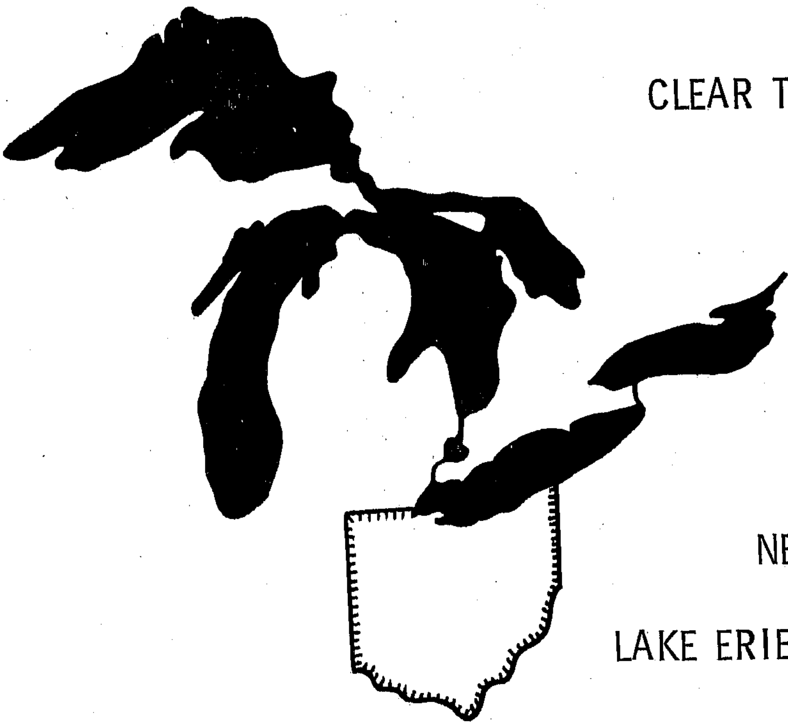

CLEAR TECHNICAL REPORT NO. 128

SUMMARY OF LAKE ERIE NEARSHORE CHARACTERISTICS AND LAKE ERIE NEARSHORE SURVEILLANCE DESIGN

FINAL REPORT

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SUMMARY OF LAKE ERIE NEARSHORE CHARACTERISTICS

The dense population, high degree of industrialization, the high level of chemical loading and its small volume are the reasons that Lake Erie has the poorest quality water of the five Great Lakes. The physical and chemical processes resulting from natural events and human activity produces complex interactions among and between the biotic and abiotic components of the lake ecosystem. Several types of inputs are known to degrade water quality. Nutrient loads stimulate plant production. These combine with man's organic waste effluents to create demands on the oxygen system. Toxic metals and pesticides enter the sediments and the food chain and are subsequently concentrated in organisms at every trophic level. In many instances, toxicants may make the organisms at higher trophic levels unsafe for human consumption (Upchurch, 1976).

In response to these and other conditions in the Great Lakes, the Governments of Canada and the United States authorized (Article VI, 1, (a) of the Great Lakes Water Quality Agreement of 1972) the development of an international surveillance plan to collect, analyze and disseminate information relating to the water quality of the Great Lakes. The overall surveillance design consists of six general design components: inputs, whole lake, outflows, data quality, data management and reporting. The whole lake component consists of the nearshore areas including the water intake, beach and cladophora elements and the main lake component. To facilitate a reliable evaluation of nearshore water quality, the nearshore portion of the whole lake component was divided into annual and intensive subcomponents. Due, in part, to the specific problems outlined above, Lake Erie was chosen as the site for the first intensive whole lake surveillance study.

This summary serves to recommend a surveillance station plan (Herdendorf, 1978) and present the findings of a series of technical reports which serve as the foundation of the design. Eight historical reviews were conducted to assess environmental conditions in the nearshore areas, summarize the nature and extent of historical data, and better identify problem areas. The individual reports and the surveillance plans are listed below:

1. <u>CLEAR Technical Report No. 77</u>:

   "Lake Erie Nearshore Surveillance Station Plan for the United States: Preliminary Design"

2. <u>CLEAR Technical Report No. 112</u>:

   "Water Quality of the Nearshore Zone of Lake Erie: A Historical Analysis and Delineation of Nearshore Characteristics of the United States Waters"

3. CLEAR Technical Report No. 80:

   "Lake Erie Nearshore Water Quality Data: 1928-1978"

4. CLEAR Technical Report No. 85:

   "Description of Sediment Samples and Cores from the Michigan and Ohio Waters of Lake Erie"

5. CLEAR Technical Report No. 68:

   "An Analysis of Data Relating to Toxic Substances in the Nearshore Waters and Sediments of Lake Erie"

6. CLEAR Technical Report No. 94:

   "Toxic Organic Substances in the Nearshore Waters and Biota of Lake Erie"

7. CLEAR Technical Report No. 86:

   "Zooplankton, Phytoplankton and Bacteria as Indicators of Water Quality in the Nearshore Zone of Lake Erie: A Prospectus"

8. CLEAR Technical Report No. 126:

   "An Overview of the Nearshore Macroinvertebrates of Lake Erie"

9. CLEAR Technical Report No. 127:

   "Inventory and Review of Literature Data Sources Pertaining to Ichthyological and Fisheries Research in the Nearshore Zone of Lake Erie"

10. CLEAR Technical Report No. 128:

    "Summary of Lake Erie Nearshore Characteristics and Lake Erie Nearshore Surveillance Design: Final Report"

The surveillance station plan and the criteria used to establish specific stations were developed by Herdendorf (1978) with the assistance of staff members of the Center for Lake Erie Area Research at The Ohio State University. This plan integrates the information presented in each of the technical documents to develop a comprehensive grid network. The levels and trends of physical-chemical and biological parameters measured at these stations will, upon implementation, be determined and related to eutrophication, emerging problems and the effectiveness of remedial programs. The nearshore areas receive all the tributary and point source inputs. As the area initially impacted by waste and runoff inputs, these areas are the first to show the results of further degradation and should be the first to show indications of improvement following implementation of abatement programs.

The technical reports represent the first attempt to collect and summarize nearshore data from the U.S. waters of Lake Erie. In doing so, the reports clearly define a number of problems. The vast majority of data was located in governmental and university reports and in unpublished open file material. In each study, the problems preventing the determination of trends for most parameters are twofold. Most studies were local and of short-term duration. Fragmentation of data has made it difficult to assess levels on a lakewide basis. Even previous lakewide studies have been short-term efforts. The lack of continuity combined with the variety of analytical techniques and sampling procedures results in data of dubious comparative value. Rapid technological changes in analytic procedures makes older data less accurate and more difficult to assess in a modern context. Many studies fail to report analytic techniques and/or sampling sites. In some instances, the sampling site is listed as "Lake Erie". Overall, the information available is inadequate to allow any but isolated conclusions which are limited to one or a few parameters.

Water temperature is typically isothermal in nearshore areas. Isothermal conditions are attributed to vertical mixing associated with relatively shallow and turbulent water. Occasionally, a continuous thermal gradient occurs with cooler water encountered with greater depth. Water temperature is important in controlling water movements in the nearshore zone. In spring and early summer, density barriers may confine nearshore waters along the south shore. Water temperatures along the north shore of the lake do not vary greatly from the main lake temperature at any time of the year. The annual cycle of dissolved oxygen concentration is one of higher concentrations during periods of lower water temperatures. Lowest concentrations occur in harbors and tributary mouths in August.

Turbulence associated with seasonal storm events in the early spring, in combination with high sediment loads in tributary inputs, results in high turbidity and suspended solids values and low transparency values. Dissolved solids and transparency values improve from spring to fall during the annual cycle. Overall, dissolved solids values often exceed existing or proposed standards. Nutrients such as nitrate and phosphorus decrease from high spring values as algal populations increase and utilize these materials. During and following storm periods, nearshore water bearing higher concentrations of constituents tend to spread into the main lake. Transparency values increase and specific conductance values decrease with distance from shore. Offshore, values of most parameters indicate more stable, less widely variable conditions.

The characteristics of the nearshore zone are determined, in part, by currents and runoff inputs. The currents which disperse and relocate suspended or dissolved materials may be quite different between nearshore and offshore water due to the effects of bottom topography and density related boundary conditions. In contrast, wind-driven currents are the fastest and most variable in direction for the large-scale movement of water. Runoff carried by tributary streams during wet years serves to increase the variability of several parameters measured in the nearshore zone. During dry years, variability decreases. The decreased variability reflects decreased fluctuations accompanying decreased runoffs. Relative to the main lake, nearshore water quality is characterized by higher mean values of most parameters and a considerably wider range of variability in measurements of each respective parameter. The wide range of variability is the hallmark of nearshore water quality measurements.

The ability of investigators to characterize water quality from plankton samples is poorly developed. Straight taxonomic enumeration surveys do little to characterize nearshore water quality. Due to the inordinate amount of time required to enumerate samples, there are extremely few surveys of phytoplankton done to the species level for nearshore waters. It is very difficult to sample the water column in an integrated manner for phytoplankton. Although preferred, few whole water samples have been taken. It is concluded that water intake data represents the algae at a given depth of water. It is unreasonable to assume such data indicates the overall phytoplankton populations. Very few productivity or physiological measurements of algal activity have been made.

Aside from immediate fish mortality, persistent pesticides, toxic organic compounds and heavy metals may result in delayed mortality, reduced reproduction, restricted growth, reduced ability to withstand natural changes in the environment and lowered resistance to disease. Fish bioaccumulate many materials to levels well above detection limits. Low concentrations in water samples require fish tissue to detect trends. Unfortunately, differences in fish species, fish size, tissue sites sampled, collection dates and sites makes comparison of the limited data available both difficult and unreliable.

Conditions in the nearshore zone are not uniform or stable to the extent common to the main lake. Fluctuations may be short-term, catastrophic, seasonal or annual. The physiography, depth, bottom types, character and extent of influx, exposure to wind fields and thermal structure all cause variations in nearshore areas. It is important to note that all natural changes adhere to a basic annual cycle with the variety of short-term effects superimposed. Studies that are short term and cover a limited area may reach unwarranted conclusions. The history of efforts in the nearshore areas of Lake Erie have taught this important lesson if no other. Efforts that consider effects without analyzing causes may lead to erroneous management recommendations. Definitions of the annual cycles on a comprehensive lakewide basis are necessary to provide a baseline context in which to place localized phenomena. Factors which control physical events should be better defined, and the proper time and space perspectives of problem areas should be determined before development of any reasonable comprehensive management plan (Pinsak, 1976). The proposed surveillance and accompanying station location plan addresses these issues. The technical reports document and present historical data for 62.6% of the stations proposed in Michigan waters, 42% of the stations proposed in Ohio waters, 31% of the stations proposed in Pennsylvania waters and 37.5% of the stations proposed in New York waters.

LAKE ERIE NEARSHORE SURVEILLANCE STATION PLAN

FOR THE UNITED STATES

Introduction

The nearshore zone is the area of largest interaction between water quality and the water user. It is the source of all water for public and industrial water supply. It is the site of virtually all recreational use and it is the most important area for the propagation and support of all aquatic life forms. With the exception of that portion of atmospheric deposition falling on the main body of the lake, the nearshore zone is the recipient of most waste input. For this reason, these waters are the first to show signs of degradation and are the first indicators of progress in abating pollution.

Objectives

In response to the above considerations, the nearshore surveillance subcomponent is designed to meet the general objectives of the Lake Erie plan. The following general objectives have been established by the Surveillance Subcommittee, Great Lakes Water Quality Board, International Joint Commission for the Great Lakes Surveillance Plan (of which the Lake Erie plan is one component):

1. To search for, monitor, and quantify violations of the existing Agreement objectives (general and specific, the IJC recommended objectives, and jurisdictional standards, criteria and objectives. Quantification will be in terms of severity, areal or volume extent, frequency, and duration, and will include sources.

2. To monitor local and whole lake response to abatement measures and to identify emerging problems.

3. To determine the cause-effect relationship between water quality and inputs in order to develop the appropriate remedial/preventative actions and predictions of the rate and extent of local/whole lake responses to alternative abatement proposals.

Within the context of these general objectives and considering the key issues specific to Lake Erie, the surveillance plan will additionally focus on:

1. Determining the long-term trophic state of Lake Erie and determining to what degree remedial measures have affected improvements.

2. Assessing the presence, distribution, and impact by toxic substances.

This will then provide information to indicate the requirements for and direction of additional remedial programs, if necessary, to protect water uses. These objectives have been translated into a detailed surveillance plan for Lake Erie. It is a nine-year plan and provides for both annual and intensive efforts. This does provide, when considered with the total Great Lakes Surveillance Plan, a continuing program at a more or less stable level of effort. The plan defines the optimum effort needed, reflecting that all parameters do not need to be monitored at all times and at all locations. Intensive efforts have been designed to obtain data in areas that respond much slower to change or to examine in detail a specific issue. Annual efforts have been designed to obtain data in areas that respond rapidly to change; to monitor frequently selected critical parameters due to the variable nature of the water body; or to obtain high frequency data with a high degree of statistical confidence.

Rationale

In order to facilitate a reliable evaluation of nearshore water quality the nearshore sub-component has been divided into two elements: (1) the annual element including problem area assessments; and (2) the intensive element including detailed problem area assessments.

The annual element is designed to identify emerging problem areas, to detect changes in water quality on a broad geographic basis, and to provide information necessary for trend analyses. General annual nearshore surveillance is usually carried out less extensively between major centers of development and in other areas where water quality is not seriously degraded, but takes into consideration the seasonal nature of tributary inputs, lake circulation patterns, and nearshore-offshore gradients.

If and when problem areas are detected as a result of the annual element, more detailed local assessments will be implemented. The main thrust of problem area assessments is the identification of the nature, extent, and source of a problem. These assessments occur concommitantly with either or both the annual and intensive elements. Problem area assessments are varied, being dependent on the nature, magnitude, and geographic extent of water quality non-compliance and the extent of water use conflicts. Frequency of reassessments are usually dependent on several factors, particularly the timing of remedial measures implementation.

The intensive element is designed to provide information for detailed assessments of nearshore water quality as well as providing for linkage with the main lake intensive element. This will permit detailed whole lake nearshore water quality assessments. The Surveillance Subcommittee has recommended that the nearshore sub-component of Lake Erie be studied intensively for two consecutive years on a nine-year recurring cycle beginning in 1978.

Water Quality Parameters

For the nearshore sub-component, the common parameter list (Herdendorf, 1978) will form the basis of parameter selection for both the annual and intensive elements. For problem area assessments, emphasis will be placed on those specific parameters in non-compliance with agreement objectives and/or jurisdictional criteria, standards, or guidelines. A summary of parameter selections and frequency of measurements for nearshore sampling locations is presented by Herdendorf (1978).

Station Locations

The concept of continuing review is a fundamental aspect of station location design. The review process includes: the critical evaluation of historical data as well as the assessment of available background information on mixing, dispersion and prevailing currents, lake meteorology, and bathymetry.

The following design criteria were used to effect a consistency in sample collection for all nearshore work in Lake Erie. These design criteria have evolved from experience in conducting nearshore studies.

1. Stations with historical long-term data bases are maintained for the continuance of trend evaluations.

2. Stations are located at or near significant point sources; significant tributaries; and past, potential, and/or existing problem areas to assess the extent of zones of influence.

3. Stations are located at or near selected municipal intakes in order to verify how representative intake sampling is of nearshore water quality.

4. The use of inshore/offshore transects perpendicular to shore is required to detect inshore/offshore water quality gradients. Stations along such transects are depth and/or distance related depending on local bathymetry, source influences, and local mixing. Transects are located near point sources, tributaries, problem areas, intakes, and extended from the main lake station grid.

5. The intensive element include those stations sampled during the annual element with additional stations added along those transects extended from the main lake station grid. Additional stations during the intensive year allow greater spatial resolution for intensive whole lake detailed assessments.

The general locations of the United States and Canadian stations are shown on Figure 1-3 and the detailed positions of the United States stations are shown on figures 4-23. The geographic coordinates and station selection rationale are given by state in Tables 1-4. Table 5 presents a description of the rationale codes for station selection.

Sampling Frequency and Depth

The general basis of sample frequency for all parameters is presented in the common parameter list (Herdendorf, 1978). The following design criteria are presented to allow for a more specific delineation of sample frequency.

