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Arkansas Water Resources Center

THE MOORE'S CREEK MONITORING PROJECT

Final Report Submitted to:
Arkansas Soil and Water Conservation Commission

By

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EXECUTIVE SUMMARY

Lincoln Lake is a relatively small lake (89 acres) in northwestern Washington County that serves as the public water supply for Lincoln, a town of approximately 1400 inhabitants. Documented problems with the quality of the Lake's water and the possibility that animal production within the Lincoln Lake basin might be a contributor to those problems prompted the Arkansas Soil and Water Conservation Commission (ASWCC), the USDA Soil Conservation Service (SCS) in association with the Washington County Conservation District, and the University of Arkansas Cooperative Extension Service (CES) to initiate in 1990 an intensive program designed to minimize the impact of agricultural practices on water quality. Activities conducted by SCS and the Conservation District were generally "one-on-one" oriented and included farm plan development and assistance with implementing Best Management Practices, or BMPs, the costs of which were sometimes shared with the USDA Agricultural Stabilization and Conservation Service. While CES activities included individual contacts, they were generally oriented more toward group activities such as public meetings, tours, and other mass education efforts. The project was later expanded as the Muddy Fork of the Illinois River Hydrologic Unit Area (HUA) Program In 1991, the ASWCC and US Environmental Protection Agency (USEPA) strengthened their support of the Program by funding a District water quality technician who assists the Conservation District with farm plan development.

Each of the specific practices advocated by SCS and CES (e.g., constructing dead bird composters and matching animal manure application rates to plant nutrient

requirements) can improve the quality of surface and ground water resources if implemented properly. However, there are little data that demonstrate the degree of water quality improvement that can accompany BMP implementation. It would thus have been virtually impossible to determine the water quality impact of the HUA activities within the Lincoln Lake basin without site-specific water quality monitoring. The ASWCC and USEPA subsequently sponsored monitoring in the Lincoln Lake basin to demonstrate the effectiveness, in terms of water quality, of (a) the overall programs implemented by CES and SCS and (b) nutrient management, a specific management practice involving matching animal manure application rates with plant nutrient requirements that was judged as having a particularly high potential for positively impacting water quality.

Stream flow at five sites on Lincoln Lake's two major tributaries (Moores Creek and Beatty Branch) was sampled and analyzed from September 1991 to April 1994 to demonstrate the water quality effectiveness of HUA activities within the basin. Runoff from two pairs of small (1.4 to 3.6 acres) fields was sampled and analyzed to demonstrate the effectiveness of nutrient management in comparison to unmanaged fertilizer application for situations in which both poultry litter and poultry manure were the primary fertilizer sources.

The data from the stream monitoring sites generally indicated decreasing trends (from 14 to 75% per year) in average stream flow concentrations of nitrogen forms and chemical oxygen demand. Average concentrations of phosphorus, fecal coliform, and fecal streptococcus generally did not change over the monitored period. The information collected from the four fields indicated that nutrient management based on phosphorus as the limiting nutrient (i.e., applying inorganic fertilizer to soils with sufficient phosphorus content) decreased both average soil phosphorus content and runoff phosphorus concentration (approximately 28% per year). However, no significant increases in average soil phosphorus content or runoff phosphorus concentration were observed for fields in which nutrient management was based on nitrogen as the limiting nutrient (i.e., applying animal manure to soils with sufficient phosphorus content).

Apart from the HUA activities, there were no reported activities within the Lincoln Lake basin that should have caused the water quality changes observed over the monitoring period. Furthermore, the observed water quality changes were consistent with the effects that SCS and CES activities would be expected to produce. The improving trend in the quality of Lincoln Lake's major tributaries is thus attributed to CES and SCS programs within the basin; i.e., the activities were effective in positively influencing water quality in the basin. The data collected from monitoring the four small fields demonstrate that proper nutrient management can lead to agronomically small losses of nutrients in runoff. The information further points out that if phosphorus is the dominant water quality concern, then an appropriate nutrient management strategy can significantly reduce runoff losses of phosphorus in perhaps a relatively short time.

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ACKNOWLEDGEMENTS

The authors gratefully acknowledge the generous support of the Arkansas Soil and Water Conservation Commission (ASWCC) and the U.S. Environmental Protection Agency (USEPA), Region VI. This work would have been simply impossible without the resources that were made available to conduct the water quality monitoring described herein. The patience, unwavering support, and helpful suggestions of Bob Morgan, Earl Smith, and J. Randy Young of ASWCC were crucial throughout the duration of the project and are especially appreciated. The support and constructive technical suggestions offered by Russell Bowen, David Reazin, Traci Fambrough, and Susan Alexander of USEPA were likewise greatly appreciated.

The cooperation provided by related Federal and State agencies was a model for future studies of this nature. Billy Moore and Merle Gross of the University of Arkansas Cooperative Extension Service were vital in meeting landowners in the Lincoln Lake basin and gaining a sound practical perspective of the issues involved. Mark Habiger and Helen Burks of the USDA Soil Conservation Service provided significant background information on their specific activities in the basin and also gave detailed summaries of where and when various management practices were implemented.

Finally, a multitude of private citizens were tremendously supportive of the project and helped in all matters requested. Don Rutherford and Brian Weaver allowed monitoring of fields on their property, implemented fertilization schemes that facilitated the study, and were helpful in numerous other matters. Their cooperation was essential to the success of the study. Bob Russell and Lee Reed cooperated greatly by allowing access to Beatty Branch and Moores Creek, respectively, along routes across their property. Ruth Parker was a tremendous asset to the project in communicating our objectives to residents in the Lincoln Lake basin. Junior McCratic was extremely helpful in helping identify a route for access to Moores Creek and offered many kind words of encouragement during the study. Bill Keen was also of great assistance in selecting routes and monitoring locations for the streams monitored in the study. Frank Holt provided a location to install an automated weather station and was always very eager to help in any way possible during the project.

INTRODUCTION

Use of manures from confined animal production is the subject of increasing concern in Arkansas, which leads the nation in broiler production and has significant egg and swine production (Arkansas Agricultural Statistics Service, 1993). Northwestern Arkansas water bodies such as Beaver Lake (the water source for approximately 100,000 persons) and the scenic Illinois River are focal points for such concerns because of the value of the water resources and the relatively dense production of poultry (particularly broilers) in the respective basins. Past research has demonstrated potential runoff quality impacts of poultry litter (a combination of manure and bedding material) and manure application to range/pasture land areas (e.g. Westerman et al., 1983; McLeod and Hegg, 1984; Edwards and Daniel, 1992, 1993). There is general agreement on the part of the poultry industry, state and federal agencies, and private citizens that any adverse impacts of poultry litter/manure application in northwestern Arkansas should be minimized to the greatest possible extent subject to applicable constraints.

Users of animal manures have several options they can implement to minimize losses of manure constituents via runoff or subsurface transport. Examples of such options include applying manures at rates compatible with plant nutrient requirements, using buffer zones or "set-backs", timing manure application to make nutrients available when most needed by the plant, and avoiding application to areas that are susceptible to either excessive runoff or excessive leaching. If a management option meets certain criteria, it may be designated as a "Best Management Practice", or BMP. Specifically, a BMP is defined as "a practice or combination of practices that is determined by a state (or designated area-wide planning agency), after problem assessment, examination of alternative practices, and appropriate public participation, to be the most effective practicable (including technological, economic, and institutional considerations) means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals" (Bailey and Waddell, 1979). Options designated as BMPs can be eligible for cost-sharing with agencies such as the USDA Agricultural Stabilization and Conservation Service (ASCS).

Practices designated as BMPs have, by definition, the potential for positively influencing water quality if properly implemented. In the case of some practices, there is firm scientific evidence to indicate how effective a practice will be. In other cases, however, the experimental basis of a particular practice might not be as well-established due to lack of directly applicable research for the particular application. There is also relatively little information to indicate the effectiveness of BMP implementation on moderate to large scales, since BMP effectiveness studies are typically conducted on plots or small fields. Thorough assessment of BMP effectiveness is critical to prioritizing resources and focusing efforts during basin-wide programs to reduce nonpoint source pollution.

Opportunities for basin-scale BMP assessment are rare, but one arose in northwestern Arkansas in 1990. Lincoln Lake, a small (89 acres) lake west of Fayetteville that serves as the public water supply for the city of Lincoln (population approximately 1400), had been reported as experiencing water quality problems such as profuse algal growth and high alkalinity (USDA Soil Conservation Service and

University of Arkansas Cooperative Extension Service, 1990). There was a concern that the problems with Lincoln Lake's quality might be due in part to the animal production occurring within the Lake's drainage area. The Arkansas Soil and Water Conservation District, University of Arkansas Cooperative Extension Service (CES) and USDA Soil Conservation Service (SCS) in association with the Washington County Conservation District subsequently initiated in 1990 an ambitious project to reduce losses of animal manure constituents from land application sites and contributions from dead bird disposal pits to improve the quality of Lincoln Lake. The areal extent of the project was later expanded, and the project became known as the Muddy Fork of the Illinois River Hydrologic Unit Area (HUA) Program. ASWCC and the US Environmental Protection Agency (EPA) strengthened their support of the program by in 1991 by funding a water quality technician who assisted the Conservation District with farm plan development. The bulk of the work performed by CES and SCS in the hydrologic unit was to include public education and technical assistance for implementing Best Management Practices (BMPs), many of which were to be cost-shared through ASCS, respectively. A comprehensive description of activities that were initially planned by those two agencies was provided by SCS and CES (1990)

The major BMPs that were anticipated to be implemented included nutrient management, waste utilization, pasture and hayland management, dead poultry composting, and waste storage structure (pond/lagoon for liquid manure or stacking shed for dry manure). Nutrient management is defined (SCS, 1992a) as "managing the amount, form, source, placement, and timing of applications of plant nutrients. The major water quality benefits that could be expected with nutrient management in the context of animal manure application include reduced runoff concentrations of nitrogen (N) and chemical oxygen demand (COD). No reductions in runoff losses of phosphorus (P) would be expected, primarily because application rates for animal manure are based on meeting plant N requirements, which leads to overapplication of P. Waste utilization is defined (SCS, 1987b) as "using agricultural waste or other waste on land in an environmentally acceptable manner while maintaining or improving soil and plant resources." From the standpoint of potential water quality impacts, waste utilization is very similar to nutrient management in that nutrient management principles are involved in determining waste application parameters (e.g., amount and timing). Pasture and hayland management is defined (SCS, 1987a) as "proper treatment and use of pastureland or hayland" and includes guidelines for beginning and ending grazing, harvesting the forage, and controlling weeds. The potential water quality benefits of pasture and hayland management are related to maintaining desirable soil cover and structure and could include reduced runoff losses of nutrients, solids, and organic matter. Dead poultry composting is defined (SCS, 1990) as "a process in which the normal daily accumulation of dead birds from a poultry facility is mixed with other organic ingredients and converted through biological activity to a stable and useful end product (compost)." In comparison to dead poultry disposal pits (a formerly typical means of handling dead poultry), implementation of dead poultry composting would be expected to influence water quality by reducing N and organic matter loadings to subsurface water, which could be evidenced by an improvement in the quality of flow (particularly base flow) in nearby streams. A waste storage structure is defined (SCS, 1977) as "a fabricated structure for temporary storage of animal or other agricultural waste." A waste storage structure is closely related to and would be expected to produce the same water quality benefits as nutrient management, because the structure can give the manure user the flexibility to time manure application appropriately. However, if the structure alleviates a prior condition in which manure was moving more or less directly into a stream, then relatively dramatic improvements in water quality could result, including reductions in nutrients, organic matter, bacteria, viruses, and other manure constituents. The key practice of all those just mentioned is probably nutrient management, because perhaps the best use of most agricultural by-products (whether manure or dead animals) is land application, and nutrient management principles lead to identification of the best land application parameters.

The Arkansas Soil and Water Conservation Commission (ASWCC) and US Environmental Protection Agency (EPA) determined that the SCS and CES programs provided a good opportunity to gain relevant information regarding the effectiveness of BMP implementation and subsequently sponsored a water quality monitoring program with the objectives of demonstrating the effectiveness of (a) the overall programs implemented by CES and SCS and (b) a specific BMP (nutrient management) with high potential for positively influencing water quality. This report describes the monitoring program that was conducted, the data collected as a result of the monitoring, and conclusions drawn from the data.

DESCRIPTION OF THE AREA

The Lincoln Lake basin is located in northwestern Arkansas, approximately 12 miles west of Fayetteville (Fig. 1). The two major tributaries of the Lake are Moores Creek and Beatty Branch. The Lincoln Lake basin consists of approximately 8001 acres; about 5230 acres drain into Moores Creek with the remainder (2771 acres) draining into Beatty Branch. SCS and CES (1990) reported that portions of the basin lie within both the Boston Mountains and Springfield Plateau regions. The major soil series within the Lincoln Lake basin include Allegheny, Enders, Captina, Hector, Linker, and Mountainburg (SCS and CES, 1990).

There is a diversity of land uses within the Lincoln Lake basin, but the majority of the basin is either forested (approximately 43%) or pasture (approximately 45%). Urban area, orchards/vineyards, and surface water comprise roughly 3, 6, and 2% of the basin area, respectively (SCS and CES, 1990).

Significant confined animal production occurs within the Lincoln Lake basin. SCS and CES (1990) estimate that over 4,000,000 broilers and 128,000 pullets are produced annually. An additional estimated 942,000 caged hens and 62,000 breeders are maintained within the basin (SCS and CES, 1990). SCS and CES (1990) estimated the total manure production from these four production categories as approximately 22,000 tons/year; if applied to all available pasture land in the basin, the application rate would be approximately 6.2 tons of manure/acre/year. The contributions of dairy and beef cattle as estimated by SCS and CES (1990) would amount to another 3.4 tons of manure/acre/year.

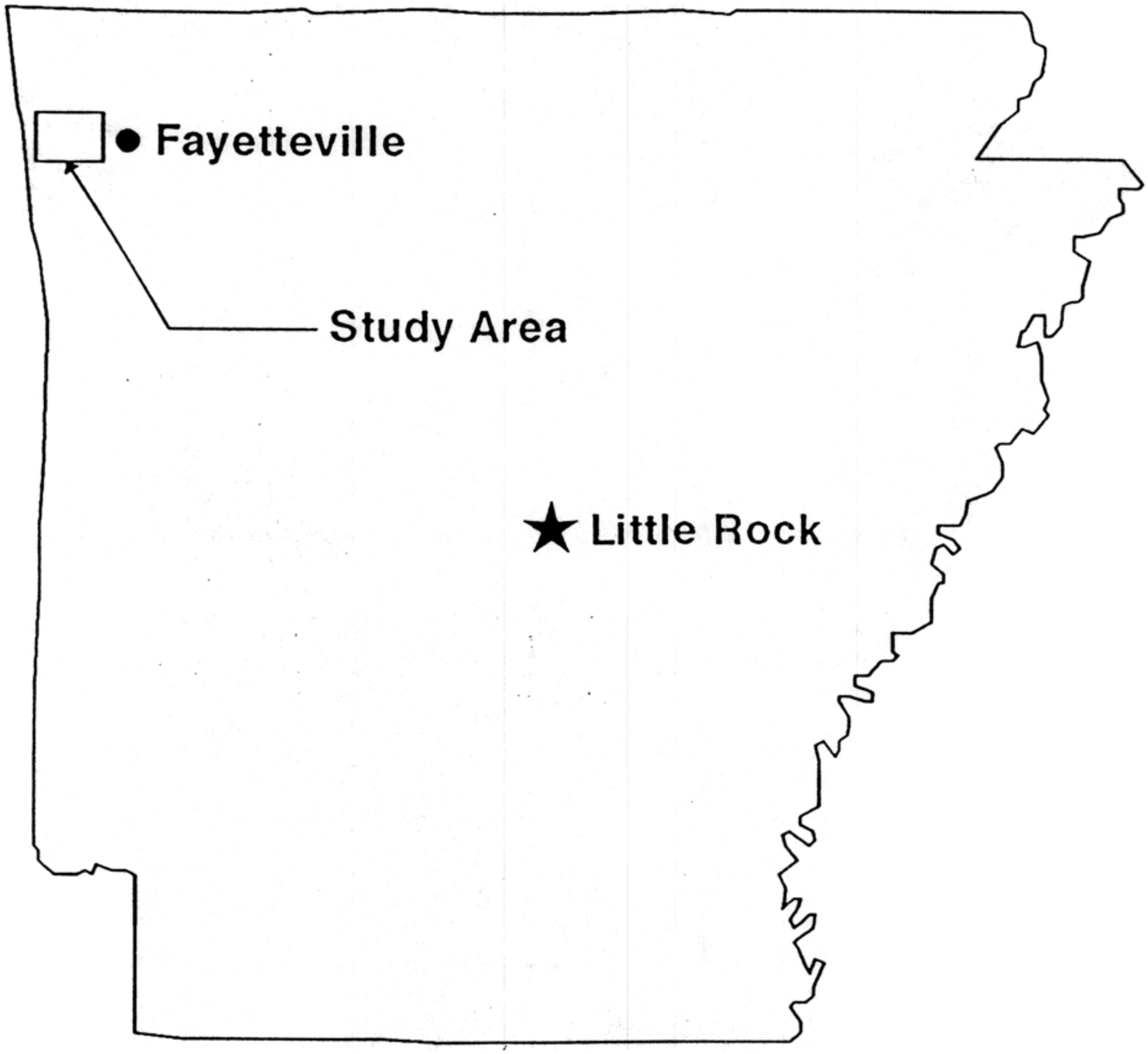


Fig. 1 Vicinity map of the study area

PROCEDURES

Overall Program Demonstration

Rationale

As discussed earlier, the goal of SCS and CES efforts in the Lincoln Lake basin was to improve the quality of water in the Lake, and these efforts were accordingly focused on reducing loadings of nutrients (primarily N) to the lake. Assessing the effectiveness of those activities should thus involve direct measurement of the quality of water entering Lincoln Lake, especially through its two main tributaries (Moores Creek and Beatty Branch).

The BMPs that SCS anticipated installing in the basin had the potential to affect both surface water quality (e.g., nutrient management) and subsurface water quality (e.g., replacing dead bird disposal pits with composters). The monitoring program was thus designed to capture the behavior of water quality in response to any changes in subsurface pollutant inputs (through grab sampling primarily during base flow conditions) as well as surface pollutant inputs (through storm event sampling).

Site Selection and Characteristics

Two sites, one on Moores Creek and one on Beatty Branch, designated as ML (Moores Creek, lower site) and BL (Beatty Branch, lower site), respectively, were identified and designated as storm event monitoring stations (Fig. 2). These sites were located as close as possible to the lake subject to the constraints of landowner cooperation, wheeled vehicle access, and security of instruments. The ML site represents approximately 4437 (85%) of the 5230 acres drained by Moores Creek, whereas the basin of the BL site consists of 1964 acres (71%) of the total area drained by Beatty Branch. The streams at both sites have stony (approximately 3-6 inches diameter) beds with some formation of small pools occurring during low flow periods. The streams flow for most of the year but have been observed to become completely dry during extended periods of low rainfall.

A total of five sites were identified and designated as grab sampling stations (Fig. 2). Sites ML and BL were used for grab sampling as well as for storm event sampling. The three remaining grab sampling sites were selected primarily on the basis of ease of access. Sites MU1 and MU2 (Moores Creek, first and second upper sites, respectively) have drainage basins of approximately 922 and 230 acres, respectively, while site BU (Beatty Branch, upper site) drains approximately 371 acres.

Storm Sample Monitoring Equipment and Procedures

Each of the sites used for storm event monitoring (ML and BL) had instrumentation installed to measure stream stage and to collect water samples during storm events. A pressure transducer (model PCDR950, Druck, Inc.) was secured to a concrete flagstone and emplaced in the bed of each stream to measure stage. The output from the pressure transducers was measured and recorded at 5-minute intervals by data loggers (model CR10 measurement and control modules, Campbell Scientific, Inc.). Automatic water samplers (model 800SL portable liquid sampler, American Sigma) collected samples during storm events. The sample intakes were secured to trees at the edges of the stream beds in the immediate vicinity of the pressure transducers. The sampler tubing and pressure transducer wiring were shielded with plastic conduit and buried from the stream beds to the instrument shelters. The instrument shelters were constructed of wood and sealed to prevent water entry. The shelters were painted with a camoflage pattern and locked for security. The pressure transducers and water samplers were interfaced so that sampling (1 L sample volume) initiated upon detection of a storm event and continued at 2-hour intervals until the storm event had ended. All instruments were powered by batteries and were operational on an essentially continuous basis over the project duration. The monitoring equipment was installed and fully operational by September 23, 1991

Rating curves for the ML and BL monitoring stations were developed by measuring discharge at a range of stages using procedures described by US Geological Survey (USGS) (1969). The rating curves were then constructed according to techniques recommended by USGS (1984). The slope-conveyance method was used to extend the rating curve for stages above which discharge measurements were available.

Water samples were collected as soon as possible (but not later than 24 hr) following each storm event. Samples were transported to the Arkansas Water Resources Center Water Quality Laboratory, prepared for analysis, and analyzed for nitrate nitrogen (NO_3-N), ammonia nitrogen (NH_3-N), total Kjeldahl nitrogen (TKN), ortho-phosphorus (PO_4-P), total phosphorus (TP), chemical oxygen demand (COD), total suspended solids (TSS), fecal coliforms (FC), and fecal streptococci (FS). Standard methods of analysis (Greenberg et al., 1992) were used in all analyses. Ion chromatography was used in analyses of NO_3-N and PO_4-P. The ammonia-selective electrode method was used to determine NH_3-N. The macro-Kjeldahl method was used in TKN analyses. Total P was determined by the ascorbic acid colorimetric method following sulfuric acid-nitric acid digestion. The closed-reflux, colorimetric method was used for COD determinations. The membrane filtration technique was used to analyze runoff concentrations of fecal coliforms and streptococci.

Due to resource constraints, it was not possible to analyze all runoff samples collected. Thus, a subset of runoff samples was selected for analysis from each storm event so that the rising and falling limbs as well as the peak of the runoff hydrograph were represented. Flow-weighted means of analysis parameters were computed by integrating with respect to time the products of analysis parameter concentrations and flow rates and then dividing the result by the total runoff amount, determined by integrating runoff rate with respect to time. Event losses, or masses transported past the monitoring station, of analysis parameters were computed simply as the integral, with respect to time, of the products of analysis parameter concentrations and runoff rates with appropriate conversions for consistency of units.

Grab Sample Monitoring Equipment and Procedures

Grab samples (1 L sample size) were collected from each of the grab sampling sites (ML, MU1, MU2, BL, and BU) on approximately a two-week sampling interval. The grab samples were analyzed as described previously for storm event samples. In addition, *in situ* measurements of pH, electrical conductivity, dissolved oxygen, and temperature were conducted using a portable water analyzer (Industrial and Chemical Measurement, Model 51000) that was calibrated prior to each use.

Handling and Use of Data

In the cases of sites ML and BL, for which flow and water quality data were available, the data were used to estimate transport of analysis parameters by integrating the products of concentration and flow rate. Flow-weighted mean concentrations of analysis parameters then calculated by dividing parameter transport by flow volume. The time bases of the integrations were chosen so that each set of concentration and mass transport computations reflected either a discrete storm event or a discrete period of base flow. Natural logarithms of the parameter transport and concentrations for the various time periods were then regressed against time to determine whether there were any statistically significant trends in the data. The natural logarithms of the data were used in preference to the original data because (a) the concentration and transport data have a lower bound of zero, and (b) the results of this type of analysis were judged to provide a much better basis for assessing rates of change in analysis parameter concentrations and mass transport. All statistical tests of significance were conducted at the $p=0.05$ level. Investigation of trends in water quality parameters were conducted using (a) all concentration and mass transport data, (b) concentration and mass transport data associated primarily with storm events, and (c) concentration and mass transport data associated primarily with base flow.

Only analysis parameter concentration data were available for sites MU1, MU2, and BU, so it was not possible to compute flow-weighted concentrations or transport of analysis parameters. Thus, only the natural logarithms of observed concentrations of analysis parameters were regressed against time to define whether significant trends were present in the data.

BMP Installation Tracking

Data based on farm plan records were provided from the SCS Washington County District that indicated when and where BMPs were installed during the duration of the monitoring. These data were used to compute cumulative area affected by BMP installation for each monitoring site as a function of time.

Nutrient Management Demonstration

Rationale

Nutrient management effectiveness was assessed by selecting two pairs of fields and then analyzing the quality of samples of runoff from the fields. Fertilizer application to one of each pair of fields was to be managed based on nutrient management principles described by SCS (1992b); the other field in each pair would receive "unmanaged" fertilizer application. The primary fertilizer sources were to be poultry litter for one pair of fields and poultry manure for the other. These types of animal manures were selected for use because they are commonly land-applied to pasture areas in the Lincoln Lake basin.

Field Selection and Characteristics

Fields to be monitored were selected by first identifying potential cooperators and then conducting an on-site reconnaissance of favorably inclined land-owners' property. Cooperating land-owners' property was inspected for suitable potential monitoring sites (i.e., fields of small to moderate size with well-defined outlets), ease of wheeled (all-terrain) vehicle access, and security of monitoring instruments. Specific pairs of fields were then selected based on similarity of cover and management. One of the pairs of fields selected was owned by one individual, and the other pair was owned by another. The approximate locations of the fields are shown in Fig. 2. The predominant cover for all fields was "tall" fescue (*Festuca arundinacea* Schreb.).

Professional surveyors were contracted to prepare topographic maps, with drainage basins delineated, of the monitored fields (Figs. 3-6). Table 1 lists selected characteristics of the monitored fields. As may be inferred from Table 1, there were some differences in field characteristics, particularly with respect to area and soil. Unfortunately, it was not possible to identify identical paired fields, and the final field selections represented several compromises in terms of desirable characteristics.

Runoff Monitoring Equipment and Procedures

Each monitored field had instrumentation installed at the outlet to measure runoff rates and to collect runoff samples during storm events. Runoff was channeled into type "H" flumes (Agricultural Research Service, 1979) with flume depths of 12 inches for fields RM ("R" site, managed) and WU ("W" site, unmanaged) and 18 inches for fields RU ("R" site, unmanaged) and WM ("W" site, managed). Stilling wells were constructed and attached to the flumes. A pressure transducer (model PCDR950, Druck, Inc.) was placed inside each stilling well to measure water height inside the flume. The stilling wells were constructed so that the pressure transducers were approximately 1 inch beneath the flume floor. Pressure transducer output was measured and recorded at 5-minute intervals by data loggers (model CR10 measurement and control modules, Campbell Scientific, Inc.). Flume rating tables reported by Agricultural Research Service (1979) were used to convert water height inside the flume to discharge rate. Runoff was sampled by automatic water samplers (model 800SL portable liquid sampler, American Sigma) installed at each flume.

Sampler intake holders were constructed from a horizontal wooden base to which wooden blocks were attached to form a narrow (1 inch wide, 2.5 inches deep) channel with one end (toward the flume) of the channel blocked. The sampler intake holders were positioned and secured just below the flume outlets. The sample intake apparatus ensured the collection of well-mixed samples and minimal air pumpage. The water sampler and data logger were interfaced so that when water height inside the flume reached 1 inch, runoff sample (1 L sample volume) collection initiated with samples collected at 5-minute intervals until either all 24 sample bottles were filled or flume water height had fallen below 1 inch. In addition to the runoff measurement and sampling equipment, a tipping bucket rain gage was installed in the vicinity of each pair of fields. All instruments were powered by batteries and were operational on an essentially continuous basis over the project duration. The monitoring equipment was installed and operational by September 1, 1991

Runoff samples were collected as soon as possible (but not later than 24 hr) following each runoff event. Runoff samples were transported to the Arkansas Water Resources Center Water Quality Laboratory, prepared for analysis, and analyzed for NO_3-N, NH_3-N, TKN, PO_4-P, TP, COD, TSS, FC, and FS. Standard methods of analysis (Greenberg et al., 1992) were used in all analyses as described earlier for the stream samples.

As with storm event samples at the ML and BL monitoring stations, a subset of runoff samples from each event was selected for analysis so that the rising and falling limbs as well as the peak of the runoff hydrograph were represented. Flow-weighted means of analysis parameters were computed by integrating with respect to time the products of analysis parameter concentrations and flow rates and then dividing the result by the total runoff amount, determined by integrating runoff rate with respect to time. Event losses of analysis parameters were computed simply as the integral, with respect to time, of the products of analysis parameter concentrations and runoff rates with appropriate conversions for consistency of units.

Handling and Use of Data

The data on runoff rates and analysis parameter concentrations were used to estimate losses and mean event concentrations of analysis parameters as described earlier for the stream monitoring stations. The natural logarithms of event parameter losses and concentrations were then regressed against time as described for the stream flow data to determine whether there were any statistically significant trends in the data. All statistical tests of significance were conducted at the $p=0.05$ level. No separation of the data into storm and base flow events was necessary, because flow from the fields occurred only in association with storm events.

Field Management

The determinations of which field in each pair would be nutrient-managed and which would be unmanaged were based on soil P contents as assessed through initial analyses of soil samples. For each pair of fields, the field with the higher soil P content was to have been used to demonstrate nutrient management relative to "unmanaged" fertilizer application to the field with the lower soil P content. Extractable (Mehlich III) P contents of the upper 6 inches of soil were found to be 312 and 614 lb/ac for fields RU and RM, respectively. This finding suggested a history of animal manure application at rates exceeding plant P requirements. The lower soil P content for field RU was consistent with the land-owner's observations that the field was not as trafficable after rainfall as field RM and thus was not fertilized as often. A similar disparity in soil P contents was found for fields WM and WU. Extractable soil P content of the upper 6 inches of soil was initially found to be 1260 lb/ac for field WM and 420 lb/ac for field WU. The soil test results again suggested relatively long-term application of animal manures at rates in excess of plant P requirements and were consistent with information from the land-owner regarding a large application of animal manure to field WM.

As discussed earlier, proper nutrient management includes the application of appropriate amounts of nutrients at appropriate times with amounts and times determined from such information as soil testing results, type of crop grown, and reasonably expected yield. In the cases of fields RM and WM, soil P levels were sufficiently high that further additions of P would not be expected to result in increased forage yields. Application of additional P to these fields through animal manures would have thus constituted P disposal. Fields RM and WM were therefore selected as the fields on which nutrient management would be implemented, and the management would consist of application of inorganic fertilizer (NH_4NO_3) at approximately agronomic rates, adjusted for losses (leaching and denitrification). Fields RU and WU were treated as unmanaged fields. Poultry litter and manure were applied to fields RU and WU, respectively, at approximately agronomic rates, even though the soil P in those fields was also sufficiently high for maximum forage production. The nutrient-managed fields were thus RM and WM, and the management consisted of NH_4NO_3 application because of high soil P; fields RU and WU received poultry litter and manure, respectively, and were considered unmanaged because the additional P applications were unjustifiable on an agronomic basis.

The schedule of fertilizer applications to the monitored fields is given in Table 2. Only one application of poultry manure per year to field RU was possible because of poor trafficability in the field. The application rate for field RM, which received split applications of NH_4NO_3, was adjusted upward in 1993 to better offset leaching and denitrification losses as estimated using SCS (1992) methods. Field WM was to also receive split applications of NH_4NO_3, but received only a single application in 1992 because the actual amount applied was greater than the target rate. Field WU received split applications of poultry litter at an approximate gross application rate of 2.5 tons/ac. Laboratory analyses of the poultry litter and manure applied to fields RU and WU appear in Tables 3 and 4, respectively.

All monitored fields were grazed during the monitoring period. The grazing densities, as determined from information supplied by the landowners, are shown in Table 5. In the cases of fields WM and WU, there were differences in grazing strategies during the monitoring period. The impact of the grazing differences in runoff quality is unknown, but was probably relatively slight. While it would certainly have been preferable to have equal grazing densities for fields WM and WU, this was not possible because of the landowner's pasture management strategy.

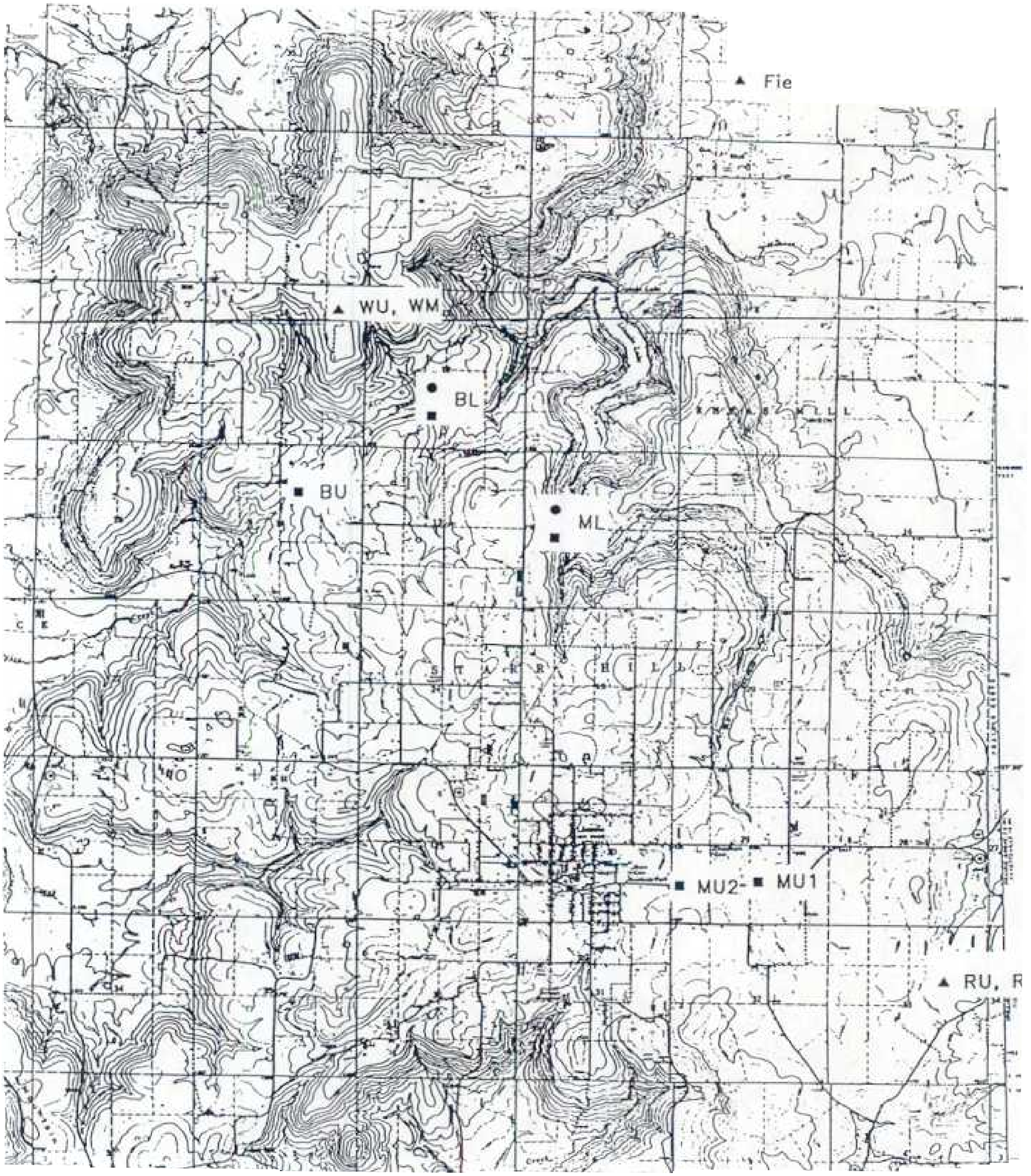


Fig Locations of storm event and grab sampling sites

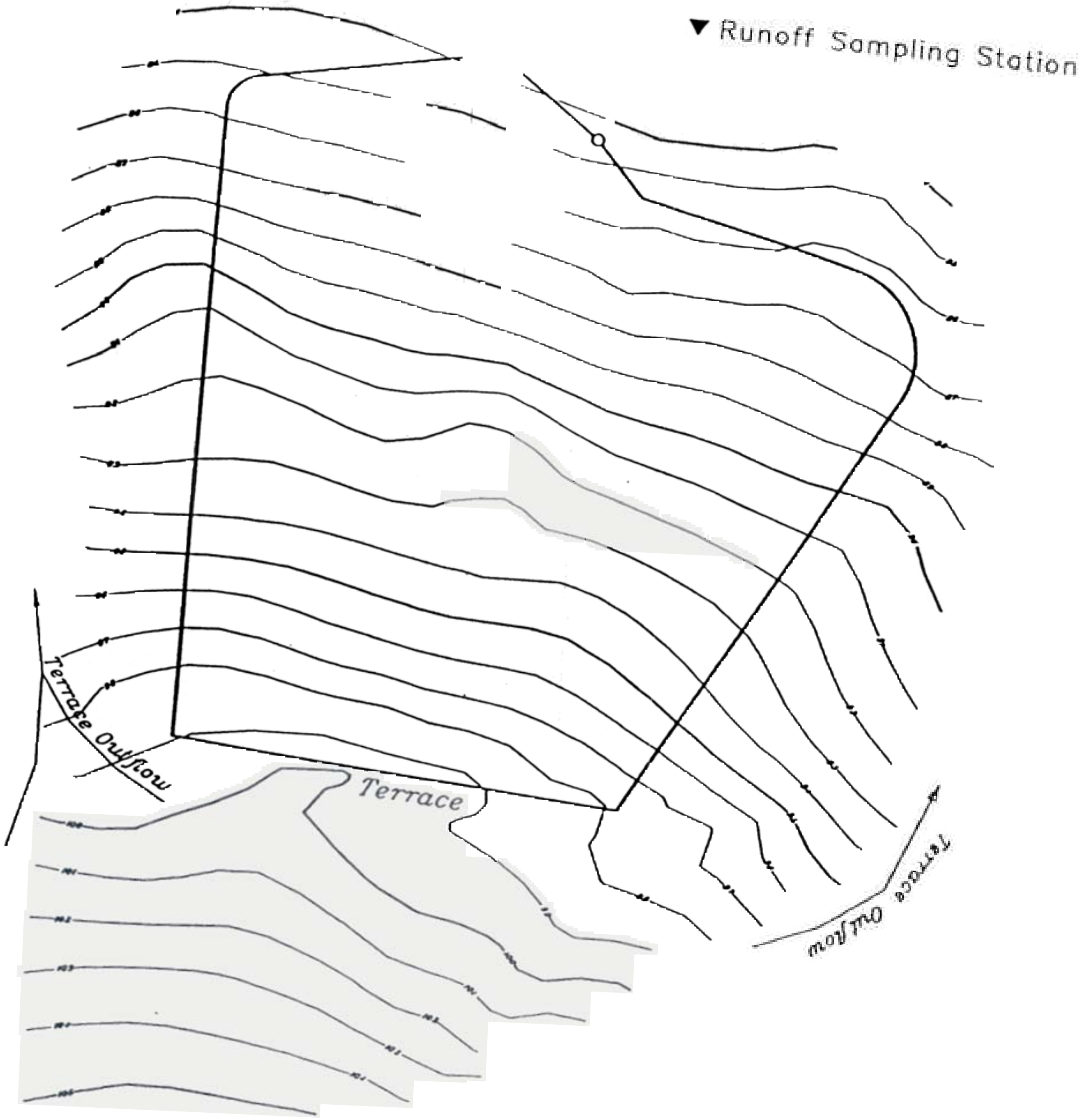


Fig. Topographic map of field RU

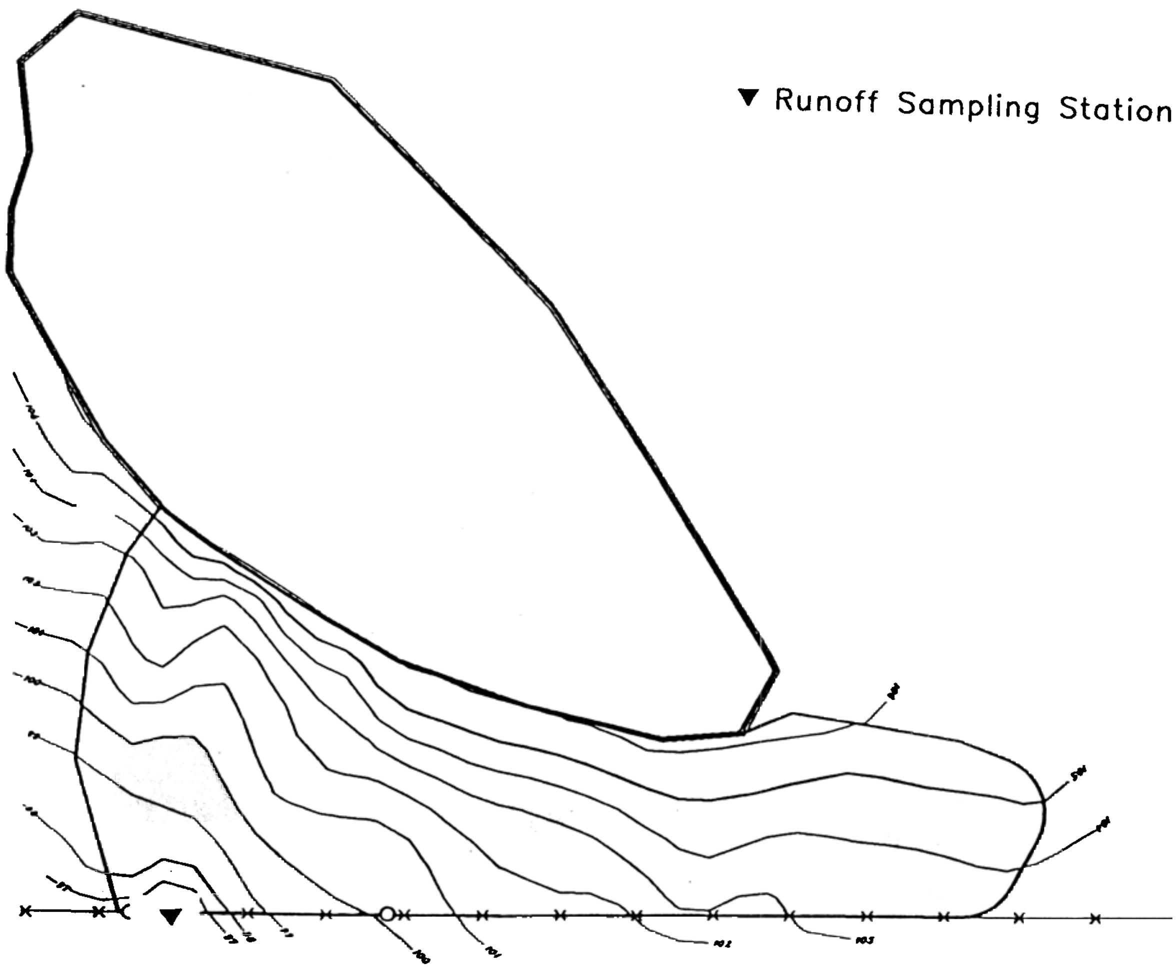


Fig. 4. Topographic map of field RM

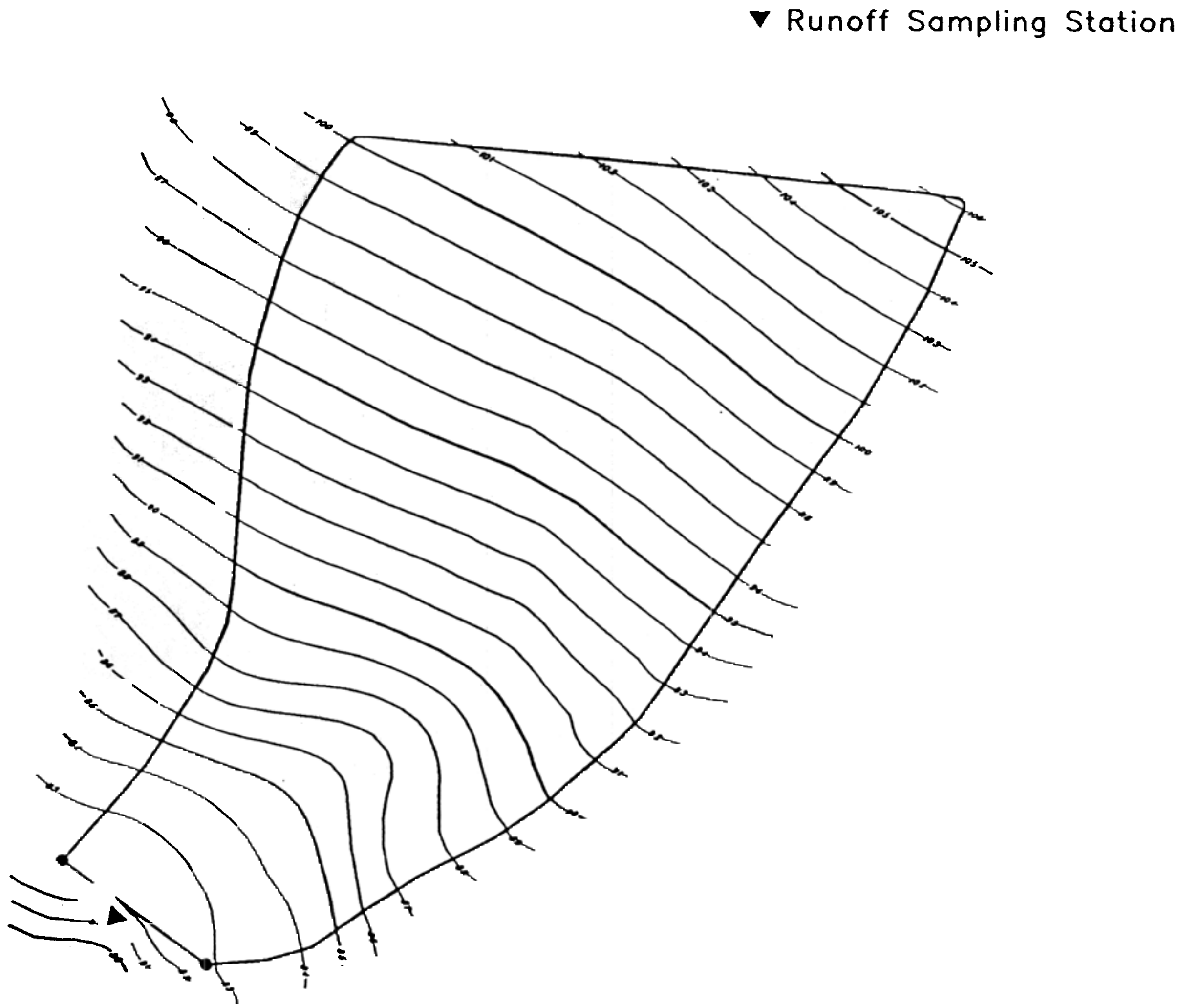


Fig. 5. Topographic map of field WU

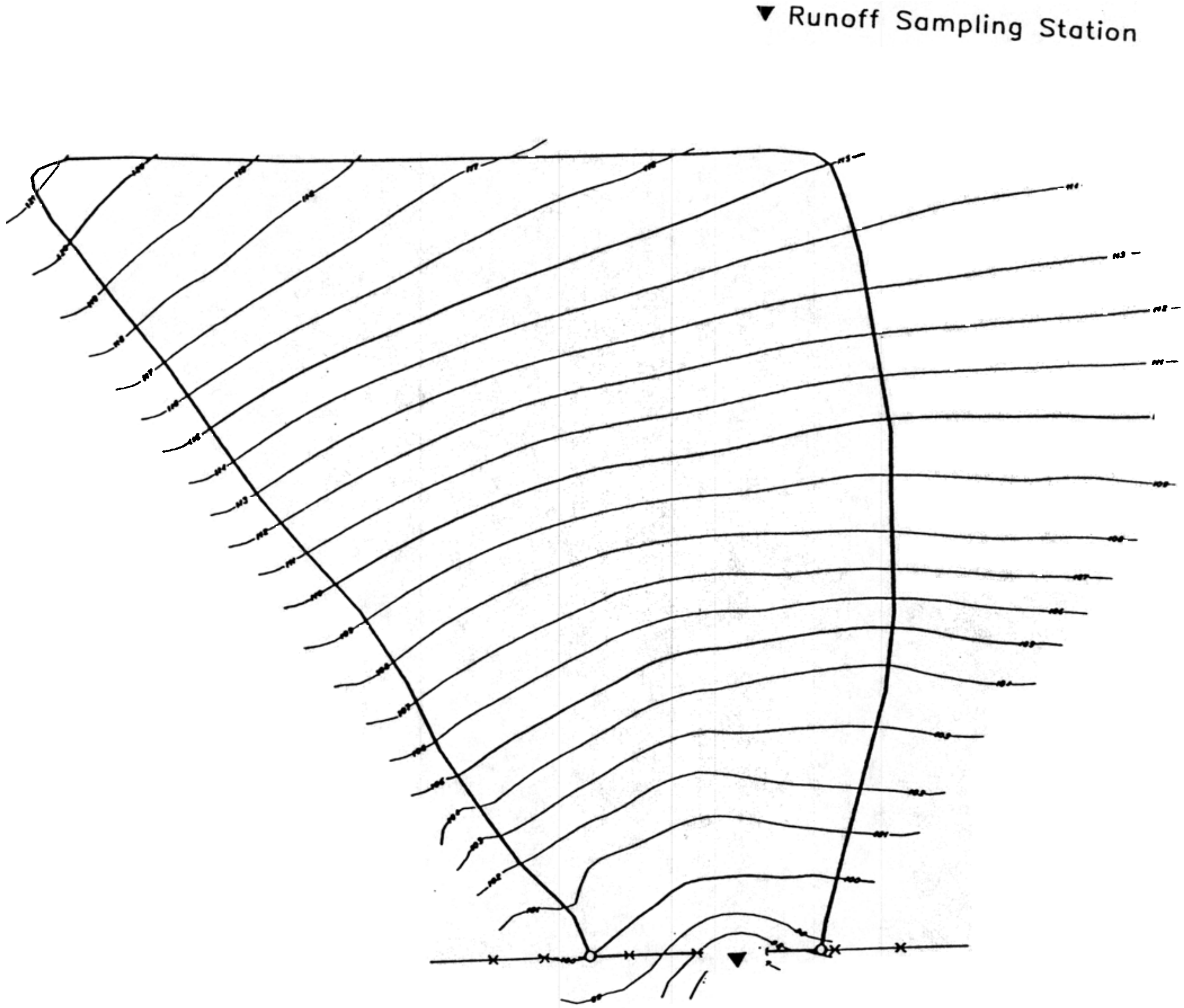


Fig. 6. Topographic map of field WM

Table 1

Selected characteristics of the monitored fields

	Area acres	Soil[1]	Curve[2] Number	Average Slope	Slope Length ft	Erodibility[3] tons/ac/year
RU	3.04	Captina silt loam	74	0.03	450	0.44
RM	1.41	Fayetteville fine sandy loam	61	0.02	465	0.24
	2.62	Hector-Mountainburg stony fine sandy loam/ Allegheny gravelly loam	64	0.04	590	0.22
	3.61	Linker loam	79	0.04	635	0.24

[1] Harper et al., 1969
[2] Soil Conservation Service, 1986
[3] Soil Conservation Service, 1983

Table 2

Fertilizer application schedule for the monitored fields

	Date	Fertilizer Type	Application Rate lb/ac	
			N	P
	03/15/92	Poultry Manure	296	106
	07/13/93	Poultry Manure	402	186
RM	03/23/92	NH_4NO_3	60	0
	08/14/92	NH_4NO_3	60	0
	04/22/93	NH_4NO_3	103	0
	07/14/93	NH_4NO_3	121	0
WU	03/23/92	Poultry Litter	194	55
	08/13/92	Poultry Litter	128	53
	04/13/93	Poultry Litter	141	38
	07/20/93	Poultry Litter	173	63
	03/29/94	Poultry Litter	166	63
	03/23/92	NH_4NO_3	123	0
	04/13/93	NH_4NO_3	91	0
	07/20/93	NH_4NO_3	91	0
	03/24/94	NH_4NO_3	90	0

Table 3

Composition of poultry manure applied to field RU

Date	Gross Application Rate gallons	Water %	Total N	NH_4-N	NO_3-N	Total P	K	Fe	Cu
			------------------- lb/1000 gal -------						
03/15/92	13,750	88.11	65.20	40.36	3.60	23.36	31.64	0.76	0.31
07/13/93	13,750	87.00	88.64	52.46	0.96	41.01	44.31	2.18	0.48

Table 4

Composition of poultry litter applied to field WU

Date	Gross Application Rate tons	Water %	Total N lb/ton	NH_4-N lb/ton	NO_3-N lb/ton	Total P lb/ton	K lb/ton	Fe lb/ton	Cu lb/ton
03/23/92	5.7	19.1	89.00	11.71	0.48	25.33	30.07	0.33	1.04
08/13/92	6.0	36.1	55.85	0.50	0.01	23.24	53.82	0.63	0.68
04/13/93	5.4	18.7	68.48	11.86	1.30	18.24	40.28	0.47	2.98
07/20/93	7.2	25.4	63.00	8.08	1.43	23.02	52.20	0.32	0.62
03/29/94	7.2	24.3	60.65	5.78	0.24	23.20	44.15	0.19	0.79

Table 5

Grazing schedule for the monitored fields

Month	Field			
	RU	RM	WU	WM
	------ animal units/ac --------			
08/91	2.0	2.0	0.3	0.3
09/91	2.0	2.0	0.3	0.3
10/91	2.0	2.0	0.3	0.3
11/91	2.0	2.0	0.3	0.3
12/91	2.0	2.0	0.3	0.3
01/92	2.0	2.0	0.3	0.3
02/92	2.0	2.0	1.0	0.0
03/92	2.0	2.0	1.0	0.0
04/92	0.0	0.0	1.0	0.0
05/92	0.0	0.0	1.0	0.0
06/92	0.0	0.0	1.0	0.0
07/92	0.0	0.0	1.7	0.0
08/92	0.0	0.0	1.7	0.0
09/92	1.5	1.5	1.1	1.1
10/92	1.5	1.5	1.1	1.1
11/92	1.5	1.5	1.1	1.1
12/92	1.5	1.5	1.1	1.1
01/93	1.5	1.5	1.5	0.0
02/93	1.5	1.5	1.5	0.0
03/93	1.5	1.5	1.5	0.0
04/93	1.5	1.5	1.5	0.0
05/93	0.0	0.0	1.5	0.0
06/93	0.0	0.0	0.9	0.0
07/93	0.0	0.0	0.0	0.0
08/93	1.4	1.4	0.0	1.0
09/93	1.4	1.4	0.0	1.0
10/93	1.4	1.4	0.0	1.0
11/93	1.4	1.4	0.5	0.5
12/93	1.4	1.4	0.5	0.5
01/94	1.4	1.4	0.5	0.5
02/94	0.0	0.0	0.5	0.5
03/94	0.0	0.0	0.5	0.5
04/94	0.0	0.0	1.0	0.0

RESULTS AND DISCUSSION

Weather

Daily rainfall recorded by the rain gages at fields RU/RM and WU/WM is given in Tables 6-9 and 11-14. Monthly and annual total rainfall are summarized in Tables 10 and 15. Rainfall observed at the four fields was higher than historical average amounts recorded for Fayetteville, Arkansas (the nearest weather station with available daily rainfall data). Rainfall observed at fields RU and RM was 14% higher than average, and rainfall at the WM and WU fields was 28% higher than average.

