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An Assessment of the Effluent Discharged by the Anil Canada Ltd. Mill, at East River, Nova Scotia and its Effect on the Aquatic Environment

Surveillance Report EPS 5-AR-74-15
Atlantic Region

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AN ASSESSMENT OF THE EFFLUENT DISCHARGED BY THE ANIL CANADA LTD. MILL, AT EAST RIVER, NOVA SCOTIA AND ITS EFFECT ON THE AQUATIC ENVIRONMENT

by

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ABSTRACT

As part of the continuing pollution surveillance activities at Anil Canada Ltd., a hardboard plant located in East River, Nova Scotia, the Environmental Protection Service has conducted routine testing of the effluent and conducted receiving water investigations of the Little East River and Mahone Bay. The results of bioassays and treatment efficiency evaluations completed over a period of several years are summarized, and the results of water quality and biological sampling completed in August and November of 1973 in the receiving waters of Mahone Bay are presented.

The results of these studies suggest that the efficiency of the existing treatment system is low. The effluent exhibits significant toxicity and does not meet recommended regulatory toxicity limits. Little East River, after the entry of the treated effluent, exhibits the effects of gross organic loading and is unfit for any typical clean-water aquatic community. The intertidal area of Little East River Cove has also been significantly affected. Beyond the headlands of the Cove, biological effects of the discharge are minimal owing to several fortuitous hydrographic factors. Water quality of this area, however, has been degraded and no longer meets bacteriological standards for an approved shellfish growing area. This area has been closed to the direct harvesting of shellfish in the Nova Scotia Fishery Regulations due to the potential bacteriological health hazard.

Objectionable aesthetic effects, including odor, color and turbidity are clearly prevalent in the Little East River and at Little East River Cove. Excessive color and turbidity levels persist in the surface waters of the Cove,as well as along the shore far beyond the headlands of the Cove east or west depending upon the direction of the wind. The adverse effect of this industrial discharge on these aesthetic qualities is particularly important in view of the historical recreational use of beaches within the study area.

Résumé

Pour évaluer l'effet de l'effluent provenant de l'usine Anil Canada Ltéé. à East River, Nouvelle-Ecosse, le Service de Protection de l'Environnement a conduit des épreuves pour determiner la toxicité de l'effluent, et des recherches biologiques dans la Baie Mahone. Les résultats des essais biologiques et des évaluations de l'efficacité du traitement, entreprises pendant divers années, sont résumés ainsi que les résultats de l'échantillonnage des eaux et des organismes faite aux mois d'août et novembre 1973.

Les conclusions des études suggèrent que l'efficacité du traitement de l'effluent est faible. L'effluent est toxicque d'une manière significative et ne satisfait pas les règlements fédérales pour la toxicité. "Little East River" est très pollué par la matière organique et ne peut supporter des organismes typiquement naturelles. En plus, la région de la côte entre les marées basses et les marées hautes a été affectée significativement. Dans la Baie Mahone propre, les effets sur l'ecologie sont minimums à cause des conditions océanographiques. La qualité des eaux, pourtant, à été degradée par l'effluent et ne satisfait pas les criterès bactériologiques pour la pêche coquillière. La pêche coquillière à été interdite à cause du danger à la santé publique.

Les effets esthétique, comme la couleur, l'odeur et la turbidité se démontrent dans "Little East River" et dans l'anse "Little East River." Les problèmes de la couleur et de la turbidité persistent au déla des promontoires de l'anse à l'est et à l'ouest. La direction, cependant, dépend sur le vent. Les effets esthétiques sont importants à cause de l'usage historique des plages pour la récréation.

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1 INTRODUCTION

The report is intended as a summation of the activities and projects which have been conducted by the Surveillance and Analysis Division and the Environmental Control Division of EPS in the past three years. These studies have been designed to determine the waste loadings and the environmental consequences of the discharge of liquid effluent from the Anil Canada Ltd. plant at East River, Nova Scotia. These assessments have been carried out primarily by the Biological Monitoring Unit and the Toxicity Evaluation Unit and have been concerned with the ecological effects in receiving waters and the toxicity of the effluent. An evaluation of the pollution control systems at the mill has also been done by the Environmental Control Division of EPS.

The Anil mill was constructed in 1966 to produce a pressed wood (panelling) hardboard. The process is relatively simple (compared to a chemical pulp mill) and could be accomplished using very little water, hence generating a relatively small effluent discharge. Unbarked wood, mostly hardwood, is chipped and fed to a high pressure, steam-cook in batch digestors. The chips, softened by the cooking, are fed to high pressure refiners to produce fibres that will form a sheet on a four-drinier wire. Approximately 15% of the stock passes through a second refining stage and is used as a thin overlay on the sheet to give a smooth surface. The sheet is cut, pressed and dried, and then finished with surface coatings before storage and marketing. Mill production is now 300 to 330 tons/day.

The effluent from the mill is pumped to the treatment system where it flows through one of three settling ponds and then into an aerated lagoon with 6 x 15 h.p. and one 40 h.p. aerator. The aerated lagoon consists of an old limestone quarry, which has subsequently been lined with clay. The lagoon encompasses an area of approximately 3.5 acres and has a normal retention time of 4 days. The effluent is discharged through a swamp to the Little East River which in turn flows into Mahone Bay (see Figure 1).

2 MATERIALS AND METHODS

Sampling was completed in Mahone Bay in August and again in November of 1973. Water quality samples were collected at 13 stations. Diving was done at 9 of these stations and biological collections were made at 5 of these. Sediment samples were collected at the diving sites wherever the substrate permitted. Additional sediment and water samples were also provided by divers employed by Anil Canada Ltd. In situ measurements of dissolved oxygen, temperature and salinity were also made with portable YSI and Beckman meters.

All chemical analyses were completed according to methods for Chemical Analysis of Water and Wastewater (EPS 1973) with the exception of carbon, and nitrogen. Heavy metals values reported are MIBK extractable values. Water samples for suspended heavy metals were analyzed after filtration with 0.45μ HA (Millipore) acid washed filters. The filtrant was analysed and the results are reported as dissolved heavy metal values. The results of heavy metal analyses on sediment samples are reported as total MIBK extractable values on a dry weight basis.

All carbon and nitrogen analyses were done on a Perkin Elmer Model 240 elemental analyzer standardized daily with NBS grade acetanilide. Sediment samples for CN analysis were dried for 24 hr. at 40°C ground with a mortar and pestle and stored in a dessicator until analysis. Samples to be analyzed were then weighed on a Cahn electro-balance, model G and three aliquots analyzed. In total 0.1 - 0.2 gm. of sediment were analyzed. Results are reported as Percent Dry Weight. Water samples for carbon- nitrogen analysis were filtered on preweighed 0.8μ silver filters (Selas Flowtronics Springhouse Pa) which had to be prefired at 550°C. Volumes filtered were recorded and the whole filter was dried 40°C for 24 hr. and analyzed intact.

