Nitrogen and Pesticide Concentrations in an Agricultural Basin in North-Central Connecticut

By JOHN R. MULLANEY and MARC J. ZIMMERMAN

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FOREWORD

The mission of the U.S. Geological Survey (USGS) is to assess the quantity and quality of the earth resources of the Nation and to provide information that will assist resource managers and policymakers at Federal, State, and local levels in making sound decisions. Assessment of water-quality conditions and trends is an important part of this overall mission.

One of the greatest challenges faced by water-resources scientists is acquiring reliable information that will guide the use and protection of the Nation's water resources. That challenge is being addressed by Federal, State, interstate, and local water-resource agencies and by many academic institutions. These organizations are collecting water-quality data for a host of purposes that include: compliance with permits and water-supply standards; development of remediation plans for specific contamination problems; operational decisions on industrial, wastewater, or water-supply facilities; and research on factors that affect water quality. An additional need for water-quality information is to provide a basis on which regional- and national-level policy decisions can be based. Wise decisions must be based on sound information. As a society we need to know whether certain types of water-quality problems are isolated or ubiquitous, whether there are significant differences in conditions among regions, whether the conditions are changing over time, and why these conditions change from place to place and over time. The information can be used to help determine the efficacy of existing water-quality policies and to help analysts determine the need for and likely consequences of new policies.

To address these needs, the U.S. Congress appropriated funds in 1986 for the USGS to begin a pilot program in seven project areas to develop and refine the National Water-Quality Assessment (NAWQA) Program. In 1991, the USGS began full implementation of the program. The NAWQA Program builds upon an existing base of water-quality studies of the USGS, as well as those of other Federal, State, and local agencies. The objectives of the NAWQA Program are to:

- Describe current water-quality conditions for a large part of the Nation's freshwater streams, rivers, and aquifers.
- Describe how water quality is changing over time.
- Improve understanding of the primary natural and human factors that affect water-quality conditions.

This information will help support the development and evaluation of management, regulatory, and monitoring decisions by other Federal, State, and local agencies to protect, use, and enhance water resources.

The goals of the NAWQA Program are being achieved through ongoing and proposed investigations of 59 of the Nation's most important river basins and aquifer systems, which are referred to as study units. These study units are distributed throughout the Nation and cover a diversity of hydrogeologic settings. More than two-thirds of the Nation's freshwater use occurs within the 59 study units and more than two-thirds of the people served by public water-supply systems live within their boundaries.

National synthesis of data analysis, based on aggregation of comparable information obtained from the study units, is a major component of the program. This effort focuses on selected water-quality topics using nationally consistent information. Comparative studies will explain differences and similarities in observed water-quality conditions among study areas and will identify changes and trends and their causes. The first topics addressed by the national synthesis are pesticides, nutrients, volatile organic compounds, and aquatic biology. Discussions on these and other water-quality topics will be published in periodic summaries of the quality of the Nation's ground and surface water as the information becomes available.

This report is an element of the comprehensive body of information developed as part of the NAWQA Program. The program depends heavily on the advice, cooperation, and information from many Federal, State, interstate, Tribal, and local agencies and the public. The assistance and suggestions of all are greatly appreciated.

Robert M. Hirsch

Robert M. Hirsch
Chief Hydrologist

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CONVERSION FACTORS

Multiply	By	To obtain
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
inch per year (in/yr)	25.4	millimeter per year
mile (mi)	1.609	kilometer
pounds per day per square mile [$(lb/d)/mi^2$]	2.205	kilogram per day per square mile
square mile (mi^2)	2.590	square kilometer

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

VERTICAL DATUM

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Nitrogen and Pesticide Concentrations in an Agricultural Basin in North-Central Connecticut

By John R. Mullaney *and* Marc J. Zimmerman

Abstract

Concentrations and yields of selected nitrogen compounds and herbicides fluctuated with changes in river discharge during a stormflow event in samples from three subbasins of the Scantic River in north-central Connecticut during May 31–June 2, 1992. Concentrations of nitrite plus nitrate nitrogen and the herbicide metabolite desethyl atrazine decreased with increasing river discharge, indicating that the ground-water runoff component of streamflow contained larger concentrations of these constituents than the surface-water runoff component. Concentrations of ammonia plus organic nitrogen, atrazine, and metolachlor increased with increasing river discharge, indicating that overland runoff from fertilizer and pesticide-treated fields contained larger concentrations of these constituents than baseflow. Analysis of additional water-quality data from Broad Brook at Broad Brook, Connecticut, from 1993 to 1994 showed that concentrations of nitrate nitrogen had an inverse relation with streamflow, indicating that ground water was a major nitrate nitrogen source. Concentrations and yields of ammonia nitrogen and total organic nitrogen in Broad Brook increased when streamflow exceeded 100 cubic feet per second, indicating that large concentrations of these nitrogen constituents are derived primarily from overland runoff from agricultural fields.

INTRODUCTION

Understanding the nonpoint sources of nutrients and pesticides in surface water and ground water has become an important research area (Puckett, 1995). Increased nitrogen loading to estuaries, such as Long Island Sound, has caused algal blooms and subsequent episodic, seasonal hypoxia (low dissolved-oxygen concentrations) (Long Island Sound Study, 1993). Pesticides in ground water and surface water are a serious issue in many agricultural areas in the United States, including the Midwest, where the highest concentrations of herbicides have been detected in surface water sampled during storms following spring application of herbicides to fields (Thurman and others, 1991). In Connecticut, recent studies by the U.S. Geological Survey (USGS) have demonstrated that concentrations of nitrite plus nitrate nitrogen in shallow ground water are higher in agricultural areas than in forested or undeveloped areas (Grady, 1994) and that concentrations commonly exceeded the U.S. Environmental Protection Agency Maximum Contaminant Level (MCL) of 10 mg/L (Mullaney and others, 1991). These two studies also determined that atrazine and other triazine and acetanilide herbicides may be present at low concentrations in ground water beneath agricultural areas.

The study described here was conducted as part of the National Water Quality Assessment Program (NAWQA) (Leahy, 1990) to collect additional data about nitrogen and pesticides and the mechanisms of their transport in surface water and ground water in New England agricultural areas. The Scantic River

Basin (fig. 1), a 114-mi^2 watershed in north-central Connecticut, was chosen for study because it has a high percentage of agricultural land use. Water samples were collected in three subbasins during the first two storms in 1992 following springtime application of agricultural chemicals. Additional monthly data were collected during 1993–94 at one location in the basin. These data will be useful to help in determining the timing and magnitude of pesticide and nutrient fluxes from source areas and ground water.

