INTERNATIONAL TECHNOLOGY CORPORATION

RESPONSIVE TO THE NEEDS OF ENVIRONMENTAL MANAGEMENT

DIAGNOSTIC/FEASIBILITY STUDY
FOR ONOTA LAKE, PITTSFIELD, MASSACHUSETTS

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FOR ONOTA LAKE, PITTSFIELD, MASSACHUSETTS

PREPARED FOR:

THE MASSACHUSETTS DEP
DIVISION OF WATER POLLUTION CONTROL

PREPARED BY:

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EXECUTIVE SUMMARY

ABSTRACT

A Diagnostic/Feasibility Study of Onota Lake was conducted by IT Corporation for the City of Pittsfield, Massachusetts. The purpose of the study was to identify factors which have contributed to the degradation of the lake, quantify their impact, and recommend strategies for their mitigation. Field sampling took place from March, 1986 through March 1987.

Problems identified during the course of the study included:

1) Excessive growth of aquatic macrophytes
2) Severe dissolved oxygen depletion in the hypolimnetic waters
3) Sediment accumulation
4) Impacted fishery resulting from dissolved oxygen limitations.

These problems were attributed to urbanization of the watershed, faulty agricultural practices and stormwater runoff.

The management and restoration plan devised for Onota Lake incorporated both long-term and short-term measures. Long-term watershed management measures were recommended to address the source of the problems in the lake. Included in the recommendations were sewering, the implementation of more stringent zoning ordinances, and enforcement of soil erosion control ordinances.

In order to realize an immediate tangible improvement, short-term, in-lake procedures were also recommended. These included weed harvesting, public education, hypolimnetic aeration, dredging, and modification of the lake's flow pattern.

Lake eutrophication is a natural aging process which proceeds over a period of thousands of years. During this process, the lake undergoes a series of successional changes from a clear, clean water body to a marsh and eventually solid land, as a result of erosion and sedimentation of the soils and rocks within the lake's watershed and the associated input of fertilizing nutrients. The combined effect of these processes contributes to the decline of the lake's water quality and results in the "filling in" of the lake due to the deposition of both silt and organic material (decayed macrophytes, algae, fish, etc.)

Anthropogenic activities, such as construction, agriculture, and discharge of sewage effluent accelerates the natural eutrophication process. This phenomenon, associated with watershed urbanization, is referred to as cultural eutrophication. The eutrophication process, even when subjected to the accelerating effects of cultural eutrophication, still proceeds slowly over thousands of years. However, the negative effects of nutrient enrichment and sedimentation may become apparent within a very short time frame. Initially, the changes in water quality seem minimal, perhaps increased turbidity or a slight greenish hue to the water. Eventually, problems related to the development of algal scums, the growth of nuisance aquatic macrophytes, unpleasant odors, and fish kills are observed. Under such a scenario, the lake may degrade from a pristine state to a condition where the aesthetics, recreational potential, and water quality are below acceptable levels within a few years.

Nutrients include inorganic compounds such as phosphate and nitrate, and organic, or carbon based materials. As the amount of nutrients entering a lake increases, so does lake productivity. Organic material will stimulate bacterial activity, and inorganic material will stimulate the growth and development of primary producers such as phytoplankton, algae and aquatic weeds. Respiration by bacteria during the decomposition of organic material, and by plants, at night when they are not photosynthesizing, may tax the oxygen content of the lake to a point where more sensitive organisms can no

longer be supported. Although oxygen depletion is initially observed in the hypolimnion, the deep non-mixed water of the lake, during summer stratification eutrophication, oxygen depletion (anoxia) may occur even in the surface waters.

There are numerous natural sources of nutrients to a lake. Usually, the annual contribution from such sources is relatively low and does not promote excessive growth and production of algae and aquatic weeds. Human activities which disturb the soils and promote erosion, such as improper logging, farming, and construction practices, increase the contribution of fertilizing nutrients to the lake. The discharge of stormwater, municipal or industrial sewage and septic leakage serve as additional nutrient sources. Increased nutrient contributions stimulate the growth and development of phytoplankton, algae and aquatic weeds to nuisance levels. At high densities, the aesthetic and recreational attributes of the lake are decreased due to discoloration of the water and the impairment of swimming and boating. In addition, taste and odor problems may occur. Upon their death, the tissues of the primary producers settle to the bottom of the lake. Bacterial decomposition of this material decreases oxygen levels in the lake. Nutrients associated with these tissues initially become chemically bound with the sediments. However, when environmental conditions are correct and oxygen levels are low, these nutrients are released and recycled into the water column and further stimulate plant growth in subsequent years.

Thus, cultural eutrophication effects a lake as follows:

1) Primary producers increase to nuisance densities and reduce the water quality, aesthetics, and recreational attributes of the lake.

2) Death and decomposition of these primary producers contributes to the depletion of oxygen in the deep areas of the lake due to bacterial respiration. The shape of the lake and the volume of the hypolimnion may exacerbate the oxygen depletion problem.

3)   The depletion of oxygen shifts the composition of the fish and other organisms toward that characterized as pollution tolerant. Most of these fish species are of poor harvestability and angling potential.

4)   The internal recycling of sediment released nutrients within the lake may contribute additional nutrients further stimulating plant growth.

5)   The deposition of sediments transported to the lake as a result of watershed urbanization and organic material associated with in-lake productivity contribute to the "filling in" of the lake and its eventual extinction.

By examining key physical, chemical and biological parameters of a water body, the extent of eutrophication, referred to as trophic status, can be measured and quantified. Limnologists have historically classified lakes in terms of their productivity. Lakes of low productivity in which no organic matter is sedimented are termed oligotrophic while those of elevated productivity are termed eutrophic. Those lakes which are somewhat productive and are in the stage where organic matter is initially being deposited are referred to as mesotrophic. This classification scheme, although simplistic, provides a means by which the condition of lakes can be qualified in very general terms. A more detailed assessment of lake trophic status involves measuring nutrient concentrations water transparency, lake flushing rate and the density of aquatic weeds and phytoplankton.

In order to assess the ecological conditions of Onota Lake, a comprehensive limnological investigation was conducted. The purpose of the study was to identify those factors which have contributed to the degradation of the lake, quantify their impact, and determine what must be done to improve the condition of Onota Lake. In brief:

1)   Onota Lake presently receives an annual load of fertilizing nutrients substantial enough to promote the growth of aquatic weeds to nuisance densities throughout the north basin and in the shallow backwaters of the south basin.

2)   The majority of nutrients originate from diffuse, nonpoint sources, but
     improperly functioning septic tanks and a leaking sewer line are
     responsible for a portion of the annual nutrient load.

3)   A large amount of organic matter (dead plant tissue and phytoplankton
     cells), sinks to the bottom of the lake. Temperature and density
     differences between the surface and deep water layers physically prevent
     mixing of the deep water and replenishment of its dissolved oxygen
     content throughout the summer. As a result, bacterial respiration,
     associated with the decomposition of the plant tissues, depletes the
     dissolved oxygen content of the deep water layer. This occurs primarily
     in the south basin, and to a lesser extent in the north basin.

4)   Oxygen depletion in the deep, cool waters affects the fishery of the
     lake as trout and many other game species require cool, well oxygenated
     water throughout the year. The deep cool waters of Onota Lake, which
     amounts to a significant percentage of its total volume, are void of
     oxygen throughout the summer. Valuable habitat needed for the
     maintenance of a cold water fishery has been lost.

5)   During the winter, ice cover coupled with reduced water flow, decreases
     the opportunity for oxygen exchange in the north basin. The bacterial
     decomposition of accumulated organic detritus leads to a depletion of
     oxygen, and could potentially trigger a winter fish kill.

6)   Future development in currently forested areas of the lake's watershed,
     could substantially accelerate the lake's eutrophication. Guidelines,
     ordinances and zoning which could control or mitigate potential
     development impacts must be developed and enacted.

Thus, problems and symptoms associated with accelerated eutrophication of
Onota Lake have been observed. The initial effects have been a decrease in
water quality, the loss of valuable fishery habitat, and impaired recreational
utilization of the lake. The further demise of the recreational
attractiveness of the lake must be halted and restoration measures
implemented.

The means by which the accelerated eutrophication of Onota Lake can be mitigated or abated is provided within the context of the restoration/management plan. The primary goal of this plan is to decrease nutrient and sediment loading. This goal is achievable only through a comprehensive, well coordinated <u>watershed management program</u>. Such a program must focus on reducing point and non-point source pollution contributions. Simultaneously, due to the recreational importance of Onota Lake, it is necessary that an intensive <u>in-lake restoration and management program</u> be implemented immediately. The in-lake program must focus on ameliorating symptoms of accelerated eutrophication such as weed growth, silt accumulation and degradation of the fishery. Through such a program, immediate, user orientated improvements in lake quality could be realized. Thus, a restoration/management study which encompasses both in-lake and watershed techniques has been proposed for the long-term improvement of the lake, as well as short-term symptomatic relief.

Such an approach insures that over the long-term, future eutrophication of the water body is better controlled. In addition, it also guarantees that during the implementation of the long-term program, the aesthetic and recreational attributes of the lake are not compromised any further. The specifics of the Onota Lake restoration/management plan are discussed within the text of this report. A summary of the overall scope of the prescribed plan is as follows.

Watershed Management

1) Reduction in loading of septic inputs through sewering of the Blythewood Drive area and repair of the leaking Pecks Road sewer line.

2) The use of passive treatment devices such as retention basins and catch basins to decrease the stormwater related contribution of pollutants and sediments.

3) Enforcement of existing soil erosion control ordinances in order to reduce soil transport and the subsequent filling of the lake. This includes stabilization of existing sources of eroded soils.

4) Sound land use management to avoid improper development of lake shore
    properties, environmentally sensitive areas and land adjacent to the
    tributaries of Onota Lake. The sub-basins along the lake's southwest
    shore would benefit from environmentally sensitive ordinances, which
    could help avoid improper development of these open areas.

5) Use of non-phosphorus detergents and low phosphorus fertilizers.

6) Public education through seminars, flyers, etc. to inform the users and
    residents of the lake how they themselves can protect the lake.

In-Lake Restoration

1) The use of mechanical weed harvesters to decrease the density and
    distribution of aquatic weeds throughout the lake.

2) Short circuiting of flow, through the creation of a culvert under the
    Thomas Island causeway. This should help divert nutrient rich waters out
    of the north basin of the lake and promote the flushing of certain
    sections which are currently stagnant.

3) Aeration of the hypolimnion of the lake's south basin as a means of
    decreasing the annual regeneration of phosphorus from the lake's anoxic
    sediments during the summer. In the north basin aeration should be
    implemented in the winter in order to avoid winter kill.

4) Dredging selected areas of the lake to remove accumulated nutrient rich,
    highly organic sediments which presently serve as an internal source of
    nutrients for the lake's aquatic macrophytes.

5) Restoration and improvement of the lake's fishery, particularly in terms
    of available habitat.

6) Restriction in motor boat speed in certain areas of the lake. This could aid in decreasing the spread of _Elodea_ and reduce the opportunity for nutrient release from shallow littoral sediment currently disturbed by boat propellers and wakes.

The watershed and in-lake management approaches presented above are not prioritized. It would be very effective, however, if the in-lake restoration tasks begin with the short circuiting of flow. This project would entail the placement of a culvert under Thomas Island Road and sediment removal from Thomas Island Cove and the small cove north of the causeway. Removal of this material would greatly reduce the organic load and weed densities which presently plague the north basin. With the culvert in place, harvesting equipment and winter aeration would not be needed. The remaining macrophyte problem would probably be best controlled through contract harvesting. Creation of an in-lake sediment catch basin south of Dan Casey Memorial Causeway could also be scheduled so as to coincide with the culvert project thus making effective use of dredging equipment.

In conjunction with the restoration/management plan, a public education/ involvement program is highly recommended. In this way, the public will come to realize that the restoration of Onota Lake will benefit all those who directly and indirectly utilize or rely on the lake. They will be informed of those practices that can be implemented individually on a voluntary basis to reduce nutrient inputs into the lake. Only through public support and involvement can the prescribed plan be accomplished.

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1.0 ONOTA LAKE - GENERAL DESCRIPTION AND IDENTIFICATION

Onota Lake is located in the northwest sector of the City limits of Pittsfield and just southwest of Pontoosuc Lake (Figure 1). This 250 hectare lake is the largest body of water in the upper Housatonic River Basin. The lake itself is entirely within the City of Pittsfield but some portions of the lake's watershed encompasses areas of Hancock and Lanesborough. A total of six tributaries flow into the lake, the largest being Parker Brook which drains an extensive area of the Pittsfield State Forest. The outlet of Onota Lake, Onota Brook, flows southeast into Pecks Pond before entering the West Branch of the Housatonic River in Pittsfield.

Local climate is characterized as humid with a temperature regime characteristic of the North Temperate Zone. The mean annual temperature is approximately 46°F. Record temperatures are a high of 95°F and a low of -25°F recorded at the Pittsfield airport. Weather patterns alternate roughly twice-weekly from fair to cloudy or stormy conditions. It is infrequent for any regular weather pattern to continue for several weeks. Changeability is the most normal characteristic, and a "normal" month, season, or year is indeed the exception rather than the rule.

Precipitation averages about 117 cm annually, and is rather evenly distributed throughout the year. The average monthly precipitation varies from a low of 6.9 cm in October to a high of 10.9 cm in April. Much of the winter precipitation falls as snow which averages about 190.5 cm annually. Continuous snow cover lasts on the average from 2 to 3 months depending upon the elevation.

The topography of the Upper Housatonic River Basin is typical of Berkshire County. The Basin can be divided into a three-part physiographic system consisting of the valley of the Housatonic River and its major tributaries, the highland area to the east and the Taconic Range on the west. Elevations range from a high of 800 meters above sea level at Brodie Mountain in Hancock to a low of approximately 290 meters above sea level near the Pittsfield-Lenox boundary. The valley area ranges from 290 to 335 meters above sea level. The

ONOTA LAKE

PITTSFIELD

LANESBOROUGH

PITTSFIELD

LENOX

OND

INSET MAP

ONOTA LAKE

MASSACHUSETTS

N
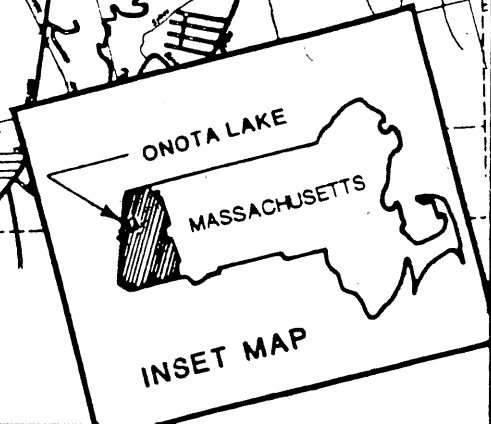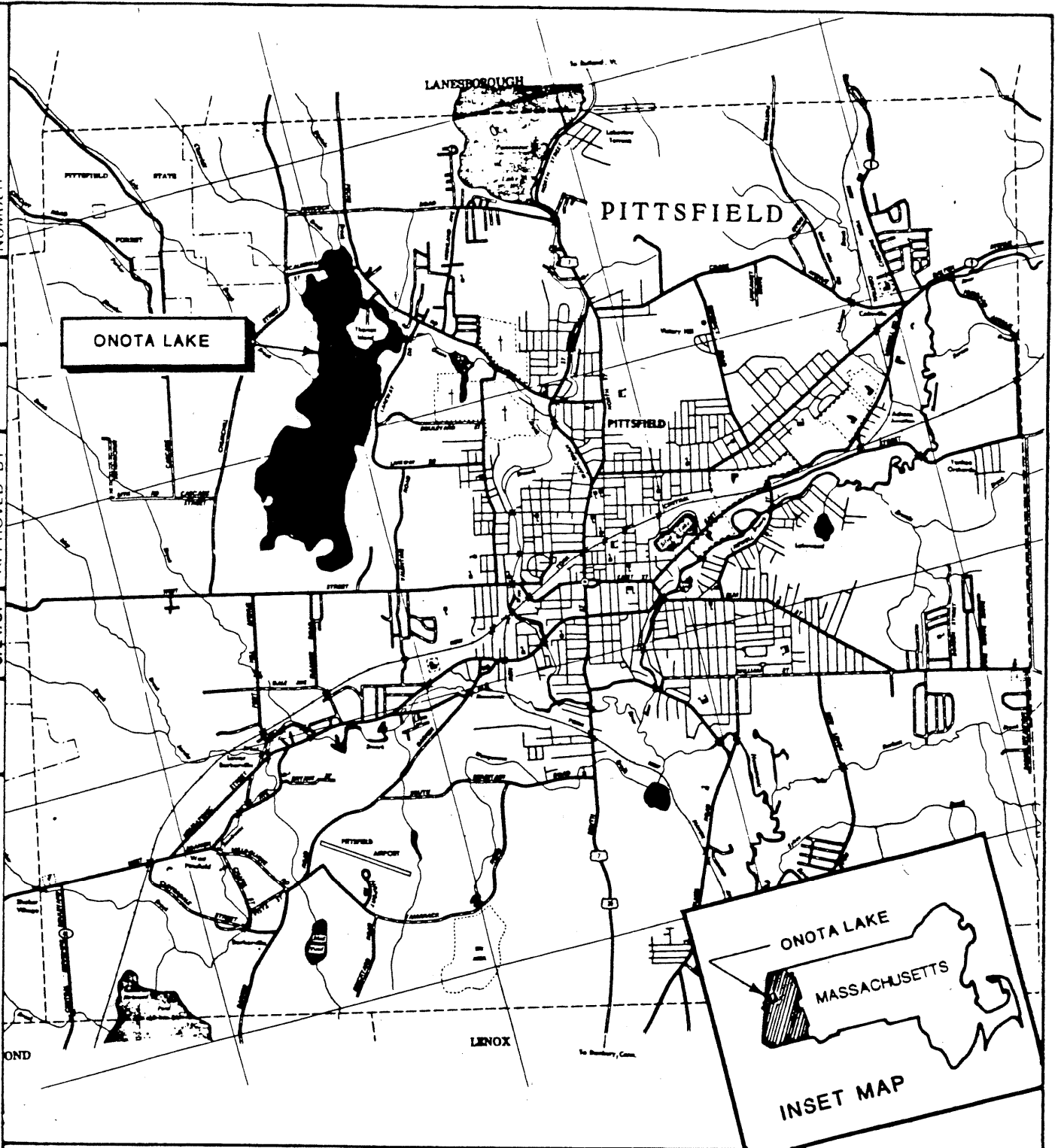
FIGURE 1
SITE LOCATION MAP
ONOTA LAKE
PITTSFIELD, MASSACHUSETTS
IT PROJECT NO. 1645

IT

132298

Do Not Scale This Drawing

Taconic Range and the eastern highland area exhibit relief of about 305 meters above the valley floor.

Residential development around Onota Lake and its immediate watershed is very sparse. The northeastern section of the watershed is the most densely populated. Specifically this encompasses the residential areas of Thomas Island and the more northern end of Pecks Road. Some development also exists along Churchill Street and Blythewood Drive in the western section of the watershed. There are quite a few residences which have been converted from seasonal to year-round occupancy. The average residence time is 0.895 years or approximately eleven months per year. As is common for the larger lakes in Berkshire County, there are several summer camps and a city park in the lake's immediate area. Burbank Park, a public access area to Onota Lake, has undergone extensive improvements as of late including construction of a new boat ramp and fishing pier, designated use areas and planning for a new pavilion.

2.0 PRESENT AND HISTORICAL USES OF ONOTA LAKE

Onota Lake, once known as West Pond and nicknamed "Lake of the White Deer" has a long history of recreational utilization. Onota Lake provides a wide variety of recreational activities including fishing, swimming, boating and water skiing. Of the numerous lakes and ponds located in Berkshire and Franklin Counties, Onota Lake is one of the few which provides public access in the form of beach, park, boat ramp and fishing pier. Silver Lake, Goodrich Pond, Morewood Lake, Mud Pond and Pecks Pond, in addition to Onota Lake, are located within Pittsfield City limits. There is no public access to Pecks Pond. Silver Lake, Mud Pond, and Morewood Lake are accessable only to lake residents (MDWPC, 1976). Goodrich Pond does have a public boat ramp, but the pond is only 13 acres in size. In term of water quality, all but Onota Lake are classified as eutrophic, and it is the only Pittsfield Lake routinely stocked (MDWPC, 1976). Richmond Pond and Pontoosuc Lake lie partially within Pittsfield's boundaries. Although both water bodies offer public access and are important recreational lakes, they are plagued by aquatic macrophyte problems and do not offer the recreational potential of Onota Lake. This is particularly true in respect to sport fishing.

The City of Pittsfield has extensively improved public access to Onota Lake. Since 1968, Burbank Park, located along Lakeway Drive on the lake's eastern shore, has undergone a series of upgrades. Pittsfield officially purchased the water rights to Onota Lake from the Berkshire Woolen Company in 1971. Initial improvements consisted of the construction of a fishing pier (1976) and a new boat ramp (1984). To better meet the recreational needs and interests of lake users, designated use areas have been developed. The objective of these areas is to decrease the negative interaction of different users, such as water skiers, power boaters, sailboarders and swimmers. This has resulted in a more orderly use of the lake and has decreased the potential for mishap. Burbank Park provides the following user amenities: boat ramp (2 car), fishing pier, on-site parking, swimming beach, picnic areas, sailboard access, public pavilion, and rest rooms.

Lake's and reservoirs are typically important community focal points. Not

only do they provide aesthetic qualities, but serve as a source of recreational enjoyment. Major recreational waterbodies may even play an important role in the regional economic base (Souza and Perry, 1977). To establish the recreational use of the lake, a survey was distributed to local residents. Of 314 questionnaires circulated, 95 were returned (Table 2.1).

The survey results indicate that the more popular recreational activities are: boating, swimming, fishing, and water skiing (Table 2.1). Of those surveyed, 73% have access from their property, while the remainder use the boat ramp or the public beach. The greatest percentage of boats on the lake are motorized (41%). Other boating includes canoes, rowboats, and sailboats. Based on the survey, Onota Lake is used primarily from April through October. Of those surveyed, 24% use it week days only and 17% use it weekends only. It should be noted though that this survey solicited information primarily from lake residents. The utilization of Burbank Park, the fishing pier and the boat ramp is probably more greatly skewed toward non-lake residents. The proximity of the lake to Pittsfield as well as its excellent reputation as a game fishing lake probably results in a larger number of non-resident and day users than indicated by the survey. Improvements to the park will probably increase the number of transient users. Informal surveys conducted during water quality monitoring activities, found the lake to be used throughout the year. There were usually individuals fishing from the pier, even during inclement weather. During the summer, the parking lot near the boat ramp was often near capacity.

The popularity of the lake is largely a result of the long term stocking and fishery management of the lake. Available data reviewed as part of this study show that stocking of the lake with game fish dates back to the early 1900's. A list of some of the fish historically introduced to the lake are listed below:

Species	Number	Date
Largemouth Bass	9,000	1917-1952
Smallmouth Bass	96,500	1914-1948
Bullhead	37,500	1916-1945
Pike Perch	4,345,000	1915-1937
Yellow Perch	1,500,000	1915-1945

Smelt	7,450,000	1903-1937
Brown Trout	17,900	1933-1955
Rainbow Trout	113,000	1902-1951
White Perch	1,100	1923-1933
Crappie	6,000	1928-1930
Pickerel	1,100	1932-1945
Silver Trout	50,000	1920
Kokanee Salmon	10,000	1970-1973

Management techniques have included the application of rotenone in 1957 for the control of non-game fish densities. Creel census data indicate that over 50,000 angler hours per season is not unusual (MDFG, 1972, 1973 and 1978; Daly, per Comm, 1987). Interestingly, since 1947 there has been a decline in trout habitat from approximately 40% of lake volume to about 25% (MDFG, 1956 and 1978). Apparently, this has not adversely affected the sport fishing utilization of the lake. The decrease in aerobic, cold water habitat has probably influenced the lake's summer holding capacity for trout, but since the lake is aggressively managed, the negative effects appear to have been minimized in respect to sport fishing pressure and/or attractiveness.

TABLE 2.1
SUMMARY OF RECREATION ACTIVITIES OF ONOTA LAKE

Number Distributed - 314
Number Returned   - 95

TYPE OF LAKE ACTIVITIES (PERCENT)		TYPE OF BOATS (PERCENT)		DAYS OF LAKE USE (NUMBER)*		ACCESS TO ONOTA LAKE (PERCENT)	
Fishing	23%	Sail	10%	April-Oct.	36	Ramp	6%
Boating	29%	In-board	17%	Once a Week	1	Home	73%
Swimming	27%	Row	16%	Daily	29	Boat Livery	1%
Camping	2%	Canoe	17%	Weekends	17	Causeway	2%
Water Skiing	13%	Outboard	24%	Year Round	7	Cove	1%
Other	2%	Other	2%	No Response	21	Beach	3%
None	4%	None	14%			No Response	14%

3.0 GEOLOGY AND SOILS OF THE ONOTA LAKE WATERSHED

The Onota Lake watershed lies within the New England Province of the Appalachian Highlands. The watershed encompasses portions of two distinct physiographic regions: the Taconic Mountains and the Berkshire Valley. The Taconic Mountain Range borders the lake to the west and northwest, comprising most of its drainage area. The Berkshire Valley underlies the immediate vicinity of the lake and nearby Pittsfield. The geology and soils of this region have been described in a publication from the Berkshire County Regional Planning Commission (1978) which forms the basis for much of the following discussion.

The Taconic Range is composed of mostly quartz mica schistose rock with some garnetiferous schist formed 350 million years ago during the Ordovician and perhaps Cambrian Period of the Paleozoic Era. This erosion resistant metamorphic rock contains parallel layers of flakey mica, talc, and possibly iron pyrite and splits easily into thin leaves. This bedrock forms the long valleys which drain several hills of the range down to Onota Lake. These valleys constitute the majority of the lake's drainage area. Elevations along the ridge tops range from 2313 to 2157 feet above mean sea level.

The Berkshire Valley which contains Onota Lake is underlain by carbonate rocks such as limestone, dolomite, and marble. This Stockbridge Limestone is part of the Stockbridge Group of the Ordovician and Cambrian Periods. This relatively level valley with its frequent overlain deposits of glacial material is the product of complex structural relationships and simple scours of the relatively soft limestone. Elevations in the valley range from about 1200 feet at the base of the ridge to the lake surface elevation of 1078 feet.

Each of these types of bedrock contain subsurface water in fractures and faults, with the carbonate type typically exhibiting limestone solution cavities. The high porosity of carbonate rocks commonly coupled with overlain porous soils renders the ground water in these wells highly susceptible to contamination. The occurrence of limestone formations in the watershed of Onota Lake may influence the alkalinity and hardness of the lake and its'

tributary waters. It may also serve as a natural source of buffering against acidic precipitation.

The surficial geology of the Onota Lake watershed can be broadly categorized into stratified glaciofluvial deposits serving as ground water recharge areas and unstratified glacial till. The lake is largely situated upon and bordered on the east, west, and south sides by unstratified till. Stratified deposits have accumulated in a broad band at the base of the ridge draining the Taconic Range. The range itself is also overlain with predominantly unstratified till.

The unstratified till is a poorly-sorted heterogeneous mixture of boulders, stones, sand, silt, and clay in various mixtures formed 25,000 years ago during the Pleistocene epoch of the Cenozoic Era. The limited porosity of these soils results in slow infiltration and minimal ground water recharge, with most precipitation lost through surface or lateral downslope subsurface runoff. The lateral sub surface runoff contributes hydrologically to the streams and brooks which drain to the lake.

Stratified drift deposits are composed of assorted, relatively homogeneous materials, predominantly sand with varying amounts of silt and gravel, deposited by waters flowing within or from the glacier. These deposits are much more conducive to ground water recharge. Precipitation tends to move downward rapidly through the unconsolidated deposits to aquifers. The coarse nature of these deposits provides minimal filtering action and the aquifers underneath are especially susceptible to soluble pollutants from the surface (e.g. road salt, and septic leachate).

Soils

Stratified drift deposits and unstratified till overlay the carbonate rock surrounding Onota Lake to form a mosaic of soil types (Figure 3-1) which include silty and sandy loams, very stony loams and rock outcrops with steep slopes. Soil depths are also variable and become very shallow in those areas surrounding the lake that are dominated by rock outcrops. The major soils surrounding the lake are as follows (SCS, 1983):

HANCOCK

PITTSFIELD

Pittsfield Lake

Pontoosuc Water

Onota Lake

WATER

PITTSF

CENTRAL

PENN

West Branch

CORPORATE BOUNDARY

SOURCE: USDA SOIL CONSERVATION SERVICE
SOIL ASSOCIATION MAP (1980)

FIGURE 3.1
SOIL ASSOCIATION MAP FOR ONOTA LAKE

0   4200
scale   feet
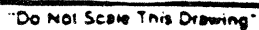
North - Pittsfield, Hinckley, Warwick series; Taconic-Macomber and Pittstown-Bernardston Associations

Northeast - Groton, Hinckley, Warwick series; Medisaprists, and Gravel Pits.

East - Fredon, Hero, Nellis, (and Warwick series;) Rock-Outcrop-Farmington Complex; Udorthents and Medisaprists.

Southeast - Amenia, Fredon, Hickley, Nellis, and Pittsfield series; Rock-Outcrop-Farmington complex; Medisaprists, and Urban Land.

South - Amenia, Kendaia, Nellis, and Pittsfield series; Rock-Outcrop-Farmington complex; Pittstown-Bernardston and Stessing-Mansfield Associations.

Southwest - Hero, Hinckley, Kendaia, and Warwick series; Rock-Outcrop-Farmingdale complex; Pittstown-Bernardston Associations; Gravel Pits, and Medisaprists.

West - Warwick series; Bernardston-Dutchess-Pittstown-Bernardston, and Taconic-Macomber Associations.

Northwest - Warwick series; Pittstown-Bernardston and Taconic-Macomber Associations.

AMENIA SERIES (430C, Figure 3.1) - These are moderately well drained soils developed in compact calcareous glacial till that contain many limestone, schist and phyllite fragments. They have a crumbly fine sandy loam or silt loam surface soil and subsoil. They are underlain at about 24 inches from the surface by a silt loam hardpan. The permeability is moderately rapid in the surface soil and subsoil and slow in the hardpan. Amenia soils have excess seepage water or a high water table for 4 to 5 months of the year, generally in late winter and early spring. These soils are very stony or extremely stony except where they have been cleared of surface stone. They occupy nearly level to steep slopes.

FREDON SERIES (523A, Figure 3.1) - These are poorly drained soils formed in thick deposits of sands and gravel derived largely from limestone, schist, and phyllite. They have a fine sandy loam surface soil and a fine sandy loam or gravelly fine sandy loam subsoil underlain at a depth of about 2 feet by layers of sands and gravel. They have rapid or moderately rapid permeability in the surface soil and subsoil and rapid permeability in the substratum. The water table is at or near the surface for 7 to 9 months of the year. They are generally free of stones and boulders but may contain cobbles. They occupy depressions and low flat areas.

GROTON SERIES (505E, Figure 3.1) - These are excessively drained soils that formed in thick deposits of neutral or calcareous sands and gravel. The sands and gravel are derived mainly from limestone, phyllite, schist and gneiss. They are very gravelly. They commonly have a gravelly sandy loam surface soil and subsoil underlain by stratified sands and gravel. Groton soils are loose throughout and have a very high permeability. They are usually stone-free but may contain cobbles and a few stones. They occupy level to very steeply sloping areas.

HERO SERIES (512A, Figure 3.1) - These are moderately well drained soils formed in thick sand and gravel deposits derived principally from limestone, schist, and phyllite. They have a crumbly fine sandy loam or gravelly fine sandy loam surface soil and subsoil. They are underlain at a depth of about 24 inches by a substratum consisting of layers of sands and gravel. Hero soils have a moderately rapid or rapid permeability in the surface soil and subsoil and rapid permeability in the substratum. A seasonal high water table is within 1 ½ to 2 ½ feet from the surface for 4 to 5 months of the year, generally in winter and early spring. These soils are commonly free of surface stones and boulders but may have cobbles. They occupy level areas and gentle slopes.

HINKLEY-GROTON ASSOCIATION (35-C, Figure 3.1) - These are excessively drained soils developed in thick deposits of sands and gravel derived mainly from granite and gneiss. They are very sandy and gravelly. They commonly have a sandy loam surface soil and a sandy and gravelly subsoil underlain by stratified sands and gravel. Hinckley soils are loose throughout and water moves rapidly through them. They are usually stone-free but may contain cobbles and a few stones. They occur on level areas to very steep slopes.

KENDAIA SERIES (432B, Figure 3.1) - These are somewhat poorly drained soils formed in calcareous glacial till derived mainly from limestone, schist, and phyllite. They have a crumbly silt surface soil and subsoil. They have a silt loam, hardpan substratum at a depth of about 18 to 24 inches from the surface. The surface soil and subsoil have a moderately rapid permeability. The hardpan has a slow permeability. The soils are wet at or near the surface

for 6 months of the year due to a high water table or excess seepage water from adjacent higher land. These soils are very stony or extremely stony except where cleared of surface stones. They occupy level areas to moderately sloping areas.

MEDISAPRISTS (ORGANIC) (48, Figure 3.1) - These are very poorly drained bog soils formed in accumulations of organic deposits that are underlain by mineral soil materials. The upper part of the organic material is generally black and has decomposed to such a degree that plant remains cannot be identified by the unaided eye. Decomposition of the materials in the lower part of the deep organic soils varies from this condition to one of practically no decomposition in which plant remains are rapidly identifiable. Organic soils occupy depressions and potholes. The water table is at or near the surface most of the year. Some organic soils have only 1 to 3 feet of organic deposits over mineral soil materials. In others, the organic deposits are many feet thick.

NELLIS SERIES - These are well drained soils formed in calcareous glacial till derived mainly from dark schist and limestone. They generally have a loam or fine sandy loam surface soil and subsoil and are crumbly to a depth of 30 inches from the surface. Below a depth of 30 inches there is generally a hard or firm loam or fine sandy loam substratum. Nellis soils have moderately rapid permeability in the surface soil and subsoil and moderately slow permeability in the hard, firm substratum. Nellis soils are very stony or extremely stony except where cleared of surface stones. They occupy gentle to very steep slopes.

PITS, GRAVEL (GP, Figure 3.1) - These are areas where the soil material has been removed for fill and other uses. The depth of excavation varies greatly. In most places the excavation consists of an exposure of unweathered sands, gravel and cobblestones.

PITTSFIELD SERIES (444D, Figure 3.1) - These are well drained soils formed in glacial till derived largely from limestone and schist. They have a loam or fine sandy loam surface soil and subsoil that contains moderate amounts of cobbles and stones. They are crumbly to a depth of 30 inches or more from the

surface but may have a hard layer below 30 inches. Pittsfield soils have moderately rapid or rapid permeability in the surface soil and subsoil and moderately slow permeability in the hard layer below 30 inches. Pittsfield soils are very stony or extremely stony except where cleared of surface stone. They occupy gentle to very steep slopes.

ROCK OUTCROP-PITTSFIELD COMPLEX (441C, Figure 3.1) - Shallow to bedrock soils formed in calcareous glacial till. They have a friable, fine sandy loam subsoil. Depth to bedrock is mostly less than 20 inches with many rock outcrops.

UDORTHENTS (520, Figure 3.1) - This land type consists of areas from which soil material has been removed. The depth of excavation is variable. In most areas, all the surface soil and part of the subsoil have been removed. In some areas, all of the surface soil and subsoil have been removed, leaving unweathered soil material exposed. Generally, there are many stones and boulders left scattered throughout the area.

URBAN LAND (52, Figure 3.1) - This land type consists of areas where the soils has been altered or obscured by buildings, industrial areas, paved parking lots, sidewalks, roads or railroad yards. These structures cover 75 percent or more of the surface area. Slopes range from nearly level to steep.

WARWICK SERIES. (152B-D, Figure 3.1) - These are somewhat excessively drained soils developed in sands and gravel that contain many dark, fine grained, phyllite fragments. The texture of the surface soils and subsoil is fine sandy loam or loam, but in some places the subsoil is sandy loam. The break between subsoil and the underlying sands and gravel is abrupt and occurs at a depth of about 2 feet. The permeability is moderately rapid or rapid in the surface soil and subsoil and rapid in the sandy and gravelly substratum. Warwick soils occupy level areas to very steep slopes.

BERNARDSTON-DUTCHESS ASSOCIATION (BDE, Figure 3.1) - Bernardston and Dutchess soils are deep and well drained. The Bernardston soils are typically on the lower and less steep slopes and the Dutchess soils are on the steeper and higher parts of slopes. Stones and boulders are approximately 5 to 20 feet

apart. This unit consists of about 50% Bernardston soils, 30% Dutchess soils and 20% other soils.

PITTSTOWN-BERNARDSTON ASSOCIATION (PBDC, Figure 3.1) - Deep, moderately well drained Pittstown soils and deep, well drained Bernardston soils. The Pittstown soils are typically on the lower parts of slopes or in convex areas. Stones and boulders are approximately 5 to 20 feet apart and are prominent features in the landscape. This unit consists of about 60% Pittstown soils, 20% Bernardston soils, and 20% other soils.

STISSING-MANSFIELD ASSOCIATION (SWB, Figure 3.1) - This association consists primarily of deep, poorly drained Stissing soils and deep, very poorly drained Mansfield soils. These nearly level and gently sloping soils are on the foot slopes and drainage ways of hills and mountains. The Stissing soils are typically on the base of slopes or in slightly concave areas with the Mansfield soils in concave areas or depressions. Stones and boulders, approximately 5 to 20 feet apart, are prominent features of the landscape. This unit consists of about 55% Stissing soils, 25% Mansfield soils, and 20% other soils.

TACONIC-MACOMBER ASSOCIATION (NDE, Figure 3.1) - These are somewhat excessively drained, shallow to bedrock soils developed in glacial till derived mainly from phyllite. These soils have a crumbly silt loam surface soil and subsoil and contain many flat, black phyllite fragments. The depth to bedrock is 0-40 inches. They have a moderately rapid or rapid permeability to the bedrock. Bedrock outcrops range from 10 to more than 100 feet apart. These soils contain many stones and rock fragments except where they have been cleared of surface stones. They occupy gentle to very steep slopes.

Most of the land around Onota Lake exhibits shallow slopes, although there are some isolated areas especially along the northern and eastern shores where the slopes exceed 15 percent. These steep slopes are vulnerable to soil erosion especially when the vegetative cover is removed or disturbed. Steep slopes also predominate in the Taconic Range approximately two miles east. Development limitations for the soil groups due to slope, drainage, strength and excessive frost action are given in Table 3.1.

TABLE 3.1
LIMITATIONS OF SOILS FOR DEVELOPMENT

SOIL MAP UNITS	Foundations for Dwellings With Basement	Without Basement	Local Roads, Streets and Parking Lots	Septic Tank Absorption Fields
Amenia stony silt loam 8-15% slopes	Severe: wetness	Moderate: wetness, slope	Severe: frost action	Moderate: wetness; slope
Fredon Variant fine sandy loam 0-3% slopes	Severe: wetness	Severe: wetness	Severe: wetness, frost action	Severe: wetness, poor filter
Groton & Hinckley soils 25-35% slopes	Severe: slope	Severe: slope	Severe: slope	Severe: poor filter, slope
Hero fine sandy loam 0-3% slopes	Severe: wetness	Moderate: wetness	Severe: frost action	Severe: wetness, poor filter
Hinckley sandy loam 8-15% slopes	Moderate: slope	Moderate: slope	Moderate: slope	Severe: poor filter
Kendaia silt loam 3-8% slopes	Severe: wetness	Severe: wetness	Severe: wetness, frost action	Severe: wetness, percs slowly
Medisaprists	Severe: wetness, low strength	Severe: wetness, low strength	Severe: wetness, low strength, frost action	Severe: wetness

3-9

TABLE 3.1
(Continued)

SOIL MAP UNITS	Foundations for Dwellings		Local Roads, Streets and Parking Lots	Septic Tank Absorption Fields
	With Basement	Without Basement		
Nellis stony loam 8-15% slopes	Moderate: slope	Moderate: slope action	Moderate: slope, frost	Severe: percs slowly
Pittsfield stony fine sandy loam 15-25% slopes	Severe: slope	Severe: slope	Severe: slope	Severe: slope
Quonset gravelly sandy loam 8-15% slopes	Severe: slope	Severe: slope	Moderate: slope	Severe: poor filter
Rock-outcrop Farmington Complex, 3-15% slopes	Severe: depth to rock to rock	Severe: depth	Severe: depth to rock	Severe: depth to rock
Rock-outcrop Farmington Complex 15-35% slopes	Severe: depth to rock, slope	Severe: slope depth to rock	Severe: depth to rock, slope	Severe: depth to rock, slope
Stockbridge stony silt loam 8-15% slopes	Moderate: slope	Moderate: slope frost action, slope	Moderate: low strength,	Severe: percs slowly
Warwick gravelly loam 8-15% slopes	Moderate: slope	Moderate: slope	Moderate: slope	Severe: poor filter

3-1

/l2: .tl

4.0 MORPHOMETRIC DATA

Onota Lake is approximately 3.4 km long and 1.0 km wide and has a shoreline length of 16.3 km (Table 4.1). The two basins which comprise the lake have a total surface area of 250 hectares and a combined volume of 15.98 x $10^6 m^3$.

The lake's major tributaries are Churchill Brook, Daniels Brook and Parkers Brook. In flow from these major tributaries total approximately 7.0 x 10^6 m^3/yr. Lulu and Hawthorne Brooks feed into Parkers Brook above Churchill Street and create a small pond prior to flowing into Onota Lake. A series of small intermittent streams feed the lake along the southwest shore off of Blythewood Drive. One of these flows fairly continuously and was monitored throughout this study along with Churchill, Daniels and Parker Brooks. Outflow from the lake is to Onota Brook which in turn feeds Pecks Pond.

The watershed surrounding Onota Lake contains ten sub-watershed which encompass 25.7 km^2 (Figure 4.1). The sub-watersheds encompassing the greatest area are VI, VII, and VIII (Table 4.2). These sub-watersheds are predominately forested, and undeveloped (Table 4.3). Although the watershed is not highly developed, sub-watersheds I, II and IX have the greatest percentage of developed versus undeveloped land.

The lake's bathymetric profile was established by conducting a survey of the lake using a continuous recording fathometer equipped with a strip chart. Readings were taken at 20 to 50 foot intervals along 23 transects. These data were integrated using Goldenware Software SURFER program to produce the bathymetric contours of the lake (Figure 4.2). The lake consists of two basins, the larger of which is the south basin (170 ha, Table 4.1). Water depths in this section of the lake reach 20.6 m. The northern basin is smaller, (80 ha) generally more shallow ($\leq$ 3m) and attains a maximum depth of only 7.3 m. A shallow sand bar bisects the lake and physically separates the two basins. Water depth along the sand bar is approximately 0.5 to 1.5 m. A 2 to 3 meter deep by 30 meter wide access channel has been cut through the sand bar to allow for unimpeded boat traffic. This channel also allows for some hydrologic exchange between the two basins. No estimate was developed

for water exchange between the north and south basin. It is assumed, based on topography, that the net water movement is from the south basin to the north basin.

Other prominant physical features of the lake include a backwater area north of the Dan Casey Causeway, Thomas Island, a 5-10 hectare wetland along the northwest shore, the fishing pier and boat launch, and three small island/peninsulas located in the south basin.

The primary public access point to the lake is via a fishing pier and a public boat ramp located at the base of Lakeway Drive. The ramp and fishing pier are part of the Burbank Park system which also offers bathing beaches, access for sailboarding, and a public pavilion. Public access and common recreational uses are detailed in Section 2.0.

TABLE 4.1

MORPHOMETRIC DATA OF ONOTA LAKE

Official Name	Onota Lake
Location	Pittsfield, Massachusetts
Lake Area (Total)	250 ha = 2.5 km^2
North Basin	80 ha = 0.794 km^2
South Basin	170 ha = 1.70 km^2
Lake Maximum Depth	20.6 m
Lake Mean Depth	6.4 m
Lake Volume	15.98 x $10^6 m^3$
Watershed Area	25.7 km^2
Shoreline Length	16.3 km
Maximum length	3.4 km
Maximum Width	1.0 km

TABLE 4.2

AREA OF ONOTA LAKE SUB-WATERSHED BASINS

Sub-watershed basin	Acres	Hectares
I	385	156
II	214	87
III	64	25
IV	66	27
V	189	77
VI	2137	865
VII	766	310
VIII	1568	635
IX	149	60
X	190	77
Lake	617	250
TOTAL	6345	2569

FIGURE 4.1
WATERSHED AND SUBBASINS OF ONOTA LAKE
SOURCE:
USGS TOPOGRAPHIC MAPS -
PITTSFIELD AND HANCOCK

scale   1"=2000'   feet

2000   0   2000
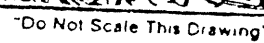
TABLE 4.3
LAND USE PER SUB-BASIN
FOR ONOTA LAKE

LAND USE CATEGORIES PRESENTED AS PERCENT TOTAL AREA

Sub-Basin	Forest	Open Covered*	Agricultural	RESIDENTIAL High Density	Low Density
I.		50		50	
II.	30		5	50	15
III.	85				15
IV.	50				50
V.	95				5
VI.	94	1	5		
VII.	89.5	.5	10		
VIII.	89	1	10		
IX.				40	60
X.				20	80

* Open areas with vegetative cover but no appreciable canopy (parks, pasture, etc.)