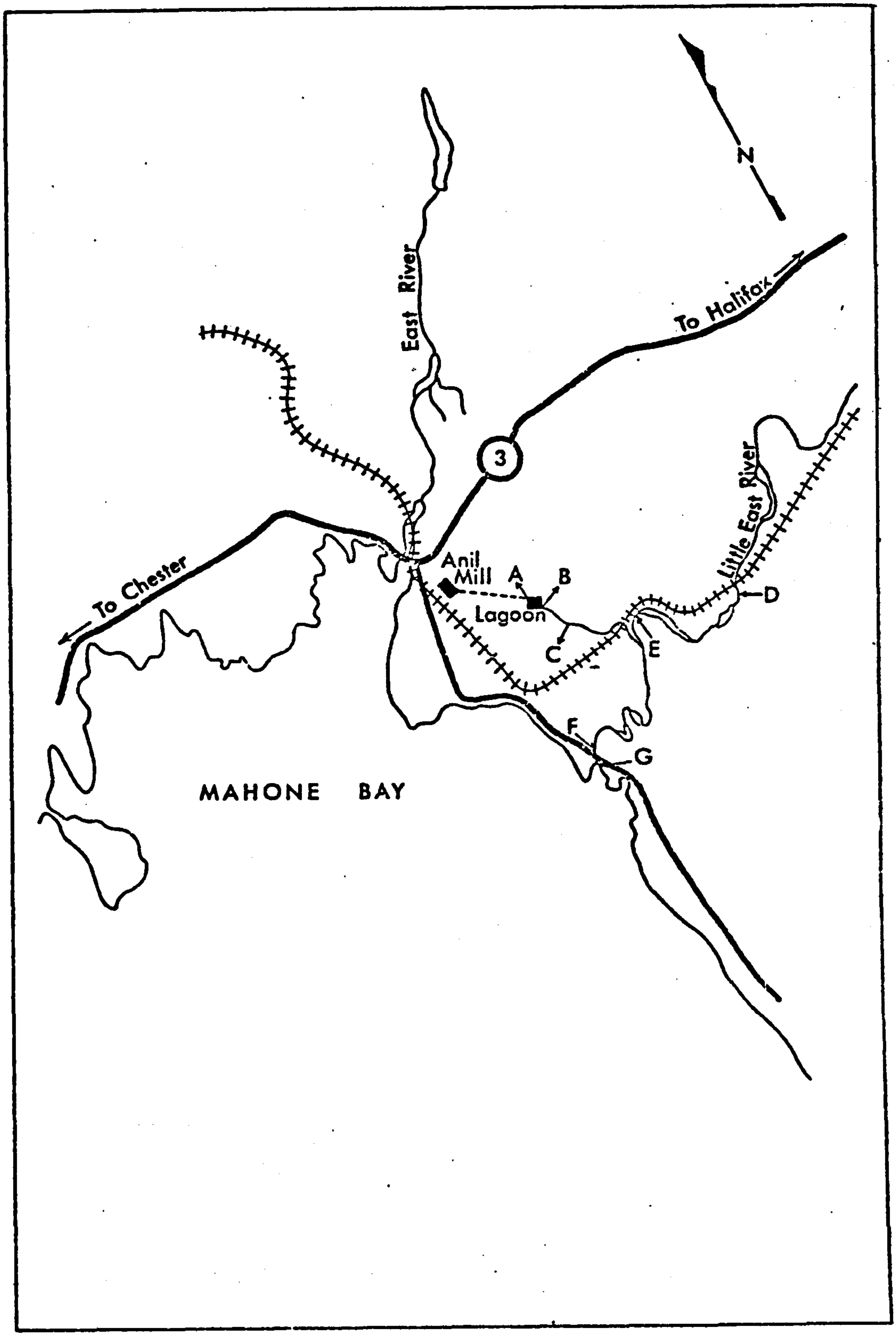

FIGURE 1 MAP OF SAMPLING STATION LOCATIONS, ANIL TREATMENT SYSTEM AND LITTLE EAST RIVER, 1973

Biological sampling was done by divers and organisms were collected by hand and by suction dredge. At two sampling sites (3 and 4) a suction dredge was used to collect three 1/10 m^2 samples 20 cm deep which were then passed through 2 mm nylon mesh. Epibenthic organisms were collected within a six foot strip along a line from the sampling site to the shore. Independent estimates of relative abundance were made by each of two divers. Biological samples were preserved and returned to Halifax for identification.

The majority of the bioassay tests were of the static type similar to those described in the APHA Standard Methods (13th Edition) and the Federal Pulp and Paper Effluent Guidelines (Environment Canada 1972).

3 RESULTS AND DISCUSSION

3.1 Existing Waste Treatment

The combined mill effluent (untreated) is estimated at 1.25 MIGPD including 35,000 lbs/BOD_5/day (115 lbs/ton), and 12,500 lbs/S.S./day (41 lbs/ton). These values were taken from the July, 1972 report done by McLaren Atlantic Ltd. for Anil Canada Ltd. This is probably the best available estimate, and measurements made by the EPS and Anil staff support this estimate. Recent data from the mill's routine sewer analyses suggest that BOD_5 discharge is between 20,000 and 25,000 lbs/day. The average suspended solids discharge is between 10,000 and 12,000 lbs/day.

During the study in August of 1973, the lagoon's discharge had a BOD_5 value of approximately 2000 ppm, a suspended-solids removal efficiency varying from 10-50% of the inflow and a resin acid content of 4.1 ppm (Station B as shown in Figure 1). Recent results of samples collected in September 1974 and analyzed by gas chromatography for resin acids suggest higher levels (G. Pelly, 1974, personal communication). Resin acid values of 9.1 mg/l and 10.7 mg/l are reported for the inlet to the lagoon and final lagoon discharge respectively. Resin acids are known to be acutely toxic to fish at levels below 1 ppm.

The present treatment system does very little to improve the characteristics of the effluent. The effluent shows 100% mortality in routine bioassay tests in less than 10 hours. BOD_5 removal varies in the lagoons but is usually between 0 and 10%. The removal of suspended-solids by the existing system varies widely but is most often between 10 and 50%.

Apart from the poor operation of the treatment system, there are other factors which must be considered. The Little East River is a very small river (estimate: less than 100 cfs and, in dry weather, probably less than 10 cfs), and even with a high degree of biological treatment of effluent, the river would not assimilate a very large organic load.

There have been frequent spills of effluent to the storm sewer which empties into the mouth of the East River. Contamination of wells in the area might be explained by the spills or by groundwater contamination by leachate from the wood storage area.

3.2 Toxicity of the Effluent

Since June of 1970, a large number of bioassay tests have been conducted on the influent and effluent of the waste treatment system at Anil Canada Ltd. These results indicate that there has been virtually no decrease in the toxicity of the effluent.

Table 1 presents bioassay results for a total of thirty-three tests which were carried out between June, 1970 and October, 1973. For a mill effluent to be in compliance with these Federal toxicity regulations, 80% of the bioassay fish must survive a 65% effluent concentration after 96 hours exposure (Canada Department of Environment, 1971). All such bioassays conducted on the liquid influent or effluent from the aerated lagoon demonstrated that there was no survival of fingerling Atlantic salmon or Rainbow trout in the 96-hour test period. Two bioassays conducted in flow-through conditions, as would be expected in Little East River, demonstrated that while there

Table 1 96-HOUR BIOASSAY TEST RESULTS FOR LAGOON INFLUENT AND EFFLUENT SAMPLES FROM THE ANIL CANADA LTD. MILL AT EAST RIVER, NOVA SCOTIA

Date	Source	LT50 (hrs.)	% Mort.
June 8, 1970	Mill Effluent	0.09	100
June 8, 1970	Lagoon Outfall	3.03	100
June 10, 1970	Mill Effluent	0.09	100
June 10, 1970	Lagoon Outfall	3.04	100
July 6, 1970	Mill Effluent	2.04	100
July 6, 1970	Lagoon Outfall	2.03	100
July 13, 1970	Mill Effluent	1.08	100
July 13, 1970	Lagoon Outfall	4.08	100
July 24, 1970	Mill Effluent	1.05	100
July 24, 1970	Lagoon Outfall	0.03	100
July 30, 1970	Mill Effluent	7.02	100
July 30, 1970	Lagoon Outfall	0.07	100
Aug. 30, 1971	Lagoon Outfall	0.05	100
Aug. 30, 1970	Little East River	15.00	100
Mar. 17, 1972	Lagoon Outfall		
	(static)	11.07	100
	(flow-through-fingerling)	6.08	100
	(flow-through-yearling)	8.08	100
May 4, 1972	By-pass		0
June 13, 1972	Mill Effluent	9.05	100
June 17, 1972	Lagoon Outfall	9.05	100
July 4, 1972	By-Pass	3.07	100
July 31, 1972	By-Pass	17.05	100
Aug. 23, 1972	Lagoon Outfall	3.08	100
Sept 6, 1972	Lagoon Outfall	4.09	100
Oct. 2, 1972	Lagoon Outfall	2.05	100
Feb. 1, 1973	Mill Effluent	8.00	100
Feb. 1, 1973	Lagoon Outfall	3.00	100
Feb. 2, 1973	Lagoon Outfall	3.00	100
Mar. 16, 1973	Mill Effluent	3.00	100
Mar. 16, 1973	Lagoon Outfall	3.00	100
June 28, 1973	Mill Effluent	4.00	100
June 28, 1973	Lagoon Outfall	2.00	100
Aug. 8, 1973	Lagoon Outfall	2.00	100
Oct. 12, 1973	Lagoon Outfall	0.47	100
Oct. 12, 1973	Little East River outfall	12.00	100

was no survival of test fish, the effluent was lethal in a significantly shorter period of time than in static tests.