Overall Program Demonstration

BMP Installation Tracking

The BMPs installed in the monitored areas included nutrient management, waste utilization, pasture and hayland management, dead poultry composting, and waste storage structures (poultry litter dry stacking shed or liquid waste storage facility). The first three BMPs were nearly always implemented simultaneously as somewhat of a "package."

The running acreage above each monitoring site under implementation of BMPs is indicated in Figs. 7 through 11 These figures address only land on which the first three BMPs (nutrient management, waste utilization, and pasture and hayland management) were implemented, since the last two (dead bird composter and waste storage structure) are not directly associated with a land area. The proportions of monitored drainage basins under BMP implementation ranged from 11.3 (site MU2) to 84.4% (site BU) at the end of the monitoring period (Figs. 9 and 11). A higher proportion of monitored area was under BMP implementation for site BL (36.8%, Fig. 10) than for site ML (24.3%, Fig. 7) at the conclusion of the monitoring period.

Several dead poultry composters and waste storage structures had been constructed by the end of the monitoring period. At the conclusion of monitoring, eight dead bird composters and one waste storage structure had been constructed within site ML's monitored area; of these, one dead poultry composter and two waste storage structures had been constructed within site MU1's monitored area. There was only one dead poultry composter and no waste storage facilities constructed within site BL's monitored area, and the composter was not located within site BU's monitored area.

Grab Sampling Sites MU1, MU2, and BU

Concentrations of analysis parameters measured for sites MU1, MU2, and BU are given in Tables 16, 17, and 18, respectively. Arithmetic mean concentrations of analysis parameters are given in Table 19. In general, most analysis parameters exhibited significant variation that could have resulted from a variety of causes (e.g. stream flow rate and application of animal manures). Noteworthy characteristics of the data include the relatively high NO_3-N concentrations that were observed during the first 6-7 months of monitoring and the FC concentrations, which often exceeded both primary and secondary contact standards (200 and 1000/100 mL, respectively; Arkansas Department of Pollution Control and Ecology, 1991). Concentrations of TKN and NH_3-N were also high for all three sites in Spring 1992. High Spring TKN and NH_3-N concentrations were also noted in 1993 for sites MU1 and MU2. The presence of significant amounts of unoxidized N in the water indicates an organic N source.

Given that the high TKN and NH_3-N concentrations occurred near the time that animal manures are typically land-applied, it is possible that the TKN and NH_3-N concentrations were related to animal manure application.

Concentrations of several analysis parameters decreased significantly during the monitoring period. Annual changes in analysis parameter concentrations are summarized in Table 20. The annual changes in analysis parameter concentrations reported in Table 20 represent the slopes of the regression lines relating the natural logarithms of concentrations to time. The following example illustrates the use of the significance of the annual changes. If the fitted regression line yields a parameter concentration of 10 mg/L at time zero, and if the annual change in the parameter concentration is -40%, then the regression line at a time of one year will pass through a concentration of 6 mg/L [10 mg/L + (10 mg/L)(-40%/100)]. At a time of two years, the regression line will pass through the point 3.6 mg/L [6 mg/L + (6 mg/L)(-40%/100)], and so forth.

For all three monitoring sites, concentrations of NH_3-N, TKN, and COD exhibited significantly decreasing trends over the monitored period (Figs. 13-15, 18-20, 23-25). Concentrations of both PO_4-P and TP decreased significantly over the monitored period for site MU2 (Figs. 16 and 17). Other analysis parameters with decreasing trends in concentrations were TP for site MU1 (Fig. 12), TSS for site MU2 (Fig. 21), and NO_3-N and TSS for site BU (Figs. 22 and 26). The decreasing trends in concentrations of N species and COD are consistent with changes in animal manure management activities, such as would have occurred with BMP installation, within the monitored areas. Activities that could have impacted subsurface water quality, such as dead poultry composter installation, appear not to have played a large role in the changes in N and COD concentrations since, as noted earlier, only one dead bird composter was installed in the MU1 drainage area, and none was installed within the drainage area of either MU2 or BU. Implementation of the waste utilization, pasture and hayland management, and nutrient management BMPs, on the other hand, could be expected to impact stream flow N and COD concentrations through more efficient application rates and more effective timing of application. No significantly decreasing trends in stream flow P concentrations would be expected as a result of waste utilization and nutrient management implementation, because the animal manure application rates are based on N rather than P, which means that P is consistently applied in excess of plant requirements and can accumulate. The reason for decreasing P concentrations observed at sites MU1 and MU2 are thus not known but might be related to better pasture management (which could reduce runoff of both soluble and sediment-bound materials) and/or decreasing stream P inputs from a non-agricultural during the monitored period. It is similarly difficult to identify the cause of the decreases in TSS concentrations for sites MU2 and BU, but those decreases might also be related to improved pasture management.

Grab and Storm Sampling Sites ML and BL

Concentrations of analysis parameters observed for sites ML and BL are given in Tables 21 and 22, respectively. Summarized flow-weighted mean concentrations of analysis parameters are given in Tables 23 and 24 for sites ML and BL, respectively. As discussed in the earlier subsection, the data exhibit significant variability, much of which can be attributed to stream flow rate. The earlier general comments regarding relatively high NO_3-N concentrations observed at the beginning of the monitoring period and the frequently high FC concentrations also hold for sites ML and BL. The pattern of relatively high concentrations of NH_3-N in Spring 1992 for both sites and in Spring 1993 for site ML also held. Tables 23 and 24, which separate mean analysis parameter concentrations according to the associated flow regime, demonstrate that storm flows had higher concentrations of PO_4-P, TP, COD, TSS, FC, and FS than did base flow.

Tables 25 and 26 summarize annual changes in analysis parameter concentrations for the ML and BL sites. Concentrations of TKN demonstrated decreasing trends with time for base flow, storm flow, and overall flow both both sites (Figs. 28, 32, 35, 38, 40, and 45). Concentrations of NO_3-N decreased only during storm flow for site ML (Fig. 30), but concentrations of NH_3 decreased during base flow, storm flow, and overall flow for site ML (Figs. 27, 31, and 34) and during base flow and overall flow for site BL (Figs. 37 and 44). Results with respect to COD, TSS, and FC were mixed. Concentrations of COD decreased only during storm flow for site ML (Fig. 33) and during both storm and overall flow for site BL (Figs. 41 and 46). TSS concentrations increased during storm flow for the BL site (Fig. 42). Increases were also observed in concentrations of FC, with concentrations increasing during base flow and overall flow for site ML (Figs. 29 and 36) and during both base and storm flow for site BL (Figs. 39 and 43). There were no trends in concentrations of PO_4-P, TP, or FS during any flow regime for either site ML or BL.

The trends in concentrations of NH_3-N and TKN are generally consistent with BMP implementation, as discussed for the grab sampling sites. The decreasing trend in COD for storm flow at the ML site and for storm and overall flow at the BL site might be due in part to decreased inputs of unoxidized N (i.e., related to BMP implementation). The increasing trends in TSS and FC concentrations are attributed to relatively higher stream flow in the later portion of the monitoring period. Storm flows demonstrated a significantly increasing trend for both sites ML and BL, and both TSS and FC concentrations were positively correlated with flow rate. It is likely that toward the end of monitoring, a relatively large number of periods designated as associated with "base flow" were actually residuals of storm flow than during the beginning of monitoring.

Mass losses of analysis parameters are given in Tables 27 and 28 for the ML and BL stations, respectively. Analysis parameter losses for the two sites are summarized in Tables 29 and 30. Tables 29 and 30 demonstrate that far more losses of analysis parameters were associated with storm events than base flow. Losses of PO_4-P, TP, COD, and TSS were more closely associated with storm events than losses of N species, indicating a relatively limited occurrence of transport via subsurface flows for those parameters.

Annual trends in analysis parameter losses are summarized in Tables 31 and 32 for sites ML and BL, respectively. Significant trends in analysis parameter losses were not as evident as for parameter concentrations. This was expected, however, since losses are the products of concentrations and flow volumes. Losses will thus have higher variance than concentrations alone, making it more difficult to declare any trends statistically significant. Assuming that flows are statistically stationary, however, trends in losses should mirror those in concentrations as the size of the data set increases.

Losses of TKN exhibited relatively consistent decreasing trends, decreasing during both storm and overall flow for the ML site (Figs. 49 and 50) and during all three flow regimes for the BL site (Figs. 51, 54 and 57). Storm flow NO_3-N losses decreased at both the ML (Fig. 48) and BL (Fig. 52) sites, but there trends were observed during base flow or overall flow. Transport of NH_3-N (Figs. 53 and 56) and COD (Figs. 55 and 58) declined during storm and combined flow at the BL site but not for the ML site. The possible reasons for declines in N species and COD losses observed at the monitoring sites are the same as discussed earlier for concentrations. There was a significant increase in TSS transport past the ML site during base flow (Fig. 47) As pointed out earlier, however, the increased TSS loss could have occurred in association with the increasing base flow rates that were observed during the study and do not necessarily reflect a worsening condition with regard to solids transport within the basin. There were no trends in transport of PO_4-N or TP for either site.

Effectiveness of the Overall Program

The quality of water measured at the five monitoring sites generally demonstrated a trend toward improvement in terms of N species and COD. This is not attributed to trends in flow; if anything, the trends in flow that were observed would have been expected to contribute toward a deteriorating trend in terms of analysis parameter transport past the monitoring stations. The trends in water quality are thus attributed to activities within the watershed. As there were no reported ongoing activities that would have logically contributed toward an improvement in stream flow quality except for SCS and CES efforts, the observed trends in water quality are attributed to changes in agricultural practices that occurred simultaneously with programs conducted by SCS and CES.

No direct relationship between proportion of monitored area under BMP implementation and water quality improvement should be inferred. One reason for not assuming a direct correlation is that it is possible for the activities on a relatively small proportion of the total area to have a disproportionately large impact on water quality, depending on what was being done prior to BMP implementation, proximity to the monitoring station, and other such factors. Another reason for exercising caution in interpreting the data is that educational activities of the CES, *per se*, are not directly reflected in the data regarding BMP implementation. While many who were contacted by CES might subsequently had a farm plan developed with SCS assistance, there might have been a significant number of persons who, as a result of CES activities, changed their management practices without having a formal farm plan developed. Such persons could have had a positive impact on water quality without having been accounted for via the information gained from the farm plans.

It is not possible to state definitively what management practice(s) had the greatest impact on stream quality during the monitored period. Some deductions based on the data, however, might clarify the potential impacts of practices that were installed during the monitored period. The improvements in quality of water monitored at sites MU1, MU2, and BU appears to be related to implementation of nutrient management, waste utilization, and pasture and hayland management. Unless dead poultry composters were installed within the MU2 and BU sites' drainage areas (and there are no data available to indicate whether this occurred), they appear to have played no role with respect to water quality at those sites, since none were installed over the monitored period. Only one dead poultry composter was installed in the drainage basin of site MU1. This composter could have positively impacted water quality at site MU1; as discussed just previously, however, the improvement might have occurred in the absence of the composter. The improvements in water quality at the BL site might also reflect primarily the implementation of nutrient management, waste utilization, and pasture and hayland management, since only one dead poultry composter was installed within the BL drainage basin during the monitored period. Again, however, previously-installed composters might have contributed to water quality improvements, but there are no data to indicate whether composters were actually installed prior to monitoring within that basin. As noted earlier, 8 dead poultry composters were installed within the ML drainage basin in addition to the implementation of nutrient management, waste utilization, and pasture and hayland management. As previously discussed, the water quality improvements observed at the ML site might have occurred without dead bird composter installation, but it would be extremely speculative to suggest that this was actually the case. Regardless of what impacts dead bird composters might have had on the results of this project, their installation should generally have a positive impact on water quality. Determining how much time will pass before the impact occurs and how significant the impact will be are different and difficult questions.

Nutrient Management Demonstration

An average of 47 runoff events per field were observed over the monitoring period. Approximately 90, 93, 83, and 88% of all runoff occurring was sampled and analyzed for fields RU, RM, WU, and WM, respectively. The reasons that less than 100% of all runoff occurring was not sampled include (a) storms too small to trigger the automatic samplers (i.e., producing less than a 1 inch depth of flow in the flumes), (b) storms occurring when all sample containers were still filled from a storm occurring just previously, and (c) a very limited number of equipment malfunctions. In spite of not sampling all runoff events, adequate runoff samples were collected to enable assessment of the water quality characteristics of all fields.

Soil Sampling Results

Results of quarterly soil testing for the monitored fields are given in Tables 33 through 36. Both soil pH and soil organic matter content exhibited detectable linear trends with respect to time only for field WM, in which pH decreased from approximately 6.9 to 6.0 (Fig. 63) and organic matter content decreased from approximately 2.4 to 1.8% (Fig. 64). The decreases in soil pH and organic matter content for field WM are attributed to the addition of only NH_4NO_3, without lime treatment, rather than organic animal manures.

Mean soil NH_4-N content decreased significantly over time for fields RU and RM (Figs. 59 and 60) but did not change for fields WU and WM. Declines in NH_4-N for these fields might have arisen due to relatively recent fertilization at a high rate before soil sampling began.

Mean soil P concentrations declined significantly for the nutrient-managed fields

(RM and WM; Figs. 61 and 65). Soil P decreased from approximately 600 to 400 lb/ac for field RM and from approximately 900 to 500 lb/ac for field WM. The decreases in soil P concentrations for fields RM and WM were too large to be attributed only to plant uptake and are probably due in part to precipitation of soil P into relatively insoluble forms that would not be detected during analysis. In any event, the findings with regard to fields RM and WM suggest that soil P concentrations can be reduced (perhaps relatively quickly) by not applying P to soils that already have sufficient P for optimal forage growth. Event though fields RU and WU continued to receive P over the monitoring period in the form of poultry manure and poultry litter, respectively, there were no detectable trends in soil P concentrations in those fields. Since not all P applied to soil in fertilizers such as poultry manure and poultry litter will be detectable during subsequent soil testing (the majority will typically precipitate relatively quickly into forms not extracted during the analysis), it appears that the P applied to fields RU and WU in the poultry manure and poultry litter, respectively, was insufficient to cause detectable increases in soil P.

Mean soil K concentrations changed significantly over time only for field RM (from approximately 500 to 350 lb/ac; Fig. 62), again due in part to no K being added to the field over the monitoring period. Mean soil concentrations of Fe, Zn, and Cu demonstrated no linear trends with respect to time over the monitoring period.

Runoff Sampling Results

Findings with regard to analysis parameter concentrations. Tables 37 through 40 contain flow-weighted mean concentrations of analysis parameters for the four fields for all recorded runoff events. Mean analysis parameter concentrations, averaged over all storm events, are given in Table 41 Concentrations of analysis parameters are generally representative of a pasture/range situation in that N, COD, and TSS concentrations are relatively low. Runoff P concentrations were relatively high, reflecting the high soil P concentrations measured throughout the monitoring period (Tables 37 through 41) By comparing Tables 37 through 40 to Table 5, it may be seen that there is no apparent relationship between concentrations of analysis parameters and the grazing schedule. There is, however, a very strong relationship between parameter concentrations and proximity to fertilizer application. Runoff during storms that occurred soon after fertilizer application often had much higher concentrations of analysis parameters than during storms preceding fertilizer application Examples include the May 11, 1992, August 24, 1993, and September 14, 1993 storms for field RU; the May 12 storm for field RM; the June 2, 1992, June 6, 1992, and April 14, 1993 storms for field WU; and the June 6, 1992 and April 14, 1993 storms for field WM (Tables 37 through 40). The April 14 storms occurred only one day following fertilizer application to fields WU and WM, although the timing of the fertilizer application relative to the storm was unintentional. These findings, particularly those relating to the April 14, 1993 storms on fields WU and WM, clearly indicate a direct runoff quality benefit to avoiding fertilizer application a short time before the occurrence of a runoff-producing storm.

Runoff concentrations of FC and FS were high (Tables 37-40) and, in the case of FC, were usually in excess of both primary and secondary contact standards. While FC and FS concentrations were much higher following the April 13, 1993 application of poultry litter to field WU (Table 39), there was no persistent relationship between fertilizer application or grazing and FC or FS concentrations in runoff. It is likely that "background" sources including undomesticated animals and old cattle droppings are sufficiently high to cause runoff FC concentrations to exceed primary and secondary contact standards. High runoff concentrations of FC and FS thus appear to be an inherent characteristic of pasture/range areas such as those monitored in this study.

Trends in analysis parameter concentrations. Annual changes in analysis parameter concentrations for the monitored fields are given in Table 42. The unmanaged fields (RU and WU) generally experienced no significant trends in runoff concentrations of analysis parameters. The exception was in FC and FS concentrations in runoff from field RU, both of which decreased with time (Figs. 66 and 67). The reason for the decline in concentrations of these parameters is unknown. Grazing density decreased over the monitoring period (Table 5), which could expected to produce declines in FC and FS concentrations; field RU, however, had the same grazing densities but did not experience a similar decline in FC and FS concentrations (as discussed in the following subsection). The lack of trends in concentrations of other analysis parameters can be attributed to the fact that there were generally no trends in soil concentrations of the same parameters for the unmanaged fields (with the exception of NH_4-N for field WU).

Both managed fields (RM and WM), which received NH_4NO_3 fertilizer instead of animal manures, experienced decreases in runoff P concentrations during the monitored period. Runoff concentrations of both PO_4-P and TP declined for field RM (Figs. 68 and 69), while runoff PO_4-P decreased for field WM (Fig. 72). These results are associated with the decreases in soil P concentration that were observed over the monitoring period and discussed earlier. The significance of these findings is that decreases in soil P concentrations were translated directly into runoff quality benefits in the form of decreases in runoff P concentrations.

Runoff concentrations of TKN and TSS decreased significantly with time for field RM (Figs. 70 and 71, respectively). Since there was no decrease in runoff NH_3-N, the decline in runoff TKN concentration may be taken as due primarily to decreasing organic N concentration in runoff. As mentioned in the discussion of soil testing results, applications of animal manure to field RM prior to soil testing might have led to residual, relatively slowly-mineralizable N present near the soil surface that contributed progressively less organic N to the runoff. The decline in TSS concentration is probably due largely to the initially high runoff TSS concentrations (Fig. 71), which were most likely atypically high due to the recent installation of the flume.

In addition to PO_4-P, event mean runoff concentrations of COD and TSS decreased significantly with time for field WM (Figs. 73 and 74, respectively). The decrease in runoff COD concentration can be linked in part to a concurrent decrease in soil organic matter content (Fig. 64). The reasons for the decrease in runoff TSS concentrations are unclear.

Findings with regard to analysis parameter losses. Runoff mass losses of analysis parameters are shown in Tables 43 through 46 for all recorded runoff events and mean event mass losses of analysis parameters are summarized in Table 47. Runoff losses of analysis parameters were in all cases low and were only very small proportions of amounts applied via fertilizers (Tables 43-46). Estimated losses were likely insignificant from a forage production standpoint and probably do not represent a high monetary loss to the individual landowner (a maximum of $2.40/ac/year assuming a cost of $0.25/lb N). Losses of analysis parameters were dominated by large runoff events; for example, 44% of all TKN losses from field WM occurring over the monitoring period occurred during only one runoff event (April 14, 1993; Table 39). If such large individual storm event losses can be reduced, by fortuitous timing of fertilizer application or by other practices, then the impact on overall losses of analysis parameters could be quite high.

Despite the presence of significantly decreasing trends in some cases for analysis parameter concentrations, there were no significant trends in losses of any analysis parameters. This result is attributed to high variability in storm event runoff amounts which, as described earlier, caused parameter losses to have much greater variability than concentrations alone. The lack of trends in analysis parameter losses thus does not, in this study, contradict the findings with respect to parameter concentrations. In those cases where significantly decreasing trends in parameter concentrations were detected, runoff mass losses would be expected to eventually (with additional monitoring to overcome runoff amount variability) exhibit similar decreases, unless runoff amounts are statistically nonstationary.

Effectiveness of Nutrient Management

It should be recognized that the two management strategies compared in this study, "nutrient-managed" and "unmanaged," are essentially equivalent to P-based and N-based fertilizer management strategies, respectively (even though it can be strongly argued that N-based fertilizer application to soils with excessive P constitutes an "unmanaged" situation, at least with regard to P) The benefits of the "nutrient management" strategy can be generally anticipated even if not predicted with high accuracy. In broad terms, the nutrient management strategy implemented in this study could have been expected to reduce runoff P (by eliminating further P inputs) and COD concentrations (by eliminating addition of organic matter in animal manures) over time. No improvements over time with respect to N species or TSS would be anticipated, if all other management practices are equal. Concentrations of FC and FS might be expected to decrease over time for "nutrient-managed" fields, but there are far too many unknowns and vagaries to be very certain of this prediction. The anticipated benefits of nutrient management (i.e., P-based management for the purposes of this study) are almost exactly what were observed during this study. Nutrient management, as implemented in this study, was thus successful in acheiving the runoff quality benefits that could logically have been expected

On the other hand, however, the results from the "unmanaged" fields (i.e., those with N-based strategies) were not negative. In no respect did runoff quality deteriorate over the monitoring period for the fields that continued to receive poultry manure and poultry litter. Increases in soil P concentrations accompanied by increases in event mean runoff concentrations would probably have been observed had the study been continued long enough, but the data available to date from this study do not indicate increasing runoff P concentrations.