The annual element will consist of three cruises per year scheduled for spring, summer, and fall. The intensive element will consist of four cruises per year including the three cruises mentioned above for the annual and an additional cruise scheduled for late summer prior to lake overturn and at the time of peak hypolimnion anoxia. The rationale for scheduling of cruises includes:

1. Spring cruises are designed primarily to detect the extent and impact of tributary loadings during annual high flow events.

2. Summer cruises are designed to measure peak summer productivity during maximum ambient light conditions and to measure public health indicators during peak periods of recreational water use.

3. Late summer cruises during the intensive element are designed to measure bottom oxygen and nutrients during the most critical time of the year for hypolimnion anoxia in the central basin of Lake Erie. Such measurements would be concommitant with main lake intensive surveys.

4. Fall cruises are designed primarily to measure the extent of bottom oxygen recovery as a result of vertical mixing and to measure the extent of nutrient regeneration from sediment.

For both the annual and intensive elements, sampling frequency will consist of three consecutive day runs per nearshore cruise. This frequency is required to provide increased accuracy of statistical evaluations made for the geographic grouping of data. The assessment of geographic groupings of data allows for the detection of problem area existence and/or emergence.

For annual and intensive nearshore work as well as problem areas, depth sampling is necessary at two depths per nearshore run per station, with a sample at 1.0 m from the surface and a sample at 1.0 m off bottom. Further consideration is also deemed necessary for three-to-five or more samples based on station location, station depth, time of sampling, water quality variable, and thermal structure. Such vertical sampling would be considered on a limited scale at selected water quality monitoring locations including those stations used for the verification of intake data and those stations located on transects extended from the main lake station grid.

Surveillance Design Summary

The annual element includes 302 stations (102 Canadian and 200 U.S.) and is designed to detect changes in water quality on a broad geographic basis, to provide information necessary for trend analysis, and identify emerging problems. These stations are shown on Figures 1-23. Parameter selections, summarized by Herdendorf (1978), include parameters from the common parameter list, parameters measured for the main lake annual program, and parameters identified as contributing to problem areas. The latter have been listed separately because of their importance to assess progress of existing remedial programs. Generally, parameters will be measured during each of three cruises scheduled for spring, summer, and fall. Each cruise consists of three, consecutive day runs. Metals, except those identified with a problem area, will be sampled only during the spring cruise. Where a controllable radioactivity source is located on the shore of a lake, the Radioactivity Subcommittee has recommended that the water should be sampled 1.0 meter below the surface at two points near the shoreline and at least two points in the lake proper at loci one kilometer from the source outfall. The selection of sampling points should allow for the sampling of at least one point likely to be in the plume at the time of sampling. The only active source discharging directly to Lake Erie is the Davis-Besse Nuclear Power Station in Ottawa County, Ohio. The proposed five monitoring locations are shown on Figure 6. Samples should be obtained monthly and composited for analysis on a quarterly basis.

A total of 401 stations (157 Canadian and 244 U.S.) have been selected for the intensive program. Station locations are shown on Figures 1-23. Herdendorf (1978) summarizes the parameter selection and measurement frequency. Station coverage and parameter selections for the intensive element include all those as included in the annual element plus additional stations, parameters, and frequencies to permit a more detailed assessment of nearshore water quality. Parameter selections include parameters from the common parameter list, parameters measured in the main lake intensive program, and parameters identified as contributing to problem areas as identified in Appendix B of the 1978 Annual Report. Sediment samples will be obtained at approximately one quarter of the stations in mid-April to complement those to be taken for the main lake sub-component. It is anticipated that data gathered, at least initially during the intensive years, will be sufficient to make detailed problem area assessments and provide information to facilitate problem area assessment designs in the future.

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TABLES

TABLE 1

LAKE ERIE NEARSHORE SURVEILLANCE STATIONS

MICHIGAN

Station No.	Longitude W	Latitude N	Rationale	Station Type: Intensive	Station Type: Annual and Intensive
M-1	83°11.5'	42°01.8'	EB, MT, NS, SG, WL		x
M-2	83°12.0'	42°01.0'	NS, SG, ST, TN, WL		x
M-3	83°10.5'	41°59.9'	CF, NB, NI, TN		x
M-4	83°14.6'	41°58.5'	DP, II, NB, NS, SG, TN		x
M-5	83°13.1'	41°58.2'	NI, TN	x	
M-6	83°11.7'	41°57.7'	CF, ND, TN		x
M-7	83°15.5'	41°56.5'	NB, NS, SG, TN		x
M-8	83°14.3'	41°56.2'	DS, IM, NI, PP, TN	x	
M-9	83°13.0'	41°55.8'	CF, ND, TM, TN		x
M-10	83°18.1'	41°56.4'	EB, NB, NS, ST		x
M-11	83°19.4'	41°55.4'	BR, HF, NS, SG, ST		x
M-12	83°19.9'	41°53.4'	DC, HA, MT, NS, TN		x
M-13	83°19.2'	41°53.2'	DC, NI, TN	x	
M-14	83°17.8'	41°52.8'	DC, NI, TN		x
M-15	83°16.4'	41°52.5'	DC, ND, TM, TN	x	
M-16	83°20.9'	41°52.4'	DP, HF, NS, SG, WL		x
M-17	83°22.7'	41°52.1'	EB, NB, NS, SG, ST		x
M-18	83°23.8'	41°50.7'	NB, NS, SG, ST, TN		x
M-19	83°22.2'	41°50.4'	CF, NI, TN	x	
M-20	83°20.8	41°50.0'	CF, NI, TN	x	
M-21	83°19.5'	41°49.7'	CF, ND, TN		x
M-22	83°24.5'	41°49.7'	BR, NB, NS, SG, ST, TN		x
M-23	83°26.2'	41°46.4'	BR, NB, NS, SG, TN		x
M-24	83°24.8'	41°47.1'	CF, NI, TN	x	
M-25	83°23.0'	41°47.9'	CF, ND, TN		x
M-26	83°25.5'	41°44.9'	BR, NB, NS, SG	x	
M-27	83°27.6'	41°44.6'	DC, EB, MT, NS, PP		x

TABLE 2

LAKE ERIE NEARSHORE SURVEILLANCE STATIONS

OHIO

Station No.	Longitude W	Latitude N	Rationale	Station Type	
				Intensive	Annual and Intensive
0-1	83°27.2'	41°44.0'	HF, NS, SG		X
0-2	83 28.0'	41°41.8'	DC, DP, DS, HA, II, MT, NS, PP, SG, TN		X
0-3	83°26.2'	41°42.7'	DC, HA, NI, PP, SG, TN		X
0-4	83°24.3'	41°43.5'	DC, NI, SG, TN		X
0-5	83°22.6'	41°44.3'	DC, NI, SG, TM, TN	X	
0-6	83°20.8'	41°45.2'	DC, ND, TM, TN		X
0-7	83°19.0'	41°46.0'	DC, ML, TM, TN	X	
0-8	83°26.0'	41°42.7'	DP, DS, HF, NS, PP, SG		X
0-9	83°22.6'	41°41.4'	BR, HF, NS, PP, SG, WL		X
0-10	83°20.5'	41°41.9'	BR, EB, NS, SG, WL	X	
0-11	83°18.4'	41°42.5'	CF, NB, NI, SG		X
0-12	83°16.7'	41°41.1'	EB, NB, NS, SG, TN, WL		X
0-13	83°15.5'	41°42.0'	CF, IM, ND, SG, TM, TN		X
0-14	83°13.2'	41°38.7'	BR, EB, NB, NS, SG, ST, WL		X
0-15	83°06.2'	41°36.9'	BR, CF, NB, NS, SG, ST		X
0-16	83°04.6'	41°36.2'	DP, NB, NS, SG, TN, WL		X
0-17	83°04.1'	41°36.4'	II, NI, SG, TM, TN	X	
0-18	83°03.6'	41°36.7'	CF, II, NI, SG, TM, TN		X
0-19	83°03.0'	41°37.1'	CF, ND, SG, TM, TN	X	
0-20	83°02.4'	41°37.4'	CF, ML, SG, TM, TN		X
0-21	83°03.6'	41°35.2'	CF, DS, MT, NS, SG, WL		X
0-22	82°57.5'	41°31.4'	BR, HF, NS, SG, WL		X
0-23	82°56.4'	41°31.4'	BR, DC, DS, HA, IM, MT, NS, SG, TN		X
0-24	82°56.1	41°32.3'	CF, NI, SG, TM, TN		X
0-25	82°56.0'	41°34.5'	CF. ML. SG. TM. TN		X

TABLE 2 CON'T.

LAKE ERIE NEARSHORE SURVEILLANCE STATIONS

OHIO

Station No.	Longitude W.	Latitude N.	Rationale	Station Type	
				Intensive	Annual and Intensive
0-26	82°54.7'	41°31.2'	BR, HF, NS, SG, WL		X
0-27	82°47.8'	41°33.4'	BR, IM, NB, NS, SG, TN, WL		X
0-28	82°45.6'	41°34.8'	CF, ND, SG, TN		X
0-29	82°57.9'	41°27.7'	DS, EB, MT, NS, PP, SG, WL		X
0-30	82°55.9'	41°25.4'	DP, EB, II, NS, SG, ST, WL	X	
0-31	82°53.0'	41°28.0'	CF, EB, NI, SG		X
0-32	82°48.6'	41°29.0'	CF, EB, NI, SG		X
0-33	82°46.0'	41°27.0'	CF, EB, HF, NS, ST	X	
0-34	82°44.4'	41°27.2'	BR, DP, DS, EB, HA, NS, PP, ST		X
0-35	82°44.3'	41°28.5'	EB, HA, NI, SG		X
0-36	82°42.2'	41°32.0'	CF, NB, NS, SG		X
0-37	82°41.8'	41°29.5'	EB, DC, HA, ND, TN		X
0-38	82°40.5'	41°30.0'	CF, DC, ND, TN	X	
0-39	82°38.6'	41°30.8'	CF, ML, TM, TN		X
0-40	82°38.6'	41°27.8'	BR, CF, IM, NB, NI		X
0-41	82°35.1'	41°24.7'	BR, HF, NS, TN		X
0-42	82°35.1'	41°25.6'	CF, NI, TN	X	
0-43	82°33.4'	41°24.3'	HF, IM, NI, ST		X
0-44	82°32.9'	41°24.0'	DC, DS, HA, MT, NS, PP, TN		X
0-45	82°32.2'	41°24.5'	HF, NI, TN		X
0-46	82°32.2'	41°25.5'	CF, ND, TN	X	
0-47	82°32.2'	41°25.6'	CF, ML, TN		X
0-48	82°30.7'	41°23.1'	BR, NB, NS, SG, ST, TN, WL		X
0-49	82°30.7'	41°24.5'	NI, TM, TN	X	
0-50	82°30.7'	41°25.6'	CF, ND, TM, TN	X	

TABLE 2 CON'T.

LAKE ERIE NEARSHORE SURVEILLANCE STATIONS

OHIO

Station No.	Longitude W	Latitude N	Rationale	Station Type: Intensive	Station Type: Annual and Intensive
0-51	82°24.0'	41°24.8'	BR, HF, NS, ST, TN		X
0-52	82°24.0'	41°27.3'	CF, ND, TN	X	
0-53	82°22.2'	41°25.7'	BR, HF, IM, NI		X
0-54	82°21.9'	41°25.7'	DC, DS, HA, MT, NS. PP, TN		X
0-55	82°21.9'	41°26.2'	NI, TN		X
0-56	82°21.1'	41°26.8'	NI, TN	X	
0-57	82°21.1'	41°27.3'	ND, TM, TN		X
0-58	82°19.8'	41°25.8'	BR, HF, NS, TN		X
0-59	82°19.8'	41°27.3'	ND, TN	X	
0-60	82°14.1'	41°26.7'	BR, NB, NS, TN		X
0-61	82°14.1'	41°29.8'	NI, TN	X	
0-62	82°14.1'	41°28.2'	ND, TN	X	
0-63	82°13.2'	41°27.4'	HF, IM, NI		X
0-64	82°11.7'	41°28.4'	HF, IM, NI		X
0-65	82°11.0'	41°28.4'	DC, DS, HA, NS, TN		X
0-66	82°11.2'	41°28.7'	DC, DP, HA, NI, TN		X
0-67	82°11.2'	41°29.8'	ND, TM, TN		X
0-68	82°08.3'	41°28.0'	HF, NS, TN		X
0-69	82°08.3'	41°29.8'	ND, TN	X	
0-70	82°00.0'	41°31.1'	NB, NS		X
0-71	81°54.1'	41°29.2'	HF, NS, TN		X
0-72	81°53.0'	41°31.2'	IM, NI, TN		X
0-73	81°54.1'	41°32.9'	NI, TN	X	
0-74	81°54.1'	41°35.1'	ND, TM, TN		X
0-75	81°50.4'	41°29.5'	DC, HA, MT, NS, PP, TN		X

TABLE 2 CON'T.

LAKE ERIE NEARSHORE SURVEILLANCE STATIONS

OHIO

Station No.	Longitude W	Latitude N	Rationale	Station Type: Intensive	Station Type: Annual and Intensive
0-76	$81^{\circ}50.4'$	$41^{\circ}29.7'$	DC, HA, NI, TN		X
0-77	$81^{\circ}49.7'$	$41^{\circ}30.8'$	NI, TN	X	
0-78	$81^{\circ}49.7'$	$41^{\circ}31.9'$	ND, TN		X
0-79	$81^{\circ}45.4'$	$41^{\circ}29.5'$	RB, HF, NS, TN	X	
0-80	$81^{\circ}45.4'$	$41^{\circ}29.8'$	HF, NI, TN	X	
0-81	$81^{\circ}45.4'$	$41^{\circ}30.8'$	ND, TN	X	
0-82	$81^{\circ}45.8'$	$41^{\circ}32.8'$	IM, ML, TM, TN		X
0-83	$81^{\circ}45.0'$	$41^{\circ}32.9'$	IM, ML, TM, TN		X
0-84	$81^{\circ}43.4'$	$41^{\circ}29.9'$	DS, HA, NS, PP		X
0-85	$81^{\circ}42.7'$	$41^{\circ}30.3'$	DC, DP, HA, MT, NS, PP, TN		X
0-86	$81^{\circ}43.0'$	$41^{\circ}30.6'$	DC, HA, NI, TN		X
0-87	$81^{\circ}41.6'$	$41^{\circ}31.0'$	DC, HA, NS, PP, TN		X
0-88	$81^{\circ}42.7'$	$41^{\circ}31.5'$	ND, TM, TN		X
0-89	$81^{\circ}43.9'$	$41^{\circ}32.0'$	ND, TM, TN		X
0-90	$81^{\circ}40.5'$	$41^{\circ}31.6'$	DC, HA, NS, PP		X
0-91	$81^{\circ}39.3'$	$41^{\circ}32.2'$	DC, DP, HA, NS, PP		X
0-92	$81^{\circ}40.5'$	$41^{\circ}32.7'$	ND, TN		X
0-93	$81^{\circ}41.6'$	$41^{\circ}33.2'$	ND, TN		X
0-94	$81^{\circ}36.9'$	$41^{\circ}33.1'$	HF, NS, TN		X
0-95	$81^{\circ}36.9'$	$41^{\circ}33.5'$	HF, NI, TN		X
0-96	$81^{\circ}38.1'$	$41^{\circ}33.9'$	ND, TN	X	
0-97	$81^{\circ}39.3'$	$41^{\circ}34.4'$	ND, TN	X	
0-98	$81^{\circ}34.0'$	$41^{\circ}35.3'$	DS, NB, NS, ST, TN		X
0-99	$81^{\circ}34.6'$	$41^{\circ}35.7'$	NI, TN		X
0-100	$81^{\circ}35.8'$	$41^{\circ}36.2'$	ND, TN		X

TABLE 2 CON'T.

