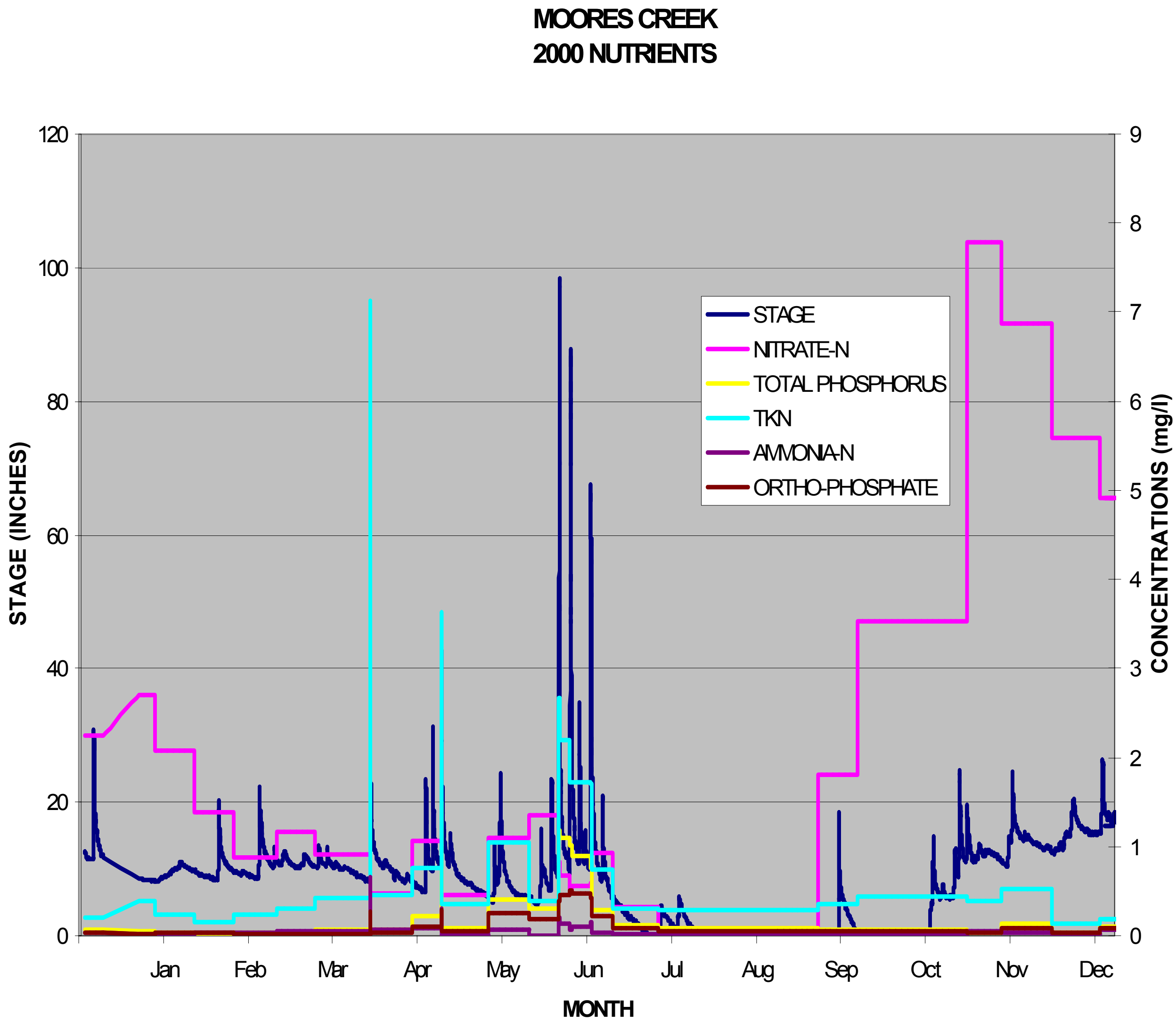

Figure 2. 2000 stage and nutrient concentrations.