Description of Study Area

Four stream sites in the Scantic River Basin in Connecticut were sampled for this study: the Scantic River at Four Bridges Road, in Somers (47 mi^2 drainage area), Broad Brook at Broad Brook, Connecticut (15.5 mi^2), Broad Brook at Melrose (11.6 mi^2), and Muddy Brook at Ellington (0.79 mi^2).

Agriculture, with corn and hay the principal crops, is a major land use in the study area (U.S. Department of Commerce, 1989); however, there are some suburban residential and forested areas (table 1). Farmers in the Scantic River Basin apply herbicides to corn fields from April to June to control weeds. The herbicides—atrazine and metolachlor—commonly are used in Tolland County at average estimated rates of 13.5 to 52.4, and 8.2 to 37.6 lb/mi^2, respectively (Battaglin and Goolsby, 1995). Fertilizers, including manure, may be applied throughout the year. No point sources of contamination such as treated wastewater discharges are present upstream of any of the sampled sites.

Precipitation is distributed evenly throughout the year. According to Hunter and Meade (1983), median annual precipitation for 1951-80 at nearby Windsor Locks, Connecticut, was 42.79 in. Much of the Scantic River Basin is underlain by a highly transmissive stratified-drift aquifer, containing mostly sand and gravel. The Scantic River aquifer is one of the most extensive surficial aquifers in Connecticut. Depth to the water table in the aquifer ranges from 1 to 50 ft below land surface, but is mostly less that 20 ft in areas adjacent to the river and tributaries. Residence time in stratified-drift aquifers in Connecticut may range from less than a year to two decades (Grady, 1994) or more. Mean ground-water runoff at the Broad Brook at Broad Brook streamflow-gaging station for 1983–94 was estimated to be 18.3 in/yr, through use of a baseflow-separation program (Rutledge, 1993).

Data Collection

Temporary streamflow-gaging stations were installed at the Scantic River and at Broad Brook at Melrose (sites 1 and 3, fig. 1) to record river stage every 30 minutes. Broad Brook at Broad Brook and Muddy Brook already had established streamflow-gaging stations. Streamwater was sampled with automated pumping samplers, which, when manually activated, could collect as many as 24 samples at preset time intervals.

Herbicides were applied to corn fields in the study area during May 1992. The first series of water samples was collected from May 31–June 2, 1992, through an entire storm. Precipitation during this storm at nearby Windsor Locks was 1.48 in. (National Oceanic and Atmospheric Administration, 1992). During the storm, samples were collected every 60 minutes at Muddy Brook and every 90 minutes at Broad Brook at Melrose and at the Scantic River. One additional grab sample was collected at each site on June 6, 1992, near the peak of a more intense storm in which 3.48 in. of precipitation fell. A hydrograph of river stage at Broad Brook at Broad Brook, and hourly precipitation at Windsor Locks is shown in figure 2.

Following sample collection, specific conductance was measured, and subsamples were screened for atrazine using an enzyme-linked immunosorbent assay. Water samples in which atrazine was detected were sent to the USGS National Water Quality Laboratory (NWQL) for gas chromatography-mass spectroscopy quantification of pesticide concentrations (Sandstrom and others, 1992). The NWQL also analyzed the samples for nitrite plus nitrate nitrogen and total ammonia plus organic nitrogen (Fishman, 1993).

Water samples were collected monthly during 1993-94 at Broad Brook at Broad Brook using an equal-width increment method (Shelton, 1994). During this period, 30 samples were analyzed for major ions, nutrients, physical properties, and dissolved and suspended organic carbon, and three of these samples were analyzed for pesticides.

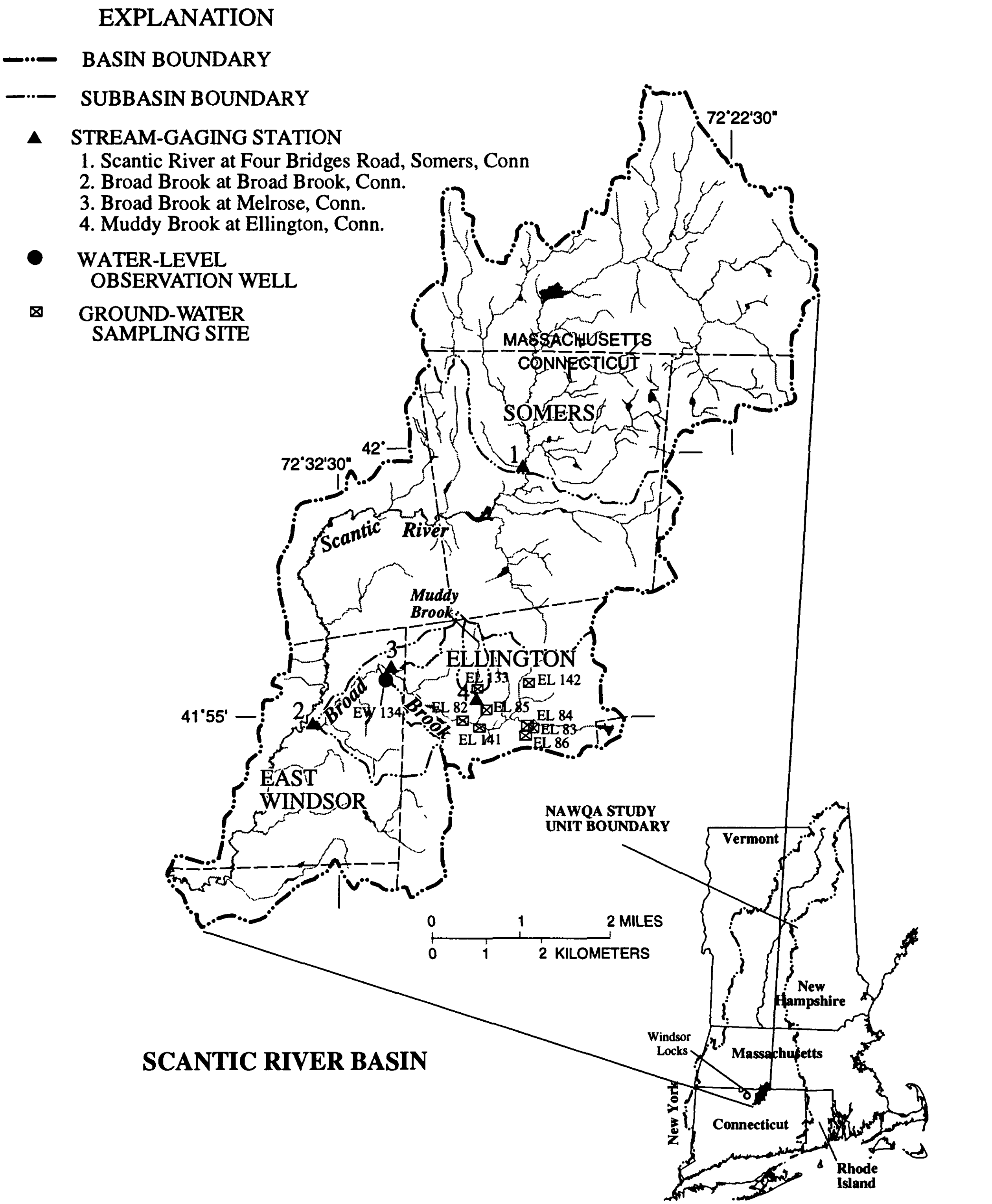

Figure 1. Locations of sampling sites in the Scantic River Basin, and location of Connecticut, Housatonic, and Thames Rivers NAWQA study area.