LAKE ERIE NEARSHORE SURVEILLANCE STATIONS

OHIO

Station No.	Longitude W	Latitude N	Rationale	Station Type	
				Intensive	Annual and Intensive
0-101	81°37.0'	41°37.1'	IM, ML, TN		X
0-102	81°33.4'	41°37.4'	NB, NI		X
0-103	81°27.1'	41°39.9'	BR, NB, NS		X
0-104	81°26.5'	41°40.5'	DP, NS, TN		X
0-105	81°26.2'	41°40.7'	BR, DC, HA, MT, NS, WL		X
0-106	81°27.1'	41°41.5'	NI, TM, TN	X	
0-107	81°28.1'	41°42.3'	ND, TN		X
0-108	81°25.1'	41°41.3'	NB, NS		X
0-109	81°18.3'	41°45.0'	BR, HF, NS, TN		X
0-110	81°17.9'	41°45.4'	HF, IM, NI, TN		X
0-111	81°18.2'	41°46.1'	HF, NI, TN	X	
0-112	81°18.3'	41°47.2'	CF, ND, TN	X	
0-113	81°16.8'	41°45.7'	DC, DS, HA, MT, NS, PP, TN		X
0-114	81°16.8'	41°46.1'	DC, DP, HA, NI, TN		X
0-115	81°16.8'	41°46.6'	ND, TN	X	
0-116	81°16.8'	41°47.2'	ND, TM, TN		X
0-117	81°16.1'	41°45.7'	DC, HA, NI, PP		X
0-118	81°15.4'	41°46.1'	HF,NI	X	
0-119	81°19.0'	41°46.1'	HF, NS, TN		X
0-120	81°19.0'	41°47.2'	ND, TM, TN		X
0-121	81°09.6'	41°48.1'	DP, II, NB,		X
0-122	81°04.6'	41°50.0'	IM, NB, NS		X
0-123	81°00.5'	41°51.2'	NS, ST, TN		X
0-124	81°00.5'	41°52.2'	NI, TN	X	
0-125	81°00.5'	41°53.3'	ND, TN		X

TABLE 2 CON'T.

LAKE ERIE NEARSHORE SURVEILLANCE STATIONS

OHIO

Station No.	Longitude W	Latitude N	Rationale	Station Type	
				Intensive	Annual and Intensive
0-126	$80^{0}58.2'$	$41^{0}51.6'$	BR, NB, NS, ST		X
0-127	$80^{0}52.8'$	$41^{0}52.4'$	NB, NS		X
0-128	$80^{0}49.0'$	$41^{0}53.9'$	BR, HF, NS, TN		X
0-129	$80^{0}48.6'$	$41^{0}54.5'$	HE, IM, NI, TN		X
0-130	$80^{0}49.0'$	$41^{0}55.2'$	HF, NI, TN	X	
0-131	$80^{0}49.0'$	$41^{0}56.3'$	ND, TN	X	
0-132	$80^{0}47.9'$	$41^{0}54.6'$	DC, DS, HA, MT, NS, PP, TN		X
0-133	$80^{0}47.6'$	$41^{0}55.2'$	DC, HA, NI, TN		X
0-134	$80^{0}47.6'$	$41^{0}55.7'$	ND, TN	X	
0-135	$80^{0}47.6'$	$41^{0}56.7'$	ML, TM, TN		X
0-136	$80^{0}46.0'$	$41^{0}54.8'$	DP, HF, NS		X
0-137	$80^{0}44.7'$	$41^{0}55.2'$	NB, NS, TN		X
0-138	$80^{0}44.7'$	$41^{0}56.7'$	ND, TN	X	
0-139	$80^{0}41.0'$	$41^{0}56.4'$	NB, NS		X
0-140	$80^{0}37.2'$	$41^{0}57.6'$	BR, HF, NS, TN		X
0-141	$80^{0}34.6'$	$41^{0}58.0'$	HF, MI, NI, TN		X
0-142	$80^{0}37.2'$	$41^{0}58.8'$	NI, TN	X	
0-143	$80^{0}37.2'$	$41^{0}59.8'$	ND, TN	X	
0-144	$80^{0}33.0'$	$41^{0}58.4'$	DC, DS, HA, MT		X
0-145	$80^{0}33.4'$	$41^{0}58.8'$	NI, TN		X
0-146	$80^{0}33.4'$	$41^{0}59.3'$	ND; TN	X	
0-147	$80^{0}33.4'$	$41^{0}59.8'$	ML, TM, TN		X
0-148	$80^{0}32.0'$	$41^{0}58.5'$	HF, DP, II, NS, ST		X

TABLE 3

LAKE ERIE NEARSHORE SURVEILLANCE STATIONS

PENNSYLVANIA

Station No.	Longitude W	Latitude N	Rationale	Station Type: Intensive	Station Type: Annual and Intensive
P-1	80°30.5'	41°58.9'	NB, NS, ST, TN		X
P-2	80°30.5'	41°59.3'	NB, NI, TN		X
P-3	80°30.5'	41°59.9'	ND, TN		X
P-4	80°29.0'	41°59.6'	NB, NS, ST		X
P-5	80°26.4'	42°00.4'	NB, NS, ST, TN		X
P-6	80°26.7'	42°01.4'	NB, NI, TN	X	
P-7	80°27.0'	42°02.3'	NB, ND, TN		X
P-8	80°22.3'	42°01.7'	NB, NS, SG, ST, TN		X
P-9	80°22.3'	42°02.2'	NB, NI, ST, TN		X
P-10	80°16.4'	42°03.7'	NB, NS, ST		X
P-11	80°14.3'	42°04.8'	NB, NS, ST, TN		X
P-12	80°14.3'	42°05.2'	NB, NI, TN		X
P-13	80°12.8'	42°05.1'	NB, NS, TN		X
P-14	80°12.8'	42°11.4'	CF, ND, TM, TN		X
P-15	80°10.2'	42°07.9'	BR, IM, NI, TN		X
P-16	80°09.2'	42°09.4'	BR, IM, NI, TN		X
P-17	80°07.1'	42°10.0'	BR, NS, TN		X
P-18	80°07.1'	42°11.4'	CF, ND, TN		X
P-19	80°08.1'	42°07.5'	DP, EE, NS		X
P-20	80°07.1'	42°08.5'	EE, NI, WL	X	
P-21	80°05.6'	42°08.5'	DC, DS, EE, HA, NS, PP		X
P-22	80°04.1'	42°09.3'	DC, HA, NS, PP		X
P-23	80°04.1'	42°10.3'	BR, HF, NS, TN	X	
P-24	80°04.1'	42°13.5'	CF, ML, TM, TN	X	
P-25	80°03.0'	42°09.5'	HF, II, NI		X
P-26	80°01.3'	42°09.8'	HF, NS	X	
P-27	79°58.3'	42°11.5'	NB, NS, ST, TN		X
P-28	79°58.3'	42°13.6'	ND, TN		X
P-29	79°50.0'	42°14.7'	NB, NS, ST		X

TABLE 4

LAKE ERIE NEARSHORE SURVEILLANCE STATIONS

NEW YORK

Station No.	Longitude W	Latitude N	Rationale	Station Type	
				Intensive	Annual and Intensive
N-1	79°47.0'	42°16.1'	NB, NS, ST		X
N-2	79°42.3'	42°17.7'	NB, NS, ST		X
N-3	79°36.5'	42°20.3'	HF, NS, ST		X
N-4	79°35.8'	42°20.8'	DC, HA, NS, ST, TN		X
N-5	79°35.8'	42°21.4'	NI, TN	X	
N-6	79°35.8'	42°22.5'	ND, TM, TN		X
N-7	79°33.6'	42°21.7'	BR, HF, NS		X
N-8	79°26.3'	42°25.6'	NB, NS, ST		X
N-9	79°25.9'	45°26.0'	BR, NB, NS, ST		X
N-10	79°22.1'	42°28.7'	HF, NS, ST		X
N-11	79°20.9'	42°29.7'	DC, DP, HA, II, NS, TN		X
N-12	79°20.9'	42°30.7'	ND, TM, TN		X
N-13	79°20.2'	42°29.6'	HA, NS, PP		X
N-14	79°18.5'	42°30.4'	HF, NS		X
N-15	79°14.7'	42°32.1'	NB, NS, ST		X
N-16	79°11.7'	42°32.8'	NB, NS		X
N-17	79°10.3'	42°33.1'	HA, NS, ST, TN		X
N-18	79°10.3'	42°33.6'	NI, TN	X	
N.19	79°10.3'	42°34.1'	ND, TM, TN		X
N-20	79°08.2'	42°34.2'	BR, MT, NS, TN		X
N-21	79°08.8'	42°34.1'	NI, TN		X
N-22	79°07.0'	42°36.4'	NB, NS		X
N-23	79°02.9'	42°41.6'	NB, NS, ST		X
N-24	78°59.0'	42°42.6'	NB, NS		X
N-25	78°58.1'	42°43.3'	NS, ST, TN		X

TABLE 4 CON'T.

LAKE ERIE NEARSHORE SURVEILLANCE STATIONS

NEW YORK

Station No.	Longitude W	Latitude N	Rationale	Station Type	
				Intensive	Annual and Intensive
N-26	78°58.1'	42°44.3'	NI, TN	X	
N-27	78°58.1'	42°45.3'	ND, TM, TN		X
N-28	78°56.9'	42°43.9'	NB, NS		X
N-29	78°52.5'	42°46.0'	NB, NS		X
N-30	78°51.4'	42°47.5'	NB, NS, ST		X
N-31	78°52.0'	42°48.6'	HF, NS, ST, TN		X
N-32	78°52.4'	42°48.3'	NI, TN	X	
N-33	78°53.6'	42°47.9'	ND, TM, TN		X
N-34	78°52.2'	42°50.7'	DC, HA, NS, TN		X
N-35	78°52.4'	42°50.3'	DC, HA, NI, TN		X
N-36	78°53.4'	42°50.2'	ND, TN	X	
N-37	78°54.8'	42°49.8'	ML, TM, TN		X
N-38	78°53.3'	42°52.7'	DC, DP, HA, MT, NS, TN		X
N-39	78°54.3'	42°53.5'	HF, NI		X
N-40	78°54.7'	42°52.8'	IM, ML, TN		X

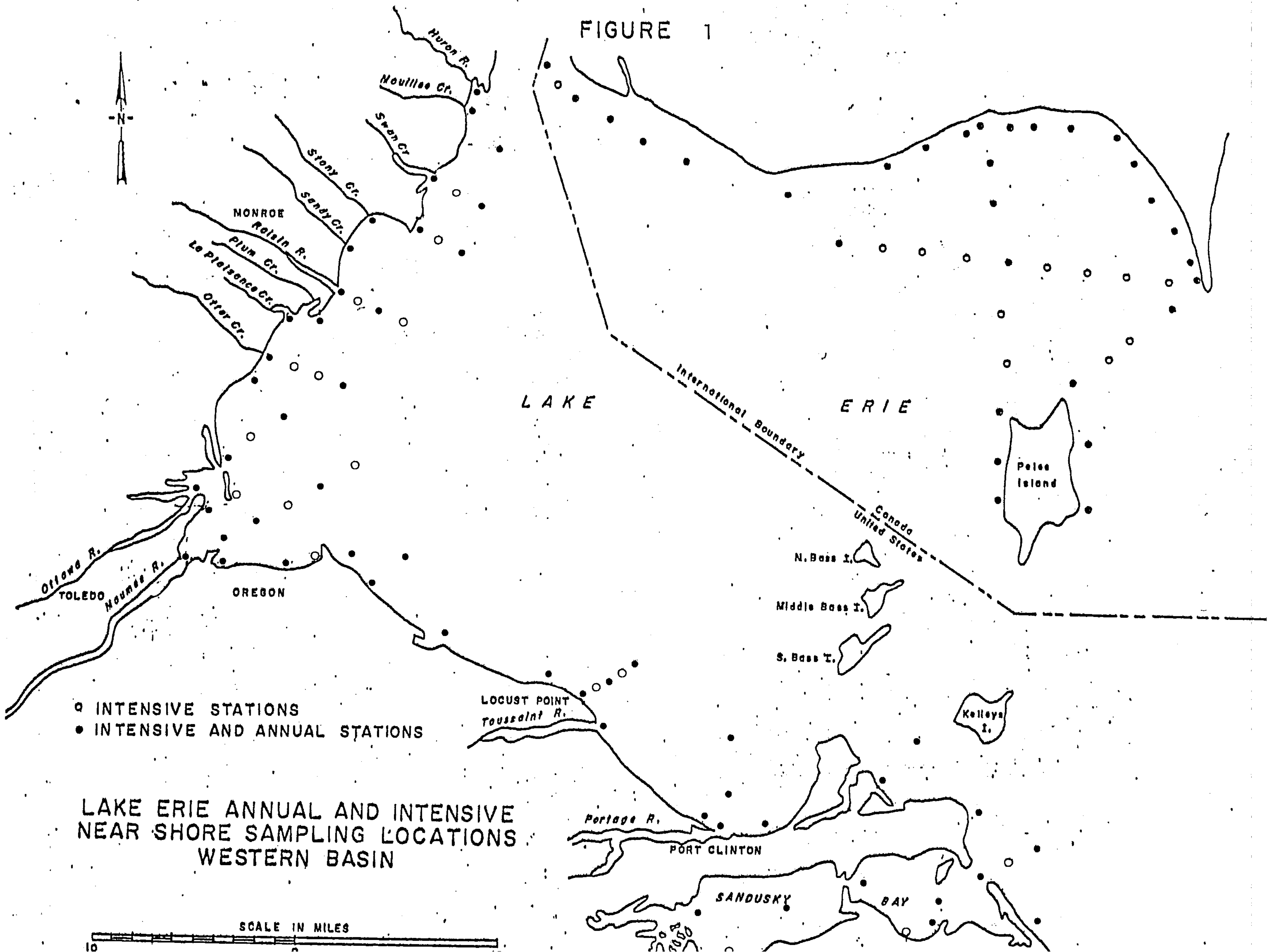
TABLE 5

RATIONALE CODE

CODE	RATIONALE
BR	beach, recreational
CF	commercial fishing grounds
DC	dredged channel
DP	discharge, power plant or industrial
DS	discharge, sewage treatment plant
EB	embayment
HA	harbor area
HF	harbor flanks
II	intake, industrial
IM	intake, municipal
ML	offshore or main lake
MT	major tributary mouth
NB	nearshore, between major harbor areas
ND	nearshore, deep or outer position
NI	nearshore, intermediate depth
NS	nearshore, shallow or inner position
PP	known pollution problems
SG	spawning grounds
ST	small tributary mouth
TM	transect, main lake connection
TN	transect, nearshore
WL	wetlands

