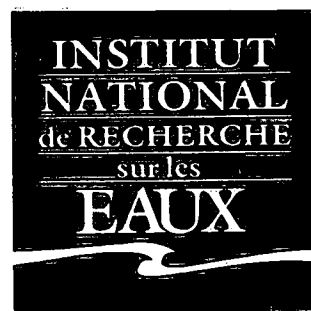
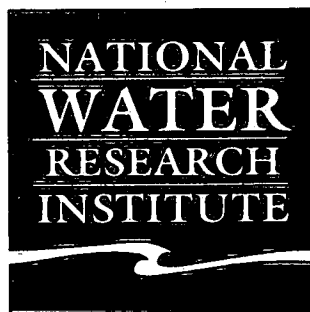
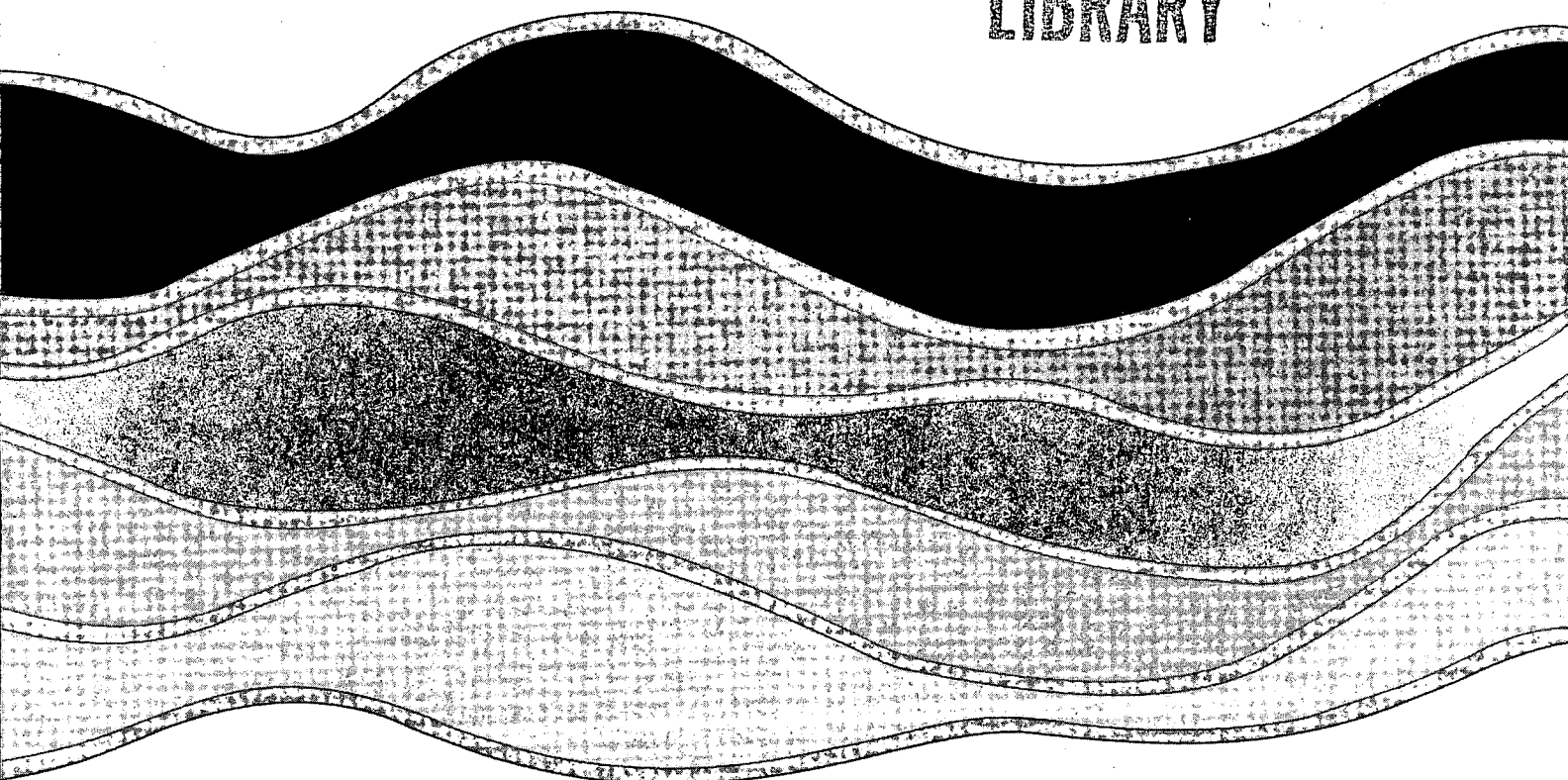


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**DISTRIBUTION OF PESTICIDES IN
STREAMS AND WETLANDS ON THE
NORTH SHORE OF LAKE ERIE**

**B.P. Bourgoïn (in memoriam), A. Mudroch and
G. Garbai**

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**DISTRIBUTION OF PESTICIDES IN STREAMS AND WETLANDS ON THE NORTH
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Introduction

Coastal wetlands on the Canadian side of Lake Erie are a unique and important ecosystem (Wormington and Fraser, 1985). There is a growing concern for the preservation of the ecosystem and its actual landscape and habitat for many plant and animal species, particularly in relation to pesticides and nutrients from intense agricultural activities. The importance of the conservation of soil, water, plants and animals, as well as the achievement of sustained, long-term agricultural production with associated income stability, need to be considered in environmental protection of the wetlands.

An estimated 21 million kg of pesticides are used annually on agricultural crops in the Great Lakes drainage basin (U.S. General Accounting Office, 1993) with herbicides representing about three-quarters of the amount. Soil erosion and unnatural, excessive sedimentation in the deltas of Lake Erie's tributaries have been observed for many years (Dickenson *et al.*, 1986; Ontario Ministry of Agriculture and Food, 1986 and 1989). However, there is insufficient information on the contamination of water and sediments by chemicals, particularly pesticides, originating from agricultural activities.

Contamination of water and sediments by metals in Lake Erie has been studied for many years (Allan and Ball, 1990; International Joint Commission, 1983, 1987; Kemp and Thomas, 1976; Mudroch,

1984). Studies of the concentrations of pesticide residues in water and suspended and bottom sediments in Lake Erie were carried out in the 1980's (Frank et al., 1981; Oliver and Bourbonniere, 1985; Strachan and Eisenreich, 1988). The studies focused on the distribution of some persistent contaminants, such as PCB, DDT, DDE, lindane and mirex, in the lake. The greatest concentrations of PCB and DDT in water (3 to 10 ppt) were found in the western-central Lake Erie (Stevens and Neilson, 1989) while mirex and lindane were detected in water and suspended sediments in the eastern part of the lake (McCrea et al., 1985). Studies by the Ontario Ministry of the Environment and Energy (Ontario Ministry of the Environment and Energy, 1992) revealed non-detectable to trace amounts of 18 pesticides and 0.02 to 0.63 ug/g PCB in sediments in Wheatley Harbour.

A cooperative multidisciplinary study has been carried out by Agriculture Canada and Department of the Environment to evaluate the distribution and transport of contaminants, particularly pesticides, from agricultural land into Lake Erie's coastal wetlands. Hydrology, chemistry, biology, geochemistry and microbiology are the disciplines involved in the study, supported by the Great Lakes Water Quality Program, Canada. The objective of the study is to determine the nature and degree of contamination of sediments and water in the wetlands; to estimate the quantity of agro-chemicals present in the watershed; and to evaluate the impact of pesticides on the wetlands. The study area

is located in Essex county of southwestern Ontario, Canada. The area was selected for its extensive agricultural land use, encompassing over 2,200 farms, and for the presence of environmentally sensitive Lake Erie coastal wetlands.

This report contains results obtained from one part of the above described multidisciplinary study, particularly the temporal and spatial distribution of pesticides in water, suspended particulate matter and bottom sediments at selected streams near Lake Erie coastal wetlands carried out by staff of the National Water Research Institute, Burlington, Ontario.

Materials and Methods

Study Area

Muddy Creek and Malden Creek are located in Essex county of southwestern Ontario, Canada (Figure 1a). It is an area of extensive agriculture activities. Malden Creek watershed, which comprises about 415 ha, is located 25 km south of Windsor, Ontario. Malden Creek joins Big Creek before entering the Big Creek Marsh. Muddy Creek, draining a 784-ha watershed, flows into Wheatley Harbour of Lake Erie, about 12 km east of Leamington, Ontario (Figures 1a and 1b). The land in both watersheds is used mainly for growing soybeans, corn, wheat and tomatoes (Ontario Ministry of Agriculture and Food, 1993). The topography of both watersheds is almost level to undulating with drainage varying from poor to imperfect depending on soil texture. Therefore a

subsurface drainage is prevalent. The natural drainage is supplemented by municipal drains, open ditches, and dredge cuts to serve as outlets for subsurface drains. Two municipal drains serve the Malden Creek watershed. Muddy Creek collects surface and drainage water from its entire watershed. During high rainfall, surface runoff occurs on the clay soils and in between row crops such as corn and tomatoes. The climate of both watersheds is classified as humid continental, with hot summers and humid winters. The mean annual precipitation is about 790 mm.

Selection of Sampling Stations

One sampling station was established in Malden Creek following a preliminary investigation of the distribution of pesticides in its watershed in 1991/92. The location of the station was selected to represent the transport of water and suspended particulate matter by the creek (Figure 1a). Five sampling stations were established in Muddy Creek. Stations 1 to 3 were located upstream of the entrance of the creek into Wheatley Harbour. Station 4 was located near the entrance of the creek into the harbour, and station 5 was near the outlet from the harbour into Lake Erie (Figure 1b). Under certain weather conditions, water from the lake enters the harbour and becomes mixed with the Muddy Creek water. The location of the sampling stations in Muddy Creek was selected to investigate the effects of Lake Erie water entering the harbour and the behaviour of pesticides, particularly on partitioning between water and

suspended particulate matter. On a few sampling dates the water level at stations 1 to 3 did not allow the collection of sufficient quantities of water and suspended particulate matter to determine all of the parameters.

Sampling and Sample Storage

Sediment sampling

Surficial sediments were collected by a mini-Ponar grab sampler at five stations in Muddy Creek and one station in Malden Creek in June 1993 (Figures 1a and 1b). Each sample was homogenized by hand mixing with a porcelain spoon in a 2-L glass container (the spoon and the container were prewashed with pesticide-grade hexane). One part of the homogenized samples was collected in a plastic bag for freeze-drying and subsequent determination of particle size distribution and sediment geochemistry. The other part was collected in glass containers, prewashed with pesticide-grade hexane and with the lid lined with prewashed aluminum foil, and stored frozen prior to the determination of pesticides. At the same sampling time, three sediment cores were collected by a modified hand-operated Kajak-Brinkhurst corer at station 3 in Muddy Creek and in Malden Creek. Retrieved sediment cores were subsampled vertically into 1-cm sections. For quantitative determination of pesticides subsections from one core were collected in glass containers prewashed with pesticide-grade hexane and with the lid lined with prewashed aluminum foil, and stored frozen prior to the analysis. Each subsection from the

second core was freeze-dried, homogenized by sieving through a 20 mesh size sieve and used in determination of particle size distribution and sediment geochemistry. Subsections from the third core were stored wet in plastic vials for sediment dating.

Water sampling

Sixty litres of water were collected at each sampling station and centrifuged by Westfahlia continuous flow centrifuge at a rate of 2 L/min. Outflowing water from the centrifuge was collected into precleaned pressurizable stainless steel beverage containers. Collected water was filtered under pressure (1 kg/cm^2) through 1.0 μm glass fibre filters at room temperature to remove all particles $>1.0 \text{ }\mu\text{m}$. The water samples were collected in November 1992, and February, April, May, the beginning and the end of June, the middle and the end of July and August, and in September and November 1993.

Suspended particulate matter sampling

At the time of collection of the water samples, additional water samples were centrifuged by the Westfahlia continuous flow centrifuge at a rate of 2 L/min to obtain about 20 to 60 g (wet weight) of suspended particulate matter. The suspended particulate matter samples were collected from the centrifuge bowl into glass jars prewashed with pesticide-grade hexane and with the lid lined with prewashed aluminum foil. All samples were stored frozen prior to the analysis.

Analytical Methods

Sediment dating

Subsections from one sediment core collected from Malden Creek and from one sediment core collected at station 3 in Muddy Creek were analyzed for polonium activity for further dating using the ^{210}Pb method (Eakins and Morrison, 1978). Details of the laboratory procedure were described by Turner (1990; 1994).

Particle size distribution

Particle size distribution in bottom sediment samples was determined by sieving and sedigraph methods described by Duncan and LaHaie (1979).

Determination of major elements in sediments

Sediment samples for the determination of the major elements (Si, Al, Ca, Mg, K, Na, P, Ti, Fe, Mn and organic C) were freeze-dried and ground prior to analysis. About 0.100 g of the sample was mixed with 0.8 g of Spectroflux 100 B (4:1 lithium meta- and tetraborate) in a graphite crucible. The mixture was fused in a furnace at 950°C for 15 to 20 minutes. The molten fusion mixture was poured and dissolved in a container with 10% HNO_3 .

Determination of the major elements, with the exception of organic C, was carried out by ICP-AES with a multi-channel Jarrell-Ash AtoComp 1100.

Total carbon was determined in all samples by a Leco Carbon

analyzer. In determination of organic carbon about 400 mg of the sediments was heated at 450°C to a constant weight (about 3 hours) to remove the organic matter, and the inorganic carbon was determined in the treated samples. The organic carbon was calculated as the difference between the total and inorganic carbon.

Analysis of water

Quantitative determination of dissolved organic carbon (DOC), Ca, Mg, alkalinity, soluble phosphorus (SP) and total phosphorus (TP) in water samples was carried out following the methods described by the National Water Research Institute (1986).

Extraction and determination of pesticides in suspended particulate matter and bottom sediment samples

Approximately 5 to 30 g of wet suspended particulate matter/surface sediment samples were extracted in Soxhlet apparatus for no less than 16 hours with 300 mL of acetone. Ten g of diatomaceous earth (CELITE 545) was placed into the fritted thimbles of the Soxhlet apparatus before the samples were added. The extracted solids were air-dried and weighed to obtain the dry weight of each sample. The extracts were concentrated to an approximate volume of 20 mL by vacuum/rotary distillation. The concentrates were then quantitatively transferred to 250 mL separatory funnels with several 5 mL acetone rinses. The acetone-water phases were then extracted with 100 mL of dichloromethane

(DCM). This volume of DCM was also used as rinses for the quantitative transfer from the round bottom distillation flask to the separatory funnel. The volume of DCM was kept in 2:1 excess of the volume of acetone to ensure efficient extraction. Prior to the acetone extraction with DCM, 10 mL of distilled water was added to enhance the water-organic interface. The organic phases (DCM/acetone) were dried, after leaving them undisturbed to turn clear (usually overnight), by vacuum filtration through 50 to 75 grams of anhydrous sodium sulphate. The separatory funnel and the water phase were rinsed with two additional 20 mL-volumes of DCM as well as thoroughly rinsing the sodium sulphate and filtering funnel. The extracts were reduced in volume to approximately 2 mL by vacuum/rotary distillation. They were then quantitatively transferred to 15 mL graduated centrifuge tubes where final volumes of 1.0 mL were obtained by means of nitrogen stream evaporation and acetone dilution. The concentrated extracts were then quantitatively analyzed for pesticide/herbicide compounds using capillary column gas chromatography with mass spectrometry and thermionic specific detection.

