CLEAR TR 201

PHASE II INTERIM REPORT

on

SITE QUALIFICATION STUDIES FOR ELECTRIC POWER GENERATION SANDUSKY BAY, OHIO

to

THE AMERICAN ELECTRIC POWER SERVICE CORPORATION

October 18, 1973

BATTELLE
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Environmental evaluation of potential nuclear power plant sites has become a critical prerequisite for expediting permit application and construction stages of nuclear power generating stations. Specifically, section 50.34 of 10CFR Part 50 of the AEC regulations requires submission of Preliminary and Final Safety Analysis Reports for construction and operation permits, respectively. In addition, AEC's implementation of the National Environmental Policy Act (NEPA, PL90-190) requires submission of an Environmental Report at each stage for consideration by the Commission's regulatory staff. The most recent guidelines directing the organization and content of Environmental Reports to be submitted to the AEC are presented in Regulatory Guide 4.2 (March, 1973).

The American Electric Power Service Corporation, through its regional subsidiary, The Ohio Power Company, has retained Battelle Columbus Laboratories and The Ohio State University under separate contract to conduct investigations pertaining to selected considerations of the characteristics and potential impacts contingent to development of a potential nuclear power plant site. The Site consists of an approximately 2,600-acre tract located at N 41°24'40" - W 82°56'15", about eleven miles west of the City of Sandusky, Ohio. The northern boundary of the Site is formed by the shoreline of the western basin of Sandusky Bay. Hereinafter, this tract will be referred to as the Site.

Phase I investigations established an initial baseline characterization of the Site and included a preliminary assessment of the environmental suitability of the Site for construction and operation of a nuclear power plant of up to 5,000 MW capacity. Preliminary assessments of environmental impacts which might occur due to Site development were also rendered. The results of these investigations are presented in Battelle Columbus Laboratories' Phase I Report submitted to The American Electric Power Service Corporation in February, 1973.

Phase II was initiated in March, 1973, in order to build upon many of the investigations initiated during Phase I. This is a progress report containing the interim results of BCL and OSU environmental investigations of the Site and environs during the first six months of Phase II.

It presents information which provides additional detail to selected characteristics of the Site and the surrounding region, including: regional demography, land and water use; regional historic and natural landmarks; geology; hydrology; and ecology. This information is responsive to the suggested content and format of nuclear power plant site characterization by AEC Regulatory Guide 4.2. The purpose of this Phase II progress report is to update corresponding chapters of the Phase I report rather than replace them.

Additional detail in the areas of "Regional Historic and Natural Landmarks", "Geology", "Hydrology", and "Aquatic Ecology" can be found in original OSU draft progress reports submitted to The American Electric Power Service Corporation in September, 1973.

REGIONAL DEMOGRAPHY, LAND AND WATER USE

INTRODUCTION

Interim Phase II supplements to Phase I in the area of Regional Demography, Land and Water Use include:

(1) Population projections for 2010 and 2020 for segments of a circular area with radii of 10 miles and 50 miles from the Site

(2) Population projections for 1980, 1990, 2000, 2010, and 2020 for segments of an area centered on the Site and 10 miles in radius

(3) A listing of all incorporated places less than 10,000 population within 50 miles of the Site

(4) A listing of all unincorporated places between 1,000 and 10,000 population and within 50 miles of the Site

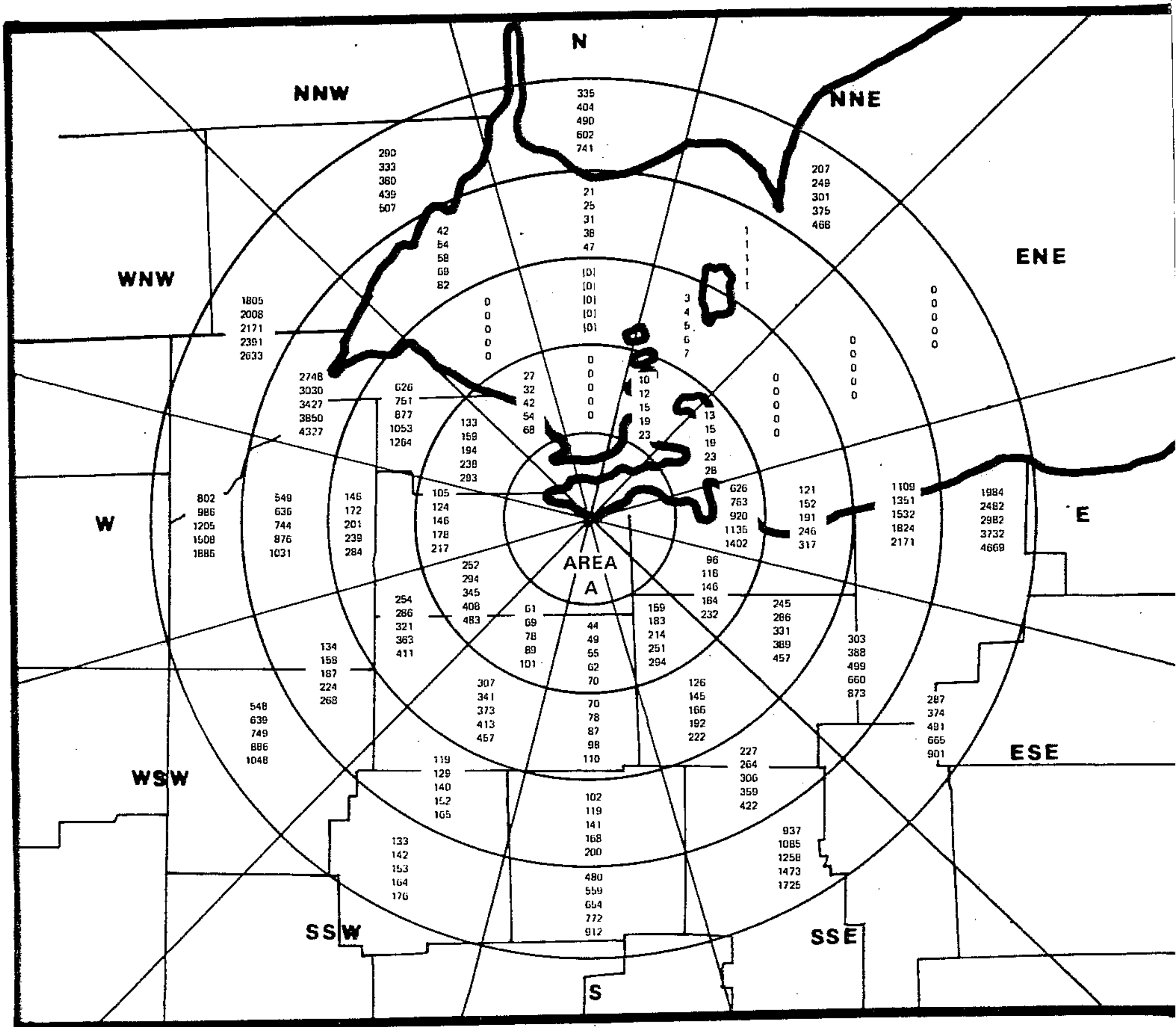
(5) Information on the presence of public facilities within 5 miles of the Site

(6) Information on diurnal population movements within 10 miles of the Site

(7) Comparative investigations relating cumulative population and distance from the Site for the years 1970, 1980, 1990, 2000, 2010, and 2020.

POPULATION PROJECTIONS

An area was divided into equal segments by constructing lines radiating from the Site and beginning at 360 degrees azimuth and repeating every 30 degrees, and concentric circles spaced at 10-mile intervals from the Site.



0–50 MILES FROM SITE
(IN HUNDREDS)

[0] = BETWEEN 0 AND 50 PEOPLE

FIGURE 1. PROJECTED POPULATION DISTRIBUTIONS – 1980, 1990, 2000, 2010, 2020 WITHIN 50 MILES OF THE SITE

TABLE 1. POPULATION DISTRIBUTION (IN HUNDREDS) AT ONE-MILE INCREMENTS WITHIN 5 MILES OF SITE AND POPULATION DISTRIBUTION 5-10 MILES FROM THE SITE

Population Distribution in "E Sector

Area	1970	1980	1990	2000	2010	2020
1	.20	.30	.30	.40	.50	.70
2	.50	.80	1.00	1.20	1.60	2.00
3	.90	1.40	1.70	2.00	2.60	3.30
4	1.20	1.90	2.30	2.90	3.60	4.60
5	1.50	2.40	3.00	3.70	4.70	5.90
6	12.70	22.70	26.20	32.70	39.00	48.50

Population Distribution in "ESE" Sector

Area	1970	1980	1990	2000	2010	2020
1	.20	.30	.30	.40	.50	.60
2	.60	.80	1.00	1.20	1.50	1.90
3	1.00	1.30	1.60	2.0	2.50	3.20
4	1.50	1.80	2.20	2.80	3.50	4.40
5	1.90	2.30	2.90	3.60	4.50	5.70
6	15.80	19.50	24.00	30.00	37.00	49.20

Population Distribution in "SSE" Sector

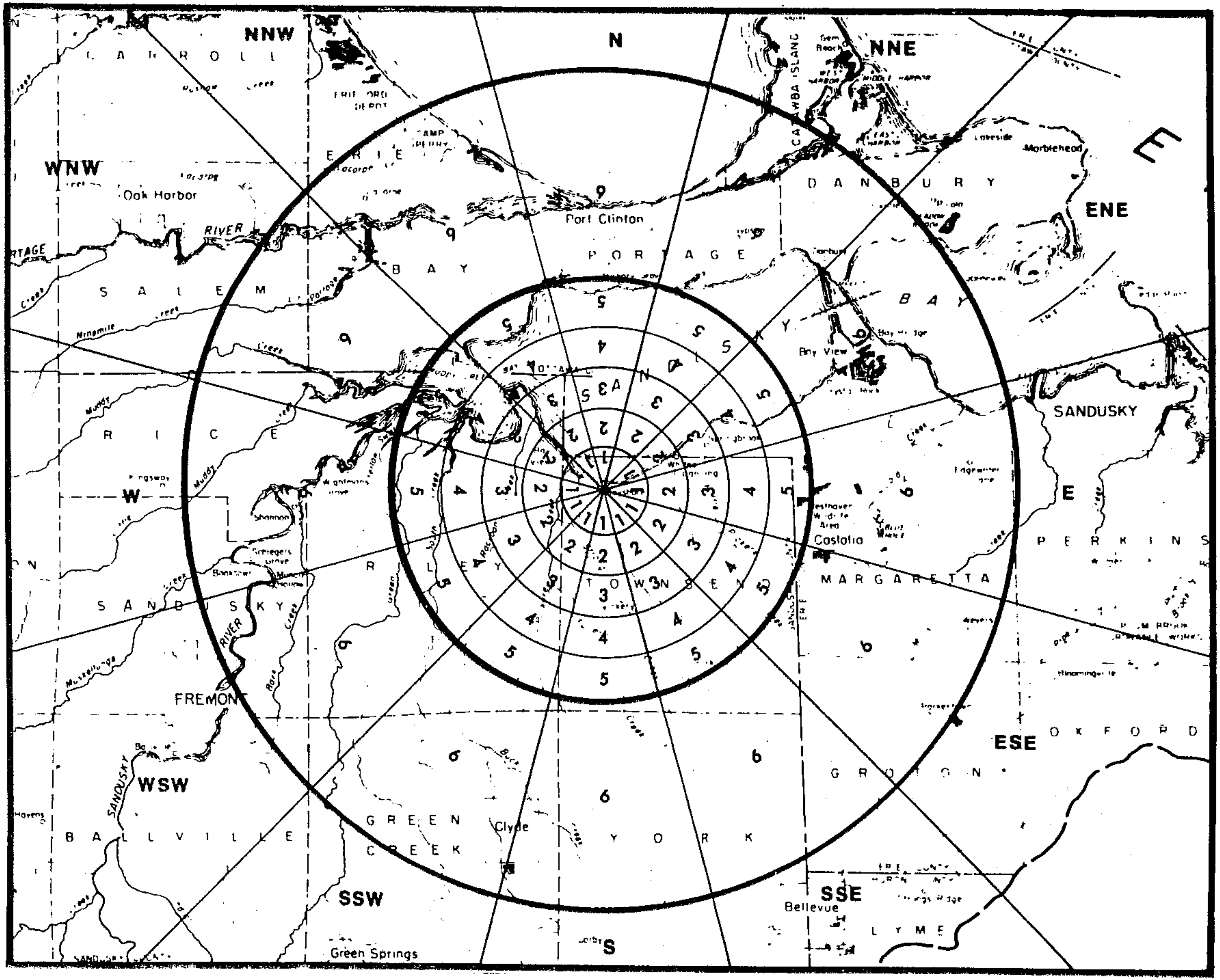
Area	1970	1980	1990	2000	2010	2020
1	.20	.20	.20	.30	.40	.40
2	.50	.60	.70	.90	1.00	1.30
3	.90	1.00	1.20	1.50	1.80	2.20
4	1.30	1.40	1.70	2.00	2.50	3.00
5	1.60	1.80	2.20	2.60	3.20	3.90
6	13.50	15.00	18.00	21.70	25.10	32.20

Population Distribution in "S" Sector

Area	1970	1980	1990	2000	2010	2020
1	.70	.70	.90	1.00	1.20	1.50
2	2.00	2.20	2.60	3.00	3.60	4.40
3	3.40	3.70	4.40	5.00	6.00	7.30
4	4.80	5.20	6.00	7.00	8.50	10.20
5	6.10	6.70	7.80	9.00	10.90	13.00
6	54.00	58.50	68.30	81.00	95.80	113.60

TABLE 1 (Continued)

Area	1970	1980	1990	2000	2010	2020
	Population Distribution in "NNW" Sector					
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	.30	.40	.50	.60	.70	.90
6	16.70	18.60	22.50	28.40	36.30	46.10
	Population Distribution in "N" Sector					
	1970	1980	1990	2000	2010	2020
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	.70	.90	1.00	1.20	1.40	1.70
6	73.30	88.10	103.00	120.80	142.60	169.30
	Population Distribution in "ENE" Sector					
1	.10	.10	.10	.10	.10	.10
2	.20	.20	.20	.30	.40	.40
3	.30	.40	.40	.50	.60	.70
4	.40	.50	.60	.70	.80	1.00
5	.50	.60	.70	.90	1.10	1.30
6	4.50	5.20	6.00	7.50	9.00	10.50



AREAS 1-5: ONE-MILE INCREMENT
AREA 6: FIVE-MILE INCREMENT

FIGURE 2. PHASE II DEMOGRAPHIC SECTORS

TABLE 2. ALL INCORPORATED PLACES UNDER 10,000 POPULATION
UNINCORPORATED PLACES OF 1,000 to 10,000
POPULATION WITHIN 50 MILES OF THE SITE

City	County	1970 Pop.	1960 Pop.	% Change	Distance & Direction from Site
Amherst city	Lorain	9902	6750	46.7	37 mi. E
Arcadia village	Hancock	689	610	13.0	37 mi. WSW
Attica village	Seneca	1005	965	4.1	25 mi. S
Bairdstown village	Wood	138	182	-24.2	39 mi. WSW
Ballville	Sandusky	1652	1424	16.0	12 mi. WSW
Bay View village	Erie	798	802	- 0.5	7 mi. ENE
Bellevue city	Huron & Sandusky	8604	8286	3.8	12 mi. SSE
Berlin Heights village	Erie	828	721	14.8	24 mi. ESE
Bettsville village	Seneca	833	776	7.3	20 mi. WSW
Bloomdale village	Wood	727	669	8.7	46 mi. WSW
Bloomdale village	Seneca	884	836	5.7	26 mi. S
Bradner village	Wood	1140	994	14.7	27 mi. W
Burgoon village	Sandusky	221	243	- 9.1	19 mi. WSW
Carey village	Wyandot	3523	3722	- 5.3	40 mi. SSW
Castalia village	Erie	1045	954	9.5	7 mi. E
Chatfield village	Crawford	291	263	10.6	40 mi. S
Clay Center village	Ottawa	370	446	-17.0	24 mi. WNW
Clyde village	Sandusky	5503	4826	14.0	9 mi. S
Crestline city	Crawford	5947	5521	7.7	45 mi. SSE
Custar village	Wood	277	246	12.6	48 mi. W
Cygnet village	Wood	629	593	6.1	38 mi. WSW
Deshler village	Henry	1938	1824	6.3	50 mi. WSW
Elmore village	Ottawa	1316	1302	1.1	19 mi. W
Genoa village	Ottawa	2139	1957	9.3	23 mi. WNW
Gibsonburg village	Sandusky	2585	2540	1.8	20 mi. W
Grafton village	Lorain	1771	1683	5.2	47 mi. E
Grand Rapids village	Wood	976	670	45.7	48 mi. W
Green Springs village	Sandusky, Seneca	1279	1262	1.3	13 mi. SSW
Greenwich village	Huron	1473	1371	7.4	35 mi. SSE
Harbor View village	Lucas	238	273	-12.8	33 mi. WNW
Harpster village	Wyandot	291	302	- 3.6	50 mi. SSW
Haskins village	Wood	549	521	5.4	40 mi. W
Helena village	Sandusky	298	281	6.0	19 mi. WSW
Holland village	Lucas	1108	924	19.9	43 mi. WNW
Hoytville village	Wood	403	334	20.7	47 mi. WSW
Huron city	Erie	6896	5197	32.7	20 mi. E
Jerry City village	Wood	470	386	21.8	36 mi. WSW
Kellys Island village	Erie	175	171	2.3	17 mi. ENE
Kipton village	Lorain	353	353	-	35 mi. ESE
Kirby village	Wyandot	178	166	7.2	49 mi. SSW
Lagrange village	Lorain	1074	1007	6.7	45 mi. E
Lindsey village	Sandusky	652	581	12.2	15 mi. W

TABLE 2 (Continued)

City	County	1970 Pop.	1960 Pop.	% Change	Distance & Direction from Site
Tiro village	Crawford	310	334	- 7.2	37 mi. S
Tontogory village	Wood	395	380	3.9	41 mi. W
Upper Sandusky village	Wyandot	5645	4941	14.2	44 mi. SSW
Van Buren village	Hancock	319	374	-14.7	42 mi. WSW
Vanlue village	Hancock	539	386	39.6	42 mi. SSW
Vermillion city	Erie, Lorain	9872	4785	106.3	30 mi. E
Wakeman village	Huron	822	728	12.9	30 mi. ESE
Walbridge village	Wood	3208	2142	49.8	31 mi. WNW
Waterville village	Lucas	2940	1856	58.4	41 mi. W
Wayne village	Wood	921	949	- 3.0	29 mi. WSW
West Millgrove village	Wood	215	196	9.7	31 mi. WSW
Weston village	Wood	1269	1075	18.0	45 mi. W
Wharton village	Wyandot	422	463	- 8.9	48 mi. SSW
Whitehouse village	Lucas	1542	1135	35.9	45 mi. W
Willard city	Huron	5510	5457	1.0	28 mi. SSE
Woodville village	Sandusky	1834	1700	7.9	23 mi. W
Forest village	Hardin	1535	1314	16.8	50 mi. SSW

Source: U.S. Bureau of Census
Census of Population: 1970
GENERAL SOCIAL AND ECONOMIC CHARACTERISTICS
Final Report PC(1)-A Ohio

Cumulative Population

Figure 3 shows the cumulative population for portions of an area of a 50-mile radius centered on the Site for the years 1970, 1980, 1990, 2000, 2010, and 2020. The population is aggregated by 10-mile intervals, i.e., the total population is given for a circular area centered on the Site and with a 10-mile radius for a circular area centered on the Site and with a 20-mile radius for a circular area centered on the Site, and with a 30-mile radius, etc. Total population is indicated on the vertical axis of the graph and distance is indicated on the horizontal axis. Figure 4 depicts cumulative population versus distance for other sites used or under consideration for nuclear power plants.

Diurnal Population Variation

Within 10 miles of the Site there are at least two causes of diurnal population variation. These are both schools which are located in rural settings. Riley School has approximately 525 students and 20 staff personnel. It is located approximately 4.3 miles southwest of the Site. Townsend School has approximately 477 students and 16 staff members. It is located 2.8 miles southeast of the Site.

The locations of both schools in relation to the Site are shown in Figure 5. Populations of the schools are also indicated. Figure 5 shows a circular area whose radius is 5 miles. The 5-mile circle is further divided into concentric circles spaced at one-mile intervals from one mile to 5 miles.

There is a probability that some portion of the rural population commutes from various locations within a 10-mile radius of the Site to industrial locations in Sandusky, Clyde, Port Clinton, and other municipalities in the region. To the extent that this type of commuting takes place, it is another cause of diurnal change in population that exists within a 10-mile radius of the Site. Investigations are being planned in order to determine the nature and extent of commuting patterns in the region surrounding the Site. It is anticipated that the results will be helpful in determining overall diurnal variations in population density and distribution in the vicinity of the Site.

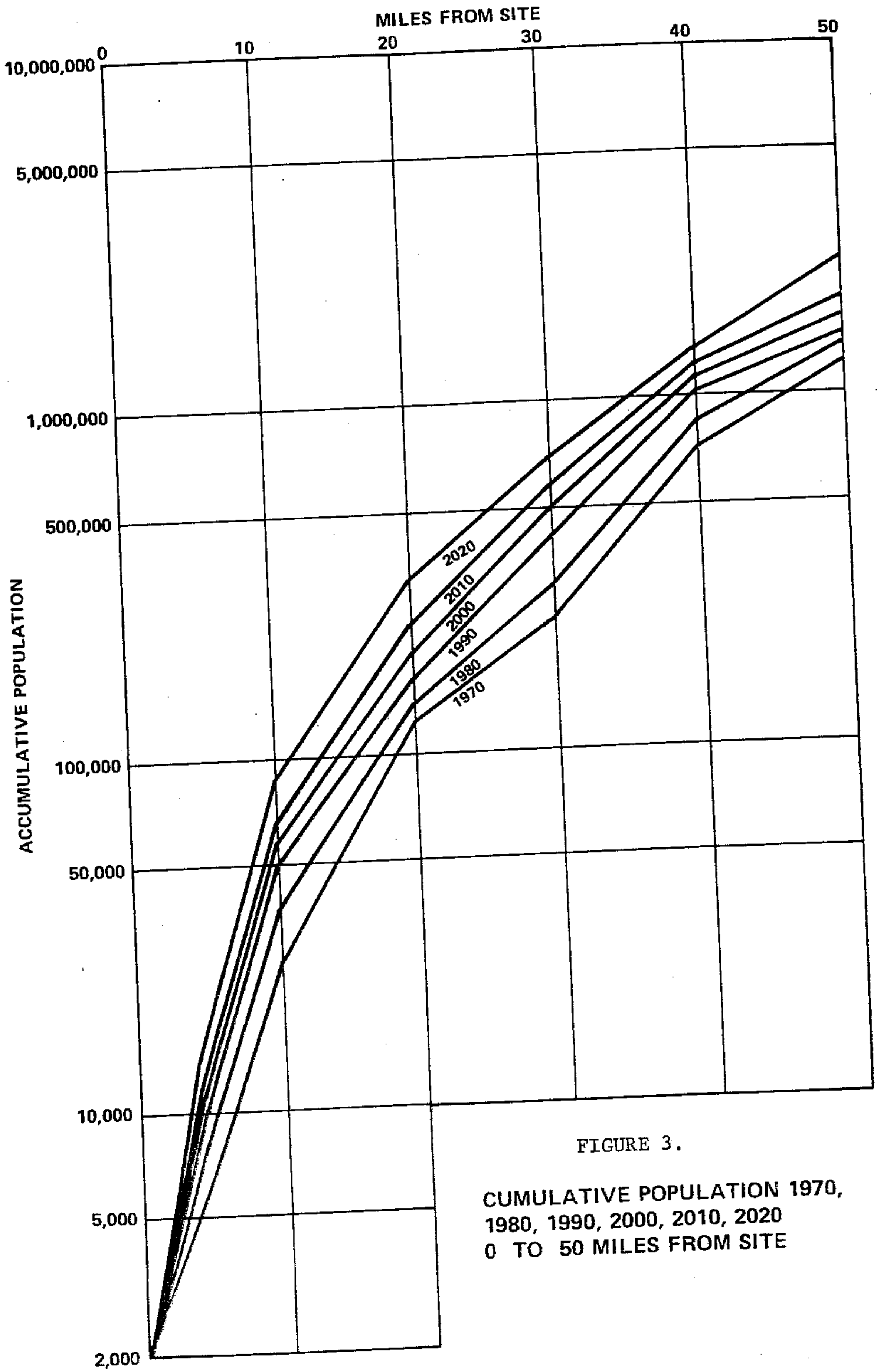


FIGURE 3.