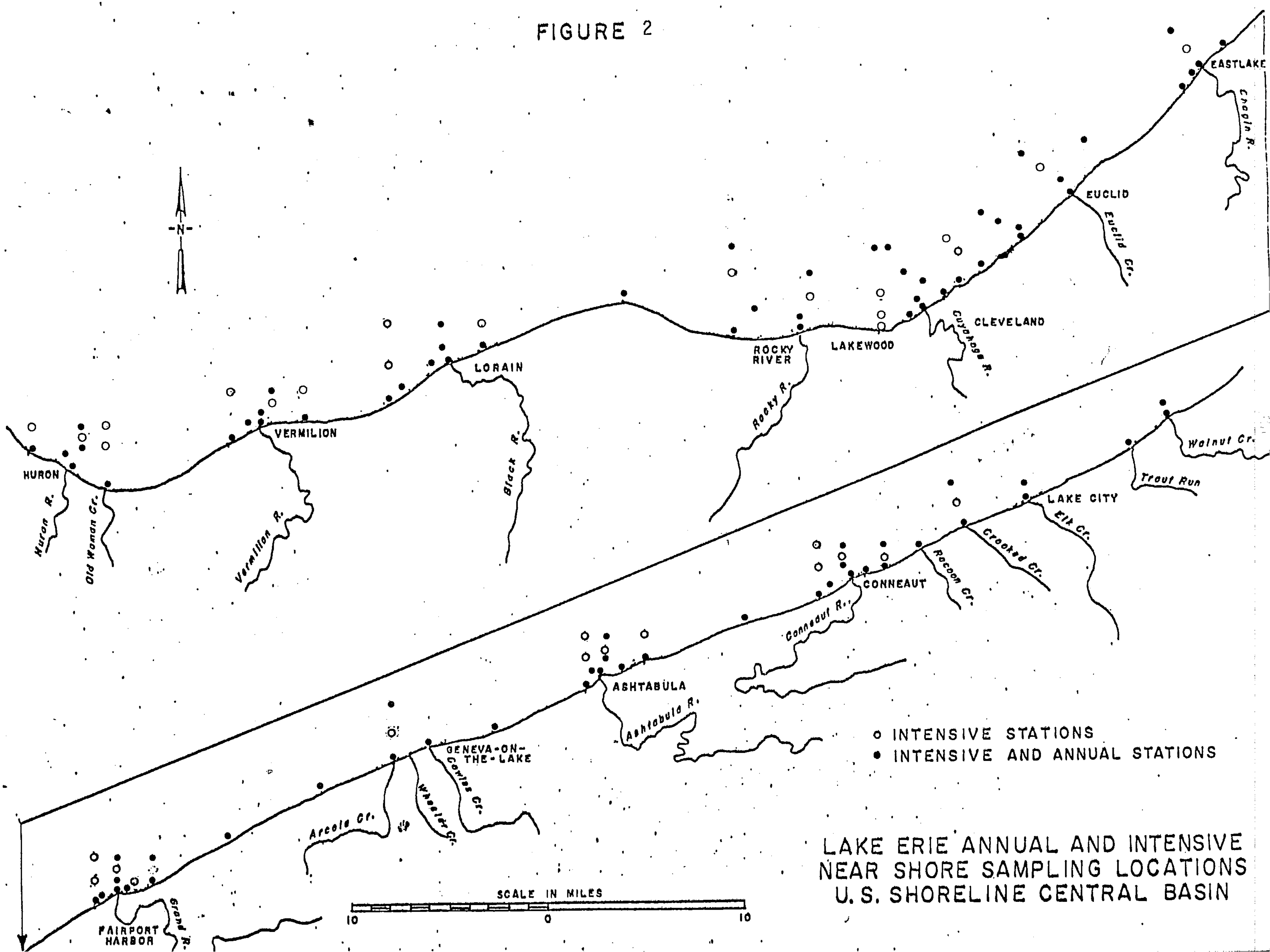
F I G U R E S

FIGURE 1



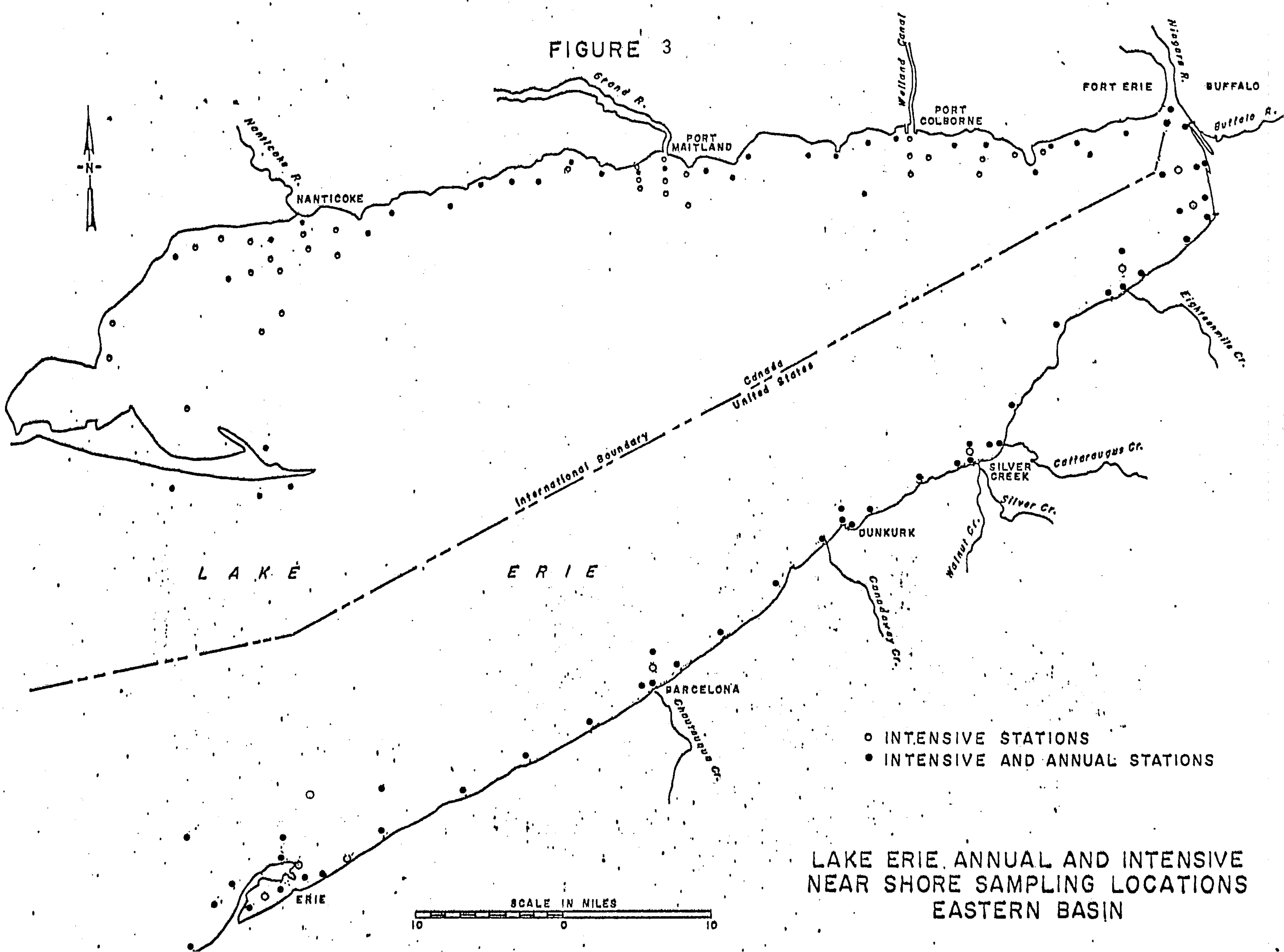
LAKE ERIE ANNUAL AND INTENSIVE NEAR SHORE SAMPLING LOCATIONS WESTERN BASIN

FIGURE 2



LAKE ERIE ANNUAL AND INTENSIVE NEAR SHORE SAMPLING LOCATIONS U.S. SHORELINE CENTRAL BASIN

FIGURE 3



LAKE ERIE ANNUAL AND INTENSIVE NEAR SHORE SAMPLING LOCATIONS EASTERN BASIN

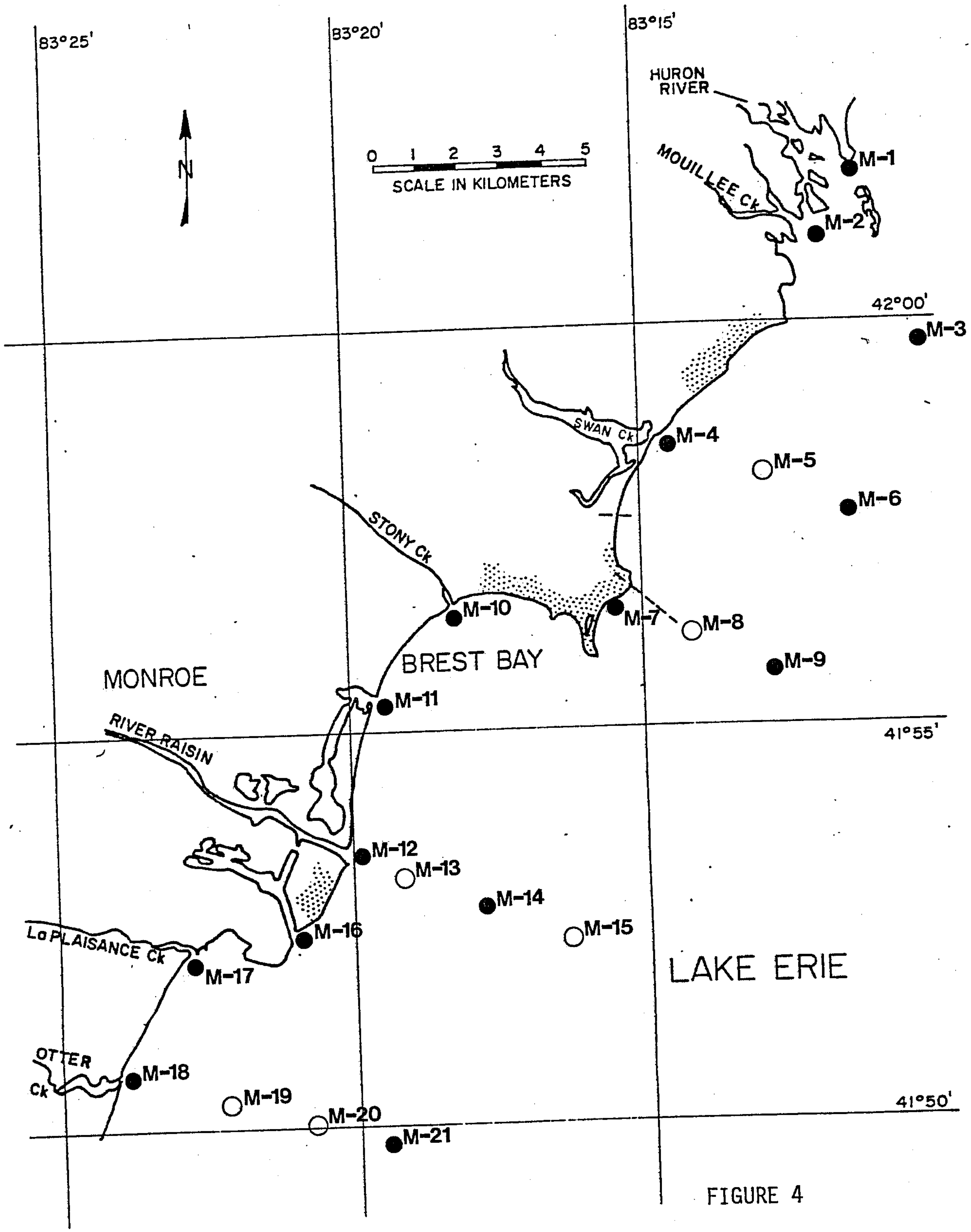


FIGURE 4