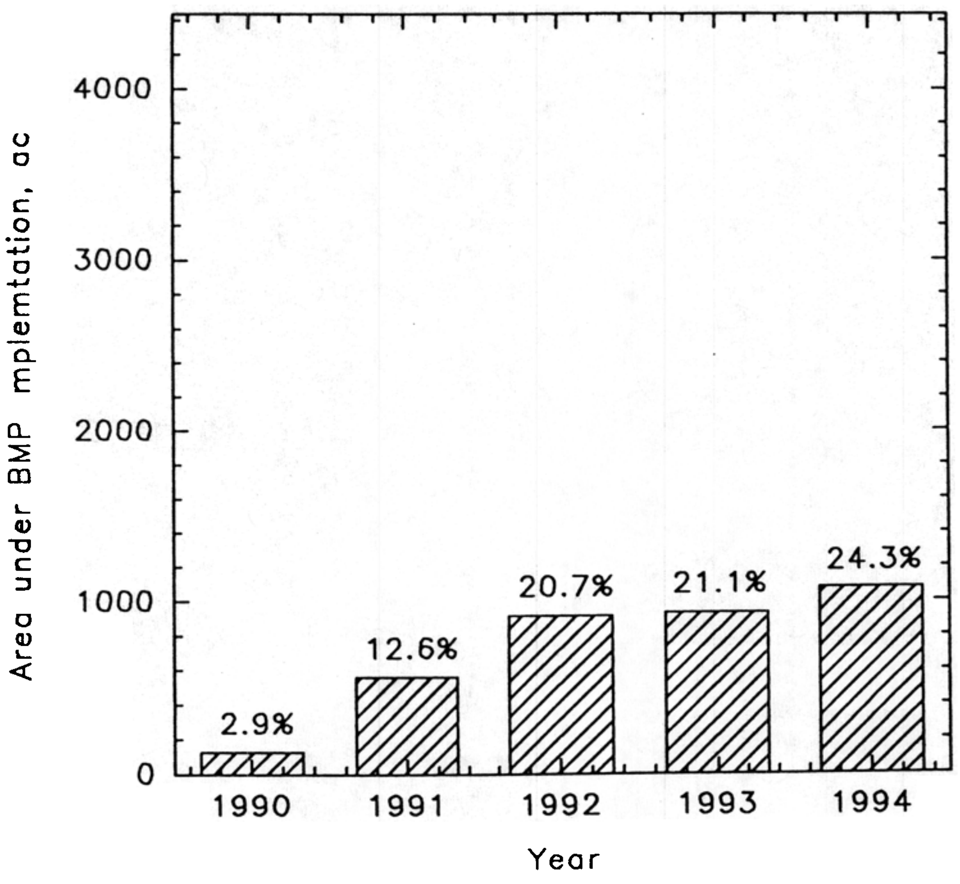


Fig. 7. Area under BMP implementation above the ML monitoring station

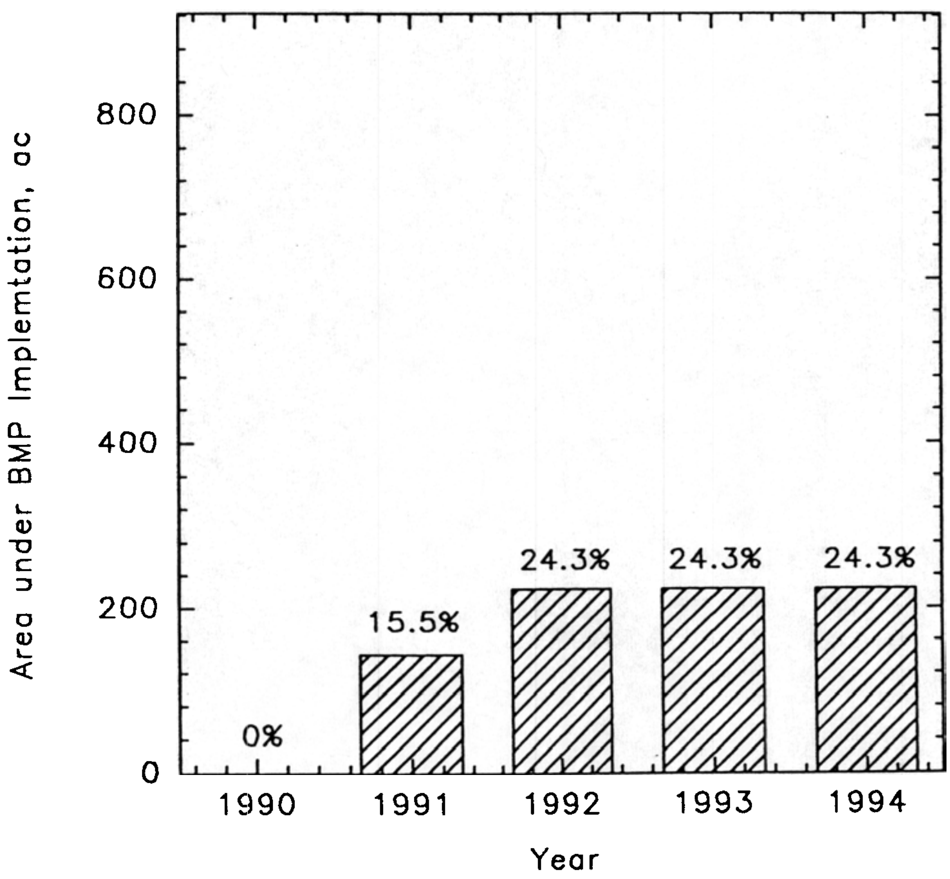


Fig. 8. Area under BMP implementation above the MU1 monitoring site

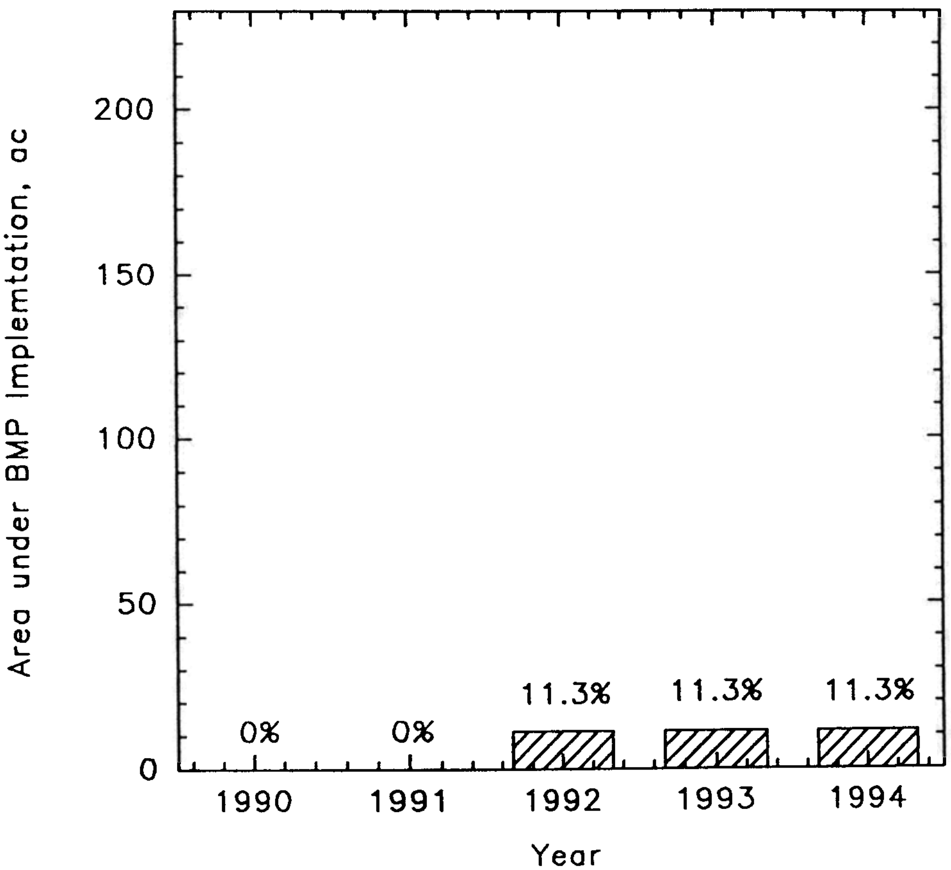


Fig. 9. Area under BMP implementation above the MU2 monitoring site

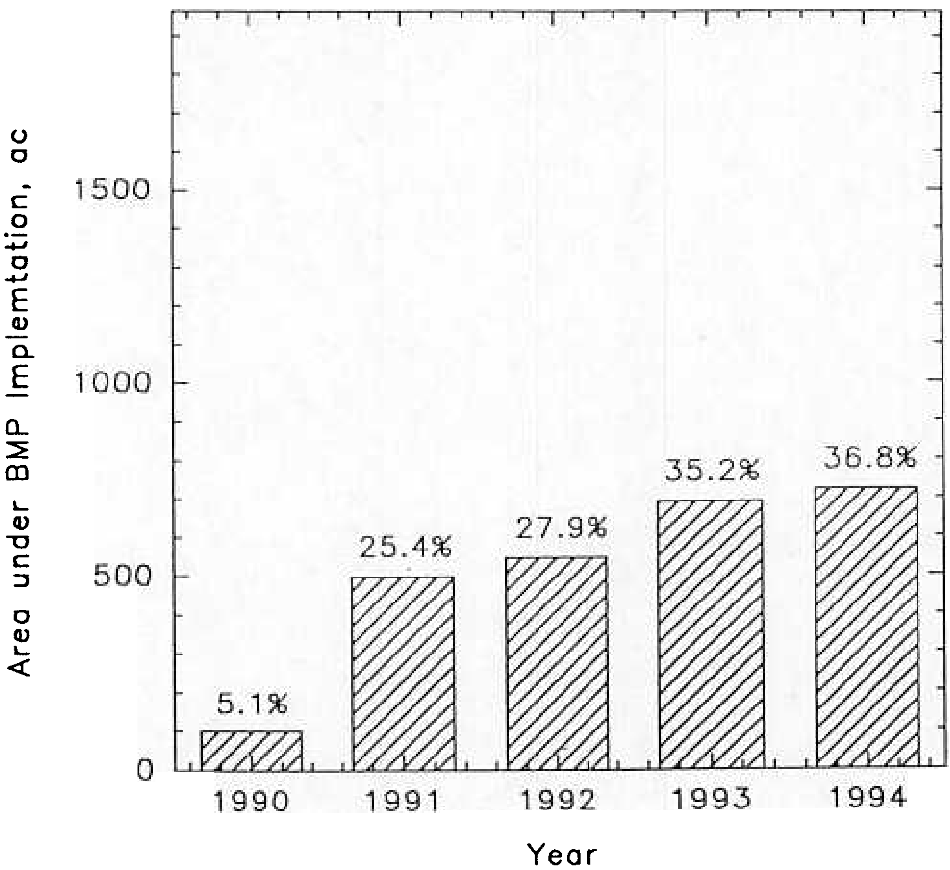


Fig. 10. Area under BMP implementation above the BL monitoring station

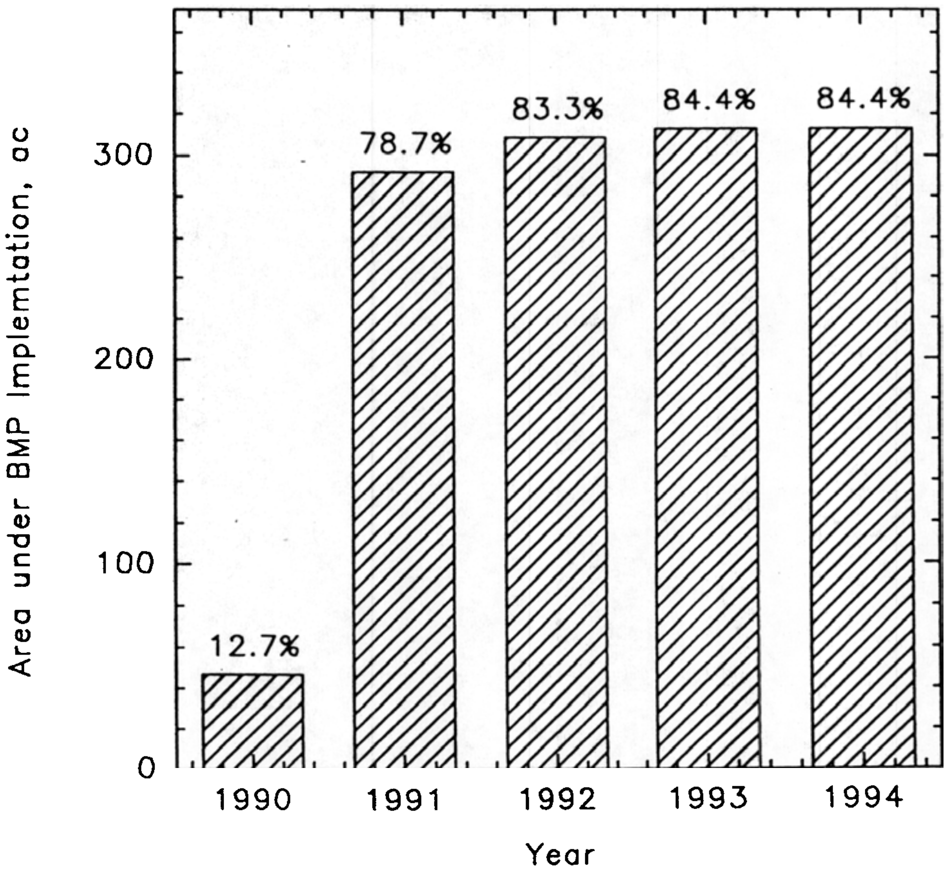


Fig. 11. Area under BMP implementation above the BU monitoring site

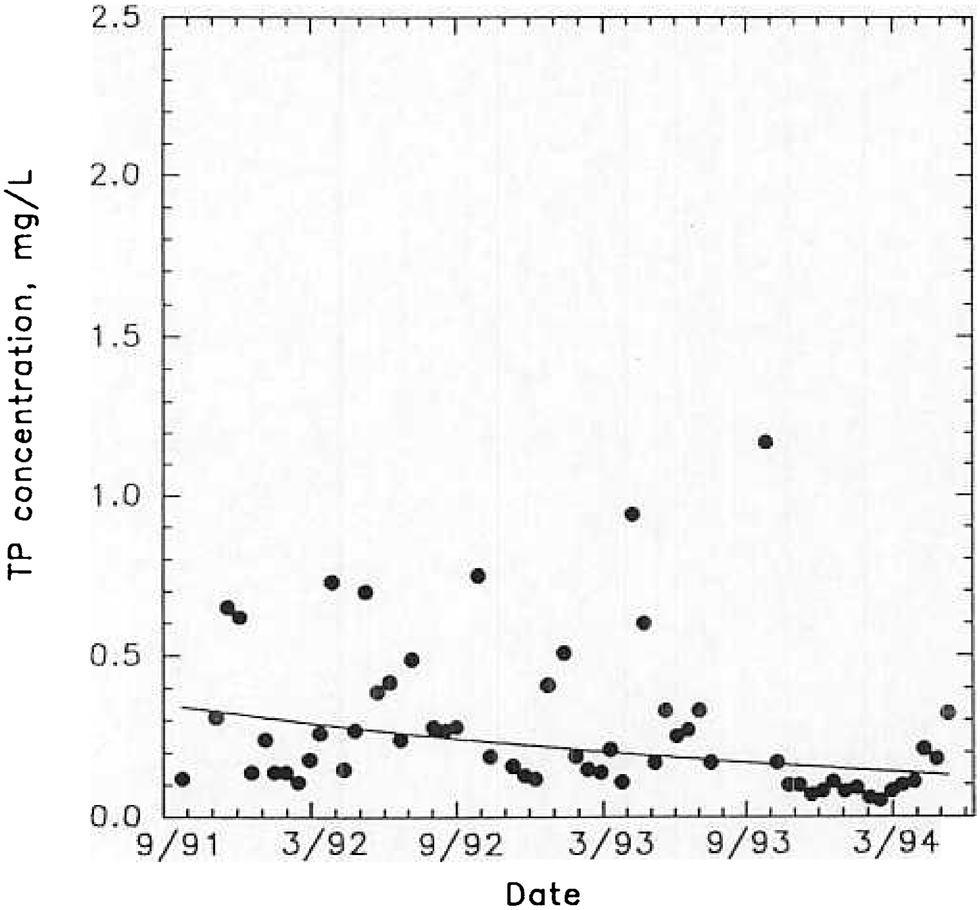


Fig. 12. TP concentrations for the MU1 monitoring site

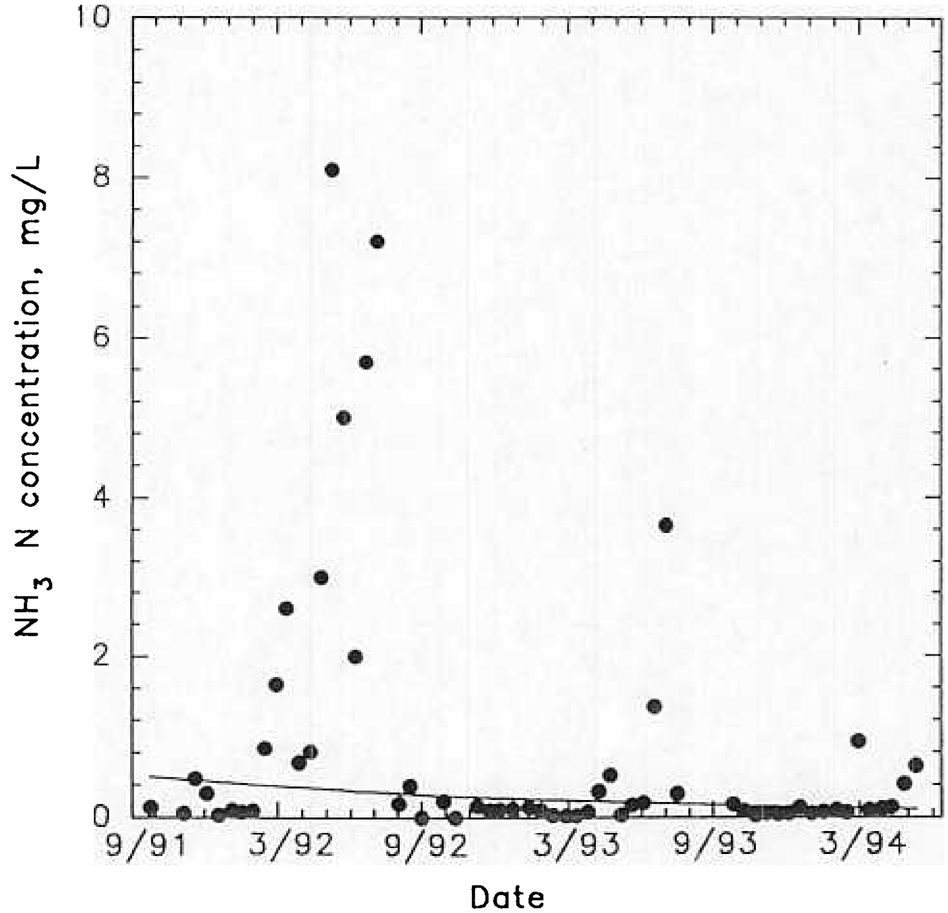


Fig. 13. NH_3-N concentrations for the MU1 monitoring site

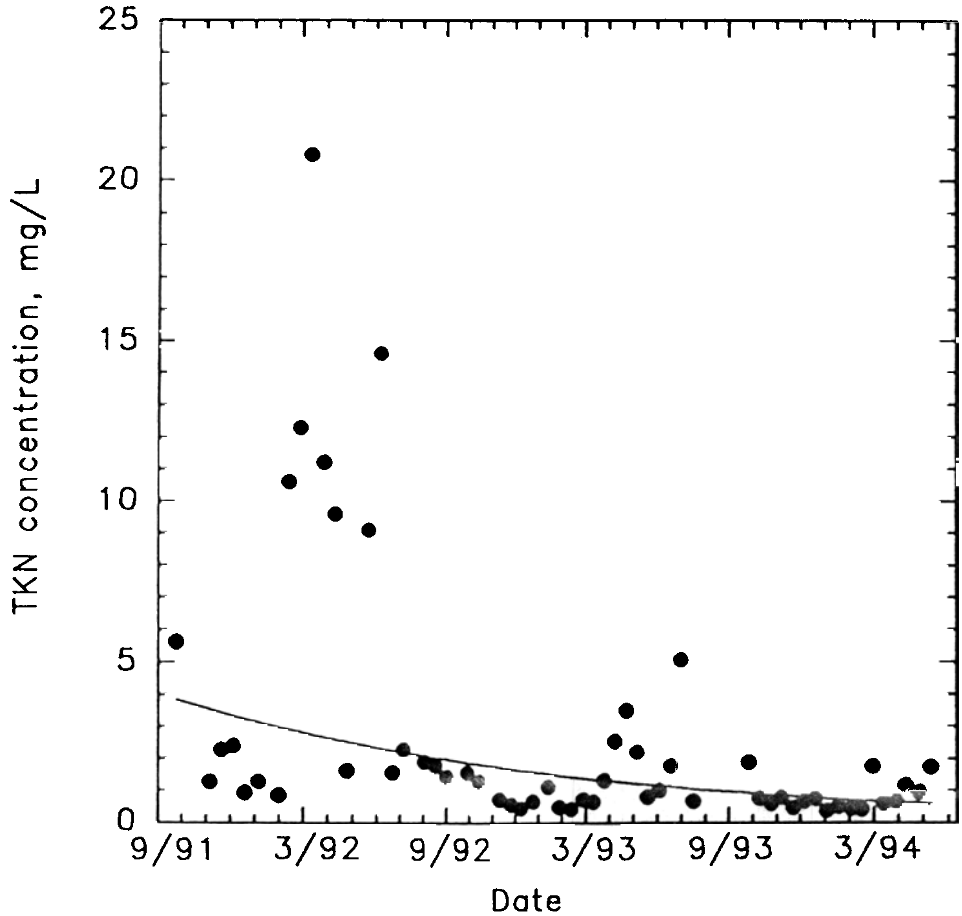


Fig. 14. TKN concentrations for the MU1 monitoring site

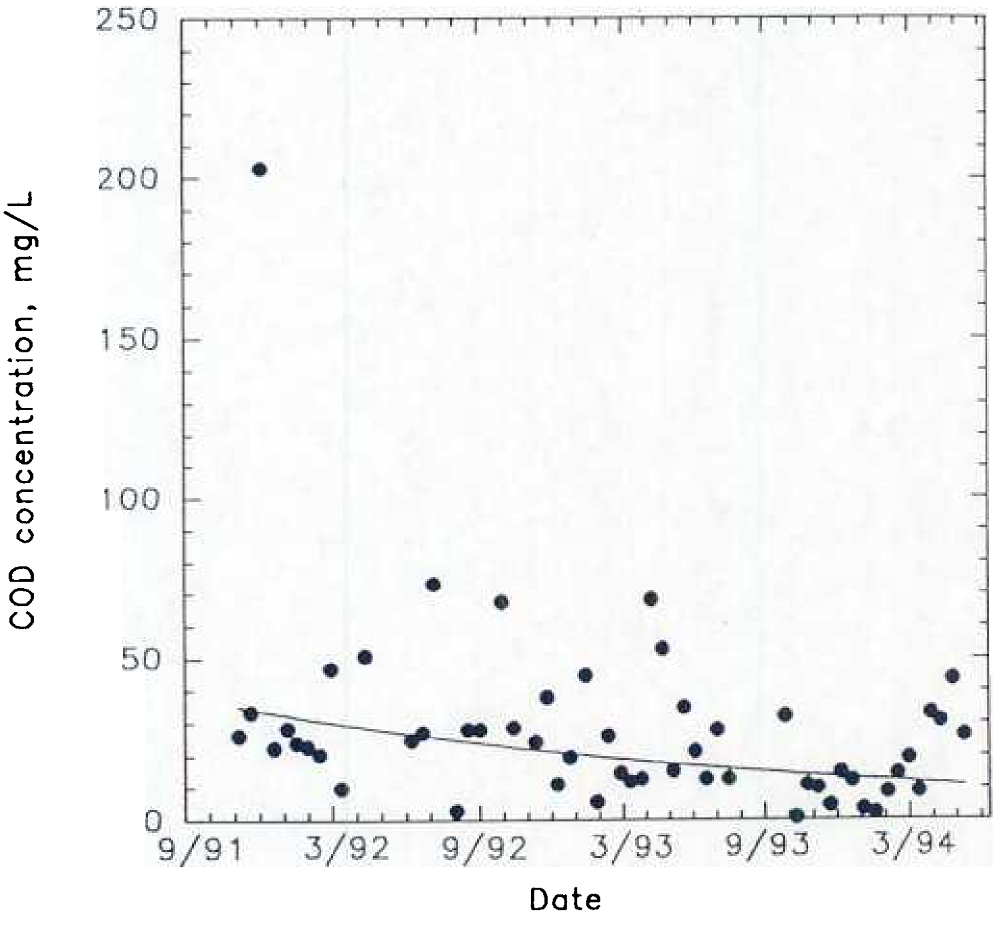


Fig. 15. COD concentrations for the MU1 monitoring site

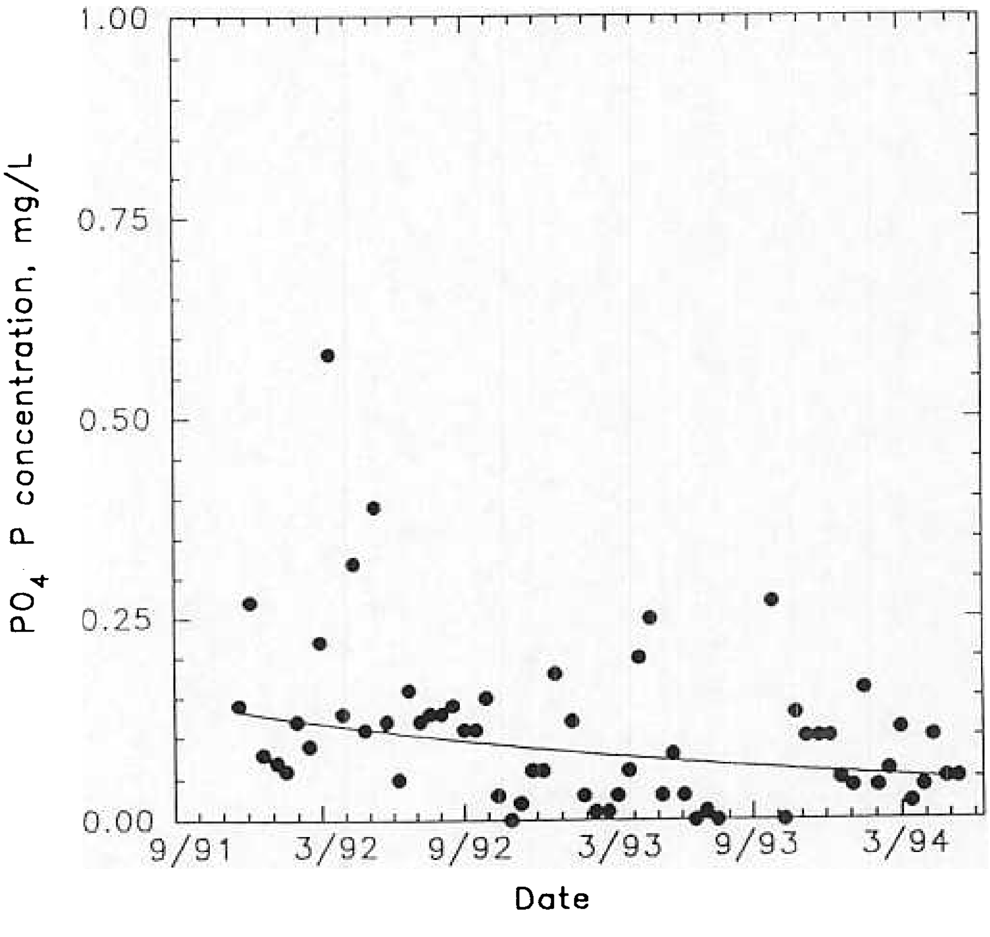


Fig. 16. PO_4-P concentrations for the MU2 monitoring site

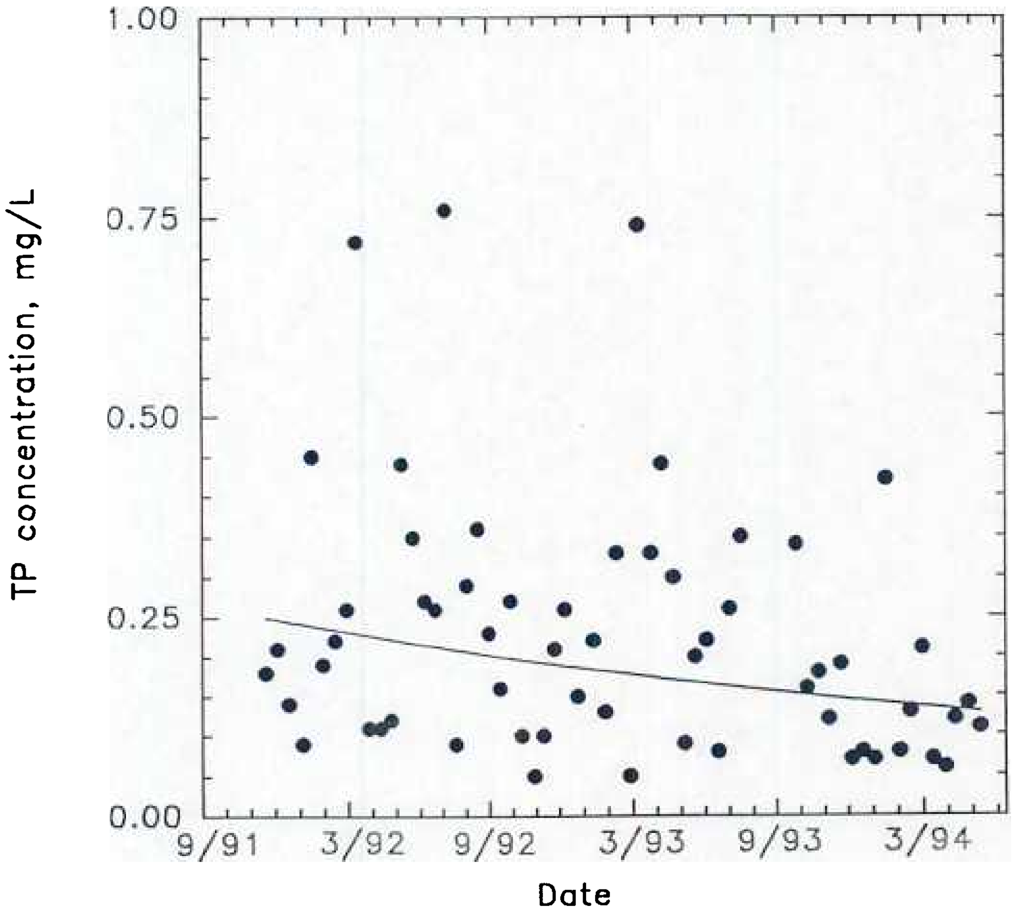


Fig. 17. TP concentrations for the MU2 monitoring site

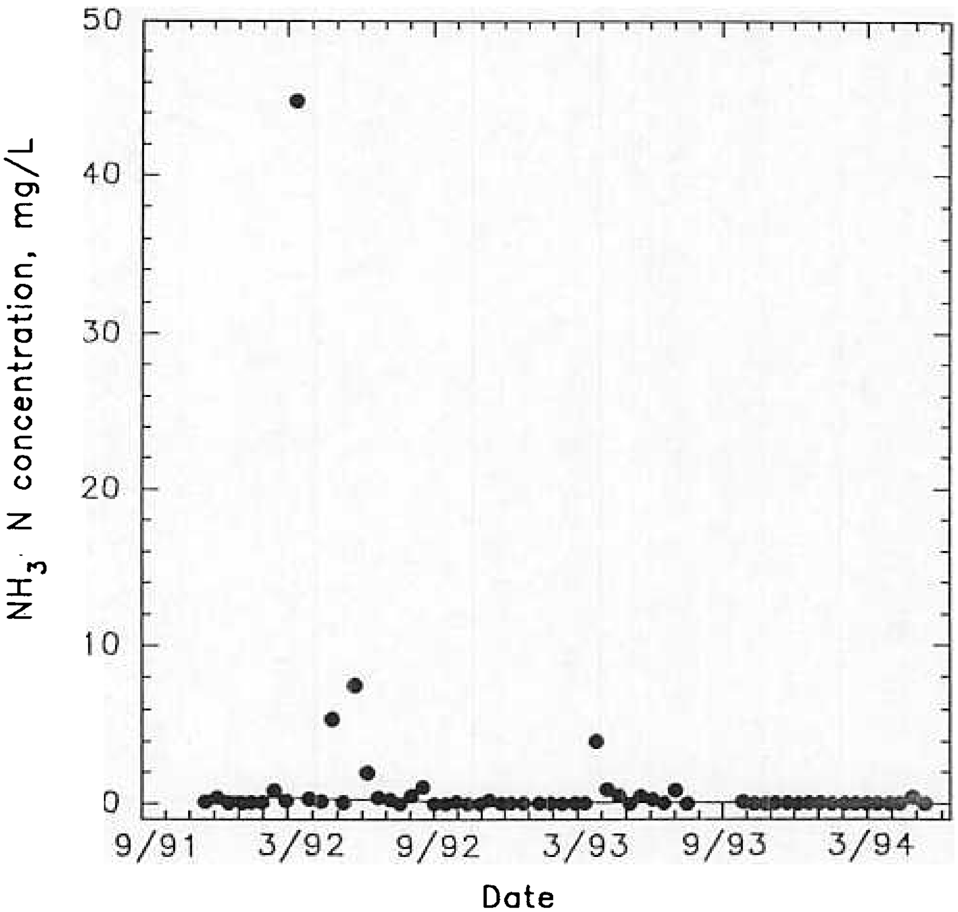


Fig. 18. NH_3-N concentrations for the MU2 monitoring site

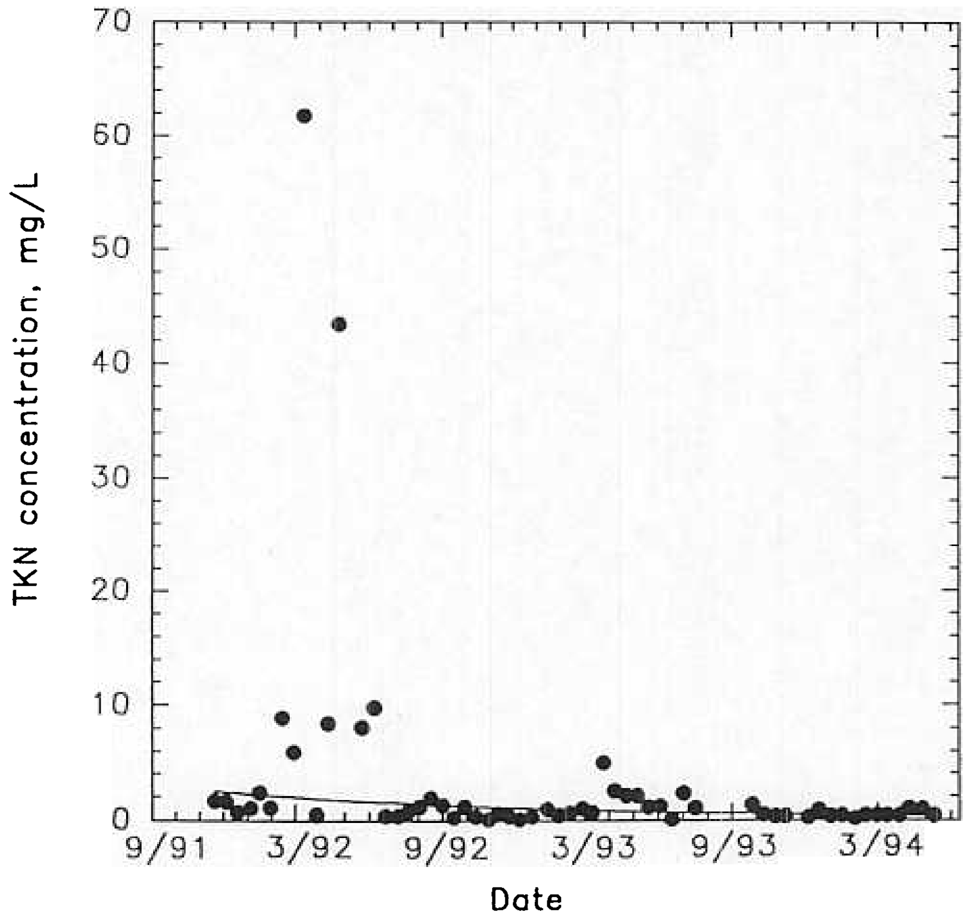


Fig. 19. TKN concentrations for the MU2 monitoring site

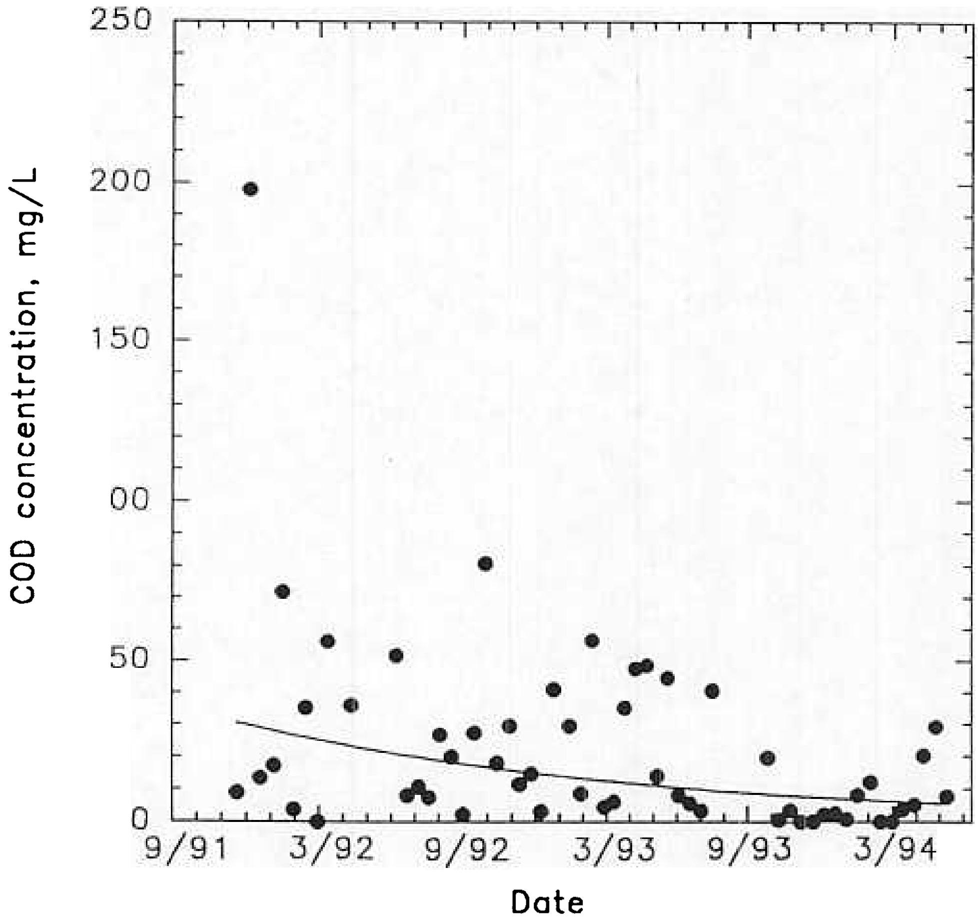


Fig. 20. COD concentrations for the MU2 monitoring site

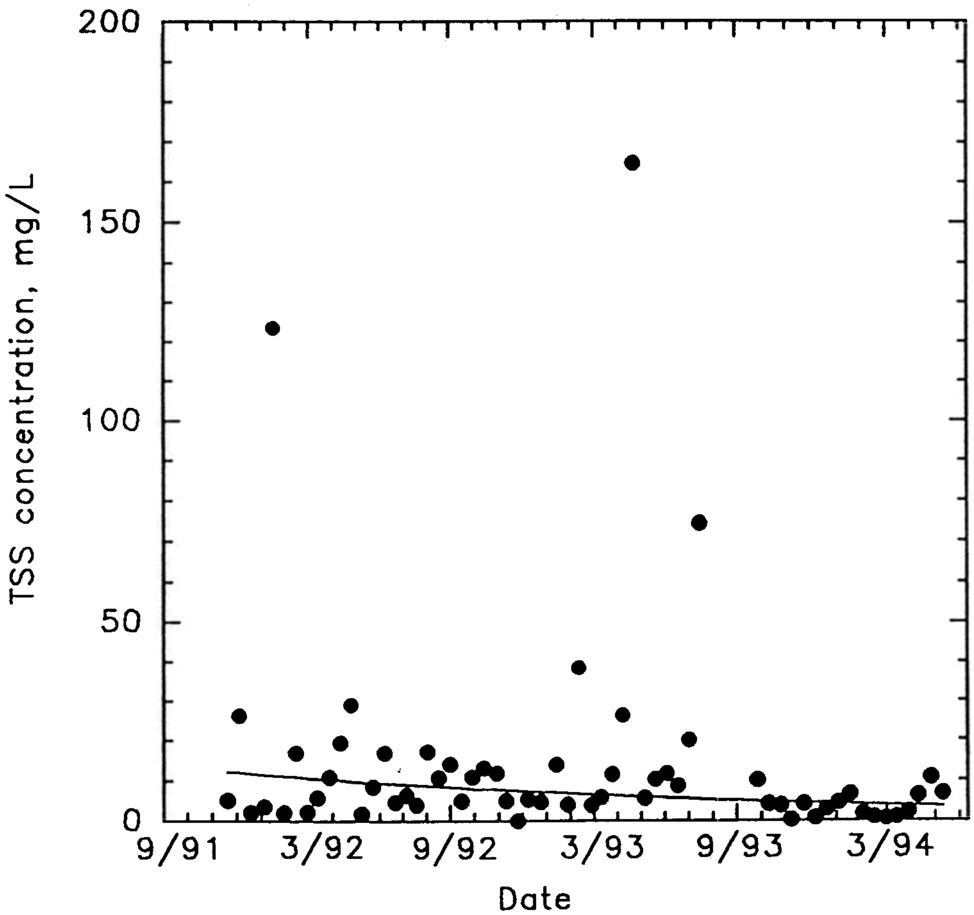


Fig. 21. TSS concentrations for the MU2 monitoring site

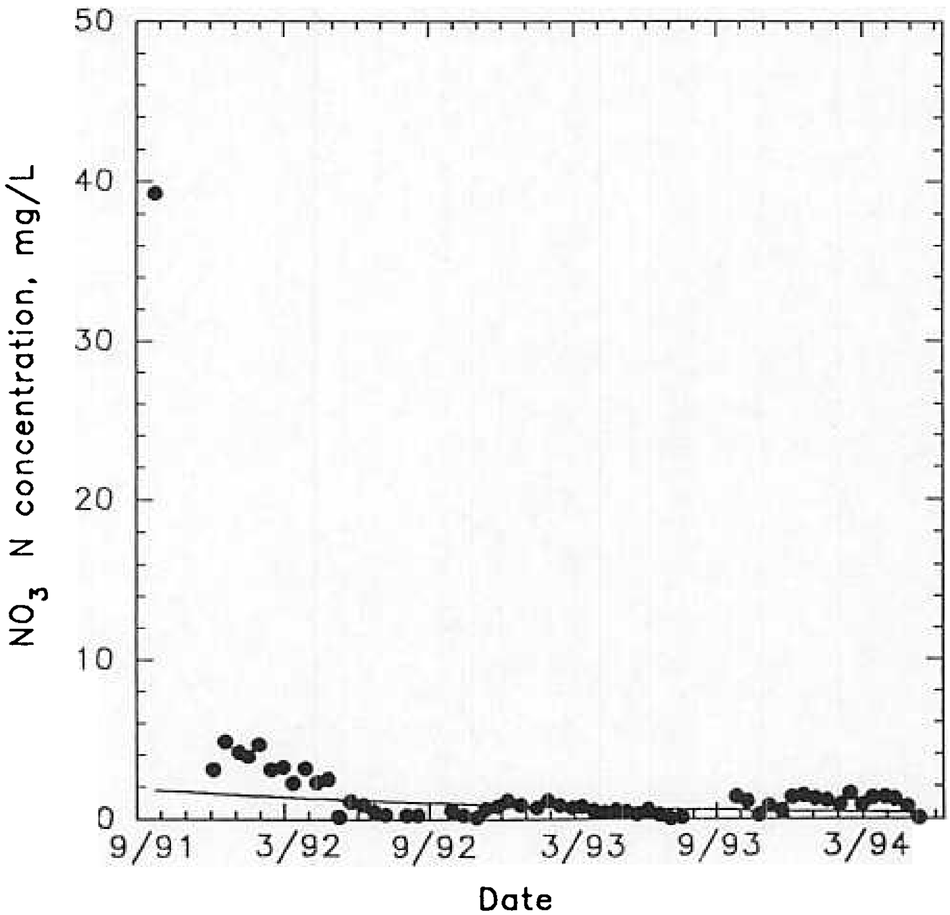


Fig. 22. NO_3-N concentrations for the BU monitoring site

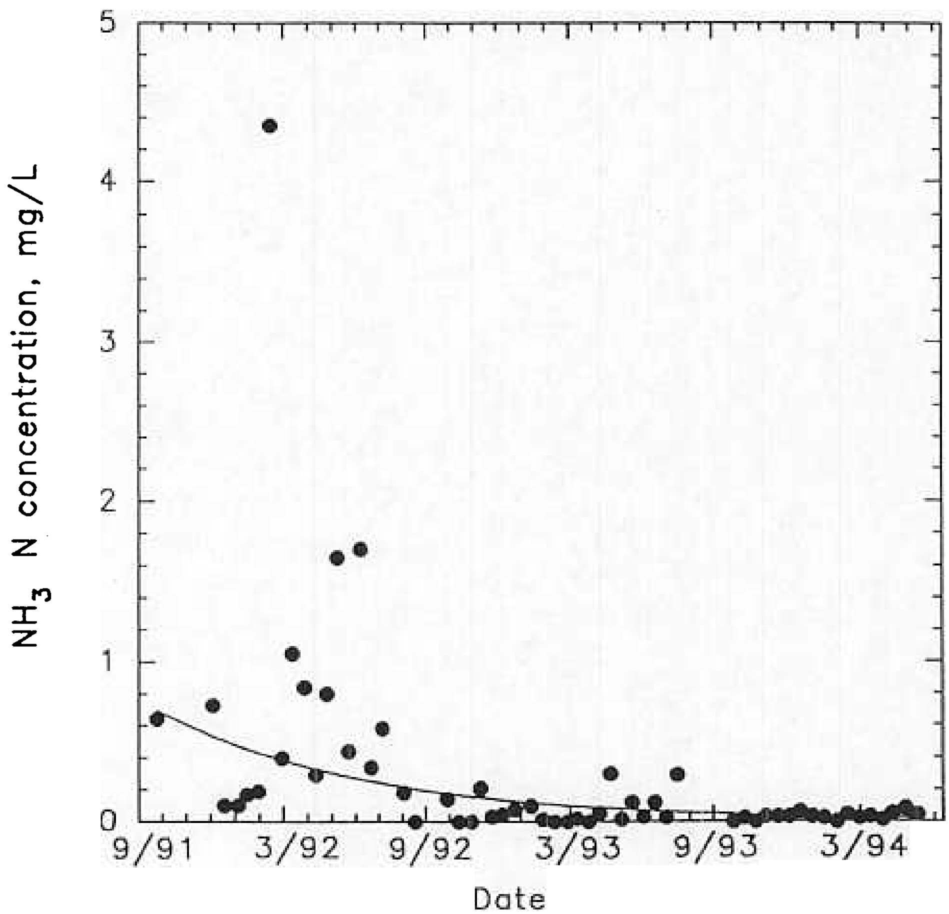


Fig. 23. NH_3-N concentrations for the BU monitoring site

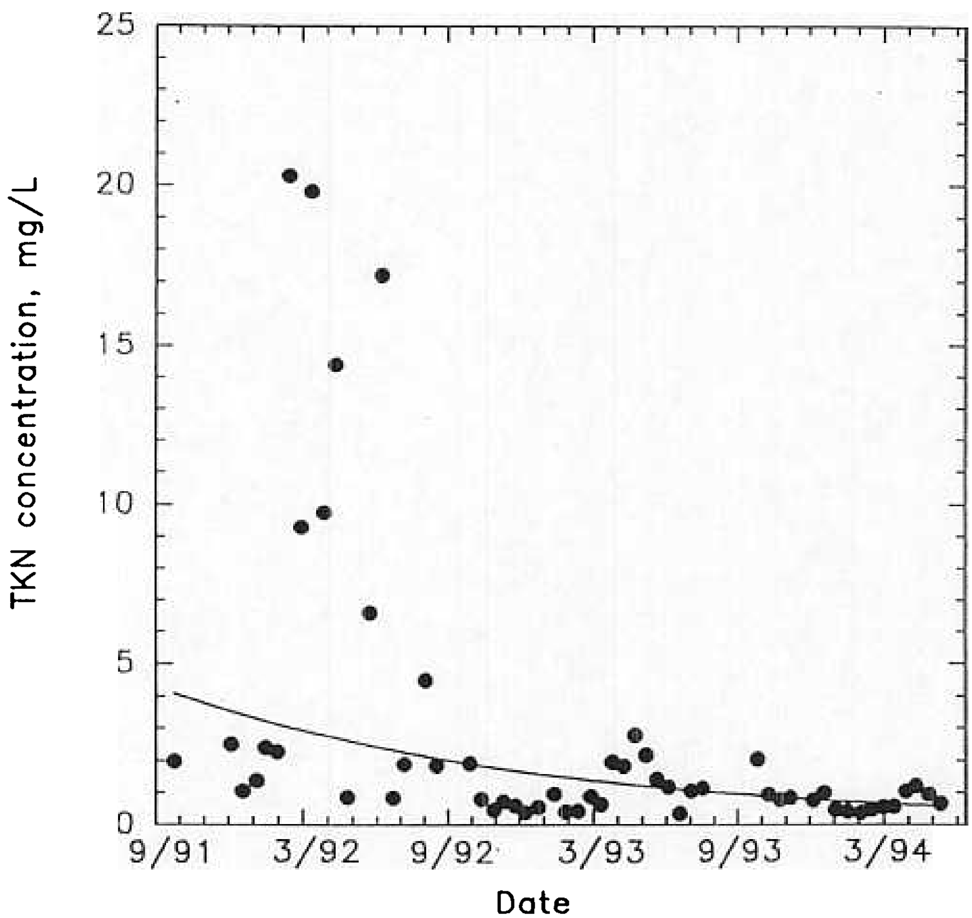


Fig. 24. TKN concentrations for the BU monitoring site

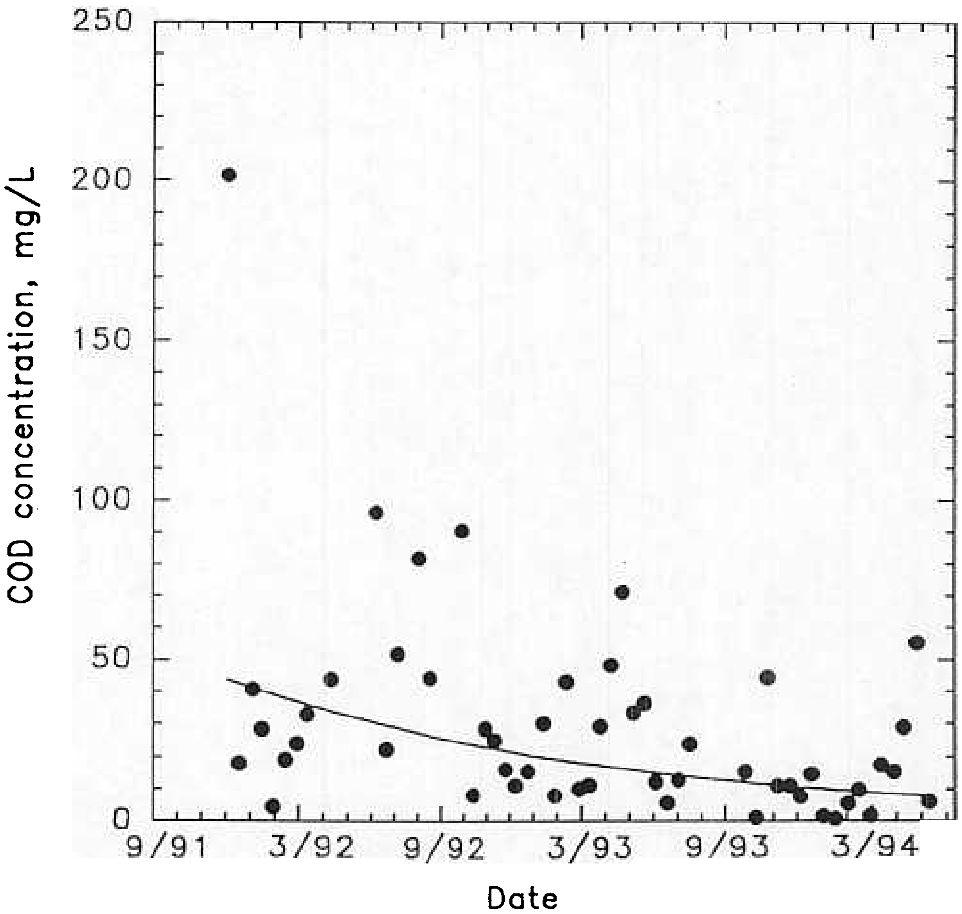


Fig. 25. COD concentrations for the BU monitoring site

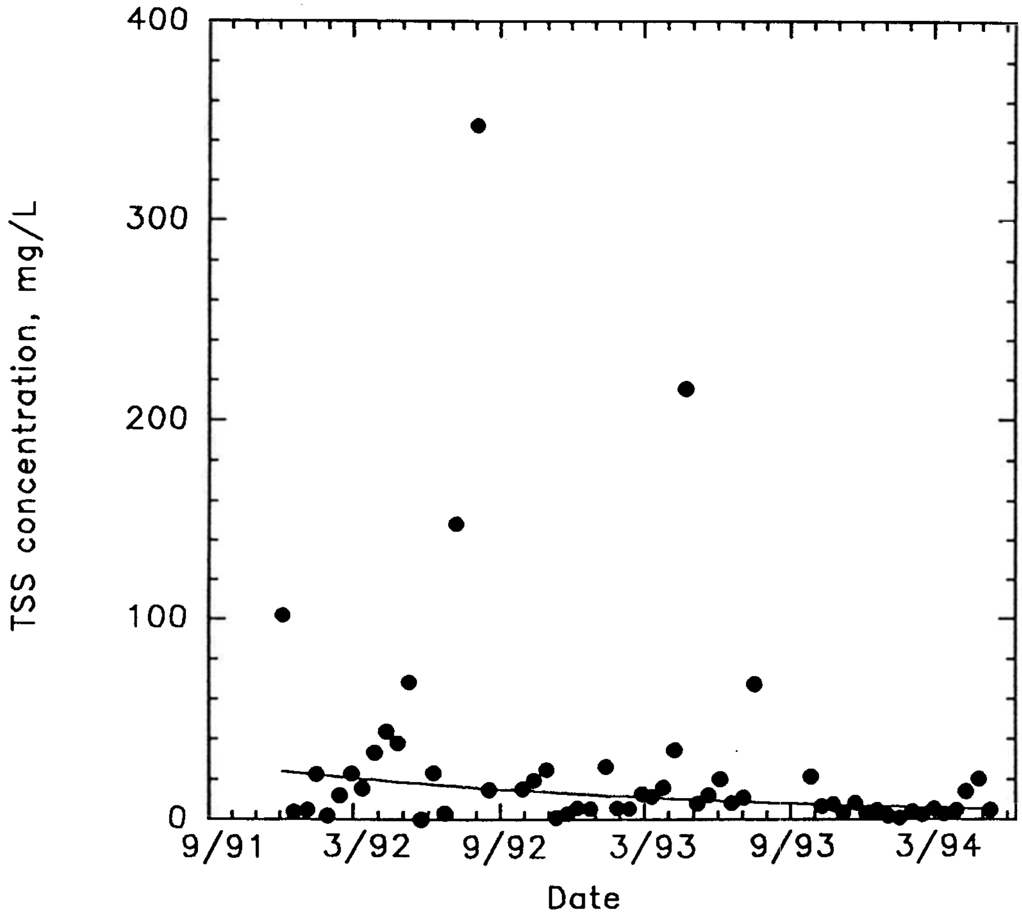


Fig. 26. TSS concentrations for the BU monitoring site

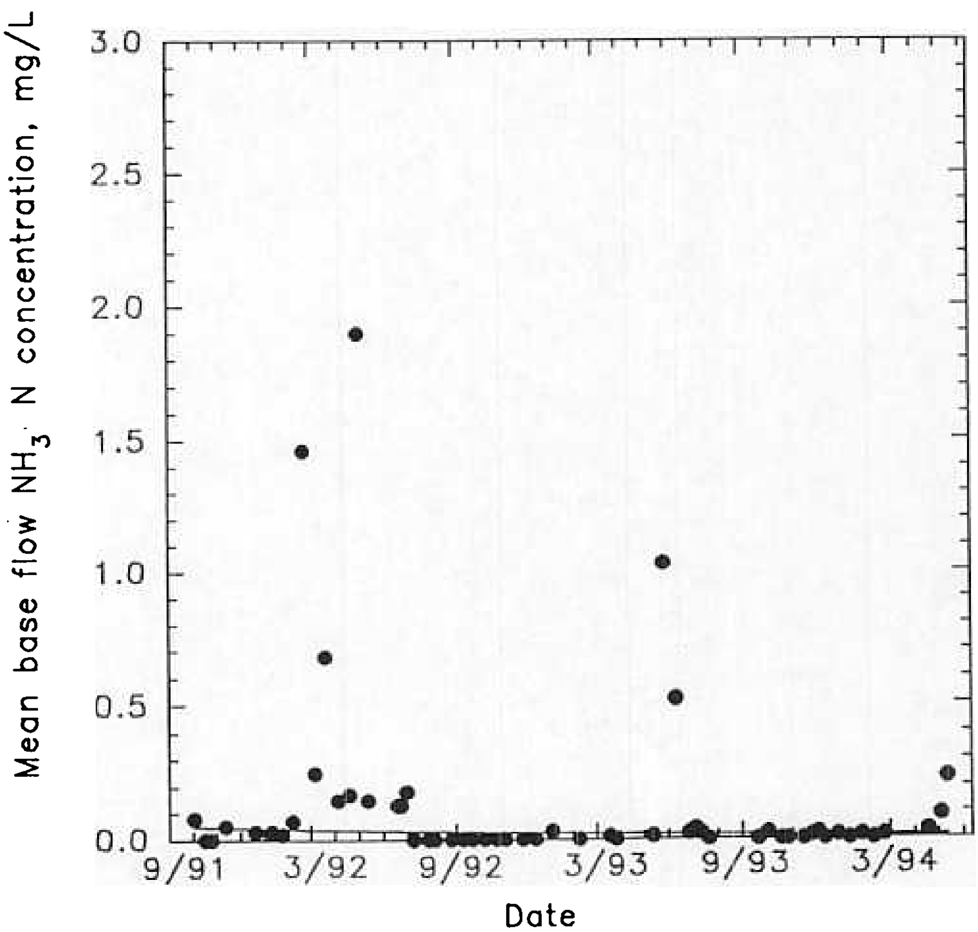


Fig. 27. Flow-weighted mean base flow NH_3-N concentrations for the ML monitoring station

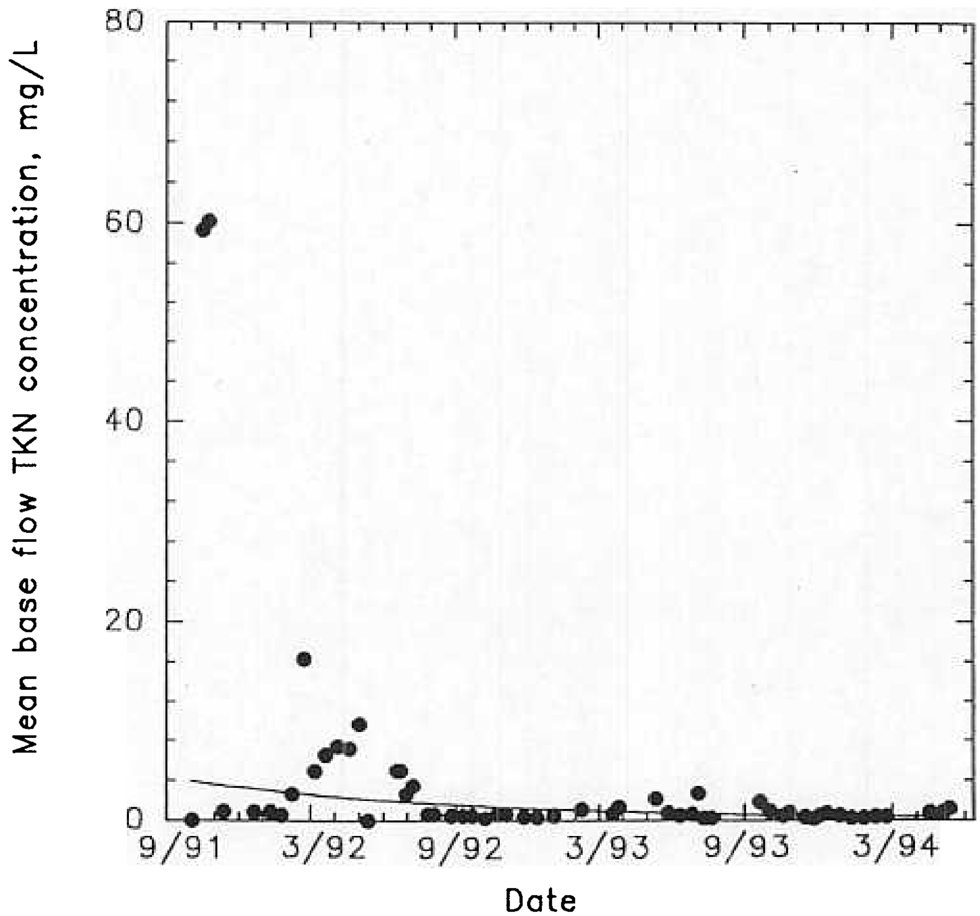


Fig. 28. Flow-weighted mean base flow TKN concentrations for the ML monitoring station

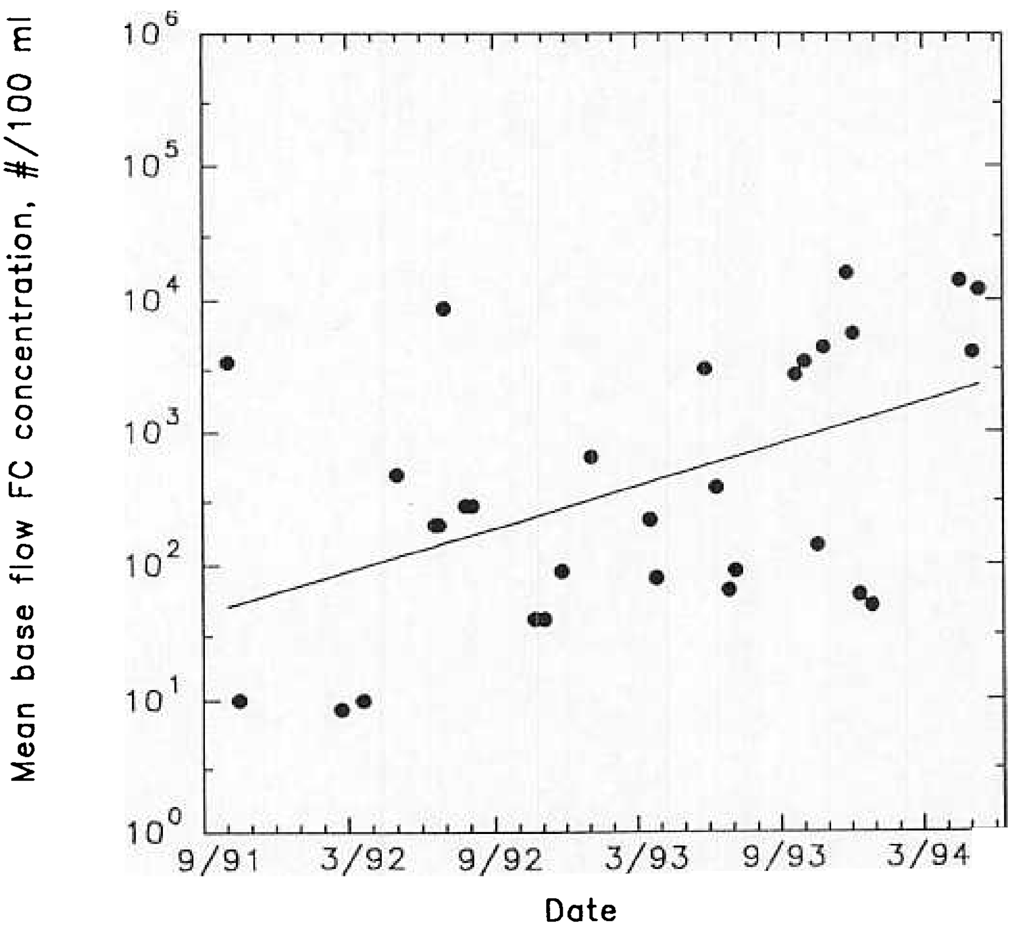


Fig. 29. Flow-weighted mean base flow FC concentrations for the ML monitoring station

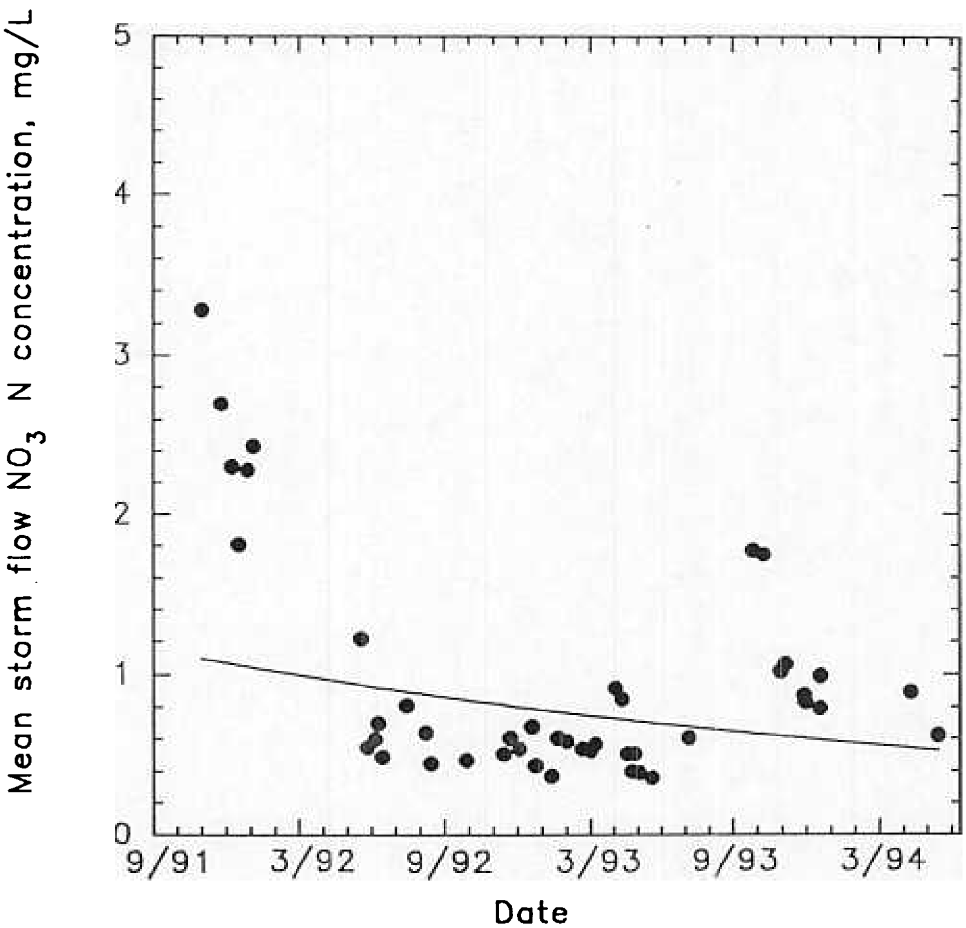


Fig. 30. Flow-weighted mean storm flow NO_3-N concentrations for the ML monitoring station

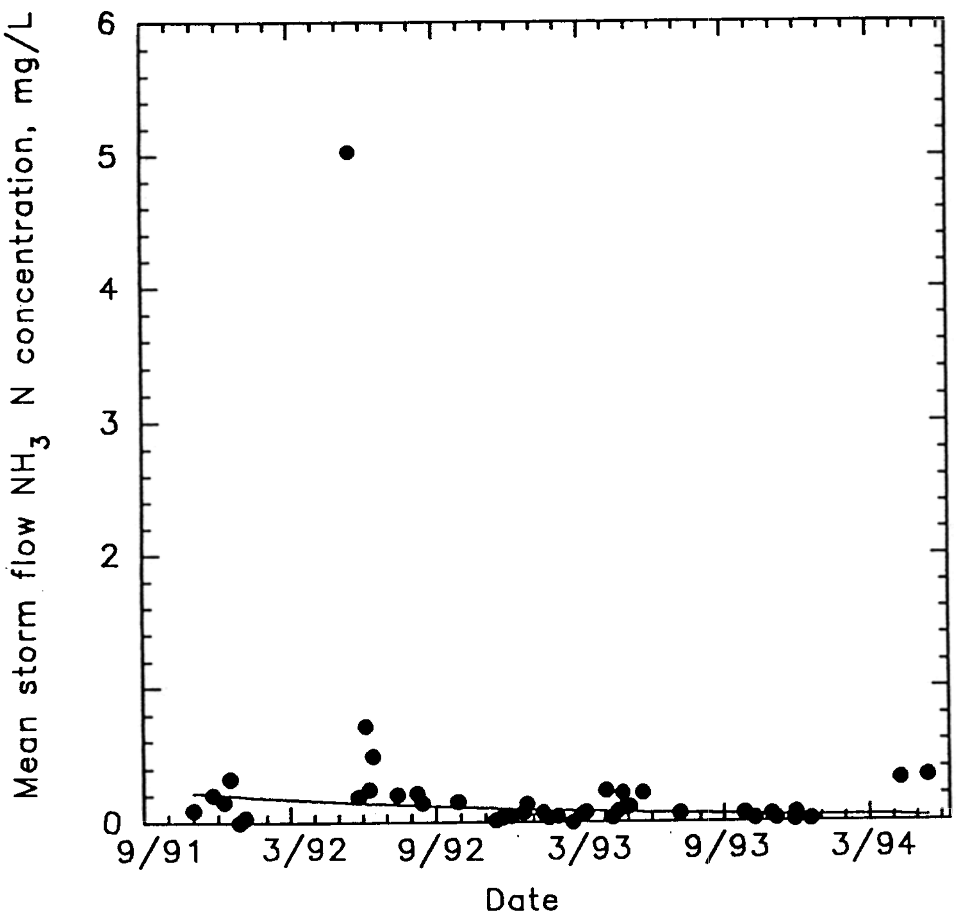


Fig. 31. Flow-weighted mean storm flow NH_3-N concentrations for the ML monitoring station

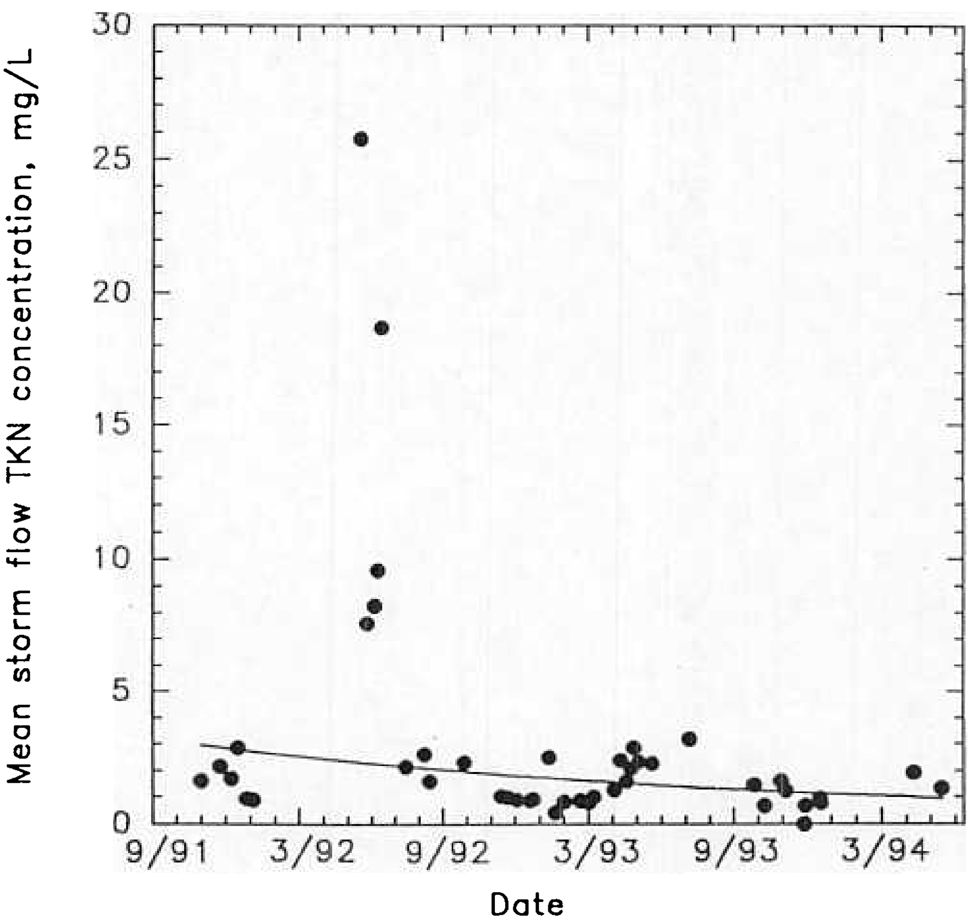


Fig. 32. Flow-weighted mean storm flow TKN concentrations for the ML monitoring station