TRIB. 2
TRIB. 1
TRIB. 3
TRIB. 4
TRIB. 5

THOMAS
ISLAND

OUTLET

TRIB. 6
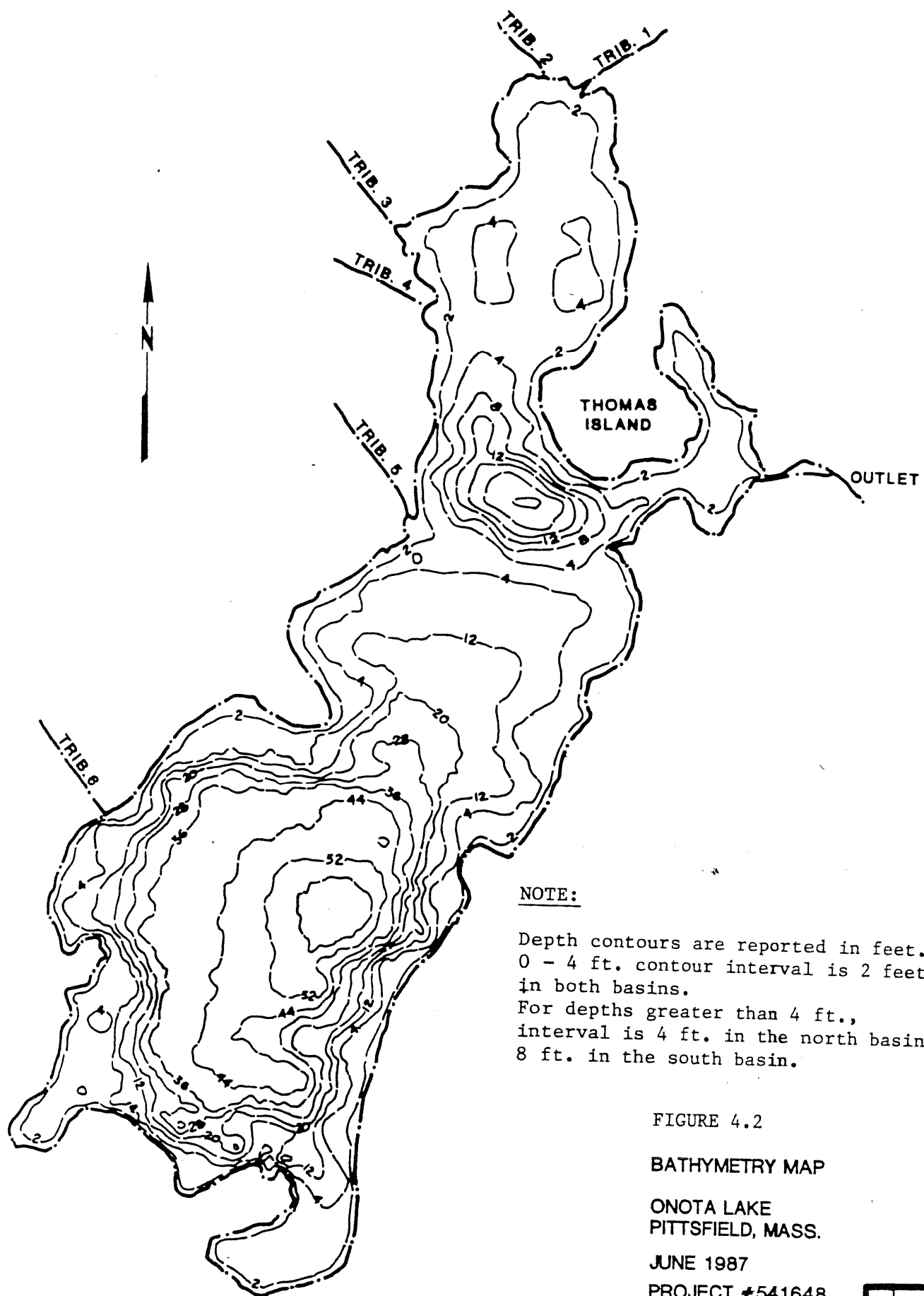
NOTE:

Depth contours are reported in feet.
0 - 4 ft. contour interval is 2 feet
in both basins.
For depths greater than 4 ft.,
interval is 4 ft. in the north basin,
8 ft. in the south basin.

FIGURE 4.2

BATHYMETRY MAP

ONOTA LAKE
PITTSFIELD, MASS.

JUNE 1987

PROJECT #541648

IT

DRAWING NUMBER 541648
DRAWN BY
CHECKED BY
APPROVED BY
DATE 6/30/87

5.0 LIMNOLOGICAL STUDY

5.1 WATER QUALITY - IN-LAKE SAMPLING

In order to establish the existing conditions of the lake and its tributaries and to identify the interrelationships among the physical-chemical-biological components of Onota Lake, a limnological monitoring program was conducted. The goal of this program was to identify the problems of Onota Lake and develop, from these data, an effective restoration action plan.

Two in-lake stations were monitored on a bi-monthly basis from March through fall circulation and monthly for the balance of the year. Station #1 was located in the main basin while Station #2 was located in the shallow basin by Thomas Island (Figure 5.1).

Samples were collected with a 4.1 liter, non-metallic Kemmerer bottle relative to lake strata. Three water samples were collected during periods of stratification, 0.5 meters below the surface, near the thermocline and 0.5 meters above the bottom. During the periods when Onota Lake was not stratified, samples were collected at 0.5 meters below the surface and 0.5 meters above the bottom. All in-situ measurements were taken at 1.0 meter intervals from surface to bottom irrespective of lake stratification.

In addition to the regular water samples, surface grab samples were collected at each station for total coliform bacteria analysis.

5.1.1 Temperature

Based on characteristics displayed in the temperature profiles (Figure 5.2, 5.10), Onota Lake can be classified as a temperature, dimictic lake. Lakes are classified dimictic if they circulate freely twice a year in the spring and fall and are directly stratified in summer and inversely stratified in winter (Wetzel, 1983). The temperature profile of Onota Lake was monitored at two locations; Station #1 (Figures 5.2-5.6) and Station #2 (Figures 5.7 - 5.10).

The thermocline measured at Station #2 was not as defined as that of Station #1. However, the difference in density resulting from the epilimnetic ($\leq$ 6 m) is significant enough to impede mixing (Kortman et al., 1982).

The lake remained ice covered until mid-March. Profiles conducted in the north and south basin from ice breakup through April revealed water temperatures to be uniform from surface to bottom. By mid-May a thermocline became established (Figures 5.3 and 5.8).

Station #1 (South Basin) epilimnetic waters (depth $\leq$ 12 m) were approximately 8°C during the winter sampling event. Over the course of the spring and summer, the epilemnetic waters of the south basin increased in temperature, but the hypolimnetic waters remained at approximately 8°C (Figures 5.3 and 5.4). During this period of stratification (April 5 to September 23) the south basin did not experience major mixing.

A similar pattern of thermal stratification was observed in the shallower north basin. An apparent thermocline became established in mid-May. The North Basin did not appear however to stratify as strongly as the South Basin. Bottom waters in the North Basin were in the 11-15°C range whereas surface waters ranged from 19 to 25°C (Figures 5.8 and 5.9).

The south basin became destratified sometime between the October 14 and November 14 sampling events (Figure 5.5). Stratification in the south basin was pronounced until mid-October. In the north basin, stratification began to weaken by August 27th and by September 10th water temperatures were relatively uniform from surface to bottom (Figures 5.9 and 5.10). These data indicate that autumnal overturn occurs twice in Onota Lake, once in late summer in the north basin approximately 45 days later in the south basin.

5.1.2 Dissolved Oxygen

Annual dissolved oxygen (DO) fluctuations in Onota Lake are influenced by its' dimictic nature. As such, Onota Lake exhibits a positive heterograde curve, or an increase in oxygen in the metalimnion during stratification.

TEMPERATURE ISOPLETH for In-Lake #1 (Main Basin)

MONTH

FIGURE 5.2

NOTE:

DEPTHS ARE REPORTED
IN FEET

LEGEND:

TRIB 1 DANIELS BROOK
    2 CHURCHILL BROOK
    3 WADHAM BROOK *
    4 UN-NAMED *
    5 PARKER BROOK
    6 BLYTHEWOOD BROOK, UN-NAMED
  * SAMPLED ONLY IN
    APRIL AND MAY, FLOW INCONSISTENT

FIGURE 5.1
SAMPLING LOCATIONS IN-LAKE
STATION 1 (SOUTH BASIN)
STATION 2 (NORTH BASIN)
PREPARED FOR:
ONOTA LAKE
PITTSFIELD, MASS.
PROJECT No. 541648
SEPTEMBER 1988

IT INTERNATIONAL
TECHNOLOGY
CORPORATION

DRAWING
NUMBER 541648

CHECKED BY
APPROVED BY

DRAWN
BY

Surface concentrations throughout the year were above 6 mg/l and followed the temperature related solubilities of oxygen in water. That is, dissolved oxygen concentration increased with decreasing ambient temperatures (Figures 5.11 to 5.18). At times concentrations in excess of saturation were measured. This reflects photosynthetic activity of algae or macrophytes.

There was a decrease in oxygen concentration of the hypolimnion as stratification of Onota Lake intensified. This is due to bacterial respiration during decomposition of organic sediments, detritus, and senecsent algal cells. The resulting oxygen deficit is sufficient to cause anoxic conditions to persist towards the bottom of the lake.

Near anoxic conditions were observed as early as June 3rd (Figure 5.12). From June 25th through October 14th the DO concentration was less than 1 mg/l at depths in excess of 10 meters (Figures 5.13-5.14). The total duration of anoxic conditions in the south basin during the 1986 survey was 99 days.

In the north basin, DO concentrations remained high during January, but decreased during February (Figure 5.15). Dissolved oxygen concentrations dropped to 1-2 mg/l in depths $\geq$ 3m. The depletion of oxygen in these lower depths was the result of the removal of oxygen by bacterial decomposition in the sediments and the slow diffusion of oxygen through the ice cover. This depletion could create a serious oxygen deficit and result in a winter fish kill beneath the ice.

No sampling was done during the month of March in the south basin. Dissolved oxygen concentrations increased throughout the period of April-May (Figure 5.16). During spring overturn conditions (April 25 - May 6) DO concentrations remained relatively stable between 10.0 - 11.0 mg/l (Figure 5.16). With warming water temperatures in June, DO concentrations decreased to 8-9 mg/l (Figures 5.16 - 5.17). Because of depth limitations in the north basin, the lower waters occurring at depths <6 m remained well oxygenated during the period of July-September (Figure 5.17). Depths $\geq$ 6m did exhibit oxygen depletion during the summer period. A limited period of stratification did occur during the later part of August and persisted through early September (Figure 5.17). Stratification did not persist as long in the south basin as

FIGURE 5.11
DISSOLVED OXYGEN PROFILE - WINTER
In-Lake #1 (Main Basin) - ONOTA LAKE
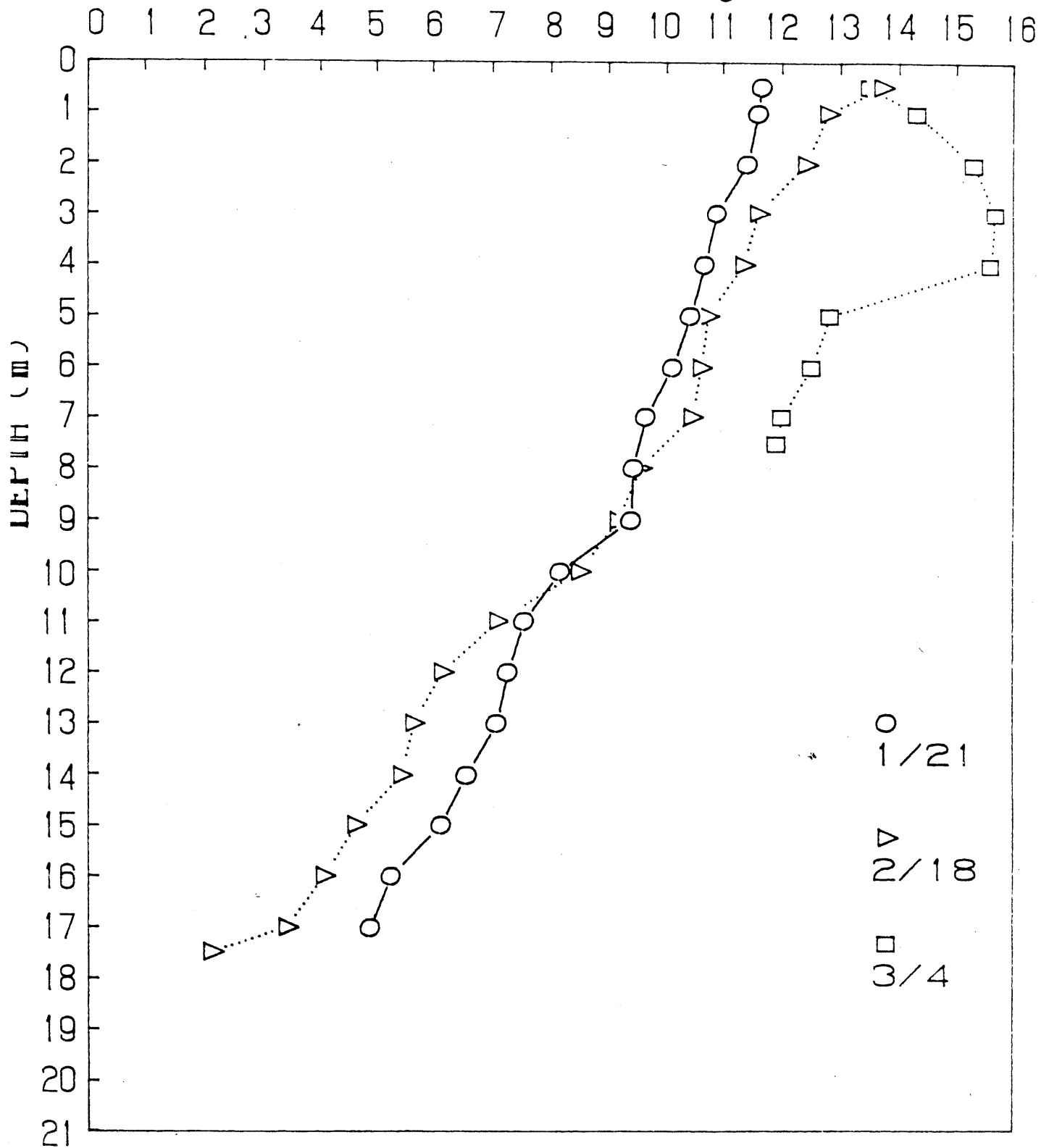
Nitrate-nitrogen concentrations ranged from 0.02 to 1.32 mg/1. The observed mean concentration of $N-NO_3$ in Daniels Brook was 0.69 mg/1 and 0.45 mg/1 in Churchill Brook (:Appendix B1-B2). The highest concentrations appeared during the late summer months (Figures 5.41 and 5.46). It is suspected that runoff, caused by the unseasonably high rainfall, leached nitrogen compounds from fertilized fields and contributed to these elevated concentrations. Ammonia-nitrogen ranged from 0.01 - 0.22 mg/1 in Daniels and Churchill Brook. The observed mean concentration in Daniels Brook was 0.065 mg/1 and 0.083 mg/1 in Churchill Brook. Total Kjeldahl nitrogen ranged from 0.05 to 0.46 in both streams. The observed mean concentration in Daniel Brook was 0.211 mg/1 and 0.21 mg/1. Elevated concentrations were associated with storm events. Total suspended solids ranged from <1 mg/1 to 37 mg/1. The observed mean concentration of total suspended solids in Daniels Brook was 5.9 mg/1 and 5.3 mg/1 in Churchill Brook. Elevated concentrations were generally associated with storm events (Figures 5.39 and 5.44). Chloride concentrations ranged from 1.0 to 19 mg/1 but were generally less than 10 mg/1. The mean concentration of chloride in Daniels Brook was 6.22 mg/1 and 3.9 mg/1 in Churchill Brook. Highest concentrations were associated with storm events (Figures 5.39 and 5.44). The high winter concentrations measured were probably due to the application of road salt. Total coliform bacteria ranged from 2 to TNTC bacteria/100 ml and fecal coliform bacteria ranged from <2 to 1760 bacteria/100 ml. The mean concentration of total coliform observed in Daniels Brook was 272 bacteria/100 ml and 1,296 bacteria/100 ml in Churchill Brook. Fecal coliform concentrations were elevated in both tributaries. The mean concentration observed in Daniels Brook was 126 bacteria/100 ml and 132 bacteria/100 ml in Churchill Brook. Highest concentrations were encountered during the summer months and suggest contamination from animal or human wastes or runoff from fertilized fields (Figures 5.38 and 5.43).

5.2.2 Parker Brook

The Parker Brook monitoring data are presented graphically in Figures 5.58 to 5.62. Parker Brook drains Onota Lake's largest watershed. As mentioned previously, Hawthorne Brook and Lulu Brook are tributaries to Parker Brook. Most of the lands drained by Parker Brook are forested. The topography of the terrain is steep and the soils somewhat shallow along steep slopes. There is

a minimum of residential development within this watershed. A major summer camp, Camp Winadu, is located in Parker Brook's watershed. The camp lies along the shoreline of the lake.

Total Phosphate-phosphorus ranged from <0.01 mg/l to 0.14 mg/l. The mean concentration of TP was 0.024 mg/l. The highest concentration was measured on July 22, 1986 (Figure 5.62). At other times, concentrations were generally less than the 0.05 mg/l maxima suggested by the EPA. Nitrate-nitrogen ranged from 0.12 to 1.1 mg/l but was less than 0.6 mg/l on all except one occasion. The mean concentration of nitrate-nitrogen was 0.37 mg/l. Ammonia nitrogen ranged from 0.03 to 0.22 mg/l and the observed mean concentration was 0.07 mg/l. Animal waste applied to fertilized fields is a likely source for elevated concentrations particularly during storm events. Total suspended solids ranged from <1 mg/l to 9 mg/l with the highest concentrations associated with storm events. The mean concentration observed during this study was 3.8 mg/l. Total dissolved solids ranged from 15-350 mg/l. The mean concentration was 93.8 mg/l. Higher concentrations were associated with higher stream discharges. Chloride concentrations ranged from 2 to 12 mg/l with one peak at 22 mg/l on July 8, 1986. The reason for this summer chloride peak is not known. The mean chloride concentration in Parker Brook was 5.0 mg/l. Coliform bacteria counts were extremely variable, with the highest numbers associated with storm events (Figure 5.58). The mean concentration of total coliform and fecal coliform bacteria for the study period were 585 and 94 bacteria/100 ml, respectively. Again, human or animal waste, as well as fertilizers may have caused these elevated concentrations.

5.2.3 Blythewood Drive - Unnamed Stream

There are small seeps, swales and intermittent streams which flow into Onota Lake. Flow from these waterways is inconsistent and is seasonal or the result of storm events. Most of these waterways are located along the lake's western shore. None of these are gagable.

There does exist a small unnamed stream which flows into the southern basin from the Blythewood Drive area. This stream drains primarily wooded areas although a small farm exists in the streams upper watershed. Closer to the

lake, residential land use characterizes the stream's watershed. Most of these residences are on 1/4 acre or larger lots and all use septic systems for the treatment and disposal of wastewater. The terrain draining to the stream ranges from nearly flat to fairly steep. The stream itself is approximately 2 to 3 meters wide, with a stoney bottom and water depths of 10 to 30 cm. Water depths however can increase 2 to 3 fold during a storm event.

The monitoring data for the Blythewood Drive tributary are presented in Figures 5.63 to 5.67.

Nitrate-nitrogen concentrations ranged from 0.05 to 0.95 mg/1, total phosphate-phosphorus concentrations ranged from 0.01 to 0.11 mg/1 with the highest concentrations associated with storm events. Phosphate concentrations were generally lower than 0.05 mg/1. TSS concentration ranged from <1 to 48 mg/1 with a significant increase in concentration evidenced during storm events. Total coliform bacteria ranged from 10 to 80,000 bacteria/100 ml and fecal coliforms ranged from 1 to 2400 bacteria/100 ml. These high coliform concentrations, in addition to the substantial and continuously elevated chloride and conductivity measurements, appears to be attributable to development in this subbasin, in particular, the use of on-site wastewater treatment and disposal. The soils, hydrology and steep slopes surrounding Blythewood Drive tend to compromise the efficiency of septic systems, exacerbate runoff, and contribute to increased nutrient and bacteriological loading to the lake.

5.2.4 Storm Sampling

On two dates, September 9, 1986 and March 31, 1987, the main tributaries to the lake were sampled during storm conditions. The samples collected during the Fall, 1986 storm event were grab samples taken during peak flow from Daniels Brook, Churchill Brook, Parker Brook, the Blythewood Drive Tributary, and the Pecks Road Tributary (Appendix C).

During the Spring, 1987 storm event, ten samples were collected from Churchill Brook, Daniels Brook, Parker Brook and the unnamed Blythewood Drive tributary. The sampling for this storm event was begun at first hydraulic

Prior to enumeration, the preserved, whole plankton samples were allowed to settle. Upon settling, they were concentrated by decantation and then enumerated using a Sedgwick-Rafter counting cell. Identification of plankton to the genus level was accomplished with a few taxa being identified to species. The algal mass was computed through use of cell volumes derived from direct measurements.

A seasonal succession of phytoplankters typically exists in temperate lakes. This pattern generally involves a winter minimum of flagellates adapted to low light and temperature. In the spring, diatom biomass increases substantially followed by a smaller increase in the green algae population. In the summer, diatom populations increase in mesotrophic and oligotrophic lakes while blue green algae blooms may occur in eutrophic lakes. As water temperatures cool in the fall, algal densities decrease. However, a resurgence in algal densities, an autumnal bloom, may occur shortly after fall overturn.

Percent composition was chosen as the method of analysis because it readily shows the seasonal changes in phytoplankton populations. In addition, this method makes obvious significant increases in taxa indicative of unhealthy conditions, such as the blue green algae (Cyanophyta). The percent composition data are presented in Tables 5.1 through 5.4. In general, the data collected for this study showed that the diatom percent composition reached a spring low at approximately the same time the lake stratified (May 25th to June 3rd). In the early summer, diatom numbers rebounded. Fragilaria was a commonly occurring species in June to early July. As summer progressed, green algae became more numerous. This was best reflected in the net plankton samples and to a lesser degree in the whole plankton samples. The percent composition of blue green algae remained relatively low throughout the summer and never reached densities indicative of unhealthy conditions. The Dinaflagellates Dinobryon and Ceratium continued to occur in the phytoplankton assemblage. The percent composition of both genera was variable and not as great as observed in the spring samples.

Toward the end of the summer and into early fall (August 27th to October 15), the diatoms once again dominated the phytoplankton assemblage. Green algae displayed a steady decline after the summer. Blue green algal percent composition in the net plankton also declined, but displayed two slight

TABLE 5.1: WHOLE PLANKTON % COMPOSITION
BASIN 1A

GENUS/DATE	4-8	4-25	5-6	5-20	6-3	6-25	7-8	7-23	8-13	8-27	9-10	9-23	10-15	11-14
CYANOPHYTA (blue green algae) TOTAL			<1	5.2	14.2			10.6	9.0				3.6	7.9
Anabaena					9.5			5.3	4.5				3.6	7.1
Polycystis									4.5					
Microcystis				5.2										
Coelosphaerium		<1			4.7			5.3						0.8
CHLOROPHYTA(greens)TOTAL	31.6	28.49	5.1		38.0	27.8	38.0	21.7	61.4	24.5	14.2	24.2	18.0	11.7
Ankistrodesmus	5.4	3.2	1.7											
Characium	1.7	2.8	<1							6.1		8.0	2.7	2.7
Chlamydomonas					19.0		20.0	10.6						1.8
Chlorella	7.9	1.3			19.0		14.0	11.1			14.2	16.2	7.2	1.8
Gonium							4.0							
Hydrodictyon														
Protococcus						2.8			36.4					3.6
Stentor									22.7	14.3				
Volvox										4.1			8.1	1.8
Ulothrix														
Zygnema	16.6	21.19	3.4	<1					2.3					
CHRYSOPHYTA (diatoms) TOTAL	8.3	49.2	70.9	20.9	47.2	55.5	44.0	42.3	9.1	71.4	56.8	54.1	65.7	69.3
Asterionella		5.8	26.3	13.2	4.7		12.0		9.1	14.3	14.2	21.7	4.5	47.3
Closterium		15.2	<1											
Coscinodiscus	<1	<1	<1				8.0	15.8		6.1		16.2		0.8
Cyclotella														
Cymbella														
Diatoma										38.8			61.2	
Fragilaria	2.9		10.4	3.3	14.2	22.2	4.0				7.0			
Navicula					9.5	5.6		10.6			14.2			
Nitzschia														
Pinnularia														
Staurastrum		<1												8.9

TABLE 5.1: WHOLE PLANKTON % COMPOSITION
BASIN 1A (Continued)

GENUS/DATE	4-8	4-25	5-6	5-20	6-3	6-25	7-8	7-23	8-13	8-27	9-10	9-23	10-15	11-14
CHRYSOPHYTA (diatoms) (con't.)														
Synedra	2.1	16.9	5.5		9.5	8.3		5.3				16.2		6.3
Synura														
Tribonema														
Tabellaria	3.3	11.3	28.7	4.4	9.3	19.4	20.0	10.6		12.2	21.4			6.3
CRYPTOPHYTA														
Cryptomonas	7.9	5.6	3.5	13.8		16.7	6.0		2.3	2.0	7.1			3.6
PYRROPHYTA TOTAL	51.4	15.4	19.0	57.5			4.0	26.4	18.2	2.0	21.4	10.8	5.4	5.4
Ceratium	43.9			<1			4.0	5.3	15.9	2.0		10.8	5.4	
Dinobryon	7.5	15.4	19.0	57.5				21.1	2.3		21.4			5.4
Peridinium														
PROTOZOANS TOTAL							4.0							1.8
Acanthocystis														
Actinophrys														1.8
Pelomyxa														
Pronodan														
Urostyla							4.0							
Vorticella														
ROTLERA TOTAL							4.0							
Rellacottia														
Keratella														
Polyarthra							4.0							

TABLE 5.2: WHOLE PLANKTON % COMPOSITION
BASIN 1B

GENUS/DATE	4-8	4-25	5-6	5-20	6-3	6-25	7-8	7-23	8-13	8-27	9-10	9-23	10-15	11-14
CYANOPHYTA (blue green algae) TOTAL				16.9	5.5	18.9	10.0	2.6		17.2	2.4	9.5	6.6	3.1
Anabaena				16.9	5.5	10.8		2.6		13.8	1.2	9.5	6.6	3.1
Polycystis							5.2							
Microcystis						8.1	4.8			3.4	1.2			
Coelosphaerium														
CHLOROPHYTA (greens) TOTAL	<1	34.2	32.2	1.2	36.1	32.4	47.4	15.8	25.0	13.8	8.1	14.3	4.6	10.1
Ankistrodesmus		1.3	<1	1.2										
Characium			1.8								1.2	14.3		2.3
Chlamydomonas	<1	1.3			11.1	10.8	9.7				2.3		2.8	
Chlorella	<1		<1		25.0	21.6	28.0		25.0		3.4		0.9	4.7
Gonium														
Hydrodictyon														
Protococcus														
Stentor														
Ulothrix							9.7			13.8	1.2			
Volvox								5.3					0.9	3.1
Zygnema		31.6	30.4											
CHRYSOPHYTA (diatoms) TOTAL	82.0	44.3	5.1	1.2	52.8	32.4	24.3	79.0	25.0	51.6	83.8	47.5	138.5	60.8
Asterionella	1.7	17.2		<1		5.4	4.8	55.3		6.9			81.0	41.4
Closterium				<1						3.4				2.3
Coscinodiscus					13.9									
Cyclotella							6.5	5.3		3.4		4.7	0.9	
Cymbella	<1													
Diatoma	74.6	15.7		<1	13.9	16.2	6.5					9.5	34.0	3.1
Fragilaria	<1	1.3			16.2			10.5				23.8	19.8	1.5
Navicula	<1													
Nitzschia		<1												
Pinnularia											73.3			
Staurastrum														

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TABLE 5.2: WHOLE PLANKTON % COMPOSITION
BASIN 1B (Continued)

GENUS/DATE	4-8	4-25	5-6	5-20	6-3	6-25	7-8	7-23	8-13	8-27	9-10	9-23	10-15	11-14
CHRYSOPHYTA (con't.)														
Synedra	1.4	8.5			8.3			7.9		6.9			2.8	
Synura	4.3	1.6	5.1		16.7									
Tabellaria						5.4	6.5		14.3	31.0	10.5	9.5		0.8
Tribonema						5.4			10.7					11.7
CRYPTOPHYTA														
Cryotomonas	<1	8.2	5.5	17.0	5.5	10.8	16.1		10.7		5.8		6.6	5.5
PYRROPHYTA TOTAL			55.3	61.8		5.4		39.4	17.3	10.5	29.0	2.8		
Ceratium										10.3	10.5			
Dinobryon									3.6			29.0		
Peridinium			55.3	61.8		5.4			17.9	6.9			2.8	
PROTOZOANS TOTAL								2.6						
Acanthocystis								2.6						
Actinophrys														
Pelomyxa														
Pronodan														
Urostyla														
Vorticella														
ROTLERA														
Rellacottia														
Keratella														
Polyarthra														

TABLE 5.3: NET PLANKTON % COMPOSITION
BASIN 1A

GENUS/DATE	4-8	4-25	5-6	5-25	6-3	6-23	7-8	7-23	8-13	8-27	9-10	10-15	11-14
CYANOPHYTA (blue green algae) TOTAL	2.5	6.4	1.3		16.0	2.4	<1	6.7		2.8	<1	<1	
Anabaena													
Polycystis	2.5	6.4	1.3		16.0	0.8	<1	6.7		2.8	<1	<1	
Microcystis					16.0	1.6							
Coelosphaerium													
CHLOROPHYTA (greens) TOTAL	-	<1	7.3	<1	10.0	<1	4.6	60.0	14.6	2.1	2.6		18.7
Ankistrodesmus									2.1		1.0	<1	
Chlamydomonas									6.3	2.1		<1	
Chlorella					2.0	0.8	4.6	20.0					
Euglena						<1		6.7			<1		
Gonium													
Hydrodictyon			7.3		8.0			33.3	4.1				4.4
Protococcus						<1						<1	
Stentor													
Ulothrix													
Volvox			<1						2.1		1.6	<1	14.3
Zygnema													
CHRYSOPHYTA (diatoms) TOTAL	76	35.8	29.0	5.4	4.0	91.3	88.0	20.0	55.5	35.8	80.5	82.3	66.2
Asterionella	15.2	10.4	6.7			2.8	37.6			2.8	4.7	10.9	53.2
Closterium													
Coscinodiscus			1.3								<1		
Cyclotella												<1	
Cymbella		<1											
Diatoma			13.0	5.4	2.0	80.0	12.8		6.3	26.0	71.6	<1	
Fragilaria												62.9	11.7
Navicula													
Nitzschia													
Pinnularia						1.2							
Staurastrum													
Synedra	1.3	4.0	2.0		2.0			6.7	2.1	7.0	4.2	6.8	1.3

ENV/L22-tbls/1

TABLE 5.3: NET PLANKTON % COMPOSITION
BASIN 1A (Continued)

GENUS/DATE	4-8	4-25	5-6	5-25	6-3	6-23	7-8	7-23	8-13	8-27	9-10	10-15	11-14
CHRYSOPHYTA (con't.)													
Synura	<1			<1		<1						<1	<1
Tabellaria	59.5	21.4	2.0						4.1			1.6	
Trinema-Tribonema			4.0			7.3	37.6	13.3	43.0				
CRYPTOPHYTA TOTAL	8.9	50.1	59.3	84.8	58.0		2.8	13.4	66.5	14.6	14.2	10.1	7.1
Cryptomonas					2.0				2.1			<1	
PYRROPHYTA													
Ceratium	<1	<1	<1	3.8	42.0	<1	2.8	6.7	54.1	11.1	5.8	10.1	1.9
Dinobryon	8.9	50.1	58.0	81.0	10.0		<1	6.7	4.1	2.1	<1		5.2
Peridinium			1.3		6.0				8.3		8.4		
PROTOZOANS TOTAL													5.2
Acanthocystis		<1	<1	1.1									
Actinophrys				4.3									5.2
Pelomyxa							<1						
Pronodan						<1							<1
Urostyla													
Vorticella				1.6						1.4			
ROTILERA TOTAL	5.7	2.9		<1	8.0	1.2			2.1	2.1		2.1	
Rellacottia	2.5				6.0								
Keratella	1.3	2.9		<1	2.0	1.2			2.1	2.1		2.1	
Polyarthra	1.9					<1							

TABLE 5.4: NET PLANKTON % COMPOSITION
BASIN 1B

GENUS/DATE	4-8	4-25	5-6	5-25	6-3	6-23	7-8	7-23	8-13	8-27	9-10	10-15	11-14
CYANOPHYTA (blue green algae) TOTAL	2.1	<1	3.4		11.1	2.4	8.7	13.7	4.5	6.4		<1	
Anabaena	<1											<1	
Polycystis	2.1	<1			6.7	2.4	8.7						
Microcystis					4.4							<1	
Coelosphaerium			3.4						4.5	6.4			2.2
CHLOROPHYTA (greens) TOTAL	1.7	<1	1.7	5.0	11.1	1.2	8.6	13.7	27.2	14.2	6.6	2.5	2.2
Ankistrodesmus										2.6			
Chlamydomonas									9.0	10.3			
Chlorella						1.2		13.7	4.5			1.9	
Gonium											<1		
Hydrodictyon											3.3		
Protococcus				2.9					13.7				
Stentor				2.1			4.3						
Volvox	<1	<1								1.3	3.3	0.6	2.2
Ulothrix					4.4								
Zygnema	1.7		1.7		6.7		4.3						
Euglena						<1							
CHRYSOPHYTA (diatoms) TOTAL	63.1	76.7	14.6	37.5	22.2	79.3	8.7	3.4	13.5	36.0	76.7	73.9	91.2
Asterionella	8.8	4.0	1.7	3.6		9.5				9.0	7.8	5.1	78.9
Closterium		<1											
Coscinodiscus			12.9										
Cyclotella													
Cymbella	11.3	10.2		7.2	4.4	<1						4.5	
Diatoma						64.5				16.7	62.8	59.2	
Fragilaria							8.7						
Navicula	<1		<1										
Nitzschia											1.1		
Pinnularia						1.2							
Staurastrum					6.7								<1
Synedra	<1	<1	<1	2.1	11.1				9.0	9.0	5.0	5.1	11.0
Synura	<1								4.5	1.3		<1	<1

ENV/A77-tbls/7

FIGURE 5.9

TEMPERATURE PROFILE – SUMMER
In-Lake #2 (Shallow Basin) – ONOTA LAKE
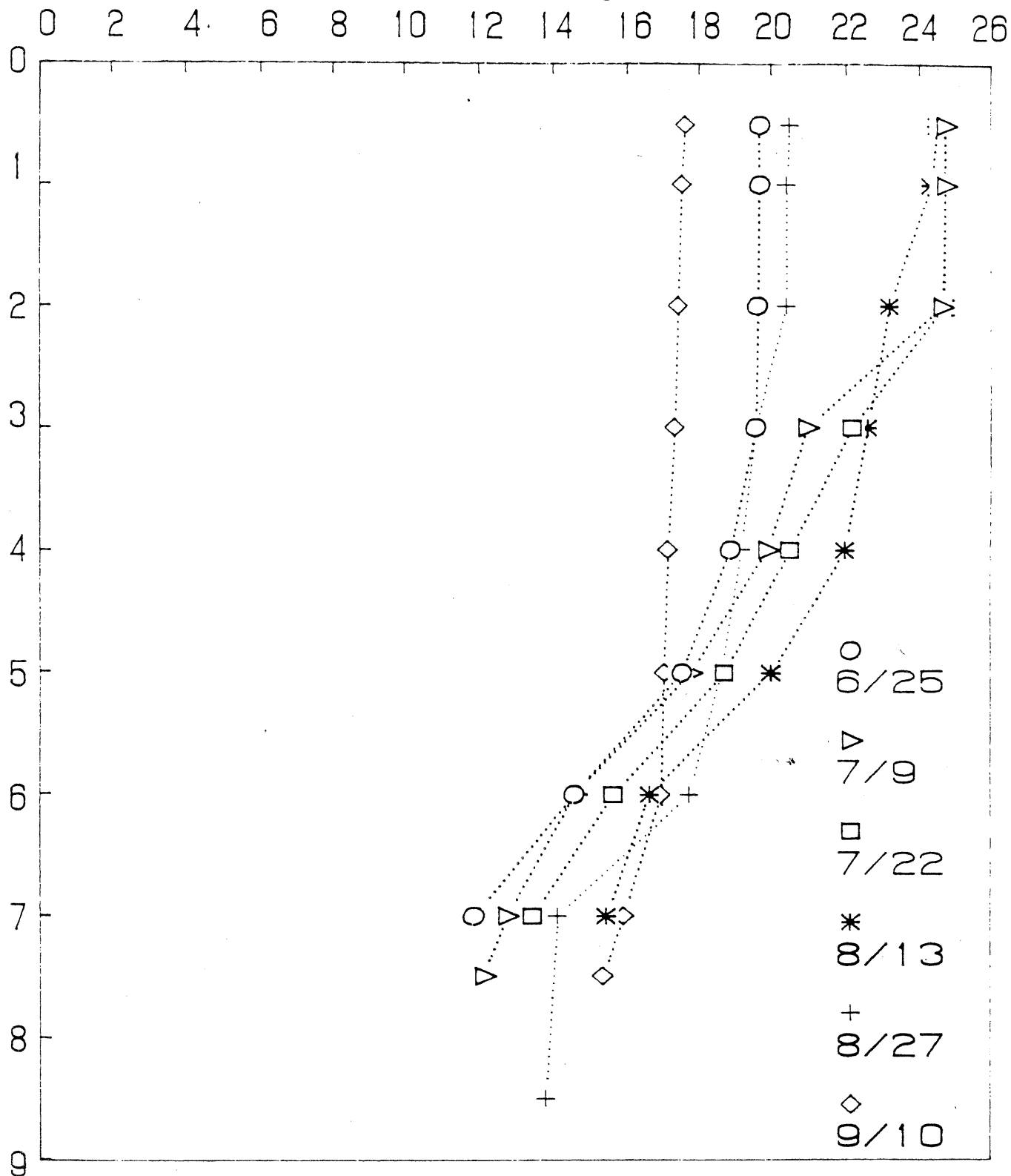
FIGURE 5.10
TEMPERATURE PROFILE - FALL
In-Lake #2 (Shallow Basin) - ONOTA LAKE
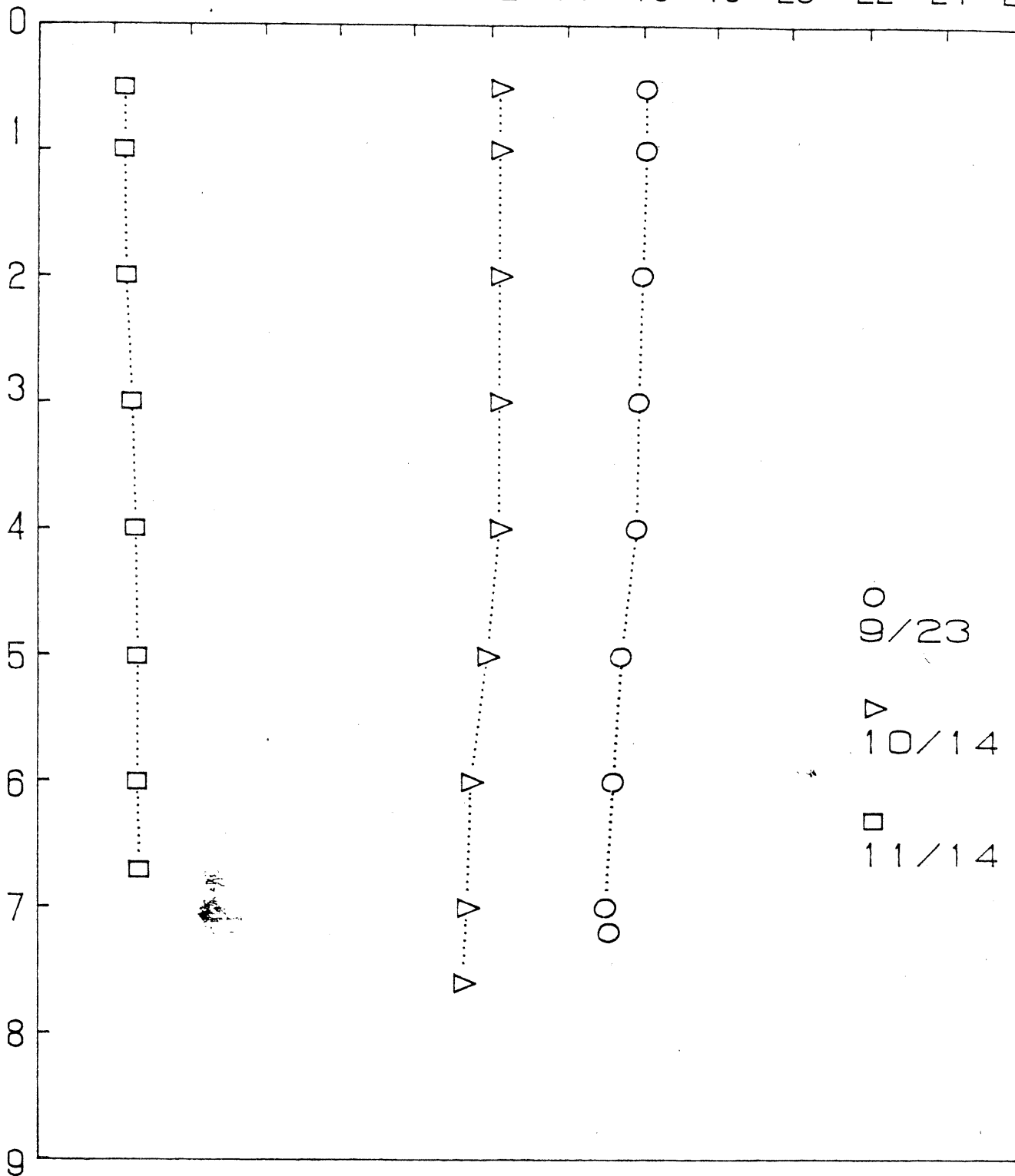
FIGURE 5.7
TEMPERATURE PROFILE - WINTER
In-Lake #2 (Shallow Basin) - ONOTA LAKE

TEMPERATURE (degrees C)

○ 1/21

▷ 2/19
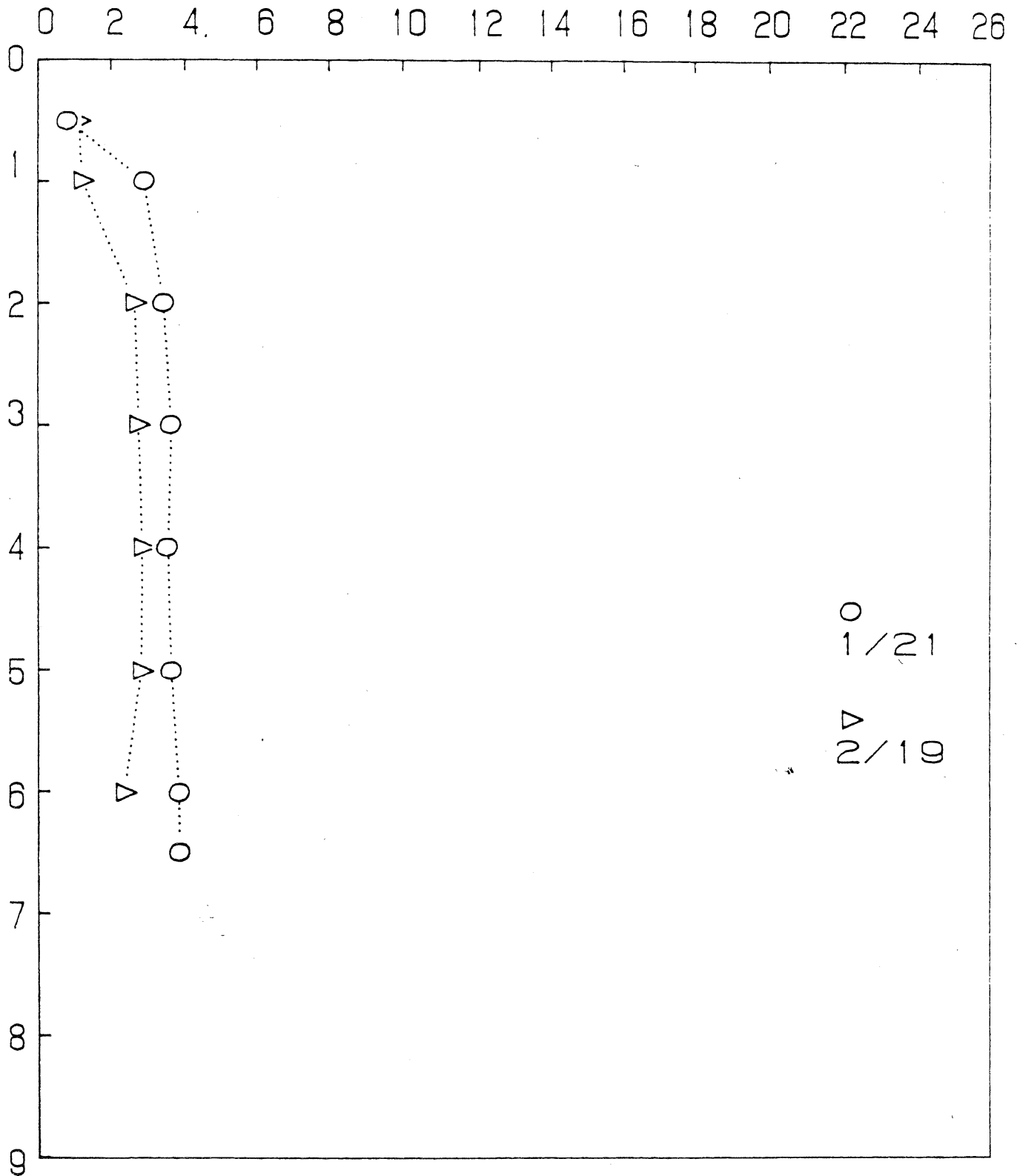
FIGURE 5.8

TEMPERATURE PROFILE - SPRING
In-Lake #2 (Shallow Basin) - ONOTA LAKE

TEMPERATURE (degrees C)