Station Locations M-1 to M-21

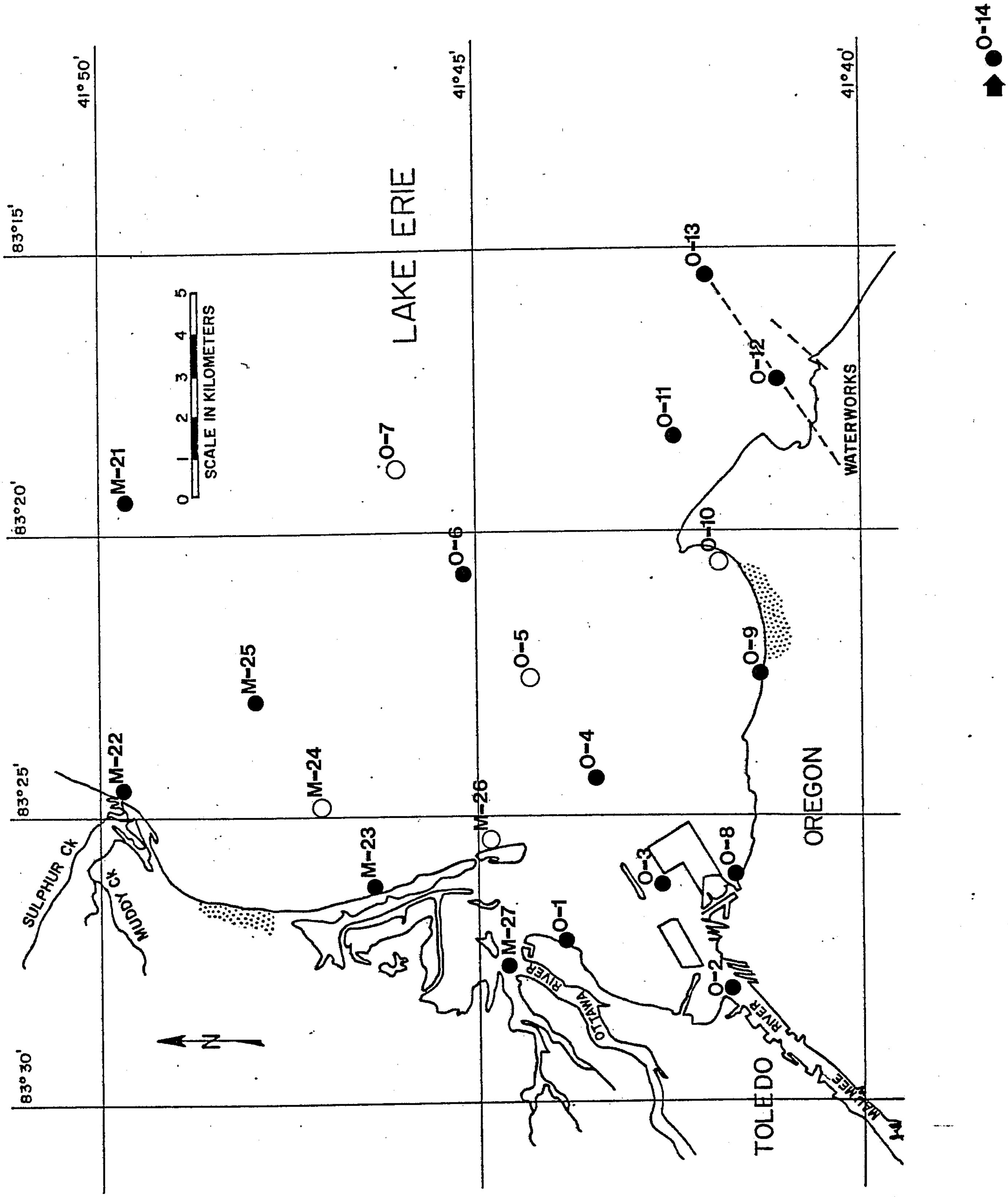


FIGURE 5

Station Locations M-21 to M-27 and O-1 to O-14

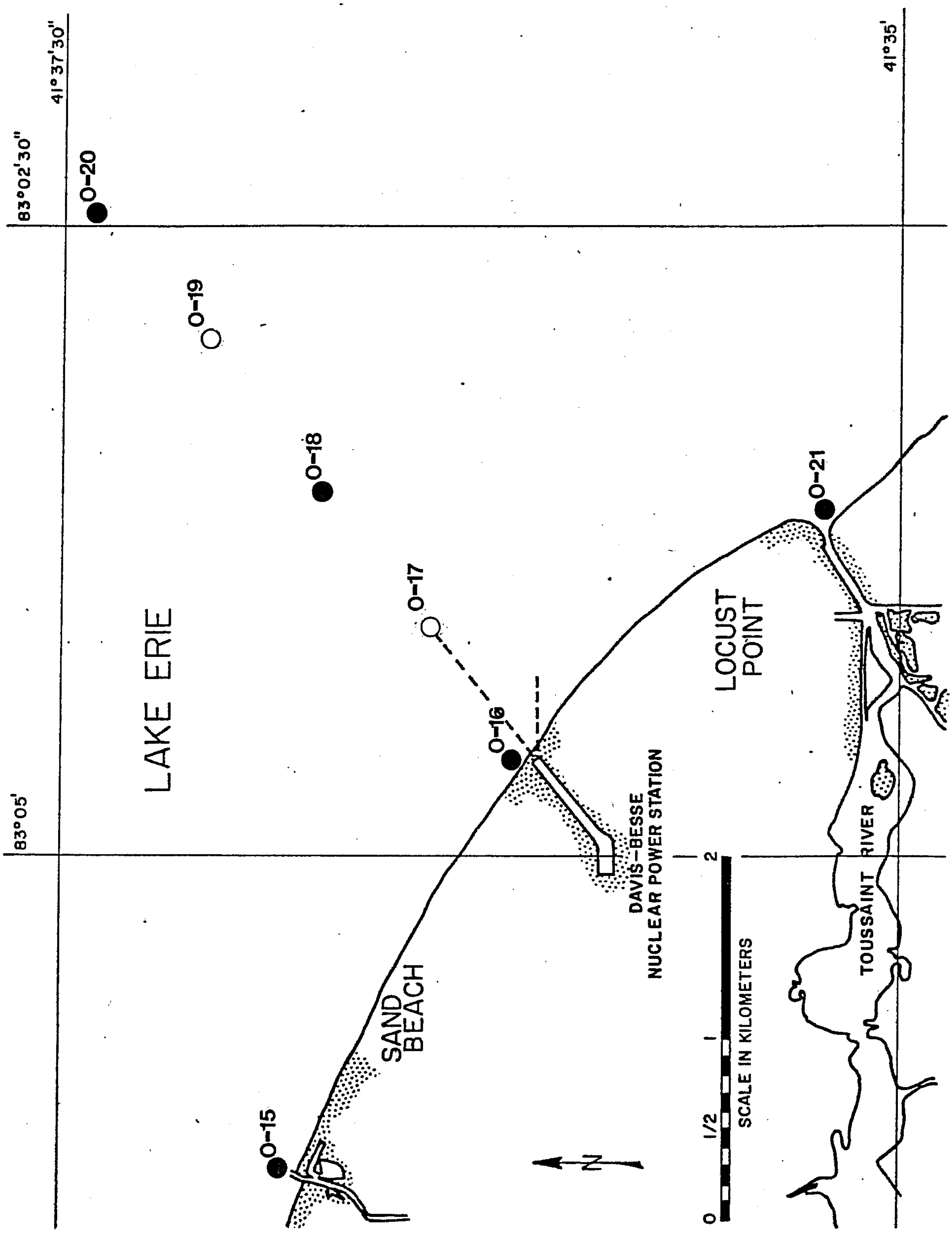


FIGURE 6

Station Locations 0-15 to 0-21

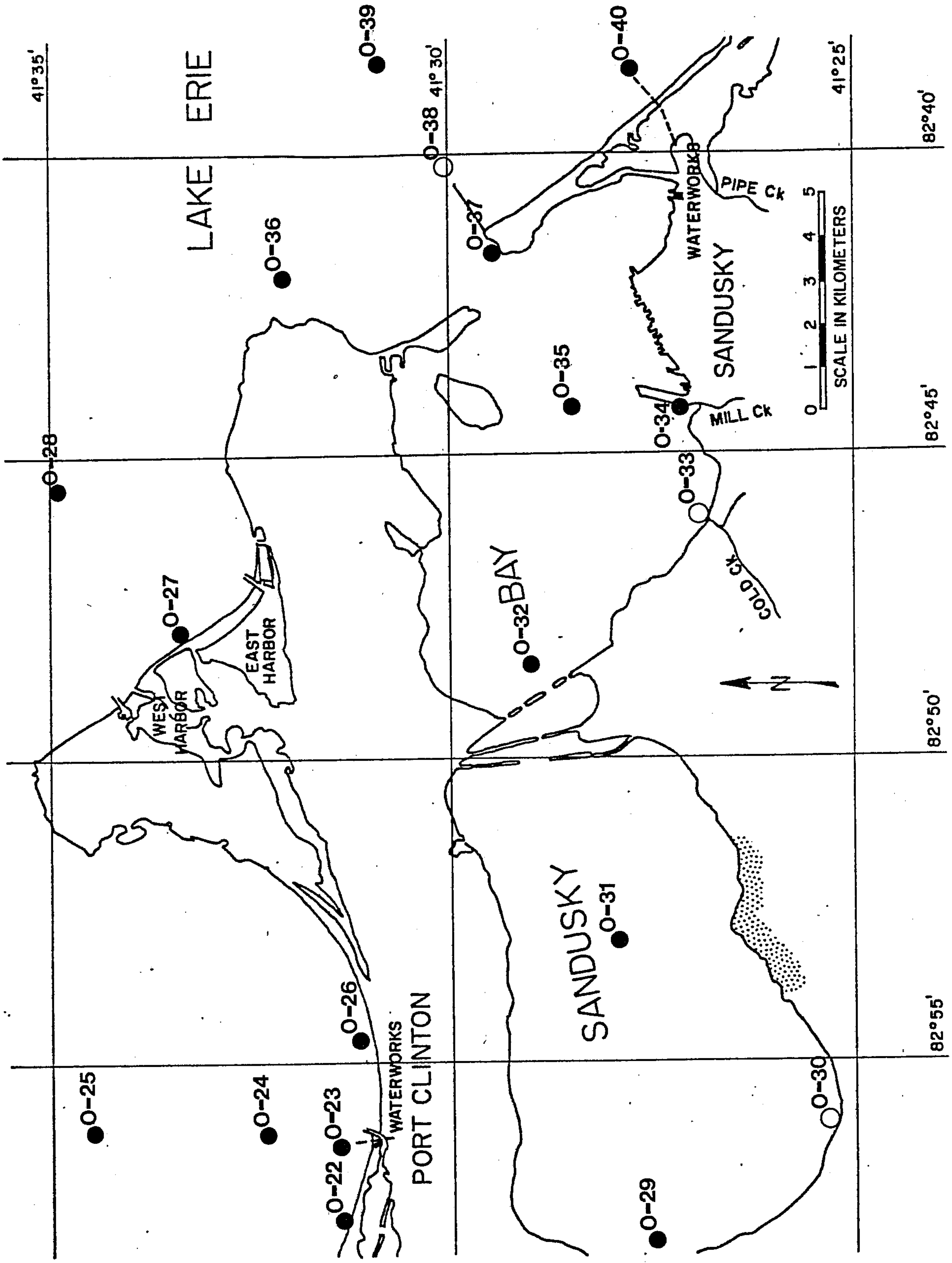


FIGURE 7

Station Locations 0-22 to 0-40

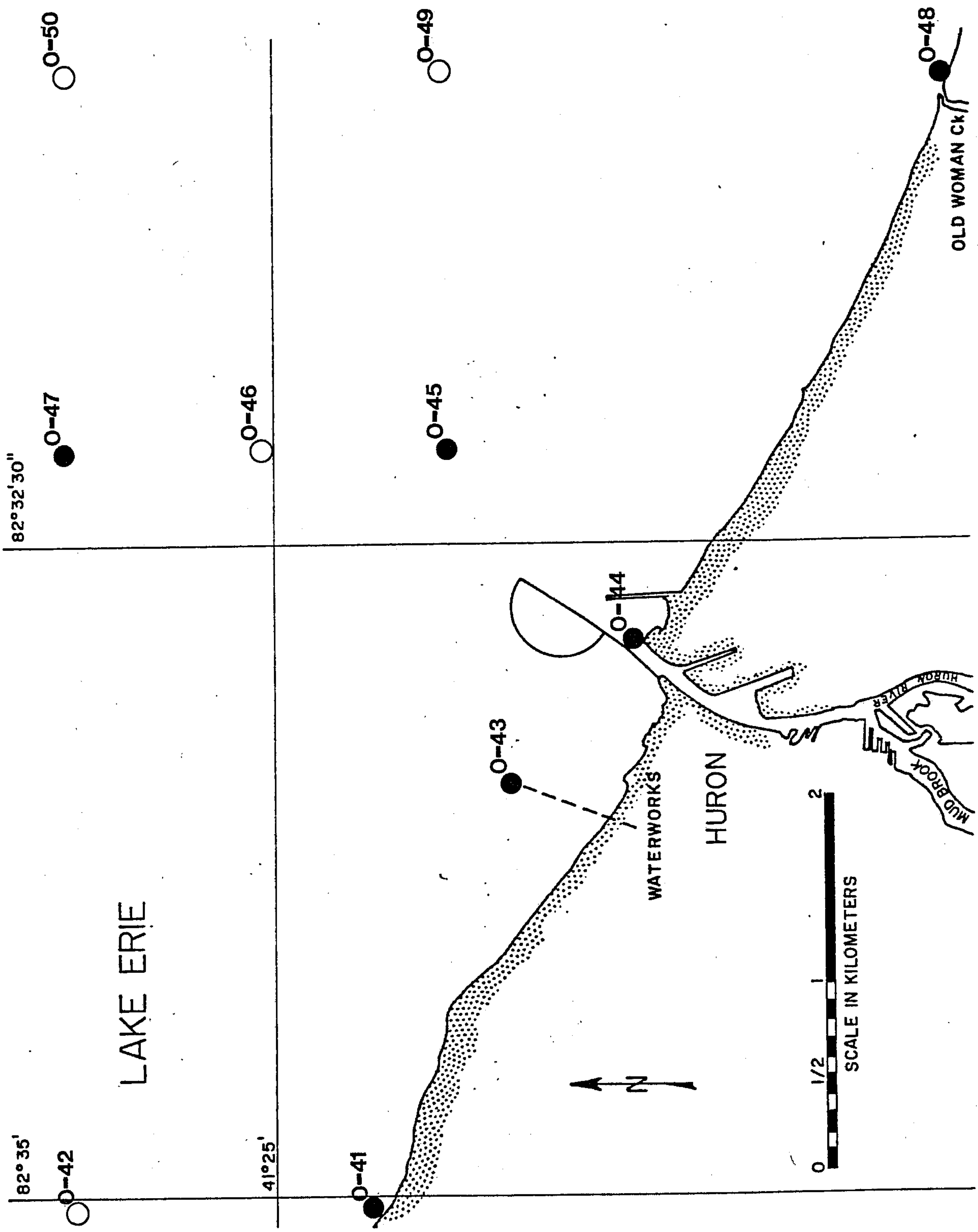


FIGURE 8

Station Locations 0-42 to 0-50

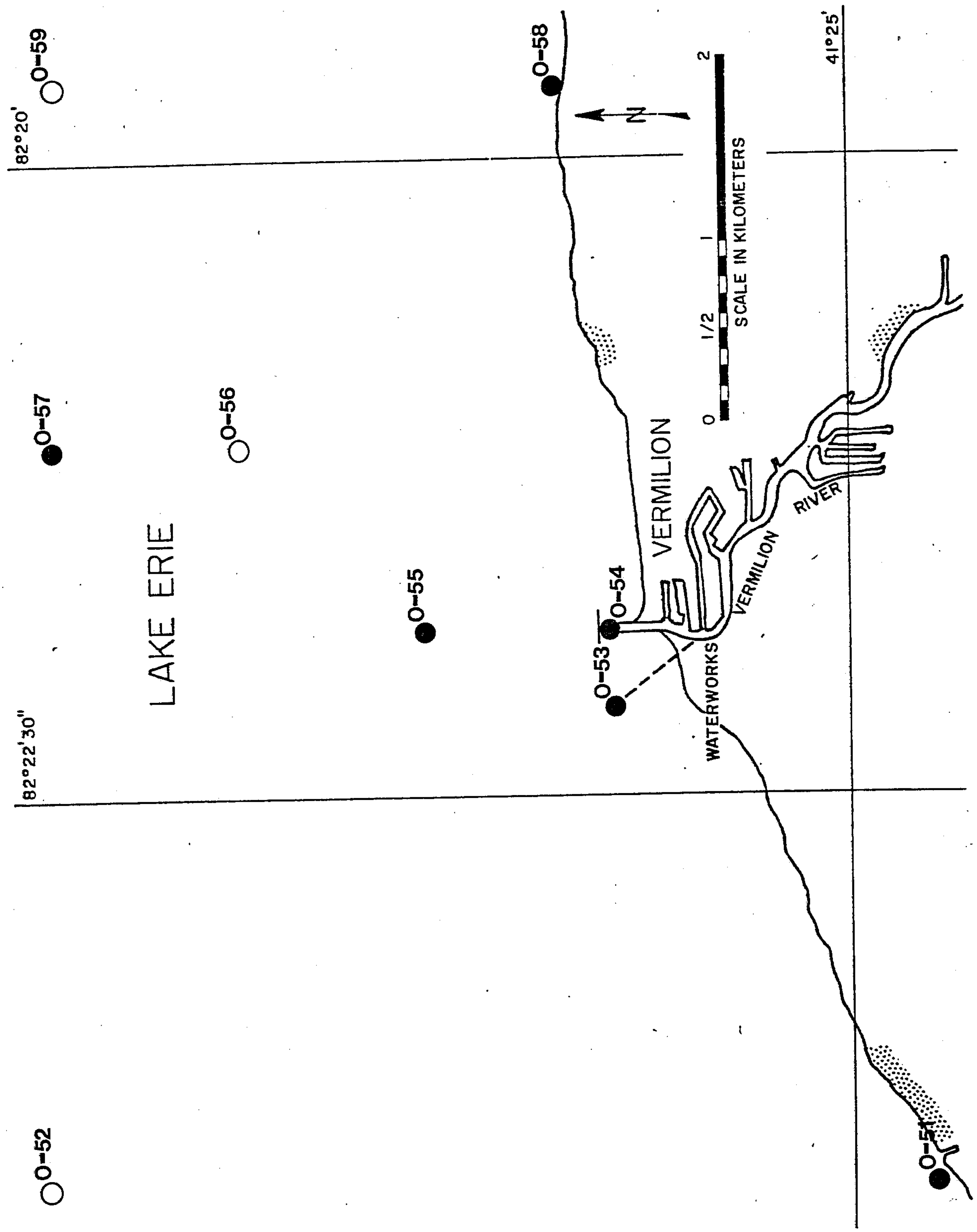


