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DRAFT PHASE II REPORT

on

SITE QUALIFICATION STUDIES FOR ELECTRIC POWER GENERATION SANDUSKY BAY, OHIO

to

AMERICAN ELECTRIC POWER SERVICE CORPORATION

August 21, 1974

BATTELLE
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EXECUTIVE SUMMARY

Since mid-November, 1972, Battelle's Columbus Laboratories and The Ohio State University have been conducting studies to determine the environmental suitability of a tract of land bordering western Sandusky Bay for construction and operation of two HTGR nuclear electric generating units and ancillary facilities. These investigations were designed and conducted to obtain information regarding the environmental characteristics of the Site and environs, and environmental implications of facilities construction and operation on the Site, in accordance with current USAEC Guidelines to the Preparation of Environmental Reports for Nuclear Power Plants.

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 MWe 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. The scope of Phase II investigations was reduced such that bedrock geology, seismology, and meteorology were not investigated further.

This report contains the results of Phase II investigations in a format consistent with USAEC guidelines for environmental reports. A brief summary of the salient aspects of the results of these investigations is provided herein.

The land area in the vicinity of the Site is predominately agricultural. Unemployment rates are fairly low; present and projected population densities are characteristic of rural regions containing scattered urban areas. Population densities in the immediate area are within the limitations set by present AEC criteria. There are very few industries within a 10-mile radius of the Site, but there are significant industrial areas between 10 and 15 miles of the Site, especially in the cities of Sandusky and Fremont.

Numerous natural historic and archaeological landmarks are located within 30 miles of the Site, but only a small number of them are located within

10 miles. The construction and operation of a nuclear power facility on the Site would have no effect on these, with the possible exception of Miller's Blue Hole, a spring. Location of transmission lines would be the only factor of significance to other landmarks in the area.

Silty clay soils on the Site which are relatively unproductive agriculturally overlay dolomite bedrock at a variable depth. There are several artesian wells located on the Site. The region is relatively stable seismically. There are no recorded earthquake epicenters for Sandusky or adjacent counties.

Sandusky Bay, bordering the Site, is quite shallow (6 to 7 feet) and is susceptible to extensive variation in water level due to storms, winds, and seiche activity. Dissolved solids concentrations are about twice those of Lake Erie due to the discharge of the Sandusky River and seepage of highly mineralized groundwater into the Bay. However, makeup water requirements for up to 5,000 MWe of generating capacity using wet natural draft cooling towers could normally be met. The shallowness of Sandusky Bay and its susceptibility to extensive water level fluctuations might constrain the number of options for intake design. Ice may periodically jam and windrow in the western portion of the Bay.

The ecological characteristics of the Site are generally typical of agricultural areas. However, marsh habitats on and near the Site are a valuable ecological resource, especially for migrating waterfowl. There is at least one active bald eagle nest on the Site. Site development might cause the nest to become inactive. However, this subspecies of the bald eagle is presently not on the Federal list of Rare or Endangered Species. Very few, if any, rare or endangered species are expected to frequent the area.

The aquatic ecology of western Sandusky Bay is extensively influenced by the shallowness turbidity, and unconsolidated sediments of the Bay. Several species of game fish frequent the area, and the western basin of the Bay is used by some species as a spawning and nursery area. Benthic species diversity is low. Literature reviews indicate that the water quality and species composition of the Bay are changing as a result of changing land use patterns, industrialization, and impoundment of the Sandusky River Basin.

A wet natural draft cooling tower heat dissipation system for 3,000 MWe of electrical generation capacity could be designed so as to product blowdown dissolved solids concentrations within present permissible limits. Blowdown characteristics would probably not result in a significant adverse impact on the aquatic ecology of the Bay. Entrainment of organisms in the makeup water would probably result in extensive mortality of those organisms, but this is not expected to have far-reaching effects on species populations with the Bay.

Site development could be conducted in such a way that, subsequent to proper decommissioning, irretrievable resource commitments would be minimal, and several long-term land use benefits could be realized, including shoreline protection, marsh protection, and maintenance.

Two plant design alternatives that would seem to warrant further consideration are those of using hybrid wet/dry cycle natural draft cooling towers for heat dissipation and employing a diffuser discharge system instead of a holding pond canal discharge system.

INTRODUCTION

Continual increases in the demand for electrical power within Ohio Power Company's service network require that the Corporation's production capacity must be increased. American Electric Power Service Corporation and the Ohio Power Company are considering the feasibility of constructing and operating a nuclear power plant at a previously purchased site on the south shore of Sandusky Bay, Ohio. The site consists of a 2,600-acre tract about 11 miles west of the City of Sandusky, Ohio. The geometric center of this tract is located at N41° 24' 40" - W82° 56' 15". The boundaries of this tract are shown in Figure 2.1.1. Hereinafter in this report, this tract will be referred to as the Site. Additionally, all subsequent designations of "distance from the Site" appearing in this report refer to the distance from the center of the Site, rather than from the nearest Site boundary.

Subsequent to the enactment of the National Environmental Policy Act of 1969 (NEPA, PL 90-190) and additional mandates by the USAEC, environmental planning and impact assessments have become critical prerequisites to the construction and operation of nuclear electric generating stations. Specifically, Section 50.34 of 10 CFR Part 50 of the AEC regulations requires that each application for a license to operate such a facility shall include a Final Safety Analysis Report (FSAR). In addition, AEC's implementation of NEPA requires that each applicant for a construction permit and operating license shall submit an Environmental Report at each stage for consideration by the Commission's regulatory staff.

The American Electric Power Service Corporation has recognized the importance of environmental factors in its current planning for future increases in electric power production. It has retained Battelle's Columbus Laboratories and The Ohio State University under separate contract to conduct investigations pertaining to selected considerations of Site suitability and selected assessments of environmental impacts contingent to Site development and operation.

This report contains the results of these investigations through Phase II. The primary objectives of these investigations have been to establish a baseline environmental characterization of the Site, to make an assessment of the environmental suitability of the Site for construction and operation of two HIGR nuclear units with a power output of 3,000 MEe, and to render assessments of environmental impacts which may occur due to Site development. Investigations and report formats have been designed in accordance with the current USAEC Guidelines to the Preparation of Environmental Reports for Nuclear Power Plants. Thus, sections of this report should be considered as preliminary drafts of selected portions of an Environmental Report for the Site fully responsive to AEC guidelines and interpretations of NEPA. Sections of the Environmental Report to be prepared by other parties are also designated.

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APPENDICES

CHAPTER 1

PURPOSE OF THE PROPOSED FACILITY
(To be prepared by AEPSC)

CHAPTER 2

THE SITE

2.1 SITE LOCATION AND LAYOUT

The Site consists of a tract of land encompassing approximately 2,600 acres 11 miles west of the City of Sandusky, Ohio. The geometric center of the Site is located at N41° 24' 30" - W82° 56' 15". Present property boundaries are shown in Figure 2.1.1. Other properties in the immediate vicinity of the Site are currently under option for purchase, but are not considered as a part of the Site at this time.

Present plans are that the two HTGR units and ancillary facilities will be located north of Highway 6 and east of Scherz Ditch. Reactor vessels will be located approximately 0.7 mile north of Highway 6 and cooling towers will be located between the reactor vessels and the highway. The exclusion area boundary will coincide with the northern edge of Highway 6, the Sandusky Bay shoreline, the eastern property boundary, and a western boundary approximately 1,000 feet east of Scherz Ditch. The exclusion area will encompass approximately 800 acres. A visitors center will be constructed immediately west of the exclusion area and immediately north of Highway 6. Approximately 250 acres of the exclusion area will be modified by the presence of the nuclear units and ancillary facilities. About 2-3 acres immediately outside of the exclusion area will be modified by the construction of the visitors center.

A railroad spur from the Norfolk and Western Line will extend northward from the southern property boundary to the center of the exclusion area. The spur's right-of-way will occupy an additional 30 acres.

The remainder of the Site will remain in its present status. This includes approximately 800 acres under cultivation and approximately 800 acres as marshland habitat.

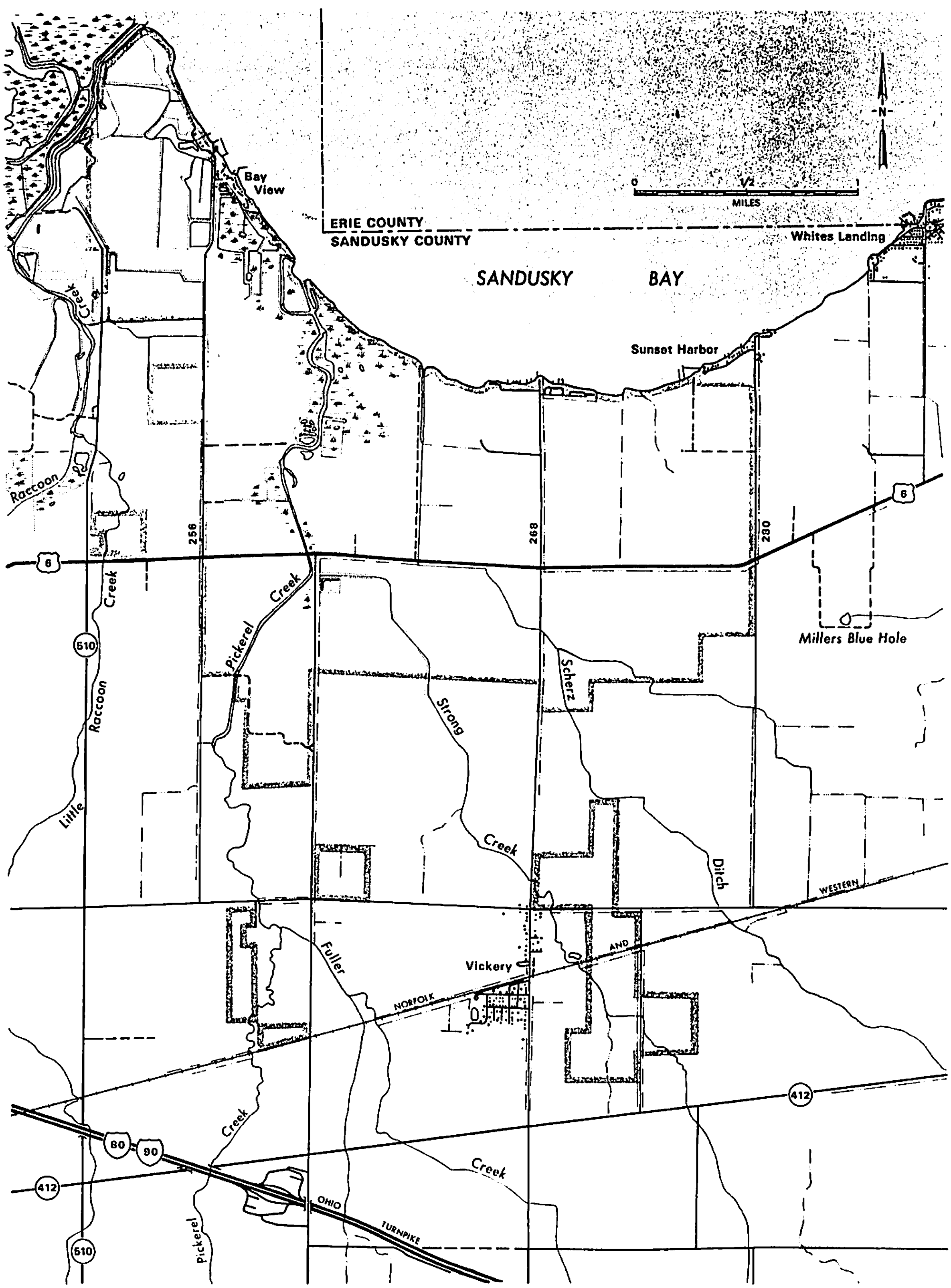


FIGURE 2.1.1 CURRENT PROPERTY BOUNDARIES

2.2 REGIONAL DEMOGRAPHY, LAND AND WATER USE

2.2.1 REGIONAL DEMOGRAPHIC CHARACTERISTICS

2.2.1.1 General Characteristics, Location of Cities and Towns

A circle of 50 miles radius centered at the Site encompasses six counties and parts of fourteen others, parts of two states and one province, and parts of two countries. The region is shown in Figure 2.2.1. Within the region are included twenty urban areas of more than 10,000 inhabitants. These are listed in Table 2.2.1. Incorporated places under 10,000 population and unincorporated places of 1,000 to 10,000 population within 10 miles are listed in Table 2.2.2. The area consists of large rural agricultural tracts and a tourist area having the summer population increase characteristic of a northern U.S. tourist area. Areas within 5- and 10-mile radii from the Site are shown in Figure 2.2.2.

TABLE 2.2.1. URBAN PLACES OF GREATER THAN 10,000 POPULATION WITHIN 50 MILES OF SITE

City	Miles From Site	County	Population(1) 1970	Population(1) 1960	Percent Change	Projected Population(2) 1980	Projected Population(2) 1990	Projected Population(2) 2000
Fremont	9.5 SW	Sandusky	18,490	18,767	-1.5	20,201	23,267	27,163
Sandusky	9.5 E	Erie	41,175	36,713	12.2	50,962	62,145	75,862
Norwalk	20.0 SE	Huron	13,386	12,900	3.8	16,701	19,382	22,417
Tiffin	24.0 SW	Seneca	21,596	21,478	0.5	23,952	26,557	29,060
Fostoria	30.0 SW	Hancock, Seneca, Wood	16,037	15,732	1.9	17,310	19,275	21,411
Toledo	32.0 NW	Lucas	383,818	318,003	20.7	[429,100]	[475,000]	[530,000]
Lorain	34.0 E	Lorain	78,185	68,932	13.4	103,482	126,688	152,410
Bowling Green	37.0 W	Wood	21,760	13,574	60.3	[24,500]	[27,500]	[31,000]
Maumee	37.5 NW	Lucas	15,937	12,063	32.1	18,499	21,766	25,438
Bucyrus	40.5 S	Crawford	13,111	12,276	6.8	14,997	17,461	20,472
Elyria	42.5 E	Lorain	53,427	43,782	22.0	71,206	88,528	107,288
Monroe	42.5 NW	Monroe (Michigan)	23,894	22,968	4.0	NA	NA	NA
Sylvania	44.0 NW	Lucas	12,031	5,187	131.9	[13,400]	[14,800]	[16,600]
Leamington	45.0 NE	Essex (Ontario, Canada)	10,435	NA	NA	14,457	17,369	20,905
Finlay	45.0 SW	Hancock	35,800	30,344	18.0	37,370	43,560	51,138
Avon Lake	47.0 E	Lorain	12,261	9,403	30.4	19,617	25,424	31,346
Trenton	47.0 NW	Wayne (Michigan)	24,127	18,439	30.8	NA	NA	NA
Galion	47.5 S	Crawford	13,123	12,650	3.7	15,542	18,109	21,241
Mansfield	47.5 SE	Richland	55,047	47,325	16.3	67,156	78,075	90,633
Ashland	49.5 SE	Ashland	19,872	17,419	14.1	24,461	28,439	33,012

(1) U.S. Census, 1970.

(2) "Population and Employment Projections for Northwest Ohio", BMI, Columbus (1966).

[illegible] [ ] figures for Toledo and Bowling Green extrpolated from estimate for smaller area.

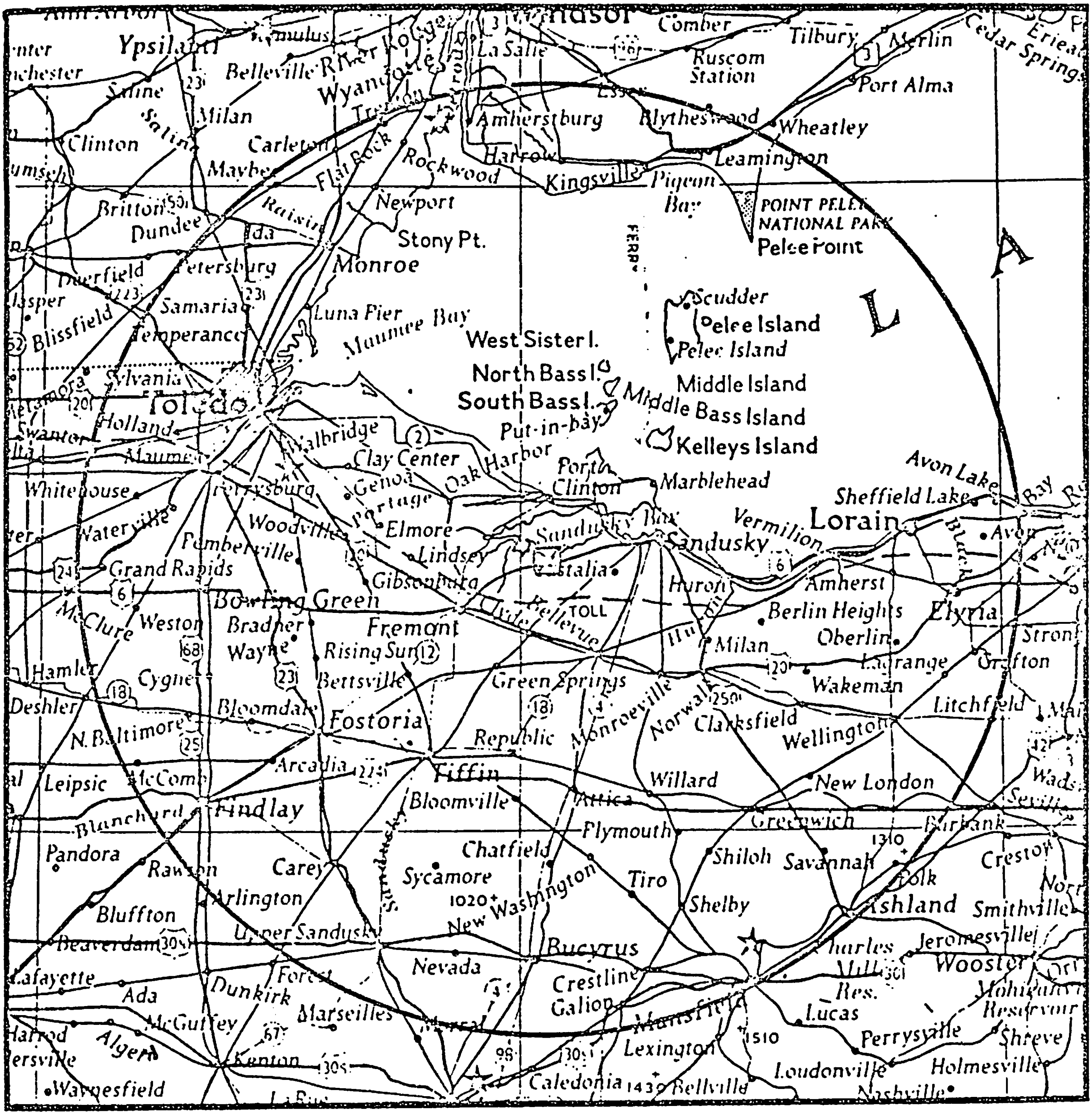


FIGURE 2.2.1. LOCATIONAL MAP OF AREA WITHIN 50 MILES OF SITE

TABLE 2.2.2. ALL INCORPORATED PLACES UNDER 10,000 POPULATION AND 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 2.2.2. (Continued)

City	County	1970 Pop.	1960 Pop.	% Change	Distance & Direction from Site
Luckey village	Wood	996	946	5.3	18 mi. W
McClure village	Henry	699	651	7.4	50 mi. W
McComb village	Hancock	1329	1176	13.0	49 mi. WSW
Milan village	Erie, Huron	1405	1309	7.3	19 mi. ESE
Millbury village	Wood	771	730	5.6	17 mi. WNW
Milton Center village	Wood	244	251	- 2.8	47 mi. W
Monroeville village	Huron	1455	1371	6.1	17 mi. SSE
Mount Blanchard village	Hancock	473	432	9.5	48 mi. SSW
Nevada village	Wyandot	917	919	- 0.2	43 mi. S
New London village	Huron	2336	2392	- 2.3	37 mi. ESE
New Riegel village	Seneca	340	349	- 2.6	33 mi. SSW
New Washington village	Crawford	1251	1162	7.7	33 mi. S
North Baltimore village	Wood	3143	3011	4.4	42 mi. WSW
North Fairfield village	Huron	540	547	- 1.3	18 mi. SSE
North Robinson village	Crawford	277	289	- 4.2	44 mi. S
Northwood village	Wood	4222	...	...	40 mi. W
Oak Harbor village	Ottawa	2807	2903	- 3.3	12 mi. WNW
Oberlin city	Lorain	8761	8198	6.9	39 mi. E
Ontario village	Richland	4345	3049	42.5	49 mi. SSE
Ottawa Hills village	Lucas	4270	3870	10.3	40 mi. WNW
Pemberville village	Wood	1301	1237	5.2	17 mi. W
Perrysburg city	Wood	7693	5519	39.4	37 mi. W
Plymouth village	Huron, Richland	1993	1822	9.4	33 mi. SSE
Polk village	Ashland	435	358	21.5	50 mi. ESE
Portage village	Wood	494	420	17.6	37 mi. W
Port Clinton city	Ottawa	7202	6870	4.8	6 mi. N
Put-in-Bay village	Ottawa	135	357	-62.2	17 mi. NNE
Reno Beach	Lucas	1049	...	...	25 mi. WNW
Republic village	Seneca	705	729	- 3.3	21 mi. S
Rising Sun village	Wood	730	815	-10.4	28 mi. WSW
Rochester village	Lorain	210	226	- 7.1	39 mi. ESE
Rocky Ridge village	Ottawa	385	441	-12.7	16 mi. WNW
Rossford village	Wood	5302	4406	20.3	35 mi. WNW
Sandusky South	Erie	8501	4724	80.0	12 mi. E
Savannah village	Ashland	361	409	-11.7	44 mi. SSE
Sheffield Lake city	Lorain	8734	6884	26.9	44 mi. E
Sheffield village	Lorain	1730	1664	4.0	44 mi. E
Shiloh village	Richland	817	724	12.8	36 mi. SSE
South Amherst village	Lorain	2913	1657	75.8	36 mi. E
Spencer village	Medina	758	742	2.2	49 mi. ESE
Stony Prairie	Sandusky	1913	1720	11.2	8 mi. W
Swanton village	Fulton	2927	2306	26.9	50 mi. W
Sycamore village	Wyandot	1096	998	9.8	35 mi. SSW

TABLE 2.2.2 (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

SOURCE: U. S. GEOLOGICAL SURVEY (1956)

FIGURE 2.2.2. LOCATIONAL MAP OF AREA WITHIN 5 MILES (INNER CIRCLE) AND 10 MILES (OUTER CIRCLE) FROM THE SITE

Population centers dot the Sandusky Bay-Lake Erie shoreline rather uniformly to the east of the Site, cluster about the mouth of the Maumee River to the northwest, and are scattered nearly uniformly in other inland areas. That part of Essex County, Provice of Ontario, Canada, which impinges on the 50-mile radius from the Site exhibits a similar pattern of shoreline population clustering.

The five largest cities within 50 miles of the Site, with their 1970 populations and percentage increases over 1960 are: Toledo, 35 miles to the northwest (383,818-20.7 percent); Lorain, 35 miles to the east (78,185-13.4 percent); Elyria, 40 miles to the east, adjoining Lorain (53,427-22.0 percent); Sandusky, 11 miles to the east (41,175-12.2 percent); and Findlay, 45 miles to the southwest (35,800-18.0 percent).

The nearest incorporated town to the Site is Port Clinton, located just beyond the 5-mile radius directly to the north, across Sandusky Bay. Its population in 1970 was 7,202, an increase of 4.8 percent over the 1960 figure.

Most of the area within 10 miles of the Site lies within Sandusky County. The economy of the county is predominantly agricultural and the average annual household income is $10,394.00. The unemployment rate as of October, 1972, stood at 3.8 percent as compared with 4.0 percent for the State of Ohio. The county's population of 60,983 includes residents of eight incorporated communities, the largest of which is Fremont, the county seat, with 18,490 inhabitants. Including these population centers, the population density of Sandusky County is 149.1 persons/square mile; excluding them, 68.8 persons/square mile. Larger towns and cities are found along rivers (Fremont on the Sandusky River, Woodville on the Portage River) and major cross-county highways (Fremont, Clyde, Bellevue are along U.S. Route 20). Smaller towns and unincorporated villages are located at junctions of county roads serving the nearby rural farm areas and along the Sandusky Bay coast largely serving vacationing summer populations.

Three resort villages and two rural villages, all of which have less than 500 inhabitants, are located within 5 miles of the Site (not including abandoned Bayshore on the Site itself).

All parts of Sandusky County are expected to increase in population in the future, but the most rapid increases will likely be in the medium-sized towns of Ballville, Bellevue, and Story Prairie, and in inland rural areas. No sudden population growth or decline is predicted for the area immediately surrounding the Site. Of all thirteen townships in Sandusky County, Townsend Township which includes the Site had the lowest growth between the 1960 and 1970 censuses. Growth rates of all Sandusky County townships are listed in Table 2.2.3

TABLE 2.2.3. POPULATION OF TOWNSHIPS WITHIN SANDUSKY COUNTY--1960, 1970

Township	1960	1970	Percent Increase
Ballville	4,425	5,851	32
Bellevue	3,992	4,212	5
Green Creek	8,374	9,412	12
Jackson	1,595	1,668	4
Madison	3,696	3,849	4
Rice	753	853	13
Riley	1,340	1,381	3
Sandusky	4,747	4,936	4
Scott	1,225	1,279	4
Townsend	1,701	1,709	0.5
Washington	2,265	2,375	5
Wood	3,087	3,156	2
York	1,713	2,084	22

Source: U.S. Census, 1960 and 1970.

2.2.1.2 Population Projections

The area within 50 miles of the Site was divided into sectors (see Figure 2.2.3) by constructing concentric circles at 10-mile intervals and by subdividing these with segments centered on each of the 16 cardinal compass points. A similar construction was used for the area within 10 miles except concentric circles were at 1, 2, 3, 4, 5, and 10 miles (see Figure 2.2.4). Population projections at 10-year intervals from 1970 to 2020 for 0-5 miles are shown in Tables 2.2.4 to 2.2.9, while projections for 5-50 miles are shown in Tables 2.2.10 to 2.2.15. Sector numbers along the vertical axis of the table correspond to the compass directions with 1 corresponding to N, 2 to NNE, 3 to NE, etc. Numbers along the horizontal axis correspond to the rings of various radii. That is, 1 is for 0-1 mile, 2 is for 1-2 miles, etc. However, ring 6 represents the area from 5-10 miles.

The following steps were involved in calculating sector populations.

For each county:

- Subtract water and urban land area from county total
- Subtract urban population from county total
- Calculate rural population density
- Calculate projected rural population (It is assumed to remain in the same proportion to the county total as in 1970).

For each city:

- Calculate projected urban population assuming its ratio to the county population remains constant.

For each sector:

- Determine its area
- Determine the proportion composed of various counties

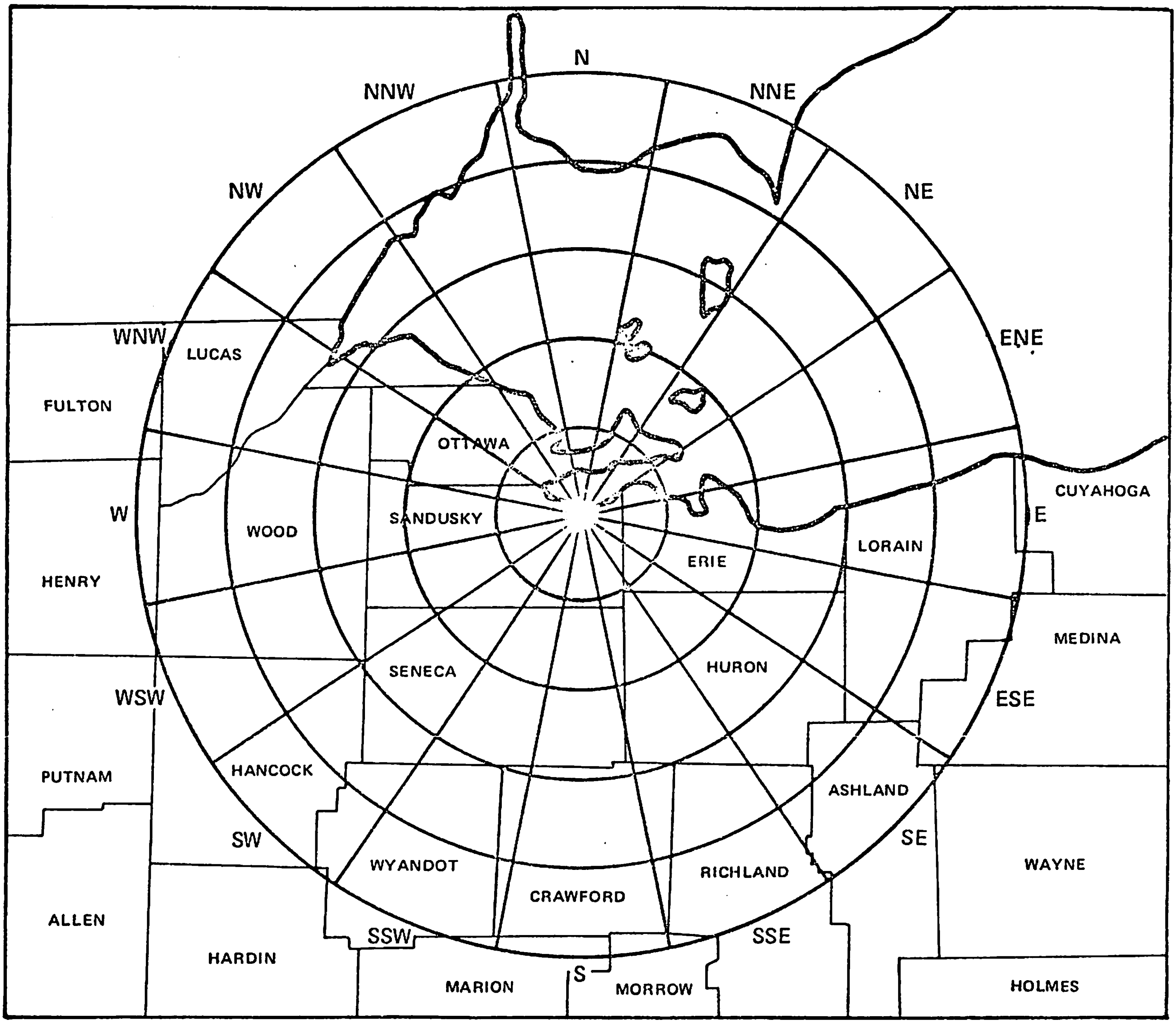


FIGURE 2.2.3. SECTOR DIVISIONS WITHIN 50 MILE RADIUS

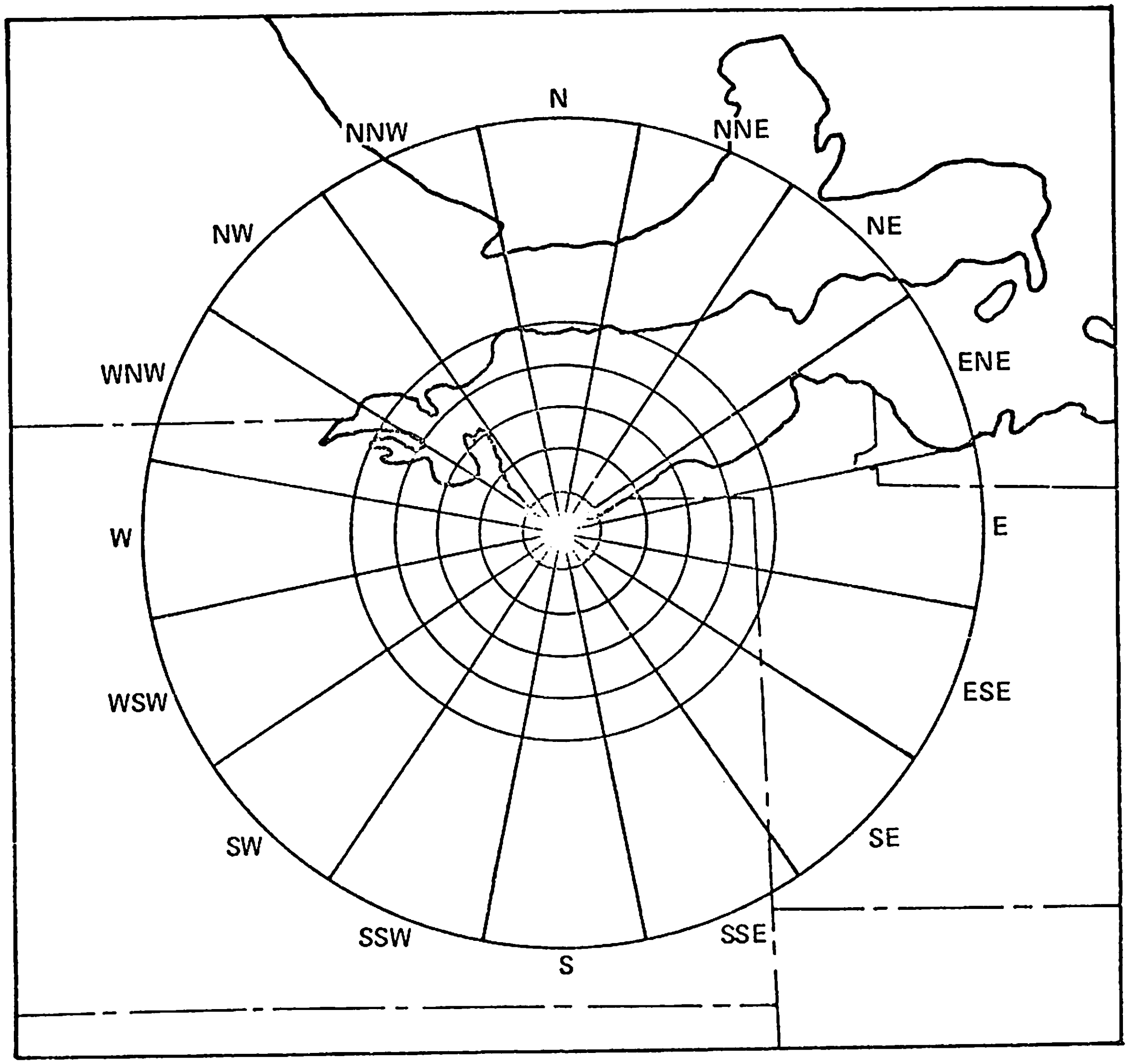


FIGURE 2.2.4. SECTOR DIVISIONS WITHIN 10 MILE RADIUS

TABLE 2.2.4. POPULATION ESTIMATES FOR 1970, 0-5 MILES

Segment	Population Estimates for Bands 1 through 5: 1	2	3	4	5	Sum 1-5
1	0	0	0	0	61	61
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	5	14	80	129	83	311
5	9	28	46	65	109	257
6	9	28	46	65	84	232
7	9	28	46	65	84	232
8	9	28	46	65	84	232
9	9	28	46	65	84	232
10	9	28	42	52	58	189
11	9	22	31	43	56	161
12	9	19	31	43	56	158
13	9	19	31	43	56	158
14	3	19	31	43	28	124
15	0	0	31	0	41	72
16	0	0	0	0	41	41

TABLE 2.2.5. POPULATION ESTIMATES FOR 1980, 0-5 MILES

Segment	Population Estimates for Bands 1 through 5: 1	2	3	4	5	Sum 1-5
1	0	0	0	0	70	70
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	5	16	92	148	95	356
5	11	32	53	74	125	295
6	11	32	53	74	96	266
7	11	32	53	74	96	266
8	11	32	53	74	96	266
9	11	32	53	74	96	266
10	11	32	48	59	67	217
11	11	25	35	49	63	183
12	11	21	35	49	63	179
13	11	21	35	49	63	179
14	3	21	35	49	31	139
15	0	0	35	0	46	81
16	0	0	0	0	46	46

TABLE 2.2.6. POPULATION ESTIMATES FOR 1990, 0-5 MILES

Segment	Population Estimates for Bands 1 through 5					Sum
	1	2	3	4	5	1-5
1	0	0	0	0	81	81
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	6	18	107	172	111	414
5	12	36	60	84	143	335
6	12	36	60	84	109	301
7	12	36	60	84	109	301
8	12	36	60	84	109	301
9	12	36	60	84	109	301
10	12	36	54	67	76	245
11	12	29	40	56	72	209
12	12	24	40	56	72	204
13	12	24	40	56	72	204
14	4	24	40	56	36	160
15	0	0	40	0	54	94
16	0	0	0	0	54	54

TABLE 2.2.7. POPULATION ESTIMATES FOR 2000,
0-5 MILES

Segment	Population Estimates for Bands 1 through 5					Sum
	1	2	3	4	5	1-5
1	0	0	0	0	90	90
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	7	20	123	197	127	474
5	13	39	66	92	159	369
6	13	39	66	92	119	329
7	13	39	66	92	119	329
8	13	39	66	92	119	329
9	13	39	66	92	119	329
10	13	39	59	73	83	267
11	13	31	44	61	79	228
12	13	26	44	61	79	223
13	13	26	44	61	79	223
14	4	26	44	61	39	174
15	0	0	44	0	60	104
16	0	0	0	0	60	60

TABLE 2.2.8. POPULATION ESTIMATES FOR 2010, 0-5 MILES

Segment	Population Estimates for Bands 1 through 5					Sum
	1	2	3	4	5	1-5
1	0	0	0	0	97	97
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	7	21	139	222	143	532
5	14	42	70	98	174	398
6	14	42	70	98	127	351
7	14	42	70	98	127	351
8	14	42	70	98	127	351
9	14	42	70	98	127	351
10	14	42	63	78	88	285
11	14	42	46	65	84	243
12	14	34	46	65	84	237
13	14	28	46	65	84	237
14	14	28	46	65	42	185
15	4	28	46	0	65	111
16	0	0	0	0	65	65

TABLE 2.2.9. POPULATION ESTIMATES FOR 2020, 0-5 MILES

Segment	Population Estimates for Bands 1 through 5					Sum
	1	2	3	4	5	1-5
1	0	0	0	0	103	103
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	8	22	155	248	160	593
5	15	44	73	102	186	420
6	15	44	73	102	133	367
7	15	44	73	102	133	367
8	15	44	73	102	133	367
9	15	44	73	102	133	367
10	15	44	66	82	92	299
11	15	35	48	68	87	253
12	15	29	48	68	87	247
13	15	29	48	68	87	247
14	5	29	48	68	43	193
15	0	0	48	0	68	116
16	0	0	0	0	68	68

TABLE 2.2.10. POPULATION ESTIMATES FOR 1970, 0-50 MILES

Segment	Population Estimates for Bands 1 through 10					
	Sum 1-5	6	7	8	9	10
1	61	7,503	0	0	682	22,723
2	0	1,356	2,058	75	75	24,574
3	0	678	1,531	0	0	0
4	311	517	305	0	0	0
5	257	1,724	50,381	4,168	103,635	107,491
6	232	2,710	7,183	6,846	22,867	27,171
7	232	1,431	4,539	16,621	11,647	30,214
8	232	828	10,895	8,926	21,805	81,661
9	232	908	2,552	5,026	7,138	33,499
10	189	6,499	2,695	25,381	5,671	10,908
11	161	1,023	3,653	4,014	24,989	42,528
12	158	3,112	4,802	6,945	9,441	14,756
13	158	723	26,679	10,571	27,671	28,143
14	124	1,119	8,132	22,611	422,482	49,514
15	72	1,695	4,450	7,939	13,413	52,816
16	41	1,186	651	0	1,186	19,222

TABLE 2.2.11. POPULATION ESTIMATES FOR 1980, 0-50 MILES

Segment	Sum 1-5	6	7	8	9	10
	Population Estimates for Bands 1 through 10					
1	70	8,593	0	0	703	23,407
2	0	1,553	2,396	90	90	25,313
3	0	776	1,762	0	0	0
4	356	596	315	0	0	0
5	295	1,989	58,134	4,810	117,150	107,491
6	266	3,127	8,280	7,848	25,857	27,171
7	266	1,650	5,152	18,707	13,018	30,214
8	266	950	12,207	9,959	24,267	81,661
9	266	1,028	2,708	5,302	7,810	33,499
10	217	6,861	2,887	26,654	5,976	10,908
11	183	1,121	4,080	4,215	26,295	42,528
12	179	3,571	5,511	7,862	10,663	14,756
13	179	830	30,614	12,065	31,185	28,143
14	139	1,283	9,314	24,998	457,591	49,514
15	81	1,941	5,097	8,611	14,487	52,816
16	46	1,359	745	0	1,281	19,222

TABLE 2.2.12. POPULATION ESTIMATES FOR 1990,
0-50 MILES

Segment	Population Estimates for Bands 1 through 10					
	Sum 1-5	6	7	8	9	10
1	81	9,934	0	0	773	25,737
2	0	1,796	2,709	97	97	27,833
3	0	898	2,024	0	0	0
4	414	693	321	0	0	0
5	335	2,311	67,566	5,590	129,640	134,464
6	301	3,634	9,606	8,996	28,644	33,989
7	301	1,910	5,782	20,603	14,221	33,937
8	301	1,078	13,428	10,925	26,505	99,211
9	301	1,155	2,910	5,679	8,669	40,683
10	245	7,244	3,124	28,417	6,390	12,042
11	209	1,224	4,548	4,494	28,082	50,595
12	204	4,055	6,257	8,891	12,133	18,560
13	204	942	34,790	13,750	35,438	33,987
14	160	1,476	10,768	27,859	498,740	58,133
15	94	2,245	5,892	9,403	15,747	62,004
16	54	1,571	862	0	1,392	22,565

TABLE 2.2.13. POPULATION ESTIMATES FOR 2000,
0-50 MILES

ment	Population Estimates for Bands 1 through 10					
	Sum 1-5	6	7	8	9	10
1	90	11,058	0	0	833	27,740
2	0	1,999	2,947	101	101	29,999
3	0	999	2,239	0	0	0
4	474	792	326	0	0	0
5	369	2,642	77,226	6,390	137,510	142,626
6	329	4,154	10,952	10,102	30,453	36,052
7	329	2,170	6,312	21,901	14,981	33,937
8	329	1,181	14,277	11,595	27,945	104,587
9	329	1,257	3,071	5,979	9,359	43,920
10	267	7,552	3,312	29,817	6,724	12,581
11	228	1,307	4,922	4,716	29,525	54,472
12	223	356	6,855	9,782	13,535	20,506
13	223	511	38,143	15,248	39,418	36,806
14	174	1,637	11,986	30,309	533,931	62,067
15	104	2,498	6,559	10,071	16,815	66,221
16	60	1,749	959	0	1,487	24,100

TABLE 2.2.14. POPULATION ESTIMATES FOR 2010, 0-50 MILES

Segment	Population Estimates for Bands 1 through 10					
	Sum 1-5	6	7	8	9	10
1	97	11,963	0	0	884	29,415
2	0	2,162	3,146	105	105	31,811
3	0	1,081	2,413	0	0	0
4	532	894	330	0	0	0
5	398	2,980	87,115	7,208	140,760	145,997
6	351	4,686	12,321	11,166	31,284	36,904
7	351	2,428	6,743	22,616	15,304	32,599
8	351	1,259	14,764	11,977	28,587	106,979
9	351	1,334	3,190	6,202	9,880	46,367
10	285	7,783	3,453	30,853	6,980	12,997
11	243	1,369	5,203	4,880	30,625	57,711
12	237	646	7,304	10,534	14,867	22,310
13	237	579	40,675	16,561	43,123	39,279
14	185	1,765	12,968	32,348	563,163	65,279
15	111	2,703	7,096	10,615	17,687	69,664
16	65	1,892	1,038	0	1,565	25,353

TABLE 2.2.15. POPULATION ESTIMATES FOR 2020, 0-50 MILES

Segment	Population Estimates for Bands 1 through 10					
	Sum 1-5	6	7	8	9	10
1	103	12,651	0	0	924	30,763
2	0	2,287	3,306	108	108	33,269
3	0	1,143	2,547	0	0	0
4	593	998	333	0	0	0
5	420	3,326	97,231	8,045	139,388	144,574
6	367	5,230	13,711	12,186	31,134	36,545
7	367	2,684	7,070	22,717	15,297	31,015
8	367	1,311	14,868	12,055	28,932	108,305
9	367	1,385	3,268	6,348	10,233	48,022
10	299	7,938	3,545	31,526	7,157	13,291
11	253	1,411	5,390	4,986	31,381	60,313
12	247	4,929	7,605	11,147	16,130	23,971
13	247	1,145	42,386	17,687	46,555	41,406
14	193	1,860	13,713	33,977	586,437	67,767
15	116	2,859	7,504	11,037	18,360	72,311
16	68	2,001	1,098	0	1,624	26,317

- Determine which cities it contains
- Calculate its total urban population
- Determine its rural land area and multiply by appropriate population density to obtain total rural population
- Sum rural and urban populations of the sector.

For the area within 10 miles, the unit of analysis was the township instead of the county as was done for the 50-mile radius. County population projections were calculated using a dynamic simulation program described in Appendix A.

2.2.1.3 Cumulative Population

Figure 2.2.5 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, with a 10-mile radius for a circular area centered on on the Site, with a 20-mile radius for a circular area centered on thethe 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 2.2.5 depicts cumulative population versus distance for other sites used or under consideration for nuclear power plants.

2.2.1.4 Transient Population

In forming a demographic overview of the area around the Site, one must distinguish between summer and winter seasonal populations in some areas. Vacationers flocking to shoreline communities, particularly along the Lake Erie coast in Ottawa County, inflate population figures by up to ten times the permanent resident figure. Within a 5-mile radius of the Site, summer population could be expected to exceed winter population by 50 percent. In addition, farm laborers, mostly from Mexico, migrate into the

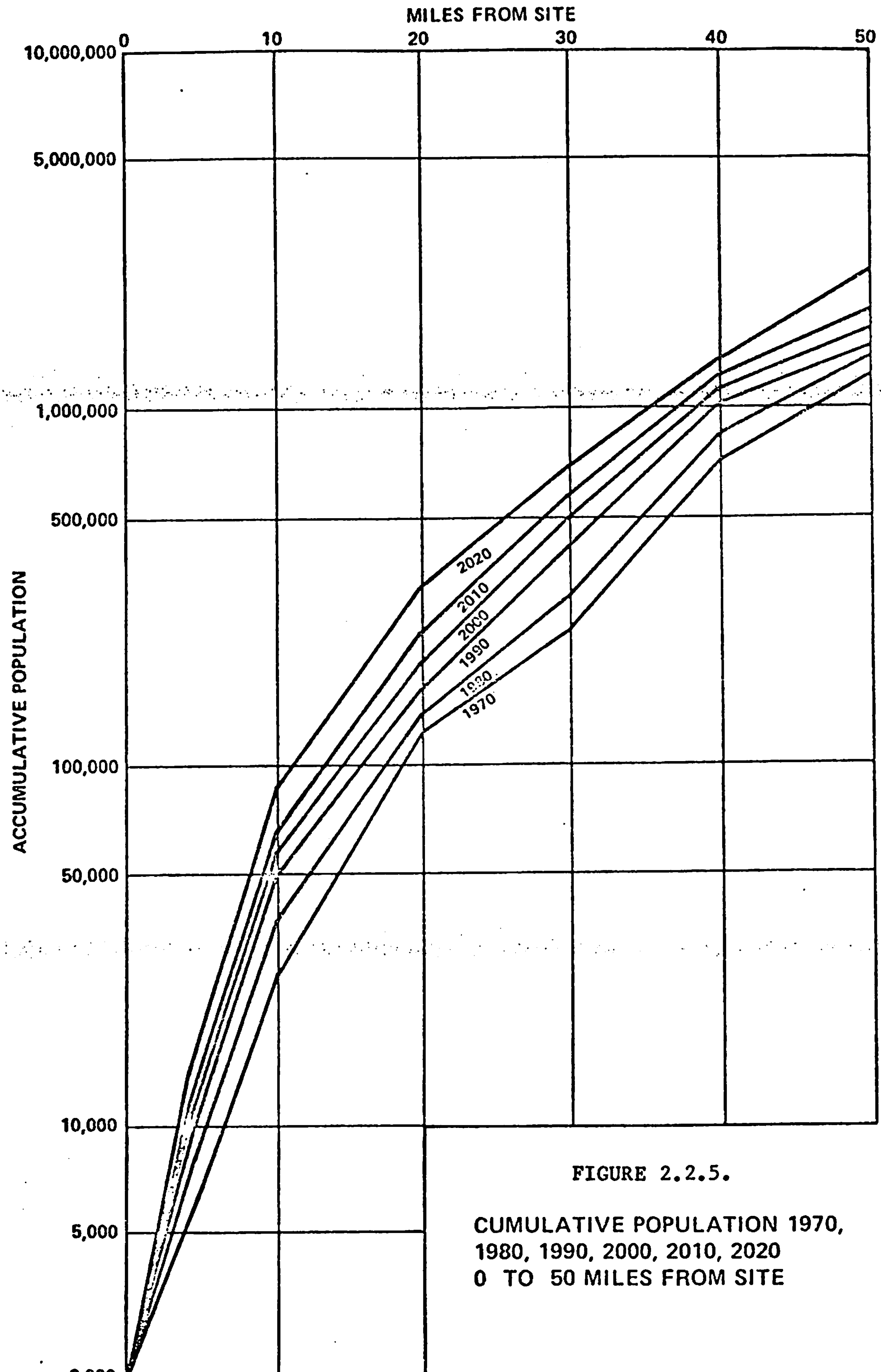


FIGURE 2.2.5.

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

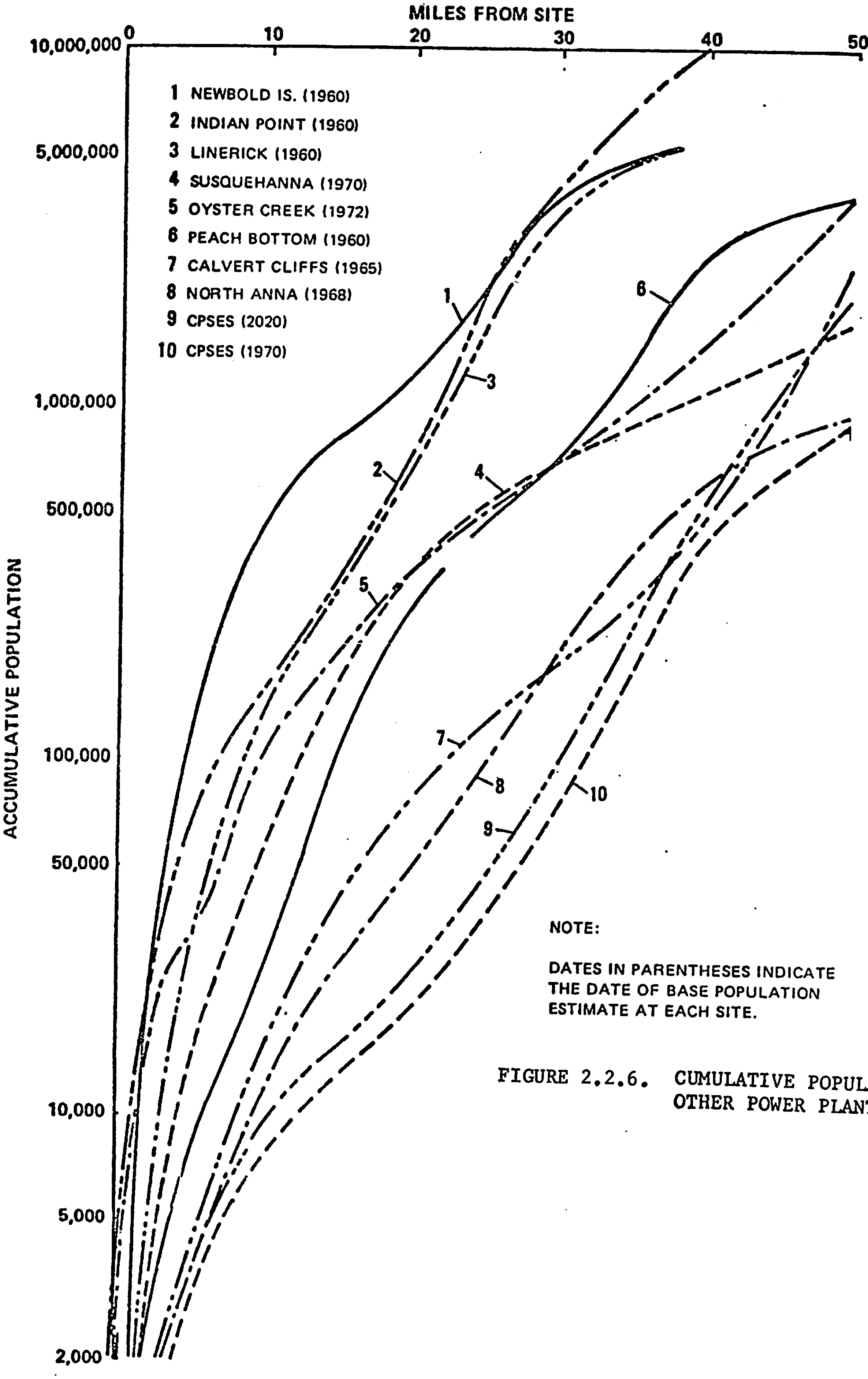


FIGURE 2.2.6. CUMULATIVE POPULATION AT OTHER POWER PLANT SITES

Sandusky Bay region in considerable numbers (10,000 in Sandusky County in 1972) for summer vegetable growing and harvesting, staying at migrant labor camps throughout the area.