CUMULATIVE POPULATION 1970, 1980, 1990, 2000, 2010, 2020 0 TO 50 MILES FROM SITE

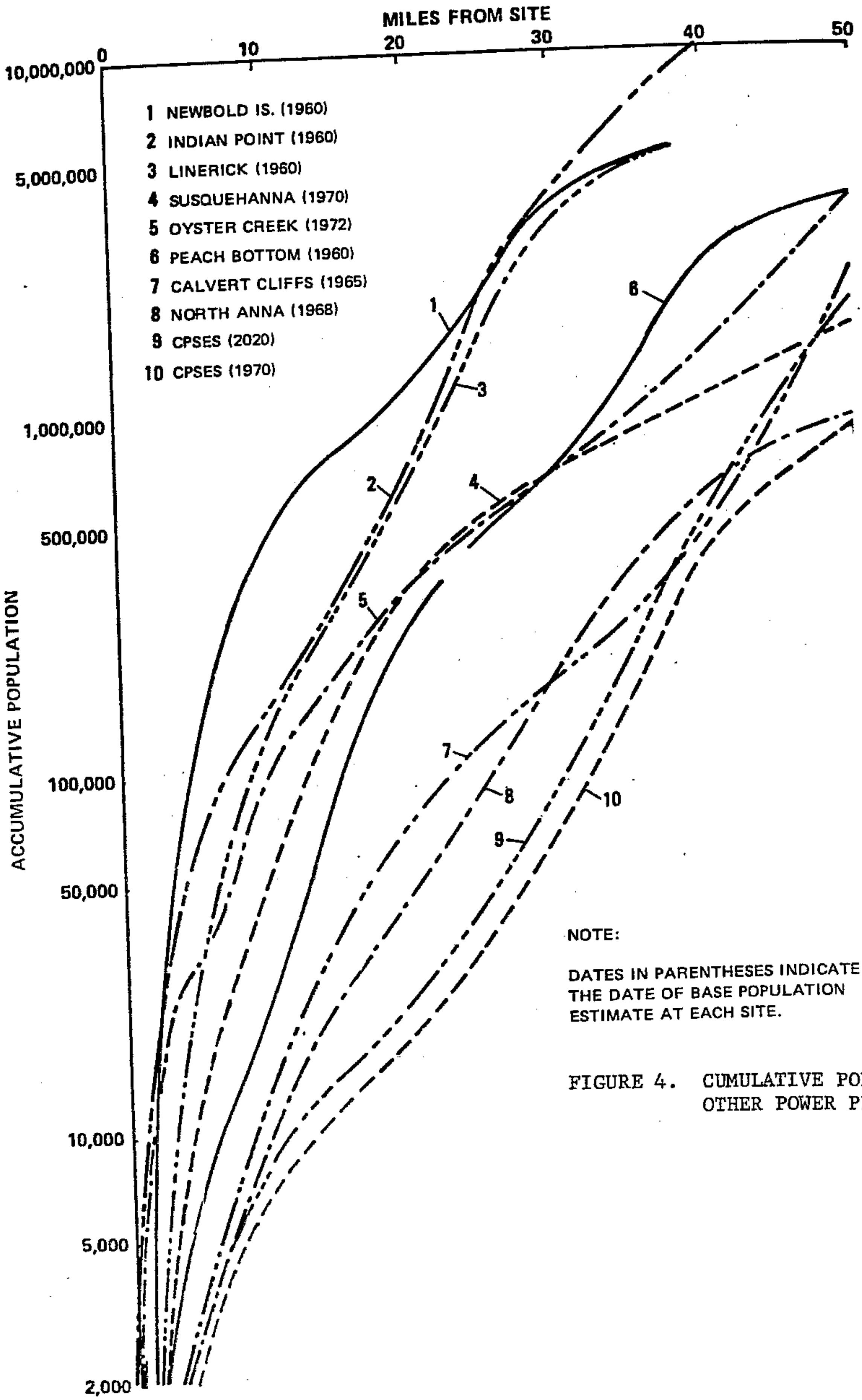
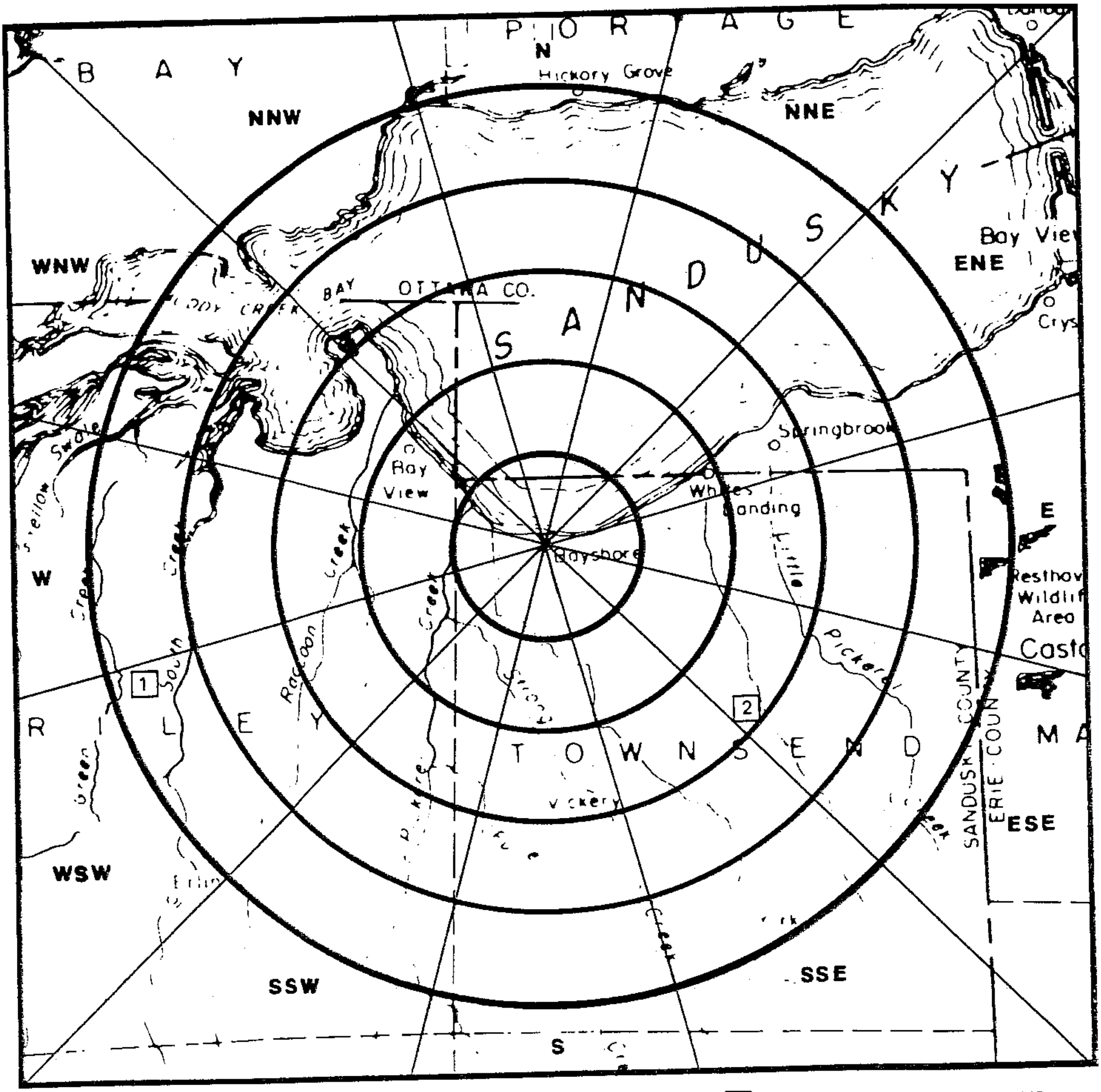


FIGURE 4. CUMULATIVE POPULATION AT OTHER POWER PLANT SITES

PUBLIC FACILITIES WITHIN 5 MILES OF SITE



1 RILEY SCHOOL: 545 PERSONS

2 TOWNSEND SCHOOL: 493 PERSONS

FIGURE 5. LOCATION OF SCHOOLS IN RELATION TO SITE

PUBLIC FACILITIES WITHIN FIVE MILES OF THE SITE

Within five miles of the Site there are only two public facilities in which there are substantial concentrations of people. Both facilities are schools, Riley School and Townsend School (see Figure 5).

Riley School: Riley School, approximately 4.3 miles southwest of the Site, has 22 classrooms, 525 students, and approximately 20 staff members. Given this number of students and classrooms, there is an average of 24 students per classroom. Any projections of future school enrollment at a particular school depend not only on population increases but also on capacity of the total school system and capacity of the particular school. The future capacity of the school system depends on many factors, including voter approval of financing. The capacity of Riley School is at or near capacity according to the school district superintendent. It is, therefore, assumed that enrollment at Riley School will not exceed approximately 550 students.

Townsend School: There are approximately 477 students and 16 staff members at Townsend School which is located 2.8 miles southeast of the Site. Townsend, according to the school district superintendent, is also at or near capacity. It is thus assumed that future enrollment at this school will not exceed 500 students.

REGIONAL HISTORIC AND NATURAL LANDMARKS

NATURAL LANDMARKS

Several additions to the Phase I list of natural landmarks within 30 miles of the Site have been made during Phase II. The following listing includes only these new landmarks. Bracketed numerals and letters designate distance in miles and direction from the Site. Letters and numerals in parentheses designate corresponding map locations. The locations of all natural landmarks discovered to date within 30 miles of the Site are shown in Figure 6.

Natural Features Located Between 0 and 10 Miles From the Site

Crystal Rock Caves: Castalia [5,E] (E-10)

Two small caves in the Put-in-Bay Formation, a dolomite of Silurian age, are open to the public at this location on a rocky ridge one-half mile south of Sandusky Bay. The caves are shallow, contain dripstone deposits, and one has an underground lake and spring. The caves appear to be the result of a small dome structure which has collapsed, possibly as interbedded evaporite deposits were removed by groundwater solutioning. A commercial campground and a natural woodlot are located on the property. Area: 50 acres.

Natural Features Located Between 10 and 20 Miles From the Site

Cedar Point: Sandusky [14,ENE] (E-13)

This area was once a natural sand spit seven miles long at the east side of Sandusky Bay. Much of the natural area is now lost to development except for marshes inside the boundary of an amusement park. Area: 100 acres.

Camp Hertzer: Tiffin [17,SW] (SE-1)

The camp is situated on the east bank of the Sandusky River which is reported to be too shallow for swimming or boating. Twelve acres are reforested farmland designated as a "wildlife conservation area" which contains 10,000 black walnut, white pine, Carolina poplar, and locust trees planted in 1959. Twelve acres are in open grassland with the balance riverbank, an old mill race, and woodland. Two deep ravines in their natural condition may be explored along undeveloped trails. Wildflowers, birds, and small mammals are normally in residence. Mature trees include several varieties of oak, maple, elm, ash, sycamore, tulip, dogwood, and sassafras. Area: 43 acres.

Crane Creek Wildlife Experiment Station or
Magee Marsh: Oak Harbor [17,NW] (O-6)

The Lake Erie marshes have been famous for 75 years as one of the best waterfowl hunting areas in the U. S. This applies to hunting-to-see as well as hunting-to-kill. Magee Marsh, purchased in 1951, has two functions: it serves as headquarters for wildlife waterfowl research and management projects and it is a controlled, hunting-by-permit waterfowl area. Canada geese, mallards, blue wing teal, wood duck, and smaller numbers of other waterfowl nest here. But the number and large variety of migrating waterfowl is amazing. State biologists have reported concentrations exceeding 100,000 birds in this general area for brief periods. Flocks of migrating whistling swans, peak at 5,000 birds, appear in March. Warbler concentrations during migration are reported to be among the best in the state. Bitterns, herons, and a wide variety of shorebirds are common to the area. A bird nature trail as well as dikes for hiking, reached from the Turtle Creek Fishing Access where parking is available, facilitate seeing the wildlife. A full-time naturalist is available and maps may be requested. A new facility known as the Sportsmen Migratory Bird Center has been added.

Hauk's Pond: Middle Bass Island [20,NNE] (0-17)

This pond is formed by gravel bars on the east point of Middle Bass Island. The area is a good example of pond succession and a swamp forest. Area: 2 acres.

Lotus Beds: Huron [19,E] (E-12)

Located in Huron where Ohio Route 13 crosses Mud Creek are large beds of lotus. American lotus as well as Oriental lotus are present in the creek. Area: 10 acres.

Sand Point: Marblehead [12,ENE] (0-18)

Sand Point is a long sand peninsula between Lake Erie and Sandusky Bay. The area is now a private resort but there are still natural dunes and marshes which are choice bird habitats. Winuous Point in western Sandusky Bay, 4.4 miles northwest of the Site is also a choice waterfowl area.

Natural Features Located Between 20 and 30 Miles From the Site

Berlin Heights Ravine: Berlin Heights [24,ESE] (E-11)

The ravine of Old Woman Creek in the southwest corner of the village provides many natural habitats. Steep cliffs composed of Berea Sandstone (Mississippian age) form the sides of the ravine and contain large flow-roll structures. The flora is rich consisting of hemlock, up to 18" DBH, and butternut trees. Area: 100 acres.

Pearson Metropolitan Park: Oregon [30,NW] (LU-3)

Pearson Park is the most developed of the Toledo Metropolitan Parks. There is fishing for children on the lake, ice skating in season, and pedal boats for rent during the warm months. Macomber Lodge can be reserved for meetings and programs. Spring wildflowers can be seen along the trails and it is an excellent area for migrating bird species with some nesting species. Area: 320 acres.

HISTORIC AND ARCHAEOLOGICAL LANDMARKS

Numerous archaeological landmarks in the vicinity of the Site have been discovered during Phase II literature surveys and field reconnaissance. The following listing includes all new landmarks discovered during Phase II. Bracketed numerals and letters designate distance in miles and direction from the Site. Letters and numerals in parentheses designate corresponding map locations. The locations of all historic and archaeological landmarks discovered to date within 30 miles of the Site are shown in Figure 7.

Historical and Archaeological Landmarks Located Within 0 and 10 Miles of the Site

Arthur Libbens Site: Bank of Portage River [10,NW] (0-12)

Located south-southeast of the intersection of Routes 163 and 358, this site was excavated by Olaf Prufer in the summer of 1967. A small surface collection was made at this burial site by A. E. Galbraith, Jr. in 1957.

Burial Site: Sandusky Bay [6, ENE] (E-48)

The location of this site is northwest of Crystal Rock on Sandusky Bay.

Burial Sites: South of Sandusky [10,E] (E-44)

These sites are located on Mills Creek 2 miles south of Sandusky.

Early Gypsum Quarry: Margaretta Township [7, E] (E-50)

This quarry is located at the intersection of Routes 6 and 269, Margaretta Township, on Sandusky Bay north of Castalia.

Earthwork: Venice [9,E] (E-43)

Gill Burial Ground: Portage Township [6,N] (0-11)

This site is located near Port Clinton. It was excavated by Emiel Hostrup and C. J. Riley; burials and pottery were found.

Indian Village Site: Gypsum [7,NE] (0-17)

Lacarne Cemetery Site and Village: Erie Township [9,NW] (0-10)

This site is located 4 miles west of Port Clinton on the north bank of the Portage River. It was excavated by Bob Bell, Bob Phelps, and Aronhalt in May, 1934. This is an Iroquois culture site.

Montgomery Burial Site: Portage River [9,NW] (0-13)

This site is located on a sand knoll projecting into the Portage River about 3/4 mile downstream from LaCarne on the Montgomery farm. Burials were excavated by Myron Weiss and Arthur G. Smith in 1917. It is either Erie or Late Woodland culture.

Mound: Northwest of Bellevue, York Township [10,SSE] (SA-15)

Port Clinton Mound: Portage Township [6,N] (0-8)

This mound near Port Clinton was excavated by E. F. Greenman in June, 1932.

Ream Indian Village Site: Sandusky Township [8,W] (SA-9)

This village, located on the east side of the Sandusky River just west of center section 14, Sandusky Township, was excavated by Robert Goslin on May 30, 1930.

Indian Village Site: Catawba [12,NNE] (0-18)

Inscription Rock State Memorial: Kellys Island [17,NE] (E-24)

Sometime between 1200 and 1650 A.D., the prehistoric Erie Indians, called the Cat Nation, incised pictographic writings in this boulder. The inscriptions are untranslated. This is the only known Erie culture example of pictograph writing. The rock qualifies for the National Register.

Lakeside Mound: Between Lakeside and Marblehead [11,NE] (0-7)

This mound, located on a hill southeast of Lakeside, was excavated by Clarence Loveberry in 1897. The stone mound is 60 feet in diameter and 3-foot high.

Lonz Winery: Middle Bass Island [19,NNE] (0-21)

The winery, built in 1884, is a two-story, castle-like building (Romanesque Revival) of stone and brick 150 feet by 100 feet in size, surmounted by turrets and battlements.

Mixter Site: vicinity of Milan [20,ESE] (E-39)

This site was excavated in 1951-1954 by A. G. Smith and is located 2 miles northeast of Milan.

Mound: Kelleys Island [17,NE] (E-26)

A mound is located on the northwest shore of Kelleys Island, probably constructed by the Erie Nation.

Mound: 2 Miles East of Locust Point, Carroll Township [15,NW] (0-20)

Mounds, Burial Sites: South of Wilmer [13,ESE] (E-42)

These mounds are located south of Wilmer midway between Sand Hill and Union Corners.

New Salem Site: Vicinity of Huron [20, ESE] (E-34)

This archaeological site is located 3½ miles northeast of Milan on the Huron River.

North Bass Island Mound: South Shore of North Bass Island [20,NNE] (O-14)

This Woodland culture burial mound was reported by David M. Stothers of the University of Toledo in 1973 and tested by Prowell in 1971.

Norwalk Works: Norwalk [20,SE] (H-13)

The Norwalk Works is located on the west side of Norwalk. In 1848 it was partially excavated and consisted of a circle with 9 mounds, triangular earthworks, and 2 circles.

Oxford Village Site: South of Bloomingville [13,ESE] (E-31)

Surface collection of the Oxford Village Site was done in 1930 by Grunman.

Pete Williams Earthworks Group: Vicinity of Milan [19,ESE] (E-33)

This group of earthworks is located 1½ miles northeast of Milan.

Pontiac: Near Standardsburg [19,SE] (H-16)

This campsite is located on a ridge between two branches of Slate Run west of the railroad. The site has been surface collected only.

Raccoon Farm Earthworks: Vicinity of Milan [18,ESE] (E-32)

The Raccoon Farm Earthworks, 1½ miles west of Milan, was surveyed by Dr. Raymond Baby in 1966.

South Bass Island Site #1: Vicinity of Put-in-Bay [16,NNE] (0-15)

This Middle Woodland habitation site was excavated by the University of Toledo.

South Bass Island Site #2: Vicinity of Put-in-Bay [16,NNE] (0-16)

This site was excavated by D. Stothers, University of Toledo.

Stone Mound: Kelleys Island [17,NE] (E-27)

Stone Mound, on the northeast shore of Kelleys Island, is probably an Erie mound.

Taylor Village Site: south of Huron [20,ESE] (E-30)

The Taylor Village Site located on the Huron River 3½ miles south of Huron was excavated by Grunman in 1930. His field notes are available at the Ohio Historical Museum.

Three Mounds: Perkins Township [15,E] (E-45)

These mounds are located north of Bogart Road on Plum Brook.

Village and Burial Sites: Near Fort Seneca [19, SW] (SE-3)

These sites are located 6 miles north of Tiffin on the Sandusky River.

Village Site: Wilmer [13,E] (E-41)

This Indian site is located at Wilmer in Perkins Township.

Wickert Mound: Ballville Township [13,SW] (SA-11)

This 25-foot high mound was excavated in 1907 by Ralph Wickert and Harry Flumerfelt.

Historical and Archaeological Landmarks
Located Within 20 and 30 Miles of the Site

Betschman Site: Norwalk [21,SE] (H-14)

The site is located on West Main Street, Norwalk. Surface collections have been made at this ancient Indian village.

Earthwork: 3 Miles South of Tiffin on Honey Creek [28,SW] (SE-6)

Earthwork: 2 Miles Northwest of Bloomville On Honey Creek [26,SSW] (SE-7)

First Congregational Church: Florence [28,ESE] (E-23)

This church, built ca. 1840 in Greek Revival style, is an excellent example of the early Western Reserve-Firelands church. It qualifies for the National Register.

Genoa Town Hall: Genoa [23,WNW] (O-22)

Located on the corner of Main and Sixth Streets, this 1886 vintage building is an excellent example of Victorian architecture. It qualifies for the National Register.

Great Lakes Museum: Vermilion [29,E] (E-49)

This building, located at Perry Street at the waterfront in Vermilion, is the old Wakefield Mansion now used as a museum of Great Lakes History.

Historic Indian Campsite: Vicinity of Huron [21,E] (E-36)

An Indian campsite is located 2 miles south-southwest of Huron on the east bank of the Huron River.

Indian Burial Site: Bascom [27,SW] (SE-9)

Indian Village Site: Vicinity of Tiffin [27,SW] (SE-5)

This site is located 2 miles south of Tiffin on Honey Creek.

Indian Village Site: 1 Mile South of Melmore on South Bank, Honey Creek [30,SSW] (SE-8)

Mound: West of Trowbridge, Benton Township [22,NW] (0-19)

Reno Beach Excavations: Reno Beach [25,NW] (L-1)

These excavations have been conducted by the University of Toledo.

Three Mounds: Vicinity of Tiffin [26,SW] (SE-4)

These three mounds 2 miles southeast of Tiffin on Rock Creek are burial mounds.

Historical and Archaeological Landmarks
Located Within 30 and 45 Miles of the Site

Fitchville Cemetery: Fitchville [33,SE] (H-15)

The Fitchville Cemetery was excavated in 1910 and reburied.

Harbor View Excavations: Harbor View [33,NW] (L-2)

These excavations have been conducted by the University of Toledo.

GEOLOGY

GEOLOGICAL CHARACTERISTICS OF THE SITE

Bedrock

The bedrock underlying the Site is consolidate sedimentary rock deposited during the Paleozoic period when the entire area was inundated. These sedimentary rocks have been folded into a broad anticlinal structure called the Cincinnati Arch. The axis of the arch passes along the western boundary of the Sandusky watershed. The arch is composed primarily of limestones of the Mississipian, Devonian, and Silurian ages (in order of decreasing elevation and hence increasing age). The bedrock involved in this fold dips east and west away from the axis.

Outcrops of these various limestones are distributed from Mississipian in the southeastern parts of the region to Silurian along the western boundary of the Sandusky Basin as shown in Figure 8.

The Niagaran formations of Silurian age are predominately dolomites and limestones with interbedded shales. The blue-gray crystalline dolomite and limestones are quite dense and fine-grained.

The deposition of the Monroe Group began during Silurian and continued into Devonian time. Typically dense dolomite and limestone are the predominant rock type, but thin-bedded anhydrite and shale are also present. The upper part of the Monroe Group, the Cayugan Series, contains gypsum and salt.

The Devonian rocks may be divided into two groups. The Columbus and Delaware Formations are composed of limestone with chert and small amounts of fine sand and clay-sized material. The upper Devonian material of the Ohio and Olentangy Groups consists of gray to black carbonaceous and argillaceous shale with minor zones of siltstone.

The Mississipian rocks consist of shales and sandstones with minor amounts of conglomerate. The sandstones and conglomerates have a high porosity and usually make excellent farm and domestic aquifers if not contaminated.