FIGURE 9

Station Locations O-51 to O-59

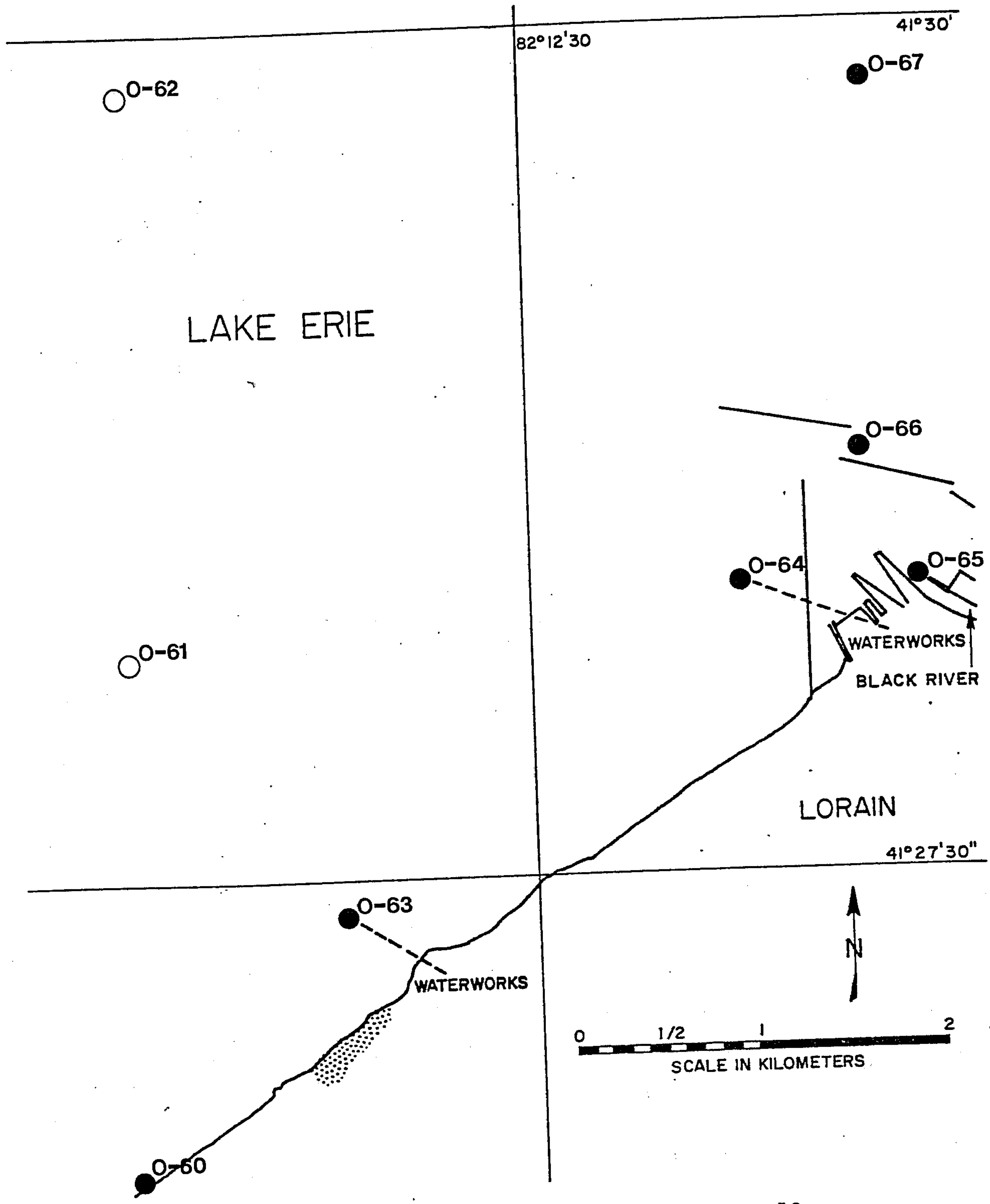


FIGURE 10

Station Locations O-60 to O-67

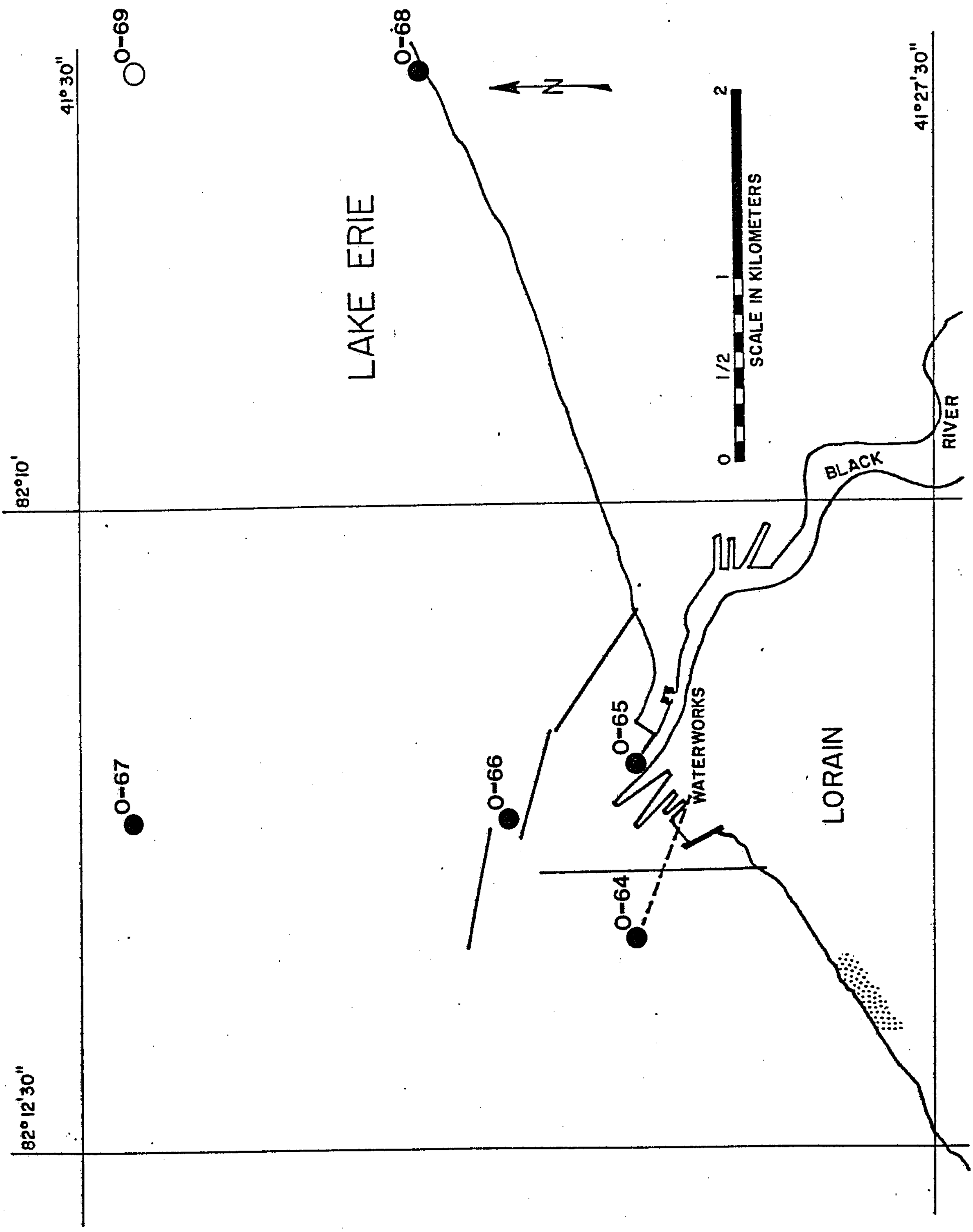


FIGURE 11

Station Locations 0-64 to 0-69

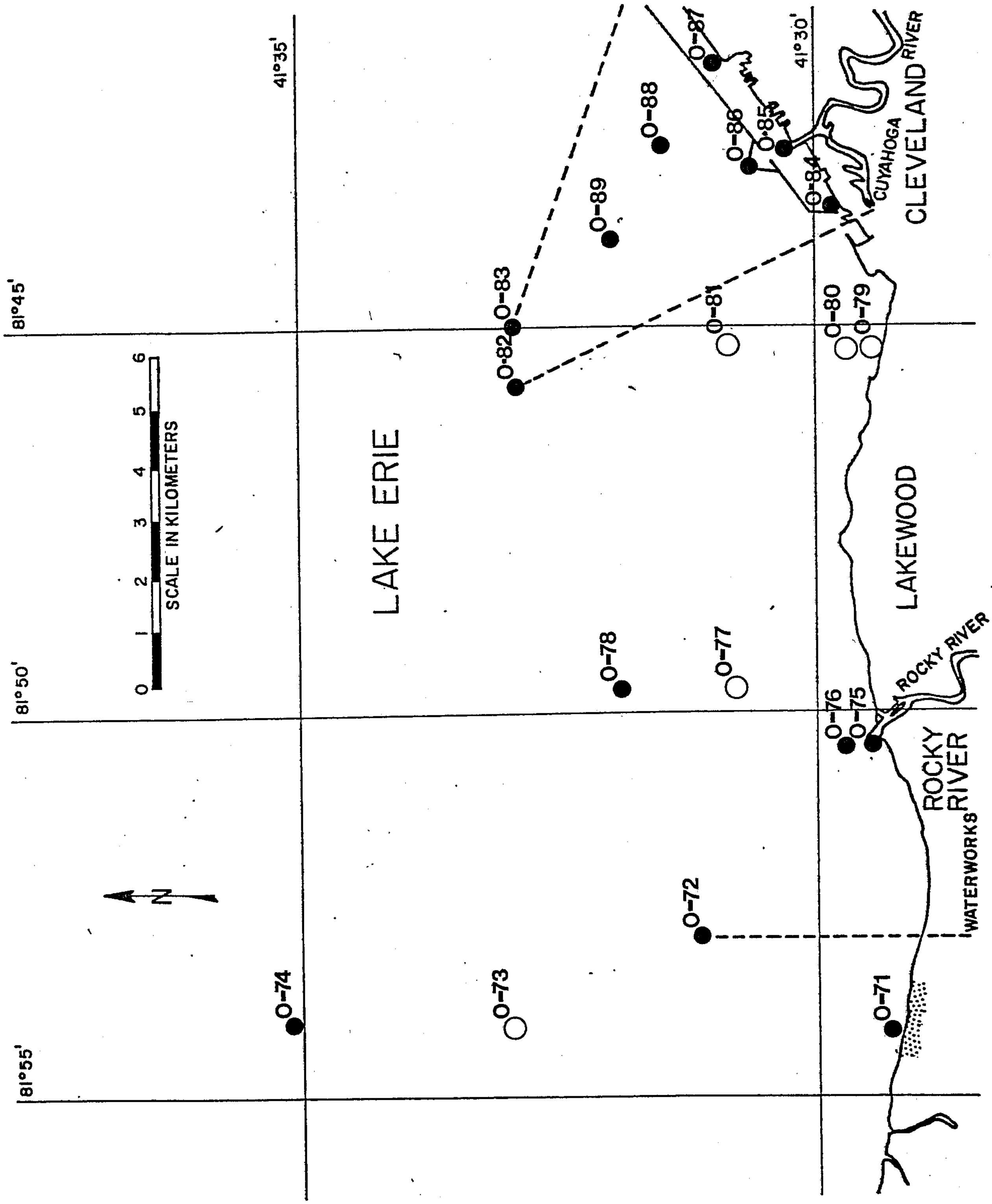


FIGURE 12

Station Locations O-70 to O-87

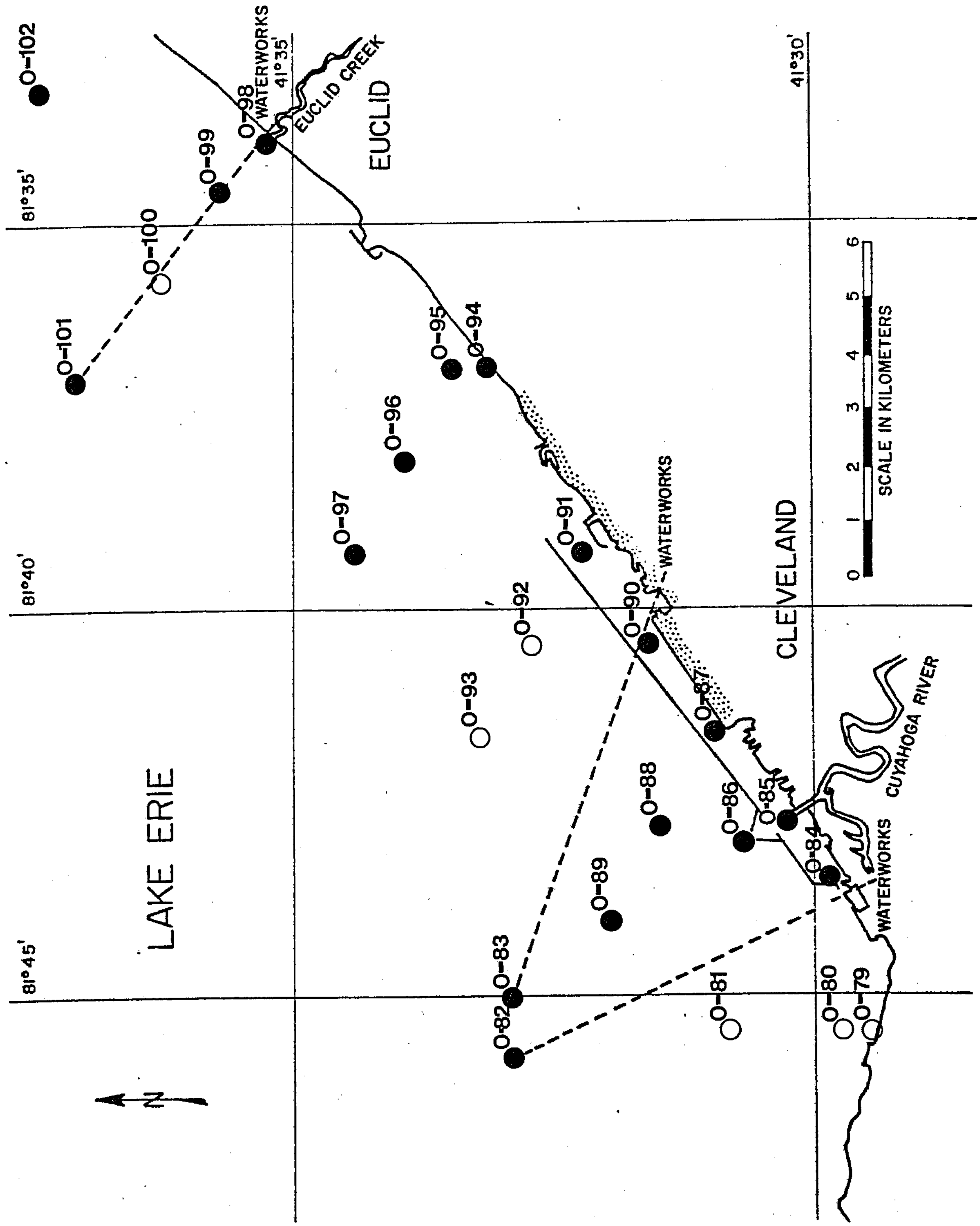


FIGURE 13

Station Locations O-79 to O-102

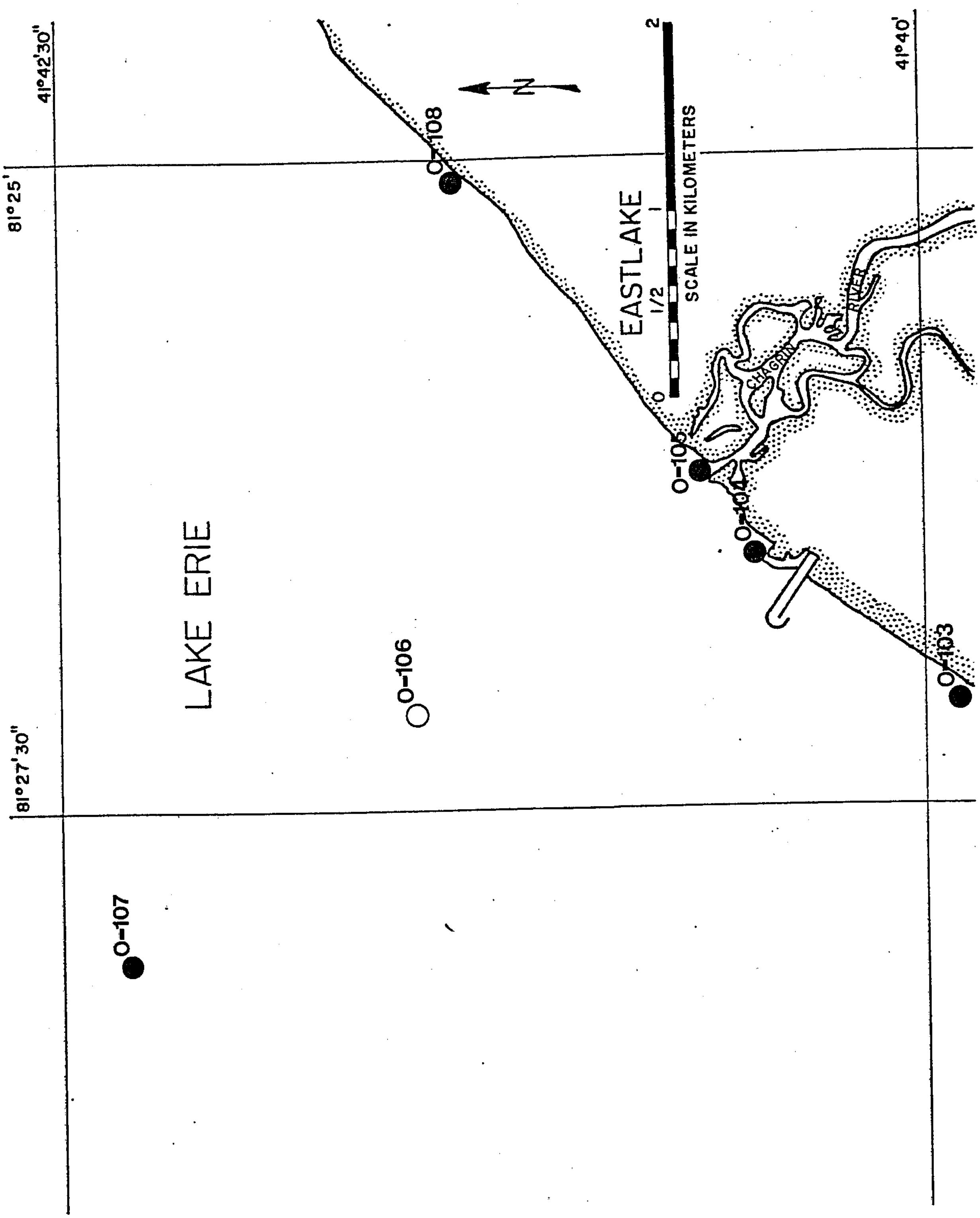