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.

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. Riley School is at or near capacity and it is assumed that enrollment will not exceed approximately 550 students from kindergarten through 8th grade.

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 is also near capacity and it is thus assumed that future enrollment will not exceed 500 students.

2.2.2 LAND USE PATTERNS

A tabulation of past and projected future land use for all counties at least partially included within a 10-mile radius from the Site are given in Table 2.2.16. Land use patterns in this area are typical of moderately rural area devoted primarily to agriculture. The percentage of non-agricultural land is fairly high in comparison to other regions, indicating a significant amount of uncultivatable land. Most commercial operations are located close to or in various towns in the region. Various aspects of land use patterns in the region are discussed in the following subsections.

TABLE 2.2.16. LAND USE IN COUNTIES AT LEAST PARTIALLY INCLUDED WITHIN 10-MILE RADIUS OF SITE--1958 AND PROJECTED 1975

(As Percentage of Total Land Area)

Land Use	Sandusky	Erie	Ottawa	Seneca	Huron
Total land area					
Acres	262,400	168,960	168,320	352,640	317,960
Square miles	410	264	263	551	497
Land in farms					
1958	91.0	75.4	85.4	93.6	90.8
1975	88.0	73.7	78.0	91.0	88.8
Cropland					
1958	75.6	57.5	65.8	74.6	62.8
1975	74.9	52.9	62.1	77.4	63.1
Pasture					
1958	2.0	5.2	2.2	4.0	9.8
1975	1.5	3.9	1.5	1.1	7.9
Farm woodland					
1958	7.8	5.8	4.4	9.6	11.8
1975	6.1	4.9	3.1	7.5	11.6
Other farmland					
1958	5.7	7.0	13.0	5.3	6.4
1975	5.5	7.1	11.3	4.9	6.2
Land not in farms					
1958	8.9	24.6	14.6	6.4	9.2
1975	12.0	26.3	22.0	9.0	11.2
Nonfarm forest					
1958	0.2	5.9	0	0	3.0
1975	0.1	4.9	0	0	2.5
Other land					
1958	0.9	0.4	1.0	0.8	0.2
1975	0.7	0.9	0.7	0.4	0.3
Urban Water and build up					
1958	7.8	18.3	13.6	5.5	5.9
1975	11.1	20.4	21.3	8.6	8.4

Source: "Water Inventory of the Portage River and Sandusky River Basins", Report No. 20, Department of Natural Resources, State of Ohio (1966).

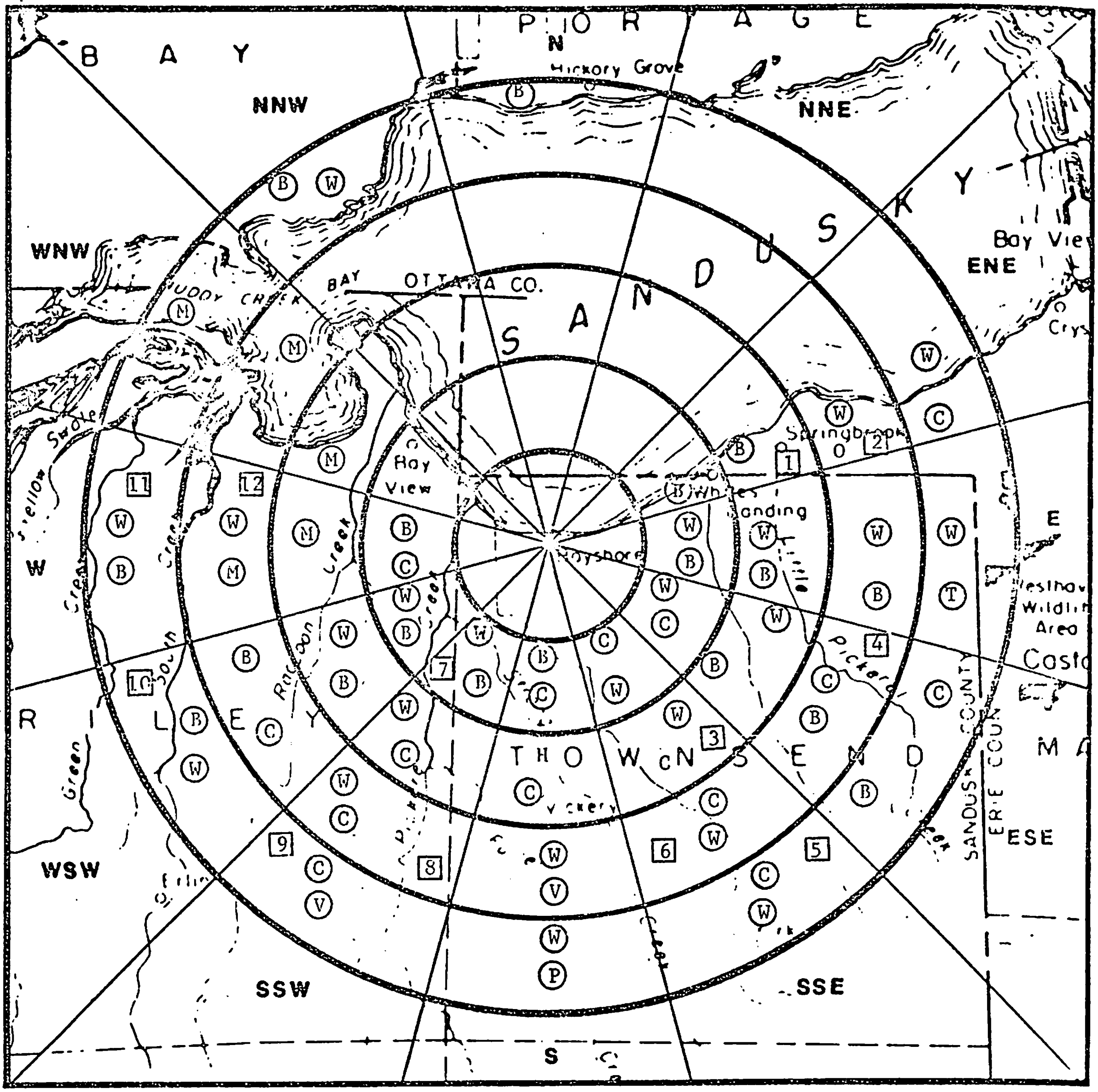
2.2.2.1 Agriculture

Farming accounts for well over 70 percent of land use within 10 miles of the Site, for over 80 percent in Sandusky County, and for more than that within 5 miles of the Site. With exception of the marshlands surrounding Muddy Creek Bay, virtually all the land around Sandusky Bay is arable although greatly improved by the addition of drainage ditches. In fact, according to recent reports (Sandusky County Chamber of Commerce), the fertility rating of Sandusky County soils is about 50 percent above the national average. Abundant rainfall during the growing season (May to October) and temperature variability lessened by proximity to Lake Erie add to the attractiveness of the Site and environs for farming.

A survey of land use was performed within a 5-mile radius from the sites. Through this procedure estimates concerning the acreage of land comprised by various crops, wooded areas, and marshlands were obtained. Also obtained were approximate numbers and locations of farm animals.

Shown in Figure 2.2.7 are the most prevalent crops within each sector as well as the number of farm animals in the area. Crops in the vicinity of the Site are primarily soybeans and wheat. Corn is not grown in this area to any great extent due to the presence of blackbirds. However, farther from the Site corn becomes the main crop followed by wheat and soybeans. In the region 3-5 miles from the Site and to the south and southeast, vegetable crops, such as sugar beets and lettuce, are grown.

Within Sandusky County in 1971 there were 1,509 farms averaging 155 acres each, with the number of farmers decreasing and the output increasing yearly. The county ranked tenth among the 88 counties in Ohio in gross agricultural income ($30,000,000-$117 per acre), largely from



Primary Crops:

(M)	Marsh, Water	(P)	Pasture
(W)	Wheat	(H)	Hay
(B)	Soy Beans	(V)	Vegetables/ Beets, Lettuce
(C)	Corn	(T)	Trees, Wooded Area
(O)	Oats		

Farm Animals:

1	30 Beef Cattle	7	200 Sheep
2	20 Beef Cattle	8	50 Hogs
3	50 Beef Cattle	9	100 Beef Cattle
4	50 Beef Cattle	10	50 Beef Cattle
5	20 Beef Cattle	11	50 Dairy Cattle
6	50 Beef Cattle	12	50 Beef Cattle

FIGURE 2.2.7. AGRICULTURAL LAND USE WITHIN 5 MILES OF SITE

vegetables, soybeans, and decreasingly from livestock. Agricultural statistics for the county are listed in Table 2.2.17. Among the major crops grown in Sandusky County are corn, oats, wheat, hay, soybeans, tomatoes, and sugar beets. In general, land nearer the shoreline is more widely cultivated as cropland and land farther inland (i.e., beyond the 5-mile radius from the Site) is increasingly devoted to pasture and orchards. Agricultural statistics for counties at least partially included within the 20-mile radius from the Site are listed in Table 2.2.18.

TABLE 2.2.17. AGRICULTURAL STATISTICS FOR SANDUSKY COUNTY--1965, 1970, 1971

Category	1965	1970	1971
Income (in $ thousands)			
Livestock	7,491	7,717	7,856
Crops	11,999	15,405	18,385
Total	19,490	23,122	27,938
Government payments	1,681	1,940	NA
Total cash receipts	21,171	25,062	NA
Average per farm ($)	14,030	16,934	NA
Average per acre ($)	91	110	117
Source of farm income in rank (and percent)			
First	Soybeans (15)	Soybeans (22)	Vegetables (21)
Second	Cattle (14)	Vegetables (14)	Soybeans (19)
Third	Vegetables (14)	Cattle (12)	Corn (12)
Fourth	Corn (13)	Dairy (10)	Cattle (11)
Fifth	Dairy (12)	Corn (10)	Dairy (10)
Sixth	Hogs (8)	Sugar beets (10)	Sugar beets (8)
Seventh	Wheat (6)	Hogs (7)	Hogs (6)
Eighth	Poultry (4)	Wheat (4)	Wheat (4)
Other	(14)	(11)	(9)

Source: News release, State of Ohio Cooperative Extension Service in Agriculture and Home Economics, January 5, 1973.

TABLE 2.2.18. AGRICULTURAL STATISTICS, FOR COUNTIES AT LEAST PARTIALLY INCLUDED WITHIN 20-MILE RADIUS FROM SITE--1971

Statistic	Sandusky County	Ottawa County	Erie County	Seneca County	Huron County	State
Corn for grain						
Acres (hundreds)	591 (4)[1]	150 (10)	241 (8)	713 (1)	624 (3)	35,260
Bushels per acre	90 (3)	70 (10)	97 (1)	95 (2)	88 (4)	89
Bushels (thousands)	5,319 (4)	1,050 (10)	2,338 (8)	6,774 (1)	5,491 (3)	313,814
Soybeans for beans						
Acres (hundreds)	541 (4)	418 (6)	241 (8)	843 (1)	679 (2)	24,940
Bushels per acre	31 (1)	29.5 (2)	29.5 (2)	27.0 (5)	26.5 (7)	30.5
Bushels (thousands)	1,677 (3)	1,233 (6)	711 (8)	2,276 (1)	1,799 (2)	76,067
All wheat						
Acres (hundreds)	206 (3)	126 (6)	94 (9)	317 (1)	206 (3)	9,810
Bushels per acre	44 (1)	40 (6)	43 (2)	42 (3)	41 (5)	43.5
Bushels (thousands)	906 (3)	504 (6)	404 (7)	1,331 (1)	845 (4)	42,674
Oats for grain						
Acres (hundreds)	69 (8)	49 (9)	38 (10)	140 (1)	124 (2)	5,200
Bushels per acre	80 (1)	77 (3)	77 (3)	78 (2)	71 (7)	67.0
Bushels (thousands)	552 (7)	377 (9)	293 (10)	1,092 (1)	880 (2)	34,840
All hay (1971)						
Acres (hundreds)	129 (7)	137 (5)	49 (10)	172 (3)	118 (9)	15,700
Tons per acre	2.65 (3)	2.75 (2)	2.80 (1)	2.40 (5)	2.00 (9)	2.03
Tons (thousands)	342 (6)	377 (5)	137 (10)	413 (3)	236 (3)	3,180
Livestock[2] (hundreds)						
All cattle and calves	214 (5)	65 (10)	96 (9)	221 (4)	177 (7)	22,440
Milk cows and heifers	4[illegible] (6)	15 (10)	30 (7)	60 (3)	43 (5)	4,440
Hogs and pigs	241 (5)	59 (10)	74 (9)	408 (2)	276 (4)	26,110
Stock sheep	66 (7)	--	20 (9)	196 (3)	123 (4)	5,640

Source: Ohio Agricultural Statistics --1971, Ohio Crop Reporting Service (April, 1972).

(1) Number in parentheses refers to rank of county within 10-county agricultural district (Ashland, Crawford, Erie, Huron, Lorain, Ottawa, Richland, Sandusky, Seneca, Wyandot counties).

(2) Figures as of January 1, 1972.

2.2.2.2 Industry

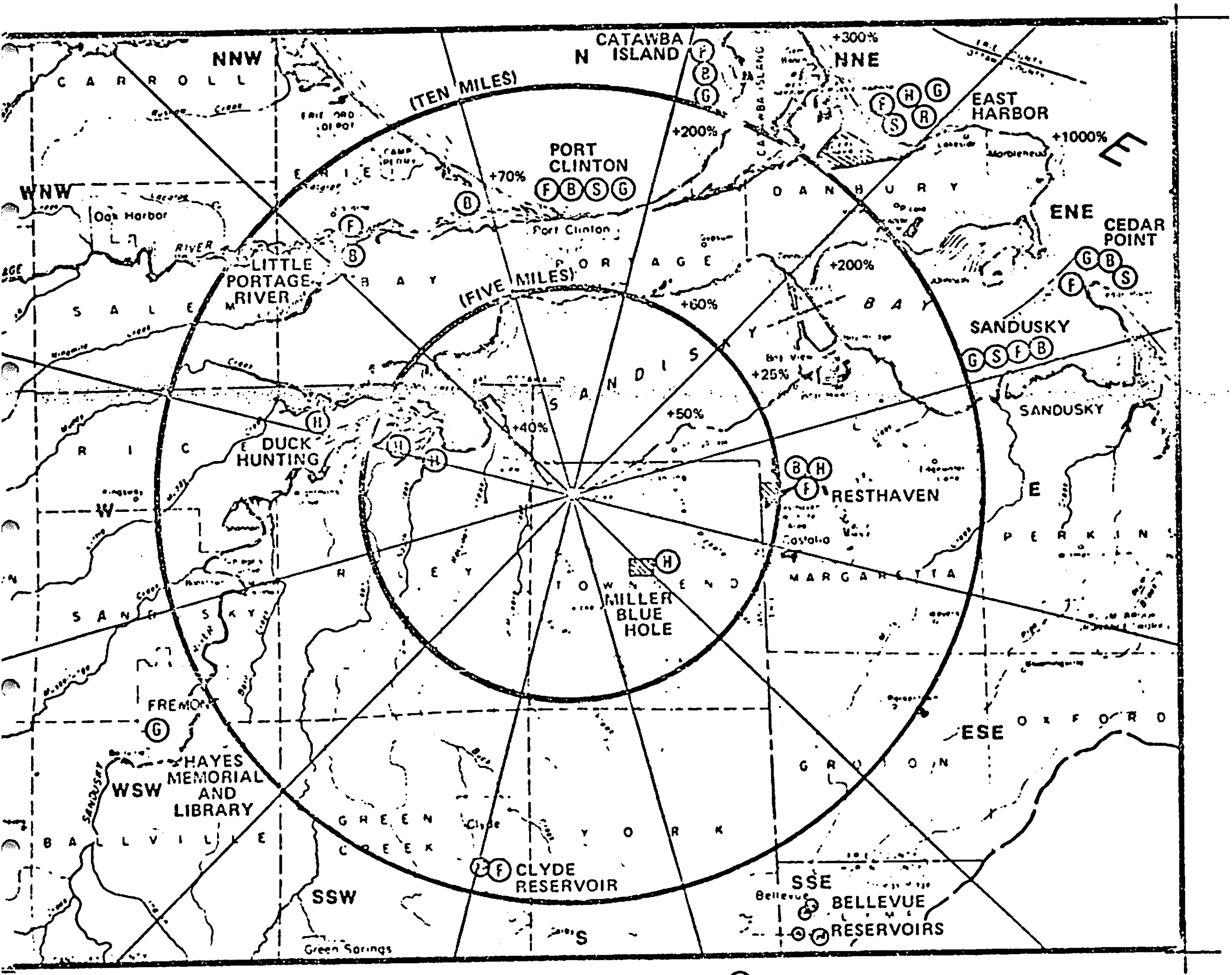
As listed in Table 2.2.19, there were 79 manufacturing firms within 12 miles of the Site in 1971, concentrated primarily in Sandusky and Fremont, and to a lesser degree in Port Clinton and Clyde. Only five firms in this area employ over 500 people, and there are no significant industries located within 5 miles of the Site. Although there are processing plants in Fremont, Gibsonburg, Clyde, and Bellvue for the considerable agricultural produce of the area, the largest share of the industrial labor market is employed by the electrical machinery,

TABLE 2.2.19. INDUSTRIES WITHIN 10 MILES OF SITE

I. 500 and Over Employed	
A. Port Clinton	
(1) Standards Products Co.	Rubber goods
(2) U.S. Gyspum Co.	
B. Clyde	
(1) Whirlpool Corp.	Washing machines
C. Sandusky	
(1) Ford Motor Co.	Automotive parts
(2) New Departure-Hyatt Bearings Division	Ball bearings
II. 100 to 499 Employed	
A. Port Clinton	
(1) Aim Packaging Inc.	Plastic bottles
(2) Celotex Corp.	Wall board
(3) Matthews Company	Wood and fiber glass yachts
(4) Uniroyal Inc.	Vinyl coated plastics
(5) USCO Services	Ware housing
(6) Wilson Cabinet Co.	Kitchen cabinets
B. Sandusky	
(1) A-M Division, Vulcan Materials Co.	Raw materials
(2) American Crayon Co., Div.	Crayons
(3) Brown Industries, Inc.	Castings
(4) Chrysler Plastic Products Corp.	Vinyl coated fabrics
(5) Foster Grant Co.	Plastic food containers
(6) A. L. Garber Co.	Packing materials
(7) The G&C Foundry Co.	Castings
(8) H-D Container Division Westuaco Corp.	Packing materials
(9) Industrial Nut Corp.	Industrial nuts
(10) Litton Power Transmission Div. Union Chain Operation	Machine parts
(11) Sandusky Foundry and Machine Co.	Machine parts
(12) Scott Paper Co.	Paper products
C. Fremont	
(1) Clauss Cultery Co.	
(2) H. J. Heinz Co.	
III. 25 to 99 Employed	
A. Port Clinton	
(1) Ayling & Reichart	Plumbing fixtures
(2) Displays Vendors	Display material
(3) Milan Steel	Steel buildings
(4) Ottawa Rubber Co.	Rubber goods
(5) Port Clinton Mfg. Co.	Machine products
(6) Silver Fleece, Inc.	Canning
(7) Snark Products, Inc.	Small boats
B. Sandusky	
(1) Lower Lake Dock Co.	Cartage
(2) Peerless Stove and Mfg. Co. Inc.	Stove manufacture
(3) Sandusky Fabricating and Sales, Inc.	Steel products
(4) Stephens Publishing Co., Div. of Stephens Printing Corp.	
(5) Stowe-Woodward	Rubber products
(6) Toft Dairy Inc.	Milk products
(7) Vogel, A. H., Co. Inc.	Cake decorations
C. Fremont	
(1) Consolite Corp.	Metal adv. signs
IV. Under 25 Employed	
A. Port Clinton	
(1) Bay Transportation Co.	Local cartage
(2) Black's Machine Shop	Metal fabrication
(3) Bolus Trucking	Trucking

TABLE 2.2.19. (Continued)

(4) Cadillac Gage Co.	Military service
(5) Englebeck Packing Co.	Slaughter house
(6) Gentry Tool and Die Co.	Machine shop
(7) Lakecraft Welding Co.	Metal fabricators
(8) Meyrs & Oleksa Tool Co.	
(9) Quikstir Inc.	Mixing equipment
(10) Riehl Mfg. Co.	Metal welders
B. Clyde	
(1) Clyde Metal Stripping	Metal and wood stripping
(2) Clyde Paint and Supply Co., Inc.	Paints, varnishes
(3) Clyde Products and Mfg. Co.	Tools, machines
(4) Clyde Tool and Die Inc.	
(5) Clyde Welding Co.	
(6) Formulated Products Inc.	Canned pet food
(7) No-Load Co.	Grinding wheel dressing
(8) Progress Design & Machine, Inc.	Special machinery
(9) Senior Chemical Co.	
(10) Taylor Made, Inc.	Wood products
C. Sandusky	
(1) A. V. Lake Steel Co.	Steel products
(2) Busch & Thiem Co.	Sheet metal
(3) Cantelli Concrete Block Mfg., Inc.	Concrete building materials
(4) Coca Cola Bottling Co.	Coca Cola
(5) Erie-Co., Mfg. Inc.	Asphalt materials
(6) Erie Sand and Gravel	Lake sand
(7) Evlo Plastics	Carton holders
(8) Hohler Furnace and Sheet Metal Inc.	Air units
(9) F. M. Koch Corporation DBA, Kelko Products Co.	Machine products
(10) Mantey Vineyards Inc.	Wines
(11) Rudow Mfg. Co.	Foundry supplies
(12) Sandusky Cement Products	Cement products
(13) Sandusky Machine and Tool Inc.	Machine parts
(14) Sandusky Packaging Corp.	Cardboard boxes
(15) Schwab Machine Inc.	Machine parts
(16) Travel Products Inc.	Travel trailers
(17) Union Fabricating & Machine Co.	Steel products
D. Fremont	
(1) Atlas Machinery Div.	
(2) Crown Battery Mfg. Co.	
(3) Grove Machine Works	
(4) Mercury Neon Sign Co.	
(5) Modern Construction Co.	
(6) Ohio Tank Co.	



(F) FISHING
(H) HUNTING
(G) PICNICKING, AMUSEMENT
(B) BOATING CENTER
(S) SWIMMING BEACH
SUMMER COTTAGE AREA
+20% INCREASE OF SUMMER POPULATION OVER WINTER POPULATION

SOURCE: "WATER INVENTORY OF THE PORTAGE RIVER AND SANDUSKY RIVER BASINS", REPORT NO. 20, OHIO WATER PLAN INVENTORY (1966)

FIGURE 2.2.8. RECREATION AND SUMMER VACATION AREAS WITHIN 5 MILES AND 10 MILES OF THE SITE.

TABLE 2.2.21. PRINCIPAL RECREATION AREAS AT LEAST PARTIALLY INCLUDED WITHIN A 10-MILE RADIUS OF THE SITE

	County	Nearest Highway	Hunting	Fishing	Boating	Motors	Boat Rental	Boat Launch	Swimming	Camping	Historic	Picnic Areas	Water Area, acres	Land Area, acres
Portage River Area														
Little Portage River Wildlife Area	Ottawa	SR-53		X	X	B		X						357
Port Clinton	Ottawa	SR-2		X	X	A	C	P	X			X	LE	
Pickerel-Pipe Creek Area														
Clyde Reservoir	Sandusky	SR-101		X									40	
East Harbor	Ottawa	SR-163-240	W	X	X	A	C	X	X	X		X	670	584
Miller Blue Hole	Sandusky	US 6	F											13
Resthaven Wildlife Area	Erie-Sandusky	SR-269	FSW	X	X								322	2,207
Sandusky	Erie	SR-2-US 6		X	X	A	X	X	X			X	SB	

A - Motors of unlimited hp permitted.
B - Motors of liminted hp permitted.
C - Facilities nearby.
D - Land owned, no development.
E - Hunting by special permit only.
F - Farm game.
LE - Areas on Lake Erie.
SB - Sandusky Bay.
P - Permitted, no facilities provided.
S - Fur game.
W - Waterfowl.
X - Available activities.

2.2.2.4 Schools and Hospitals

Only two schools - one elementary, the other elementary and junior high - serve the area within 5 miles of the Site. These are listed in Table 2.2.22. Each belongs to one of the two school districts that share the area: The Margaretta Local School District administered by Erie County and the Fremont City Schools. The nearest high school to the Site is in Castalia in Erie County (1,070 students, grades 6-12, and 32 full-time staff). The nearest institution of higher learning is the Fremont branch of Bowling Green State University with facilities 10.5 miles from the Site.

equipment and supplies industry. Major industries for each of the four industrial centers within 12 miles of the Site are:

- Port Clinton - gypsum, rubber, plastics, boat-building
- Fremont - display materials, machine parts
- Clyde - washing machines
- Sandusky - machine parts, automobile parts.

The nearest concentrations of industries are Erie Industrial Park (formerly Erie Ordinance Depot) 5 miles northwest of Port Clinton with nearly one thousand employees in ten industries; and Fremont Industrial Park with half that number of plants and workers. Both lie just over 10 miles from the Site.

Table 2.2.20 lists 1960 manufacturing data for watersheds at least partially included within the 20-mile radius from the Site.

TABLE 2.2.20. MANUFACTURING DATA FOR WATERSHEDS AT LEAST PARTIALLY INCLUDED WITHIN 20-MILE RADIUS FROM SITE--1960

Industry	Portage River Basin			Sandusky River Basin			Pickerel-Pipe Creek Area		
	Rank in Water Use	No. of Plants	No. of Employees	Rank	Plants	Employees	Rank	Plants	Employees
Stone, clay, and glass products	1	18	2,120	3	18	2,535	12	2	110
Food and kindred products	2	17	1,960	1	22	1,006	6	16	887
Rubber and miscellaneous plastics	3	6	911	4	14	2,448	5	2	342
Primary metal industries	4	8	3,445	7	7	551	3	8	1,151
Electrical machinery, equipment, and supplies	5	3	3,004	2	6	1,653	8	2	2,232
Transportation equipment	6	6	1,475	8	1	250	1	3	1,986
Machinery, except electrical	7	3	198	5	13	2,799	10	3	2,416
Other fabricated metals	8	7	349	6	8	530	11	9	731
Printing, publishing, etc.	9	1	140	--	--	--	--	--	--
Miscellaneous manufacturing industries	10	1	10	--	--	--	2	3	238
Leather and leather products	11	1	19	--	--	--	--	--	--
Clothing and fabrics	12	1	67	9	1	220	--	--	--
Chemicals and allied products	13	2	62	11	3	10	7	2	110
Furniture and fixtures	--	--	--	10	1	41	13	1	164
Ornaments and accessories	--	--	--	--	--	--	4	1	550
Paper and allied products	--	--	--	--	--	--	9	3	681
Total	--	74	13,760	--	94	12,043	--	55	11,518

Source: "Water Inventory of the Portage River and Sandusky River Basins", Report No. 20, Ohio Water Inventory Plan, Department of Natural Resources, State of Ohio (1966).

2.2.2.3 Recreation Areas

As the "Gateway to Lake Erie", the Sandusky Bay area is a busy region for summer vacationers. Although summer cottages are much more prevalent on Catawba Island and the Marblehead Peninsula, the number of summer residents on the south shore of Sandusky Bay to the east of the Site exceeds the winter population by about 50 percent (Sandusky County Chamber of Commerce, 1973). Fishing and ice fishing for perch and white bass in both Sandusky Bay and Lake Erie, and duck hunting in the marshes to the northwest of the Site, as well as boating, swimming, and sight-seeing attract seasonal visitors and weekend visitors to the area within 10 miles of the Site. However, most summer visitors go to Marblehead and Catawba Island, and most duck hunters go to privately-owned grounds to the northwest of Port Clinton, well beyond the 10-mile radius from the Site. Further west from Port Clinton along the Lake Erie coast are located the Magee Marsh and Metzger Wildlife Areas (where fishing and hunting with a special permit are actively pursued) and the Ottawa National Wildlife Refuge. Together, these three areas constitute more than 7,000 acres of coastal marshland. These and other recreational areas within 10 miles of the Site are shown in Figure 2.2.8. Recreational attributes of these areas are listed in Table 2.2.21.

TABLE 2.2.22. SCHOOLS WITHIN 5 MILES OF SITE

Miles From Site		Grades	Staff	Enrollment
2.8 SE	Townsend Central School, Route 1, Vickery, Ohio	K-5	15	448
4.3 SW	Riley Center School, Route 6, Riley Center, Ohio	K-8	9	245

Source: Figures for 1972-73; Sandusky County Board of Education and Erie County Board of Education.

There are no hospitals within 5 miles of the Site. Magruder Hospital in Port Clinton with 134 beds and Fremont Memorial Hospital with 242 beds and 349 full-time staff, are the closest, 6.4 and 10.2 miles distant, respectively. These are listed in Table 2.2.23.

TABLE 2.2.23. HOSPITALS WITHIN 5 MILES OF SITE

	Distance, miles	Location	No. of Beds	Staff Full-time	Staff Part-time
None	5				
Nearest hospitals	6.4	Magruder Hospital Port Clinton, Ohio	134		
	10.2	Freemont Memorial Hospital 715 South Taft Street Freemont, Ohio	242	349	93

2.2.2.5 Transportation

The Site is crossed by U. S. Route 6, a two-lane road that serves as a main east-west artery connecting Sandusky and Fremont. The nearby area is served by a rectangular grid of two-lane paved county roads, Ohio Route 101 connecting Clyde and Castalia, Ohio Route 412 linking Fremont and Castalia, and the Ohio Turnpike 4 miles due south of the Site with a service plaza 4 miles southwest of the Site. All major roads within 10 miles of the Site run east-west, with the exception of Ohio Route 510 from Clyde northward to U. S. Route 6.

The Penn Central and Norfolk and Western Railroads pass through Bellevue, Clyde, and Fremont. The Norfolk and Western then proceeds to double back in a northeasterly direction toward Sandusky, passing within 3 miles of the Site.

The major airport nearest to the Site is Toledo Express, serviced by commercial airlines. Fremont, Sandusky, and Port Clinton all maintain small, city-owned airports within 20 miles of the Site.

2.2.2.6 Military Installations

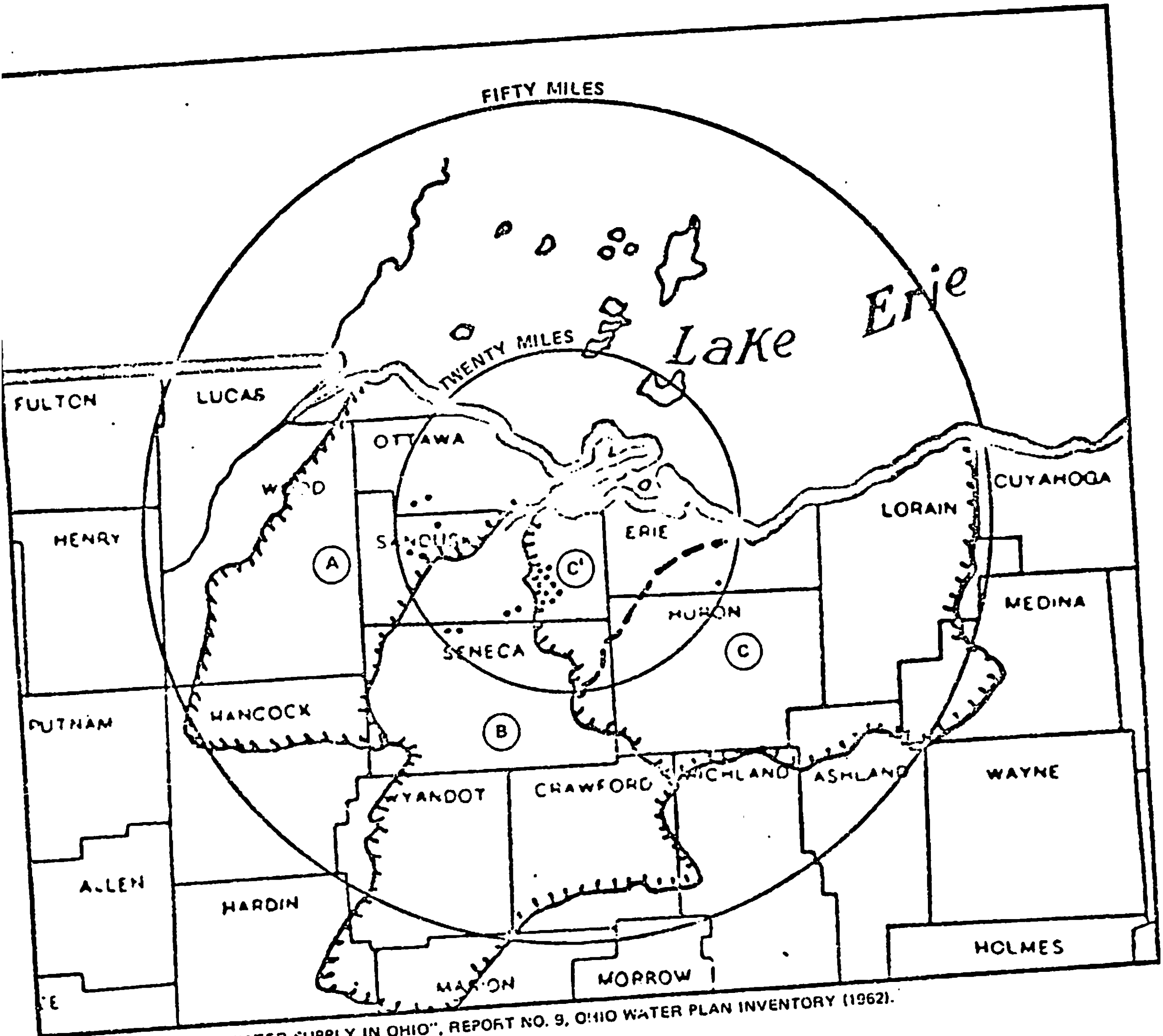
Camp Perry, an Ohio National Guard training center is 8 miles northwest of the Site on the shore of Lake Erie. As of 1969, about 200,000 man-days of weekend training were conducted annually at the camp. The National Rifle Competition is held there every August with about one thousand people in attendance. The small amount of ordnance testing which still continues involves automatic weapons and mortars, the maximum caliber shell being 120 mm. An estimate by an official was that about 50,000 rounds of machine gun and 100 rounds of mortar shells are fired annually in testing sessions on Tuesdays and Thursdays. The restricted areas used by Camp Perry are designated as Areas I and II on the U. S. Department of Commerce navigational maps of Lake Erie and as restricted area R-5502 by the Federal Aviation Administration.

2.2.3 WATER USE

The Site and most of the surrounding 50-mile radius lies within the Portage, Sandusky, and Huron-Black River Basins of the Northwest Ohio Water Development Region. Watershed boundaries are shown in Figure 2.2.9. Tables 2.2.24 and 2.2.25 summarize the nature and extent of present and projected water use within 20 miles of the Site for municipal, industrial, agricultural, and transportation purposes. The data, though mostly more than 10 years old, are the most recent available and delineate only general patterns of water use.

All five counties at least partially included within a 20-mile radius from the Site draw upon groundwater for municipal, industrial, and agricultural purposes. Sandusky County is particularly dependent on this source, especially within 5 miles of the Site where public wells serve the communities. Underground water is largely contained in cracks and crevices in the underlying limestone and dolomite formations. Supplies for farming can be tapped by wells only 150 feet deep whereas municipalities and industries must often sink wells up to 500 feet below the surface. Nevertheless, within 5 miles of the Site there exists an abundant supply of underground water and yields of more than 100 gallons per minute can be developed. In York and the very eastern edge of Townsend Township in Sandusky County and in Margaretta and Groton Townships in western Erie County, a large percentage of public wells have been contaminated due to underground sewage disposal.

All five counties also make use of inland surface waters, Ottawa and Erie Counties less so because they draw more heavily on Lake Erie-Sandusky Bay waters. Except for water obtained from Lake Erie, supplies within the study area depend on local climatic conditions with very little influence from areas outside the Portage, Sandusky, and Huron-Black River Basins. For this reason the State Department of Natural Resources has recommended that several on-stream or impounding type reservoirs be built along the headwaters of the Sandusky River. None of the proposed possible locations falls within 10 miles of the Site. Additional water use information is contained in Appendix B.



SOURCE: "MUNICIPAL WATER SUPPLY IN OHIO", REPORT NO. 9, OHIO WATER PLAN INVENTORY (1962).

(A) PORTAGE RIVER BASIN

(B) SANDUSKY RIVER BASIN

(C) HURON-BLACK RIVERS BASIN

(C') PICKEREL-PIPE CREEK AREA WITHIN HURON-BLACK RIVERS BASIN

● PUBLIC WELL

FIGURE 2.2.9. WATERSHED AREAS AROUND SITE AND PUBLIC WELLS WITHIN 20 MILES OF SITE (1957)

TABLE 2.2.24. SUMMARY OF ALL WATER WITHDRAWAL, BY USE AND SOURCE, FOR WATERSHEDS (1) IMPINGING ON 20-MILE RADIUS FROM SITE--1955 (IN MILLIONS GALLONS DAILY)

	Use	Public Supplies				Private Supplies				Total Public and Private	Total by Source		
		Ground Water	Surface Water	Lake Erie	Total Public	Ground Water	Surface Water	Lake Erie	Total Private		Ground Water	Surface Water	Lake Erie
Portage River Basin	Manufacturing	N	0.7	0.7	1.4	2.8	2.6	--	5.4	6.8	2.8	3.3	0.7
	Domestic and commercial	0.9	0.7	0.7	2.3	0.2	--	--	0.2	2.5	1.3	0.6	0.6
	Suburban homes	--	--	--	--	0.8	--	--	0.8	0.8	0.8	--	--
	Farm homes	--	--	--	--	1.6	--	--	1.6	1.6	1.6	--	--
	Livestock	--	--	--	--	0.8	--	--	0.8	0.8	0.8	--	--
	Golf courses	--	--	--	--	0.4	--	--	0.4	0.4	0.4	--	--
	Farm irrigation	--	--	--	--	0.5	N	--	0.5	0.5	0.5	N	--
	Greenhouses	--	--	--	--	0.1	--	--	0.1	0.1	0.1	--	--
	Nursuries	--	--	--	--	N	--	--	--	N	N	--	--
	Railroads	--	--	--	--	--	--	--	--	--	--	--	--
	Sand and gravel	--	--	--	--	--	--	--	--	--	--	--	--
Portage River Basin Totals		0.9	1.4	1.4	3.7	7.2	2.6	--	9.8	13.5	8.1	4.0	1.4
Sandusky River Basin	Manufacturing	0.1	1.2	--	1.3	5.6	--	--	5.6	6.9	5.7	1.2	--
	Domestic and commercial	1.1	4.3	--	5.4	0.2	--	--	0.2	5.6	1.9	3.7	--
	Suburban homes	--	--	--	--	0.7	--	--	0.7	0.7	0.7	--	--
	Farm homes	--	--	--	--	1.3	--	--	1.3	1.3	1.3	--	--
	Livestock	--	--	--	--	2.0	--	--	2.0	2.0	2.0	--	--
	Golf courses	--	--	--	--	0.2	--	--	0.2	0.2	0.2	--	--
	Farm irrigation	--	--	--	--	0.3	N	--	0.3	0.3	0.3	N	--
	Greenhouses	--	--	--	--	N	--	--	N	N	N	--	--
	Nursuries	--	--	--	--	N	--	--	N	N	N	--	--
	Railroads	--	--	--	--	N	--	--	N	N	N	--	--
	Sand and gravel	--	N	--	--	N	N	--	N	N	N	N	--
Sandusky River Basin Totals		1.2	5.5		6.7	10.3	N		10.3	17.0	12.1	4.9	
Pickerel-Pipe Creek Area	Manufacturing	--	0.6	3.5	4.1	1.0	N	7.3	8.3	12.4	1.0	0.6	10.8
	Domestic and commercial	N	0.6	4.9	5.5	--	--	--	--	5.5	N	0.6	4.9
	Suburban homes	--	--	--	--	0.3	--	--	0.3	0.3	0.3	--	--
	Farm homes	--	--	--	--	0.6	--	--	0.6	0.6	0.6	--	--
	Livestock	--	--	--	--	0.3	--	--	0.3	0.3	0.3	--	--
	Golf courses	--	--	--	--	0.2	--	--	0.2	0.2	0.2	--	--
	Farm irrigation	--	--	--	--	--	0.1	N	0.1	0.1	--	0.1	N
	Greenhouses	--	--	--	--	0.1	--	--	0.1	0.1	0.1	--	--
	Nursuries	--	--	--	--	N	--	--	N	N	N	--	--
	Railroads	--	0.9	0.1	1.0	--	--	--	--	1.0	--	0.9	0.1
	Sand and gravel	--	--	--	--	--	0.4	--	0.4	0.4	--	0.4	--
Pickerel-Pipe Creek Area Totals		N	2.1	8.5	10.6	2.5	0.5	7.3	10.3	20.9	2.5	2.6	15.8

Source: "Water Inventory for the Portage River and Sandusky River Basins", Report No. 20, Department of Natural Resources, State of Ohio (1966).

(1) = Portage River Basin, Sandusky River Basin, and Pickerel-Pipe Creek Area within Huron-Black River Basin, see Map F.

N = Negligible.

TABLE 2.2.25. ESTIMATED FUTURE WATER USE (YEAR 2000) FOR WATERSHEDS AT LEAST PARTIALLY INCLUDED WITHIN 20-MILE RADIUS FROM SITE

	Use	1960 Use Rate,(1) mgd	2000 With Accelerated Use Rate,(2) mgd	2000 With Declining Use Rate,(3) mgd
Portage River Basin	Domestic and commercial	10.4	10.4	10.4
	Manufacturing	9.9	18.2	6.5
	Power	0	0	0
	Other industrial	0	0	0
	Irrigation	1.5	1.7	1.5
	Rural	3.2	3.2	3.2
Portage River Basin Totals		25.0	33.5	21.6
Sandusky River Basin	Domestic and commercial	12.6	12.6	12.6
	Manufacturing	9.9	14.9	3.6
	Power	0	0	0
	Other industrial	N	N	N
	Irrigation	1.0	1.3	1.0
	Rural	4.0	4.0	4.0
Sandusky River Basin Totals		27.5	32.8	21.2
Pickerel-Pipe Creek Area	Domestic and commercial	12.6	12.6	12.6
	Manufacturing	20.7	23.2	11.0
	Power	0.7	0.7	1.7
	Other industrial	1.0	1.0	1.0
	Irrigation	1.5	1.8	1.5
	Rural	1.2	1.2	1.2
Pickerel-Pipe Creek Area Totals		37.7	40.5	28.0

Source: "Water Inventory of the Portage River and Sandusky River Basins", Report No. 20, Ohio Water Plan Inventory, Department of Natural Resources, State of Ohio (1966).

(1) Based on 1955 use rate and long-term trends of population and economic activity.

(2) Based on 1955 use rate and increased economic activity.

(3) Based on 1955 use rate and increased reuse of industrial water.

N = Negligible.

2.3 REGIONAL HISTORIC AND NATURAL LANDMARKS

2.3.1 NATURAL LANDMARKS

Nine Ohio counties (Erie, Hancock, Huron, Lorain, Lucas, Ottawa, Sandusky, Seneca, and Wood) and an Ontario county (Essex) lie within a 30-mile radius of the Site. Each of these counties contains areas of considerable natural interest. In order to develop a list of "Natural Landmarks" within this area several sources were consulted: (1) "Nation Registry of Natural Landmarks", U.S. Government Printing Office, (2) "A Guide to Ohio Outdoor Education Areas", Ohio Department of Natural Resources and Ohio Academy of Science (Melvin, 1970), (3) "Enchanting Isles of Erie" (Ross, 1949), and (4) government agencies, promotional literature, personal interviews, map surveys, and field investigations.

The following listing contains the notable natural features found within 30 miles of the Site. The locations of these landmarks are shown on Figure 2.3.1. (Bracketed figures designate distance in miles and direction from the Site. Figures in parentheses designate corresponding map locations on Figure 2.3.1.)

2.3.1.1 Natural Features Located Within 10 Miles of the Site

Blue Hole: Castalia [5,E] (E-1.)

The "Blue Hole of Castalia" is famous throughout the country because of its beauty and seemingly bottomless depth. Although its source is usually termed an "underground river", geologic study indicates that it is a spring, its source the rainfall and drainage of more than 100 square miles, for the most part lying south of Castalia. The southern region is higher in elevation so that, as the rain water drains into surface sinkholes, small cracks, and joints, it produces a network of solution channels in the limestone. With groundwater in these solution channels flowing north, eventually, the springs, geared to lower land beyond, come to the surface. Nearly two million gallons of water per day come welling to ground level

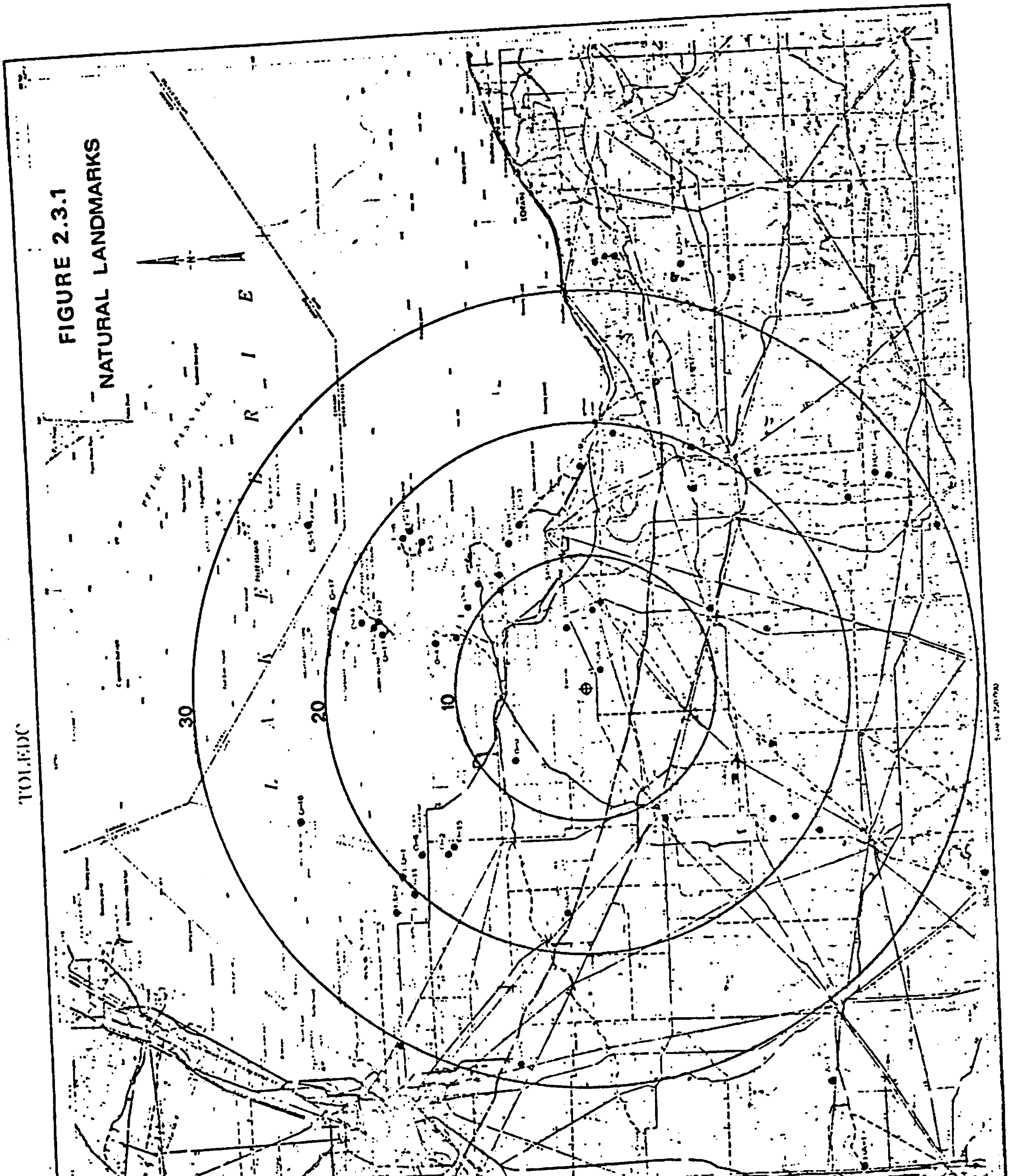


FIGURE 2.3.1
NATURAL LANDMARKS
TOLEDO
30
20
10
UNITED STATES 1:250,000

to create the unusual pool. The water contains no oxygen and fish cannot live in it until it splashes over rocks and waterfalls. A mill pond nearby is stocked with trout.

Area: 10 acres.

Of great interest also in Castalia is a 12-acre pond in the middle of town which does not freeze over during the winter because of the steady flow of water from underground. Waterfowl become extremely numerous there when nearby waters freeze over.

Camp Plymouth Shore: Marblehead [10,NE] (0-1.)

This is a private girls' camp specializing in water-related activities and horseback riding. The Lake Erie shore offers a good study area for aquatic vegetation, wind and wave action, fossiliferous limestone rocks, and glacial deposits. The woodland contains elm, cottonwood, silver poplar, horse chestnuts, spruce, cedars, and wildflowers in spring.

Area: 5 acres.

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.

Marblehead Peninsula: Lakeside [7,NW] (0-10.)

The Methodist Church campground contains a large winterized lodge which accommodates up to 100 persons. The town of Lakeside is a tourist attraction, especially during the summer months; this facility is advantageous as a home base for hikes and field trips into adjacent or nearby areas. The peninsula is a rock ridge over which the glaciers passed but left only a thin coat of drift. It is underlain by the Columbus limestone which is

highly fossiliferous. It has been quarried extensively and the lands are now returning to a natural state. Waterfowl and shorebirds are found on the lake; songbirds are present in the woods and along the shoreline.
Area: 10 acres.

Miller Blue Hole: White's Landing [2,SE] (SA-4.)