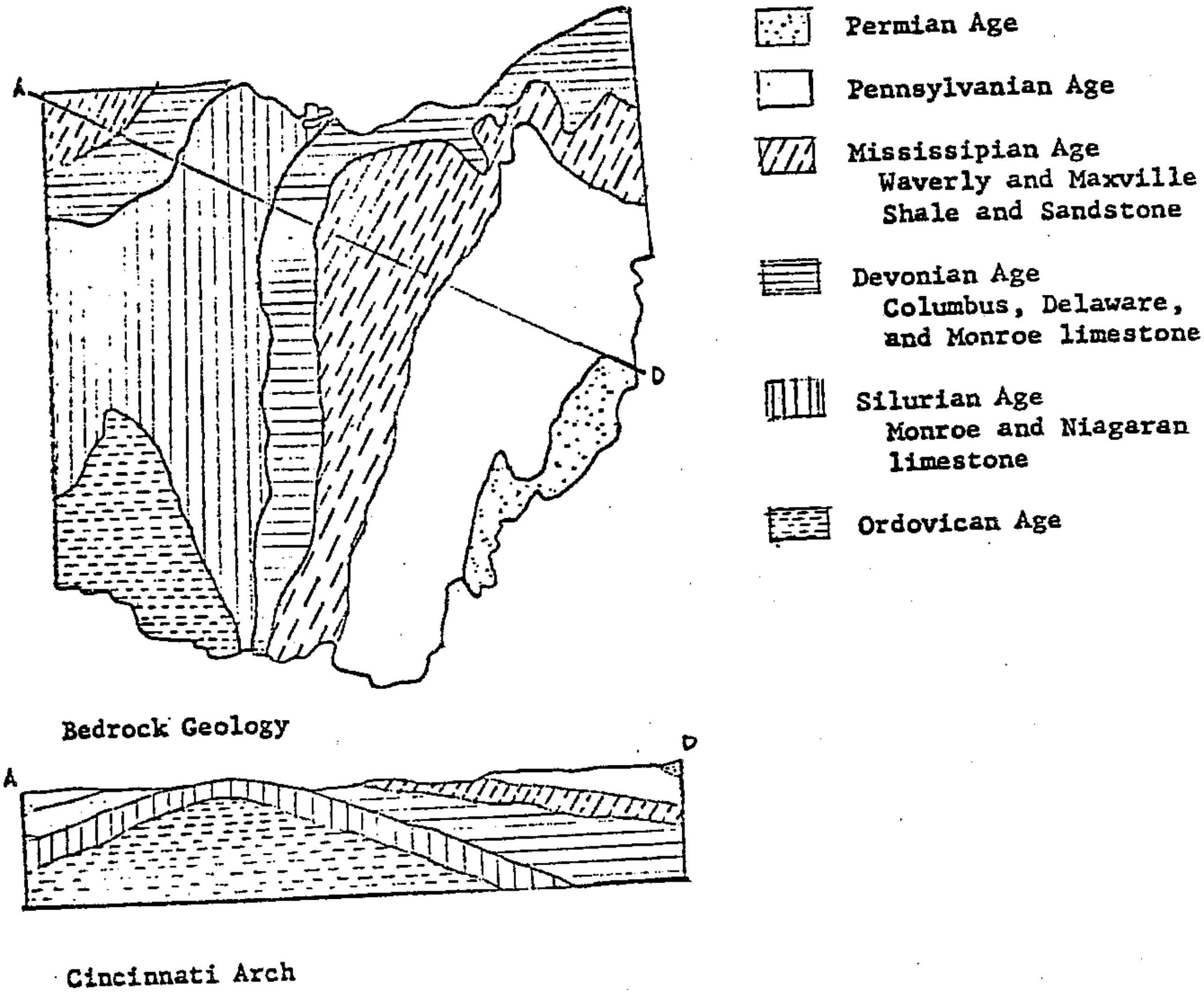


FIGURE 8. BEDROCK GEOLOGY OF OHIO

In two places (Crystal Rock, five miles east of the Site and Put-in-Bay on South Bass Island) collapse-type caves apparently made by settlement caused by solution of underlying gypsum are known, but these appear to be localized. The chances of encountering such a feature at the proposed power plant Site are very small. Chemical analysis of the bedrock (Stout, 1941) from near Gypsum on the north shore of Sandusky Bay are given in Tables 3 and 4.

Topography of the buried bedrock surface (Figure 9) reveals buried valleys to the east and west, but only somewhat irregular buried upland at elevations of 520-530 feet under the Site (Carman, 1927, 1957; Stout, 1941; Shaffer, 1951; and Forsyth, 1971).

Surficial Materials

Lying above the bedrock is a layer of glacial till about 40-foot thick overlain along the Sandusky Bay shore by about 20 feet of lacustrine (lake) clay. Thickness of the entire section of surficial materials is thus about 60 feet as shown in Figure 9.

The till, like all other northwest Ohio tills, is compact and calcareous and is composed dominantly of clay and silt with a small amount of sand and pebble-sized material and rare boulders scattered throughout it. The till is saturated with as much water as its compact clayey nature will permit.

Between the till and the bedrock in places is a thin zone, generally about 5-foot thick (though locally increasing to as much as 10 to 12 feet), which is called variously by drillers "sand and gravel" or "broken rock". This zone is apparently a combination of broken fragments of bedrock, meltwater-washed sediments, and/or other periglacial-type materials which is quite permeable in some places and almost completely impermeable in others. Where it is thick enough and permeable enough, this zone carries water which can be tapped by wells. In such places near the Site, the water in this zone is under pressure, perhaps being related to the water in the series of springs called blue holes, one of which (Miller Blue Hole) lies less than a mile southeast of the Site.

TABLE 3. CHEMICAL ANALYSIS OF BEDROCK IN THE VICINITY OF THE SITE

Silica, SiO_2	6.50
Alumina, Al_2O_3	1.65
Ferric oxide, Fe_2O_3	0.12
Ferrous oxide, FeO	0.28
Pyrite, FeS_2	< 0.01
Magnesium oxide, MgO	18.42
Calcium oxide, CaO	25.72
Strontium oxide, SrO	3.43
Barium oxide, BaO	< 0.01
Sodium oxide, Na_2O	0.04
Potassium oxide, K_2O	0.10
Water, hydroscopic, H_2O-	0.19
Water, combined, H_2O+	0.40
Carbon dioxide, CO_2	40.35
Titanic oxide, TiO_2	0.07
Phosphorus pentoxide, P_2O_5	0.07
Sulphur trioxide, SO_3	2.70
Manganous oxide, MnO	0.035
Carbon, organic, C	0.08
TOTAL	100.155 %

TABLE 4. MINERAL COMPONENTS OF BEDROCK IN THE VICINITY OF THE SITE

Sericite, $(K,Na)_2O.3Al_2O_3.6SiO_2.2H_2O$				1.33
Kaolinite, $Al_2O_3.2SiO_2.2H_2O$				2.86
Celadonite, $(Fe, Mg, K_2, Na_2)O.2SiO_2H_2O$: $Fe_2O_3.6SiO_2.3H_2O$				0.26
Quartz or free silica, SiO_2				4.40
Limonite, $2Fe_2O_3.3H_2O$				0.12
Pyrite, FeS_2				0.00
Rutile, TiO_2				0.07
Apatite, $3CaO.P_2O_5$				0.15
Anhydrite, $CaO.SO_3$				0.09
Celestite, $SrO.SO_3$				6.08
Dolomite	Main Components	$MgO.CO_2$	38.52	84.21
		$CaO.CO_2$	45.69	
	Parts in solid solution	$FeO.CO_2$	0.37	
		$MnO.CO_2$	0.055	
Water, hydroscopic, H_2O-				0.425
Hydrocarbons, C_nH_{2n+2}				0.08
Unbalanced parts (excess CO_2, H_2O)				−0.11
TOTAL				100.155 %

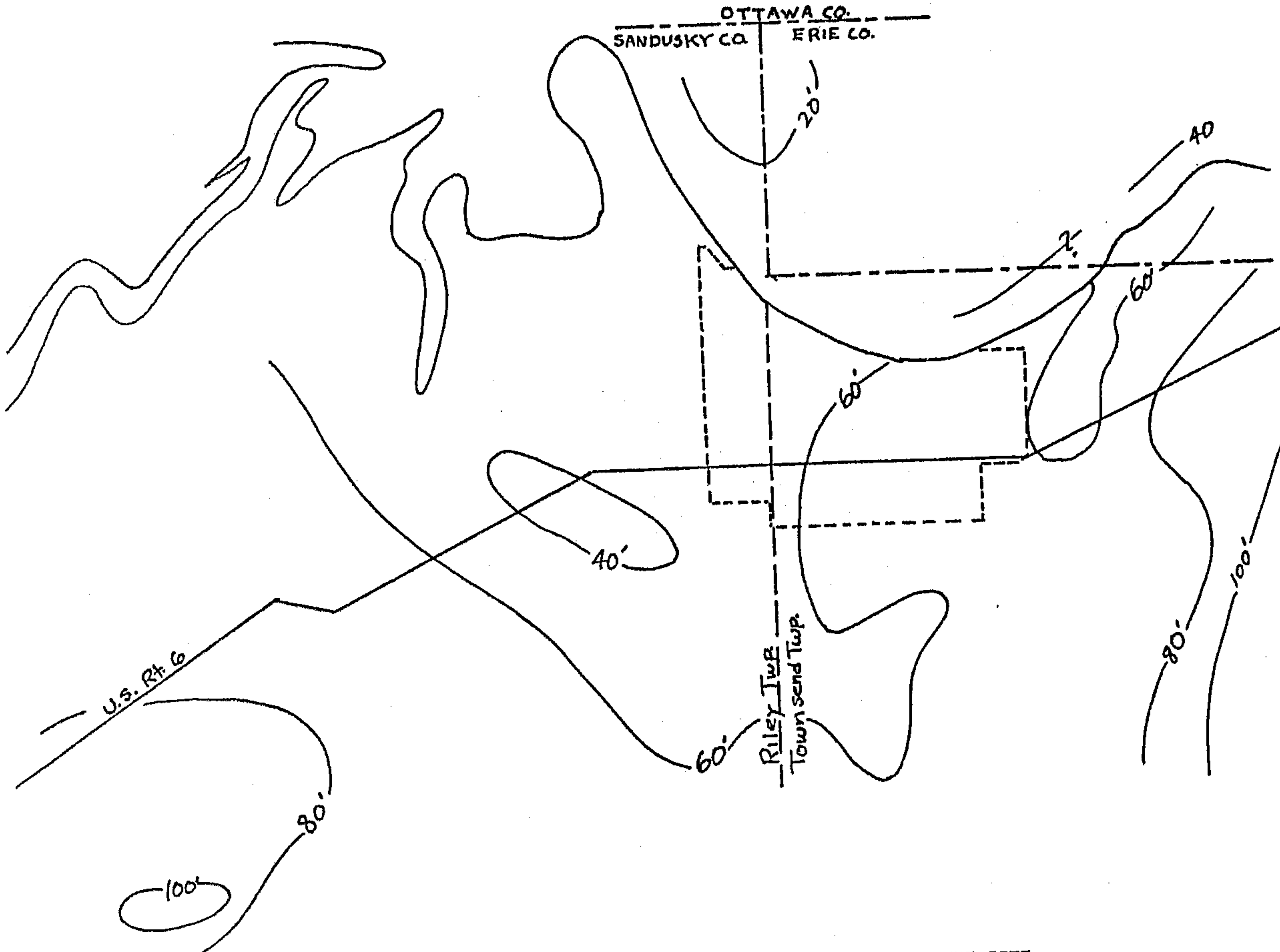


FIGURE 9. DEPTH TO ROCK (THICKNESS OF SURFICIAL MATERIAL) IN THE VICINITY OF THE SITE

Above the till is about 20 feet of lacustrine clay, which is the material present at the surface throughout the Site area. The entire five-foot exposure along the low wave-cut cliff west of Bayshore is composed of this material which is vulnerable to wave erosion. The material is composed dominantly of silt and clay with the latter predominating and has very faint laminations. It is weak and, at the surface where it is exposed to the air, granulates or tends to crack and break into small pieces. In addition, larger cracks form which may extend as deep as two feet down into the clay. This combination of granulation and cracking makes the clay susceptible both to erosion by waves and to attack by frost action and rain wash. In addition, the clay is reported to slake, that is, after having been thoroughly dried in the sun, the clay, if it becomes completely soaked with water again, will break down into a mass of poorly cohesive material (Shaffer, 1951).

The soil at the surface of this deposit is the Toledo silty clay (Redmond et al, 1971) originally called the Newton silty clay. This soil, which appears dark colored at the surface and mottled brownish to dark gray in the subsoil, is characterized by its poor drainage. Water completely saturates the clayey material composing this soil, but because of its tight nature, does not readily drain out. For this reason and also because of the extreme flatness of the ground and the low height of the area above Sandusky Bay, the soil is very poorly drained, often having small ponds of water standing at the surface for extended periods of time. The organic content is high and the tilth is generally good. Where the land has been satisfactorily drained the soil is very productive. For normal construction uses the soil is marginal because of its clayey plastic nature, its unstable character, its poor drainage, its high shrink-swell potential, and its high corrosion potential for steel (Redmond et al, 1971; Moseley, 1905, 1906; Shaffer, 1951; Corps of Engineers, 1953; and Erie Regional Planning Commission, 1967). However, suitable engineering design can circumvent many of these problems.

Surface Topography

The land surface south of Sandusky Bay is very flat, rising very gradually to the south away from the Bay. Along the shore the land surface is almost at the level of the water so that, at times of especially high water (such as now in 1972-73), flooding and erosion are extensive. A shore of the Bay, and the fact that the greatest storms come mainly from the northeast so that the winds which have gained strength by blowing straight across the whole of central and eastern Lake Erie blow directly into the mouth of Sandusky Bay resulting in tremendous erosion. Because of the orientation of the Bay's shores in comparison with the long axis of Lake Erie it is especially the shore by the Site where erosion has been greatest. Locally, where rocks, trees, fallen tree trunks, or human construction of some kind provide a little strengthening of the shoreline, the shore has not been eroded so fast resulting in small promontories at each edge of the Site suggesting that adequate protection from shore erosion would not be difficult to accomplish here. The rise in water level in the Bay during northeast storms (seiche) can be as much as 5 feet, but waves rarely get bigger than 2 or 3 feet because of the restricted size of the mouth of the Bay and its shallow waters so that shore erosion design need not be higher than 7 or 8 feet.

The combination of rising water levels in Sandusky Bay and northeast storm winds, winds that are especially effective when water levels are higher, has almost destroyed many islands and much Bay-shore mainland in the western end of the Bay. Islands such as Eagle Island and Squaw Island have been completely or almost completely destroyed, and many marginal mainland areas that were once farmed are now marshes or flooded land (effects recorded by Moseley and shown by photographs of old maps and of the modern shoreline by Lowden).

Flooding will not get significantly worse in the next 50 to 100 years at the Site; the land is already very low and swampy and will simply remain that way. Wave erosion, however, unless checked, will cause considerable loss of land; the unusually big storm of November, 1972, produced an estimated retreat of the shoreline in this area of about 20 to 30 feet. Unless erosion-control structures are built in the area adjacent to the Site, destruction of the vulnerable clay to either side of the Site might result in the formation of a peninsula or even an island in the Bay, which will increase the strength of wave erosion here. This could be alleviated by additional erosion-control measures (Moseley, 1905, 1906; Moore, 1948; Corps of Engineers, 1953; Lewis, 1969; and Lowden, 1969).

5-foot bluff (called 8 feet by the Corps of Engineers in 1953 when the lake was about 2 feet lower) is present along the shore. Back from this bluff the slope of the land up to the south is only about 8 to 10 feet per mile. Because of the flatness of the land, drainage by field tile and open ditches has been used almost everywhere (Moseley, 1905, 1906; Shaffer, 1951; and Corps of Engineers, 1953).

Sandusky Bay Topography

The bottom of Sandusky Bay is very flat and water depths are shallow. The bottom slopes out away from the shore at a rate of 4 to 8 on 100 for the first 100 feet and then, farther offshore, becomes more gentle with a slope of only 0.5 to 1.0 on 100 (Corps of Engineers, 1951).

The material on the surface of the Bay basin is soft lake mud material that was originally sediment suspended in the water and is easily resuspended. Sediment is generally 4- to 6-foot thick, almost as thick as lake water standing above it. Farther out in the Bay some of the sediment is part of the estimated 30,000 tons of material brought into the Bay and Lake each month by the Sandusky River.

Beneath the mud is very compact clay, so compact that bottom-sampling devices which penetrate the mud with ease can be forced into it only with the greatest difficulty. This clay is lake clay underlain at about 40 feet by clay-rich glacial till (Moseley, 1905, 1906; Corps of Engineers, 1951; Lake Erie Navigational Chart 39 published by the Lake Survey Center; and 1972 Ohio Geological Survey unpublished sampling data).

Shore Erosion

Erosion is most evident along the south shore of Sandusky Bay where measurements show that the shoreline had retreated as much as 1,150 feet between 1820 and 1951, an average rate of retreat of more than 9 feet per year. This very fast rate of erosion is a product of two factors: the very soft, easily eroded lacustrine clay forming the south

HYDROLOGY

WATERSHED ANALYSIS

General Characteristics

The Sandusky and Pickerel Creek watersheds are situated in the northcentral part of Ohio. They border on Sandusky Bay to the north which forms part of Lake Erie. The Sandusky watershed is far larger than the Pickerel Creek watershed. The drainage area of Pickerel Creek is approximately 3.26 percent of the drainage area of the Sandusky River. The Pickerel Creek Basin lies almost entirely in Sandusky County while the Sandusky Basin extends through Sandusky, Seneca, Wyandot, and Crawford Counties.

A large portion of these watersheds lies within the lake plain of ancient Lake Maumee. This plain is crossed to the southeast by three narrow, nearly parallel ridges representing shore deposits laid down at successive stages of the receding glacial lakes known as Lakes Maumee, Whittlesey, and Warren (in chronological and volumetric order).

A difference in drainage characteristics is apparent between the upper and lower Pickerel Creek watershed. The lower portion of the basin exhibits some parallelism in its natural drainage and man-made ditches are prevalent. In the upper basin there is a noticeable lack of drainage with the exception of a few man-made ditches.

The upper basin, with its definite lack of any developed surface drainage, must exhibit better subsurface drainage than the lower portion. This section of the basin is underlain by limestone and dolomite covered by only a few feet of glacial till. The many depressions in this area of the watershed seem to indicate that most of the incoming precipitation is delivered directly to the groundwater. The limestone and dolomite can transfer this water through fractures, solution channels, and along bedding planes providing adequate, although chemically hard, water to areas in the lower basin.

The subsurface hydrology is by far the most important in this basin and produces several very interesting effects. Where the greatest amount of water enters the bedrock aquifer, in the upper basin, the elevation is much higher than the lower basin areas. This leads to artesian conditions in many wells penetrating this aquifer in the lower portion of the watershed. Miller's Blue Hole is a natural spring which lies on the boundary of the Pickerel Creek watershed. It is fed from the above-mentioned aquifer but the water is then diverted out of the basin through an apparent man-made channel. The fact that Pickerel Creek is a perennial stream is also due to the underlying artesian conditions of the groundwater in the upper basin.

Instantaneous Unit Hydrograph

In order to analyze the hydrologic performance of the Sandusky River Basin it is necessary to derive an outflow hydrograph for the watershed. One method that has been applied is the Instantaneous Unit Hydrograph Method. This procedure synthesizes a unit hydrograph of an instantaneous rainfall by routing a time-area histogram through the basin.

To derive the required time-area histogram, the basin is first divided into areas of equal flow time by equal time contours known as isochrones. This is accomplished by computing the flow time from various points along the main stream and its tributaries to the basin outlet. A formula, proposed by Kirpich for watersheds with an area greater than fifteen square miles, is used for computing the time of concentration at various points. This formula is

$$T_c = 0.0078 \left[\frac{L}{\sqrt{S}} \right]^{0.77}$$

where: T_c is the flow time in minutes

L is the flow length in feet, and

S is the channel slope in feet per foot

Taking the length from topographic maps, the isochrone map (Figure 10) was constructed when equal flow times were plotted on the streams and lines were drawn connecting these points. The total time of concentration for the basin was found to be 120 hours and since a six-element isochrone was desired the time interval was chosen as 20 hours.

After completion of the isochrone plot, the area between each contour was planimetered to determine its area. These are expressed as a fraction of the total basin area in Table 5.

TABLE 5. WATERSHED CONTOUR AREAS

Time (hrs)	Area (sq mi)	Fraction of the Total Area
0 - 20	81	.057
20 - 40	304	.214
40 - 60	271	.191
60 - 80	225	.158
80 - 100	221	.156
100 - 120	317	.224

Since the input has two distinct maxima, it is likely that the associated hydrograph will have two maxima. Their occurrence, however, will probably be lagged due to the attenuation of the flood wave in the channel storage. This resulting hydrograph would, however, represent an instantaneous input over the entire basin. Since the basin is so large (1,420 square miles) and the time of concentration so great (120 hours or 5 days) it is unlikely that there will ever be a storm over the entire basin at the same time such that each area could contribute to form the derived hydrograph shape.

It can be seen then that one hydrograph could not be representative of all climatological situations over the basin. Storm characteristics such as duration, time-intensity pattern, and areal distribution will effect the shape.

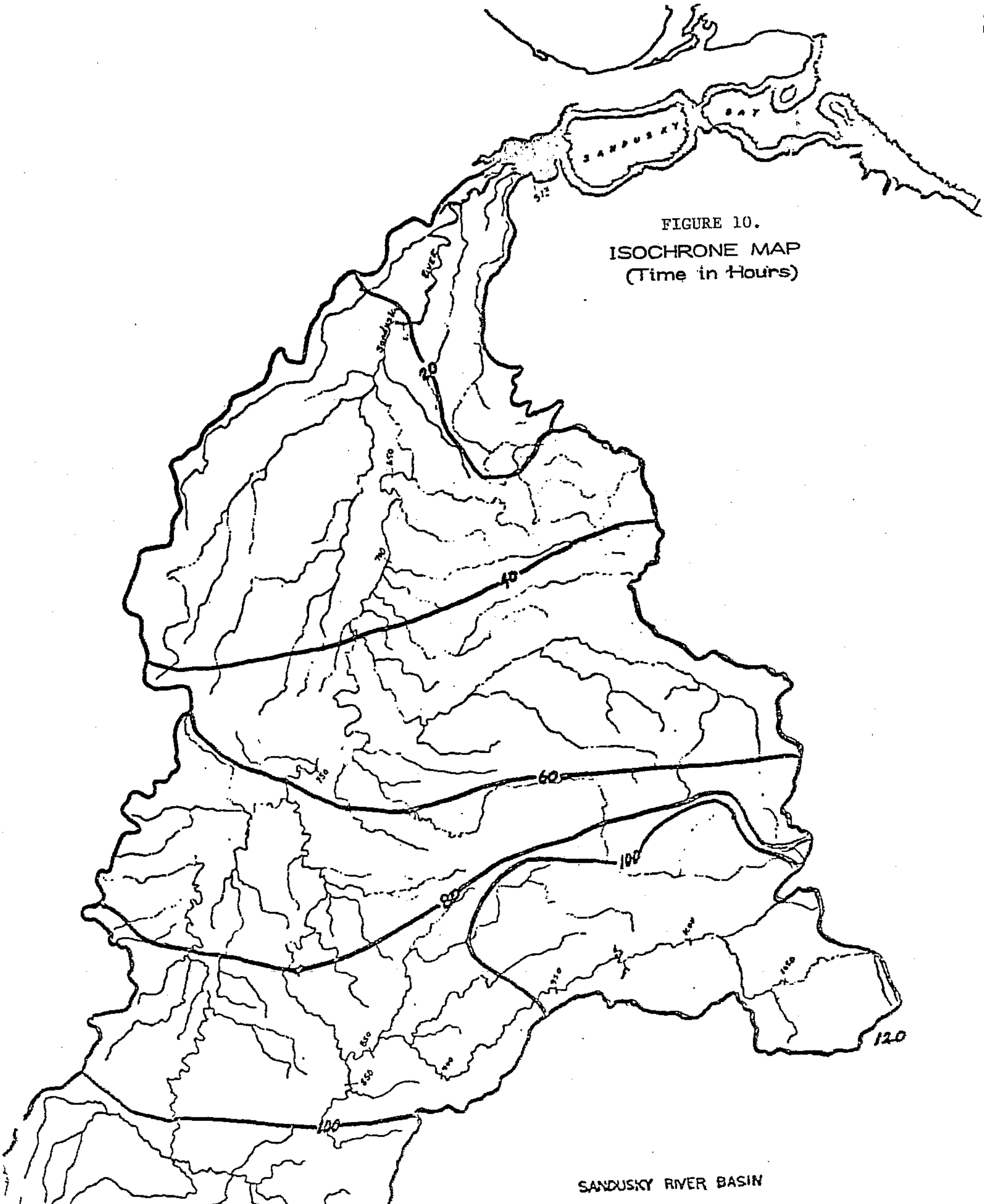


FIGURE 10.
ISOCHRONE MAP
(Time in Hours)

SEICHE ACTIVITY

Verber (1959) conducted several experiments to determine empirically the applicability of the Merian Formula to Lake Erie. For his first experiment he used a rectangular tank of uniform depth. After initiating a seiche with a glass plate he timed the period and found it to be in agreement with the period calculated by the Merian equation. He then modified the end and side slopes and again found the Merian formula to yield the same quantity as the observed results. In his last experiment he modified the shape of the tank to simulate the Lake Erie Basin. He found from visual observations that the western basin of the simulated lake did not actually participate in the seiche. The Merian formula did verify his assumption. The only length that yielded the proper period of oscillation was the length excluding the western basin.