Extraction and determination of pesticides in water samples

Sixty litres of water were centrifuged and collected at a rate of 2 L/min in pressurizeable stainless steel "pepsi" cans. The water samples were then pressure filtered ($1 \text{ kg/cm}^2 \text{ N}_2$) through $0.45 \text{ }\mu\text{m}$ glass fibre filters at room temperature.

The extraction of the organic compounds from the water samples was performed in a Goulden continuous liquid-liquid all-glass extractor. A make-up rate of 0.5 mL/min was used to maintain the 300 mL of dichloromethane (DCM) within the extractor as the extracting solvent. The water sample flow rates were held between 150 to 175 mL/min. The extracts were then quantitatively transferred into 1 L separatory funnels. They were then dried by 50 to 75 g of anhydrous sodium sulfate using vacuum filtration, and reduced in volume to 2 mL by vacuum/rotary distillation. The concentrated extracts were then quantitatively transferred to 15 mL graduated centrifuge tubes where final volumes of 1.0 mL were obtained by nitrogen stream evaporation and acetone dilution.

The concentrated extracts were then analyzed by capillary column gas chromatography with mass spectrometry and thermionic specific detection for the trace organic contaminants of concern.

Results and Discussion

Bottom sediments and suspended particulate matter

The concentrations of major elements in surficial sediments collected at five stations in Muddy Creek are shown in Table 1. The results indicated similar geochemical composition of the sediments at the sampling stations. The sediments consisted of 4.2 to 10.5% sand, 16.8 to 38.2% silt and 57.5 to 72.7% clay. The concentrations of selected trace elements in the sediments are shown in Table 2. With the exception of Cd, the concentrations of

the trace elements were similar to the background concentrations found in the lower Great Lakes bottom sediments (Mudroch et al., 1988; Mudroch, 1993). The concentrations of major and trace elements in bottom sediments collected in Malden Creek were similar to those in Muddy Creek. The concentration profiles of major and trace elements in the sediment core collected in Muddy Creek at station 3 indicated an input of geochemically similar material over the past (Tables 3 and 4). Sediment dating by ^{210}Pb clearly showed that these sites were in areas where either very little sediment has accumulated over the past 150 years or in areas with cyclic deposition and removal of the fine-grained sediments with its subsequent transport downstream (Turner, 1994).

The concentrations of pesticides determined in sediment cores collected at these sites supported the second alternative. Only trifluarine and metolachlor were detected at relatively low concentrations (0.5 to 3.0 and 5 to 83 ng/g, respectively) in the sediment cores. The concentration of the pesticides in surficial sediments at five stations in Muddy Creek and at the station in Malden Creek are shown in Table 5. Trifluralin, atrazine and metolachlor were the only pesticides found in concentrations greater than the method detection limit in the surficial sediments in Muddy and Malden Creeks. The results indicated a limited deposition of pesticides in the bottom sediments in the creeks and suggested their transport by water and suspended

particulate matter downstream into Lake Erie.

The concentrations of suspended particulate matter in Muddy and Malden Creeks are shown in Table 6. Generally, the greatest concentrations of suspended particulate matter in the creeks occurred in June and November 1993 following the period of spring and fall rain seasons. Part of the suspended particulate matter in the creeks was most likely soil eroded from the fields. The geochemical composition of the suspended particulate matter collected from May to August 1993 at station 3 in Muddy Creek and at the sampling station in Malden Creek suggested the transport of geochemically similar material by the creeks during the sampling period (Tables 7 and 8). However, the geochemical composition of the suspended particulate matter was different from that of the bottom sediments in the creek. The differences were mainly in the concentrations of Al_2O_3 , with greater concentrations of Al_2O_3 in the suspended particulate matter than in the sediments. This probably reflected the greater concentrations of clay-size material in the suspended particulate matter than in the sediments. The clay-size material usually contains more aluminum silicates than coarser material. Further, the suspended particulate matter contained considerably smaller concentrations of CaO than the bottom sediments. This can be explained by association of calcite with the silt-size particles in Lake Erie bottom sediments (Mudroch, 1984). The results indicated that the suspended particulate matter contained

considerably greater amounts of fine-grained particles than the bottom sediments. It was impossible to determine the particle size distribution of the suspended particulate matter due to the distortion of the particles during their separation from the water by the continuous flow centrifuge. No significant changes were observed in the concentrations of Cu, Zn, Cd, Pb, Ni and Co in the suspended particulate matter at station 3 in Muddy Creek from May to August 1993. The concentrations of Cu, Pb and Co in suspended particulate matter were similar to those in the bottom sediments in Muddy Creek. However, the concentrations of Zn, Ni and Cd were greater in the suspended particulate matter than in the bottom sediments (Table 9). There is no industrial activity within Malden and Muddy Creek watersheds. However, some drains in the watershed may transport non-agricultural pollutants, such as surfactants, oil and trace elements, from truck and agricultural equipment washing areas, households, etc.

The concentrations of inorganic carbon in the suspended particulate matter were greatest at station 5 in Muddy Creek (Figure 2). Transport of carbonates containing particles by inflow of Lake Erie water was most likely responsible for greater concentrations of inorganic carbon in the suspended particulate matter at this station. The concentrations of inorganic carbon in the suspended particulate matter in Malden Creek were similar to those at stations 1 to 4 in Muddy Creek (Figure 3). The greatest concentrations of organic carbon (up to 13%) were found in the

suspended particulate matter at station 2 in Muddy Creek in August 1993 (Figure 4). Up to 13.8% organic carbon was found in the suspended particulate matter in Malden Creek at the end of July 1993 (Figure 5). The organic carbon most likely originated from phytoplankton and decomposing macrophytes abundant in the marshes during the second half of the summer.

The concentrations of pesticides in the suspended particulate matter in Muddy Creek during the 1992/93 sampling period are shown in Table 10. Trifluralin, atrazine, metolachlor, alachlor, metribuzin, cyanazine, pebulate and alpha- and beta-endosulfan were found in the suspended particulate matter collected in Muddy Creek. The concentrations of simazine, terbufos, fonofos, metribuzin, dursban, diphenamid, methidathion, fensulfothion, phosmet and cypermethrin were lower than the detection limit of the analytical method used in the quantitative determination of the pesticides (Table 10). Alachlor which was detected in the suspended particulate matter at station 4 in Muddy Creek in April (Table 10) was banned in 1989. Generally, the greatest concentrations of pesticides in the suspended particulate matter were found in samples collected at the beginning and end of June (Figures 6 to 8). The concentrations of the pesticides, particularly atrazine, metolachlor and trifluralin, were greater in the suspended particulate matter at stations 1 to 3 than at stations 4 and 5 in Muddy Creek. The latter two stations were located upstream of the bridge over Muddy Creek and at the end of

Wheatley Harbour (Figure 1b). Under certain weather conditions, Lake Erie water with suspended particulate matter enters the harbour. Therefore the lower concentrations of pesticides in the suspended particulate matter at stations 4 and 5 may be due to the dilution of Muddy Creek water and suspended material by the water and suspended particulate matter flowing into the creek from Lake Erie. This is supported by the above described observation of the distribution of inorganic carbon in suspended particulate matter at the five stations in Muddy Creek.

Only trifluralin and metolachlor were present in the suspended particulate matter collected in Malden Creek, with concentrations of trifluralin 1.7 and 2 ng/g, and metolachlor 13 and 48 ng/g in April and at the end of June, respectively.

Water

The range of concentrations of selected parameters in centrifuged water samples collected during the 1992/93 sampling period in Muddy and Malden Creeks are shown in Table 11. The concentrations of dissolved organic carbon (DOC) were greater in water at stations 1 to 3 than those at stations 4 and 5 in Muddy Creek. Generally, no distinct pattern existed in the concentrations of DOC in creek water over the sampling period at each station. The concentrations of soluble phosphorus (SP) in the creek water many times exceeded those found in Lake Erie water. Typically, the concentrations of SP in Lake Erie are about 7 ug/L (F. Rosa,

National Water Research Institute, personal communication).

Therefore the concentrations of SP in the creeks were up to two orders of magnitude greater than those in Lake Erie. High concentrations of SP in the creek water most likely originated from the application of fertilizers on the fields in the creeks watershed.

The concentrations of Ca, Mg and alkalinity (expressed as mg/L CaCO_3) in the water collected at stations 1 to 4 in Muddy Creek and at the station in Malden Creek exceeded those in Lake Erie over the sampling period (Table 11). Reported ranges of concentrations of Ca, Mg and alkalinity in the lake were 33 to 40 mg/L, 4 to 10 mg/L and 85 to 105 mg/L, respectively (Rathke and Clayton, 1985). The concentrations of the three parameters in water at station 5 were within the range of those reported for Lake Erie, and reflected the inflow of the lake water into Wheatley Harbour. High concentrations of Ca, Mg and alkalinity in the upper part of Muddy Creek and in Malden Creek most likely resulted from soil leaching and application of fertilizers in the creeks' watersheds.

The concentrations of pesticides in centrifuged water collected at five stations in Muddy and Malden Creeks are shown in Tables 12 and 13. Trifluralin, simazine, atrazine, metribuzin, metolachlor and cyanazine were present in most of the water samples collected during the 1992/93 sampling period (Figures 9

to 15). At stations 1 and 2 in Muddy Creek, the greatest concentrations of the pesticides in the water, particularly metolachlor, were found in samples collected between May and July. The greatest concentrations were observed in June and July at station 3 and in June at station 4. Generally, at station 5 the greatest concentrations of trifluralin, simazine, atrazine, metribuzin, cyanazine and metolachlor in the water occurred in November 1992. In Malden Creek, the concentrations of the pesticides in the water increased at the end of June and decreased at the end of August. However, the concentrations of metolachlor, atrazine and metribuzin increased in November (Figure 15).

The amount of atrazine, metolachlor, metribuzin and trifluralin used in the Muddy Creek watershed in 1993 and in the Malden Creek watershed in 1992 and 1993 is shown in Table 14. Metolachlor was used more extensively than the other pesticides in both watersheds. The values in Table 14 indicated that alachlor and simazine were not used in the watersheds in 1992 and 1993. However, simazine was found in the water at all sampling stations in Muddy and Malden Creeks with the greatest concentrations in June and July (Tables 12 and 13). Studies by Gamble and Khan (1990) and Gamble and Ismailly (1992) indicated binding of dissolved pesticides to soil particles and long-term diffusion from the particles into the environment. On the other hand, relatively large concentrations of simazine, i.e., up to 1,653

ng/L, in water collected in July at station 1 in Muddy Creek suggested the use of the pesticide in the creek's watershed. The values in Table 14 are based on information obtained from local farmers by personnel from Agriculture Canada. However, not all farmers submitted the information. Therefore it is possible that simazine was applied to some fields in the creek's watershed. Further, due to the similar chemical structure, the presence of simazine in technical grade atrazine may be considered as a source of simazine in the study area.

The major portion of the pesticides was transported by the creek water in both Muddy and Malden Creeks. The portion of metolachlor transported by the suspended particulate matter in Muddy Creek during the sampling period is shown in Table 15. With the exception of station 3 in May 1993, and station 5 in May and at the end of June 1993, the amount of metolachlor transported by the suspended particulate matter represented only a small fraction of the total amount of metolachlor transported by the creek water (Table 15). No relationship was observed between the concentrations of metolachlor and organic carbon in either the suspended particulate matter or in the centrifuged water. The distribution of the other investigated pesticides was similar to that of metolachlor in Muddy Creek. The results indicated that the partitioning of the pesticides between the solid and liquid phase in the creeks was not affected by association of the pesticides with organic matter.

The concentrations of some pesticides in Malden and Muddy Creeks exceeded the guidelines shown in Table 16. For example, metolachlor in centrifuged water collected at station 1 in Muddy Creek exceeded both drinking and freshwater guidelines in May 1993, and the freshwater guidelines at the beginning and the end of June 1993. At stations 2, 3 and 4 in Muddy Creek, the concentrations of metolachlor exceeded the freshwater guidelines at the beginning of June 1993. The concentrations of atrazine in centrifuged water exceeded the freshwater guidelines at stations 1 and 2 in Muddy Creek at all four sampling times in June and July 1993, and, in addition, at station 2 at the end of August 1993. The concentrations of atrazine exceeded the freshwater guidelines in centrifuged water collected at station 3 in Muddy Creek at the beginning of June and the middle of July 1993, and at station 4 at the beginning of June 1993. In Malden Creek the concentrations of atrazine in centrifuged water were greater than the freshwater guidelines at the end of June and the middle of July 1993. The concentrations of metribuzin in centrifuged water were greater than the freshwater guidelines at station 1 in Muddy Creek at the beginning and the end of June 1993, at station 2 at the end of June and the middle of July 1993, and at stations 3 and 4 at the beginning of June 1993.

Generally, the concentrations of atrazine, metolachlor and metribuzin in centrifuged water exceeded the freshwater guidelines particularly in June and July 1993 in Muddy Creek. In

Malden Creek the concentrations of atrazine exceeded the freshwater guidelines in June and July 1993. Both June and July are the months of high productivity season for macrophytes, plankton and other biota in Lake Erie's coastal marshes and nearshore zone. Although the concentrations of the pesticides in water did not exceed the freshwater guidelines during the other months, they were considerably high (Tables 12 and 13). Chronical exposure of the marsh and lake biota to these concentrations of pesticides in the water as well as the cumulative effect need to be considered in the evaluation of the impact of pesticides released from agricultural activities on Lake Erie's coastal marshes and nearshore area.