This area contains a small blue pool similar to the Blue Hole at Castalia. Owing to its limited access, it is not as noted as the Castalia Blue Hole as a tourist attraction. However, it is of considerable ecological interest and is frequently visited by aquatic biology classes from various institutions of higher learning throughout the State. A limited amount of vegetation is found which includes chara and other filamentous algae characteristically found in hard waters. Fish in the upper layer of water are green sunfish and top minnows; the stream flowing from the pool contains such species as sculpin, black nose dace, and occasionally rainbow trout. The land surrounding Miller Blue Hole has vegetation such as brush, small trees, and grassland.
Area: 13 acres.

Resthaven Wildlife Area: Castalia [6,E] (E-8.)

Resthaven is mostly in permanent grass and shrubby cover, with some woodland and crop rotation. More than one-half has been stripmined for marl. The area lies in what was originally a wet marl prairie underlain by the clays of an ancient Lake Erie. About 322 acres of ponds have been developed for rearing large fish populations. A great variety of waterfowl are to be found on them during spring and fall migrations. Wood ducks, mallards, black duck, and blue wing teal nest in the area. Woodcock nest there also and large numbers of migrants are present occasionally in the fall. Of interest also are the many remnant prairie plants: big and little bluestem, Indian grass, and prairie dock, relics of the vegetation present when the state was new. Pheasants, quail, muskrats, and other fur species are also present.
Area: 3.45 square miles.

2.3.1.2 Natural Features Located Between 10 and 20 Miles From the Site

Aldrich Pond Wildlife Area: Lindsey [17,W] (SA-1.)

The area is little more than an excavated, shallow pond, situated on the glaciated flat Lake Plain. It has abundant aquatic vegetation including cattails, spike rushes, coontail, myriopyllum, certain potomegetons, filamentous algaes, sagittaria, and others. It has been stocked with a wide variety of fish. Aquatic organisms and migrating waterfowl may be observed there.
Area: 1 acre.

Bellevue Reservoir No. 4: Bellevue [12,SSE] (HU-1.)

A small park has been developed at this reservoir. The reservoir is one of 5 supplying the city water. A project of the Junior Chamber of Commerce, the park has new facilities for picnicking. The city lies on the glaciated, rather smooth Lake Plain, on the broken beach ridges of old Lake Maumee. It has a thin coating of glacial drift above the Columbus limestone of Devonian age. The area is famous for the great number of sinkholes in which the surface water drains to underground channels which emerge at lower levels, probably in the Blue Hole and other springs of the Castalia prairie. The plot contains mixed hardwood trees and some species typical of wetlands. Birds, wildflowers, and small mammals may be seen.
Area: 8 acres.

Camp Hertzer: Oldfort [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 in the camp include several varieties of oak, maple, elm, ash, sycamore, tulip, dogwood, and sassafras.

Area: 43 acres.

Camp Sabroske: Oak Harbor [17,NW] (0-2.)

This church retreat across the Touissant River from the Touissant Wildlife area contains uncommon trees such as English walnut and almond and others typical of the elm-ash-swamp forest. Many varieties of birds, small mammals, wildflowers, and marsh flora may be studied. A winterized lodge, boats and canoes may be used in the spring and fall except during duck season.

Area: 110 acres.

Camp Seneca: Green Springs [16,SSW] (SE-3.)

A large woodland area on a dairy farm is used as a campground but may serve as an area for outdoor education. Three major habitats are present, a pond, and a creek providing for the study of aquatic plants and animals. Waterfowl are seen occasionally and a mallard hen is reported to have nested by the creek for 5 years. Open fields and meadows may be observed. The wooded area contains beech-maple forest types together with some sycamore, ash, and cottonwood along the stream. Wildflowers are abundant; deer, fox, quail, pheasant, and numerous other small animals are observed. The glaciated soils are high in lime content, though poorly drained because of the smooth lake plain surface.

Area: 215 acres.

Camp Yukita: Port Clinton [11,NNE] (0-3.)

With its Lake Erie shore, lagoon, woodland, and field, this camp has much to offer for outdoor education. The 3-acre wooded area is primarily of trees typical of moist habitats such as willow, cottonwood, walnut, and others, The underlying rocks are the thin-bedded dolomites of the Tymochtee member of the Monroe group, late Silurian age.

Area: 35 acres.

Catawba State Park: Port Clinton [12,NNE] (O-4.)

A small site on the lake at the tip of the peninsula serves primarily as a boat launch facility and picnicking site. There is no significant flora due to limited acreage and extensive use.
Area: 8 acres.

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.

Cook's Woods: Marblehead [11,NE] (O-5.)

This small plot contains a great variety of trees, shrubs, and herbs typical of swamp forest. It is a part of a larger property which has been quarried for limestone. This is the highly fossiliferous Columbus limestone, the bedrock of the area. Birds and small mammals may be observed also.
Area: 30 acres.

Crane Creek State Park: Oak Harbor [20,NW] (LU-1.)

Crane Creek State Park is reached by a road running through Magee Marsh. A bird trail where many species can be seen extends from the parking lot through a marshy area behind the beach and picnic areas. This is an outstanding area for shorebirds and waterfowl. There is a natural sand beach which is shaded by many large trees, mostly cottonwoods. The vegetation is typical of that found in association with Lake Erie; in addition there are many grasses and sedges in the marsh area. A new nature interpretive center and waterfowl hunting museum has been completed.
Area: 72 acres.

Crane Creek Wildlife Experiment Station (Magee Marsh):
Oak Harbor [18,NW] (0-6.)

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, up to 5,000 birds, appear in March. Warbler concentrations during migration are reported to be among the highest 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 wildlife observation. A full time naturalist is available and maps may be requested. A new facility known as the Sportsmen Migratory Bird Center has been completed recently.
Area: 4.06 square miles.

Crystal Cave: South Bass Island [17,NNE] (0-7.)

Known to geologists as the "Immense Geode" this cave has a mass of the dazzling mineral celestite (strontium sulphate) completely covering the interior. The sidewalls are of solid material and the ceilings are arch shaped and hung with crystals. The crystals are prismatic; the angles of each of the crystal faces are exactly alike on each one.

Strontium sulphate is a heavy mineral, often white with a bluish tint and is usually associated with limestone as it is in this cavity. The deposit is reported to be the biggest in the U.S. and contains the largest crystals, some being 18 inches in length.
Area: 1 acre.

East Harbor State Park: Lakeside [11,NE] (0-8.)

A long sand beach at this park extending for 2-1/2 miles is considered one of the finest along Lake Erie. Diverse aquatic vegetation can be found on the shore and bays. Shorebirds and waterfowl can be studied during migration. There is typical emergent natural vegetation but most of the trees occur in open parklike areas. A nature interpretation program is conducted during the summer.
Area: 2.52 square miles.

Erie County 4-H Camp: Kelleys Island [18,NE] (E-3)

A small acreage provides a tremendous opportunity for campers to study a variety of trees and shrubs, early spring wildflowers, many features of geology or earth science related to limestone formations, fossils of Devonian age, glacial grooves, shore action, and weathering. An abundance of animals include pheasant, waterfowl, tern, raccoon, fox, snakes, turtles, fish and snails. An Audubon group has recorded 70 different species of birds.
Area: 21 acres.

Galpin Wildlife Preserve: Milan [20,ESE] (E-4.)

Willed to Milan to be preserved in a wild state as long as time shall endure, this property is recognized widely as a choice natural area. Wooded ravines with many specimens of virgin trees in a hardwood forest and a rich understory of shrubs and wildflowers are a part of its attraction. The village stream, a tributary of the Huron River, gives bottomland habitat where birds and small animals are abundant.
Area: 37 acres.

Green Springs Nursery: Green Springs [14,SW] (SA-2.)

This is a forest tree nursery on which are grown approximately five million seedlings annually for reforestation purposes. The nursery was established in 1948 and at the present time the unskilled labor requirements are provided by a part-time seasonal female labor force. This

area presents an opportunity for gaining an understanding of the process of seed gathering, planting, transplanting, protection, and distribution.
Area: 120 acres.

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.

Hayes State Memorial: Fremont [11,WSW] (SA-3.)

This is the historic and beautiful wooded estate of Rutherford B. Hayes, 19th president of the United States. Spiegel Grove became the Hayes home in 1873 after the famous Ohio lawyer had served his second term as governor. A distinguished congressman, governor and president, Hayes' significant achievements were in the reconstruction of the South, in civil service reforms, and in strengthening the national currency.

The wooded estate surrounding the spacious home, the tomb, the library, and the museum contains a section of a famous Indiana trail (the Sandusky-Scioto Trail which extended from the Ohio River to Lake Erie). It winds for nearly one-half mile through a grove of majectic hardwood trees. On a quiet wooded knoll is a Vermont granite monument. Many of the great trees have been named for famous Americans who visited Spiegel Grove, a custom initiated by President Hayes which continued after his death. The walks, driveways, planted trees, shrubs, and flowers reflect the love of the President and Mrs. Hayes for their home.
Area: 25 acres.

Inscription Rock and Glacial Grooves:
Kelleys Island [17, NE] (E-5.)

An exposed layer of the Columbus limestone at the northwest corner of the island showing glacial grooves gouged out by the advancing ice sheet has been saved in perpetuity by the Ohio Historical Society. On the south shore, Inscription Rock is preserved under a shelter so future

generations may see the unique pictographs carved on the limestone boulder by prehistoric inhabitants.
Area: 1 acre.

Kelleys Island State Park: Kelleys Island [18,NE] (E-6.)

The area lies on the north shore and includes an excellent sand beach where water movement and shore vegetation may be observed. Primary woody plants are in the hackberry-elm association, with some scrub trees, oldfields, and small marsh areas for study of plants and animals. Without a doubt the outstanding feature of the island is geologic in significance. Glacial grooves cut by an advancing glacier 1 mile in thickness are as deep as a man is tall. These were gouged out by hard igneous rocks plucked from Canadian granites and other hard rocks to the north. Imbedded in the ice, their sharp edges scraped across the softer sedimentary limestones of the Devonian age to form the grooves. Much of the park is covered by limestone quarries, abandoned long ago and now returning to native vegetation. These areas offer excellent collecting sites for fossils typical of the Columbus limestone.
Area: 590 acres.

Knoblaugh Farm: Tiffin [19,SW] (SE-4.)

This small area provides a study in ecological succession as trees grow and the associated plant and wildlife composition change. It is a reforested plot, with deciduous seedlings started 10 years ago and conifers 4 years ago. A small private lake is adjacent to the farm.
Area: 5 acres.

Little Portage Wildlife Area: Oak Harbor [12,NE] (O-9.)

The area is a combination of river marsh and low-lying agricultural ground, a portion of which has been diked for water level control. The area is bounded by the Portage and Little Portage Rivers. It lies on the flat, glaciated Lake Plain on the silts and clays which were deposited in an earlier Lake Erie. Waterfowl and many varieties of shorebirds are present during spring and fall migrations. Wood ducks, mallards, and blue wing teal

nest here. Fish species include carp, channel catfish, bullheads, and crappies. A boat launching ramp and other facilities are present.
Area: 357 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.

Milan Wildlife Area: Milan [18,ESE] (E-7.)

The Huron River bisects the area with approximately one mile of the river within the boundaries. In places the river has eroded perpendicular shale cliffs from 6 to 60 feet in height. Over 200 acres are woodland, the primary tree species being red and white oak, hickory, cottonwood, ash, maple, and walnut. Animals include fox, red and flying squirrels, raccoon, rabbit, opossum, and woodchucks. Wood ducks nest in trees along the river and pileated woodpeckers are occasionally seen.
Area: 296 acres.

Perry's Cave: South Bass Island [17,NNE] (0-12.)

The discovery of this cave is credited to Commodore Perry, hero of the battle of Lake Erie, while his squadron lay at anchor in the bay a few days prior to the battle. Tradition claims that Perry stored ammunition and cannon in the cave and kept British prisoners there.

The cave is located 52 feet below the surface; it is 208 feet long and 165 feet wide. It is heavily encrusted with precipitated calcium carbonate which was deposited by the evaporation of dissolved limestone water as it dripped from the ceiling. Of wide-spread fame is the wishing well, a pool within the cave that rises and falls with the level of Lake Erie. The property above ground has a variety of trees, wildflowers, birds, and small animals.
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.

Seneca Caverns: Bellevue [15,SSE] (SE-6.)

This cave, developed on three levels in the crystalline, thick-bedded Columbus limestone was not formed by solution, but by the separation of the walls of a fissure. The amount of water seeping through the limestone is negligible, as indicated by the lack of stalactites and stalagmites. A subterranean river of considerable depth flows 147 feet below the surface of the ground.
Area: 2 acres.

Sheldon's Folly [18,E] (E-9.)

A privately managed woodland, a sand beach on Lake Erie, a waterfowl refuge pond, and natural marshes make this property a sanctuary of considerable renown. Cultivated fields, a tree farm section, multiflora rose hedges, and a farm pond have been Man's contribution to its beauty and attractiveness to wildlife, particularly birds. In addition to the woodland of oak, hickory, ash, sassafras, and black walnut, approximately 8,000 hardwood and softwood seedlings have been planted. This extensive variety of habitats furnishes nesting sites and migration cover for a great number of waterfowl and other birds.
Area: 64 acres.

Adjacent to Sheldon's Folly is Sawmill Creek Lodge and Golf Course. Fifty acres have been set aside as natural marsh, woodland, and shoreline. A sand beach 3,400 feet long fronts this property and forms the base of Cedar Point spit. The marshes, which are connected to Sandusky Bay, are rich in waterfowl and aquatic vegetation. The woodland contains a virgin stock of oak and black walnut estimated by the Ohio Division of

Forestry and Reclamation to be 300 years old.

Area: 200 acres.

South Bass Island State Park: Put-in-Bay [16,NNE] (0-13.)

The park is situated on dolomite cliffs with excellent exposure on a rugged shore line. The area is predominately an oak-maple woods with associated wildflowers, birds, and small mammals. The remains of glacial grooves are found in the bedrock. This island also contains the famous Perry's Memorial and Perry's and Crystal Caves.

Area: 32 acres.

Stone Laboratory: Gibralter Island [17,NNE] (0-14.)

The Franz Theodore Stone Laboratory Teaching and Research Program is an extension of The Ohio State University biology curriculum. It is a two-term summer school program designed by the College of Biological Sciences to meet the needs of biology and general science teachers, and graduate and undergraduate biological science majors. Since its origin in 1896, it has provided continuous training and research opportunities.

Twenty courses are taught on a regular basis during the summer months by OSU and visiting faculty members. These encompass such aspects of biology as limnology, fish ecology, algology, plant physiology, mycology, entomology, radiobiology, and parasitology. Typical enrollment is approximately 60 students per summer. In addition, numerous individual research projects are conducted by both faculty and students.

The entire field station complex contains approximately 25,000 square feet of classroom and laboratory space. Numerous boats are available for field research and sampling operations. An extensive inventory of sampling and analytical equipment is maintained and used for research purposes.

Stone Laboratory is located on Gibralter Island in Put-in-Bay Harbor. The island is composed of cavernous Put-in-Bay dolomite which rises in lake cliffs up to 30 feet high. In places the rocks exhibit

glacial grooves. Cooke Castle, now the men's residence lodge, is the former summer mansion of Jay Cooke, a Civil War financier.
Area: 10 acres.

Toussaint Wildlife Area: Oak Harbor [16,NW] (O-15.)

A combination of marsh and low lying farmland, this area is diked for water level control. Approximately 1-1/4 miles of Toussaint Creek shoreline bounds the property. Fish, migrating waterfowl, and shorebirds constitute the animal life; a wide variety of marsh flora may be observed.
Area: 236 acres.

2.3.1.3 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.

Camp Conger: North Fairfield [28,SE] (HU-2.)

Situated on the floodplain and banks of the East Branch of the Huron River this camp was one of the earliest established in the State. The main entrance is at the Lewis Conger residence; the camp is a part of the farm property. The area lies near the edge of the Defiance moraine on sandstones and shales of Mississippian age. About one-third of the campsite is wooded with a wide variety of species, some of them labeled. A 2-1/4-acre lake was constructed in a ravine above the camp but the river itself is a better resource for studying aquatic animals and plants. A bank on the west side of the river is a cut bank showing the glacial drift deposits. Bedrock exposures are evident in the river farther north.
Area: 30 acres.

Camp Singing River: North Fairfield [27,SE] (HU-3.)

Many wildflowers including some of the prairie species such as bottle or closed gentian may be found here. The habitats include grassland, creek and river bank, fence rows, and woodland. A great variety of trees such as willow, sycamore, ash, walnut, beech, maple, oak, tulip, sassafras, dogwood, and papaw reflect the diversity of environment. Several stalwart oaks boast longevity. The camp lies near the crest of the Defiance moraine and only a short distance from the Norwalk Esker ridge. Sandstone and shale of Mississippian age are exposed in the river bed. The glacial deposits include large erratics and numerous small igneous granites brought from the Canadian Shield by the glacier. Birds of edge-of-forest and field are seen, including the prized bluebird.
Area: 93 acres.

Camp Todimeca: Monroeville [25,SE] (HU-4)

The environment of the camp is rich in natural features. The West Branch of the Huron River, shallow above the dam at Monroeville, wanders through the property. A 2-acre pond provides an additional habitat for the study of aquatic plants and animals. Much of the site is wooded with floodplain vegetation as well as uplands of maple, beech, and oak. A heronry in the beech trees has existed for many years although the population has diminished considerably. No permanent marsh is available; the herons feed at Lake Erie. An old orchard is another interesting habitat. A very old farmhouse built of bricks and wood from the area by a West Virginian who walked to the site of his new home may also be viewed. Hiking trails and canoes give access to all wooded parts of the property.
Area: 297 acres.

Metzger Marsh Wildlife Area: Oak Harbor [23,NW] (LU-2)

Situated in the southeast corner of the county near Lake Erie the area is about evenly divided between open water and cattail marsh. Open to the lake, the marsh is subject to fluctuating water levels. A large variety of waterfowl and shorebirds are present during spring and fall migrations. Blanding turtles are found; other aquatic animals are abundant. Many fish species including goldfish and fresh water drum are present.

Area: 558 acres.

<u>Ottawa National Wildlife Refuge: Oak Harbor [21,NW] (O-11.)</u>

This is the only federal wildlife refuge in the State of Ohio. It consists of diked marshes bordering Lake Erie and farmland with a few woodlots. Crane Creek flows through the refuge. It is one of the few bald eagle nesting sites left on the Great Lakes. Over 250 species of birds have been found on the refuge along with a variety of mammals, reptiles, and insects. It is managed for waterfowl migrations and nesting. The marsh vegetation is predominately cattail with a variety of sedges and many species of grasses. Colorful aquatic plants bloom through the summer months. White pond lilies and yellow spatterdocks are interspersed with blue pickerel weeds. Later marsh mallow blossoms turn the marshes pink. There are many miles of dikes which are excellent for hiking. Interpretive tours are conducted by members of the Toledo Naturalists' Association. Crane Creek State Park adjoins the refuge.

Area: 7.50 square miles.

<u>Pelee Island: Lake Erie [25,NE] (ES-1.)</u>

Pelee Island, the largest island in Lake Erie, is a low-lying island composed of Columbus limestone. It lies 20 miles north of Sandusky. Glacial grooves occur in the northeastern part of the island near Scudder. The southwestern tip is called Fish Point and is a natural sand spit formed by Lake Erie currents which converge at this point. Most of the island is under cultivation.

Area: 17 square miles.

<u>Pearson Metropolitan Park: Oregon [30,NW] (LU-3)</u>

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.

Pleasant Valley Girl Scout Camp: Tiffin [21,SW] (SE-5.)

Situated in the pleasant valley of the Sandusky River, this camp is wooded beech-maple forest association on the uplands with ash and elm swamp forest along the stream. The woodland provides sanctuary for many species of birds, some reported to be found rarely in Seneca County. Wildflowers, too, are profuse with some unusual species present.
Area: 98 acres.

Rock Circus: Lemonyne [29,WNW] (W-2.)

The owner of this area emphasizes one feature on the farm, a museum collection of rocks and minerals. Lectures and demonstrations are given by appointment to groups with a geological interest. A campground for groups wishing to extend their field trips to quarries or other points of interest is also provided.
Area: 200 acres.

Valley Beach Park: Norwalk [21,SE] (HU-6.)

This is a recreation enterprise with campsites and picnic facilities. It is situated along the East Branch of the Huron River which provides studies in stream erosion and deposition, floodplain vegetation, and animal life. This includes a number of tree species on a variety of soil types. Also of interest is the broken beach ridge of old Lake Whittlesey. A third glacial lake level, old Lake Warren, may be observed a short distance north of the city of Norwalk.
Area: 30 acres.

West Sister Island: Lake Erie [24,NNW] (O-16.)

West Sister Island is part of the Ottawa National Wildlife Refuge and is the only island in the lake serving as a federal wildlife preserve. It is a favorite rendezvous for the heron, and here sanctuary is afforded to thousands of black-crowned night heron, the big white heron, also known as the American egret, and the great blue heron. The island is almost entirely covered with hackberry woods which provides an ideal nesting place for these birds. As many as six nests can be found in a single tree. The entire shore line is rocky and at the northeast end is a perpendicular dolomite bluff about 70 feet high. The island is not inhabited.
Area: 84 acres.

Green Island, 13 miles to the southeast, is also a wildlife preserve operated by the Ohio Division of Wildlife. It consists of rocky woodlands which have been undisturbed since 1915.
Area: 20 acres.

Willard Marsh Wildlife Area: Celeryville [30,SSE] (HU-7.)

This property lies in an old glacial lake bed; the waters are impounded by the Defiance moraine on the north and the Wabash on the south. It is a portion of one of the most extensive peat bogs in the State. Peat depth ranges to 20 feet. Several unique plant species typical of northern bogs may be observed as well as deer, fox, squirrel, muskrat, mink, and rabbit. Most of the property has been burned over and aspen has become established subsequent to the bog fires.
Area: 4.18 square miles.

2.3.1.4 Selected Natural Features Located Between 30 and 45 Miles From the Site

Camp Iss-See-Kes: Vermilion [34,E] (LO-1.)

This wooded property located near densely populated urban areas has many natural features making it advantageous. It lies on the Vermilion River which has eroded deeply through the Berea sandstone and Devonian shales to make good geologic studies. The region is glaciated and the old beach

ridges of former levels of Lake Erie may be observed. The woods are composed of mixed hardwood trees with wildflowers in season. The camp has hiking trails, a dining lodge with cabins, and tents for sleeping. The Elyria YMCA manages this camp.
Area: 40 acres.

Camp Pittenger: McCutchenville [35,SW] (SE-2.)

This property lies on the gently rolling glacial till plain on the banks of the Sandusky River and includes a number of interesting natural features. Wildflowers and animals may be seen in season. Conservation practices are the most important features to be seen.
Area: 30 acres.

Camp Timberlane: Birmingham [32,ESE] (E-2.)

This Girl Scout property is a T-shaped piece of land with the east fork of the Vermilion River flowing throughout from southwest to northeast. The northern section is relatively flat farmland now in natural succession vegetation; the southern section has rolling topography, is considerably wooded with a beech-maple forest type and ash, black walnut, and red elm in association. The stream has eroded through the Mississipian sandstone, exposures of which may be found on its banks. A multiflora rose hedge provides cover for the bird population. Deer may be seen as well as smaller wildlife. Wildflowers grow in the woodland and may be observed from the developed trails. A five-acre pond is rich in aquatic flora and fauna.
Area: 284 acres.

Chance Creek: Vermilion [33,E] (LO-2.)

This property was purchased by Oberlin College for a recreation area and has proven to be a benefit to the Biology Department. It is located partly on the floodplain of the Vermilion River with a wooded slope on the east side, and partly on an entrenched meander valley of Chance Creek, a tributary of the Vermilion. The site is almost completely wooded except for the shale cliffs through which the streams have cut. The Chance Creek ravine contains beech and hemlock among more extensive stands of beech-maple forest. A few unusual plants are present with fern especially abundant.

Area: 68 acres.

Firelands Reservation: Oberlin [33,ESE] (LO-3.)

This Boy Scout property has an exceptional number and variety of trees, flowers, and shrubs. The majority of the land is wooded in the Beech-maple forest type with ash, oak, and tulip in the association. Twenty-five acres have been planted in conifers. A 20-acre pond, a small river, and a swamp give an ample environment for studying aquatic plants and animals. The property lies on glaciated land, the ice sheets leaving a variable but thin coating of deposit. The Berea Sandstone of Mississippian age outcrops in the region where the river has eroded through the formation. The camp is used for the Lorain County Youth Conservation Camp.

Area: 300 acres.

French Property: Wakeman [33,ESE] (HU-5.)

A real effort has been made by the owners of this farm to preserve some woodland, "green islands" among the cultivated fields of the area. Five woodlots varying in size from 3 to 8 acres have not been pastured for 40 years permitting new growth and an understory to develop. The predominant trees are sugar maples with typical trees and shrubs in association. Natural forest succession is demonstrated by volunteer maples invading a small planting of pines. A small tributary of the Vermilion River runs through the property. The stream-dissected glacial plain is quite scenic for this part of Ohio.

Area: 230 acres.

Lakota School Land Laboratory: Lakota [35,SE] (W-1.)

Two small plots provide beginning experiences for the children in this school. One is a grass area surrounded by multiflora rose, autumn

olive, and a confier windbreak - a good habitat for birds. The second is an old wooded area containing elm, linden, oak, hickory, sumac, hawthorn, maple, and red bud. A wildflower area containing approximately ten species is associated with the woodland. The area lies within the Lake Plain province with dominantly dark, poorly drained clay soil. Remnants of the old beach ridge of Lake Maumee may be traced in places.
Area: 1 acre.

Mill Hollow-Bacon Woods Park: Vermilion [32,E] (LO-4.)

This site is on the Vermilion River, one-half of it left in its natural state which is mostly floodplain forest and wooded hillsides. The area has been glaciated and subsequently dissected by the river and its tributaries, forming shale cliffs and narrow sandstone outcrops. Marked nature trails have guides available at the nature center. An historic museum, deer run, duck-pond, picnic acres, and camping sites are added features. This park is one of three Lorain County Metropolitan Parks.
Area: 217 acres.

Van Buren State Park: Van Buren [42,SW] (HA-1.)

The impoundment of Rock Ford Creek provides a 70-acre lake which is surrounded for the most part by open park land. This is interspersed with some beech-maple woods. The area lies on the glaciated plain typical of northwest Ohio where thick clay till averaging 50 feet covers the bedrock. This consists of a light gray dolomite which is the Guelph member of the Niagara formation of the Silurian age. The resulting soils are known as high-lime till. Remnants of an old sand beach ridge, mapped as Lake Maumee, an early level of Lake Erie, are found in the vicinity.
Area: 138 acres.

2.3.2. HISTORICAL LANDMARKS

Historical landmarks are abundant within a 30-mile radius of the Site. The following listing by county contains the notable historic features found within 30 miles of the Site, and rudimentary descriptions of each landmark. The locations of historic and archaelogical landmarks are shown on Figure 2.3.2. (Bracketed figures designate distance in miles and direction from the Site. Figures in parentheses designate corresponding map locations on Figure 10.)

2.3.2.1 Historical Landmarks Located Within 10 Miles of the Site

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.

George W. Norris Birthplace and Boyhood Home [5,SSE] (SA-4.)

Located on Township Road 270, York Township. Built ca 1859 by Chauncey Norris, Greek Revival farmhouse, rather undistinguished architecturally, but birthplace of George W. Norris, the famous U.S. Senator from Nebraska. Now a private residence owned by Floyd Zechman.

James McPherson House: Clyde [8,SSW] (SA-7.)

Located at 300 East McPherson Highway, Clyde. Built 1833 as the home of Civil War General McPherson.

Ottawa County Courthouse: Port Clinton [7,N] (O-1.)

Built in 1898-1901, designed in the Romanesque Revival style by the architectural firm of Wing and Mahurin, contractors were Caldwell and Drake, Columbus. One of the 15 finest courthouses, architecturally, of the 88 in Ohio. Qualifies for the National Register.

2.3.2.2 Historical Landmarks Located Between 10 and 20 Miles From the Site

Breakers Hotel: Cedar Point [14,ENE] (E-51)

The Breakers Hotel at the Cedar Point Amusement Park was built ca 1905. This 1,000-room resort hotel is still in operation.

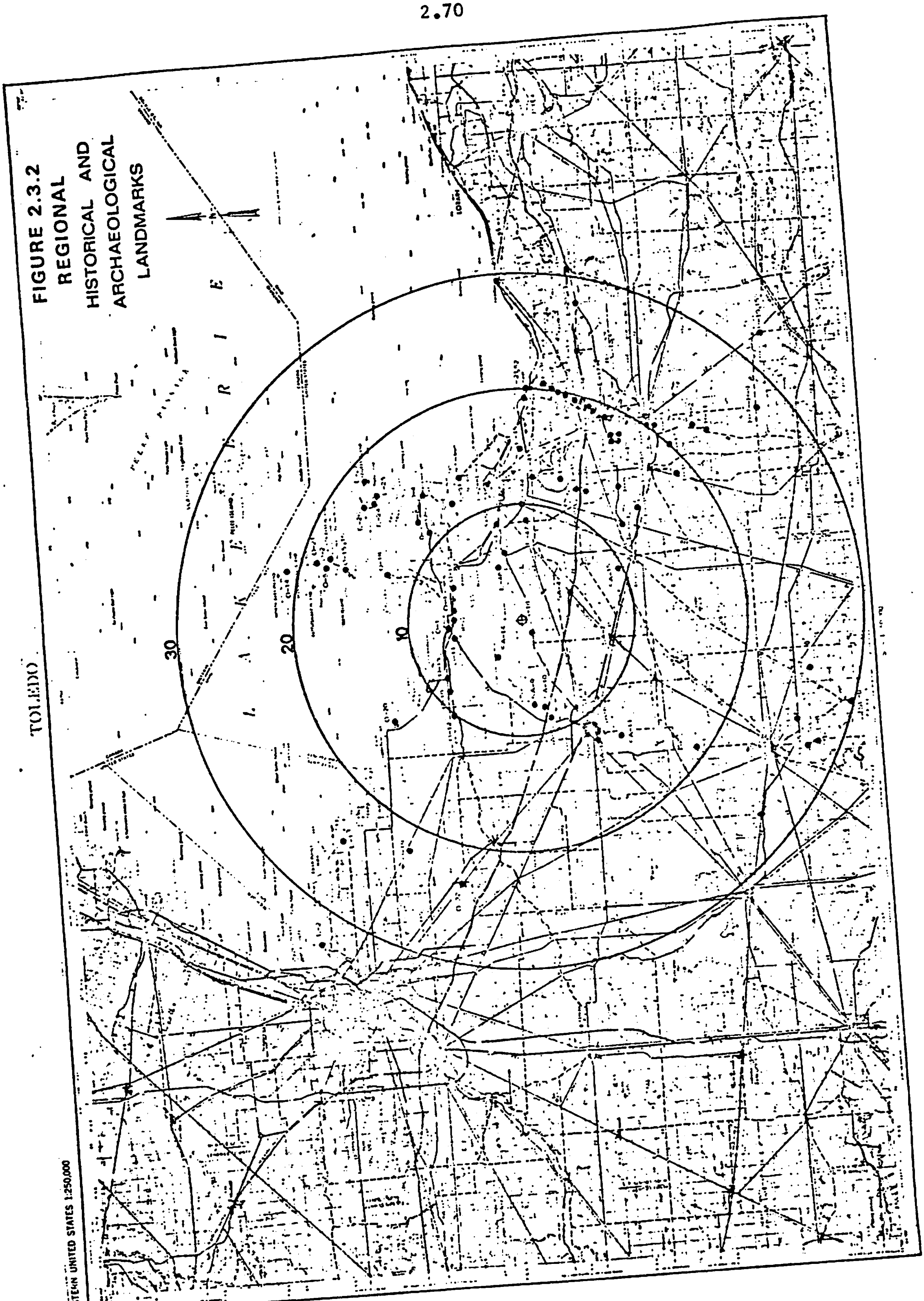


FIGURE 2.3.2
REGIONAL
HISTORICAL AND
ARCHAEOLOGICAL
LANDMARKS

Brown-Simmons-Schug House: Monroeville [17,SE] (H-3.)

Located on The Commons in Monroeville. Built ca 1920, this Greek Revival house is one of the finest examples of its style in the state. The diminutive templeform frame building has a 2-bay front facade with a pedimented portico. There is a single wing to the side. Noteworthy are the decorative frieze grilles. Building has been recorded by the Historic American Buildings Survey and qualifies for the National Register.

Buckland House: Fremont [11,WSW] (SA-3.)

Located on Birchard at Park Avenue, Fremont. Greek Revival-Victorian style house built by Ralph P. Buckland, in 1873, a law partner of Rutherford B. Hayes, Civil War general and congressman. Two-story brick, 3-bay front with corner pilasters, entrance in center with 2 columns in antis flanking doorway, which is recessed in a projecting bay, low-hipped roof, pilasters at sides, ornate Classical cornice, Victorian window detailing. Qualifies for the National Register.

Cherry-Lockwood-Moore House: Milan [19,SE] (E-14.)

Located on West Front Street, Milan. Built 1835-1836 by Nathan Jenkins, Greek Revival and Neo-Classic styles, interesting templeform structure with oddly-proportioned portico.

Confederate Prison Site: Johnson Island [12,NE] (O-6.)

From 1862 to 1866, the Federal Government maintained a prison here for Confederate prisoners of war, where 2,500 soldiers, most of them officers, were confined. The island compound was also an objective of the famous "Lake Erie Conspiracy". The cemetery on the island is maintained by the U.S. Government. Earthen artillery implacements are all that remain of the original prison complex. A National Register application for this site is in process. The site has been researched and recorded by the Historic American Buildings Survey.

Drake Funeral Home: Monroeville [17,SE] (H-5.)

Located at Main and Hollister Streets, Monroeville. Built as a residence about 1840, this 2-story brick building has an interesting Federal style doorway with elliptical fanlight. The house has an addition and the roof has been altered.

Edison Birthplace: Milan [19,SE] (E-10.)

Thomas A. Edison birthplace, Edison Drive, Milan. Built by Samuel Edison (Thomas' father) in 1841, country brick Greek Revival home, Thomas born here in 1847. Building now open to the public by its owner, the Edison Birthplace Association. This house is a National Historic Landmark and as such is on the National Register of Historic Places.

Egerton House: Fremont [11,WSW] (SA-5.)

Located on Buckland Avenue, Fremont, Early 19th century frame, 1-story house. Recorded by the Historic American Buildings Survey in 1934. Qualifies for the National Register.

Fort Stephenson Site: Fremont [11,WSW] (SA-2)

Located at Croghan, Arch and High Streets, Fremont. This site was the scene on August 2, 1813, of the Battle of Fort Stephenson. The fort was successfully defended, contrary to orders from General Harrison, by Major George Croghan with 160 men and a cannon called "Old Betsy". This was the last battle of the War of 1812 fought on Ohio soil. The Fort was erected in 1813 on a site acquired by the U.S. Government in 1795. In 1873 Sardis Birchard of Fremont purchased the site for Fremont's first public library. "Old Betsy" may be seen today on the library lawn. Qualifies for the National Register. It is recorded in the Historic American Buildings Survey.

Fremont Cemetery: Fremont [12 WSW] (SA-8)

This cemetery is located between Wheeling Depot and Croghan Hotel on Front Street in Fremont. Six burials were excavated with artifacts by workmen digging a sewer on June 30, 1891.

Hamilton-Rodman House: Milan [19, SE] (E-16.)

Built 1828, frame house with a fine doorway.

Historic Blockhouse: West of Milan [18,ESE] (E-35)

This blockhouse is located 1-1/2 miles west of Milan.

Hosford-Menard House (Octagon House): Monroeville [17,SE] (H-4.)

Located on Route 20, Monroeville. Built ca 1860, this is one of the best-preserved octagon houses in Ohio. There are 4 square rooms on each of 3 floors (2 above grade, and 1 basement) and a circular center stairway which rises to a cupola. Each of the 8 sides of this brick house is 2-bay; the 8-sided cupola has arched windows. A single story porch covers 3 sides of the structure. Qualifies for the National Register.

Huron Town Hall: Huron [20,E] (E-52)

Located at the corner of Main and Shirley Streets, the Huron Town Hall was built in 1876. The T-shaped, Victorian structure was constructed of wood and masonary and built in two sections, the second of which was erected in 1907. The Hall was once considered for the National Register, but due to the Huron Urban renewal program the building is scheduled to be torn down.

Inscription Rock State Memorial: Kelley's 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 cultural example of pictographic writing. Qualifies for the National Register.

J. C. Lockwood House: Milan [19,SE] (E-15.)

Located at 30 Edison Drive, Milan. One of the most pretentious Victorian style houses of the Western Reserve-Firelands area, built 1851 as an early Victorian house with 2 stories, but in 1880 the mansard roof, tower, and other decorative elements altered the style considerably. Qualifies for the National Register.

Jay Cooke Home: Gibraltar Island, Put-in-Bay [18,NNE] (0-5.)

Cooke, a Civil War financier, built this Victorian stone summer home on the island in 1864-1865. Cooke's fiscal acumen contributed to the stability of the Federal Government and thus to its victory in the Civil War. The home and its grounds were a summer retreat for Cooke's family and friends until 1905. Since then the house has been used by The Ohio State University. This building is a National Historic Landmark and as such is on the National Register.

Kelley Block: Milan [19,SE] (E-11.)

Located on The Commons, Milan. Built ca 1869, this block of stores dominates the eastern side of the town commons. Storefronts have cast iron arcades, second floor is brick with pilasters, bracketed cornice with raised, curved section to suggest a pediment. This building, plus The Commons, qualify for the National Register.

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.

Lyme Church: Lyme [12,SE] (H-12.)

Located on Ohio Route 113 northwest of Bellevue. A frame church, built in 1800's and altered considerably in recent years, has great local significance.

Mad River and Lake Erie Railroad Groundbreaking Site [12,E] (E-3.)

Located at Meigs and Water Streets, Sandusky. William Henry Harrison broke ground on this spot on September 17, 1835, for the first railroad chartered in Ohio. The line was planned to link Dayton and the Miami Valley to Lake Erie. The site, symbolic of the inauguration of the railroad era in Ohio, is now the entrance to East Battery Park, and is owned by the city of Sandusky. Application has been submitted to the National Register of Historic Places.

Marblehead Lighthouse: Marblehead [15,NE] (0-4.)

Located at Lighthouse Point, Marblehead. Built in 1821-1822 and designed by William Kelley. A stone tower, the lighthouse is the second built on the Great Lakes and the oldest in service. It is presently administered by the U.S. Coast Guard. Listed on the National Register.

Milan Canal Basin: Milan [19,SE] (E-17.)

In 1839, P. R. Hopkins and Charles Wheaton designed and constructed this turning basin as a terminus of the Huron Canal, which was opened to give Milan access to the Great Lakes. The basin is about 1,200 feet in length and nearly 300 feet wide. As many as 20 lake vessels were docked here at one time, being served by 13 warehouses and a shipyard where vessels were built for the grain and produce trade.

One warehouse, now a lumber yard, remains. In 1847, 917,000 bushels of wheat were shipped from this port, for a brief period second only to Buffalo in tonnage handled on the lakes. Railroad competition brought doom to the canal and basin, beginning in the 1850's. The basin is undeveloped and overgrown at present. It is owned by the Edison Birthplace Association. Qualifies for the National Register.

Mitchell-Turner House: Milan [19,SE] (E-13.)

Located at 128 Center Street, Milan. Built in 1848 by Zenas King, this is an incredible late Greek Revival style structure, exquisite detailing. Qualifies for the National Register.

North Monroeville Congregational Church: North Monroeville [15,SE] (H-6.)

A small church with triple-hung windows, frame construction. A square cupola is in keeping with the simplicity of the body of the building.

Oran Follet House: Sandusky [12,E] (E-2.)

Located at 404 Wayne Street, Sandusky. Built 1837, late Greek Revival style, built by Oran Follett, editor and publisher, constructed of local limestone, 3-story with hipped roof, sophisticated porch and cornice detailing, 5-bay front, entrance to first floor raised above exposed ground floor (basement). Presently serves as offices for Sandusky School of Practical Nursing, owned by Sandusky Board of Education. Qualifies for the National Register of Historic Places.

Perry's Victory National Monument: Put-in-Bay [18,NNE] (O-2.)

A National Historic Landmark administered by the National Park Service. On the National Register of Historic Places.

Police Station: Milan [19,SE] (E-12.)

Built 1886, tiny brick building with a mansard roof and single front dormer, detailed pedimented window hoodmilds, stone foundation.

Presbyterial Church: Huron [20,E] (E-22.)

Built ca 1848 in Greek Revival style, 3 stage tower, pedimented and pilastered temple front.

"Railroad Building": Sandusky [12,E] (E-6.)

Located at Adams and McDonough Streets, Sandusky. Two-story brick row building, used as apartments.

Roft House: Sandusky [12,E] (E-1.)

Roft House, 914 West Perkins Avenue, Sandusky, was built ca 1858. Early Victorian Italianate style brick house, 2-story, 3-bay front, entrance porch at side bay. Stone foundation, large bracketed eaves, wood cupola, n hoodmolds. Qualifies for the National Register of Historic Places.

<u>erford B. Hayes Home (Spiegel Grove) and Presidential Library: mont [12,WSW] (SA-1.)</u>

Located at 1337 Hayes Avenue, Fremont. Sardis Birchard built a mmer home in 1859 on the outskirts of the Fremont of that time. He named e estate after the pools which reflected the towering trees. His nephew, therford B. Hayes, inherited the estate in 1873 and enlarged the Victorian nsion. Since 1909, the property has been a State Memorial, administered the Ohio Historical Society and the Hayes Foundation. The memorial ontains the following: ornamental iron gates which formerly marked the ntrances to the White House, the Vermont granite monument over the graves f President and Mrs. Hayes, the Hayes home, occupied by the President and is family since 1873 and now open to the public, and the first of the presidential libraries. This house is a National Historic Landmark and as such is on the National Register of Historic Places.

<u>Sandusky County Courthouse: Fremont [11,WSW] (SA-6.)</u>

Located on South Park Street, Fremont. Built 1840-1844, but completely rebuilt in expansion of 1936. Building is recorded in the Historic American Buildings Survey (1934, before rebuilding). Original architect was Cyrus Williams, contractor Isaac Knapp, 1949 courthouse is Greek Revival style brick.

<u>Sprigg-Garrett-Hahn House: Huron [20,E] (E-23.)</u>

Located on Bogart Road, west of Huron. Built ca 1845, a Greek Revival style farmhouse, now covered with asphalt brick siding; original columned porch remains, pilastered corners intact, pedimented front.

<u>Stone House: Sandusky [12,E] (E-9)</u>

Located at 207 Decatur Street, near Market Street, Sandusky. Two-story stone house, gable to front.

Stone House: Sandusky [12,E] (E-7.)

Located at Adams and Franklin Streets, Sandusky.

Two Houses: Sandusky [12,E] (E-8.)

Located at Market Street near Warren Street, Sandusky. Brick and stone houses, deteriorated conditon.

War of 1812 Battle Site: Lakeside-Marblehead [11,NE] (0-3.)

Site of the first battle of the War of 1812 fought on Ohio soil. Erected on the site is a marker donated by Congressman Joshua Giddings. Listed on the National Register.

Water Street District: Sandusky [12,E] (E-4.)

Located on the north side of Water Street, between Decatur Street on the west and Warren Street on the east. A 6-block row of 3-and 4-story stone and brick warehouses and commercial buildings which, except for the effects of time and neglect, are largely unchanged from their original appearances in 1850-1890. The style is commercial Victorial Italianate, typical for the period. The three best buildings in the district are: 149 Water Street-a 3-story stone building dropping 1/2 story at the rear, 5-bay facade at Water Street, Italianate detailing, original storefront largely intact except for the addition of a garage door, property is presently occupied. Northwest corner of Water and Columbus Streets - also built of local limestone, 4 stories at Water Street dropping 1/2 story to rear, building provides a good anchor at the water front for the Columbus Street primary commercial district; some alterations are evident. At 201 Water Street-stone with contrasting stone trim, 7-bay with larger center bay, 3 stories at Water Street, storefronts largely intact. District qualifies for the National Register of Historic Places.

Water Street Wineries: Sandusky [12,E] (E-5.)

Located on the south side of Water Street on either side of Hancock Street, Sandusky. Two stone buildings built as wineries and now apparently vacant.

2.3.2.3 Historical Landmarks Located Between 20 and 30 Miles From the Site

Firelands Community Bank: Berlin Heights [24,ESE] (E-19.)

Built in 1897 in a heavy, Romanesque Revival style, but actually unique in form. Three-bay front, entrance in side bay, arched openings, bullet windows in second floor, all stone rusticated, raised pedimented section in center with name and date. Qualifies for National Register.

First Congregational Church: Florence [28,ESE] (E-21.)

Build ca 1840 in Greek Revival style, an excellent example of the early Western Reserve-Firelands church. Qualifies for the National Register.

Founder's Hall, Heidelberg College: Tiffin [25,SSW] (SE-1.)

Built 1825-1858, the building has been called one of the best Greek Revival style structures in Ohio. Three stories constructed of brick, with frieze windows. Qualifies for the National Register.

Genoa Town Hall: Genoa [23,WNW] (0-22)

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.

Hoyt's Department Store: North Fairfield [27,SE] (H-7.)

Build ca 1882, this building dominates the town center of North Fairfield. Built of brick, the tall 2-story building has a modified mansard roof and cast iron storefront columns.

Judge Reed House: North Fairfield [27,SE] (H-8.)

Built after 1850 by Sackville West, this Gothic Revival style 1-1/2-story brick house has interesting lancet-arched entrance sidelights and a typical center gable.

Marint Hestor House: Norwalk [23,SE] (H-2.)

Located on Ridge Road 5 miles south of Norwalk. Built about 1833, the house, with its stepped gables and bridged chimneys, is reminiscent of the Carpenter House, 54 West Main Street, Norwalk. The building is in fair condition.

Methodist Church: Peru [23,SE] (H-11.)

This now-abandoned church, a rather large brick building, has a rather simple doorway and a segmental-arched window high in the gable.

Roger Bacon Mill: Tiffin [24,SSW] (SE-2.)

Grist mill built 1822 and 1875. The milldam, miller's house, and grist mill are of significance, important historically to the area.

Rolley House: North Fairfield [27,SE] (H-9.)

Built in 1840, this house has a 2-story center section with 1-story wings, brick construction. The center section has a single-story porch and the wings have integral porches. It was built by Scott and Alcott Rolley and is now in only fair condition. Qualifies for the National Register.

Town Hall: Florence [28,ESE] (E-20.)

Built ca 1860, octagonal stone building erected as a school. Qualifies for the National Register.

West Main Street Historic District: Norwalk [21,SE] (H-1.)

This Norwalk street presents a succession of American home buildings from the Federal style to the prairie style. Well-maintained and not in jeopardy except for gradual change, the structures on the street need more individual study. This may come when the district is nominated to the National Register of Historic Places. This is the best individual street of homes, architecturally, in the State. Some of the notable houses are: Sooster-Boalt-Overhuls House, 114 West Main Street - built in 1848 as a young ladies' seminary. It was bought in 1858 by H. M. Wooster, Creek Revival in style with large fluted Ionic columns, no portico (columns rest only inches from front wall of house), splendidly-proportioned front, doorway in center, simple Doric pilaster, pedimented gable. Sturgis-Kennan-Fulstow House, 99 West Main Street - built in 1834 and designed by William Gale Meade, this house has a columned-pedimented portico, two stories in height, columns are octagonal in section. This house was recorded by the Historic American Buildings Survey in 1935 and 1936. Vredenburgh-Gardiner House, 133 West Main Street - built in 1834 and set far back from Main Street, this house has had several alterations and additions; but the front, with its center gable and Federal and Greek Revival detailing, remains essentially as built. Preston, Samuel House (Firelands Museum), originally located on West Main Street and now located at 4 Case Avenue, just off Main Street - built in 1835 for Preston, editor of the Norwalk Reflector, the second floor of the house was originally used for printing and publishing, alterations to the front portico have occurred. The house is frame, two stories with a temple front. Now the Firelands Museum, the building is devoted to library and exhibits. Kimball-Wooster-Carpenter House, 54 West Main Street - built 1833-1835 in the Federal style, the tall two-story brick house with stepped gables and bridged chimneys retains nearly all of its interior woodwork, including mantles and the stairway. It is a well-proportioned house, 5 bays at the front, with a 3-bay, one-story porch, and a well-executed doorway. Later additions are at the rear. The building has been meticulously restored by its present owners, the Carpenters. It was recorded in 1934 by the Historic American Buildings Survey. At that time it was the Martin House. House at 161 West Main Street - built ca 1857, this 2-story brick house has a 3-bay front with doorway at the side bay, simple Classical detailing.

2.3.2.4 Selected Historical Landmarks Located Between 30 and 45 Miles From the Site

Butler-Carlson-Bettcher House: Birmingham [31,ESE] (E-18.)

Built in 1827, a combination Federal and Greek Revival Structure, brick, 2 stories with stepped gables and bridged chimneys, good proportions, 3-bay front facade with doorway at side bay. Qualifies for the National Register.

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

The Fitchville Cemetery was excavated in 1910 and reburied.

L. A. Selyem House: Fitchville [33,SE] (H-10.)

Located on Route 162, Fitchville. Built ca 1835, this Greek Revival style 2-story frame building has a recessed first floor porch. Its builder was "Lize" Palmer. It qualifies for the National Register.

2.3.3 ARCHAEOLOGICAL LANDMARKS

2.3.3.1 Archaeological Landmarks on or in the Immediate Vicinity of the Site

Approach

An area of approximately 15 square miles lying between the town of Vickery, Sandusky County, Ohio, and the southern shore of Sandusky Bay has been intensively surveyed for archaeological remains. The work was done during the last 3 weeks of April, 1974.

Field conditions were unusually good for such a survey, for much of the area is under cultivation--predominately corn and soybeans-- and the washed fields of the previous year had not yet been plowed for spring planting. All open ground in the area was field walked. The remaining portions of the region were inaccessible because of forest cover, cultural features, or crop cover which did not permit field walking. With the exception of three days of snow and rain, the weather was excellent, greatly facilitating the survey work.

Contacts with residents of the area, farmers, land owners, and citizens of nearby Clyde, Ohio, produced nothing in the way of archeological material from the survey area proper. The usual attitude encountered was one of surprise that any archeological remains exist in the area.

Survey Procedures

Figure 2.3.3 shows the area actually covered in the field survey. Areas shown in white were open fields, usually planted in last year's corn or soybean crop. Survey conditions in such fields varied from good to excellent, depending upon the amount of week cover. The ground surface of all open areas was carefully examined. On the average, about one township section was covered per day. Hachured areas on the accompanying map represent wooded tracts. These are usually (at least during the spring months) very swampy. Such areas were tested only when peculiarities of topography suggested that an archaeological site might be present. Stippled areas on the accompanying map represent fields planted in winter wheat. It was impossible to surface hunt such fields without damaging the crop and these fields were examined only along the margins.