Legend:
- ○ 4/8
- ▷ 4/25
- □ 5/6
- ✳ 5/20
- + 6/3
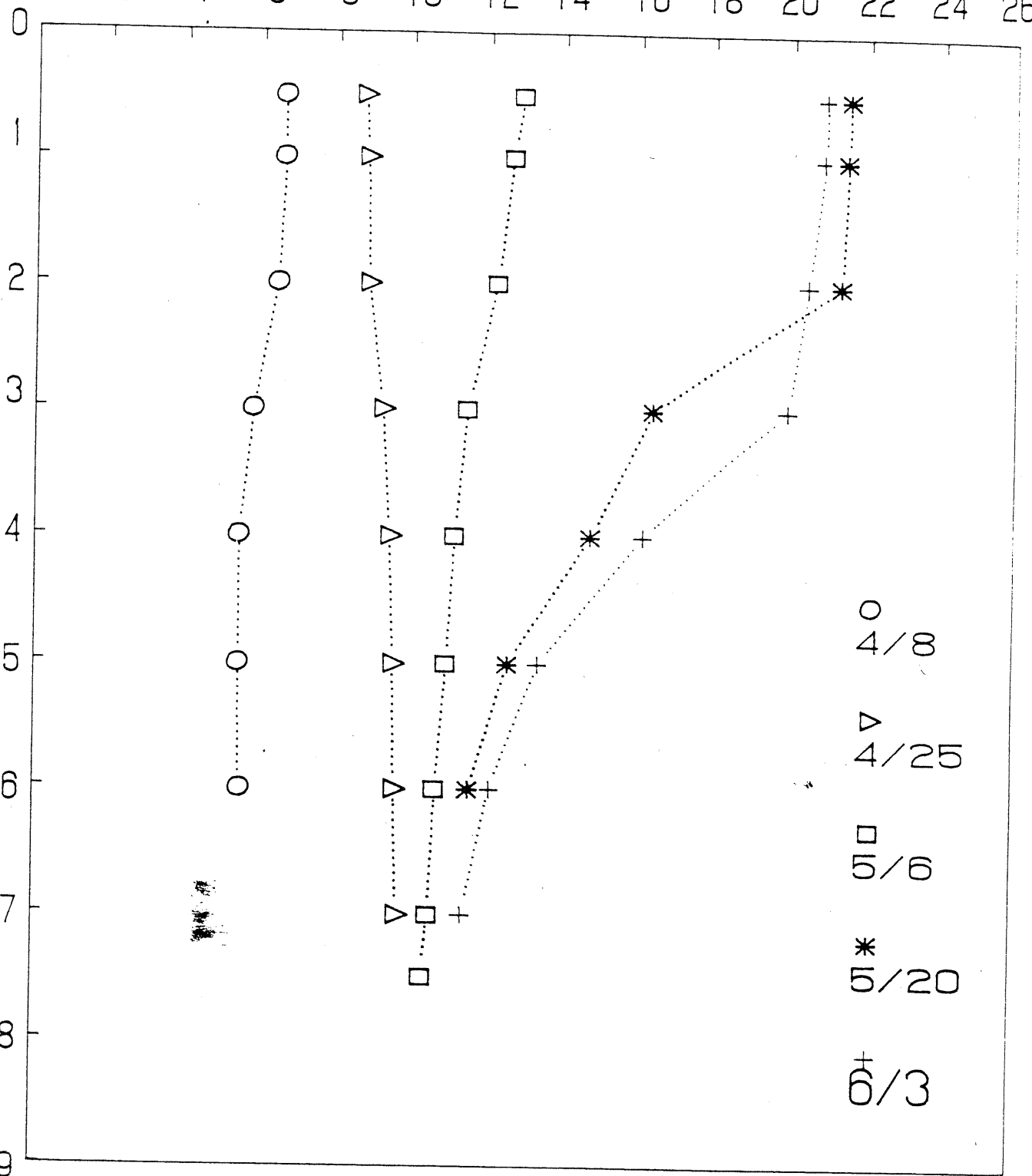
FIGURE 5.12

DISSOLVED OXYGEN PROFILE - SPRING
In-Lake #1 (Main Basin) - ONOTA LAKE

DISSOLVED OXYGEN (mg/l)

O
3/26

▷
4/8

□
4/25

✳
5/6

+
5/20

◇
6/3
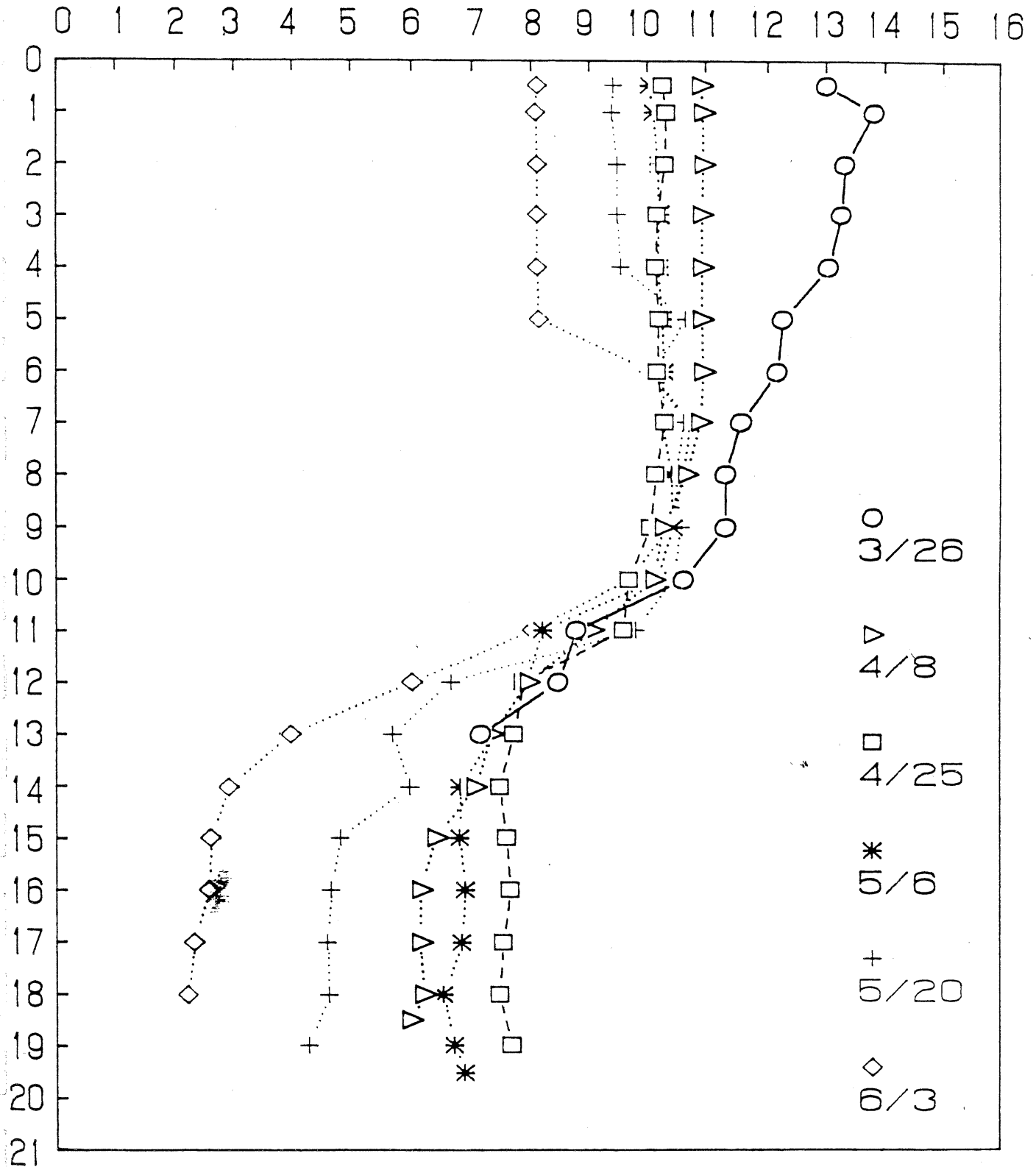
FIGURE 5.13
DISSOLVED OXYGEN PROFILE – SUMMER
In-Lake #1 (Main Basin) – ONOTA LAKE
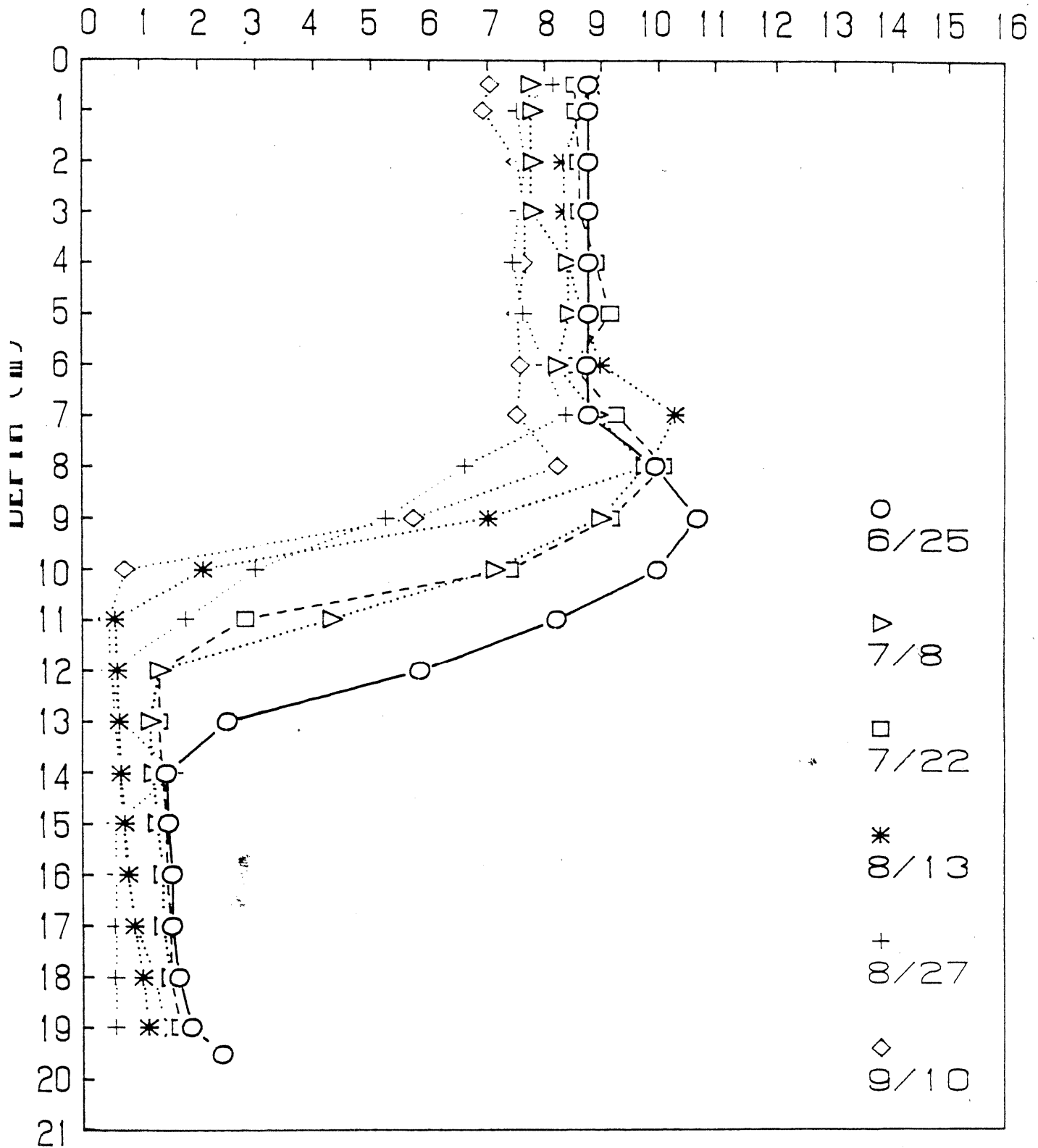
FIGURE 5.14

DISSOLVED OXYGEN PROFILE - FALL
In-Lake #1 (Main Basin) - ONOTA LAKE
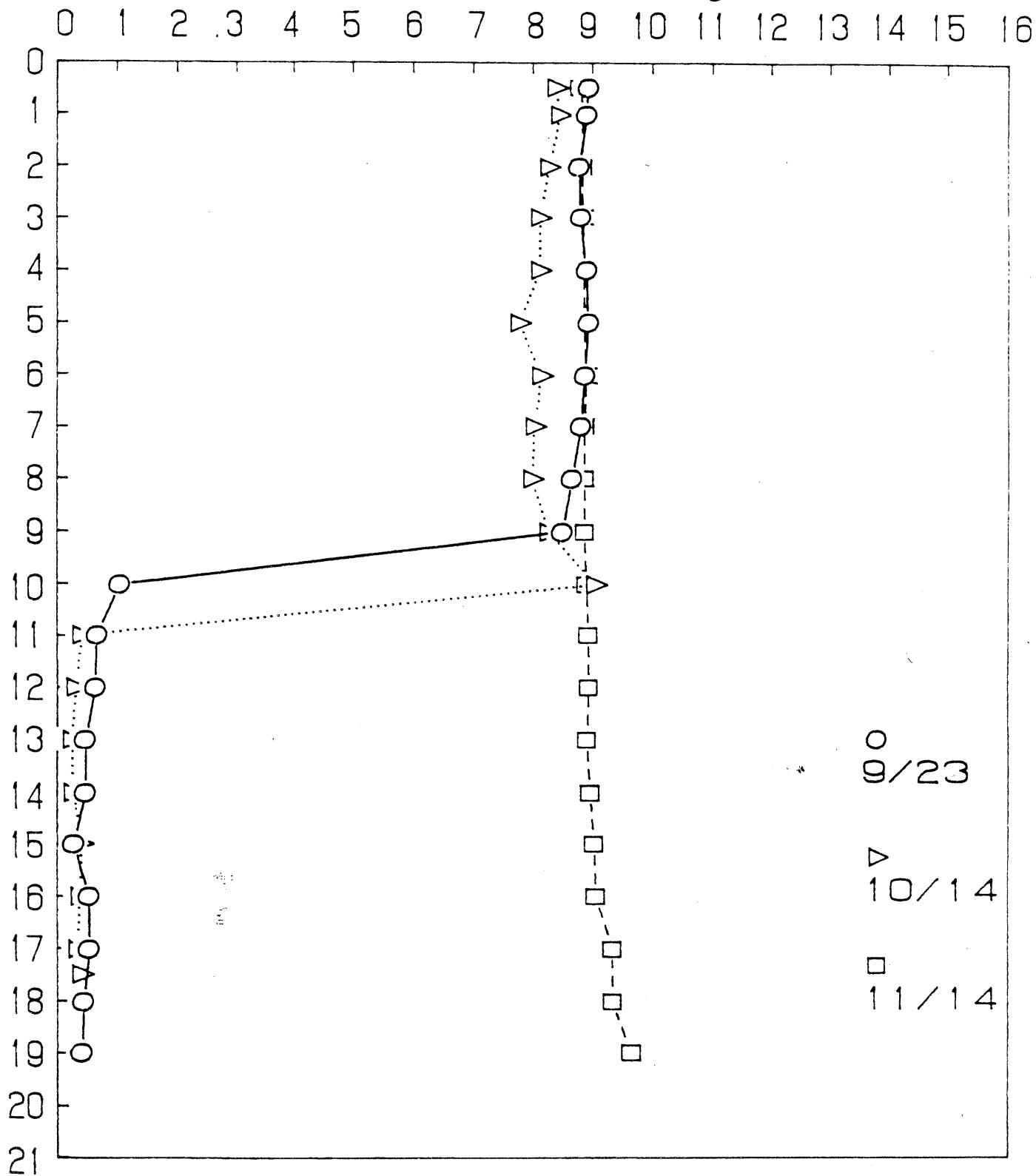
DISSOLVED OXYGEN (mg/l)

Legend:
○ 9/23
▷ 10/14
□ 11/14

FIGURE 5.15

DISSOLVED OXYGEN PROFILE – WINTER
In-Lake #2 (Shallow Basin) – ONOTA LAKE

DISSOLVED OXYGEN (mg/l)

○ 1/21

▷ 2/19
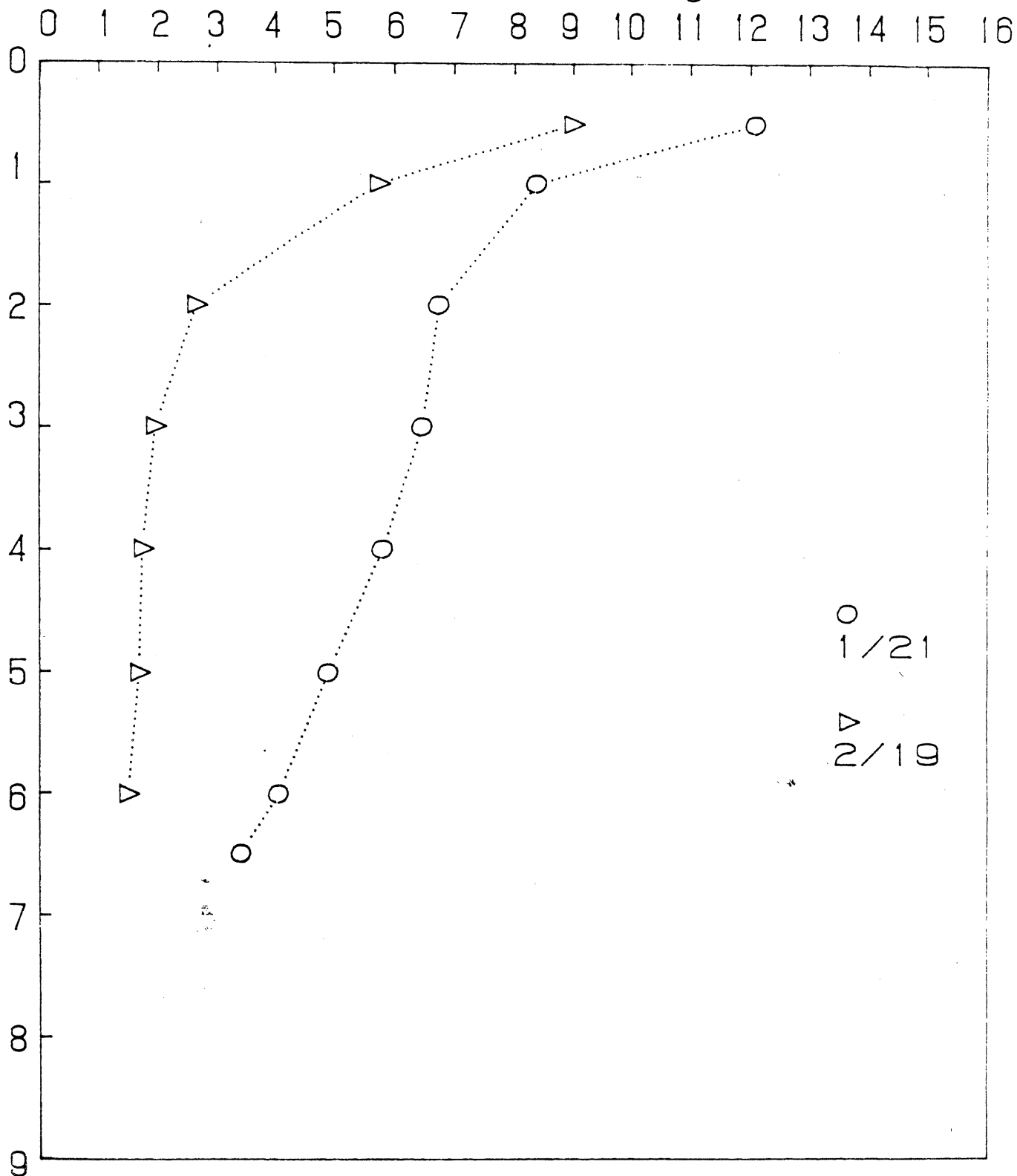
FIGURE 5.16
DISSOLVED OXYGEN PROFILE − SPRING
In-Lake #2 (Shallow Basin) − ONOTA LAKE

DISSOLVED OXYGEN (mg/l)

Legend:
- ○ 4/8
- ▷ 4/25
- □ 5/6
- ∗ 5/20
- + 6/3
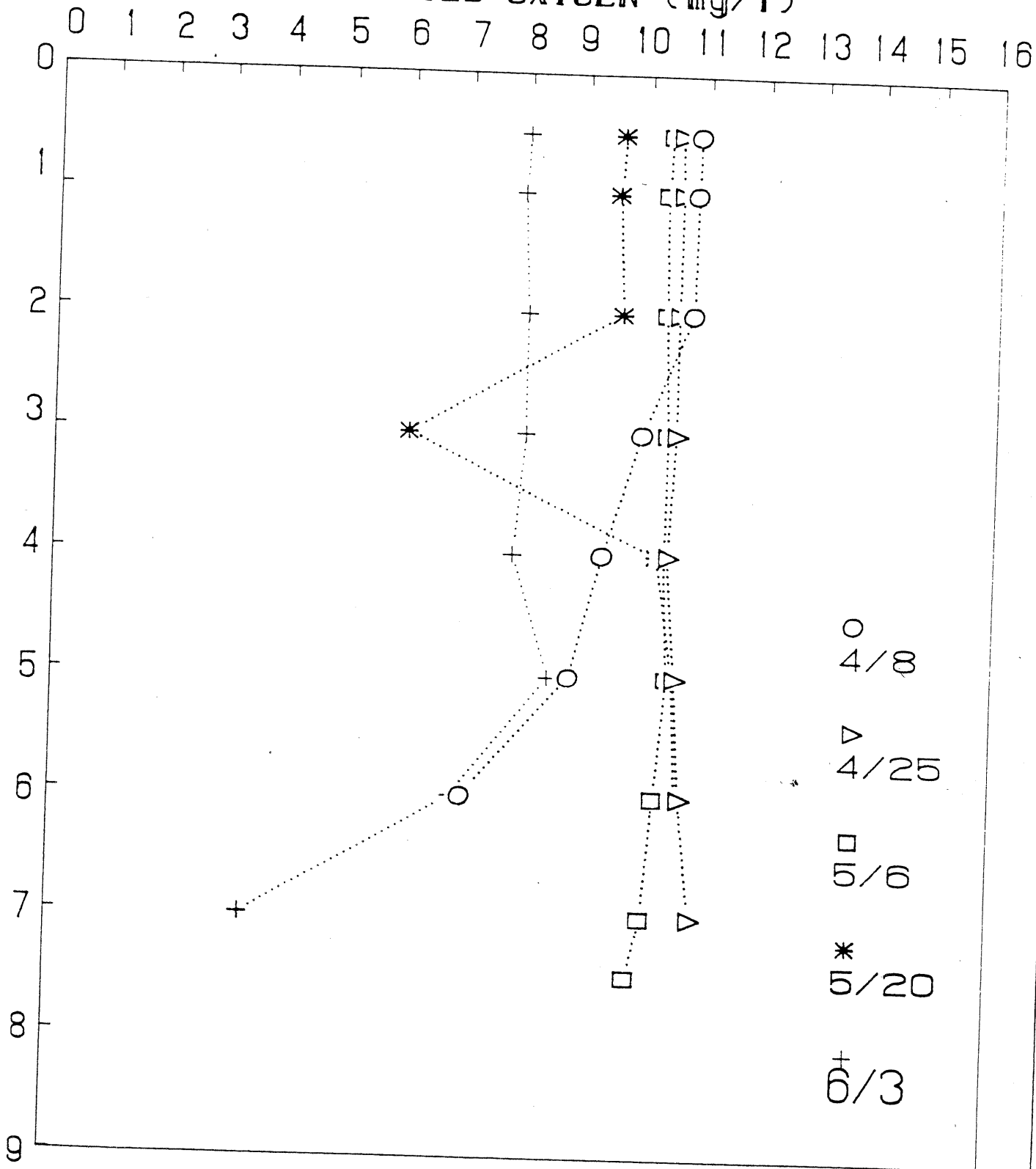
FIGURE 5.17
DISSOLVED OXYGEN PROFILE – SUMMER
In-Lake #2 (Shallow Basin) – ONOTA LAKE
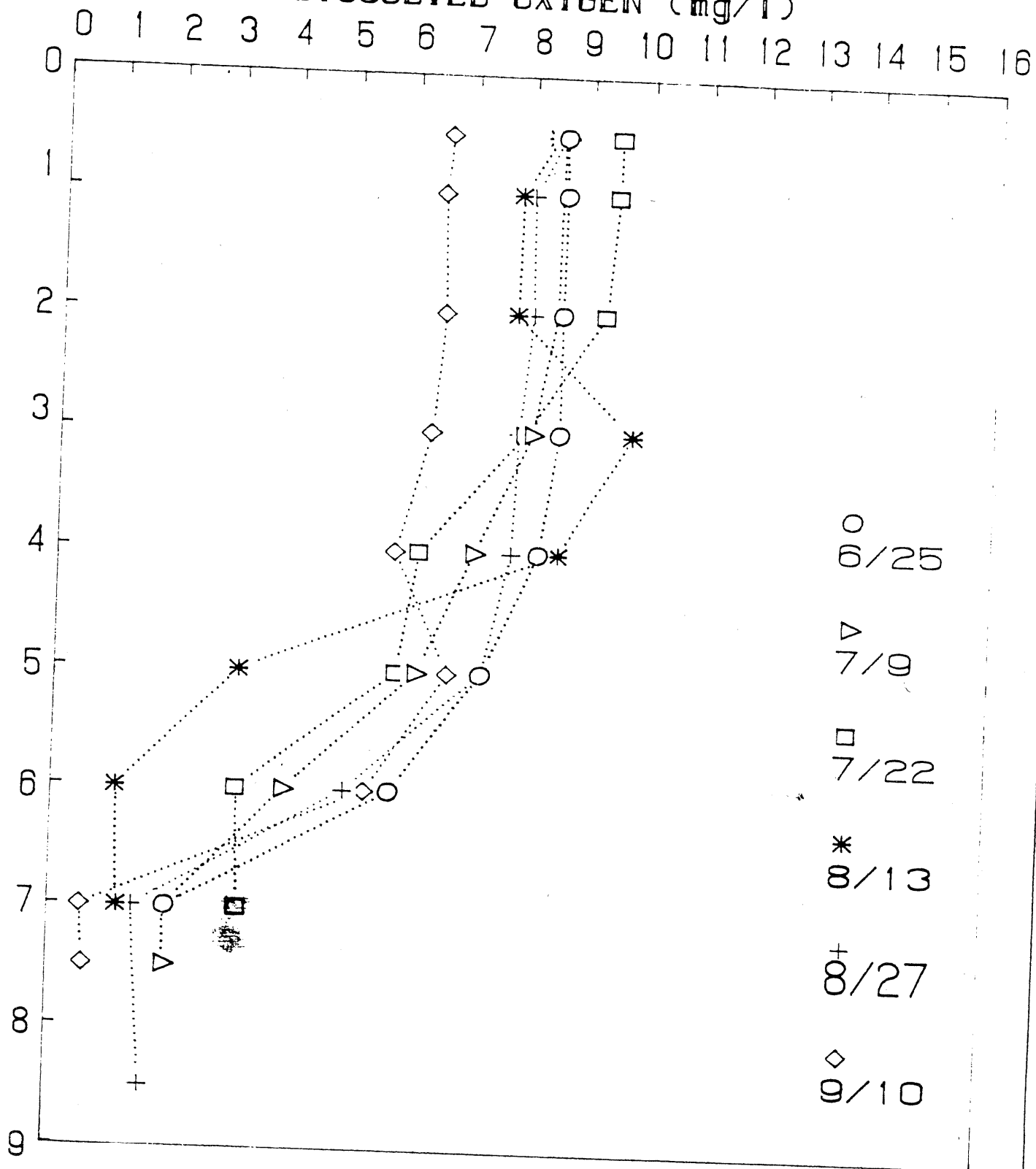
FIGURE 5.18
DISSOLVED OXYGEN PROFILE - FALL
In-Lake #2 (Shallow Basin) - ONOTA LAKE
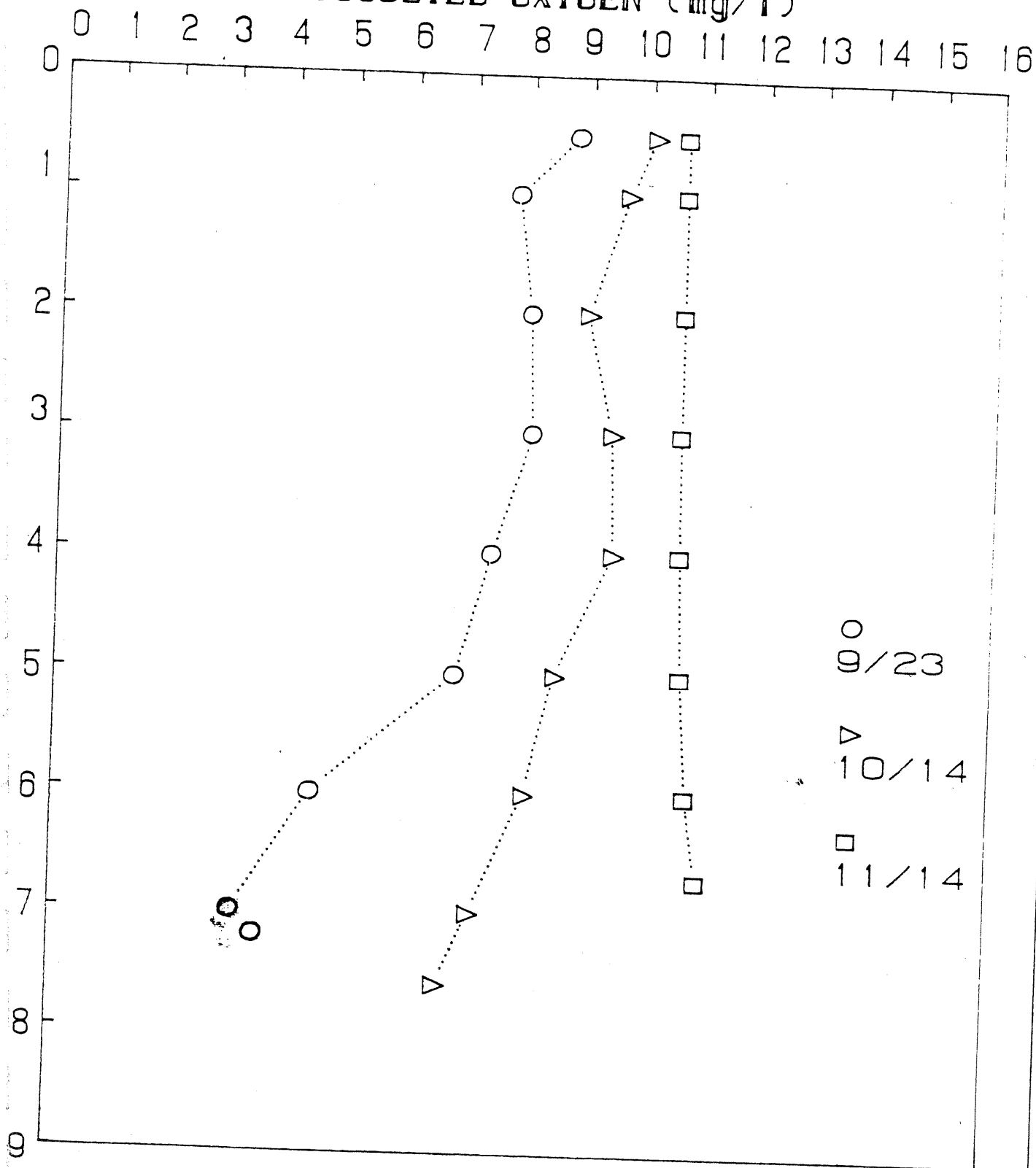
compared to the north basin, nor was it as strongly developed. Although DO concentrations declined over the summer, near anoxic conditions were not observed until August. As compared to the south basin, the period of anoxic conditions, 29 days in 1986, was short.

An increase in dissolved oxygen in the metalimnion was observed during summer stratification at Station 1 between 6 and 11 meters. This increase was first measured in early June (Figure 5.12), and is likely the result of oxygen produced by stenothermal algal populations. This phenomenon occurs as a result of settling algae encountering the thermocline. The density difference is sufficient to impede settling. At this depth light penetration is adequate enough to sustain photosynthesis. The dense accumulation of algae and its photosynthetic activity is sufficient to cause the observed oxygen increase.

5.1.3   Nitrogen

The concentration of ammonia and nitrate are influenced by a variety of biological processes. Ammonia is generated by heterotrophic bacteria as an end product of the decomposition of organic matter. Nitrate is formed as a result of the biological conversion of organic and inorganic nitrogen compounds from a reduced state to a more oxidized state. This process is known as nitrification. Nitrate and ammonia ions are readily utilized as nutrients by phytoplankton and aquatic macrophytes (Wetzel, 1983).

The concentration of ammonia in Onota Lake ranged from <0.02 to 0.58 mg/l (Figure 5.19 and 5.21). The observed mean concentrations at 0.5 meters below the surface were 0.098 mg/l at Station 1 and 0.09 mg/l at Station #2. Mid-depth concentrations were similar to those observed at the surface. The mean concentration at station 1 was 0.08 mg/l and 0.103 mg/l at station #2. Concentrations were generally higher in the lower strata of the lake. At station 1, the mean concentration at 19 meters was 0.192 mg/l. At 7 meters, near the bottom at station 2, the concentration was 0.092 mg/l. This appears to be a result of stratification and anoxic conditions in the hypolimnion. Under anoxic conditions ammonia generated as a result of decomposition will not be oxidized to the nitrate form. This results in an accumulation of ammonia in the lower strata which can be recycled into the water column during

FIGURE 5.19

AMMONIA VS TIME

In-Lake #1 - ONOTA LAKE

□ SURFACE   ○ METALIMNION   △ BOTTOM

DATE
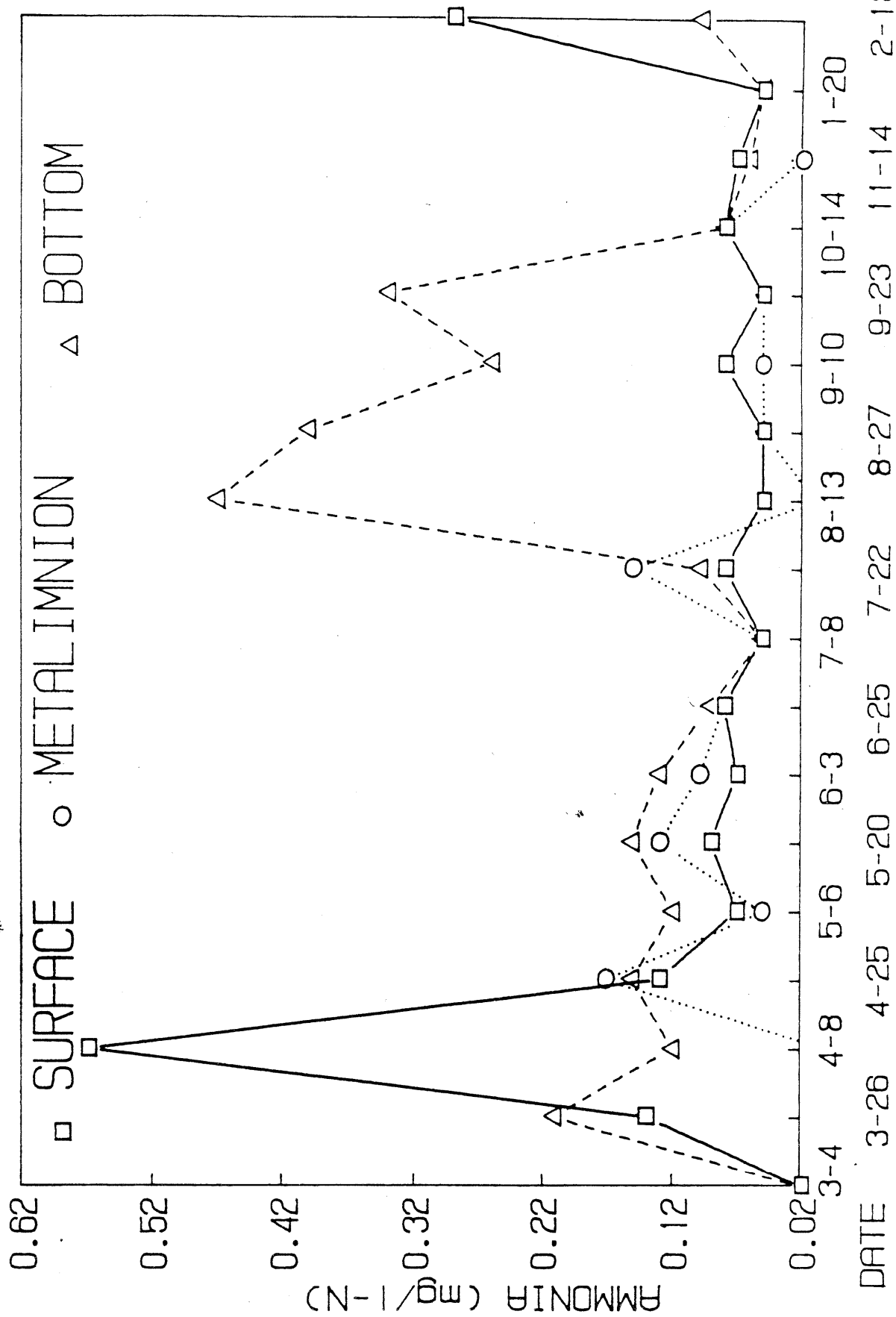
FIGURE 5.20

NITRATE vs TIME

In-Lake #1 - ONOTA LAKE
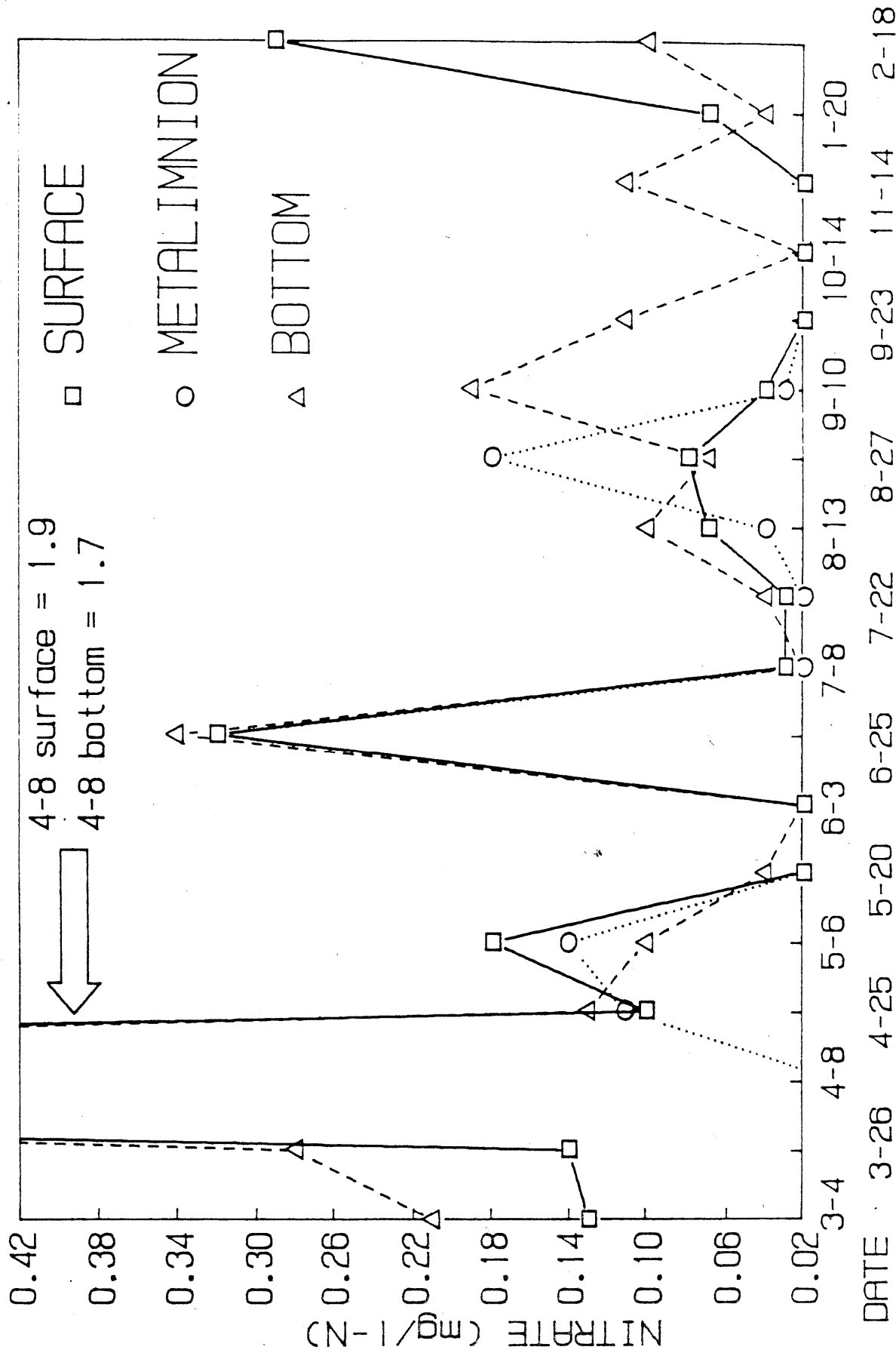
FIGURE 5-21

AMMONIA VS TIME

In-Lake #2 - ONOTA LAKE

□ SURFACE ○ METALIMNION △ BOTTOM
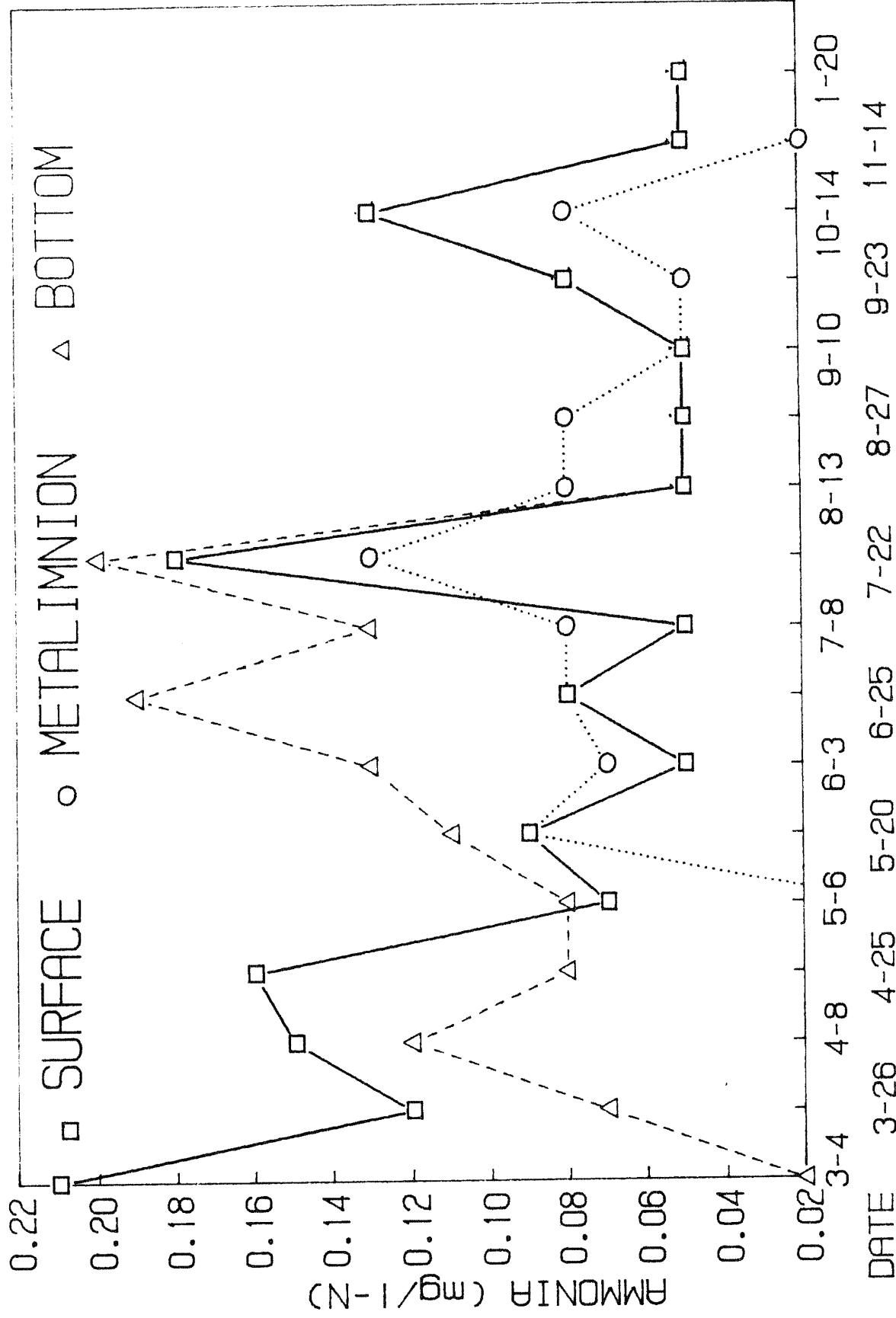
FIGURE 5.22

NITRATE VS TIME
In-Lake #2 - ONOTA LAKE

NITRATE (mg/1-N)

DATE

3-4 surface = 1.1

□ SURFACE   ○ METALIMNION   △ BOTTOM
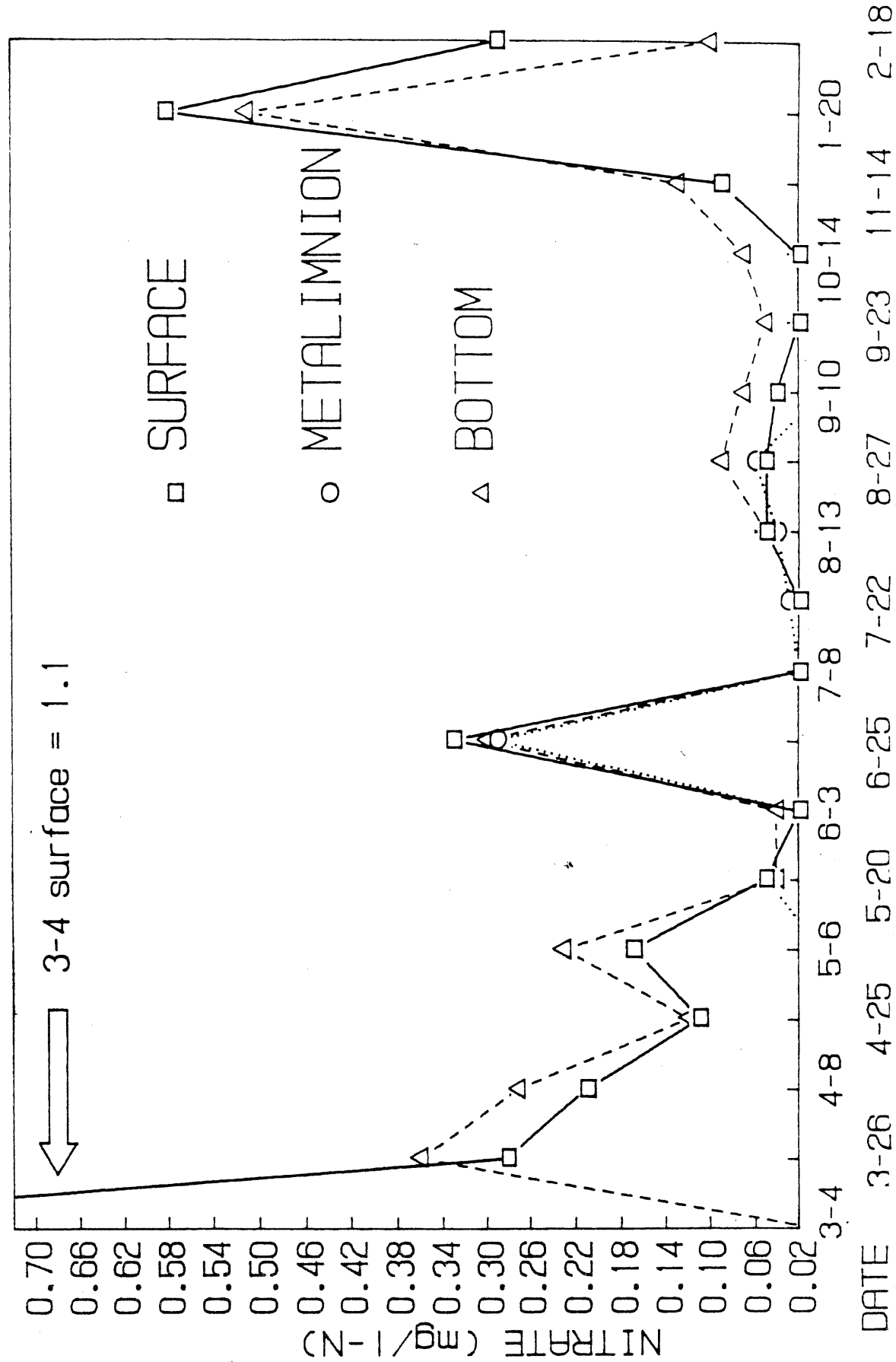
periods of mixing and subsequent oxidation. Nitrate-nitrogen exhibited a sharp increase in concentration during the winter season (Figures 5.20 and 5.22). This pattern is similar to that commonly found in temperate lakes and is attributable to the decreased rate of assimilation by plankton and decreased rate of reduction by bacteria. Additional disparity between summer and winter concentrations may also be attributable to the decreased rate of nitrification during periods of stratification as the hypolimnion becomes anaerobic.