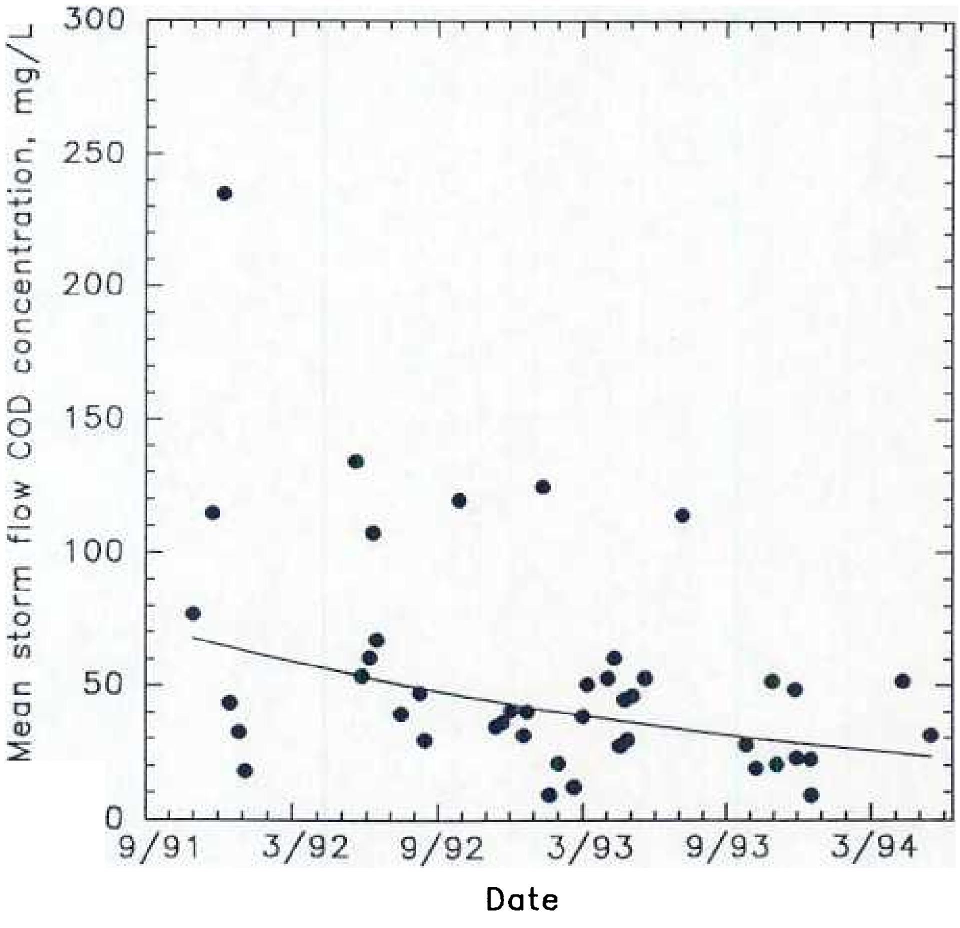


Fig. 33. Flow-weighted mean storm flow COD concentrations for the ML monitoring station

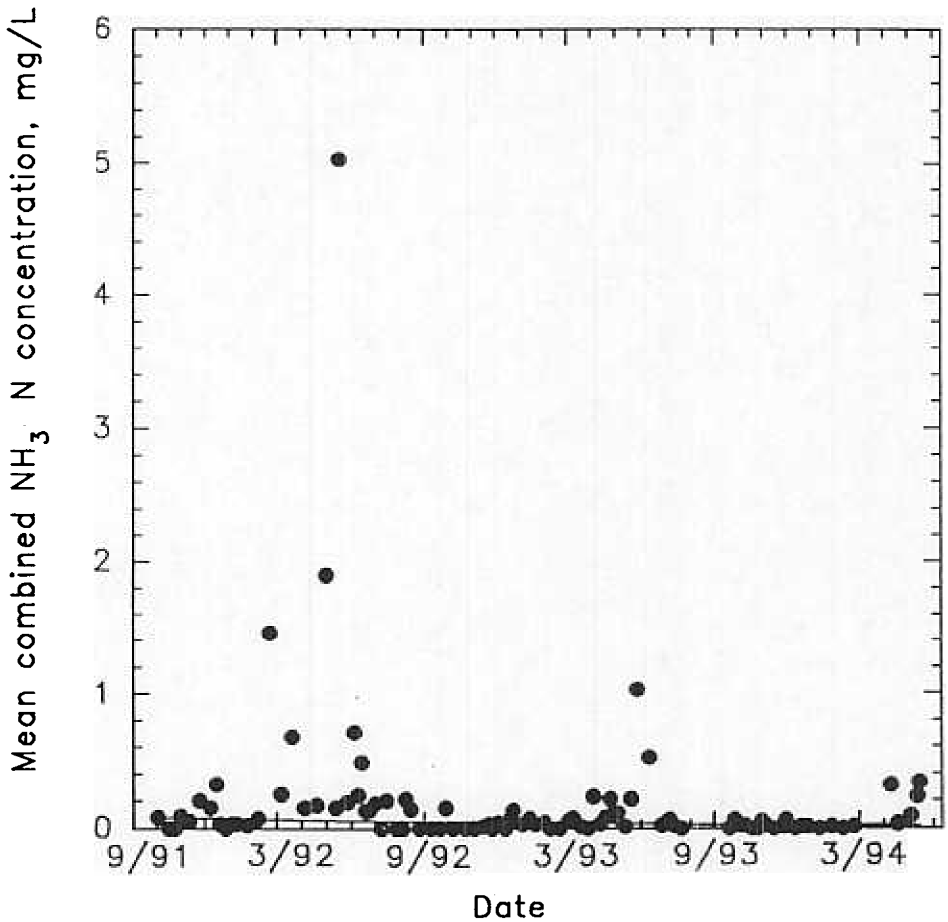


Fig. 34. Flow-weighted mean overall NH_3-N concentrations for the ML monitoring station

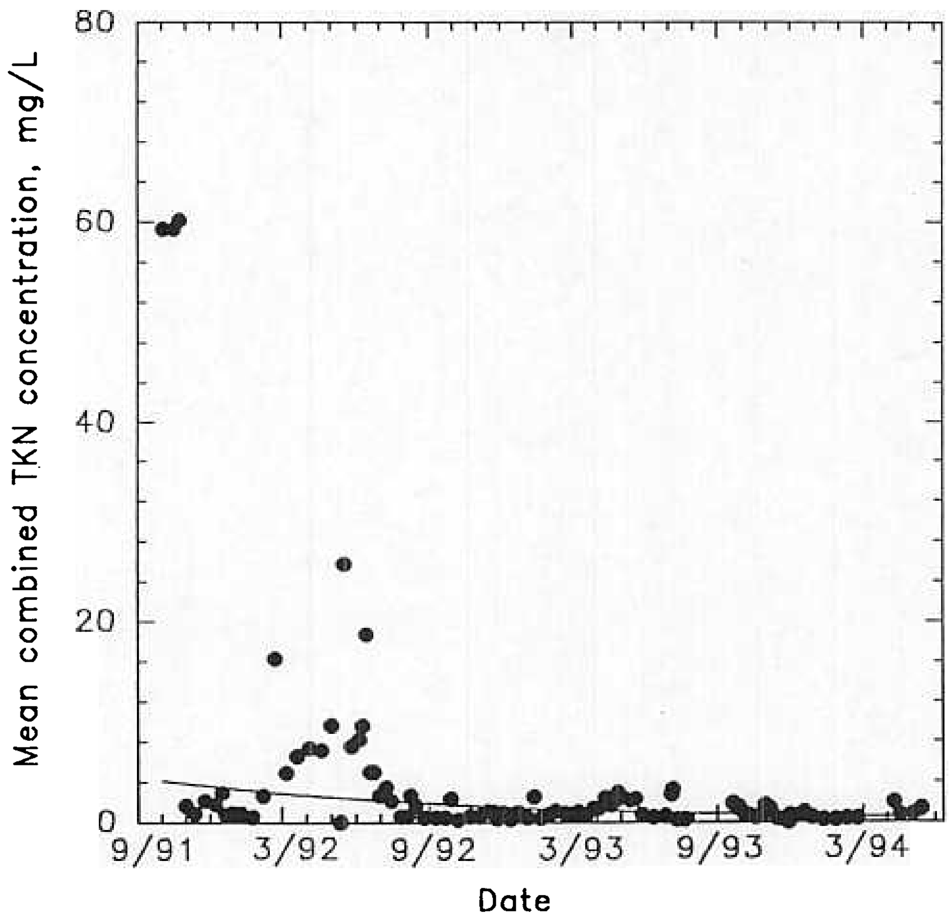


Fig. 35. Flow-weighted mean overall TKN concentrations for the ML monitoring station

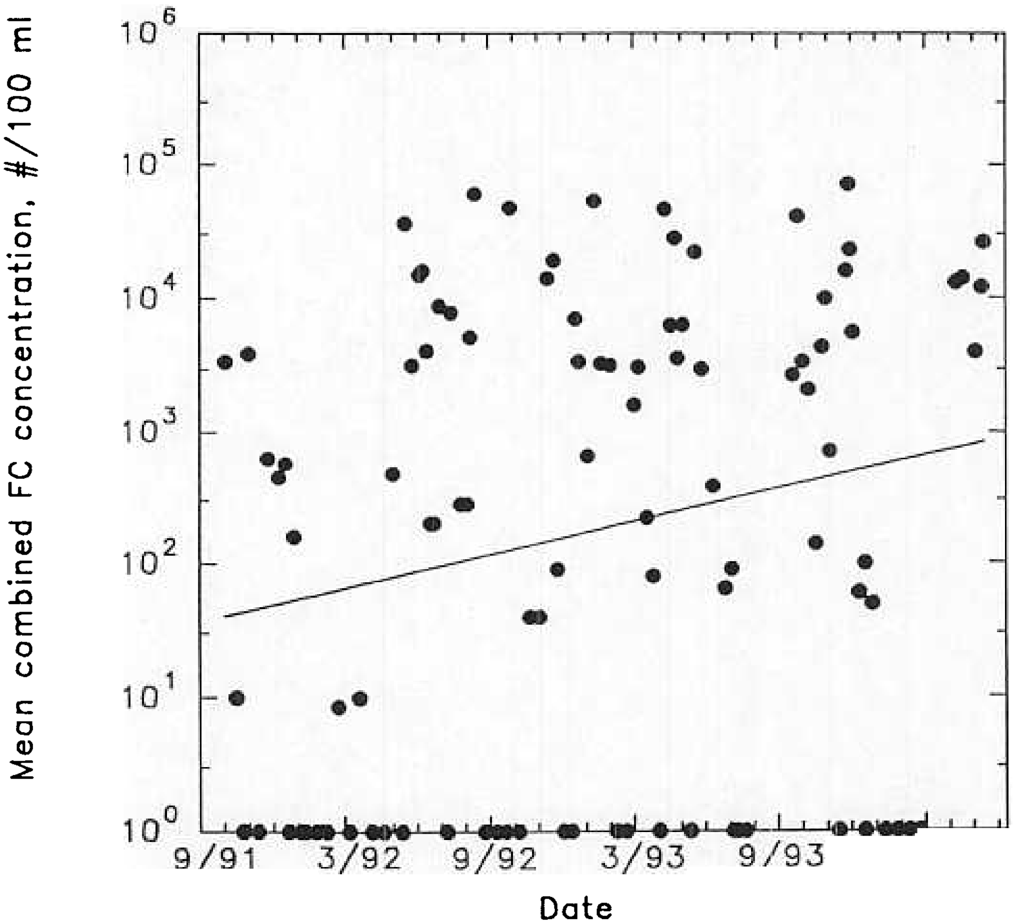


Fig. 36. Flow-weighted mean overall FC concentrations for the ML monitoring station

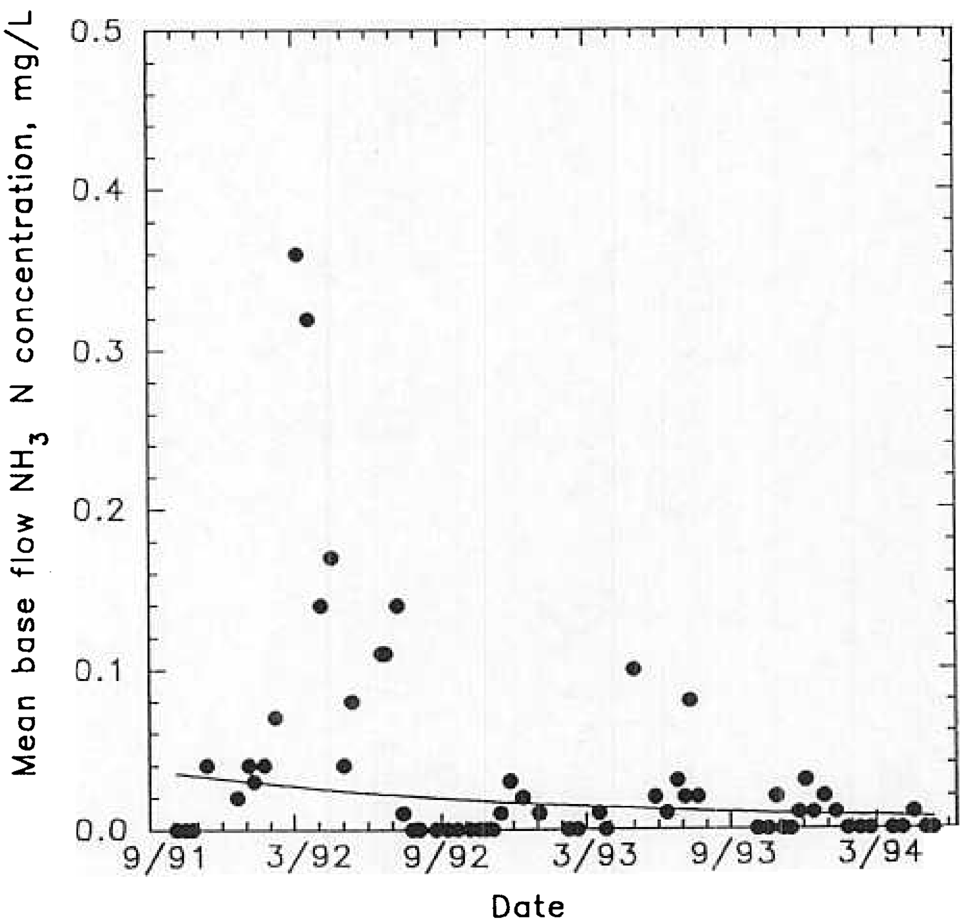


Fig. 37. Flow-weighted mean base flow NH_3-N concentrations for the BL monitoring station

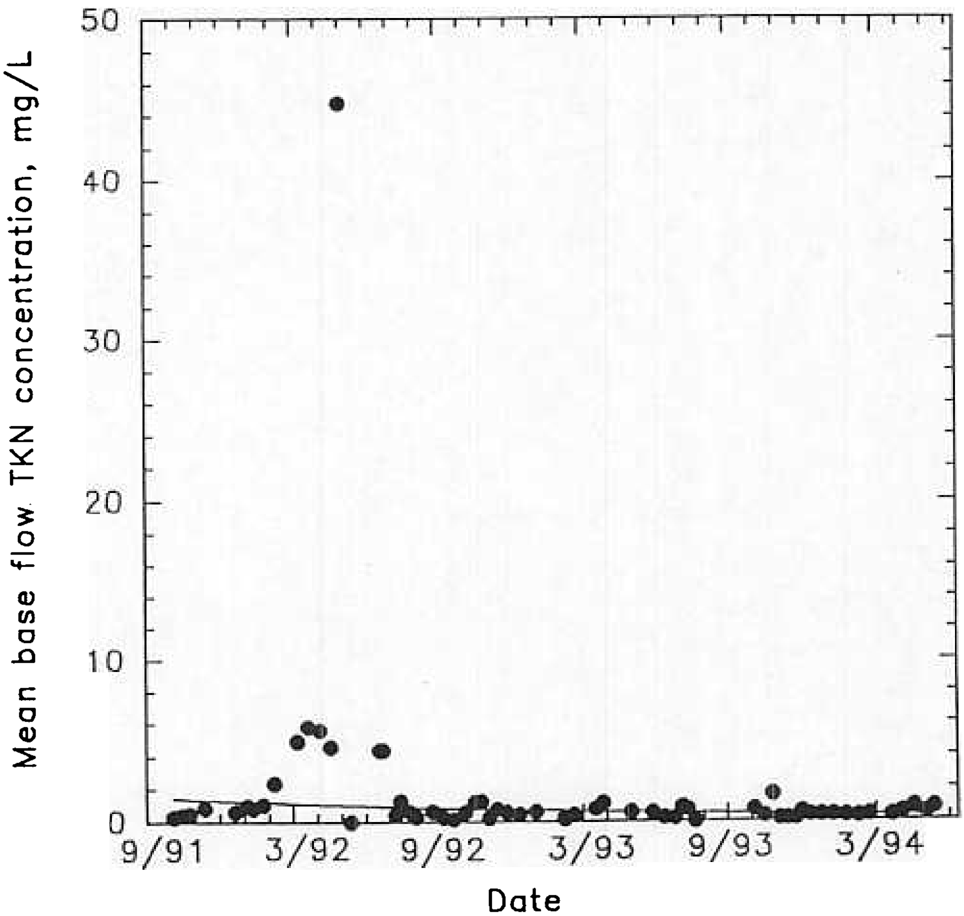


Fig. 38. Flow-weighted mean base flow TKN concentrations for the BL monitoring station

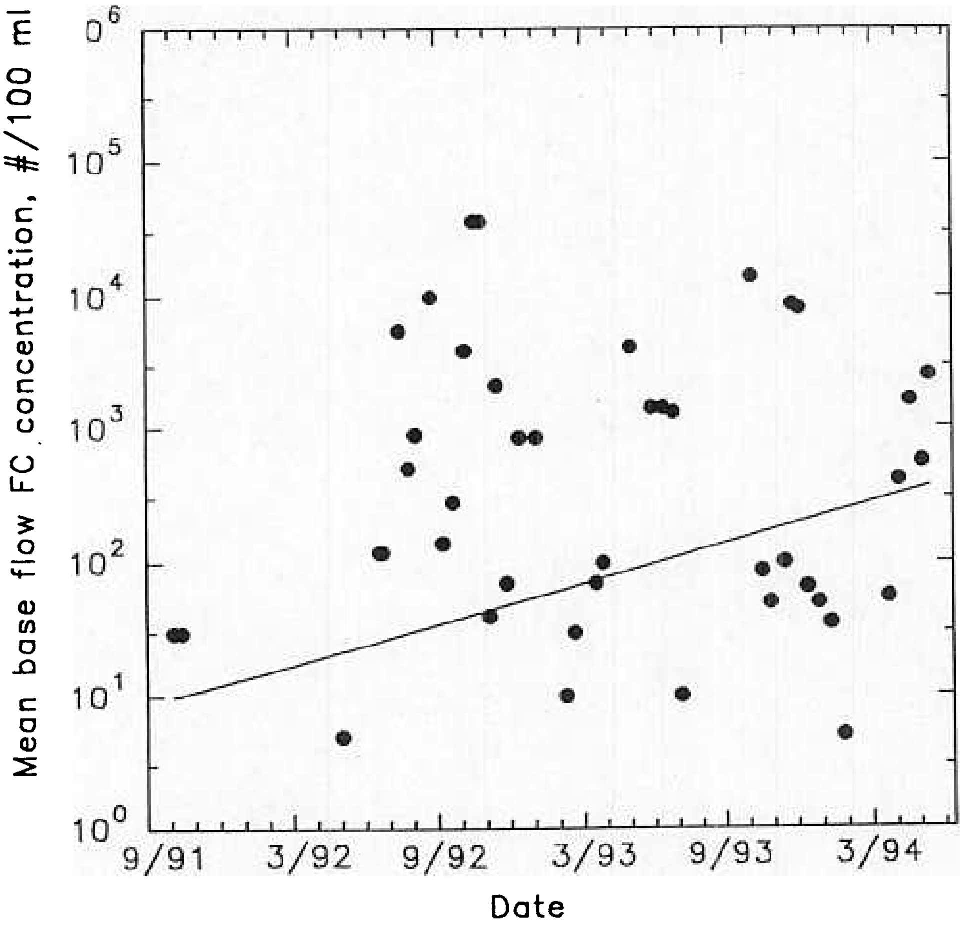


Fig. 39. Flow-weighted mean base flow FC concentrations for the BL monitoring station

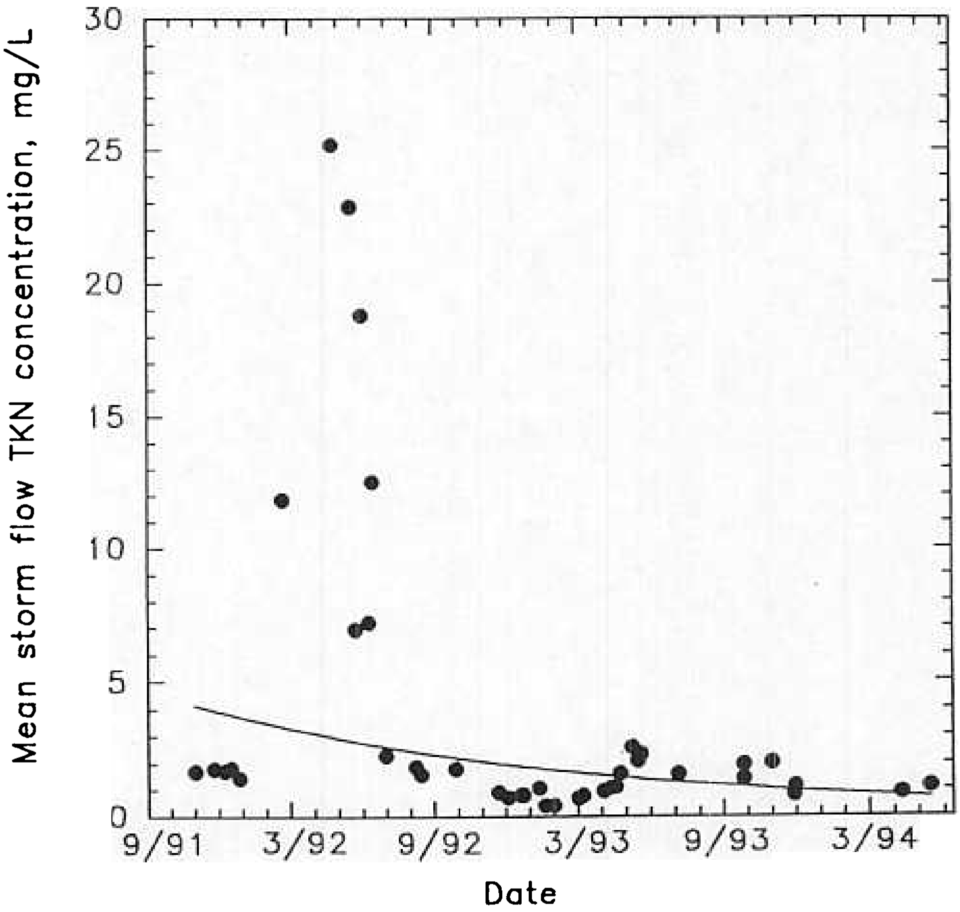


Fig. 40. Flow-weighted mean storm flow TKN concentrations for the BL monitoring station

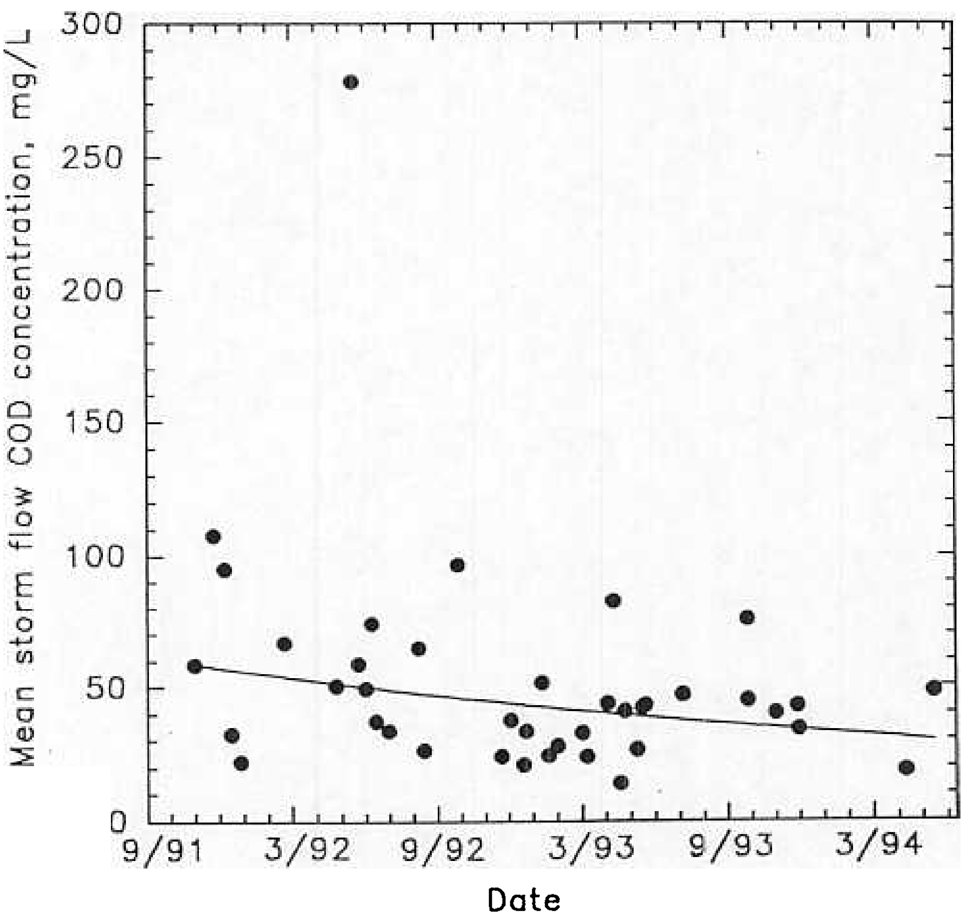


Fig. 41. Flow-weighted mean storm flow COD concentrations for the BL monitoring station

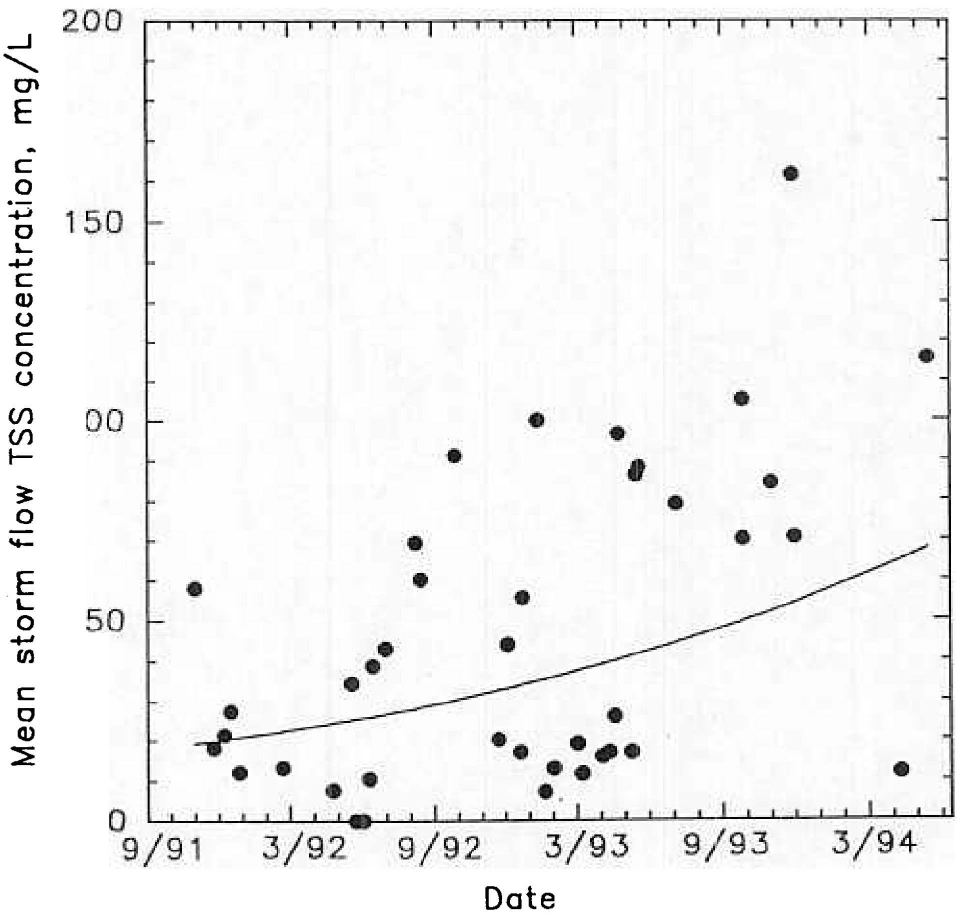


Fig. 42. Flow-weighted mean storm flow TSS concentrations for the BL monitoring station

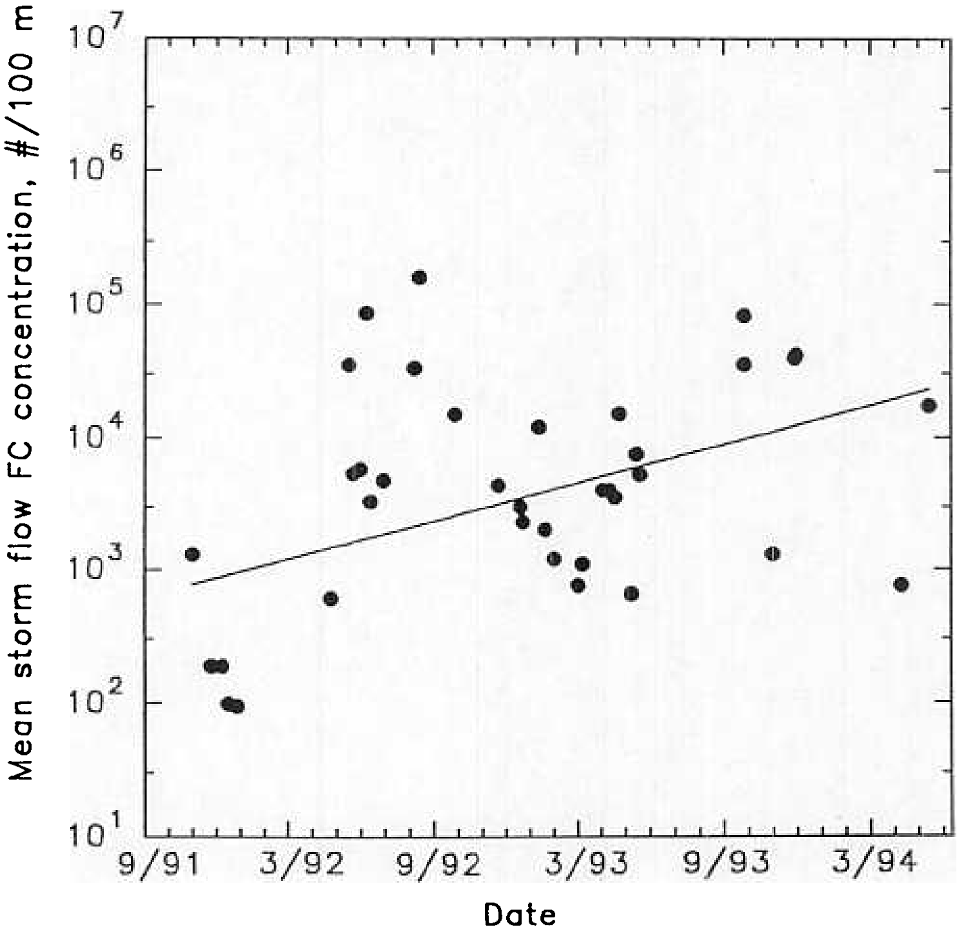


Fig. 43. Flow-weighted mean storm flow FC concentrations for the BL monitoring station

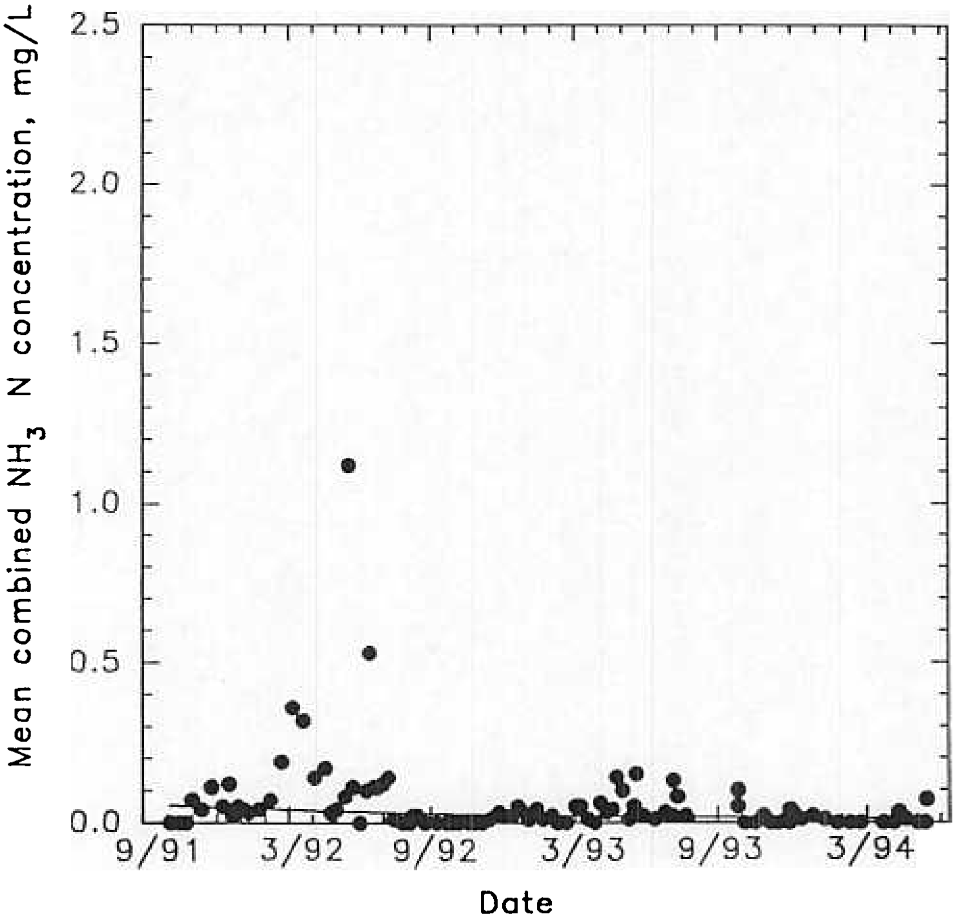


Fig. 44. Flow-weighted mean overall NH_3-N concentrations for the BL monitoring station

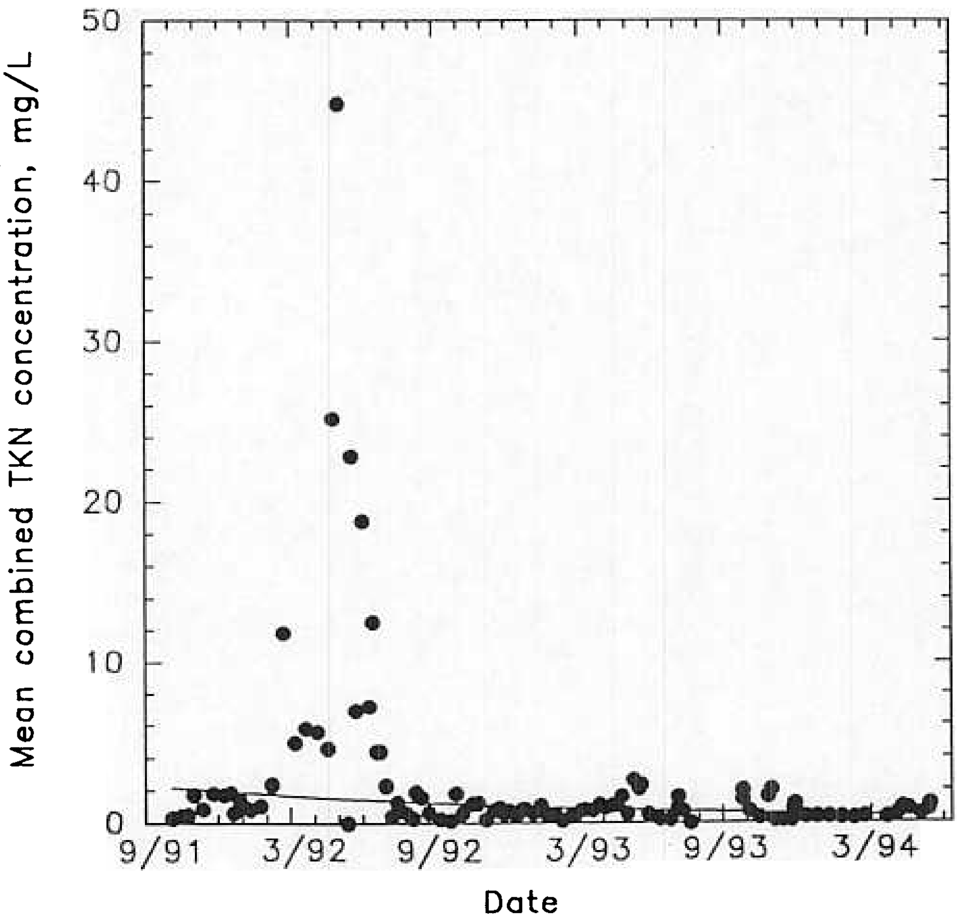


Fig. 45. Flow-weighted mean overall TKN concentrations for the BL monitoring station

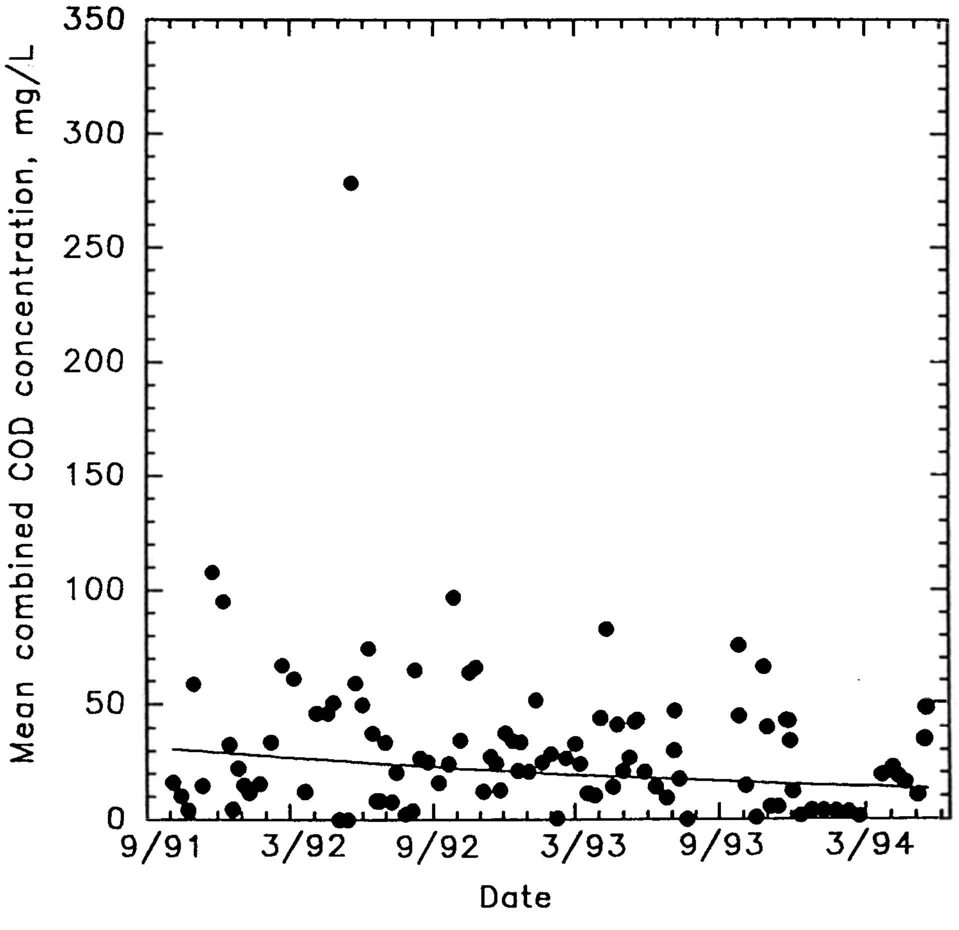


Fig. 46. Flow-weighted mean overall COD concentrations for the BL monitoring station