It would appear that the liquid from the lagoon outfall was actually more toxic in the summer of 1973 than it was in the summer of 1970. This observation has not, however, been subjected to statistical analysis.

3.3 Water Quality of Little East River

The effluent leaving the lagoon enters a swamp as a dark brown liquid, high in suspended and dissolved material. This swamp widens appreciably and reduces the flow rate of the effluent, thereby acting as a further settling and biological treatment system for the waste. A buildup of semi-decomposed fiber has resulted, greatly increasing the offensive odor in the area. The vegetation which is normally found in or on the edge of such a swamp is buried under fiber (see Plates 1, 2 and 3). The effluent flows into the Little East River at a point approximately 2500 to 3000 feet from the Blandford Highway. Above this junction, the river waters are coloured but clear; below the point where the effluent mixes with the river, the water is highly turbid and gas bubbles continually break the surface. Resin acid levels measured in samples from the unpolluted part of the river were below the limit of detection, that is, 0.1 mg/l.

With regard to Little East River, the water quality results are given in Table 2. Little East River, below the entry of Anil's effluent, is grossly contaminated. The water quality of Little East River above the entry of the effluent is variable. Between Stations D and E, large quantities of wood chips have been deposited on the edge of the river. This deposition was caused by a railway accident a few years ago. These chips may adversely influence water quality downstream at Station E to some degree. Further upstream at Station D, water quality appears to be that of a bog and marsh drainage with significant biological and chemical-oxygen demand. This appears to be a natural phenomenon and cannot be considered as adverse. Station D can be considered as a control.

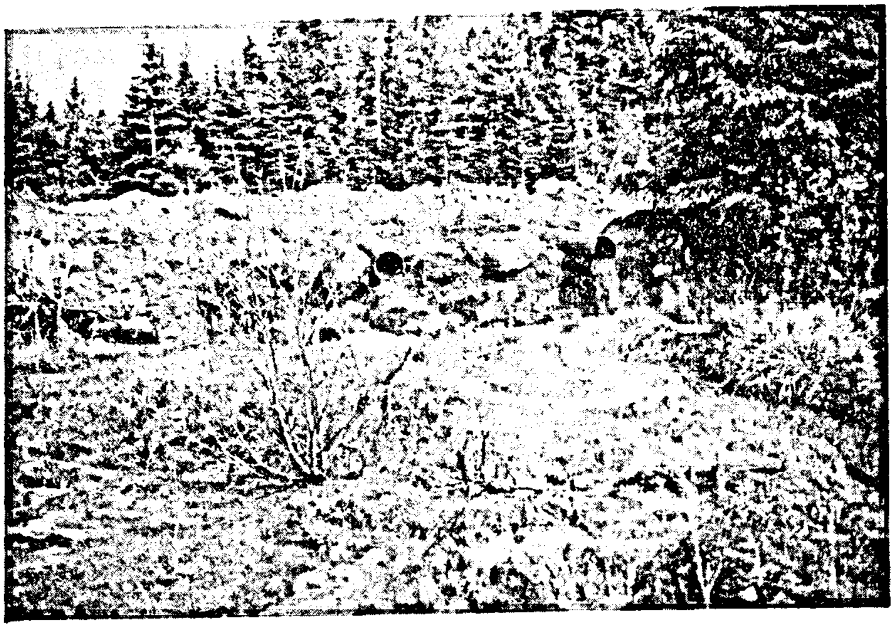

PLATE 1 DISCHARGE FROM THE SETTLING POND TO THE AERATION LAGOON AT ANIL CANADA LTD.'S MILL AT EAST RIVER, N.S

PLATE 2 OUTFALL FROM AERATION LAGOON TO THE SWAMP AT THE ANIL CANADA LTD. MILL AT EAST RIVER, N.S. NOTE THE SOLIDS DISCHARGED WITH THE EFFLUENT

PLATE 3 PHOTOGRAPH TAKEN FROM THE RAILROAD TRACKS AT THE LOWER END OF THE SWAMP APPROXIMATELY 2500 FEET BELOW THE LAGOON OUTFALL. NOTE THE ACCUMULATION OF SOLIDS

TABLE 2

WATER QUALITY RESULTS
LITTLE EAST RIVER, N.S., 1973

STATIONS	August 10 BOD$_5$ mg/l	August 10 COD mg/l	August 10 Resin Acids mg/l	November 22 BOD$_5$ mg/l	November 22 COD mg/l
A Plant effluent before lagoon	1,050	4,000	-	-	-
B Lagoon outfall	760	3,680	4.13	-	-
C Effluent 1/8 mile below lagoon outfall	100	1,080	1.46	-	-
D Little East River above Station 3	-	-	-	5.3	54
E Little East River above effluent entry St. 3	35	800	N.D.	1.9	14
F Little East River above highway	135	1,080	1.94	-	-
G Little East River Mahone Bay	140	1,120	0.46	-	-

At sampling Stations F and G near the mouth of Little East River (see Figure 1), the BOD_5 levels range between 135 and 140 ppm while the resin acid concentrations are 0.9 and 0.4 ppm respectively. The rocks of the stream are covered with a brown bacterial slime (probably Chlamydobacteriaceae).

3.4 Water Quality and Sediments in Mahone Bay

Water and sediment samples were collected in Mahone Bay in August and November of 1973. The sampling sites are given in Figure 2. The analytical results of these samples are summarized in Figures 3-6 and are given in the Appendix. The water samples collected represent above-bottom conditions and are more indicative of the potential influence of the pollutants on the bottom communities. These water quality results do, however, represent more dilute conditions than are present in the surface water. Due to the organic, primarily carbonaceous, nature of the effluent, it was felt that the concentration and distribution of suspended, particulate, total carbon and nitrogen was of particular interest. With regard to the influence of the waste on the benthic communities of the area, particulate carbon levels were highest at stations 1 and 5 on separate sampling dates and were measured at 4.7 and 2.8 mg/l respectively; elevated carbon levels (>1 mg/l) were measured at stations 1, 2, 4 and 6. The distribution of suspended, particulate carbon was variable during the two sampling periods and appears to be dependent upon the direction of the prevailing winds. Generally, elevated levels of suspended, particulate carbon were restricted to the shore area both east and west of the discharge location due to the presence of onshore winds on the sampling dates. Suspended particulate nitrogen levels greater than 0.1 mg/l were associated with elevated carbon levels with only one exception.

BOD_5 levels were less than 1.0 mg/l at most stations. Stations 3, 4 and 7 had BOD_5 levels that ranged from 7.9 to 2.8 mg/l and were not associated with elevated particulate carbon and nitrogen levels.