Table 1. Land use in four subbasins of the Scantic River, north-central Connecticut and south-central Massachusetts

[Land use determined by method described by Hitt (1994)]

Station	Drainage area (square miles)	Percentage of agricultural land	Percentage of urban land	Percentage of forest and water
Scantic River at Four Bridges Road, Somers, CT	47	16.7	13.8	69.5
Broad Brook at Broad Brook, CT	15.5	54.9	8	37.1
Broad Brook at Melrose, CT	11.6	49.6	7.1	43.3
Muddy Brook at Ellington, CT	.79	39.9	0	60.1

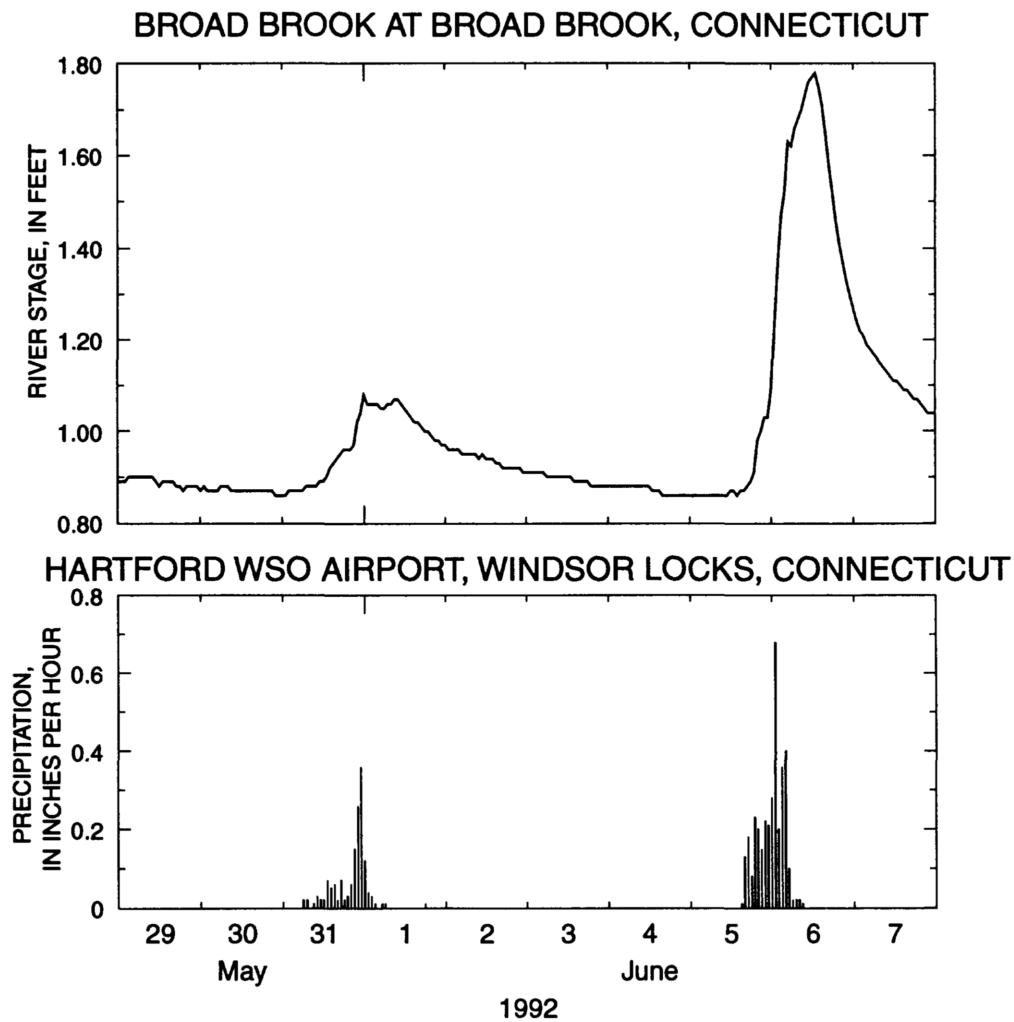

Figure 2. Gage height at the Broad Brook at Broad Brook, Connecticut, streamflow-gaging station, and precipitation at Hartford WSO airport weather station in Windsor Locks, Connecticut, during sampled storms.

Acknowledgments

We thank the officials of the towns of East Windsor and Somers for their cooperation and Dr. John Clausen, University of Connecticut, Department of Natural Resources Management and Engineering, for assisting us in sampling at the University riparian zone research site on Muddy Brook in Ellington.

NITROGEN SPECIES IN WATER IN THE SCANTIC RIVER BASIN, 1992

Nitrite Plus Nitrate Nitrogen

The concentrations of nitrite plus nitrate nitrogen decreased with increasing discharge at the three sites sampled from May 31 to June 2 (fig. 3). At Muddy Brook, concentrations decreased with increasing discharge, but the instantaneous yield increased with river discharge. At Broad Brook at Melrose, concentrations also were inversely related to river discharge, but the instantaneous yield increased only slightly [by 1.4 (kg/d)/mi^2], indicating that some nitrite plus nitrate nitrogen was derived from runoff during the early part of the storm. Data from the Scantic River were similar to that from Broad Brook—concentration decreased with river discharge, but instantaneous yield increased slightly. These data indicate that the nitrite plus nitrate concentrations were derived from surface and ground-water runoff, and that ground water contained higher concentrations than the surface runoff. In comparing the instantaneous yields, Broad Brook at Melrose had the largest overall yields per square mile, and Muddy Brook, and the Scantic River had similar yields per square mile. This is likely due to the larger percentage of agricultural land use at Broad Brook (49.6 percent) than Muddy Brook (39.9 percent) or the Scantic River (16.7 percent). The intensity of agriculture also may be greater in this subbasin.