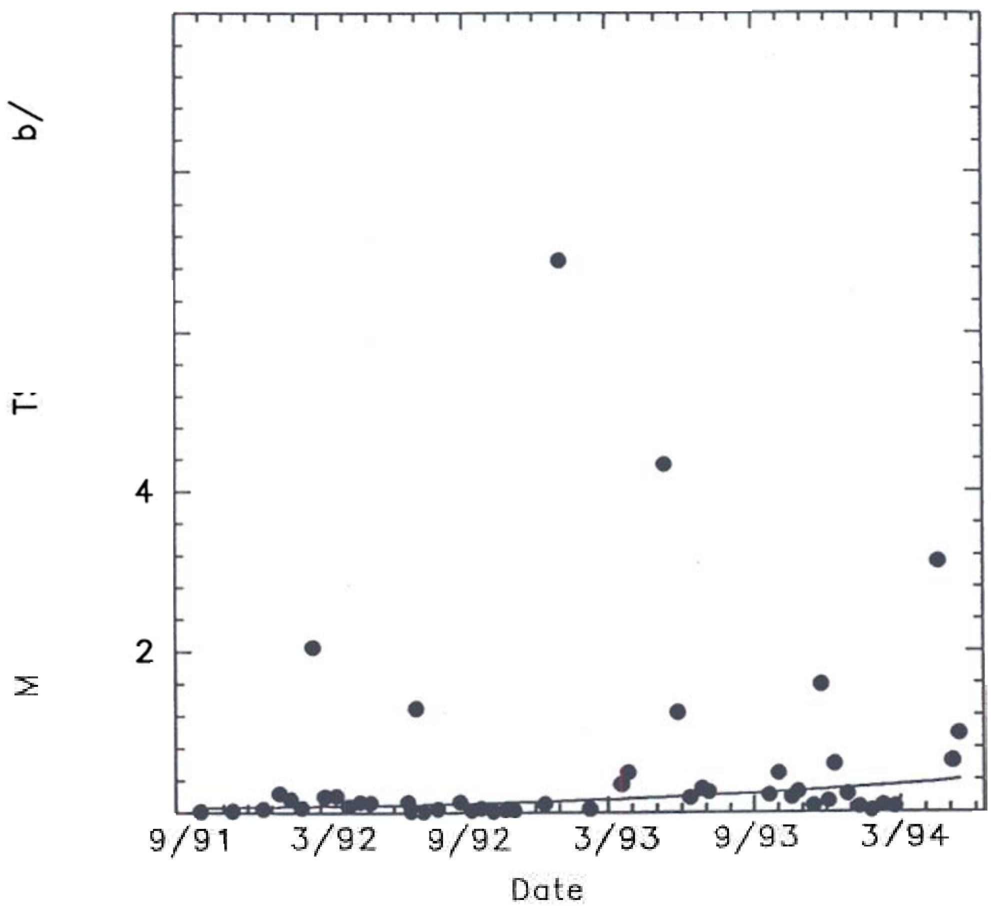


Fig Base flow TSS transport monitoring station

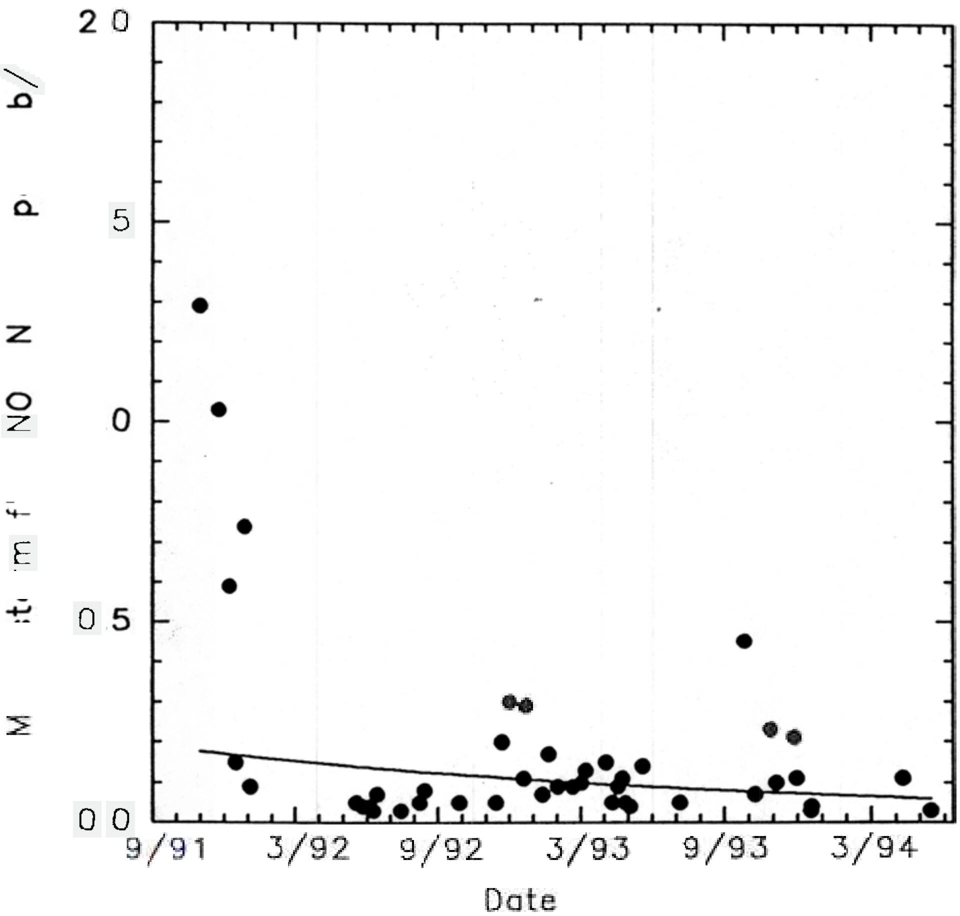


Fig Storm flow NO_3-N transport monitoring station

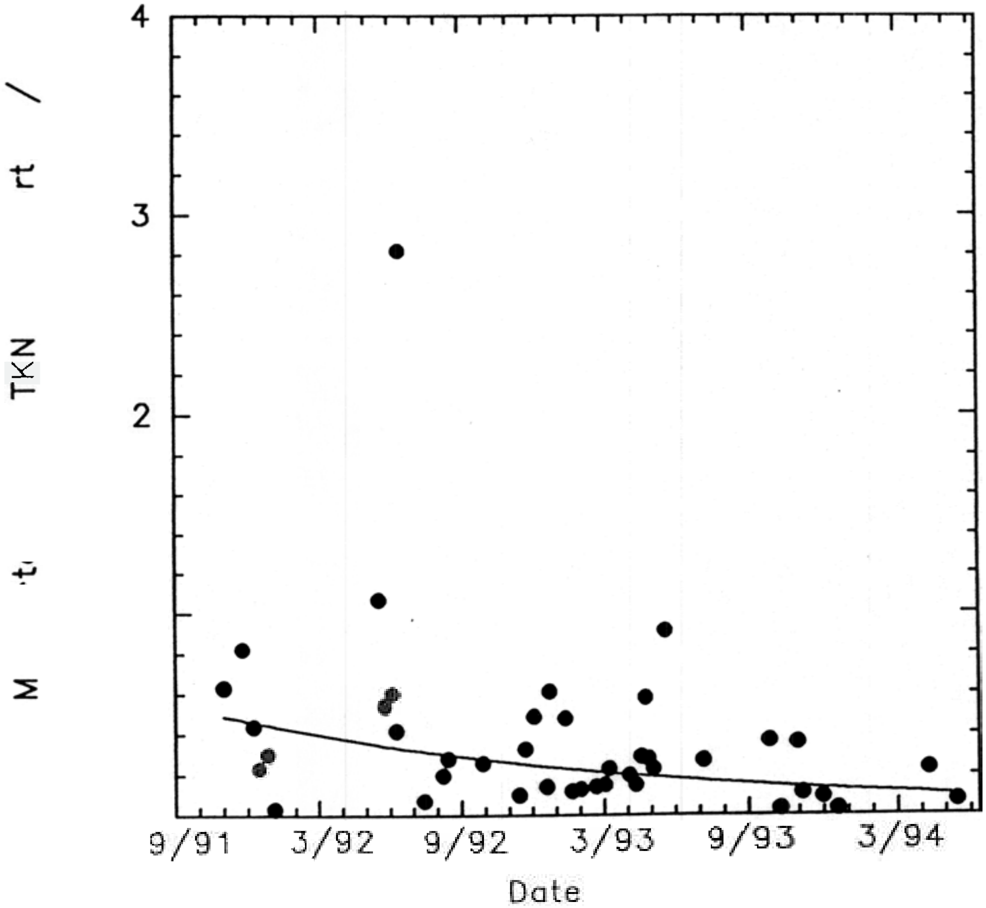


Fig. Storm flow TKN transport monitoring station

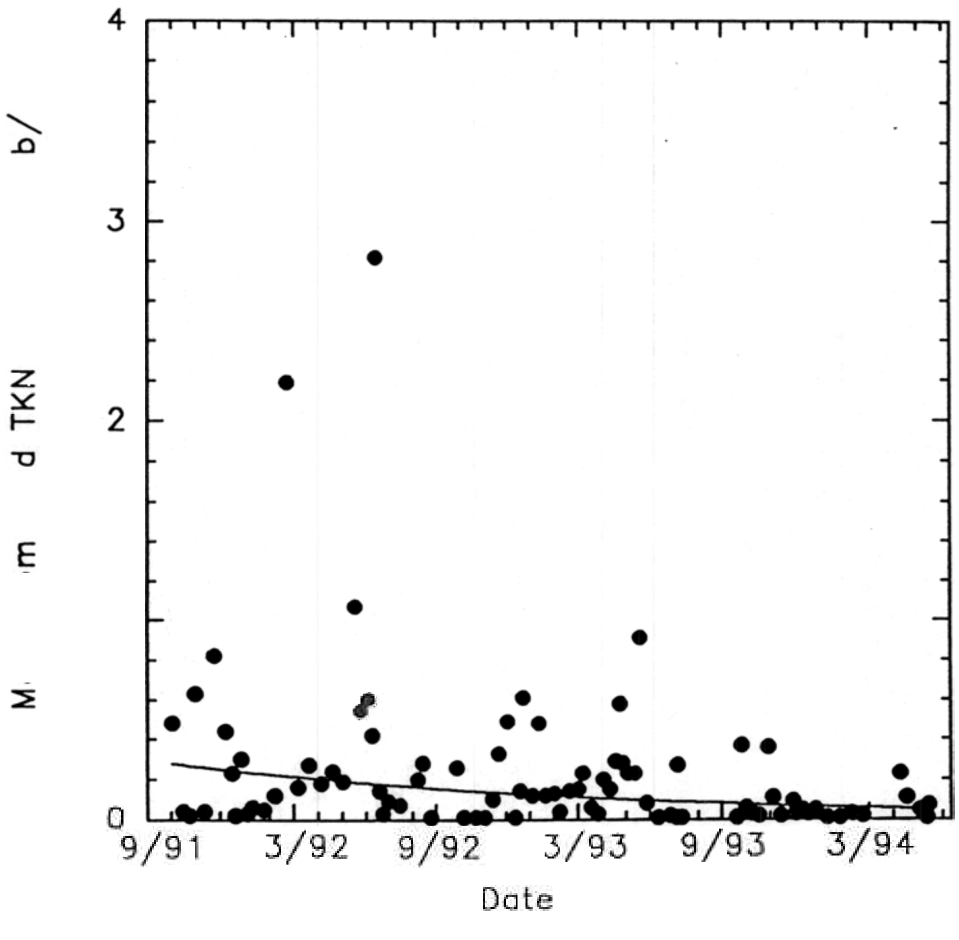


Fig Overall TKN transport monitoring station

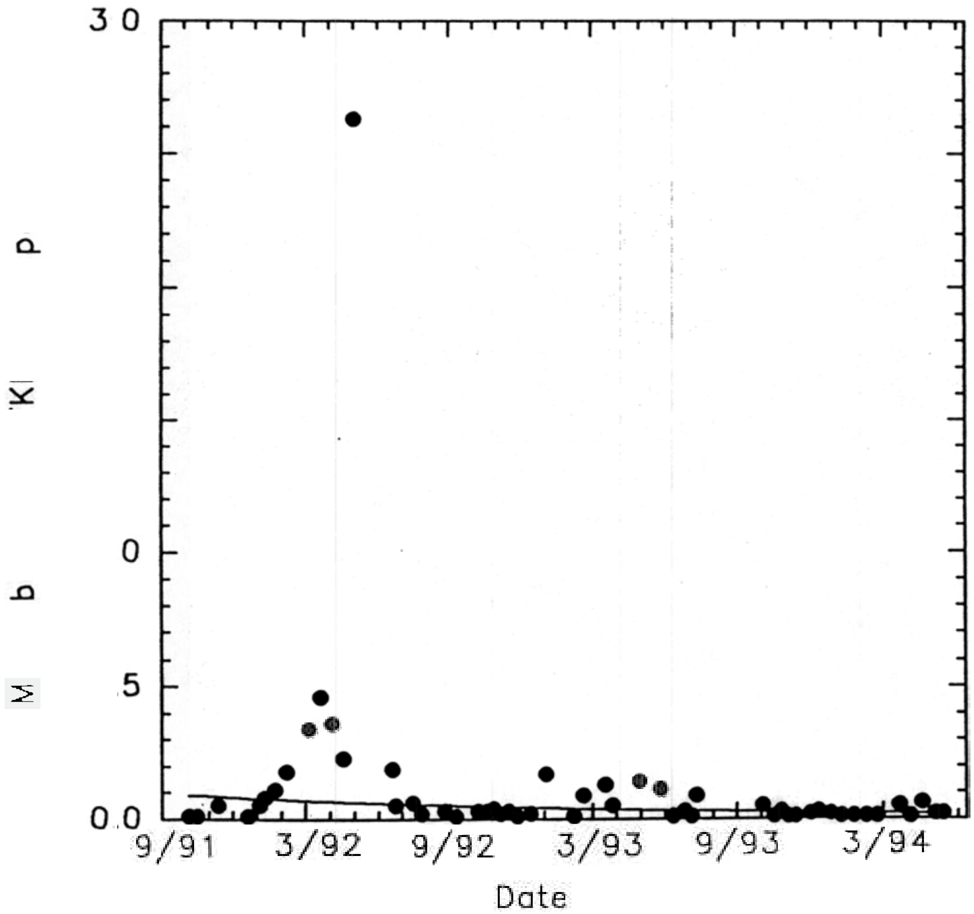


Fig Base flow TKN transport monitoring station

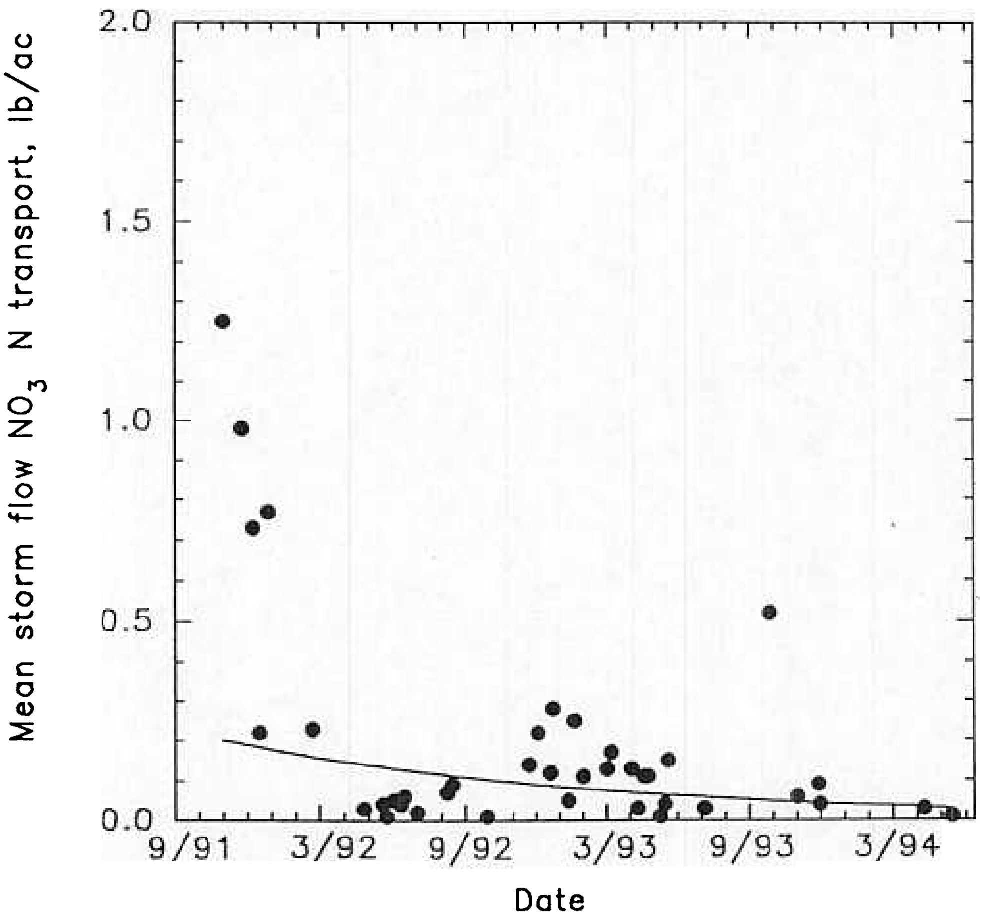


Fig. 52. Storm flow NO_3-N transport for the BL monitoring station

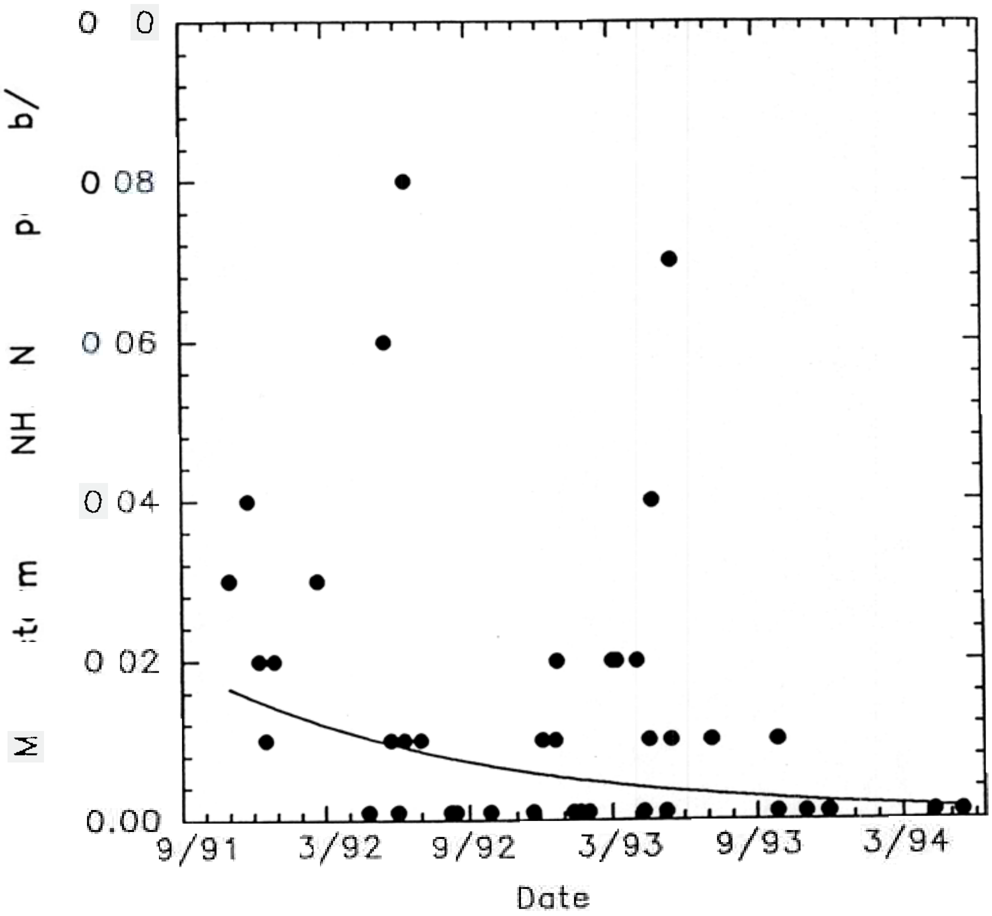


Fig Storm flow NH_3 transport monitoring station

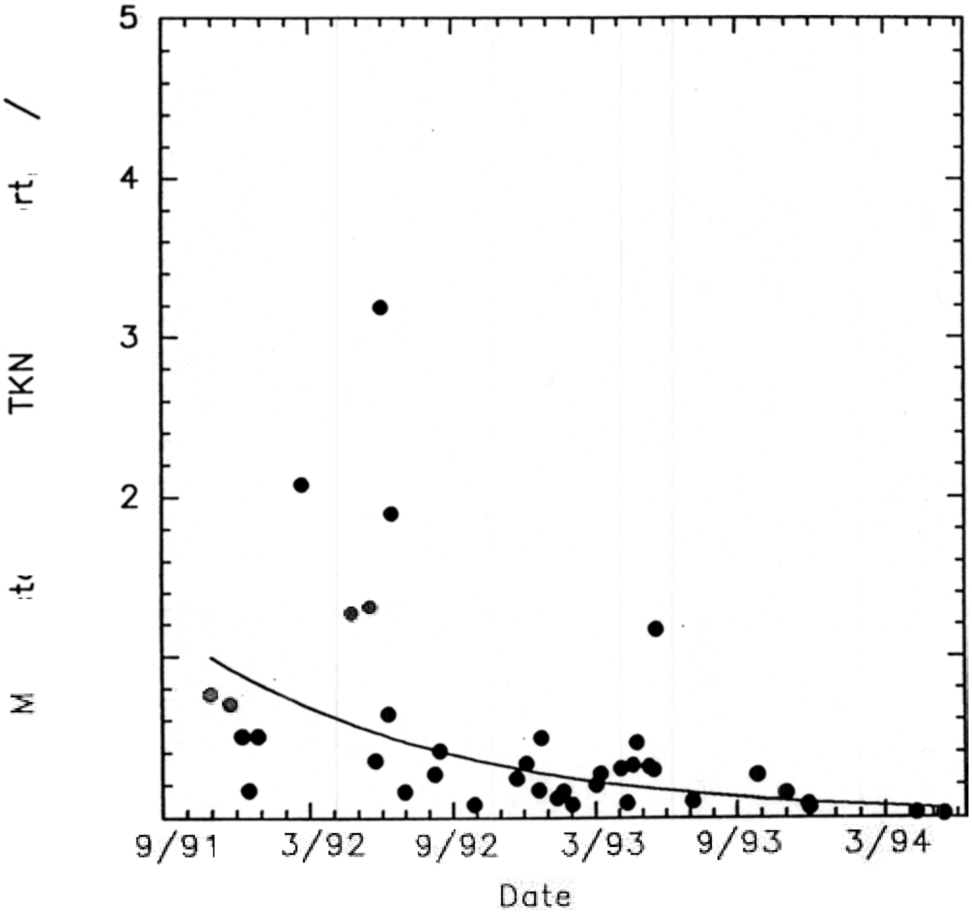


Fig 54 Storm flow TKN transport the BL monitoring station

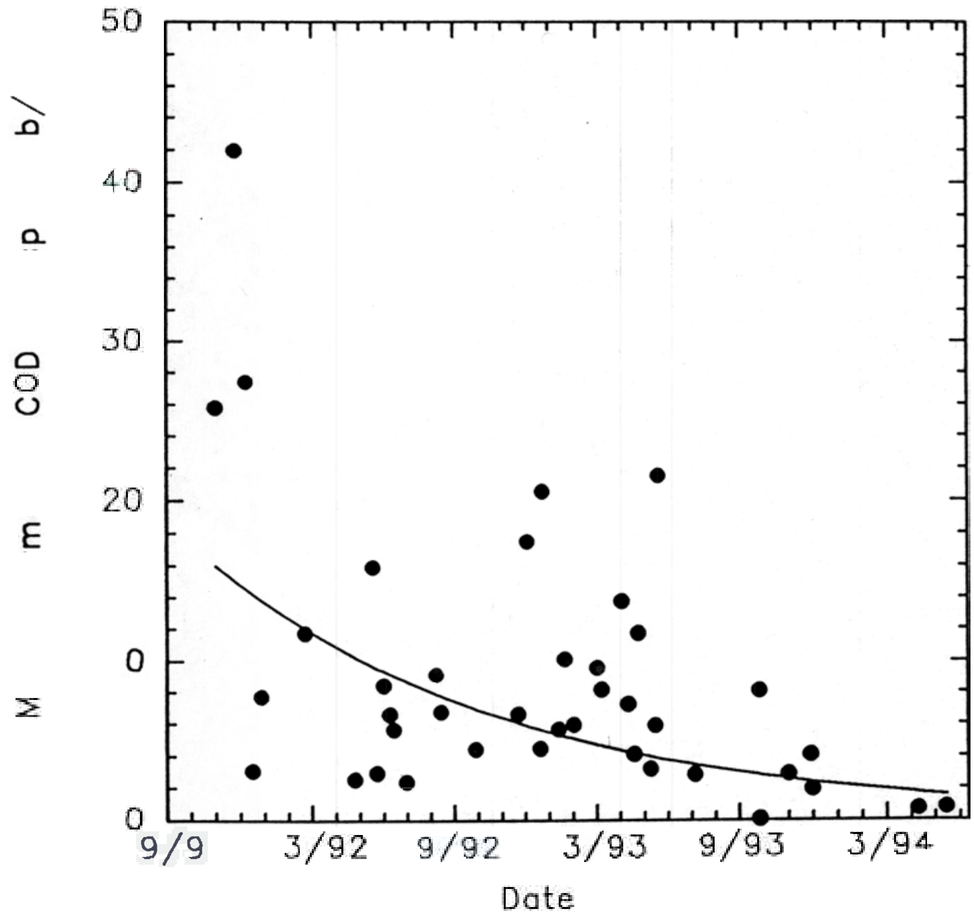


Fig. Storm flow COD transport monitoring statior

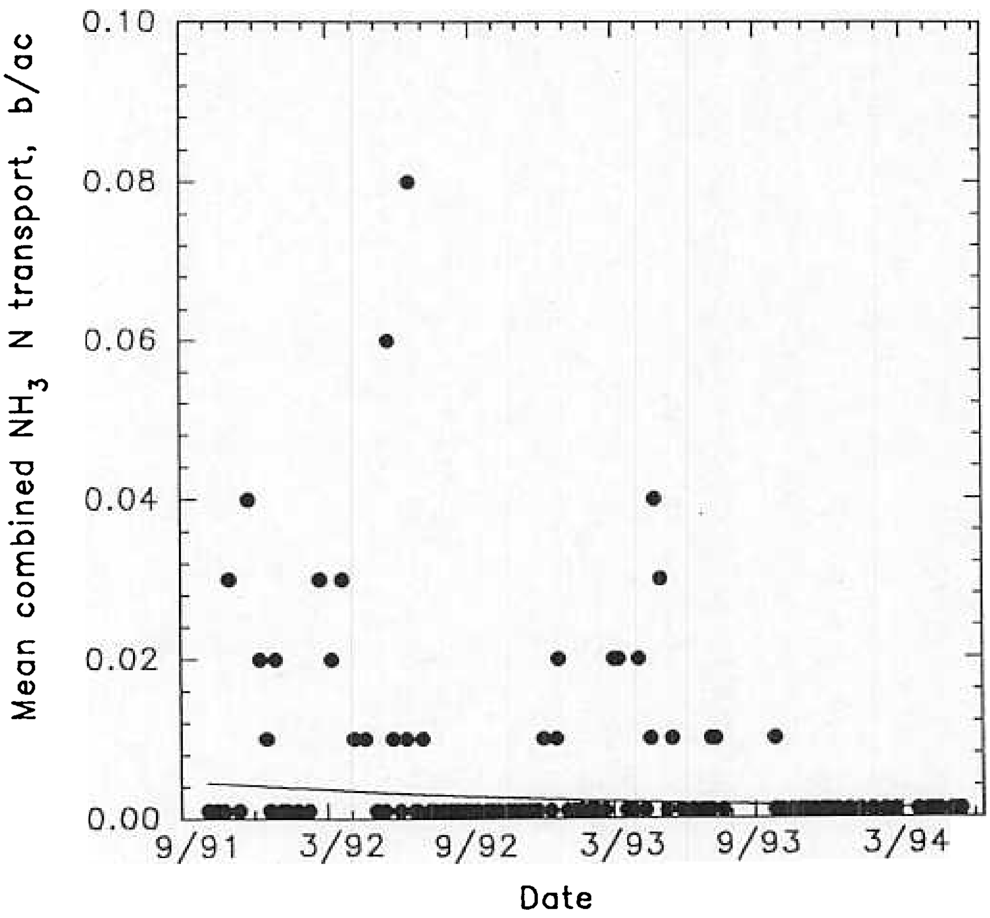


Fig. 56. Overall NH_3-N transport for the BL monitoring station

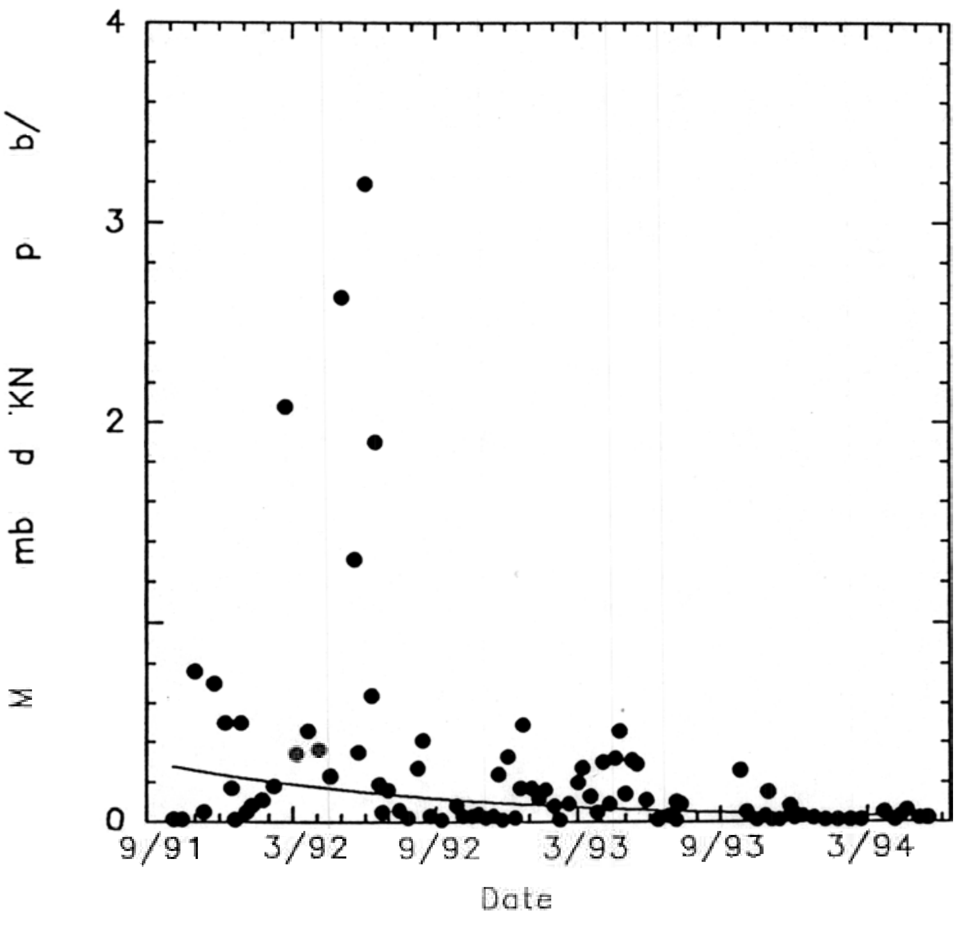


Fig. Overall TKN transport monitoring station

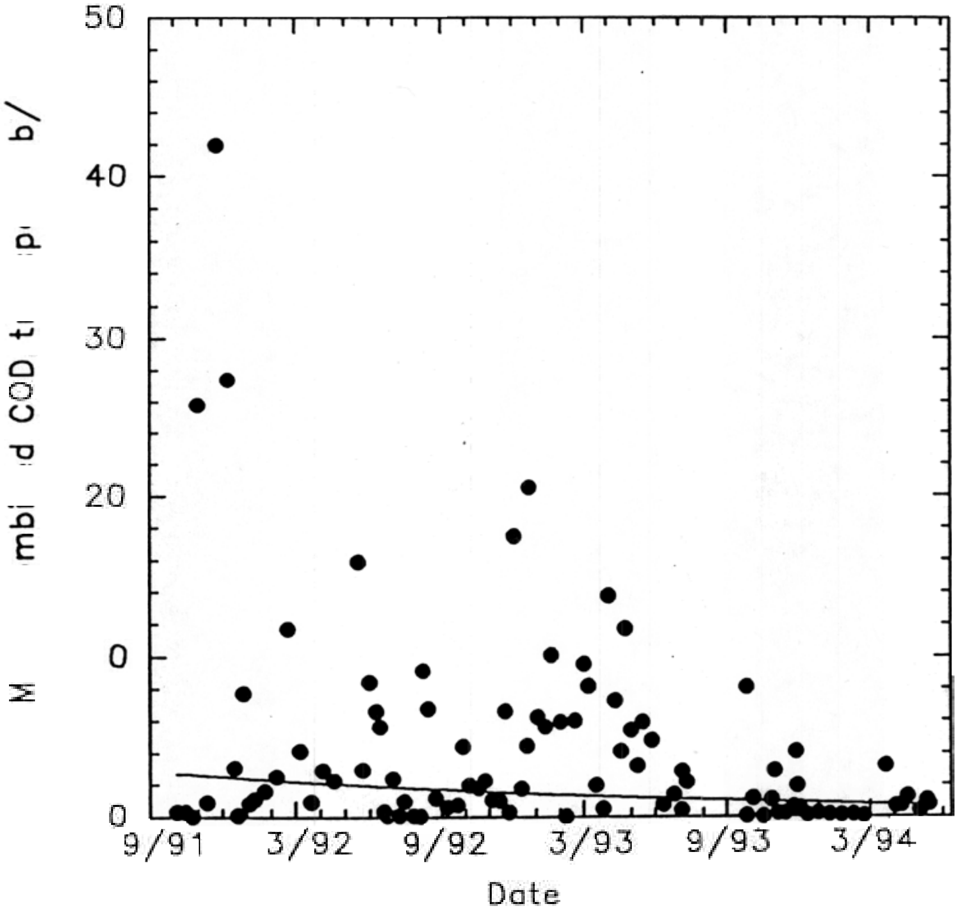


Fig Overall COD transport for monitoring station

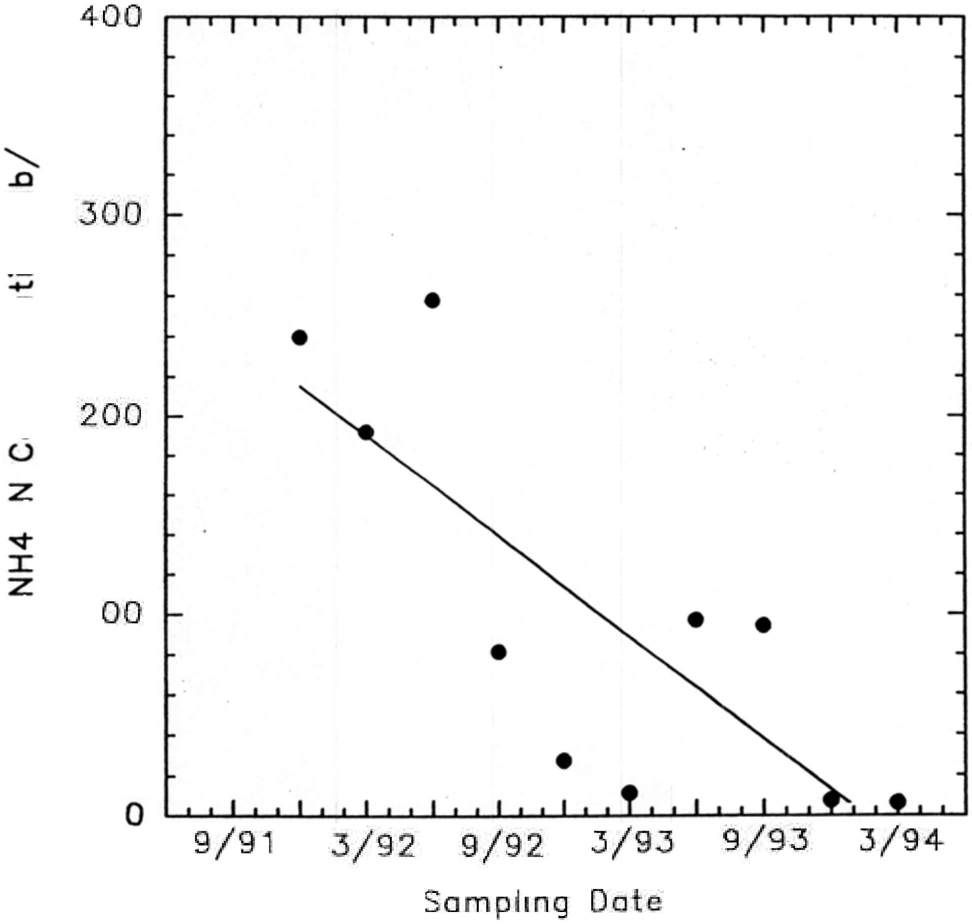


Fig Mean NH_4 content field

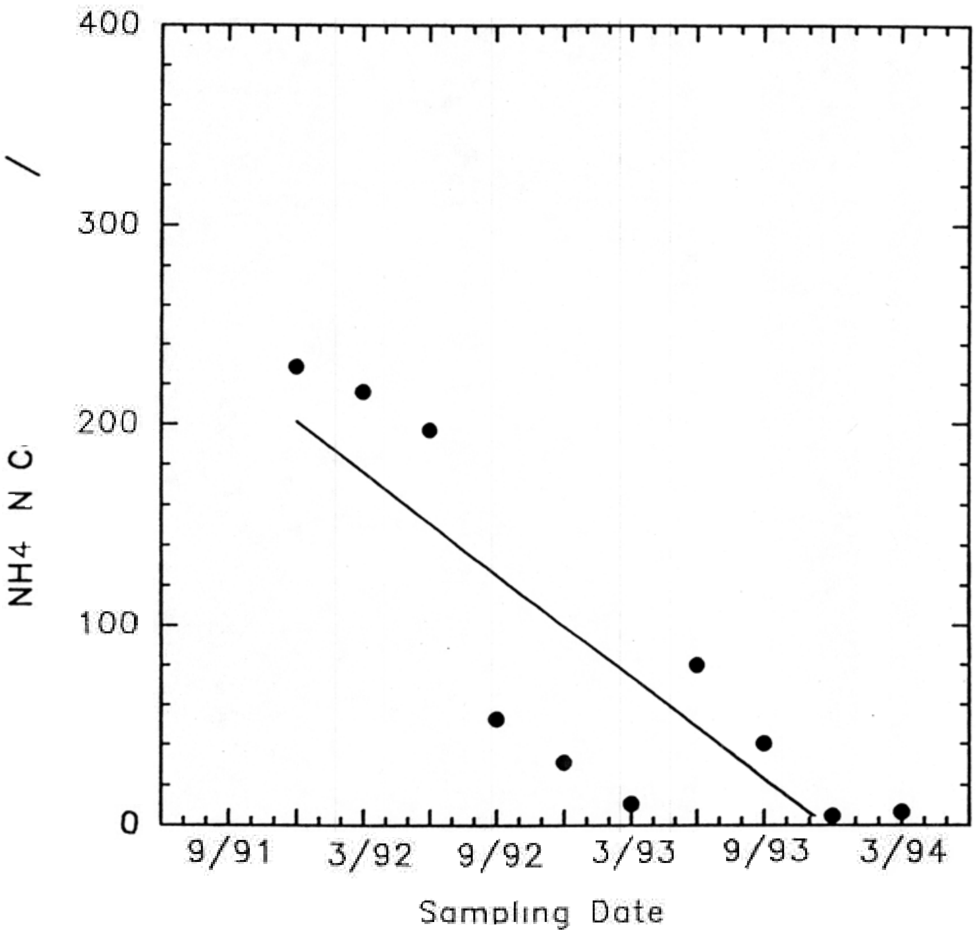


Fig. Mean NH_4 content field

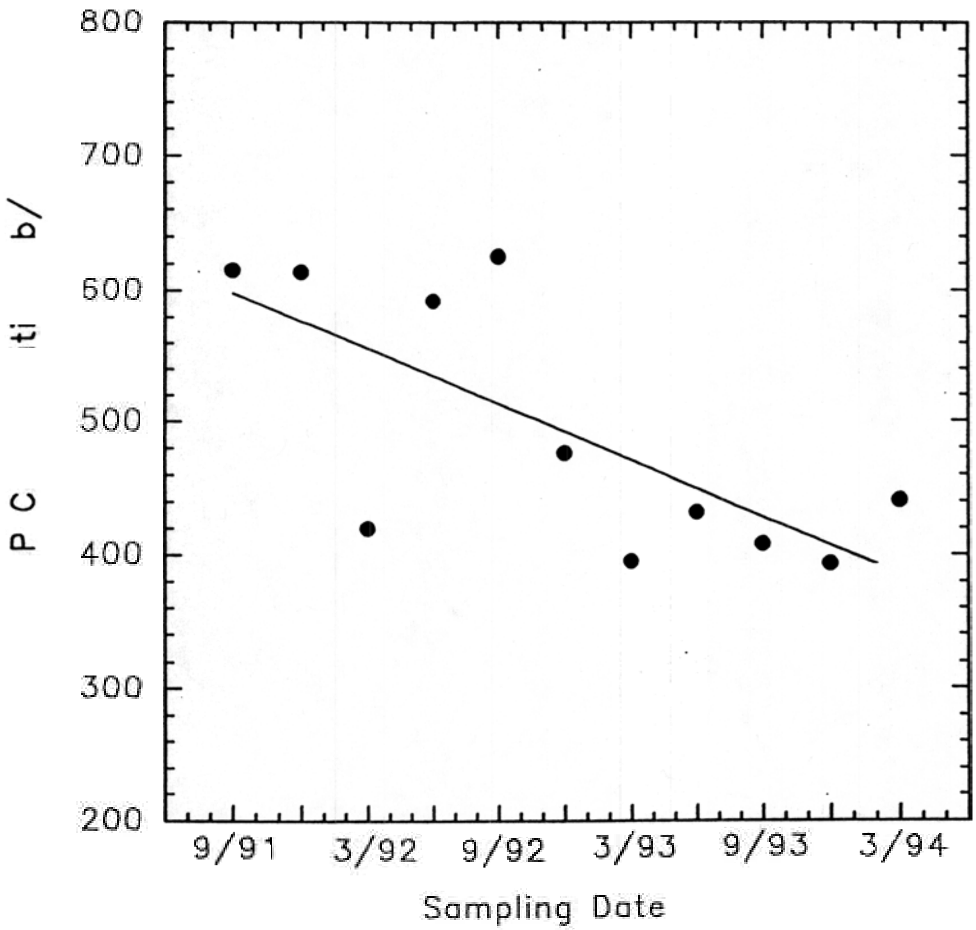
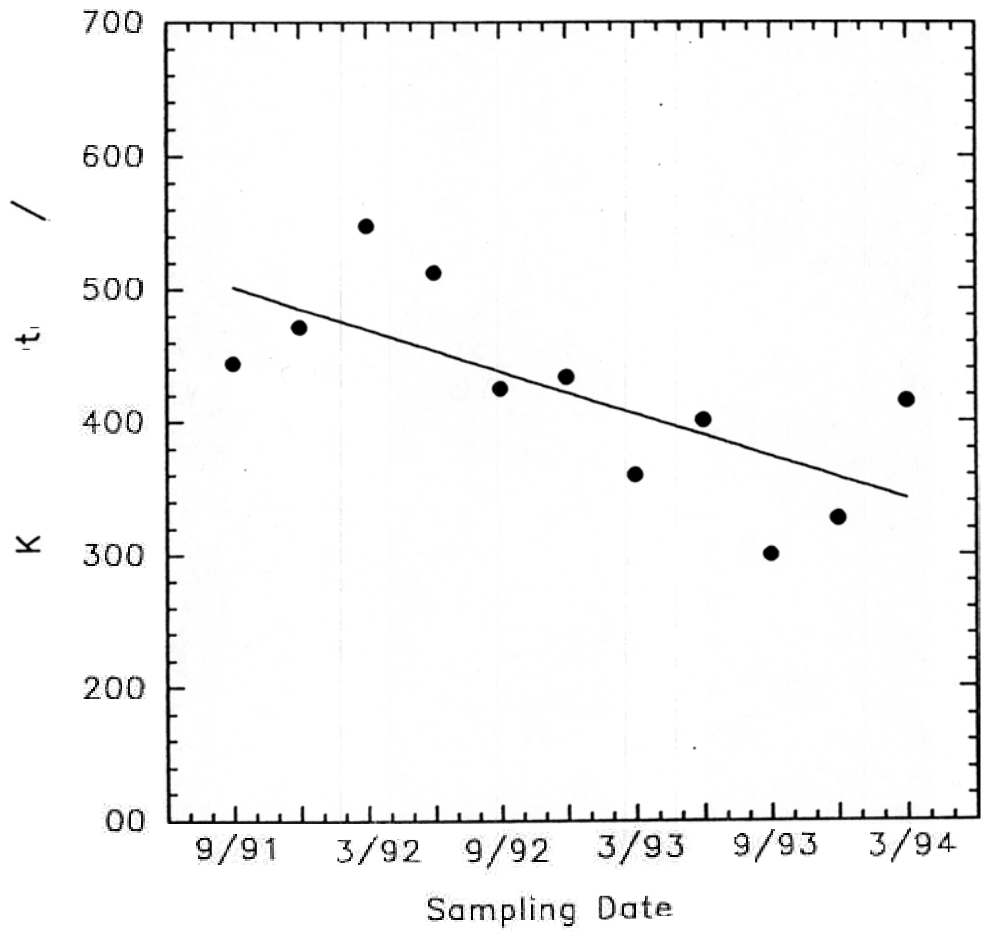