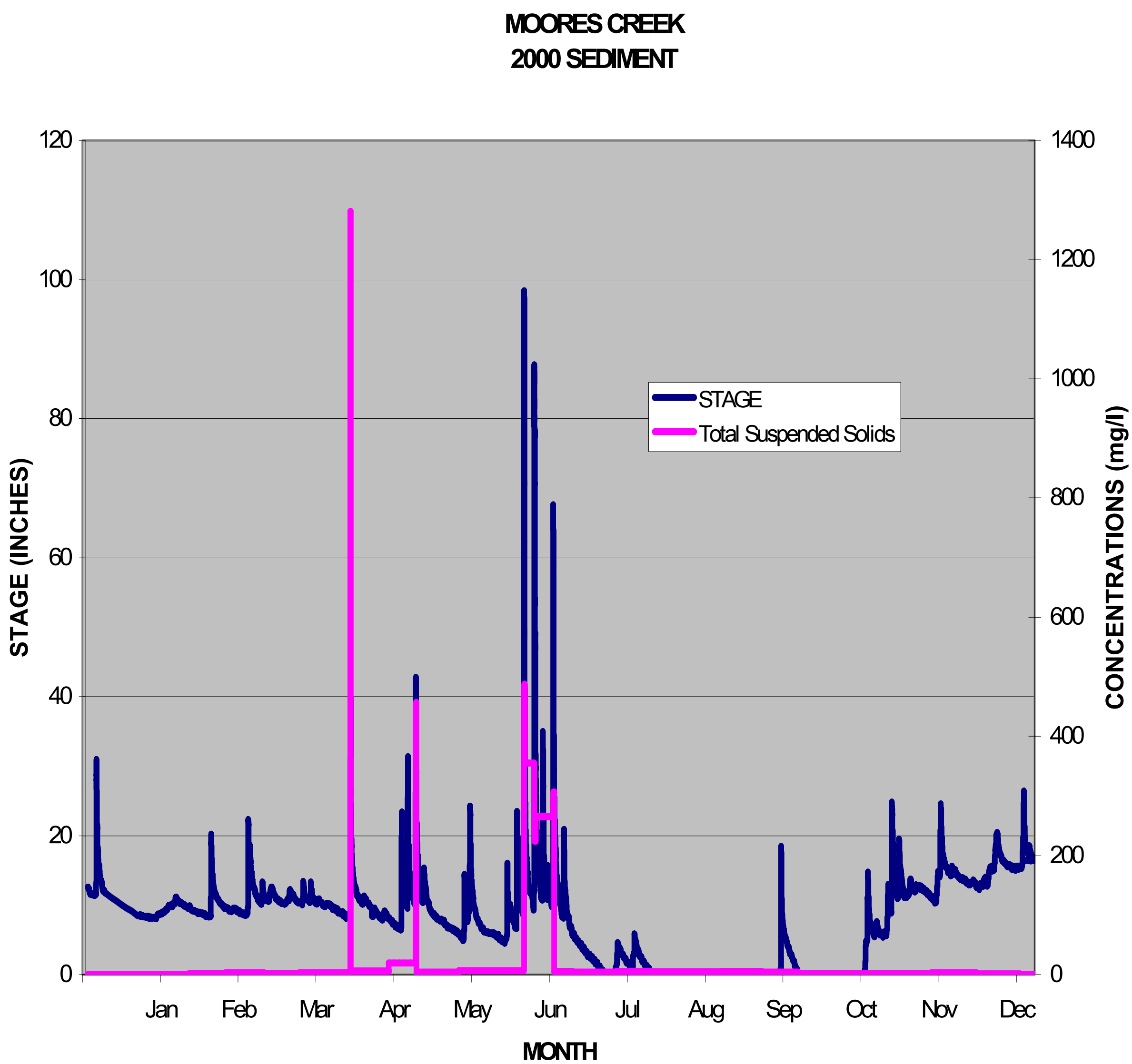

Figure 3. 2000 stage and total suspended solids concentrations.