Ground-water-quality data collected during the NAWQA program and in previous studies have detected elevated nitrite plus nitrate nitrogen concentrations beneath agricultural areas in these basins, supporting the above hypothesis that ground water is a major source of nitrate to the streams. Concentrations of nitrite plus nitrate nitrogen ranged from 1.50 to 60.0 mg/L in water samples from eight shallow wells at selected agricultural sites in the Muddy Brook and Broad Brook subbasins in 1987–88 (Grady, 1994) and 1993–94 (fig. 1, table 2).

Total Ammonia Plus Organic Nitrogen

Total ammonia plus organic nitrogen concentrations increased with river discharge at the three study sites from May 31 to June 2 (fig. 3), indicating overland runoff of chemical and organic fertilizers from treated agricultural fields as a major source. Other possible sources include precipitation and decay of natural organic matter. Highest concentrations were detected in samples collected near the peak of the intense storm of June 6, which generated substantially more overland runoff than the May 31 storm (table 3). Yield of total ammonia plus organic nitrogen also increased with river discharge at the sites. Broad Brook at Melrose had the largest yield, followed by the Scantic River and Muddy Brook, reflecting the percentage of agricultural land use (table 1).

NITROGEN DATA AT BROAD BROOK, 1993–94

Broad Brook at Broad Brook, about 2 mi downstream from the Broad Brook at Melrose site (fig. 1), was sampled at least monthly from 1993 through 1994. In addition to nitrite plus nitrate, and total ammonia plus organic nitrogen, samples were analyzed for dissolved nitrite, ammonia, and dissolved ammonia plus organic nitrogen. With these data, the concentrations and instantaneous yields of nitrate nitrogen and dissolved and suspended organic nitrogen concentrations could be calculated.

Streamflow records at Broad Brook were analyzed to test the hypotheses concerning whether storm runoff or ground-water inflow was the source of the various forms of nitrogen. Analysis of stream-discharge data using the hydrograph separation computer program "PART" (Rutledge, 1993) was helpful as a guide to determine which samples were collected during baseflow and stormflow conditions. Samples collected when at least 90 percent of the stream discharge was ground-water inflow were classified as baseflow samples (26 samples); all other samples were considered stormflow samples (4 samples).

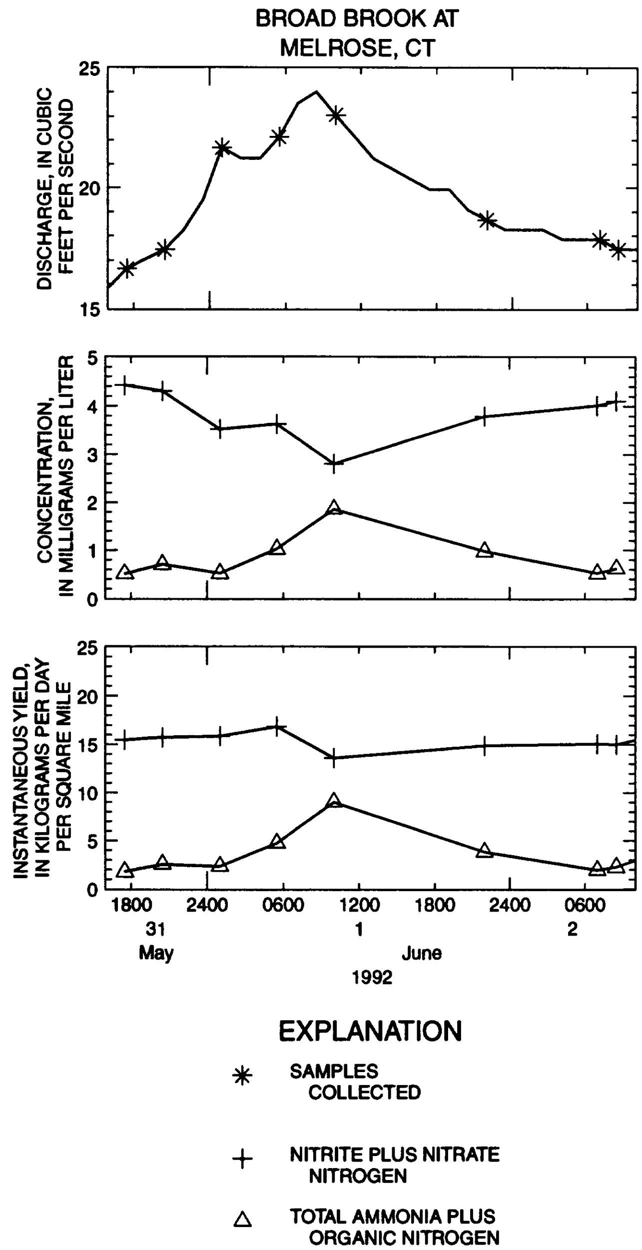

Figure 3. River discharge, and concentrations of nitrite plus nitrate and total ammonia plus organic nitrogen, and concentrations and instantaneous yields, May 31-June 2, 1992.