The reason that the western basin may not participate in the longitudinal seiche is the constrictions in line with Point Pelee and the shallowness of the basin. The western basin may act as a runoff for the rising water during a seiche. As the water rises on the western end it surges through the southern channel then the water recedes and pours out of the western basin through the northern channel. This creates a circular motion in the western basin and deposits sediment on the east side of Point Pelee.

The major rise and fall of Sandusky Bay is due to the primary seiche on the longitudinal axis of the lake. There is a secondary rise and fall within the individual basins which can be attributed only to the seiches within the respective basins.

Verber (1959) also made a physical model of the Sandusky Bay to determine whether or not a seiche could act over the entire basin. He found that at no time could a seiche started on one side propagate to the opposite side. This is due to the constriction at the middle. However, the water did tend to pile up at the constriction causing currents that in actuality sometimes attain a velocity of five miles per hour through the constriction caused by bridge abutments.

Consequently, even if the resonant period of the outer basin did occur it may not affect water levels in the inner basin. Additional investigations, including the acquisition of empirical data, will be required to gain insight into the response of the western basin of Sandusky Bay to seiche activity in Lake Erie.

The level of Lake Erie (and therefore the level in Sandusky Bay) varies through the years, depending on the overall amounts of precipitation and rates of evaporation throughout the Great Lakes watershed; at the present time (1972-73) Lake Erie is at an all-time high. Judging from past records published by the Corps of Engineers' Lake Survey Center in Detroit, the level of the lake should begin to lower in a few years reaching a low level in the cycle about 1985 or so, and then it should rise again, reaching a maximum height about 1994. Whether that height will be as high as the present level cannot be predicted, but the possibility must be considered. Superimposed on the overall pattern of lake-level cycles are smaller variations related to season, rainy spells, etc.

There is also a very slow rise of water levels in the Lake and Bay as a result of very gentle tilting of the region produced by removal of the heavy weight of the Ice Age (Pleistocene) glaciers. The heavy ice weighed the land down, especially to the north and northeast in Canada where it was thicker; melting of the ice has permitted the land to rise. These responses go on very slowly, however, with considerable lag after the act which triggered them. Most of the postglacial rise appears to have taken place already, but it is still going on very slowly. The present rate of uplift at the east end of the Lake Erie Basin, the position of the outlet which, of course, also controls the level of the Lake is extremely slow having been estimated at rates from 0.5 to as much as 2 feet per century (Moseley, 1905, 1906; Corps of Engineers, 1953; and Lewis, 1969). Clearly, therefore, though this uplift of both the outlet and the Lake and Bay is indeed going on, its rate is not enough to produce any serious flooding problems in the next 50 to 100 years.

There are no strong currents in Sandusky Bay. Gentle inflow of water from the Sandusky River produces a very slow movement of water toward Lake Erie, but drifting of marked bottles, even submerged ones (released by Moseley), appeared to respond only to the effects of the wind. Littoral drift along the shore adjacent to the Site is very weak, but is toward the west, apparently as an eddy off the main Sandusky River water flow to the east. None of the current is strong enough to create any shoreline erosion problems or even to stir, to any observable extent, the soft mud on the bottom of the Bay. The same cannot be said for the effects of strong northeast winds which commonly stir up this soft mud and greatly increase the turbidity of the Bay water.

GROUNDWATER

Groundwater occurs in both dolomite bedrock and the clay-rich surficial materials (lacustrine clay and glacial till), but it cannot readily be removed from the latter.

In terms of obtaining a water supply from wells, water is available from the bedrock; present wells close to the Site provide approximately 15 gallons per minute from depths of 60 to 75 feet. Some of this water comes from shallow aquifers in the rock, but much is derived from the "broken-rock" zone. Greater amounts of water, reportedly up to 300 gallons per minute (Walker, 1962), are available from depths of several hundred feet in the rock, though this water in some places may contain considerable amounts of sulphur.

All water here is artesian and in almost all wells is flowing at the surface. It is possible that the extra pressure which produces such a high percentage of flowing wells may be a result of water coming from springs like the Blue Hole and welling up through the bedrock and into the "broken-rock" zone from which many of the local wells derive their water. In only a few places is this zone so thin and/or so impermeable that it does not contain much water.

Water quality reported from wells in the immediate area of the Site is good, though the water is hard (as is the water of Sandusky Bay). Sulphur water, a problem elsewhere in northwest Ohio, has not been reported for this part of Sandusky County, though it is possible that deep drilling here (to depths of several hundred feet) might encounter it as happens elsewhere in northwest Ohio. More critical, in terms of water quality, is the belt of contaminated water flowing northward through the bedrock from the sewage-disposal wells of Bellevue to the south. Only recently has this town built a sewage treatment plant. Before that sewage of both individual homes and the entire municipality was disposed of in wells leading down into the cavernous limestone below the town, the same area that, in part, serves as a watershed feeding the Blue Hole. The distribution of the groundwater contamination produced by this disposal has been mapped (Figure 11); it lies entirely east of the Site, its western margin extending just into the eastern edge of Townsend Township. Now that Bellevue has a sewage treatment plant, it is highly unlikely that such contamination will ever spread as far west as the Site.

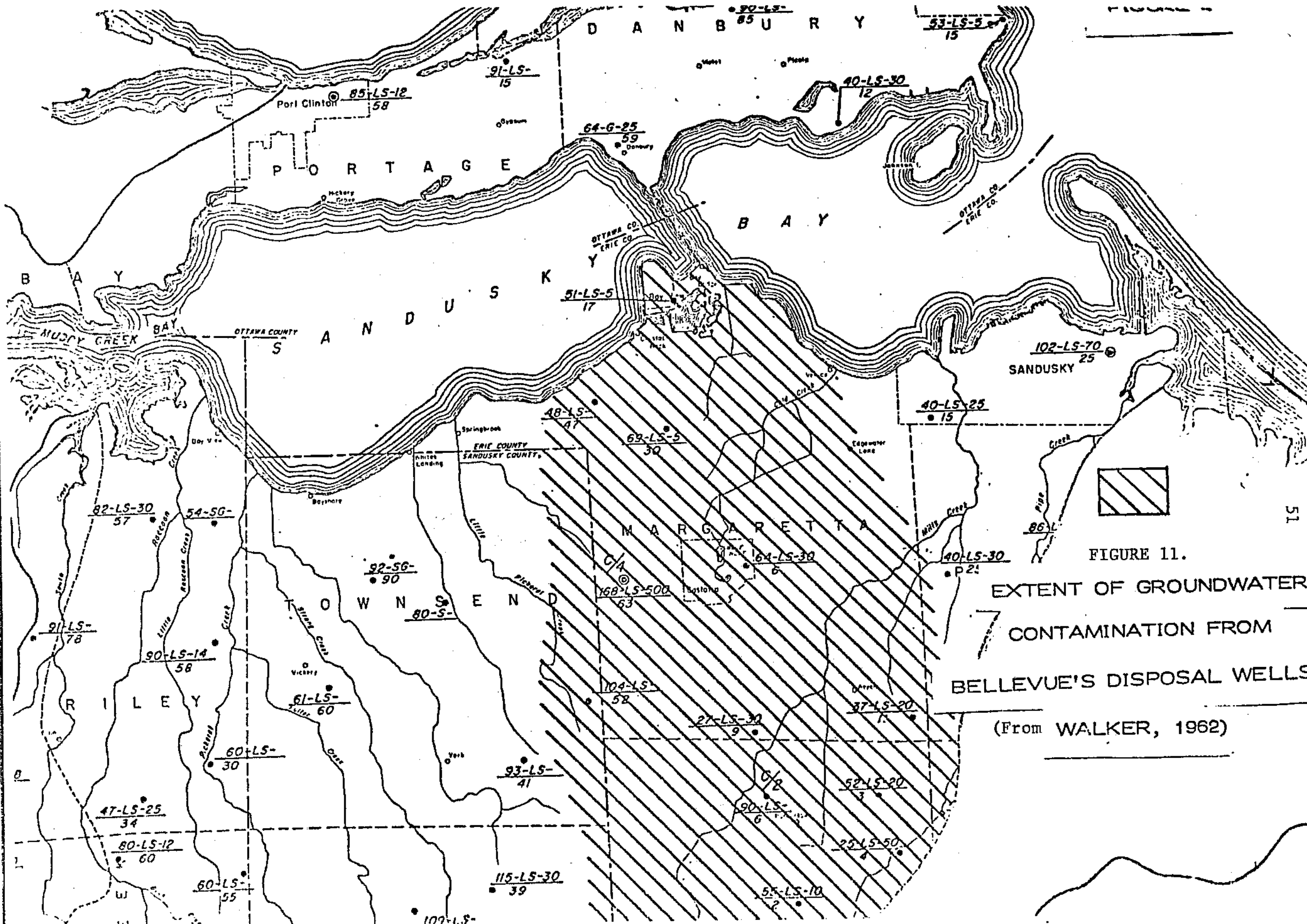


FIGURE 11.

EXTENT OF GROUNDWATER CONTAMINATION FROM BELLEVUE'S DISPOSAL WELLS

(From WALKER, 1962)

Although there has been no extensive groundwater study done on the Site itself, many regional studies have discussed portions of the area which may give a helpful insight to the area's general groundwater picture. An important consideration when undertaking any groundwater study is the surface water characteristics, such as drainage patterns, stream hydrographs, and seepage runs. These studies can be instrumental in determining permeability rates and recharge areas. It was for this reason that reference is made to published works on the Sandusky River, the Portage River, Pickerel Creek, and other tributaries of Sandusky Bay.

There are pronounced buried valleys which run through the Site and out into the Bay. Another buried valley occurs just east of the Site. These valleys, depending on the character of their fill, are potential areas of high groundwater yield. In this case, previous studies have indicated only variable amounts of sand and gravel in these valleys, most of the fill being composed of lacustrine clay. Therefore, only locally high yields in the fill are expected.

Former beach ridges are located northeast of the city of Clyde, Ohio. They run northeast-southwest through the city. In the area of these beach ridges are located sand and gravel deposits. These permeable deposits, which underlie a thin layer of lake clay, are rather loose in texture and therefore, transmit water readily to the underlying rocks. Recharge for the dolomite bedrock is derived from precipitation falling directly on this sandy area. Because of the flow of underground water toward the bay, the recharge water from the Clyde-Bellevue area flows northward into the Site area (the general assumption that the water flows north shall be substantiated when additional data become available). So recharge for the dolomite on the Site comes from northward flowing water from the beach ridge recharge area, and also from areas on the Site where the bedrock is covered by only a thin veneer of glacial drift.

The beach deposits noted in the above discussion is probably the reason accounting for the fact that the Clyde-Bellevue area has no surface drainage. The deposits, which are very permeable and thus allow water to infiltrate easily, are formed by the beach ridges of three former glacial lakes. These lakes are known as Warren, Whittlesey, and Maumee. In this particular area, the proximity of the three beaches and their permeable deposits accounts for the absence of surface drainage.

A considerable amount of time has been spent on the hydraulic properties of the Site with particular attention given to an estimation of the transmissibility of the dolomite aquifer. The transmissibility of an aquifer is a measure of the movement of water through the entire thickness of the aquifer. The importance of transmissibility is that it serves as a basic tool in determining the maximum yield of an aquifer, in case development of the Site required groundwater to supplement its supply from the shallow Sandusky Bay. Also, determination of transmissibility is required to predict the effect of pumpage on other wells and springs in the vicinity.

The best way to determine transmissibility is by a pumping test. This is a test of the response of an aquifer when pumping water out at a particular rate. Unfortunately, there are no pumping tests on file with the Ohio Division of Water for any wells on the Site. The only information available to estimate the transmissibility for the Site area are some specific capacity data from some wells just outside the area. The method used for the transmissibility approximation from the specific capacity was taken partly from Ogden (1955). It involves a rearrangement of Theis' non-equilibrium equations for a non-leaky artesian aquifer.

Theis' equations

$$s = \frac{114.6Q\ W(u)}{T} \qquad \text{where} \qquad u = \frac{1.87r^2S}{Tt}$$

are rewritten as:

$$T = \frac{114.6Q\ W(u)}{s} \qquad \text{and} \qquad T = \frac{1.87r^2S}{ut}$$

Then the two above expressions for T are equated and solved for uW(u).

$$uW(u) = \frac{1.87r^2Ss}{114.6Qt}$$

Where Q = discharge, in gpm

s = drawndown, in feet

T = coefficient of transmissibility, in gpd per foot

S = coefficient of storage, fraction

r = distance from the pumped well, in feet

t = time after pumping started, in days

W(u) = well function

All variables on the right-hand side of the equation can be determined except S, which is assumed. After uW(u) has been determined, a table and/or graph of uWu(u) versus u is constructed from previous tables of u versus W(u) and then a corresponding u is determined; u is substituted into the following equation and T is calculated.

$$T = \frac{1.87r^2S}{ut}$$

The value determined for T may or may not be a good estimate. In this particular case, after comparison with known T's in the area (values obtained from the Ohio Division of Water) it was found that by use of this method, T is consistently about 65 percent too large. This value of 65 percent was determined by finding the T of wells in the general area of the Site from information at the Division of Water. When this T was compared with the T found from the above method, it was noted that the T value calculated was about 65 percent larger than the value obtained by the Division of Water. Since the closest well to the Site (about 10,000 feet southeast of the Site) is located in the same area as those above, the T should then be multiplied by 0.65 to obtain a value corresponding to the work of the Division of Water. This fraction is a correction factor for the area's hydraulic characteristics in reference to this particular method. The following calculation is a calculation for T from specific capacity data on a well 10,000 feet southeast of the Site:

$Q = 60$ gpm

$s = 17$ ft

$t = 2880$ min. or 2 days

$r = 0.33$ ft

$S = 0.0002$ (assumed value for artesian conditions)

$$uW(u) = \frac{1.87(.33)^2(.0002)17}{114.6(60)2} = 4.7 \times 10^{-8}$$

by the graph $u = 2 \times 10^{-9}$

T then is equal to $\frac{1.87(.33)^2(.0002)}{(2 \times 10^{-9})2} = 10,000$ gpd per foot

Actual T, 10,000(.65) gpd per foot

Walton (1970) gives a formula which relates T to the specific capacity, so this gives a means to check the computed value for T. The equation is as follows:

$$\frac{Q}{s} \quad \frac{T}{264 \log \frac{Tt}{2693r\ S} - 65.5}$$

$\frac{Q}{s}$ specific capacity, in gpm per foot

Q discharge, in gpm

s drawdown, in ft

T coefficient of transmissibility

S coefficient of storage, fraction

r radius of well

t time after pumping began, in min.

ECOLOGY

TERRESTRIAL ECOLOGY

Vegetation

Existing Vegetation

The portion of the terrestrial field work designed to assess the existing dominant vegetation is largely completed. This work has included the statistical analysis of the tree canopy and understory vegetation of the woodlots on the Site.

Location of the woodlots is shown on Figure 12. Quantitative sampling was accomplished in those areas numbered 1 through 10 on Figure 12. Qualitative information in the form of notes taken on apparent dominants and/or any unusual or flowering species was taken in those areas numbered N1 through N10. In areas where quantitative information was obtained a transect was laid out to a maximum length of 100 meters. Several lengths were shorter since many woodlots were not of sufficient size to contain this length. Widths of the transects were usually two meters but was extended to ten meters in one particularly open woodlot (No. 4), i.e., sparse canopy with very few trees. The total size of each sample is reported on the appropriate table (Tables 6 through 15). Within this area all woody plants were recorded as to species location within the unit and diameter if greater than one inch. Herbaceous vegetation for each area was sampled by means of a 1/4-meter quadrat placed at 10-meter intervals along the transect. Data for these areas were recorded to individuals and species.

Statistical analyses of observed terrestrial vegetation patterns were conducted. Frequency, density, dominance, and relative importance of each species in each woodlot were calculated according to various approaches (Oosting, 1948; Phillips, 1959; and Daubenmier, 1968). Expressions in the analyses are as follows:

After plugging in all values, the specific capacity $(\frac{60 \text{ gpm}}{17 \text{ ft.}})$ ends up being equal to 3.3 which is close to what would be expected. The T of 6500 is given additional confidence by observing the transmissibility of a well in Port Clinton, Ohio. It was found to be 6400 by the Division of Water.

Because all of the aforementioned wells were drilled in the Tymochtee dolomite, complication results due to the relatively high solubility of the carbonate rock. If the groundwater usually moves through openings between grains and so results in fairly uniform flow and (if the aquifer's thickness remains constant and there is no loss or gain of water) a fairly uniform T. However, in limestone and dolomite the space between the grains is very small and the water moves along joints and fractures which slowly enlarge due to dissolution. As a result the flow of water through these carbonates is erratic depending on susceptibility to solution, occurrence of joints or fractures, and the length of time of exposure to groundwater movement. Therefore, it is because of the nature of limestone and dolomite that T can vary greatly over very short distances. Great care must be given when estimating T in carbonate aquifers of any size.

Much information is still needed in order to interpret the groundwater conditions of the area. Such data as piezometric elevations, thin sections, chemical analyses, stream hydrographs to determine basin permeability, and, if available, seismic refraction surveys will be helpful for additional detail on groundwater hydrology in the vicinity of the Site and at the Site itself.

TABLE 6. WOODLOT TRANSECT I

Species	Total Count	Percent Density	Percent Frequency	Percent Dominance	Relative Importance
Green & white ash	15	2.16	10.87	73.13	28.87
Black locust	261	45.39	13.04	.00	19.48
Dogwood	155	26.96	15.22	.00	14.06
Silver maple	7	1.22	4.35	16.88	7.48
Hawthorn	25	4.35	13.04	.00	5.80
N. Red oak	4	.70	4.35	9.99	5.01
Red elm	36	6.26	8.70	.00	4.99
Bur oak	11	1.91	8.70	.00	3.54
Eastern wahoo	30	5.22	4.35	.00	3.19
Blue ash	9	1.57	4.35	.00	1.97
Grapevine	2	.35	4.35	.00	1.57
Serviceberry	8	1.39	2.17	.00	1.19
Mulberry	5	.87	2.17	.00	1.01
Black ash	5	.87	2.17	.00	1.01
Chestnut oak	2	.35	2.17	.00	.84

Diversity index = 2.426

Total area = 160 sq. m .

TABLE 7. WOODLOT TRANSECT II

Species	Total Count	Percent Density	Percent Frequency	Percent Dominance	Relative Importance
Dogwood	136	48.75	16.07	2.14	22.32
Pin oak	12	4.30	7.14	54.33	21.93
Silver maple	34	12.19	14.29	19.35	15.27
Red elm	24	8.60	12.50	4.59	8.56
Box elder	10	3.58	12.50	1.46	5.85
Shagbark hickory	3	1.08	3.57	12.65	5.76
Hawthorn	29	10.39	5.36	.00	5.25
Green & white ash	5	1.79	5.36	4.08	3.74
Black cherry	7	2.51	5.36	.41	2.76
Sumac	6	2.15	5.36	.00	2.50
Grapevine	3	1.08	5.36	.00	2.14
N. Red oak	5	1.79	3.57	.76	2.04
Hazelnut	3	1.08	1.79	.23	1.03
Black ash	2	.72	1.79	.00	.83

Density index = 2.609

Total area = 200 sq. m .

TABLE 8. WOODLOT TRANSECT III

Species	Total Count	Percent Density	Percent Frequency	Percent Dominance	Relative Importance
Silver Maple	94	24.74	17.31	54.98	32.34
Green & white ash	184	48.42	17.31	15.82	27.18
Box elder	6	1.58	1.92	18.12	7.21
Sumac	23	6.05	9.62	.82	5.49
Hawthorn	21	5.53	9.62	.00	5.05
Swamp white oak	11	2.89	9.62	.95	4.49
Black ash	18	4.74	7.69	.23	4.22
Pin oak	2	.53	1.92	7.87	3.44
Red elm	7	1.84	5.77	.00	2.54
Grapevine	3	.79	5.77	.00	2.19
Shagbark hickory	2	.53	3.85	.97	1.78
Dogwood	5	1.32	3.85	.00	1.72
Unidentified	2	.53	1.92	.00	.82
Basswood	1	.26	1.92	.24	.82
N. Red oak	1	.26	1.92	.00	.73

Diversity index = 2.340

Total area = 166 sq. m .

TABLE 9. WOODLOT TRANSECT IV

Species	Total Count	Percent Density	Percent Frequency	Percent Dominance	Relative Importance
Pin oak	5	33.33	28.57	37.69	33.20
Bur oak	3	20.00	21.43	16.56	19.33
Swamp white oak	2	13.33	14.29	19.93	15.85
Shagbark hickory	2	13.33	14.29	5.69	11.10
Green & white ash	1	6.67	7.14	7.64	7.15
Walnut	1	6.67	7.14	6.33	6.71
N. Red oak	1	6.67	7.14	6.16	6.66

Diversity index = 2.549 Total area = 1000 sq. m .

TABLE 10. WOODLOT TRANSECT V

Species	Total Count	Percent Density	Percent Frequency	Percent Dominance	Relative Importance
Red elm	85	25.99	26.32	43.71	32.01
Dogwood	166	50.76	23.68	10.33	28.26
Hawthorn	39	11.93	23.68	28.06	21.22
Box elder	32	9.79	13.16	4.58	9.18
Walnut	1	.31	2.63	7.10	3.35
Green & white ash	2	.61	5.26	2.22	2.70
Honey locust	1	.31	2.63	4.00	2.31
Grapevine	1	.31	2.63	.00	.98

Diversity index = 1.817 Total area = 196 sq. m .

TABLE 11. WOODLOT TRANSECT VI

Species	Total Count	Percent Density	Percent Frequency	Percent Dominance	Relative Importance
N. Red oak	9	2.71	9.84	69.41	27.32
Green & white ash	93	28.01	14.75	8.28	17.02
Shagbark hickory	36	10.84	14.75	17.93	14.51
Dogwood	86	25.90	13.11	.05	13.02
Hawthorn	33	9.94	14.75	1.36	8.68
Red elm	28	8.43	8.20	1.97	6.20
Black cherry	15	4.52	11.48	.05	5.35
Eastern wahoo	25	7.53	4.92	.00	4.15
Hackberry	4	1.20	3.28	.32	1.60
Bur oak	2	.60	3.28	.64	1.51
Grapevine	1	.30	1.64	.00	.65

Diversity index = 2.769

Total area = 200 sq. m.

TABLE 12. WOODLOT TRANSECT VII

Species	Total Count	Percent Density	Percent Frequency	Percent Dominance	Relative Importance
Pin oak	2	2.22	8.70	77.09	29.33
Dogwood	40	44.44	21.74	.12	22.10
Green & white ash	15	16.67	17.39	10.73	14.93
Mulberry	6	6.67	8.70	4.34	6.57
Black locust	7	7.78	8.70	.00	5.49
Hawthorn	1	1.11	4.35	3.99	3.15
Swamp white oak	1	1.11	4.35	3.05	2.84
Red elm	2	2.22	4.35	.49	2.35
Bitternut hickory	1	1.11	4.35	.00	1.82
Shagbark hickory	1	1.11	4.35	.00	1.82

Diversity index = 2.506

Total area = 100 sq. m.