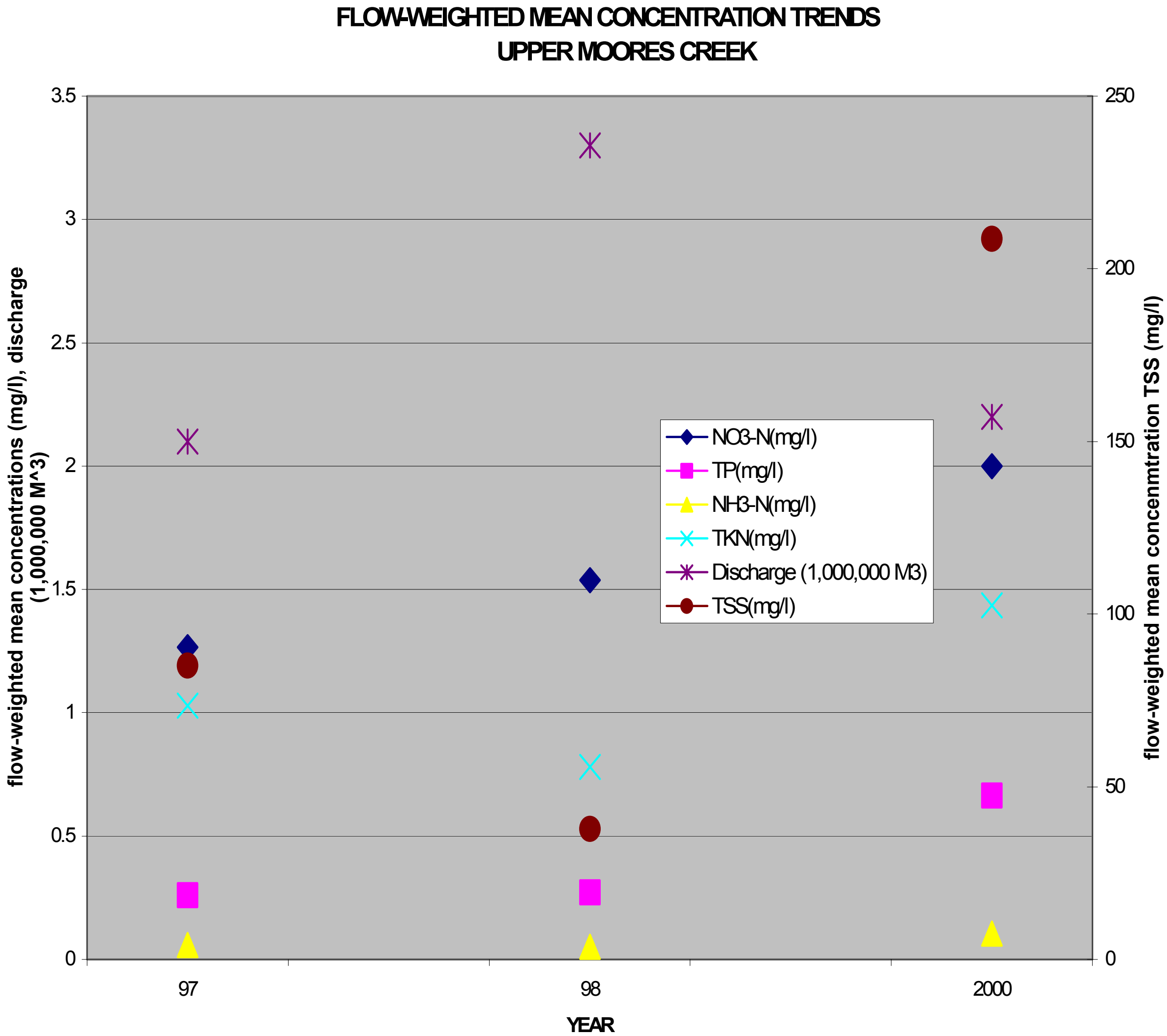

Figure 4. Flow-weighted mean concentration trends.