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TABLE 1

Distribution of major elements in bottom sediments at five sampling stations in Muddy Creek (in % dry weight)

Station	Element										
	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MnO	MgO	CaO	K ₂ O	Na ₂ O	P ₂ O ₅	OC*	IC**
MC1	48.11	10.81	4.23	0.05	3.14	9.85	2.23	0.66	0.20	3.27	0.82
MC2	47.13	12.26	4.71	0.05	3.24	9.67	2.18	0.54	0.20	3.32	0.64
MC3	45.72	12.69	4.84	0.06	3.05	9.51	2.29	0.59	0.30	3.74	0.51
MC4	46.33	13.07	3.93	0.06	3.35	10.19	2.22	0.65	0.20	4.11	1.04
MC5	48.81	10.89	4.25	0.07	3.46	9.53	2.08	0.63	0.20	3.43	2.13

* OC=Organic carbon

** IC =Inorganic carbon

Detection Limits: K₂O 0.05%; P₂O₅ 0.03%; OC and IC 0.01%; others 0.01%

TABLE 2 **Distribution of selected trace elements in bottom sediments at five sampling stations in Muddy Creek (in ug/g dry weight)**

Station	Element					
	Cu	Zn	Cd	Pb	Ni	Co
1	26	115	0.4	22	29	11
2	28	132	0.8	29	33	12
3	31	127	0.9	28	35	11
4	29	114	1.3	32	28	12
5	28	124	0.6	25	31	12

Detection Limits: Cd 0.2 ug/g; Pb 2 ug/g; others 1 ug/g

TABLE 3

Concentration profiles of major elements in bottom sediment core collected at station MC3 (in % dry weight)

Depth cm	Element					
	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MnO	MgO
0-1	57.03	0.76	14.33	4.97	0.05	1.75
1-2	57.44	0.77	14.16	4.86	0.04	1.72
2-3	56.90	0.75	13.99	4.74	0.04	1.68
3-4	57.58	0.73	13.82	4.64	0.04	1.64
4-5	58.02	0.75	13.99	4.85	0.04	1.77
5-6	58.66	0.75	14.24	4.95	0.04	1.79
6-7	60.03	0.70	13.61	4.38	0.04	1.56
7-8	58.59	0.72	13.55	4.47	0.04	1.58
8-9	59.09	0.72	13.72	4.52	0.04	1.60
9-10	59.88	0.75	13.99	4.65	0.04	1.64
10-11	59.24	0.72	13.84	4.50	0.04	1.58
11-12	59.77	0.72	13.62	4.52	0.04	1.60
12-13	59.24	0.73	13.42	4.45	0.04	1.56
13-14	59.70	0.73	13.60	4.50	0.04	1.58
14-15	60.00	0.74	13.69	4.51	0.04	1.60
15-16	59.30	0.72	13.41	4.41	0.04	1.56
16-17	58.11	0.72	13.62	4.48	0.04	1.61
17-18	57.95	0.71	14.37	4.71	0.04	1.71
18-19	55.40	0.71	14.73	4.76	0.03	1.64
19-20	55.09	0.73	14.89	4.84	0.03	1.65
20-21	54.40	0.74	14.86	4.95	0.04	1.65
21-22	55.07	0.76	15.33	5.10	0.04	1.71
22-23	54.18	0.74	15.22	5.06	0.04	1.68
23-24	53.64	0.72	15.08	5.03	0.04	1.66
24-25	53.90	0.75	15.27	5.47	0.04	1.72

TABLE 3

(continued)

Depth cm	Element						
	CaO	Na2O	K2O	P2O5	LQI	OC*	IC**
0-1	1.72	0.66	2.97	0.42	13.94	2.38	0.69
1-2	1.70	0.63	2.98	0.44	14.08	2.16	0.63
2-3	1.61	0.68	2.99	0.39	14.19	3.09	0.65
3-4	1.61	0.64	2.95	0.36	13.94	2.64	0.65
4-5	1.67	0.66	2.93	0.34	14.26	2.84	0.62
5-6	1.66	0.64	2.95	0.37	14.05	2.74	0.67
6-7	1.66	0.74	2.86	0.32	13.16	2.19	0.68
7-8	1.63	0.84	2.96	0.32	13.44	2.42	0.68
8-9	1.70	0.73	2.96	0.35	13.18	2.29	0.61
9-10	1.67	0.75	2.90	0.30	13.15	2.14	0.69
10-11	1.63	0.67	2.83	0.36	13.30	2.62	0.55
11-12	1.72	0.73	2.82	0.36	13.22	2.53	0.74
12-13	1.68	0.75	2.73	0.35	13.27	2.22	0.74
13-14	1.71	0.74	2.74	0.38	13.06	1.87	0.58
14-15	1.68	0.84	2.78	0.33	13.16	2.31	0.64
15-16	1.67	0.75	2.72	0.34	13.16	2.34	0.66
16-17	2.07	0.67	2.81	0.36	13.70	2.40	0.73
17-18	2.00	0.62	2.82	0.39	15.07	2.25	0.94
18-19	1.43	0.48	2.97	0.45	16.00	2.31	0.82
19-20	1.29	0.45	2.99	0.35	16.06	1.95	0.84
20-21	1.55	0.41	3.01	0.67	16.49	2.20	0.56
21-22	1.28	0.43	3.06	0.43	16.58	1.74	0.72
22-23	1.30	0.48	3.08	0.45	16.97	2.05	0.96
23-24	1.23	0.44	3.08	0.45	16.87	2.36	0.67
24-25	1.26	0.44	3.14	0.66	16.40	2.93	0.70

* OC=Organic carbon

** IC =Inorganic carbon

Detection Limits: K2O 0.05%; P2O5 0.03%; OC and IC 0.01%; others 0.01%

TABLE 4 Concentration profiles of selected trace elements in bottom sediment core collected at station MC3 (in ug/g dry weight)

Depth cm	Element					
	Co	Ni	Cu	Zn	Cd	Pb
0-1	11	36	30	139	1.3	19
1-2	11	35	31	140	1.0	19
2-3	11	35	32	141	1.7	18
3-4	11	36	32	139	0.9	19
4-5	11	36	32	140	0.9	20
5-6	11	36	32	139	1.2	20
6-7	11	35	31	132	1.6	21
7-8	11	35	31	132	1.2	21
8-9	10	34	29	129	1.2	19
9-10	11	37	31	136	0.9	19
10-11	10	34	30	129	1.2	19
11-12	10	35	30	128	1.4	19
12-13	10	33	31	130	0.9	18
13-14	11	35	31	134	1.1	19
14-15	11	34	32	131	1.2	19
15-16	11	35	31	135	1.6	19
16-17	11	37	32	139	1.6	22
17-18	12	40	35	152	1.0	22
18-19	12	39	35	153	1.2	25
19-20	11	40	34	144	1.7	24
20-21	12	40	34	156	1.4	24
21-22	12	40	34	160	0.7	23
22-23	12	41	35	160	1.0	23
23-24	12	40	36	170	1.6	23
24-25	12	42	36	200	1.4	26

Detection Limits: Cd 0.2 ug/g; Pb 2 ug/g; others 1 ug/g

TABLE 5

Pesticides in surficial sediment samples (in ng/g dry weight)

PESTICIDE	Muddy Creek Station No.					Malden Creek
	1	2	3	4	5	
TRIFLURALIN	22.0	5.0	2.0	<MDL*	2.0	0.7
ATRAZINE	103	119	64	14	<MDL	79
METOLACHLOR	157	132	61	21	38	136

* <MDL=Less than method detection limit (0.5 ng/g for trifluralin; 1 ng/g for all other pesticides)

TABLE 6

Concentrations of suspended particulate matter
in creeks in (in mg/L dry weight)

Date	Station					
	MC #1	MC #2	MC #3	MC #4	MC #5	MALDEN CREEK
November 92	N.S.*	31.2	N.S.	82.5	77.1	42.3
February 93	9.3	5.7	8.4	34	22	17
April 93	126	92	N.S.	80	35	62
May 93	137	29	139	68	34	196
8-June-93	110	127	305	347	29	214
26-June-93	506	671	229	92	20	178
13-July-93	63	42	166	83	28	66
27-July-93	N.S.	N.S.	156	68	24	94
10-Aug-93	N.S.	118	188	90	26	92
31-Aug-93	N.S.	163	155	47	27	114
September 93	N.S.	32	N.S.	101	24	91
November 93	881	46	89	190	102	74

*N.S. = No sample available

MC#1=Muddy Creek station 1

TABLE 7

Distribution of major elements in suspended particulate matter
in Muddy Creek May to August, 1993 (in % dry weight)

Sampling Date	Element											
	SiO ₂	TiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MnO	MgO	CaO	K ₂ O	Na ₂ O	P ₂ O ₅	OC*	IC**
27-May-93	48.98	0.72	18.21	6.73	0.05	2.20	1.27	3.80	0.31	0.35	2.94	0.58
8-June-93	51.60	0.78	18.77	6.69	0.04	2.16	1.27	3.77	0.35	0.32	3.80	1.05
29-June-93	55.65	0.88	17.00	6.15	0.04	1.98	1.24	3.56	0.46	0.31	2.32	0.55
13-July-93	53.94	0.83	14.55	5.21	0.06	1.75	1.28	3.11	0.54	0.37	3.55	0.61
27-July-93	51.28	0.75	13.86	5.00	0.09	1.70	1.28	3.01	0.46	0.55	5.33	0.57
10-Aug-93	51.40	0.78	15.33	5.51	0.10	1.87	1.15	3.27	0.36	0.59	3.85	0.18
31-Aug-93	49.03	0.75	16.87	6.11	0.09	2.07	1.07	3.59	0.38	0.60	2.93	0.82

* OC=Organic carbon

** IC=Inorganic carbon

Detection Limits: K₂O 0.05%; P₂O₅ 0.03%; OC and IC 0.01%; others 0.01%

TABLE 8

Distribution of major elements in suspended particulate matter
in Malden Creek April to August, 1993 (in % dry weight)

Sampling Date	Element											
	SiO2	TiO2	Al2O3	Fe2O3	MnO	MgO	CaO	K2O	Na2O	P2O5	OC*	IC**
25-May-93	51.19	0.74	12.90	5.06	0.09	1.73	3.55	2.72	0.52	0.49	3.54	1.17
30-June-93	53.64	0.85	17.77	7.11	0.05	2.06	1.62	3.55	0.29	0.23	2.17	0.90
15-July-93	49.19	0.75	15.59	6.33	0.07	1.96	2.52	3.24	0.41	0.50	1.75	1.28
30-Aug-93	47.14	0.70	15.23	6.92	0.12	1.93	2.28	3.12	0.38	0.58	5.56	0.88
19-Apr-93	55.95	0.81	14.31	5.44	0.05	1.91	4.08	2.87	0.48	0.18	1.20	1.08
26-July-93	40.95	0.61	10.82	4.30	0.14	1.44	2.59	2.39	0.33	0.68	14.55	0.57
7-June-93	49.64	0.72	14.41	5.98	0.07	1.91	3.61	3.06	0.36	0.47	3.01	0.95

* OC=Organic carbon

** IC = Inorganic carbon

Detection Limits: K₂O 0.05%; P₂O₅ 0.03%; OC and IC 0.01%; others 0.01%

TABLE 9 Distribution of selected trace elements in suspended particulate matter
in Muddy Creek May to August, 1993 (in ug/g dry weight)

Sampling Date	Element					
	Cu	Zn	Cd	Pb	Ni	Co
27-May-93	30	192	1.2	25	52	15
8-June-93	36	198	2.1	25	55	14
29-June-93	28	172	0.8	24	47	14
13-July-93	25	152	0.7	16	39	12
27-July-93	26	151	1.4	14	41	12
10-Aug-93	28	169	1.1	20	44	13
31-Aug-93	29	182	0.9	23	48	14

Detection Limits: Cd 0.2 ug/g; Pb 2 ug/g; others 1 ug/g

TABLE 10

Concentrations of pesticides in suspended particulate matter in Muddy Creek during 1992-93 sampling period (in ng/g dry weight)

COMPOUND	DATE								
	APRIL	MAY	JUNE 8	JUNE 28	JULY 12	JULY 28	AUGUST	SEPT	NOV
STATION 1									
TRIFLURALIN	1.3	1.4	5	8.4	3.4	N.S.**	N.S.	N.S.	3.3
ATRAZINE	50	8	20	113	<MDL*	N.S.	N.S.	N.S.	9
METOLACHLOR	91	196	112	247	103	N.S.	N.S.	N.S.	29
CYANAZINE	<MDL	26	<MDL	<MDL	<MDL	N.S.	N.S.	N.S.	<MDL
ALPHA-ENDOSULFAN	<MDL	<MDL	<MDL	10	MDL	N.S.	N.S.	N.S.	<MDL
BETA-ENDOSULFAN	<MDL	<MDL	<MDL	7	MDL	N.S.	N.S.	N.S.	<MDL
STATION 2									
TRIFLURALIN	3	N.S.	11	40	2.4	N.S.	N.S.	<MDL	N.S.
ATRAZINE	<MDL	N.S.	44	223	24	N.S.	N.S.	<MDL	N.S.
METOLACHLOR	53	N.S.	216	519	66	N.S.	N.S.	14	N.S.
ALPHA-ENDOSULFAN	<MDL	N.S.	<MDL	31	<MDL	N.S.	N.S.	<MDL	N.S.
BETA-ENDOSULFAN	<MDL	N.S.	<MDL	42	<MDL	N.S.	N.S.	<MDL	N.S.
STATION 3									
TRIFLURALIN	N.S.	0.8	0.9	11.3	N.S.	N.S.	N.S.	N.S.	N.S.
ATRAZINE	N.S.	<MDL	<MDL	112	N.S.	N.S.	N.S.	N.S.	N.S.
METOLACHLOR	N.S.	<MDL	361	173	N.S.	N.S.	N.S.	N.S.	N.S.
STATION 4									
PEBULAT	<MDL	N.S.	<MDL	<MDL	<MDL	N.S.	<MDL	N.S.	<MDL
TRIFLURALIN	3	N.S.	10	6	2	N.S.	1	N.S.	1
ATRAZINE	<MDL	N.S.	27	24	<MDL	N.S.	<MDL	N.S.	<MDL
ALACHLOR	25	N.S.	<MDL	<MDL	<MDL	N.S.	<MDL	N.S.	<MDL
METOLACHLOR	<MDL	N.S.	111	46	17	N.S.	<MDL	N.S.	<MDL
STATION 5									
TRIFLURALIN	1.1	2.2	0.7	4	1.4	<MDL	1	N.S.	1
ATRAZINE	<MDL	<MDL	<MDL	11	<MDL	<MDL	<MDL	N.S.	<MDL
METRIBUZIN	<MDL	<MDL	<MDL	<MDL	<MDL	196	135	N.S.	<MDL
METOLACHLOR	14	81	17	30	13	13	9	N.S.	<MDL

* MDL=Method detection limit (approximately 5 ng/g; trifluralin 0.5 ng/g)

** N.S.=No sample available

TABLE 11 Range of selected parameters in water samples in Muddy and Malden Creeks during sampling period (in mg/L)

Muddy Creek Station 1 Sampling date	Element					
	DOC	alk	Ca	Mg	SP	TP
November 92	N.S.*	N.S.	N.S.	N.S.	N.S.	N.S.
February 93	2.0	185.0	109.0	27.2	N.S.	N.S.
April 93	3.4	156.0	73.5	17.3	0.030	0.238
May 93	8.3	208.0	103.0	25.7	0.022	0.156
8-June-93	11.8	86.5	67.6	14.6	0.098	0.252
28-June-93	9.2	75.5	57.7	12.0	0.143	0.831
13-July-93	7.1	242.0	114.0	25.8	0.168	0.205
27-July-93	9.1	260.0	138.0	38.5	0.057	0.210
9-Aug-93	9.9	280.0	185.0	46.7	N.S.	0.143
30-Aug-93	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
September 93	8.5	117.0	101.0	24.3	0.056	0.528
November 93	N.S.	245.0	174.0	34.0	0.035	0.283