Previous Work

Only two archaeological sites within the study area have been described in the literature. Williams (1882) mentions an earthern fort or "ring" in the swampy "Muskash" region of Section 1, Riley Township, and another earthern ring on the Stull farm in Section 12, Townsend Township. The Stull site has been relocated and is described in Figure 2.3.3 as Site 5. The Muskash site has not been definitely located, and this problem is discussed in conjunction with Site 11. Mills' (1914) Archaeological Atlas of Ohio locates two forts in the study area, very probably

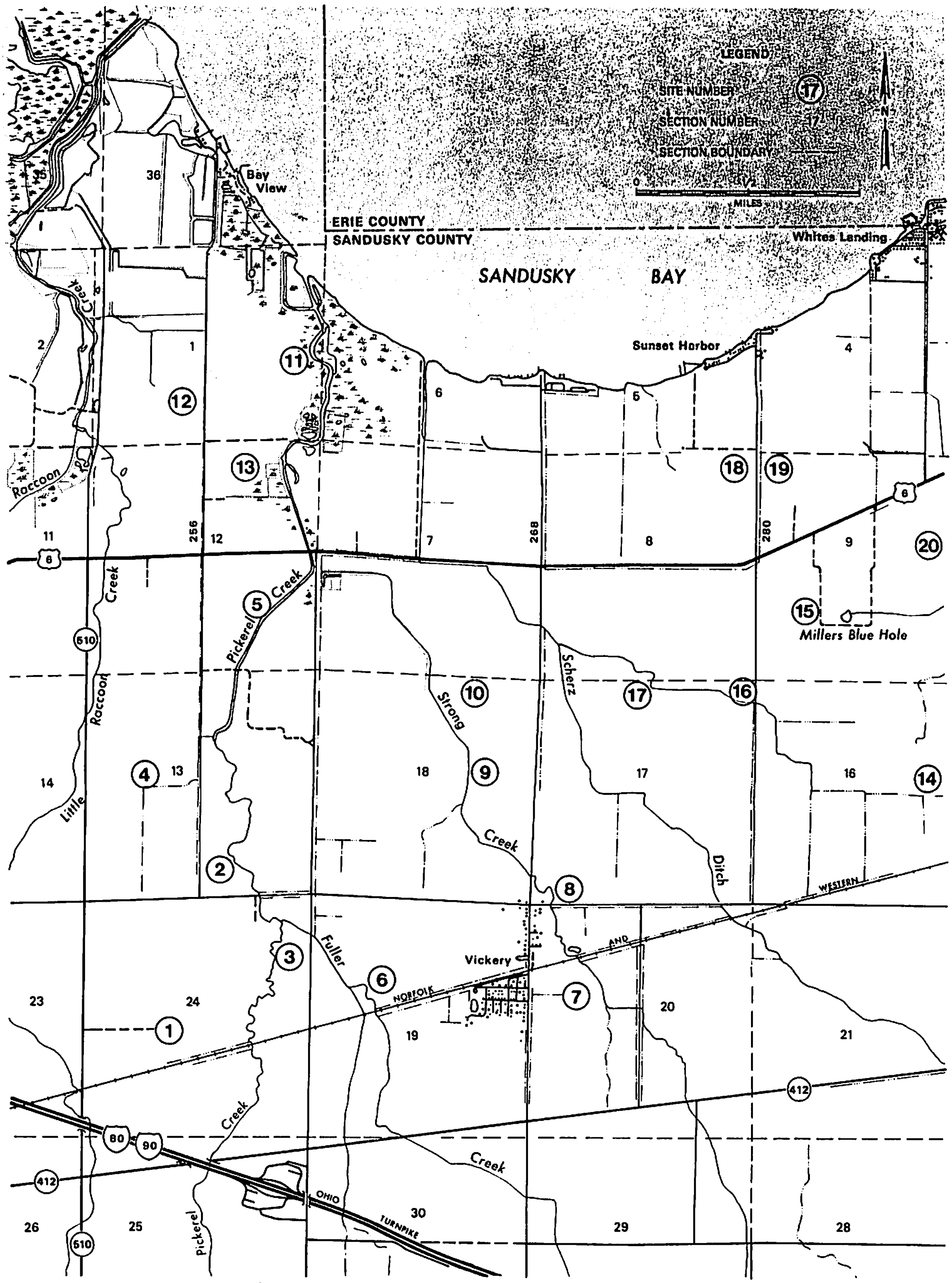


FIGURE 2.3.3 ARCHAEOLOGICAL SITES IN THE IMMEDIATE VICINITY OF THE SITE

SEE FIGURE 2.7.1 FOR DETAILED MAP OF FORESTED AND AGRICULTURAL AREAS the Stull and Muskash sites; in at least the former case, however, Mills has incorrectly placed the site at least one-half mile from its actual location.

Site Distribution and Prediction

Before actual survey work began, topographic maps of the study area were examined in an attempt to predict the location of archaeological sites in the area. Based upon knowledge of site locations in northeastern Ohio, it seemed probable that sites in the Vickery region would be limited largely to the banks of the major streams, the lake shore, and topographical "highs" that might have provided easily defensible positions. Several factors that became evident during the course of field work render these basic postulates difficult or impossible to apply. Mosely (1905) has shown that the southern shore of Sandusky Bay has receded at a remarkably high rate. According to him, at least 264 feet of land has eroded away along the stretch of Bay from Raccoon Creek to Pickerel Creek during the 50 years prior to 1905, and as much as 1,650 feet in the area just north of the mouth of Raccoon Creek. Regardless of the exact rate of shore erosion, any archaeological sites that once existed along the shore have long since been washed away. The entire shoreline along the northern edge of the study area was examined without discovering any traces of aboriginal activity.

The extensive channelization of the streams of the Vickery region has done much to obscure the original courses of the waterways. Topographic relief is so slight that the abandoned stream channels are not always indicated on even the recent, large-scale topographic maps of the area. The rectilinear drainage pattern that has resulted from stream channelization does much to mitigate the value of selectively searching for sites along the stream courses. Nonetheless, it is apparent that stream bank localities were preferentially selected by the aborigines, as nearly every site discovered in the area can be related to either the present course of a stream or to an abandoned channel. Whether this relationship is due to dependency upon streams for travel or is due to the fact that topographic highs are commonly restricted to the river bank remains unclear. It is worth noting that total relief in the survey area is no more than 45 feet and that in some sections (one square mile in area) maximum relief is no more than 10 feet. In a region of such small relief, extremely small differences in elevation assume considerable importance. In most instances slight topographic highs too insignificant to be indicated by the 5-foot contour interval of the most recent topographic maps can readily be spotted in the field because of the differences in soil coloration. Low, poorly drained areas, including abandoned stream channels, are marked by a black calcareous loam whereas higher land is composed of yellow clayey loam. The striking contrast in color permits tracing of abandoned stream channels for considerable distances, even where the eye can detect no noticeable difference in elevation or change of slope.

One additional factor which has an influence upon site distribution and which was not taken into account prior to actual field survey is the influence of springs in developing small topographic highs. Two factors, actually, are probably at work. Stresses caused by the advance of Pleistocene glacial ice or by elastic rebound of the southern Lake Erie shore following the removal of the last ice sheet have created a number of small anticlinal mounds or ridges. These are often of sufficient magnitude to bring to the surface deposits of marl and tufa similar in every respect to the Castalia marl described by Sterki (1920) from Erie County, Ohio. In addition, such marl mounds are often the loci of artesian springs, the water from which forms additional deposits of tufa, thereby adding to the height of the mound.

Traces of aboriginal occupation have been found surrounding these natural artesian springs, for the combination of good abundant water, relatively high and dry ground, and abundant game attracted by the springs provided an ideal situation for the Indians. One inherent difficulty for the archaeologist is the fact that bone and shell refuse found on such sites can rarely be associated with an archaeologist component. Many of the bones may merely represent animals that visited the springs and happened to die there; only a few burned bone fragments can certainly be related to an aboriginal manifestation. Similarly, the many fish bones and drumfish (Aplodinotus) otoliths found at Sites 5 and 10 do not, as was first thought, indicate that the sites were basically fishing camps. Most of these bones are instead associated with the marl that formed along the old lake bottom. The same is true, of course, for most if not all of the freshwater and pulmonate gastropod species found on these sites, though some of the specimens may actually represent individuals that lived on the site at the time of the aboriginal occupation or subsequent to it.

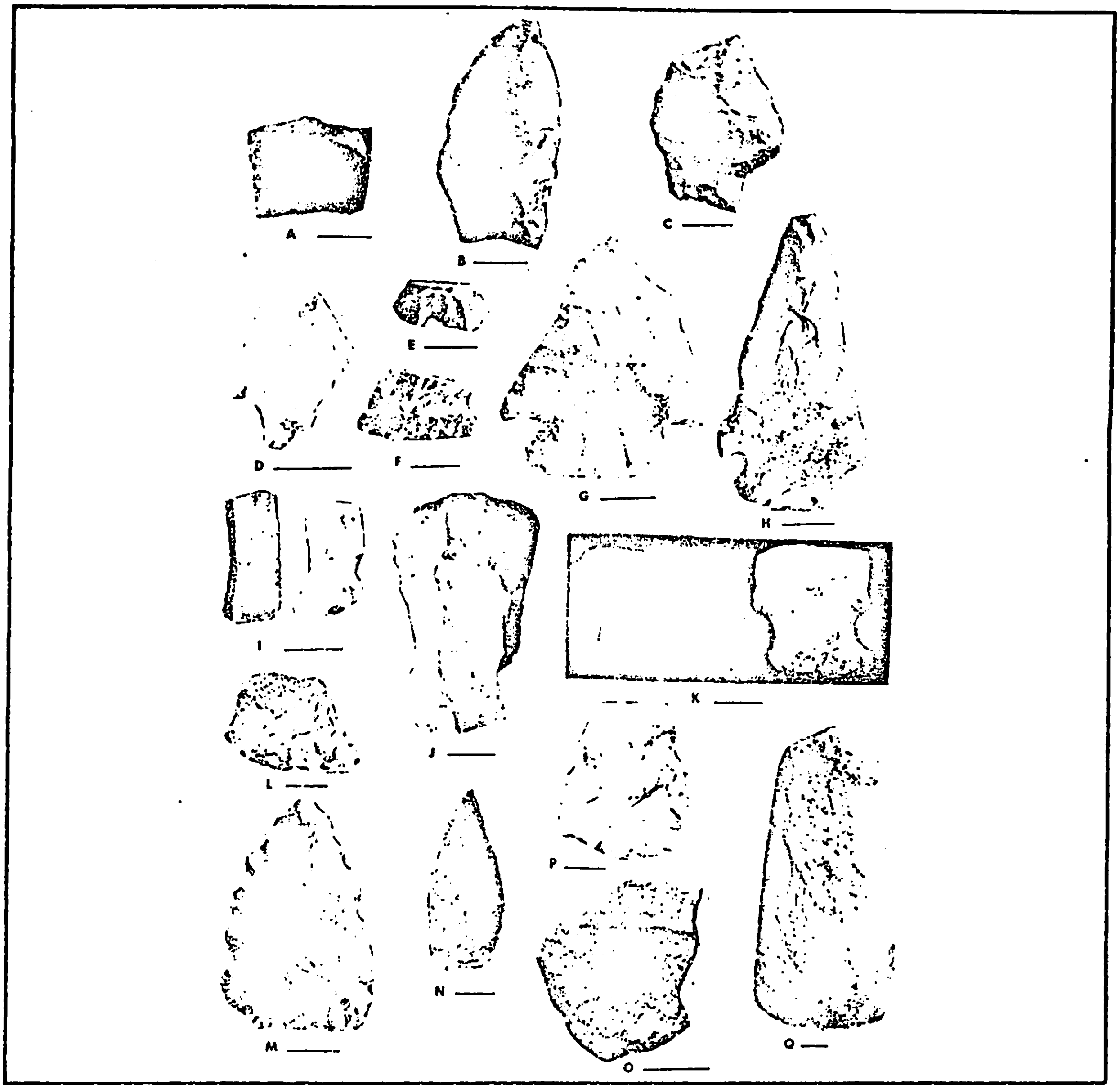
The nature of the "Black Swamp" region did not encourage development of large village areas. It is doubtful that even the several sites that have yielded evidence of pottery were occupied year-round. The bulk of the sites probably represent nothing more than transitory campsites or hunting stations. Such an interpretation is consonant with the small areal extent of the sites as well as their location on or near streams.

Cultural and Temporal Interpretation

Analysis of the artifact material recovered from the 20 sites discovered within the study area indicates that the Vickery region was occupied by man at least as early as 8000 B.C. Evidence for this statement is the solitary, broken Plano lanceolate or stemmed flint point found at Site 8, just north of the town of Vickery. Undoubtedly, earlier groups of migrant Paleo-Indians also traversed the area, but no fluted points or other diagnostic Paleo-Indian artifacts have yet been found in the Vickery area. The lengthy Archaic Period is represented by numerous flint points, and by far the greatest number of known sites represent components belonging to this period. Both Early Archaic point types such as the LeCroy point illustrated in Figure 2.3.4 and Late Archaic types are represented in the collections. Diagnostic affiliations of each Site are described in Appendix C.

Surprisingly, the Early Woodland period is not represented by any lithic tools; however, Site 5 has yielded a single thick grit-tempered potsherd that is undoubtedly Early Woodland, probably representing the ceramic type Leimbach Thick originally described from the Leimbach site in Lorain County. Leimbach Thick pottery has been dated at 520 B.C. (Shane, 1967).

The Middle Woodland period is represented by one or two Hopewellian type flint bladelets (Figure 2.3.4). No diagnostic Middle Woodland point types have been found during the course of the survey. Site 18, which has yielded a number of grit-tempered cordmarked pottery sherds, has also yielded two broken side-notched points (Figure 2.3.4) attributable to the Late Woodland period. These are comparable to Chesser Notched points described from the Late Woodland of southeastern Ohio (Prufer, 1967),



EXPLANATION OF FIGURE 2.3.4

A. Plano lanceolate or stemmed base showing secondary use as scraper. Site 8.
B. "Transitional" point from Site 9.
C. "Transitional" point of Plum Brook flint from Site 12.
D. Le Croy Bifurcated Base point from Site 4.
E. Archaic bifurcated base point fragment from Site 6.
F. Side notched Late Woodland point base of unidentified flint. Site 18.
G. Archaic corner notched point from Site 4. Devonian chart.
H. Archaic point or knife from Site 17. Devonian chart.
I. Hopewellian flake knives of Plum Brook flint (Site 20) and unidentified flint (Site 4).
J. Endscraper on large blade of white Devonian flint. Site 10.
K. Two broken side-notched Late Woodland points of Plum Brook flint and Devonian chert. Site 18.
L. Broken Levanna point of Plum Brook flint. Site 20.
M. Large serrated triangular point of Plum Brook flint. Site 4.
N. Asymmetrical triangular point of Devonian chart. Site 20.
O. Parker Festooned grit tampered rim sherd from Site 18.
P. Large triangular point of Devonian chart. Site 20.
Q. Quartzite celt from Site 13.

dating from 700 A.D. to 1000 A.D. It is possible that some or all of the small grit-tempered potsherds recovered from Site 18 are associated with these Late Woodland projectile points, but the pottery may be somewhat later. The only diagnostic pottery sherd recovered during the entire survey is a small rim sherd of Parker Festooned ware found at Site 5. This pottery type is known to date from around 1200 A.D. to 1500 A.D. and occurs throughout southwestern Ontario, southeastern Michigan, and nearly all of northern Ohio. Finally, nearly every site investigated has yielded varying amounts of Historic materials--fragments of salt-glazed earthenware, ironstone crockery, white "kaolin" pipe fragments, and buttons. Such material was given only cursory attention in the field and is invariably representative of abandoned 19th Century house sites. The geography of the Vickery area is such that virtually every site inhabitable by primitive man was subsequently occupied by the first pioneer settlers of the region.

Archaeological Significance

Prior to the archaeological survey in the vicinity of the Site, only two prehistoric Indian manifestations were recorded for the area in the files of the Ohio Historical Society--the two circular enclosures located by Mills (1914). During the course of the investigation, it was found that one of these circles had been incorrectly located on Mills' map. The discovery, therefore, that 20 sites exist within the region is quite significant to continuing efforts to record as many of Ohio's prehistoric Indian habitations as possible.

To the archaeologist, every Site is important since each one will provide another bit of information about prehistoric cultures. In the context of this particular survey, however, those sites within the boundaries of the Ohio Power Company's property and those immediately adjacent to it are particularly crucial. In general terms, the loci within the OPC's holdings should be investigated further. Site II should be assessed more extensively since it may be the location of the Muskash earthworks. The fact that the cultural affiliation of Site 13 cannot be determined now tends to decrease its importance; however, it is possible that more material might be below the surface. Sites 18 and 19, perhaps portions of a single camp, appear interesting since they may provide important data on various economic pursuits of the Late Woodland Indians.

Sites adjacent to the Ohio Power Company property (5, 10, 12, 15, and 16) are perhaps less important in the context of this report since they lie beyond the area where construction would be concentrated. Site 5 may be the location of a circular earthwork, and both Site 5 and Site 10 appear to be hunting/fishing camps of the Late Woodland Indians; little is known about that culture. The remaining sites appear on the surface to be of little significance since they yielded few diagnostic artifacts and were rather small in extent.

2.3.3.2 Archaeological Landmarks Located Within 1 and 10 Miles of the Site

The following listings include 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 2.3.2.

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.

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

Gill Burial Ground: Portage Township [6,N] (O-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] (O-17)

Lacarne Cemetery Site and Village: Erie Township [9,NW] (O-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] (O-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] (O-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.

Schlagel Indian Village Site: Sandusky Township [8,W] (SA-10)

This village, located in the eastern part of Section 14, Sandusky Township, was excavated by Schlaegel and visited by Goslin in May, 1930.

Squaw Island Site: Riley Township [4,NW] (SA-14)

This site is located in Sandusky Bay on Squaw Island's highest point. It was reported by David Stothers of the University of Toledo and collected by John Kinn, Fostoria, Ohio. The pottery collection is in the possession of the Ohio Historical Society.

Village Site and Burials: Margaretta Township [9,E] (E-47)

This site is located between Castalia and Sandusky on the south side of Castalia Road.

Williams Mound: Vicinity of Fremont [9,W] (SA-12)

This mound is located on the Sandusky River 2 miles from Groghansville near Fremont. The mound is 50 feet in diameter and 8-foot high and was excavated by John Shannon and his brother about 1840.

2.3.3.3 Archaeological Landmarks Located Within 10 and 20 Miles of the Site

Bluff Site: Vicinity of Huron [20,E] (E-37)

This Indian site near Huron was excavated by A. G. Smith.

Bogart Burial Site: Fremont [11,WSW] (SA-13)

This site is located at 2426 North River Road, Fremont. It was uncovered during plowing, collected, and brought to the Ohio Historical Society Museum by Bruce R. Baby and Beverly Mosley, 1972.

Bores Site: Vicinity of Norwalk [20,SE] (H-17)

This is the site of a gravel pit located approximately 3 miles southwest of Norwalk.

Burial Sites: Bloomingville [12,ESE] (E-46)

These sites are located 2-1/2 miles south of Bloomingville.

Erie Earthworks: Kelleys Island [17,NE] (E-25)

Located on the southcentral shore of Kelleys Island about 200 feet east of Inscription Rock are irregular, crescent-shaped earthworks enclosing an Erie Village site.

Esch Mounds Land 2: Vicinity of Huron [20,E] (E-28)

The Esch Mounds on the Huron River 2-1/2 miles south-southwest of Huron have been partially excavated by Boy Scouts and again by Grunman in 1930. The Ohio Historical Society has his unpublished field notes.

Heckleman Site: West of Milan [18,ESE] (E-38)

This archaeological site is located 1-1/2 miles west of Milan on the Huron River.

Heimberger Village Site: Vicinity of Huron [20,E] (E-29)

The Heimberger Village Site on the Huron River 2-1/2 miles south-southwest of Huron and south of Esch Mounds was excavated by Grunman in 1930. The Ohio Historical Society has his unpublished field notes.

Herner Site: Lyme Township [14,SE] (H-18)

This is a glacial kame near Sand Hill Road. Salvage work has been done at this archaeological site.

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

Inscription Rock State Memorial: Kelleys 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] (O-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.

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] (O-29)

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 3-1/2 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 nine mounds, triangular earthworks, and two 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 1-1/2 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, 1-1/2 miles west of Milan, was surveyed by Dr. Raymond Baby in 1966.

South Bass Island Site No. 1: Vicinity of Put-in-Bay [16,NNE] (O-15)

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

South Bass Island Site No. 2: Vicinity of Put-in-Bay [16,NNE] (O-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 3-1/2 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.

2.3.3.4 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)

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.

2.3.3.5 Selected Archaeological Landmarks Located Within 30 and 45 Miles of the Site

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

These excavations have been conducted by the University of Toledo.

2.4 GEOLOGY

The following discussion has been abstracted from a Master of Science thesis by Palombo (1974) in which details and substantiations may be found.

The Site is located within the Lake Plains section of the Central Lowlands. The area has very little relief and slopes toward Sandusky Bay at about ten feet per mile. As indicated in Figure 2.4.1 the thickness of unconsolidated deposits on the Site ranges from 60 feet to at least 80 feet. The thickest deposits are centered around the Bayshore area where there exists a buried valley (Figure 2.4.2). This valley can also be detected from photo interpretation as analyzed by Beimel and Lloyd (1974). Overlying the bedrock in this valley there are about 10-15 feet of sand and gravel deposits. Lying on these deposits in the valley and above the bedrock in the rest of the area is about 40 feet of glacial till. The till is generally compact and calcareous and is dominantly composed of clay and silt with a small amount of sand and gravel (Forsyth, 1973). Some wells in the Site area have indicated a layer of broken rock at the base of the till and at the top of the bedrock. This zone, usually five feet thick, probably has been caused by the periglacial climate which had existed several times during the Pleistocene (Forsyth, 1973).

Overlying the till is about 20 feet of glaciolacustrine clay and silt. This is the surficial material on the Site and is exposed on the 5-8 feet bluffs along the shore. Analysis of aerial photographs shows vertical slopes along the shoreline, indicative of silt soil with low cohesion (Beimel and Lloyd, 1974). Since the Site surface soils consists predominantly of silts and also because of the flatness of the area, the land is poorly drained. Developed on this material, is the Toledo silty clay soil (Redmond et al, 1971). This dark gray soil, characterized by its poor drainage, has a plastic nature and is limited, therefore, in its foundational capacity. Also this material granulates and cracks, thus making it extremely susceptible to wave erosion and frost action as well as rain wash (Forsyth, 1973).

The bedrock, subcropping beneath the till within the Site, is of Silurian age and has been called the Monroe Formation by Stout (1941), the Tymochtee Dolmite by Forsyth (1973), and the Salina Group by Ulteig (1964). The latter term has been used since it has recently been discussed in log descriptions by the Ohio Department of Natural Resources, Division of the

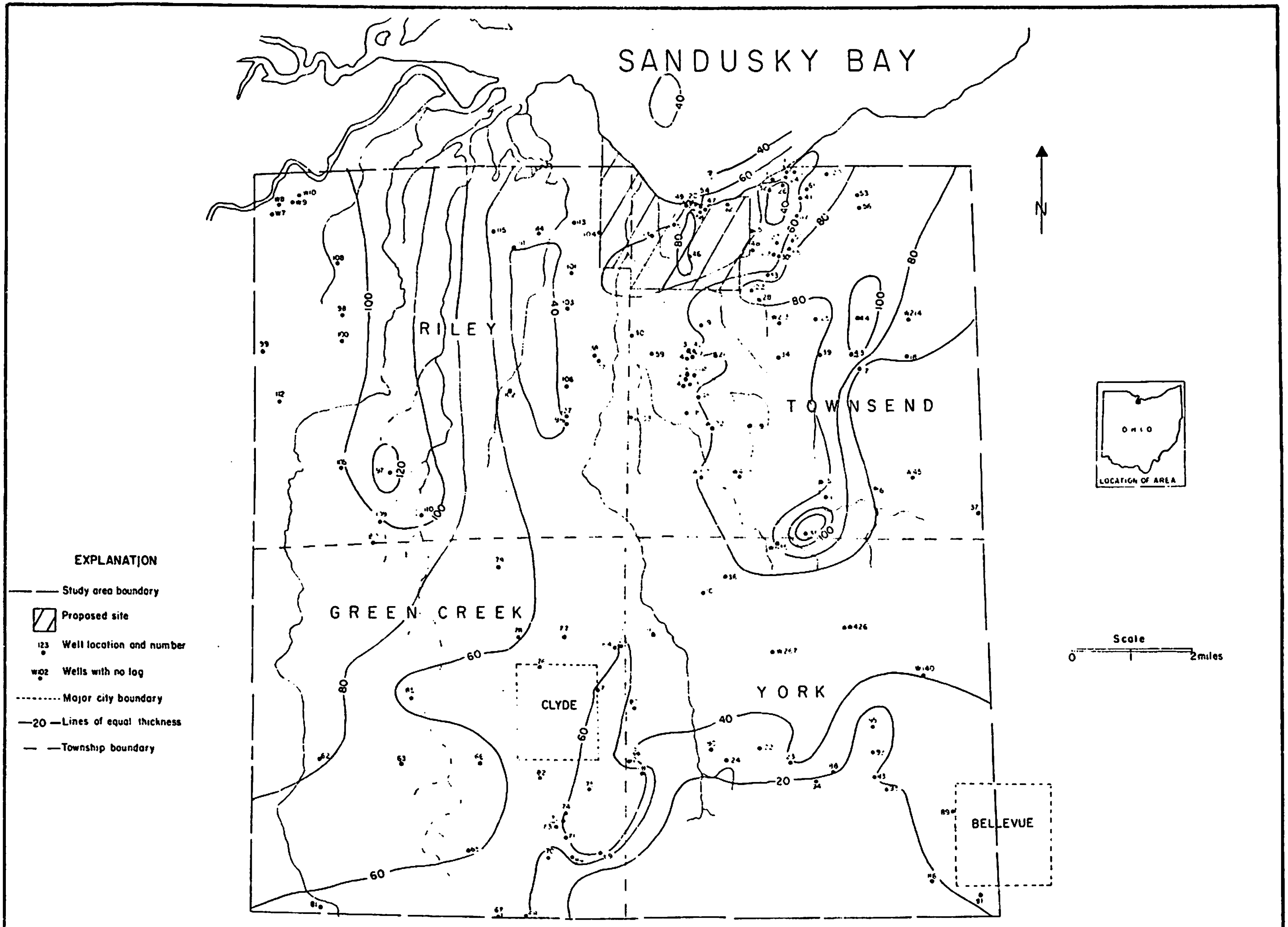


FIGURE 2.4.1. THICKNESS OF UNCONSOLIDATED MATERIALS OF THE STUDY AREA

Contour interval 20 feet.

Geological Survey. Due to the lack of detailed drillers' logs on the Site, it is not known exactly which unit of the Salina subcrops on the Site. However, a cross-section between a well in southern Townsend Township and one in Ottawa County, indicates that the F-unit or G-unit may be the uppermost bedrock at Bayshore (Figure 2.4.3).

A generalized columnar section and a map of the bedrock geology is shown in Figure 2.4.4. Whatever term is given to the rocks, the rock is an argillaceous dolomite with interbeddings of anhydrite. A mineral and oxide analysis of the bedrock from a sample in Section 14 of Ballville Township is given in Table 2.4.1. Stout (1941) has assumed that this type of rock is the uppermost bedrock in Townsend Township. Due to the relatively high solubility of this carbonitic rock, it is possible that sinkholes could have developed in the area of the Site. However, color aerial photography has picked up only small circular depressions which may or may not be due to solution of bedrock (Figure 2.4.5).

Structurally, the Site lies on the eastern flank of the Findlay Arch where the rocks dip eastward at the rate of 10 to 15 feet per mile into the Appalachian Basin. Because there have been no earthquakes recorded in this area, this structural feature is considered to be stable (Pawlowicz, 1973). Beimel and Lloyd (1974) have identified a possible fault lying about 15 miles southeast of the Site from ERTS images. This fault or fracture trace is distant enough to be of no concern.

The major active erosional processes on the Site are operating along the shoreline of Sandusky Bay. These include wave and storm effects, groundwater seepage, frost and ice action and bay water levels. Several erosion studies have been conducted along the shoreline of the bay. Those by Leverett (1931), Hyland (1959), Gutenberg (1933) and Shaffer (1951), have determined that the shoreline along the Site area has been retreating at the rate of five to nine feet per year over the past 125 years, and should continue at this rate if left unprotected. Erosion occurs most rapidly when the bay level is highest and when storm wind driven waves strike the easily erodable silty bluffs.

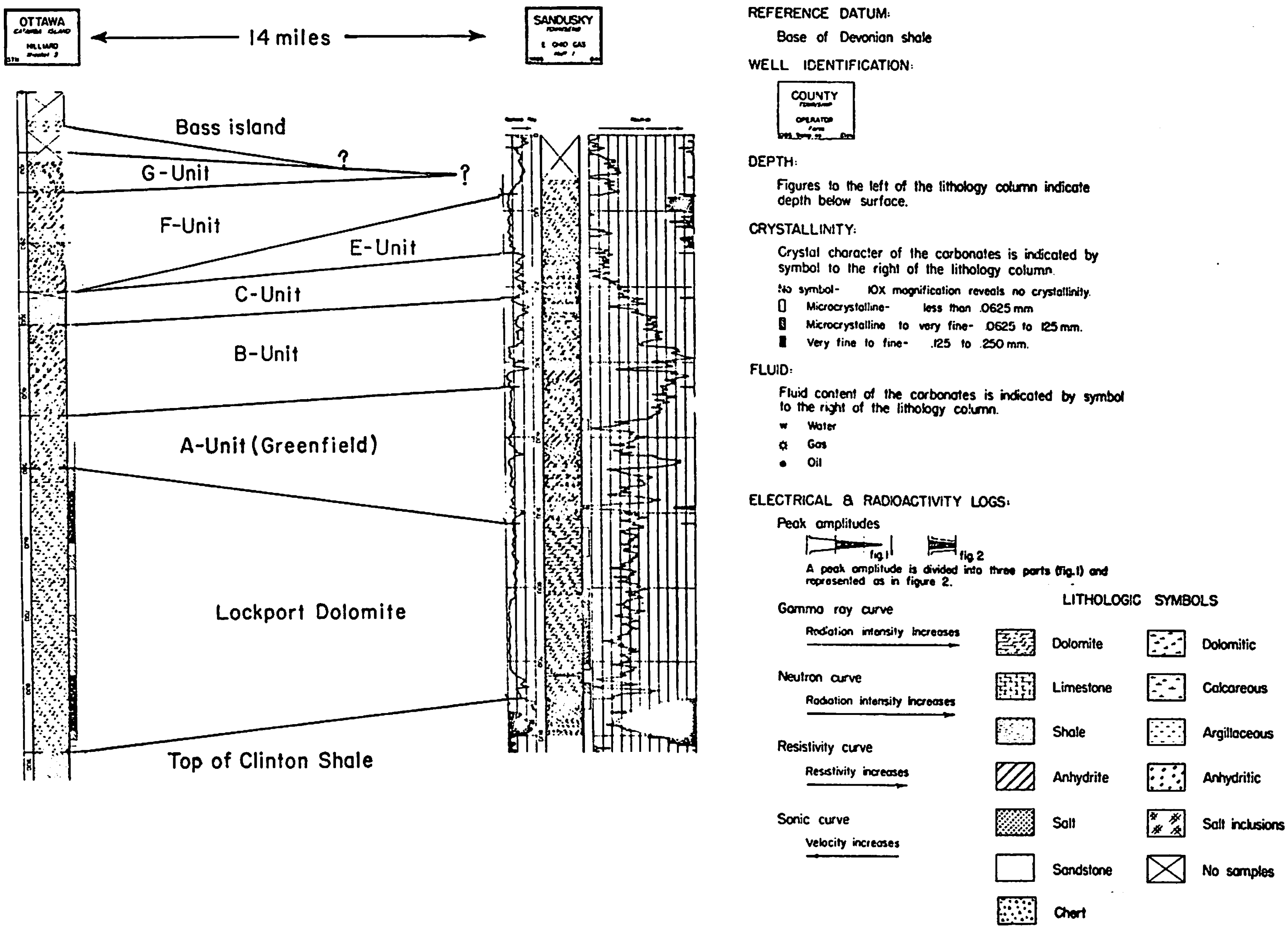


FIGURE 2.4.3 GEOLOGIC SECTION BETWEEN OTTAWA AND SANDUSKY COS., OHIO. LOGS FROM ULTEIG (1964).

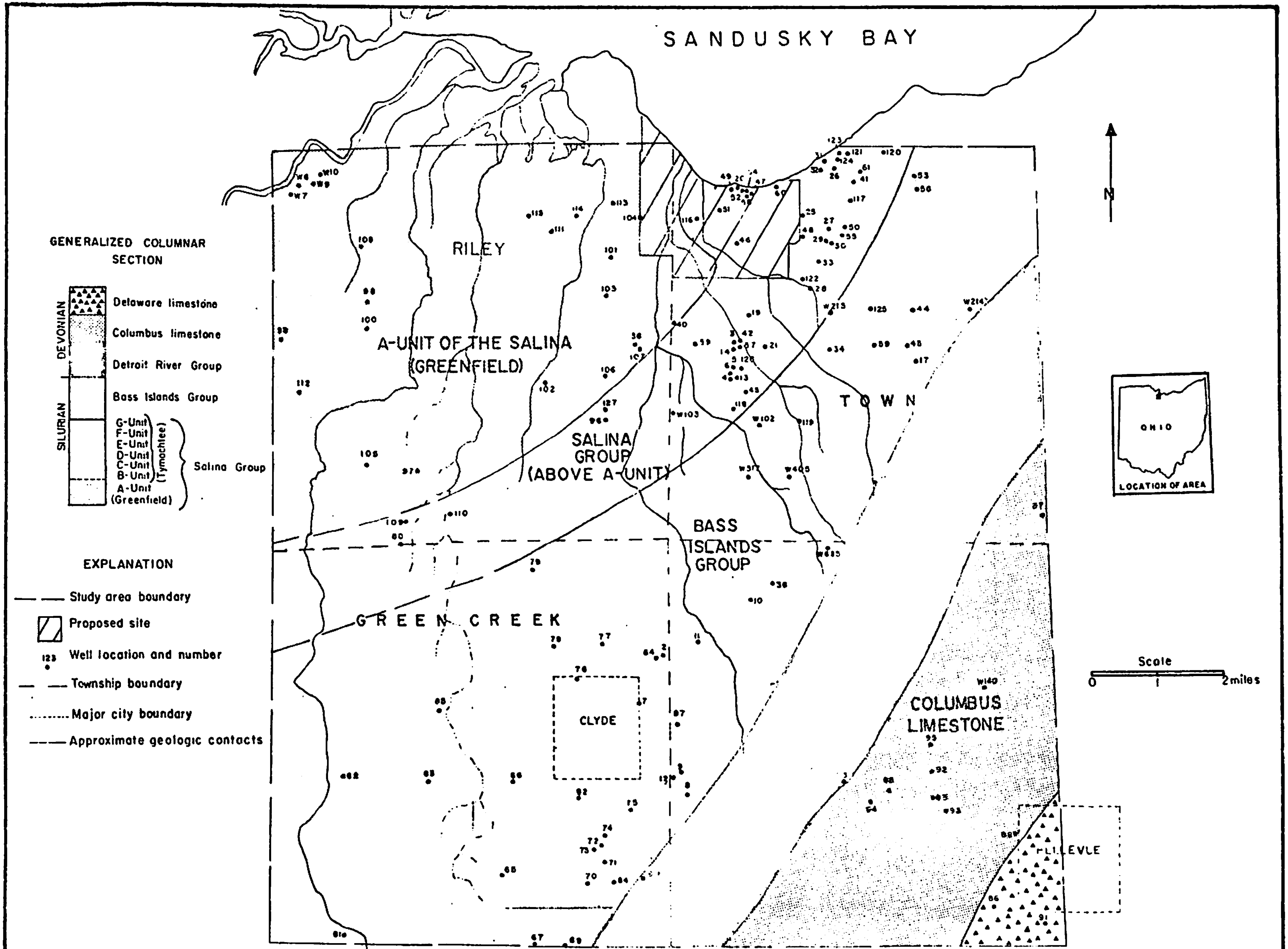


FIGURE 2.4.4. BEDROCK GEOLOGY OF THE STUDY AREA

Adapted from Herdendorf (1973).

TABLE 2.4.1. MONROE FORMATION, STOUT (1941)*

Oxide	Percentage, by weight
Silica (SiO_2)	0.34
Alumina (AL_2O_3)	0.05
Ferric Oxide (Fe_2O_3)	0.04
Ferrous Oxide (FeO)	0.14
Pyrite (FeS_2)	Less than 0.01
Magnesium Oxide (MgO)	20.32
Calcium Oxide (CaO)	28.28
Strontium Oxide (SrO)	3.56
Barium Oxide (BaO)	Less than 0.01
Sodium Oxide (Na_2O)	Less than 0.01
Potassium Oxide (K_2O)	Less than 0.01
Water (H_2O)	0.07
Carbon Dioxide (CO_2)	44.43
Sulphur Trioxide (SO_3)	2.80
Carbon (C)	0.07

Mineral Composition

Mineral	Percentage, by weight
Sericite	0.00
Kaolinite	0.13
Quartz	0.28
Limonite	0.05
Pyrite	0.00
Celestite	6.31
Anhydrite	0.09
Dolomite	92.90
Hydrocarbons	0.07
Water	0.07

* According to Stout (1941), the bedrock beneath most of York, Riley, Townsend, and Green Creek Townships of Sandusky County, is the Monroe Formation. The above sample from the Monroe was taken near a bridge over the Sandusky River in the central part of Section 17, Ballville Township, Sandusky County. This sample was taken in 1938 by Stout from the bend of the river at this point.

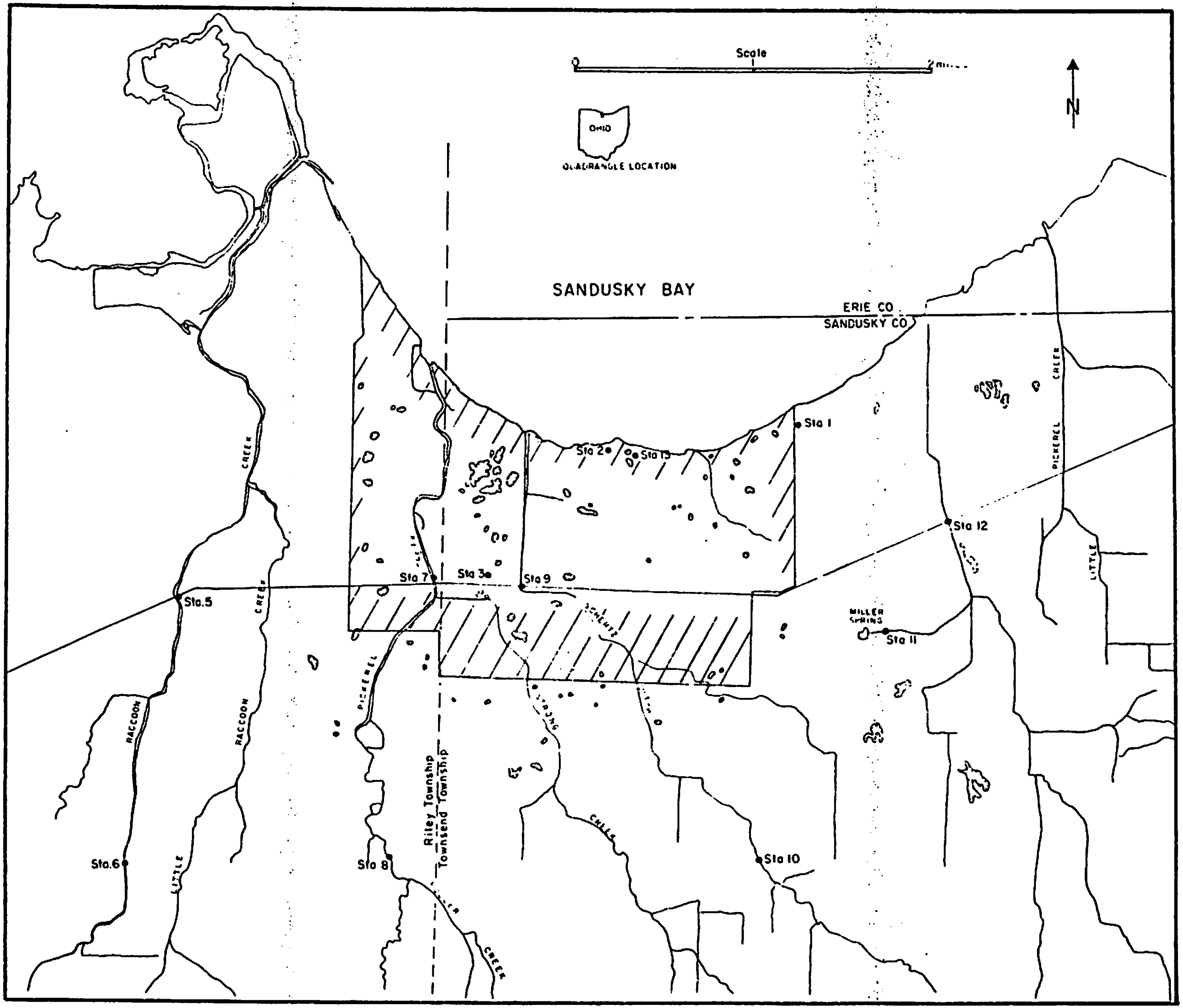


FIGURE 2.4.5. LOCATION OF MONITORING STATIONS AND DEPRESSIONS IN THE PROPOSED SITE AREA

Vickery 7.5 minute quadrangle, U.S.G.S. 1957.

2.5 HYDROLOGY

2.5.1 SURFACE WATERS

2.5.1.1 Streams

On the Site and nearby environs, there are four streams that have been studied. Two on the Site are Pickerel Creek and Scherz Ditch, two off the Site are Raccoon Creek to the west and Millers Spring Creek to the east. Each stream has two monitoring stations on it. At all monitoring points, data are collected on stage, surface velocity, and temperature. Measurements are taken daily at the on-Site streams and weekly on the off-Site ones. Stream cross sections were made for the monitoring stations so that flow rates can be computed from the stage and velocity, corrected by a coefficient established by Ricca (1974) to represent the average value through the section. These data have been collected starting September 2, 1973, been reduced up through April, and are continuing. The streams and their monitoring points are shown in Figure 2.4.5 .

Discharge data on the Sandusky River, which is monitored by the U.S.G.S. at Fremont, have been included for the study period. These data are not yet published but have been obtained from the raw records of the U.S.G.S. (Gravelly, 1974).

Raccoon Creek

This creek lies about 1 mine west of the Site and flows north, discharging into Sandusky Bay. This creek is in its natural state and no evidence of channelization can be found. Monitoring stations Number 5 and 6 are on the Raccoon Creek about 1-1/2 miles apart. The maximum discharge observed in this program was 427 cubic feet per second and the minimum was zero. The maximum recorded water temperature was 76 F in September and the minimum was 32 F in December. Values for extremes, averages, etc. for these parameters throughout the study period are listed in Tables 2.5.1 and 2.5.2 below.

Table 2.5.1 Summary of Streamflows
(Data from September, 1973 through April, 1974)

Stream Name	Raccoon Creek		Pickerel Creek		Scherz Ditch		Millers Spring Stream		Sandusky River[3]
Monitoring Stations	5	6	7	8	9	10	11	12	Fremont
Maximum flow (cfs)	427.	NCS[1]	391.	NCS	99.	NCS	NCS	NCS	17400.
Minimum flow (cfs)	0.0	NCS	-67.[2]	NCS	-9.	NCS	NCS	NCS	54.
Mean Monthly flows (cfs)									
September, 1973	0.54	NCS	5.55	NCS	2.24	NCS	NCS	NCS	66.
October	0.97	NCS	7.57	NCS	2.18	NCS	NCS	NCS	116.
November	4.49	NCS	9.94	NCS	2.07	NCS	NCS	NCS	400.
December	3.13	NCS	21.32	NCS	5.45	NCS	NCS	NCS	2500.
January, 1974	166.63	NCS	96.19	NCS	22.47	NCS	NCS	NCS	7080.
February	6.55	NCS	38.59	NCS	11.19	NCS	NCS	NCS	1800.
March	35.05	NCS	46.02	NCS	12.01	NCS	NCS	NCS	3040.
April	7.16	NCS	30.03	NCS	9.44	NCS	NCS	NCS	2020.

1000 gpm

1 NCS means no cross-section (Those have been surveyed, 5/74, but no information available yet), therefore, no value for flow can be given

2. Negative sign indicaters backflow into stream from high bay level (Seiche or wind)

3 Provisional data obtained from raw data files of U.S.G.S.

Table — (Data from September, 1973 through April, ...

Stream Name	Raccoon Creek		Pickerel Creek		Scherz Ditch		Millers Spring Stream		Sandusky River[2]
Monitoring Station	5	6	7	8	9	10	11	12	Fremont
Maximum Temperature (°F)	76.	74.	82.	66.	83.	79.	65.	68.	80.
Minimum Temperature (°F)	32.	32.	32.	32.	32.	30.[1]	41.	35.	33.
Mean Temperature (°F)	48.	47.5	50.2	46.5	51.5	47.5	50.7	49.2	49.
Mean Monthly Temperatures (°F)									
September, 1973	67.2	65.4	68.7	60.6	71.4	69.1	57.2	61.8	72.
October	56.5	54.3	58.9	56.4	61.8	60.1	53.0	57.0	62.
November	43.8	44.0	45.8	47.9	45.5	45.3	48.5	47.5	46.
December	35.2	35.0	37.4	39.0	37.5	35.5	46.8	42.8	37.
January, 1974	39.0	39.0	39.4	37.1	40.1	36.1	47.0	41.0	37.
February	34.7	35.0	36.5	35.8	38.6	35.0	46.5	39.0	36.
March	44.2	44.6	41.9	42.7	42.5	43.4	50.5	47.2	
April	57.3	57.0	53.2	53.5	54.1	57.4	54.5	56.5	56.

1 Data shows water temperature of 30° on 12/18/73.

2 Provisional data obtained from U.S.G.S. raw records.

Pickerel Creek

This creek is on the Site near its west boundary and flows north discharging into Sandusky Bay. It is channelized for about half its length, most of the channelized portion being on the Site. Towards its mouth, the stream meanders through an area of manmade lagoons. Monitoring stations Numbers 7 and 8 are located on Pickerel Creek about 1-1/2 miles apart. The discharge extremes for the study period ranged from a high of 391 cfs to -20 crs. this negative flow indicating a backflow from the bay due to seiche and wind action. However, backflow conditions are infrequent. The maximum recorded water temperature was 82 F in September and the minimum was 32 F in December. Other values for flows and temperatures are given in Tables 2.5.1 and 2.5.2.

Scherz Ditch

It flows through the southern and central portions of the Site and discharges into Sandusky Bay. It is highly channelized and partially lined throughout to promote drainage for more intensive use of the adjacent farmlands. Monitoring Stations 9 and 10 are about 2 miles apart on Scherz Ditch. The maximum discharge measured during this study was 99 cfs and the minimum -9 cfs, coincident with the backflow observed in Pickerel Creek. Temperature variations were from a maximum of 83 F in September to a low of 32 F in December. Complete parameter values are shown in Tables 2.5.1 and 2.5.2.

Millers Spring Stream

This stream originates at the Millers Blue Hole about 1/2-mile west of the southwest corner of the Site. The stream flows westerly, then north before discharging into Sandusky Bay. It is fed by an artesian aquifer which underlies the entire region (See Section 2.4). The stream is highly channelized, except for the portion near its source, to promote better drainage in the surrounding farmlands. The discharge from the spring is fairly steady at about 2.3 cfs (1000 gpm) [in addition to this monitoring program, Eagon (1968) also found this flow value]. The above flow rates are from weirs located in the stream at the spring hole. Stations 11 and 12 about 3/4 mile apart are in the spring stream as it flows towards the bay. The discharges at these points are fairly constant throughout the year as would be expected since these waters originate at the fairly constant (2.3 cfs) flowing spring. The spring discharge temperatures follow those of the other groundwater discharges discussed later (ranging from highs in the fifties Fahrenheit in September to lows in the forties in April). The spring stream responds more to the seasonal air temperatures with greater variabilities showing at the monitoring Station 12 furthest from the spring hole. The temperature extremes here are 68 F maximum in September to 35 F minimum in February.

Sandusky River

The Sandusky River Basin is about 12.51 square miles lying to the west of the Site, and is the major inflow into the western Sandusky Bay. The gaging station is about 22 miles from the Site at Fremont, Ohio, and is monitored by the U. S. Geologic Survey. Since the records for the study period, September 2, 1973, to date, are not yet published, they were obtained as provisional data from the raw records file at the U.S.G.S., Columbus, Ohio, Office from Gravelly (1974). The maximum discharge measured during the study period was 17,400 cfs and the minimum was 54 cfs. Temperatures varies from a high of 80 F in September to a low of 33 F in December and February. Complete parameter values are shown in Tables 2.5.1 and 2.5.2.

2.5.1.2 Western Sandusky Bay

Since the Site fronts on the southern shore of the western basin of Sandusky Bay, its hydrology has been studied in depth. Attention is focused herein on the hydrology of the entire western portion of Sandusky Bay (i.e., that part to the west of the Thomas A. Edison bay crossing bridge). Expanded discussions on the following subject matter can be found in the Master of Science Thesis by Lloyd (1974).

Surface Water Characteristics

The Sandusky River accounts for the majority of the runoff entering western Sandusky Bay. Long-term flow records (1923 to 35, 37 to 1972) are published for a gaging station located at Fremont, Ohio, about 10 miles upstream from the river mouth at the bay. The drainage area above the gaging station is 1,251 square miles. This accounts for about 85 percent of the total drainage area of the western Sandusky Bay according to U. S. Department of the Interior (1972).

Flow measurements have been taken on the lesser streams in the contributing watershed. Muddy Creek and Green Creek have occasional data, while Raccoon Creek, Pickerel Creek, and Scherz Ditch have consistently recorded data collected since September, 1973 (See previous discussion in this Section for their flows). Generally, the average discharge per unit area of all these streams is similar, running at about 0.45 mgd/sq mi according to the Ohio Department of Natural Resources (1966). The average discharge of the Sandusky River above Fremont is 0.46 mgd/sq mi. As can be expected during flood and drought periods, the flows of this major contributor, the Sandusky River, dominate the situation. However, during droughts the unit (mgd/sq mi) contribution of the lesser streams with their watersheds adjacent to the western bay is higher due to their sustained base flows from the underlying artesian aquifer. However, their flow contribution is still negligible during drought periods and the drought flows can be taken as that of the Sandusky River alone. Flood discharges into the western basin of Sandusky Bay are likewise dominated by those of the Sandusky River. Table 2.5.3 summarized the above discussion.

Since the western Sandusky Bay inflows are due primarily to the Sandusky River discharges under all conditions, a statistical analysis on these discharges was assumed to apply to the majority of inflows into the western basin of Sandusky Bay.

The distribution of daily flows to western Sandusky Bay is shown on the cumulative frequency curve of Figure 2.5.1.

Using the U.S.G.S. records (1923-72), U. S. Department of the Interior (1972), the average discharge of the Sandusky River into the western Sandusky Bay was computed by Lloyd (1974) to be 920 cfs (600 MGD). The daily flow exceeds this average value only 15 percent of the time as can be read from Figure 2.5.1. The maximum flow on record into the bay occurred on January 15, 1930, and was measured at 27,300 cfs (17,610 MGD). However, the Ohio Department of Natural Resources (1966) reports that the Scioto-Sandusky Conservancy District has estimated (no details) the 1913 flood as having a discharge of approximately 65,000 cfs (41,935 MGD). Since this flow was not officially gaged by the U. S. Geological Survey (U.S.G.S.) and has not, therefore, been recorded, it has not been used within the statistical analyses of the Sandusky River discharges. The minimum recorded runoff cccurred on October 20-21, 1963, and was measured at 5.0 cfs (3.2 MGD).

Table 2.5.3.- Flow Characteristics for Streams Discharging into Western Sandusky Bay

Stream and Gaging Point	Drainage Area sq. mi.	Average Flow mgd	Average Flow mdg/sq. mi	Median Flow[1] mgd	Median Flow[1] mgd/sq. mi.	Low Flow[2] mgd	Low Flow[2] mgd/sq. mi
Muddy Creek near Kingsway	66.7	31.7	0.4785	4.22	0.063	0.027	0.004
Green Creek near mouth	81.5	34.1	0.419	13.6	0.168	9.55	0.117
Pickerel Creek near Vickery	21.4	8.98	0.420	3.32	0.155	1.69	0.079
Sandusky River near Fremont	1251.0	600	0.460	131	0.105	20.4	0.016

[1] flow equalled or exceeded 50 percent of time

[2] flow equalled or exceeded 90 percent of time

Values are taken from Ohio Department of Natural Resources (1966).