5.1.4 Phosphorus

In north temperate waterbodies, phosphorus is usually the limiting nutrient for plant growth (Sawyer, 1970). In essence, the availability of phosphorus, its annual load to the lake and subsequent concentration in the water column will greatly influence productivity. As the supply of phosphorus is increased, productivity is accelerated and/or increases as well (Lee et al., 1976). As a result of this classical relationship between phosphorus and productivity the EPA (USEPA, 1980) and other regulatory agencies have developed trophic "guidelines" based on the in-lake concentration of phosphorus. The Massachusetts Division of Water Pollution Control has identified in lake TP concentrations exceeding 0.01 mg/l as potentially degrading. This implies that phosphorus concentrations of this magnitude could accelerate the eutrophication process. In Onota Lake, total phosphorus (TP) concentrations ranged from <0.01 to 0.63 mg/l, but were generally less than 0.05 mg/l (Figures 5.23 and 5.24).

TP concentrations measured in the lake over the survey period displayed great variation. This variation, under closer inspection, is largely the result of stratification and mixing phenomena, phytoplankton activity and interval regeneration from anaerobic sediments. When viewed in respect to seasonal biophysical processes, the TP dynamics of Onota Lake are fairly typical.

At Station 1, the South Basin, TP concentrations displayed three unique peaks. The first occurred in the spring approximately at the onset of stratification (Figure 5.23). This peak was probably the result of spring thaw loading and lake mixing which occurred in March and April. As the growing

The north basin did not exhibit an increase in epilimnetic TP following destratification as did the South Basin (Figure 5.24). This observation may be the result of two factors. First, if there were sediments entrained in the July 8 sample, causing a higher TP peak, these results should be discounted. Upon exclusion of the July 8 data point the TP in the North Basin's bottom water never reached the magnitude observed in the South Basin. As such, the internally regenerated load was probably insignificant (See Section 10). Second, in the North Basin, the volume of the epilimnion is relatively much greater than that of the hypolimnion, as most of the North Basin is shallow (Figure 4.2). When the North Basin destratifies its volumetric contribution to the epilimnion is minimal. The combination of the small volume below the thermocline and the small quantity of the internally regenerated TP load, results in only a minor increase in epilimnetic TP being realized in the fall (Figure 5.24).

5.1.5 pH

In typical northern lakes, such as Onota Lake, the pH ranges from 6.0 to 9.0. The pH of Onota Lake was found to range from 6.8 to 8.3 with a marked decrease evident with increasing depth (Figures 5.25 and 5.26). This vertical distribution is mostly attributable to the (a) photosynthetic utilization of carbon dioxide (CO_2) in the trophogenic zone, which tends to reduce CO_2 content and to increase pH, and (b) the degradation of organic matter in the hypolimnion which generates CO_2 and tends to decrease pH.

Vertical variations in pH became more pronounced during summer stratification due to increased photosynthetic activity and decreased mixing of the water column. During those periods when Onota Lake exhibited a positive heterograde oxygen curve at Station 1, a corresponding positive heterograde pH curve was also evident.

5.1.6 Alkalinity

Alkalinity or buffering capacity is a measure of the ability of a lake to maintain neutral pH. Onota Lake can be considered to be a waterbody of medium buffering capacity. Total alkalinity, measured as $CaCO_3$, ranged from 60 to 80

season progressed, the concentration of TP in the surface waters declined, but hypolimnetic concentrations rose. The observed increase in hypolimnetic TP concentrations became most obvious after July 22nd. It is at approximately this date that the hypolimnion became anoxic. Under anoxic conditions, lake sediment chemistry is altered, and the remineralization of phosphorus occurs (Freedman and Canale, 1977). This can lead to the accumulation of significant quantities of phosphorus in the non-mixed hypolimnion (Souza and Koppen, 1984). When the lake destratifies and undergoes mixing, the soluble phosphorus which was remineralized can be circulated into the epilimnion and may stimulate algal productivity. This result is an autumnal bloom. As the stratification of the south basin weakened in the fall, hypolimnetic concentrations declined and metalimnetic concentrations increased. When the lake began to turn over in the fall, a dramatic increase in epilimnetic TP was observed (Figure 5.23). The usual condition is for nutrients to be nearly evenly distributed in the water column after overturn. The reason for the great disparity in surface and bottom total phosphorus concentrations found in the November south basin sample is not known. As such, stratification, mixing, and internal regeneration of sediment bound phosphorus were processes which appeared to most greatly influence TP dynamics to the south basin.

In the North Basin, Station 2, the pattern which developed was somewhat different than observed in the South Basin. In the spring, a peak in TP was observed in the surface, metalimnion and bottom waters (Figure 5.24). As with the South Basin, these peaks occurred shortly after the North Basin became stratified. Once stratified, epilimnetic TP concentrations declined and remained low (<0.05 mg/l) for the remainder of the growing season. Bottom water TP however rose dramatically in July and to a lesser degree in August (Figure 5-24). It is suspected that the July 8th concentration may be an aberration of faulty data point. Anoxic conditions did not persist in the North Basin's hypolimnion until August. The second bottom water TP peak coincides with the advent of anoxic conditions, and is probably the result of internal TP regeneration from anaerobic sediments. The first bottom water TP peak however occurred prior to anoxic conditions. It is possible that sediment was disturbed during sampling and became entrained in the sample.

mg/l. This range is typical for most Berkshire Lakes (Mass. Div. of Fisheries and Game, 1979). No substantial fluctuation in the lake's alkalinity was observed over the duration of the study. The observed pH and alkalinity values indicate that the lake is, at present, not affected by acid precipitation. The limestone geology of the watershed contributes to this historical resistance in a decline in pH and a stable buffering capacity.

5.1.7 Secchi Disc Transparency

Secchi disc transparency provides a subjective means of determining transparency and subsequently estimating productivity of a lake. Transparency is affected by a number of factors including density of planktonic algal cells, dissolved and particulate matter, water color, surface conditions, time of day, and observer bias. When algal biomass is the primary factor influencing transparency, Secchi disc measurements can be used as an indicator of productivity in the following manner: lakes with transparencies greater than 8 meters are considered oligotrophic, those less than 2 meters are eutrophic and those falling in between 2 and 8 meters are associated with mesotrophic lakes. Utilizing these criteria, Onota Lake can be considered mesotrophic.

Readings at Station 1 were generally 5 meters with the maximum transparency reaching approximately 7 meters on October 14 and a minimum of 3.5 meters on April 8. As illustrated in Figure 5.27, these variations relate to algal growth.

Readings at Station 2 were generally 3.5 meters with a maximum of approximately 4.7 meters reached on June 3, July 22, and October 14. Minimum transparencies of approximately 2 meters were reached on June 25 and February 19. The February low is attributable to ice cover whereas the June low is a combination of algal growth and macrophyte shading (Figure 5.28). The relationship of secchi disc transparency and phytoplankton growth is addressed further in sections 5.1.8 and 5.2.

5.1.8 Chlorophyll

Concentrations of chlorophyll a, b, c, and pheophytin were monitored throughout the study and employed as an indicator of primary production. These data were utilized in combination with net and whole phytoplankton data (Section 5.3.1) as an indicator of the lake's trophic condition. Changes in chlorophyll a were examined in relation to changes in season, station, and secchi disc depth. Chlorophyll concentrations ranged from 0.1 to 7.5 mg/m^3. These concentrations are generally indicative of a mesotrophic water bodies.

Generally, chlorophyll concentrations in Station 1 were higher than at Station 2 (Figures 5.27 and 5.28). Decreased concentrations of chlorophyll a at Station 2 may be attributable to the high density of macrophytes found at this station. Macrophytes tend to compete with the resident phytoplankton populations primarily for available light but also nutrients. This typically reduces the establishment of dense phytoplankton communities.

A seasonal increase in the concentration of algae is evident in late May and September. The peak in May is probably the result of a combination of optimal temperature, light and nutrients. The September peak is probably due to macrophyte dieback in the north basin, epilimnetic erosion of the hypolimnetic TP rich water (Kortman, et al. 1982) and eventually destratification and turnover of the lake.

Chlorophyll concentrations were generally lowest during the winter months when population densities are reduced as a result of low light and temperatures.

5.1.9 Bacteria

Coliform bacteria are utilized as indicator organisms of septic or sewage contamination of waters. Although some coliform bacteria occur naturally in the environment, fecal coliform bacteria are resident in the intestinal tract of birds and mammals. The occurrence of coliform bacteria may signify the potential presence of pathological bacteria or viruses. As such, standard bacteriological analyses are routinely conducted for any water body which is used for potable water or contact recreation such as swimming. The

FIGURE 5.23

TOTAL PHOSPHATE vs TIME
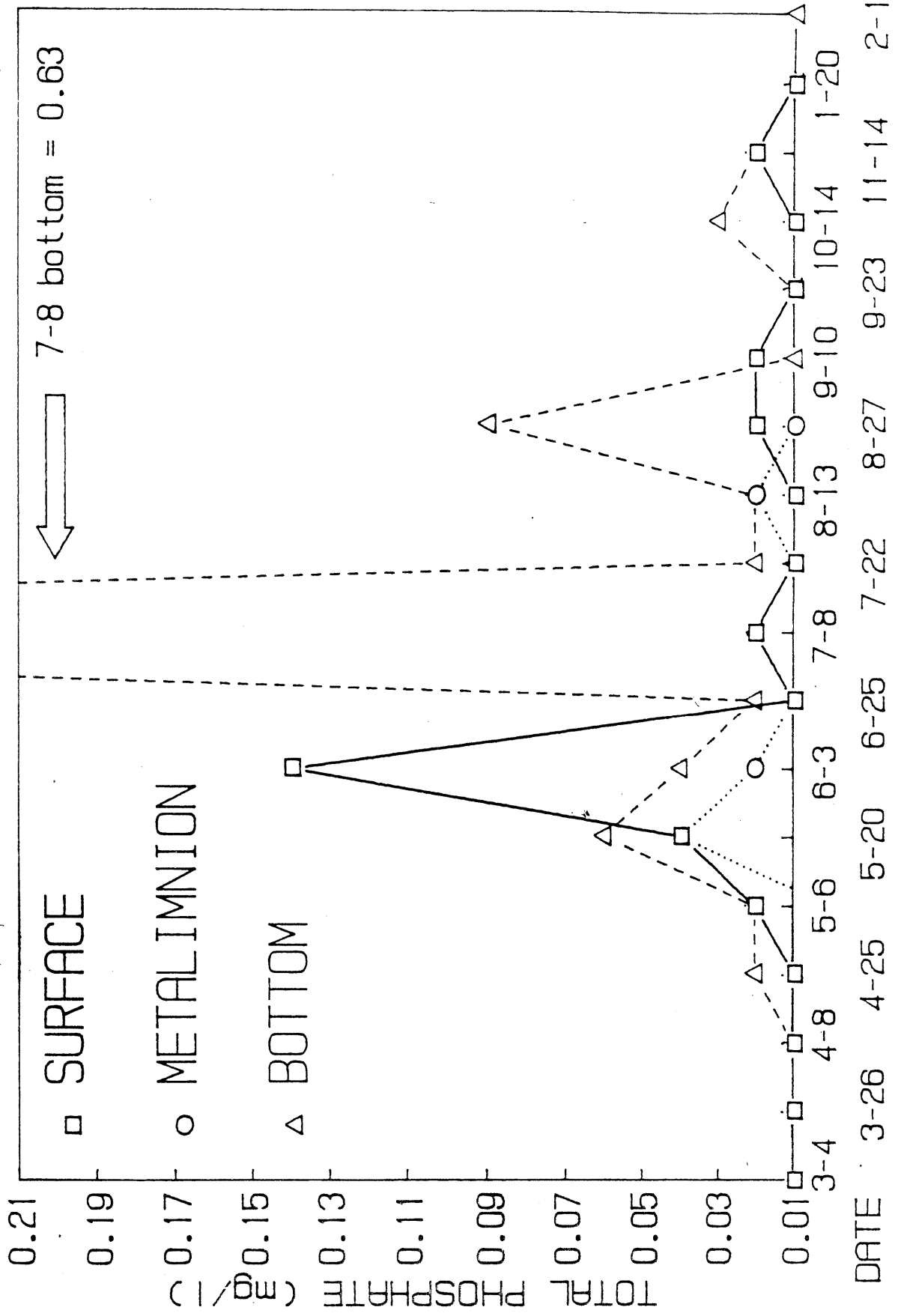
In-Lake #1 - ONOTA LAKE

11-14 surface = 0.41

□ SURFACE   ○ METALIMNION   △ BOTTOM
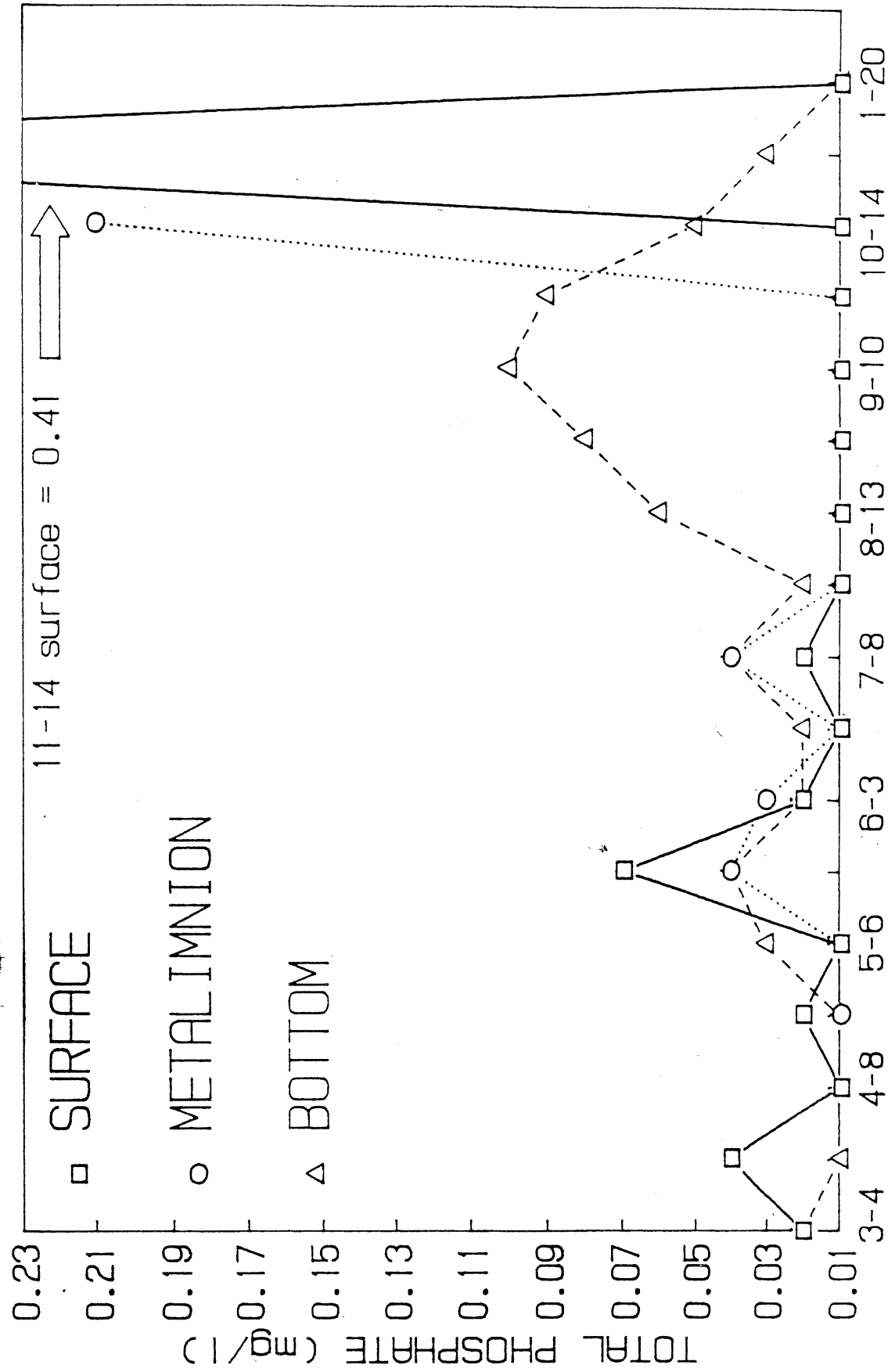
FIGURE 5.24

TOTAL PHOSPHATE VS TIME

In-Lake #2 - ONOTA LAKE

7-8 bottom = 0.63

□ SURFACE   ○ METALIMNION   △ BOTTOM

FIGURE 5.25

pH vs TIME

In-Lake #1 - ONOTA LAKE

□ SURFACE   ○ METALIMNION   △ BOTTOM

pH (units)

DATE   3-4   4-8   5-6   6-3   7-8   8-13   9-10   10-14   1-20
       3-26 4-25 5-20 6-25 7-22 8-27   9-23   11-14   2-18
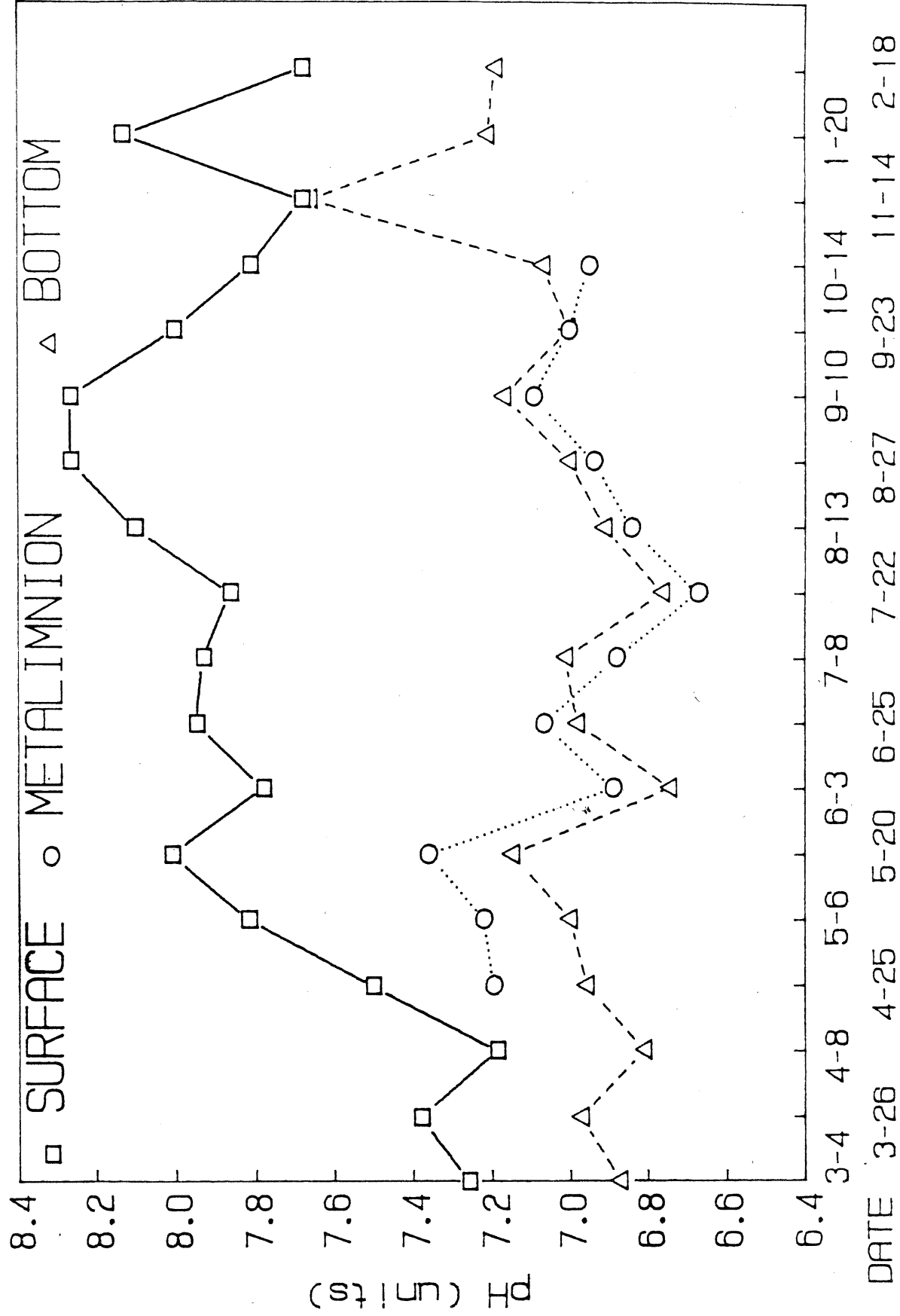
FIGURE 5.26

pH VS TIME
In-Lake #2 - ONOTA LAKE

□ SURFACE ○ METALIMNION △ BOTTOM
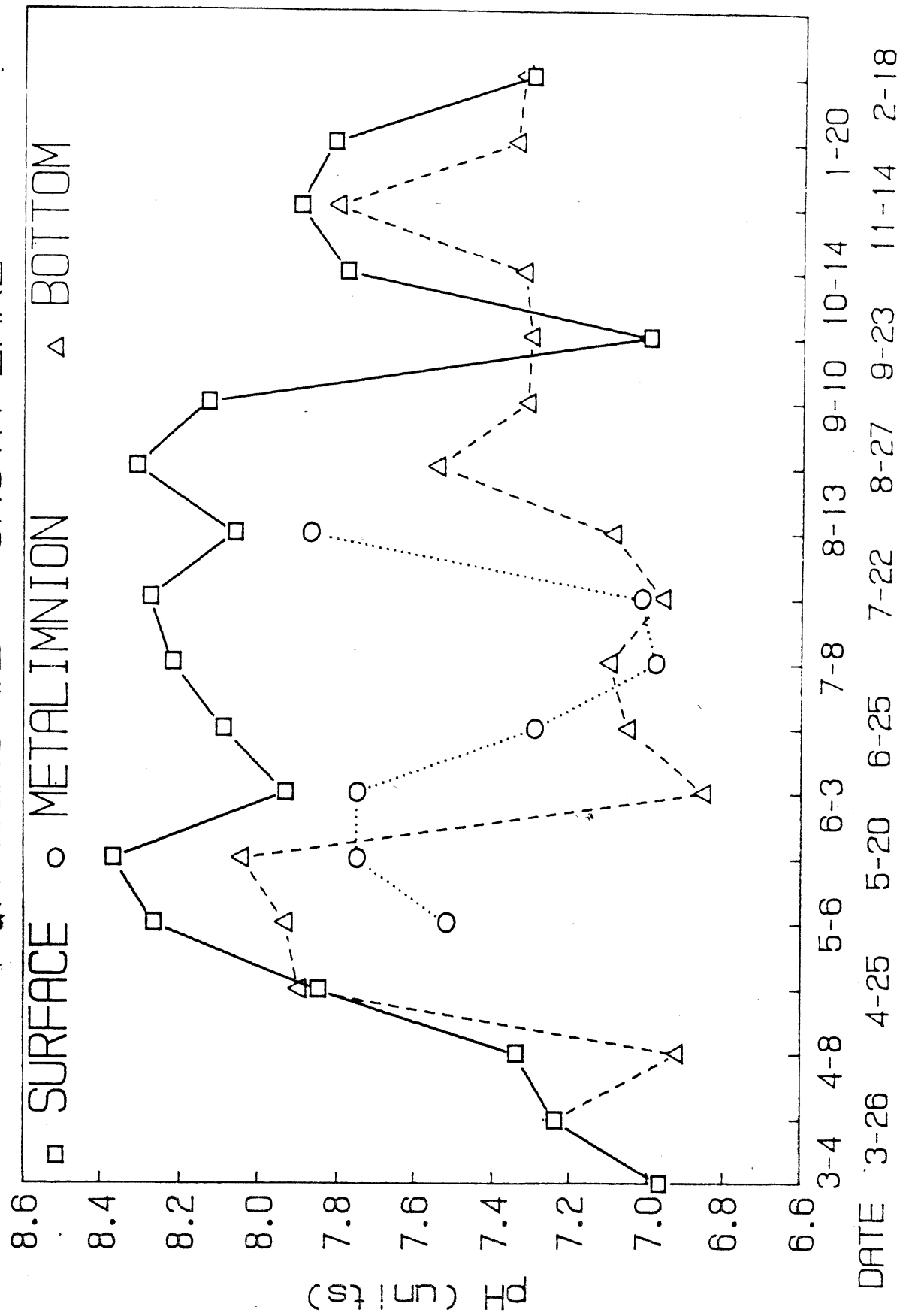
FIGURE 5.27
SECCHI DEPTH & TOTAL CHLOROPHYLL VS TIME
In-Lake #1 (Main Basin)
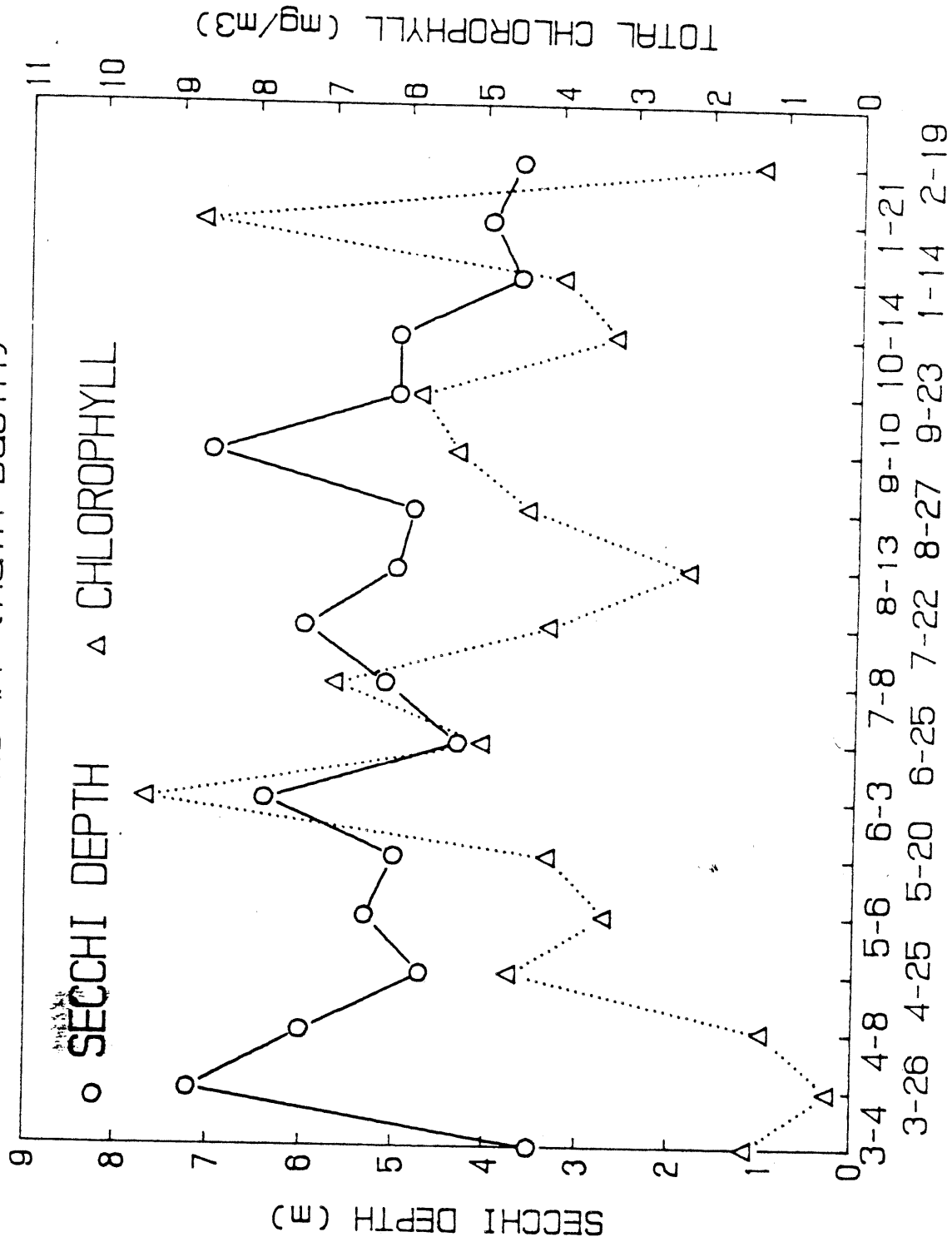
ONOTA LAKE

FIGURE 5.28

SECCHI DEPTH & TOTAL CHLOROPHYLL VS TIME
In-Lake #2 (Shallow Basin)

□ SECCHI DEPTH   o CHLOROPHYLL
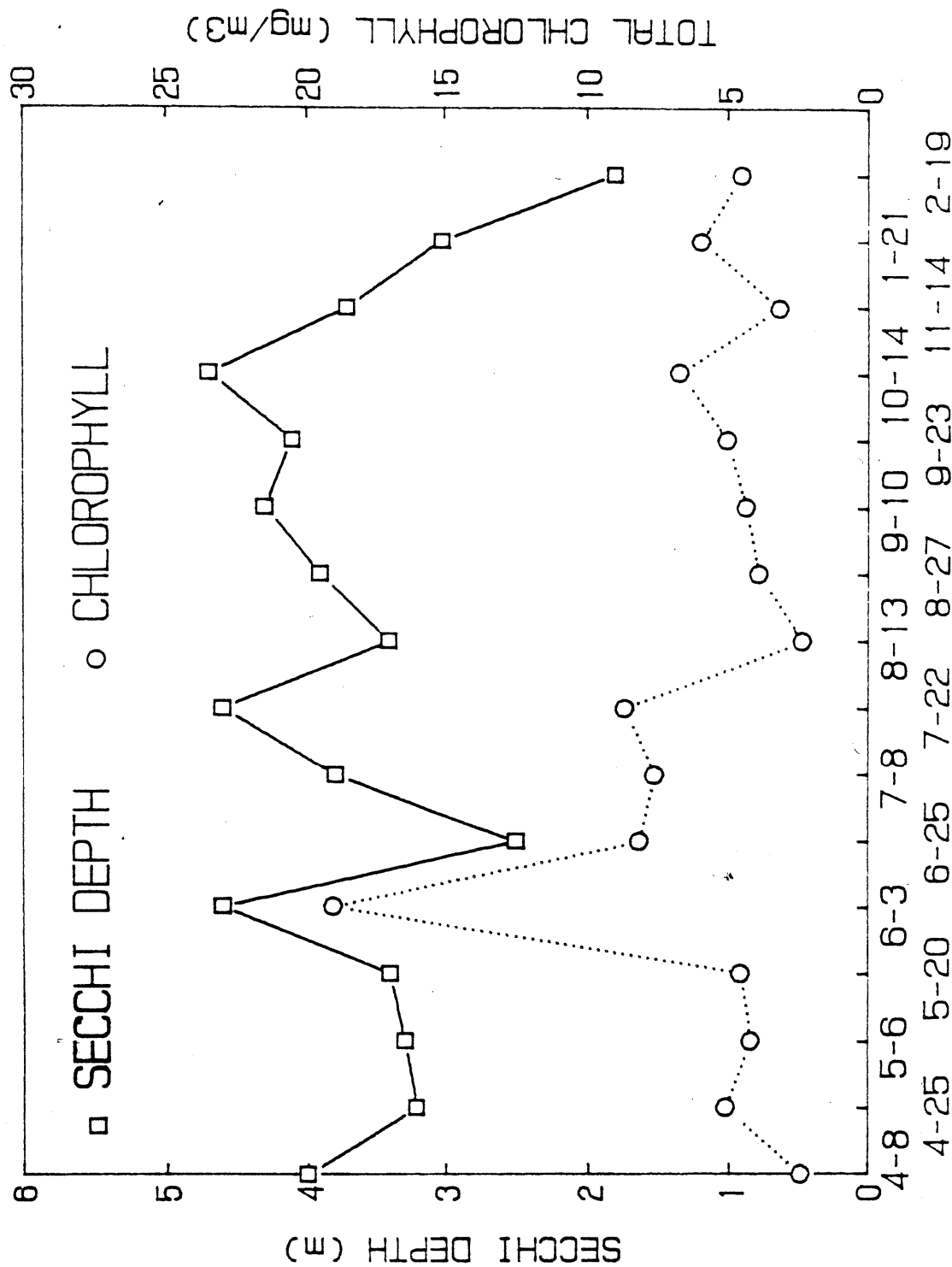
ONOTA LAKE

Massachusetts Surface Water Quality Standards (314 CMR) identify the water quality criteria required to sustain the designated use of a water body. Class B waters must meet the following criteria in respect to fecal coliform bacteria:

"Shall not exceed a log mean for a set of samples of 200 per 100 ml, nor shall more than 10% of the total samples exceed 400 per 100 ml during any monthly sampling period, except as provided in 310 CMR 4.01(1)."

Throughout the study fecal coliform numbers measured in the lake were relatively low and did not exceed state standards. The analysis for non-fecal coliforms is important as well, because their abundance may also result in unsatisfactory water quality (APHA, 1976). In-lake total coliform concentrations were variable (Figure 5.29 and 5.30), and at various times over the sampling program, peaks were observed. These peaks tended to coincide with periods of heavy lake usage (Memorial Day, July 4) or significant rainfall events (6/23; 7/2-7/6, 8/7-8/11; 8/27, 9/23, and 10/15). Total coliform levels were elevated (>400 colonies/100 ml) for most of August in the North Basin. This may be attributable to the unseasonably high rainfall which occurred during July and August 1988. The majority of the lake's watershed drains to the north basin. Storm activity could have increased soil erosion and street runoff which in turn exacerbated coliform levels in this section of the lake.

5.2 WATER QUALITY - TRIBUTARY SAMPLING

Six streams are tributaries to Onota Lake. Two are intermittent, seasonal streams. The four major tributaries are: Daniels Brook, Churchill Brook, Parker Brook and a small tributary which drains the Blythewood Drive area along the western shore (Figure 5.1). The lake's primary tributary is Parker Brook. Parker Brook is fed by Hawthorne and Lulu Brook. The three streams converge approximately 1/2 mile upstream of Onota Lake. The three streams drain a total area of 865 hectares (see Section 4). In addition to the intermittent streams, there are seasonal seeps and drainage along the western shore and at the southeast end of the lake near Blythewood Drive.
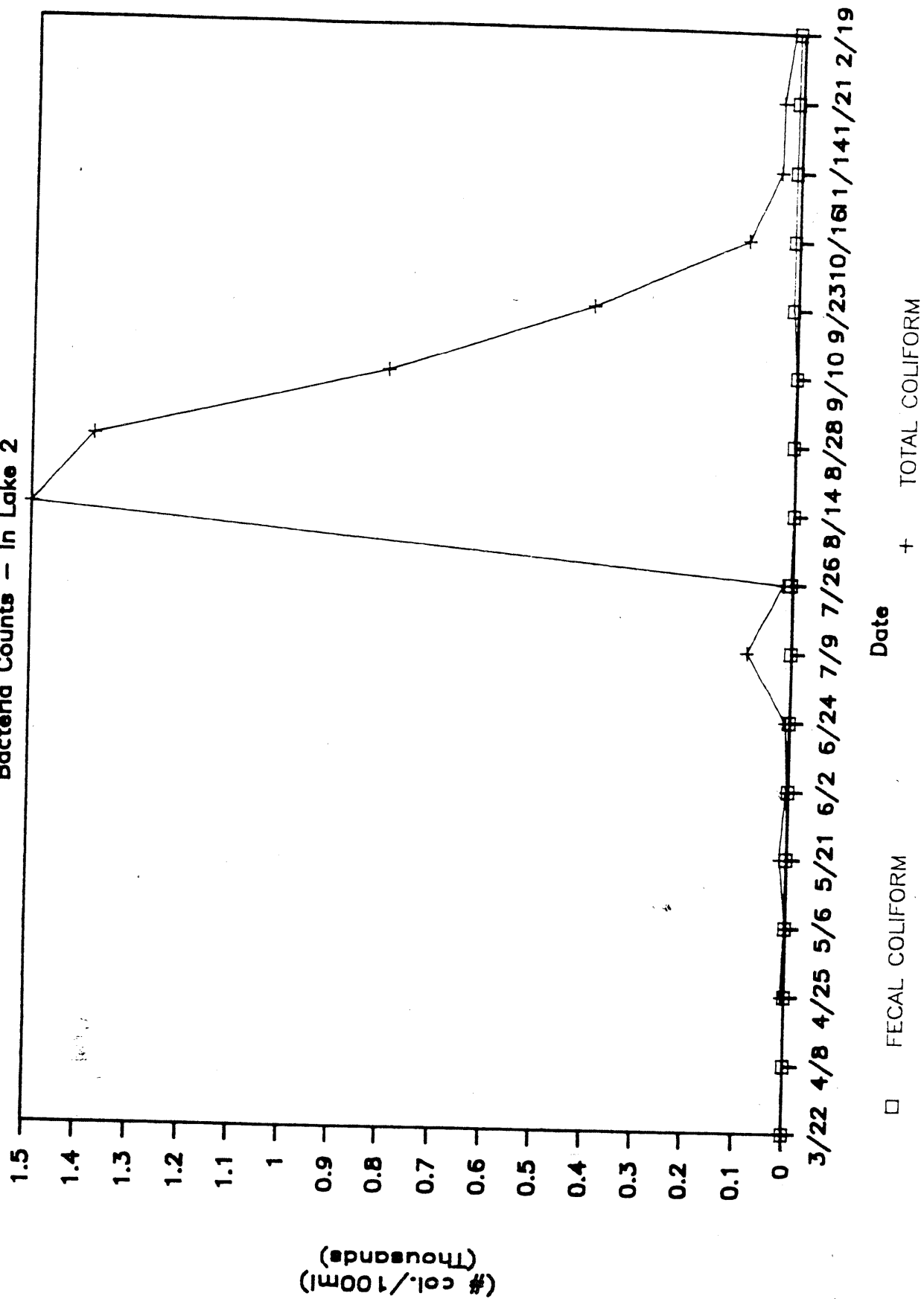
FIGURE 5.29

Bacteria Counts – In Lake 1

(# col./100ml)

Date

3/22 4/8 4/25 5/6 5/21 6/2 6/24 7/9 7/26 8/14 8/28 9/10 9/23 10/16 11/14 1/21 2/19

□   FECAL COLIFORMS   +   TOTAL COLIFORMS
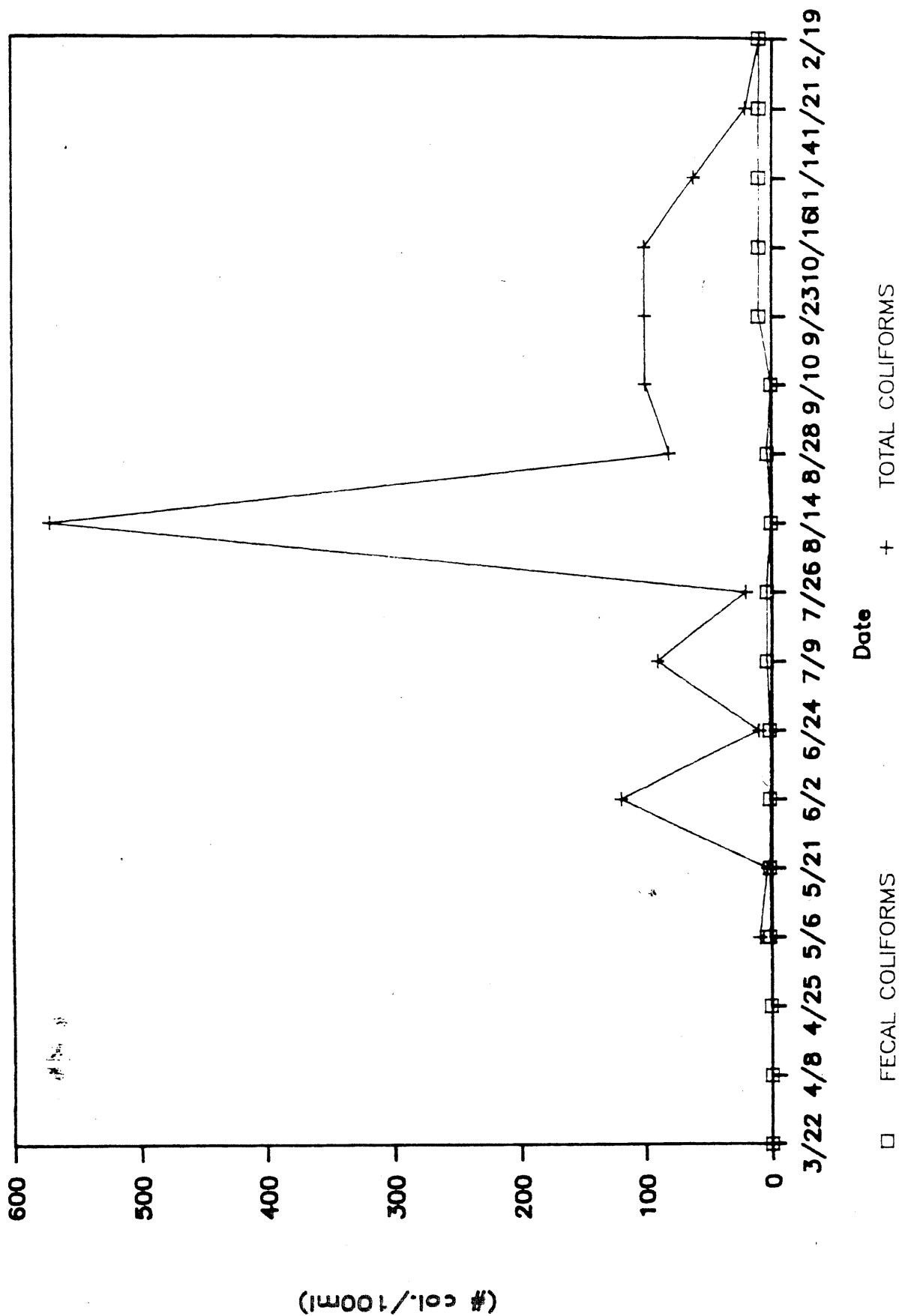
FIGURE 5.30

Bacteria Counts – In Lake 2

Date

□ FECAL COLIFORM + TOTAL COLIFORM

(# col./100ml)
(Thousands)

Surface water samples were collected at mid-channel at the four major tributaries and the outfall on a bi-monthly basis from March through fall circulation, and monthly for the rest of the year. Two additional tributaries (Tributaries 4 and 5) were originally included and sampled on a bimonthly basis, however after four sampling events it was deemed that neither were major components of the lake's water or nutrient budgets. Sampling of these two tributaries was terminated at the end of May, and the effort allocated to different aspects of the project.

The tributaries were monitored in accordance with the Phase I Scope of Work, under baseline and storm conditions. Storm events were monitored on 9-24-86 and 3-31-87.

Results of the chemical and microbiological analysis of the various tributaries feeding Onota Lake are presented in Figures 5.31 to 5.67 and Appendix B. In general, these data indicate that the waters which feed Onota Lake are well oxygenated, and characterized by high nutrient and coliform bacteria concentrations. The high nutrient and coliform bacteria concentrations are attributable to land use within the drainage areas of these tributaries. Of specific concern is loading resulting from agriculture activities, residential development, and septic contributions.

5.2.1 Churchill Brook and Daniels Brook

Churchill and Daniels Brooks drain the lakes, two northern-most sub-basins. Land use within these sub-basins is largely a combination of forest/farmland with sparse residential development. Sections of both sub-watersheds were quarries at one time and remain erosion prone.