DOC = Dissolved organic carbon

alk = Alkalinity

SP = Soluble phosphorus

TP = Total phosphorus

*N.S.=No sample available

TABLE 11 (continued)

Muddy Creek Station 2 Sampling date	Element					
	DOC	alk	Ca	Mg	SP	TP
November 92	N.S.*	227.0	92.5	20.5	N.S.	0.086
February 93	3.4	228.0	111.0	26.3	N.S.	N.S.
April 93	7.1	150.0	67.7	14.9	0.040	0.183
May 93	12.5	212.0	89.1	22.3	0.368	0.502
8-June-93	10.2	83.0	61.4	12.0	0.094	0.262
28-June-93	8.1	96.1	59.5	12.2	0.124	0.852
13-July-93	6.3	181.0	80.3	16.5	0.222	0.289
27-July-93	14.1	271.0	89.5	21.3	0.424	0.664
9-Aug-93	17.1	264.0	68.1	20.5	0.194	0.277
30-Aug-93	19.9	310.0	76.6	19.5	N.S.	0.989
September 93	9.5	160.0	74.4	11.9	0.187	0.278
November 93	N.S.	218.0	88.7	17.4	0.635	0.773

DOC=Disolved organic carbon

alk =Alkalinity

SP =Soluble phosphorus

TP =Total phosphorus

*N.S.=No sample available

TABLE 11 (continued)

Muddy Creek Station 3 Sampling date	Element					
	DOC	alk	Ca	Mg	SP	TP
November 92	17.8	N.S.*	N.S.	N.S.	N.S.	N.S.
February 93	5.5	174.0	80.9	19.9	N.S.	N.S.
April 93	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
May 93	68.8	168.0	66.5	15.4	0.021	0.378
8-June-93	9.2	75.6	52.9	10.1	0.079	0.504
28-June-93	8.3	124.0	124.0	12.9	0.058	0.384
13-July-93	8.7	133.0	55.4	10.8	0.084	0.137
27-July-93	11.5	179.0	59.7	12.1	0.082	0.333
9-Aug-93	10.4	152.0	50.9	10.5	0.143	0.227
30-Aug-93	12.0	186.0	58.6	12.6	0.166	0.431
September 93	6.8	161.0	52.3	11.2	0.281	0.050
November 93	6.0	208.0	53.4	11.9	0.082	0.402

DOC=Disolved organic carbon

alk =Alkalinity

SP =Soluble phosphorus

TP =Total phosphorus

*N.S.=No sample available

TABLE 11 (continued)

Muddy Creek Station 4 Sampling date	Element					
	DOC	alk	Ca	Mg	SP	TP
November 92	4.0	153.0	49.5	10.3	N.S.*	0.119
February 93	5.7	11.0	40.0	9.9	N.S.	N.S.
April 93	7.3	131.0	51.9	12.0	0.091	0.336
May 93	4.8	112.0	45.6	9.7	0.054	0.245
8-June-93	7.2	78.4	44.6	8.6	0.049	0.422
28-June-93	4.3	94.0	94.0	9.0	0.037	0.222
13-July-93	4.1	106.0	38.2	8.8	0.057	0.149
27-July-93	4.3	108.0	36.9	8.7	0.072	0.246
9-Aug-93	4.1	93.9	33.0	8.7	0.314	0.316
30-Aug-93	3.7	108.0	38.1	9.3	0.161	0.292
September 93	4.9	130.0	44.2	9.5	0.039	0.203
November 93	N.S.	146.0	35.7	8.7	0.049	0.087

DOC=Disolved organic carbon

alk =Alkalinity

SP =Soluble phosphorus

TP =Total phosphorus

*N.S.=No sample available

TABLE 11 (continued)

Muddy Creek Station 5 Sampling date	Element					
	DOC	alk	Ca	Mg	SP	TP
November 92	12.7	94.5	32.6	8.4	N.S.*	0.043
February 93	3.5	93.0	35.5	9.1	N.S.	N.S.
April 93	6.1	94.6	31.8	8.5	0.033	0.027
May 93	4.7	89.1	32.5	8.5	0.013	0.037
8-June-93	4.0	86.1	32.2	8.4	0.011	0.038
28-June-93	3.3	82.4	30.9	8.2	0.018	0.016
13-July-93	2.1	87.7	31.3	8.3	0.011	0.015
27-July-93	2.4	92.8	32.8	8.3	0.023	0.060
9-Aug-93	2.6	87.5	32.6	8.3	0.018	0.027
30-Aug-93	2.4	91.0	32.1	8.5	0.020	0.040
September 93	3.1	90.3	31.9	8.5	0.009	0.033
November 93	N.S.	101.0	31.9	8.4	0.027	0.020

DOC=Disolved organic carbon

alk =Alkalinity

SP =Soluble phosphorus

TP =Total phosphorus

*N.S.=No sample available

TABLE 11 (continued)

Malden Creek	Element					
Sampling date	DOC	alk	Ca	Mg	SP	TP
November 92	N.S.*	238.0	115.0	21.6	N.S.	0.067
February 93	3.0	249.0	109.0	25.3	N.S.	N.S.
April 93	3.6	212.0	94.6	23.0	0.021	0.094
May 93	8.1	216.0	96.0	25.6	0.026	0.212
8-June-93	9.2	N.S.	N.S.	N.S.	N.S.	0.493
28-June-93	5.9	180.0	78.9	17.0	0.022	0.167
13-July-93	6.2	193.0	77.9	18.5	0.022	0.041
27-July-93	8.2	210.0	76.8	21.4	0.036	0.195
9-Aug-93	10.3	218.0	75.9	21.9	N.S.	0.079
30-Aug-93	12.3	236.0	81.9	24.5	0.032	0.078
September 93	10.6	182.0	72.8	22.5	0.023	0.327
November 93	N.S.	200.0	85.0	26.2	0.020	0.014

DOC = Dissolved organic carbon

alk = Alkalinity

SP = Soluble phosphorus

TP = Total phosphorus

*N.S.=No sample available

TABLE 12

Concentrations of pesticides in centrifuged water from Muddy Creek
during 1992-93 sampling period (in ng/L)

COMPOUND	DATE											
	11/92	02/93	04/93	05/93	06/08/93	06/29/93	07/13/93	07/27/93	08/10/93	08/31/93	09/93	11/93
STATION 1												
TRIFLURALIN	N.S.*	0.20	2.00	0.55	3.00	5.00	3.00	0.10	N.S.	N.S.	<MDL	<MDL
SIMAZINE	N.S.	<MDL**	<MDL	<MDL	664	1450	1653	106	N.S.	N.S.	38	42
ATRAZINE	N.S.	92	811	489	5655	39538	9744	3784	N.S.	N.S.	198	204
METRIBUZIN	N.S.	35	<MDL	<MDL	1460	13114	<MDL	484	N.S.	N.S.	646	11
METOLACHLOR	N.S.	125	1397	80314	21647	25042	1568	3888	N.S.	N.S.	733	360
CYANAZINE	N.S.	<MDL	<MDL	<MDL	295	183	104	42	N.S.	N.S.	<MDL	16
STATION 2												
TRIFLURALIN	0.40	0.40	1.20	0.30	2.00	0.60	0.60	<MDL	<MDL	<MDL	<MDL	0.40
SIMAZINE	<MDL	<MDL	4	17	300	1041	69	1226	105	363	4	<MDL
ATRAZINE	208	174	492	402	3421	7495	3173	3882	973	3364	67	297
METRIBUZIN	58	25	<MDL	391	<MDL	1906	1634	468	73	<MDL	11	<MDL
METOLACHLOR	201	201	852	5534	20650	7073	5049	2894	436	1063	69	693
CYANAZINE	<MDL	<MDL	7	392	4275	125	117	302	57	263	<MDL	<MDL

* N.S. = No sample available

** <MDL = Less than method detection limit (0.01 ng/L for trifluralin; 1 ng/L for all other pesticides)

TABLE 12 (continued)

COMPOUND	DATE											
	11/92	02/93	04/93	05/93	06/08/93	06/29/93	07/13/93	07/27/93	08/10/93	08/31/93	10/93	11/93
STATION 3												
TRIFLURALIN	N.S.	0.09	N.S.	<MDL	1.20	<MDL	0.10	<MDL	<MDL	<MDL	0.57	0.10
SIMAZINE	N.S.	<MDL	N.S.	4	484	127	63	47	13	<MDL	45	<MDL
ATRAZINE	N.S.	87	N.S.	165	4295	680	2389	1401	287	208	162	103
METRIBUZIN	N.S.	30	N.S.	35	5993	15	632	96	10	<MDL	10	<MDL
METOLACHLOR	N.S.	212	N.S.	743	25988	249	2740	673	118	3910	61	51
CYANAZINE	N.S.	<MDL	N.S.	24	2980	24	286	115	22	31	<MDL	<MDL
STATION 4												
TRIFLURALIN	0.07	0.30	0.10	<MDL	0.80	0.07	0.10	<MDL	0.08	<MDL	<MDL	<MDL
SIMAZINE	34	<MDL	4	4	238	48	15	6	6	6	115	14
ATRAZINE	174	129	139	86	3675	1838	345	153	102	108	247	139
METRIBUZIN	28	<MDL	<MDL	4	3516	112	15	<MDL	<MDL	<MDL	<MDL	<MDL
METOLACHLOR	225	148	169	179	17474	1046	231	106	49	55	99	57
CYANAZINE	<MDL	<MDL	9	18	1931	31	19	18	21	55	<MDL	215
STATION 5												
TRIFLURALIN	0.31	0.05	<MDL	0.09	0.08	0.09	0.08	<MDL	0.04	<MDL	<MDL	0.40
SIMAZINE	41	<MDL	<MDL	3	7	11	4	4	6	5	18	14
ATRAZINE	1439	68	57	57	102	674	116	77	120	88	188	162
METRIBUZIN	213	<MDL	<MDL	<MDL	<MDL	21	4	<MDL	<MDL	<MDL	<MDL	<MDL
METOLACHLOR	1408	40	77	18	45	283	125	62	58	43	65	62
CYANAZINE	<MDL	<MDL	14	12	13	20	14	17	38	49	76	415

N.S. = No sample available

**<MDL = Less than method detection limit (0.01 ng/L for trifluralin; 1 ng/L for all other pesticides)

TABLE 13

Concentrations of pesticides in centrifuged water from Malden Creek
during 1992-93 sampling period (in ng/L)

COMPOUND	DATE											
	10/18/92	02/11/93	04/19/93	05/25/93	06/07/93	06/30/93	07/15/93	07/26/93	08/11/93	08/30/93	09/27/93	11/02/93
TRIFLURALIN	0.07	1.20	1.20	0.05	<MDL*	3.00	0.30	0.10	<MDL	<MDL	<MDL	0.30
SIMAZINE	9	<MDL	5	9	9	97	75	26	86	3	7	12
ATRAZINE	144	250	189	170	171	4366	3057	1019	603	42	275	460
METRIBUZIN	<MDL	13	<MDL	6	<MDL	927	437	33	<MDL	<MDL	<MDL	238
METOLACHLOR	125	168	142	87	63	5537	5322	902	190	7	52	705
CYANAZINE	<MDL	<MDL	3	23	13	304	330	115	44	<MDL	30	<MDL

* <MDL = Less than method detection limit (0.01 ng/L for trifluralin; 1 ng/L for all other pesticides)

TABLE 14 Application of atrazine, metolachlor, metribuzin and trifluralin in the Malden and Muddy Creek watersheds (Modified from Millete et al., 1994)

Pesticide	Amount Applied in Watershed					
	Malden Creek				Muddy Creek	
	1992		1993		1993	
	ha	kg	ha	kg	ha	kg
Atrazine	55.5	61.1	44.5	44.2	100.8	100.8
Metolachlor	167.3	319.8	162.7	312.4	192.7	370.0
Metribuzin	177.0	67.2	139.4	52.9	28.2	10.7
Trifluralin	57.8	34.6	5.9	3.5	0	0

TABLE 15 **Metolachlor in SPM in 1 m3 of Muddy Creek water**
(as % of total metolachlor in 1 m3 of raw water)

Date	Station				
	1	2	3	4	5
November 92	N.S.*	NIL**	N.S.	1.80	0.14
April 93	0.84	0.58	N.S.	1.16	0.64
May 93	0.04	NIL	NIL	NIL	15.00
8-June-93	0.06	0.13	0.43	0.22	1.11
26-June-93	0.52	4.71	13.79	0.38	66.70
13-July-93	0.44	0.06	NIL	0.60	0.32
27-July-93	NIL	NIL	NIL	NIL	0.50
10-Aug-93	NIL	NIL	NIL	NIL	0.36
31-Aug-93	NIL	NIL	NIL	NIL	NIL
September 93	NIL	0.72	NIL	NIL	NIL
November 93	6.40	NIL	NIL	NIL	NIL

* N.S.=No sample available

** NIL=Concentrations in SPM below detection limit

TABLE 16 Guidelines for concentrations of pesticides
in drinking and fresh water*

Pesticide	Drinking water ng/L	Fresh water ng/L
Atrazine	60,000	2,000
Cyanazine	10,000	2,000
Metolachlor	50,000	8,000
Metribuzin	80,000	1,000
Simazine	10,000	10,000
Trifluralin	45,000	100

* Guidelines obtained from Canadian Water Quality Guidelines, Task Force on Water Quality Guidelines, Canadian Council of Resource and Environment Ministers, 1987 and updates.