FIGURE 14

Station Locations 0-103 to 0-108

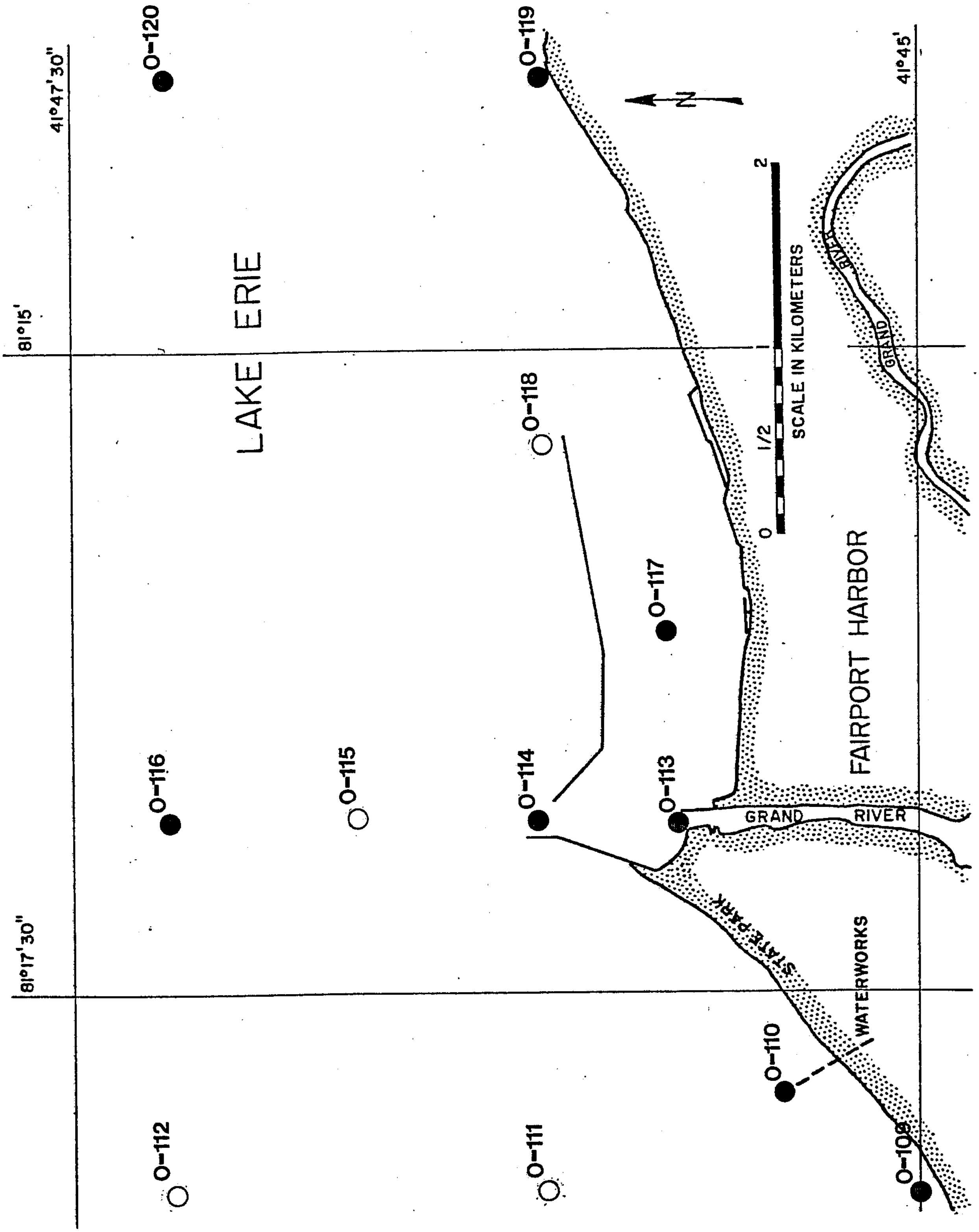


FIGURE 15

Station Locations O-109 tp O-120

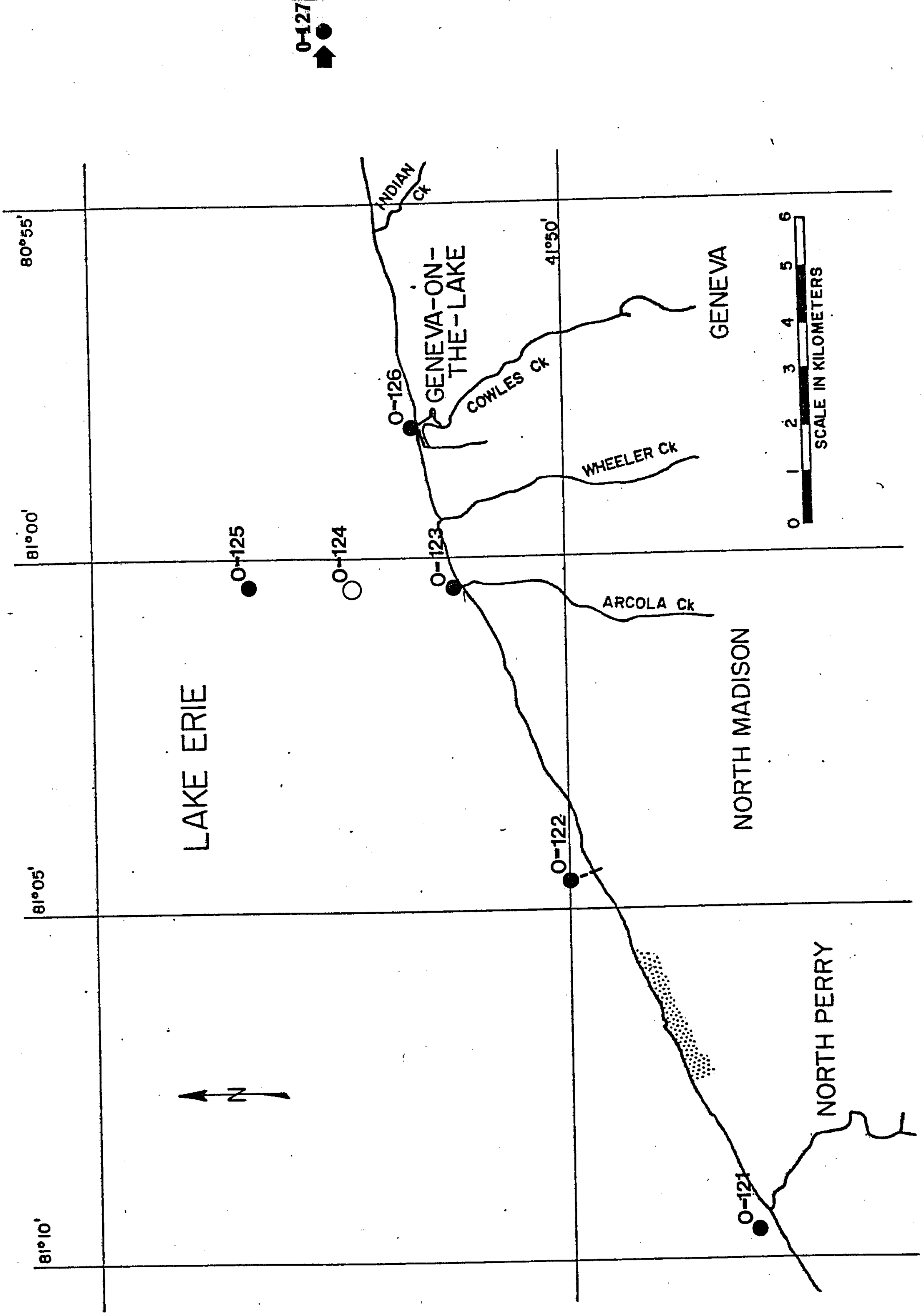


FIGURE 16

Station Locations O-121 to O-127

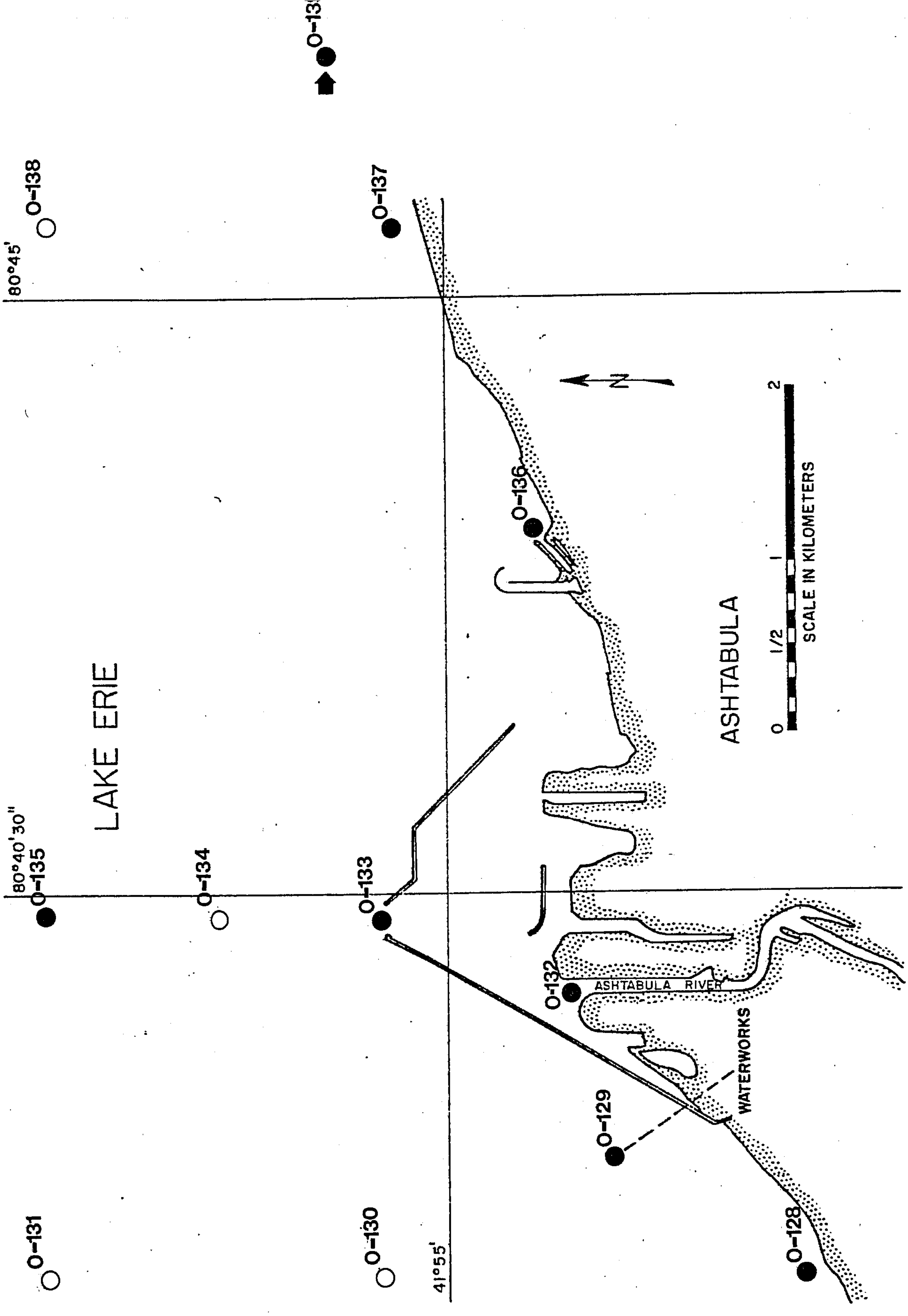


FIGURE 17

Station Locations 0-128 to 0-139

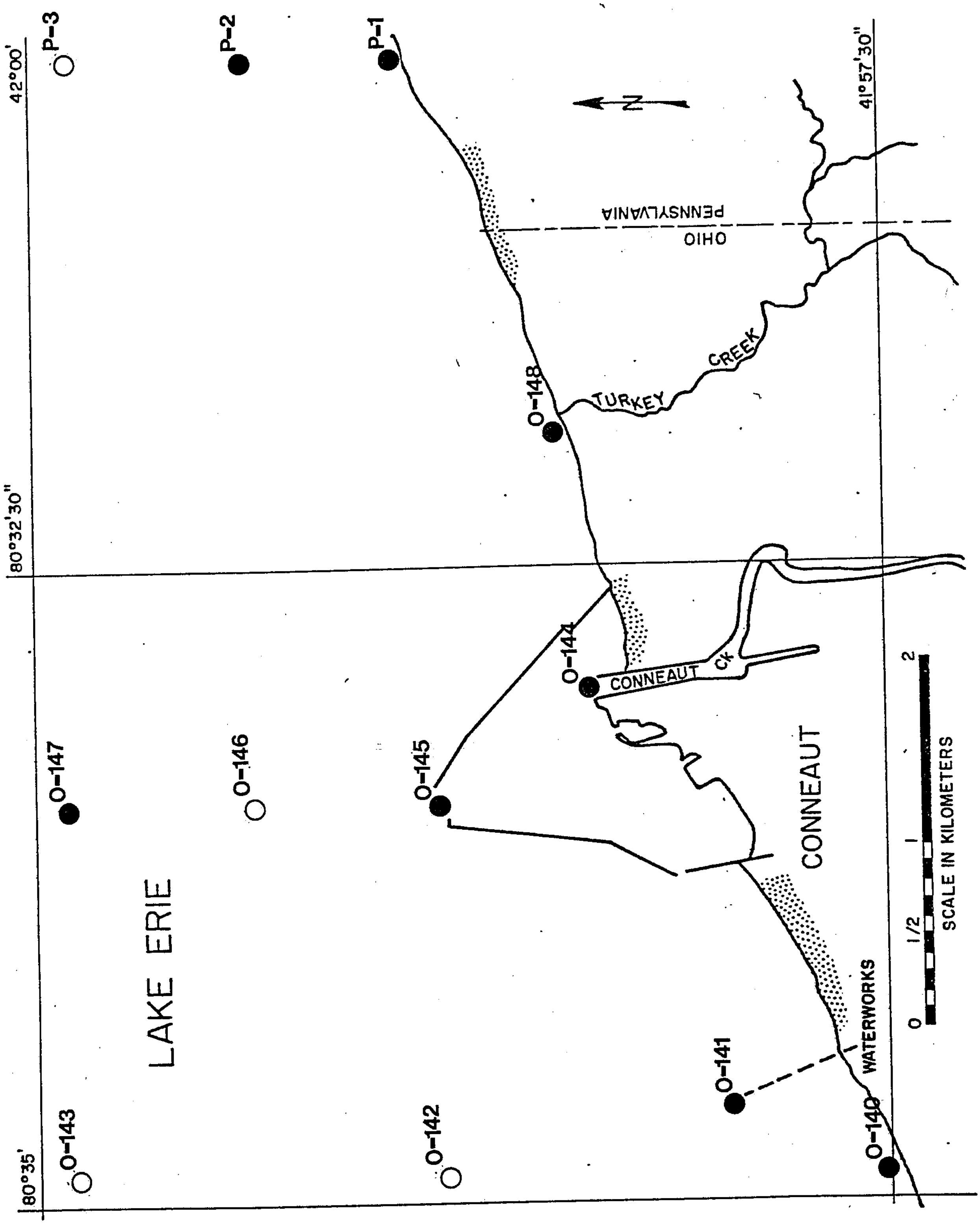


FIGURE 18

Station Locations O-140 to O-148 and P-1 to P-3