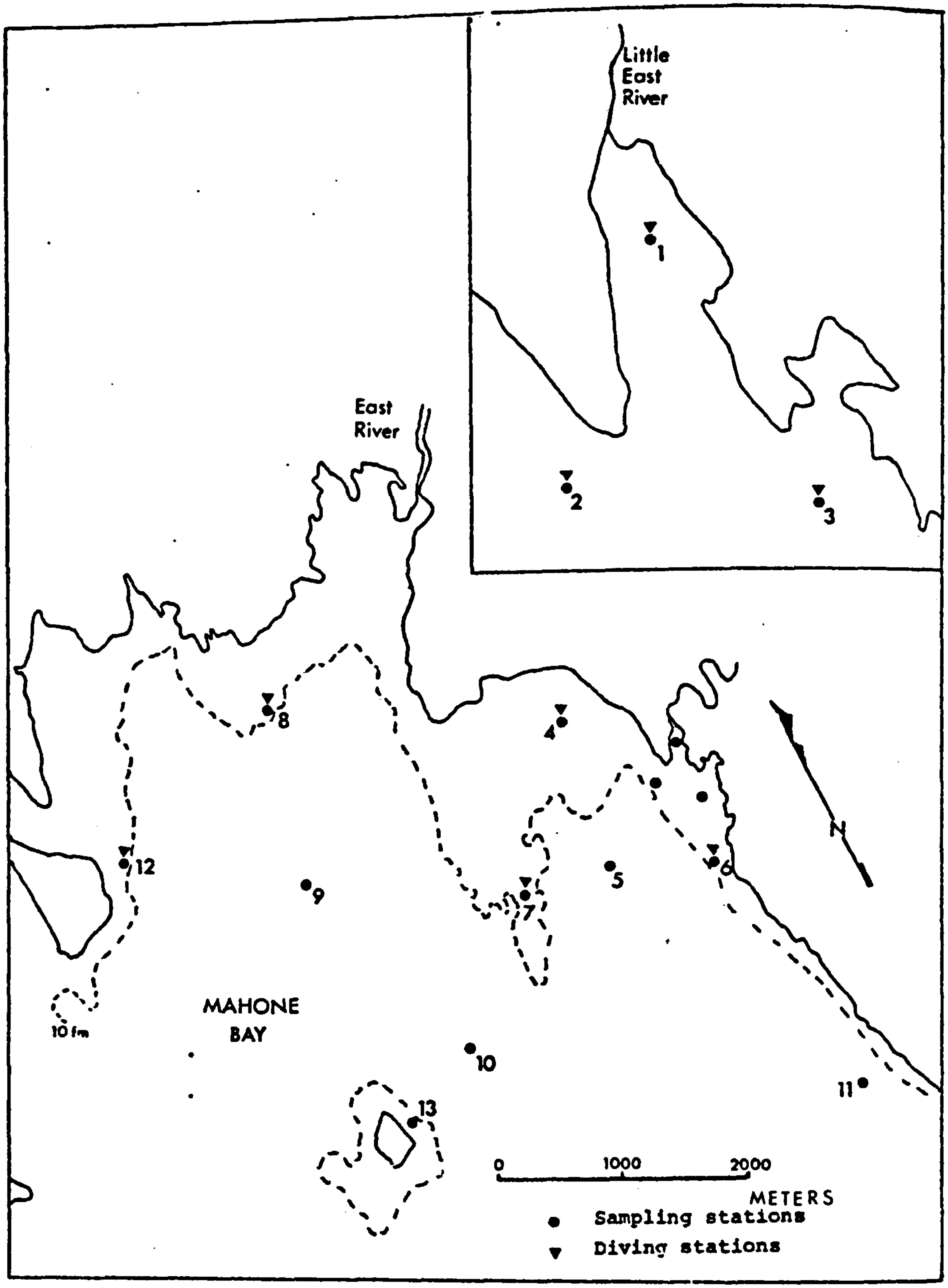

FIGURE 2 MAP OF SAMPLING STATIONS, MAHONE BAY, 1973

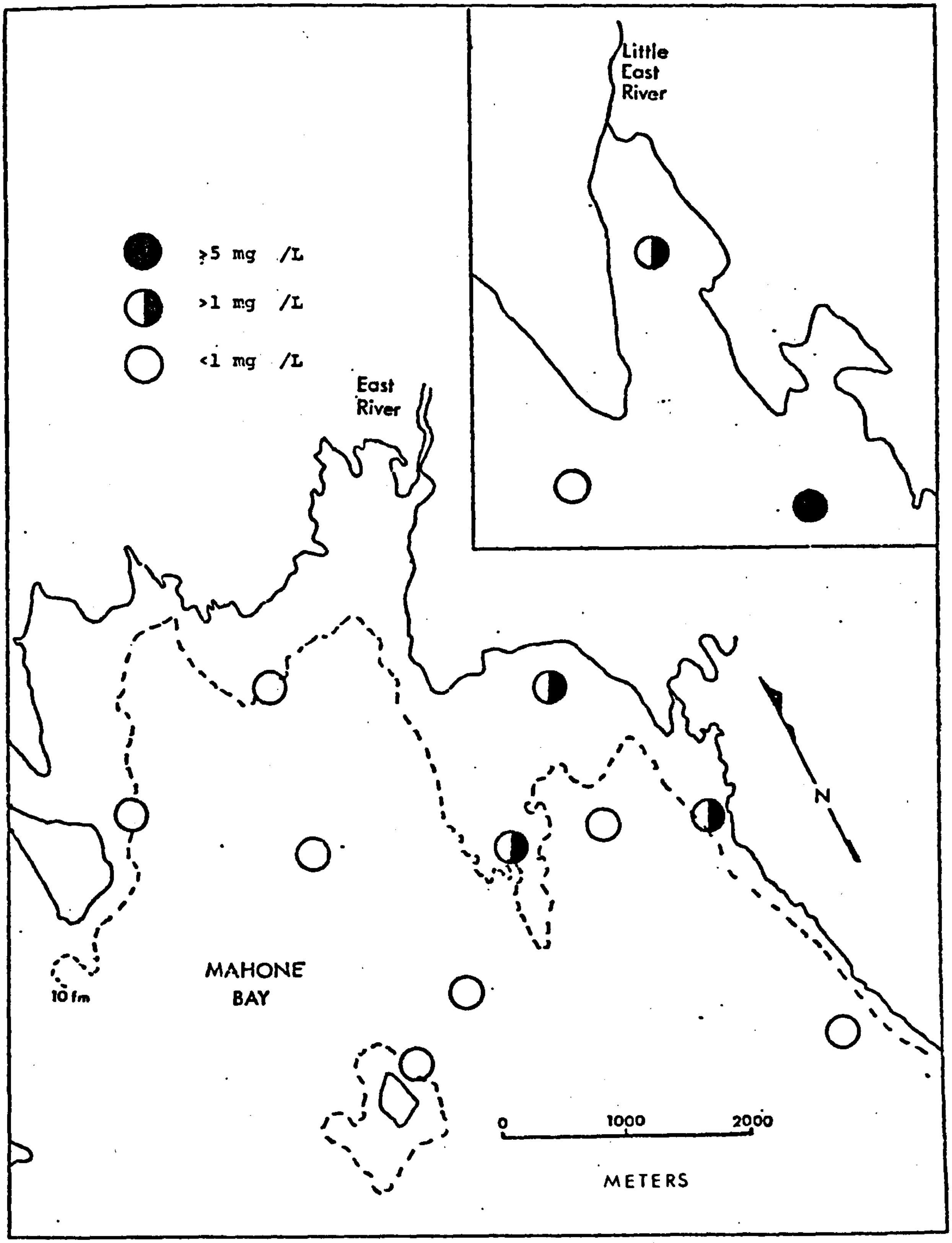

FIGURE 3 THE DISTRIBUTION OF BOD_5 LEVELS MAHONE BAY, NOVEMBER 22, 1973

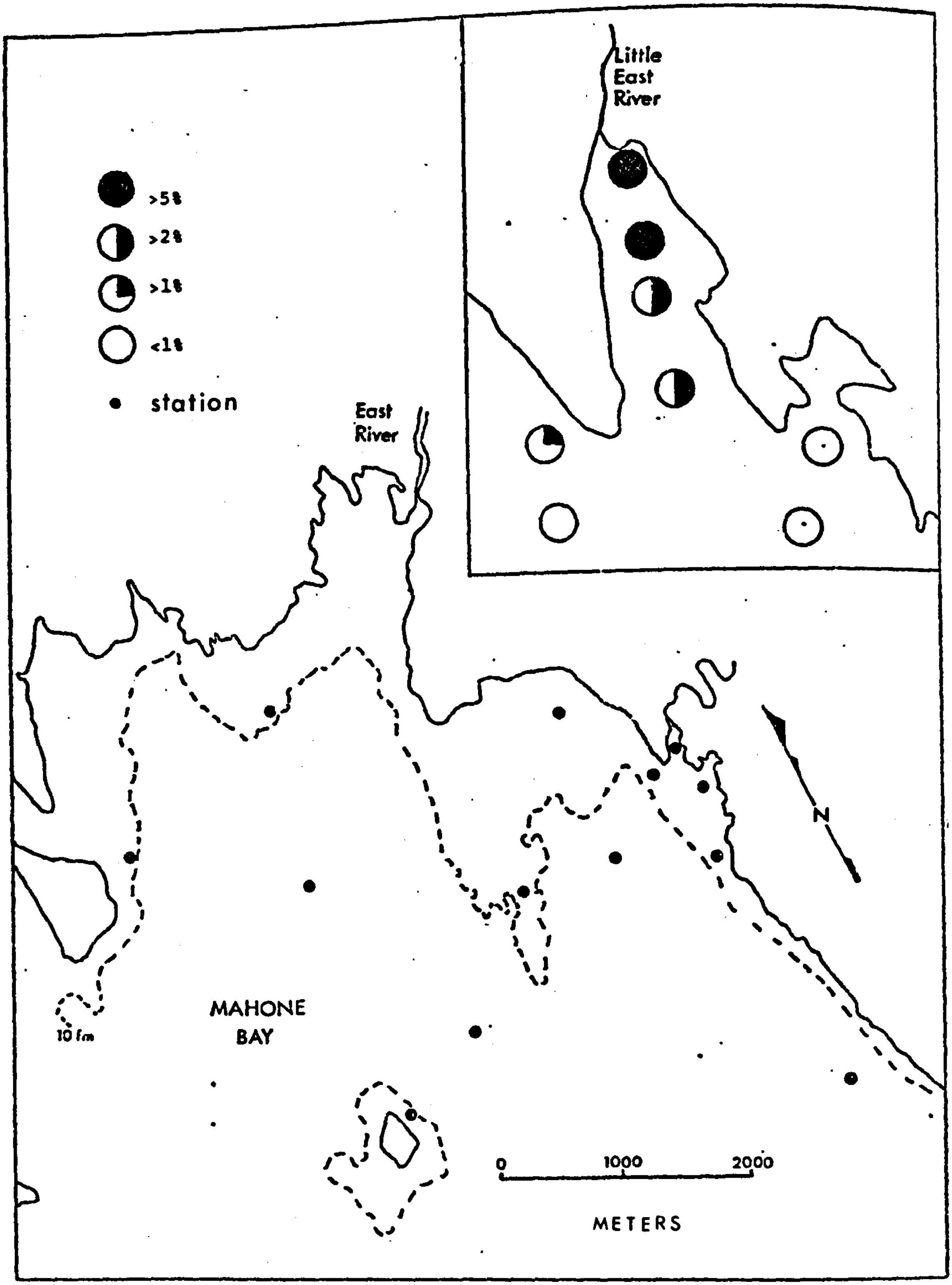