STUDY AREAS

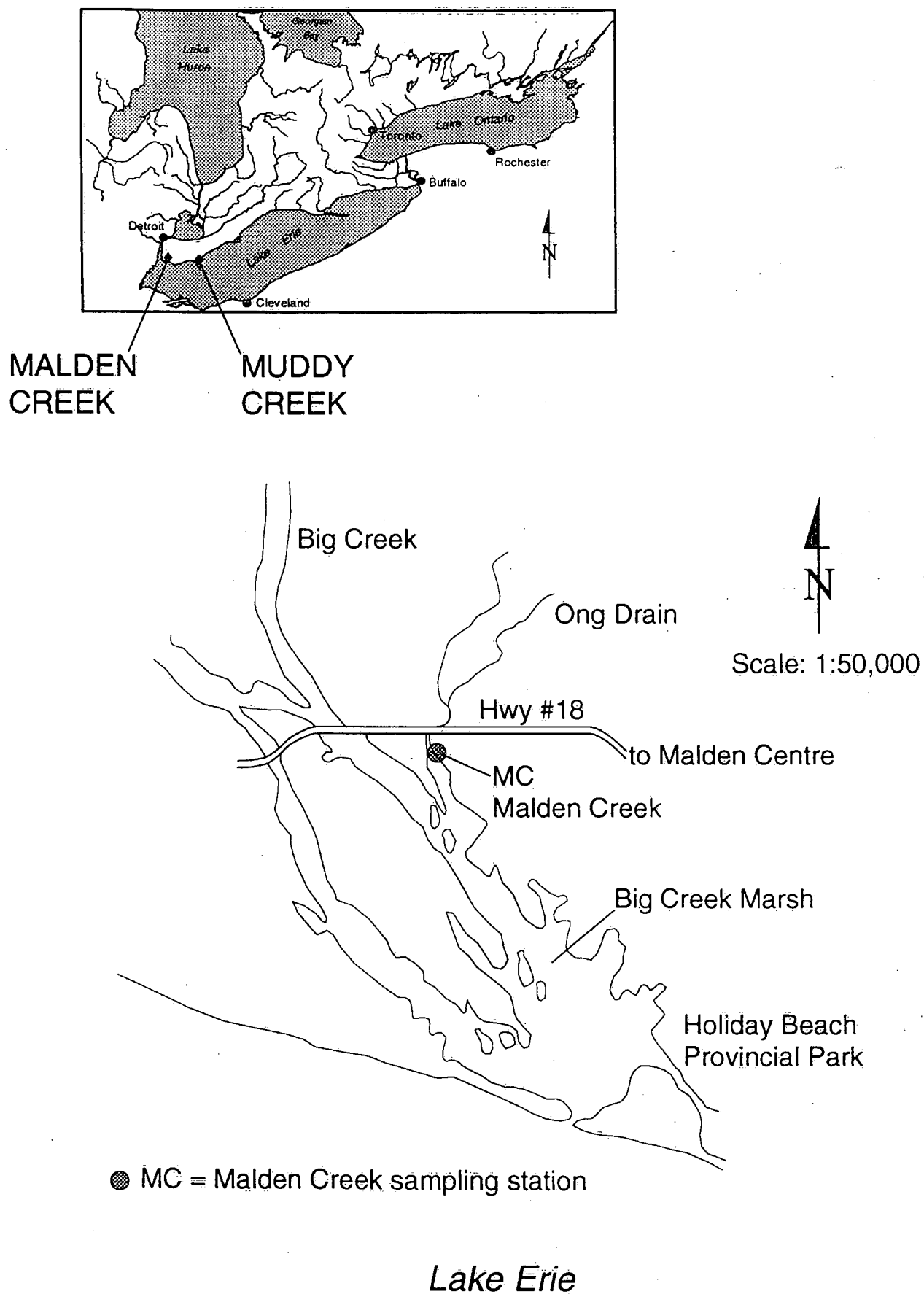


FIGURE 1a

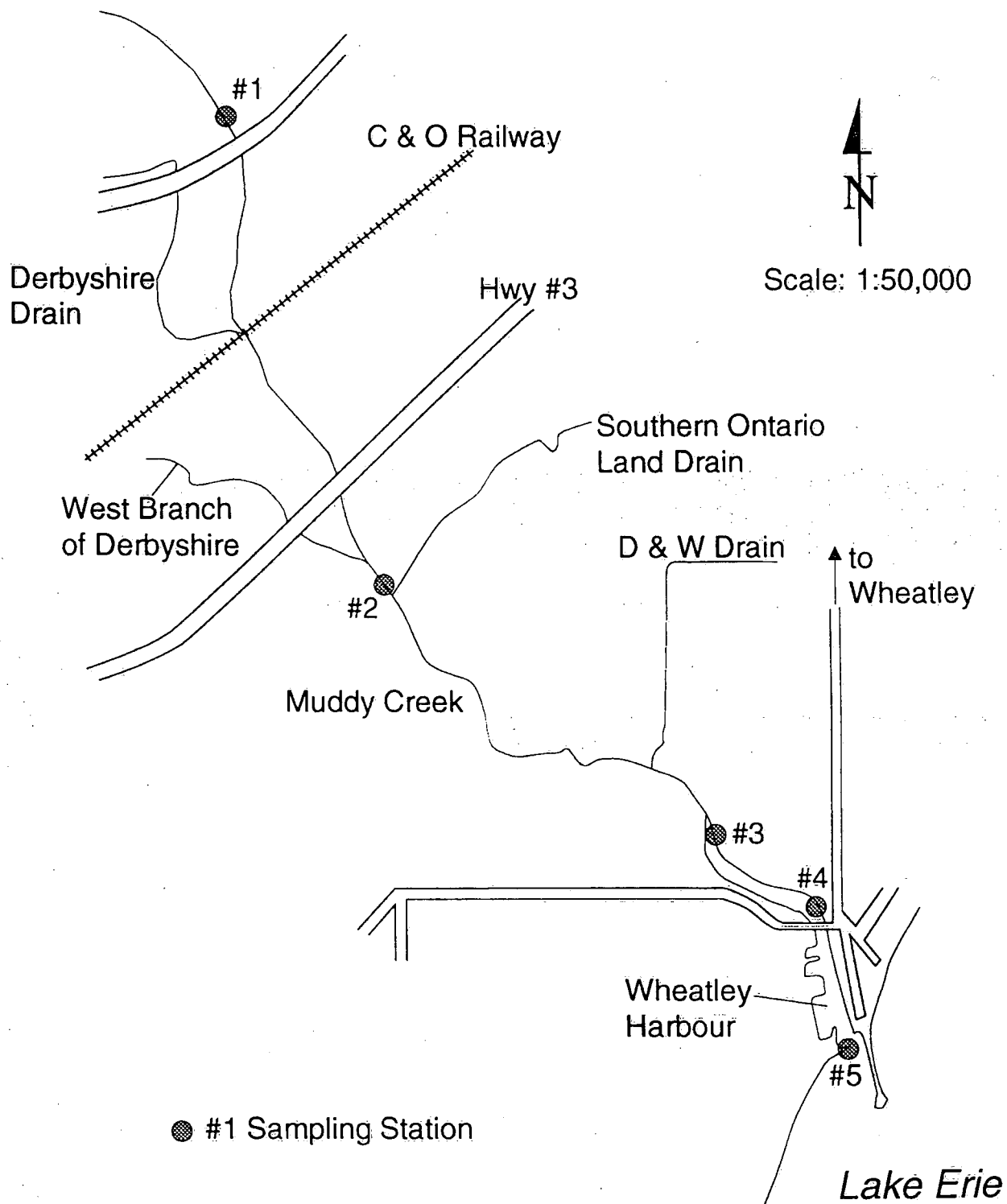


FIGURE 1b

Inorganic Carbon in SPM Muddy Creek

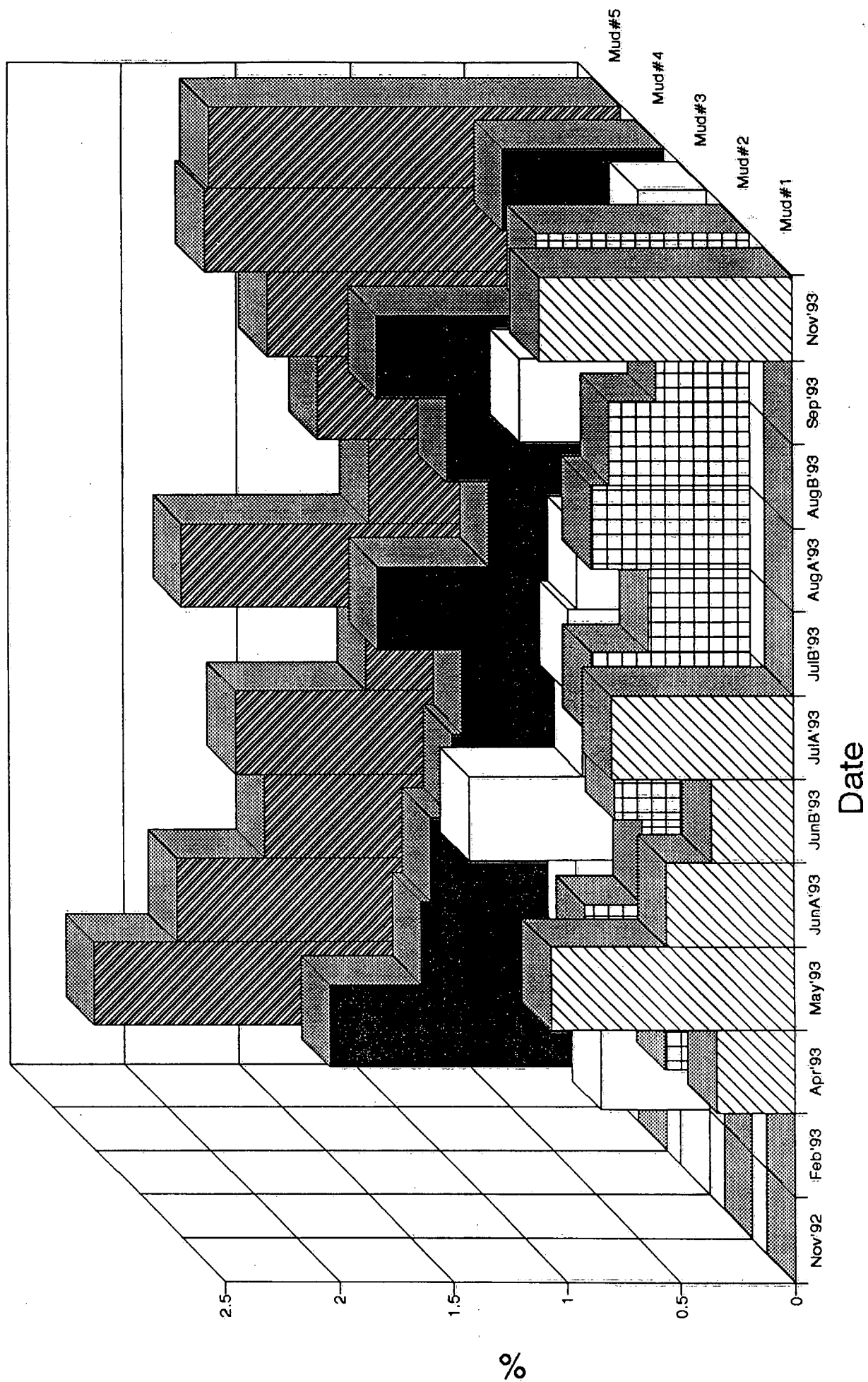


FIGURE 2

Inorganic Carbon in SPM Malden Creek



FIGURE 3

Organic Carbon in SPM Muddy Creek

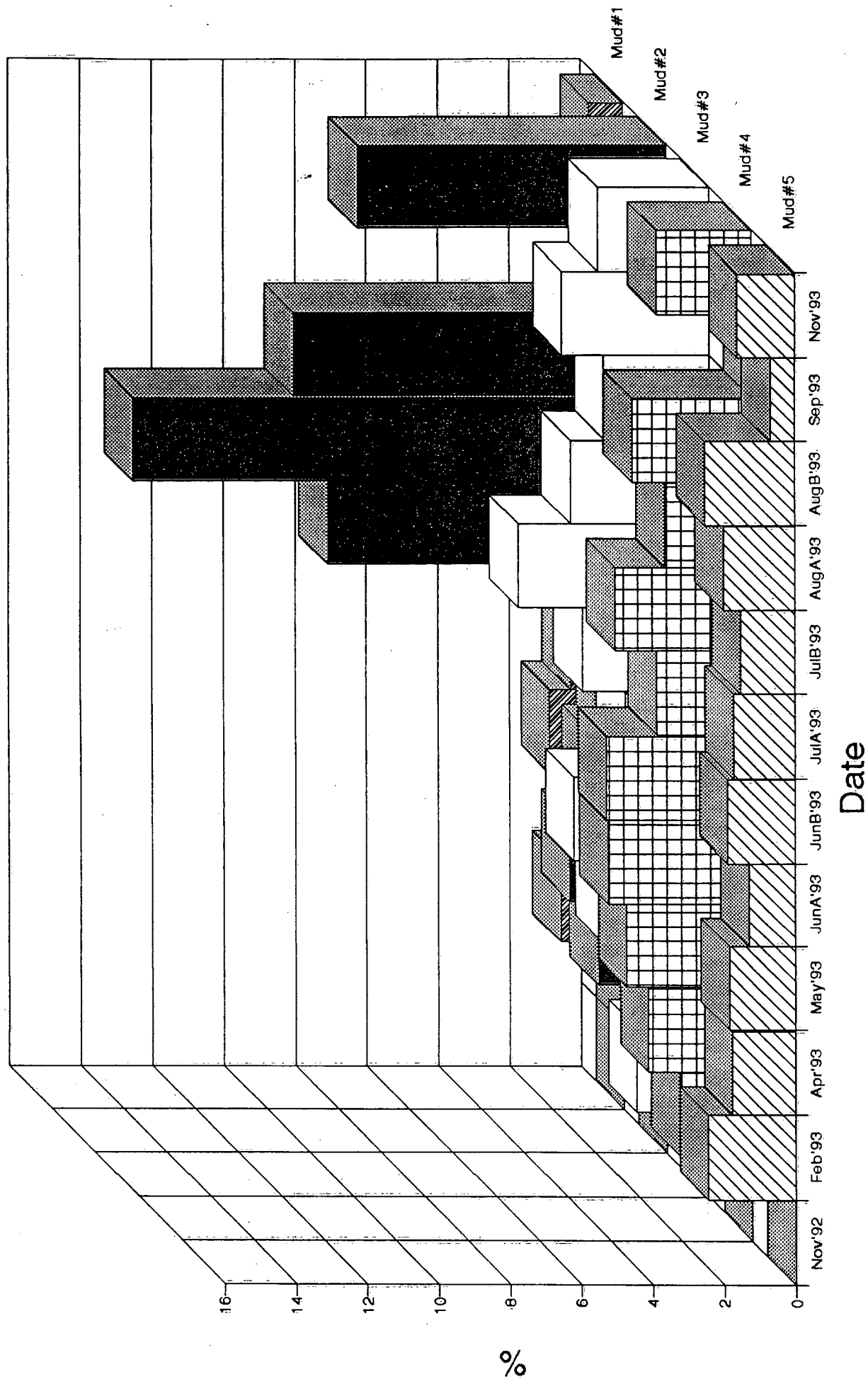


FIGURE 4