Fig Mean soil content for field



ıg Mean content field

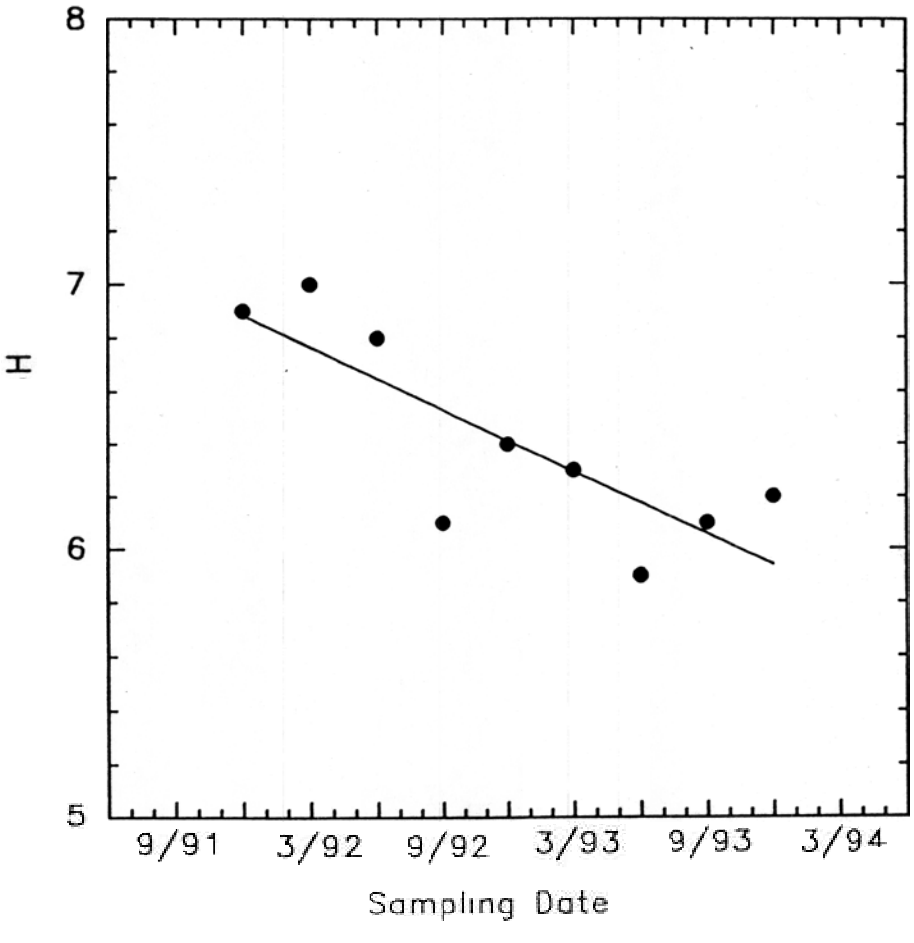


Fig Mean field

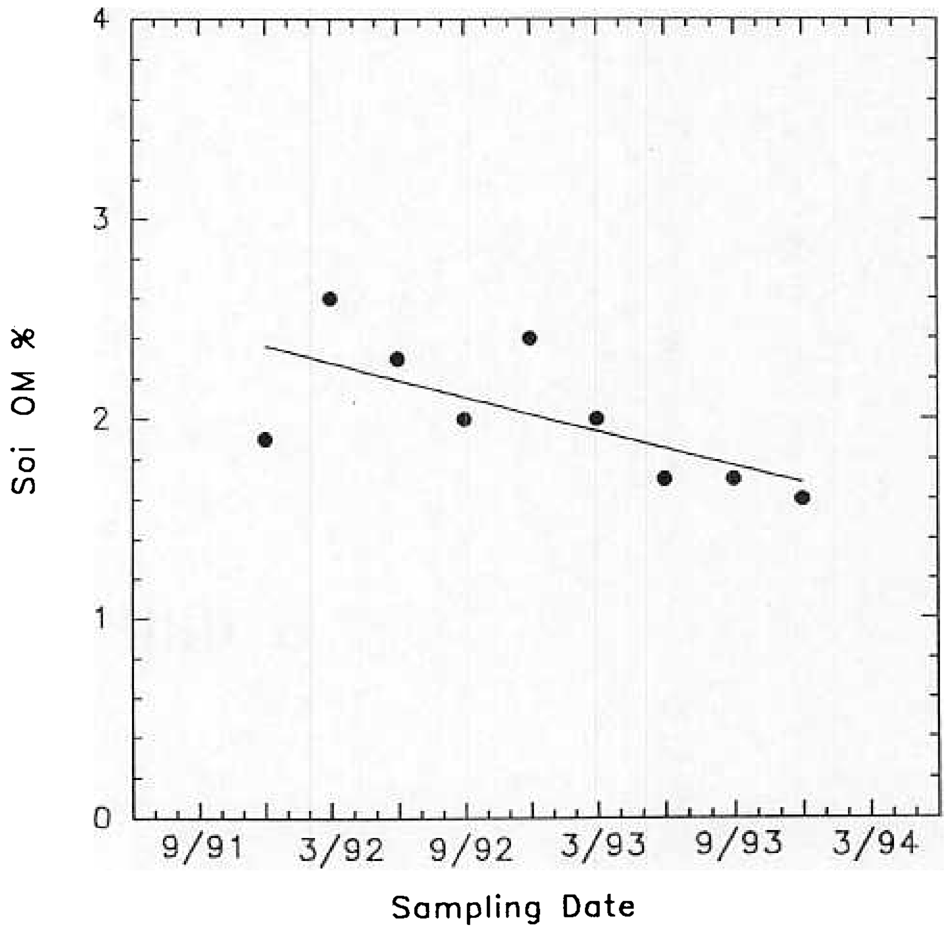


Fig. 64. Mean soil organic matter content for field WM

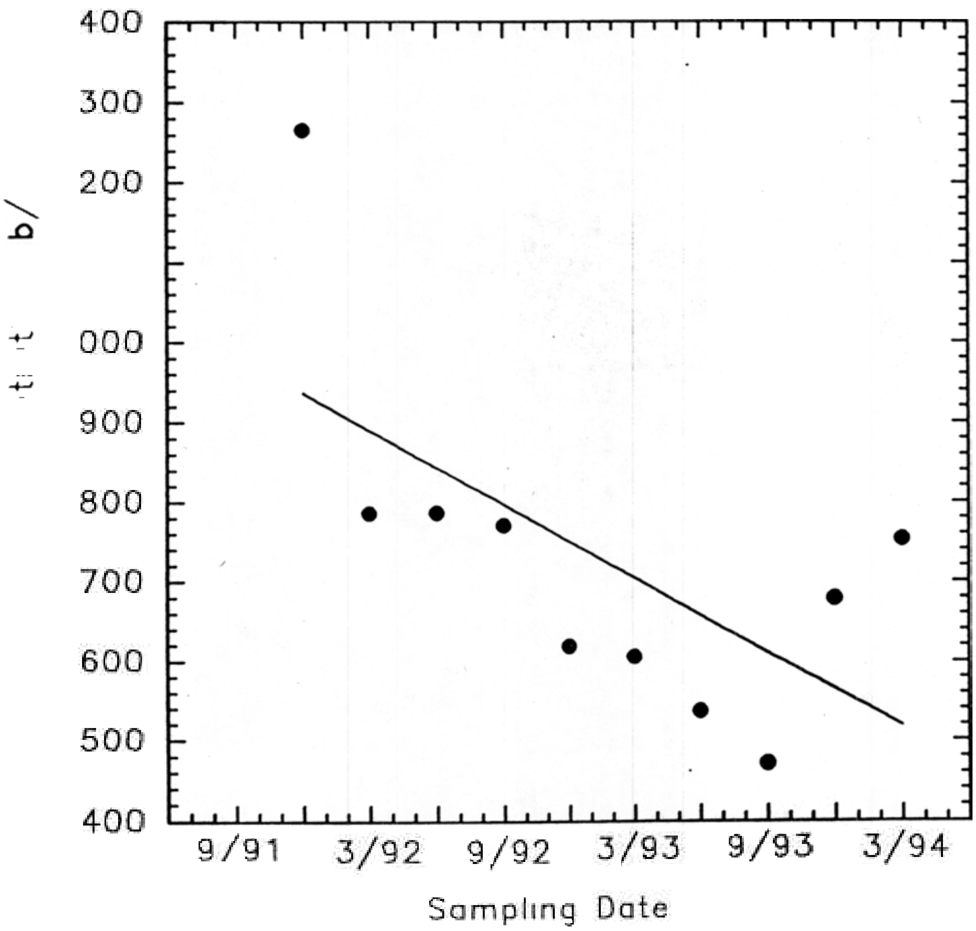


Fig Mean content field WM

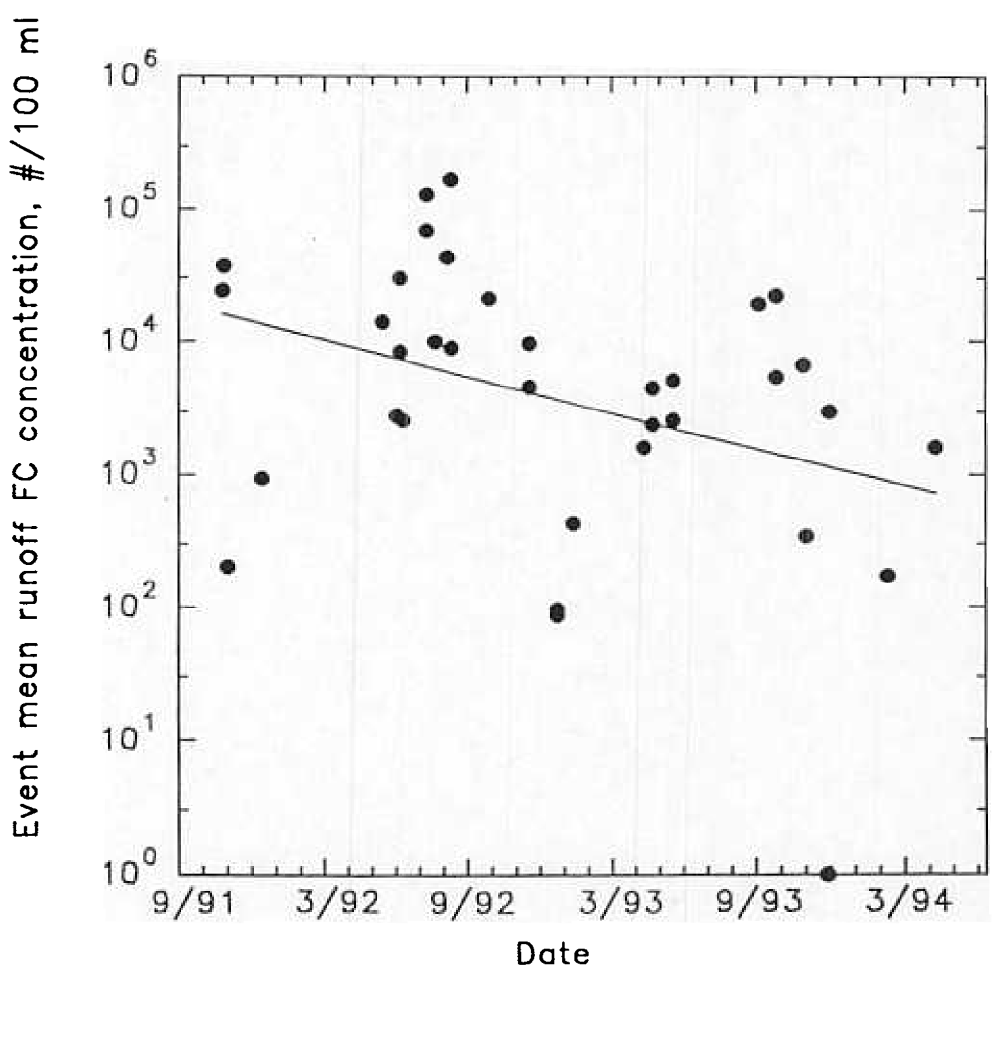


Fig. 66. Event flow-weighted mean runoff concentrations of FC for field RU

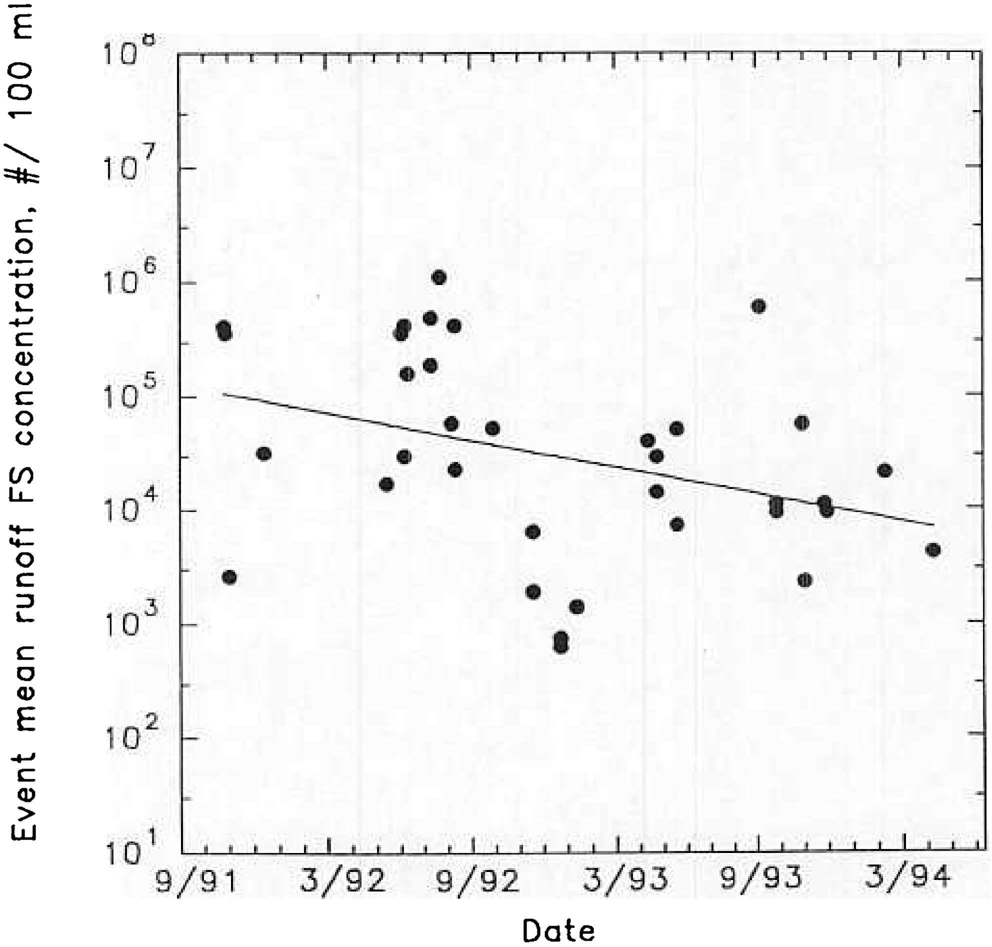


Fig. 67. Event flow-weighted mean runoff concentrations of FS for field RU

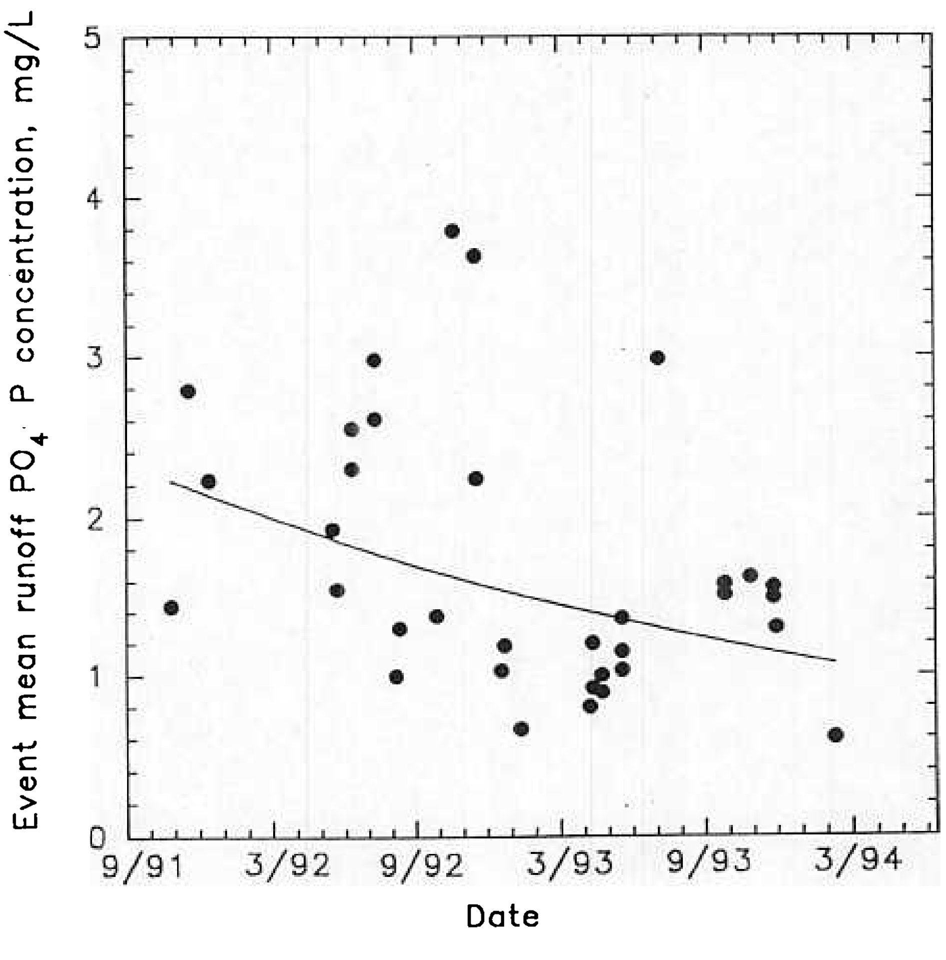


Fig. 68. Event flow-weighted mean runoff concentrations of PO_4-P for field RM

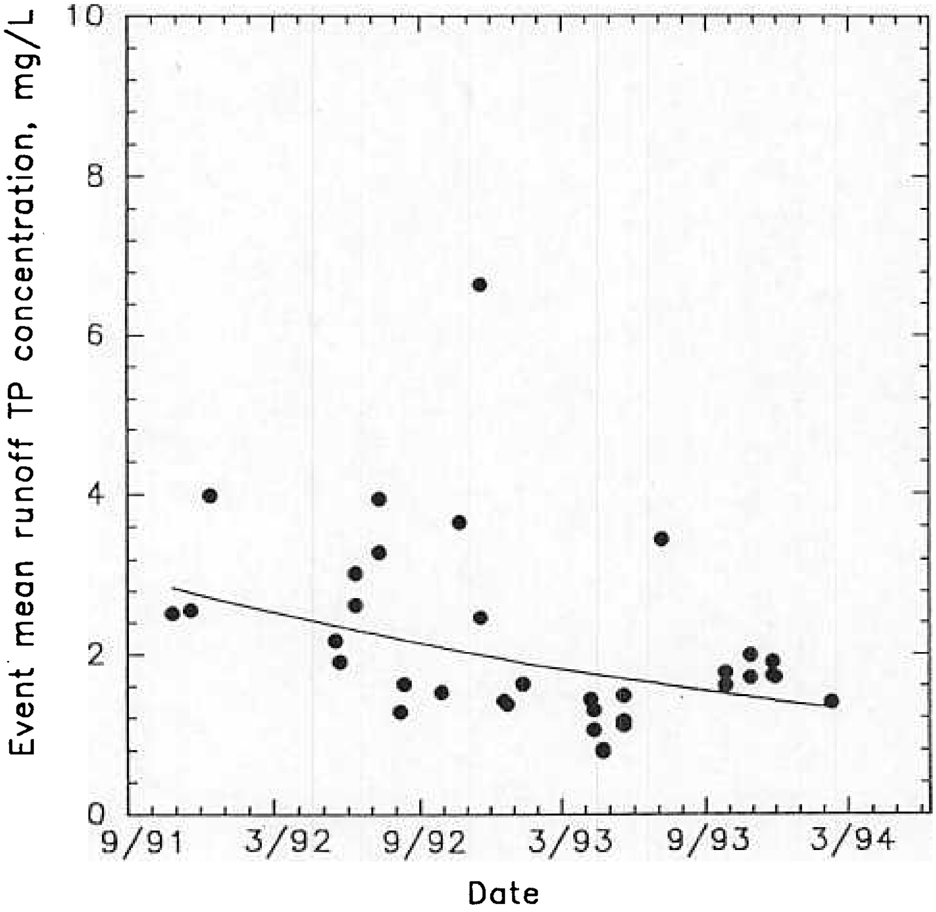


Fig. 69. Event flow-weighted mean runoff concentrations of TP for field RM

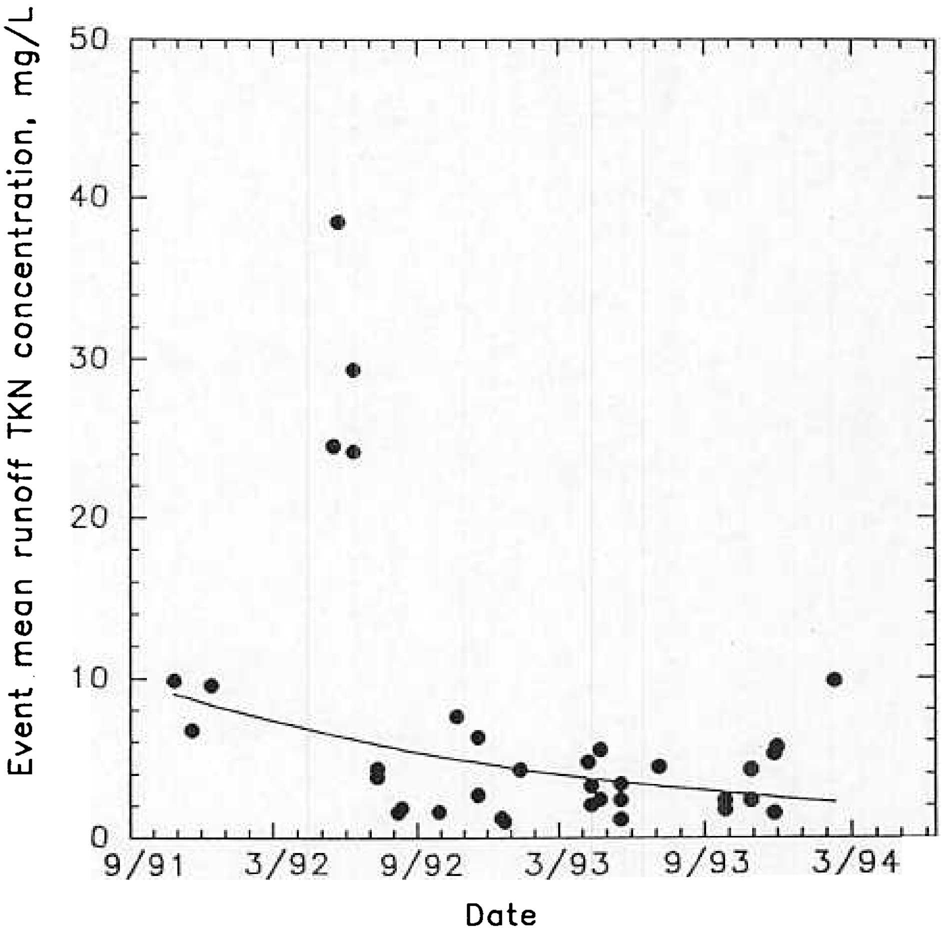


Fig. 70. Event flow-weighted mean runoff concentrations of TKN for field RM

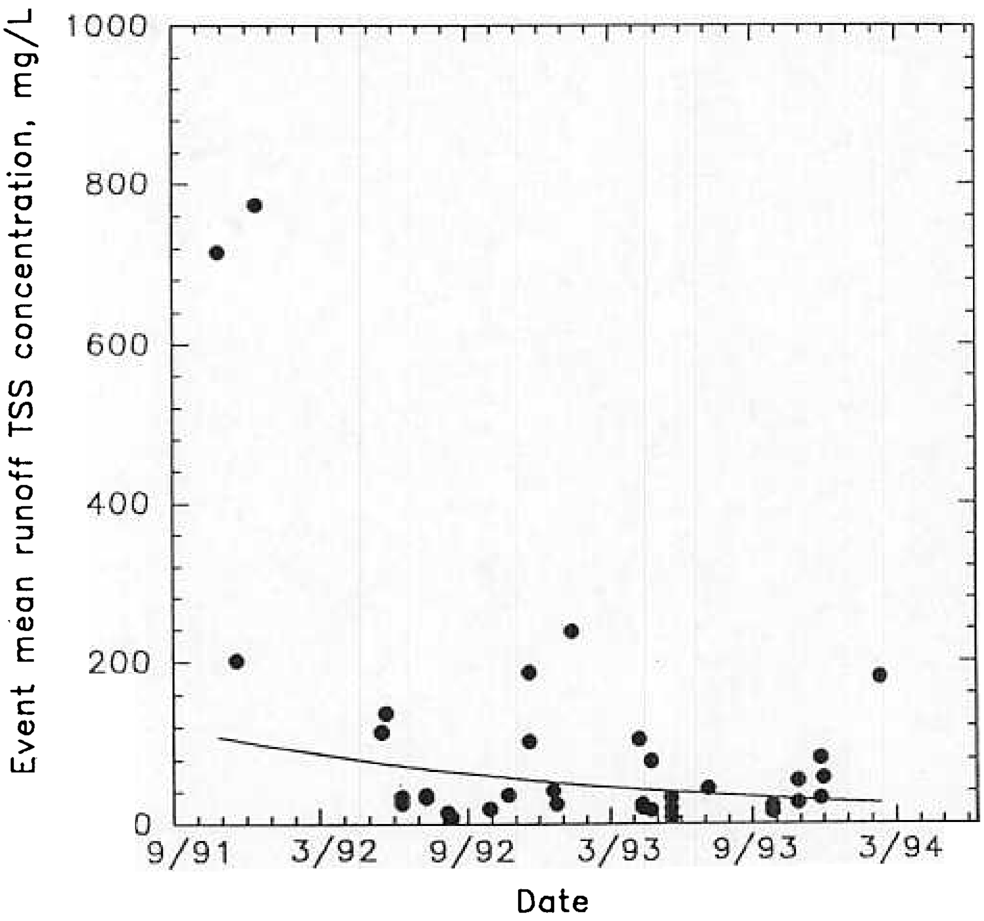


Fig. 71 Event flow-weighted mean runoff concentrations of TSS for field RM

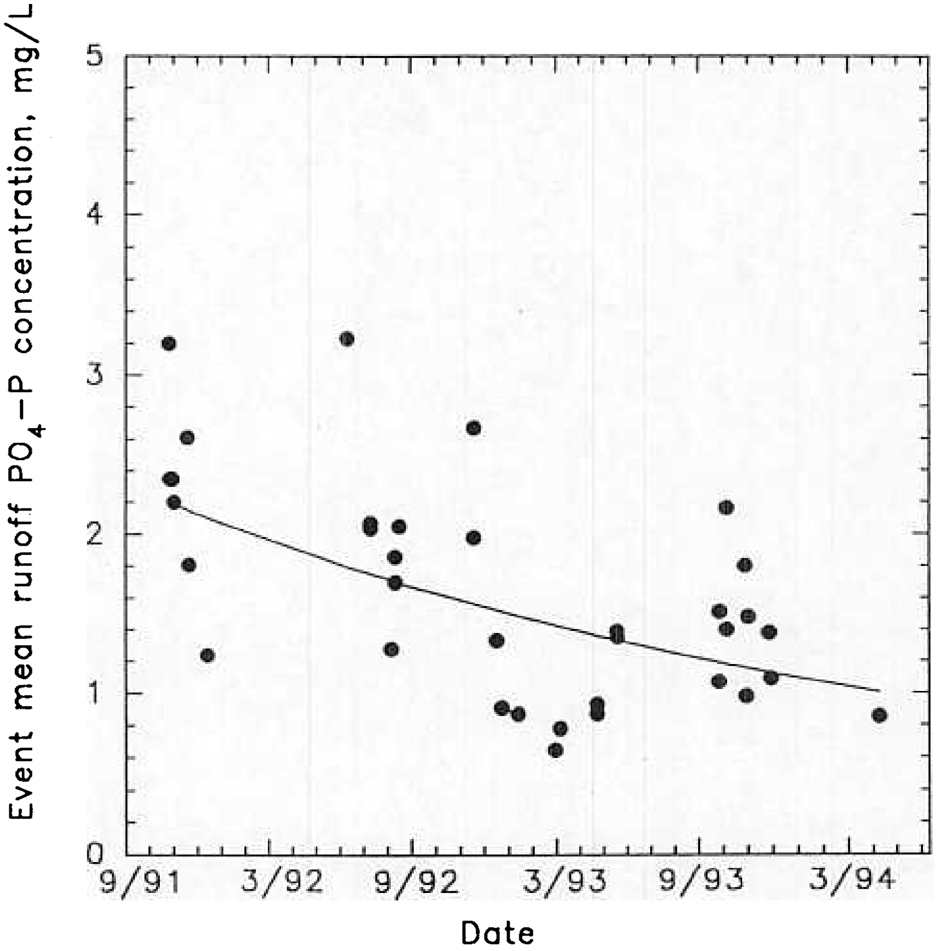


Fig. 72. Event flow-weighted mean runoff concentrations of PO_4-P for field WM

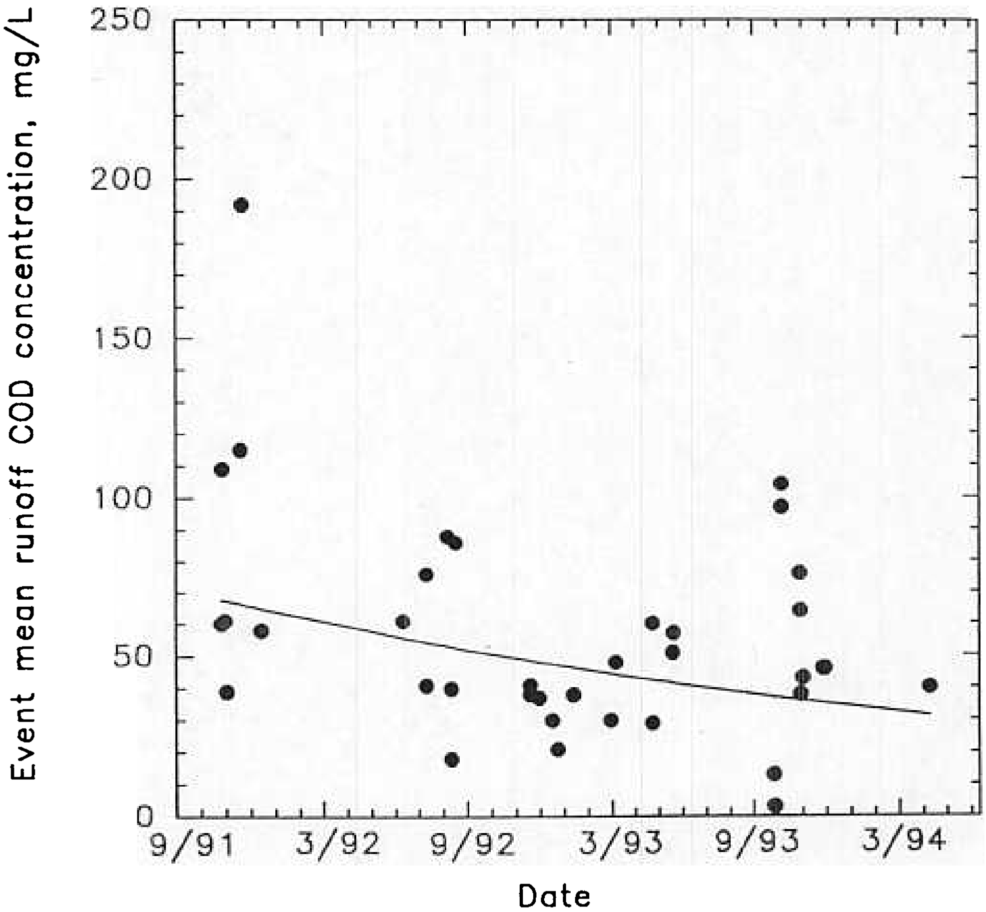


Fig. 73. Event flow-weighted mean runoff concentrations of COD for field WM

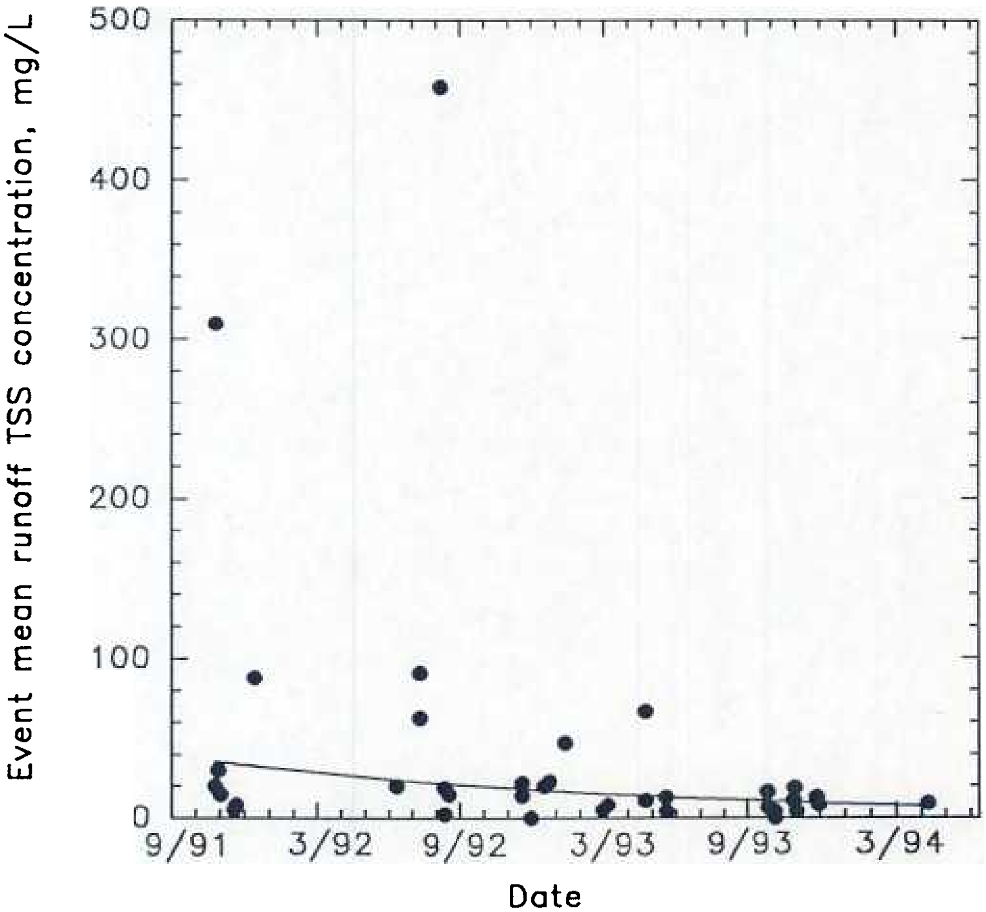


Fig. 74. Event flow-weighted mean runoff concentrations of TSS for field WM

Table

Daily rainfall measured at fields RU and during 1991

Day	Jan	Feb	Mar	Apr	May	Jun	Aug	Sep	Oct	Nov	Dec
								0.18	0.00	0.00	0.37
								0.04	0.00	0.00	0.54
								0.00	0.00	0.00	0.01
								0.00	0.31	0.00	0.00
								0.00	0.00	0.00	0.00
								0.00	0.00		0.00
								0.08	0.00	0.00	0.00
								0.31	0.00	0.00	0.00
								0.00	0.00	0.00	0.00
								0.00	0.00	0.00	0.00
								0.00	0.00	0.00	0.06
12								0.00	0.00	0.00	0.41
								0.00	0.00	0.00	0.00
14								0.00	0.00	0.01	0.00
								0.08	0.00	0.00	0.00
								0.82	0.00	0.78	0.00
17								0.01	0.00	0.62	0.00
								1.00	0.00	0.00	0.00
								0.00	0.00	0.51	0.31
								0.00	0.00	0.07	0.95
								0.00	0.00	0.00	0.07
								0.75	0.00	0.00	0.00
								0.01	0.00	0.00	0.01
								0.11	2.49	0.00	0.00
								0.00	0.24	0.00	0.00
								0.00	2.16	0.00	0.00
								0.00	0.00	0.00	0.04
								0.00	0.76	0.00	0.00
								0.00	0.19	0.39	0.00
								0.00	0.32	0.00	0.00
											0.00

Table 7

Daily rainfall measured at fields RU and RM during 1992

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	in											
1	0.28	0.00	0.00	0.06	0.00	0.07	0.00	0.00	0.02	0.00	0.35	0.00
2	0.00	0.00	0.00	0.00	0.00	0.52	0.30	0.00	0.41	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.17	0.00	0.00	0.00	0.00
4	0.00	0.00	0.03	0.00	0.00	0.00	0.00	1.92	0.00	0.00	0.00	0.00
5	0.00	0.00	0.32	0.00	0.00	0.00	1.74	0.23	0.00	0.00	0.00	0.01
6	0.00	0.00	0.00	0.21	0.00	1.47	0.00	0.00	0.22	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.04
8	0.00	0.00	0.15	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.27	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	1.25
10	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.12	0.00
11	0.00	0.23	0.00	0.00	2.26	0.01	0.00	0.00	0.00	0.00	2.49	0.00
12	0.00	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.45
14	0.03	0.19	0.03	0.00	0.35	0.49	0.10	0.00	0.00	1.80	0.00	1.89
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60
16	0.00	0.00	0.03	0.30	0.18	0.00	1.88	0.00	0.00	0.01	0.00	0.17
17	0.00	0.04	0.07	0.29	0.84	0.00	0.02	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.17	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.01	0.33	0.01	0.76	0.00	0.00	0.00	0.00	0.13	0.04
20	0.00	0.00	0.00	0.67	0.58	0.02	0.00	0.00	0.00	0.08	1.28	0.00
21	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.37	0.00	1.34	0.00
22	0.01	0.00	0.48	0.00	0.05	0.00	0.17	0.00	0.14	0.00	0.67	0.01
23	0.00	0.10	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24	0.00	0.01	0.08	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.05	0.00
25	0.00	0.02	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.04	0.16
26	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.16	0.09	0.12	0.00	0.00
27	0.00	0.00	0.00	0.00	0.02	0.00	0.36	0.00	0.01	0.00	0.00	0.00
28	0.00	0.00	0.00	0.01	1.28	0.00	0.00	0.00	0.00	0.01	0.00	0.00
29	0.00	0.00	0.04	0.01	0.04	0.02	0.00	0.00	0.00	1.05	0.00	0.00
30	0.00		0.00	0.01	0.00	0.00	2.32	0.00	0.00	0.00	0.00	0.02
31	0.00		0.15		0.02		0.00	0.00		0.57		0.13

Table 8

Daily rainfall measured at fields RU and RM during 1993

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						---- in ----						
	0.00	0.00	0.10	0.05	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00
2	0.04	0.00	0.02	0.00	0.29	0.09	0.00	0.00	0.00	0.60	0.28	0.44
3	0.17	0.00	0.01	0.26	0.08	0.00	0.00	0.04	0.01	0.00	0.00	0.53
4	1.31	0.04	0.04	1.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00
6	0.00	0.00	0.01	0.00	0.01	0.00	0.58	0.03	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.05	0.00	0.00	0.01	1.26	0.70	0.00	0.00	0.65	1.14	0.00	0.00
9	0.94	0.00	0.00	0.00	2.34	0.51	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.21	0.00	0.00	0.20	0.19	0.00	0.00	0.00	0.04	0.00	0.00
11	0.18	0.33	0.00	0.00	0.07	0.06	0.00	0.00	0.00	0.05	0.00	0.00
12	0.02	0.00	0.00	0.00	0.02	0.03	0.00	0.01	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	2.03	0.00	1.41	0.70
14	0.00	0.00	0.00	2.89	0.00	0.03	0.00	0.00	2.68	0.00	1.28	0.00
15	0.00	0.50	0.26	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.02	0.17	0.00	0.00	0.00	0.00	0.00	0.00	1.94	1.07	0.01
17	0.00	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
18	0.06	0.08	0.13	0.01	0.36	0.71	0.00	0.00	0.00	0.21	0.00	0.00
19	0.21	0.19	0.90	0.42	0.00	0.59	0.00	0.00	0.00	0.72	0.00	0.00
20	0.86	0.01	0.03	0.00	0.00	0.17	0.01	0.00	0.00	0.35	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.04	0.00	0.00	0.00	0.82	0.00	0.00	2.71	0.00	0.00	0.00	0.00
24	0.00	0.01	0.00	0.24	0.01	0.00	0.00	0.91	0.93	0.00	0.00	0.00
25	0.00	0.09	0.00	0.03	0.00	2.38	0.00	0.01	0.37	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.27	0.00
27	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
28	0.00	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.00	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30	0.00		0.87	0.01	0.65	0.00	0.00	0.00	0.00	0.03	0.00	0.00
31	0.00		0.04		0.00		0.00	0.03		0.00		0.00

Table 9

Daily rainfall measured at fields RU and RM during 1994

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						in						
	0.00	0.00	0.40	0.34								
2	0.21	0.00	0.40	0.24								
3	0.00	0.00	0.00	0.00								
4	0.00	0.00	0.00	0.31								
5	0.00	0.09	0.00	0.01								
6	0.00	0.00	0.00	0.00								
7	0.00	0.00	0.00	0.00								
8	0.00	0.00	1.04	0.00								
9	0.00	0.01	0.29	0.00								
10	0.00	0.00	0.00	0.04								
11	0.00	0.01	0.00	0.73								
12	0.00	0.00	0.00	0.01								
13	0.00	0.00	0.13	0.00								
14	0.00	0.00	0.00	0.00								
15	0.00	0.00	0.00	0.08								
16	0.00	0.00	0.00	0.00								
17	0.00	0.00	0.00	0.00								
18	0.00	0.00	0.00	0.00								
19	0.00	0.99	0.00	0.00								
20	0.59	0.03	0.00	0.00								
21	0.01	0.00	0.00	0.00								
22	0.00	1.15	0.00	0.00								
23	0.06	0.01	0.00	0.00								
24	0.04	0.00	0.12	0.00								
25	0.00	0.00	0.00	0.04								
26	0.84	0.00	1.51	0.00								
27	0.00	0.00	0.00	0.48								
28	0.00	0.61	0.00	0.02								
29	0.00		0.00	1.19								
30	0.00		0.00	0.49								
31	0.00		0.00									

Table 10

Summarized monthly and annual rainfall at fields RU and RM

	1991	1992	1993	1994	Historical Average
		---------------------- in			----------
01		0.33	3.88	1.75	1.78
02		1.41	1.51	2.59	2.45
03		1.83	2.73	3.89	3.46
04		1.89	6.51	3.98	4.44
05		6.46	6.13		5.17
06		3.42	5.48		4.55
07		7.26	0.94		3.56
08		2.98	4.16		3.47
09	3.39	4.26	7.29		4.09
10	7.51	3.84	5.09		3.21
11	2.38	6.81	4.31		3.23
12	2.77	5.77	1.86		2.52
	16.05	46.26	49.89	12.21	41.93

Table 11

Daily rainfall measured at fields WU and WM during 1991

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						in						
1									0.06	0.00	0.00	0.25
2									0.01	0.00	0.00	0.54
3									0.00	0.00	0.00	0.02
4									0.00	0.36	0.00	0.00
5									0.00	0.00	0.00	0.00
6									0.00	0.00	0.00	0.00
7									0.09	0.00	0.00	0.00
8									0.03	0.00	0.00	0.00
9									0.00	0.00	0.00	0.00
10									0.00	0.00	0.00	0.00
11									0.00	0.00	0.00	0.08
12									0.00	0.00	0.00	0.71
13									0.00	0.00	0.00	0.00
14									0.00	0.00	0.01	0.00
15									0.07	0.00	0.10	0.00
16									1.02	0.00	1.95	0.00
17									0.01	0.00	0.83	0.00
18									1.73	0.00	0.00	0.00
19									0.00	0.00	0.48	0.59
20									0.00	0.00	0.11	1.45
21									0.00	0.00	0.00	0.00
22									1.17	0.00	0.00	0.17
23									0.01	0.00	0.00	0.02
24									0.17	3.57	0.00	0.00
25									0.00	0.18	0.00	0.00
26									0.00	2.14	0.00	0.01
27									0.00	0.00	0.00	0.05
28									0.00	1.25	0.00	0.00
29									0.00	0.17	0.88	0.00
30									0.00	0.27	0.01	0.00
31										1.37		0.00

Table

Daily rainfall measured at fields WU and WM during 1992

Day	Jan	Feb	Mar	Apr	May	Jun		Aug	Sep	Oct	Nov	Dec
						in						
	0.43	0.00	0.00	0.06	0.00	0.11	0.00	0.00	0.00	0.00	0.49	0.00
	0.00	0.00	0.00	0.00	0.00	1.15	0.25	0.00	0.48	0.00	0.00	0.00
	0.00	0.00					0.00	0.22	0.00	0.00		0.00
	0.00	0.00	0.03	0.00	0.00	0.00	0.00	2.04	0.00	0.00	0.00	0.01
	0.00	0.00	0.41	0.00	0.00	0.00	1.75	0.71	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.19			0.00	0.00	0.15	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.19
	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.27	0.01	0.00	0.00
	0.00	0.00	0.43	0.00	0.00	0.17	0.00	0.00	0.38	0.00	0.00	1.50
	0.00	0.46	0.00	0.00	0.00	0.01	0.00	0.75	0.89	0.01	0.06	0.00
	0.00	0.27	0.00	0.00		0.07	0.00	0.03	0.00	0.00		0.00
	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00				0.00
	0.32	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	
	0.02	0.13	0.00	0.00	0.42	0.68	0.21	0.00	0.00	1.52	0.01	2.17
	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.01	0.00	1.47
	0.00	0.00	0.00	0.24	0.20	0.00	1.90	0.00	0.00	0.00	0.00	0.21
	0.00	0.02	0.07	0.18	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.12	0.02	0.22		0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.01	0.51	0.00	0.03	0.00	0.00	0.19	0.23	0.24	0.03
	0.00	0.00	0.00	1.12	0.98	0.07	0.00	0.00	0.58	0.00		0.00
	0.03	0.00	0.00	0.00	0.00	0.00		0.00	1.76	0.00	1.28	0.00
	0.08	0.00	0.35	0.00	0.52	0.00	0.54	0.00	0.08	0.00	0.52	0.00
	0.00		0.00	0.00	0.13	0.01	0.01	0.00	0.00	0.00	0.00	0.00
	0.00	0.01	0.08	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.09	0.00
	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.06	0.02	0.15
	0.00	0.00	0.00	0.00	0.00	0.00	0.81	0.83	0.08	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.01	0.00	0.39	0.00	0.00	0.00	0.01	0.00
	0.00	0.00	0.00	0.07	1.05	0.00	0.00	0.00	0.00	0.56	0.00	0.01
	0.00	0.00	0.00	0.02	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.02
	0.00		0.01	0.00	0.00	0.00	3.76	0.00	0.00	0.00	0.00	0.03
	0.00				0.03		0.00	0.00		0.40		0.11

Table 13

Daily rainfall measured at fields WU and WM during 1993

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	in											
1	0.00	0.00	0.07	0.04	0.00	0.00	0.00	0.05	0.17	0.00	0.00	0.00
2	0.06	0.00	0.01	0.00	0.68	0.01	0.00	0.00	0.66	0.64	0.33	0.00
3	0.15	0.01	0.04	0.22	0.04	0.07	0.00	0.00	0.02	0.00	0.01	0.00
4	0.92	0.05	0.01	1.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.02	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.03	0.00	0.00	0.04	2.23	0.87	0.00	0.00	0.85	0.79	0.00	0.00
9	0.85	0.00	0.00	0.00	2.40	0.68	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.18	0.00	0.00	0.16	0.20	0.00	0.00	0.00	0.02	0.00	0.00
11	0.19	0.46	0.00	0.00	0.03	0.07	0.07	0.00	0.00	0.00	0.02	0.00
12	0.01	0.01	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.10	0.00
13	0.00	0.00	0.00	0.00	0.39	0.00	0.05	0.00	4.18	0.00	1.20	0.75
14	0.00	0.00	0.41	2.77	0.00	0.68	0.00	0.00	2.84	0.00	0.60	0.00
15	0.00	0.32	0.18	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
16	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.76	1.18	0.00
17	0.00	0.00	0.19	0.46	0.01	0.00	0.00	0.00	0.00	0.03	0.00	0.00
18	0.01	0.31	0.95	0.01	0.19	0.49	0.00	0.00	0.00	0.23	0.00	0.00
19	0.05	0.00	0.01	0.17	0.00	1.42	0.00	0.00	0.82	0.77	0.00	0.00
20	0.94	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.04	0.25	0.00	0.00
21	0.01	0.01	0.25	0.00	0.00	0.00	0.28	0.04	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
23	0.08	0.00	0.00	0.00	0.61	0.00	0.00	1.70	0.02	0.00	0.00	0.00
24	0.00	0.01	0.00	0.17	0.00	2.17	0.00	0.00	1.59	0.00	0.00	0.00
25	0.00	1.47	0.00	0.03	0.00	0.03	0.00	0.00	0.29	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.50	0.00	0.18	0.00
27	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
28	0.00	0.03	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29	0.00		0.44	1.02	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00
30	0.00		0.03	0.01	0.32	0.00	0.00	0.03	0.00	0.01	0.00	0.00
31	0.00		0.04		0.00		0.00	0.01		0.05		0.00

Table 14

Daily rainfall measured at fields WU and WM during 1994

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						in						
	0.00	0.01	0.41	0.00								
2	0.14	0.00	0.02	0.16								
3	0.05	0.00	0.00	0.20								
4	0.00	0.00	0.00	0.00								
5	0.01	0.04	0.00	0.41								
6	0.00	0.00	0.00	0.01								
7	0.00	0.00	0.00	0.00								
8	0.00	0.00	1.12	0.00								
9	0.00	0.01	0.38	0.00								
10	0.00	0.01	0.00	0.10								
11	0.00	0.00	0.00	0.55								
12	0.00	0.00	0.00	0.00								
13	0.00	0.00	0.03	0.00								
14	0.00	0.00	0.00	0.00								
15	0.00	0.00	0.00	0.23								
16	0.51	0.00	0.00	0.00								
17	0.00	0.00	0.00	0.00								
18	0.00	0.00	0.00	0.00								
19	0.00	0.98	0.00	0.00								
20	0.20	0.04	0.00	0.00								
21	0.00	0.00	0.00	0.00								
22	0.00	1.31	0.00	0.00								
23	0.09	0.02	0.01	0.00								
24	0.04	0.00	0.09	0.00								
25	0.00	0.00	0.00	0.06								
26	0.72	0.00	1.87	0.00								
27	0.01	0.00	0.00	0.09								
28	0.00	0.61	0.00	0.10								
29	0.00		0.00	1.42								
30	0.00		0.00	0.50								
31	0.00		0.00									

Table 15

Summarized monthly and annual rainfall at fields WU and WM

Month	1991	1992	1993	1994	Historical Average
	------	------	in	------	------
01		0.88	3.30	1.77	1.78
02		1.69	3.10	3.10	2.45
03		1.75	2.71	3.93	3.46
04		2.41	6.06	3.83	4.44
05		6.67	7.10		5.17
06		3.92	6.82		4.55
07		9.62	0.49		3.56
08		4.58	1.85		3.47
09	4.37	4.86	11.99		4.09
10	9.31	2.84	4.58		3.21
11	4.37	6.87	3.63		3.23
12	3.89	6.90	0.75		2.52
Total	21.94	52.99	52.38	12.63	41.93

Table 16

Concentrations of analysis parameters for the MU1 monitoring site

Date	NO_3-N	PO_4-P	TP	NH_3-N	TKN	COD	TSS	FC	FS
	mg/L							-- #/100 mL --	
09/23/91	0.38	0.09	0.12	0.12	5.60			7800	23000
11/04/91	7.53	0.26	0.31	0.05	1.30	26.18	4.30	5	
11/18/91	3.90	0.47	0.65	0.48	2.30	33.40	7.70	430	400
12/02/91	1.79	0.77	0.62	0.30	2.40	203.10	328.40	2100	12200
12/16/91	3.95	0.07	0.14	0.03	0.96	22.49	10.50	0	120
01/02/92	2.87	0.22	0.24	0.09	1.30	28.57	6.20	10	210
01/13/92	3.13	0.07	0.14	0.07		24.01	20.80	0	20
01/27/92	2.57	0.01	0.14	0.08	0.88	22.82	2.90	0	0
02/11/92	2.00	0.03	0.11	0.85	10.60	20.60	10.00	0	50
02/25/92	1.50	0.05	0.18	1.65	12.30	47.00	7.00	0	10
03/09/92	0.94	0.10	0.26	2.60	20.80	10.00	20.60	90	120
03/24/92	0.68	0.06	0.73	0.68	11.20		13.50	0	20
04/07/92	0.33	0.01	0.15	0.81	9.60	51.00	10.60	60	50
04/21/92	0.49	0.09	0.27	3.00	1.59		20.50	660	460
05/04/92	0.39	0.01	0.70	8.10			62.30	20	110
05/19/92	0.42	0.15	0.39	5.00	9.10		0.00	7000	640
06/03/92	0.66	0.08	0.42	2.00	14.60	24.95	32.80	15700	4600
06/16/92	0.67	0.02	0.24	5.70	1.54	27.03	11.70	1130	180
06/30/92	0.51	0.02	0.49	7.20	2.30	73.13	78.20	110	360
07/13/92	No flow								
07/27/92	0.09	0.05	0.28	0.17	1.90	2.90	19.40	5900	4300
08/11/92	0.85	0.06	0.27	0.39	1.78	28.00	19.30	3900	70
08/25/92	0.17	0.03	0.28	0.00	1.44	28.00	30.50	300	800
09/08/92	No Flow								
09/22/92	0.70	0.55	0.75	0.20	1.56	67.70	14.70	6900	48000
10/06/92	0.40	0.03	0.19	0.00	1.30	28.70	41.70	50	130
10/22/92	No Flow								
11/03/92	0.81	0.01	0.16	0.14	0.72	24.31	2.60	580	230
11/17/92	1.17	0.03	0.13	0.09	0.56	38.00	0.00	390	190
11/30/92	1.33	0.13	0.12	0.10	0.44	11.27	5.90	0	40
12/16/92	0.82	0.24	0.41	0.11	0.66	19.47	14.80	1000	1500
01/05/93	0.38	0.33	0.51	0.12	1.12	44.81	31.40	34000	6200
01/19/93	1.26	0.04	0.19	0.09	0.48	5.64	6.00	120	20
02/02/93	1.09	0.02	0.15	0.03	0.43	26.13	5.55	30	20
02/18/93	0.79	0.03	0.14	0.02	0.72	14.52	14.10	10	0
03/02/93	0.84	0.59	0.21	0.02	0.67	12.03	6.80	70	10
03/16/93	0.88	0.02	0.11	0.07	1.31	12.78	8.50	980	70
03/30/93	0.55	0.43	0.94	0.32	2.54	68.26	91.90	25000	2600
04/13/93	0.26	0.50	0.60	0.52	3.48	52.96	333.20	59000	79000
04/27/93	0.63	0.03	0.17	0.03	2.20	15.40	10.60	2400	0
05/10/93	0.35	0.20	0.33	0.15	0.81	34.89	25.68	8700	1500
05/24/93	0.71	0.04	0.25	0.18	1.00	21.30	26.20	2400	160
06/08/93	0.30	0.01	0.27	1.36	1.76	12.81	22.70	190	180
06/22/93	0.06	0.01	0.33	3.65	5.05	27.90	20.20	70	0
07/06/93	0.39	0.00	0.17	0.29	0.68	12.80	8.10		
07/20/93	No flow								
08/03/93	No flow								
08/17/93	No flow								
08/31/93	No flow								
09/14/93	1.81	1.00	1.17	0.16	1.88	32.10	17.00	52000	61000
09/28/93	2.46	0.00	0.17	0.08	0.77	0.80	8.50	290	500
10/12/93	2.14	0.03	0.10	0.03	0.60	10.90	8.10	650	140
10/25/93	2.31	0.06	0.10	0.05	0.78	10.00	5.60	20	10
11/09/93	1.07	0.02	0.07	0.04	0.49	4.50	11.90	80	60

	NO_3-N	PO_4-P		NH_3-N		COD		
	mg/L							#/100 mL
11/22/93								
12/06/93								
12/20/93								
01/03/94								
01/19/94								
02/01/94		0.03						
02/15/94								
02/28/94								
03/15/94							5.70	
03/27/94						30.40		
04/12/94								6200
04/26/94						26.12	28.10	

Table 17

Concentrations of analysis parameters for the MU2 monitoring site

Date	NO_3-N	PO_4-P	TP	NH_3-N	TKN	COD	TSS	FC	FS
	mg/L							-- #/100 mL --	
09/23/91	No flow								
11/04/91	No flow								
11/18/91	2.88	0.14	0.18	0.12	1.64	8.87	5.00	10	160
12/02/91	1.29	0.27	0.21	0.38	1.56	197.80	26.10	1200	34000
12/16/91	2.12	0.08	0.14	0.03	0.70	13.39	1.90	0	0
01/02/92	1.31	0.07	0.09	0.03	1.04	17.18	3.40	0	40
01/13/92	1.23	0.06	0.45	0.07	2.38	71.83	123.40	0	500
01/27/92	0.98	0.12	0.19	0.08	1.10	3.66	2.00	0	0
02/11/92	1.45	0.09	0.22	0.85	8.90	35.14	16.70	0	60
02/25/92	0.74	0.22	0.26	0.20	5.90	0.00	2.20	0	0
03/09/92	6.19	0.58	0.72	44.80	61.80	56.00	5.60	50	1600
03/24/92	0.75	0.13	0.11	0.30	0.46		10.70	0	80
04/07/92	0.12	0.32	0.11	0.17	8.40	36.00	19.30	10	230
04/21/92	1.52	0.11	0.12	5.40	43.36		28.90	190	490
05/04/92	0.06	0.39	0.44	0.08			1.60	0	90
05/19/92	1.76	0.12	0.35	7.50	8.10		8.40	500	900
06/03/92	0.81	0.05	0.27	2.00	9.80	51.76	16.80	2600	1700
06/16/92	0.47	0.16	0.26	0.38	0.34	8.08	4.50	1370	470
06/30/92	0.17	0.12	0.76	0.27	0.37	10.70	6.27	0	50
07/13/92	0.15	0.13	0.09	0.00	0.67	7.50	3.90	3200	1130
07/27/92	0.69	0.13	0.29	0.54	1.13	26.70	17.00	5500	7900
08/11/92	2.69	0.14	0.36	1.10	1.86	19.90	10.50	71000	2200
08/25/92	0.13	0.11	0.23	0.00	1.32	2.00	13.80	50000	4800
09/08/92	0.13	0.11	0.16	0.00	0.26	27.30	4.80	500	2500
09/22/92	0.80	0.15	0.27	0.12	1.16	80.80	10.80	36000	9000
10/06/92	0.12	0.03	0.10	0.00	0.33	18.00	12.90	60	110
10/22/92	0.16	0.00	0.05	0.00	0.07	29.50	11.70	350	630
11/03/92	0.44	0.02	0.10	0.22	0.52	11.42	4.90	530	350
11/17/92	0.52	0.06	0.21	0.04	0.32	14.64	0.00	60	260
11/30/92	0.54	0.06	0.26	0.03	0.08	3.03	5.20	0	0
12/16/92	0.49	0.18	0.15	0.04	0.32	40.97	4.60	1300	260
01/05/93	0.39	0.12	0.22	0.05	0.90	29.45	13.65	14100	9000
01/19/93	0.28	0.03	0.13	0.02	0.44	8.71	3.95	40	20
02/02/93	0.17	0.01	0.33	0.00	0.57	56.48	38.30	130	70
02/18/93	0.39	0.01	0.05	0.02	0.96	4.52	3.75	0	0
03/02/93	0.38	0.03	0.74	0.02	0.63	6.02	5.60	110	10
03/16/93	4.46	0.06	0.33	4.00	4.95	35.28	11.30	4100	410
03/30/93	1.19	0.20	0.44	0.90	2.54	47.47	26.10	34000	24000
04/13/93	0.56	0.25	0.30	0.51	2.08	48.53	164.60	43000	51000
04/27/93	0.13	0.03	0.09	0.01	2.08	13.90	5.50	100	0
05/10/93	0.66	0.08	0.20	0.46	1.14	44.63	10.12	24000	4800
05/24/93	0.78	0.03	0.22	0.28	1.17	8.02	11.50	3500	1230
06/08/93	0.43	0.00	0.08	0.05	0.07	5.69	8.50	490	1720
06/22/93	0.52	0.01	0.26	0.85	2.29	3.28	19.90	1070	20
07/06/93	0.67	0.00	0.35	0.01	1.01	40.60	74.20		
07/20/93	No flow								
08/03/93	No flow								
08/17/93	No flow								
08/31/93	No flow								
09/14/93	2.60	0.27	0.34	0.13	1.32	19.60	10.00	42000	45000
09/28/93	1.26	0.00	0.16	0.00	0.45	0.40	4.00	150	250
10/12/93	0.78	0.13	0.18	0.00	0.28	3.30	3.70	140	280
10/25/93	0.59	0.10	0.12	0.02	0.29	0.00	0.20	0	0
11/09/93	0.17	0.10	0.19	0.02		0.00	4.10	0	60

	NO_3-N	PO_4-P		NH_3-N				
	mg/L							#/100 mL
11/22/93								
12/06/93								
12/20/93								
01/03/94								
1/19/94								
02/01/94							0.80	
02/15/94								
02/28/94								
03/15/94								
03/27/94								
04/12/94						29.10	10.60	10300
04/26/94								

Table 18

Concentrations of analysis parameters for the BU monitoring site

Date	NO_3-N	PO_4-P	TP	NH_3-N	TKN	COD	TSS	FC	FS
	mg/L							-- #/100 mL --	
09/23/91	39.26	0.32	0.16	0.64	1.98			6000	2800
11/04/91	No flow								
11/18/91	No flow								
12/02/91	3.10	0.86	0.71	0.73	2.50	201.60	101.60	920	40000
12/16/91	4.88	0.10	0.17	0.10	1.06	17.94	3.70	40	120
01/02/92	4.20	0.21	0.24	0.10	1.38	40.71	4.50	0	0
01/13/92	3.93	0.13	0.21	0.17	2.40	28.57	22.40	0	40
01/27/92	4.65	0.00	0.17	0.19	2.30	4.43	1.60	0	30
02/11/92	3.09	0.11	0.21	4.35	20.30	19.07	11.80	0	430
02/25/92	3.25	0.05	0.15	0.40	9.30	24.00	22.70	0	10
03/09/92	2.23	0.14	0.26	1.05	19.80	33.00	15.40	10	520
03/24/92	3.14	0.03	0.29	0.84	9.76		33.10	20	2700
04/07/92	2.28	0.00	0.15	0.29	14.40	44.00	43.70	20	70
04/21/92	2.49	0.12	0.27	0.80	0.86		37.80	2700	720
05/04/92	0.15	0.09	0.29	1.65			68.10	10	60
05/19/92	1.11	0.14	0.34	0.44	6.60		0.00	1600	670
06/03/92	0.91	0.22	0.62	1.70	17.20	96.44	23.10	12500	2600
06/16/92	0.50	0.14	0.27	0.34	0.84	22.29	3.00	420	80
06/30/92	0.31	0.05	0.80	0.58	1.90	51.81	148.13	170	10
07/13/92	No flow								
07/27/92	0.26	0.08	0.78	0.18	4.50	81.80	347.60	75000	25000
08/11/92	0.25	0.36	0.60	0.00	1.86	44.30	14.80	53000	2900
08/25/92	No flow								
09/08/92	No flow								
09/22/92	0.52	0.68	0.77	0.14	1.92	90.60	15.20	20000	22000
10/06/92	0.26	0.06	0.15	0.00	0.80	8.20	19.10	700	770
10/22/92	0.10	0.09	0.12	0.00	0.47	28.70	24.60	93	27
11/03/92	0.62	0.12	0.20	0.21	0.72	25.11	0.70	700	370
11/17/92	0.78	0.21	0.28	0.03	0.60	16.25	2.80	350	130
11/30/92	1.12	0.18	0.25	0.04	0.38	11.27	5.70	40	290
12/16/92	0.90	0.39	0.52	0.07	0.54	15.58	5.20	2600	480
01/05/93	0.71	0.31	0.58	0.10	0.96	30.22	26.10	25000	11000
01/19/93	1.14	0.13	0.20	0.02	0.40	7.94	5.45	0	140
02/02/93	0.86	0.02	0.14	0.00	0.43	43.25	5.25	30	110
02/18/93	0.70	0.03	0.13	0.00	0.88	10.02	12.40	80	150
03/02/93	0.78	0.35	0.21	0.02	0.65	11.28	11.15	570	30
03/16/93	0.54	0.04	0.25	0.00	1.95	29.28	15.60	3300	210
03/30/93	0.42	0.12	0.39	0.05	1.84	48.27	34.50	10900	7600
04/13/93	0.55	0.49	0.50	0.30	2.78	71.36	215.20	37000	61000
04/27/93	0.46	0.05	0.12	0.01	2.18	33.39	7.80	400	0
05/10/93	0.32	0.32	0.45	0.12	1.42	36.38	12.04	6600	2800
05/24/93	0.56	0.08	0.26	0.03	1.18	12.17	19.70	4100	190
06/08/93	0.27	0.03	0.10	0.12	0.35	5.66	7.95	2000	350
06/22/93	0.03	0.02	0.13	0.02	1.06	12.81	10.50	240	10
07/06/93	0.12	0.00	0.34	0.29	1.15	23.90	67.10		
07/20/93	No flow								
08/03/93	No flow								
08/17/93	No flow								
08/31/93	No flow								
09/14/93	1.36	1.48	1.62	0.00	2.04	15.40	21.00	30000	26000
09/28/93	1.11	0.34	0.46	0.02	0.95	1.00	6.50	480	340
10/12/93	0.26	0.06	0.13	0.00	0.78	44.30	7.50	400	70
10/25/93	0.81	0.23	0.31	0.03	0.84	11.10	3.20	80	40
11/09/93	0.55	0.06	0.10	0.03		11.10	8.10	90	100