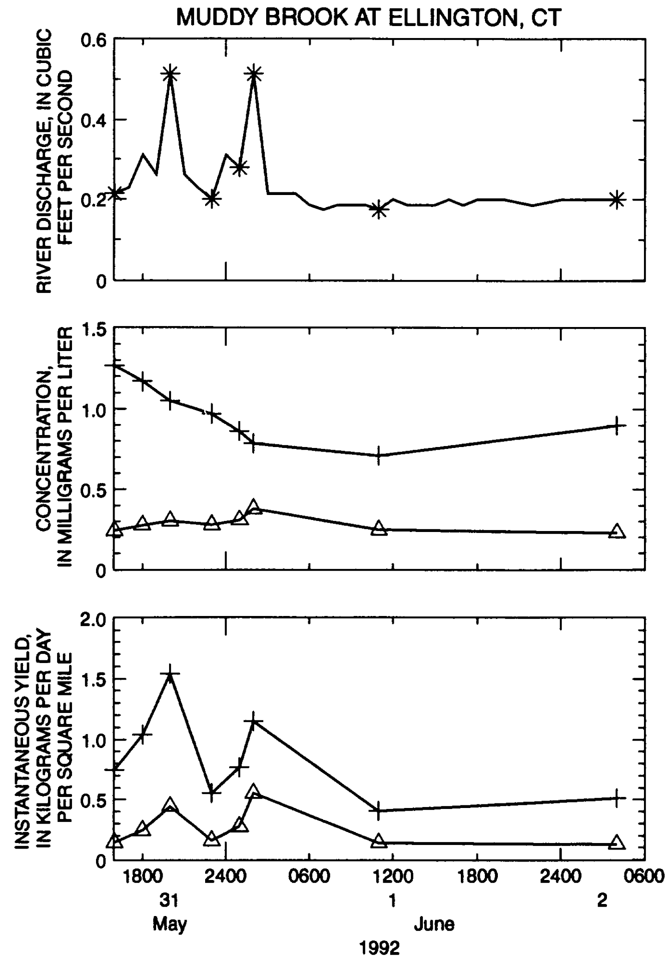

Figure 3.—*Continued.*

Nutrient and discharge data collected at Broad Brook at Broad Brook from March 1993 through September 1994 indicate relations of concentration to streamflow that are similar to those measured at the three other stations. Highest concentrations of nitrite plus nitrate nitrogen (mostly in the form of nitrate) were measured during periods of baseflow, especially at low flow (fig. 4). Although nitrate concentrations were highest during low flows, instantaneous yields of nitrate nitrogen were calculated to be to 5 to 52 (kg/d)/mi^2 and were greatest during periods of high streamflow, indicating that nitrate nitrogen could have both surface runoff and ground-water discharge components. But it is also possible that during stormflow, ground-water discharge to Broad Brook increased, accounting for the difference, or that precipitation was responsible for increased yield. Data from the USGS ground-water-level observation network show that ground-water levels at well EW 134 about 600 ft from Broad Brook were rising (indicating that ground-water recharge was occurring) during the end of March 1993 and 1994 (Davies and others, 1995).

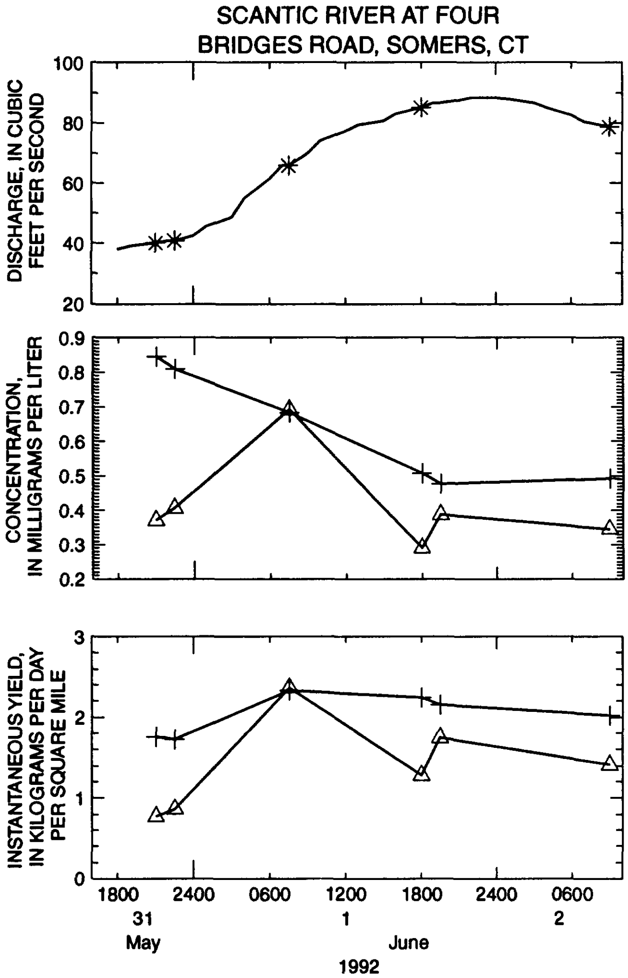

Figure 3.—*Continued.*

Table 2. Concentrations of dissolved nitrite plus nitrate, ammonia, and ammonia plus organic nitrogen in water samples from shallow wells in the Broad Brook and Muddy Brook Basins, Connecticut, 1987-88 and 1993-94

[Data from Cervione and others (1987 and 1988). <, actual value is less than value shown; na, not analyzed; mg/L, milligram per liter; N, nitrogen]

U.S. Geological Survey local well number	Date	Dissolved nitrite plus nitrate (mg/L as N)	Dissolved ammonia (mg/L as N)	Dissolved ammonia plus organic (mg/L as N)
EL 82	7-31-87	7.20	<0.01	na
	9-02-94	7.50	.02	<0.2
EL 83	7-21-87	1.50	.21	na
EL 84	7-21-87	8.00	<.01	na
EL 85	6-22-87	56.0	na	na
	7-23-87	60.0	.01	na
	8-24-87	11.0	na	na
	9-22-87	56.0	na	na
	10-19-87	54.0	na	na
	11-19-87	50.0	na	na
	2-17-88	28.0	na	na
	3-18-88	5.50	na	na
	4-26-88	33.0	na	na
	5-24-88	33.0	na	na
	6-24-88	7.20	na	na
EL 86	7-21-87	3.30	<.01	na
	8-15-88	<.10	[1].03	na
	9-02-94	3.50	<.01	<.2
EL 133	8-14-93	8.60	.03	<.2
EL 141	7-27-94	4.00	<.01	<.2
EL 142	7-27-94	12.0	.01	<.2

[1] Total.

Table 3. Concentrations of dissolved nitrogen species and herbicides in water samples from streams in three subbasins of the Scantic River, June 6, 1992

[<, actual value is less than the specified detection limit]

Station	Gage height (feet)	Concentration, in milligrams per liter		Concentration, in micrograms per liter		
		Dissolved nitrite plus nitrate nitrogen	Total ammonia plus organic nitrogen	Atrazine	Desethyl atrazine	Metolachlor
Scantic River at Four Bridges Road, Somers, CT	2.75	0.51	1.00	<0.05	<0.05	<0.05
Broad Brook at Melrose, CT	3.39	2.80	2.80	4.6	.91	.25
Muddy Brook at Ellington, CT	2.68	.34	.50	.23	.11	<.05