Total phosphorus ranged from 0.008 to 0.07 mg/l at Churchill and Daniels Brook. The observed mean concentration of TP in Daniels Brook was 0.021 mg/l and 0.015 mg/l in Churchill Brook (Appendix B1-B2). The U.S. Environmental Protection Agency (1976) suggests that to prevent accelerated eutrophication, in-stream total phosphorus concentrations should not exceed 0.05 mg/l. TP concentrations exceeded this criteria on two occasions, both of which were associated with storm events (Figures 5.42 and 5.47).
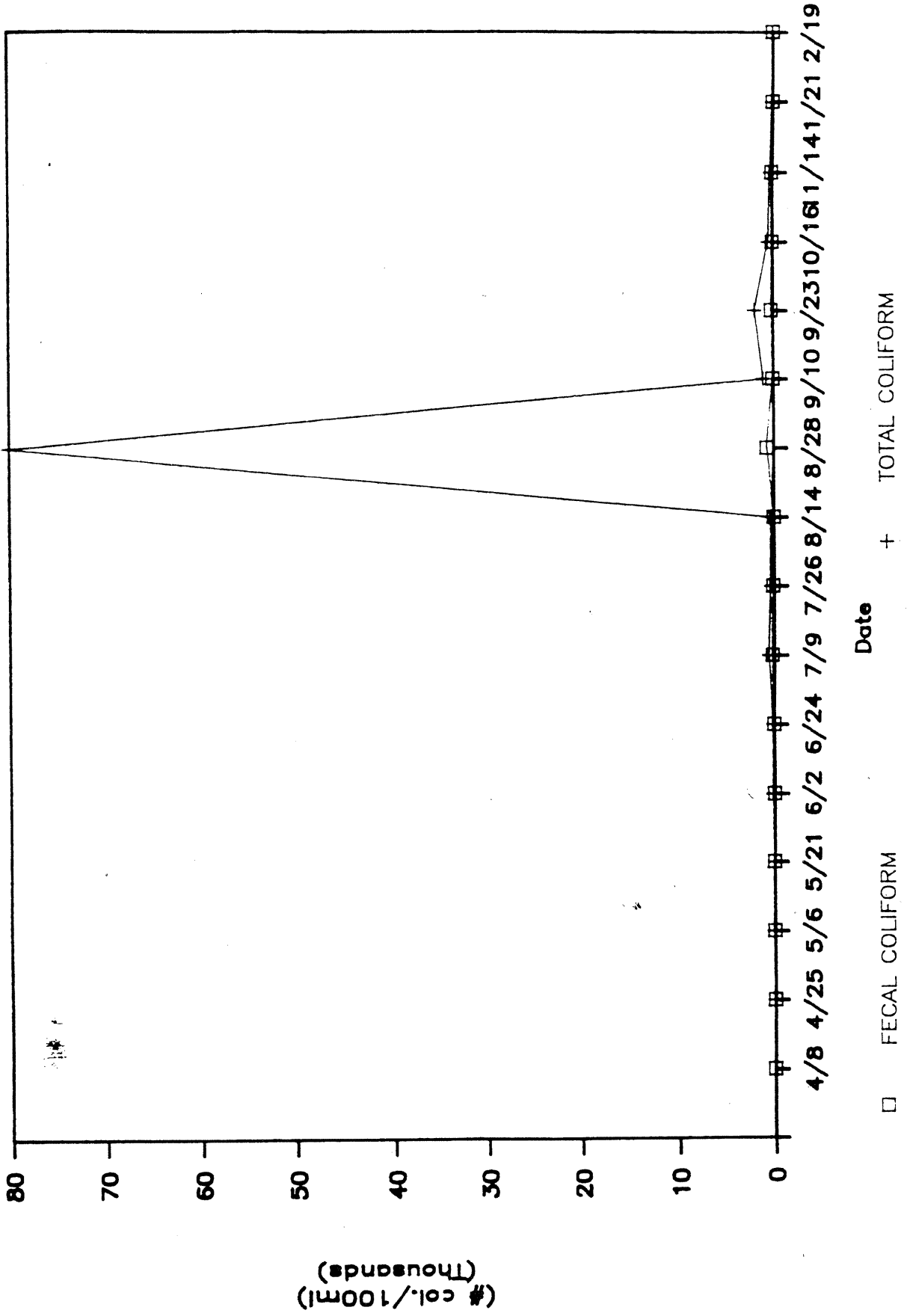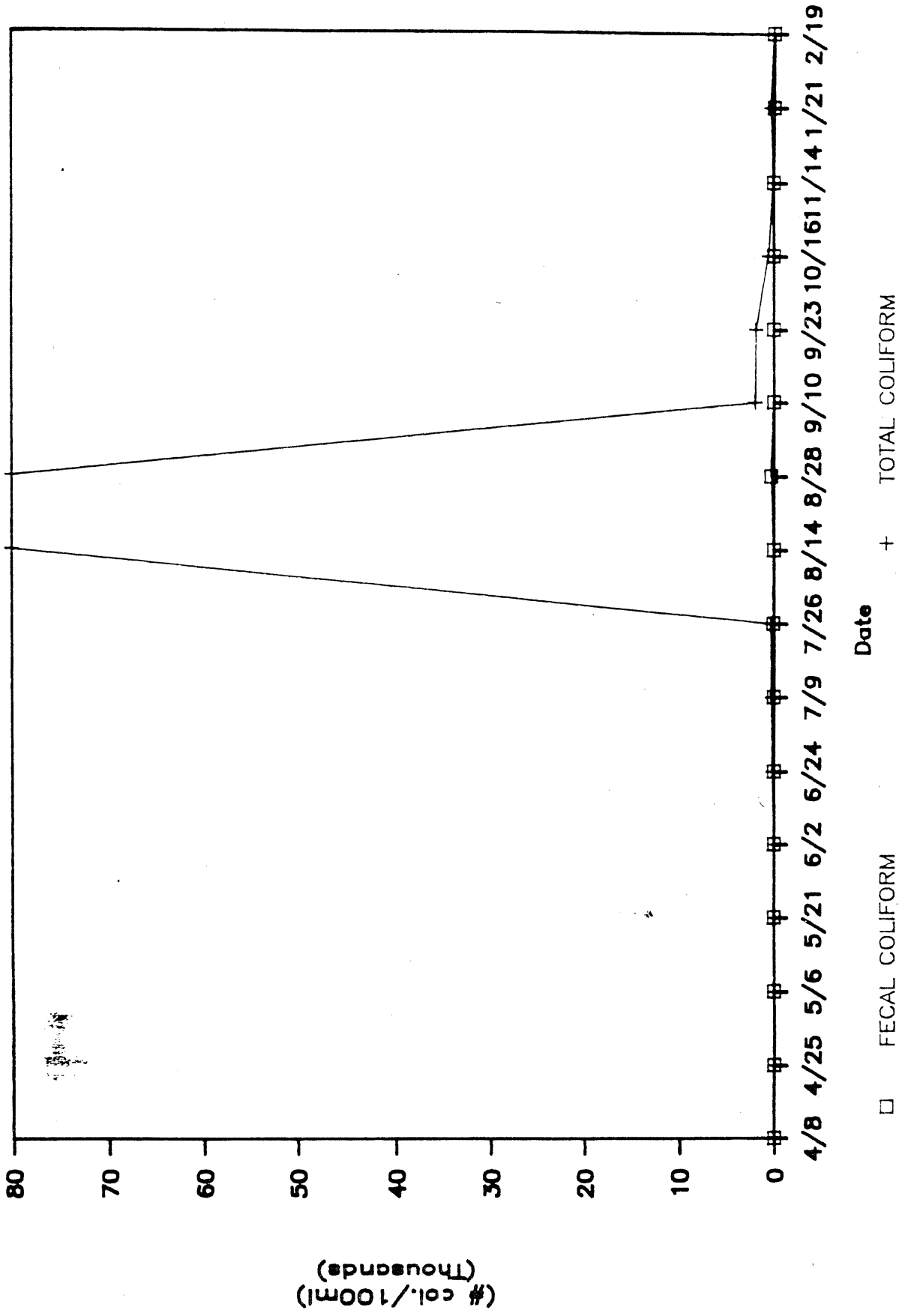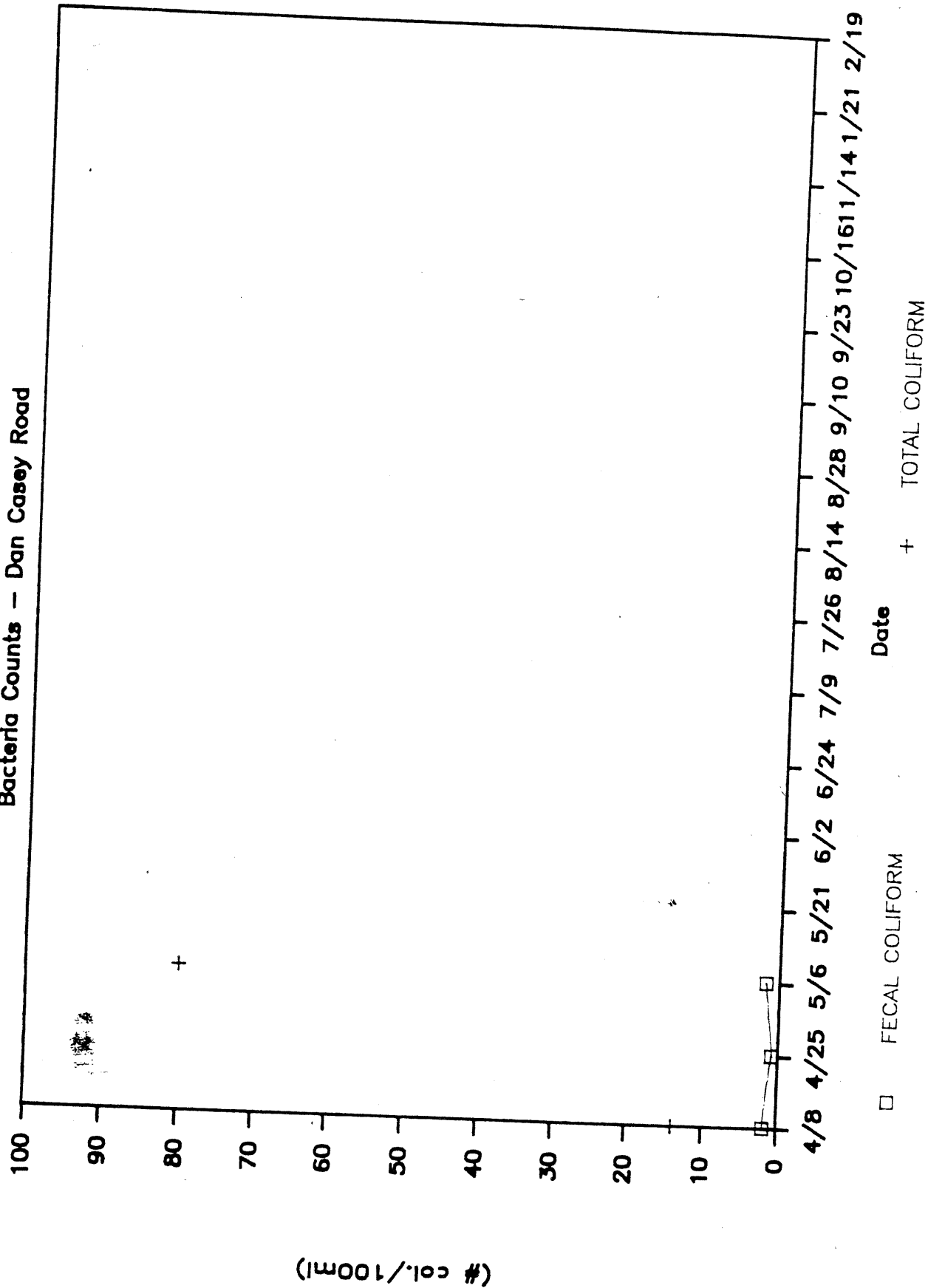
FIGURE 5.31

Bacteria Counts – DANIELS BROOK

Date

□ FECAL COLIFORM   + TOTAL COLIFORM

(# col./100ml)
(Thousands)

4/8 4/25 5/6 5/21 6/2 6/24 7/9 7/26 8/14 8/28 9/10 9/23 10/16 11/14 1/21 2/19

FIGURE 5.32

Bacteria Counts – Churchill Brook

(# col./100ml)
(Thousands)

Date

□ FECAL COLIFORM   + TOTAL COLIFORM

4/8 4/25 5/6 5/21 6/2 6/24 7/9 7/26 8/14 8/28 9/10 9/23 10/16 11/14 1/21 2/19

FIGURE 5.33

Bacteria Counts – Dan Casey Road

(# col./100ml)

100
90
80
70
60
50
40
30
20
10
0

4/8 4/25 5/6 5/21 6/2 6/24 7/9 7/26 8/14 8/28 9/10 9/23 10/16 11/14 1/21 2/19

Date

□ FECAL COLIFORM   +   TOTAL COLIFORM

FIGURE 5.34

Bacteria Counts — Camp Winadu
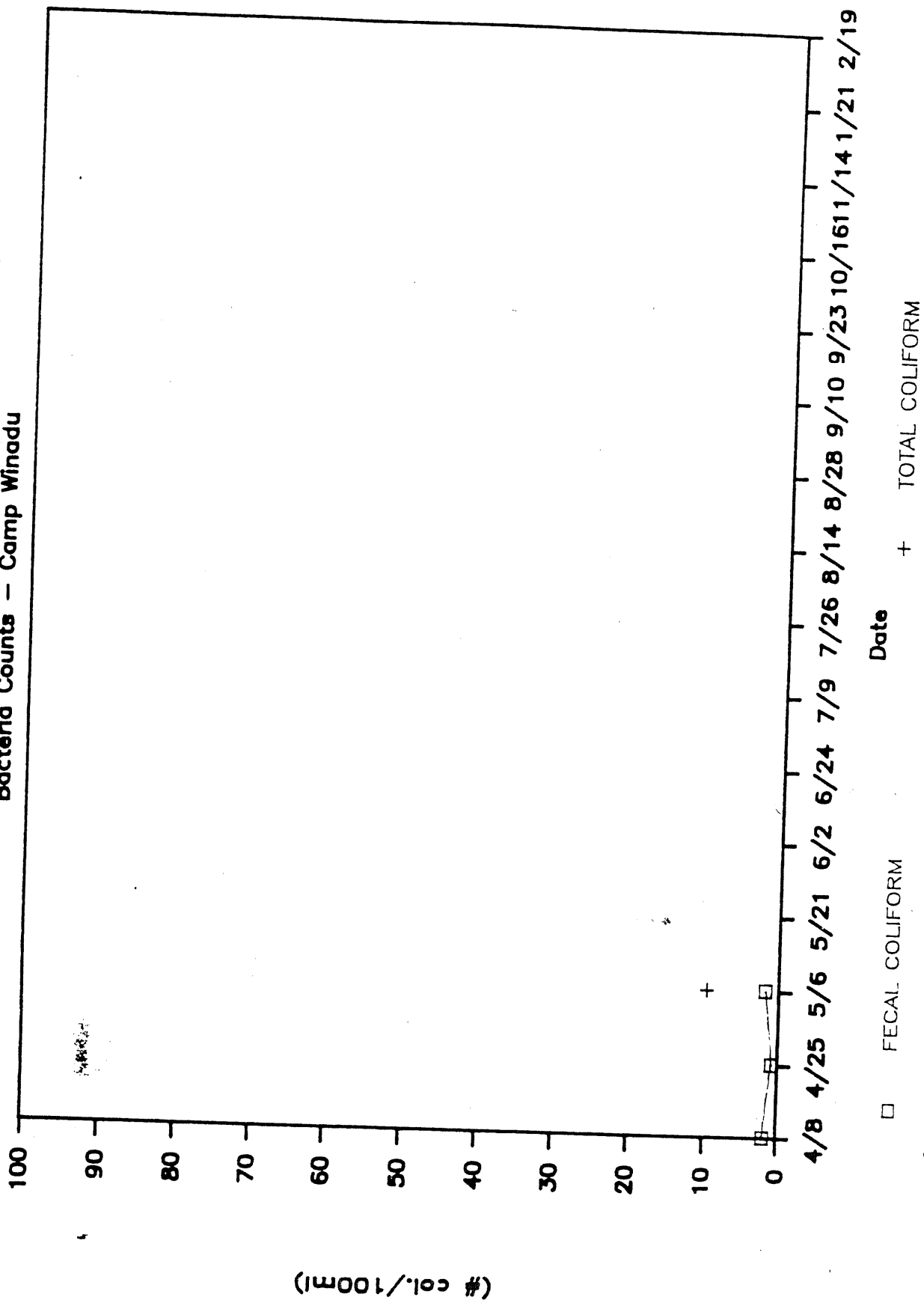
FIGURE 5.35

Bacteria Counts – Parker Brook

Date

□   FECAL COLIFORM   +   TOTAL COLIFORM

4/8 4/25 5/6 5/21 6/2 6/24 7/9 7/26 8/14 8/28 9/10 9/23 10/16 11/14 1/21 2/19

(# col./100ml)
(Thousands)

80 70 60 50 40 30 20 10 0
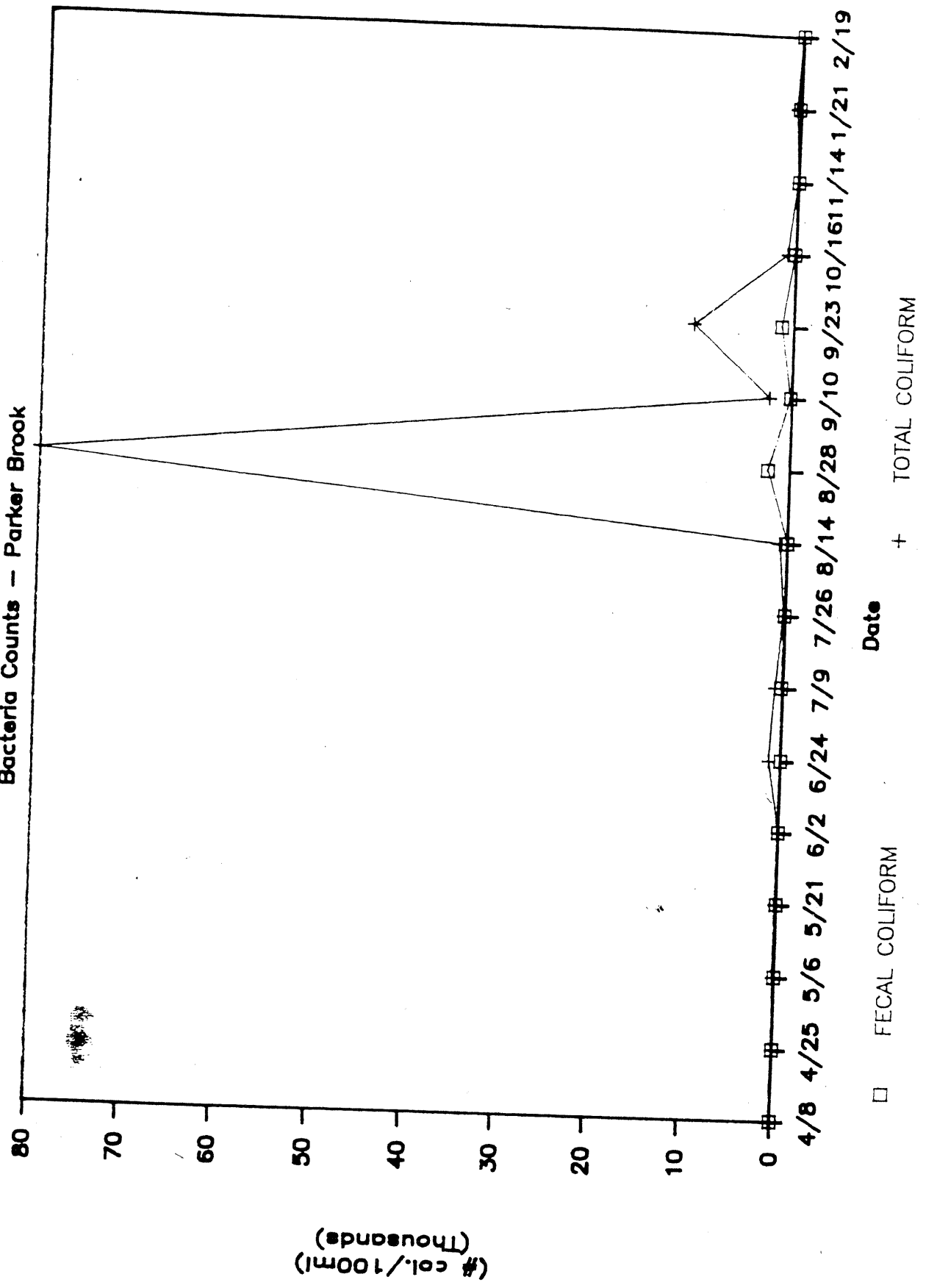
FIGURE 5.36

Bacteria Counts – Blythewood Drive

x-axis: Date

Dates: 4/8 4/25 5/6 5/21 6/2 6/24 7/9 7/26 8/14 8/28 9/10 9/23 10/16 11/14 1/21 2/19

y-axis: (# col./100ml) (Thousands)

0 10 20 30 40 50 60 70 80

□ FECAL COLIFORM   + TOTAL COLIFORM
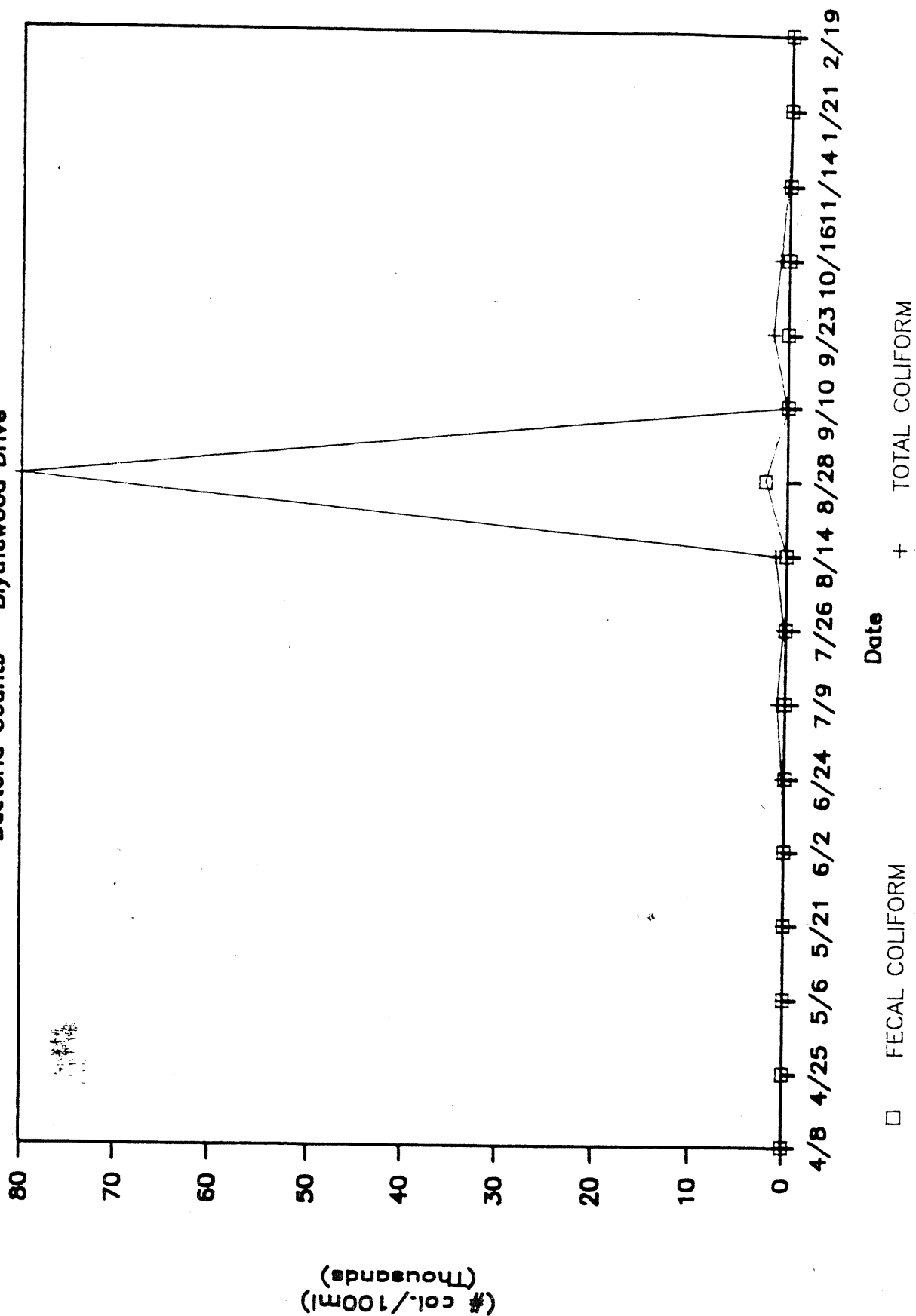
increases in the whole plankton collected from the North Basin. The increases appeared to coincide with the destratification of the North Basin and the seasonal dieback of macrophytes.

5.3.2 Benthic Colonization

The benthic infauna represents an important element in the energy pathways and ecology of a lake system. The benthos (oligochaetes, aquatic insect larva, snails, amphipods, etc.) represent a direct link between the sediment/detrital component of the lake and upper trophic levels. Organic material produced in the euphotic zone of the lake settles to the bottom. Decomposition of this material releases carbon, nutrients and trace metals needed by primary producers to aid in additional productivity. The benthos are a key factor in the breakdown of this material. In addition, many benthic organisms are important forage for fish. As the majority of benthic forms are sedentary, they serve as good indicator organisms since they are more directly affected by their immediate environment than other members of the biota (phytoplankton, zooplankton, fish). Their community structure can often times provide insight into the intricacies of a lake ecosystem (Wiederholm, 1980).

Benthic samples were collected on a monthly basis from key sites in the lake, using an Ekman dredge. All samples were preserved with a 10% Rosebengal-Formalin solution with sorting and identification being conducted in the lab. All organisms were identified to the lowest practical taxon and their community structure analysed in terms of species composition, dominant organism, abundance, diversity, and evenness (Pennak, 1978; Merritt and Cummins, 1978; Pielou, 1966).

Benthic colonization was investigated at three in-lake, littoral zone stations. A station was located in the north basin, and two stations in the south basin, one at the extreme southern shore and the other near the east shore approximately 20 meters south of the fishing pier. Each station was sampled once in spring, summer and fall. The taxa composition percentages calculated for the samples are presented in Figures 5.68 through 5.76.

TABLE 5.4: NET PLANKTON % COMPOSITION
BASIN 1B (Continued)

GENUS/DATE	4-8	4-25	5-6	5-25	6-3	6-23	7-8	7-23	8-13	8-27	9-10	10-15	11-14
CRYSOPHYTA (diatoms) (con't.)													
Tabellaria	43.0	62.5		24.6									
Tribonema				<1		4.1		3.4					1.3
CRYPTOPHYTA													
Cryptomonas				1.4							2.2		
PYRROPHYTA TOTAL	31.0	12.4	66.4	49.3	20.0	1.8	22.0	3.4	54.2	41.3	12.8	20.3	2.6
Ceratium									36.0	31.0	6.1	<1	
Dinobryon	31.0	12.4	66.4	49.3	20.0	1.8	22.0	3.4	4.5	1.3	6.7	20.3	
Peridiaum									13.7	9.0			2.6
PROTOZOANS TOTAL							13.0						
Acanthocystis													
Actinophrys													
Pelomyxa		<1					4.3						
Pronodan							8.7						
Urostyla		<1											
Vorticella													
ROTLERA TOTAL		1.1	9.3	1.4	31.1	13.0	26.0		4.0	2.6	1.1		2.6
Rellacottia		<1	1.7		8.9	<1						<1	
Keratella			7.6	1.4	13.3	13.0	13.0		4.0	2.6	1.1		2.6
Polyarthra		1.1			8.9	<1	13.0						

Typically, the benthic fauna of the littoral zone is diverse and abundant. Littoral sediments are characteristically rich in organic material and can support a wide variety and high density of organisms due to the availability of food sources. However, benthic colonization is greatly affected by sediment grain size, as grain size can determine stability, influence interstial dissolved oxygen concentrations and reflect the amount of organic matter (i.e. food) present. The benthic samples collected from Onota Lake reflect a community of low diversity and abundance. The sediments from the south basin were relatively homogeneous sandy materials of low organic content. The sediment from the north basin, although rich in detritus, was very silty and unstable. These sediment characteristics may be the cause of the relatively low diversity and abundance of benthic organisms found in the Onota Lake samples. The benthos in this lacustrine zone is typically characterized by relatively diverse and abundant population with high oxygen requirements. The homogenous substrate and the low amount of organic matter found in the sampled areas are probably the limiting factors. No substantial seasonal variation in diversity was observed. This is typical of lakes providing there is a relatively constant food source.

The benthic community was comprised mainly of the scud (Hyallella), midges (Chironomus), caddisflies (Trichoptera), and mayflies (Ephemeroptera). Hyalella, the genus most frequently encountered is a common amphipod found in unpolluted waters. Hyalella, and amphipods in general, have high oxygen requirements and are usually restricted to waters of high oxygen concentrations. Mayflies and caddisflies also have high oxygen requirements and are indicative of clean waters. Chronomid larvae are ubiquitous and may dominate certain benthic communities. No distinct, seasonal or spatial pattern in species composition were observed in the benthic community. The community assemblage of benthic organisms in Onota Lake indicates a well oxygenated, unpolluted lake.

5.4 FISHERY

A fishery of a lake represents its upper trophic level and is a focus of a great deal of recreational attention. A qualitative assessment of Onota Lake's fishery was conducted using beach seine, trap net, and

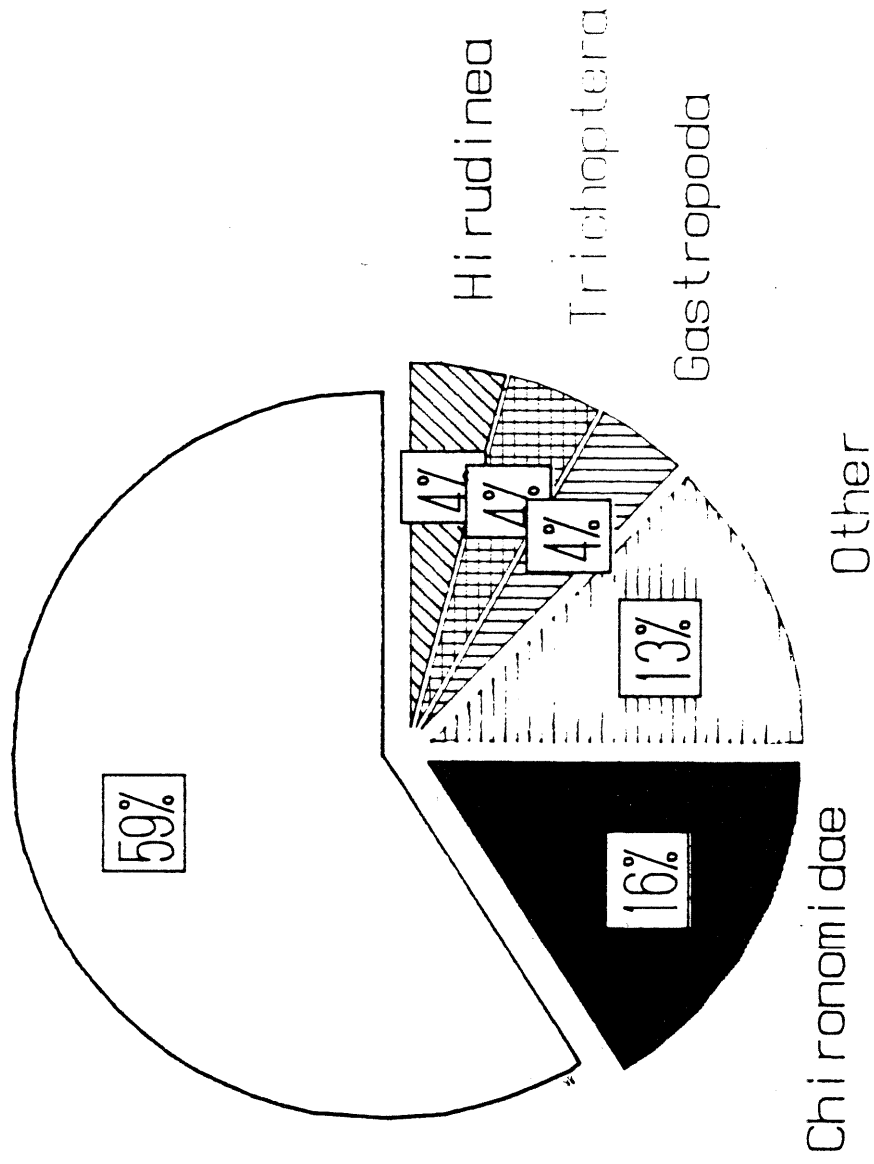PERCENT COMPOSITION of BENTHOS

EAST SIDE

FALL 1986

Hyalella 59%

Chironomidae 16%

Other 13%

Gastropoda 4%

Trichoptera 4%

Hirudinea 4%

FIGURE 5.76

electroshocking. The species captured were examined, measured and released. The fishery analysis included species composition, abundance, dominant species, and proportional stock density.

Onota Lake supports a diverse fish community. Fourteen different species were collected as part of this study, but a greater number of species are known to occur in the lake (Table 5.5). Many species have been stocked officially and some unofficially (see Section 2.0) the most important game fish present in the lake include northern pike and a variety of trout. Currently the Massachusetts Division of Fisheries and Wildlife stocks approximately 16,000 trout annually in Onota Lake.

Of the species collected during the 1986 survey, chain pickeral (Esox niger), pumpkinseed (Lepomis gibbosus), bluegill Lepomis macrochirus), rock bass (Ambloplites rupestris) and yellow perch (Perca flavescens) dominated the catch. Also abundant were golden shiner (Notemigonus crysoleucas) and northern pike (Esox lucius). Although not captured, there was evidence of large schools of smelt (Osmerus mordax) being present at mid-water depths. Species distribution conformed generally to that found in a 1978 survey conducted by the Massachusetts Division of Fisheries and Wildlife. However, the 1986 data suggest that bluegill dominance has increased.

Proportional Stock Density (PSD) for the more abundant species: the pumpkinseed, bluegill, yellow perch, rockbass and chain pickerel, was computed. PSD is the proportion of fish of quality size in a stock expressed as a percentage. This analysis demonstrated that the sampled pumpkinseed, bluegill, yellow perch, and rockbass populations include a high percentage of quality size individuals. Analysis of the 1978 survey indicated that only the yellow perch and rockbass had a high percentage of quality size individuals.

TABLE 5.6
FISHERY DATA

Species	4/24	5/20	6/23	7/22	8/13	8/26	9/23	10/14	11/13	Total	1978 Survey	PSD*	PSD 1978
Golden Shiner			8	2	2		1	1	4	18	180	.	
Chain Pickerel		1		1	8	7	4	4		25	124	9	2
Pumpkinseed	6		22	6	11	10	7	2		64	89	85	15
Bluegill		2	13	12	4	3	1	1		35	5	61	
Rock Bass			7	13	4	8	1	2		35	26	46	56
Yellow Perch			12	8	1	1	2	11		35	179	61	44
Brown Bullhead			1		2		3			8	10		
Black Crappie		1					1			2	2		
Smallmouth Bass				1	5					6			
Carp		1	5							6	8		
Northern Pike			7			3				10	7		
White Sucker			1							1	1		
Common Shiner						2				2	2		
Largemouth Bass				1						1	115		
										247			

*Proportional stock density

Onota Lake contains both a warm and cold water fishery. The volume of water available for trout, (the trout layer) was calculated. The trout layer, is that volume of water less than 71°F but containing at least 5 ppm of dissolved oxygen. The trout layer appears to have declined over the years. In 1947, this layer amounted to 42% of the lake's volume, but by 1972 it had declined to 18.5%. Anoxic conditions in the hypoliminion act to reduce the volume of this layer. As the duration and extent of hypolimnetic anoxic conditions increases, the amount of available trout habitat will decrease. Temperature and oxygen profiles conducted over the course of the present study indicated that during the summer stratification, approximately 13% of Onota Lake's volume was suitable for trout. This apparent decline in available trout waters is likely due to an increased sediment oxygen demand (SOD), which has steadily increased the volume of water with an oxygen deficit. It appears that a hypolimnetic aeration system which will oxygenate yet maintain the temperature integrity of this layer, is needed. The issue is discussed in detail as part of the restoration and management plan.

FIGURE 5.37

Bacteria Counts - Onota Brook

(# col./100ml)
(Thousands)

Date

□ FECAL COLIFORM   + TOTAL COLIFORM
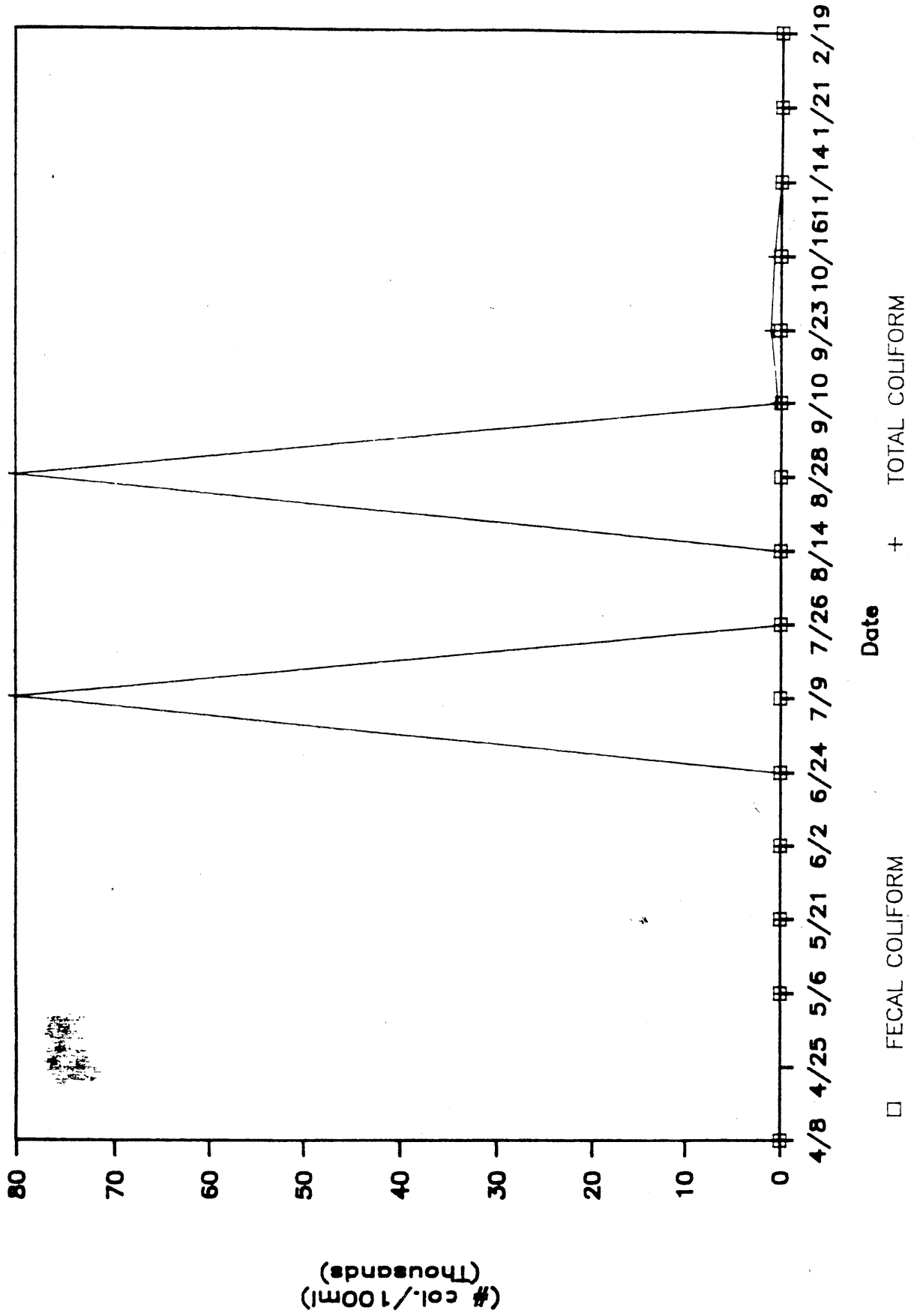
FIGURE 5.38

TOTAL BACTERIA vs TIME

Trib. #1 (Daniels Brook) - ONOTA LAKE
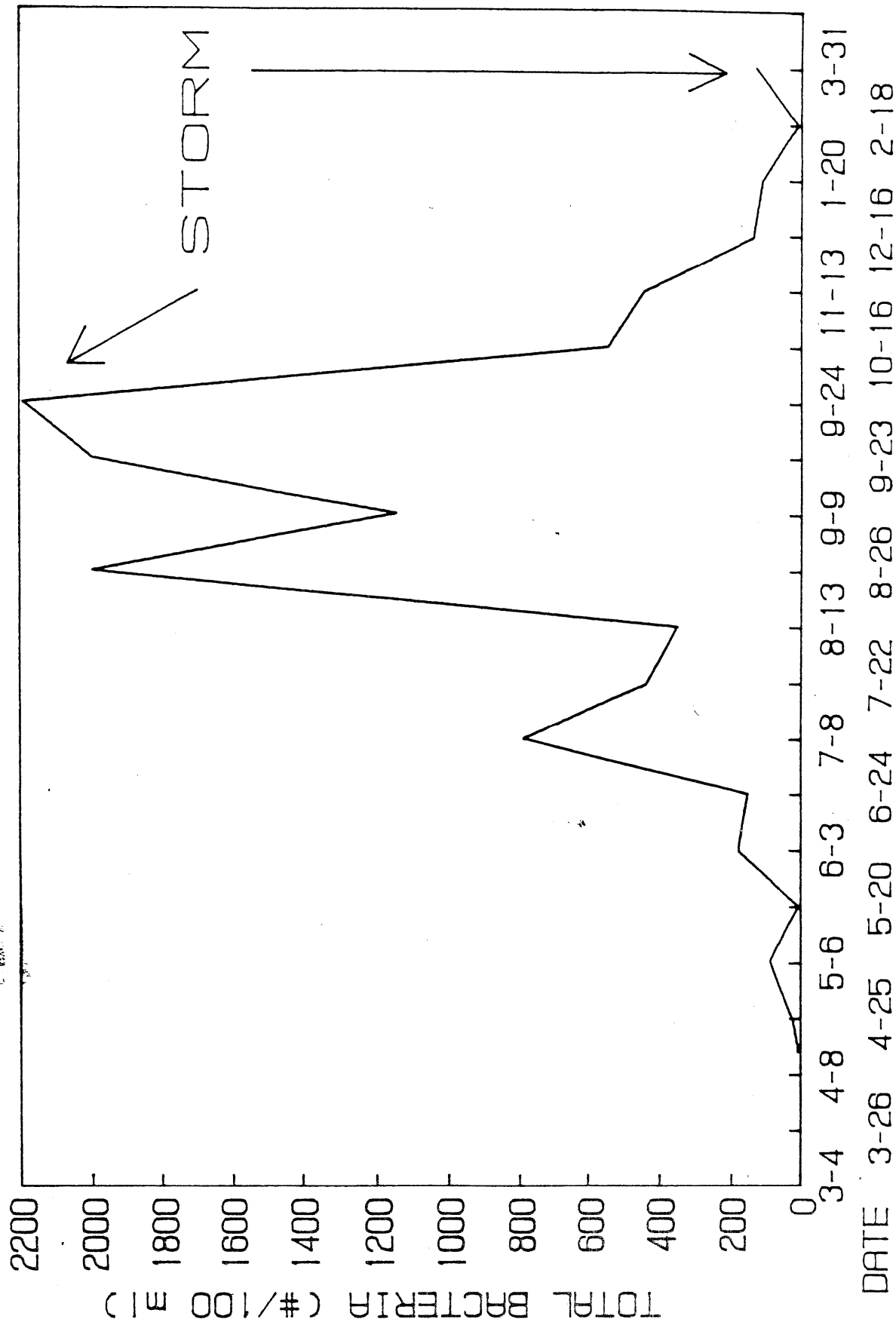
FIGURE 5.39

CHLORIDE vs TIME

Trib. #1 (Daniels Brook) - ONOTA LAKE

STORM

CHLORIDE (mg/l)

20 18 16 14 12 10 8 6 4 2 0

DATE 3-4 4-8 5-6 6-3 7-8 8-13 9-9 9-24 11-13 1-20 3-31
3-26 4-25 5-20 6-24 7-22 8-26 9-23 10-16 12-16 2-18
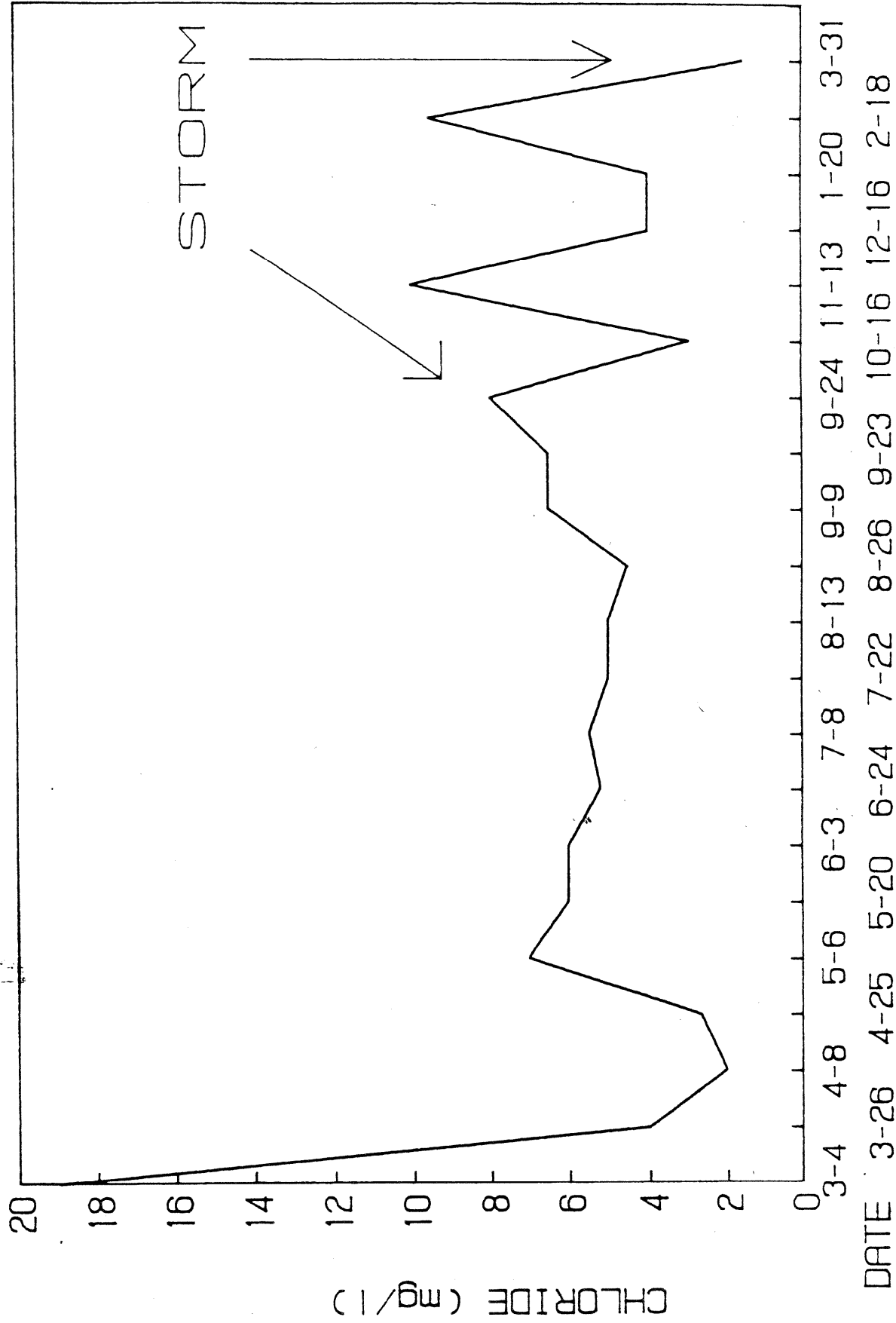
FIGURE 5.40