TABLE 2.5.3. (Continued)

Flood Flow by Various Distribution (cfs)

Return Periods (T_r) (years)	CDF Plot	Normal	Pearson Type III	Log Pearson III	Gumbel	Log Gumbel
5	17,200	18,000	18,000	18,600	17,300	17,200
10	20,000	20,400	20,000	20,000	20,300	20,000
25	24,000	22,800	22,800	20,800	24,000	23,700
50	27,200	24,400	24,400	21,100	27,000	26,900
100	30,100	25,800	25,800	21,400	29,600	29,900
150	31,600	26,400	26,400	21,500	31,200	---[1]
200	32,800	27,100	27,100	21,700	32,400	---[1]
500	36,000	28,600	28,600	22,000	---[1]	---[1]

1. exceeded maximum return period of graph.

TABLE 2.5.3. (Continued)

Return Periods (Tr) (years)	Drought Flow by Various Distributions (cfs) CDF Plot	Pearson Type III	Log Pearson III	Log Gumbel
5	14.5	15.5	14.9	15.0
10	11.3	14.1	11.9	11.0
25	8.0	13.6	9.6	8.0
50	7.0	13.1	8.4	6.5
100	6.1	13.0	7.4	5.4
150	6.0	12.9	7.1	---*
200	6.8	12.7	6.8	---*
500	4.4	---	6.1	---*

*exceeded maximum graph return period

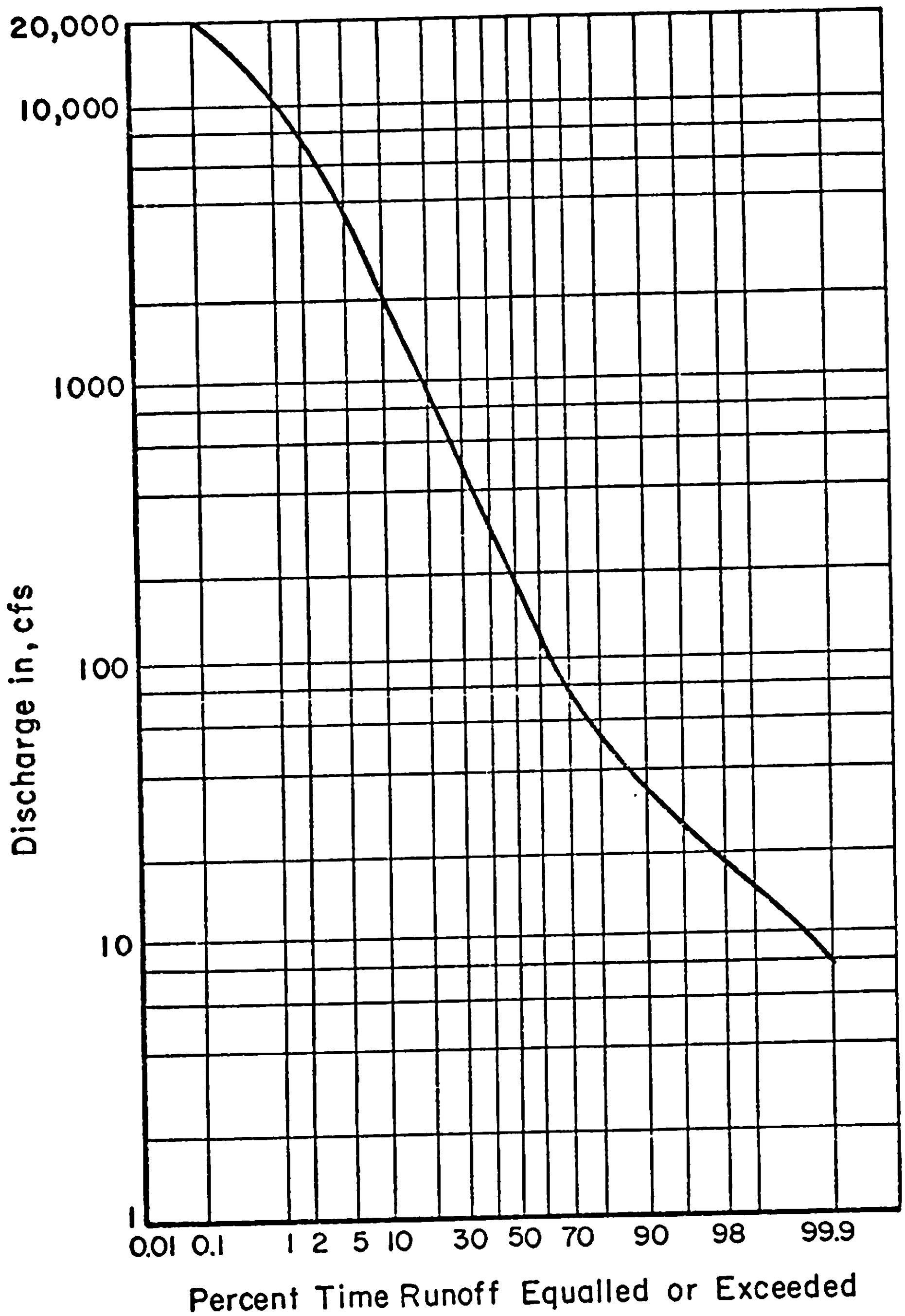


FIGURE 2.5.1. FLOW-DURATION CURVE FOR TOTAL RUNOFF ENTERING WESTERN SANDUSKY BAY (1023-35, 1937-72) Constructed by Lloyd (1974),

The driest quarter of the year for this watershed is stated in the ..se I Report by Battelle (1973) as approximately August 16 through ..vember 15. During the years 1961-1964, the average runoff was 22.6 cfs ..6 mgd). However, this period coincided with the severe droughts in the ..ast Coast and was drier than normal. Normal runoff for this period appears ..o be closer to 32.3 cfs (20.8 mgd). The wettest period of the year ..usually occurs between January 15 and March 15 as substantiated by the U.S.G.S.' long-term records. Lloyd (1974) found that approximately 80 percent of the maximum annual flows occurred during this period.

Flood Flow Analyses of the Sandusky River

Using the recorded flow on the Sandusky River (1923-1972), several annual series flood analyses were made by Lloyd (1974). The flood flow distributions as presented by Chow (1964) investigated were: Normal, Pearson Type III, Log Pearson III, Gumbel, and Log Gumbel. Initial results obtained by these various distributions are shown in Table 2.5.3 as assigned return period and corresponding flood flow. The studies were done by using both mathematical and graphical fits.

To substantiate the findings from the distributions tested, a cumulative distribution frequency (CDF) curve, by Kimball Method as described by Chow (1964), for the maximum annual peak flows of the study record was made and is shown in Figure 2.5.2. Extrapolation of this CDF curve for flows greater than 27,300 cfs will give a percent frequency representing a magnitude of flood flow which is equal to or greater than the given flood. The corresponding return period (T_r in years) for this given flood flow can be calculated as the reciprocal of the probability of exceedance ($T_r = 1/P_e$). Selected return periods calculated from exceedance probabilities taken from Figure 2.5.2 are included in Table 2.5.3 for judging and substantiating those values found from the above mentioned probability distributions applied to the record. The results obtained by all methods are in reasonable agreement. The CDF plot consistently overestimates the flows, but within acceptable bounds, for the higher return periods. A possible reason for this might be that the two recorded maximum flow readings were taken in the winter and could be subjected to error due to icing conditions at the gaging station as stated by U. S. Department of Interior (1972).

According to Benson (1968), Federal agencies concerned with computing flood flows are encouraged to use the Log Pearson Type III distribution in performing their statistical analysis, unless other methods or distributions

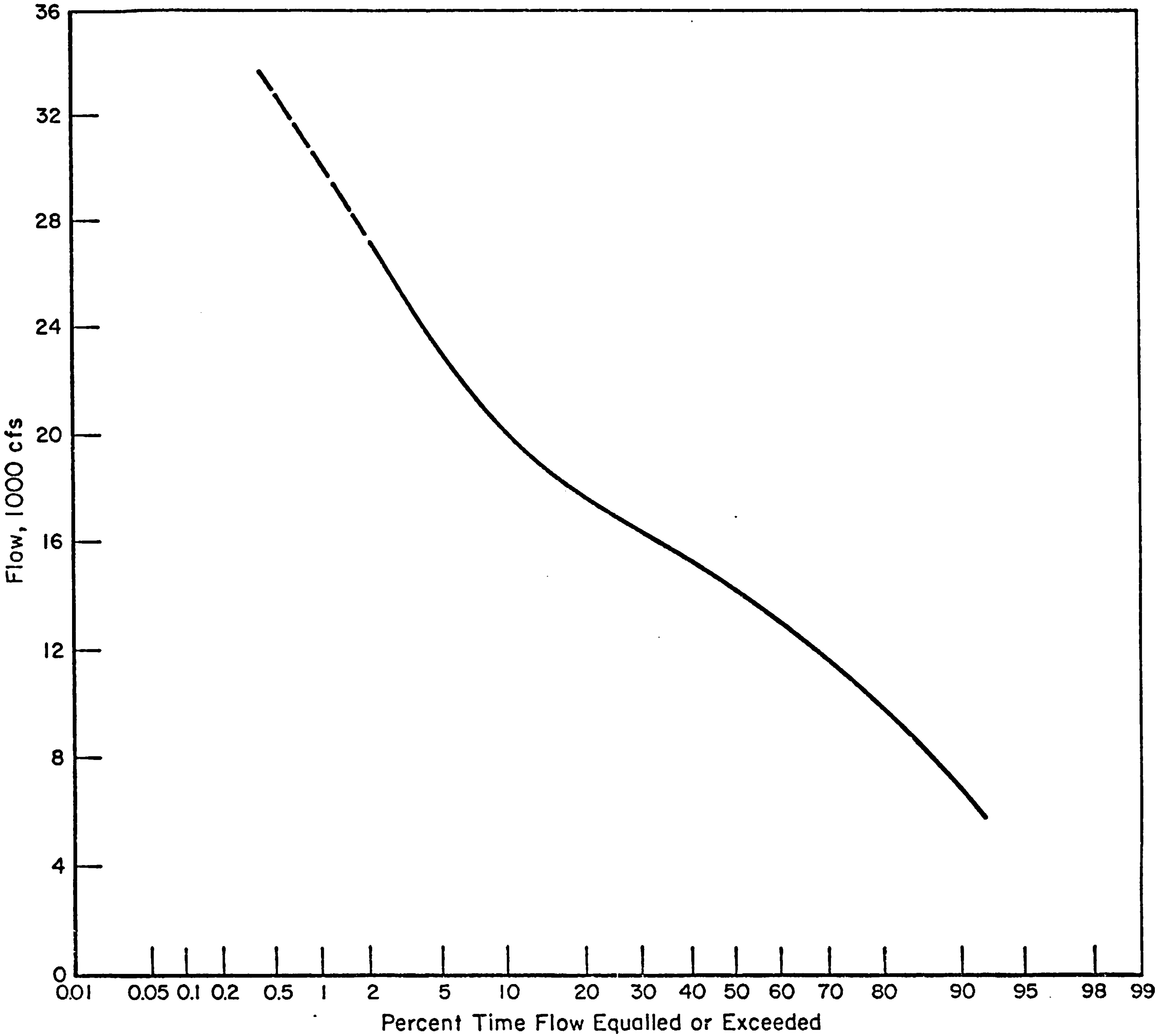


FIGURE 2.5.2. FLOW-DURATION CURVE FOR MAXIMUM ANNUAL FLOODS ENTERING WESTERN SANDUSKY BAY

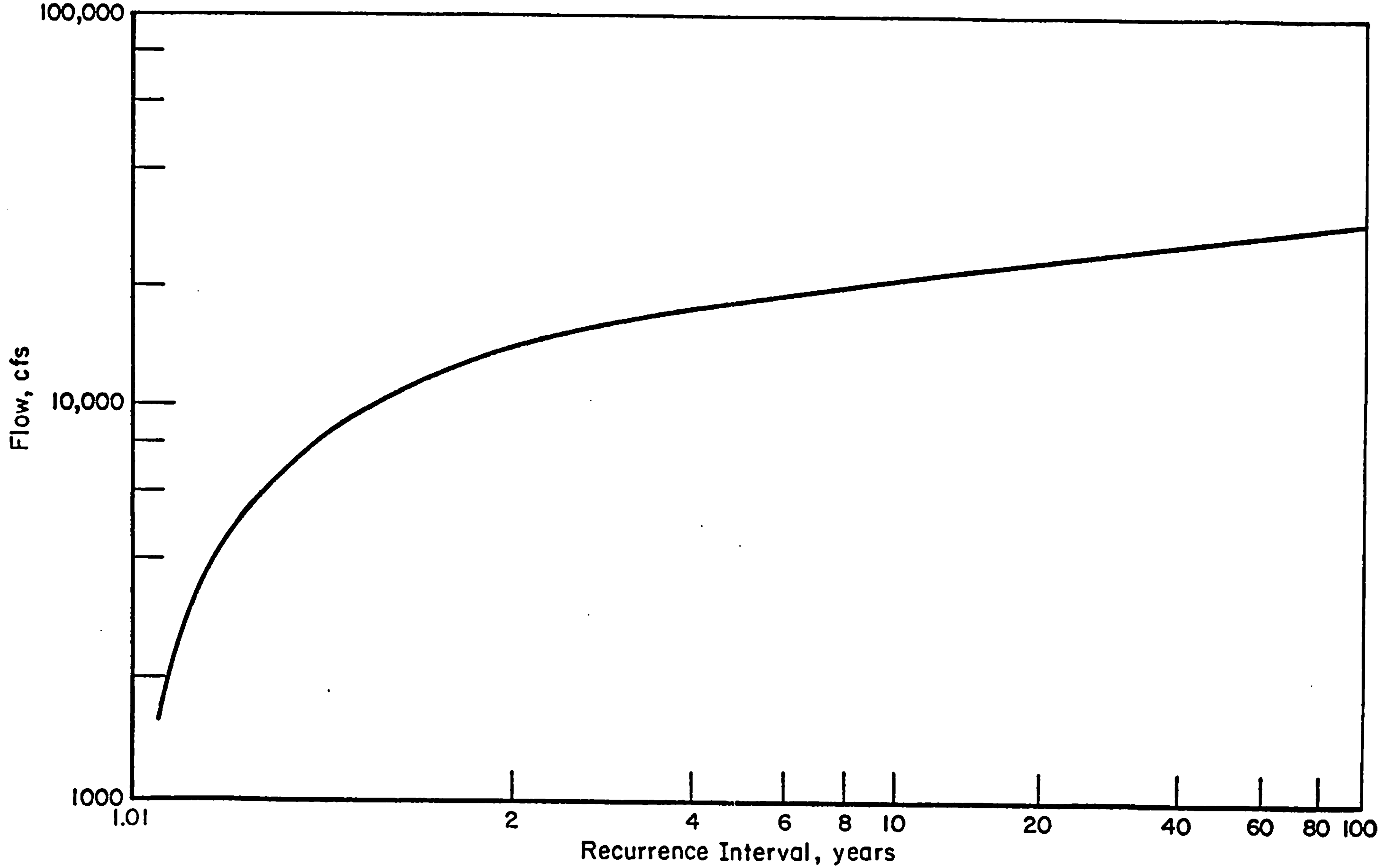


FIGURE 2.5.3. LOGARITHMIC GUMBEL (ACCORDING TO METHODOLOGY DESCRIBED BY CHOW, 1964) PLOT OF MAXIMUM ANNUAL FLOODS

can be justified as being more applicable to the situation in study. In this analysis, the justification for not using it is inherent in the discrepancy that it tends to underestimate flood flows at higher return periods more than do the other distribution methods or those of the standard value indicated by the CDF plot.

It is apparent from Table 2.5.3 that by using the Log Pearson Type III method, the maximum flood magnitude of a return period equal to 500 years is 22,000 cfs. However, this "500" year flow is equalled or exceeded 6.3 percent of the time in the actual record. Therefore, it is recommended that design flood flows be taken from any one of the methods except the Log Pearson III analysis. Again referring to Table 2.5.3, it is also apparent that the Normal and Pearson Type III methods of analyses produce almost identical results. This is due to the normal distribution of the flows. The skewness coefficient, C_s, is equal to -0.01 indicating very little skewed behavior. Therefore, for zero (negligible) skew, the Pearson Type III distribution will reduce to the Normal type as shown by Viessman (1972). Further details may be found in the work by Lloyd (1974).

To be on the conservative side (i.e., using the larger predicted flood flows for assigned return periods), we will adopt the Log Gumbel distribution applied to the records of flood flow. A plot of this distribution fit to the data is shown in Figure 2.5.3.

Drought Flow Analyses of the Sandusky River

An annual drought flow analysis has been performed using the hydrologic statistical analysis previously mentioned. In compliance with the regulation of the United States Atomic Energy Commission, the 7-day - 10-year low flow must be used when any surface water input to the system is being considered. As in the flood analysis, this study was based on the minimum "yearly" drought flows. For each year of record, the 7-day lowest flow period was found by determining the minimum yearly flow, then retaining both the preceding and following three days. Figure 2.5.4 shows the results obtained by ranking and plotting on probability paper the average 7-day low flows for all years of record. The average 7-day - 10-year low flow is 11.3 cfs which corresponds to the average 7-day low flow of 1955. Table 2.5.4 lists the data and sequence of flows as recorded for that year's drought period. As before, the various distributions (Normal, Pearson Type III, Log Pearson III, Gumbel and Log Gumbel) have been fitted with mathematical curves. Again, the drought flow ... calculated for a given magnitude of an average 7-day flow

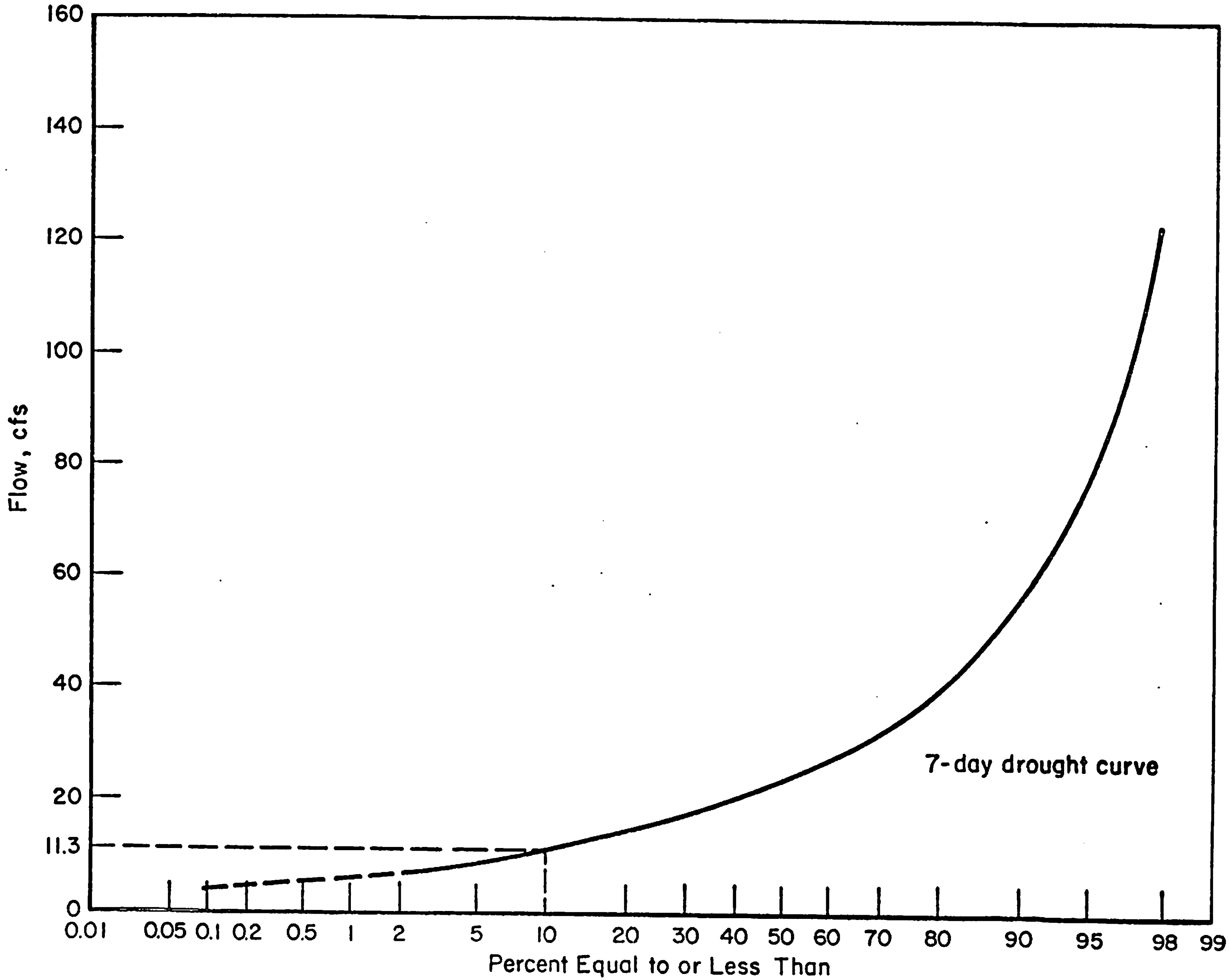


FIGURE 2.5.4. FLOW-DURATION CURVE FOR ANNUAL DROUGHT FLOWS ENTERING WESTERN SANDUSKY BAY

for any probability of drought flow exceedance. Table 2.5.4 shows the results of the study. Here again, selected return periods have been assigned and tabulated from

Table 2.5.4. The 7-Day Drought of 1955

Determined 7-Day - 10-Year Low Flow Sequence	
Date	Flow, cfs
September 17, 1955	13
September 18, 1955	11
September 19, 1955	11
September 20, 1955	10
September 21, 1955	10
September 22, 1955	11
September 23, 1955	13

Average 7-day - 10-year low flow = 11.3 cfs.

both the statistical distributions and the CDF (Cumulative Distribution Frequency) plot in order to provide a means for comparison and substantiation. Both the Normal and the Gumbel distribution produced a poor fit and hence they were excluded from further consideration. However, the two remaining distributions will work equally well to determine low flow recurrence intervals. The Log Gumbel distribution gives values which are somewhat low, i.e., conservative, and the Pearson Type III gives values which are somewhat high in comparison with the actual low drought flows from the CDF plot.

2.5.1.3 Flooding

Western Sandusky Bay Level Behavior

Since the Site fronts on the Sandusky Bay, the effects of high water levels and flooding have been considered. Also, since the power plant may withdraw bay water for cooling tower operations, the effect of low bay levels must be investigated. These conditions will be discussed below.

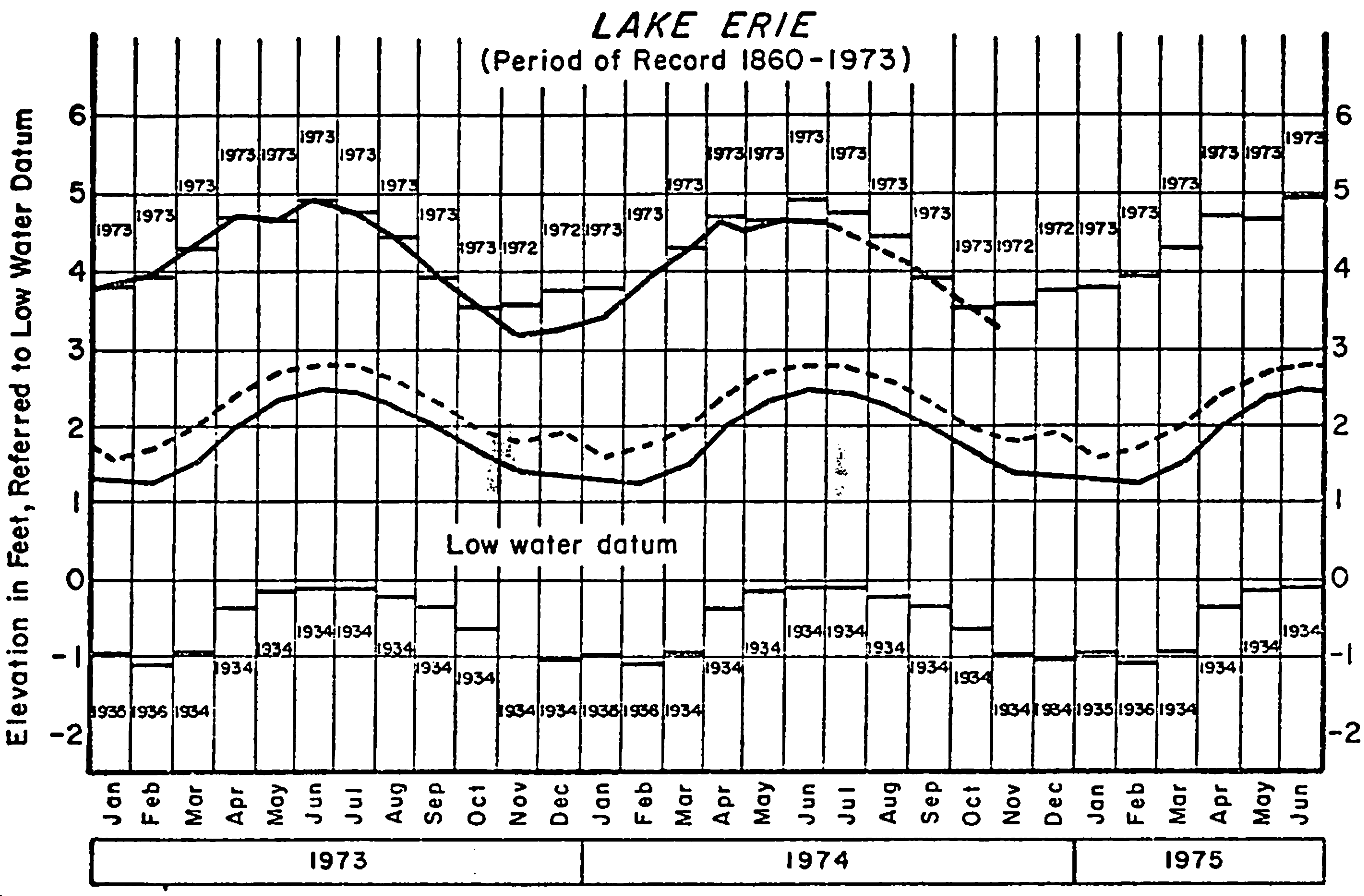
General Fluctuations in Bay Levels

Since the connecting opening between the eastern and western Bay (Thomas A. Edison bay crossing bridge) is quite large, it has been assumed that the level of Sandusky Bay's water surface varies as does Lake Erie's water surface elevation. Therefore, mean monthly Bay levels have been recorded by the U. S. Department of Commerce (1973). In a study by Lloyd (1974), he established that the long-term surface elevation records show two predominant cycles occurring simultaneously. The first cycle represents the seasonal variations of the Great Lakes Basin. Seasonally, the Bay level peaks in elevation during June-August with a relative frequency of 30 percent. Seasonal low Bay levels occur during January-February. The lag time which occurs between the wettest months of the Sandusky River Basin and the maximum Bay levels (June-August) is due to the storage capacity available within the Great Lakes which attenuates incoming flow magnitudes from the entire Great Lakes Basin. The second cycle which is particularly noticeable after 1900 is one of 10-15 year duration. This cycle varies the maximum and minimum Bay levels over a longer period of time while seasonal variations occur simultaneously. Figure 2.5.5 shows the extreme monthly conditions of Lake Erie for the long-term period (1860-1973) of record.

Lake Erie and, therefore, the Bay are presently on a "macro" cycle peak as well as being at its highest level (573.50 - United States Lake Survey) in 114 years of record. The lowest level of record occurred in February, 1936, and was recorded at 567.50 (USLS). Presently, the major portion of the Bay is 4-1/2 to 5 feet in depth (based on Low Water Datum). Lloyd (1974) estimates that swamps and/or marshes compose roughly 5 percent of the Bay's surface area and the surface area of the western Sandusky Bay, excluding Muddy Creek Bay, is 20 sq mi.

Basically, two problems of concern when considering bay level characteristics are:

(1) The possibility of flooding
(2) The possibility of high velocity reverse flow through the Thomas A. Edison bridge waterways, thus causing navigational hazards and structural damage due to excessive scour during periods of low bay depth, and also causing reduction in



The solid red lines of the graphs on this bulletin present the recorded monthly mean levels and the end-of-month levels of the current month. The dashed red lines present the probable end-of-month levels of MAY 1974 through OCTOBER 1974 , as furnished by the Detroit District, Corps of Engineers. The black lines present monthly mean average and extreme levels recorded during the periods of record. See legend below.

LEGEND

Recorded levels — Probable levels
Average levels (period of record) — Average levels (last 10 years)
Extreme high levels and year of occurrence (period of record)
Extreme low levels and year of occurrence (period of record)

APRIL 1974 WATER LEVELS

Lake	Referred to IGLD (1955)*	Referred to Low Water Datum**
Superior	600.51	+0.51
Michigan-Huron	580.28	+3.48
St. Clair	575.86	+4.16
Erie	573.20	+4.60
Ontario	246.49	+3.69

*International Great Lakes Datum (1955). Elevations are in feet above mean water level in Gulf of St. Lawrence at Father Point, Quebec.

**Elevations are in feet above (+) or below (-) Low Water Datum, the plane on each lake to which Lake Survey chart depths and Federal navigation improvement depths are referred.

FIGURE 2.5.5. EXTREME MONTHLY CONDITIONS OF LAKE ERIE

availability of cooling water dependent on specific types of intake structure used.

The following sections show the maximum or minimum boundaries of both problems, as well as providing explanations of the approaches used for the analysis of the situation.

Flooding Due to Stream Floods

To ascertain maximum expected water levels in the western Sandusky Bay, a combination of worst hydrologic conditions was analyzed. This situation was constructed by using a 50-year flood flow from the Sandusky River, plus flows from the lesser rivers discharging into the western Sandusky Bay, plus rainfall directly onto the bay and superimposing these inputs onto a high stage bay (highest stage on record) while assuming no major withdrawals from the system. This set of events is extremely conservative and may be considered as a worst case condition.

The above situation was hydraulically analyzed by considering the western Sandusky Bay as a reservoir and then routing the flood inputs through the bay pool using the hydraulics associated with the Thomas A. Edison pier openings as the outlet control. Details of the procedure follow:

Inflow Hydrographs. The design inflow hydrograph was taken as the worst flood flow in the records of the Sandusky River (see earlier discussion on Flood Flow Analyses of the Sandusky River). The particular flood flow used is that of January 15, 1930. Its compound hydrograph which includes a preceding flood flow is shown in Figure 2.5.6 as "Recorded Flood". It can be noted at this time that its peak flow is 27,300 cfs corresponding to a 50-year return period as shown in Table 2.5.3.

Local inflows from the lesser streams (Green Creek, Muddy Creek, Raccoon Creek, Pickerel Creek, and Schertz Ditch), as well as direct rainfall on the western bay were assumed to contribute (by area percentage) an additional 15 percent surcharge flow to this Sandusky River Flood hydrograph. By doing this, a Design Inflow Hydrograph for Q_{50} was made and is shown in Figure 2.5.6 as "Design Flow" Hydrograph. This "Design Flow" Hydrograph peaks at 32,400 cfs, which if we restricted our input to the Sandusky River alone (i.e., considered no rainfall on the western Sandusky Bay) would correspond

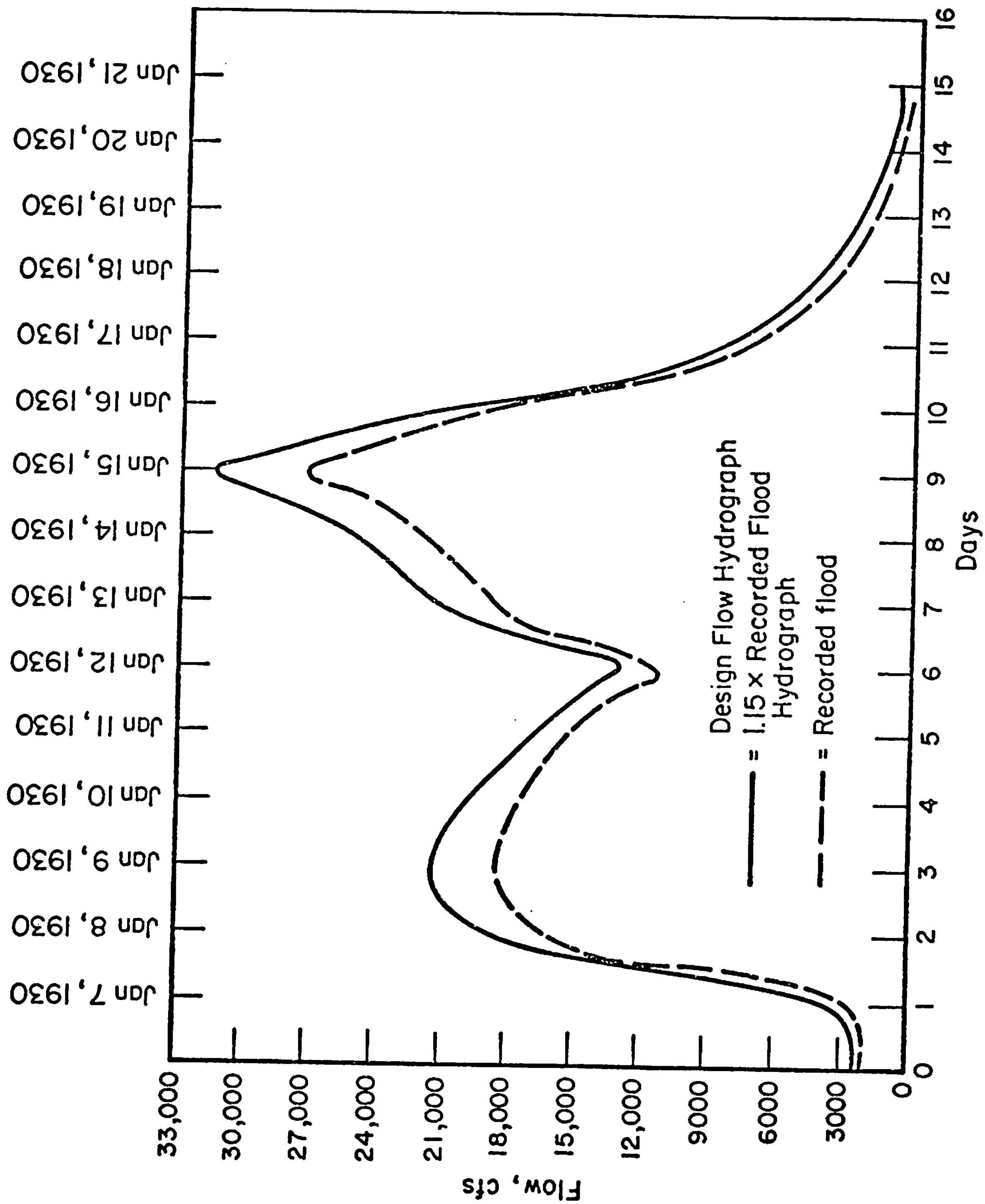


FIGURE 2.5.6. DESIGN FLOOD HYDROGRAPH (ACCOUNTS FOR ENTIRE FLOW)

to a flood in the Sandusky River Basin with well over a 100-year return period.

Bay Stage. The maximum recorded January Bay level from the 114-year (1860-1974) record of the U. S. Department of Commerce (1973) was 572.4 (USLS) occurring in 1973. This high stage also occurred within the same period for which the Sandusky River flow was recorded (1923-73).

Outlet Works. Hydraulic principles applied to the waterway openings in the Thomas A. Edison bay crossing bridge permitted a bay state versus flow discharge through the bridge piers to be computed. There are two other bridges further east of the inner Sandusky Bay which have comparable waterway openings. Therefore, the first bridge in the system was used to compute the outlet hydraulics. From the Ohio Department of Highways (1963) design plans, the bridge spans the bay on 7-foot diameter piers about 90-foot center apart given a total opening width of 1,773 feet. The water depth at the piers is about 11 feet during this situation. The discharge through these openings was computed using the hydraulics described by Nagler (1918), Yarnell (1934), and d'Aubuison (1840). To be on the conservative side, the eastern portion of Sandusky Bay was also considered to rise in stage as the flood waters passed through the bridge pier openings.

Flood Routing Results. Using the above described design inflow, initial high bay pool stage, and outlet hydraulics, the flood was level-pool routed to obtain these findings for the passage of the flood:

(1) Maximum Western Sandusky Bay stage = 572.6 ft (USLS)

(2) Maximum discharge under the bridge = 31,000 cu ft/sec

(3) Maximum velocity through the piers = 1.75 ft/sec (1.3 mph).

Lloyd's thesis (1974) has the detailed computations to support the above findings.

As an added point of interest, the so-called worst flood remembered, the 1913 Ohio disaster, was taken from the Scioto-Sandusky Conservancy District flood report as discussed by the Ohio Department of Natural Resources (1966), and also routed with the same conditions as considered above. This flood was estimated to have peaked at 65,000 cfs, which according to Table 2.5.3 will exceed the 500-year return period. By using the January 15, 1930, flood hydrograph described above (and Figure 2.5.6) and increasing its peak from 31,400 to 65,000, a hypothetical hydrograph was taken to resemble the undocumented 1913 flood. Again, routing this flood as above, these results were obtained:

(1) Maximum Western Sandusky Bay stage = 572.7 ft (USLS)

(2) Maximum discharge under the bridge = 64,000 cfs

(3) Maximum velocity through the piers = 3.5 ft/sec (2.6 mph).

Flooding due to Seiches and Waves

A second means of investigation of flooding potential is to examine the behavior of seiches and waves in western Sandusky Bay whereon the Site fronts. This was accomplished by taking the maximum bay stage from the 114-year record and superimposing a maximum seiche computed by using results of earlier work done in the bay, along with wind wave setup computed for the situation.

Bay Stage. The maximum recorded Lake Erie Level in the 114-year (1860-1974) record was 573.5 feet (USLS) occurring in June, 1973. This level was assumed to apply to Sandusky Bay also.

Seiche Action. A study done on seiche activity in the Sandusky Bay earlier by Verber (1959) and extended by Lloyd (1974) indicates that the maximum expected seiche amplitude will be about ± 1 foot. This is substantiated by the recently (December, 1973) installed stage recorder at the Site shoreline. Although Lake Erie experiences larger seiches, these have been shown by Verber (1959) not to have any direct influence on the seiche sizes in Sandusky Bay.

Waves. For the fetch orientation at the Site, wave heights were calculated by Bedford (1974) and by Forsyth (1973) to be about 3 feet in height (double amplitude). During our one year of visual monitoring of wave heights, we have estimated these waves occurring:

April 8, 1974 - 3 ft to 4 ft height (double amplitude), with 40-50 mph winds
April 14, 1974 - 2-1/2 ft to 3 ft height (double amplitude), with 50-60 mph winds
April 4, 1974 - 2 ft height (double amplitude), with 35-40 mph winds

In view of the above discussion, it seems reasonable to assign 4-foot high waves as expected maximums. This would give amplitudes (height above still water) of 2 feet.

Stream Flooding. The chance of extreme stream flood inputs into the bay at this season of high bay stage have been investigated by Lloyd (1973) and found to be about a 4 percent chance. Regardless of this chance, if it did happen it was shown earlier that the passage of Sandusky River flood flows would cause the bay stage to rise only several tenths of a foot. Therefore, this will not be superimposed herein.

Seiche and Wave Analysis Results

By combining the above discussed findings, a maximum wave top height near the Site shoreline can be computed as follows:

Maximum high bay stage	573.5 ft (USLS)
High seiche fluctuation	+ 1.0 ft
Maximum wave amplitude	+ 2.0 ft
Total, elevation of wave crest	576.5 ft (USLS)

2.5.1.4 Drawdown

Low Bay Stage Analysis

Low Bay Stage. The lowest recorded level of Lake Erie and hence Sandusky Bay occurred in February, 1936, and was at 567.5 feet (USLS). The lowest September level (to be consistent with the 7-day - 10-year September drought found earlier) occurred in 1934 at 568.2 feet (USLS). To be on the conservative side for this analysis, and since the drought flows are relatively insignificant, we have adopted the lowest stage (1936) on record as the critical case to discuss.

Seiche Action. As shown earlier in the discussion of Site flooding, the seiche amplitude on the western Sandusky Bay will be about ± 1 foot.

Waves. Discussions similar to that in the previous discussions of flooding also apply here. However, due to the shallow bay depth (low stage) the wave amplitudes will not develop as much as they would for deeper bay depths discussed earlier. The average bay depth at low stage is approximately 4 feet and this will limit maximum expected wave heights (double amplitude) to about 1-1/2 feet according to Bedford (1974). This gives a trough of approximately 0.8 feet below still water level.

Minimum Expected Bay Level at the Site Shoreline

By combining the above effects, the minimum western Sandusky Bay level can be computed as follows:

Lowest recorded level	567.5 ft (USLS)
Seiche depression	- 1.0 ft
Wave trough	- 0.8 ft
Lowest instantaneous level	567.7 ft (USLS)

Some Additional Comments on Low Bay Level

Over the last few years, Lake Erie has been experiencing consistently high levels. Besides a hydrologically wet period in the Great Lakes Basin, it is suspected that this high level is also due to a geological phenomenon occurring in the Lake Erie region. Herdendorf and Brandt (1972) found that the Lake Erie basin is slowly tipping in that the western end is lowering and the eastern end, where its outlet is located, is rising. Estimated rates are about 1/2 foot per century on each end. Implications of this phenomenon may be interpreted as follows. On the long-term basis, the Sandusky Bay region should be slowly dropping thus instigating deeper depths in the bay. Also, since the Lake outlet is rising, it too will have the general effect of maintaining deeper depths in all of Lake Erie. The combined results of this tipping can be construed to cause deeper depths in Sandusky Bay. In view of this and assuming meteorological behavior as in the past, it is very unlikely that the 1936 lowest bay stage recorded will occur again and hence some adjustments on it would be justifiable For simplicity, assume a linear adjustment as follows: Since 1936, tilting amounts are (40/100) x 1/2 x 2 = 0.4 ft stage increase. Therefore, the above lowest instantaneous level might be taken as perhaps 566 feet (USLS).

2.5.1.5 Ice Formation

Photographic surveys were conducted over Sandusky Bay to provide preliminary information about the physical and hydrological characteristics of the bay during the winter season. The surveys provided information about ice conditions in Sandusky Bay between December, 1973, and March, 1974. The photographic data were analyzed and interpreted in conjunction with other hydrological data collected and compiled between September, 1973, and March, 1974, and published results of previous Lake Erie ice monitoring efforts.

All available information regarding ice conditions in the Sandusky Bay area have been examined for their applicability to this Site evaluation. This includes radar and thermal sensor overflights conducted by NASA's Lewis Facility in Cleveland, Ohio (R. J. Jirberg et al, 1973; R. S. Vickers et al, 1973; and R. J. Schertler et al, 1973). Also, NASA ERTS-I* and Skylab photos were analyzed to show areas of high, medium, and low suspended sediment loads, and the area and direction of predominant flow within the Bay.

Most lake-ice information refers to the Great Lakes, in general, where wave and wind conditions form characteristic ice patterns. However, the relatively sheltered western basin of Sandusky Bay appears to be more typical of large reservoirs and inland lakes. The information derived from interpretation of the aircraft photography shows ice conditions characteristic of a relatively mild winter. More severe winters would result in thicker and more permanent ice cover in the bay. Other information regarding Great Lakes ice cover shows that in 1963-1964, Sandusky Bay was covered 100 percent during ice reconnaissance overflights on January 2, 15, and 30, and February 11. It was covered 70 to 90 percent on February 27 and was free of ice on March 11, 1964. Ice reconnaissance surveys flown during the winter of 1965 show that Sandusky Bay was covered 100 percent with ice on January 21, February 4, and 50 percent along the northern and southern shores on March 14, with the center of the bay free of ice (R. E. Wilshaw et al, 1965 and D. R. Rondy, 1969).

Data Correlations and Photoanalysis

A comparison of ground-truth data (Herdendorf, 1974) and aircraft and satellite imagery used in this analysis are shown in Figures 2.5.7, 2.5.8, and 2.5.9. The correlations, in graphic form, show: percentage of ice cover for the western and eastern portions of Sandusky Bay, the bay

*ERTS - Earth Resources Technology Satellite.

Figure 2.5.7 **CORRELATION OF ICE DATA**
SANDUSKY BAY
DECEMBER 1973

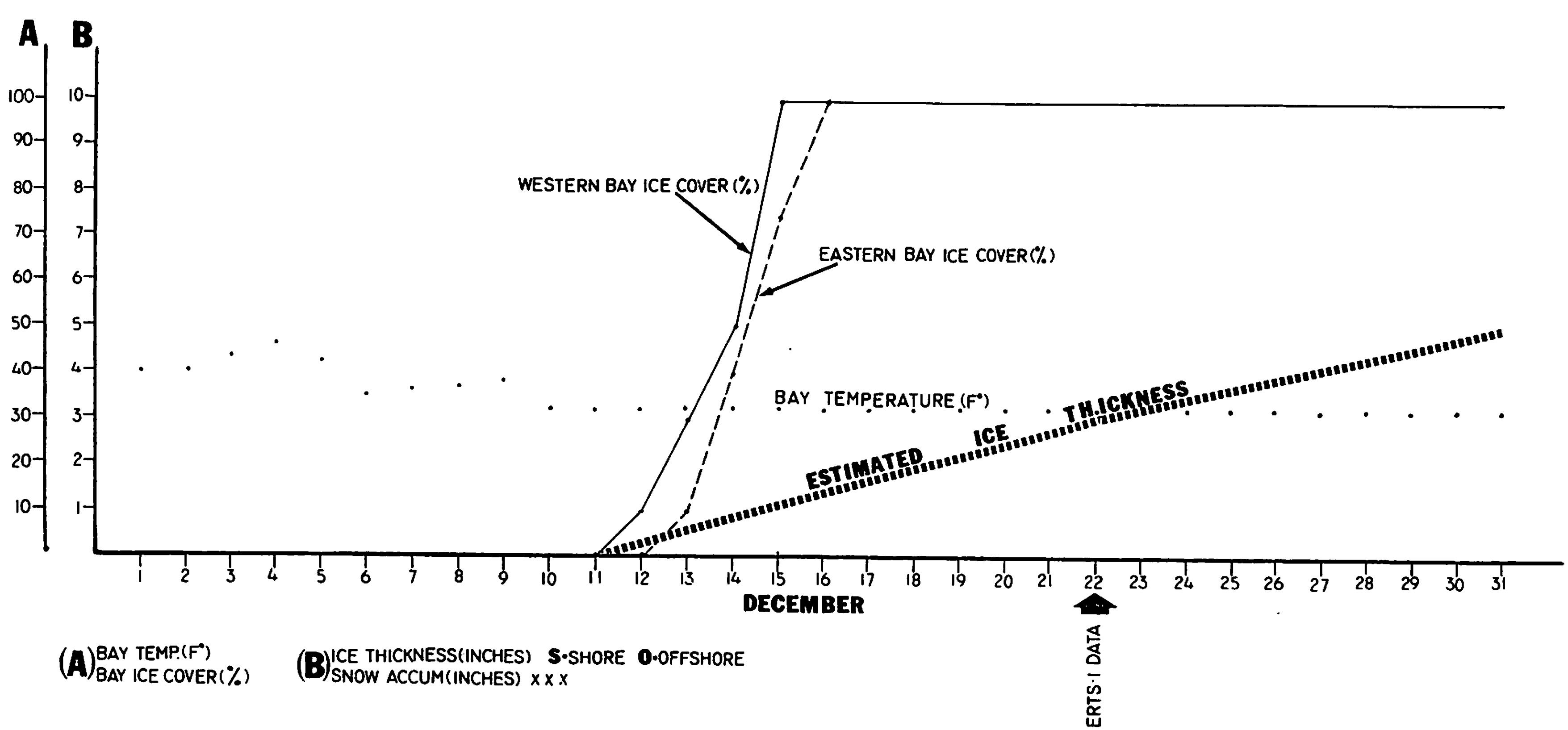


Figure 2.5.8 **CORRELATION OF ICE DATA**

SANDUSKY BAY

JANUARY 1974

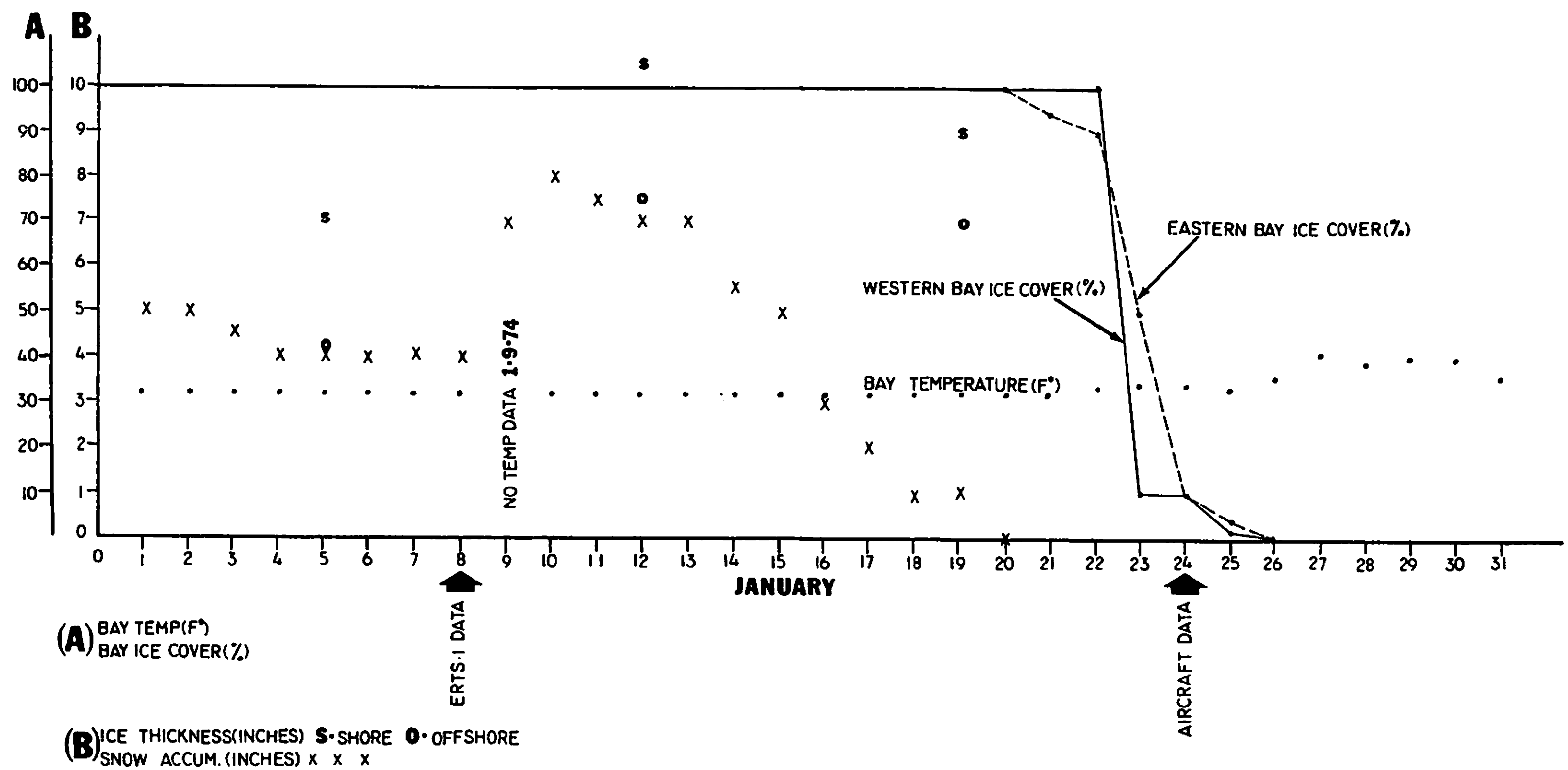
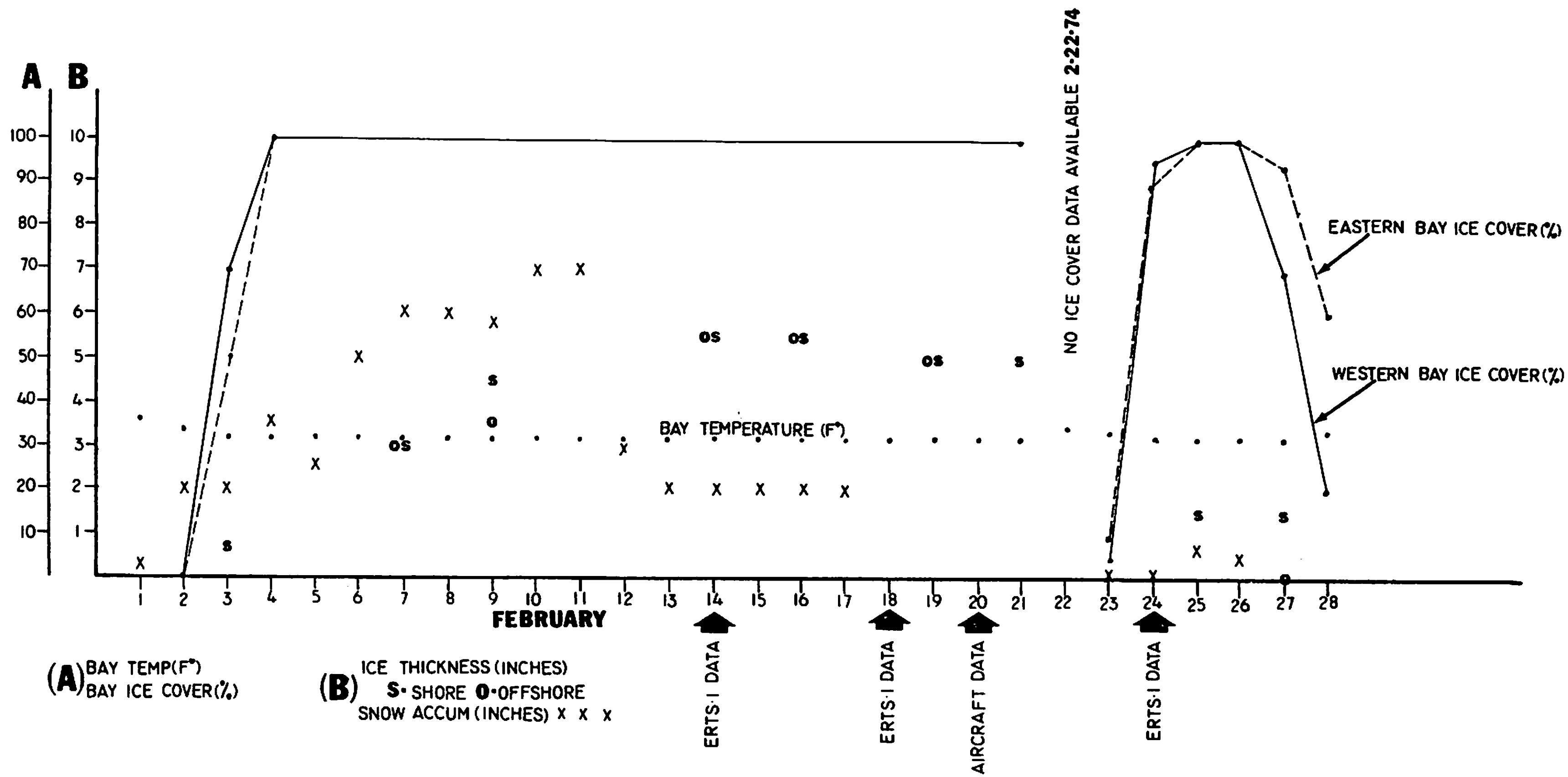


Figure 2.5.9 **CORRELATION OF ICE DATA**

SANDUSKY BAY
FEBRUARY 1974



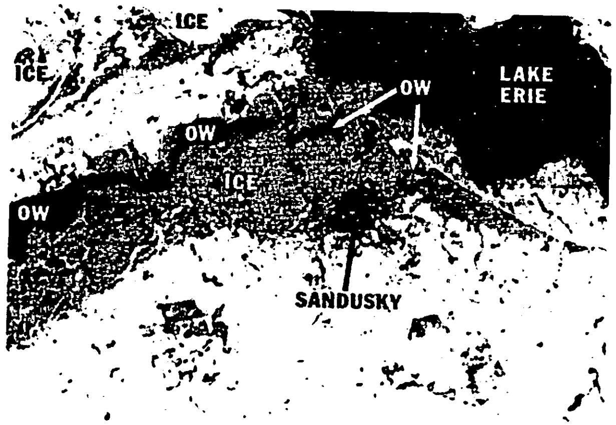
temperature, ice thickness, and when appropriate, snow accumulation. Further, the specific dates for which either aircraft or satellite data are available showing ice formations are indicated. An estimate of ice thickness made from imagery analysis only for December, 1973, is plotted in Figure 2.5.7. All aircraft imagery was examined stereoscopically and selected aircraft and ERTS-I photographs were analyzed on a Spatial Data Color Image Enhancement Viewer. This device "slices" the grey levels or density values of a black and white image into distinct, selected bands and displays each level in a vivid color. The satellite imagery was also analyzed in a Multispectral Viewer which projects up to four satellite images or up to four multidate images simultaneously for comparison.