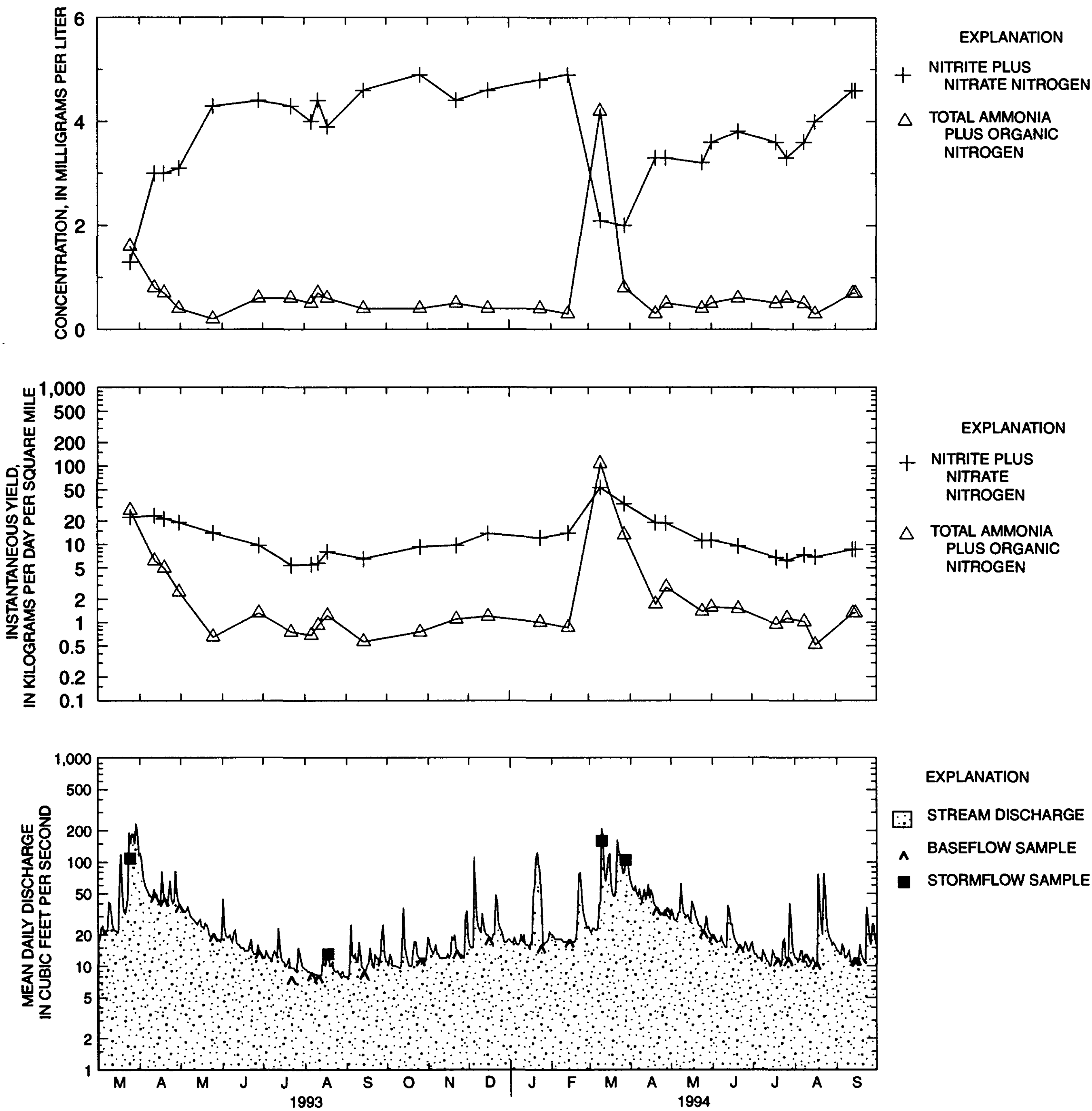

Figure 4. Stream discharge, and concentrations and instantaneous yields of nitrite plus nitrate, total ammonia plus organic nitrogen sampled at Broad Brook at Broad Brook, 1993-94.

Precipitation concentrations of nitrate measured at Muddy Brook during these storms were much lower than stormflow concentrations of nitrate at Broad Brook at Broad Brook (Dr. John Clausen, University of Connecticut, written commun., 1995). The increase in nitrate yield is likely due to a combination of the above three factors. Nitrite concentrations remained low and yields only increased slightly with flow.

Instantaneous yields of total ammonia plus organic nitrogen ranged from 0.5 to 107 (kg/d)/mi^2 and were largest during three of the four storm events that were sampled. Highest concentrations and yields of total ammonia plus organic nitrogen were measured during high streamflow resulting from precipitation and snow melt in March (fig. 4). In the early spring, rainfall and subsequent runoff from fertilizer- and(or) manure-treated fields increased the concentrations of total ammonia plus organic nitrogen for short periods. Manure application to frozen fields in the late autumn and early winter is a common practice in the Scantic River Basin. Increased concentrations of total ammonia plus organic nitrogen possibly were due to the availability of these nutrients once the snow pack had melted. These concentrations remained relatively constant on the basis of monthly samples collected during the rest of the year; however, many storm-related events were not sampled. Some percentage of this yield may be derived directly from precipitation containing ammonia and organic nitrogen, but during the three large storms sampled, where discharge was greater than 100 ft^3/s, precipitation concentrations of total ammonia plus organic nitrogen measured at Muddy Brook were lower than the concentrations measured in Broad Brook at Broad Brook (Dr. John Clausen, written commun., 1995).

If the concentration of total ammonia plus organic nitrogen is separated into its components (ammonia nitrogen and total organic nitrogen), all concentrations increased for sampled flows greater than 100 ft^3/s, indicating that surface runoff is the primary source of high concentrations of these constituents in Broad Brook (fig. 5). Therefore, total annual nitrogen yields may be greatly affected by storms. For all samples collected, nitrate represented the largest percentage of the instantaneous nitrogen yield, followed by total organic nitrogen, ammonia, and nitrite.