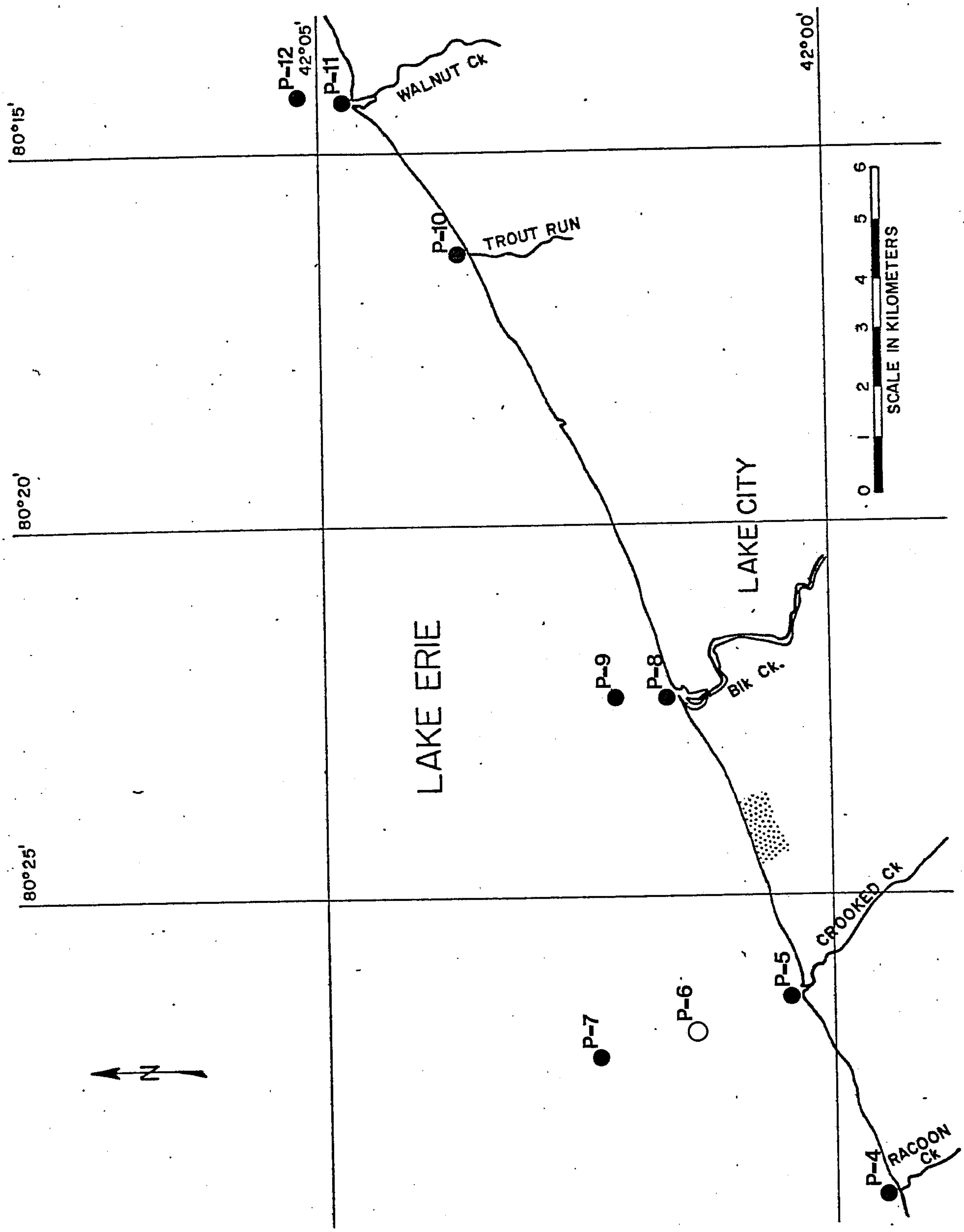


FIGURE 19

Station Locations P-4 to P-12

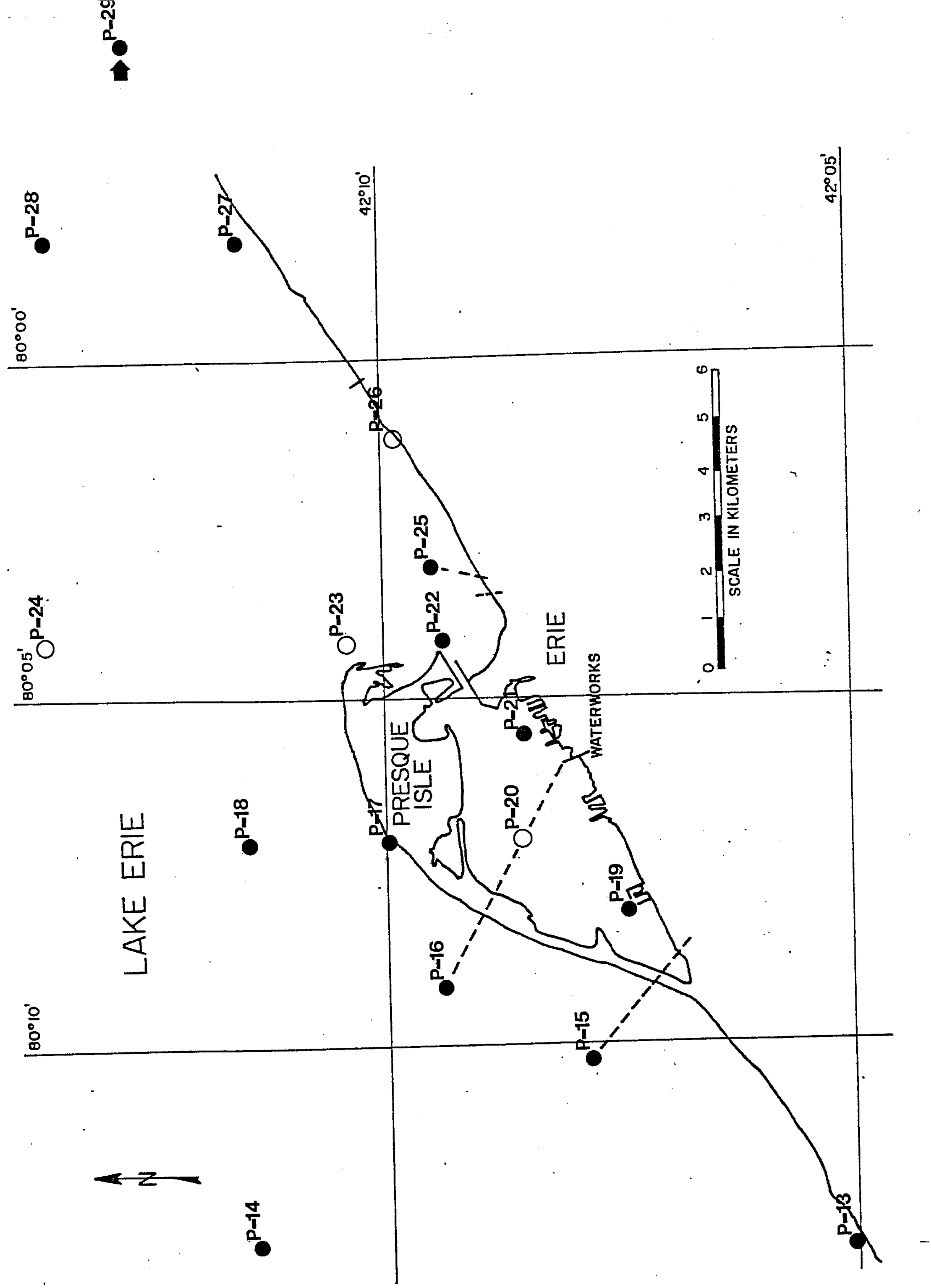


FIGURE 20

Station Locations P-13 to P-29

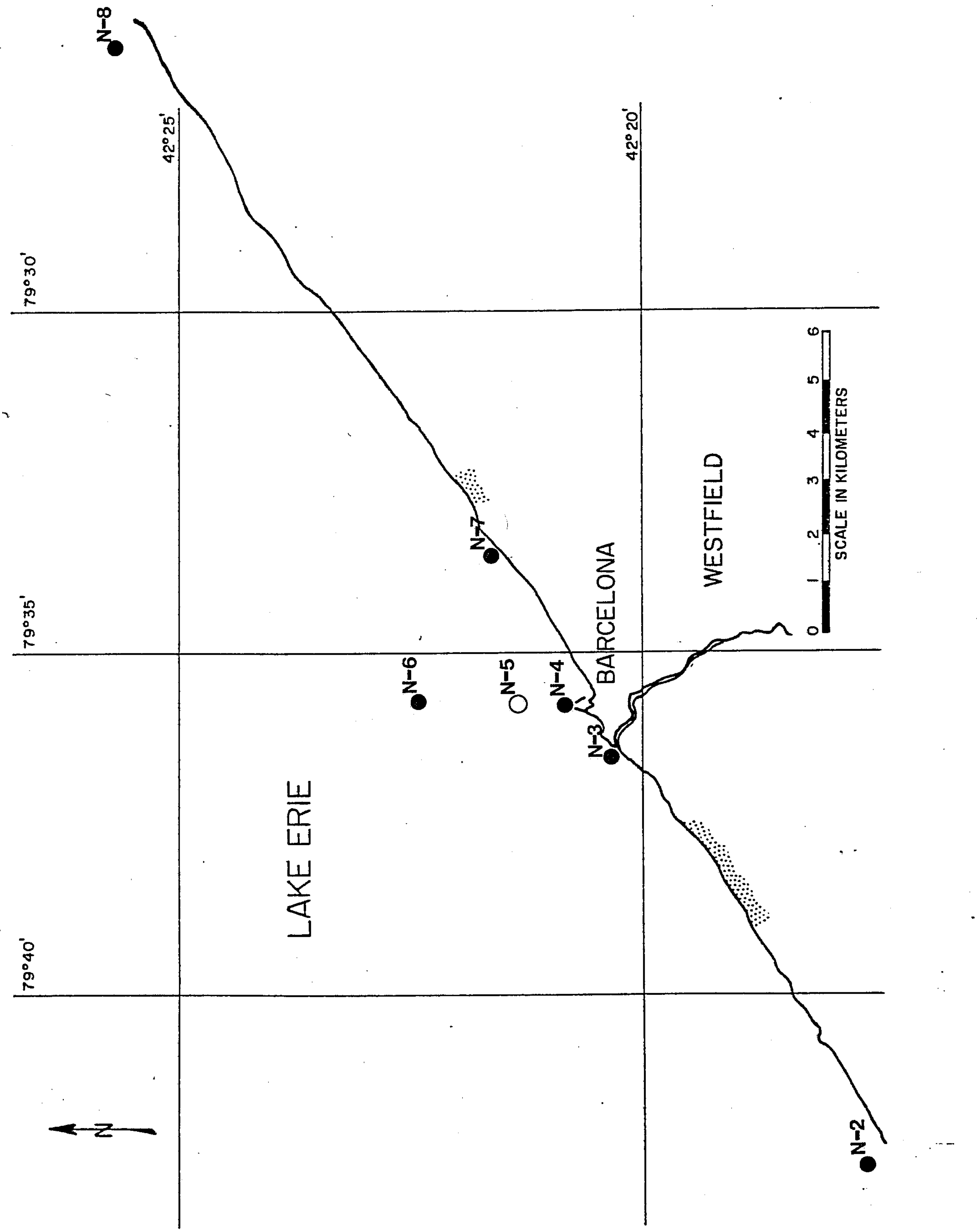


FIGURE 21

Station Locations N-1 to N-8

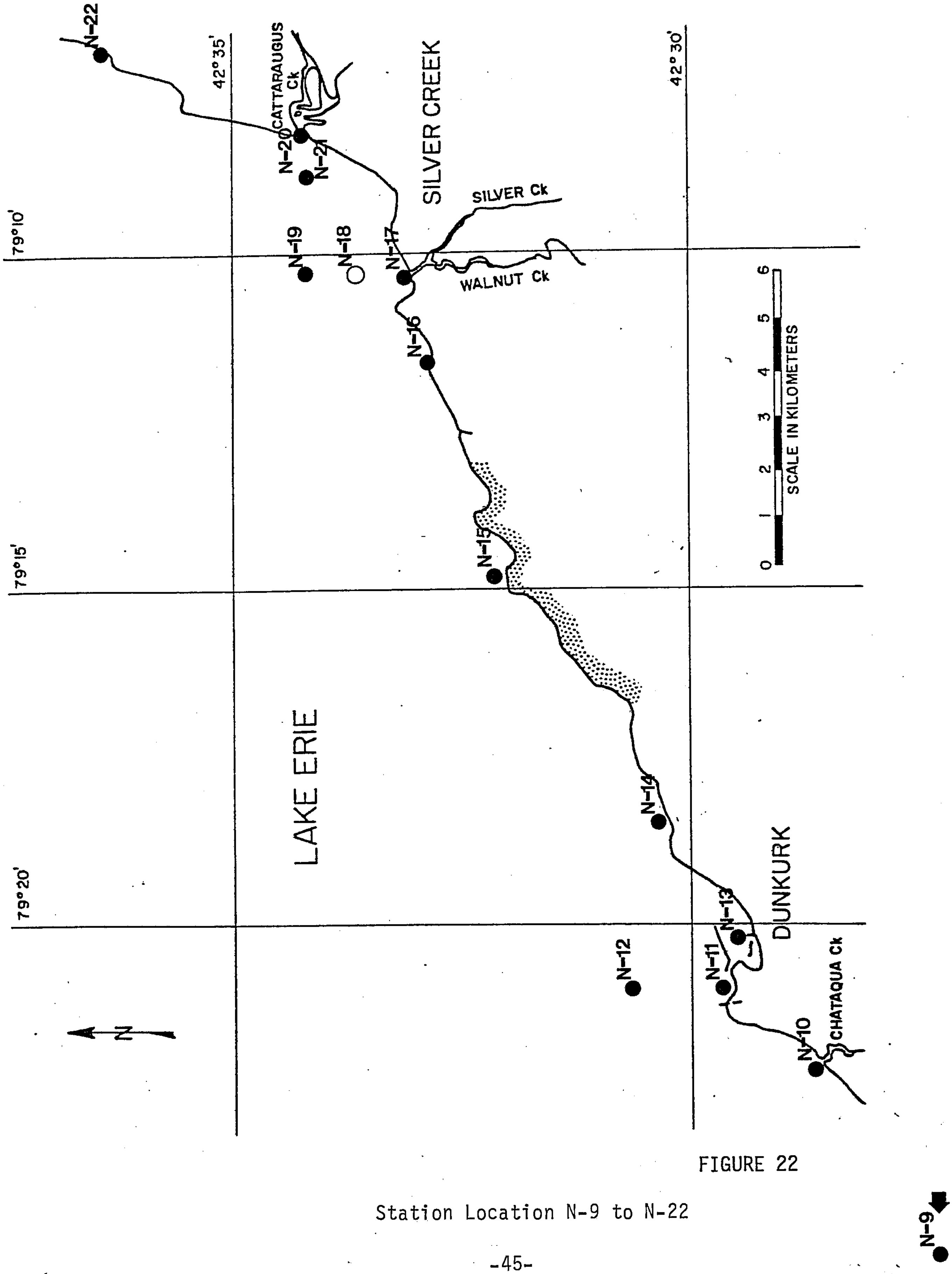


FIGURE 22

Station Location N-9 to N-22

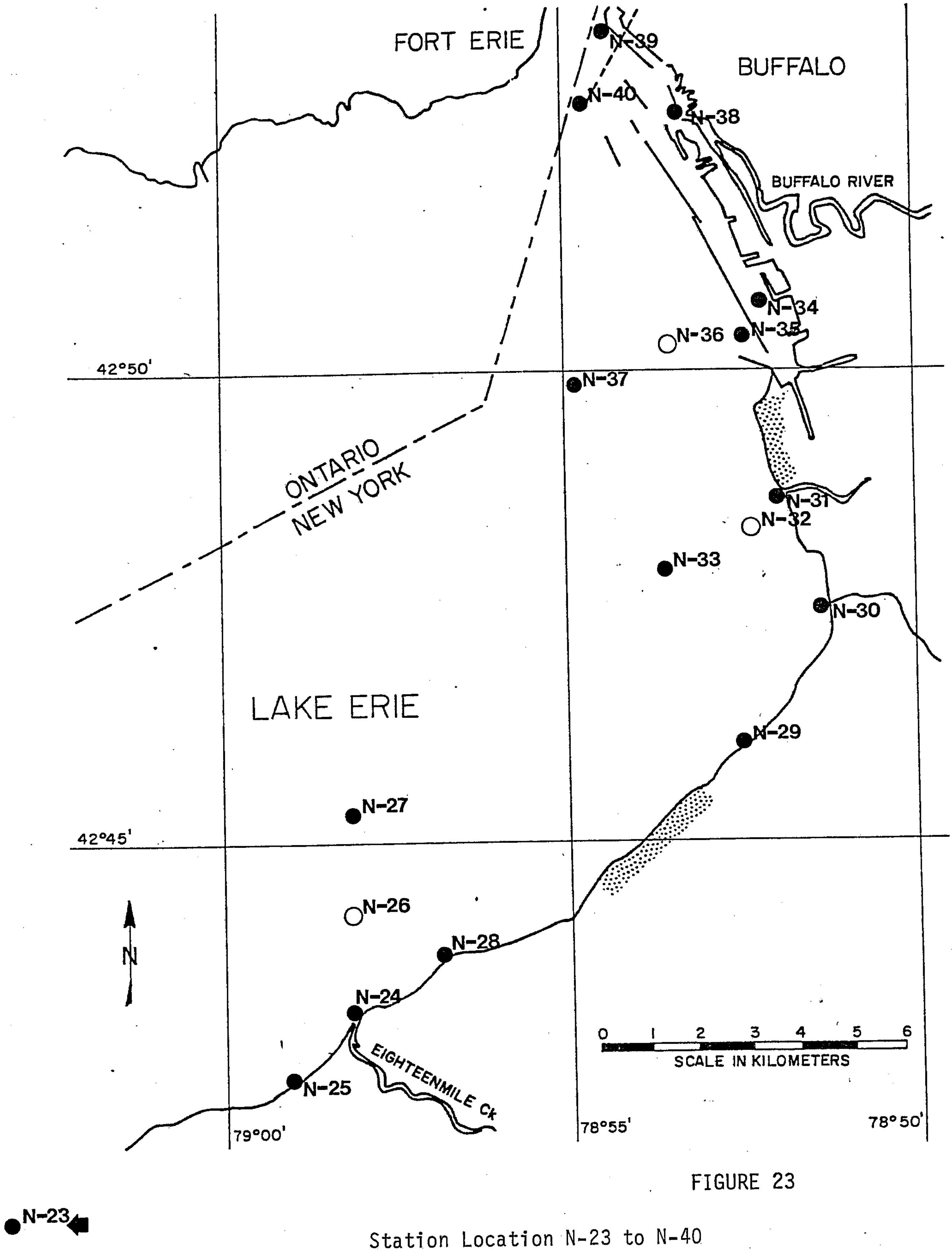


FIGURE 23

Station Location N-23 to N-40