Major results of the data analysis are described chronologically below. Correlative ground-truth data used in the photo interpretations are summarized in Figures 2.5.7-2.5.9.

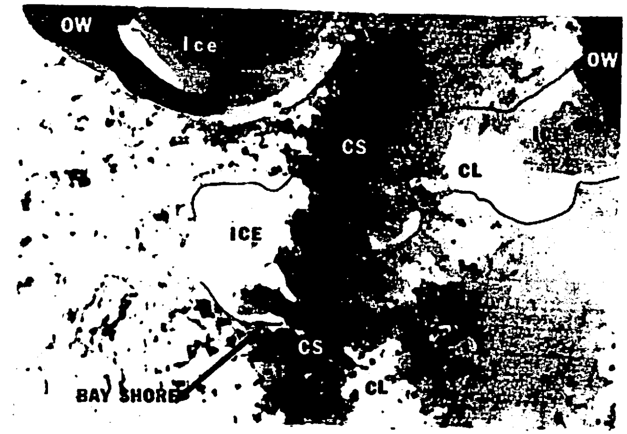
December 22, 1973 (ERTS-I) Figure 2.5.10(b) - The eastern portion of the bay was overshadowed by a large cloud, however, the imagery clearly showed the entire bay frozen over with relatively new and thin ice. As recently as December 12, no measurable ice thickness had been recorded by ground measurements. It was estimated that the ice thickness on December 22 was at least 3 inches thick in the bay, since a prominent channel was visible in the southwest portion of the bay, and the formation of "fast ice" was visible on Lake Erie. Recently fallen snow (2.5 inches on December 19 and 4.5 inches on December 20) covered all of the Bay area. A dark spot in the center of the bay was ice that was very thin and was partially covered with water.

January 8, 1974 (ERTS-I) Figure 2.5.10(c) - Only the eastern portion of the bay was visible. The fact that this portion looked solidly frozen suggested that the western basin of Sandusky Bay was also frozen. This was confirmed through ground observations, which observed that ice near shore was at least 4 inches thick and on shore as much as 7 inches. A 4-inch accumulated (old) snow cover was visible in the bay area.

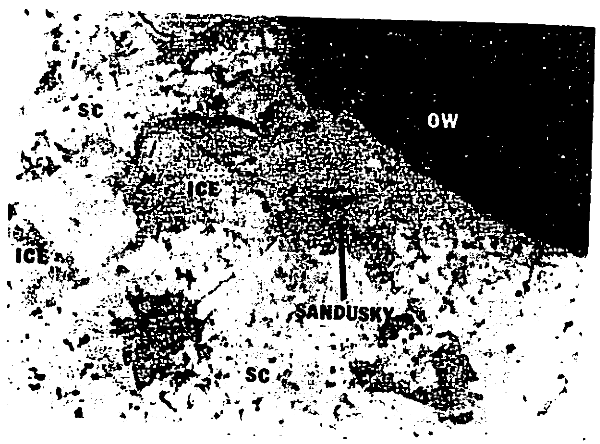
January 24, 1974 (Aircraft) Figure 2.5.11 - The bay appeared nearly ice free. Melting of a 7-inch thick ice cover in the bay had begun on January 19. By January 24, only 10 percent of the western portion of the bay was covered with melting ice,



a FEBRUARY 18, 1973 ERTS-1 PHOTOGRAPH (Visible Band)



b DECEMBER 22, 1973 ERTS-1 PHOTOGRAPH (Visible Band)



c JANUARY 8, 1974 ERTS-1 PHOTOGRAPH (Visible Band)

d FEBRUARY 14, 1974 ERTS-1 PHOTOGRAPH (Visible Band)

CL - Cloud
CS - Cloud Shadow
HS - Heavy Suspended Sediment
LS - Light Suspended Sediment
MS - Moderate Suspended Sediment
OW - Open Water
SC - Snow Cover
SP - Sediment Plume
US - Uniform Suspended Sediment

Figure 2.5.10

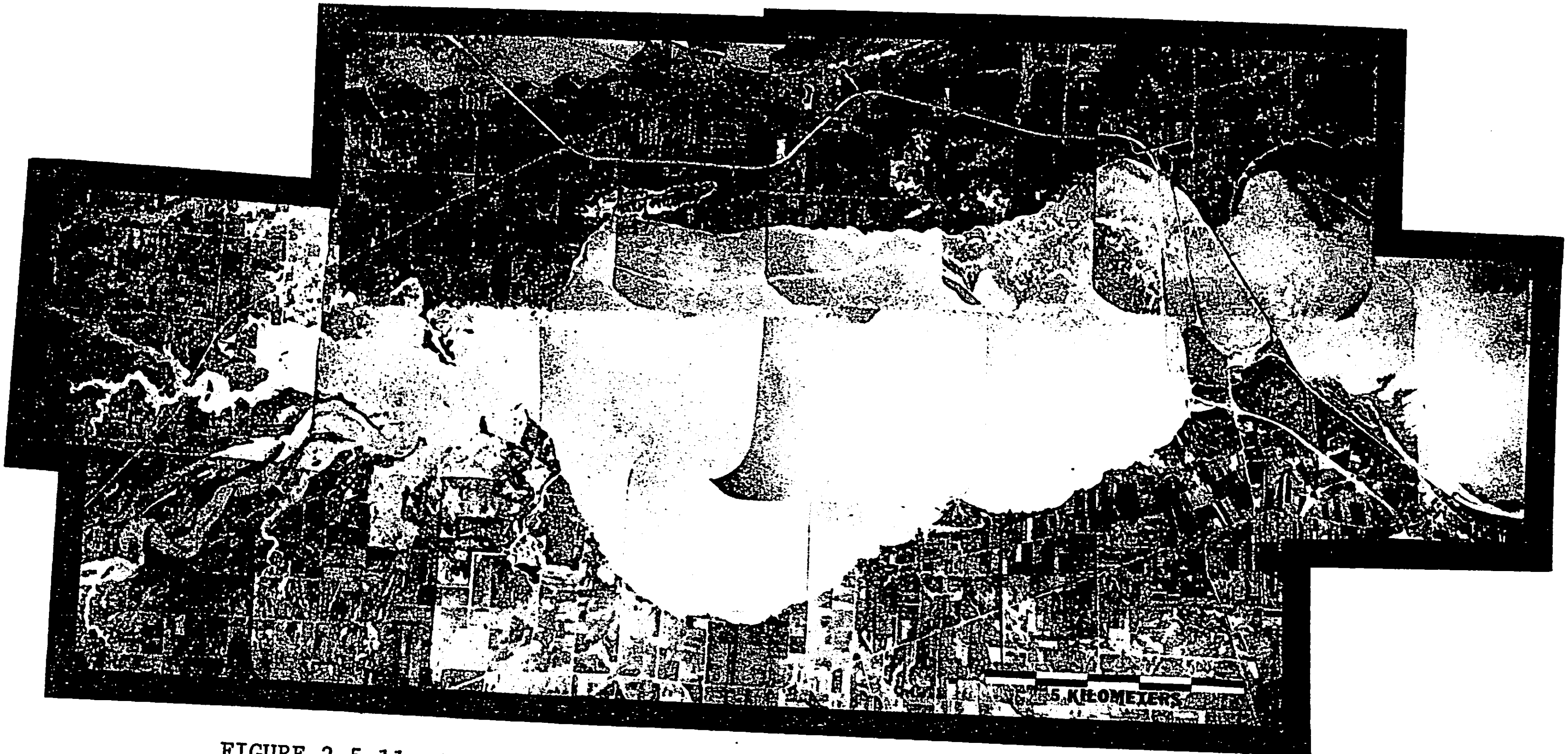


FIGURE 2.5.11 AERIAL PHOTOMOSAIC OF SANDUSKY BAY TAKEN JANUARY 24, 1974 SHOWING LATE STAGE OF MELTING WHICH BEGAN ON THE 19TH. ICE IS STILL PRESENT IN THE WESTERN, SOUTHERN, AND NORTH-EASTERN PORTION OF THE BAY

(Original Photo Scale 1:24,000)

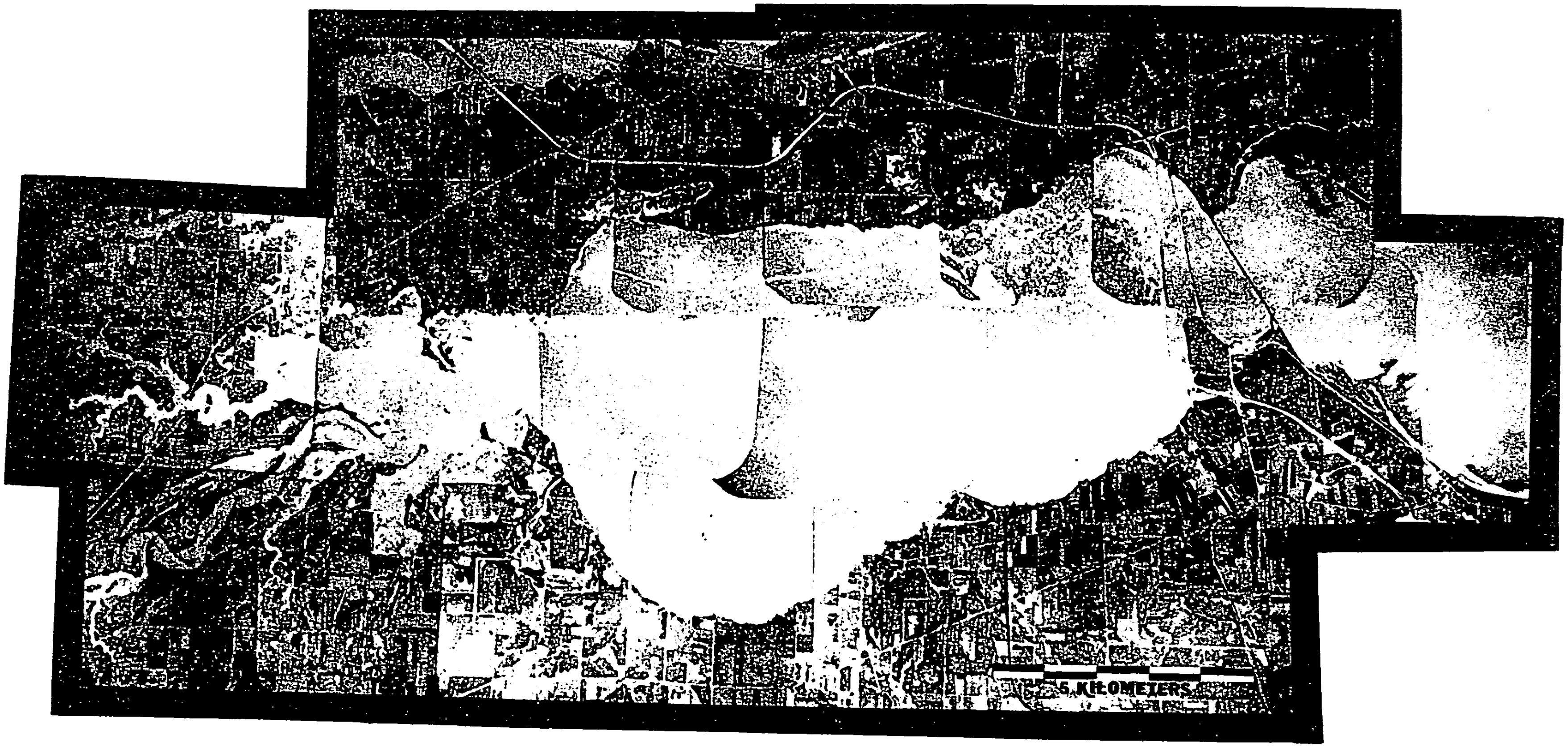


FIGURE 2.5.11 AERIAL PHOTOMOSAIC OF SANDUSKY BAY TAKEN JANUARY 24, 1974 SHOWING LATE STAGE OF MELTING WHICH BEGAN ON THE 19TH. ICE IS STILL PRESENT IN THE WESTERN, SOUTHERN, AND NORTH-EASTERN PORTION OF THE BAY

(Original Photo Scale 1:24,000)

January 24, 1974 (Continued) - and by 40 percent in the northeastern portion. From the time that the photography was flown (approximately noon to 1830 when the ground observations were made), the ice in the northeastern area was reduced to 10 percent. The bay remained ice free from January 26 to February 3.

February 14, 1974 (ERTS-I) Figure 2.5.10(d) - When the satellite passed over Ohio at 1030 hours, most of the bay was covered by clouds. However, examination of the 4 data channels revealed a 95 percent ice cover. Ground observations recorded a 5.5-inch free ice thickness on and near shore. Open areas could be observed in the center of the western bay area west of the Edison Bridge.

February 20, 1974 (Aircraft) Figures 2.5.12 and 2.5.13 - The entire bay appeared solidly frozen, with the exception of areas near and under the three bridges spanning the eastern bay area, and portions of the Sandusky River channel. The photo overlay shows that the northern, eastern, and southern portions were covered with ice older than that in the mid-channel portion of the bay. This was suggested by the numerous channels, cracks, and finger rafting patterns which appear in those areas. Most channels appeared solidly refrozen and a few appeared slightly refrozen. Ground measurements found the thickness of the ice near and on shore to be 5 inches, however, the ice pattern suggested that the ice was thinner than 5 inches in areas covered with relatively new ice. Melting of the ice began February 27. The ice persisted at least partially until March 3; after that date, no ice was recorded in Sandusky Bay.

The photographic and ground-truth data collected during the winter of 1973/74 indicated that freezing of the Sandusky Bay occurs initially in the western, northern, and southern portions, with the central portion affected by the Sandusky River channel freezing last. However, an ERTS-I photo obtained the previous winter on February 18, revealed the entire northern line of the bay ice free out to one kilometer. At that time, the ice on the bay was in a condition of melting. The entire bay appears to be quite active throughout the winter, with several cycles of freezing, melting, and refreezing. The presence of rafting patterns, and the numerous channels and cracks suggest that the bay waters are quite active, with most

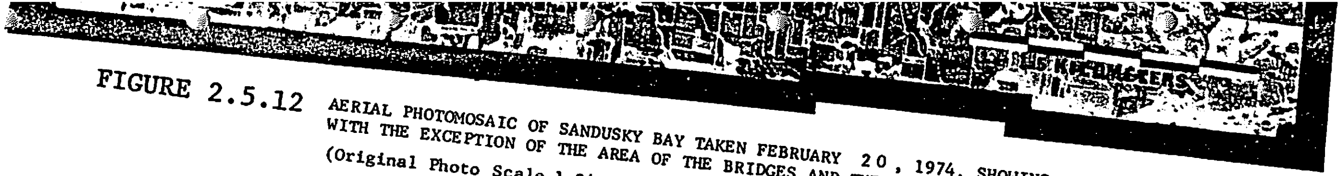
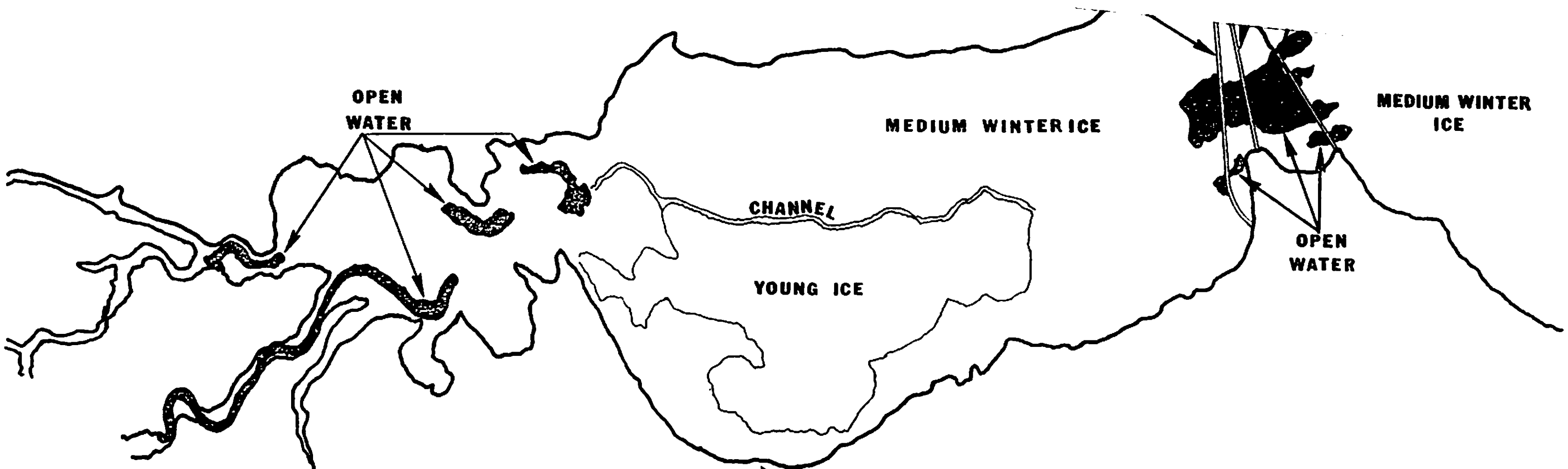


FIGURE 2.5.12 AERIAL PHOTOMOSAIC OF SANDUSKY BAY TAKEN FEBRUARY 20, 1974, SHOWING THE BAY ALMOST ENTIRELY FROZEN WITH THE EXCEPTION OF THE AREA OF THE BRIDGES AND THE SANDUSKY RIVER CHANNEL AREA

(Original Photo Scale 1:24,000)



OVERLAY TO FIGURE 2.5.12

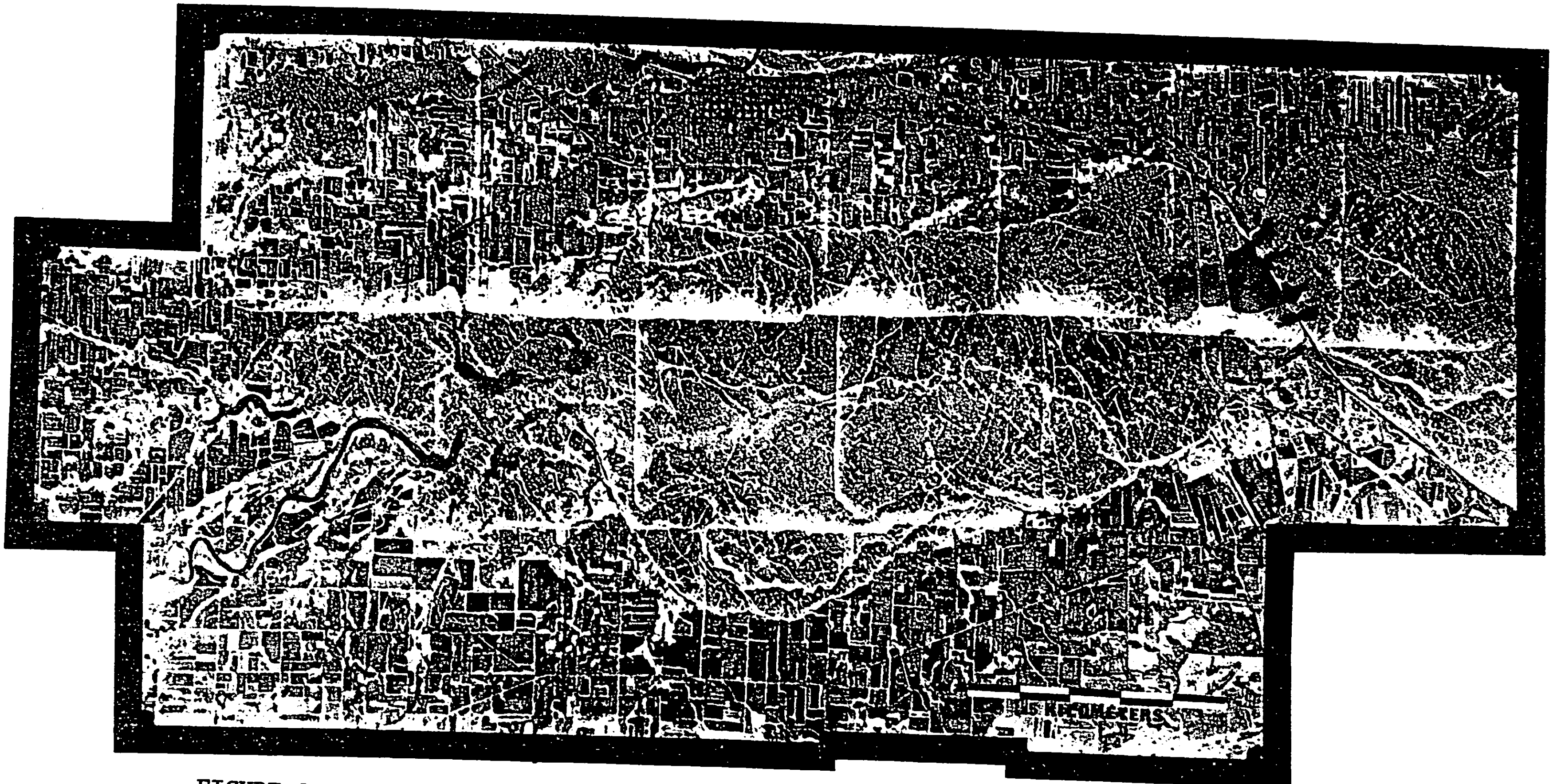
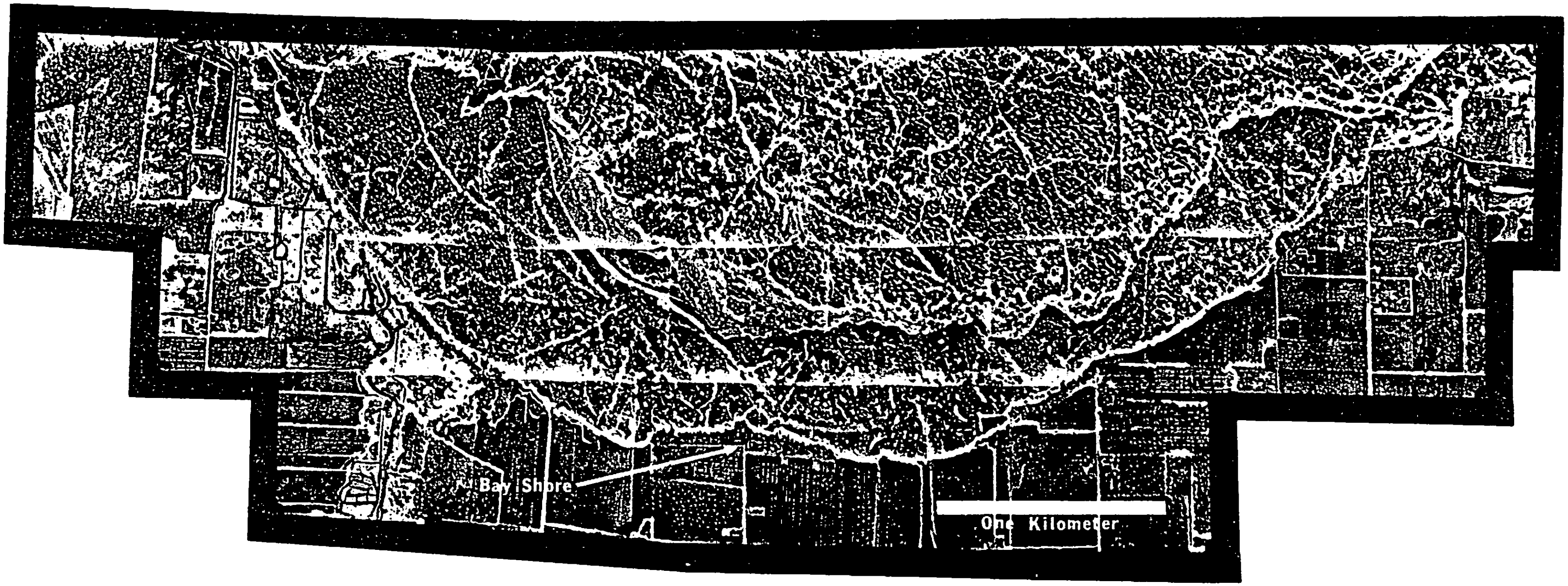


FIGURE 2.5.12 AERIAL PHOTOMOSAIC OF SANDUSKY BAY TAKEN FEBRUARY 20, 1974, SHOWING THE BAY ALMOST ENTIRELY FROZEN WITH THE EXCEPTION OF THE AREA OF THE BRIDGES AND THE SANDUSKY RIVER CHANNEL AREA

(Original Photo Scale 1:24,000)



LARGE SCALE AERIAL PHOTOMOSAIC TAKEN FEBRUARY 20, 1974 SHOWING THE SHORELINE NEAR BAY SHORE AND THE OFF SHORE BAY AREA. ICE THICKNESS WAS REPORTED TO HAVE BEEN 5-1/2 INCHES ON THE DATE THAT THE RECONNAISSANCE WAS FLOWN.

(Original Photo Scale 1:5,000)

frozen-over channels occurring in south-north direction suggesting an east-west water movement. However, a major channel (the longest) ran from the western to the eastern bay area. The initial impression of this feature was that it was cut by a vessel moving through the bay. None of the aircraft photographs revealed the presence of ice ridges or an ice build-up higher than one-half meter. As in the case of the ice morphology, circulation and sedimentation patterns in the bay are very complex and dynamic and the current analysis is indicative of gross features only.

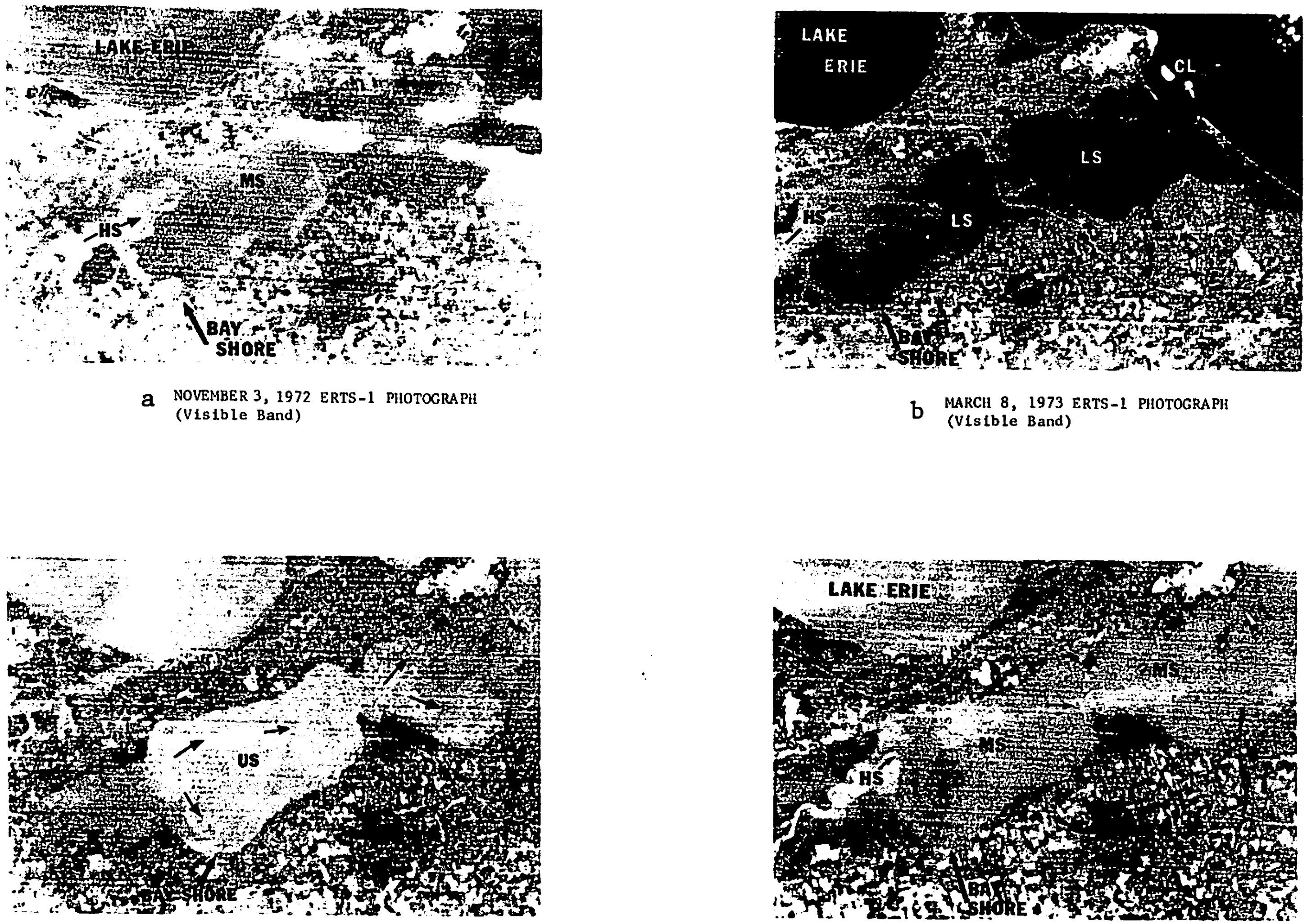
2.5.1.6 Gross Circulation Patterns

An effort was made to add to other information pertinent to circulation patterns in Sandusky Bay. Since the aerial photography was obtained to record ice conditions, its usefulness to determine gross circulation patterns was fairly limited. However, ERTS-I data obtained during 1973-1974 and Skylab SL-3 imagery were helpful in delineating gross circulation patterns in the bay. The photography indicates that most of the sediment load carried out of the mouth of the Sandusky River moves in a northeasterly direction along the northern shoreline of the bay. Lesser sediment loads are carried in a southeasterly direction toward the Bayshore area. The direction of the prevailing wind and resulting wave action affects the uniformity and direction of the flow as can be observed in Figures 2.5.14-2.5.16. Detailed analysis of the aircraft imagery obtained on January 24 clearly shows a wind-driven intrusion of sediment-laden water. In Figures 2.5.14(d), 2.5.15(a), and 2.5.16(d), a sediment plume can be seen on the eastern side of the three bridges. The western portion of the bay is more heavily sediment laden than the eastern portion. The bridges appear to be offering a barrier to the sediment load and this is possibly causing a much higher sedimentation rate in the area west of the bridges.

2.5.1.7 Surface Water Quality

Introduction

The quality of water in the western basin of Sandusky Bay shows slight vertical, geographic, and seasonal variations among the stations



a NOVEMBER 3, 1972 ERTS-1 PHOTOGRAPH (Visible Band)

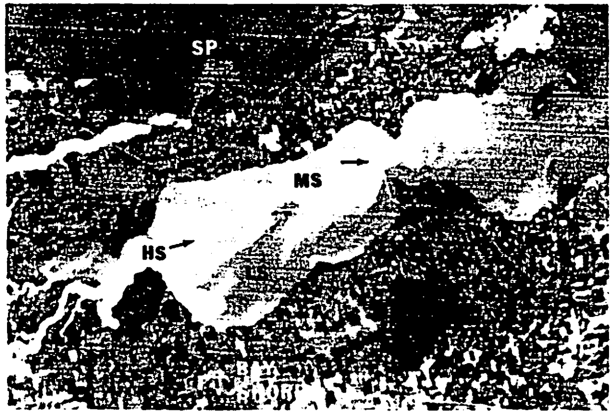
b MARCH 8, 1973 ERTS-1 PHOTOGRAPH (Visible Band)

c MARCH 27, 1973 ERTS-1 PHOTOGRAPH (Visible Band)

d APRIL 14, 1973 ERTS-1 PHOTOGRAPH (Visible Band)

CL - Cloud
CS - Cloud Shadow
HS - Heavy Suspended Sediment
LS - Light Suspended Sediment
MS - Moderate Suspended Sediment
OW - Open Water
SC - Snow Cover
SP - Sediment Plume
US - Uniform Suspended Sediment

FIGURE 2.5.14



a JUNE 7, 1973 ERTS-1 PHOTOGRAPH
(Visible Band)

b JUNE 24, 1973 ERTS-1 PHOTOGRAPH
(Visible Band)

c JUNE 25, 1973 ERTS-1 PHOTOGRAPH
(Visible Band)

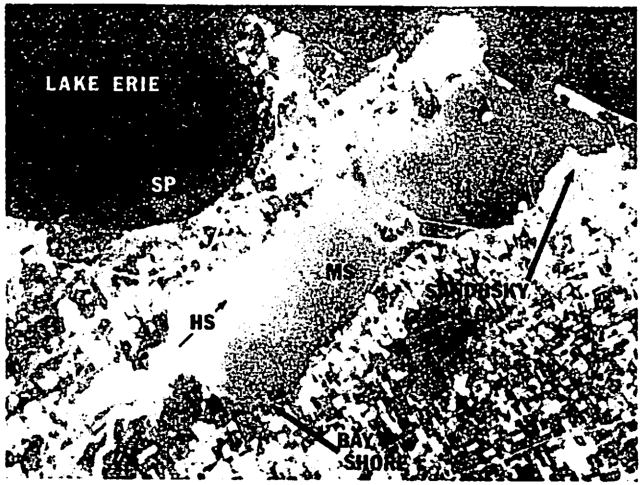
d JULY 13, 1973 ERTS-1 PHOTOGRAPH
(Visible Band)

CL - Cloud
CS - Cloud Shadow
HS - Heavy Suspended Sediment

LS - Light Suspended Sediment
MS - Moderate Suspended Sediment
OW - Open Water

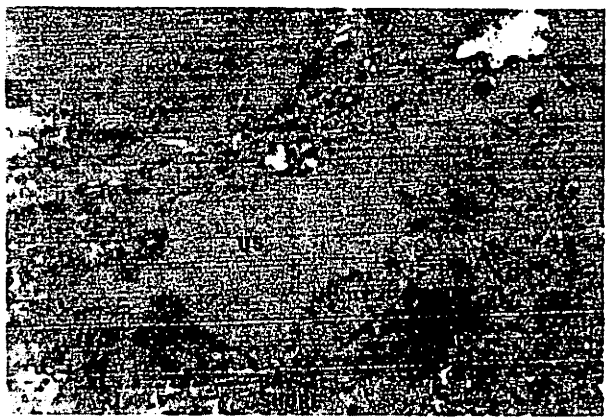
SC - Snow Cover
SP - Sediment Plume
US - Uniform Suspended Sediment

FIGURE 2.5.15

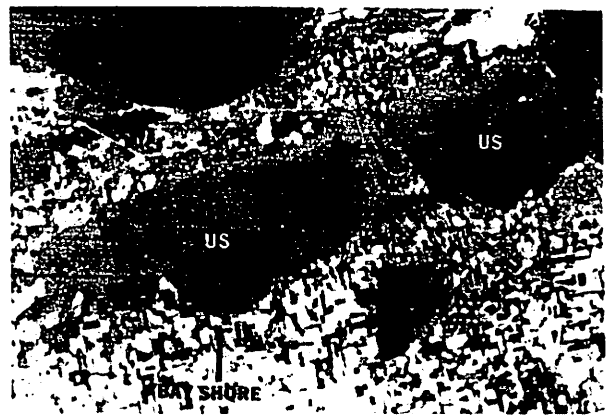


a AUGUST 5, 1973 SKYLAB SL-3, S 190 A PHOTOGRAPH
(Visible Band)

b AUGUST 18, 1973 ERTS-1 PHOTOGRAPH
(Visible Band)



c SEPTEMBER 1973 ERTS-1 PHOTOGRAPH
(Visible Band)



d JUNE 2, 1974 ERTS-1 PHOTOGRAPH
(Visible Band)

CL - Cloud
CS - Cloud Shadow
HS - Heavy Suspended Sediment
LS - Light Suspended Sediment
MS - Moderate Suspended Sediment
OW - Open Water
SC - Snow Cover
SP - Sediment Plume
US - Uniform Suspended Sediment

FIGURE 2.5.16

sampled. Some of these variations become more evident when the data are grouped into the three geographic areas; the mid-bay area, the shore/near-shore area, and the on-shore area. The location of stations can be found in the Aquatic Ecology Section, Figures 2.7.6 and 2.7.7. Eleven stations were sampled in a biweekly schedule and seven stations were sampled monthly. Table 2.7.22 of the Aquatic Ecology Section shows the sampling schedule.

Water Temperature

Since no measurements of water temperature were taken in the months of December, January, and February, the lowest water temperatures were recorded in November and the highest in July and August. The results of all temperature measurements may be found in Appendix K.

The range of water temperature change through the seasons was greatest at Station 16 (See Figure 2.7.7) and the shore/near-shore area. Water temperature at Station 16 ranged from a low of 5 C in November to a high of 28.5 C in August, with a mean of 19.7 C. The seasonal variation in water temperature was the lowest in the Millers Blue Hole stream and the flowing well at Bayshore, both of which are groundwater fed. Seasonal variation in temperature of the discharge of Millers Blue Hole ranged from 9 to 14.5 C with a mean of 12.7 C. The range of variation at the flowing well ranged from 10.5 to 13.2 C with a seasonal mean of 11.7 C. The slightly higher mean and variation of the Millers Blue Hole stream is probably the result of the exposure and retention of groundwater in the Blue Hole itself.

There were no appreciable differences in water temperatures at different stations in the western basin of Sandusky Bay indicating that the western basin is a well mixed body of water. Table 2.5.5 show seasonal mean and range of water temperatures for the shore/near-shore and mid-bay stations, respectively. The mean surface water temperature of the shore/near-shore stations was 19.4 C as compared to 18.8 C for the mid-bay stations indicating a difference of only 0.6 C between the two areas. This difference is probably due to the influence of water from Lake Erie and depth.

TABLE 2.5.5. SEASONAL MEAN AND RANGE OF CHEMICAL PARAMETERS OF WATER QUALITY
SHORE/NEAR-SHORE STATIONS (GRID)
MARCH, 1973 - MARCH, 1974

tation	Dissolved O_2 (ppm) Surface	Dissolved O_2 (ppm) Bottom	pH	Total Alkalinity (ppm)	Ortho-phosphate (ppm)	Nitrate Nitrogen (ppm)	Silicon (ppm)
5	11.6 / 8.0-14.0	11.4 / 8.0-13.0	7.7 / 6.7-8.6	165.8 / 120-257	0.37 / 0.05-1.48	13.8 / .02-35.0	0.95 / 0.7-1.1
6	12.0 / 8.6-13.0	11.0 / 8.0-14.0	8.1 / 7.8-8.5	157.8 / 103-274	0.08 / 0.07-0.10	2.1 / 0.02-4.0	0.83 / 0.6-1.3
8	12.1 / 8.6-14.0	9.7 / 8.0-13.0	8.0 / 7.3-8.5	154 / 103-290	0.14 / 0.07-0.25	3.0 / 0.015-8.0	0.9 / 0.7-1.2
16	10.8 / 6.4-17.[illegible]	8.3 / 6.0-11.0	8.0 / 7.7-8.4	140 / 103-180	0.2 / 0.1-0.5	5.5 / 0.03-11.0	0.8 / 0.8
17	11.4 / 7-18	9.4 / 6.4-12.0	7.8 / 6.7-8.4	140.8 / 103-253	0.40 / 0.05-1.8	7.3 / 0.03-13.0	0.8 / 0.5-1.1
19	12.0 / 8.2-17.0	8.8 / 3.1-11.0	7.9 / 6.7-8.4	150.9 / 103-274	0.13 / 0.05-0.25	8.0 / 8.0	2.2 / 0.5-5.2
23	11.2 / 8.5-17.0	9.5 / 8.4-11.0	8.2 / 7.7-8.5	150.8 / 103-274	0.11 / 0.05-0.16	5.0 / 0.03-10.0	0.7 / 0.4-1.1
31	11.5 / 8.5-18.0	9.0 / 8.0-10.0	8.1 / 7.8-8.5	181 / 103-325	0.10 / 0.05-0.10	6.0 / 0.017-12.0	2.4 / 0.3-0.65
37	10.4 / 7.0-15.0	8.9 / 7.0-11.2	7.2 / 6.8-7.7	158.4 / 103-307	1.7 / 0.07-3.6	7.8 / 0.5-13.0	0.55 / 0.35-0.6[illegible]
Mean	11.6	9.7	8.0	152.6	0.19	0.3	1.2

Station	Sulfate (ppm)	CO_2 (ppm)	Water Temp. °C Surface	Water Temp. °C Bottom	Conductivity (umhos/cm) @ 25°C	Transparency Secchi (cm)	Turbidity (J.T.U.)
5	271.7 / 225-300	5 / 0-15	19.9 / 6-27.0	19.8 / 6-26.0	604 / 425-1000	18.9 / 15.2-20.0	40.3 / 21.0-31.0
6	207.5 / 175-240	5.5 / 0-15	19.5 / 6.0-27.5	19.1 / 6.0-26.0	492.1 / 425-540	23.9 / 18.3-27.4	30 / 22.0-[illegible]
8	225 / 150-300	3.5 / 0-10	19.3 / 6.0-26.0	19.0 / 6.0-26.5	549 / 390-630	23.5 / 15.2-30.5	34.4 / 26.0-[illegible]
10	190 / 180-200	3.5 / 0-10	19.7 / 6.0-28.5	19.2 / 5.0-27.0	523 / 400-660	22.8 / 15.5-33.5	[illegible] / 23.0-[illegible]
17	207.5 / 190-240	5 / 0-10	19.3 / 5.0-28.0	18.8 / 5.0-26.0	527 / 400-700	21.9 / 12.4-30.8	33.4 / 17.0-[illegible]
19	175 / 170-180	3.8 / 0-10	19.3 / 5.0-27.0	18.8 / 5.0-25.5	[illegible] / 370-580	27.0 / 18.6-33.5	[illegible] / 17.0-33.0
29	170 / 0.4-1.1	2.5 / 0-5	19.2 / 5.0-27.0	18.9 / 6.0-26.5	471 / 365-540	26.0 / 18.6-33.5	[illegible] / 23.0-[illegible]
31	190 / 190	2.5 / 0-5	19.3 / 5.5-27.0	18.8 / 5.5-26.5	475.7 / 390-540	29.8 / 18.6-40.3	[illegible] / 24.0-40.0
37	198.3 / 145-230		19.2 / 10.0-28.0	19.1 / 10.0-25.0	500.8 / 450-580	28.1 / 21.7-33.5	25.6 / 14.0-54.0
Mean	204.6	3.7	19.4	19.0	527	24.2	33.8

TABLE 2.5.5. (Continued)

Station	Dissolved O_2 (ppm) Surface	Dissolved O_2 (ppm) Bottom	pH	Total Alkalinity (ppm)	Ortho-phosphate (ppm)	Nitrate Nitrogen (ppm)	Silicon (ppm)
33	9.8 / 7.0-17.0	7.9 / [illegible]-11.2	7.5 / 6.3-8.4	184 / 120-333	0.35 / 0.01-0.8	7.7 / 0.5-12.0	3.2 / 0.6-3.0
21	10.7 / 8.8-16.0	9.6 / 6.4-13.0	8.0 / 7.0-8.5	141.5 / 103-240	0.49 / 0.09-3.1	11.2 / 0.5-34.0	3.8 / 0.15-0.9
35	10.6 / 6.6-15.0	9.7 / 7.1-11.0	7.6 / 6.5-8.3	179 / 103-370	0.14 / 0.05-0.35	7.5 / 0.3-11.0	0.78 / 0.9-1.3
36	11.5 / 8.8-14.0	9.1 / 7.8-11.0	7.7 / 7.4-7.9	147.8 / 103-200	0.3 / 0.01-1.0	6.8 / 0.4-10.0	0.75 / 0.6-1.3
38	11.5 / 9.7-17.0	8.7 / 6.4-10.0	7.2 / 6.4-7.9	120.5 / 86-171	0.1 / 0.01-0.16	27.8 / 0.5-65	0.7 / 0.5-0.9
Mean	10.6	9.0	7.6	156	0.28	12.2	1.8

Station	Sulfate (ppm)	CO_2 (ppm)	Water Temp. °C Surface	Water Temp. °C Bottom	Conductivity (umhos/cm) @ 25°C	Transparency Secchi (cm)	Turbidity (J.T.U.)
33	242.5 / 160-290	7.6 / 0-15	19.2 / 6.5-26.5	19.0 / 6.5-25.0	531 / 425-675	16.9 / 9.3-24.7	60.4 / [illegible]
21	164 / 140-210	4.2 / 0-10	18.4 / 6.0-25.5	18.2 / 6.0-25.5	490 / 330-600	25.1 / 12.4-43.4	23.3 / [illegible]
35	176.3 / 140-220	5 / 0-5	18.9 / 6.5-26.0	18.8 / 5.0-28.0	443 / 440-580	32.6 / 23.3-40.3	25.8 / 11.0-48.0
36	158.8 / 140-178	3.8 / 0-10	17.2 / 6.0-25.0	17.0 / 6.0-25.0	422 / 340-500	26.8 / 18.3-42.7	31.0 / 13.0-41
38	124 / 40-200	4.2 / 0-10	17.4 / 5.0-27.0	17.2 / 5.0-26.5	344 / 360-550	32.1 / 18.6-42.7	21.4 / 12.0-33.0
Mean	173	4.9	18.2	18.0	446	28.7	33.6

Vertical differences in water temperature ranged from 0.1 to 1.5 C between surface and bottom. The greatest differences occurred during the summer months in the shore/near-shore area. The slight difference between surface and bottom temperatures indicates the lack of any thermo-density stratification that might prevent mixing of surface and bottom waters.

Water temperatures at Station 37, on the north side of the western basin of Sandusky Bay, showed no appreciable difference when compared to the south shore. This further substantiates the lack of any thermal anomalies in the western basin.

Water temperatures of the central and eastern basins of Sandusky Bay are slightly lower than the western basin. Mean annual temperature of surface water at the mouth of Muddy Creek Bay (western end of western basin) was 19.2 C and decreased to 17.4 C in the eastern basin.

Table 2.5.6 lists the seasonal variation in water temperature over a twelve year period, at Gypsum on the western basin of Sandusky Bay. Water temperature data from the present study show no significant variation from the twelve year averages.

The water temperature of the on-shore tributaries of Pickerel Creek and Scherz Ditch was lower than the western basin of Sandusky Bay. Water temperatures of both tributaries increased toward the Bay indicating the influence of Sandusky Bay water in the tributaries. The mean annual water temperatures of Pickerel Creek at Route 247 was 15.2 C and increased to 17.8 C at Route 6 and finally to 19.9 C at the mouth. At the junction of Scherz Ditch and Route 247, the mean water temperature was 18.2 C increasing to 18.8 C at Route 6 and 19.7 C at the shore of the western basin of Sandusky Bay. Scherz Ditch at Route 6 showed no seasonal difference between surface and bottom waters, while in Pickerel Creek at Route 6 the surface water temperature was 1.0 C higher.