	NO_3-N	PO_4-P		NH_3-N				FC
	mg/L							#/100 mL
11/22/93								
12/06/93								
12/20/93			0.22					
01/03/94								
01/19/94					0.36			
02/01/94			0.10					
02/15/94			0.09					
02/28/94			0.20			17.40		
03/15/94		0.15				15.30		
03/27/94						28.80	13.80	
04/12/94	0.78		0.34				19.80	
04/26/94								

Table 19

Arithmetic mean concentrations of analysis parameters for the MU1, MU2, and BU monitoring sites

Parameter	Field		
		MU2	BU
	---------- mg/L ----------		
NO_3-N	1.24	0.89	1.91
PO_4-P	0.13	0.11	0.19
TP	0.28	0.22	0.32
NH_3-N	0.85	1.21	0.29
TKN	2.73	3.32	2.81
COD	27.76	22.48	29.39
TSS	26.80	14.09	27.51
	-------- #/100 mL --------		
FC	192	154	305
FS	148	217	187

Table 20

Annual changes in concentrations of analysis parameters for the MU1, MU2, and BU monitoring sites

Parameter	Site		
	MU1	MU2	BU
NO_3-N	NC*	NC	-45.6%
PO_4-P	NC	-33.8%	NC
TP	-31.1%	-23.7%	NC
NH_3-N	-46.4%	-74.7%	-75.0%
TKN	-51.6%	-57.5%	-55.4%
COD	-37.6%	-50.9%	-51.5%
TSS	NC	-40.0%	-47.2%
FC	NC	NC	NC
FS	NC	NC	NC

* No change

Table 21

Event flow-weighted mean concentrations of analysis parameters for the ML monitoring station

Inclusive Dates Starting	Ending	Mean Flow cfs	NO_3-N	PO_4-P	TP	NH_3-N	TKN	COD	TSS	FC	FS
			mg/L							#/100 mL	
09/23/91	10/07/91	0.48	0.60	0.04	0.02	0.08	59.30	0.64	1.23	3400	1400
10/07/91	10/21/91	0.04	0.25	0.04	0.00	0.00	59.30	0.44	1.23	10	0
10/21/91	10/24/91	0.08	0.07	0.04	0.07	0.00	60.20	0.37	0.50	0	0
10/24/91	11/04/91	29.69	3.28	0.12	0.23	0.09	1.60	76.95	49.30	3900	65000
11/04/91	11/16/91	3.17	5.11	0.09	0.76	0.05	0.88	16.39	0.40	0	0
11/16/91	11/29/91	22.92	2.70	0.25	0.44	0.20	2.15	114.61	39.32	620	3900
11/29/91	12/12/91	16.84	2.30	0.19	0.22	0.15	1.71	234.90	30.15	450	11000
12/12/91	12/16/91	16.14	1.81	0.16	0.29	0.32	2.87	43.42	33.77	570	14000
12/16/91	12/19/91	4.84	2.59	0.08	0.06	0.03	0.78	29.33	2.20	0	10
12/19/91	12/30/91	25.98	2.28	0.09	0.17	0.00	0.94	32.50	11.87	160	2400
12/30/91	01/02/92	9.78	2.43	0.15	0.06	0.03	0.88	17.94	3.30	0	100
01/02/92	01/13/92	5.49	2.43	0.15	0.06	0.03	0.88	17.94	3.30	0	100
01/13/92	01/27/92	5.54	1.86	0.08	0.15	0.02	0.52	14.90	1.80	0	0
01/27/92	02/11/92	2.45	1.71	0.02	0.08	0.07	2.64	67.27	1.40	0	0
02/11/92	02/25/92	7.91	1.02	0.03	0.18	1.46	16.28	19.79	15.36	860	710
02/25/92	03/09/92	2.10	1.03	0.05	0.07	0.25	4.90	224.00	5.90	0	0
03/09/92	03/24/92	2.23	0.50	0.04	0.09	0.68	6.60	15.00	5.10	10	20
03/24/92	04/17/92	1.43	0.48	0.02	0.17	0.15	7.40	0.00	3.40	0	10
04/17/92	04/27/92	1.99	0.05	0.00	0.04	0.17	7.20	144.00	3.80	0	0
04/27/92	05/04/92	1.27	1.00	0.06	0.19	1.90	9.65	0.00	6.10	480	780
05/04/92	05/11/92	0.18	0.06	0.02	0.22	0.15	0.00	0.00	0.10	0	20
05/11/92	05/16/92	7.50	1.22	0.13	0.53	5.03	25.76	134.11	95.88	36000	83000
05/16/92	05/28/92	4.93	0.55	0.05	0.63	0.19	7.60	53.74	0.00	3200	13000
05/28/92	06/02/92	11.28	0.60	0.09	0.14	0.71	8.27	60.53	28.94	15000	23000
06/02/92	06/06/92	9.47	0.70	0.08	0.27	0.24	9.60	107.60	11.40	16000	4100
06/06/92	06/11/92	23.70	0.49	0.21	0.62	0.49	18.69	67.23	168.81	4100	11000
06/11/92	06/16/92	4.44	0.35	0.04	0.10	0.13	5.00	12.03	4.70	200	60
06/16/92	06/19/92	1.39	0.35	0.04	0.10	0.13	5.00	12.03	4.70	200	60
06/19/92	06/30/92	2.49	0.38	0.10	0.20	0.18	2.61	52.54	38.97	8800	12000
06/30/92	07/05/92	0.16	0.15	0.04	0.14	0.00	3.46	67.79	13.47	0	30
07/05/92	07/13/92	3.15	0.81	0.21	0.43	0.20	2.16	39.36	78.94	7900	52000
07/13/92	07/27/92	0.34	0.15	0.04	0.11	0.00	0.63	12.82	7.20	280	2100
07/27/92	07/30/92	0.15	0.15	0.04	0.11	0.00	0.63	12.82	7.20	280	2100
07/30/92	08/03/92	15.69	0.64	0.38	0.85	0.21	2.63	47.29	139.22	5200	28000
08/03/92	08/11/92	18.06	0.45	0.28	0.56	0.14	1.60	29.54	94.45	60000	13000
08/11/92	08/25/92	0.80	0.25	0.06	0.09	0.00	0.50	19.87	9.20	0	70
08/25/92	09/08/92	0.18	0.18	0.00	0.09	0.00	0.48	9.20	8.90	0	100
09/08/92	09/19/92	0.45	0.18	0.00	0.09	0.00	0.48	9.20	8.90	0	100
09/19/92	09/22/92	27.21	0.47	0.29	0.82	0.15	2.33	119.58	73.67	47000	60000
09/22/92	10/06/92	1.62	0.19	0.02	0.07	0.00	0.22	4.10	0.40	0	10
10/06/92	10/22/92	1.10	0.06	0.04	0.10	0.00	0.60	14.66	1.20	40	40
10/22/92	10/31/92	1.86	0.06	0.04	0.10	0.00	0.60	14.66	1.20	40	40
10/31/92	11/10/92	8.19	0.51	0.13	0.32	0.01	1.04	34.74	31.45	14000	23000
11/10/92	11/17/92	40.40	0.61	0.35	0.53	0.03	0.98	36.08	64.45	19000	5800
11/17/92	11/19/92	4.63	0.53	0.04	0.08	0.00	0.36	21.98	0.00	90	70
11/19/92	12/01/92	36.55	0.54	0.24	0.42	0.04	0.90	40.38	39.02	0	20
12/01/92	12/09/92	4.65	0.63	0.05	0.06	0.00	0.28	5.50	2.60	0	20
12/09/92	12/13/92	30.54	0.68	0.19	0.36	0.07	0.86	31.40	22.00	7000	20000
12/13/92	12/16/92	193.51	0.44	0.22	0.41	0.13	0.91	40.03	58.73	3400	3300
12/16/92	01/04/93	10.21	0.53	0.11	0.19	0.03	0.51	45.57	29.17	650	1100
01/04/93	01/04/93	183.84	0.37	0.13	0.80	0.07	2.50	124.65	393.98	53000	24000
01/04/93	01/19/93	15.48	0.61	0.06	0.11	0.03	0.43	9.10	6.58	3300	2100

Table 21, cont.

Inclusive Dates Starting	Ending	Mean Flow cfs	NO_3-N	PO_4-P	TP	NH_3-N	TKN	COD	TSS	FC	FS
			mg/L							#/100 mL	
01/19/93	01/26/93	19.27	0.59	0.03	0.24	0.04	0.83	20.85	29.16	3200	7700
01/26/93	02/02/93	4.78	0.38	0.01	0.05	0.00	1.03	8.24	0.85	0	10
02/02/93	02/18/93	8.39	0.54	0.01	0.07	0.00	0.87	12.13	2.93	0	10
02/18/93	02/23/93	25.18	0.53	0.03	0.23	0.05	0.80	38.57	34.99	1600	720
02/23/93	03/02/93	31.74	0.57	0.06	0.24	0.07	1.01	50.27	29.00	3100	1600
03/02/93	03/16/93	5.39	0.53	0.04	0.07	0.01	0.64	9.40	3.78	220	15
03/16/93	03/19/93	6.25	0.31	0.06	0.11	0.00	1.31	16.22	22.62	80	30
03/19/93	03/30/93	12.28	0.92	0.17	0.23	0.23	1.28	52.77	15.25	0	0
03/30/93	04/03/93	10.27	0.85	0.18	0.68	0.03	2.40	60.37	124.34	46000	17000
04/03/93	04/04/93	No Data									
04/04/93	04/14/93	14.68	0.51	0.11	0.27	0.08	1.61	27.19	39.51	6300	16000
04/14/93	04/15/93	180.37	0.40	0.22	0.57	0.21	2.08	44.77	168.11	28000	73000
04/15/93	04/19/93	18.72	0.51	0.11	0.16	0.10	2.86	29.59	20.49	3600	19000
04/19/93	04/27/93	10.53	0.39	0.10	0.24	0.11	2.35	46.05	36.80	6400	9500
04/27/93	05/09/93	7.66	0.14	0.04	0.19	0.01	2.14	50.61	40.41	0	200
05/09/93	05/10/93	218.29	0.36	0.19	0.50	0.21	2.28	52.63	93.32	22000	7300
05/10/93	05/24/93	6.52	0.87	0.11	0.34	1.03	0.70	24.10	11.14	3000	1800
05/24/93	06/08/93	1.16	0.84	0.03	0.25	0.52	0.46	9.40	9.18	380	250
06/08/93	06/22/93	2.02	0.99	0.03	0.13	0.02	0.63	8.05	8.63	65	50
06/22/93	06/25/93	0.89	1.08	0.17	0.58	0.04	2.70	84.55	83.51	90	0
06/25/93	06/25/93	152.25	0.61	0.32	0.86	0.06	3.20	114.01	144.22	0	0
06/25/93	07/06/93	2.50	0.26	0.04	0.12	0.02	0.20	13.60	0.10	0	0
07/06/93	07/13/93	0.11	0.26	0.04	0.12	0.00	0.20	13.60	0.10	0	0
07/13/93	09/02/93	No Flow									
09/02/93	09/13/93	0.55	0.07	0.09	0.38	0.00	1.83	113.10	30.00	2700	7400
09/13/93	09/14/93	250.22	1.77	0.30	0.48	0.06	1.47	27.77	67.98	41000	49000
09/14/93	09/25/93	4.76	2.09	0.15	0.23	0.02	0.92	21.33	7.99	3400	14000
09/25/93	09/28/93	10.07	1.74	0.04	0.13	0.02	0.67	19.02	4.94	2100	5700
09/28/93	10/12/93	2.19	1.14	0.02	0.10	0.00	0.49	10.24	5.05	140	100
10/12/93	10/16/93	1.32	0.63	0.07	0.17	0.00	0.72	22.31	41.07	4400	16000
10/16/93	10/20/93	45.54	1.02	0.20	0.36	0.05	1.61	51.51	64.84	10000	38000
10/20/93	10/25/93	14.97	1.06	0.13	0.18	0.02	1.24	20.34	8.37	710	2100
10/25/93	11/09/93	3.57	0.68	0.02	0.06	0.00	0.32	4.50	1.30	0	10
11/09/93	11/13/93	3.14	0.42	0.06	0.20	0.01	0.18	33.54	96.83	16000	38000
11/13/93	11/16/93	71.63	0.87	0.21	0.34	0.01	0.00	48.46	112.14	71000	92000
11/16/93	11/17/93	110.85	0.83	0.14	0.24	0.06	0.67	22.63	22.73	23000	13000
11/17/93	11/22/93	10.41	1.08	0.07	0.11	0.02	0.48	6.40	2.30	5600	1400
11/22/93	12/03/93	4.96	0.94	0.02	0.09	0.00	0.69	16.26	9.11	60	30
12/03/93	12/04/93	31.14	0.79	0.07	0.12	0.01	0.94	22.37	10.02	0	0
12/04/93	12/06/93	16.45	0.99	0.04	0.09	0.01	0.77	8.91	3.36	100	40
12/06/93	12/20/93	6.32	1.03	0.02	0.06	0.01	0.48	3.65	2.10	50	20
12/20/93	01/03/94	2.24	0.72	0.01	0.04	0.00	0.24	0.40	1.83	0	0
01/03/94	01/19/94	1.97	0.85	0.01	0.04	0.01	0.25	6.40	0.60	0	0
01/19/94	02/01/94	5.08	1.11	0.02	0.03	0.00	0.37	6.05	0.97	0	0
02/01/94	02/15/94	2.59	0.87	0.02	0.03	0.01	0.36	0.10	1.55	0	0
02/15/94	03/26/94	No data									
03/26/94	03/27/94	104.49	0.89	0.18	0.45	0.31	1.91	51.53	136.53	13000	15000
03/27/94	04/11/94	7.82	0.72	0.04	0.16	0.03	0.75	13.90	21.44	14000	1600
04/11/94	04/26/94	3.24	0.53	0.04	0.18	0.09	0.83	21.66	11.45	4000	2000
04/26/94	04/29/94	3.27	0.66	0.05	0.26	0.23	1.08	34.62	71.84	12000	28000
04/29/94	04/30/94	59.50	0.62	0.13	0.32	0.33	1.32	31.06	58.61	26000	51000

Table 22

Event flow-weighted mean concentrations of analysis parameters for the BL monitoring station

Inclusive Dates Starting	Ending	Mean Flow cfs	NO_3-N	PO_4-P	TP	NH_3-N	TKN	COD	TSS	FC	FS
			mg/L							#/100 mL	
10/01/91	10/07/91	1.12	1.80	0.02	0.00	0.00	0.30	16.00	0.90	30	0
10/07/91	10/21/91	0.76	1.02	0.02	0.00	0.00	0.40	10.00	0.90	30	0
10/21/91	10/24/91	0.47	0.23	0.01	0.00	0.00	0.50	4.00	0.00	0	0
10/24/91	11/04/91	14.39	2.84	0.13	0.22	0.07	1.71	58.48	58.12	1300	230000
11/04/91	11/16/91	1.89	4.23	0.08	0.08	0.04	0.84	14.64	0.00	0	0
11/16/91	11/29/91	10.40	2.51	0.20	0.29	0.11	1.80	107.69	18.33	190	1200
11/29/91	12/12/91	8.54	2.52	0.15	0.20	0.05	1.72	94.92	21.44	190	6000
12/12/91	12/16/91	7.89	2.27	0.08	0.15	0.12	1.83	32.37	27.60	99	2700
12/16/91	12/19/91	2.56	2.50	0.03	0.04	0.02	0.60	4.28	2.30	0	0
12/19/91	12/30/91	12.06	2.20	0.15	0.19	0.05	1.43	22.19	12.07	95	3500
12/30/91	01/02/92	6.12	2.50	0.07	0.11	0.04	0.98	14.90	9.00	0	40
01/02/92	01/13/92	3.11	2.41	0.05	0.10	0.03	0.83	11.49	8.55	0	20
01/13/92	01/27/92	2.73	2.24	0.03	0.06	0.04	1.05	15.44	4.10	0	0
01/27/92	02/11/92	1.81	1.98	0.03	0.04	0.07	2.36	33.57	0.25	0	0
02/11/92	02/25/92	4.56	1.30	0.03	0.12	0.19	11.85	66.78	13.43	5	110
02/25/92	03/09/92	1.91	1.18	0.03	0.07	0.36	4.95	60.99	2.20	0	45
03/09/92	03/24/92	1.92	0.78	0.03	0.23	0.32	5.82	12.00	1.35	0	45
03/24/92	04/07/92	1.66	0.34	0.01	0.20	0.14	5.62	46.00	0.30	0	0
04/07/92	04/20/92	1.43	0.15	0.00	0.02	0.17	4.60	46.00	0.40	0	0
04/20/92	04/21/92	13.82	0.54	0.03	0.16	0.03	25.20	50.51	7.77	610	3200
04/21/92	05/04/92	1.64	0.28	0.02	0.24	0.04	44.83	0.00	1.30	5	130
05/04/92	05/11/92	0.96	0.06	0.02	0.38	0.08	0.00	0.00	1.00	0	10
05/11/92	05/16/92	4.13	0.66	0.15	0.39	1.12	22.85	278.37	34.59	35000	63000
05/16/92	05/20/92	4.53	0.26	0.03	0.31	0.11	6.94	58.95	0.00	5400	11000
05/20/92	06/02/92	4.84	0.29	0.06	0.18	0.00	18.80	49.65	0.00	5800	34000
06/02/92	06/06/92	8.79	0.39	0.03	0.22	0.10	7.20	74.30	10.62	86000	4700
06/06/92	06/11/92	10.53	0.36	0.23	0.45	0.53	12.51	37.32	38.85	3300	4400
06/11/92	06/16/92	3.11	0.17	0.05	0.10	0.11	4.40	8.09	3.00	120	20
06/16/92	06/19/92	1.64	0.17	0.05	0.10	0.11	4.40	8.09	3.00	120	20
06/19/92	06/30/92	2.27	0.29	0.13	0.19	0.12	2.29	33.59	43.05	4800	5700
06/30/92	07/05/92	0.91	0.07	0.02	0.07	0.14	0.43	7.66	7.87	0	0
07/05/92	07/13/92	2.01	0.52	0.31	0.40	0.01	1.25	20.48	36.94	5500	37000
07/13/92	07/27/92	0.96	0.38	0.03	0.06	0.00	0.61	2.48	6.50	500	2300
07/27/92	07/30/92	1.17	0.71	0.06	0.09	0.00	0.30	3.77	3.70	890	3600
07/30/92	08/03/92	12.90	0.50	0.19	0.46	0.02	1.88	64.93	69.41	33000	7400
08/03/92	08/11/92	11.80	0.33	0.22	0.41	0.02	1.58	26.45	60.24	160000	11000
08/11/92	08/25/92	1.23	0.51	0.09	0.17	0.00	0.63	24.78	4.65	10000	12000
08/25/92	09/08/92	0.99	0.41	0.01	0.04	0.00	0.24	15.84	3.30	140	750
09/08/92	09/19/92	1.03	0.09	0.00	0.04	0.00	0.16	24.00	1.70	280	1500
09/19/92	09/22/92	4.99	0.28	0.27	0.58	0.00	1.80	96.73	91.24	15000	35000
09/22/92	10/06/92	1.48	0.28	0.16	0.25	0.00	0.59	34.32	6.16	3900	17000
10/06/92	10/15/92	1.08	0.27	0.03	0.34	0.00	1.16	63.83	119.22	36000	34000
10/15/92	10/22/92	1.89	0.25	0.02	0.33	0.00	1.22	66.03	119.82	36000	34000
10/22/92	11/03/92	2.62	0.07	0.00	0.02	0.00	0.22	12.14	0.65	40	71
11/03/92	11/11/92	1.80	0.07	0.05	0.15	0.01	0.75	27.16	27.90	2100	1700
11/11/92	11/17/92	15.82	0.51	0.20	0.30	0.02	0.88	24.19	20.45	4400	3000
11/17/92	11/20/92	3.01	0.34	0.07	0.15	0.03	0.58	12.72	8.33	70	30
11/20/92	12/01/92	15.26	0.48	0.17	0.30	0.02	0.71	37.48	44.06	0	0
12/01/92	12/09/92	2.43	0.49	0.06	0.13	0.02	0.43	34.02	23.63	850	1300
12/09/92	12/13/92	16.47	0.55	0.13	0.23	0.05	0.80	21.04	17.29	3000	9000
12/13/92	12/16/92	88.41	0.45	0.21	0.37	0.04	0.80	33.44	55.65	2300	2700
12/16/92	01/04/93	5.95	0.42	0.10	0.21	0.01	0.56	20.58	48.20	850	1500

Table 22, cont.

Inclusive Dates Starting	Ending	Mean Flow cfs	NO_3-N	PO_4-P	TP	NH_3-N	TKN	COD	TSS	FC	FS
			mg/L							#/100 mL	
01/04/93	01/04/93	63.15	0.45	0.16	0.42	0.04	1.06	51.50	99.98	12000	7300
01/04/93	01/19/93	10.13	0.61	0.04	0.11	0.01	0.40	24.48	7.15	2000	1800
01/19/93	01/26/93	11.87	0.52	0.01	0.24	0.02	0.40	28.06	13.11	1200	1200
01/26/93	02/02/93	3.13	0.33	0.01	0.04	0.00	0.13	0.46	0.55	10	0
02/02/93	02/18/93	5.15	0.38	0.01	0.04	0.00	0.39	26.59	1.73	30	0
02/18/93	02/24/93	17.30	0.46	0.02	0.16	0.05	0.68	32.60	19.22	760	630
02/24/93	03/02/93	21.18	0.50	0.07	0.20	0.05	0.78	24.01	11.74	1100	1700
03/02/93	03/16/93	4.55	0.42	0.04	0.07	0.01	0.72	11.28	5.82	70	25
03/16/93	03/19/93	5.98	0.32	0.02	0.07	0.00	1.07	10.53	6.60	100	20
03/19/93	03/30/93	10.31	0.40	0.10	0.18	0.06	0.95	43.76	16.06	4000	700
03/30/93	04/04/93	7.09	0.35	0.06	0.22	0.03	1.06	82.66	17.10	4000	700
04/04/93	04/14/93	10.46	0.36	0.07	0.19	0.04	1.10	13.92	26.11	3500	11000
04/14/93	04/15/93	81.48	0.40	0.20	0.37	0.14	1.61	40.89	96.48	15000	83000
04/15/93	04/27/93	7.97	0.36	0.09	0.14	0.10	0.53	20.65	8.30	4100	5100
04/27/93	05/02/93	8.00	0.07	0.03	0.09	0.01	2.59	26.64	17.08	650	580
05/02/93	05/08/93	8.41	0.26	0.07	0.33	0.05	2.07	42.09	86.36	7500	12000
05/08/93	05/10/93	120.35	0.30	0.18	0.41	0.15	2.33	42.89	88.06	5300	11000
05/10/93	05/25/93	5.67	0.40	0.07	0.21	0.02	0.48	20.51	7.26	1400	1600
05/25/93	06/08/93	1.40	0.39	0.01	0.12	0.01	0.21	13.96	3.86	1400	170
06/08/93	06/22/93	3.81	0.17	0.02	0.06	0.03	0.19	9.45	3.31	1300	130
06/22/93	06/25/93	1.83	0.20	0.04	0.18	0.02	0.85	29.68	51.91	10	0
06/25/93	06/25/93	88.43	0.42	0.17	0.40	0.13	1.58	46.85	79.01	0	0
06/25/93	07/06/93	4.19	0.28	0.08	0.19	0.08	0.70	17.20	16.52	0	0
07/06/93	07/13/93	0.58	0.15	0.01	0.05	0.02	0.00	0.00	0.70	0	0
07/13/93	09/13/93	No Flow									
09/13/93	09/13/93	11.48	0.88	0.00	0.26	0.10	1.95	75.50	105.00	81000	17000
09/13/93	09/14/93	110.90	2.85	0.34	0.49	0.05	1.41	44.65	70.17	35000	35000
09/14/93	09/28/93	2.00	2.55	0.20	0.31	0.00	0.70	14.68	9.54	14000	10000
09/28/93	10/12/93	0.84	0.95	0.01	0.05	0.00	0.30	0.70	1.65	85	40
10/12/93	10/16/93	1.32	0.26	0.03	0.10	0.02	1.62	66.11	81.19	50	30
10/16/93	10/20/93	7.18	0.81	0.15	0.27	0.01	2.01	39.98	84.30	1300	4500
10/20/93	10/25/93	2.71	0.57	0.03	0.05	0.00	0.16	5.40	0.60	0	0
10/25/93	11/09/93	1.04	0.41	0.02	0.04	0.00	0.15	5.40	0.92	100	5
11/09/93	11/13/93	1.23	0.42	0.10	0.26	0.01	0.13	42.59	110.64	8700	27000
11/13/93	11/16/93	12.90	0.89	0.27	0.50	0.00	0.80	42.48	161.38	39000	31000
11/16/93	11/17/93	50.02	0.78	0.27	0.49	0.04	1.13	33.84	70.53	41000	29000
11/17/93	11/22/93	2.85	0.86	0.16	0.24	0.03	0.52	12.13	11.85	8100	10000
11/22/93	12/06/93	1.89	0.93	0.03	0.06	0.01	0.34	1.65	1.47	65	45
12/06/93	12/20/93	1.53	0.87	0.02	0.05	0.02	0.33	3.65	2.47	50	30
12/20/93	01/03/94	0.89	0.64	0.02	0.04	0.01	0.35	3.70	1.42	35	10
01/03/94	01/19/94	0.76	0.62	0.01	0.02	0.00	0.30	3.60	0.45	5	5
01/19/94	02/01/94	1.47	0.79	0.02	0.02	0.00	0.26	3.10	1.02	0	0
02/01/94	02/15/94	0.93	0.72	0.01	0.02	0.00	0.34	1.20	1.67	0	0
02/15/94	02/28/94	No Data									
02/28/94	03/15/94	4.07	0.74	0.02	0.05	0.00	0.31	19.15	2.05	55	30
03/15/94	03/26/94	0.98	0.74	0.07	0.09	0.00	0.49	22.05	5.32	400	300
03/26/94	03/26/94	45.74	0.82	0.07	0.13	0.03	0.87	18.56	11.78	750	390
03/26/94	04/12/94	1.68	0.62	0.06	0.09	0.01	0.81	15.90	6.65	1600	620
04/12/94	04/26/94	0.94	0.28	0.02	0.07	0.00	0.48	10.51	5.25	550	240
04/26/94	04/30/94	2.95	0.26	0.02	0.16	0.00	0.76	34.65	74.18	2500	4000
04/30/94	04/30/94	34.74	0.47	0.08	0.31	0.07	1.10	48.03	115.54	17000	59000

Table 23

Summarized flow-weighted mean concentrations of analysis parameters for the ML monitoring station

Parameter	Type of flow		
	Base Flow	Storm Flow	Combined Flow
	----------- mg/L -----------		
NO_3-N	0.93	1.02	1.00
PO_4-P	0.06	0.18	0.15
TP	0.15	0.38	0.32
NH_3-N	0.19	0.14	0.15
TKN	2.13	2.02	2.09
COD	24.72	55.17	48.16
TSS	11.99	64.33	52.29
	--------- #/100 mL ---------		
FC	1.8×10^3	1.3×10^4	1.1×10^4
FS	1.5×10^3	1.9×10^4	1.5×10^4

Table 24

Summarized flow-weighted mean concentrations of analysis parameters for the BL monitoring station

Parameter	Type of flow		
	Base Flow	Storm Flow	Combined Flow
	mg/L		
NO_3-N	0.72	0.92	0.82
PO_4-P	0.05	0.14	0.11
TP	0.12	0.28	0.23
NH_3-N	0.04	0.07	0.06
TKN	1.60	2.49	2.20
COD	18.46	44.87	36.16
TSS	11.90	40.63	31.15
	#/100 mL		
FC	1.8×10^3	1.1×10^4	8.0×10^3
FS	2.5×10^3	2.2×10^4	1.6×10^4

Table 25

Annual changes in concentrations of analysis parameters for the ML monitoring station

Parameter	Type of flow		
	Base Flow	Storm Flow	Combined Flow
NO_3-N	NC*	-25.3%	NC
PO_4-P	NC	NC	NC
TP	NC	NC	NC
NH_3-N	-45.6%	-53.9%	-44.8%
TKN	-64.9%	-36.9%	-13.9%
COD	NC	-34.8%	NC
TSS	NC	NC	NC
FC	76.4%	NC	221.0%
FS	NC	NC	NC

* No change

Table 26

Annual changes in concentrations of analysis parameters for the BL monitoring station

Parameter	Type of flow		
	Base Flow	Storm Flow	Combined Flow
NO_3-N	NC*	NC	NC
PO_4-P	NC	NC	NC
TP	NC	NC	NC
NH_3-N	-47.8%	NC	-48.0%
TKN	-45.4%	-50.7%	-48.2%
COD	NC	-23.7%	-28.3%
TSS	NC	64.9%	NC
FC	304.4%	285.8%	NC
FS	NC	NC	NC

* No change

Table 27

Event losses of analysis parameters for the ML monitoring station

Inclusive Dates Starting	Ending	Mean Flow cfs	NO_3-N	PO_4-P	TP	NH_3-N	TKN	COD	TSS
			lb/ac						
09/23/91	10/07/91	0.48	0.00	0.00	0.00	0.00	0.48	0.01	0.01
10/07/91	10/21/91	0.04	0.00	0.00	0.00	0.00	0.04	0.00	0.00
10/21/91	10/24/91	0.08	0.00	0.00	0.00	0.00	0.02	0.00	0.00
10/24/91	11/04/91	29.69	1.29	0.05	0.09	0.03	0.63	30.19	19.34
11/04/91	11/16/91	3.17	0.23	0.00	0.03	0.00	0.04	0.74	0.02
11/16/91	11/29/91	22.92	1.03	0.10	0.17	0.08	0.82	43.46	14.91
11/29/91	12/12/91	16.84	0.59	0.05	0.06	0.04	0.44	7.75	0.00
12/12/91	12/16/91	16.14	0.15	0.01	0.02	0.03	0.23	3.52	2.74
12/16/91	12/19/91	4.84	0.05	0.00	0.00	0.00	0.02	0.60	0.04
12/19/91	12/30/91	25.98	0.74	0.03	0.05	0.00	0.30	10.53	3.85
12/30/91	01/02/92	9.78	0.09	0.01	0.00	0.00	0.03	0.70	0.13
01/02/92	01/13/92	5.49	0.18	0.01	0.00	0.00	0.06	1.32	0.24
01/13/92	01/27/92	5.54	0.18	0.01	0.01	0.00	0.05	1.40	0.17
01/27/92	02/11/92	2.45	0.08	0.00	0.00	0.00	0.12	3.01	0.06
02/11/92	02/25/92	7.91	0.14	0.00	0.02	0.20	2.19	2.66	2.06
02/25/92	03/09/92	2.10	0.03	0.00	0.00	0.01	0.16	7.43	0.20
03/09/92	03/24/92	2.23	0.02	0.00	0.00	0.03	0.27	0.61	0.21
03/24/92	04/17/92	1.43	0.01	0.00	0.00	0.00	0.18	0.00	0.08
04/17/92	04/27/92	1.99	0.00	0.00	0.00	0.01	0.24	4.88	0.13
04/27/92	05/04/92	1.27	0.02	0.00	0.00	0.04	0.19	0.00	0.12
05/04/92	05/11/92	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00
05/11/92	05/16/92	7.50	0.05	0.01	0.02	0.21	1.07	5.57	3.98
05/16/92	05/28/92	4.93	0.04	0.00	0.04	0.01	0.54	3.83	0.00
05/28/92	06/02/92	11.28	0.04	0.01	0.01	0.05	0.60	4.43	2.12
06/02/92	06/06/92	9.47	0.03	0.00	0.01	0.01	0.42	4.69	0.50
06/06/92	06/11/92	23.70	0.07	0.03	0.09	0.07	2.82	10.16	25.52
06/11/92	06/16/92	4.44	0.01	0.00	0.00	0.00	0.14	0.33	0.13
06/16/92	06/19/92	1.39	0.00	0.00	0.00	0.00	0.03	0.06	0.02
06/19/92	06/30/92	2.49	0.01	0.00	0.01	0.01	0.09	1.75	1.30
06/30/92	07/05/92	0.16	0.00	0.00	0.00	0.00	0.00	0.06	0.01
07/05/92	07/13/92	3.15	0.03	0.01	0.01	0.01	0.07	1.27	2.54
07/13/92	07/27/92	0.34	0.00	0.00	0.00	0.00	0.00	0.08	0.04
07/27/92	07/30/92	0.15	0.00	0.00	0.00	0.00	0.00	0.01	0.00
07/30/92	08/03/92	15.69	0.05	0.03	0.06	0.02	0.20	3.59	10.56
08/03/92	08/11/92	18.06	0.08	0.05	0.10	0.02	0.28	5.13	16.39
08/11/92	08/25/92	0.80	0.00	0.00	0.00	0.00	0.01	0.27	0.13
08/25/92	09/08/92	0.18	0.00	0.00	0.00	0.00	0.00	0.03	0.03
09/08/92	09/19/92	0.45	0.00	0.00	0.00	0.00	0.00	0.05	0.05
09/19/92	09/22/92	27.21	0.05	0.03	0.09	0.02	0.26	13.15	8.10
09/22/92	10/06/92	1.62	0.01	0.00	0.00	0.00	0.01	0.11	0.01
10/06/92	10/22/92	1.10	0.00	0.00	0.00	0.00	0.01	0.31	0.03
10/22/92	10/31/92	1.86	0.00	0.00	0.00	0.00	0.01	0.31	0.03
10/31/92	11/10/92	8.19	0.05	0.01	0.03	0.00	0.10	3.34	3.02
11/10/92	11/17/92	40.40	0.20	0.12	0.18	0.01	0.33	12.18	21.75
11/14/92	11/19/92	4.63	0.01	0.00	0.00	0.00	0.00	0.21	0.00
11/19/92	12/01/92	36.55	0.30	0.13	0.23	0.02	0.49	22.08	21.34
12/01/92	12/09/92	4.65	0.03	0.00	0.00	0.00	0.01	0.24	0.11
12/09/92	12/13/92	30.54	0.11	0.03	0.06	0.01	0.14	5.25	3.68
12/13/92	12/16/92	193.51	0.29	0.15	0.27	0.08	0.61	26.63	39.06
12/16/92	01/04/93	10.21	0.13	0.03	0.04	0.01	0.12	10.77	6.90
01/04/93	01/04/93	183.84	0.07	0.03	0.15	0.01	0.48	23.87	1.06
01/04/93	01/19/93	15.48	0.17	0.02	0.03	0.01	0.12	2.50	1.80

Table 27, cont

Inclusive									
			NO_3	PO_4				COD	
Starting	Ending					lb/ac			
01/19/93	01/26/93	19.27							
01/26/93	02/02/93								
02/02/93	02/18/93					0.00			
02/18/93	02/23/93								
02/23/93	03/02/93								
03/02/93	03/16/93		0.05				0.06		
03/16/93	03/19/93								
03/19/93	03/30/93								
03/30/93	04/03/93								
04/03/93	04/04/93	No Data							
04/04/93	04/14/93								
04/14/93	04/15/93	180.37			0.16			12.40	46.54
04/15/93	04/19/93								
04/19/93	04/27/93	10.53							
04/27/93	05/09/93								
05/09/93	05/10/93	218.29						20.93	37.12
05/10/93	05/24/93								
05/24/93	06/08/93								
06/08/93	06/22/93								
06/22/93	06/25/93								
06/25/93	06/25/93	152.25							
06/25/93	07/06/93								
07/06/93	07/13/93								
07/13/93	09/02/93								
09/02/93	09/13/93								
09/13/93	09/14/93	250.22							17.29
09/14/93	09/25/93					0.00			
09/25/93	09/28/93								
09/28/93	10/12/93								
10/12/93	10/16/93								
10/16/93	10/20/93								
10/20/93	10/25/93								
10/25/93	11/09/93								
11/09/93	11/13/93								
11/13/93	11/16/93							11.84	27.41
11/16/93	11/17/93	110.85							
11/17/93	11/22/93								
11/22/93	12/03/93								
12/03/93	12/04/93								
12/04/93	12/06/93								
12/06/93	12/20/93	6.32							
12/20/93	01/03/94								
01/03/94	01/19/94			0.00					
01/19/94	02/01/94								
02/01/94	02/15/94								
02/15/94	03/26/94	No data							
03/26/94	03/27/94	104.49							
03/27/94	04/11/94								
04/11/94	04/26/94								
04/26/94	04/29/94								
04/29/94	04/30/94	59.50							

Table 28

Event losses of analysis parameters for the BL monitoring station

Inclusive Dates Starting	Ending	Mean Flow cfs	NO_3-N	PO_4-P	TP	NH_3-N	TKN	COD	TSS
			lb/ac						
10/01/91	10/07/91	1.12	0.04	0.00	0.00	0.00	0.01	0.32	0.02
10/07/91	10/21/91	0.76	0.03	0.00	0.00	0.00	0.01	0.29	0.03
10/21/91	10/24/91	0.47	0.00	0.00	0.00	0.00	0.00	0.01	0.00
10/24/91	11/04/91	14.39	1.25	0.06	0.10	0.03	0.76	25.79	25.62
11/04/91	11/16/91	1.89	0.26	0.00	0.00	0.00	0.05	0.88	0.00
11/16/91	11/29/91	10.40	0.98	0.08	0.11	0.04	0.70	41.94	7.14
11/29/91	12/12/91	8.54	0.73	0.04	0.06	0.02	0.50	27.42	6.19
12/12/91	12/16/91	7.89	0.22	0.01	0.01	0.01	0.17	3.09	2.64
12/16/91	12/19/91	2.56	0.06	0.00	0.00	0.00	0.01	0.10	0.05
12/19/91	12/30/91	12.06	0.77	0.05	0.07	0.02	0.50	7.73	4.21
12/30/91	01/02/92	6.12	0.14	0.00	0.01	0.00	0.05	0.82	0.49
01/02/92	01/13/92	3.11	0.23	0.00	0.01	0.00	0.08	1.08	0.80
01/13/92	01/27/92	2.73	0.23	0.00	0.01	0.00	0.11	1.62	0.43
01/27/92	02/11/92	1.81	0.15	0.00	0.00	0.00	0.18	2.51	0.02
02/11/92	02/25/92	4.56	0.23	0.00	0.02	0.03	2.08	11.71	2.35
02/25/92	03/09/92	1.91	0.08	0.00	0.00	0.02	0.34	4.15	0.15
03/09/92	03/24/92	1.92	0.06	0.00	0.02	0.03	0.46	0.95	0.11
03/24/92	04/07/92	1.66	0.02	0.00	0.01	0.01	0.36	2.93	0.02
04/07/92	04/20/92	1.43	0.01	0.00	0.00	0.01	0.23	2.29	0.02
04/20/92	04/21/92	13.82	0.03	0.00	0.01	0.00	1.27	2.55	0.39
04/21/92	05/04/92	1.64	0.02	0.00	0.01	0.00	2.63	0.00	0.08
05/04/92	05/11/92	0.96	0.00	0.00	0.01	0.00	0.00	0.00	0.02
05/11/92	05/16/92	4.13	0.04	0.01	0.02	0.06	1.31	15.92	1.98
05/16/92	05/20/92	4.53	0.01	0.00	0.02	0.01	0.35	2.96	0.00
05/20/92	06/02/92	4.84	0.05	0.01	0.03	0.00	3.19	8.43	0.00
06/02/92	06/06/92	8.79	0.04	0.00	0.02	0.01	0.64	6.63	0.95
06/06/92	06/11/92	10.53	0.06	0.04	0.07	0.08	1.90	5.66	5.89
06/11/92	06/16/92	3.11	0.01	0.00	0.00	0.00	0.19	0.35	0.13
06/16/92	06/19/92	1.64	0.00	0.00	0.00	0.00	0.05	0.09	0.03
06/19/92	06/30/92	2.27	0.02	0.01	0.01	0.01	0.16	2.41	3.08
06/30/92	07/05/92	0.91	0.00	0.00	0.00	0.00	0.00	0.09	0.09
07/05/92	07/13/92	2.01	0.02	0.01	0.02	0.00	0.06	0.96	1.73
07/13/92	07/27/92	0.96	0.01	0.00	0.00	0.00	0.02	0.09	0.24
07/27/92	07/30/92	1.17	0.01	0.00	0.00	0.00	0.00	0.04	0.04
07/30/92	08/03/92	12.90	0.07	0.03	0.06	0.00	0.27	9.15	9.78
08/03/92	08/11/92	11.80	0.09	0.06	0.10	0.00	0.41	6.78	15.44
08/11/92	08/25/92	1.23	0.02	0.00	0.01	0.00	0.03	1.18	0.22
08/25/92	09/08/92	0.99	0.02	0.00	0.00	0.00	0.01	0.60	0.13
09/08/92	09/19/92	1.03	0.00	0.00	0.00	0.00	0.00	0.72	0.05
09/19/92	09/22/92	4.99	0.01	0.01	0.03	0.00	0.08	4.41	4.16
09/22/92	10/06/92	1.48	0.02	0.01	0.01	0.00	0.03	1.95	0.35
10/06/92	10/15/92	1.08	0.01	0.00	0.01	0.00	0.03	1.79	3.34
10/15/92	10/22/92	1.89	0.01	0.00	0.01	0.00	0.04	2.24	4.06
10/22/92	11/03/92	2.62	0.01	0.00	0.00	0.00	0.02	1.05	0.06
11/03/92	11/11/92	1.80	0.00	0.00	0.01	0.00	0.03	1.03	1.06
11/11/92	11/17/92	15.82	0.14	0.05	0.08	0.00	0.24	6.61	5.58
11/17/92	11/20/92	3.01	0.01	0.00	0.00	0.00	0.01	0.30	0.20
11/20/92	12/01/92	15.26	0.22	0.08	0.14	0.01	0.33	17.51	20.58
12/01/92	12/09/92	2.43	0.03	0.00	0.01	0.00	0.02	1.76	1.22
12/09/92	12/13/92	16.47	0.12	0.03	0.05	0.01	0.17	4.46	3.66
12/13/92	12/16/92	88.41	0.28	0.13	0.23	0.02	0.49	20.56	34.22
12/16/92	01/04/93	5.95	0.13	0.03	0.07	0.00	0.17	6.24	14.61

Table 28, cont.

Inclusive Dates Starting	Ending	Mean Flow cfs	NO_3-N	PO_4-P	TP	NH_3-N	TKN	COD	TSS
			lb/ac						
01/04/93	01/04/93	63.15	0.05	0.02	0.05	0.00	0.12	5.64	10.95
01/04/93	01/19/93	10.13	0.25	0.01	0.05	0.00	0.16	10.08	2.94
01/19/93	01/26/93	11.87	0.11	0.00	0.05	0.00	0.08	5.94	2.78
01/26/93	02/02/93	3.13	0.02	0.00	0.00	0.00	0.01	0.03	0.04
02/02/93	02/18/93	5.15	0.09	0.00	0.01	0.00	0.09	6.02	0.39
02/18/93	02/24/93	17.30	0.13	0.01	0.05	0.02	0.20	9.54	5.62
02/24/93	03/02/93	21.18	0.17	0.02	0.07	0.02	0.27	8.14	3.98
03/02/93	03/16/93	4.55	0.07	0.01	0.01	0.00	0.13	1.97	1.02
03/16/93	03/19/93	5.98	0.02	0.00	0.00	0.00	0.05	0.50	0.31
03/19/93	03/30/93	10.31	0.13	0.03	0.06	0.02	0.30	13.77	5.05
03/30/93	04/04/93	7.09	0.03	0.01	0.02	0.00	0.09	7.23	1.50
04/04/93	04/14/93	10.46	0.11	0.02	0.06	0.01	0.32	4.09	7.67
04/14/93	04/15/93	81.48	0.11	0.06	0.10	0.04	0.46	11.72	27.64
04/15/93	04/27/93	7.97	0.09	0.02	0.04	0.03	0.14	5.41	2.18
04/27/93	05/02/93	8.00	0.01	0.00	0.01	0.00	0.31	3.18	2.04
05/02/93	05/08/93	8.41	0.04	0.01	0.05	0.01	0.29	5.88	12.07
05/08/93	05/10/93	120.35	0.15	0.09	0.21	0.07	1.17	21.49	44.20
05/10/93	05/25/93	5.67	0.09	0.02	0.05	0.00	0.11	4.78	1.69
05/25/93	06/08/93	1.40	0.02	0.00	0.01	0.00	0.01	0.75	0.21
06/08/93	06/22/93	3.81	0.02	0.00	0.01	0.00	0.03	1.38	0.48
06/22/93	06/25/93	1.83	0.00	0.00	0.00	0.00	0.01	0.42	0.73
06/25/93	06/25/93	88.43	0.03	0.01	0.02	0.01	0.10	2.84	4.79
06/25/93	07/06/93	4.19	0.03	0.01	0.02	0.01	0.09	2.16	2.07
07/06/93	07/13/93	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.01
07/13/93	09/13/93	No Flow							
09/13/93	09/13/93	11.48	0.00	0.00	0.00	0.00	0.00	0.04	0.06
09/13/93	09/14/93	110.90	0.52	0.06	0.09	0.01	0.26	8.07	12.68
09/14/93	09/28/93	2.00	0.20	0.02	0.02	0.00	0.05	1.13	0.73
09/28/93	10/12/93	0.84	0.03	0.00	0.00	0.00	0.01	0.02	0.05
10/12/93	10/16/93	1.32	0.00	0.00	0.00	0.00	0.03	1.04	1.27
10/16/93	10/20/93	7.18	0.06	0.01	0.02	0.00	0.15	2.89	6.09
10/20/93	10/25/93	2.71	0.02	0.00	0.00	0.00	0.01	0.20	0.02
10/25/93	11/09/93	1.04	0.02	0.00	0.00	0.00	0.01	0.23	0.04
11/09/93	11/13/93	1.23	0.01	0.00	0.00	0.00	0.00	0.63	1.64
11/13/93	11/16/93	12.90	0.09	0.03	0.05	0.00	0.08	4.07	15.48
11/16/93	11/17/93	50.02	0.04	0.02	0.03	0.00	0.06	1.94	4.03
11/17/93	11/22/93	2.85	0.04	0.01	0.01	0.00	0.02	0.52	0.51
11/22/93	12/06/93	1.89	0.07	0.00	0.00	0.00	0.03	0.12	0.11
12/06/93	12/20/93	1.53	0.05	0.00	0.00	0.00	0.02	0.21	0.14
12/20/93	01/03/94	0.89	0.02	0.00	0.00	0.00	0.01	0.13	0.05
01/03/94	01/19/94	0.76	0.02	0.00	0.00	0.00	0.01	0.12	0.02
01/19/94	02/01/94	1.47	0.04	0.00	0.00	0.00	0.01	0.16	0.05
02/01/94	02/15/94	0.93	0.03	0.00	0.00	0.00	0.01	0.04	0.06
02/15/94	02/28/94	No Data							
02/28/94	03/15/94	4.07	0.12	0.00	0.01	0.00	0.05	3.21	0.34
03/15/94	03/26/94	0.98	0.02	0.00	0.00	0.00	0.01	0.65	0.16
03/26/94	03/26/94	45.74	0.03	0.00	0.00	0.00	0.03	0.69	0.44
03/26/94	04/12/94	1.68	0.05	0.00	0.01	0.00	0.06	1.23	0.51
04/12/94	04/26/94	0.94	0.01	0.00	0.00	0.00	0.02	0.38	0.19
04/26/94	04/30/94	2.95	0.01	0.00	0.00	0.00	0.02	1.00	2.15
04/30/94	04/30/94	34.74	0.01	0.00	0.01	0.00	0.02	0.78	1.87

Table 29

Summarized losses of analysis parameters for the ML monitoring station

Parameter	Type of flow		
	Base Flow	Storm Flow	Combined Flow
Runoff			
inches	10.35 (23%)	34.63 (77%)	44.97
inches/year	3.97	13.30	17.27
NO_3-N			
tons	4.84 (22%)	17.72 (78%)	22.56
lb/acre	2.18	7.99	10.17
lb/acre/year	0.84	3.07	3.90
PO_4-P			
tons	0.28 (8%)	3.09 (92%)	3.38
lb/acre	0.13	1.39	1.52
lb/acre/year	0.05	0.54	0.58
TP			
tons	0.75 (10%)	6.54 (90%)	7.29
lb/acre	0.34	2.95	3.29
lb/acre/year	0.13	1.13	1.26
NH_3-N			
tons	1.01 (29%)	2.44 (71%)	3.45
lb/acre	0.46	1.10	1.55
lb/acre/year	0.17	0.42	0.60
TKN			
tons	12.1 (26%)	35.2 (74%)	47.3
lb/acre	5.5	15.9	21.3
lb/acre/year	2.1	6.1	8.2
COD			
tons	128.5 (13%)	842.9 (87%)	971.4
lb/acre	57.9	379.9	437.9
lb/acre/year	22.2	145.9	168.1
TSS			
tons	62.3 (6%)	936.8 (94%)	999.2
lb/acre	28.1	422.3	450.4
lb/acre/year	10.8	162.2	173.0

Table 30

Summarized losses of analysis parameters for the BL monitoring station

Parameter	Type of flow		
	Base Flow	Storm Flow	Combined Flow
Runoff			
inches	17.43 (33%)	35.40 (67%)	52.83
inches/year	6.69	13.59	20.29
NO_3-N			
tons	2.78 (22%)	7.25 (78%)	10.03
lb/acre	2.83	7.39	10.22
lb/acre/year	1.09	2.84	3.93
PO_4-P			
tons	0.20 (8%)	1.09 (92%)	1.29
lb/acre	0.20	1.11	1.31
lb/acre/year	0.08	0.43	0.51
TP			
tons	0.47 (10%)	2.18 (90%)	2.65
lb/acre	0.48	2.22	2.70
lb/acre/year	0.18	0.85	1.03
NH_3-N			
tons	0.15 (29%)	0.58 (71%)	0.73
lb/acre	0.15	0.59	0.74
lb/acre/year	0.06	0.23	0.29
TKN			
tons	6.2 (26%)	19.6 (74%)	25.8
lb/acre	6.3	20.0	26.3
lb/acre/year	2.4	7.7	10.1
COD			
tons	71.6 (13%)	353.2 (87%)	424.8
lb/acre	72.9	359.7	432.6
lb/acre/year	28.0	138.1	166.1
TSS			
tons	46.1 (6%)	319.8 (94%)	365.9
lb/acre	47.0	325.7	372.6
lb/acre/year	18.0	125.1	143.1

Table 31

Annual changes in losses of analysis parameters for the ML monitoring station

Parameter	Type of flow		
	Base Flow	Storm Flow	Combined Flow
NO_3-N	NC*	-35.9%	NC
PO_4-P	NC	NC	NC
TP	NC	NC	NC
NH_3-N	NC	NC	NC
TKN	NC	-36.9%	-46.6%
COD	NC	NC	NC
TSS	200.9%	NC	NC

* No change

Table 32

Annual changes in losses of analysis parameters
for the BL monitoring station

Parameter	Type of flow		
	Base Flow	Storm Flow	Combined Flow
NO_3-N	NC*	-53.2%	NC
PO_4-P	NC	NC	NC
TP	NC	NC	NC
NH_3-N	NC	-62.9%	-42.6%
TKN	-48.0%	-68.3%	-61.1%
COD	NC	-60.6%	-40.7%
TSS	NC	NC	NC

* No change

Table 33

Selected Soil Properties Field

Date	pH	OM	NH_4-N	NO_3-N			Fe		
			----------	----------	----------	lb/ac	----------	----------	----------
09/91	6.6			22.4	362	255	228		10.5
12/91			239.8	30.8	388	229		25.1	
03/92			191.8	19.6	230	256	287	20.9	
06/92			257.6	27.2	506	223		33.6	14.7
09/92			81.5	23.2	493		250	41.5	20.1
12/92			27.3		304	169	269	40.5	10.2
03/93			11.4					18.4	
06/93			97.1	17.3	257			21.0	
09/93			94.0	14.4	397	275	263	26.4	.8
12/93					343	185	243	25.6	11.2
03/94			6.2	11.0	346	208	313	21.8	11.0

Each value is the mean of five samples.