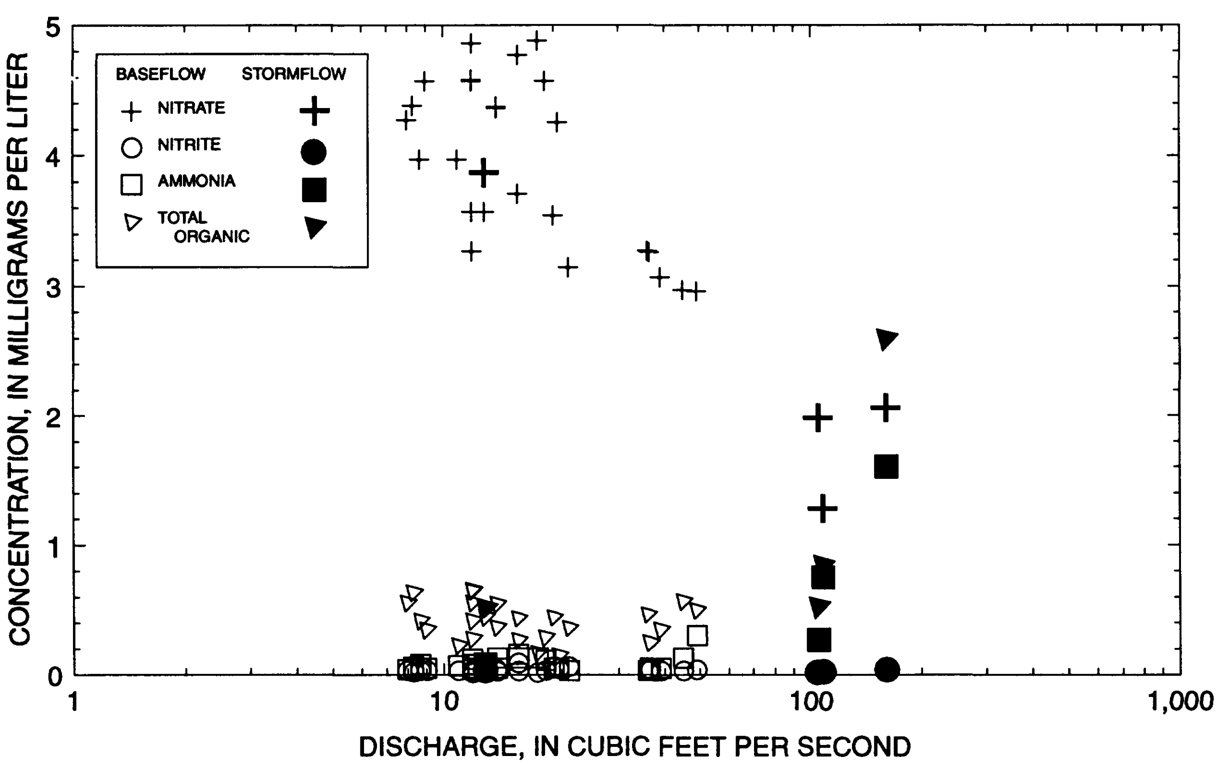

Figure 5. River discharge, type of sample and concentrations of nitrate, nitrite, ammonia, and total organic nitrogen at Broad Brook at Broad Brook, Connecticut, 1993-94.

PESTICIDES

Atrazine, desethyl atrazine (an atrazine metabolite), and metolachlor were detected in water samples collected during the May 31 storm. Fourteen of 22 samples sent to the NWQL contained detectable concentrations of atrazine; 17 samples contained detectable concentrations of desethyl atrazine; and 8 samples contained detectable concentrations of metolachlor. These compounds also were detected in some of the water samples collected during the June 6 storm.

Pesticides were detected most frequently in samples from Muddy Brook and Broad Brook at Melrose; only two samples collected at the Scantic River contained detectable concentrations. Concentrations in the Scantic River possibly were diluted by runoff from upstream forested areas. Atrazine concentrations ranged from less than 0.05 (the detection limit) to 4.6 µg/L. The sample with the highest concentration was collected at Broad Brook at Melrose during the storm of June 6, 1992; it exceeded the 3.0 µg/L MCL for atrazine in drinking water (U.S. Environmental Protection Agency, 1992). Desethyl atrazine concentrations ranged from less than 0.05 to 0.91 µg/L, and metolachlor concentrations ranged from less than 0.05 to 0.25 µg/L. Three samples collected at Broad Brook at Broad Brook during 1993-94 were analyzed for herbicides. Samples were collected at relatively low flows, but one sample was collected following a small storm on June 1, 1994. The compounds atrazine, desethyl atrazine, and metolachlor were each detected at least twice in the three samples from Broad Brook at Broad Brook (table 4).

Table 4. Pesticides detected at Broad Brook at Broad Brook, Connecticut, 1993-94

[Data from Cervione and others (1987; 1988). µg/L, microgram per liter; <, actual value is less than specified detection limit; E, estimated]

Date	Stream discharge (ft^3/s)	Atrazine (µg/L)	Desethyl atrazine (µg/L)	Metolachlor (µg/L)
6-28-93	14	<0.05	0.05	0.05
6-01-94	20	.027	<.005	.078
9-14-94	12	.054	.035E	.110

Atrazine and metolachlor concentrations increased with river discharge in water samples collected from Broad Brook at Melrose during the May 31 storm (fig. 6). At Muddy Brook, where metolachlor was detected in only one sample, atrazine concentrations increased with river discharge and concentrations of desethyl atrazine initially increased slightly, then decreased with increasing discharge. The changes in herbicide concentrations suggest that atrazine and metolachlor concentrations increased as a result of surface runoff from recently treated fields. Decreasing concentrations of desethyl atrazine with increasing discharge indicate that ground-water discharge to the streams is the primary source of this compound. Analyses of water samples from the studied basins indicate that atrazine, desethyl atrazine, and metolachlor are present in shallow ground water beneath these agricultural areas (table 5). Samples from well EL 133, only 100 ft from the Muddy Brook sampling site, had concentrations that were similar to those measured in Muddy Brook. Desethyl atrazine concentration was highest in one sample collected at Broad Brook at Melrose just before the runoff peak of the June 6 storm. This storm generated more runoff than the May 31 storm over a shorter period, and rainfall may have penetrated deeper into the soil, mobilizing desethyl atrazine metabolized from earlier atrazine applications (table 3). Yields of these compounds remained small during the May 31 storm, but were larger during the intense June 6 storm. At Broad Brook at Melrose, the instantaneous yield of atrazine, based on an estimated discharge, was calculated to be about 0.075 $(kg/d)/mi^2$, which was 90 times larger than any of the yields computed for any previous samples at any of the study sites. The information shows that large pesticide concentrations are possible during stormflow in the period following application.