Specific Conductance

The total concentration of dissolved solids in the western basin of Sandusky Bay is considerably higher than in Lake Erie. A large measure of this high concentration must come from the Sandusky River and nearby ground and surface runoff.

TABLE 2.5.6.

SANDUSKY BAY WATER TEMPERATURES AT GYPSUM, OHIO
(Scholl, 1971)
(C^o at 4:00 PM Daily)

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	Average
January		0.7	1.3	0.6	1.4	1.0	0.6	0.5	0.4	0.6	0.3	0.8	0.7
February		1.0	1.1	1.4	1.0	1.4	0.5	0.5	1.1	1.1	0.9	1.1	1.0
March		2.3	2.4	2.9	0.8	3.6	3.0	3.0	2.5	2.0	3.2	2.3	2.5
April		10.6	11.2	9.3	7.7	8.5	9.8	11.4	9.6	11.0	10.3	9.2	9.9
May		19.1	16.0	19.4	18.8	13.8	13.1	14.5	15.5	18.5	15.4	16.9	16.5
June		22.9	22.8	22.4	21.5	21.8	22.6	21.0	19.5	22.1	22.4	19.4	21.7
July	23.5	23.2	25.1	25.3	24.1	25.0	22.8	24.4	23.5	23.0	23.9	23.5	23.9
August	18.6	23.3	22.2	22.1	22.6	22.9	21.9	23.6	23.4	23.8	22.6	22.4	22.5
September	22.2	18.5	18.9	19.3	19.6	16.4	18.0	18.8	16.8	20.8	20.6	19.9	19.2
October	13.4	11.9	15.8	11.7	11.1	9.3	10.9	13.1	11.5	13.4	16.4	11.1	12.5
November	5.6	4.6	7.1	8.0	5.1	4.4	2.8	4.5	2.5	5.5	6.4	5.5	5.2
December	0.5	1.2	0.3	0.8	1.2	1.0	1.2	0.1	0.0	0.5	2.5	0.6	0.8
Average		11.6	12.0	11.9	11.2	11.0	10.6	11.3	10.5	11.9	11.2	11.1	11.4

The specific conductance of the water in the on-shore stations was three to eight times higher than the water of the Bay. As might be expected, the T.D.S. were highest in the ground water outfalls of the Millers Blue Hole stream and the flowing well at Bayshore. Table 2.5.7 lists the seasonal mean and range of the conductivity of the on-shore stations. The flowing well at Bayshore (42) was the highest in T.D.S. of all stations having a range of conductance between 2,000 and 2,900 umhos/cm at 25 C with a seasonal mean of 2,316 umhos/cm at 25 C.

The effect of the high concentration of dissolved solids in the surface and groundwater runoff can be noted in the higher specific conductance recorded in the shore/near-shore area. From Tables 2.5.9 and 2.5.10, the mean conductance recorded at the shore/near-shore stations was 527 umhos/cm at 25 C as compared to 446 umhos/cm at 25 C for the mid-bay stations. There is a dilution effect from the on-shore tributaries to the mid-bay area. Station 37 (north shore) was most comparable with the data from the south shore.

The specific conductance of the water mass along the mid-bay transect diminished toward the eastern basin of Sandusky Bay. From Muddy Creek Bay conductance values diminished as 53, 490, 443, 422, and 344 umhos/cm at 25 C to the eastern basin. Variations in the T.D.S. concentration did not show any seasonal pattern possibly because of high water and water level fluctuations.

Transparency

Due to the effect of wind agitation on the shallowness of the Bay, Secchi disc transparencies can change within an hour. The annual mean transparency of the mid-bay area was 26.7 cm, slightly higher than 24.2 cm for the shore/near-shore area. At the mouths of Muddy Creek Bay and Pickerel Creek (Stations 5 and 33) transparency was the lowest in both annual mean and range. From Table 2.5.5 Station 33 had a mean transparency of 16.9 cm which was considerably lower than the mean of 26.7 for all mid-bay stations. Stations 5 and 16, both shore stations, were below the mean for all shore/near-shore stations.

Transparency of the water in Pickerel Creek and Scherz Ditch at their Route 6 intersections was 25.5 cm mean value and was most similar

TABLE 2.5.7. SEASONAL MEAN AND RANGE OF CHEMICAL PARAMETERS OF WATER QUALITY ON-SHORE STATIONS MARCH, 1973 - MARCH, 1974

Station	Dissolved O_2 (ppm) Surface	Dissolved O_2 (ppm) Bottom	pH	Total Alkalinity (ppm)	Ortho-phosphate (ppm)	Nitrate Nitrogen (ppm)	Silicon (ppm)
39	9.8 / 6.8-17.0	6.7 / 1.8-9.0	7.5 / 7.1-8.5	225 / 171-300	0.20 / 0.3-0.0	5.9 / 4.5-10.0	10.8 / 10.8
40	9.0 / 6.0-11.0	7.6 / 5.8-10.0	7.0 / 6.7-8.3	204.7 / 68-260	0.53 / 0.05-2.4	8.4 / 0.02-14	10.0 / 10.0
41	3.9 / 2.0-5.0		7.4 / 7.0-8.4	234 / 154-274	0.16 / 0.02-0.7	8.3 / 0.01-10.0	7.0 / 7.0
42	5.7 / 1.0-10.0		7.1 / 8.4-8.0	273.3 / 250-308	0.29 / 0.03-1.2	6.1 / 0.03-11.0	10.8 / 10.8
43	7.7 / 4.6-11.0		7.8 / 7.2-8.4	230.5 / 120-308	0.42 / 0.07-1.0	6.8 / 0.03-12.0	10.0 / 10.0
44	8.8 / 1.0-13.0		7.5 / 7.1-8.2	203.8 / 188-260	0.3 / 0.03-0.9	9.4 / .05-14.0	9.0 / 9.0
Mean	7.1		7.6	230	0.33	7.2	9.6

Station	Sulfate (ppm)	CO_2 (ppm)	Water Temp. °C Surface	Water Temp. °C Bottom	Conductivity (umhos/cm) @ 25°C	Transparency Secchi (cm)	Turbidity (J.T.U.)
39	333 / 200-500	6 / 0-15	17.0 / 6.5-24.0	16 / 5.6-22.5	1630 / 800-2500	26.1 / 18.6-33.5	38.9 / 15.0-90.0
40	275 / 200-300	5 / 0-10	18.8 / 6.5-25.0	18.8 / 5.5-25.0	1302 / 700-1950	25.0 / 18.6-33.8	72.7 / 20.0-210
41	653 / 160-1500	24.2 / 0-45	12.7 / 9.0-14.5		2316 / 1880-2700	Bottom	7.0 / 2.7-15.0
42	1183 / 300-1750	26.4 / 0-50	11.7 / 10.6-13.2		2610 / 2000-2900	———	17.4 / 0.25-75.0
43	210 / 160-300	14.2 / 0-38	15.2 / 6.0-22.0		1773 / 800-2800	Bottom	27.5 / 8.0-60.0
44	330 / 240-460	4.2 / 0-10	18.2 / 6.0-25.0		1320 / 750-2600	Bottom	29 / 15.0-60.0
Mean	497	13.2	16.7		1826	25.6	32

to Bay conditions. This indicates water mass interactions between the Bay and tributary at least to Rt. 6.

Turbidity

The concentration of suspended material in water is obviously related to the transparency of that water. Stations 33 (mouth of Muddy Creek Bay), 5 and 16 (south shore) had the lowest transparency and the highest concentration of suspended materials in the water column. Turbidity data (Tables 2.5.5) from the near-shore stations correlate very closely with the mid-bay stations in the western basin of Sandusky Bay. Station 37 (north shore) turbidity data correlate with mid-bay and south shore data indicating a rather complete mixing and agitation of the water mass of the western basin.

The seasonal turbidity values along the mid-bay transect were 60.4, 29.3, 25.8, 31.0, and 21.4 J.T.U. from the mouth of Muddy Creek Bay to the eastern basin adjacent to the City of Sandusky. Turbidity values were slightly less in the central basin.

Turbidity was extremely high in Scherz Ditch at Rt. 6 (Station 40) where the range of 28.0 to 210 J.T.U. calculated to a mean of 72.7 J.T.U. Suspended material in the waters of Pickerel Creek and Scherz Ditch, as well as the ground water outfalls of the Bayshore well and Millers Blue Hole stream were very low in comparison to other stations.

Dissolved Oxygen

Oxygen (dissolved) concentrations of the Bay were found to vary slightly between surface and bottom of the water column. The difference in dissolved oxygen concentration between top and bottom ranged between 0.1 and 1.4 ppm depending on the station and season. Differences were greatest during July and August and in the mid-bay stations.

No significant differences in dissolved oxygen concentrations were noted in the surface waters between the mid-bay and shore/near-shore areas. Seasonal means in dissolved oxygen show an increase between the western and eastern basins; the concentration being higher toward Lake Erie. The difference is 1.8 ppm between the mouth of Muddy Creek Bay and the eastern basin.

TABLE 2.5.8. SUMMARY OF WELL FLOWS (DATA FROM SEPTEMBER, 1973 THROUGH APRIL, 1974)

Monitoring Station	well # 1	well # 2	well # 3
Maximum Flow (gpm)	1.13	7.50	0.31
Minimum Flow (gpm)	1.02	6.67	0.28
Mean Monthly Flows (gpm)			
September, 1973	1.13	7.50	0.31
October	1.13	7.50	0.30
November	1.13	7.50	0.30
December	1.08	6.96	0.29
January, 1974	1.04	6.67	0.29
February	1.04	6.67	0.29
March	1.06	6.67	0.29
April	1.07	6.70	0.29

2.5.2 GROUNDWATER HYDROLOGY

Three existing and flowing wells, two on the Site and one just east of its eastern boundary, have been monitored for flow rate and temperature on a daily basis since September 2, 1973, and are still being observed. The location of these monitoring stations 1, 2, and 3 are shown in Figure 2.4.5 of Section 2.4. Details of the monitoring program, computer programs for data reduction, raw data, and reduced data can be found in the Phase III report by Battelle (1974).

2.5.2.1 Well Descriptions and Records Collected

Well #1

It is an active, domestic, flowing well pipe just east of the eastern Site boundary near the Bay. The discharge varies between a maximum of 1.13 gpm in September to a minimum of 1.02 gpm in February. This variation can be interpreted as responding to the underlying artesian aquifer's variation in potentiometric surface over the year (see Section 2.4). Temperatures of these artesian water discharges ranged from a high of 54 F in September to a low of 45 F in December. Data on this well are summarized in Tables 2.5.8 and 2.5.9.

Well #2

This is an abandoned, domestic, flowing well pipe located near the bay at the center of the Site. The discharge behavior of this well is to run fairly constant at a high of 7.5 gpm through the months and then drop to and maintain a discharge rate of 6.7 gpm throughout the winter and spring. This indicates a very slightly changing potentiometric surface in the underlying artesian aquifer throughout the year. Groundwater temperatures varied from a 53 F high in September to a 48 F low in December. Tables 2.5.15 and 2.5.16 show the data for this well.

A water sample taken from this well showed a background concentration of 2,000 ppm sulfate and 1,500 ppm hardness.

TABLE 2.5.9. SUMMARY OF WELL TEMPERATURE DATA (DATA FROM SEPTEMBER, 1973 THROUGH APRIL, 1974)

Monitoring Stations	1	2	3
Maximum Temperature (°F)	54.	55.	58.
Minimum Temperature (°F)	45.	48.	46.
Average Temperature (°F)	50.9	51.4	51.3
Mean Monthly Temperatures (°F)			
September	53.1	52.9	56.0
October	53.0	52.8	54.7
November	50.7	51.2	50.8
December	47.7	49.7	48.8
January, 1974	50.2	50.0	49.6
February	50.1	50.7	48.8
March	50.5	51.0	49.5
April	52.1	52.6	52.1

Well #3

Also an abandoned domestic flowing well pipe located towards the center eastern part of the Site. Its flow varied from 0.31 to 0.28 gpm throughout the study period. This again illustrates the slight variability in potentiometric surface of the aquifer. The water temperatures ranged from a maximum of 58 F in September to a minimum of 52 F in April. Data variation detail can be seen in Tables 2.5.15 and 2.5.16.

Well #13

This is an abandoned, domestic, flowing well, near to Well #2 discussed above, which has recently been discovered. Reduced data on this monitoring station are not yet available, but it is expected that its behavior will be similar to the other wells.

2.5.2.2 Regional Groundwater Hydrology

The following discussion has been abstracted from a Master of Science thesis by Palombo (1974). Additional details and substantiation may be found in his work.

Groundwater underlying the Site is under enough pressure to flow whenever the aquifer is made open to the surface. The level to which the water will rise is called the potentiometric surface. The altitude of this surface has been mapped (Figure 2.5.17) by the use of well data, pressure measurements on some wells, and by the altitude of springs, particularly Millers Blue Hole. Because the water level is only taken when a well is initially drilled, this surface must be considered as an average altitude. Judging from the flow of certain wells on the Site which have been monitored continuously over a nine-month period, the seasonal variation approaches seven feet. The highest levels are obtained during the spring and gradually decline to lowest levels in the late autumn.

The groundwater flows generally in a north-northwest direction from recharge areas to the south, to discharge points along major streams, and eventually to the bay. This can be seen in Figure 2.5.17, 2.5.18, and and 2.5.19.

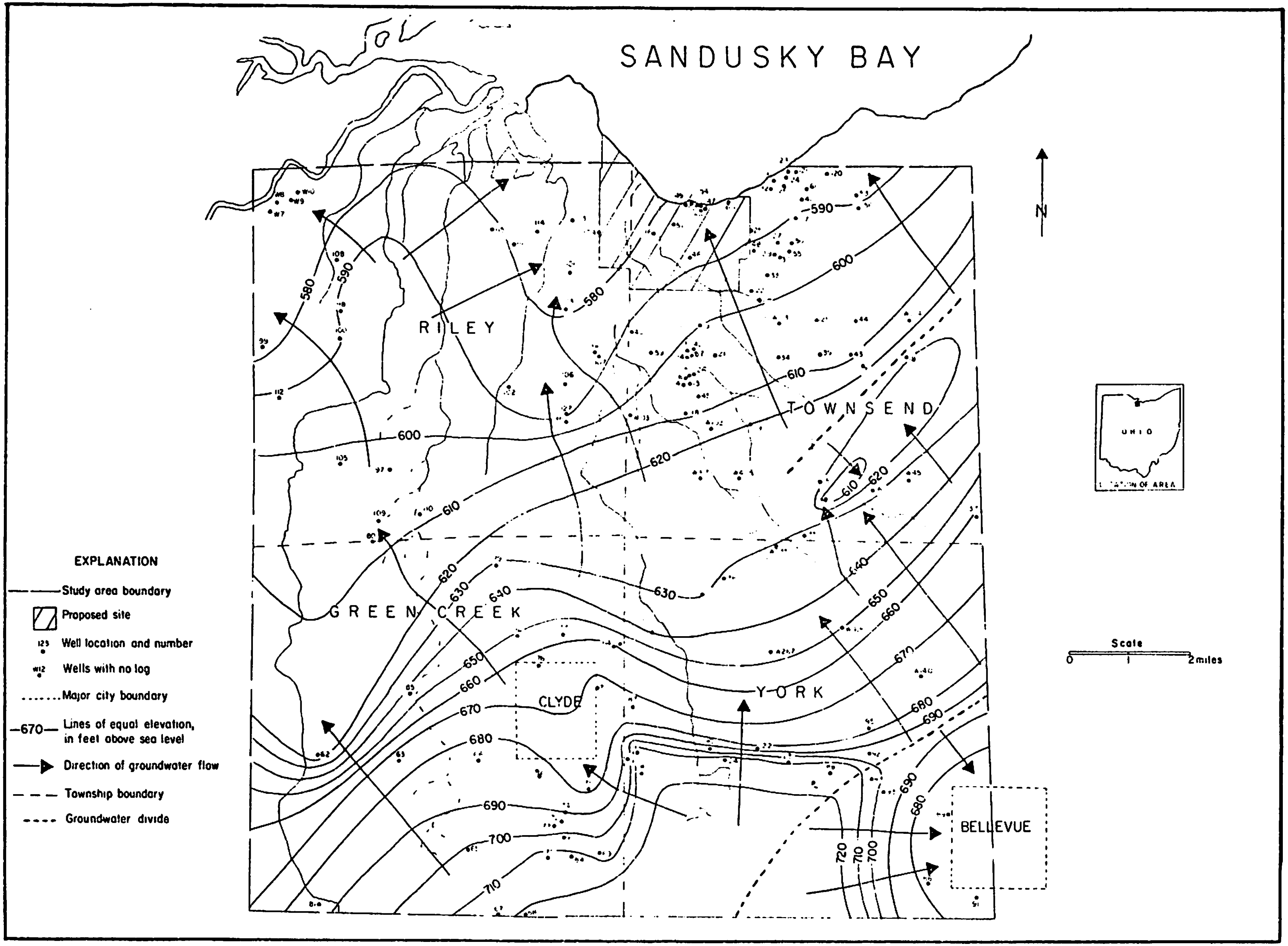


FIGURE 2.5.17. POTENTIOMETRIC SURFACE OF THE BEDROCK AQUIFER AND DIRECTION OF GROUND-WATER FLOW

Contour interval 10 feet.

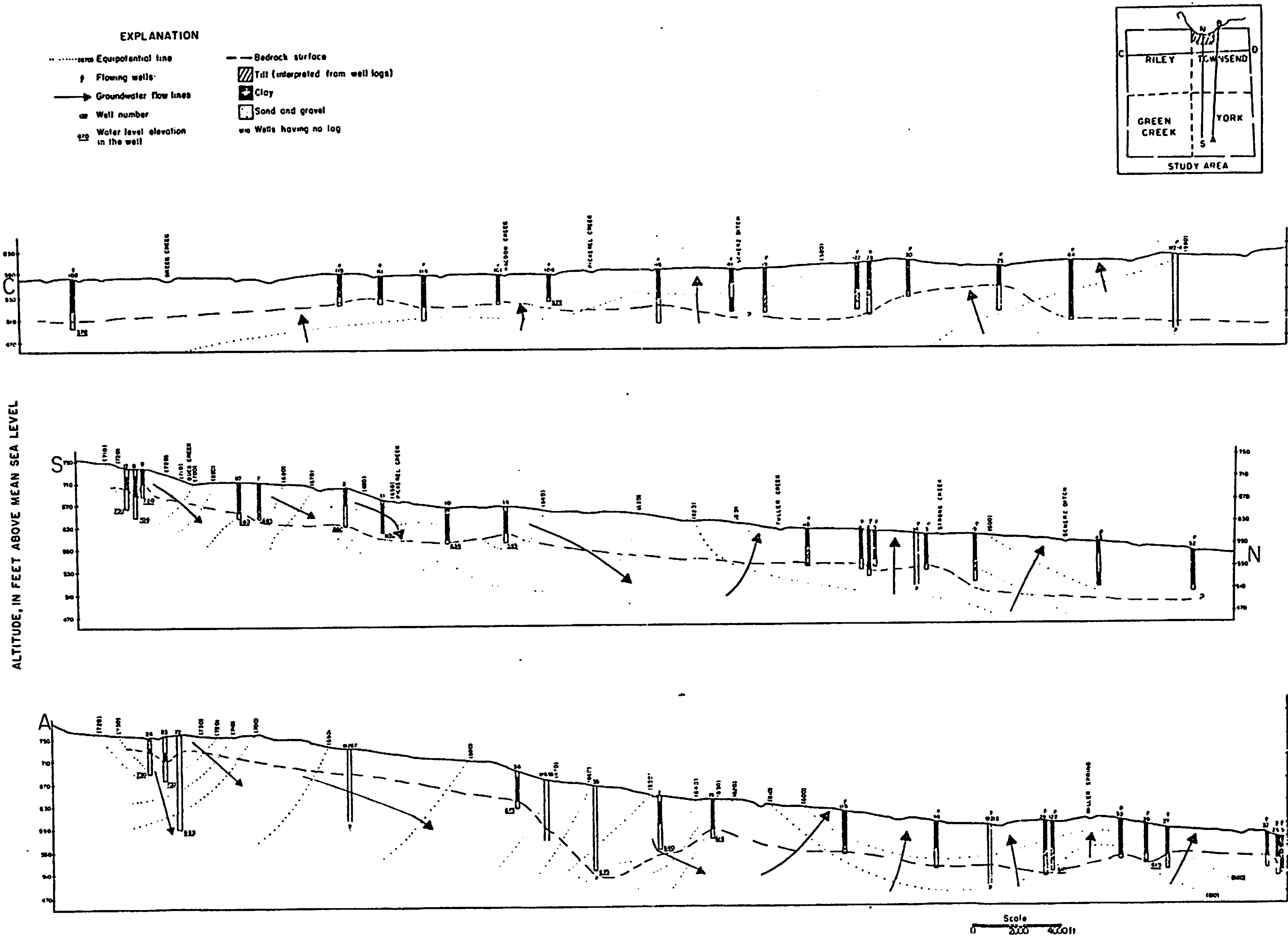


FIGURE 2.5.18. CROSS-SECTIONS SHOWING GROUND-WATER FLOW PATTERNS

The bedrock is the principal aquifer in the area. but wherever sand and gravel deposits intersect the bedrock, they become hydraulically connected and are considered as part of the bedrock aquifer. Information obtained studying well logs in the area indicates that there is about 100 feet of dolomite underlain by another 100 feet of shale and argillaceous dolomite. For this reason, the bedrock aquifer is assumed to be 100 feet in thickness in the general area of the Site. The capacity of the shale beneath and the overlying clay to transmit water is much less than that of the dolomite. Due to the small size of the particles making up the glaciolacustrine deposit and the shale, the ability of water particles to move through the pores between the grains is greatly restricted. Because of the solubility of the dolomite, small interconnected passageways are formed and later enlarged by the movement of water through it. This makes the aquifer extremely variable, depending on the size, extent, and interconnection of these small passageways.

The velocity of groundwater within the aquifer and the permeability of the aquifer is based on the specific capacities of the wells within the area. The method described by Walton (1970) and illustrated in Palombo (1974) was used to determine these parameters. The average velocity has been determined to be 3.9 feet per day, and the average permeability has been calculated to be 360 gallons per day per square foot per foot of head. These values are averages over the Site and therefore may vary over small distances laterally and vertically, due to the nature of flow through the carbonate aquifer.

2.5.2.3 Groundwater Quality

The chemical quality of the groundwater underlying the Site has been determined by chemical analyses by Walton and Schaefer (1956), Ohio Division of Water (1970) and Eagon (1968) to be very hard. This means that the calcium and magnesium concentrations combined are greater than 500 parts per million. The other constituent which causes major problems in regard to drinking, staining, and scaling is the high sulfate ion concentration. Eagon (1968) measured a concentration of 1,253 ppm of sulfate in the surface water of Millers Blue Hole. A complete listing of the chemical analysis of the water is shown in Table 2.5.10.

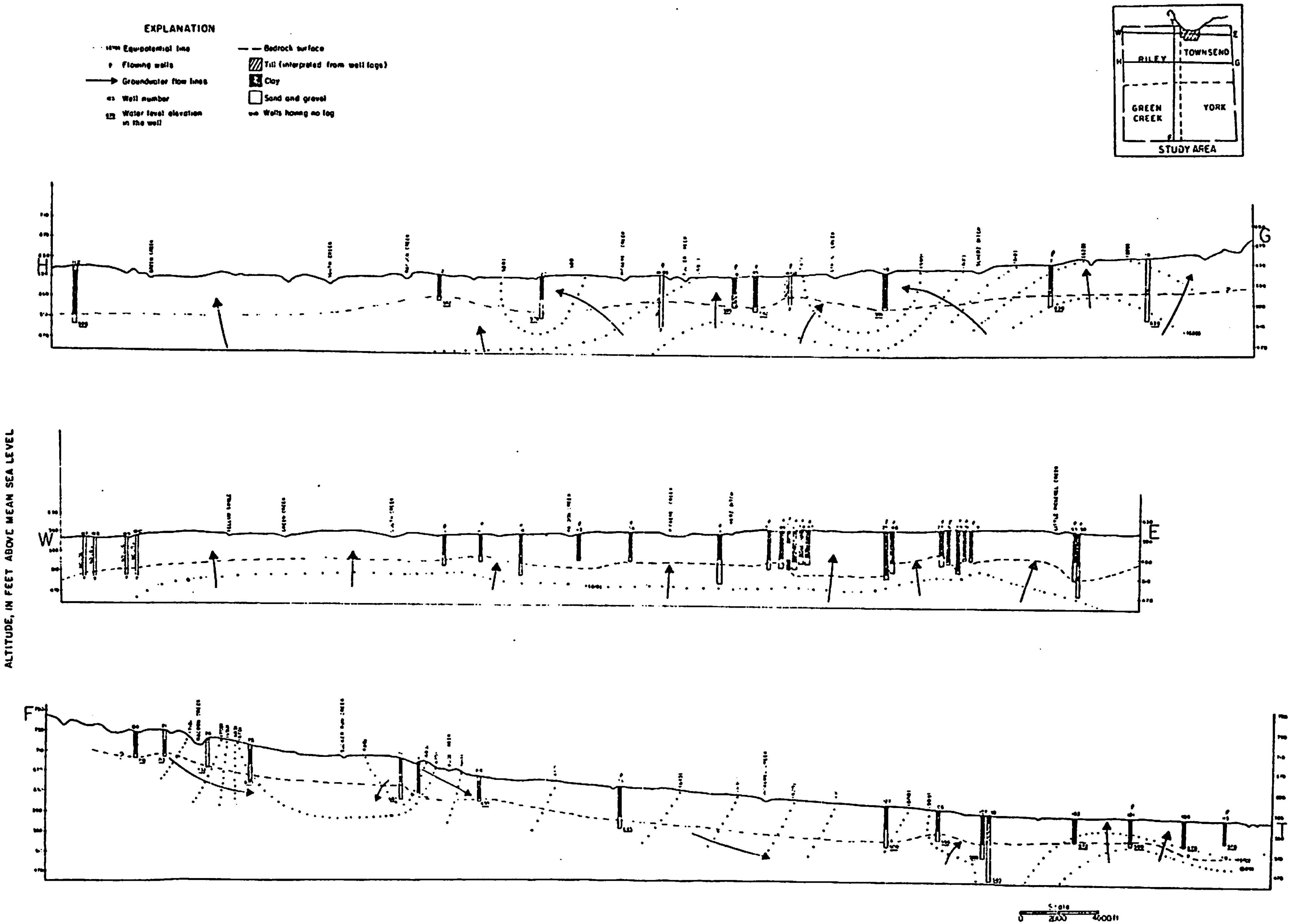


FIGURE 2.5.19. CROSS-SECTIONS SHOWING GROUND-WATER FLOW PATTERNS

Walton and Schaefer (1956) have indicated that a concentration of 3,000 ppm of sulfate may exist in this area. Analyses by the Ohio Division of Water (1970) have substantiated these facts. Also, they indicate that the groundwater in the Site area may contain over three parts per million of hydrogen sulfide gas. The large concentration of all these constituents relates directly to the bedrock. The solution of carbonate rock yields calcium and magnesium, whereas the solution of the sulfate minerals present (anhydrite and celestite, particularly) yield sulfate and more calcium ions.

Dissolved oxygen concentrations were near saturation for the varying temperature regimes throughout the period of study. On several occasions, during the high water temperatures in August and September, the oxygen concentrations exceeded saturation.

pH

The pH of the water mass in the shore/near-shore stations was generally higher than the mid-bay stations. The mean pH for shore and near-shore stations was 7.6, while the mid-bay water was 8.0. The greatest range of pH values (6.7 - 8.4) existed at the mouth of Muddy Creek Bay. Fluctuations in pH at different stations in the western basin did not correlate with either the seasons or specific locality.

The water in Pickerel Creek and Scherz Ditch at Route 6 showed a slightly higher mean pH than the water of the western basin of the Bay. The lowest mean pH was found in the flowing well at Bayshore. pH ranged from 6.4 to 8.0 with a mean of 7.1 at this well. This low value of 7.1 is probably due to the high concentration of carbon dioxide resulting in carbonic acid presence. The Millers Blue Hole stream approximated the flowing well in having a mean pH of 7.4 through a seasonal range of 7.0 - 8.4. The pH of Station 37 (north shore) was comparable with the data from the south shore.

Total Alkalinity

Phenolphthalein alkalinity did not exist during the period of study, thus alkalinity must be attributed to normal carbonate and bicarbonate and not the hydroxide forms. Total alkalinity in the water mass of the mid-bay and shore/near-shore areas showed no appreciable differences. Alkalinity values in the whole western basin showed no correlation with seasonal changes.

TABLE 2.5.10. Chemical Analysis of Millers Blue Hole[a]

Specific Conductance	2550 micromhos
pH	7.4
Temperature	60 degrees
Silica	9.8 ppm
Iron	0.11 ppm
Calcium	560 ppm
Magnesium	44 ppm
Sodium	5.0 ppm
Potassium	1.4 ppm
Bicarbonates	312 ppm
Sulfates	1253 ppm
Chlorides	13 ppm
Fluorides	1.2 ppm
Nitrates	0
Dissolved solids	2194 ppm

(a) Eagon (1968).

Carbon Dioxide

Concentrations of dissolved free carbon dioxide were highest in the groundwater-supplied Bayshore well and the Millers Blue Hole stream. Mean concentrations of 24.2 ppm and 26.4 ppm were recorded for the well and Blue Hole stream, respectively.

Small concentrations of free carbon dioxide were found at all stations in the western basin. The absence of carbon dioxide from the water of the Bay was most prevalent. Free carbon dioxide is quickly consumed by phytoplankters during the daylight period. Bound carbon dioxide, in the form of carbonates and bicarbonates, represents the subsequent reservoir for carbon after free carbon dioxide is removed. Carbon dioxide presence or absence in the western basin can be correlated with the time of day the water is analyzed.

When dissolved carbon dioxide was present, its concentration was generally greater in the mid-bay stations than the shore/near-shore stations.

Biochemical Oxygen Demand (BOD)

BOD determinations were initiated in August, 1973, at selected shore/near-shore and mid-bay stations. Table 2.5.11 summarizes the BOD values for the four-month period. All BOD determinations were performed according to Standard Methods (APHA).

The near-shore and mid-bay areas were in close agreement with each other indicating a rather homogeneous BOD in the bay. Station 37 on the morth shore of the Bay was likewise no different from the mid-bay and south shore. Stations 5 and 6, which are directly in line with the mouth of Pickerel Creek, showed a higher BOD, probably due to the organic loading in the Creek. This organic loading might be the result of: organic material swept into the Creek from the Bay by high water, wind-sheltered characteristics of the Creek which reduce the aeration process, low-gradient between Creek and Bay with temporary periods of stagnation, and the small volume of water.

Total alkalinity was less in the eastern basin as compared to the western basin of Sandusky Bay and probably due to the proximity and influence of Lake Erie water.

Alkalinity was significantly higher in the water of the on-shore stations and especially in the groundwater well at Bayshore and the Millers Blue Hole Stream. The mean of 230 ppm for all on-shore stations compared much higher than 156 ppm and 152.6 ppm for the mid-bay and shore/near-shore areas, respectively. Station 37 was no different from the south shore.

<u>Silicon</u>

The concentration of silicon in the waters of the mid-bay and shore/near-shore areas was approximately the same. Mean silicon concentrations for the mid-bay were 1.8 ppm and 1.2 ppm for the shore/near-shore area.

In the mid-bay transect, silicon concentrations decreased sharply toward the eastern basin. West to east transect values for silicon concentration were 3.2, 3.6, 0.78, 0.75, and 0.70 ppm.

Silicon concentrations generally decreased in the colder months probably due to increasing diatom standing crops. Station 37 did not show any difference in silicon concentration from the south shore area.

<u>Sulfate</u>

Concentrations of sulfate were highest in the groundwater-supplied well at Bayshore and the Millers Blue Hole stream. The seasonal means of 1,183 ppm and 653 ppm for the Bayshore well, and Millers Blue Hole stream, respectively, were considerably higher than the mean of 204.8 ppm and 173 ppm for the shore/near-shore and mid-bay areas. The mid-bay water showed the lowest range of fluctuation and lowest seasonal mean for sulfate concentration. Sulfate concentrations were lower in the central and eastern basins as compared to the western basin of Sandusky Bay.

TABLE 2.5.11

BIO-CHEMICAL OXYGEN DEMAND OF SANDUSKY BAY
(GRID AND TRANSECT)
(ppm)

Stations	Aug 23	Sept 13	Oct 24	Nov 27	Mean
Shore/near-shore					
5	10.5	10.4			10.5
6	9.0	7.3			8.2
8	8.0	4.5			6.3
17	8.0	10.2	4.1	3.9	6.6
19	5.0	6.2			5.6
31	6.0	6.3			6.2
Mid-bay					
33	6.0	8.1	5.7	6.1	6.5
21		7.5	4.1	4.8	5.5
35	6.0	8.4	4.2	3.5	5.5
36	5.0	9.8	6.0	7.4	7.1
38	7.0	10.1	4.1	2.6	6.0
North Shore					
37	3.0	10.5	4.4		6.0

The Lake Erie Pollution Survey of 1953 recorded the mean BOD in the Sandusky River below Fremont at 3.2 ppm. These data indicate greater than a twofold increase in BOD in Sandusky Bay. Whether this increase is the result of eutrophication or increased cultural pollution is not known.

Coliform Bacteria

Total coliform and fecal coliform determinations were also initiated in August, 1973. Determinations were in accordance with Standard Methods (APHA). The specific method was the Millipore technique. Coliform and fecal coliform densities were determined for a few selected stations in the Bay. The data show great variability and it is difficult to characterize. Low fecal coliform values indicate that large quantities of sewage are not entering the Bay in the vicinity of the Site. The continued surveying of this parameter may disclose more significant seasonal trends; the data in Table 2.5.12 represent present baseline information.

2.5.2.4 Nutrient Budgets

Although investigations of nutrient concentrations in Sandusky Bay have not previously been conducted, Baker (1971) examined the relationship between water quality and flow volume in a 60-mile section of the Sandusky River, and Hartley and Potos (1971) determined the seasonal concentration and distribution of nutrients in western Lake Erie. A short discussion of the results of these latter studies is pertinent to the topic of nutrient supplies in Sandusky Bay.

Baker (1971) reported that concentrations of both total phosphorus and soluble orthophosphorus increased as flow volume in the Sandusky River increased. He attributed these increases in phosphorus concentrations to agricultural surface runoff. Nitrate concentrations showed no correlation with flow volume. Values (mg/l) for total phosphorus, soluble orthophosphorus, and nitrate-nitrogen ranged from undetectable to highs of 4.40, 1.20, and 9.00, respectively.

TABLE 2.5.12

COLIFORM AND FECAL COLIFORM OF SANDUSKY BAY
(Near-shore and Mid-bay Stations)
(density/100 ml)

Stations	July		Oct		Nov	
	Coliform	Fecal	Coliform	Fecal	Coliform	Fecal
Near-shore						
17	287	26			350	10
Mid-bay						
33	1,540	233	110	40	1,187	67
21			46	13		
35	10,000	630	6	5	5	0
North Shore						
37	625	12	13	3	42	10

Throughout the spring, summer, and fall soluble phosphorus levels in near-shore areas of western Lake Erie averaged 0.05 mg/1, and more than doubled during the winter season (Hartley and Potas, 1971). Organic nitrogen, which reflects fluctuations in biological productivity was remarkably uniform throughout the lake during all seasons at about 0.300-0.400 mg/l.

Nitrate-nitrogen occurred at concentrations greater than 150 mg/l in winter in the near-shore waters of the western basin. A noticeable drop in the nitrate-nitrogen occurred in spring correlated with high algal populations. Summer and fall were characterized by low concentrations (0.20 mg/l or less) after strong algal uptake in both near-shore and open waters.

The Sandusky River contributes approximately 85 percent of the tributary water inflow to Sandusky Bay. As such, the principal nutrient input to Sandusky Bay from its tributaries comes from the Sandusky River.

Water samples for nutrient analyses were obtained from 4 stations in the western basin of Sandusky Bay and from 5 tributaries to the Bay (see Figure 2.7.12); data are listed in Appendix K. Data for each station within the Bay was pooled to yield an average concentration; these summary data of nutrient concentrations throughout western Sandusky Bay are listed in Table 2.5.13.

Total Phosphorus

Total phosphorus levels in Sandusky Bay ranged from 0.136 mg/l in August to 1.903 mg/l in October, 1973. The average value for the time period covered by these investigations was a 0.472 mg/l. The mean total phosphorus value for the Lake Erie Basin has been reported as 0.153 mg/l (EPA, 1973).

With respect to phosphorus, Sandusky Bay is a "well-nourished" aquatic environment. Total phosphorus concentrations in uncontaminated lake districts range from 0.010 to 0.030 mg/1, many aquatic systems exceed this level with some potable water supplies exceeding 0.200 mg/l total phosphorus.

TABLE 2.5.13. NUTRIENT CONCENTRATIONS IN SANDUSKY BAY

Date	Total Phosphate mg/l	Dissolved Orthophosphate mg/l	NO_3-N mg/l	Org-N mg/l	Org-C mg/l
8-16-73	0.136	0.073	0.13	0.343	18
8-29-73	0.208	0.021	<0.01	0.640	19
9-12-73	0.192	0.087	0.07	0.065	19
9-25-73	0.189	0.050	<0.01	0.390	14
10-10-73	1.758	0.255	0.01	0.196	15
10-24-73	1.903	0.648	0.02	0.238	18
11-7-73	0.198	0.066	0.05	0.175	15
3-20-74	0.645	0.128	4.37	1.266	13
4-3-74	0.404	0.124	3.89	0.999	12
4-17-74	0.405	0.129	3.33	0.959	12
5-1-74	0.226	0.040	3.12	0.851	11
5-15-74	0.237	0.015	1.41	1.390	16
5-29-74	0.212	0.021	0.74	1.204	14
6-12-74	0.189	0.068	0.16	1.137	11
6-25-74	0.174	0.041	0.02	1.187	17

The seasonal trend in total phosphorus concentrations appears to be inversely related to the algal biomass present in Sandusky Bay. To date, primary productivity has been greatest during August, 1973, a period when total phosphorus levels have been lowest. This indicates that phosphorus is removed from the water column due to uptake by algae.

Dissolved Orthophosphate

Dissolved inorganic orthophosphate is that fraction of the total phosphate which can be utilized directly by algae. The biologically mediated transition of orthophosphate to particulate phosphate (organismic bound particulate phosphate) represents the incorporation of orthophosphate by living organisms. When primary productivity and concomitant algal biomass production in Sandusky Bay are high, as in August, orthophosphate concentrations are low. With the onset of fall weather, productivity declines and orthophosphate concentrations increase; concentrations reached a maximum of 0.648 mg/l in late October, 1973. The transition of particulate phosphate back to orthophosphate is the result of several simultaneous processes: (1) the release of orthophosphate from organic compounds, such as dissolved organic phosphorus, which have been broken down by bacteria; the source could be dissolved compounds taken-up from water or obtained from dead cells, organic detritus, or organic colloids, (2) the return of orthophosphate to water from phytoplankton and bacteria as a result of exchange in which inorganic phosphate is continually passing into and out of living cells, and (3) autodephosphorylation of labile organic phosphorus compounds contained in organisms which have died. Thus, seasonal trends in orthophosphate concentrations are strongly linked to biological processes.

The average concentration of dissolved orthophosphate in Sandusky Bay throughout the study period was 0.118 mg/l. This value is approximately twice that concentration of orthophosphate reported for near-shore western Lake Erie water (Hartley and Potos, 1971).

Nitrate-Nitrogen

Concentrations of inorganic nitrogen follow a trend similar to that of total phosphorus and orthrophosphorus in Sandusky Bay. Values have ranged from <0.01 mg/l during late August, 1973, to 4.37 mg/l during March, 1974. Nitrate-nitrogen concentrations have been high during early spring and appear to decrease gradually as summer and increasing biological activity approaches. Average nitrate-nitrogen concentration in Sandusky Bay during the study period, August, 1973, to July, 1974, was 1.16 mg/l.

Comparison of these data with those obtained by Baker (1971) indicates that concentrations of nitrate-nitrogen are much higher in the Sandusky River than in Sandusky Bay. Comparison of data for the Sandusky Bay and western Lake Erie near-shore waters indicates similar concentrations of nitrate-nitrogen in both areas.

Organic Nitrogen

Organic nitrogen concentrations in Sandusky Bay decline with the onset of winter and the rise during spring and early summer, a pattern reflecting fluctuations in biological productivity. Average concentrations of organic nitrogen have ranged from 0.175 to 1.390 mg/l. The seasonal average organic nitrogen concentration during the study period was 0.736 mg/l. This value is about twice that reported for western Lake Erie, which was 0.300 to 0.400 mg/l.

Organic Carbon

Average total organic carbon concentrations in Sandusky Bay have ranged from 11 to 19 mg/l during the study period. Data for total organic carbon concentrations do not indicate a particularly consistent trend of increasing organic carbon concentrations with elevated biological activity, i.e., primary production in Sandusky Bay.

Data for organic carbon levels in Lake Erie are not available, thus negating comparisons with Sandusky Bay.

2.6 METEOROLOGY
(To be prepared by AEPSC)

2.7 ECOLOGY

2.7.1 TERRESTRIAL ECOLOGY

2.7.1.1 Vegetation

Historical Development

The Site lies within a region which historically was dominated by Elm-Ash Swamp Forests (Gordon, 1969). Primarily due to glacial actions and the poor internal drainage inherent in the lacustrine clay of the region, wet prairies and marshes were commonly the initial state in vegetational succession. With the gradual development of natural drainage in some areas, the elm-ash-soft maple type of swamp forest succeeded the marshes and wet prairies. The dominant species in this association were American elm (*Ulmus americana*), black and/or white ash (*Fraxinus nigra* and *F. americana*), and silver and/or red maple (*Acer saccharinum* and *A. rubrum*). In extremely wet phases, sycamore (*Platanus occidentalis*) and cottonwood (*Populus deltoides*) were more commonly the dominants. Additionally, a number of other species such as pin oak, swamp white oak, black willow and others, exhibited less dominance within the association. In a 1930 publication, H. C. Sampson (1930) discussed the swamp forests in terms of successional phases, the initial phase being the elm-ash-soft maple, followed by a "swamp-oak-hickory" phase in which the dominant species became shellbark hickory (*Carya laciniosa*), bur oak (*Quercus macrocarpa*), and white ash (*Fraxinus americana*).

American elm maintains a relatively high level of importance (see Section 6.1.4) in this association today also, but it has decreased markedly in importance due to the Dutch elm disease attack of the last few decades. Further succession within the swamp oak-hickory association brought about an increasing number of species important in the association. Sampson (1930) described this stage as Phase III in the successional scheme of the swamp forest. The wooded areas of the Site are generally undergoing this third phase of succession. The species making up the swamp forests of this phase generally include red elm, basswood, cherry, mulberry, shagbark hickory, dogwood, red oak, bitternut hickory, hop hornbeam, green ash, blue ash, red ash, Kentucky coffeetree, and mockernut hickory (Sampson, 1930). Several species from earlier phases retain an important position in the association. Variations occur in both abundance and occurrence of these species between different woodlots on the Site. This variation is evident in the statistical data in Appendix E.

Present Conditions

In general, the wooded areas of the Site are characteristic of Sampson's (1930) Phase III successional order. The elm-ash-maple forest type is probably climax on the wettest areas (U.S.D.A. Forest Service Handbook 445, 1973). The fourth and final phase of succession results in a climax forest of American beech (*Fagus grandifolia*) and sugar maple *Acer saccharum*). Within the immediate region of the Site, the beech-maple climax association is uncommon. This is primarily due to the heavy lacustrine soils and lack of sufficient drainage. Within the Site, tree species composition undergoes fluctuations in abundances of species, but it is unlikely that the beech-maple climax association would ever fully develop.

The vegetational structure of the Site is greatly varied in its composition. The two major types of vegetational associations are those found in woodlots and agricultural lands. Additionally, there exist areas less dominant in acreage yet of significance to the Site ecosystem. These areas include roadsides, fencerows, oldfields, and marsh areas. Distribution of these areas on the Site is depicted on Figure 2.7.1. These associations vary compositionally between types (i.e., woodlots versus marsh), but generally they are similar within any given type.

Woodlots. The wooded areas of the Site are composed of species characteristically found in the region. No unique or unusual species have been found. The tree species consistently high in importance are green and white ash (*Fraxinus pennsylvanica*, *F. americana*); silver maple (*Acer saccharinum*); pin, bur, swamp white and red oaks (*Quercus palustris*, *Q. macrocarpa*, *Q. bicolor*, and *Q. rubra*, respectively); red elm (*Ulmus rubra*); and shagbark hickory (*Carya ovata*) (see Appendix E).

The general numerical trends of species occurrence in any given woodlot are listed in Table 2.7.1. Variations occurring between woodlots reflect both natural and artificial influences on the vegetation. Natural influences include such actions as fire, flooding, and high water tables,

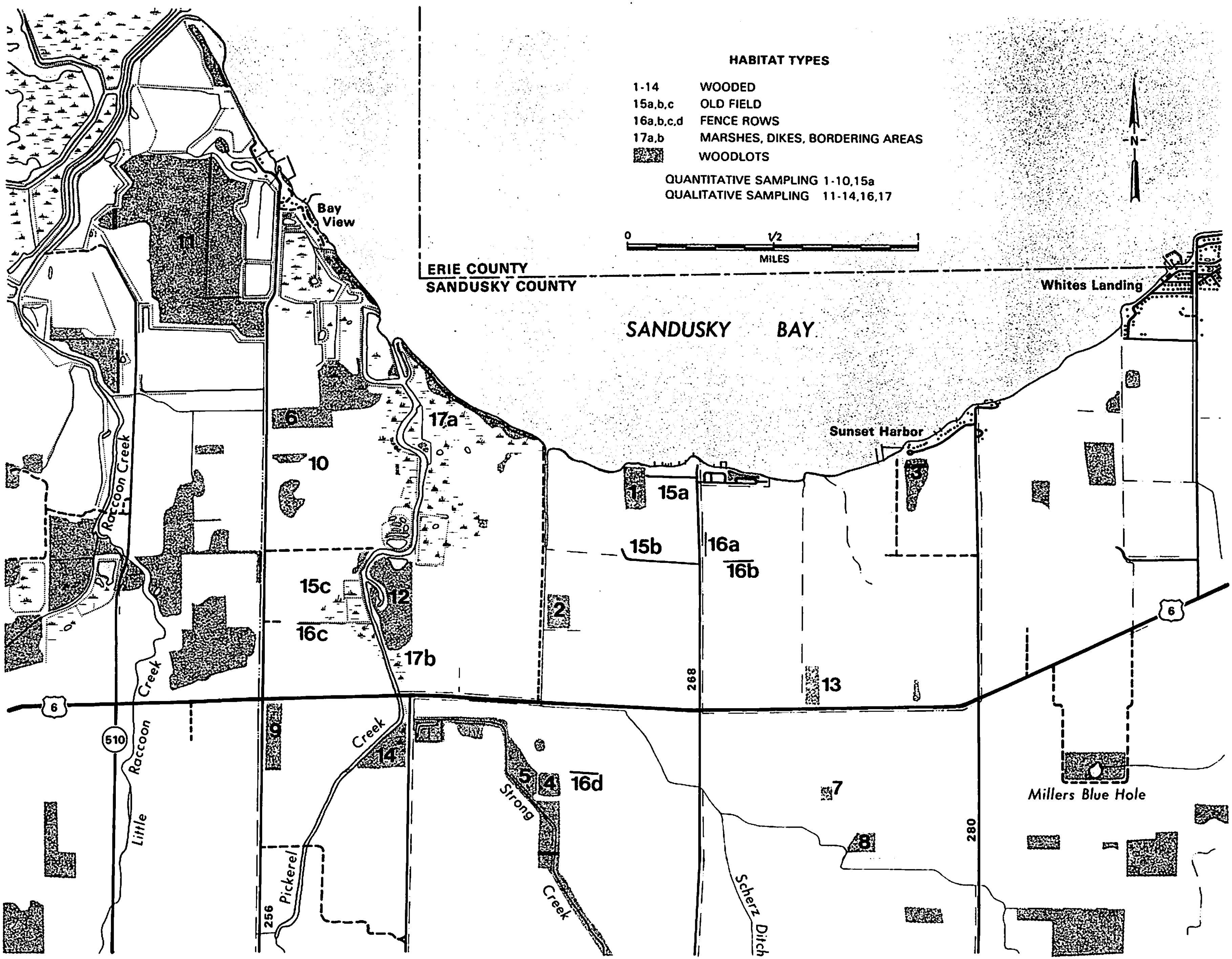


FIGURE 2.7.1 VEGETATIONAL STUDY AREAS OF THE SITE

TABLE 2.7.1. OCCURRENCE OF WOODY VEGETATION

Species Latin Name	Common Name	Habitats* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15a	16a,b,c,d	17
CANOPY:																		
<u>Acer negundo</u>	Boxelder		+	+		+						+						+
<u>Acer saccharinum</u>	Silver maple	+	+	+								+	+	+	+		+	+
<u>Acer saccharum</u>	Sugar maple								+			+						
<u>Carya cordiformis</u>	Bitternut hickory							+	+									
<u>Carya ovata</u>	Shagbark hickory		+	+	+		+	+	+	+	+	+	+		+			+
<u>Celtis occidentalis</u>	Hackberry						+		+									
<u>Fraxinus americana</u>	White ash	+	+	+	+	+	+	+	+	+	+	+			+			+
<u>Fraxinus nigra</u>	Black ash	+	+	+														
<u>Fraxinus pennsylvanica</u>	Green ash	+	+	+	+	+	+	+	+	+	+	+	+		+		+	+
<u>Fraxinus quadrangulata</u>	Blue ash	+																
<u>Gleditsia triacanthos</u>	Honey locust					+						+						+
<u>Juglans nigra</u>	Black walnut				+	+			+				+		+			
<u>Malus</u> sp.	Apple													+				
<u>Morus</u> spp.	Mulberry	+						+	+			+					+	
<u>Platanus occidentalis</u>	Sycamore											+						+
<u>Populus deltoides</u>	Cottonwood											+						+
<u>Prunus serotina</u>	Black cherry		+				+			+	+						+	
<u>Quercus bicolor</u>	Swamp white oak			+	+			+	+			+	+					+
<u>Quercus macrocarpa</u>	Bur oak	+			+		+		+	+	+		+		+			
<u>Quercus palustris</u>	Pin oak		+	+	+			+				+	+		+			
<u>Quercus prinus</u>	Chestnut oak	+							+		+							
<u>Quercus rubra</u>	Northern red oak	+	+	+	+		+		+		+		+					
<u>Robinia pseudoacacia</u>	Black locust	+						+	+	+								
<u>Salix nigra</u>	Black willow											+			+			+
<u>Tilia americana</u>	American basswood			+					+									
<u>Ulmus rubra</u>	Red elm	+	+	+		+	+	+	+	+	+	+		+	+		+	+
UNDERSTORY:																		
<u>Amelanchier arborea</u>	Shadbush	+						+	+	+								
<u>Cephalanthus occidentalis</u>	Buttonbush														+			
<u>Cornus</u> spp.	Dogwood	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+
<u>Crataegus</u> spp.	Hawthorn	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+
<u>Corylus americanus</u>	American hazelnut		+															
<u>Euonymus atropurpureus</u>	Eastern wahoo	+																
<u>Rhus</u> spp.	Sumac		+	+											+		+	+
<u>Sambucus canadensis</u>	Elderberry								+	+					+			+
<u>Vitis</u> spp.	Grape	+	+	+		+	+	+				+			+		+	+

* Habitats 1 through 14 are wooded areas; 15a is the old field study area; 16a,b,c,d are fencerow areas; and 17 encompasses dikes and areas bordering marshes.

all of which influence the establishment and succession of the various species of the system. Artificial influences are generally those which have been in some way created by man. These include the clearing of land for agriculture, the altering of water tables through tile drainage, logging, use of fertilizers and herbicides, and the introduction of live-stock grazing. Pre-existing environmental stresses are described in greater detail later in this section. The effects of both natural and artificial influences are greatly varied and may have included the total destruction of a woodlot, the loss of a single species, the loss of tree seedling establish-ment, or numerous other effects.