FIGURE 4 DISTRIBUTION OF TOTAL CARBON (PERCENT DRY WEIGHT) IN SEDIMENTS OF THE LITTLE EAST RIVER AREA OF MAHONE BAY, 1973

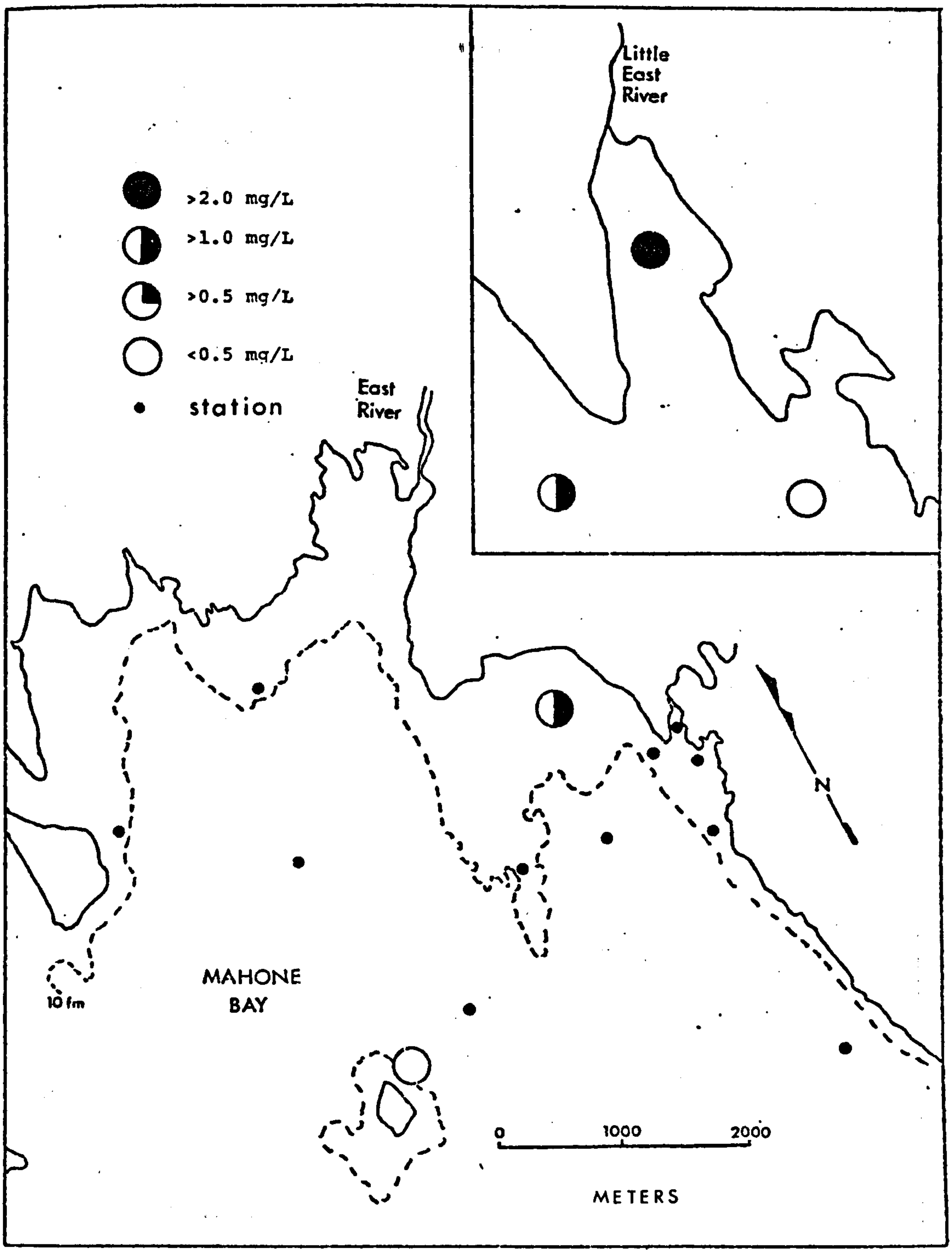

FIGURE 5 DISTRIBUTION OF SUSPENDED (>.8µ) PARTICULATE TOTAL CARBON IN THE LITTLE EAST RIVER AREA OF MAHONE BAY AUGUST 10, 1973