TOTAL SUSPENDED SOLIDS vs TIME
Trib. #1 (Daniels Brook) - ONOTA LAKE
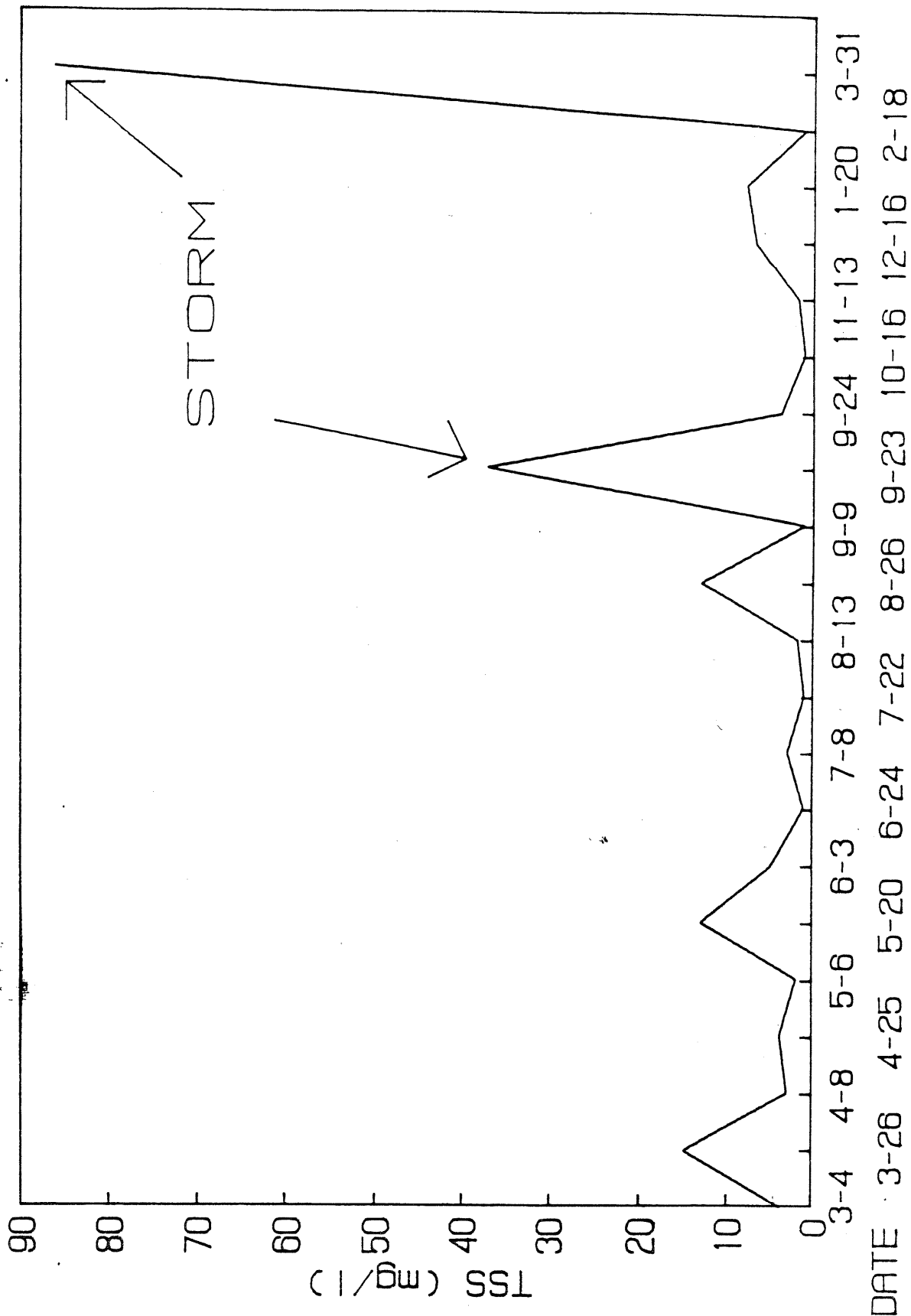
FIGURE 5.41

NITRATE vs TIME

Trib. #1 (Daniels Brook) - ONOTA LAKE

NITRATE (mg/l)

DATE

FIGURE 5.42

TOTAL PHOSPHATE vs TIME

Trib. #1 (Daniels Brook) - ONOTA LAKE

FIGURE 5.43

TOTAL BACTERIA vs TIME

Trib. #2 (Churchill Brook) - ONOTA LAKE

9-23 storm = 14,360

STORM

TOTAL BACTERIA (#/100 ml)

DATE
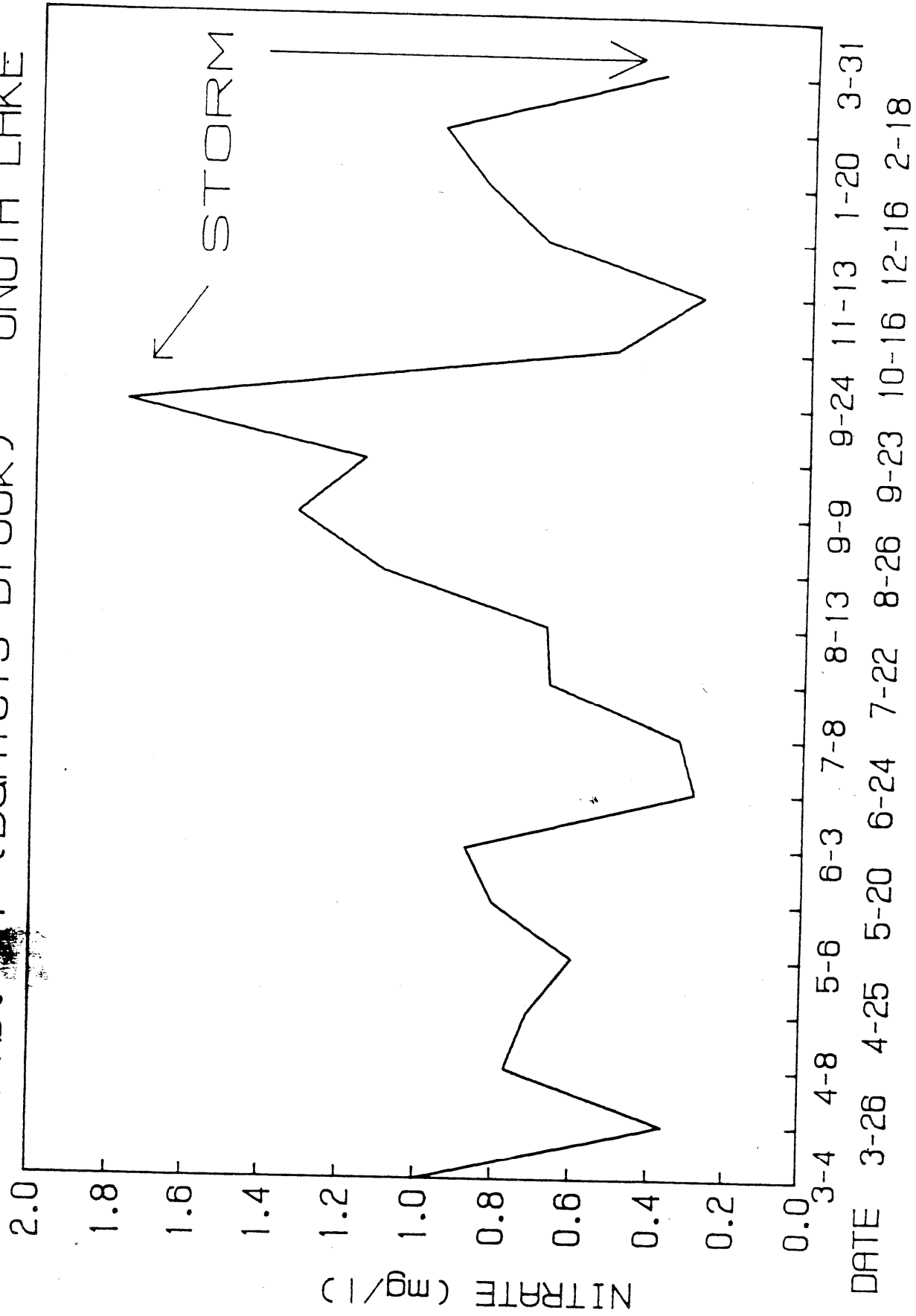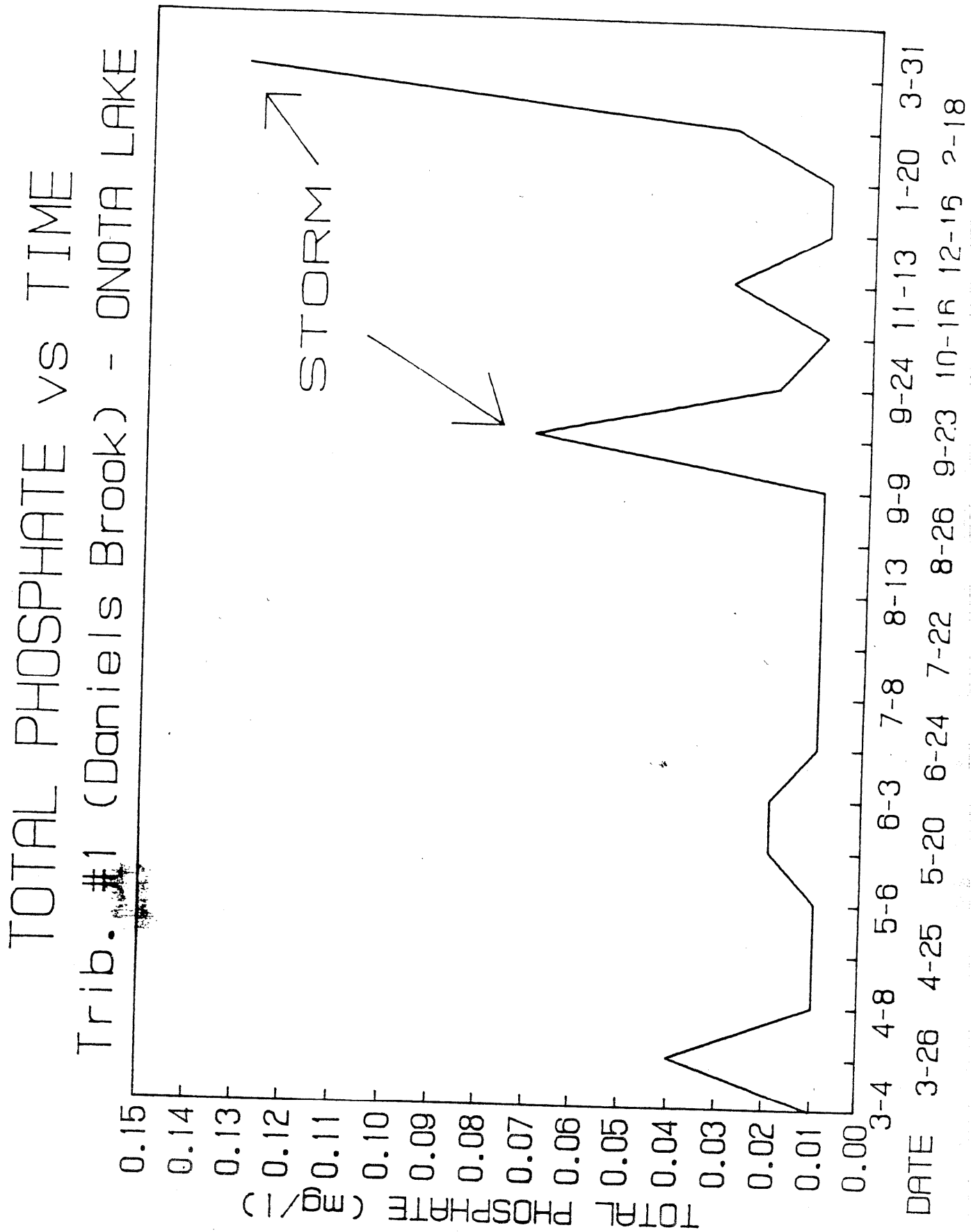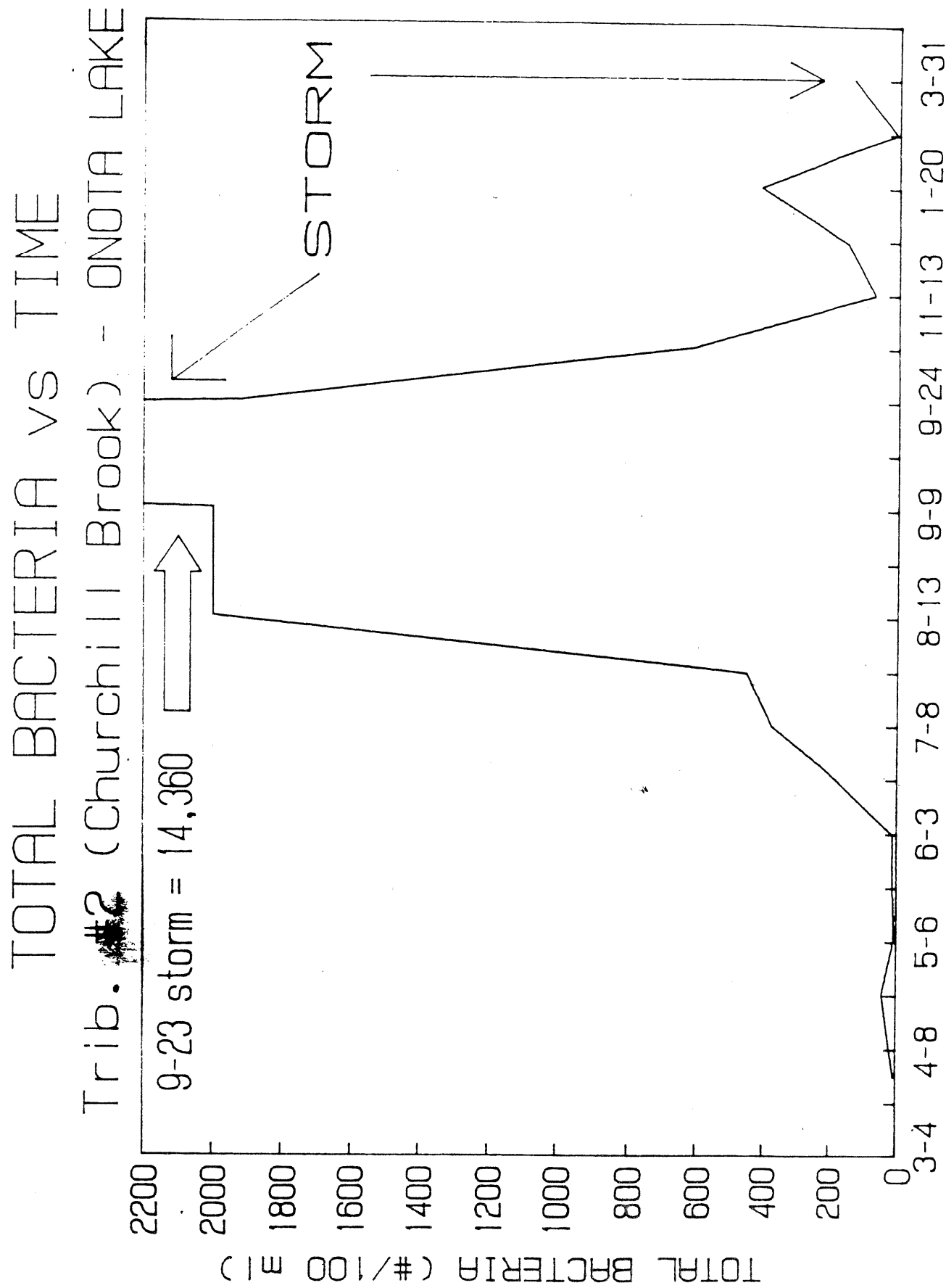
FIGURE 5.44

CHLORIDE vs TIME

Trib. #2 (Churchill Brook) - ONOTA LAKE

STORM

X-axis: 3-4 4-8 5-6 6-3 7-8 8-13 9-9 9-24 11-13 1-20 3-21

Y-axis: CHLORIDE (mg/l) 0 2 4 6 8 10 12
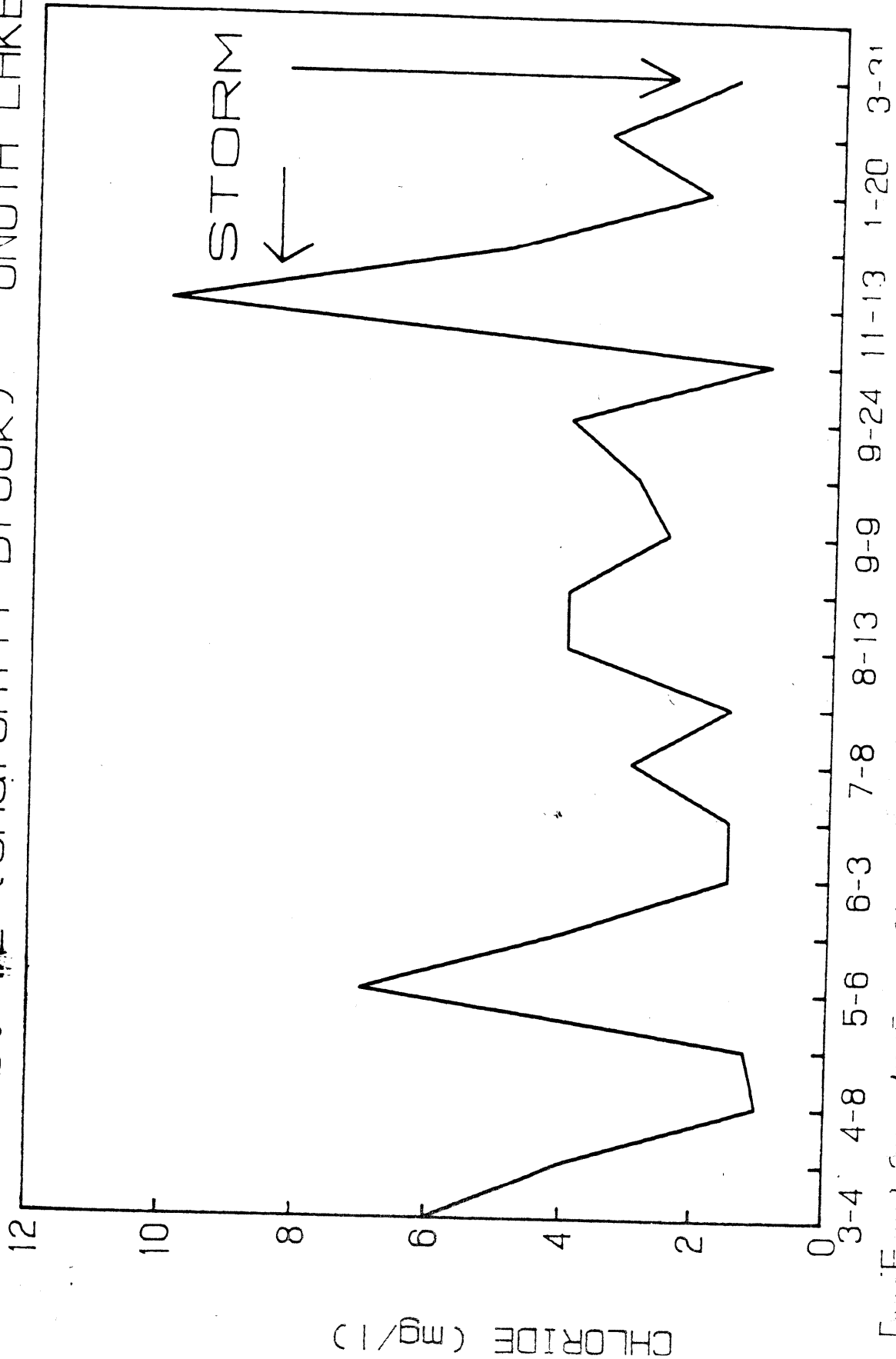
FIGURE 5.45

TOTAL SUSPENDED SOLIDS vs TIME
Trib. #2 (Churchill Brook) - ONOTA LAKE

STORM
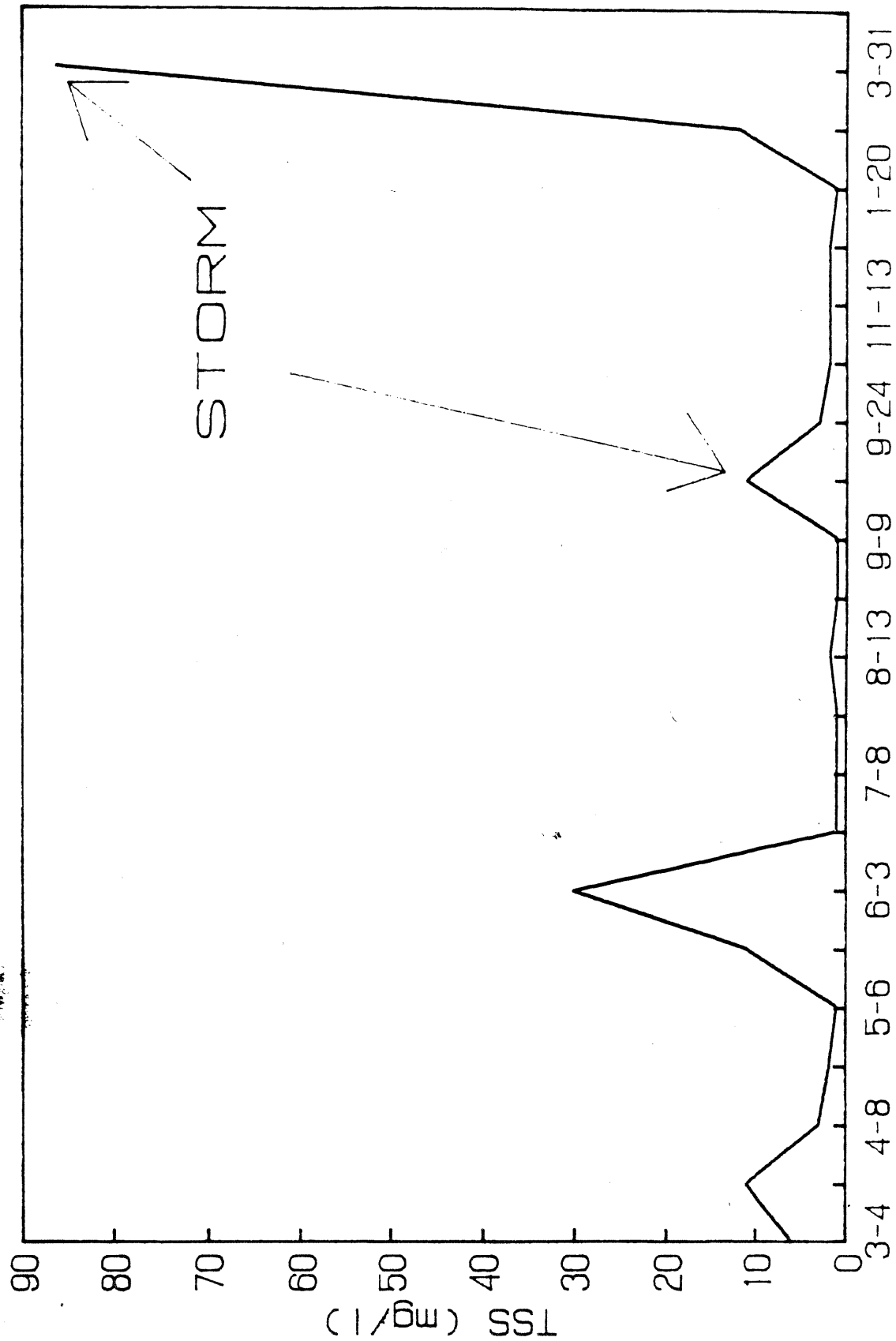
FIGURE 5.46

NITRATE vs TIME

Trib. #2 (Churchill Brook) - ONOTA LAKE
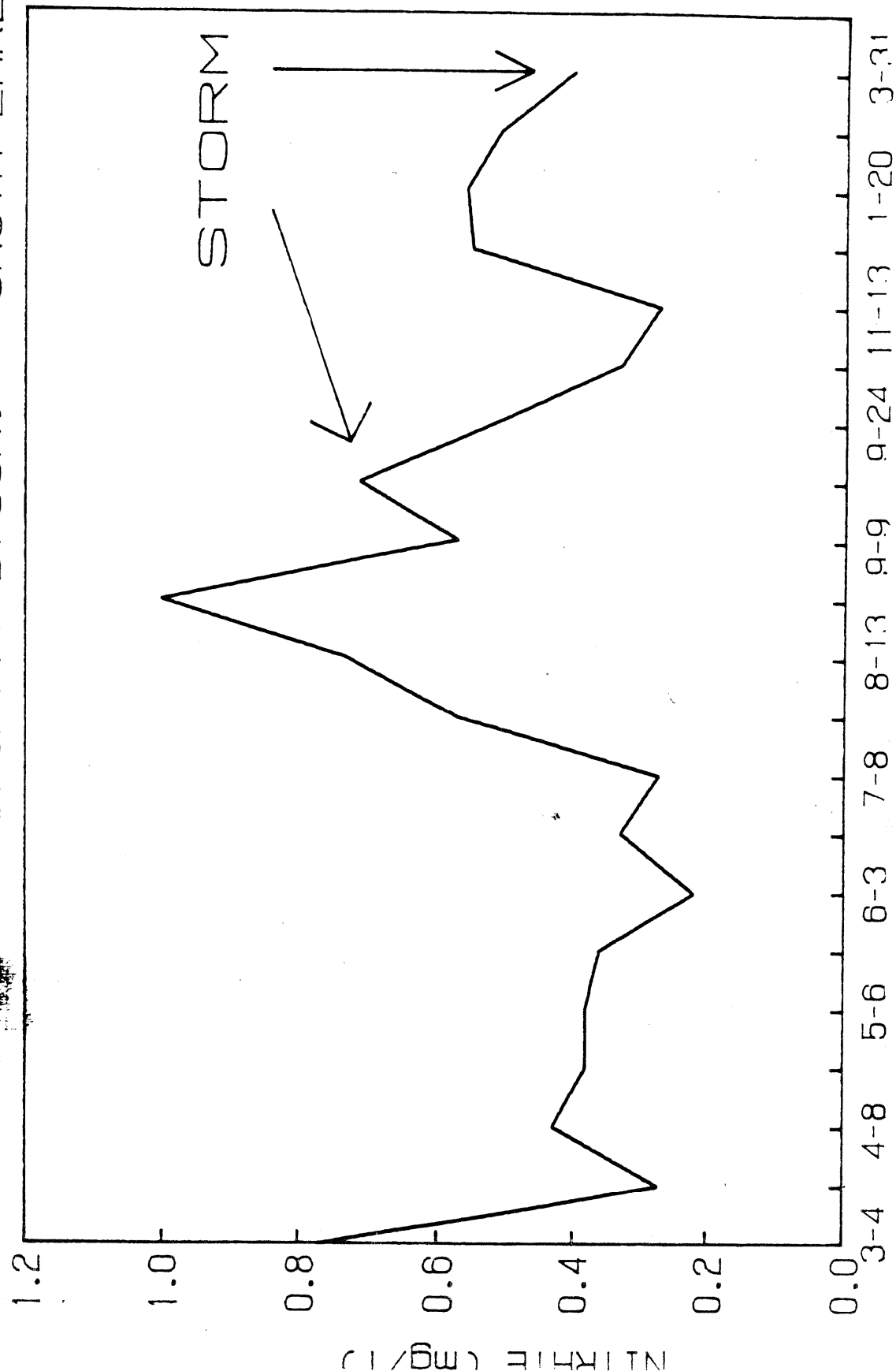
FIGURE 5.47

TOTAL PHOSPHATE vs TIME

Trib. #2 (Churchill Brook) - ONOTA LAKE
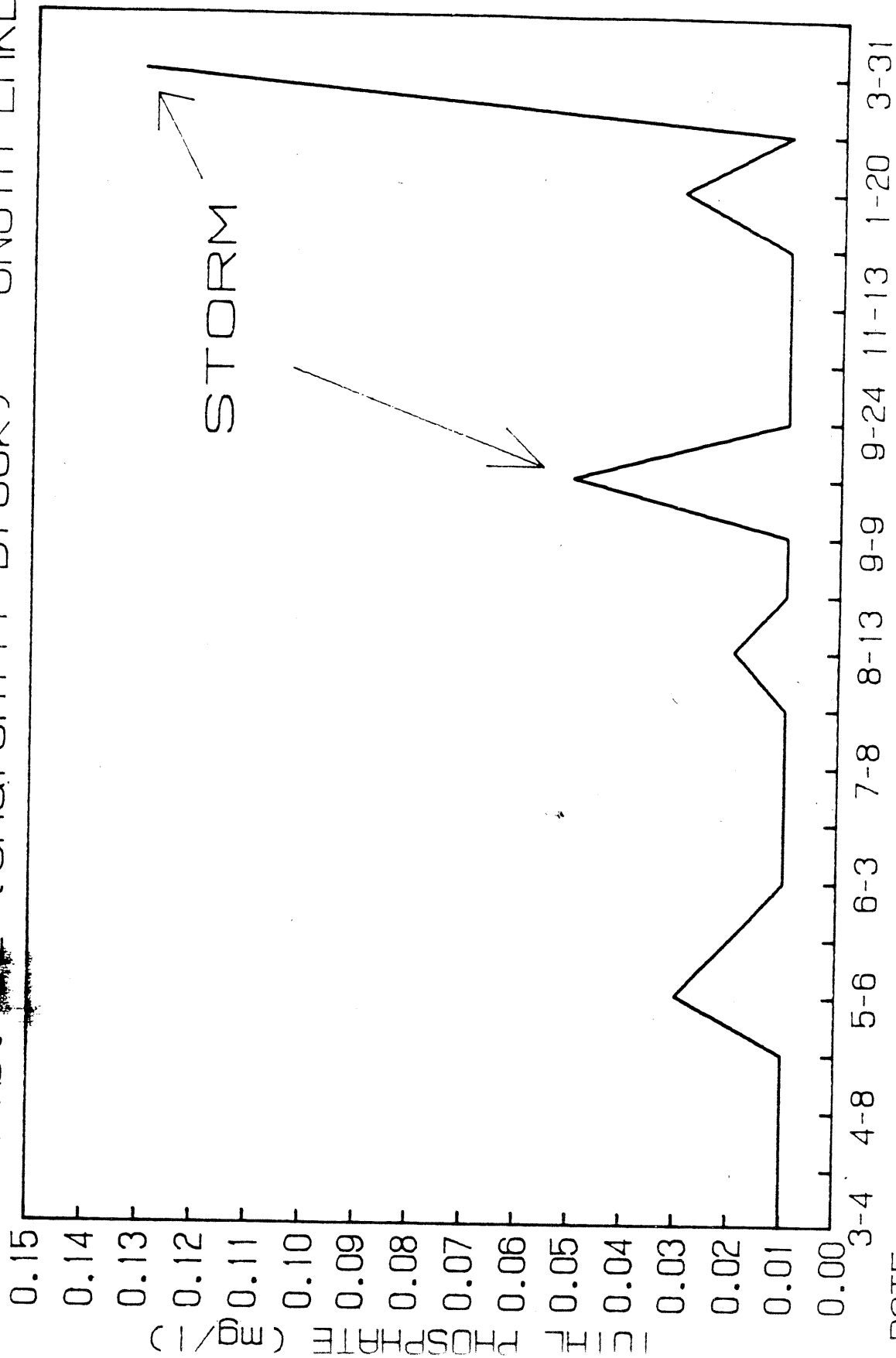
FIGURE 5.48

TOTAL BACTERIA VS TIME
Trib. #3 (Dan Casey Rd.) – ONOTA LAKE
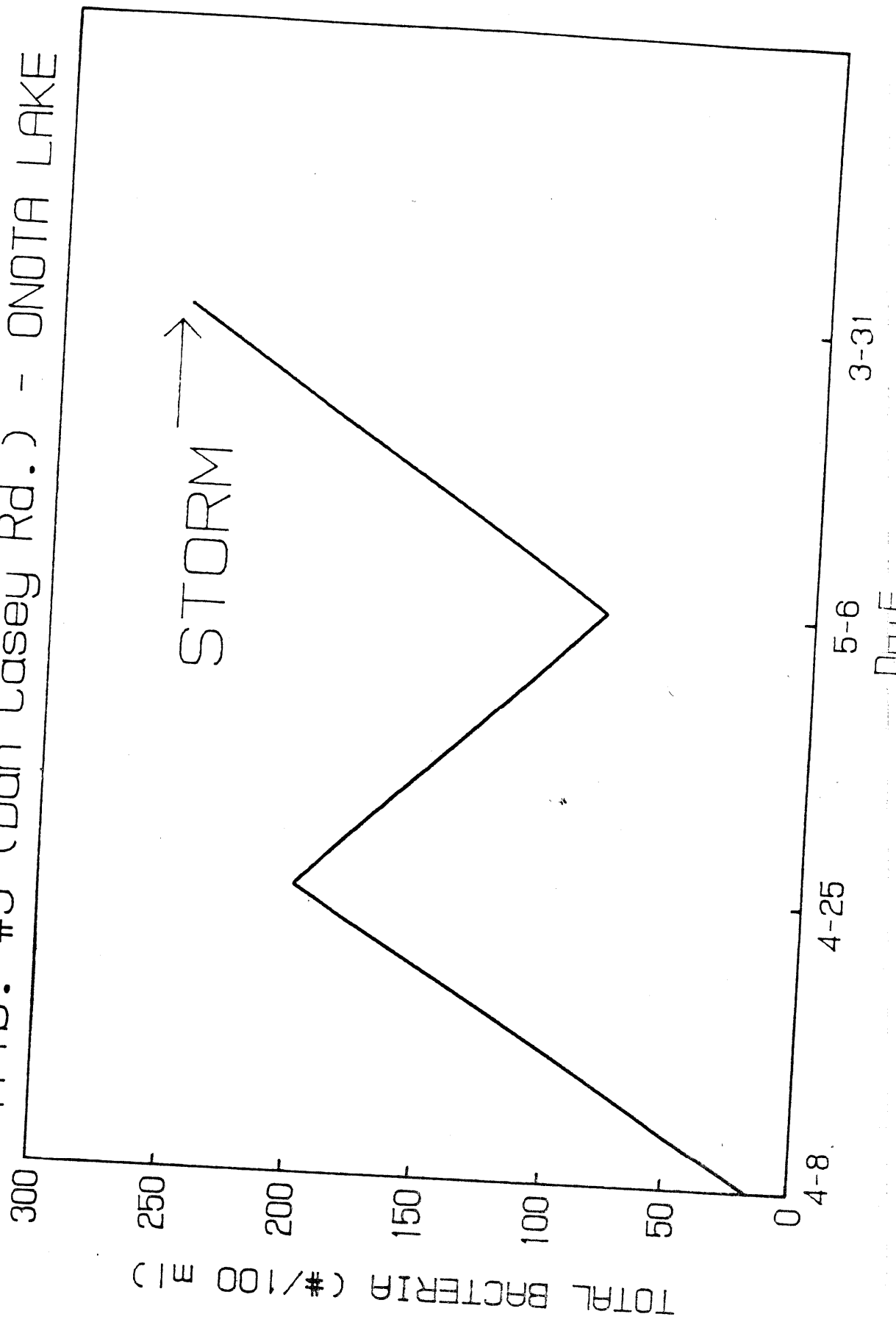
FIGURE 5.49

CHLORIDE VS TIME

Trib. #3 (Dan Casey Rd.) - ONOTA LAKE
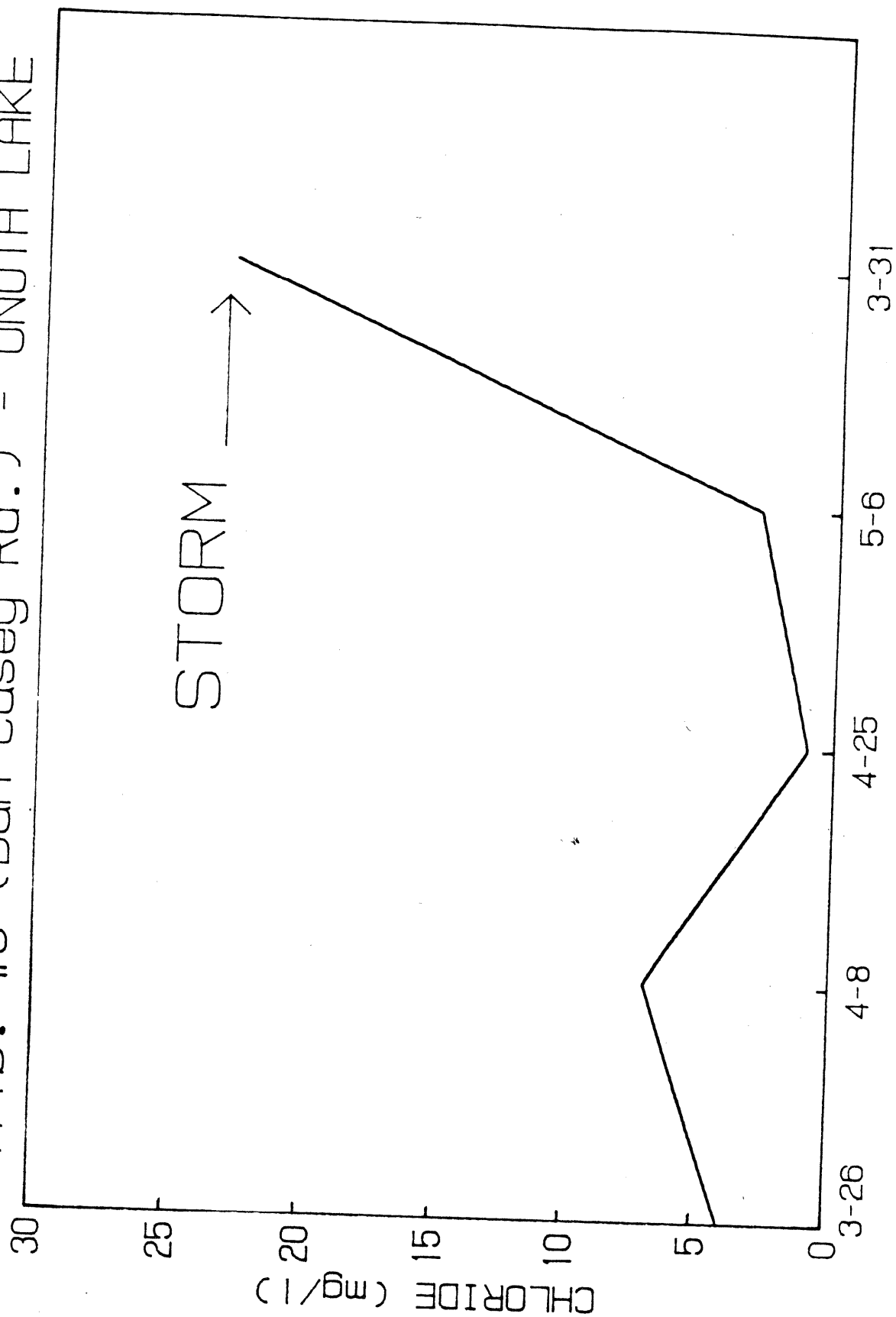
FIGURE 5.50

TOTAL SUSPENDED SOLIDS vs TIME
Trib. #3 (Dan Casey Rd.) - ONOTA LAKE
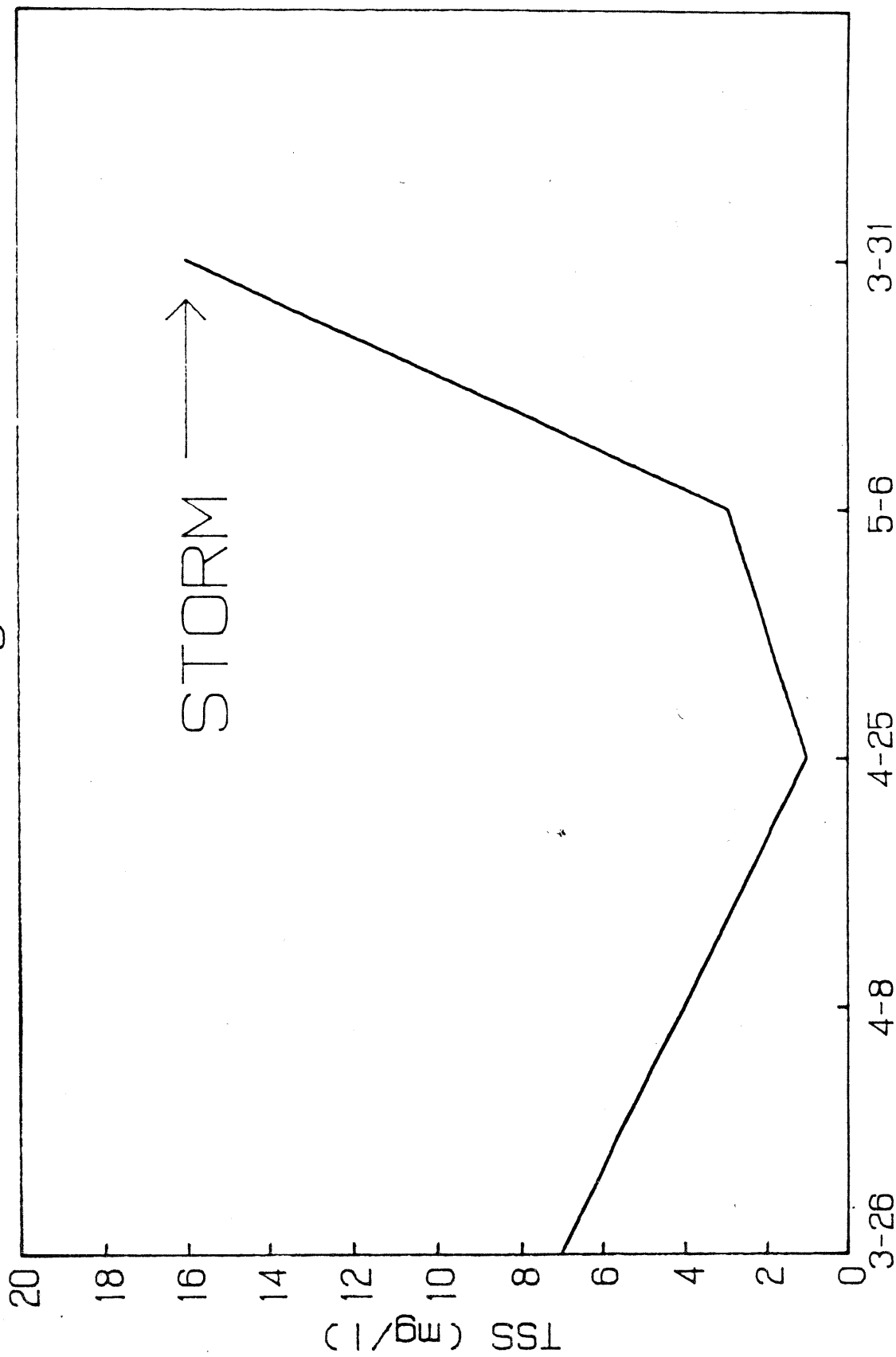
FIGURE 5.51