TABLE 13. WOODLOT TRANSECT VIII

Species	Total Count	Percent Density	Percent Frequency	Percent Dominance	Relative Importance
Basswood	26	13.47	11.27	40.13	21.62
Bur oak	3	1.55	2.82	52.10	18.82
Red elm	41	21.24	14.08	.15	11.82
Green & white ash	40	20.73	14.08	.09	11.63
Hackberry	30	15.54	11.27	2.96	9.92
Bitternut hickory	7	3.63	7.04	3.10	4.59
Dogwood	13	6.74	7.04	.00	4.59
Black locust	9	4.66	7.04	.00	3.90
Mulberry	4	2.07	5.63	.00	2.57
Serviceberry	4	2.07	4.23	.00	2.10
Shagbark hickory	5	2.59	1.41	.00	1.33
Hawthorn	2	1.04	2.82	.09	1.31
Elderberry	2	1.04	2.82	.00	1.28
Chestnut oak	2	1.04	2.82	.00	1.28
Swamp white oak	1	.52	1.41	1.31	1.08
Sugar maple	2	1.04	1.41	.09	.84
Walnut	1	.52	1.41	.00	.64
N. Red oak	1	.52	1.41	.00	.64

Diversity index = 3.247

Total area = 200 sq. m .

TABLE 14. WOODLOT TRANSECT IX

Species	Total Count	Percent Density	Percent Frequency	Percent Dominance	Relative Importance
Green & white ash	21	15.91	13.79	60.22	29.98
Dogwood	39	29.55	17.24	.92	15.90
Red elm	13	9.85	6.90	17.39	11.38
Shagbark hickory	11	8.33	13.79	6.56	9.56
Serviceberry	19	14.39	13.79	.00	9.40
Bur oak	3	2.27	6.90	14.91	8.03
Black cherry	14	10.61	10.34	.00	6.98
Elderberry	4	3.03	6.90	.00	3.31
Black locust	3	2.27	6.90	.00	3.06
Hawthorn	5	3.79	3.45	.00	2.41

Diversity index = 2.895

Total area = 100 sq. m..

TABLE 15. WOODLOT TRANSECT X

Species	Total Count	Percent Density	Percent Frequency	Percent Dominance	Relative Importance
Green & white ash	182	54.49	21.43	17.80	31.24
Shagbark hickory	17	5.09	16.67	32.42	18.06
Bur oak	3	.90	4.76	42.48	16.05
Black cherry	68	20.36	14.29	.00	11.55
Red elm	39	11.68	16.67	.00	9.45
Dogwood	20	5.99	14.29	.00	6.76
N. Red oak	2	.60	4.76	7.30	4.22
Chestnut oak	2	.60	4.76	.00	1.79
Hawthorn	1	.30	2.38	.00	.89

Diversity index = 1.943

Total area = 180 sq. m.

$$\text{Relative Density} = \frac{\text{Total Number of Individuals of Species}}{\text{Total Area } (m^2)}$$

$$\text{Relative Frequency} = \frac{\text{Number of Units in Which Species Occurred}}{\text{Total Number of Units Measured}}$$

$$\text{Total Basal Area/Species} = \frac{\sum(\text{diameter})^2 \pi}{4}$$

$$\text{Relative Dominance} = \frac{\text{Total Basal Area for Species}}{\text{Total Area } (m^2)}$$

Percent density, percent frequency, and percent dominance are calculated by summing the "relative" values for all species for each calculation for each quadrat and dividing the "relative" value by the corresponding sum. The importance value of each species is calculated by summing percent density, percent frequency, and percent dominance and dividing by 3. These measures of density, frequency, and dominance give a picture of the structure of the vegetative community in a quantitative but dimensionless manner.

Density reflects the absolute number of individuals per area sampled. As such, it is a dimensional expression and may misrepresent the densities of tightly-clumped species as opposed to abundant but evenly-distributed species.

Frequency, on the other hand, provides information as to the uniformity of distribution. Frequency is defined as the percentage of occurrence of a species in a series of samples of uniform size contained in a single stand. This measurement is obtained by dividing a transect up into a series of smaller units and recording the presence or absence of each species in each subunit.

The measure of dominance expresses the size or bulk of the species within the sample in relation to the space available within the area.

By calculation of these statistics a measure of the abundance of each species, its spacial layout within the unit being measured, and each species' contribution to the ground cover or its spacial occupation is obtained. By blending the three independent measures a measure of "importance" is achieved. While useful in determining the relative importance of a species, evaluation of the data requires interpretation of all statistics available on that species. Results of these analyses are presented in Tables 6 through 15.

Cursory analysis of the results indicate that each of the woodlots at White's Landing has developed under slightly different conditions, i.e., soils, surface water stresses, grazing pressures, etc., and as such, exhibit singular compositions. Taken as a whole, the woodlots do not present any new or unique species but do in total reflect the composition of larger less disturbed forests of the region.

Further detailed comparison will require completion of the herbaceous vegetation analysis. Data collection on the herbaceous ground cover of the woodlots is complete and is currently undergoing statistical treatment. Oldfield herbaceous plants and wildflowers are also being studied. Data collection for summer-blooming species is complete for this year. Fall-flowering plants are currently under investigation and spring flower work is anticipated to follow. Spring-flowering plant analysis was attempted in the spring of 1973 but was abandoned due to unusually high winter and spring water levels which precluded terrestrial plant growth over most of the White's Landing Site area.

The species account required for vegetational characterization of the Site is being continued by field surveillance.

The vegetation species list presented in the Phase I report is being used as a complete list on which all vegetation species observed can be recorded. The updated list is presented in Table 16.

Effects of Environmental Stress on Existing Vegetation. Investigations of the effects of several types of environmental stress on vegetational communities on the Site are in progress. Stresses include vegetational stripping and salt spray application and were selected on the basis of those most likely to occur coincident with Site development. This aspect of the program includes: determination of oldfield productivity in the region, investigations into the initial successional patterns, i.e., natural revegetation following land clearing, and investigations of the potential for detectable effects of soil and leaf salinization.

TABLE 16. TERRESTRIAL AND SEMI-AQUATIC FLORA EXPECTED TO OCCUR ON AND/OR IN THE VICINITY OF THE SITE**

PTERIDOPHYTA

Equisetaceae

*Equisetum arvense L. Field Horsetail.

Equisetum kansanum Schaffner Scouring-rush.

Ophioglassaceae

*Botrychium virginianum (L.) Sw. Rattlesnake Fern

Polypodiaceae

Dryopteris Thelypteris (L.) Gray, var. pubescens (Lawson) Nakai Marsh Fern.

SPERMATOPHYTA-
MONOCOTYLEDONAE

Typhaceae

*Typha angustifolia L. Narrow-leaved Cat-tail

Sparganiaceae

Sparganium eurycarpum Engelm. Bur-reed.

Zosteraceae

Potamogeton foliosus Raf. Leafy Pondweed.

Juncaginaceae

Triglochin palustris L. Arrow-grass.

Alismataceae

Alisma subcordatum Raf. Water-plantain.

---

* Species has been identified during current field investigations, 1972-1973.

**After Lowden, 1969.

TABLE 16 . (Continued)

Gramineae

*Bromus inermis Levss. Awnless Brome Grass

*Dactylis glomerata L. Orchard Grass.

*Note: Other less abundant and/or less identifiable grasses have been identified only to family, thus GRAMINEAE.

Cyperaceae

*Note: This family has been identified only to genus. Members of the genera Carex, Scirpus, and Cyperus have been identified.

Lemnaceae

*Lemna minor L. Small Duckweed.

Lemna trisulca L. Star Duckweed.

Juncaceae

Juncus balticus Willd. Rush.

Juncus dudleyi Wieg. Dudley's Rush.

Juncus torreyi Coville Torrey's Rush.

Liliaceae

*Allium canadense L. Wild Garlic.

*Allium vineale L. Field Garlic.

Asparagus officinalis L. Garden Asparagus.

TABLE 16. (Continued)

Erythronium americanum Ker Yellow Dog's-tooth-violet.

Hemerocallis fulva L. Common Orange Day-lily.

Lilium michiganense Farw. Michigan Lily.

Smilacina stellata (L.) Desf. Starry False Solomon's Seal.

* Smilax tamnoides L. var. hispida (Muhl.) Fern. Bristly Greenbrier.

Iridaceae

Iris versicolor L. Iris.

Sisyrinchium angustifolium Mill. Blue-eyed-grass.

SPERMATOPHYTA-
DICOTYLEDONAE

Salicaceae

* Populus deltoides Marsh. Cottonwood.

Populus tremuloides Michx. Quaking Aspen.

* Salix nigra Marsh. Black Willow.

Salix humilis Marsh. Small Pussy Willow.

Juglandaceae

* Carya ovata (Mill.) K. Koch Shagbark Hickory.

Corylaceae

Carpinus caroliniana Walt. American Hornbeam.

Corylus americana Walt. American Hazelnut.

Fagaceae

* Quercus alba L. White Oak.

* Quercus bicolor Willd. Swamp White Oak.

* Quercus macrocarpa Michx. Burr Oak.

* Quercus rubra L. Red Oak.

TABLE 16. (Continued)

Ulmaceae

*Celtis occidentalis L. Hackberry.

*Ulmus americana L. American Elm.

*Ulmus rubra Muhl. Slippery Elm.

Moraceae

Maclura pomifera (Raf.) Schneid. Osage-orange.

*Morus alba L. White Mulberry.

Cannabinaceae

Humulus lupulus L. Common Hop.

Urticaceae

Pilea pumila (L.) Gray Clearweed.

*Urtica procera Muhl. Nettle.

Santalaceae

Comandra umbellata (L.) Nutt. Bastard-toadflax.

Polygonaceae

Rumex altissimus Wood Pale Dock.

*Rumex crispus L. Curled or Yellow Dock.

*Rumex obtusifolius L. Blunt-leaved Dock.

TABLE 16. (Continued)

Chenopodiaceae

Atriplex patula L. Orach

Chenopodium album L. Lamb's-quarters.

Amaranthacea

Amaranthus hybridus L. Green Amaranth.

Phytolaccaceae

* Phytolacca americana L. Pokeweed.

Portulacaceae

Portulaca oleracea L. Common Purslane.

Caryophyllaceae

Cerastium nutans Raf. Nodding Mouse-ear Chickweed.

Lychnis alba Mill. White Campion.

Saporaria officinalis L. Soapwort.

Silene cucubalus Wibel Bladder Campion.

Ranunculaceae

Anemone quinquefolia L. Wood Anemone.

Anemone virginiana L. Thimble weed.

Clematis virginiana L. Virgin's-bower.

Ranunculus abortivus L. Kidney-leaf Buttercup.

Thalictrum dasycarpum Fisch. & Lall. Purple Meadow-rue.

Berberidaceae

* Podophyllum peltatum L. May-apple.

Menispermaceae

Menispermum canadense L. Moonseed.

TABLE 16. (Continued)

Cruciferae

Arabis canadensis L. Sicklepod.

Barbarea vilgaris R. Br. Yellow Rocket.

* *Brassica kaber* (DC.) L. C. Wheeler Charlock.

Brassica nigra (L.) Koch Black Mustard.

* *Capsella bursa-pastoris* (L.) Medic. Shepherd's Purse.

Descurainia pinnata (Walt.) Britt., var. *brachycarpa* (Richards.) Fern. Tansy Mustard.

Lepidium campestre (L.) R. Br. Cow-cress.

* *Lepidium virginicum* L. Poor Man's Pepper.

Nasturtium officinale R. Br. True Water Cress.

* *Thlaspi arvense* L. Field Penny-cress.

Crassulaceae

Sedum telephium L. Garden Orpine.

Saxifragaceae

Ribes americanum Mill. Wild Black Currant.

Platanaceae

* *Platanus occidentalis* L. Sycamore.

Rosaceae

Agrimonia parviflora Ait. Small-flowered Agrimony.

* *Crataegus sp.* Hawthorn.

* *Crataegus sp.* Hawthorn.

* *Fragaria virginiana Duchesne* Strawberry.

* *Geum canadense* Jacq. White Avens.

Potentilla norvegica L. Rough Cinquefoil.

Prunus americana Marsh. Wild Plum.

TABLE 16. (Continued)

Prunus virginiana L. Choke Cherry.

Pyrus coronaria L. Wild Crab.

* *Rosa palustris* Marsh. Swamp Rose.

Rubus flagellaris Willd. Common Dewberry.

* *Rubus occidentalis* L. Black Rasberry.

Leguminosae

* *Amphicarpa bracteata* (L.) Fern. Hog-peanut.

Cassida hebecarpa Fern. Wild Senna.

Desmodium perplexum Schub. Tick-trefoil.

* *Gleditsia triacanthos* L. Honey-locust.

Lathyrus palustris L. Vetchling.

Medicago lupulina L. Black Medick.

* *Medicago sativa* L. Alfalfa.

* *Melilotus alba* Desr. White Sweet Clover.

Melilotus officinalis (L.) Lam. Yellow Sweet Clover.

* *Trifolium hybridum* L. Alsike Clover.

* *Trifolium pratense* L. Red Clover.

Oxalidaceae

* *Oxalis europaea* Jord. Wood Sorrel.

Geraniaceae

Geranium maculatum L. Wild Cranesbill.

Rutaceae

Xanthoxylum americanum Mill. Prickly-ash.

TABLE 16. (Continued)

Euphorbiaceae

Acalypha virginica L. Three-seeded Mercury.

Euphorbia dentata Michx. Toothed Spurge.

Euphorbia maculata L. Eyebane.

Anacardiaceae

* *Rhus glabra* L. Smooth Sumac.

* *Rhus radicans* L. Poison-ivy.

* *Rhus typhina* L. Staghorn Sumac.

Celastraceae

* *Celastrus scandens* L. Climbing Bittersweet.

* *Euonymus atropurpureus* Jacq. Wahoo.

Aceraceae

* *Acer negundo* L. Box-elder.

* *Acer saccharinum* L. Silver Maple.

Balsaminaceae

* *Impatiens capensis* Meerb. Spotted Touch-me-not.

Rhamnaceae

Rhamnus lanceolata Pursh Buckthorn.

Vitaceae

Parthenocissus inserta (Kerner) K. Fritsch Woodbine.

* *Vitis riparia* Michx. River-bank Grape.

Tiliaceae

* *Tilia americana* L. Basswood.

Malvaceae

Abutilon theophrasti Medic. Velvet-leaf.

* *Malva neglecta* Wallr. Common Mallow.

TABLE 16. (Continued)

Violaceae

*Viola papilionacea Pursh Common Blue Violet.

Onagraceae

Gaura biennis L. Gaura.

Oenothera biennis L. Common Evening-primrose.

Umbelliferae

Angelica atropurpurea L. Alexanders.

Chaerophyllum procumbens (L.) Crantz Spreading Chervil.

Cicuta bulbifera L. Bulb-bearing Water-hemlock.

Cicuta maculata L. Spotted Water-hemlock.

Cryptotaenia canadensis (L.) DC. Honewort.

*Daucus carota L. Wild Carrot.

Osmorhiza longistylis (Torr.) DC. Anise-root.

Pastinaca sativa L. Parsnip.

*Sanicula canadensis L. Black Snakeroot.

Sanicula gregaria Bickn. Black Snakeroot.

*Thaspium trifoliatum (L.) Gray Meadow-parsnip.

TABLE 16. (Continued)

Cornaceae

* *Cornus drummondi* Meyer. Dogwood.

* *Cornus obliqua* Raf. Silky Dogwood.

* *Cornus racemosa* Lam. Panicled Dogwood.

* *Cornus stolonifera* Michx. Red Osier.

Primulaceae

Lyrimachia ciliata L. Loosestrife.

Oleaceae

* *Fraxinus pennsylvanica* Marsh. Green Ash.

* *Fraxinus americana*.

Syringa vulgaris L. Lilac.

Apocynaceae

Apocynum cannabinum L. Indian Hemp.

Asclepiadaceae

* *Asclepia incarnata* L. Swamp Milkweed.

* *Asclepias syriaca* L. Common Milkweed.

Asclepias tuberosa L. Butterfly-weed.

Convolvulaceae

Convolvulus sepium L. Hedge Bindweed.

* *Cuscuta campestris* Yuneker Dodder on *Trifolium pratense* L.

Boraginaceae

Hackelia virginiana (L.) I. M. Johnston. Stickseed.

Lithospermum arvense L. Corn Gromwell.

Verbenaceae

Verbena hastata L. Blue Vervain.

Verbena urticifolia L. White Vervain.

TABLE 16. (Continued)

Labiatae

Ayastache nepetoides (L.) Ktze. Yellow Giant Hyssop.

Glechoma hederacea L. Ground-ivy.

Lamium amplexicaule L. Common Henbit.

Lycopus americanus Muhl. Water-horehound.

* Mentha arvensis L. Mint.

Mentha piperita L. Peppermint.

Nepeta cataria L. Catnip.

Prunella vulgaris L. Heal-all.

Pycnanthemum virginianum (L.) Durand & Jackson. Mountain-mint.

Scutellaria lateriflora L. Mad-dog Skullcap.

Stachys tenuifolia Willd. Hedge-nettle.

Teucrium occidentale Gray. Hairy Germander.

Solanaceae

Datura stramonium L. Common Jimsonweed.

Physalis heterophylla Nees. Ground-cherry.

Physalis subglabrata Mackenz. & Bush. Ground-cherry.

* Solanum dulcamara L. Bittersweet Nightshade.

Solanum nigrum L. Black Nightshade.

Scrophulariaceae

Gerardia purpurea L. Gerardia.

Mimulus ringens L. Monkey-flower.

Scrophularia marilandica L. Carpenter's-square.

Verbascum blattaria L. Moth Mullein.

* Verbascum thaspus L. Common Mullein.

TABLE 16. (Continued)

Lentibulariaceae
Utricularia vulgaris L. Bladderwort.
Plantaginaceae
Plantago lanceolata L. English Plantain.
* Plantago major L. x P. rugelii Dcne. Plantain.
Rubiaceae
* Galium aparine L. Common Cleavers.
* Galium concinnum T. & G. Shining Bedstraw.
Galium triflorum Michx. Fragrant Bedstraw.
Caprifoliaceae
Lonicera tatarica L. Tartarian Honeysuckle.
* Sambucus canadensis L. Common Elder.
Triosteum perfoliatum L. Tinker's Weed.
Viburnum lentago L. Sweet Viburnum.
Valerianaceae
* Valerianella umbilicata (Sulliv.) Wood. Corn-salad.
Dipsacaceae
* Dipsacus sylvestris Huds. Wild Teasel.
Cucurbitaceae
Echinocystis lobata (Michx.) T & G. Wild Cucumber.
Campanulaceae
Lobelia siphilitica L. Great Blue Lobelia.
Lobelia spicata Lam. Pale-spike Lobelia.
Compositae
* Ambrosia artemesiifolia L. Common Ragweed.
Ambrosia trifida L. Great Ragweed.
Anthemis cotula L. Stinking Chamomile.
Arctium minus (Hill) Bernh. Common Burdock.

TABLE 16. (Continued)

Aster junciformis Rydb. Aster.

Aster novae-angliae L. New England Aster.

Aster pilosus Willd. Aster.

Aster sagittifolius Wedemeyer. Arrow-leaf Aster.

Aster simplex Willd. Aster.

*Bidens cernua L. Stick-tight.

*Bidens connata Muhl. Beggar-ticks.

*Cichorium intybus L. Chickory.

*Cirsium arvense (L.) Scop. Canada Thistle.

Cirsium vulgare (Savi) Tenore. Bull Thistle.

Erigeron annuus (L.) Pers. Daisy Fleabane.

Erigeron canadensis L. Horse-weed.

*Erigeron philadelphicus L. Philadelphia Fleabane.

Eupatorium maculatum L. Joe-Pye-Weed.

Eupatorium perfoliatum L. Common Boneset.

Eupatorium rugosum Houtt. White Sankeroot.

Galinsoga ciliata (Raf.) Blake. Galinsoga.

*Helianthus giganteus L. Sunflower.

Heliopsis helianthoides (L.) Sweet Ox-eye.

*Lactuca floridana (L.) Gaertn. Blue Lettuce.

Lactuca scariola L. Prickly Lettuce.

Prenanthes alba L. White Lettuce.

Ratibida pinnata (Vent.) Barnh. Prairie-coneflower.

Rudbeckia laciniata L. Coneflower.

Rudbeckia triloba L. Coneflower.

Senecio aureus L. Golden Ragwort.

TABLE 16. (Continued)

<u>Silphium</u> <u>terebinthinaceum</u> Jacq. Prairie-dock.
<u>Solidago</u> <u>altissima</u> L. Goldenrod.
<u>Solidago</u> <u>canadensis</u> L. Canada Goldenrod.
<u>Solidago</u> <u>gigantea</u> Ait., var. leiophylla Fern. Goldenrod.
<u>Solidago</u> <u>graminifolia</u> (L.) Salisb. Grass-leaved Goldenrod.
*<u>Sonchus</u> <u>oleraceus</u> L. Common Swo-thistle.
*<u>Taraxacum</u> <u>officinale</u> Weber. Common Dandelion.
<u>Vernonia</u> <u>altissima</u> Nutt. Tall Ironweed.
*<u>Xanthium</u> <u>pensylvanicum</u> Wallr. Cocklebur.

The first phase of these experiments will be completed in the fall of 1973. Replications and slight expansions will occur next summer with work beginning early in the spring to get full growing season effects. Procedures and interim results are discussed in the following subsections.

Productivity. Productivity studies were initiated in July, 1973, and will continue through the fall of 1974. The studies are designed to analyze seasonal productivity as well as yield data relevant to quantitative analysis of net productivity. Since biomass analysis will be done at a species level this information would be useful in the determination of successional patterns of revegetation following land clearing required for construction activities.

Standard methods are being utilized for the productivity studies. $1/4^2$m quadrats are established on a random basis within an oldfield on the Site (see Figure 1) selected for the study. The quadrats are then clipped and the vegetation is separated by species, dried, and weighed. Percent composition by weight of each species is calculated to determine standing biomass of each species within the oldfield. Studies will be continued throughout the next year in order that a seasonality index to productivity may be determined. Table 17 lists the data obtained to date. This information includes the percent biomass contribution of the species present in each quadrat. This information will be useful (1) for baseline assessment and (2) for inclusion in measurement of productivity which is preceding.

Succession. Succession studies have been initiated to provide a record of the reappearance of vegetation following disruption of the vegetative cover. This study will result in determination of the order of vegetation reappearance on a seasonal basis for one year and it would also serve in prediction of the type of post-construction revegetation that would be anticipated to occur naturally. Data are being collected from 2 x 2-meter plots from which all vegetation was cut and removed and the soil tilled (see Figure 12). Although seed sources would not be as abundant on the Site following construction as at present, it is felt that the results of this testing program will be applicable to post-construction conditions.

TABLE 17. STANDING BIOMASS AT PRODUCTIVITY QUADRATS ON THE SITE, JULY, 1973

Sample	Wt (Grams)	Percent by wt
Productivity Quadrat No.		
1P 1/4 m^2		
Clover	86.3	65.9
Ragweed	18.1	13.8
Grass	12.1	9.2
Meadow garlic	10.0	7.6
Sedge	4.0	3.1
Broadleaf Dock	0.3	0.2
Unknown #3	0.1	0.08
	130.9	
2P 1/4 m^2		
Curled dock	40.9	29.6
Clover	32.5	23.6
Grass	24.7	17.9
Queen Anne's Lace	23.9	17.3
Sedge	15.0	10.9
Smartweed	0.5	.3
Plantain	0.2	.14
Broadleaf Dock	0.1	.07
	137.8	
3P 1/4 m^2		
Clover	51.6	32.4
Queen Anne's Lace	39.4	24.7
Grass	31.9	20.0
Scelepus	11.0	6.9
Ragweed	10.0	6.3
Curled Dock	7.1	4.5
Meadow Garlic	6.5	4.1
Sedge	0.8	.5
Smartweed	0.7	.4
Unknown #1	0.1	.06
Unknown #2	0.1	.06
	159.2	
4P 1 m^2		
Clover	150.9	37.1
Queen Anne's Lace	91.6	22.5
Grass	34.5	8.5
Curled Dock	34.3	8.4
Miscellaneous	33.6	8.3
Brome grass	13.6	3.3
Meadow garlic	12.7	3.1
Ragweed	11.6	2.9
Sedge	8.8	2.2
Unknown	6.2	1.5
Alfalfa	2.9	.7
Smartweed	2.9	.7
Broadleaf Dock	1.7	.4
Unknown #4	0.5	.1
Plantain	0.3	.07
Unknown #5	0.2	.04
	406.3	

Salinization. The short-term effects of salt application are being investigated at the present time. The data collected should lead to a limited statement regarding the potential effect, if any, of salt application on vegetation. $1m^2$ test plots were set up in an oldfield on the Site (see Figure 13). Salt spray application rates approximate the net amount of salts in one month's drift from 4 cycle cooling towers required to dissipate the heat from five 1100-megawatt units running at 80 percent capacity. Salt solution composition approximates the average dissolved solids composition of Sandusky Bay water. Applications were made as follows: 3 control plots with no spray, 3 plots at 1/2 the base concentration applied once, 3 plots with 1 application of the base concentration, 3 plots with 2 applications of the base concentration applied one month apart, and 3 plots with 3 applications of the base concentration applied one month apart. This method while yielding short-term effects approximates accumulative effects also. Figure 12 is a schematic diagram of the plot layout. Table 18 lists the data obtained to date. This includes analyses of the vegetative composition of the test plots and percent cover of the ground by vegetation.