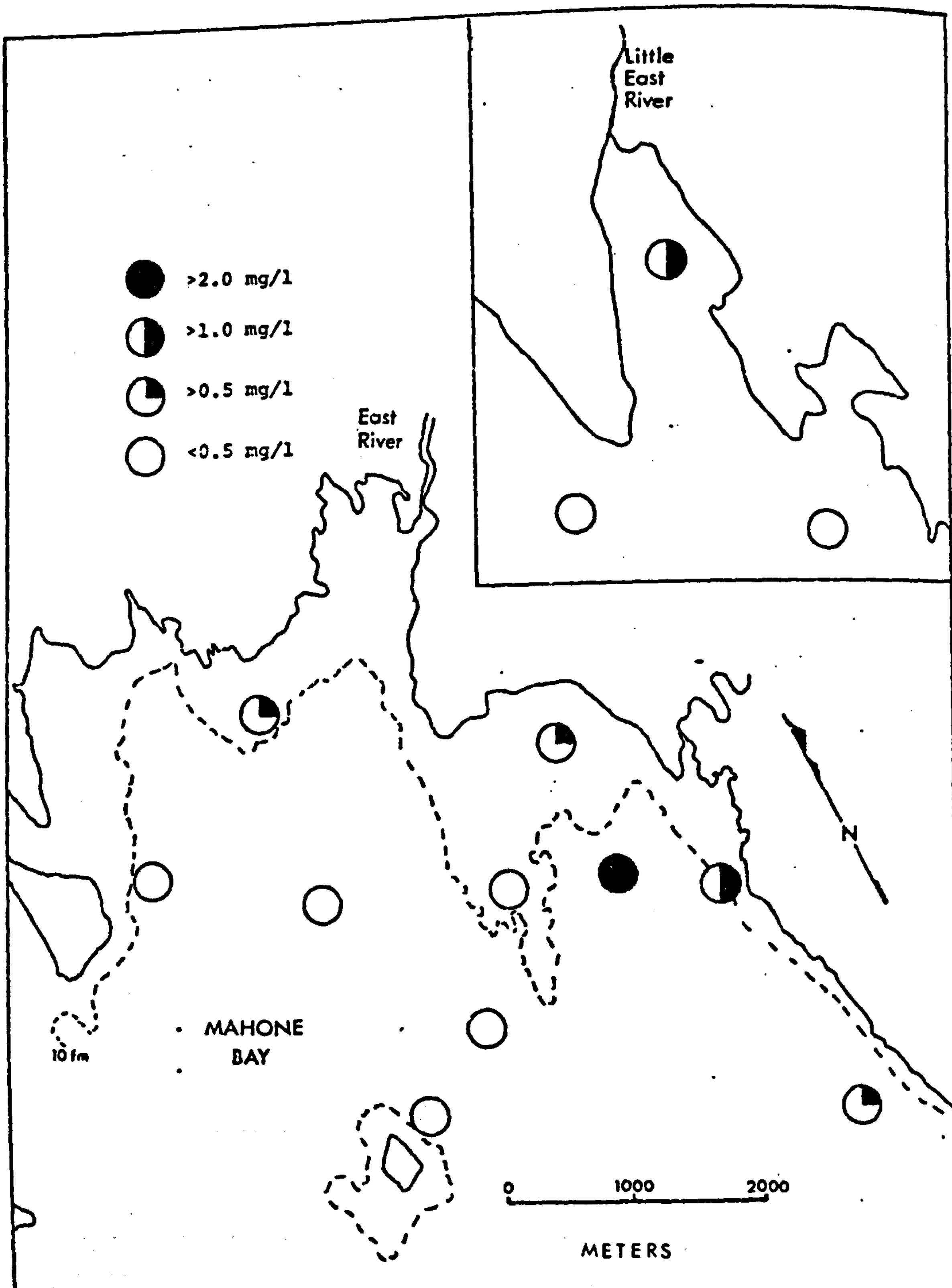

FIGURE 6 DISTRIBUTION OF SUSPENDED (>.8μ) PARTICULATE TOTAL CARBON IN MAHONE BAY, NOVEMBER 22, 1973

Sediment samples were collected at nine sites for total carbon and nitrogen analysis. Five of these were collected by Anil Canada Ltd. and analyzed by EPS laboratories. The highest carbon and nitrogen levels in the sediment occurred in samples taken from the intertidal and subtidal zones of the Little East River. Sediment from the intertidal zone had a carbon content of 12.2% and nitrogen content of 0.45%. Within the cove, subtidal sediment had a carbon content ranging from 8.8% to 3.1% and nitrogen content ranging from 0.48% to 0.19%.

Outside the cove, elevated carbon and nitrogen in the sediment were measured only at Station 2a. The divers did note the accumulation of a thin layer of material on the bottom at Station 4. Elevated sediment carbon levels were associated with elevated nitrogen levels. Values above background levels also occurred along the bottom of the cove and along the bottom near the shore, west of the headlands of the cove.

3.5 Bacteriological Assessment of Mahone Bay Receiving Waters

Based on the results of the Environmental Protection Service's 1972 bacteriological investigation of the area adjacent to the mouth of Little East River, a shellfish closure was recommended and approved (Baxter, 1972). The closure is described in Schedule G of the Nova Scotia Fishery Regulations as follows:

> "13-6A That portion of Mahone Bay, Lunenbury County, including Little East River, inside or north of a straight line drawn from Survey Monument No. 1 as shown on the Mahone Bay Area Plan to Survey Monument No. 2 as shown on that Plan."

Both total coliform and fecal coliform counts were high in this area as measured at 30 sampling stations. The source of these high populations of coliform bacteria is clearly Little East River. Figure 7 gives the distribution of some total coliform medians observed during the 1972 survey. Waters approved