Organic Carbon in SPM Malden Creek

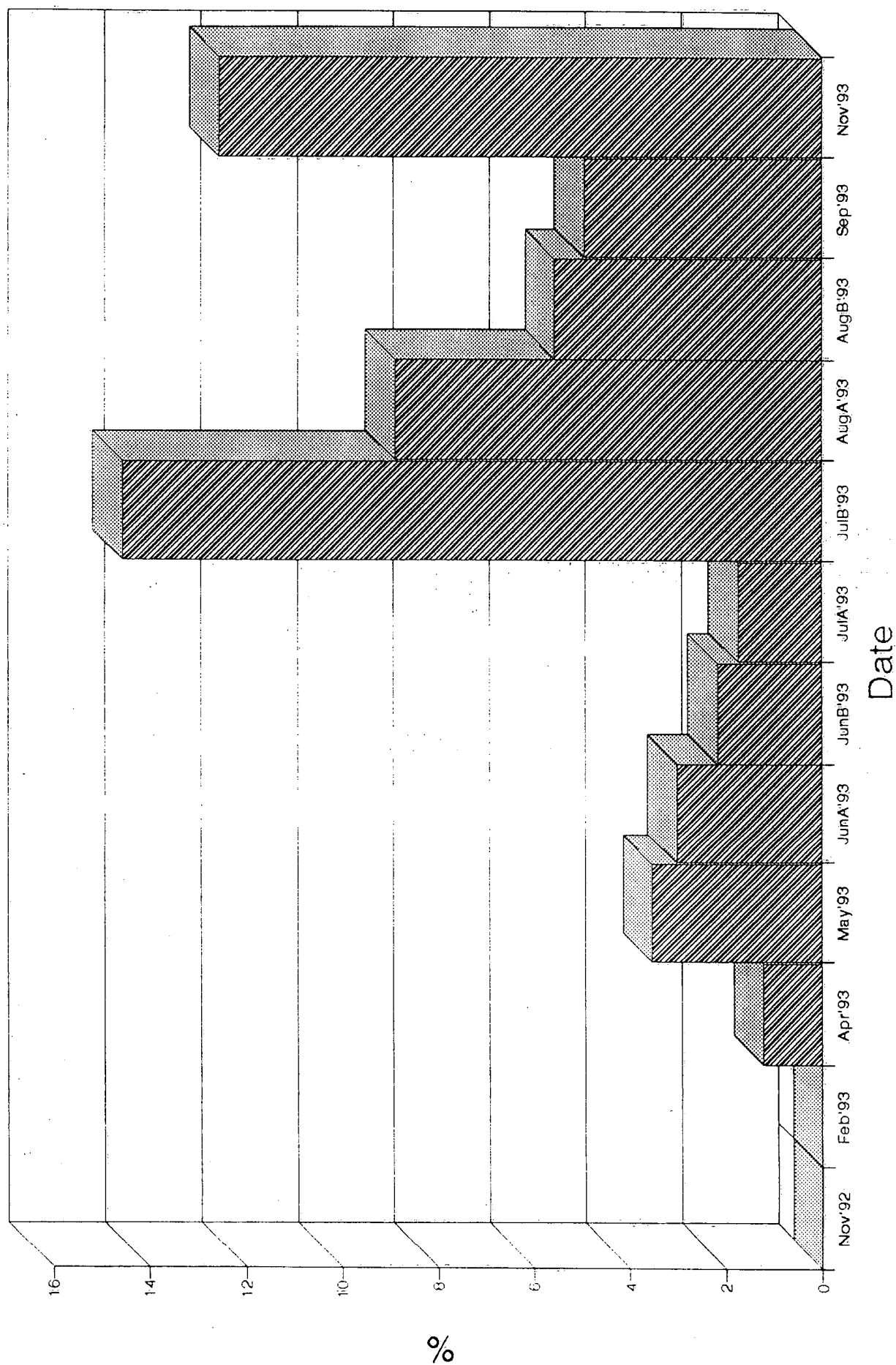


FIGURE 5

Atrazine in SPM Muddy Creek

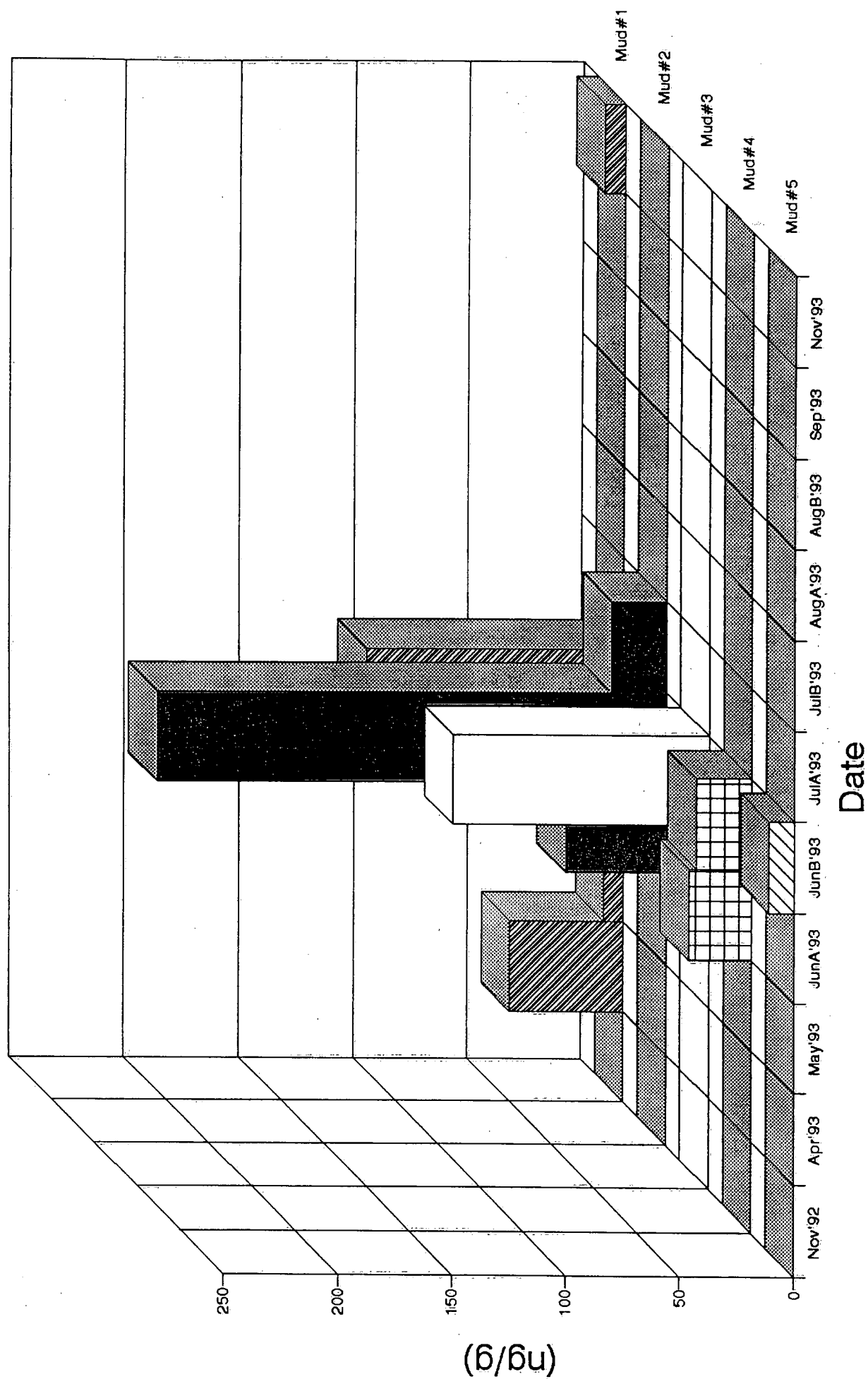


FIGURE 6

Metolachlor in SPM Muddy Creek

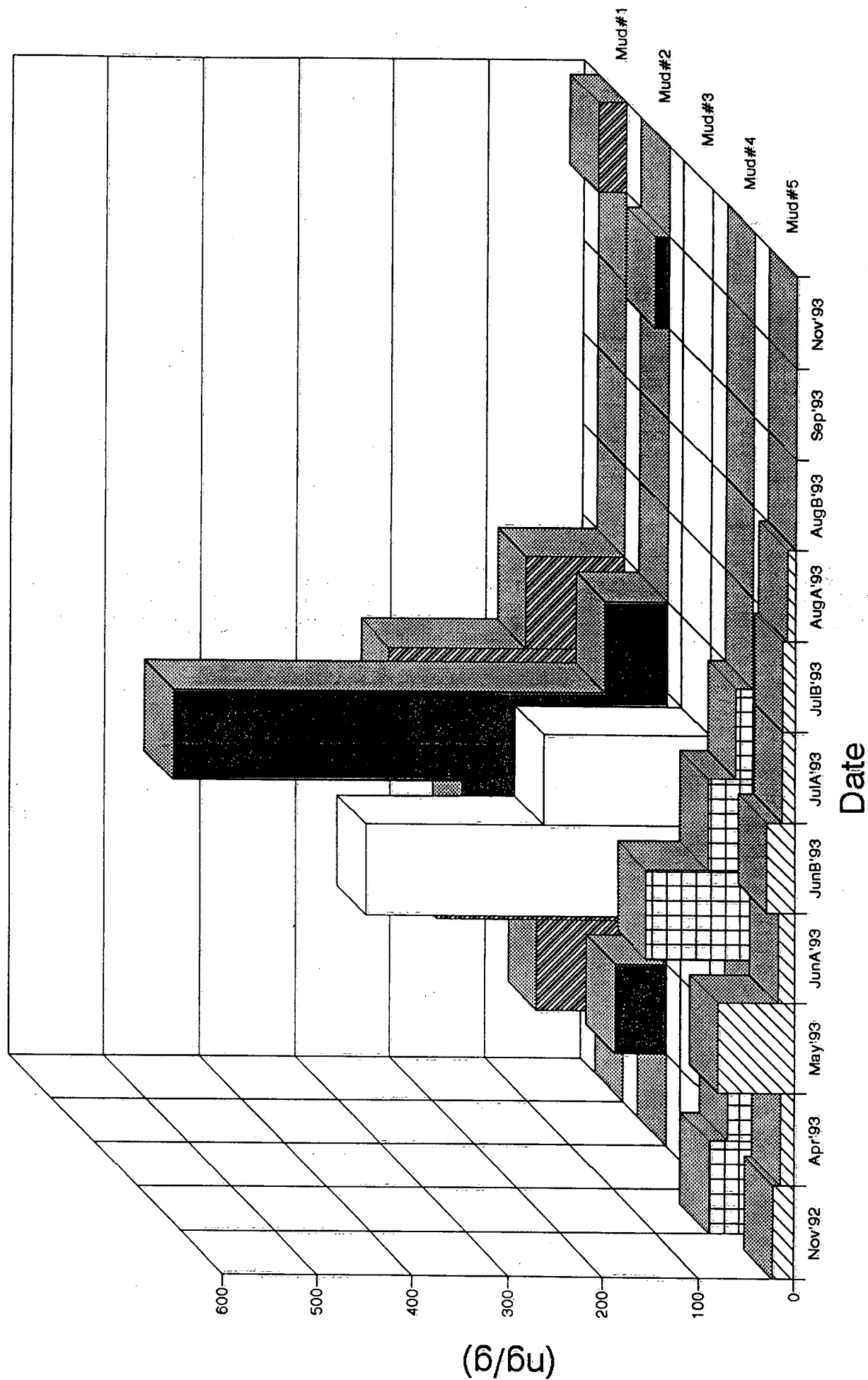


FIGURE 7

Trifluralin in SPM Muddy Creek

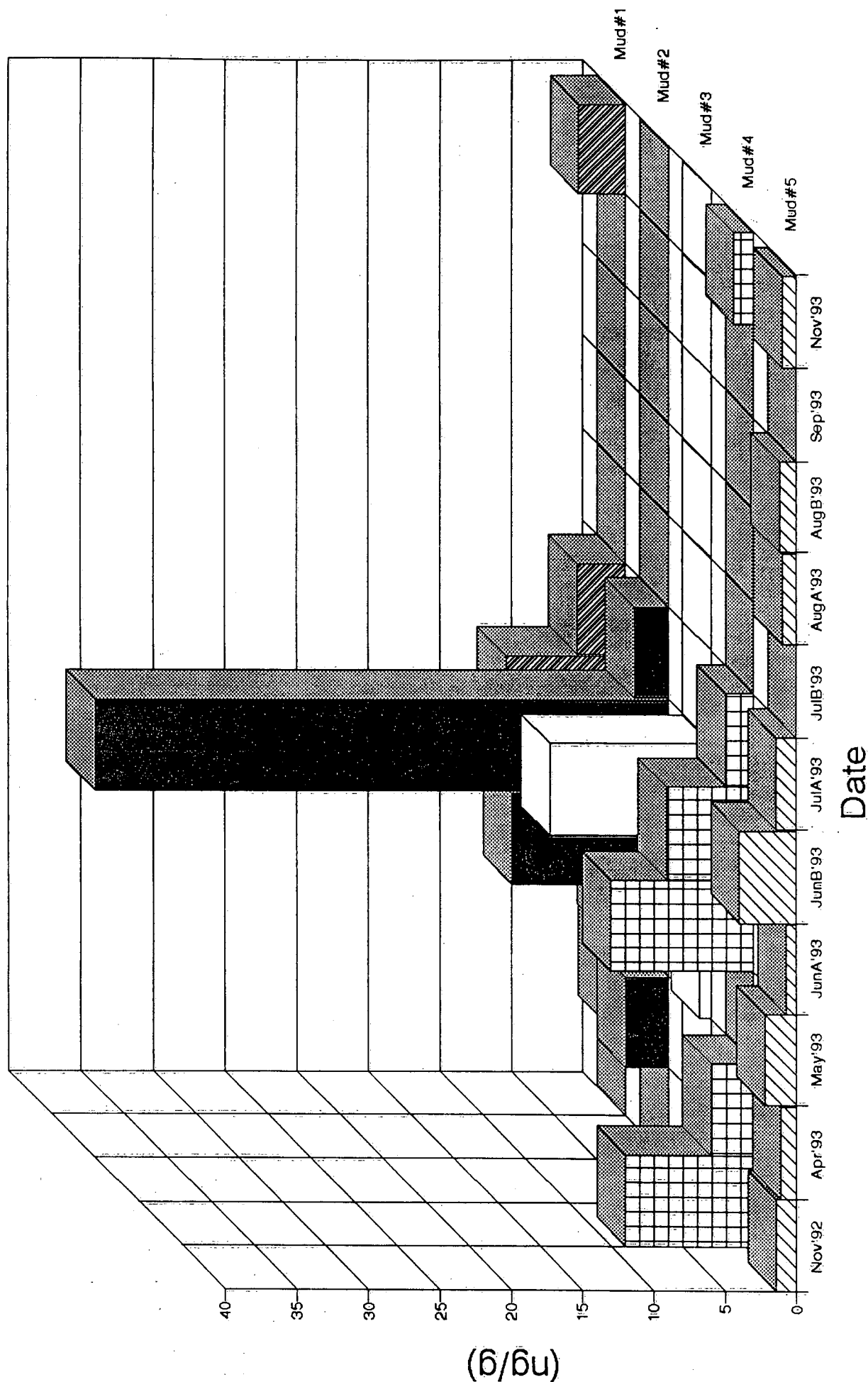
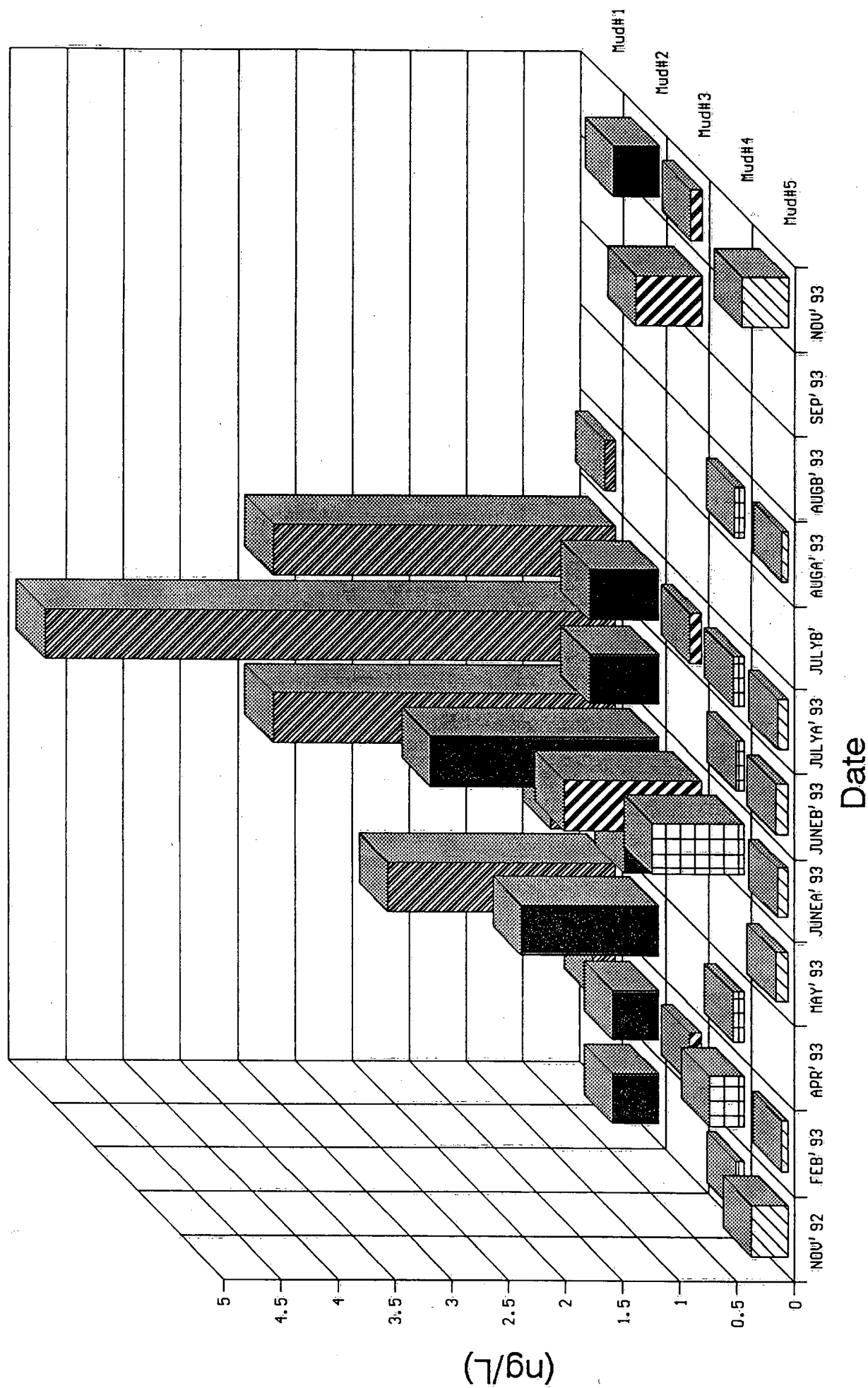