Following the final spraying vegetative composition and percent ground cover will be reevaluated in order that any significant changes may be identified. A series of monthly pictures of each quadrat is being made to further facilitate any necessary interpretation.

Wildlife

Mammals

Preliminary investigations show that at least 13 species of mammals utilize the Sandusky Bay Site (Table 19). The marsh and adjoining flooded areas are inhabited by both mink and muskrat. The western portion of the Site is frequently used by deer, particularly the woodlots and adjacent fields. The fields and fence rows appear to support high populations of mice, voles, and shrews. Fox tracks are common in the fields and along the fence rows. Rabbits are frequently seen along the fields, fence rows, and abandoned house sites. Woodchucks are present in some of the fields and road banks. Fox squirrels have been seen occasionally in the woodlots. Raccoons, oppossums, and skunks are also present on the Site.

TABLE 18. (Cont.)

of Plants	Plant-Common Name	Latin Name	% Cover
		Quadrant 7 (total percent cover 65)	
1	Unknown thistle	COMPOSITAE	2
4	Platain	*Plantago* sp.	7
	Red and white clover	*Trifolium* spp.	15
	Ragweed	*Ambrosia* sp.	10
	Grass	GRAMINEAE	15
2	Broad leaf dock	*Rumex obtusifolius*	1
12	Curled dock	*Rumex crispus*	10
4	Unknown		5
		Quadrant 8 (total percent cover 97)	
20	Curled dock	*Rumex crispus*	20
	Grass	GRAMINEAE	27
	Ragweed	*Ambrosia* sp.	20
	White clover	*Trifolium repens*	25
3	Unknown-smooth		3
1	Plantain	*Plantago* sp.	1
1	Unknown-serrated		1
		Quadrant 9 (total percent cover 100)	
2	Curled dock	*Rumex crispus*	2
	Ragweed	*Ambrosia* sp.	20
20	Smartweed	*Polygonum* sp.	10
	White clover	*Trifolium repens*	35
	Sedge	*Scirpus* sp.	15
	Unknown-serrated		15
	Grass	GRAMINEAE	3

TABLE 18. (Cont.)

No. of Plants	Plant-Common Name	Latin Name	% Cover
		Quadrant 10 (total percent cover 100)	
17	Field pepper grass	*Lepidicum virginicum*	17
7	Curled dock	*Rumex crispus*	5
	Ragweed	*Ambrosia* sp.	20
	Red and white clover	*Trifolium* spp.	40
	Grass	GRAMINEAE	15
1	Thistle unknown	COMPOSITAE	1
3	Meadow garlic	*Allium canadense*	1
2	Unknown-smooth		1
		Quadrant 11 (total percent cover 96)	
	Sedge	*Scirpus* sp.	20
	Plantain	*Plantago* sp.	3
3	Broad leaf dock	*Rumex obtusifolius*	2
8	Curled dock	*Rumex crispus*	10
2	Field pepper grass	*Lepidicum virginicum*	20
	White clover	*Trifolium repens*	30
6	Ragweed	*Ambrosia* sp.	5
	Grass	GRAMINEAE	2
5	Queen Anne's Lace	*Baucus carota*	2
3	Smartweed	*Polygonum* sp.	1
2	Meadow garlic	*Allium canadense*	1
		Quadrant 12 (total percent cover 75)	
13	Curled dock	*Rumex crispus*	12
	Ragweed	*Ambrosia* sp.	20
	Grass	GRAMINEAE	25
	Smartweed	*Polygonum* sp.	5
	White clover	*Trifolium repens*	10
	Unknown-serrated		1
	Plantain	*Plantago* sp.	1
	Broad leaf dock	*Rumex obtusifolius*	1

TABLE 18. (Cont.)

of Plants	Plant-Common Name	Latin Name	% Cover
		Quadrant 13 (total percent cover 85)	
	Smartweed	*Polygonum* sp.	5
	Ragweed	*Ambrosia* sp.	31
2	Common sow thistle	*Sonchus oleraceus*	2
6	Curled dock	*Rumex crispus*	5
	Red and white clover	*Trifolium spp.*	30
	Grass	GRAMINEAE	10
1	Unkn-serrated		1
1	Unkn-smooth		1
		Quadrant 14 (total percent cover 98)	
	Red and white clover	*Trifolium spp.*	25
	Pepper grass	*Lepidicum virginicum*	15
	Plantain	*Plantago sp.*	10
10	Curled dock	*Rumex crispus*	7
	Smartweed	*Polygonum sp.*	3
	Unkn-serrated		10
	Ragweed	*Ambrosia sp.*	17
	Grass	GRAMINEAE	10
1	Meadow garlic	*Allium canadense*	1
		Quadrant 15 (total percent cover 100)	
15	Circled dock	*Rumex crispus*	7
	Ragweed	*Abrosia sp.*	33
5	Alfalfa	*Medicago sativa*	5
1	Meadow garlic	*Allium canadense*	1
3	Unkn-serrated		5
	Smartweed	*Polygonum sp.*	
	Plantain	*Plantago sp.*	1
	Grass	GRAMINEAE	14
	Red and white clover	*Trifolium spp.*	32

TABLE 18. (Cont.)

No. of Plants	Plant-Common Name	Latin Name	% Cover
	Quadrant 16 (total percent cover 100)		
14	Curled dock	*Rumex crispus*	15
	Brome grass	*Bromus sp.*	10
	Sedge	*Scirpus sp.*	15
	Ragweed	*Ambrosia spp.*	20
	Red and white clover	*Trifolium spp.*	34
	Smartweed	*Polygonum sp.*	3
	Unkn-serrated		0
	Grass	GRAMINEAE	3
	Quadrant 17 (total percent cover 75)		
12	Curled dock	*Rumex crispus*	7
	Smartweed	*Polygonum sp.*	40
1	Unkn-serrated smooth		1
	Red and white clover	*Trifolium spp.*	15
	Unkn-serrated		3
	Grass	GRAMINEAE	2
	Ragweed	*Ambrosia sp.*	7
	Quadrant 18 (total percent cover 95)		
1	Broad leaf dock	*Rumex obtusifolius*	1
	sedge	*Scirpus sp.*	10
4	Swamp thistle	*Cirsium muticum*	27
	Smartweed	*Polygonum sp.*	15
7	Curled dock	*Rumex crispus*	3
	Ragweed	*Ambrosia sp.*	10
1	Meadow garlic	*Allium canadense*	1
	Red and white clover	*Trifolium spp.*	25

TABLE 19. MAMMALS OBSERVED ON THE SANDUSKY BAY SITE TO DATE

Common Name	Scientific Name
Oppossum	*Didolphis virginianus*
Shorttail shrew	*Blurina brevicauda*
Eastern Cottontail	*Sylvilagus floridanus*
Meadow vole	*Microtus pennsylvanicus*
Wood mouse	*Peromyscus leucopus*
Muskrat	*Ondatra zibenthica*
Woodchuck	*Marmota monax*
Fox squirrel	*Sciurus niger*
Red fox	*Vulpes fulva*
Raccoon	*Procyon lotor*
Mink	*Mustella vison*
Striped skunk	*Mephitis mephitis*
Whitetail deer	*Odocoileus virginianus*

Mammal studies conducted on the Site have thus far been preliminary and of a limited nature. Records and notes have been kept on all mammals and animal signs observed during the course of work in progress on other faunal components. Intensive studies will be conducted in both the fall and spring to determine the composition and abundance of mammalian populations on the Site.

Birds

Bird populations on the Site have been studied in the spring and summer much more intensively than the mammals. A list of the species found on the Site and the habitats in which they were observed is presented in Table 20. This list also includes the birds observed during the Phase I winter observation period. An intensive bird study is planned for the fall and winter to determine the utilization of the area by migrating waterfowl, winter residents, and permanent residents. Additional work is planned for next spring to observe use of the Site by spring migrants.

There are indications that bald eagles may use the northwestern portion of the Site for nesting. Battelle personnel have seen two adult eagles on the Sandusky Bay Site as recently as September 12, 1973. Two nests on the Site have been located. Eagles were observed using the northern nest during the winter of 1972-73. No eagles were seen while conducting other field studies in the spring of 1973. The Pickerel Creek nest and the Schlegel farm nest were both used for nesting in 1972; only the Pickerel Creek nest was used for nesting in 1973 (Branzell, personal communication).

Present population estimates for bald eagles in the continental United States (which includes members of both subspecies) is 750 breeding pairs (Knoder, 1972). About a dozen of these magnificent birds nest in the vicinity of Lake Erie and its larger bays, but their numbers are decreasing (Campbell, 1968).

TABLE 20. BIRD SPECIES OBSERVED IN VARIOUS HABITATS ON THE SITE.

Species	Areas Utilized											
	Bay	Shore-Line	Creek & Marsh	Flooded Fields	Cultivated Fields	Aband. Field	Fence Row	Second Growth Woods & Understory	Mature Woodlot	House Sites	"Orchard"	Flyover	Power Line
Great Blue Heron		x	*x	x									
Green Heron			x	x									
Canada Goose					*							x	
Mallard		x	x	x									
Wood Duck												x	
Red-breasted Merganser	x												
Turkey vulture												x	
Red-tailed hawk									x			x	
Bald eagle		x	x						*			*	
Sparrow hawk												x	x
Bob white					x	x	x						
Ring-necked Pheasant						x	x				x		
Sora			x	x									
Killdeer			x	x	x	x							
Wilson's Snipe				x									
Spotted Sandpiper		x		x									
Lesser Yellowlegs				x									
Herring Gull	x	x											
Ring-billed Gull	x	x			x								
Rock Dove												x	
Mourning Dove										x	x	x	x
Yellow-billed Cuckoo								x					
Black-billed Cuckoo									x				
Chimney Swift												x	
Ruby-throated Hummingbird									x				
Belted Kingfisher			x										
Flicker									*x	x		x	*x
Red-bellied Woodpecker									x				
Red-headed Woodpecker									*x	x			

TABLE 20'. (Cont.)

Species	Areas Utilized: Bay	Shore Line	Creek & Marsh	Flooded Fields	Cultivated Fields	Aband. Field	Fence Row	2nd Growth Woods & Understory	Mature Woodlot	House Sites	"Orchard"	Flyover	Power Line
Downy Woodpecker									x	x			
Eastern Kingbird									x	x	x		x
Crested Flycatcher									x				
Yellow-bellied Flycatcher									x				
Acadian Flycatcher							x				x		
Wood Peewee								x					
Horned Lark					x								
Tree Swallow												x	x
Rough-winged Swallow												x	
Barn Swallow												x	
Purple Martin										x		x	
Blue Jay								*x	x	x			
Crow									x				
Black-capped Chickadee								*					
Tufted Titmouse									x				
Red-breasted Nuthatch									x				
House Wren								x	x				
Long-billed Marsh Wren			x					x					
Catbird							x	x					
Brown Thrasher							x		x				
Robin					x				x	x			
Woodthrush									x				
Hermit Thrush									x				
Gray-checked Thrush									x				
Swaison's Thrush									x				
Blue-Gray Gnatcatcher									x				
American Pipit					x								
Starling			x		x				x	x	x		x

TABLE 20. (Cont.)

Species	Areas Utilized												
	Bay	Shore-Line	Creek & Marsh	Flooded Fields	Cultivated Fields	Aband. Field	Fence Row	Second Growth Woods & Understory	Mature Woodlot	House Sites	"Orchard"	Flyover	Power Line
Wide Eyed Vireo								x					
Red-eyed Vireo								x	x				
Philadelphia Vireo									x				
Black and White Warbler								x					
Nashville Warbler									x				
Yellow Warbler								x			x		
Magnolia Warbler								x		x			
Myrtle Warbler								x	x				
Bay-breasted Warbler									x				
Yellow-throat							x	x			x		
American Redstart									x		x		
House Sparrow					x	x				x			
Bobolink						x				x			
Eastern Meadowlark					*x	*x	x						x
Red Wing				x	x		x	x	x				x
Orchard Oriole									x	x			
Baltimore Oriole									x	x			
Common Grackle			x		x				x	x			x
Cowbird							x						
Scarlet Tanager									x				
Cardinal							x	x	x				
Indigo Bunting							x	x					x
Dickcissel						x							
Goldfinch			x		x	x	x			x	x		x
Towhee							x	x	x		x		

TABLE 20. (Cont.)

Species	Areas Utilized												
	Bay	Shore Line	Creek & Marsh	Flooded Fields	Cultivated Field	Aband. Field	Fence Row	2nd Growth Woods & Understory	Mature Woodlot	House Sites	"Orchard"	Flyover	Power Line
Savannah Sparrow					x								
Vesper Sparrow						x							
Field Sparrow						x	x						
White-Crowned Sparrow					x						x		
White-Throated Sparrow									x				
Fox Sparrow								*	x				
Swamp Sparrow								*					
Song Sparrow					x	x	x	x					

* Denotes winter sightings

x Denotes late spring and summer sightings

Richard Branzell, U. S. Game Management Agent, (personal communication) reports that there are 10 traditional bald eagle nesting sites in the Lake Erie region of Ohio. His aerial survey in 1972 revealed only six nesting pairs with no young produced. In 1973 there were seven nesting pairs which produced a total of two eaglets.

"Causes of eagle nesting failure are complex. Some leading authorities state the presence of humans and their interference are greater factors than pesticides. In 1961, a pair which built a nest at Crane Creek Beach (Ottawa County, Ohio) was ultimately driven away by persons who pounded on the tree with large clubs in order to frighten the female from her eggs so that they could see her." (Campbell, 1968:91-92).

Alexander Sprunt, IV, Research Director of the National Audubon Society, (personal communication) stated that detrimental effects of pesticides on bald eagle production may be decreasing due to bans on the use of DDT in recent years. He feels that an increase in the Chesapeake Bay eagle population may indicate an upward trend in continental bald eagle populations formerly on the decline due to eggshell thinning caused by DDT and its metabolites. Both Roger Thacker (personal communication) and Sprunt (personal communication, 1969) believe that the greatest limiting factor to eagle populations in Ohio will probably be human disturbance. Shooting of bald eagles may also be a significant limiting factor (Branzell, personal communication).

There are two subspecies of the bald eagle: Haliaeetus leucocephalus, the southern bald eagle, and Haliaeetus leucocephalus alascanus, the northern bald eagle which is the subspecies nesting in Ohio (Snow, 1973 and H. G. Smith, personal communication). Only the southern subspecies is on the Threatened Species List of the United States (U.S.D.I., 1973). However, the northern subspecies is on the Rare and Endangered Vertebrate List of Ohio to be published soon by the Ohio Chapter of the Wildlife Society (H. G. Smith, personal communication).

The Federal Code of Regulations states that the taking, possession, or transport of bald eagles or their parts, nests, or eggs is prohibited except by a permit issued by the Bureau of Sport Fisheries and Wildlife. Branzell (personal communication) indicated that building a power plant next to an eagle's nest which caused the eagle to abandon the nest, would not be illegal, but it would certainly have public relations ramifications.

Ohio law states that bald eagles may not be killed or possessed and the nest may not be disturbed. No legal definition of "disturbed" is available (Dick Francis, Enforcement Section, Ohio Division of Wildlife, personal communication).

> "It must be evident that those who live in the vicinity of an eagle's nest become very much attached to these stately birds, and view their comings and goings with unfailing interest. In some parts of Erie and Ottawa Counties the eagles are regarded very highly, and anyone who attempted to molest one of them would get into serious trouble with its human neighbors." (Dawson, 1903:416)

Although the preceding statement is old, the current interest in bald eagles nesting along Lake Erie is still high. Preservation of nesting habitat around the bald eagle nests on the Site if it were developed would be highly recommended in order to avoid unfavorable public reactions (Smith, Branzell, Sprunt, and Thacker, personal communication).

Sprunt (personal communication) recommended two strategies for maintaining the potential for bald eagles to use onsite nests.

1. Establish a refuge of at least a 0.25-mi. radius around each nesting site. These areas should be closed to construction activities, particularly during the nesting season (March 1 to August 1).
2. Leave several acres of old-growth trees (in the vicinity of the present nests) for potential renesting sites and roosting trees.

These recommendations concur with those made by Snow (1973) for the Bureau of Land Management. She reported that the Bureau of Sport Fisheries and Wildlife does not allow timber cutting or human disturbance (including construction) within a 0.5-mi. radius around nest trees during the nesting season on national wildlife refuges. They reserve three to five old-growth trees for roosting and potential nest trees within the buffer zone.

Two examples of successful eagle nests in the vicinity of heavy human disturbance were recorded. An eagle pair continued to nest after construction of a freeway in Florida. The nest was 400 yards from the road (Thacker, personal communication). Another pair of eagles renested in the vicinity of the Site when their original nest blew over in a windstorm. This nest is about 0.25 mile from the end of the Sandusky Airport runway in Ohio (Branzell, personal communication).

AQUATIC ECOLOGY

Plankton

Species Composition

To date work has consisted primarily of sample cleaning and slide preparation for analysis of the diatom community. So far, 127 species of diatoms have been identified from samples of both bay plankton and stream diatometer slides, with a greater diversity in the stream samples. These are listed in Table 21. No unusual diatoms have been encountered in appreciable numbers. The diatometer slides and stream samples have consisted primarily of epiplytic genera of Cocconeis and Synedra. The stream from the Miller's Blue Hole has a considerably different flora than do Bayshore Ditch and Pickerel Creek. The planktonic diatom community made up the majority of the phytoplankton of Sandusky Bay during the spring months with Melosira ambigua, Melosira granulata, and Diatoma tenue Var. elongatum the dominant taxa. Other common planktonic diatoms of the genera Asterionella, Coscinodiscus, Stephanodiscis, and Fragilaria were present in smaller numbers.

With the onset of summer, the abundance of diatoms in plankton samples decreased and was largely replaced by blue-green algae. Although not yet counted, samples from July show a bloom of Aphanizomenon flos-aquae with some Anabaena sp.

Plankton samples show a considerable difference in quantity between various stations. Those obtained further out toward Lake Erie show a greater number of planktonic organisms than do samples obtained further back in the Bay.

Primary Productivity

The radioactive carbon technique is being employed for determination of carbon fixation rates by pelagic phytoplankton. Although this technique is rather complex, its accuracy outweighs any disadvantages. The general work plan for primary productivity analyses in Sandusky Bay involves

TABLE 21. SANDUSKY BAY DIATOM LIST

1. *Achnanthes affinis*	51. *Gomphonema montanum*
2. *Achnanthes coarctata*	52. *Gomphonema montanum var. subclavatum*
3. *Achnanthes exigua*	53. *Gomphonema olivaceum*
4. *Achnanthes hungarica*	54. *Gomphonema parvulum*
5. *Achnanthes lanceolata*	55. *Gyrosigma spencerii*
6. *Achnanthes lanceolata var. dubia*	56. *Hantzschia amphioxys*
7. *Achnanthes microcephala*	57. *Mastogloia grevillei*
8. *Achnanthes minutissima*	58. *Mastogloia smithii var. lacustris, Grun.*
9. *Achnanthes pinnata*	59. *Melosira italica*
10. *Achnanthes* sp.	60. *Meridion circulare*
11. *Amphipleura pellucida*	61. *Navicula biconica*
12. *Amphora ovalis*	62. *Navicula capitata*
13. *Amphora ovalis var. pediculus*	63. *Navicula cincta*
14. *Amphora veneta*	64. *Navicula circumtexta*
15. *Amphora submontana*	65. *Navicula conferaceae var. peregrina*
16. *Caloneis amphisbaena*	66. *Navicula contenta var. biceps*
17. *Caloneis bacillaris var. thermalis*	67. *Navicula cryptocephala*
18. *Caloneis bacillum*	68. *Navicula cuspidata*
19. *Caloneis limosa*	69. *Navicula (dicephala?)*
20. *Caloneis ventricosa var. truncatula*	70. *Navicula exigua var. capitata*
21. *Cocconeis pediculus*	71. *Navicula heufleri var. leptocephala*
22. *Cocconeis placentula*	72. *Navicula lanceolata*
23. *Cossoneis placentula var. lineata*	73. *Navicula lyra*
24. *Cyclotella kutzingiana*	74. *Navicula menisculus var. upsaliensis*
25. *Cyclotella meneghiniana*	75. *Navicula minuscula*
26. *Cymatopleura solea*	76. *Navicula mutica*
27. *Cymbella cistula*	77. *Navicula mutica var. cohnii*
28. *Cymbella parva* (W. Sm.) Cl.	78. *Navicula oblonga*
29. *Cymbella parva*	79. *Navicula pupula*
30. *Cymbella ventricosa*	80. *Navicula pupula var. elliptica*
31. *Diatoma tenue*	81. *Navicula pupula var. rectangularis*
32. *Diatoma vulgare*	82. *Navicula radiosa*
33. *Diploneis oblongella*	83. *Navicula secreta var. apiculata*
34. *Epithemia turgida*	84. *Navicula simplex*
35. *Epithemia zebra*	85. *Navicula* sp.
36. *Epithemia zebra var. saxonica*	86. *Navicula tenera*
37. *Eunotia curvata*	87. *Navicula tripunctata*
38. *Fragilaria capucina var. mesolepta*	88. *Neidium iridis*
39. *Fragilaria construens var. binodis*	89. *Nitzschia amphibia*
40. *Fragilaria construens var. pumila*	90. *Nitzschia bremensis*
41. *Fragilaria construens var. venter*	91. *Nitzschia dissipata*
42. *Fragilaria lapponica*	92. *Nitzschia fonticola*
43. *Fragilaria pinnata*	93. *Nitzschia hungarica*
44. *Fragilaria vaucheriae*	94. *Nitzschia linearis*
45. *Frustulia vulgaris*	95. *Nitzschia microcephala*
46. *Gomphonema acuminatum var. coronata*	96. *Nitzschia palacea*
47. *Gomphonema angustatum*	97. *Nitzschia palea*
48. *Gomphonema constrictum*	98. *Nitzschia sigma*
49. *Gomphonema gracile*	99. *Nitzschia sigmoidea*
50. *Gomphonema intricatum*	100. *Nitzschia* sp. 2 (Young)

TABLE 21. (Continued)

101.	*Nitzschia* sp.
102.	*Nitzschia tryblionella var. debilis*
103.	*Nitzschia tryblionella var. victoriae*
104.	*Pinnularia brebissonii*
105.	*Pinnularia clevei*
106.	*Pinnularia maior*
107.	*Pinnularia/Navicula* sp.
108.	*Pinnularia* sp.
109.	*Pinnularia substomatophora*
110.	*Pinnularia viridis*
111.	*Pinnularia viridis var. minor*
112.	*Rhoicosphenia curvata*
113.	*Rhopalodia gibba*
114.	*Rhopalodia gibberula*
115.	*Stauroneis anceps*
116.	*Stauroneis phoenicenteron f. gracilis*
117.	*Stauroneis* sp.
118.	*Surirella ovalis*
119.	*Surirella ovata*
120.	*Surirella ovata var. pinnata*
121.	*Synedra fasciculata var. truncatula*
122.	*Syndra filiformis var. exilis*
123.	*Synedra parasitica var. subconstricta*
124.	*Synedra pulchella*
125.	*Synedra* sp.
126.	*Synedra tenera*
127.	*Synedra ulna*

placement of water samples enclosed in glass bottles and "spiked" with aliquots of carbon-14 solution at 6 stations throughout Sandusky Bay (Figure 14). At each station water is obtained from 0.2-m and 0.8-m depths using a PVC Kemmerer sampler. This water containing constituent phytoplankters is decanted into 125 Pyrex glass-stoppered containers serving as incubation bottles. At each station, 3 bottles are used for each depth; one of the bottles to be incubated at the two depths is covered with a black polyethylene bag in order to exclude sunlight. Activity inside the "dark" bottle is used to indicate uptake of carbon-14 by non-phototrophic organisms, i.e., heterotrophs. The contents of each incubation bottle is innoculated with precisely 2μCi of C^{14} prior to _in situ_ suspension. After addition of the isotope, the bottles are placed into holders designed specifically to support 3 bottles, equally spaced, in a horizontal position. Each set of 3 incubation bottles is then suspended at that depth from which the water was obtained (one set at 0.2 m and the other at 0.8 m). The bottles are held in place by a system of lines, floats, and anchors and allowed to incubate _in situ_ for approximately 4 hours during midday.