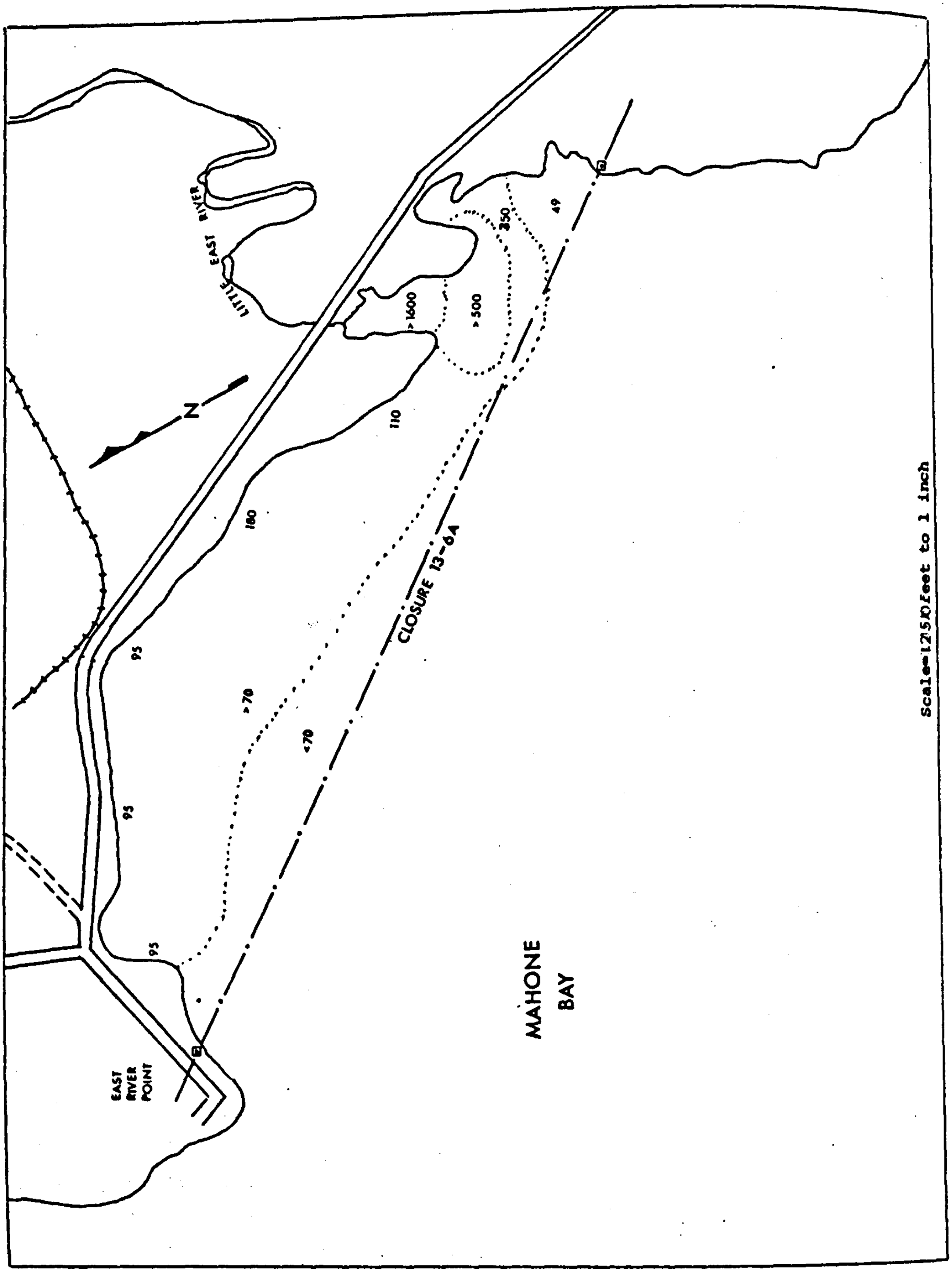

FIGURE 7 DISTRIBUTION OF TOTAL COLIFORM MEDIANS (MPN) SEPTEMBER 14 - OCTOBER 10, 1972 IN THE LITTLE EAST RIVER AREA OF MAHONE BAY

for the harvesting of shellfish must have a bacteriological water quality of 70 MPN Total Coliforms or less in order to comply with international shellfish agreements. High surface MPN (most probable number) values were observed to extend some distance westerly from the mouth of Little East River. This tends to confirm other water quality and water-current observations made during 1973. High MPN values were also present east of the river mouth, although they do not extend as far along this shore as they do on the western shore.

3.6 Biological Assessment of Mahone Bay Receiving Waters

During August and November of 1973, SCUBA investigations were carried out at nine stations adjacent to the mouth of Little East River and in Mahone Bay. Sampling locations are given in Figure 2. Station 13 represents a control site on the western side of Snake Island, approximately one mile from the mouth of Little East River. Table 3 is a list of the intertidal organisms collected in the cove (Station 1), and at the remaining sampling sites.

At Station 1, in the small cove into which Little East River flows, further deleterious effects of the effluent were observed. No macrophytes (i.e. *Fucus* sp., *Ascophyllum* sp.) were evident along the intertidal shore zone. With the exception of nematodes which were abundant in the areas of soft substrate, no fauna was observed in the intertidal areas (see Table 3). The absence of macrophytes is considered to be at least partly related to the reduced surface salinity caused by the discharge of Little East River. Reduced salinity would have also contributed to the scarcity of common intertidal invertebrates. However, the abundance of nematodes was clearly related to the anaerobic nature of the sediment caused by the deposition of particulate material near the river mouth (see Figure 2) and has been observed in other similar situations (Peer, 1972).

On the bottom of the cove near Station 1, *Volcella modiolus*, *Asteris vulgaris*, *Pagurus* sp. and *Metridium* sp. have

TABLE 3

QUALITATIVE BIOLOGICAL SAMPLING, INTERTIDAL RESULTS, MAHONE BAY, NOVA SCOTIA

Intertidal Species	Stations 1	2	3	4	13
Chlorophyceae					
Ulva lactuca	-	A	P	S	
Phaeophyceae					
Fucus evanescens	-	C	C	C	No samples taken
Fucus vesiculosus	-	A	A	A	
Ascophyllum nodosum	-	C	A	A	
Rhodophyceae					
Chondrus crispus	-	P	P	P	
Nematoda	A	A	A	-	
Mollusca					
Thais lapillus					
Littorina littorea	-	A	A	C	
Mytilus edulis	-	A	A	A	
Arthropoda					
Rivulogammarus sp.	-	A	A	-	
Balanus sp.	-	A	A	A	
Total number of Taxa observed	1	9	9	8	

Abundance Symbols:

P = Present in the area but relative abundance not estimated.

S = Sparse - widely scattered throughout the area but nowhere numerous.

C = Common - unevenly present throughout the area and only occasionally numerous and evenly distributed throughout the area.

A = Abundant - numerous and evenly distributed throughout the area.

TABLE 4

QUALITATIVE BIOLOGICAL SAMPLING SUBTIDAL RESULTS MAHONE BAY, NOVA SCOTIA

Subtidal Species	Stations 1	2	3	4	13
Phaeophyceae					
Ascophyllum nodosum	-	A	C	-	A
Fucus vesiculosus	P	P	C	C	A
Fucus serratus	-	-	-	-	A
Rhodophyceae					
Chorda sp.	-	-	-	-	A
Chondria sp.	-	-	-	-	C
Zostera marina	-	-	-	-	A
Coelenterata					
Metridium senile	P	A	A	C	-
Mollusca					
Nassarius trivittatus	-	-	P	S	-
Cerastoderma pinnulatum	-	-	P	-	-
Littorina littorea	-	A	A	A	A
Volsella modiolus	P	C	A	C	A
Placopecten magellanicus	-	S	S	-	-
Arthropoda					
Balanus sp.	-	C	A	-	A
Cancer irroratus	-	C	C	C	-
Pagurus acadianus	P	A	A	C	A
Homarus americanus	-	P	-	P	-
Amphipoda	-	-	P	P	-
Annelida					
Lumbrineridae	-	-	C	-	-
Arabellidae	-	-	C	-	-
Polynoidae	-	-	-	P	-
sp. unidentified	-	-	C	P	-
Echinodermata					
Strongylocentrotus droebachiensis	C	A	A	C	A
Echinarachnius parma	-	C	S	P	-
Asterias vulgaris	P	C	C	-	S
Henricia sangiunolenta	-	C	C	-	-
Chordata					
Tautogolabrus adspersus	-	-	P	P	-
Lophius americanus	-	P	-	-	-
Sculpin	P	C	-	P	A
Flounder	-	-	-	P	A
Sand Lance	-	-	-	-	A
Skate	-	-	-	-	-
Total number of Taxa observed	7	16	20	16	15

Abundance Symbols:

P = Present in the area but relative abundance not estimated.
S = Sparce - widely scattered throughout the area but nowhere numerous.
C = Common - unevenly present throughout the area and only occasionally numerous.
A = Abundant - numerous and evenly distributed throughout the area.

been observed (see Table 4). The observed layering effect of the effluent with the receiving water reduced the influence of the waste on the bottom community of the cove. The lack of plants on the bottom of the cove was probably due to insufficient photopenetration due to turbidity and the color of the effluent, and the gravel substrate which did not afford a suitable surface for holdfasts.

Water depth rapidly increased to approximately 14 fathoms beyond the headlands of the cove in the area of Station 2. The bottom community at this station was quite diverse. Organisms observed included both Homarus americanus (lobster) and Placopecten magellanicus (scallop). Communities at the remaining outer stations were diverse with a number of species being commonly represented (see Tables 3 and 4). In the area adjacent to the mouth of the cove, sea anemones were abundant and some of these anemones were the largest seen by the divers during this summer's field program.

Similar bottom areas in the Mahone Bay, St. Margaret's Bay, and the approaches to Lunenburg Harbour were observed to have comparable numbers of organisms, although the communities were observed to differ in the relative abundance of certain species. Several of these species which were observed at the diving sites and described "very common" to "abundant" included hermit crabs (Pagurus sp.) and anemones (Metridium sp.) in particular. These species appeared to be more abundant at stations 1, 2 and 3 than at other similar locations along this coast.

The presence of large numbers of anemones as found in this area and the abundance of nematodes in the immediate cove area suggested an unnatural or unbalanced system. Although the number of taxa observed were comparable at most stations (excluding Station 1) to other clean water environments, the observed abundance of certain organisms suggested decreased diversity.