NITRATE vs TIME

Trib. #3 (Dan Casey Rd.) - ONOTA LAKE

STORM
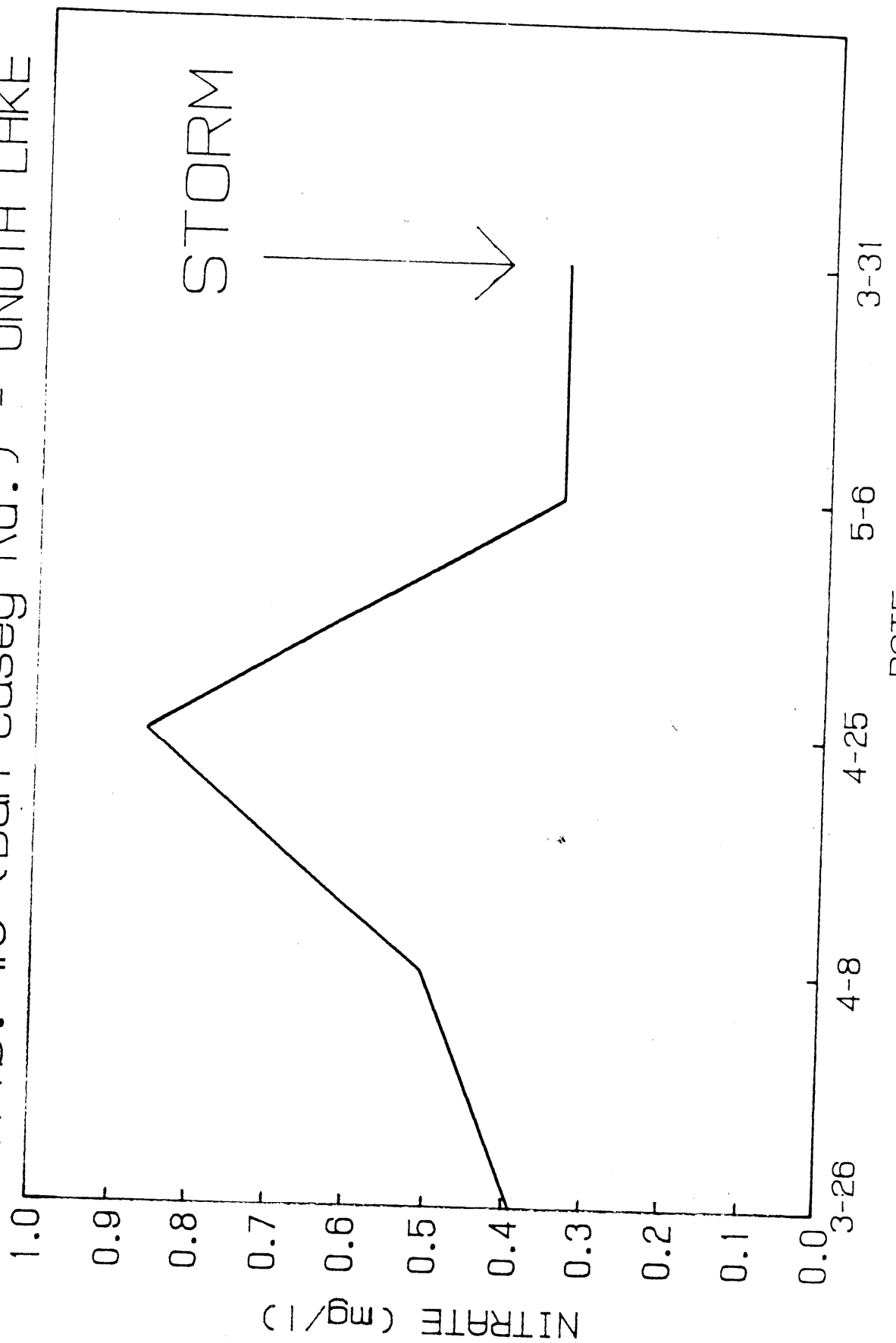
FIGURE 5.52

TOTAL PHOSPHATE vs TIME

Trib. #3 (Dan Casey Rd.) - ONOTA LAKE
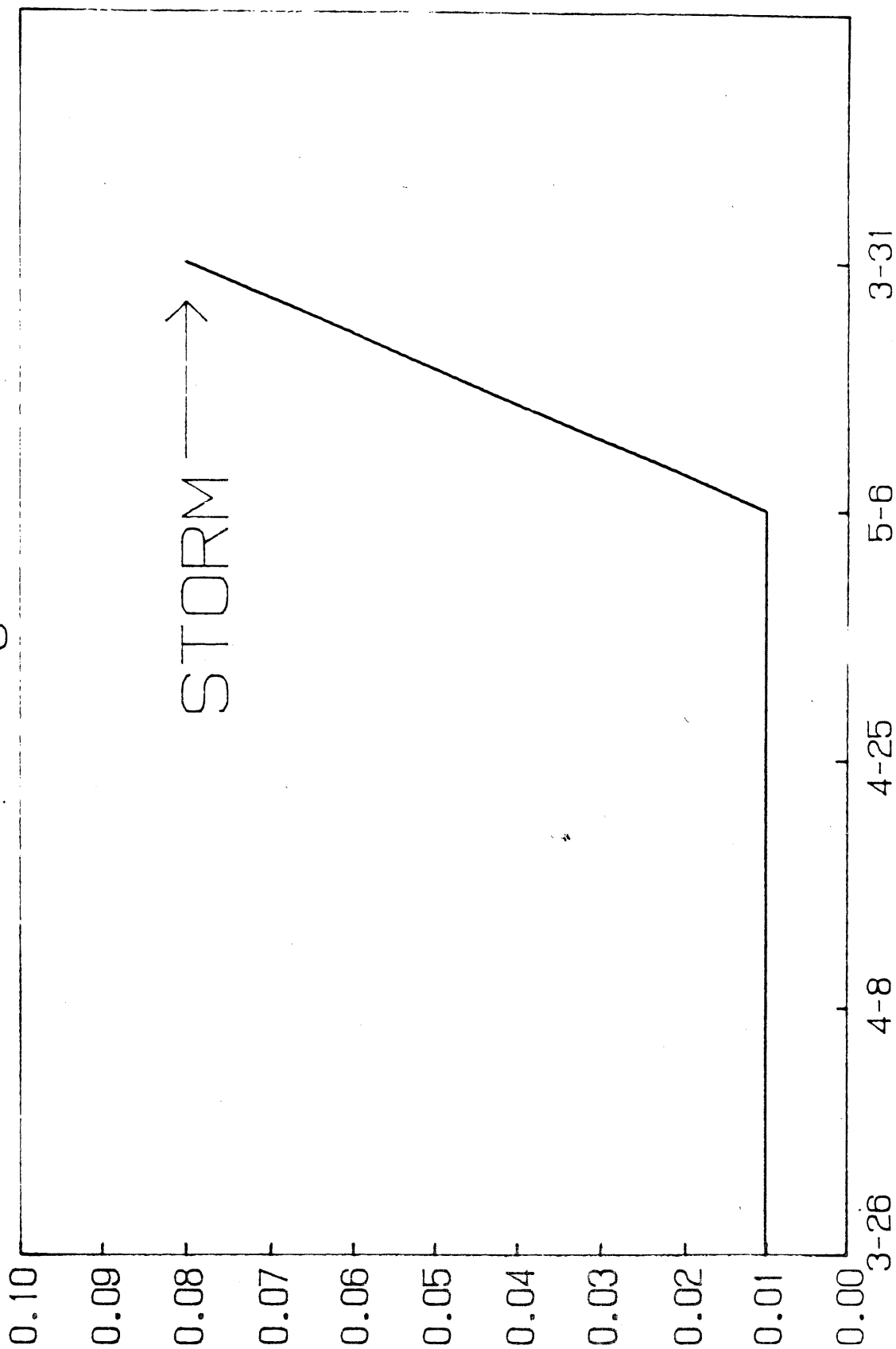
FIGURE 5.53

TOTAL BACTERIA vs TIME

Trib. #4 (Camp Winadu) - ONOTA LAKE
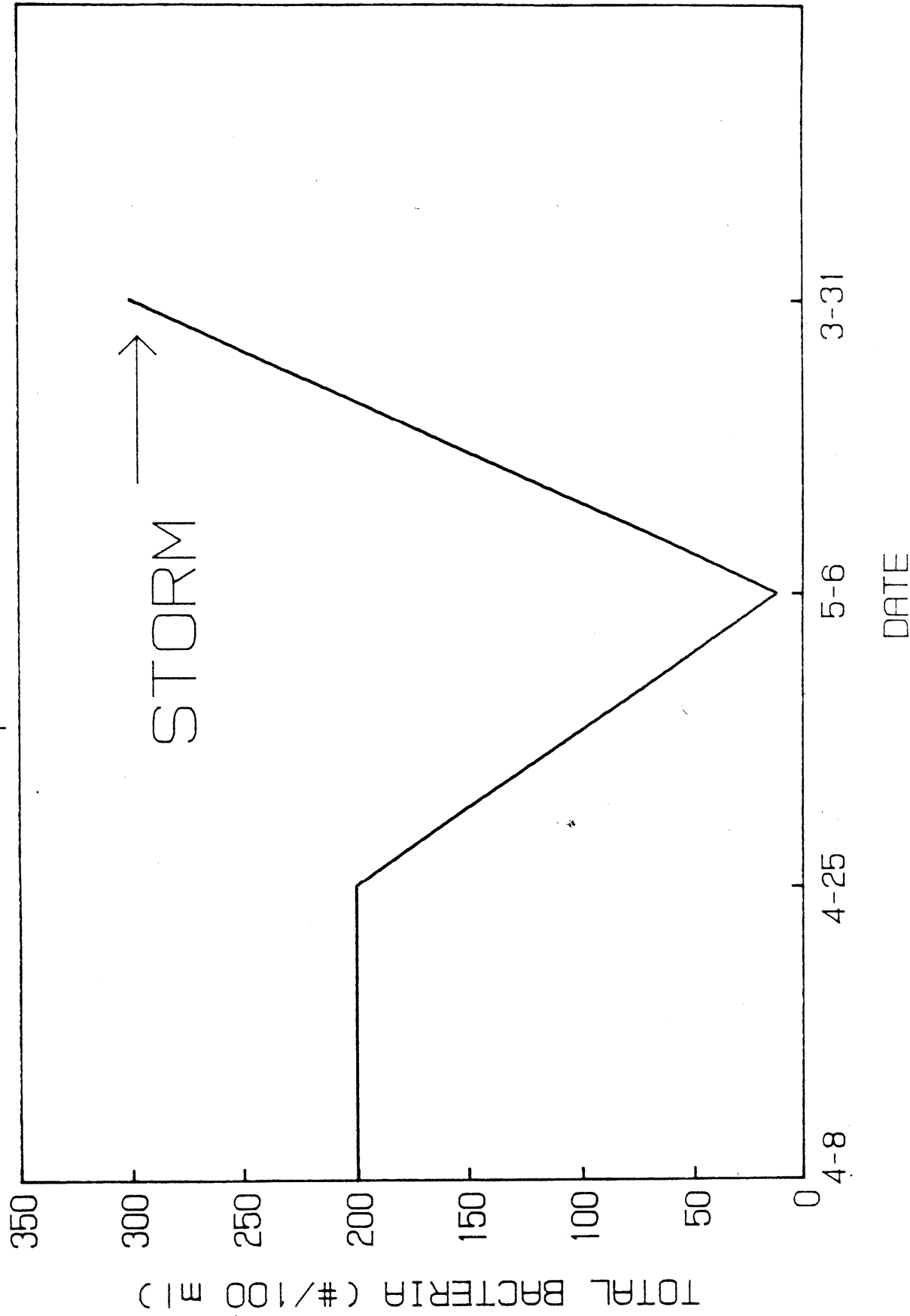
FIGURE 5.54

CHLORIDE vs TIME

Trib. #4 (Camp Winadu) - ONOTA LAKE.
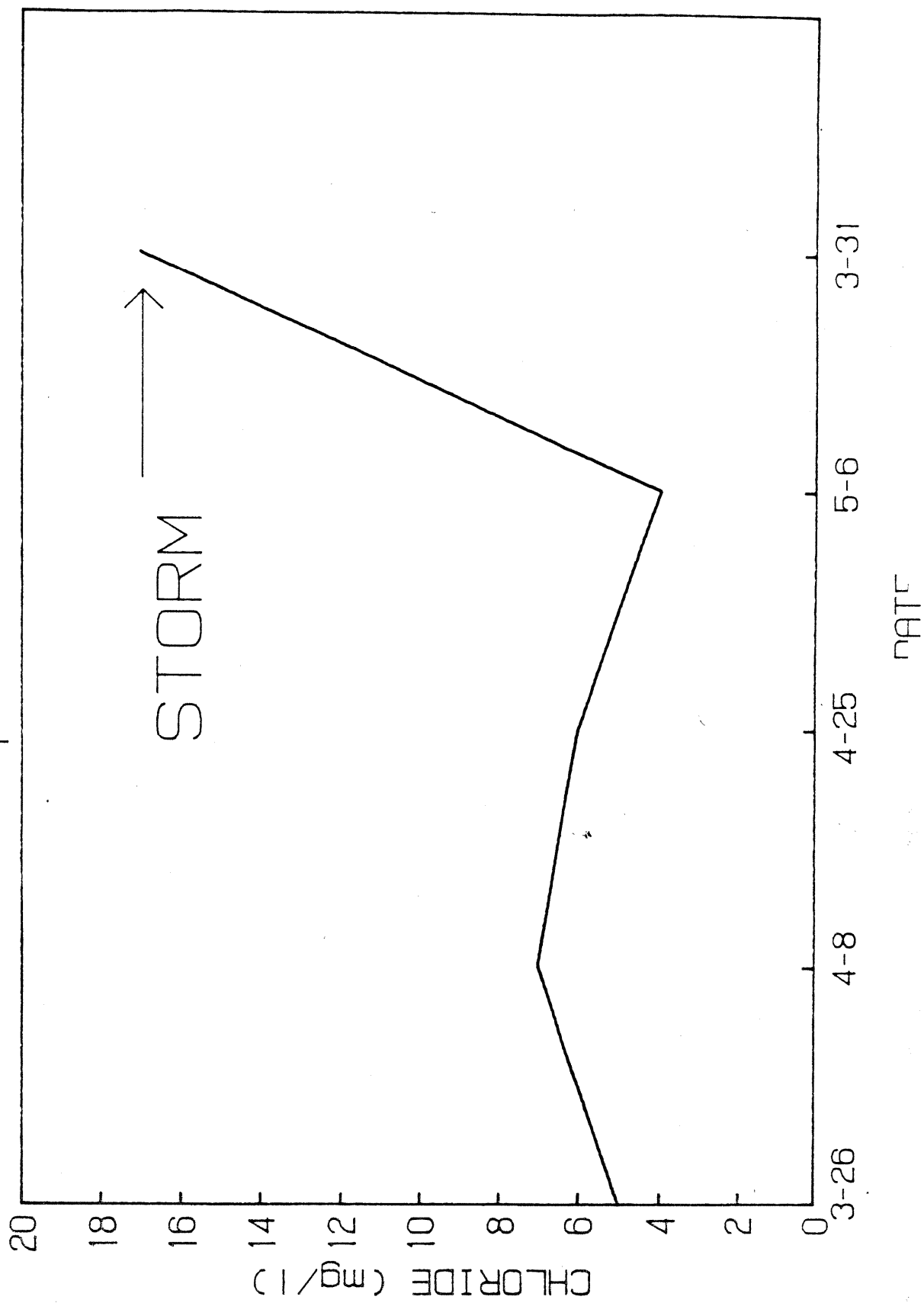
FIGURE 5.55

TOTAL SUSPENDED SOLIDS vs TIME
Trib. #4 (Camp Winadu) - ONOTA LAKE.
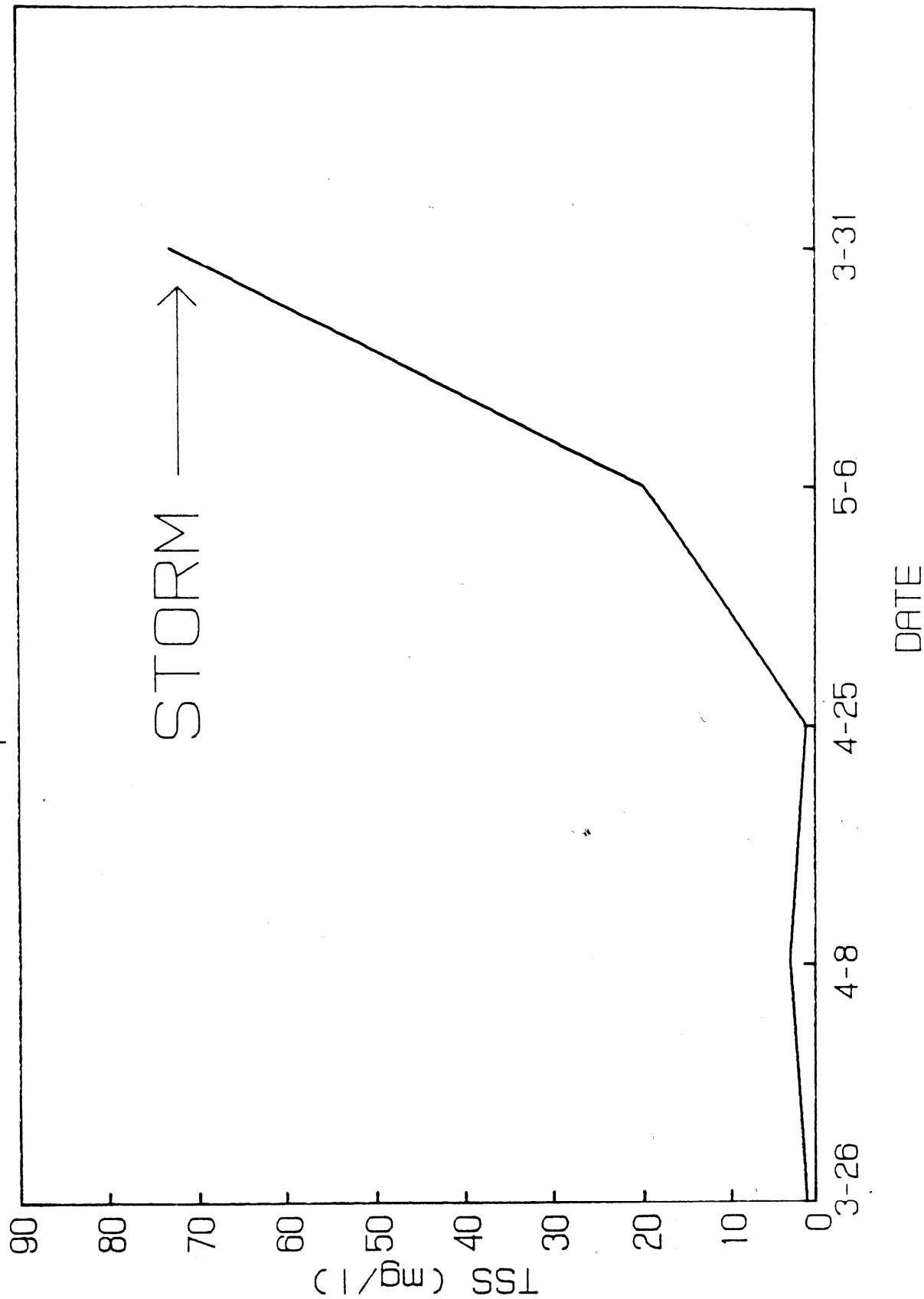
FIGURE 5.56

NITRATE VS TIME
Trib. #4 (Camp Winadu) - ONOTA LAKE

NITRATE vs TIME plot for Trib. #4 (Camp Winadu) - Onota Lake. Y-axis: NITRATE (mg/l) from 0.0 to 0.9. X-axis: DATE from 3-26 to 3-31. STORM arrow indicated.
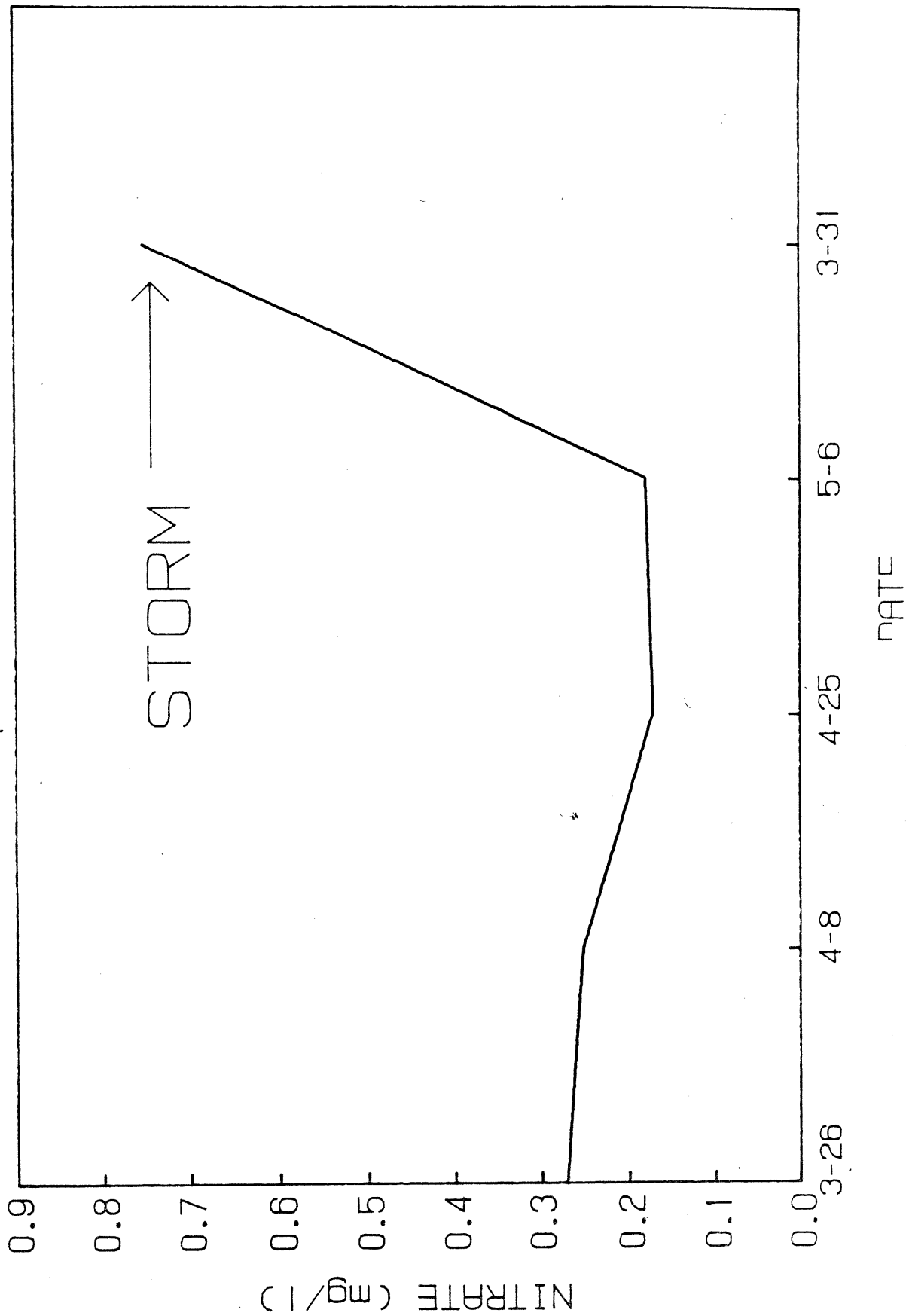
FIGURE 5.57

TOTAL PHOSPHATE vs TIME
Trib. #4 (Camp Winadu) - ONOTA LAKE

FIGURE 5.58

TOTAL BACTERIA VS TIME
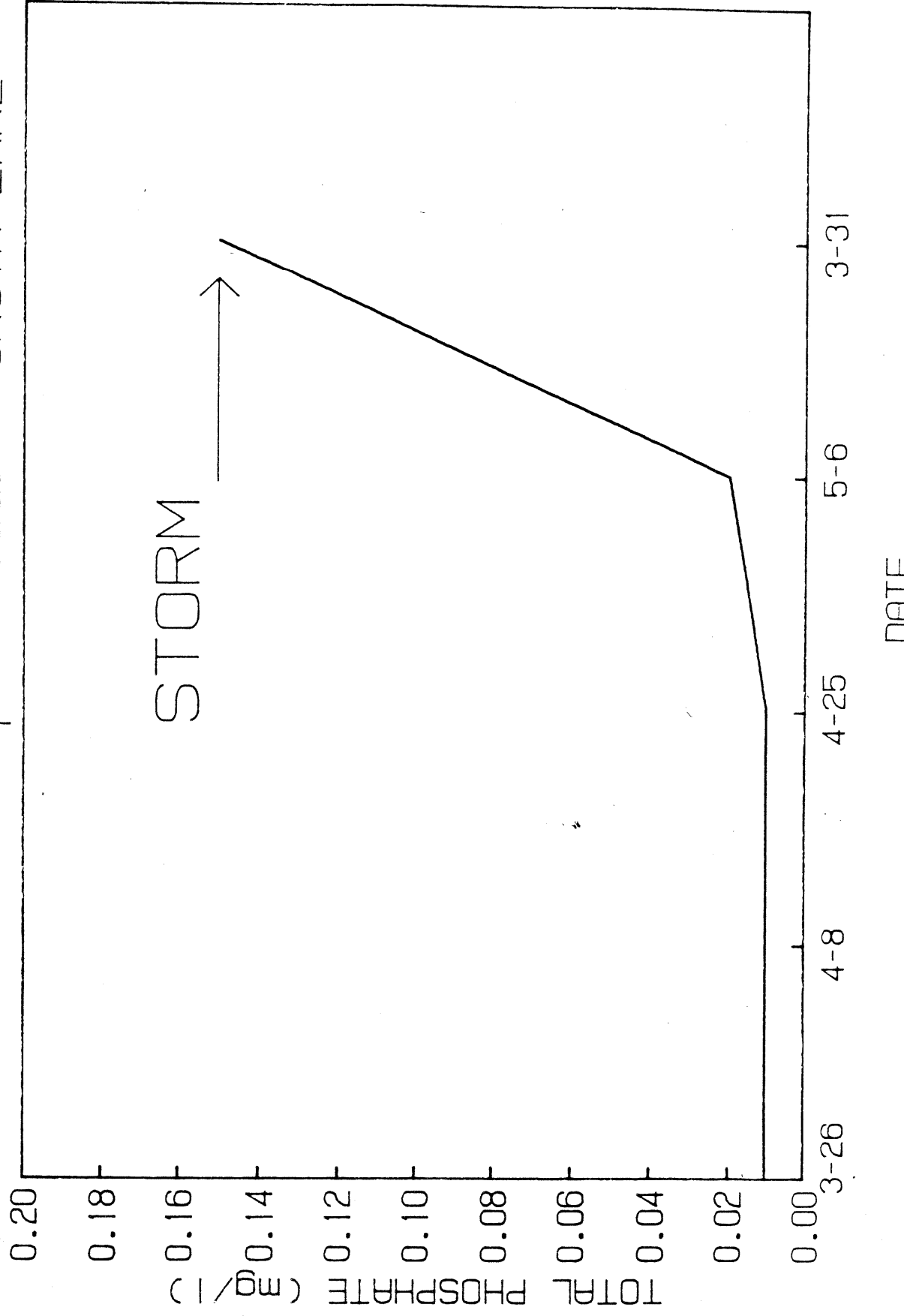
Trib. #5 (Parker Brook) - ONOTA LAKE.
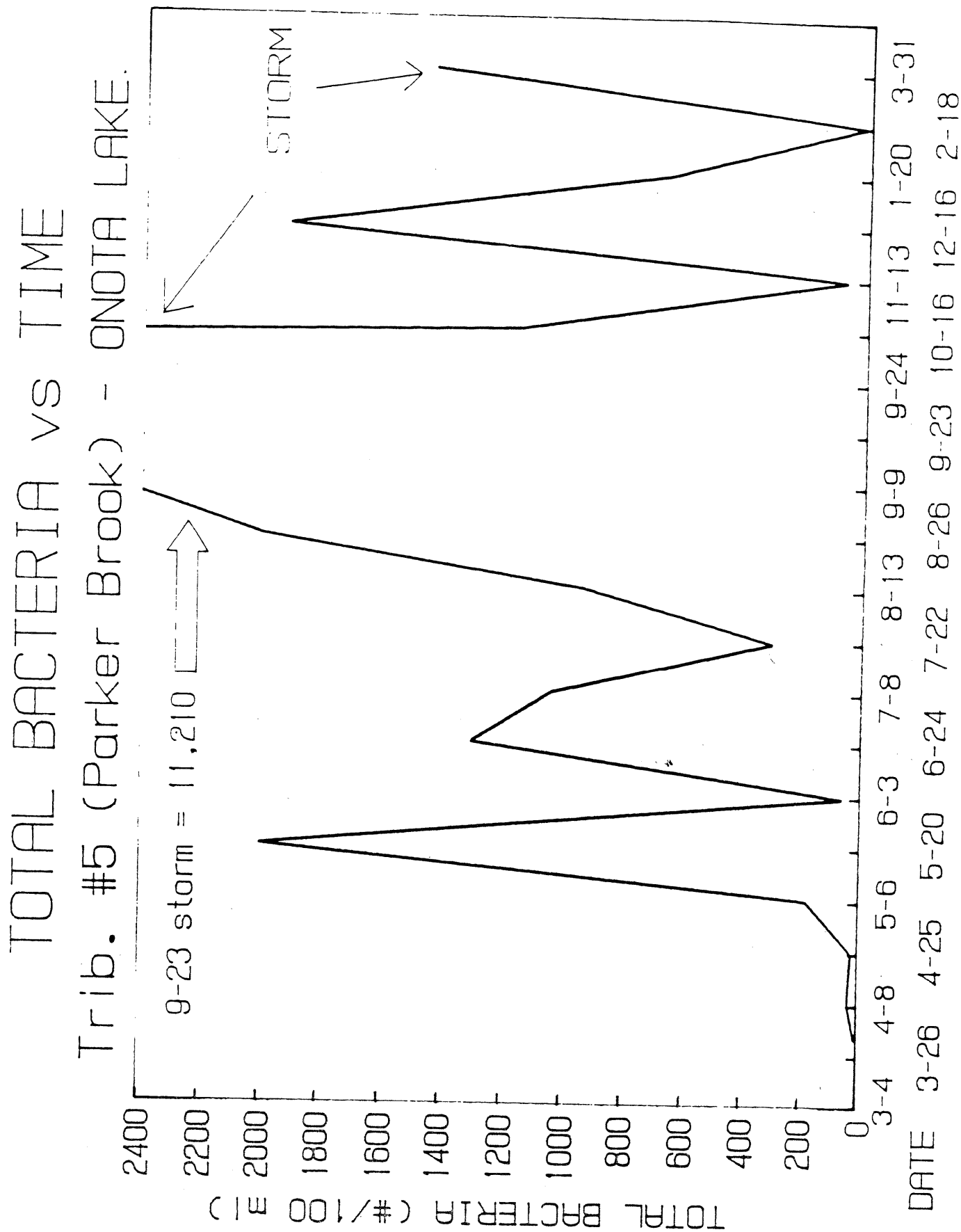
FIGURE 5.59

CHLORIDE VS TIME

Trib. #5 (Parker Brook) - ONOTA LAKE

STORM

CHLORIDE (mg/l)

24 22 20 18 16 14 12 10 8 6 4 2 0

DATE 3-4 4-8 5-6 6-3 7-8 8-13 9-9 9-24 11-13 1-20 3-31
      3-26 4-25 5-20 6-24 7-22 8-26 9-23 10-16 12-16 2-18
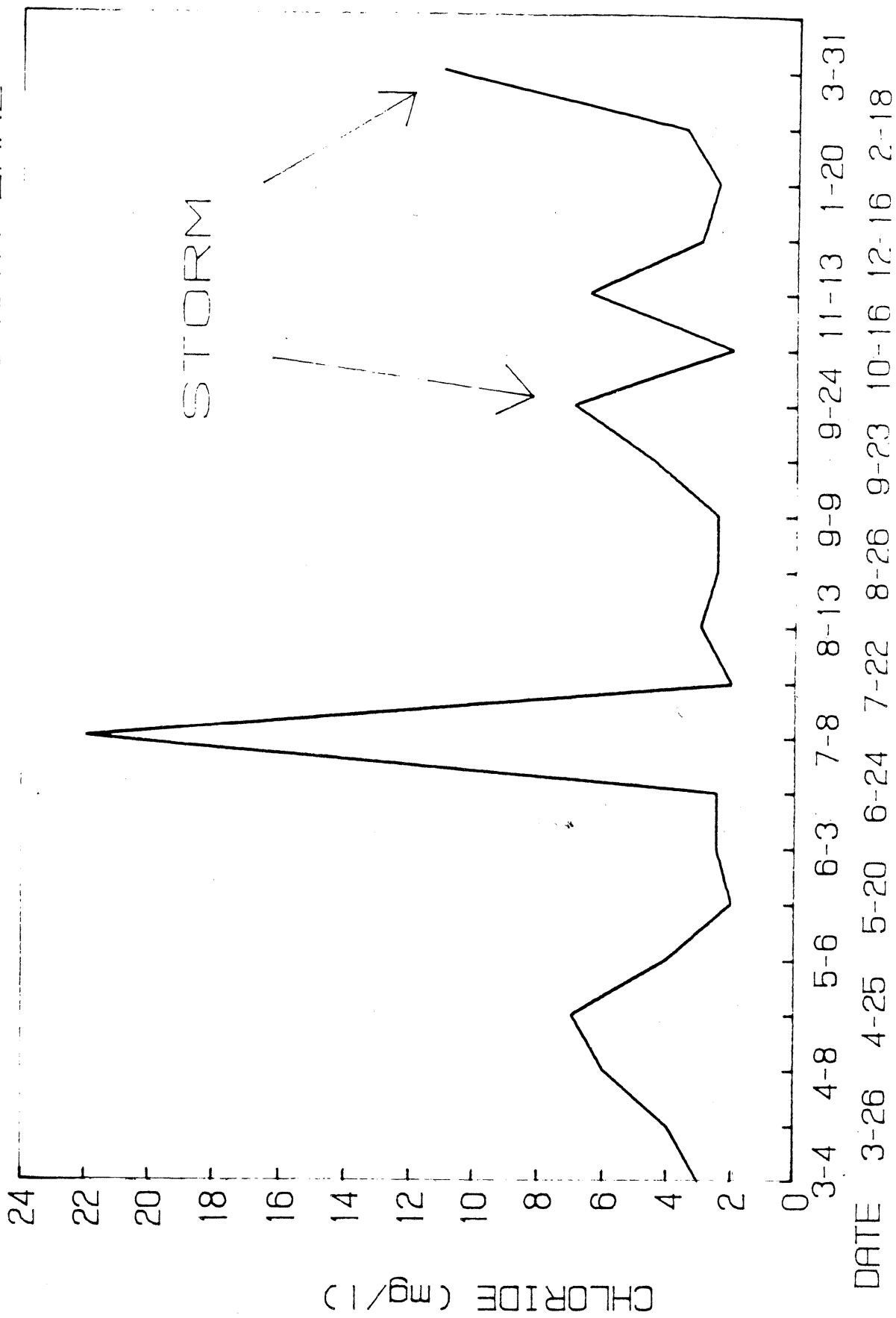
FIGURE 5.60

TOTAL SUSPENDED SOLIDS vs TIME
Trib. #5 (Parker Brook) - ONOTA LAKE

STORM

TSS (mg/l)

DATE
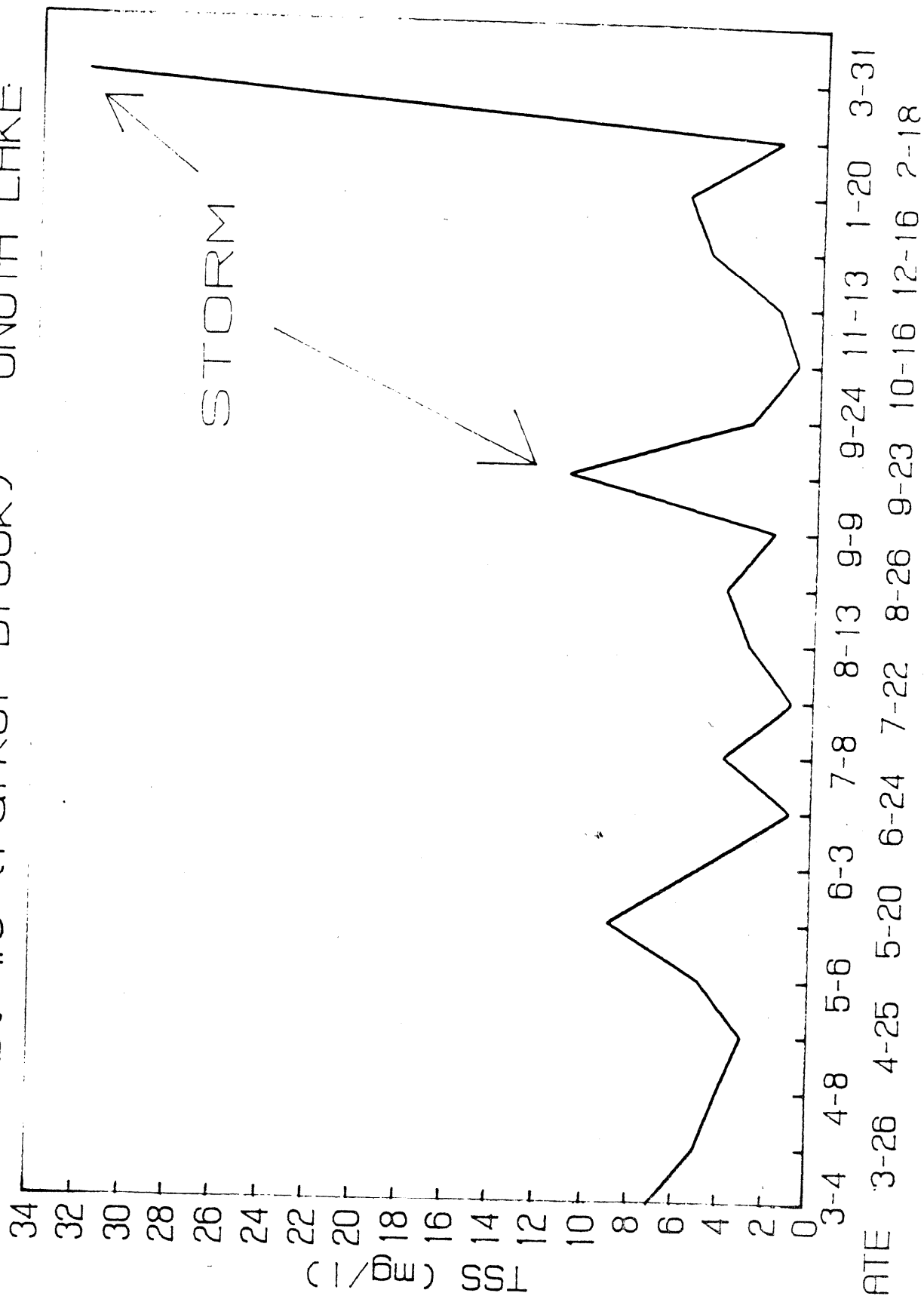
FIGURE 5.61

NITRATE vs TIME

Trib. #5 (Parker Brook) - ONOTA LAKE.

STORM
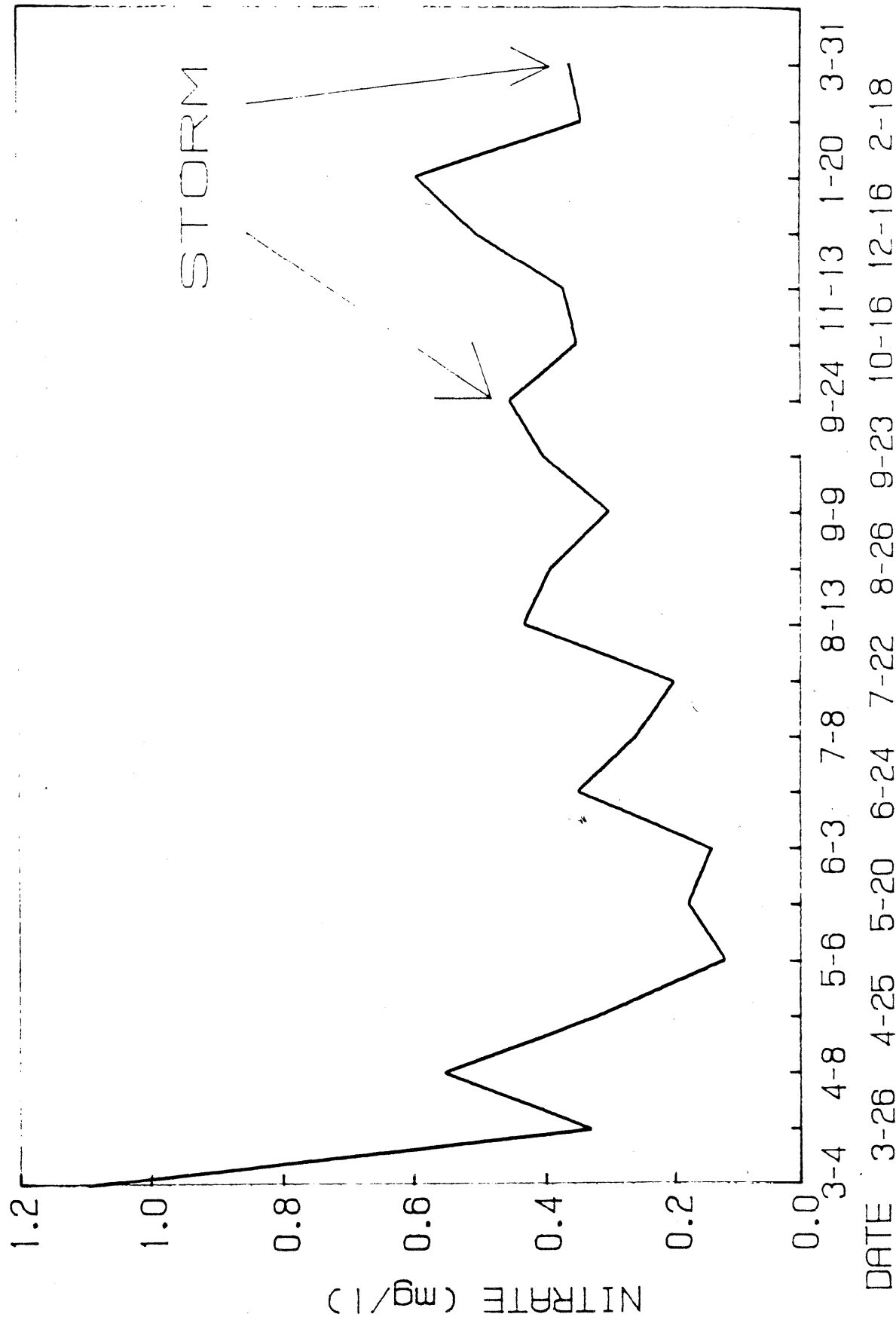
FIGURE 5.62

TOTAL PHOSPHATE vs TIME
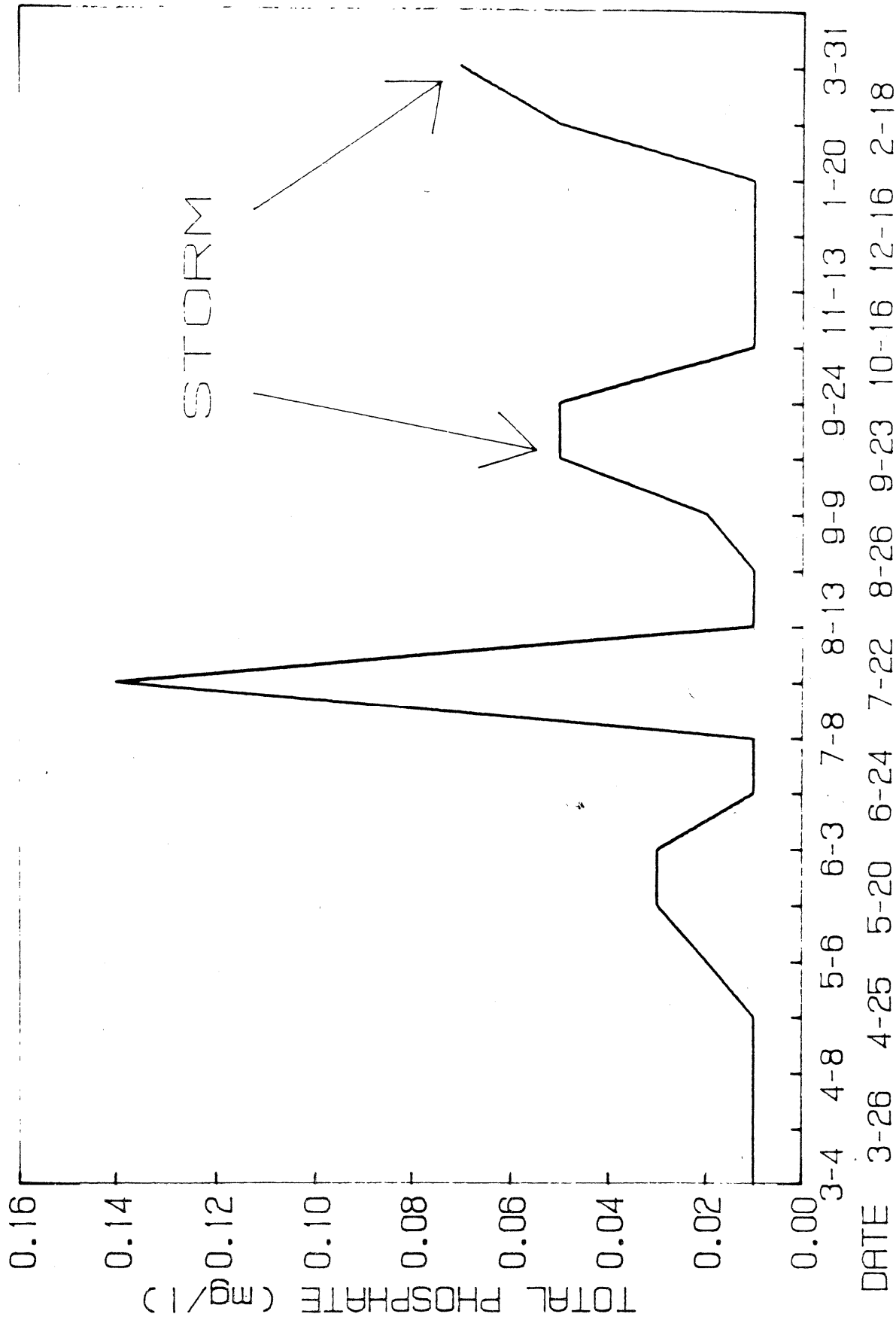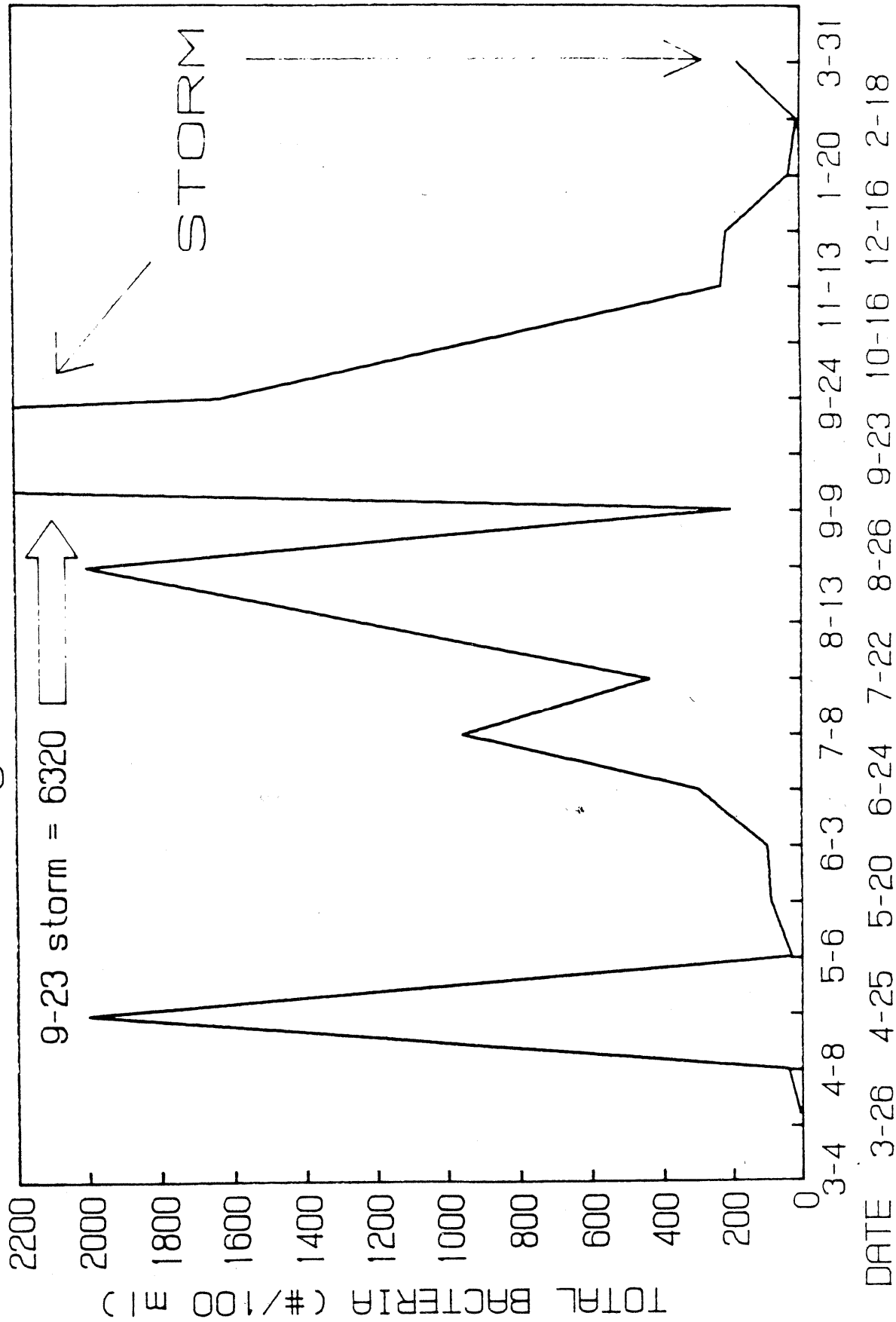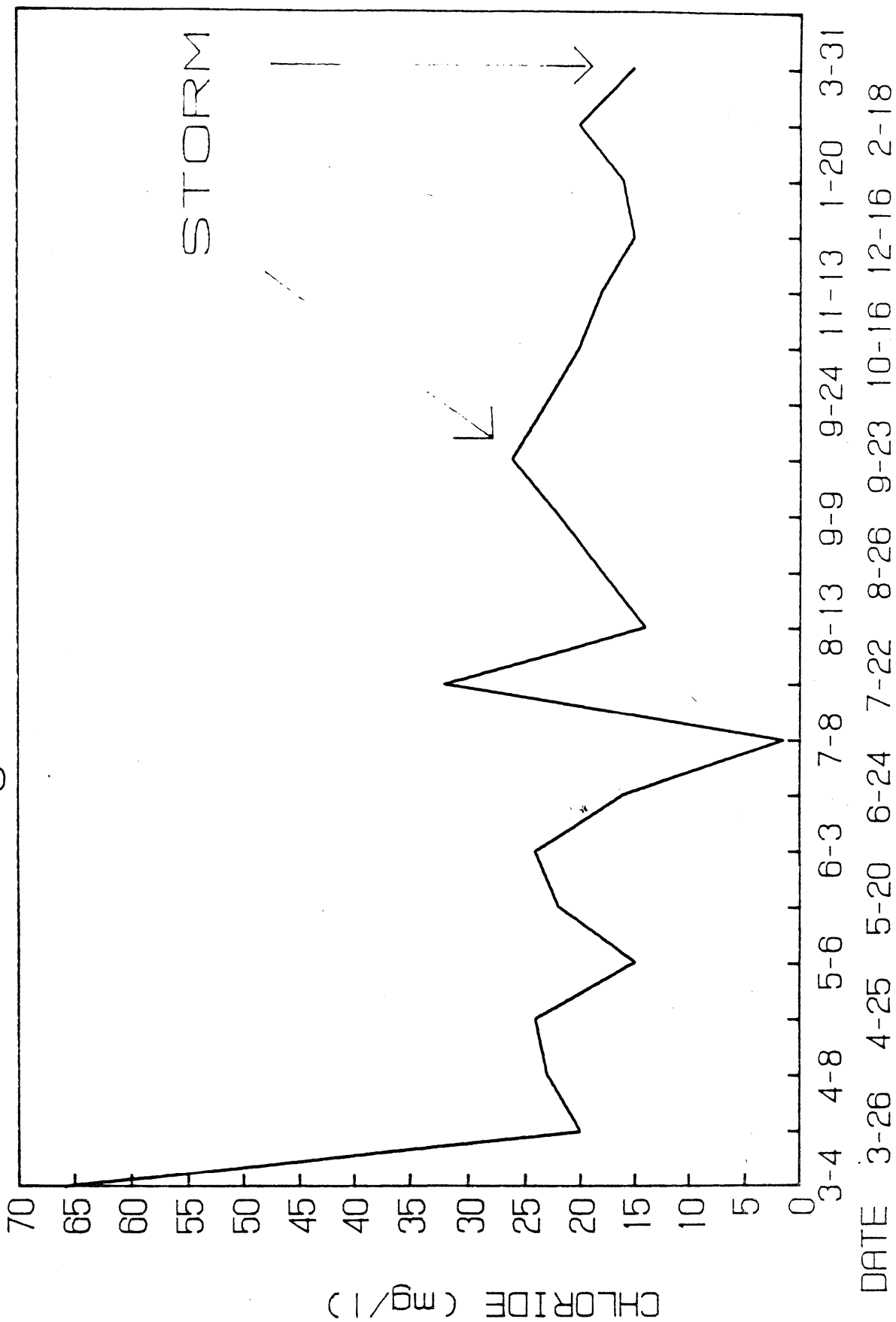### Trib. #5 (Parker Brook) - ONOTA LAKE