Upon terminating the incubation period, the suspended bottles are removed from the Bay and their phytoplanktonic contents are killed by the addition of formalin. This is done to stop active uptake or incorporation of C^{14} by the phytoplankton. A portion (25 ml) of the contents of each bottle is filtered using special filters (Millipore: 25 mm dia., 0.45μ pore) and filtering apparatus. The phytoplankton remain as a residue upon the filters and these in turn are air-dried, dissolved in a scintillation cocktail, and radioassayed using a Packard Tri-Carb Scintillation Unit. Primary productivity rates are computed from the count data obtained.

Concommitantly, several other physical and chemical parameters are measured: alkalinity, pH, temperature, solar insolation, and transparency of the water. Temperature is measured at each station using a YSI telethermometer. Secchi disc readings are also made at each station. Water samples are obtained at each station, returned to the field laboratory where pH is determined with a Beckman ChemMate Portable pH meter, and total alkalinity is determined potentiometrically (A.P.H.A., 1971).

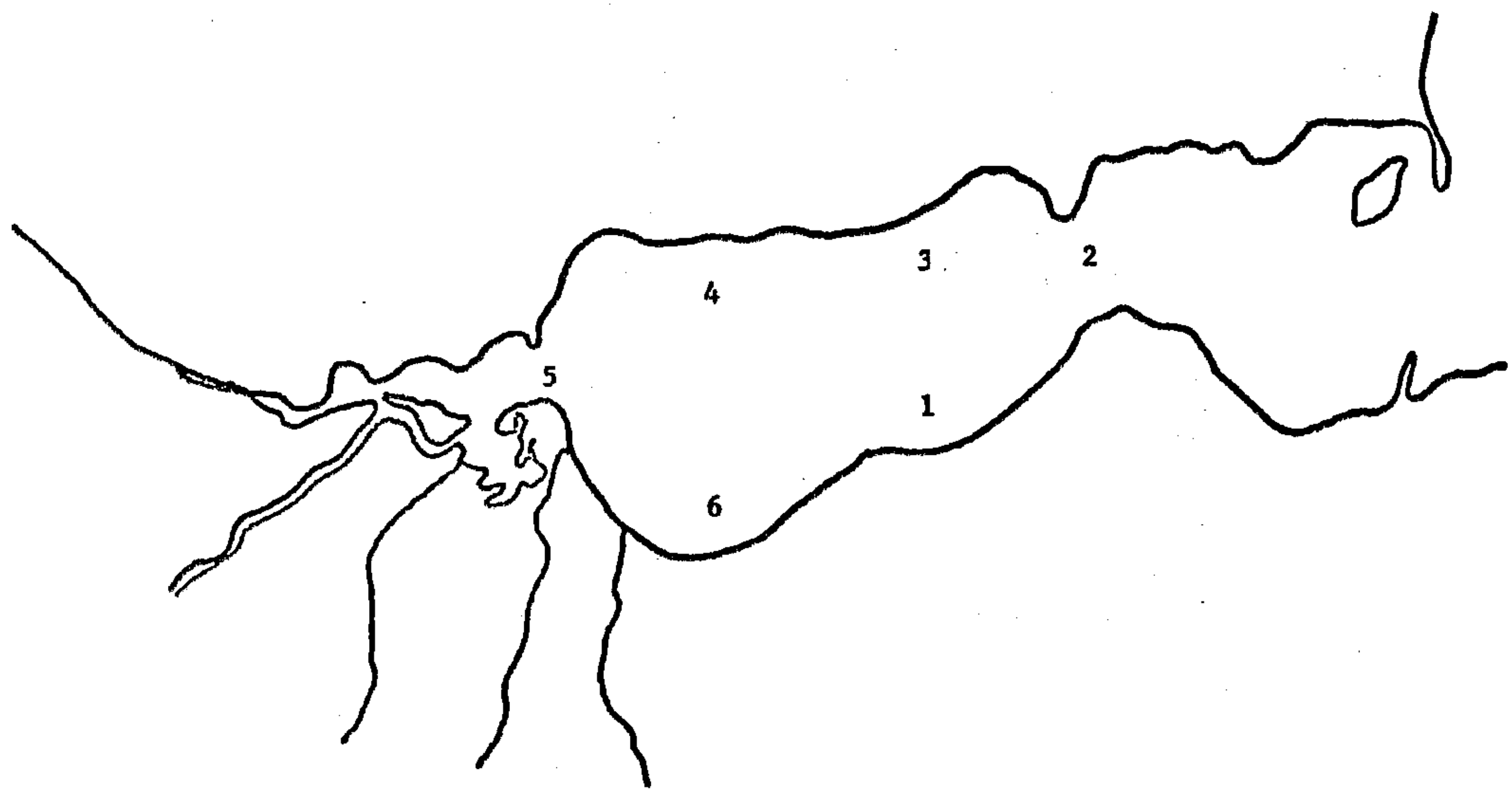


FIGURE 14. SANDUSKY BAY, SHOWING STATIONS WHERE PRIMARY PRODUCTIVITY EXPERIMENTS ARE CONDUCTED

Solar insolation is measured in langleys/min using a YSI Model 68 pyranometer equipped with a silicon solar cell and attached to a strip-chart recorder. Data from the pyranometer charts are transferred to numerical data, langleys/incubation period and langleys/12-hr day, by using a K&E polar planimeter. These data are required for calculating carbon fixation rates on a daily basis.

Primary productivity experiments have, to date, been conducted biweekly commencing August 16, 1973. Results from the most recent field mission are being processed. A portion of the findings resulting from these investigations are presented in Table 22. Optimum carbon assimilation rates represent carbon fixation rates recorded from surface (0.2 m) waters in Sandusky Bay. Other data available, but not yet completely processed, include areal and daily carbon fixation rates and carbon uptake due to heterotroph activity.

Highest productivity rates within the Bay were recorded from Station 4. Lowest values were recorded at Station 5 located in or near the mouth of the Sandusky River. The trend in carbon assimilation rates for that portion of Sandusky Bay examined appears to be as follows: (1) lowest values near the mouth of the Sandusky River possibly due to high turbidity and low transparency acting in concert to reduce light penetration and photosynthetic activity (Secchi disc readings have regularly been lowest at Station 5);

TABLE 22. OPTIMUM CARBON ASSIMILATION RATES mgC m^{-3} hr-1

Date	Stations 1	2	3	4	5	6
8-16-73	62.0	99.3	112.3	156.4	45.8	116.7
8-29-73	12.1	23.1	29.2	37.2	24.7	33.6
9-12-73	15.3	14.6	19.0	21.8	14.7	17.5

(2) highest values at Stations 4 and 7 -- an apparent settling-out of suspended sediments occurs and since these stations are closest to the Bay's primary nutrient input, the Sandusky River, these waters exhibit high carbon fixation rates; and (3) a general lessening in rate of carbon assimilation moving away from the Sandusky River toward the outer Bay.

On a preliminary reconnaissance mission to Sandusky Bay during the week of July 9-12, 1973, a "heavy" phytoplankton (*Aphanizomenon flos-aquae*) bloom was in progress. The alga bloom covered approximately 2/3 of the inner Bay. Although comparisons between primary productivity measurements reported here and those reported by other workers for Sandusky Bay and western Lake Erie (see Cody, 1972) cannot at this time be made, the Bay waters are apparently capable of supporting plankton blooms greater than those known to occur in the western basin of Lake Erie.

Benthos

Methods

Seventeen stations have been sampled in Sandusky Bay and adjacent areas to determine the structure and spatial distribution of benthic populations and communities. The sampling sites were selected to gain information on the benthos from three potentially different habitats: the open Bay, most probably influenced by the Sandusky River outflow, the shore and immediate offshore area of the Bay adjacent to the Site, and the onshore tributaries in the vicinity of the Site. Stations 21, 33, 35, 36, and 38 (see Figures 15 and 16) are situated in almost a straight transect from the mouth of the Sandusky River to the outer Bay between the City of Sandusky and Johnson's Island. Samples taken at these stations would be most indicative of Bay and accompanying River influence. Stations 5, 6, 8, 16, 17, 19, 29, and 31 are situated at the shore and offshore sites and would be most indicative of Bay and shore conditions. Stations 29, 40, 41, 42, and those located at Sherz Ditch and Miller's Blue Hole Stream are representative of onshore tributaries.

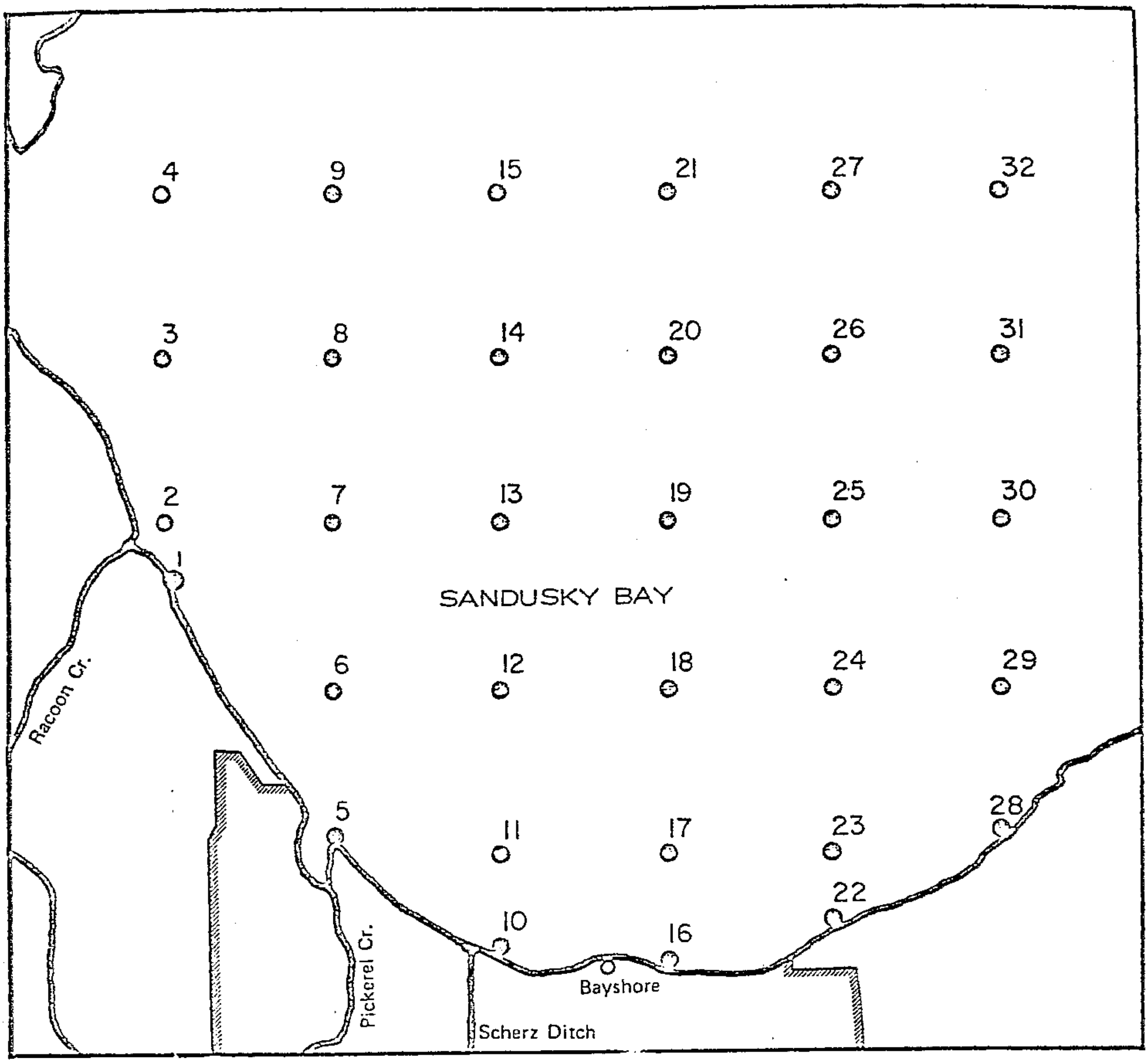


FIGURE 15. POSITIONS OF SANDUSKY BAY SAMPLING STATIONS ADJACENT TO PROPOSED SITE

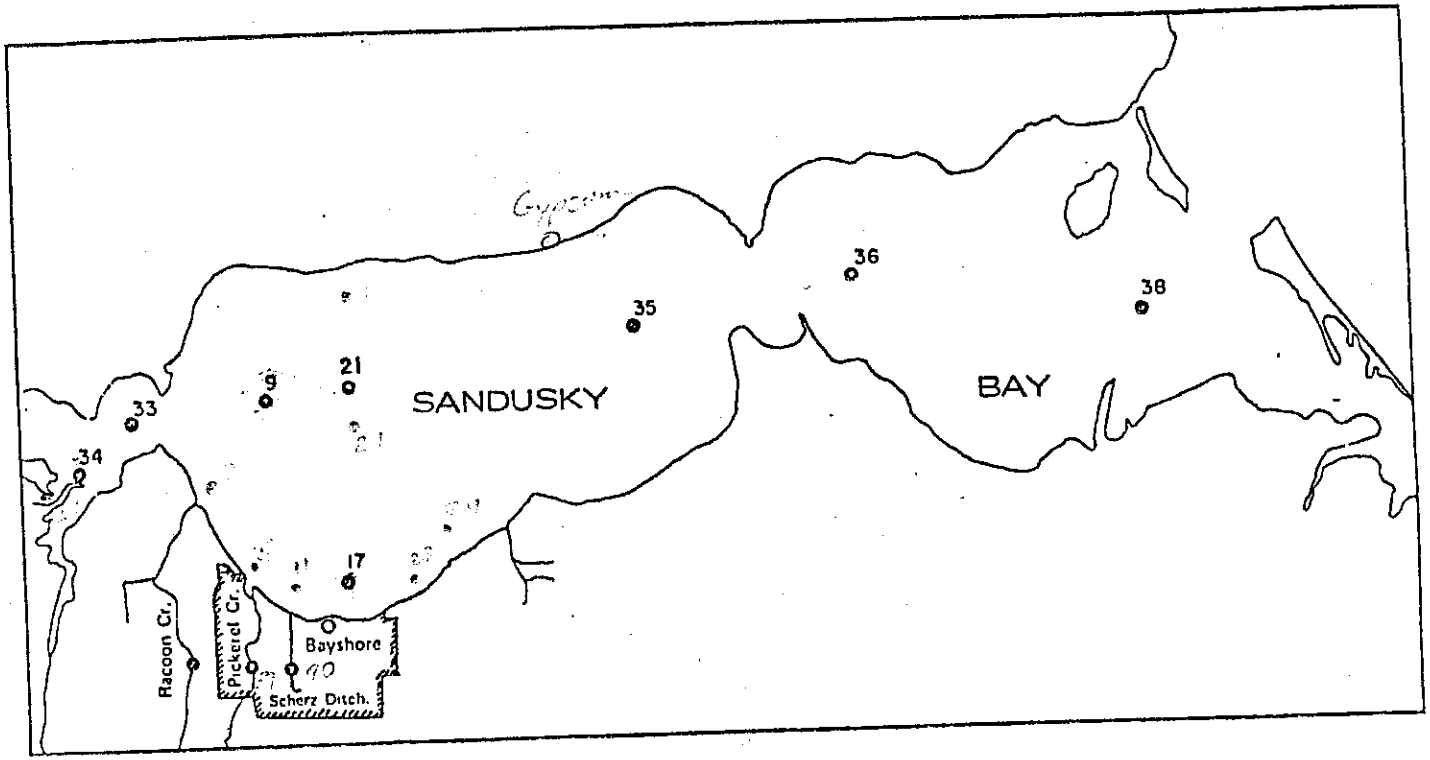


FIGURE 16. POSITION OF SAMPLING STATIONS IN SANDUSKY BAY

All samples were taken with either a 6" x 6"- or 9" x 9"-Ekman dredge and the organisms screened from the accompanying mud and silt through a Wildco wash bucket with a bottom of 40-mesh wire cloth. All organisms were placed in wide-mouth polyethylene bottles and fixed in 10 percent formalin.

Results

Seven taxa have been identified from the open Bay and shore-offshore habitats.

Data on the benthic community, at this point in time, indicate a larger number of organisms living in the open Bay habitats. The mean number of organisms collected in the open Bay stations (21, 31, 35, 36, and 38) is 3,965 per square meter as compared to 1,762 for the shore-offshore areas. Spatial distribution and abundance of benthos as determined from Phase II sampling and analysis are listed in Table 23.

The benthic community structure in both the open Bay and shore-offshore area habitats is apparently dominated by Oligochaetes (aquatic segmented worms). The Dipterans (insect midge larvae) comprise the bulk of the remaining community. The Hirudineans (leeches) while present in both habitats, never represented more than 2.6 percent of the total community.

The Oligochaetes occurred in 100 percent of the open Bay stations and showed a mean concentration of 3,574 organisms per square meter. They represented between 77.0 and 95.0 percent of the total organisms collected at each station in the open Bay. In the shore-offshore stations, the Oligochaetes occurred in 75 to 87.5 percent of the stations and showed a mean concentration of 1,530 per square meter.

Oligochaetes were most abundant at Stations 31, 35, and 36 which are located toward mid-Bay, northeast of the Site. The lowest number of Oligochaetes were found at Stations 5 and 8 which are located southwest of the Site.

Immature Oligochaetes were most numerous, representing as high as 91.7 percent of the total Oligochaetes at a single station. In the open Bay the immatures totaled 76.1 percent and in the shore-offshore habitat they represented 64 percent of the total Oligochaete community.

TABLE 23. SUMMARY OF BENTHOS DATA FOR MAY, 1973

SHORE-OFF-SHORE STATIONS (GRID)--5, 6, 8, 16, 17, 19, 29, 31
MAY, 1973

Taxa	5 #/sq. m.	5 % Taxa	5 % Total	6 #/sq. m.	6 % Taxa	6 % Total	8 #/sq. m.	8 % Taxa	8 % Total	16 #/sq. m.	16 % Taxa	16 % Total	17 #/sq. m.	17 % Taxa	17 % Total
Oligochaeta															
Brauchiura	0			134	9.7	9.5	0			19	5.2	3.8	191	34.5	23.2
Limnodrilus	19	8.3	5.5	96	7.0	6.8	57	60.0	42.9	76	21.0	15.4	115	20.8	14.0
Peloscolex				96	7.0	6.8	38	40.0	28.6	38	10.5	7.7	76	13.7	9.2
Immatures	210	91.7	61.0	1051	76.3	74.3	0			229	63.3	46.3	172	31.0	20.9
		100.0			100.0			100.0			100.0			100.0	
Total	229			1377			95			362			554		
% of Total Station	66.6			97.3			71.4			73.1			67.4		
Diptera															
Chironomus	0			0			0			0			0		
Procladius	96	83.5	28.0	19	50.0	1.3	38	100.0	28.6	76	57.1	15.4	115	46.2	14.0
Coelotanypus	19	16.5	5.5	19	50.0	1.3	0			57	42.8	11.5	134	53.8	16.3
		100.0			100.0			100.0			100.0			100.0	
Total	115			38			38			133			249		
% of Total Station	33.4			2.7			28.6			26.9			30.3		
Hirudiuea															
Helobdella	0			0			0			0			19	100.0	2.3
		100.0			100.0			100.0			100.0			100.0	100.0
Total	0			0			0			0			19		
% of Total Station													2.3		
Station Total	344			1415			133			495			822		

TABLE 23. (Continued)

19 #/sq. m.	19 % Taxa	19 % Total	29 #/sq. m.	29 % Taxa	29 % Total	31 #/sq. m.	31 % Taxa	31 % Total	Total Grid Stations	% of Total Grid	% of Stations Occurrence	Mean of Grid	% of Taxa of Total Grid
229	32.4	21.8	172	6.9	5.5	115	1.8	1.7	860	6.1	75	107.5	7.0
439	2.2	41.8	0			1509	23.4	22.4	2311	16.4	87.5	288.9	18.9
38	.4	3.6	0			955	14.9	14.2	1241	8.8	87.5	155.1	10.1
0			2311	93.1	74.2	3858	60.0	57.4	7831	55.6	75	978.9	64.0
	100.0			100.0			100.0						100.0
706			2483			6437			12,243			1530.4	
67.2			79.8			95.7							
76	22.1	7.2	38	6.0	1.2	38	12.3	0.6	152	1.1	37.5	19	8.3
134	39.0	12.8	210	33.3	6.7	134	46.7	2.0	822	5.8	100.0	102.8	44.8
134	39.0	12.8	382	60.6	12.2	115	40.1	1.7	860	6.1	87.5	107.5	46.9
	100.0			100.0			100.0						100.0
344			630			287			1834			229.3	
32.8			20.2			4.3							
0			0			0			19	0.1	12.5		
100.0			100.0			100.0				100.0			
0			0			0			19				
1050			3113			6724			14,096			1762	

TABLE 23. (Continued)

OPEN BAY STATIONS--33, 21, 35, 36, 38
MAY 1973

Taxa	33 #/sq. m.	33 % Taxa	33 % Total	21 #sq. m.	21 % Taxa	21 % Total	35 #/sq. m.	35 % Taxa	35 % Total	36 #/sq. m.	36 % Taxa	36 % Total	38 #/sq. m.	38 % Taxa	38 % Total
Oligochaeta															
Brauchiura	115	2.8	2.7	267	24.1	21.5	688	11.7	10.6	210	3.8	3.4	301	23.3	17.9
Limnodrilus	172	4.2	4.0	497	44.9	40.0	172	2.9	2.7	172	3.1	2.8	431	33.4	25.7
Peloscolex	306	7.6	7.2	229	21.0	18.4	229	3.9	3.5	401	7.2	6.5	86	6.7	5.1
Immatures	3457	85.0	80.8	115	10.4	9.3	4775	81.4	73.7	4775	86.0	77.6	474	36.7	28.2
		100.0			100.0			100.0			100.0			100.0	
Total	4050			1108			5864			5558			1292		
% of Total Station	95.0			89.2			90.6			90.4			77.0		
Diptera															
Chironomus	0	0		19	14.2	1.5	57	9.6	0.8	115	20.1	1.9	129	38.0	7.7
Procladius	229	100.0	5.4	19	14.2	1.5	535	90.4	8.3	229	40.0	3.7	129	38.0	7.7
Coelotanypus				96	72.0	7.7	0			229	40.0	3.7	86	24.6	5.1
		100.0			100.0			100.0			100.0			100.0	
Total	222			134			592			573			344		
% of Total Station	5.0			10.8			9.1			9.3			20.5		
Hirudinea															
Helobdella	0			0			19	100	0.3	19	100	0.3	43	100	2.6
		100.0			100.0			100.0	100.0		100.0	100.0		100.0	100.0
Total	0			0			19			19			43		
% of Total Station	0			0			.3			.3			2.6		
Total	4279			1242			6475			6150			1679		

TABLE 23. (Continued)

Total ransect	% of Total Transect[1]	% of Stations Occurrence	Mean of Transect	% of Taxa of Total Transect[2]
1581	8.0	100	316	8.8
1444	7.3	100	288	8.1
1251	6.3	100	250	7.0
13,596	68.6	100	2719	76.1
				100.0
17,872			3574	
320	1.6	80	64	17.1
1141	5.8	100	228	61.0
411	2.0	60	82	22.0
				100.0
1872			374.4	
81	0.4	60		
	100.0			
			3965	

[1]% of Branchiura from all stations against total organisms from all stations 1581/19,825.