The abundance of Metridium sp. at Station 2, in particular, might well be related to the presence of increased suspended particulate material of organic origin at this sampling site (see Figures 5 and 6). This particulate material in the water column might favor the occurrence of a relatively nonselective suspension feeder such as Metridium sp. Jones (1971) refers to Actinia sp. as such a feeding type. However, it should be noted that Metridium sp. is nonselective only with regard to particle size. Feeding is initiated by mechanical and most importantly by chemical stimuli (Batham and Pantin 1950). Reaction to mechanical stimuli undergoes rapid adaptation and inert material is usually rejected. Definite preferential behavior to particular chemical stimuli has been shown in Anemonia sulcata (Pantin and Pantin 1943). The presence of Metridium in similar conditions of pollution has been noted by the authors. Other species such as Corynactis californica have been reported as abundant on submerged sewage outfalls in California (Turner et al 1966). To summarize, the factors governing the occurrence of Metridium sp. at these sites are unknown, and physical and chemical characteristics apart from particulate organic material may well be governing factors.

Generally speaking, the discharge of the effluent into the marine environment did not appear to have an extensive effect on species diversity nor abundance, beyond the headlands of the cove. However, there were several important factors which acted to prevent the occurrence of a much more serious situation. The waters outside the small cove are deep and the area is well flushed. These two factors, both of which increase the rate of dilution, enable a large volume of effluent to enter the system with limited adverse effects on the immediate area. Secondly, the effluent consisting of fresh warmer water sets up a layering effect with the clean, cooler saline water underneath. All species of shellfish and other benthic organisms in the subtidal area immediately adjacent to the discharge are not bathed directly in concentrated amounts of effluent. High carbon values on the bottom of the cove represent minor accumulations occurring on the gravel bottom; these solids, however, do not obscure the natural bottom. Suspended, particulate material is more widespread and probably causes increased turbidity and may interfere with light penetration along the adjacent shore and especially in the cove. The color of the effluent also adds to the latter effect. This color and suspended material whose distribution is primarily dependent on wind conditions, is particularly undesirable west of the headland of the cove in view of the fact that this is a beach area which is utilized for recreational purposes.

4 EFFLUENT CRITERIA

The mill was expanded in 1971 and is, therefore, defined as an "expanded mill" by the Federal Pulp and Paper Effluent Regulations (Environment Canada, November 1971). The regulations for BOD_5 and suspended solids are applicable from the date of start-up of the new line and the mill is now in violation of these regulations.

The Federal Pulp and Paper Effluent Regulations show an allowable discharge of suspended solids of 15 lbs/ton of product while no allowance has been set for BOD_5. The effluent must also meet the toxicity requirement.

The criteria for effluent discharge were given to the mill in a letter (C.P. Ruggles) of December 3, 1970.
These are:

1) Suspended solids - 15 lbs/ton of production
2) BOD_5 - 21 lbs/ton of production; and
3) Non-toxic to juvenile salmon for 96 hours at 65% effluent concentration.

The Nova Scotia Dept. of the Environment has stated that they will also be satisfied with the above criteria. Jointly the Environmental Protection Service and Nova Scotia Department of the Environment have also requested that the mill construct a pipeline to deliver the treated effluent to an adequate outfall/diffuser in Mahone Bay. The mill is required to supply a design report by March, 1974 describing the manner in which compliance with these criteria will be achieved. These effluent criteria are to be achieved no later than December, 1975.

5 CONCLUSIONS

1 The acute toxicity of the final effluent of the Anil Canada Ltd. mill at East River has not improved during the past three years.

2 Little East River is grossly contaminated and has poor water quality.

3 Little East River and the drainage area below the lagoons serve to remove suspended solids from the effluent and thus to partially treat the effluent, which protects to a degree, the Mahone Bay receiving waters.

4 Both Little East River and the cove at the river mouth are aesthetically objectionable due to the color, odor, and turbidity of the effluent.

5 Little East River is clearly the source of high coliform counts in the cove adjacent to the mouth of the river which results in an area closed to shellfish harvesting.

6 Other ecologically deleterious effects of the effluent appear to be restricted to the area between the aerated lagoon and the headlands of the cove, a distance of approximately 2 1/2 miles.

7 Aesthetically objectionable color and solids are apparent on the shore 2000 meters from Little East River Cove depending upon the direction of the wind.

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APPENDIX

TABLE 1A

WATER QUALITY RESULTS
MAHONE BAY
AUGUST 10, 1973

PARTICULATE

STATION	Total Suspended Solids mg/l	Carbon Total >.8μ mg/l	Nitrogen Total >.8μ mg/l	Cu >.45μ mg/l	Zn >.45μ mg/l	Pb >.45μ mg/l	Fe >.45μ mg/l
1	75.5	4.765	0.328	0.001	0.003	0.015	0.138
2	40.0	1.198	0.157	0.002	0.007	-	0.488
3	15.6	0.256	.048	0.001	0.015	0.001	0.027
4	36.2	1.337	0.128	.001	0.004	-	0.083
13	15.4	0.232	0.045	.001	0.007	0.002	.038

DISSOLVED (<.45μ)

STATION	Nitrite -N mg/l	Nitrate -N mg/l	Ortho Phosphate mg/l	Hydrolyzable Phosphate mg/l	Cu mg/l	Zn mg/l	Pb mg/l	Fe mg/l
1	0.013	<.005	0.150	<.025	.004	.014	.003	.090
2	0.200	<.005	<.010	0.148	.002	.011	-	0.130
3	<.005	<.005	0.010	0.100	.005	.018	.001	0.120
4	.017	<.005	<.010	0.098	.004	.017	-	0.100
13	-	-	<.010	0.106	.005	.011	.005	0.170

TABLE 2A

WATER QUALITY RESULTS
MAHONE BAY
NOVEMBER 22, 1973.

STATION	BOD_5 mg /1	SUSPENDED SOLIDS mg/1	PARTICULATE >.8μ TOTAL CARBON mg/1	TOTAL NITROGEN mg/1	C/N
1	1.3	12.2	1.137	0.054	21.0
2	0.8	29.0	0.602	0.065	9.2
3	7.9	41.0	0.201	0.016	13.0
4	3.5	27.4	0.710	0.064	11.1
5	0.4	41.2	2.820	0.321	8.8
6	1.0	27.0	1.204	0.130	9.3
7	2.8	44.2	0.212	0.025	8.5
8	0.5	32.4	0.791	0.065	12.2
9	0.8	12.8	0.230	0.016	14.8
10	0.4	28.4	0.462	0.046	10.0
11	0.7	36.4	0.672	0.080	8.4
12	0.1	2.0	0.228	0.016	10.8
13	0.5	21.0	0.150	0.015	10.1

TABLE 3A

ANALYTICAL RESULTS OF SEDIMENT SAMPLES FROM THE LITTLE EAST RIVER AREA OF MAHONE BAY, 1973

DATE	STATION	C % dry wt.	N % dry wt.	C/N	Cu ppm	Pb ppm	Zn ppm	Fe ppm
10/25	1. A	12.21	0.445	27.45	-	-	-	-
10/25	1. B	8.81	0.480	18.35	-	-	-	-
10/25	1. C	3.04	0.185	16.71	-	-	-	-
10/25	1. D	3.93	0.264	6.78	-	-	-	-
10/25	2.	1.63	0.132	12.67	-	-	-	-
8/13		0.531	0.068	7.85	<2	6	19	2500
10/25	3.	0.400	0.054	7.68	-	-	-	-
		0.230	0.047	4.93	2	8	16	8000
		0.225	0.033	6.94	<2	4	10	1350
10/8	13.	0.514	0.066	7.84	9	<1	62	2350

TABLE 4A

PHYSICAL AND CHEMICAL CHARACTERISTICS
AT SAMPLING SITES AUGUST 8, 1973
MAHONE BAY

STATION	DEPTH meters	D.O. mg/l	TEMP. °C	SALINITY ppt	SECCHI VISIBILITY meters
1	1	11.2	19.3	23.5	1-2 (inches)
2	15	8.5	6.9	31.7	2
3	6	-	11.1	31.5	1.5
4	3	-	22.6	25.4	1
13	13	12.9	9.9	32.1	4