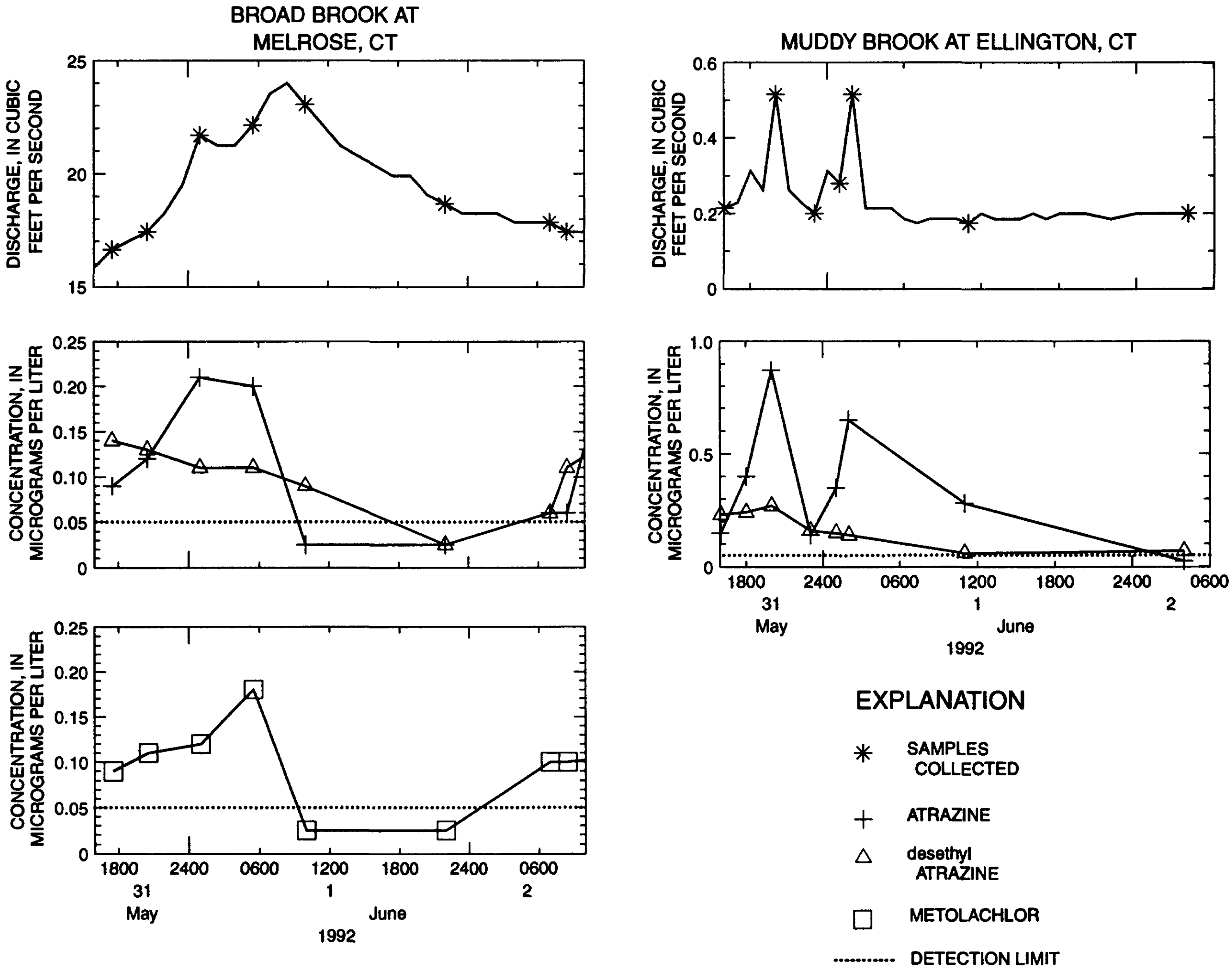

Figure 6. River discharge and herbicide concentrations at two subbasins of the Scantic River, May 31-June 2, 1992. Values less than the detection limit have been plotted halfway between zero and the detection limit.

Table 5. Detections of herbicides in shallow ground water in the Muddy Brook and Broad Brook Basins, Connecticut, 1987-88 and 1993-94

[Data from Cervione and others (1987;1988). Samples collected in 1987 were analyzed for total herbicide concentrations. Samples collected in 1993–94 analyzed for dissolved herbicide concentrations. No., number; ns, not sampled; µg/L, microgram per liter; <, actual value is less than value shown]

Well No.	Date	Atrazine (µg/L)	Desethyl atrazine (µg/L)	Metolachlor (µg/L)
EL 82	9-02-94	0.007	0.02	<0.002
EL 84	7-21-87	.10	ns	<.10
EL 85	7-23-87	.10	ns	<.10
EL 133	8-14-93	.44	.27	.006
EL 142	7-27-94	.009	.003	.003

SUMMARY AND CONCLUSIONS

Water samples collected from three streams in the Scantic River Basin, an agricultural basin in north-central Connecticut, from May 31 to June 1, 1992, were analyzed for selected nitrogen constituents and herbicides. Concentrations of nitrite plus nitrate nitrogen decreased with increasing river discharge, indicating that concentrations were higher in ground-water inflow than in surface runoff from agricultural fields. Instantaneous yields of nitrite plus nitrate nitrogen increased slightly with increasing river discharge, indicating that surface runoff and ground-water inflow are both likely sources during stormflow. Concentrations and instantaneous yields of total ammonia plus organic nitrogen increased with river discharge, indicating that concentrations were higher in surface runoff than in the ground-water inflow component of streamflow. At Broad Brook at Melrose, the instantaneous yield of nitrogen was as much as ten times higher than either Muddy Brook or the Scantic River. This is likely due to the larger percentage and intensity of agricultural land use in this subbasin.

Data collected at Broad Brook at Broad Brook during 1993-94 included analyses for a larger number of nitrogen constituents than were collected during the storms sampled in 1992. Nitrate nitrogen concentrations were related inversely to streamflow; concentrations were highest in baseflow samples and lowest in stormflow samples with flows greater than 100 ft^3/s, indicating that nitrate nitrogen is derived primarily from ground-water contributions in this basin. Elevated concentrations of nitrite plus nitrate nitrogen in water samples collected from wells at agricultural sites in the Scantic River Basin during 1987-94 support this conclusion. During stormflow, the instantaneous yield of nitrate nitrogen increased, indicating that nitrate may be derived from surface runoff as well. Ground-water discharge to Broad Brook during stormflow possibly increased, however, accounting for the difference, or elevated concentrations of nitrate in precipitation may have contributed to the increased yield. Concentrations of nitrate in precipitation measured at Muddy Brook during the sampled storms in 1993 and 1994 were much lower than those in the stream during stormflow. The increase in nitrate yield is likely due to a combination of the above three factors. Because the major source of nitrate nitrogen in the Broad Brook Basin may be ground-water inflow, and residence time in stratified-drift aquifers may be 10 years or more, any decreases in nitrate nitrogen concentrations due to changes in land use or farming practices may not become immediately evident.

Concentrations of ammonia nitrogen and suspended and dissolved organic nitrogen increased with streamflow greater than 100 ft^3/s, indicating that these constituents are likely derived from surface runoff from agricultural fields, and that storm frequency and intensity may greatly affect the total annual yield. Some proportion of this yield may be derived directly from precipitation containing ammonia and organic nitrogen. During the three large storms sampled, when stream discharge was greater than 100 ft^3/s, concentrations of total ammonia plus organic nitrogen in precipitation measured at Muddy Brook were lower than concentrations measured in Broad Brook at Broad Brook. The concentration of nitrogen constituents in precipitation may be significant during some storms.

Pesticide data collected at three stations in the Scantic River Basin during two storm events indicate that the pesticides—atrazine, desethyl atrazine, and metolachlor—were present in water samples from three subbasins draining areas with different percentages of agricultural land. Atrazine and metolachlor concentrations increased with increasing streamflow, indicating that concentrations were higher in overland runoff than in the ground-water-inflow component. Runoff from recently treated fields was the likely source of the increased concentrations. Concentrations of desethyl atrazine generally decreased with streamflow indicating that the source of this compound in these basins is ground-water inflow.

The data collected for this study help to understand the sources and timing of nitrogen and pesticide fluxes in an agricultural basin, and demonstrate that water quality can be greatly affected by spring storms. These variations in water quality may occur as a regular result of storms at different times of the year. Studies of other stormflow periods when crops are fully grown, when soil is bare in the autumn, and when snow cover is present in the winter would provide additional useful information.

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