[2]% of Branchiura from all stations against total Oligochaetes 1581/17,872.

The Oligochaete, Branchiura sowerbyi, seems to prefer the open Bay more than the shore-offshore habitat. This species was present in 100 percent of the open Bay samples and comprised 8.8 percent of the Oligochaetes while in the shore-offshore area it was only present at 75 percent of the stations and comprised the lowest, 7 percent, of the community. However, the Oligochaetes, Limnodrilus hoffmeisteri and Peloscolex ferox, were most abundant in the shore-offshore habitat. Limnodrilus represented the highest, 18.9 percent, of the Oligochaete community in the shore-offshore as compared to 8.1 percent in the open Bay area.

The Dipteran, Procladuis, was widely distributed. It was recorded at every sample station. It was, however, slightly more abundant in the open Bay where it comprised 61.0 percent of the Dipteran community as compared to 44.8 percent in the shore-offshore stations.

The Dipteran, Chironomus, was considerably more abundant in the open Bay where it appeared in 80 percent of the stations as compared to only 37.5 percent of the shore-offshore stations. It represented 17.1 percent of the Dipteran community in the open Bay and only 8.3 percent in the shore-offshore area.

The Hirudinean, Helobdella, was most abundant in the open Bay and in particular at Station 38 in the outer Bay off Johnson's Island. At this station it represented 2.6 percent of the total benthic community. It was recorded in only one station offshore (17) and represented 2.3 percent of the total community at that site.

Taxanomically, the Oligochaetes are the only organisms that are currently being identified to the species level. All other benthic organisms are identified to genus. If the species are worked out on these they will be included in the data at a later date.

For more universal ease of interpretation of data, the diversity indices discussed by Gaufin, the ASTM manual number STM528, "Biological Methods for the Assessment of Water Quality", have been modified to provide an index called "exact diversity". This provides a statistic to indicate precisely where the diversity of that particular station lies in relation to the maximum and minimum diversity of all stations. This may be a more valid statistic than "community" or "individual" diversity. All appropriate diversity indices are given in Table 24.

TABLE 24. TABULATION OF BENTHOS DIVERSITY INDICES

Station & Month	Number General Species	Number of Individuals	Community Diversity	Individual Diversity	Maximum Diversity	Minimum Diversity	Redundancy	Exact Diversity
5-May	4	345	146	.4236	204	-517	.8112	-381
5-June	5	286	160	.5579	195	-376	.7433	-230
6-May	6	1417	569	.4013	1095	-2743	.8570	-2195
6-June	6	497	363	.7312	380	-734	.6898	-389
8-May	3	133	62	.4686	61	-161	.7472	-105
8-June	3	172	63	.3675	80	-227	.8148	-171
16-May	6	498	325	.6528	381	-736	.7246	-429
16-June	6	612	612	.7221	470	-960	.7037	-536
17-May	7	823	651	.7906	687	-1342	.6905	-714
17-June	7	572	397	.6942	476	-841	.7143	-465
19-May	6	1053	701	.6657	812	-1902	.7491	-1221
19-June	6	690	435	.6302	530	-1119	.7474	-702
21-May	7	1245	841	.6751	1043	-2256	.7524	-1439
21-June	7	708	446	.6299	590	-1108	.7499	-683
29-May	5	3120	1185	.3797	2174	-7362	.8777	-6196
29-June	8	477	235	.4927	422	-635	.7987	-422
31-May	7	6737	3445	.5113	5683	-.1717 x 10^5	.8505	-.1375 x 10^5
31-June	7	3024	1689	.5586	2546	-6650	.8192	-4988
33-May	5	4287	1385	.3230	2989	-.1071 x 10^5	.9003	-9344
33-June 33-June	9	3521	1845	.5240	3347	-7590	.8345	-5780
35-May	7	6488	2654	.4091	5472	-.1643 x 10^5	.8801	-.138 x 10^5
35-June	7	4249	2175	.5120	3580	-9974	.8416	-7827
36-May	8	6164	2483	.4028	5554	-.1511 x 10^5	.8814	-.1266 x 10^5
36-June	7	4077	2387	.5855	3435	-9497	.8176	-7138
38-May	8	1679	1318	.7847	1506	-3163	.7240	-1874
38-June	7	2467	1192	.4834	2075	-5206	.8398	-4040

The organisms present in the Bay, to date, are limited to three species of Oligochaetes; three genera of Chironomids; and one genera each of leeches and mussels. There is one classification of Oligochaete that is called "Immature". They are counted and listed separately. The immature Oligochaetes cannot be identified.

The Oligochaete species are: <u>Branchiura sowerbyi</u>
<u>Peloscolex ferox</u>
<u>Limnodoilus hoffmeisteri</u>

The Chironomid genera are: <u>Chironomus</u>
<u>Proeladius</u>
<u>Coelotanypus</u>

The leech is <u>Helobdella</u> sp. and the mussel is <u>Anodonta</u> sp.

To date, there are too few monthly samples to establish any sort of seasonal trend. Based on the tabulated diversity indices, the Bay seems to be "healthy" at four stations (8, 16, 17, and 19). The actual diversity nearly equaled the maximum possible diversity. At the rest of the stations, except Stations 33 and 36, the diversity at least exceeded half-maximum diversity. At Stations 33 and 36 the diversity was only slightly below the half-maximum point. At this point, the benthos of Sandusky Bay shows a healthy diversity of soft bottom forms.

Fish

From the period of May 15, 1973, to August 10, 1973, 16 species of fish were collected. Relative abundance of species collected are listed in Table 25. Gizzard shad were found to be the most plentiful, comprising 61.9 percent of all specimens collected. Other major species were white bass, white crappie, yellow perch, and common emerald shiner. The 2-, 3-, and 4-year age classes were most frequent in this sample, a condition common to the particular season. The younger classes began to appear in the August sample and should occur more in autumn months.

Table 26 lists percentages of frequency of occurrence of food items in fish sampled from Sandusky Bay. Items identifiable in stomach contents are probable biased toward organisms more difficult to digest. Chironomids appear to be the most plentiful food item followed by Cladocerans

TABLE 25. SPECIES COMPOSITION OF FISH TAKEN FROM SANDUSKY BAY May 15, 1973 TO August 10, 1973

Species	Number of Organisms	Percent of Total
1-Family Clupeidae	1724	61.9
Dorosma cepedianum (gizzardshad)		
2-Family Cyprinidae	59	2.12
Cyprinus carpio (carp)	7	.25
Carassius auratus (goldfish)	3	.11
Carassius (hybrid)	633	22.73
Notropis atherinoides (common emerald shiner)	7	.25
Notropis spilopterus (spotfin shiner)		
3-Family Ictaluridae	26	.93
Ictalurus punctatus (northern channel catfish)	7	.25
Ictalurus nebulosus (brown bullhead)		
4-Family Esocidae	1	.04
Esox lucuis (northern pike)		
5-Family Serranidae	39	1.40
Morone chrysops (white bass)		
6-Family Percidae	182	6.53
Perca flavescens (yellow perch)	10	.36
Stizostedion vitreum (walleye)		
7-Family Centrarchidae	39	1.40
Pomoxis annularis (white crappie)	8	.28
Pomoxis nigromaculatus (black crappie)		
8-Family Sciaenidae	20	.72
Aplodinotus grunniens (freshwater drum, sheepshead)		
Total	2765	

TABLE 26. FREQUENCY OF OCCURRENCE OF FOOD ITEMS FROM SANDUSKY BAY FISH MAY 15, 1973 TO AUGUST 10, 1973

Food Item	% Occurrence
Cladocera	8.8
Copepoda	7.3
Diptera (not chironomids)	2.9
Chironomidae	
C. chironomus	14.7
C. cryptochironomous	11.7
Insecta (unidentifiable)	4.4
Amphipoda	2.9
Decapoda	4.4
Fish	5.8
Unidentifiable debris	26.4
Empty	10.2

and Copepods. One-fourth of all stomachs examined were found to contain unidentifiable debris. A large percent of the stomachs examined were found to be empty because fish tended to regurgitate when captured.

Physiochemical Measurements

Water Quality

Seventeen parameters of water quality have been measured during the period from March 23 to August 28, 1973. The following parameters have been routinely determined from March to August: (1) surface water temperature, (2) water temperature at mid-water interface (bottom), (3) dissolved oxygen of surface water, (4) pH, (5) conductivity of surface water, (6) conductivity of bottom water, (7) transparency, (8) turbidity, (9) total alkalinity, (10) ortho-phosphate, and (11) nitrate-nitrogen. Measurements of 7 additional parameters were initiated in August, but insufficient data have been accumulated on these to justify informative discussion. Parameters introduced in August were: (1) dissolved oxygen of bottom water, (2) carbon dioxide, (3) silica, (4) sulfate-sulfur, and (5) manganese. In addition to these chemical parameters, coliform and fecal coliform bacteria concentrate and BOD (Biochemical Oxygen Demand) measurements were initiated.

Water quality in the open Bay area (Stations 21, 33, 35, 36, and 38) was fairly uniform from the mouth of the Sandusky River to the outer Bay of Johnson's Island. Temperature varied no more than 1.5 degrees C along this transect and varied less than 2.0 degrees C between surface and bottom water. pH remained within a range of 7.3-8.5 with the lowest value recorded in August in the outer Bay at Station 38. Very little difference existed between conductivity of surface and bottom waters with an overall seasonal fluctuation between 330 and 560 uohms/cm^2. The Bay water showed the greatest clarity during June when transparency was highest and turbidity lowest. Dissolved oxygen concentrations ranged between 71 and 94 percent of saturation during spring and summer. There existed, during August, a difference between oxygen concentration of surface and bottom waters, sometimes as high as two-fold. Since oxygen concentration of bottom waters was not recorded during the earlier months of the study, it is not known whether surface and bottom differences existed during the spring and early summer. Ortho-phosphate showed minor fluctuations along the open Bay transect. Nitrate-nitrogen was generally higher in the outer Bay (Station 38) between Johnson's Island and the City of Sandusky.

Water quality in the shore-offshore stations (5, 6, 8, 16, 17, 19, 29, and 31) showed greatest differences and fluctuations at stations where the water was shallowest. Among the shore stations, water temperature reached a maximum of 28.5 C. Turbidity showed greatest fluctuation and magnitude along the same shore stations (5-16). The offshore stations approximated the open-Bay conditions, including the different oxygen concentrations between surface and bottom waters. Conductivity remained fairly constant within the range of 365 to 540 uohms.

In Sherz Ditch, conductivity averaged 2.5 fold higher and turbidity averaged 1/2 that of the Bay. Other water quality parameters of this man-made ditch approximated the characteristics of the Bay. The approximation of Bay conditions was more pronounced between Route 6 (Station 39) and the Bay than between Route 247 (Station 44) and Route 6. Turbidity increased from headwaters to the Bay while conductivity decreased along this course. Ortho-phosphate and nitrate-nitrogen likewise decreased in close proximity to the Bay.

In Pickerel Creek, a natural tributary, ortho-phosphate and nitrate-nitrogen decreased slightly toward the Bay, while sulfate and turbidity increased. Water temperature was from 3 to 5 C higher toward the headwater (Station 43) than at Bay-influenced Station 39 at Route 6. pH remained fairly constant in Pickerel Creek ranging between 7.3 and 8.5, the higher values occurred closer to the Bay.

The outflow from the Miller's Blue Hole was substantially different from Sherz Ditch and Pickerel Creek. Water quality of the blue hole stream and the effluent from the flowing well at Bayshore were similar. The most striking difference in the Miller's Blue Hole tributary was its low temperature and high conductivity. Water temperature remained fairly constant between 12.0 and 14.5 C while conductivity ranged between 2,200 and 2,700 uohms. Dissolved oxygen was low, between 3 and 5 ppm even with the aeration between the blue hole and Route 6. The water had a high clarity and very low turbidity, never exceeding 15 JTU. pH was rather constant varying between 7.2 and 8.4 and ortho-phosphate was quite low.

The flowing well at Bayshore, Station 42, is most probably of the same origin as the Miller's Blue Hole. The water temperature was low, between 11 and 13.2 C. Dissolved oxygen was the lowest of all stations, averaging slightly higher than 1.0 ppm. Conductivity was high, approximating the blue hole station, between 2,200 and 2,600 uohms/cm^2. Turbidity was lowest with a reading of 0.25 JTU. Ortho-phosphate was highly variable, ranging between .05 and 1.2 ppm, but nitrate-nitrogen approximated that of Bay water, around 12 ppm.

The Biochemical Oxygen Demand, while only analyzed once in August, showed the highest values in the vicinity of the mouth of Pickerel Creek. Stations 5, 6, and 8 are situated in a straight line into the open Bay from the mouth of Pickerel Creek, with Station 5 at the mouth. BODs of 10.5 were recorded at Station 5, 9.0 at Station 6, and 8.0 at Station 8. The lowest reading of BOD, 3.0, was recorded near the opposite shore of the Bay at Station 27. In the open Bay transect, the BOD was quite uniform; 6.0 at Station 33, 6.0 at Station 35, 5.0 at Station 36, and 7.0 at Station 38.

Coliform bacteria and fecal coliform bacteria were most concentrated at Station 35 which is just to the northeast of the Site; the total coliform count was 10,000 and the fecal coliform concentration was 630. The lowest total coliform concentration was only 287 and the fecal coliforms only 26. At Station 37, across the Bay, the total number was 625 and the fecal forms 12 while at the mouth of the Sandusky River the total coliform concentration was 1,540 and the fecal forms 233.

Nutrient Budgets

During those periods when the productivity experiments are conducted, water samples are obtained from Sandusky Bay and selected inflow streams(see Figure 17) stored frozen, returned to BCL, and analyzed for total phosphate, dissolved phosphate, total organic nitrogen, nitrate-nitrogen, and total organic carbon.

Phosphates are analyzed using the stannous-chloride method outlined in Standard Methods (A.P.H.A., 1971).

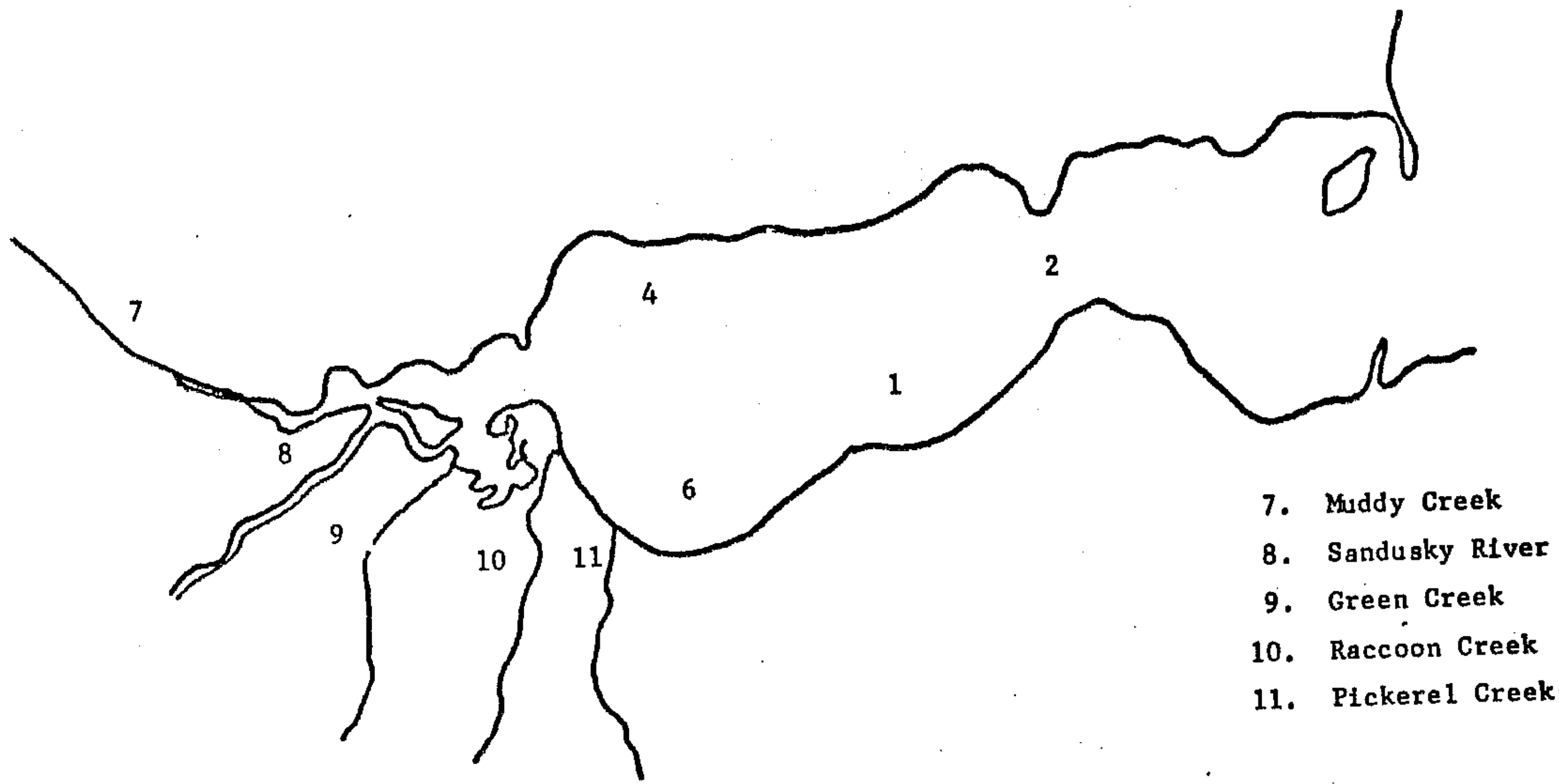


FIGURE 17. SANDUSKY BAY AND TRIBUTARIES WITH WATER SAMPLING STATIONS MARKED

Total organic nitrogen is determined by digestion of the sample following removal of free ammonia in Kjeldahl apparatus; final evaluation of organic nitrogen content is completed with a titration of ammonia in the distillate with standard 0.02N sulfuric acid. The ammonia is contained under boric acid and the titration end-point is indicated by a mixed indicator solution consisting of methyl-red and methylene-blue indicators.

The cadmium reduction method is being used to determine inorganic nitrogen components in the water samples. This method (adapted from Hach, but also discussed in Standard Methods) registers both nitrate and nitrate-nitrogen. Nitrate in the presence of cadmium is reduced almost completely to nitrate which is then analyzed colorimetrically. The final result is expressed as nitrate-nitrogen.

Analysis for total organic carbon is being conducted with a Beckman infrared gas analyzer. A micro sample of the water to be analyzed is injected into a catalytic combustion tube which is enclosed by an electric furnace at 950 C. The water is vaporized and the carbonaceous material is oxidized to carbon dioxide (CO_2) and steam in a carrier stream of oxygen. The oxygen flow carries the steam and CO_2 out of the furnace where the steam is condensed and the condensate removed. The CO_2, oxygen, and remaining water vapor enter an infrared analyzer sensitized to provide a measure of CO_2. The amount of CO_2 present is directly proportional to the concentration of carbonaceous material in the injected sample.

Water samples from nine stations (Figure 17) have been collected on five separate occasions. Analytical determinations for phosphates, organic nitrogen, nitrate-nitrogen, and total organic carbon have not been totally completed; therefore, no data tabulations are included at this time. Data obtained to date indicate high inputs of phosphorus and nitrogen to the Bay via the Sandusky River and other smaller streams. Total organic carbon is generally occurring at higher levels in the Bay waters than in the Sandusky River due, no doubt, to autochthonous organic production within the former. However, the trend is not always consistent, i.e., the Bay receives significant inputs of carbonaceous organics from the River and tributary streams.

REFERENCES

APHA, AWWA, WPCF. 1971. "Standard Methods for the Examination of Water and Wastewater". 13th Edition, 874 pp.

Branzell, R. September 11, 1973. Personal Communication. U. S. Game Management Agent, Bureau Sport Fisheries and Wildlife.

Campbell, L. W. 1968. "Birds of the Toledo Area". The Blade, Toledo, Ohio, 330 pp.

Carman, J. E. 1927. "The Monroe Division of Rocks in Ohio", J. Geol. 35, pp 481-506.

Carman, J. E. 1957. In Coash, John R., Bernhagen, Ralph J., and Jane L. Forsyth, "Geology of the Central Lake Plain". Ohio Academy of Science, Guide to the 32nd Annual Field Conference of Section of Geology, April 20, 1957 (Bowling Green University).

Cody, T. E. 1972. "Primary Productivity in the Western Basin of Lake Erie". Ph.D. Thesis, The Ohio State University, 113 pp.

Corps of Engineers. 1953. "Ohio Shoreline of Lake Erie, Sandusky Bay, Ohio. Beach Erosion Control Study". U. S. House Document No. 126, p 15.

Daubenmire, R. 1968. "Plant Communities". Harper and Row (New York), 300 pp.

Erie Regional Planning Commission. 1967. "Land Capability Report for Erie County and Townsend Township, Sandusky County, Ohio". Erie Regional Planning Commission, 1200 Sycamore Lane, Sandusky, Ohio, p 158.

Forsythe, Jane L. 1971. "Geology of the Lake Erie Islands and Adjacent Shores". Guidebook for Michigan Basin Geological Society Annual Field Excursion, p 63.

Francis, D. September 11, 1973. Personal Communication. Enforcement Section, Ohio Division of Wildlife.

Knoder, E. 1972. Personal Communication.

Lewis, C.F.M. 1969. "Late Quaternary History of Lake Levels in the Huron and Erie Basins". Proceedings of 12th Conference on Great Lakes Res., International Association for Great Lakes Res., pp 250-270.

Lowden, Richard M. 1969. "A Vascular Flora of Winous Point, Ottawa and Sandusky Counties, Ohio". Ohio J. Science, 69, pp 257-284.

Moore, Sherman. 1948. "Crustal Movement in the Great Lakes Area". Geol. Society American Bulletin, 59 (7), pp 699-709.

Moseley, E. L. 1905. "Formation of Sandusky Bay and Cedar Point". 13th Annual Report, Ohio Academy of Science 1904, pp 179-238.

REFERENCES (Continued)

Moseley, E. L. 1906. "Sandusky Bay and Cedar Point, Their Formation, The Changes Wrought by the Hand of Time, What the Waters Have Covered in Ages Past, Nature's Silent Forces". Sandusky Daily Register, Saturday, January 20, 1906, 84 (262), pp 9-10.

Ogden, L. 1963. "Determining Transmissibility with One Drawdown". Groundwater Journal, September-October (Mimeo).

Oosting, H. J. 1948. The Study of Plant Communities. Freeman (San Francisco) 440 pp.

Phillips, E. A. 1959. "Methods of Vegetation Study". Holt, Rinehart, and Winston (New York) 107 pp.

Redmond, C. E., Hale, T.J.F., Innis, C. H., and M. Wachtman. 1971. "Soil Survey of Erie County, Ohio". U.S.D.A. Soil Conservation Service, p 166.

Shaffer, Paul R. 1951. "Shore Erosion on Sandusky Bay". Ohio J. Science, 51 (1), pp 1-5 (also Ohio Geol. Survey Report of Invest. 7, p 5).

Smith, H. G. September 10, 1973. Personal Communication. Field Biologist, Soil Conservation Service.

Snow, C. 1973. "Habitat Management Series for Endangered Species". Bureau of Land Management, U. S. Department of the Interior, Rep. 5, 58 pp.

Sprunt, A. IV. 1969. "Population Trends of the Bald Eagle in North America". pp 347-351. In: J. J. Hickey (ed), Peregrine Falcon Populations; Their Biology and Decline, University of Wisconsin Press (Madison, Wisconsin).

Sprunt, A. IV. September 12, 1973. Personal Communication. Research Director, National Audubon Society.

Stout, W. 1941. "Dolomites and Limestones of Western Ohio". Ohio Geol. Survey Bulletin 42, p 468.

Thacker, R. September 11, 1973. Personal Communication. President of North American Falconers Association and Member of Raptor Research Foundation.

U. S. Department of the Interior. 1973. "Threatened Wildlife of the United States". Bureau of Sport Fisheries and Wildlife Resource Publication 114, 289 pp.

Verber, J. L. 1959. "Long and Short Period Oscillations in Lake Erie". State of Ohio, Department of Natural Resources (Mimeo).

Walton, W. L. 1970. Groundwater Resource Evaluation, McGraw-Hill (New York) 664 pp.