Table 34

Selected Soil Properties* for Field RM

Date	pH	OM %	NH_4-N	NO_3-N	P	K	Fe	Zn	Cu
			----------	----------	lb/ac	----------			
09/91	6.3	2.2	-	82.4	615	444	213	31.3	14.0
12/91	6.5	2.3	229.0	29.6	614	472	240	35.3	8.6
03/92	7.0	2.5	216.2	18.6	420	548	255	28.3	7.6
06/92	6.6	3.1	197.2	66.0	592	513	252	38.5	12.0
09/92	5.8	3.1	52.8	181.6	625	425	235	45.9	16.8
12/92	6.3	3.1	31.4	10.4	476	434	252	38.9	11.5
03/93	6.4	2.2	10.6	17.7	395	360	211	25.5	7.7
06/93	6.3	2.2	79.9	49.6	432	401	196	32.6	9.6
09/93	6.1	2.1	40.6	28.6	408	300	225	30.1	9.9
12/93	6.2	2.2	4.6	20.4	393	327	204	32.6	9.9
03/94	6.1	-	6.5	27.0	441	415	282	29.0	10.8

* Each value is the mean of five samples.

Table

Selected Soil Properties Field WU

Date	pH	OM	NH	$_3$-N					
		%	lb/ac						
09/91									
12/91			298.2	17.6	425	393	266		
03/92			267.6	22.8		585	319	25.6	
06/92			276.4		394	513	306		11.2
09/92			109.4	77.5	416	706	288	28.8	15.4
12/92			58.6		380	416	288	30.8	11.7
03/93			16.5		258		256	18.8	
06/93			116.3	27.1	320	310	284	24.2	13.7
09/93			154.9	23.5	357	473		21.3	11.4
12/93			18.6	20.6	405	370	266	26.0	13.2
03/94				27.4	416	544			14.2

Each value mean of five samples.

Table 36

Selected Soil Properties* for Field WM

Date	pH	OM %	NH_4-N	NO_3-N	P	K	Fe	Zn	Cu
			lb/ac						
09/91	-		34.8	14.8	-	-	-	-	-
12/91	6.9	1.9	195.2	21.4	1266	323	283	38.4	13.3
03/92	7.0	2.6	184.6	24.2	786	451	294	35.9	11.4
06/92	6.8	2.3	197.6	41.2	787	322	264	32.3	12.8
09/92	6.1	2.0	45.4	28.1	771	267	219	36.3	15.9
12/92	6.4	2.4	26.6	3.0	619	259	262	54.8	10.1
03/93	6.3	2.0	14.0	6.2	606	249	256	22.9	9.4
06/93	5.9	1.7	78.1	27.8	537	204	234	24.5	9.3
09/93	6.1	1.7	69.1	10.8	471	231	251	22.5	8.0
12/93	6.2	1.6	3.8	15.2	678	235	248	32.3	10.6
03/94	6.1		4.6	16.1	753	301	334	28.9	11.4

* Each value is the mean of five samples.

Table 37

Flow-weighted mean event concentrations of analysis parameters for field RU

Date	Runoff in	Samples	NO_3-N	PO_4-P	TP	NH_3-N	TKN	COD	TSS	FC	FS
			mg/L							#/100 mL	
10/24/91	0.01	3	0.64	2.37	1.78	0.12	2.49	39	34	2.4×10^{4}	4.1×10^{5}
10/24/91	0.00	0[1]									
10/26/91	0.65	9	0.15	1.01	1.11	0.18	2.82	45	105	3.7×10^{4}	3.6×10^{5}
10/26/91	0.01	0									
10/29/91	0.00	0									
10/31/91	0.18	6	0.14	1.90	0.32	0.36	2.10	12	3	2.0×10^{2}	2.6×10^{3}
12/12/91	0.34	8	0.16	1.37	1.42	0.19	2.45	103	59	9.3×10^{2}	3.2×10^{4}
05/11/92	0.25	8	0.17	4.19	2.61	1.87	24.39	70	6	1.4×10^{4}	1.7×10^{4}
05/29/92	0.06	9	0.03	5.22	3.05	1.92	20.87	87	8	2.8×10^{3}	3.6×10^{5}
06/02/92	0.01	3	0.13	2.93	2.02	1.28	29.84	118	11	8.4×10^{3}	4.2×10^{5}
06/02/92	0.01	3	0.04	3.24	1.93	0.65	23.77	61	4	3.0×10^{4}	3.0×10^{4}
06/06/92	0.67	11	0.10	3.13	3.83	1.78	20.86	62	8	2.6×10^{3}	1.6×10^{5}
07/05/92	0.19	4	1.13	3.63	4.20	0.21	2.24	56	32	1.3×10^{5}	4.9×10^{5}
07/05/92	0.11	4	0.59	3.71	4.12	0.16	2.21	45	53	6.9×10^{4}	1.9×10^{5}
07/16/92	0.01	1	0.36	3.74	1.01	-	3.43	45	26	1.0×10^{4}	1.1×10^{6}
07/31/92	0.70	7	0.25	2.61	2.32	0.17	2.04	30	59	4.3×10^{4}	5.8×10^{4}
08/04/92	0.70	8	0.13	2.70	2.56	0.14	1.56	20	17	1.7×10^{5}	4.2×10^{5}
08/05/92	0.03	3	0.06	2.99	2.35	0.05	2.15	49	4	9.0×10^{3}	2.3×10^{4}
09/22/92	1.51	5	0.29	2.56	2.24	0.11	1.47	87	154	2.1×10^{4}	5.3×10^{4}
11/11/92	0.28	7	0.10	4.12	5.02	0.05	2.18	76	25	9.7×10^{3}	6.4×10^{3}
11/11/92	0.60	7	0.04	3.36	3.02	0.09	1.83	44	39	4.6×10^{3}	1.9×10^{3}
11/20/92	0.37	6	0.02	2.89	3.04	0.04	1.42	57			
11/22/92	1.58	0									
12/09/92	0.48	5	0.10	2.48	2.52	0.03	1.42	78	14		
12/15/92	0.69	5	0.06	1.63	1.65	0.04	0.79	28	14	8.7×10^{1}	6.4×10^{2}
12/15/92	0.10	0									
12/15/93	0.69	6	0.03	1.83	1.74	0.03	0.57	43	8	9.7×10^{1}	7.5×10^{2}
01/04/93	0.98	5	0.09	1.47	1.52	0.10	1.62	82	123	4.3×10^{2}	1.4×10^{3}
01/09/93	0.14	0									
03/18/93	0.11	4	0.08	1.08	2.18	0.84	6.45	116	60		
03/30/93	0.05	0									
04/03/93	0.07	2	0.04	1.12	1.25	0.15	2.73	52	23	1.6×10^{3}	4.0×10^{4}
04/14/93	0.03	3	0.09	1.27	0.82	0.13	2.13	59	22	4.5×10^{3}	2.9×10^{4}
04/14/93	0.62	6	0.07	1.56	1.32	0.17	2.15	39	30	2.4×10^{3}	1.4×10^{4}
05/09/93	1.03	6	0.10	1.02	1.12	0.06	1.54	46	37	5.1×10^{3}	5.1×10^{4}
05/09/93	1.22	3	0.01	0.98	0.88	0.05	0.98	39	8	2.6×10^{3}	7.2×10^{3}
06/25/93	1.06	4	0.16	1.29	1.29	0.23	1.63	47	23		
08/24/93	0.01	4	8.53	15.65	11.54	4.12	16.12	103	68	1.9×10^{4}	5.9×10^{5}
09/14/93	0.08	5	0.41	7.22	6.10	0.24	2.31	23	33	2.2×10^{4}	1.1×10^{4}
09/14/93	0.66	6	0.18	6.97	7.44	0.10	1.33	31	17	5.4×10^{3}	9.3×10^{3}
10/08/93	0.09	0									
10/17/93	1.00	11	0.15	0.55	3.43	0.15	2.03	53	11	6.7×10^{3}	5.6×10^{4}

Table 37, cont.

Date	Runoff	Samples	NO_3-N	PO_4-P	TP	NH_3-N	TKN	COD	TSS	FC	FS
	in		mg/L							#/100 mL	
10/20/93	0.43	2	0.07	2.45	2.56	0.04	2.26	38	5	$3.4x10^2$	$2.3x10^3$
11/14/93	1.43	1	0.08	2.95	2.96	0.05		34	6	$0.0x10^0$	$1.1x10^4$
11/17/93	0.65	6	0.14	1.99	2.14	0.15	1.36	34	6	$3.0x10^3$	$9.3x10^3$
12/02/93	0.02	0									
12/04/93	0.17	4	0.09	2.35	2.45	0.12	2.41	48	17		
12/13/93	0.06	0									
01/26/94	0.11	4	0.29	1.96	2.58	0.17	2.80	76	72	$1.7x10^2$	$2.1x10^4$
03/26/94	0.02	2	0.05	1.53	1.70	0.04	1.77	43	15	$1.6x10^3$	$4.1x10^3$

[1] No samples analyzed.

Table 38

Flow-weighted mean event concentrations of analysis parameters for field RM

Date	Runoff	Samples	NO_3-N	PO_4-P	TP	NH_3-N	TKN	COD	TSS	FC	FS
	in		mg/L							#/100 mL	
10/24/91	0.00	0[1]									
10/26/91	0.17	12	0.58	1.44	2.52	1.33	9.87	193	715	2.9×10^5	4.9×10^5
10/26/91	0.00	0									
11/17/91	0.00	2	1.65	2.79	2.56	1.24	6.73	28	202	1.1×10^3	5.6×10^5
12/12/91	0.00	1	1.49	2.23	3.98	0.42	9.60	199	774	1.9×10^2	2.5×10^3
05/12/92	0.07	16	0.46	1.93	2.18	2.97	24.52	46	115	7.1×10^4	2.5×10^4
05/18/92	0.03	6	0.67	1.55	1.91		38.49	132	138	1.2×10^5	6.8×10^6
06/06/92	0.01	3	0.70	2.55	3.03	3.49	29.31	67	26	6.8×10^4	3.8×10^5
06/06/92	0.01	3	0.39	2.30	2.63	3.06	24.15	127	34	5.7×10^3	7.2×10^4
06/06/92	0.00	0									
07/05/92	0.04	5	2.47	2.98	3.94	0.35	4.36	76	36	2.8×10^4	2.0×10^2
07/05/92	0.07	6	0.94	2.61	3.29	0.38	3.84	155	33	2.2×10^4	1.1×10^6
07/05/92	0.00	0									
07/31/92	0.21	6	0.38	1.00	1.28	0.14	1.59	9	14	3.2×10^5	6.7×10^4
08/05/92	0.09	7	0.35	1.30	1.63	0.11	1.89	21	8	3.6×10^5	1.1×10^6
09/22/92	0.54	6	0.72	1.38	1.53	0.30	1.63	69	19	6.0×10^4	5.7×10^5
10/15/92	0.15	4	6.81	3.79	3.66	1.39	7.62	195	36	1.0×10^5	3.6×10^6
11/11/92	0.01	5	1.89	3.63	6.64	0.54	6.29	96	103	5.4×10^5	3.9×10^5
11/11/92	0.07	5	0.64	2.24	2.47	0.28	2.68	89	187	1.2×10^5	1.5×10^5
11/21/92	0.31	0									
12/09/92	0.00	0									
12/11/92	0.14	6	0.22	1.03	1.42	0.08	1.20	35	42	2.7×10^2	8.3×10^3
12/15/92	0.00	0									
12/15/92	0.50	7	0.27	1.19	1.38	0.04	1.01	54	25	2.3×10^2	6.3×10^3
01/04/93	0.14	5	0.24	0.66	1.63	0.46	4.27	95	238	6.0×10^3	5.6×10^4
03/30/93	0.04	4	0.55	0.80	1.43	0.64	4.73	76	105	2.5×10^4	7.9×10^4
04/03/93	0.00	1	0.12	1.20	1.30	0.25	3.24	63	24	6.1×10^3	2.7×10^4
04/03/93	0.03	3	0.12	0.92	1.05	0.16	2.06	41	20	3.2×10^3	1.4×10^4
04/14/93	0.01	2	0.83	0.89	0.78	0.74	5.49	87	78	4.2×10^4	3.4×10^5
04/14/93	0.49	7	0.14	1.00	0.80	0.19	2.41	43	17	1.8×10^4	5.8×10^4
05/09/93	0.16	6	1.56	1.03	1.16	0.51	2.37	68	19	2.0×10^4	1.2×10^5
05/09/93	0.00	3	0.99	1.36	1.48	0.49	3.36	68	32	4.5×10^4	5.4×10^4
05/09/93	0.09	4	0.37	1.15	1.11	0.14	1.14	35	8	1.4×10^4	3.7×10^4
06/25/93	0.35	7	3.01	2.98	3.44	0.71	4.41	75	44		
09/14/93	0.08	5	1.09	1.58	1.77	0.65	2.34	30	22	9.4×10^4	1.4×10^5
09/14/93	0.30	6	1.08	1.51	1.61	0.33	1.74	5	15	5.6×10^4	1.0×10^5
10/08/93	0.00	0									
10/16/93	0.04	5	0.60	1.62	1.99	0.35	2.32	44	26	6.1×10^4	9.9×10^4
10/16/93	0.05	3	0.79		1.70	0.49	4.21	52	54		
11/14/93	0.14	5	0.48	1.49	1.73	0.68	1.54	111	81	8.4×10^5	2.4×10^5
11/14/93	0.10	4	0.46	1.56	1.90	0.75	5.21	57	31	1.9×10^5	2.3×10^5

able 38.

Date	Runoff	Samples	NO_3	PO_4-P		NH_3-N	TKN	COD	TSS		
			mg/L							/100	
11/17/93	0.08		0.57		71	0.59	5.61			$.4\times10^5$	6.2×10^4
01/26/94	0.02			0.60	1.39	0.55	9.80			1.8×10^3	1.0×10^4

samples analyzed

Table 39

Flow-weighted mean event concentrations of analysis parameters for field WU

Date	Runoff in	Samples	NO_3-N	PO_4-P	TP	NH_3-N	TKN	COD	TSS	FC	FS
			mg/L							#/100 mL	
10/25/91	0.11	11	0.46	2.28	1.74	0.38	2.20	52	55	9.8×10^4	6.1×10^5
10/26/91	0.14	12	0.41	1.28	1.54	0.32	5.38	107	597	1.6×10^4	4.4×10^5
10/26/91	0.01	6	1.24	3.55	1.80	0.07	2.61	81	14	5.5×10^3	1.8×10^5
10/28/91	0.02	4	0.45	3.02	2.27	0.05	4.67	52	18		
10/31/91	0.13	5	1.21	2.62	2.15	0.12	2.09	44	18		
11/16/91	0.09	24	0.84	2.38	2.02	1.08	5.14	72	45	2.7×10^4	5.8×10^3
06/02/92	0.00	2	0.52	4.32	2.68	2.18	40.34	71	35	7.7×10^5	1.5×10^4
06/06/92	0.14	8	0.31	3.62	3.76	3.65	34.26	104	33	3.6×10^4	2.9×10^4
06/20/92	0.00	3	0.52	2.04	1.28	4.02	4.24	53	35	1.8×10^4	4.2×10^4
07/05/92	0.07	6	0.78	1.81	2.39	0.42	2.56	103	48	4.6×10^4	2.4×10^4
07/05/92	0.07	7	0.33	2.14	0.79	0.35	3.23	30	36	5.0×10^4	8.3×10^4
07/31/92	0.77	10	0.33	1.10	1.53	0.11	2.15	31	240	5.8×10^4	1.8×10^4
08/05/92	0.27	7	0.41	1.94	2.33	0.24	2.39	37	33	5.7×10^4	1.6×10^5
08/05/92	0.03	4	0.29	1.83	1.89	0.23	3.21	76	62	1.8×10^4	5.2×10^4
08/11/92	0.00	2	1.10	1.77	2.07	0.25	3.23	61	26	6.1×10^5	1.1×10^5
10/15/92	0.01	1	0.71	1.70	1.81	0.00	2.83	54	15	4.3×10^4	1.1×10^5
11/11/92	0.02	6	0.65	4.21	5.22	0.21	2.80	68	23	4.5×10^5	4.4×10^3
11/11/92	0.05	4	0.22	3.53	4.11	0.23	2.29	82	48	8.3×10^4	2.7×10^4
12/09/92	0.03	4	0.70	2.02	3.16	0.72	4.28	109	127	4.8×10^4	8.4×10^4
12/15/92	0.65	4	0.36	1.31	1.88	0.38	3.23	94	178	8.3×10^3	1.2×10^4
12/15/92	0.01	0[1]									
12/15/92	0.44	4	0.20	1.54	1.69	0.21	1.77	84	40	6.0×10^3	2.8×10^3
01/09/93	0.09	4	0.36	1.37	3.00	0.49	5.40	181	329	1.9×10^4	1.4×10^4
01/20/93	0.04	6	0.29	1.02	1.91	0.30	3.66	125	211	3.0×10^3	5.8×10^3
02/20/93	0.17	5	0.29	1.04	1.52	1.94	5.43	75	28	6.6×10^3	1.3×10^2
02/25/93	0.09	0									
03/18/93	0.00	3	0.52	1.47	2.37	0.57	5.72	197	90		
04/04/93	0.04	4	0.15	1.32	1.66	0.16	3.74	100	74	5.7×10^4	9.4×10^3
04/14/93	0.05	4	5.49	24.35	25.33	40.31	108.30	791	239	3.7×10^6	1.0×10^7
04/14/93	0.34	7	0.21	9.19	14.89	11.79	30.18	175	50	5.5×10^5	2.9×10^5
05/02/93	0.06	6	0.45	1.87	2.81	0.67	4.86	98	143	6.3×10^4	8.8×10^4
05/09/93	0.05	6	0.36	1.87	1.70	1.31	4.78	71	115	1.3×10^5	1.3×10^5
05/09/93	0.00	0									
05/09/93	0.01	3	0.34	2.29	3.07	1.37	5.94	104	88	1.0×10^5	2.5×10^4
05/09/93	0.00	1	0.31	2.94	3.12	1.40	4.07	105	18	8.7×10^4	2.4×10^4
05/09/93	0.30		0.07	2.08	2.51	1.33	3.22	72	22	2.6×10^4	9.5×10^3
05/13/93	0.00	0									
06/19/93	0.09	0									
06/25/93	0.31	13	0.83	2.15	2.30	0.39	2.19	57	66		
09/14/93	0.66	7	0.52	3.09	3.39	0.35	1.94	29	39	1.6×10^5	9.2×10^5
09/15/93	0.87	0									
09/25/93	0.03	4	1.50	4.54	6.11	0.48	4.24	104	31	5.7×10^4	1.8×10^5
10/17/93	0.04	4	0.36		2.45	0.21	4.19	100	122		

Table 39, cont.

Date	Runoff in	Samples	NO_3-N	PO_4-P	TP	NH_3-N	TKN	COD	TSS	FC	FS
			mg/L							#/100 mL	
10/19/93	0.01	2	0.41	2.27	2.82	0.67	6.61	77	109	$4.9x10^3$	$3.2x10^4$
10/14/93	0.02	5	0.55	1.98	2.57	1.15	7.03	86	48	$1.6x10^5$	$1.0x10^5$
11/16/93	0.04	4	0.57	1.63	1.79	0.92	4.70	87	88	$5.3x10^5$	$5.8x10^4$
11/16/93	0.00	1	0.73	1.90	1.99	0.80	4.29	68	35	$3.2x10^5$	$5.8x10^4$
03/26/94	0.00	2	0.22	1.64	1.66	0.38	4.35	66	31	$7.8x10^3$	$3.9x10^3$

[1] No samples analyzed.

Table 40

Flow-weighted mean event concentrations of analysis parameters for field WM

Date	Runoff	Samples	NO_3-N	PO_4-P	TP	NH_3-N	TKN	COD	TSS	FC	FS
	in					mg/L				-- #/100 mL ---	
10/24/91	0.07	24	3.54	3.20	2.43	0.36	2.75	60	20	$1.3x10^5$	$4.6x10^5$
10/25/91	1.23	24	2.66	2.35	2.02	0.17	3.55	109	310	$6.0x10^4$	$2.0x10^5$
10/28/91	0.65	9	3.79	2.35	1.00	0.22	3.45	61	30	$1.3x10^4$	$8.1x10^4$
10/30/91	0.01	0[1]									
10/31/91	0.76	8	3.86	2.20	1.79	0.12	1.96	39	15	$7.2x10^2$	$4.3x10^3$
11/16/91	0.61	24	5.12	2.61	2.10	0.88	3.89	115	5	$2.7x10^2$	$1.0x10^3$
11/19/91	0.05	13	4.35	1.81	1.50	1.46	4.92	192	8	$5.9x10^2$	$2.7x10^5$
12/12/91	0.01	4	3.04	1.24	0.99	0.43	2.59	58	88	$2.0x10^3$	$6.6x10^4$
06/06/92	0.62	19	2.48	3.23	2.53	2.53	26.37	61	20	$2.2x10^2$	$1.3x10^4$
07/05/92	0.00	1	4.00	2.04	4.19	0.41	4.62	76	91	$2.5x10^5$	$3.9x10^5$
07/05/92	0.03	2	1.52	2.07	2.89	0.31	3.03	41	63	$2.0x10^4$	$3.3x10^5$
07/31/92	1.13	9	0.45	1.28	2.21	0.04	3.55	88	458	$2.4x10^5$	$2.6x10^4$
08/05/92	0.69	10	0.16	1.70	1.75	0.00	1.59	18	19	$1.1x10^5$	$2.2x10^5$
08/05/92	0.27	3	0.12	1.86	1.71	0.00	1.66	40	2	$2.8x10^4$	$9.2x10^4$
08/11/92	0.00	1	0.69	2.05	1.98	0.20	3.76	86	15	$9.9x10^5$	$7.8x10^4$
11/11/92	0.05	5	0.89	2.67	5.24	0.10	1.84	41	22	$4.2x10^5$	$3.4x10^3$
11/11/92	0.30	7	0.48	1.98	1.86	0.08	1.39	38	14	$2.3x10^4$	$2.5x10^3$
11/22/92	0.29	5	0.31	1.71	1.68	0.11	1.25	37	0		
11/22/92	1.32	0									
12/09/92	0.07	2	0.26	1.33	1.50	0.20	1.37	30	20	$7.2x10^3$	$8.8x10^3$
12/15/92	0.00	0									
12/15/92	2.67	13	0.13	0.91	1.01	0.04	0.65	21	23	$1.8x10^3$	$1.3x10^3$
12/15/92	0.02	0									
01/04/93	0.06	4	0.24	0.87	15	0.15	1.68	38	47	$4.9x10^3$	$3.0x10^3$
01/09/93	0.10	0									
02/20/93	0.39	6	0.10	0.65	0.85	0.05	0.68	30	5	$5.0x10^1$	$1.8x10^1$
02/26/93	0.76	3	0.04	0.78	0.89	0.01	0.78	48	8	$6.4x10^1$	$1.1x10^3$
04/14/93	0.01	1	70.74	0.87	0.76	42.00	57.44	60	67	$2.9x10^3$	$1.4x10^5$
04/14/93	0.69	9	13.64	0.93	1.03	10.72	15.26	29	11	$7.0x10^2$	$1.3x10^4$
04/14/93	0.01	0									
05/09/93	0.45	8	0.49	1.39	1.47	0.15	2.02	51	13	$3.2x10^3$	$6.8x10^4$
05/10/93	0.87	8	0.13	1.35	1.37	0.09	1.70	57	4	$4.6x10^2$	$2.8x10^3$
05/13/93	0.00	0									
06/19/93	0.01	0									
06/25/93	0.52	0									
09/14/93	0.75	6	0.33	1.07	1.19	0.31	1.07	13	16	$1.3x10^5$	$4.5x10^4$
09/15/93	1.80	4	2.42	1.51	1.57	0.19	1.29	3	6	$7.2x10^4$	$4.9x10^4$
09/24/93	0.07	3	2.43	2.16	2.98	0.42	2.73	97	4	$5.3x10^4$	$8.3x10^4$
09/24/93	0.07	2	4.16	1.40	2.02	0.27	2.28	104	0	$3.1x10^4$	$1.9x10^4$
09/26/93	0.14	0									
10/08/93	0.00	0									
10/16/93	0.05	5	0.75	1.80	2.04	0.41	2.77	76	11	$1.2x10^5$	$6.5x10^5$
10/17/93	0.21	5	0.70		1.81	0.31	2.73	64	11		
10/18/93	0.00	1	0.45	0.98	1.04	0.34	3.08	38	19	$6.0x10^2$	$1.0x10^3$

Table cont.

Date	Runoff in	Samples	NO_3-N	PO_4-P		NH_3-N	TKN	COD	TSS	FC	
			mg/L							/100 mL	
10/20/93	0.21		0.77			0.				$2.6x10^3$	$5.1x10^4$
11/14/93	0.05		0.65	1.38	1.58	0.41	4.06	46		$5.0x10^4$	$.8x10^5$
11/16/93	0.28		0.72	1.09	1.02	0.34	6.61	46		$1.9x10^4$	$5.0x10^4$
03/26/94	0.01		0.00	0.85	0.82	5.53	6.44	40		$2.5x10^3$	$5.4x10^3$

samples analyzed

Table 41

Summarized event flow-weighted mean concentrations of analysis parameters for the monitored fields

Parameter	Field			
	RU	RM	WU	WM
	mg/L			
NO_3-N*	0.14	0.99	0.46	1.93
PO_4-P	2.25	1.54	2.60	1.55
TP	2.38	1.80	3.27	1.53
NH_3-N	0.21	0.47	1.63	0.73
TKN	2.89	3.66	4.65	3.50
COD	50.51	66.67	79.31	46.00
TSS	40.25	68.30	112.40	67.14
	#/100 mL			
FC	$1.7x10^4$	$1.1x10^5$	$1.3x10^5$	$4.7x10^4$
FS	$6.9x10^4$	$4.0x10^5$	$3.0x10^5$	$5.2x10^4$

Table 42

Annual changes in runoff concentrations of analysis parameters for the monitored fields.

Parameter	Field			
	RU	RM	WU	WM
NO_3-N	NC*	NC	NC	NC
PO_4-P	NC	-27.7%	NC	-27.7%
TP	NC	-28.8%	NC	NC
NH_3-N	NC	NC	NC	NC
TKN	NC	-46.4%	NC	NC
COD	NC	NC	NC	-27.2%
TSS	NC	-48.0%	NC	-47.2%
FC	-72.1%	NC	NC	NC
FS	-67.7%	NC	NC	NC

* No change

Table 43

Event runoff losses of analysis parameters for field RU

Date	Runoff	Samples	NO_3-N	PO_4-P	TP	NH_3-N	TKN	COD	TSS
	in					lb/ac			
10/24/91	0.01	3	0.00	0.01	0.00	0.00	0.01	0.09	0.08
10/24/91	0.00	0[1]							
10/26/91	0.65	9	0.02	0.15	0.16	0.03	0.42	6.62	15.45
10/26/91	0.00	0							
10/29/91	0.00	0							
10/31/91	0.18	6	0.01	0.08	0.01	0.01	0.09	0.49	0.12
12/12/91	0.34	8	0.01	0.11	0.11	0.01	0.19	7.93	4.54
05/11/92	0.25	8	0.01	0.24	0.15	0.11	1.38	3.96	0.34
05/29/92	0.06	9	0.00	0.07	0.04	0.03	0.28	1.18	0.11
06/02/92	0.01	3	0.00	0.01	0.00	0.00	0.07	0.27	0.02
06/02/92	0.01	3	0.00	0.01	0.00	0.00	0.05	0.14	0.01
06/06/92	0.67	11	0.02	0.47	0.58	0.27	3.16	9.41	1.21
07/05/92	0.19	4	0.05	0.16	0.18	0.01	0.10	2.41	1.38
07/05/92	0.11	4	0.01	0.09	0.10	0.00	0.06	1.12	1.32
07/16/92	0.01	1	0.00	0.01	0.00		0.01	0.10	0.06
07/31/92	0.70	7	0.04	0.41	0.37	0.03	0.32	4.75	9.35
08/04/92	0.70	8	0.02	0.43	0.41	0.02	0.25	3.17	2.69
08/05/92	0.03	3	0.00	0.02	0.02	0.00	0.01	0.33	0.03
09/22/92	1.51	5	0.10	0.88	0.77	0.04	0.50	29.74	52.65
11/11/92	0.28	7	0.01	0.26	0.32	0.00	0.14	4.82	1.58
11/11/92	0.60	7	0.01	0.46	0.41	0.01	0.25	5.98	5.3
11/20/92	0.37	6	0.00	0.24	0.25	0.00	0.12	4.78	
11/22/92	1.58	0							
12/09/92	0.48	5	0.01	0.27	0.27	0.00	0.15	8.48	1.52
12/15/92	0.69	5	0.01	0.25	0.26	0.01	0.12	4.37	2.19
12/15/92	0.69	6	0.00	0.29	0.27	0.00	0.09	6.72	1.25
12/15/92	0.10	0							
01/04/93	0.98	5	0.02	0.33	0.34	0.02	0.36	18.19	27.29
01/09/93	0.14	0							
03/18/93	0.11	4	0.00	0.03	0.05	0.02	0.16	2.89	.49
03/30/93	0.05	0							
04/03/93	0.07	2	0.00	0.02	0.02	0.00	0.04	0.82	0.36
04/14/93	0.03	3	0.00	0.01	0.01	0.00	0.01	0.40	0.15
04/14/93	0.62	6	0.01	0.22	0.19	0.02	0.30	5.47	4.21
05/09/93	1.03	6	0.02	0.24	0.26	0.01	0.36	10.73	8.63
05/09/93	1.22	3	0.00	0.27	0.24	0.01	0.27	10.77	2.21
06/25/93	1.06	4	0.04	0.31	0.31	0.06	0.39	11.28	5.52
08/24/93	0.01	4	0.02	0.04	0.03	0.01	0.04	0.23	0.15
09/14/93	0.08	5	0.01	0.13	0.11	0.00	0.04	0.42	0.6
09/14/93	0.66	6	0.03	1.04	1.11	0.01	0.20	4.63	2.54
10/08/93	0.09	0							
10/17/93	1.00	11	0.03	0.12	0.78	0.03	0.46	12.00	2.49
10/20/93	0.43	2	0.01	0.24	0.25	0.00	0.22	3.70	0.49
11/14/93	1.43	1	0.03	0.96	0.96	0.02		11.01	1.94

Table

	Runoff	Samples	$_3$-N	PO_4-P		NH_3-N	TKN	COD	TSS
						lb/ac			
11/17/93	0.65		0.02	0.29	0.31	0.02	0.20	5.00	0.88
12/02/93	0.02								
12/04/93	0.17		0.00	0.09	0.09	0.00	0.09		0.65
12/13/93	0.06								
01/26/94	0.11		0.01	0.05	0.06	0.00	0.07		
03/26/94	0.02			0.01	0.01	0.00	0.01	0.19	0.07
			0.58	9.28	9.82	0.86	10.99	208.35	162.69

samples analyzed.

Table 44

Event runoff losses of analysis parameters for field RM

Date	Runoff in	Samples	NO_3-N	PO_4-P	TP	NH_3-N	TKN	COD	TSS
			------------------	------------------	------------------	lb/ac	------------------	------------------	------------------
10/24/91	0.00	0[1]							
10/26/91	0.17	12	0.02	0.06	0.10	0.05	0.38	7.43	27.52
10/26/91	0.00	0							
11/17/91	0.00	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12/12/91	0.00	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
05/12/92	0.07	16	0.01	0.03	0.03	0.05	0.39	0.73	1.82
05/18/92	0.03	6	0.00	0.01	0.01		0.26	0.90	0.94
06/06/92	0.01	3	0.00	0.01	0.01	0.01	0.07	0.15	0.06
06/06/92	0.01	3	0.00	0.01	0.01	0.01	0.05	0.29	0.08
06/06/92	0.00	0							
07/05/92	0.04	5	0.02	0.03	0.04	0.00	0.04	0.69	0.33
07/05/92	0.07	6	0.01	0.04	0.05	0.01	0.06	2.46	0.52
07/05/92	0.00	0							
07/31/92	0.21	6	0.02	0.05	0.06	0.01	0.08	0.43	0.67
08/05/92	0.09	7	0.01	0.03	0.03	0.00	0.04	0.43	0.16
09/22/92	0.54	6	0.09	0.17	0.19	0.04	0.20	8.44	2.32
10/15/92	0.15	4	0.23	0.13	0.12	0.05	0.26	6.62	1.22
11/11/92	0.01	5	0.00	0.01	0.02	0.00	0.01	0.22	0.23
11/11/92	0.07	5	0.01	0.04	0.04	0.00	0.04	1.41	2.96
12/11/92	0.14	6	0.01	0.03	0.05	0.00	0.04	1.11	1.33
11/21/92	0.31	0							
12/09/92	0.00	0							
12/15/92	0.50	7	0.03	0.13	0.16	0.00	0.11	6.11	2.83
12/15/92	0.00	0							
01/04/93	0.14	5	0.01	0.02	0.05	0.01	0.14	3.01	7.54
03/30/93	0.04	4	0.00	0.01	0.01	0.01	0.04	0.69	0.95
04/03/93	0.00	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
04/03/93	0.03	3	0.00	0.01	0.01	0.00	0.01	0.28	0.14
04/14/93	0.01	2	0.00	0.00	0.00	0.00	0.01	0.20	0.18
04/14/93	0.49	7	0.02	0.11	0.09	0.02	0.27	4.77	1.89
05/09/93	0.16	6	0.06	0.04	0.04	0.02	0.09	2.46	0.69
05/09/93	0.00	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
05/09/93	0.09	4	0.01	0.02	0.02	0.00	0.02	0.71	0.16
06/25/93	0.35	7	0.24	0.24	0.27	0.06	0.35	5.94	3.49
09/14/93	0.08	5	0.02	0.03	0.03	0.01	0.04	0.54	0.40
09/14/93	0.30	6	0.07	0.10	0.11	0.02	0.12	0.34	1.02
10/08/93	0.00	0							
10/16/93	0.04	5	0.01	0.01	0.02	0.00	0.02	0.40	0.24
10/16/93	0.05	3	0.01		0.02	0.01	0.05	0.59	0.61
11/14/93	0.14	5	0.02	0.05	0.05	0.02	0.05	3.52	2.57
11/14/93	0.10	4	0.01	0.04	0.04	0.02	0.12	1.29	0.70

Table

	Runoff	Samples	NO_3	PO_4-P		$_3$-N lb/ac	TKN	COD	TSS
/17/93	0.08		0.01	0.02	0.03	0.01			
/26/94	0.02			0.00			0.04		0.82
			0.94				3.50	63.85	

samples analyzed

Table 45

Event runoff losses of analysis parameters for field WU

Date	Runoff in	Samples	NO_3-N	PO_4-P	TP	NH_3-N	TKN	COD	TSS
			lb/ac						
10/25/91	0.11	11	0.01	0.06	0.04	0.01	0.05	1.30	1.37
10/26/91	0.14	12	0.01	0.04	0.05	0.01	0.17	3.39	18.92
10/26/91	0.01	6	0.00	0.01	0.00	0.00	0.01	0.18	0.03
11/16/91	0.09	24	0.02	0.05	0.04	0.02	0.10	1.47	0.92
06/02/92	0.00	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
06/06/92	0.14	8	0.01	0.11	0.12	0.12	1.09	3.30	1.05
06/20/92	0.00	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
07/05/92	0.07	6	0.01	0.03	0.04	0.01	0.04	1.63	0.76
07/05/92	0.07	7	0.01	0.03	0.01	0.01	0.05	0.48	0.57
07/31/92	0.77	10	0.06	0.19	0.27	0.02	0.37	5.40	41.84
08/05/92	0.27	7	0.03	0.12	0.14	0.01	0.15	2.26	2.02
08/05/92	0.03	4	0.00	0.01	0.01	0.00	0.02	0.52	0.42
08/11/92	0.00	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10/15/92	0.01	1	0.00	0.00	0.00	0.00	0.01	0.12	0.03
11/11/92	0.02	6	0.00	0.02	0.02	0.00	0.01	0.31	0.10
11/11/92	0.05	4	0.00	0.04	0.05	0.00	0.03	0.93	0.54
12/09/92	0.03	4	0.00	0.01	0.02	0.00	0.03	0.74	0.86
12/15/92	0.65	4	0.05	0.19	0.28	0.06	0.48	13.83	26.20
12/15/92	0.44	4	0.02	0.15	0.17	0.02	0.18	8.37	3.98
12/15/92	0.01	0[1]							
01/09/93	0.09	4	0.01	0.03	0.06	0.01	0.11	3.69	6.70
01/20/93	0.04	6	0.00	0.01	0.02	0.00	0.03	1.13	1.91
02/20/93	0.17	5	0.01	0.04	0.06	0.07	0.21	2.89	1.08
02/25/93	0.09	0							
04/04/93	0.04	4	0.00	0.01	0.02	0.00	0.03	0.91	0.67
04/14/93	0.05	4	0.06	0.28	0.29	0.46	1.23	8.95	2.71
04/14/93	0.34	7	0.02	0.71	1.15	0.91	2.32	13.47	3.85
05/02/93	0.06	6	0.01	0.03	0.04	0.01	0.07	1.33	1.94
05/09/93	0.05	6	0.00	0.02	0.02	0.01	0.05	0.80	1.30
05/09/93	0.01	3	0.00	0.01	0.01	0.00	0.01	0.24	0.20
05/09/93	0.00	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
05/09/93	0.30	1	0.00	0.14	0.17	0.09	0.22	4.89	1.49
05/09/93	0.00	0							
05/13/93	0.00	0							
06/19/93	0.09	0							
09/14/93	0.66	7	0.08	0.46	0.51	0.05	0.29	4.33	5.83
09/15/93	0.87	0							
09/25/93	0.03	4	0.01	0.03	0.04	0.00	0.03	0.71	0.21
10/19/93	0.01	2	0.00	0.01	0.01	0.00	0.01	0.17	0.25
11/14/93	0.02	5	0.00	0.01	0.01	0.01	0.03	0.39	0.22
11/16/93	0.04	4	0.01	0.01	0.02	0.01	0.04	0.79	0.80
11/16/93	0.00	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
03/26/94	0.00	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10/28/91	0.02	4	0.00	0.01	0.01	0.00	0.02	0.24	0.08

Table cont.

	Runoff in	Samples	NO_3-N	PO_4-P		NH_3-N	TKN	COD	TSS
			----	----	----	lb/ac	----	----	----
10/31/91			0.04	0.08	0.06	0.00	0.06		0.53
03/18/93	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00
06/25/93	0.31		0.06		0.16	0.03	0.15	4.00	4.63
10/17/93	0.04		0.00		0.02	0.00	0.04	0.91	1.10
	6.37		0.55	3.	3.93			95.35	135.

No samples analyzed.

Table 46

Event runoff losses of analysis parameters for field WM

Date	Runoff in	Samples	NO_3-N	PO_4-P	TP	NH_3-N	TKN	COD	TSS
			--- lb/ac ---						
10/24/91	0.07	24	0.06	0.05	0.04	0.01	0.04	0.95	0.32
10/25/91	1.23	24	0.74	0.65	0.56	0.05	0.99	30.36	86.33
10/28/91	0.65	9	0.56	0.35	0.15	0.03	0.51	8.98	4.42
10/30/91	0.01	0[1]							
10/31/91	0.76	8	0.66	0.38	0.31	0.02	0.34	6.71	2.58
11/16/91	0.61	24	0.71	0.36	0.29	0.12	0.54	15.88	0.69
11/19/91	0.05	13	0.05	0.02	0.02	0.02	0.06	2.17	0.09
12/12/91	0.01	4	0.01	0.00	0.00	0.00	0.01	0.13	0.20
06/06/92	0.62	19	0.35	0.45	0.36	0.36	3.70	8.56	2.81
07/05/92	0.00	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
07/05/92	0.03	2	0.01	0.01	0.02	0.00	0.02	0.28	0.43
07/31/92	1.13	9	0.12	0.33	0.57	0.01	0.91	22.51	117.18
08/05/92	0.69	10	0.02	0.27	0.27	0.00	0.25	2.81	2.97
08/05/92	0.27	3	0.01	0.11	0.10	0.00	0.10	2.45	0.12
08/11/92	0.00	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11/11/92	0.05	5	0.01	0.03	0.06	0.00	0.02	0.46	0.25
11/11/92	0.30	7	0.03	0.13	0.13	0.01	0.09	2.58	0.95
11/22/92	1.32	0							
12/09/92	0.07	2	0.00	0.02	0.02	0.00	0.02	0.48	0.32
12/15/92	2.67	13	0.08	0.55	0.61	0.02	0.39	12.70	13.90
12/15/92	0.00	0							
12/15/92	0.02	0							
01/04/93	0.06	4	0.00	0.01	0.02	0.00	0.02	0.52	0.64
01/09/93	0.10	0							
02/20/93	0.39	6	0.01	0.06	0.08	0.00	0.06	2.65	0.44
02/26/93	0.76	3	0.01	0.13	0.15	0.00	0.13	8.26	1.38
04/14/93	0.01	1	0.16	0.00	0.00	0.10	0.13	0.14	0.15
04/14/93	0.69	9	2.13	0.15	0.16	1.67	2.38	4.53	1.72
04/14/93	0.01	0							
05/09/93	0.45	8	0.05	0.14	0.15	0.02	0.21	5.20	1.32
05/10/93	0.87	8	0.03	0.27	0.27	0.02	0.33	11.23	0.79
05/13/93	0.00	0							
06/19/93	0.01	0							
06/25/93	0.52	0							
09/14/93	0.75	6	0.06	0.18	0.20	0.05	0.18	2.21	2.72
09/15/93	1.80	4	0.99	0.62	0.64	0.08	0.53	1.22	2.45
09/24/93	0.07	3	0.04	0.03	0.05	0.01	0.04	1.54	0.06
09/24/93	0.07	2	0.07	0.02	0.03	0.00	0.04	1.65	0.00
09/26/93	0.14	0							
10/08/93	0.00	0							
10/16/93	0.05	5	0.01	0.02	0.02	0.00	0.03	0.86	0.12
10/18/93	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00
10/20/93	0.21	5	0.04	0.07	0.07	0.01	0.10	2.04	0.19
11/14/93	0.05	5	0.01	0.02	0.02	0.00	0.05	0.52	0.15

Table

Date	Runoff	Samples	NO_3-N			NH_3 lb/ac	TKN	COD	TSS
/16/93			0.05	0.07	0.06		0.42		
03/26/94	0.01		0.00	0.00			0.01	0.09	0.02
11/22/92	0.29		0.02	0.11	0.11	0.01	0.08	2.43	0.00
10/17/93	0.21		0.03		0.09	0.01	0.13	3.04	0.52
Total				5.62	5.62			169.05	246

samples analyzed

Table 47

Estimated annual runoff losses of analysis parameters for the monitored fields

Parameter	Field			
	RU	RM	WU	WM
	------	------ lb/ac/year	------	------
NO_3-N	0.24	0.38	0.25	3.01
PO_4-P	3.87	0.59	1.40	2.41
TP	4.09	0.69	1.77	2.38
NH_3-N	0.36	0.18	0.88	1.13
TKN	4.97	1.41	3.49	5.46
COD	86.81	25.68	42.86	71.66
TSS	69.19	26.31	60.75	104.59

SUMMARY AND CONCLUSIONS

Water quality at five stream sites and four pastures in the Lincoln Lake basin was monitored from September 1991 to April 1994. The monitoring was conducted concurrently with HUA activities in the region to improve the quality of water entering Lincoln Lake. The goals of the monitoring were to demonstrate (a) the overall effectiveness of HUA activities within the basin and (b) the effectiveness of nutrient management, a specific BMP implemented in association with HUA activities.

The data from the stream monitoring sites indicated a significantly decreasing trend in stream flow concentrations of N and sometimes COD, while concentrations of P, FC, and FS generally did not change over the monitored period. The information collected from the four fields indicated that nutrient management based on P as the limiting nutrient (i.e., applying inorganic fertilizer to soils with sufficient P content) decreased both soil and runoff P concentrations. However, no significant increases in soil or runoff P concentrations were observed for fields in which nutrient management was based on N as the limiting nutrient (i.e., applying animal manure to soils already having sufficient P).

Apart from the HUA program, there were no reported activities within the Lincoln Lake basin that would have caused the water quality changes observed over the monitoring period. Furthermore, the water quality changes that were observed are consistent with the impacts that SCS and CES activities would be expected to produce. The improving trend in the quality of Lincoln Lake's tributaries is thus attributed to the HUA program within the basin; i.e., the programs were effective in positively influencing water quality in the basin. The data collected from monitoring the four small fields demonstrate that proper nutrient management can lead to agronomically small losses of nutrients in runoff. The information further points out that if P is the water quality concern, then an appropriate nutrient management strategy can significantly reduce runoff losses of P in perhaps a relatively short time.

BIBLIOGRAPHY

Agricultural Research Service. 1979. Field manual for research in agricultural hydrology. Agriculture Handbook No. 224. U.S. Dept. of Agric., Washington, D.C.

Arkansas Agricultural Statistics Service. 1993. 1992 Arkansas agricultural statistics. Report Series 325, Arkansas Agricultural Experiment Station, University of Arkansas, Fayetteville.

Arkansas Department of Pollution Control and Ecology. 1991. Regulation no. 2, as amended. Regulation establishing water quality standards for surface waters of the state of Arkansas. State of Arkansas, Little Rock.

Bailey, G.W. and T.E. Waddell. 1979. Best management practices for agriculture and silviculture: An integrated overview. pp. 35-56. In R.C. Loehr, D.A. Haith, M.F. Walter, and C.S. Martin, eds. Best management practices for agriculture and silviculture. Ann Arbor Sci. Pub. Inc., Ann Arbor, MI.

Edwards, D.R. and T.C. Daniel. 1992. Potential runoff quality effects of poultry manure slurry applied to fescue plots. Trans. ASAE 35:1827-1832.

Edwards, D.R. and T.C. Daniel. 1993. Effects of poultry litter application rate and rainfall intensity on quality of runoff from fescuegrass plots. J. Environ. Qual. 22:361-365.

Greenberg, A.E., L.S. Clesceri, and A.D. Eaton (eds.) 1992. Standard methods for the examination of water and wastewater, 18th ed. American Public Health Association, Washington, D.C.

Harper, M.D., W.W. Phillips, and G.J. Haley. 1969. Soil survey of Washington County, Arkansas. Soil Conservation Service, U.S. Dept. of Agric., Washington, D.C.

McLeod, R.V. and R.O. Hegg. 1984. Pasture runoff quality from application of inorganic and organic nitrogen sources. J. Environ. Qual. 13:122-126.

Soil Conservation Service. 1977. Waste storage structure. Section IV, Field Office Technical Guide. U.S. Dept. of Agric., Little Rock, AR.

Soil Conservation Service. 1983. Predicting soil loss using the universal soil loss equation. U.S. Dept. of Agric., Little Rock, AR.

Soil Conservation Service. 1986. Urban hydrology for small watersheds. Tech. Release 55. U.S. Dept. of Agric., Washington, D.C.

Soil Conservation Service. 1987a. Waste utilization. Section IV, Field Office Technical Guide. U.S. Dept. of Agric., Little Rock, AR.

Soil Conservation Service. 1987b. Pasture and hayland management. Section IV, Field Office Technical Guide. U.S. Dept. of Agric., Little Rock, AR.

Soil Conservation Service. 1990. Dead poultry composting. Section IV, Field Office Technical Guide. U.S. Dept. of Agric., Little Rock, AR.

Soil Conservation Service. 1992a. Nutrient management. Section IV, Field Office Technical Guide. U.S. Dept. of Agric., Little Rock, AR.

Soil Conservation Service. 1992b. Agricultural waste management field handbook. U.S. Dept. of Agric., Washington, D.C.

Soil Conservation Service and University of Arkansas Cooperative Extension Service. 1990. Moores Creek hydrologic unit. U.S. Dept. of Agric., Little Rock, AR.

US Geological Survey. 1969. Discharge measurements at gaging stations. Techniques of Water-Resources Investigations, Book 3, Chap. A8. US Government Printing Office, Washington, D.C.

US Geological Survey. 1984. Discharge ratings at gaging stations. Techniques of Water-Resources Investigations, Book 3, Chapter A10. US Government Printing Office, Washington, D.C.

Westerman, P.W., T.L. Donnelly, and M.R. Overcash. 1983. Erosion of soil and poultry manure - a laboratory study. Trans. ASAE 26:1070-1078,1084.