FIGURE 5.63

TOTAL BACTERIA vs TIME
Trib. #6 (Blythewood) - ONOTA LAKE
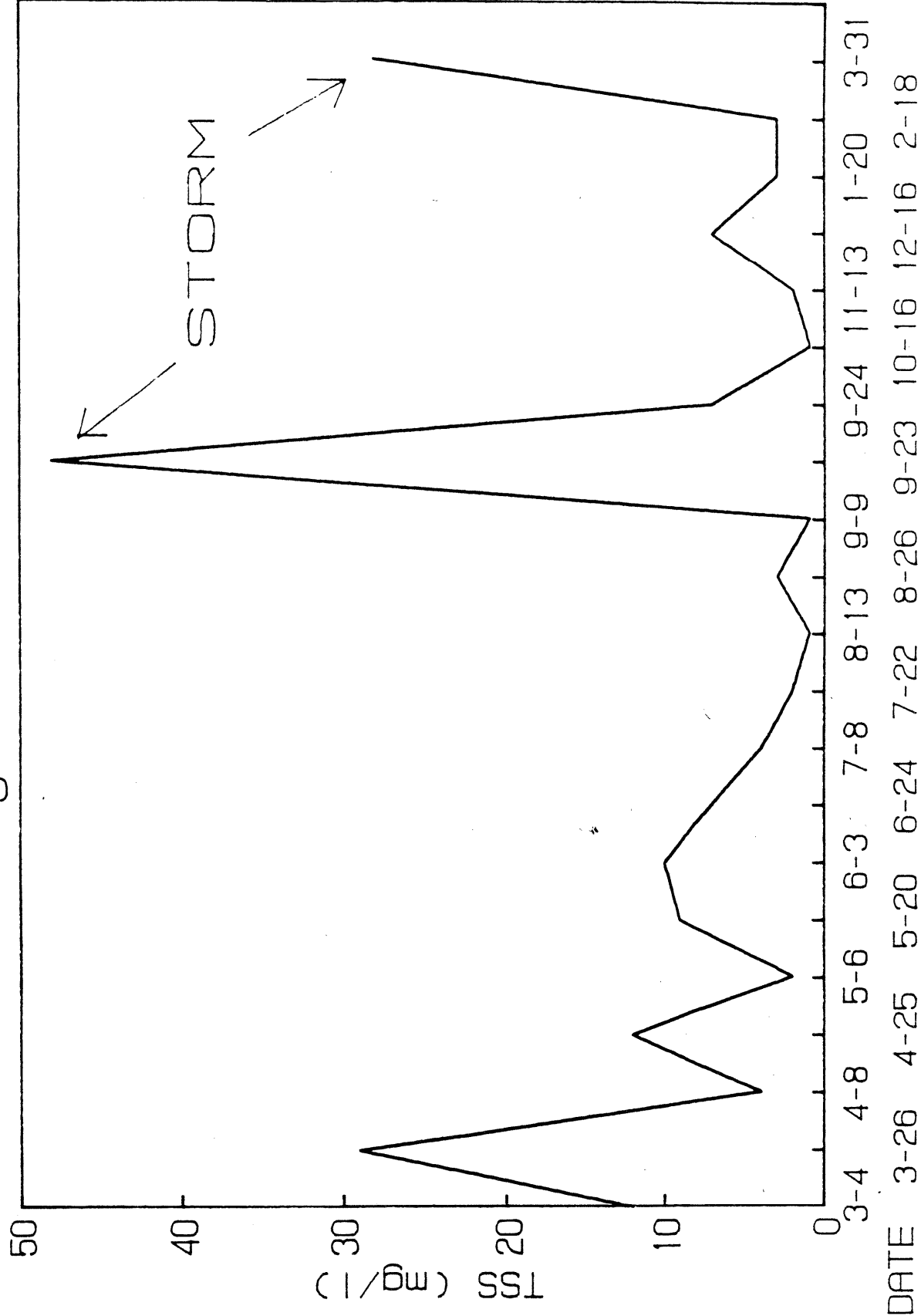
FIGURE 5.64

CHLORIDE VS TIME

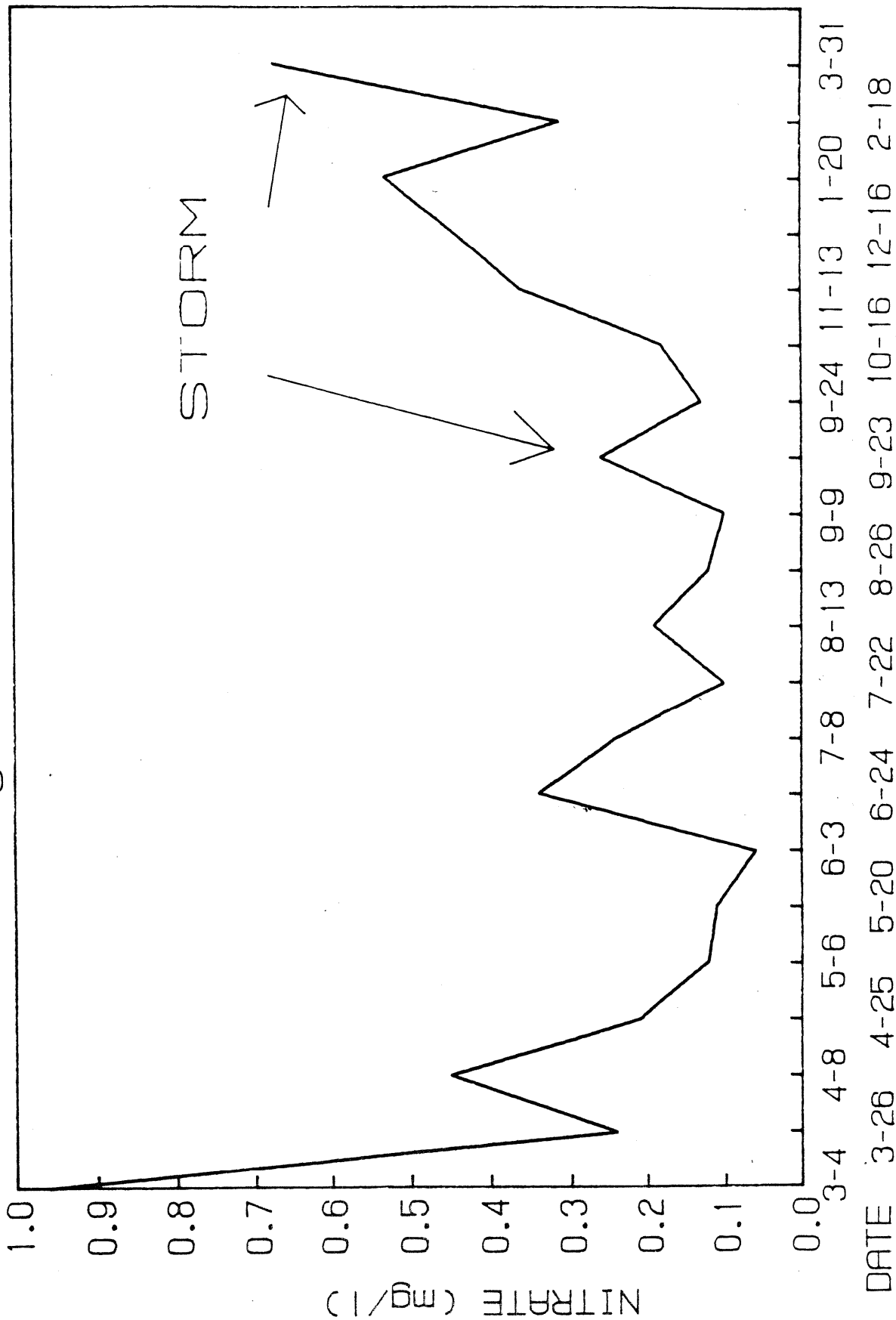### Trib. #6 (Blythewood) - ONOTA LAKE

FIGURE 5.65

TOTAL SUSPENDED SOLIDS vs TIME

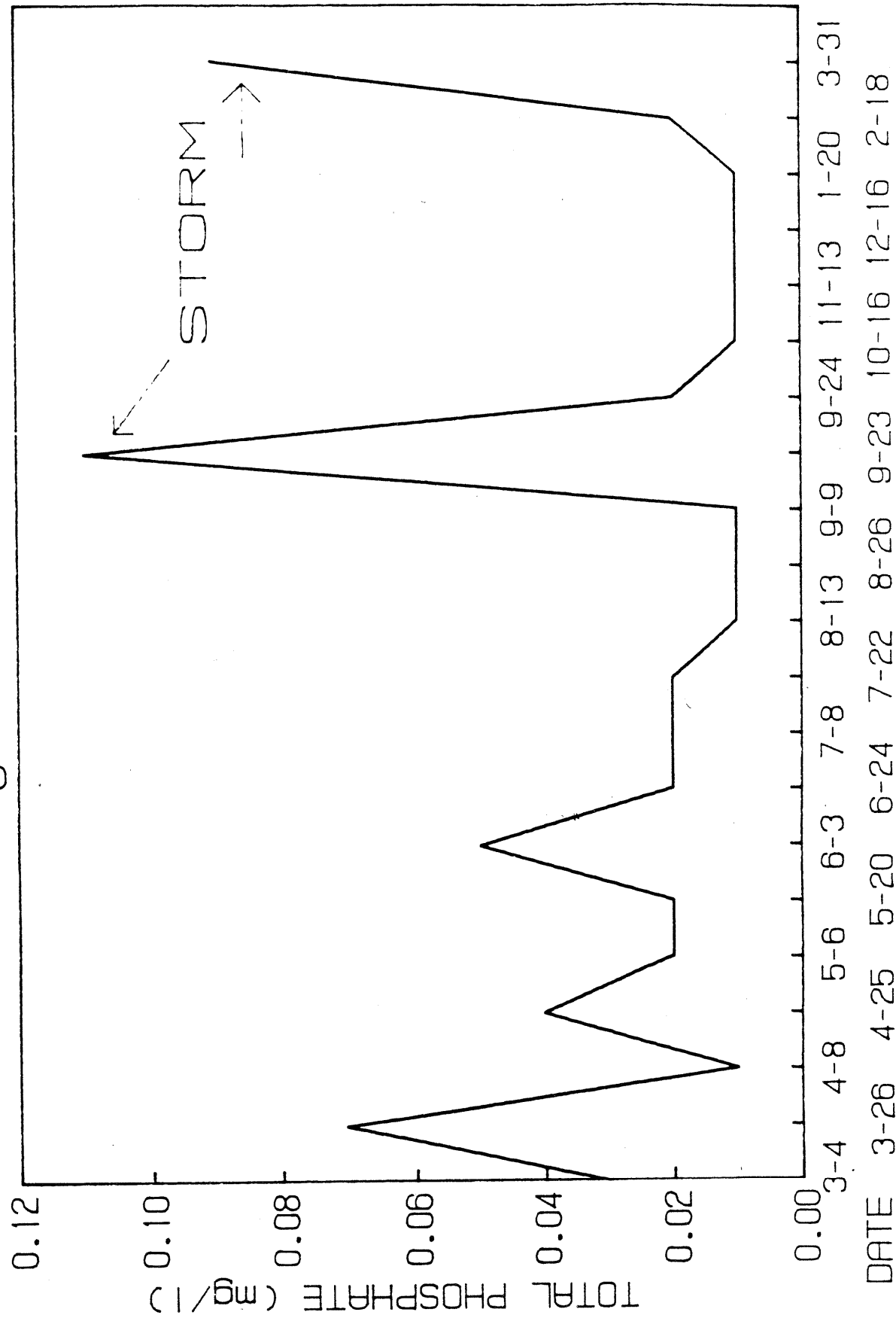Trib. #6 (Blythewood) - ONOTA LAKE

FIGURE 5.66

NITRATE vs TIME

Trib. #6 (Blythewood) - ONOTA LAKE

FIGURE 5.67

TOTAL PHOSPHATE vs TIME
Trib. #6 (Blythewood) - ONOTA LAKE

STORM

PERCENT COMPOSITION of BENTHOS

NORTH SIDE

SPRING 1986

Hyalella

64%

Other

9%

Chironomidae

10%

Gastropoda

17%
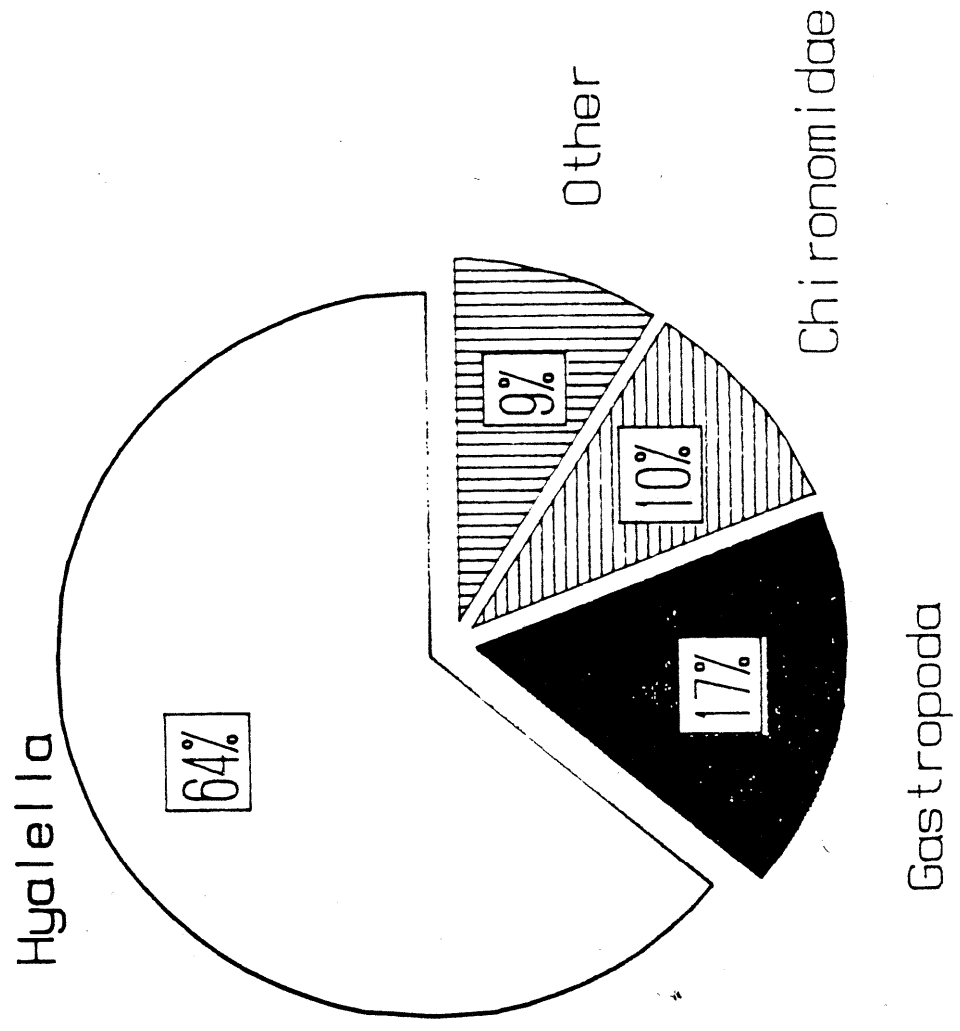
ONOTA LAKE

FIGURE 5.68

PERCENT COMPOSITION of BENTHOS
SOUTH SIDE
SPRING 1986

Chironomidae

Trichoptera

Gastropoda

Other

Oligochaeta

Hyalella

37%

18%

15%

13%

12%

5%
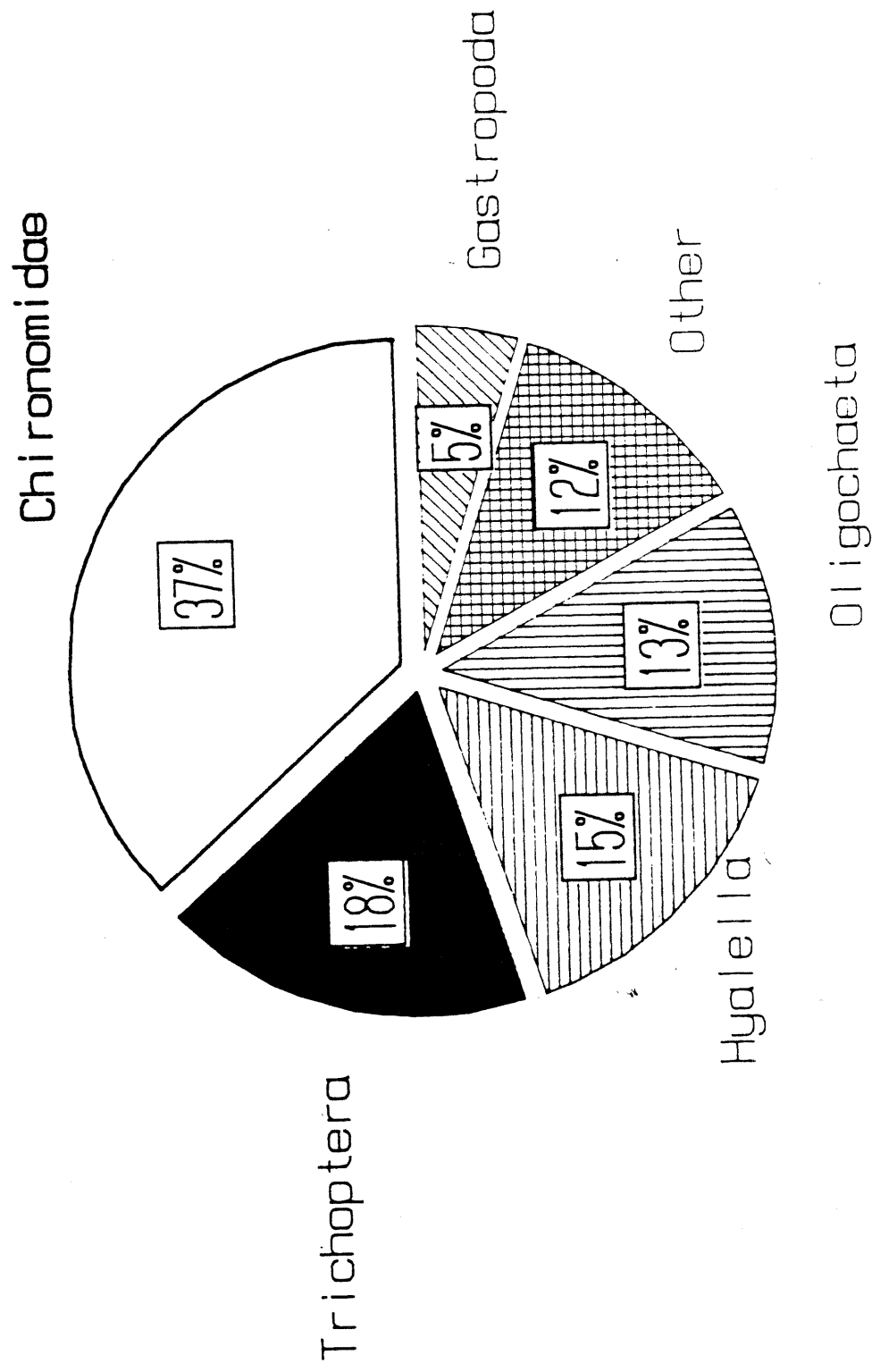
FIGURE 5.69

ONOTA LAKE

PERCENT COMPOSITION of BENTHOS
EAST SIDE
SPRING 1986

Hyalella

46%

Chironomidae

20%

Oligochaeta

19%

Hirudinea

8%

Other

7%
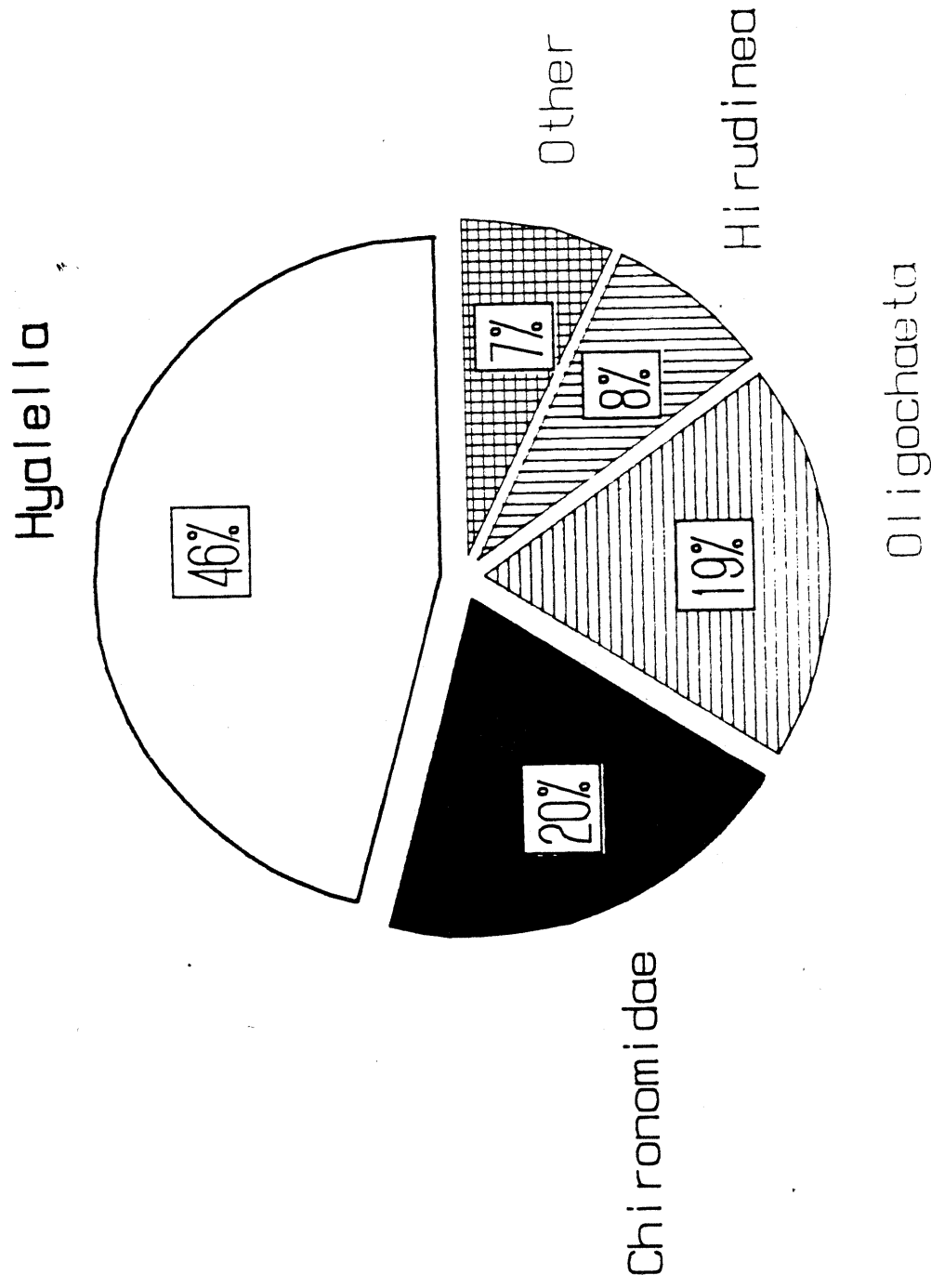
ONOTA LAKE

FIGURE 5.70

PERCENT COMPOSITION of BENTHOS

NORTH SIDE
SUMMER 1986

Hyalella

41%

Other

9%

21%

Ephemeroptera

29%

Trichoptera
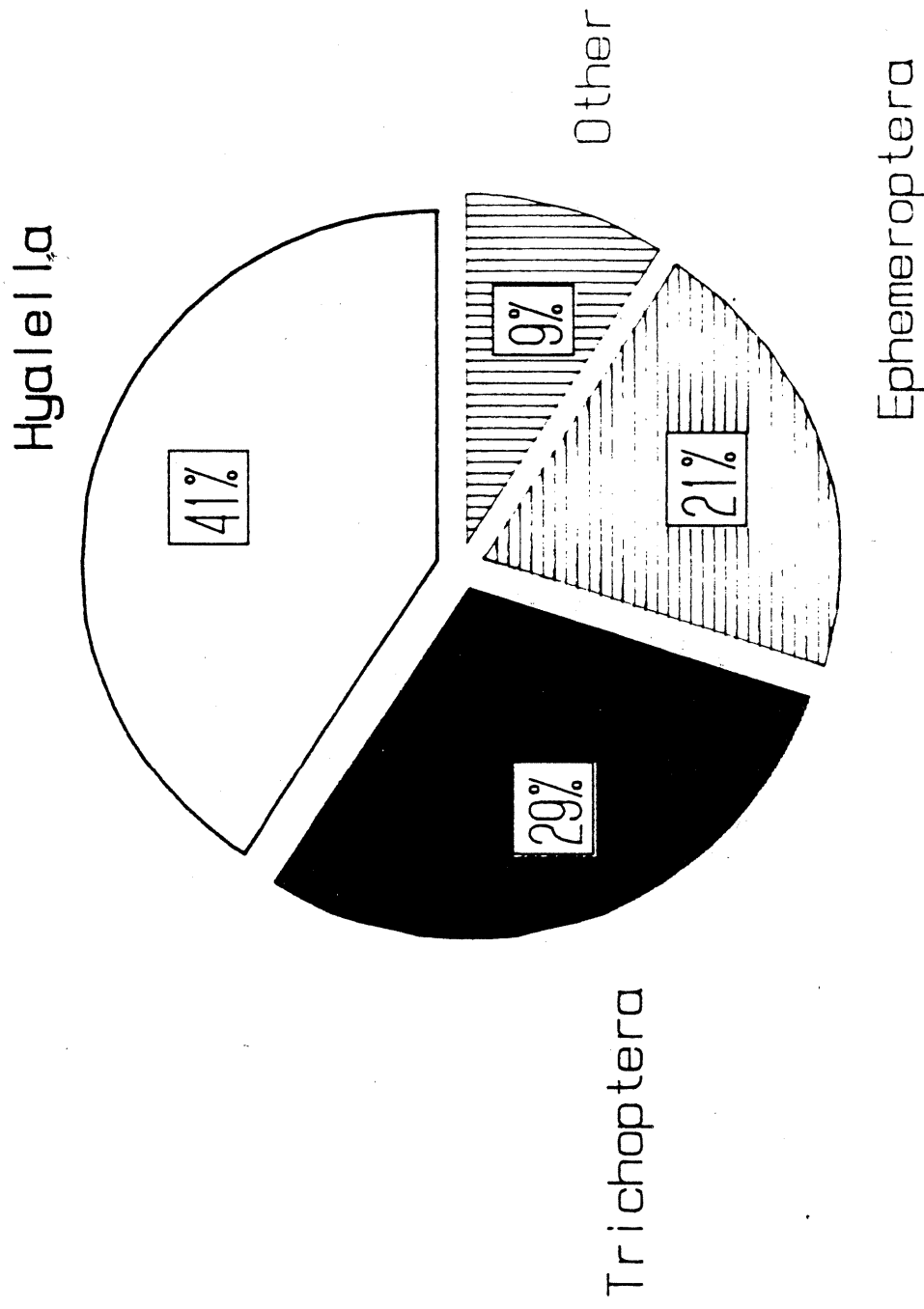
ONOTA LAKE

FIGURE 5.71

PERCENT COMPOSITION of BENTHOS

SOUTH SIDE

SUMMER 1986

Hyalella

32%

Chironomidae

24%

16%

Nematoda

9%

Other

7%

6%

Ephemeroptera

Oligochaeta

6%

Trichoptera

ONOTA LAKE

FIGURE 5.72

PERCENT COMPOSITION of BENTHOS
EAST SIDE
SUMMER 1986

Trichoptera — 27%

Hirudinea — 19%

Hyalella — 17%

Turbellaria — 15%

Oligochaeta — 11%

Other — 7%

Nematoda — 4%

ONOTA LAKE

FIGURE 5.73

PERCENT COMPOSITION of BENTHOS
NORTH SIDE
FALL 1986

Hyalella
46%

Chironomidae
36%

Trichoptera
12%

Other
6%
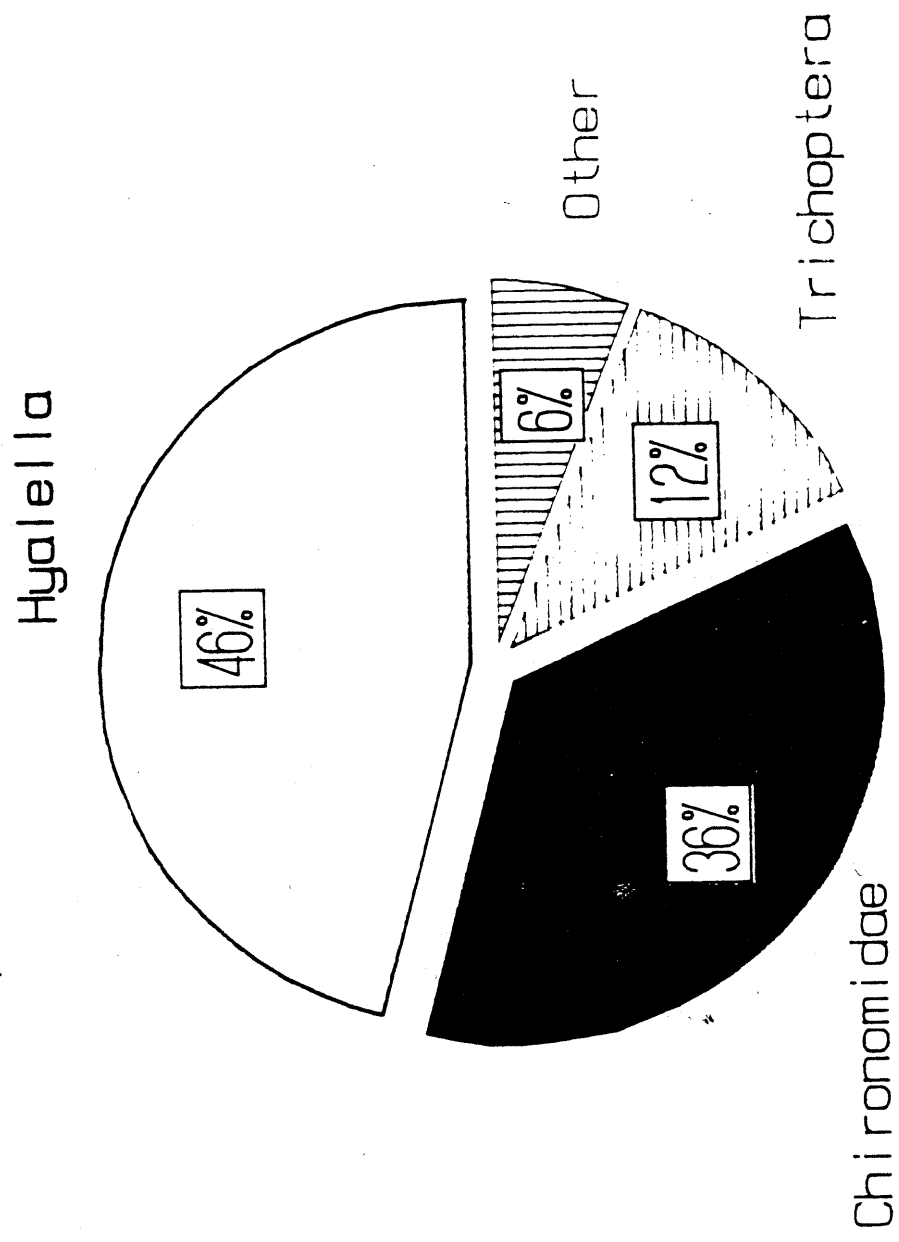
ONOTA LAKE

FIGURE 5.74

PERCENT COMPOSITION of BENTHOS
SOUTH SIDE
FALL 1986

Hyalella

40%

Chironomidae

21%

Trichoptera

16%

Oligochaeta

11%

Hirudinea

8%

Other

4%
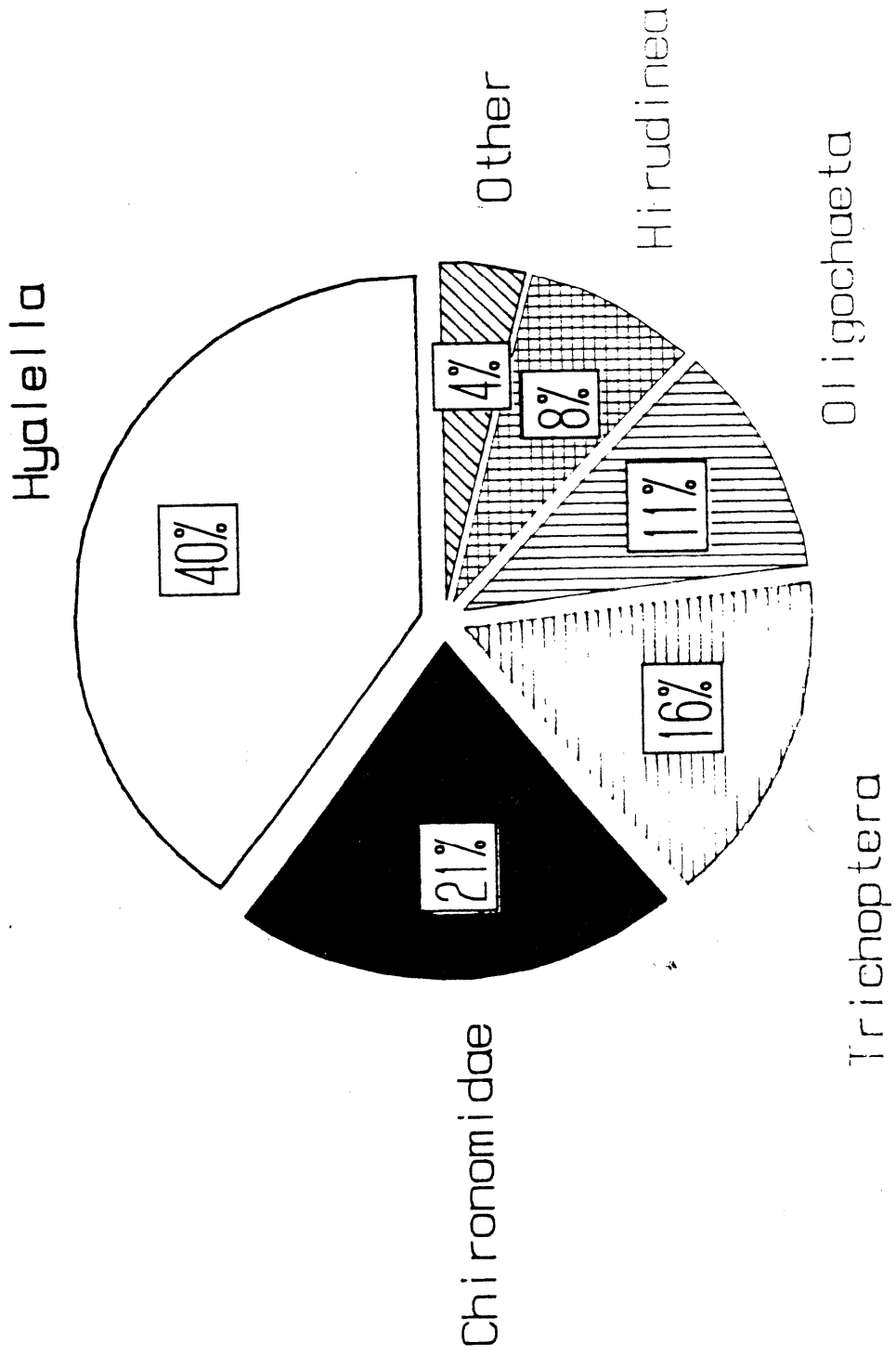
ONOTA LAKE

FIGURE 5.75

6.0 MACROPHYTE SURVEY

To establish the distribution of nuisance plant species throughout Onota Lake, multiple qualitative surveys of the submerged and emergent aquatic vegetation were conducted. The species composition, relative abundance, and dominant species of the macrophyte community was determined throughout the growing season.

A quantitative assessment was conducted in August when the macrophytes reached peak density. Biomass was determined by harvesting a series of 1 m^2 quadrats, twenty feet apart along transects set perpendicular to the shore line. Each transect extended into the lake to the limit of plant growth. Plants were cut at the sediment-water interface, rinsed, returned to the laboratory, oven dried at 103°C and weighed.

Ten species of aquatic macrophytes were observed throughout the lake (Table 6.1). The distribution and density of macrophytes differed markedly between the north and south basins. The northern shallow basin is dominated by dense stands of <u>Myriophyllum</u> <u>spicatum</u>, <u>Elodea</u> <u>sp.</u>, <u>Vallisneria</u> <u>americana</u>, and <u>Potamogeton</u> <u>perfoliatus</u>. A sizable stand of <u>Nuphar</u> <u>advena</u> exists at the outlet of Wadham Brook. By mid-summer, vegetative cover extends over approximately 70-80% of the northern basin.

Vegetation in the deeper south basin is confined mainly along the shoreline, and consists almost entirely of <u>Potamogeton</u> <u>perfoliatus</u>. The excellent clarity of Onota Lake allows this species to exist in dense stands in relatively deep waters off the shoreline ($\leq$ 2.5m). Areal coverage of <u>Potamogeton</u> increased in the northern portion of the south basin, particularly along the sandbar (Figure 6.1).

The total biomass and nutrient content of macrophytes which could potentially be harvested were estimated by calculating the total species coverage in the lake and conducting chemical analysis on various samples of harvested plants (Table 6.2). The nutrient analyses conducted on composites of dried plant tissue averaged 15,000 mg/kg TKN and 2000 mg/kg TP. These values show that a

KEY

N—NUPHAR ADVENA

M—MYRIOPHYLLUM SPICATUM

E—ELODEA SP.

P—POTAMOGETON
    (PERFOLIATUS & CRISPUS)

V—VALLISNERA AMERICANA

C—CHARA (ALGAE)

SOURCE:
U.S.G.S. 7.5" TOPOGRAPHIC QUADRANGLE

0   2000
scale   feet

N

FIGURE 6.1

MACROPHYE DISTRIBUTION MAP
SUMMER 1986

ONOTA LAKE
PITTSFIELD, MASS.

JUNE 1987

PROJECT #541648

IT

Do Not Scale This Drawing

high concentration of nutrients are stored up in the macrophytes. Total potential harvestable biomass amounts to 2.1 x 10^5kg (dry weight). The equivalent phosphorus content of harvestable biomass is 420 kg.

Welsh, et. al. (1979) reported that macrophyte harvesting can greatly decrease the internally regenerated TP load of a lake. This could, in systems where the internal load accounts for a majority of the total load, actually improve lake trophic state. Nutrient dynamics in the littoral sediments are greatly influenced by aquatic macrophytes (Carignan, 1985). In a lake such as Onota where nutrient availability is low, sedimentary organic matter (dead plant tissue) may predicate and influence the density of macrophyte growth.

Based on review of existing data and examination of existing macrophyte distributions, it appears that certain dominant plant species in the north basin may be spreading into the south basin. Potamogeton perfoliatus, a commonly occurring species in the north basin, displays a pattern of distribution which suggests that the species is emigrating from the north and becoming progressively established in the south basin. Shallow areas in the south basin have, over recent years, supported increasingly denser colonies of this species. This is most evident in the immediate proximity of the sand bar. Elodea sp. is another nuisance species which occurs in high density in the north basin and is encountered sporadically in the south basin. The spread of nuisance species from the north basin to the south may be accelerated by boat traffic, prop disturbance, and fugitive plants introduced on boat trailers.

TABLE 6.1

SPECIES LIST AND RELATIVE ABUNDANCE OF AQUATIC MACROPHYTES
COLLECTED FROM ONOTA LAKE

<u>Myriophyllum</u> <u>spicatum</u>	Abundant/Dominant
<u>Chara</u> (Alga)	Common
<u>Elodea</u> sp.	Abundant
<u>Vallisneria</u> <u>americana</u>	Abundant
<u>Potamogeton</u> <u>crispus</u>	Present
<u>Potamogeton</u> <u>perfoliatus</u>	Abundant/Dominant
<u>Potamogeton</u> <u>robinsii</u>	Present
<u>Nuphar</u> <u>advena</u>	Present
<u>Heteranthera</u> <u>dubia</u>	Sparse
<u>Nitella</u> (Algae)	Present

TABLE 6.2

TOTAL HARVESTABLE BIOMASS AND CHEMICAL CONTENT
OF MACROPHYTON IN ONOTA LAKE

Total Harvestable Area (Acres) = 132

Average Harvestable Depth (meter) = 1.5

Average Biomass/Square Meter (grams) = 265

Total Harvestable Biomass (kg) = 2.1×10^5

Total Phosphate -P of Total Biomass (kg) = 420

Total Kjeldahl Nitrogen of Total Biomass (kg) = 3,150