FIGURE 8

Trifluralin in Water Muddy Creek



Simazine in Water Muddy Creek

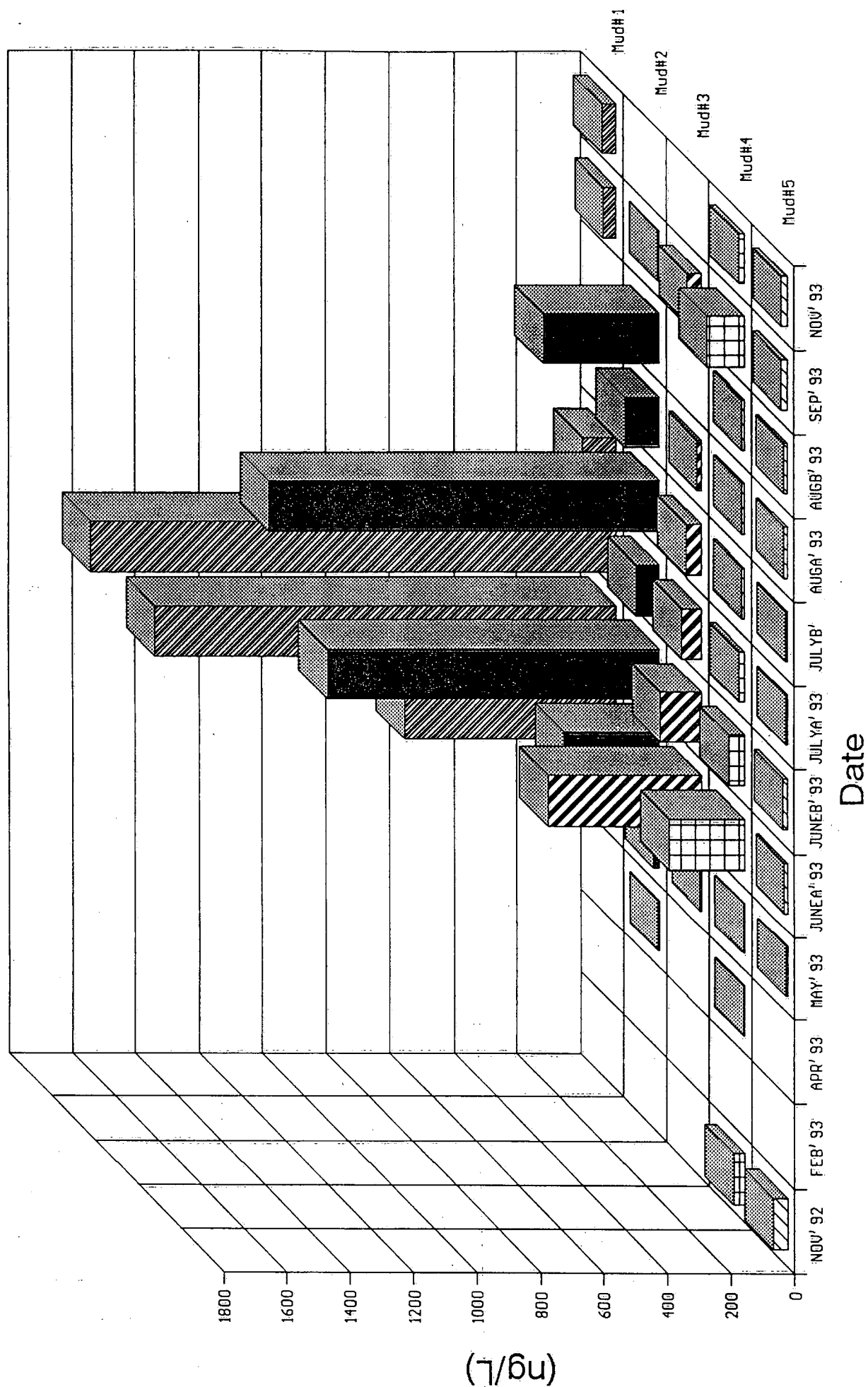


FIGURE 10

Atrazine in Water Muddy Creek

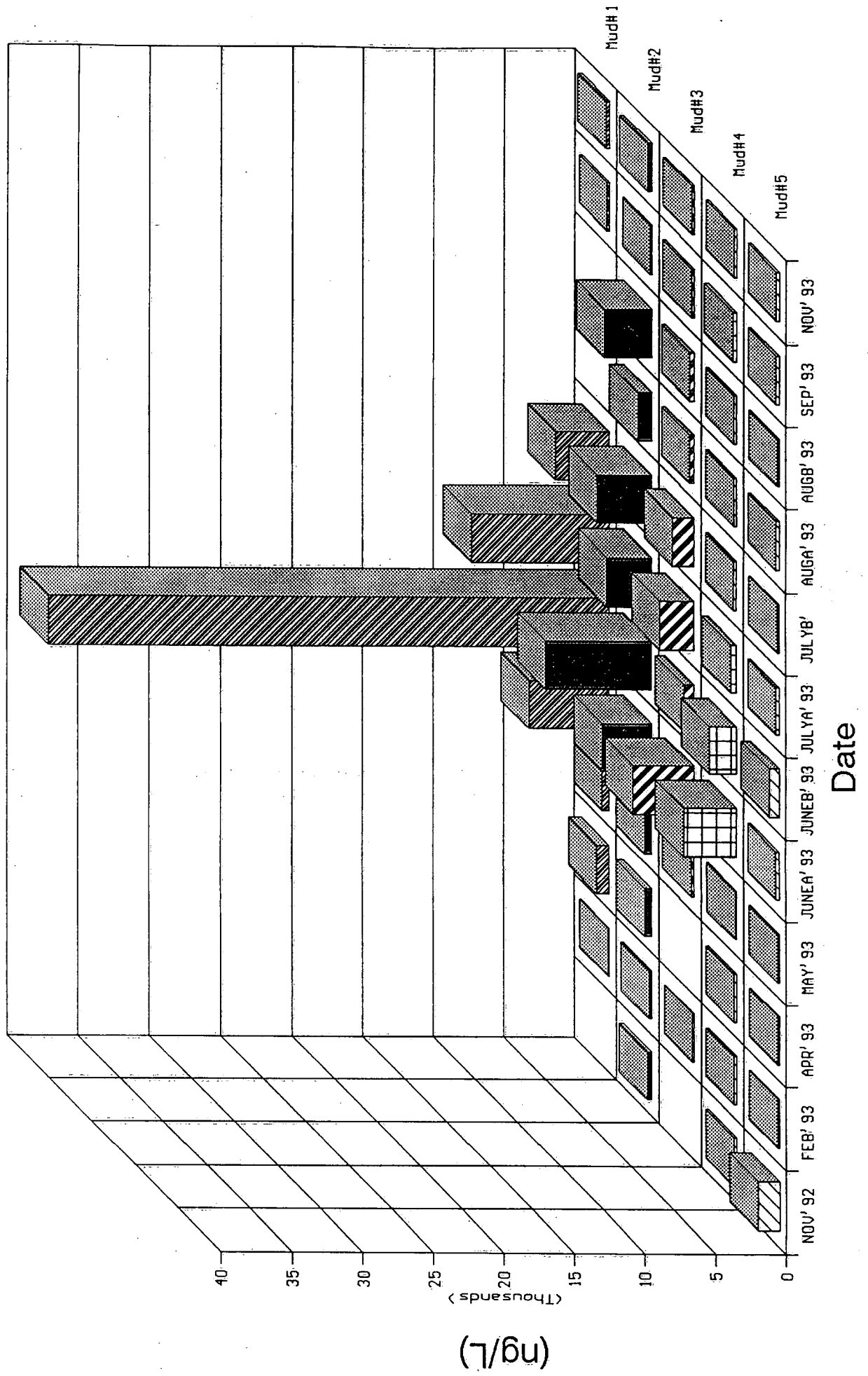
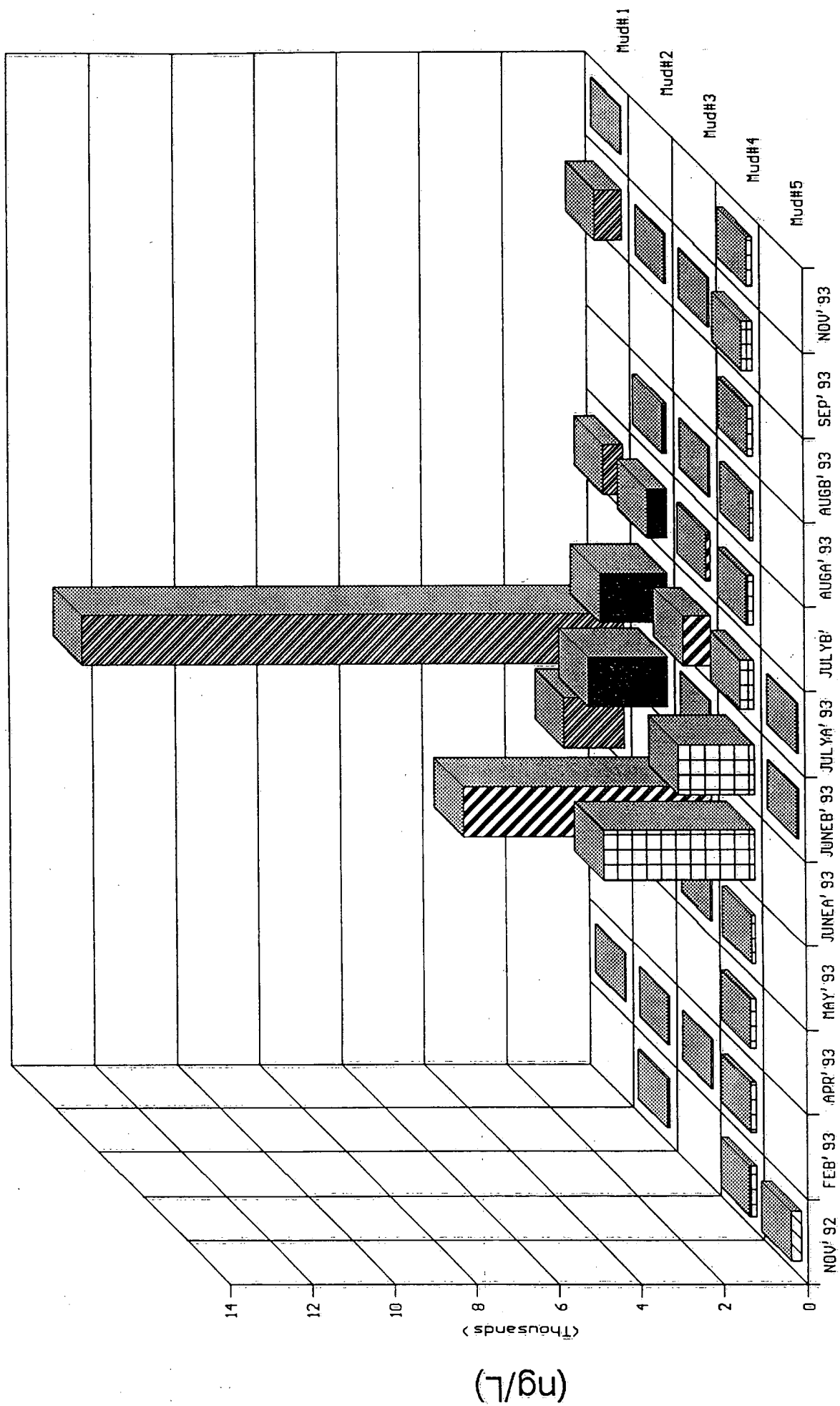


FIGURE 11

Metribuzin in Water Muddy Creek



Date

FIGURE 12

Metolachlor in Water Muddy Creek

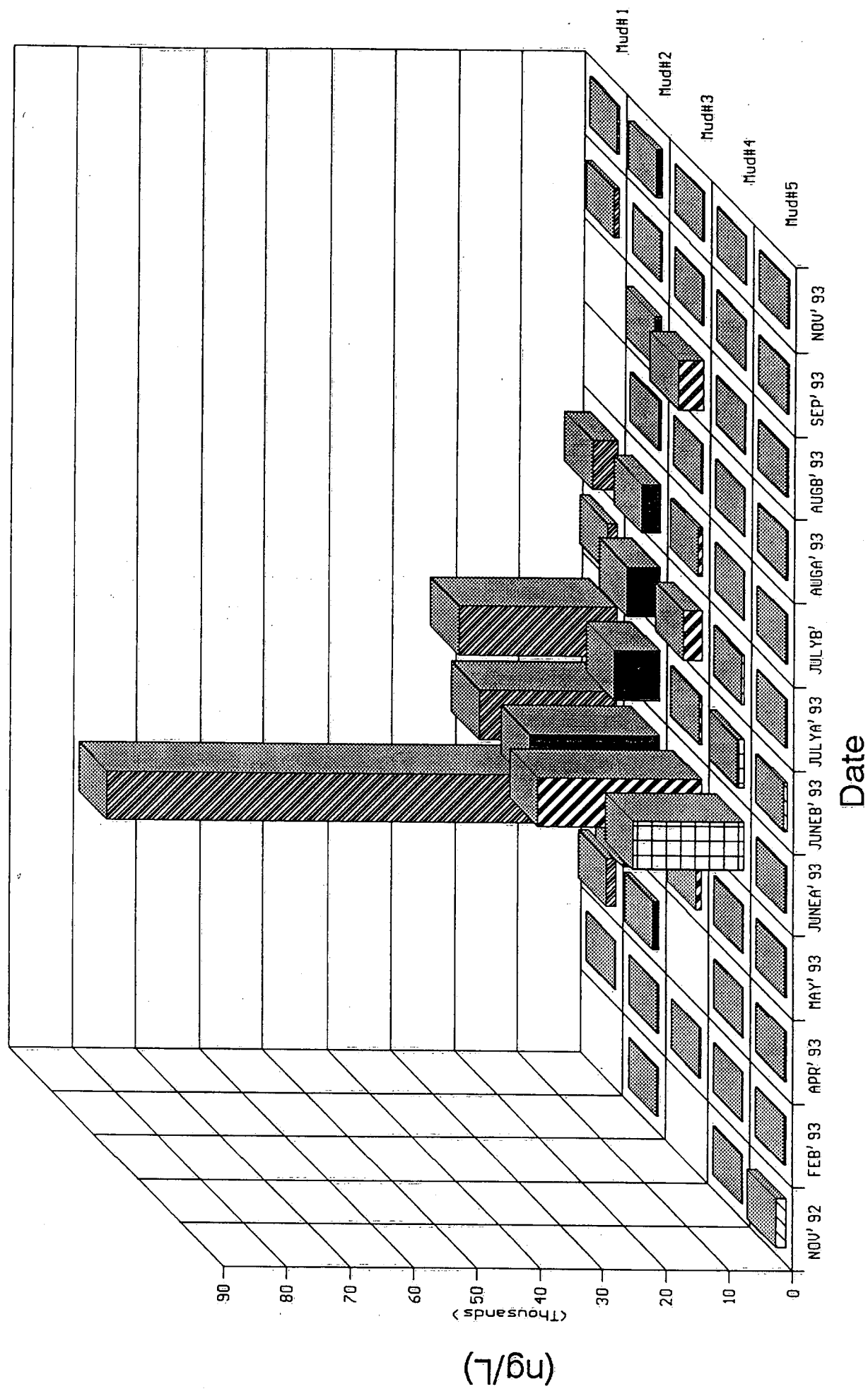
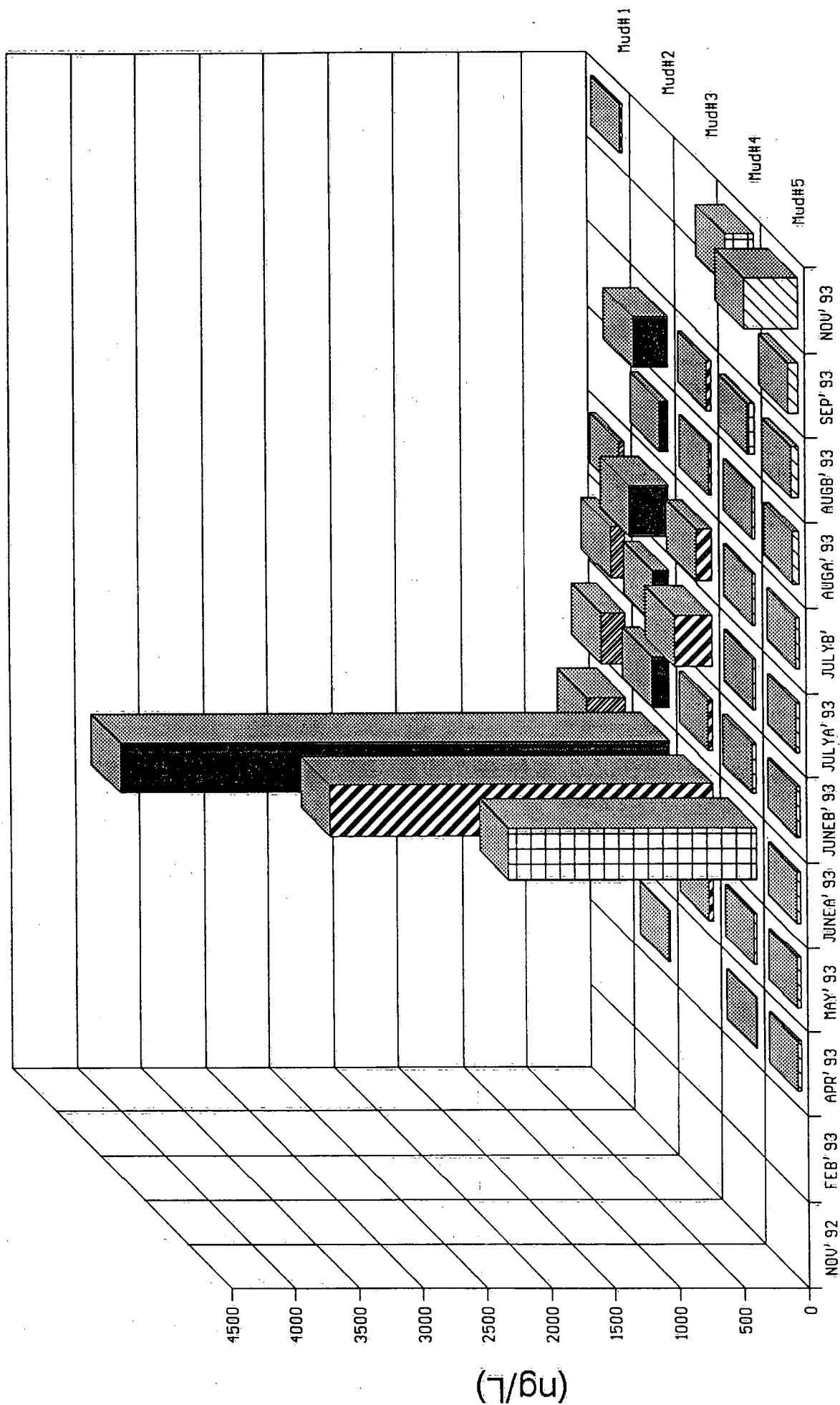


FIGURE 13

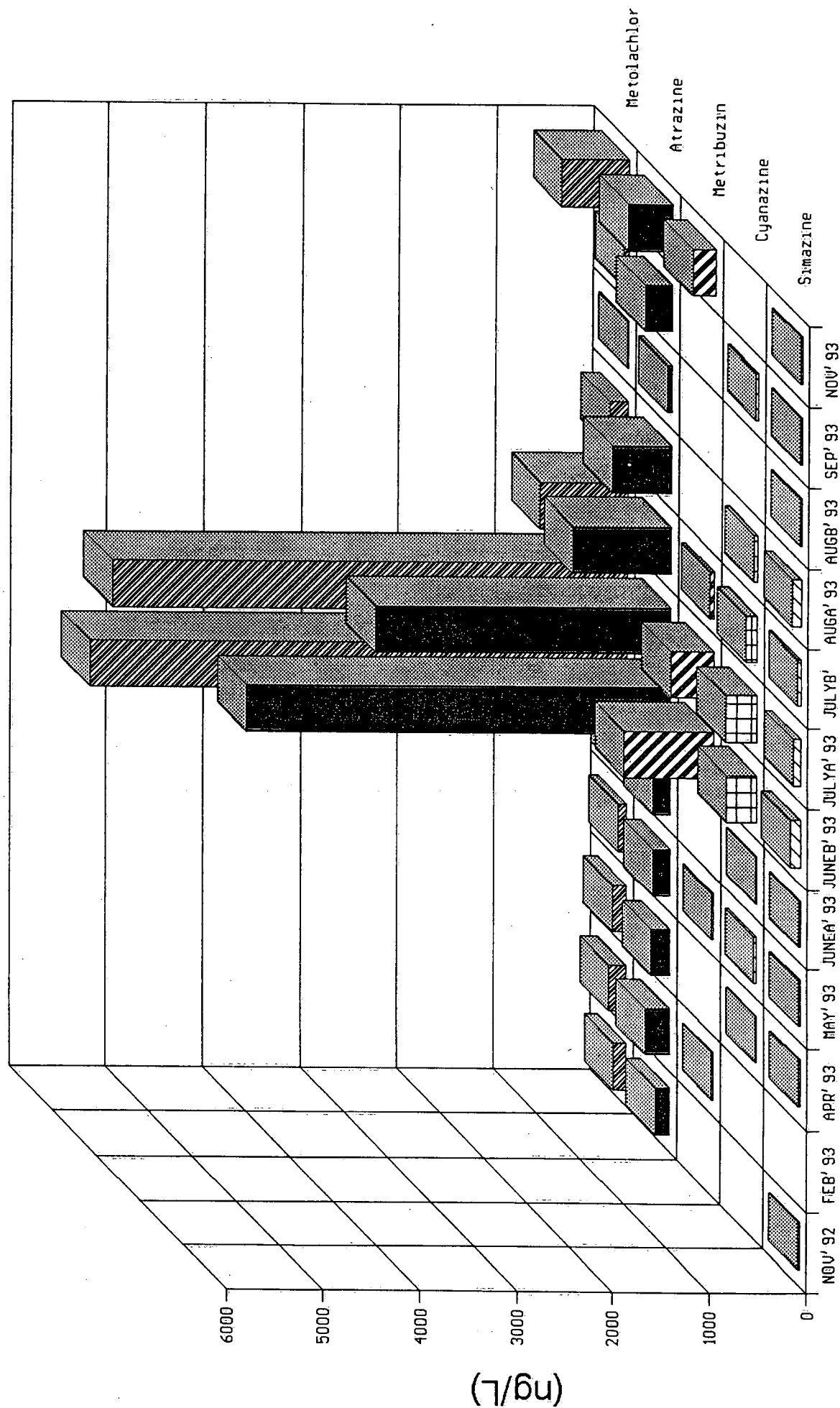
Cyanazine in Water Muddy Creek



Date

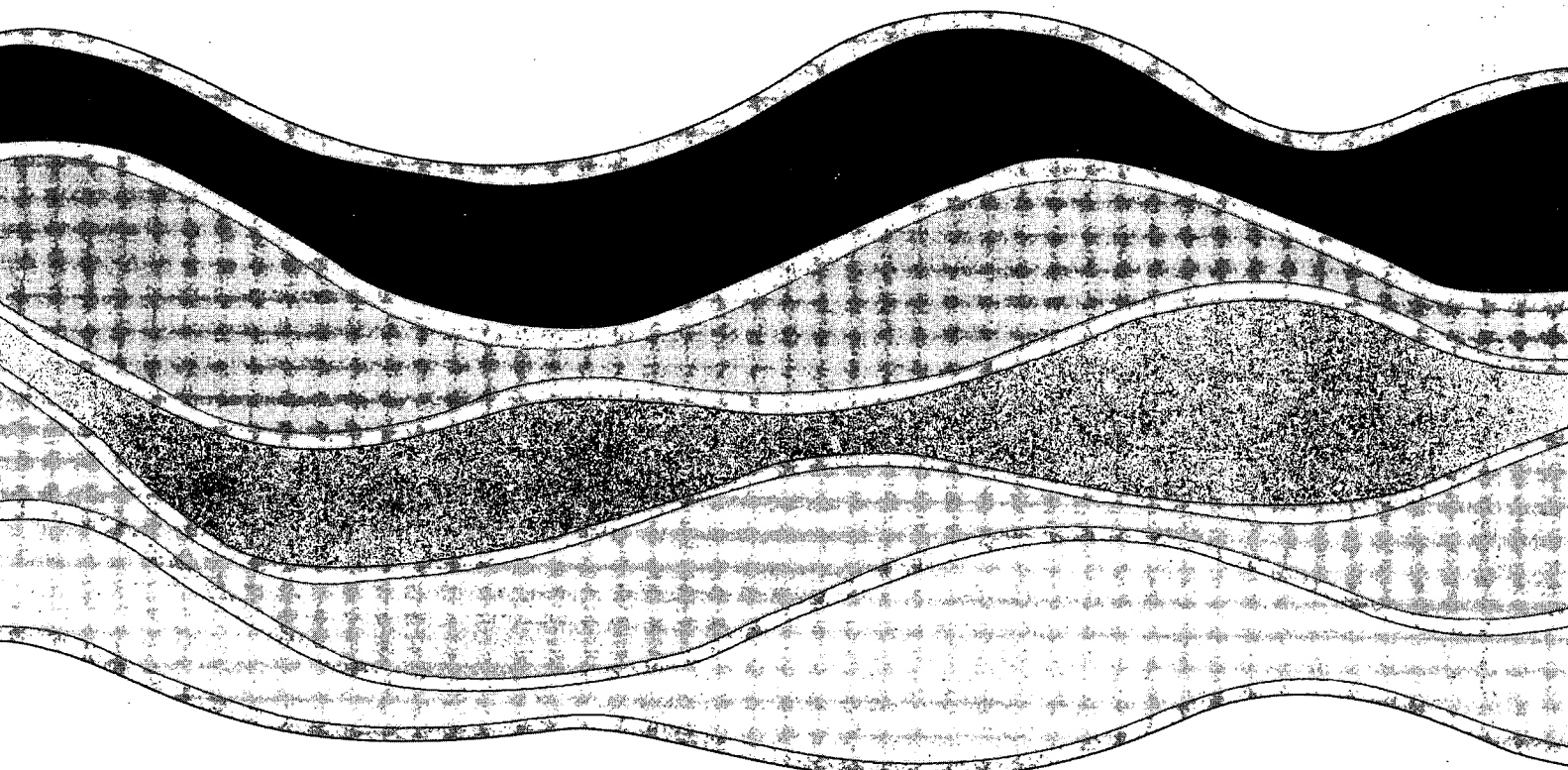
FIGURE 14

Pesticides in Water Malden Creek



Date

FIGURE 15



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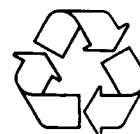
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