As previously mentioned, there are certain species which were expected and subsequently found to be generally uniform within the system. Statistical sampling (Appendix E) yielded quantitative data on the woodlots which reflected both the natural and artificial influences, as well as the natural succession expected. Quantitative amounts of timber per acre are best represented by the calculating of standing timber. Standing timber was determined by species for each woodlot habitat (Appendix E). The total standing timber in each woodlot habitat is as follows:

Standing Timber (ft^2/acre)

Habitat	Ft^2/acre	Habitat	Ft^2/acre
1	139.0	6	212.7
2	294.9	7	354.3
3	219.7	8	61.5
4	109.8	9	24.0
5	128.4	10	136.0

In addition to providing a rough estimate of the amount of wood per acre presently in a given woodlot, these data provide insight into the maturity of any given woodlot. Woodlot Number 9 (Figure 2.7.1), for example, was very low in total standing crop in comparison to others. Even though numerous individuals existed in the sample area, those species statistically dominant in this system were extremely low in total number of individuals larger than 3 inches (Appendix E). Thus, the total standing crop was very low. In this instance, logging which probably took place within the last

10 to 15 years was responsible. Presently, the majority of trees in this woodlot are sprouted from the stumps of former trees.

Herbaceous vegetation in the woodlots is also affected by natural and artificial pressures; but, with the exception of extreme cases such as flooding of a woodlot, it generally does not reflect these pressures to the degree which the woody vegetation does. The occurrence of herbaceous species in various woodlot habitats of the Site is documented in Table 2.7.2.

Marsh. Marsh areas on the Site are an important habitat to many important animal species. They cover a large portion of the western half of the Site and, due to high water levels in recent years, have increased in area. Fluctuations in water level, as well as depth of water, play an important role in establishment and maintenance of marsh plants. On the Site, many areas formerly cultivated are now being colonized by marsh species due to high water. Although there has been a net increase in marsh area, many areas formerly inhabited by marsh plants and animals have now succumbed from water too deep for plant establishment and growth. Species found in the marsh habitat are listed in Table 2.7.2. The dominant herbaceous species are cattails (Typha spp.), knotweeds (Polygonum spp.), and rushes and sedges (Cyperaceae). Woody species generally found on the borders of marsh areas are listed in Table 2.7.2.

Dikes. Dikes and areas bordering the marsh areas are generally colonized by grasses and sedges and the more water-tolerant woody species. The dikes commonly become inhabited with dense growths of scrubby dogwood species (Cornus racemosa, C. drummondi, and C. stolonifera). If left undisturbed, later successional stages are marked by the invasion of tree species such as cottonwoods and willows. The results of a detailed analysis of these areas are listed in Table 2.7.2.

Edges. Fencerows and roadsides are two habitat types which are greatly similar in factors influencing the habitat and species composition. Both habitats tend to be drier, more exposed, generally lacking a tall, dense canopy and often subject to grazing, mowing, herbicides, pesticides, and salt run-offs. Fencerow habitats are important to many animals, as shelter and food sources. The compositional makeup of these areas is

TABLE 2.7.2. OCCURRENCE OF HERBACEOUS VEGETATION

Latin Name	Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15a	16a,b,c,d	17	Roadsides
		Habitats*																	
Actaea sp.	Baneberry								+										
Allium canadense	Wild garlic					+										+	+		+
Allium stellatum	Wild onion					+	+												
Allium vineale	Field garlic															+			+
Ambrosia sp.	Ragweed															+	+		+
Anemone canadensis	Canada anemone											+							+
Anemonella thalictroides	Rue anemone								+										
Arenaria lateriflora	Grove sandwort						+												
Arisarma atrorubens	Jack-in-a-pulpit		+		+		+		+			+							
Arisaema dracontium	Green dragon						+												
Asarum canadense	Wild ginger								+				+		+				
Asclepias sp.	Milkweed													+			+		+
Asparagus officinalis	Wild asparagus																+		
Barbarea vulgaris	Wintercress	+									+		+	+	+	+			+
Brassica kaber	Charlock															+	+		
Capsella bursa-pastoris	Shepherd's purse															+	+		
Cardomine bulbosa	Springcress											+					+		
Cardamine pensylvanica	Pennsylvania bittercress											+					+		+
Cerastium arvense	Field chickweed										+		+						+
Cerastium vulgatum	Mouse-eared chickweed						+									+			
Cichorium intybus	Chicory													+			+		+
Cimicifuga racemosa	Black cohosh		+						+										
Claytonia virginica	Spring beauty	+			+		+				+								
Compositae	Thistle													+		+	+		+
Cryptotaenia canadensis	Spreading chervil		+	+															
Cyperaceae	Sedges	+	+	+	+		+				+		+	+	+			+	+
Daucus carota	Queen Anne's lace															+	+		+
Dipsacus sylvestris	Teasel													+			+		+

TABLE 2.7.2 (Continued)

Latin Name	Common Name	Habitats*																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15a	16a,b,c,d	17	Roadside
Eleocharis acicularis	Slender spike rush																	+	
Eleocharis sp.	Spike rush	+																	
Erigeron annuus	Daisy fleabane				+	+									+	+	+		+
Erythronium americanum	Trout lily						+				+								
Fragaria sp.	Wild strawberry	+				+	+						+	+			+		+
Galium aparine	Common cleavers	+	+		+	+	+	+	+	+	+	+	+	+	+		+		
Galium sp.	Bedstraw						+	+	+			+							
Geranium maculatum	Wild geranium	+	+	+	+		+	+	+	+	+		+		+		+		+
Geum sp.	Avens	+	+			+	+		+								+		
Glechoma hederacea	Ground ivy															+	+		+
Hepatica acutiloba	Sharp lobed hepatica								+										
Hydrophyllum virginianum	Virginia waterleaf		+		+		+		+						+				
Impatiens capensis	Jewelweed	+	+	+			+	+	+		+				+				
Ipomea sp.	Morning glory																+		
Iris sp.	Iris																	+	
Lepidium virginicum	Field peppergrass													+		+			
Lonicera sp.	Honeysuckle														+				
Onoclea sensibilis	Sensitive fern		+				+	+	+			+							
Osmorhiza longystylis	Anise root							+	+										
Oxalis sp.	Wood sorrel																+		+
Parthenocissus quniquefolia	Virginia creeper	+	+	+			+	+		+	+	+			+		+		
Pastinaca sativa	Parsnip																+		
Phlox divaricata	Blue phlox				+				+						+				
Phytolacca americana	Pokeweed																+		+
Plantago sp.	Plantain				+									+		+	+		+
Poaceae	Grasses	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Podophyllum peltatum	May-apple	+					+		+	+									

TABLE 2.7.2 (Continued)

Latin Name	Common Name	Habitats*																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15a	16a,b,c,d	17	Roadside
Polygonum sp.	Knotweed																	+	+
Potentilla sp.	Cinquefoil										+		+						
Ranunculus abortivus	Kidney-leaved buttercup	+			+				+				+						
Ranunculus acris	Common buttercup		+	+				+	+	+	+				+				
Ribes spp.	Currants	+	+				+	+											
Rhus radicans	Poison ivy	+	+	+		+	+	+	+	+	+	+		+	+	+	+		+
Rosa sp.	Wild rose					+													
Rumex crispus	Curled dock															+	+		+
Sagittaria sp.	Arrowhead																	+	+
Sanicula sp.	Snakeroot		+			+	+												
Scirpus validus	Softstem bull rush																	+	
Smilacina racemosa	False Solomon's Seal								+										
Smilacina stellata	Starry False Soloman's Seal								+										
Smilax sp.	Smilax	+	+			+	+		+	+	+			+					
Solidago sp.	Goldenrod	+		+						+				+		+	+		+
Sparganium sp.	Burreed																	+	
Stellaria graminea	Lesser stitchwort										+								
Stellaria media	Common chickweed	+			+									+			+		
Taraxacum officinale	Dandelion				+								+	+		+	+		+
Thalictrum dioicum	Early meadow-rue						+												
Thalictrum polygamum	Tall meadow-rue												+		+				
Thaspium trifoliatum	Meadow parsnip		+				+		+				+						+
Thlaspi arvense	Field pennycress													+		+	+		+
Trifolium spp.	Clovers				+							+		+		+	+		+
Trillium flexipes	Drooping trillium								+										
Triosteum perfoliatum	Feverwort								+										
Typha spp.	Cat-tails							+					+		+				+
Urtica sp.	Nettles		+	+				+	+								+		

TABLE 2.7.2 (Continued)

Latin Name	Common Name	Habitats* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15a	16a,b,c,d	17	Roadside
Valerianella alitoria	Corn salad		+																
Viola latiuscula	Broad leaved wood violet						+												
Viola papilionaceae	Common blue violet	+	+	+	+	+	+	+	+	+	+		+		+	+			
Vitis sp.	Wild grapevine			+	+		+										+		

* Habitats 1 through 14 are wooded areas; 15a is the old field study area; 16a,b,c,d are fencerow areas; and 17 encompasses marsh areas. These habitat numbers match those on Figure 2.7.1.

listed in Table 2.7.1, for the woody component and Table 2.7.2 for the herbaceous component.

Roadsides are usually dominated by grasses, as they can survive frequent mowing and most other herbaceous species cannot. On the Site, most roadsides have a water-filled ditch associated with them, which is commonly inhabited by species of more marshy areas (e.g., cattails). This has increased the amount of habitat available to many animals associated with marsh habitats. The species composition of roadsides is also listed in Table 2.7.2.

Oldfields. Oldfields are limited in occurrence on the Site. The value of the land for agricultural use is high, and generally all tillable land is actively being cultivated. One area, removed from cultivation, was studied and the vegetation composition is found on Table 2.7.2. In addition several areas were artificially (mechanically) denuded to determine early recovery stages and speed of replacement of ground cover (see Section 6.1.4.3 for methods). The field is representative of the Site, and the species of Table 2.7.2 have the potential to occur in any other field in which cultivation is halted. Seasonal net productivity for this field is found on Table 2.7.3. These data are part of an ongoing study which will be completed at the end of the present growing season (1974). At the present time the data acquired are not sufficient for detailed analysis. It should be noted that no older "oldfields", those where shrubs or small trees are present, were found in the area. These areas were, therefore, not studied though it is possible to make some assumptions regarding these stages based on the vegetational composition of fencerows on the property which are, in many respects, linear oldfields.

Oldfield successional patterns as described below would be anticipated in areas where vegetational cover is removed and/or the soil disturbed to approximately the depth of the plow layer. This discussion is also indicative of succession only on the better-drained (standing surface water limited to only a brief time) soils of the Site. The natural revegetation patterns of subsoil are not described though it would be anticipated that similar species would be expected though at a slower rate of cover development. Within the first full or major partial growing season

TABLE 2.7.3 OLDFIELD PRODUCTIVITY

Species		Average Dry Weight[a] (lbs/acre)	
Latin Name	Common Name	9/18/73	5/30/74
Allium sp.	Onion	3.6	121.5
Ambrosia sp.	Ragweed	199.7	16.7
Asclepias sp.	Milkweed	.6	--
Cyperaceae	Sedges	79.2	--
Daucus carota	Queen Anne's Lace	--	16.7
Desmodium sp.	Beggar's Lice	8.9	--
Glechoma lederacea	Spreading Chervil	--	1.2
Labiatae	Mints	31.8	--
Plantago sp.	Plantain	7.4	--
Gramineae	Grasses	921.3	14.3
Polygonum sp.	Knotweed	37.5	--
Rumex crispus	Curled Dock	--	10.7
Trifolium spp.	Clover	427.7	5121.0
Unknown	--	2.4	31.0
Dead Material	--	745.9	88.1
TOTAL		2466.1	5421.2

(a) Averages were calculated from data in Appendix E.

following abandonment, a ground cover of from 25 to 40 percent developed dominant species included several grasses, clovers, crucifers (Cruciferae), curled dock (Rumex crispus), Queen Anne's lace (Daucus carota), field garlic (Allium vineale), ragweed (Ambrosia sp.), and other minor contributors (Table 2.7.2). These species are among those whose seeds are widely dispersed and omnipresent but which develop only where shading of the canopy is eliminated or where the control of herbicides is eliminated.

In the second year following abandonment a complete or near complete ground cover was established (85 percent or higher). Species composition remained similar with some increases in aspect dominance by red and white clover (Trifolium spp.), Queen Anne's lace, ragweed, and curled dock. The oldfield on-site (No. 15a on Figure 2.7.1) which was used for salt spray effects studies and revegetation studies was in this stage. Through the next few growing seasons (3 to 7+ years) the field will vary in aspect dominance from curled dock to red clover to ragweed and goldenrod (Solidago sp.), though all species will probably remain present in significant quantities. As the oldfield matures, goldenrod, daisy fleabane (Erigeron annuus), thistles (Compositae), milkweeds (Asclepias spp.), and teasels (Dipsacus sylvestris) will probably begin to become aspect dominant. These same species (above) remain important in fencerow and older roadside areas as well as around abandoned homesites and orchards or in other areas where the tree canopy is open. Additional associated species which may be locally abundant include: chickweed (Cerastium arvense and C. vulgatum), bedstraw (Gallium sp.), pokeweek (Phytolacca americana), and chicory (Chichorum intybus).

Trees and shrubs become introduced into this successional pattern at virtually any stages after the first several years. The tree seedlings generally first become established adjacent to existing woodlands. This is especially true of heavy seeded varieties which are not commonly eaten by birds. Initial colonization by woody species will involve hawthorn (Crataegus sp.), dogwoods (Cornus spp.), and wild cherry (Prunus sp.). Other species such as the oaks or hickories from the adjacent woodlands may also become established in immediately adjacent oldfield areas.

However, following complete clearcutting in this region, a grass-shrub-herb stage can result which may last for decades (U.S. Forest Service Handbook 445, 1973).

Semi-permanently flooded oldfields or abandoned areas on the Site will first be invaded by cattails. Establishment of a complete ground cover may take several years in any other than optimum conditions. Such areas usually remain a monospecific habitat for many years provided water levels remain relatively stable. In wetter locations where the soil may be dry for greater than half of the year, species such as burreed (*Sparganium* sp.), spikerush (*Eleocharis* sp.) or one of several species of sedge (Cyperaceae) may become established. A very thick ground cover is not unusual. While multispecies habitats are not unusual, a monospecific aspect of one of the above is characteristic.

Preexisting Environmental Stresses

At the present time much of the Site is undergoing natural stress from high water conditions. In most affected areas of the Site, permanent high water conditions have been present for approximately 3 years. Although water levels have fluctuated over this period, inundation has still been relatively constant. The woody areas of the Site where the ground surface is totally inundated include all woodlots, except Numbers 7, 8, 5, 13, 10, and 6; and most of these have at least part of their area subject to standing water (see Figure 2.7.1).

Studies done by Yeager (1949) on the effects of flooding on woodlots indicate that mortality occurs at the same rate, regardless of tree size or depth of water. Some decrease in the rate of mortality was found to occur in a few species where the inundation was not total and the soil became muddy. It should be noted, however, that with many species temporary flooding can greatly increase diameter growth (Broadfoot and Williston, 1973). But after permanent inundation, Yeager (1949) found mortality approached 100 percent within 6 years. Within 3 years of inundation over 50 percent of most species had succumbed.

Of the most common species occurring on the Site, white and green ash are the most likely to survive the flooding in any great numbers.

Initially the effects of flooding are not readily detectable in the overall appearance of a species, but, with time, symptoms of stress due to high water do appear. The visible symptoms include decreased shoot growth, leaf chlorosis, downward curling of leaves, leaf abscission, absence of fruiting, and branch dieback (Broadfoot and Williston, 1973). Some of these symptoms have been noted in various areas on the Site, and some tree mortality due, most probably, to high water has occurred. The extent to which the flooding will result in additional tree mortality is not certain. Periodic decreases in the flooding in the last three years may extend the life of the trees. However, with water conditions as at present, even though an inundated species may continue to flower and fruit before dying, establishment of seedlings is highly unlikely even for those species common to wet habitats (i.e. cottonwoods). It is quite probable that within the next year the long-term effects of the flooding will begin to appear, and they could be quite extensive. In addition, windthrow may result in loss of many trees weakened but not yet killed by flooding.

High water levels can also be detrimental to marsh habitats. Cattails, rushes, and other typical marsh species generally do not survive increases in water depth that have been occurring on the Site. The establishment of these species in the newly flooded areas is a gradual process often requiring a number of years. In the marsh areas of the Site the loss of areas formerly inhabited by marsh species has been generally coincidental with the establishment of new marsh areas. However, this type of shift tends to stress the balance of the marsh system for a short period, which in turn stresses those animals dependent on this habitat. Decreases in relative amounts of vegetation can have wide-ranging effects. Cattails alone are an important component in the system upon which muskrats, fish, insects, ducks, and many other organisms are dependent. Therefore, changes in vegetation can directly influence the entire system.

Disease problems and insect infestations at present do not appear to be abnormal for this area. However, with the weakening of the trees due to the high water, it is possible that disease and insects may add to the net mortality. Historically, Dutch elm disease totally removed American elm from an extremely important role in the association. Where it had commonly been the most dominant tree in an association it is now entirely absent.

2.7.1.2 Wildlife

Mammals

Present Conditions. As many as 39 species of wild mammals could be found on the Site out of 43 species whose geographical ranges include the Site. Of the 39 species, 16 have been observed on the Site along with 5 species of domestic livestock. Animals that one might expect to find on the Site are listed in Appendix F.

Several important species of mammals are found on the Site. These are animals that are rare or endangered, are of commercial and recreational value, or are critical to the structure and function of the ecosystem.

Only one rare or endangered mammal, the Indiana bat (*Myotis sodalis*), has a range that includes the Site, but it has not been observed in the area and is not expected to be present. In the winter, it is found in association with limestone caves (U.S. Department of Interior, 1973) none of which are known to exist in the local area. In the summer, the Indiana bat may be found in abandoned buildings or hollow trees (Burt and Grossenheider, 1964).

Mammals of commercial or recreational value which inhabit the Site include white-tailed deer, muskrat, mink, gray fox, red fox, fox squirrel, and Eastern cottontail. Muskrat, mink, and fox are trapped for their commercial value while the squirrel and rabbit are of recreational value through hunting. Deer hunting, which is of great economic and recreational value in many areas, is prohibited in Sandusky County and has been allowed only once (1971) in recent years. Deer are considered important here for their aesthetic value and the potential recreational value if hunting is allowed in the future. Food habits of the mammals observed on the Site are summarized in Table 2.7.4.

Muskrat. The muskrat is the mammal with the greatest commercial value in the local area (excluding livestock). Muskrats are common in the marshes, streams, and ditches and often in woodlots with standing water. Based on interviews with local residents, it is estimated that approximately 800 muskrats were harvested from the Site during the winter of 1973-74. During this season muskrat pelts sold for about $2.50 each (Trabue, 1974); this resulted in a yield of approximately $2,000 from the Site. Muskrat

TABLE 2.7.4 FOOD HABITS OF AMPHIBIANS, REPTILES AND MAMMALS OBSERVED ON THE SITE

Species \ Food	Fungi	Sedges, Grasses	Burreed Cattail	Soybeans	Wheat	Corn	Seeds	Nuts	Fleshy Fruits	Hawthorn	Grapes	Apples	Bark	Browse	Snails	Crayfish	Spiders	Insects	Fish	Toads, Frogs	Snakes	Birds	Bird Eggs	Shrews	Muskrat	Mice	Rabbit	Carrion
Northern Leopard Frog *Rana pipiens pipiens*																	•	•										
Bullfrog *Rana catesbeiana*															•	•	•	•	•	•						•		
Fowler's Toad *Bufo woodhousei fowleri*																	•	•										
Eastern Box Turtle *Terrapene carolina carolina*	•								•		•	•						•										
Midland Painted Turtle *Chrysemys picta picta*		•													•	•		•										
Eastern Garter Snake *Thamnophis sirtalis sirtalis*																		•	•	•						•		
Eastern Fox Snake *Elaphe vulpina gloydi*																				•		•	•	•		•		
Northern Water Snake *Natrix sipedon sipedon*																			•	•		•	•	•				
Opossum *Didelphis marsupialis*						•		•	•		•	•				•	•	•		•	•	•	•	•				•
Short-tailed Shrew *Blarina brevicauda*															•		•	•		•						•		
Raccoon *Procyon lotor*					•	•		•	•	•	•					•	•	•		•	•		•					•
Gray Fox *Urocyon cinereoargenteus*									•	•	•	•						•		•	•	•	•	•	•	•	•	
Red Fox *Vulpes fulva*									•	•	•	•						•		•	•	•	•	•	•	•	•	
Mink *Mustela vison*																•			•	•		•	•	•	•	•		
Striped Skunk *Mephitis mephitis*									•	•	•	•			•	•		•		•	•	•	•	•		•		•
Fox Squirrel *Sciurus niger*	•			•		•	•	•	•	•	•	•										•	•					
Woodchuck *Marmota monax*		•		•	•																							
White-footed Mouse *Peromyscus leucopus*						•	•	•	•	•					•		•	•										
Meadow vole *Microtus pennsylvanicus*		•			•	•	•					•						•										
Muskrat *Ondatra zibethica*		•	•			•							•			•												
House Mouse *Mus musculus*		•					•	•	•	•	•	•					•	•										
Meadow Jumping Mouse *Zapus hudsonius*					•		•		•	•							•	•										
Eastern Cottontail *Sylvilagus floridanus*		•		•		•				•			•	•														
White-tailed Deer *Odocoileus virginianus*	•	•		•	•	•		•		•		•		•														

* Table compiled from Burt, 1957, Bruggers, 1973; Burt and Grossenheider, 1964; Conant, 1958; and Martin et al., 1951.

populations fluctuate widely from year to year due to natural population cycles, disease, water level variation, vegetation quality in the marshes, predation, trapping, and other influences. Bednarick (1953) reported that the number of muskrats trapped in Magee Marsh (approximately 15 miles northwest of the Site) ranged from 803 to 19,334 during the period 1940 to 1952.

Muskrats on the Site are found primarily along Pickerel Creek, diked areas, and the marshes to the west (Figure 2.7.2). With the increased lake level in recent years, the muskrats have moved out into low lying fields near the streams and into some of the woodlots. Constant flooding has caused the decline of cattails along the creek and an extension of their range into adjacent low lying areas. This has resulted in muskrats, which feed heavily on cattails, emigrating into these new areas. Some poorly maintained dikes have collapsed around muskrat burrows partly as a result of high water.

Mink. A few mink are present on the Site and are confined primarily to the streams, marshes, and woodlots on the west side of the property. Mink are carnivores, preying heavily on the muskrats, frogs, and fish in the area. Mink are sometimes taken in traps set for muskrats, but usually in traps set specifically for mink. Pelts were sold for about $11.00 each in 1973-74 (Trabue, 1974). Mink may utilize muskrat burrows along banks or dig their own; they often range over several miles in search of food.

Fox. Both red and grey foxes occur on the Site with the red being the more common. A few fox are trapped each year on the Site; at least two red and one gray were taken during 1972-73 (R. Gowitzka, Personal Communication). Foxes often utilize woodchuck burrows and other abandoned dens. Red fox are usually found in open areas interspersed with woodlots and fencerows while gray fox are associated with woodlots. Foxes feed primarily on mice, rats, shrews, and other small mammals, but they also eat reptiles, amphibians, insects, fruits, and berries. They may travel as much as five miles daily and have a home range of 5-10 square miles.

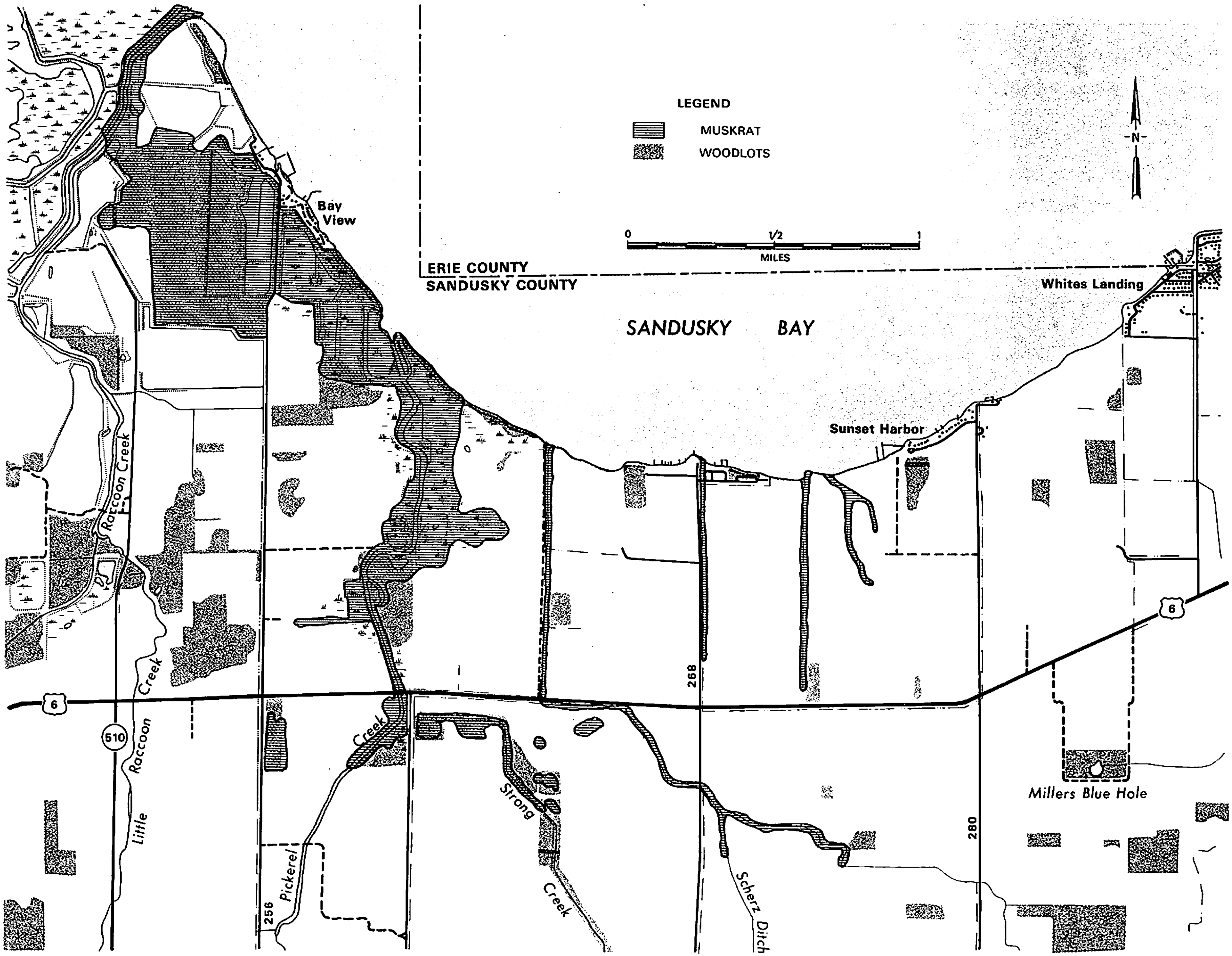


FIGURE 2.7.2 AREAS OF MUSKRAT USE

Deer. White-tailed deer are generally found on the western part of the Site where cover is more abundant (Figure 2.7.3). All woodlots are utilized by deer to some extent, with the woods along Pickerel Creek and in the northwest corner receiving the most intensive use. Townsend Township, which includes the portion of the Site east of Pickerel Creek, was classified as having 1-10 deer per township in 1969 (Ohio Department of Natural Resources, 1971) while Riley Township, which includes the area west of Pickerel Creek, was listed as having 11-25 deer. Former residents of the Site report a deer herd ranging from 13-16 individuals utilizing the western portion of the area (A. Gowitzka, 1973; Keegan, 1974). Deer were observed on several occasions, and deer sign is abundant on the west side. The other small woodlots on the Site are sometimes utilized as bedding areas during the day from which they move during the evening to forage in the fields. The eastern portion of the Site appears to be utilized by only a few deer.

Rabbits. The Eastern cottontail is found on all areas of the Site which are not flooded. Cottontail habitat includes open woods, brushy areas, fencerows, and swamp edges. Rabbits on the Site are particularly abundant around the abandoned house sites of the Bayshore area and the smaller woodlots on the west side. Fencerows and woodlots provide cover and protection for the rabbits which feed primarily on grasses and herbaceous material in open areas; they often ingest bark and twigs in the winter. The rabbit population of the region is considered low (Ohio Department of Natural Resources, 1968) and probably averages less than one rabbit per two acres. Rabbits are not hunted intensively due to their low density, but they are often hunted in conjunction with pheasants which also utilize the fencerows and woodlot edges.

Squirrel. Fox squirrels are among the more intensively hunted small game on the Site. These squirrels are found in most, if not all, of the woodlots on the area (Figure 2.7.3). Trees are utilized as den sites and feeding areas, but fox squirrels also spend a considerable amount of time foraging on the ground, both in the woods and adjacent open areas. Principal foods consist of nuts, buds, fungi, fruits, bird eggs, corn, seeds,

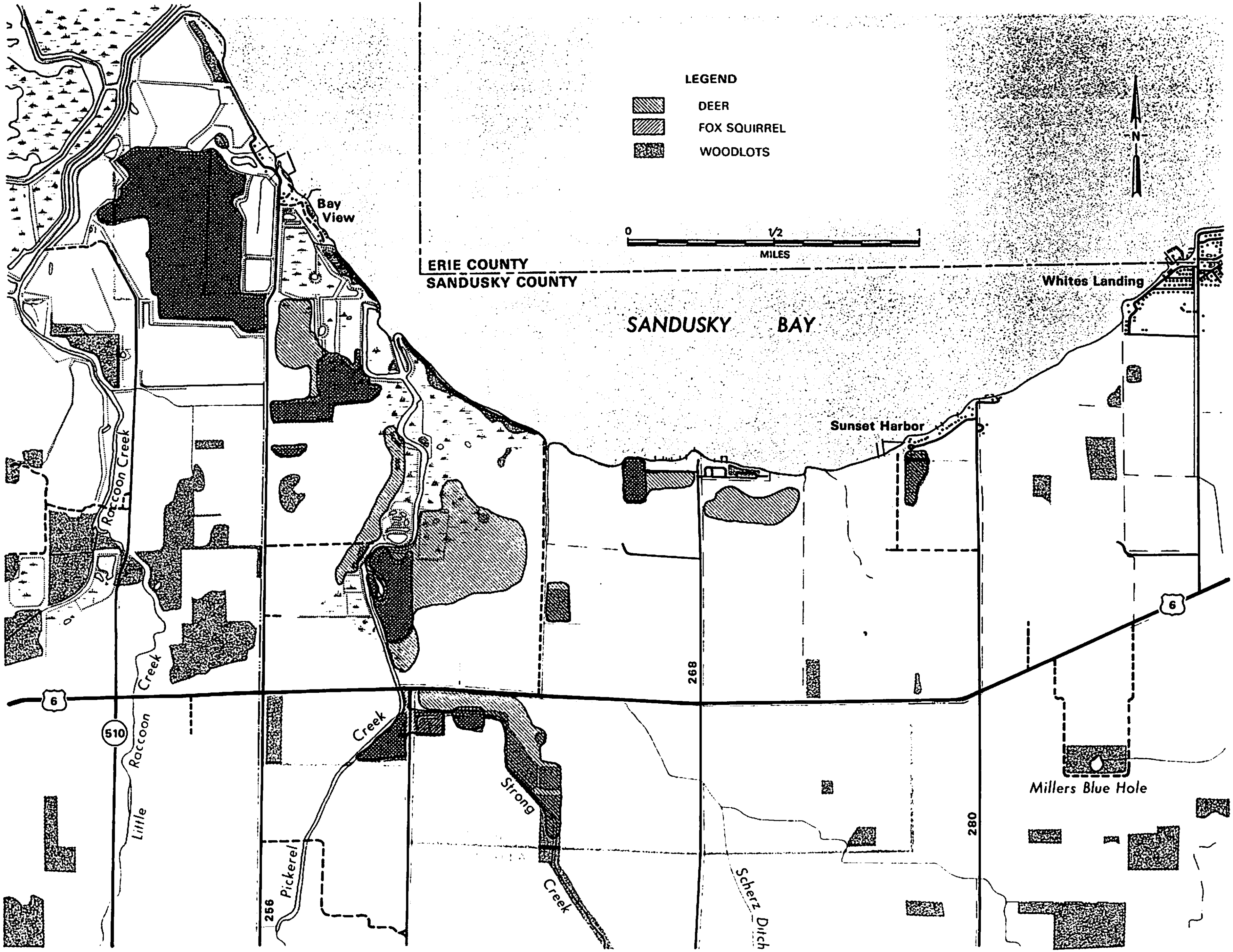
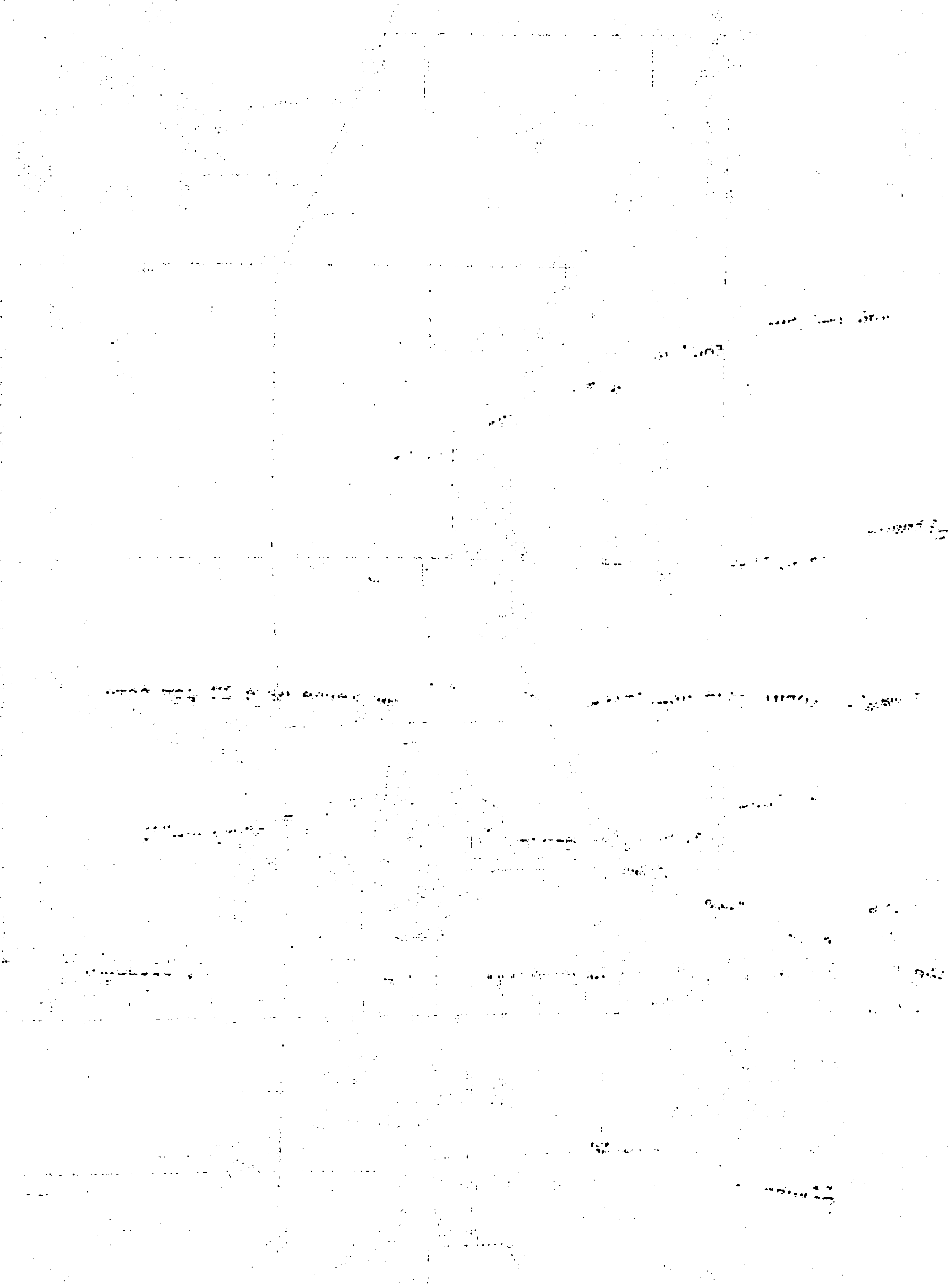


FIGURE 2.7.3 AREAS OF INTENSIVE DEER AND FOX SQUIRREL USE



and a variety of other materials. Squirrel populations may fluctuate considerably from year to year; density may range from 1 squirrel per 2 acres to 3 squirrels per acre (Burt and Grossenheider, 1964).

Small Mammals. Small mammal species such as the white-footed mouse, meadow vole, and short-tailed shrew are considered important because of the role they play in the structure and function of the ecosystem. The mice and the shrews, which also prey upon the mice, constitute a major preparation of the food base of most predatory animals on the Site such as hawks, owls, snakes, foxes, and mink. Small mammals also form a portion of the diet of other animals such as raccoon and skunks.

Meadow voles are found in and along fields, roadsides, and grassy areas when they feed on grasses and sedges. Populations are highest in abandoned fields and around the abandoned house sites at Bayshore. Populations are cyclic and may fluctuate widely varying from 1 to 230 per acre (Golley, 1960).

White-footed mice are found in all areas of the Site, particularly along fencerows and in woodlots. These mice eat insects, berries, seeds, and mast. Population densities are usually in the range of 4-12 per acre (Burt and Grossenheider, 1964).

Short-tailed shrews are found in all areas of the Site and are concentrated along fencerows and in woodlots and may be quite abundant in abandoned fields and areas with grass cover. Shrews are predominantly insectivorous but may consume snails, frogs, and mice, if available. Populations of 25 or more per acre may occur (Burt, 1957).

Several other species of small and medium-size mammals occur on the Site and are present in low numbers. These include woodchuck, opossum, raccoon, striped skunk, house mouse and meadow-jumping mouse. Opossum and raccoons inhabit the woodlots which contain several den trees while the skunk, woodchuck, and mice inhabit the more open areas, particularly in the eastern portion. Detailed data on small mammals captured on the Site and their distribution are shown in Appendix F.

Livestock. Five types of livestock have been observed on the Site; these are horses, goats, sheep, cattle, and swine. At present, only one horse, about 15 pigs, and approximately 150 sheep are found on the Site. Cattle and goats are not currently pastured on the property. The horse and swine are located in a small lot just north of U.S. 6 and approximately midway between Pickerel Creek and Scherz Ditch. The sheep are kept in fields south of Scherz Ditch along the west side of County Road 268. The number of swine kept on the Site has remained fairly constant, but the number of sheep may fluctuate as the owner often moves them to pastures outside of the Site boundary.

For more detail on regional livestock production, see Section 2.2.2.1.

Reptiles and Amphibians. There may be as many as 25 species of amphibians and 25 species of reptiles present at the Sandusky site based on range maps of the species. Of these 50 species listed in Appendix F, three species of amphibians and 7 species of reptiles have been observed on the Site. No rare or endangered species of reptiles or amphibians have a range that includes the Site, although the State of Ohio (Smith et al, 1973) has placed the spotted turtle (*Clemmys guttata*) on its endangered list. This turtle has not been observed on the Site.

One important species of amphibian, the bullfrog, is present on the Site. Bullfrogs, which are aquatic, are often hunted for food and may be sold commercially. They are common along Pickerel Creek and in the diked areas. Bullfrog diets consist primarily of insects, but also may include earthworms, small frogs, crayfish, and other small organisms (Bruggers, 1973).

Food habits of reptiles and amphibians observed on the Site are summarized in Table 2.7.4.

Pre-existing Environmental Stresses. The existing high water levels in Lake Erie are resulting in flooding of parts of the Site along Pickerel Creek and the marsh areas. This high water is causing the displacement of muskrats and other animals into adjacent areas that they did not formerly occupy, such as fields which were formerly cultivated fields and are now becoming marshes. The extreme water levels flood many muskrat dens which may result in lower population levels until they adapt to the new levels. It is expected that many of the trees and shrubs may die in the more severely flooded woodlots (See Section 2.7.1.1). This will result in a loss of habitat and food source for several species, including deer, fox squirrel, mice, shrews, and garter snakes; the number of mammals and reptiles utilizing the woodlots will likely decline in the future in areas which are not diked to prevent flooding.

2.7.1.3 Birds

The Site provides habitat for an extremely diverse bird fauna which varies considerably during the 4 seasons of the year. Surveys during winter, breeding, and migratory periods resulted in observation of the birds listed in Appendix G. Since it is obvious that 2 years of intermittent observations could not be expected to include all of the birds that make use of the Site, additional lists of birds likely to be found at this Site have been compiled in Appendix G. One of these lists includes birds observed at the Ottawa National Wildlife Refuge and its satellite refuges bordering Lake Erie in Ohio. This list probably gives a fairly good picture of the seasonal abundance of birds in the Sandusky Bay area. A total of 288 bird species has been observed on these refuges and an additional 25 species have been seen in the vicinity (U. S. Department of the Interior, 1970). The list from Trautman and Trautman (1968) has been included in Appendix G to indicate the time of year when each species is most likely to be found in or migrating through Ohio.

The Lake Erie region is one of the most heavily travelled areas of bird migration in North America (W. J. Richardson, personal communication). Lake Erie marshes, including those ringing Sandusky Bay, are foci for various waterfowl migration patterns involving both the Mississippi and Atlantic flyways (Bellrose, 1968). In the fall, dabbling ducks (shallow water feeders) such as mallards (scientific names for all bird species referred to in the remainder of the report are listed in Appendix G), American wigeon, and pintails, move from the upper Mississippi River to the Delaware and Chesapeake Bay marshes (Bellrose, 1968). Black ducks migrate from eastern Ontario to the Arkansas River across the Erie marshes. Hundreds of thousands of diving ducks (deep water feeders), such as redheads, lesser scaups, canvasbacks, and ring-necked ducks, move from the Erie marshes south to Florida and the Atlantic Flyway during the fall migrations. A principal passage of diving ducks occurs along a corridor from Lake St. Clair, the Detroit River, and Lake Erie to the Atlantic Coast, terminating at the Chesapeake Bay. Canadian geese move along a corridor south from the Jack Miner Bird Sanctuary near Kingsville, Ontario, through the Erie marshes to either Florida or Chesapeake Bay.

The easternmost migratory corridor of lesser snow geese (includes the blue subspecies) runs from the south end of James Bay to the Lake Erie marshes and then south to the Mississippi River delta (Bellrose, 1968).

Two well-defined migration routes are used by non-waterfowl avian species in the southwestern Lake Erie area. The "island-hopping route" goes from the Catawba, Marblehead, Cedar Point areas across the Lake Erie islands to Pelee Point, Ontario. This route is used in both spring and fall by perching birds (Campbell, 1968).

During the spring, a second route swings westward across Maumee Bay near Little Cedar Point in Lucas County and follows the Lake Erie shores to the narrows near Detroit. In autumn, birds cross the lake at about the same place, but then they move southwestward in a broad lane which extends across much of Monroe and Lucas counties. This route is used by migrants such as crows, hawks, woodpeckers, swallows, and blackbirds (Campbell, 1968). These birds migrate largely by day. Most nocturnal migrants, on the other hand, move across Lake Erie on a broad front, with very little deviation caused by local land forms or shorelines (Richardson, personal communication).

In the spring, the heaviest songbird migrations take place during the last week of April and the first 3 weeks of May. Songbirds migrating during this period include warblers, flycatchers, and sparrows. Other bird groups migrating at this time are shorebirds and marshbirds (Campbell, 1968).

The fall migration of songbirds normally begins in late August and continues through September and October. The warblers and flycatchers usually migrate first, followed by the sparrows and blackbirds (Campbell, 1968). The autumn migration is larger than in spring due to the addition of young birds of the year. Able (1973) determined by radar that the largest autumn flights occur during northerly winds, falling temperatures, and the anticyclonic weather that usually prevails after a cold front has passed through. However, in spring the major movements are usually in warm southerly air flows on the west side of high pressure centers.

Ohio has approximately 55 privately-owned duck clubs in 4 counties adjacent to Lake Erie and around Sandusky Bay (Maddy, personal communication, 1972). As with the nearby privately-owned and state-owned marshes, all of the marsh habitat on the Site is diked and/or artificially managed at this time. Marshes have been managed to increase natural waterfowl production by improvement of nesting habitats and by increasing natural food production via water level manipulation. This is accomplished by springtime water level reductions followed by flooding in the early fall months. Marsh managers get best results from drawdowns in May. They recommend partial reduction of water levels instead of a complete drying of the soil (Green et al, 1964).

Food habits of the birds using the Site vary widely. Appendix G has been included to indicate the plant foods which are most important to waterbirds, marsh and shorebirds, upland gamebirds, and songbirds. Appendix G deals more specifically with the important animal and food plants of 30 species of migratory waterfowl which may feed in Sandusky Bay or its adjacent marshes.

No bird species on the U. S. Department of Interior (1973) Threatened Species List has been seen during surveys on the Site. However, the northern subspecies of the bald eagle (Haliaeetus leucocephalus alascanus) is considered endangered in Ohio (Smith et al, 1973) and has been observed on the Site in both 1973 and 1974. An analysis of the bald eagle's status in Ohio is included at the end of this section.

Forty species of birds which have been seen during surveys at the Site are considered either rare (6 species), peripheral (20 species), or presently undergoing a population decline (14 species) in Ohio (Smith et al, 1973; Appendix G). The species fitting each of these categories which were observed during June are listed under breeding-bird survey results in this section.

Results of the Migratory Waterfowl Surveys

In order to determine the maximum use of the Site by migratory waterfowl (ducks, geese, and swans), surveys were made during the spring and fall periods when peak duck and goose populations normally occur in the southwestern Lake Erie marshes. The Lake Erie marshes are rather shallow and usually freeze about the third week in November. Therefore, ducks migrating in the fall normally hold over and build up in numbers until the marshes freeze. The peak of duck populations in the Lake Erie marshes occurs about the middle of November. However, 2 species of ducks, the wood duck and blue-winged teal, migrate well before this peak. The average date of peak fall populations of these two species in the Lake Erie marshes is about the first week in October (Ohio Department of Natural Resources, 1971; Bednarik, personal communication).

The spring waterfowl migration is shortened into a 3.5-month period in Ohio as opposed to the fall waterfowl migration which is spread out over a 5-month period. Peak springtime populations of waterfowl in the Lake Erie marshes normally occur during the last half of March and the first week of April (Milton B. Trautman, personal communication). This period includes both the early and late migrating species of waterfowl (Trautman and Trautman, 1968). However, the diving ducks frequently migrate north earlier than the puddle ducks. The redhead, canvasback, lesser scaup, and common goldeneye may have a substantial migration as early as the last week in January or the first week in February (Meeks, personal communication).

Fall Survey. The total number of ducks using Lake Erie marshes as a stopover during the 1973 fall migration was down by over 30 percent from normal for two reasons: (1) low production in the prairie pothole breeding grounds and (2) absence of aquatic plants used as waterfowl food in the Lake Erie marshes (K. E. Bednarik, personal communication). The 1973 Fall Flight Forecast by the Bureau of Sport Fisheries and Wildlife, U.S.D.I. (1973) indicated that the 1973 brood index for the southern Prairie Provinces of Canada was the lowest on record. This index, obtained in July, was 53 percent below the 1955-72 average. However, when the late nesting index is considered, the total expected broods were 28 percent below the

1955-72 average. This prompted the Bureau of Sport Fisheries and Wildlife, U.S.D.I. (1973) to predict that the total 1973 fall flight of ducks into the Mississippi flyway would be substantially reduced from previous years.

Aquatic plants used by waterfowl for food were largely absent in most Lake Erie marshes during 1973. Storms and record Lake Erie water levels during the spring and summer of 1973 caused the destruction of many dikes and resulted in a substantial reduction in the aquatic plants, such as smartweed, millet, and rice cutgrass, which are relished by ducks. Therefore, migrant ducks did not buildup on these marshes (Bednarik, personal communication).

Waterfowl numbers using the Site (Table 2.7.5) were probably much lower than normal due to the reduced fall populations in the Lake Erie marshes. Sixteen species of waterfowl plus coots were observed during 11 days of survey. The mallard was the most abundant duck flying over the marsh stations (Figure 6.1.4) was the common merganser (Table 2.7.5). observed most often on the water. Black ducks, gadwall, and green-winged teal were also frequently observed on the five marsh stations.

The major waterfowl species observed at the survey stations on Sandusky Bay (Figure 6.1.4) was the common merganser (Table 2.7.5). Although the male common and red-breasted mergansers are still in the eclipse plumage (they look like females) in November and are very difficult to positively identify, the one most likely to be observed is the common merganser. Campbell (1968) and Meeks (personal communication) indicate that the common merganser is the most abundant of these two mergansers in the Lake Erie area. One extremely large raft (approximately 1,000 ducks) of common mergansers was observed on November 8; apparently they were all following a school of fish, which is their major source of food (Martin et al, 1961). The birds in the back of the flock were "leap-frogging" to the front of the flock, and then began diving.

Canada geese using the southwestern Lake Erie marshes are concentrated mainly at the Magee Marsh-Ottawa National Wildlife Refuge complex and do not use Sandusky Bay as frequently (K. E. Bednarik, personal communication). Therefore, they are much more likely to be observed in Bednarik's aerial survey, which covers the State and Federal refuges, than in the survey at the Site.

TABLE 2.7.5. FALL MIGRATORY WATERFOWL SURVEY AT THE SITE
11 DAYS DURING NOVEMBER, 1973[(a)]

Common Name	Scientific Name	Total Birds Observed During Survey Period: 5 Marsh Stations[(b)] On Water	5 Marsh Stations[(b)] Flying Over	5 Bay Stations[(c)] On Water	5 Bay Stations[(c)] Flying Over	All 10 Stations On Water	All 10 Stations Flying Over
Canada Goose	Branta canadensis	0	49	0	64	0	113
Mallard	Anas platyrhynchos	55	494	10	120	65	614
Black Duck	Anas rubripes	29	29	49	16	78	45
Gadwall	Anas strepera	31	2	0	15	31	17
Green-winged Teal	Anas crecca	14	5	0	0	14	5
American Wigeon	Anas americana	94	3	6	10	100	13
Northern Shoveler	Anas clypeata	9	2	0	0	9	2
Wood Duck	Aix sponsa	0	0	0	1	0	1
Redhead	Aythya americana	0	0	0	3	0	3
Greater Scaup	Aythya marila	2	0	0	0	2	0
Lesser Scaup	Aythya affinis	1	0	0	0	1	0
Greater or Lesser Scaup	Aythya marila or A. affinis	1	0	0	1	1	1
Bufflehead	Bucephala albeola	0	0	0	3	0	3
Ruddy Duck	Oxyura jamaicensis	3	0	46	0	49	0
Hooded Merganser	Lophodytes cucullatus	5	2	0	0	5	2
Common or Red-breasted Merganser	Mergus merganser or Mergus serrator	0	1	1,887	1,151	1,887	1,152
American Coot	Fulica americana	1	0	124	0	125	0
Unidentified Ducks		0	17	1	4	1	21
TOTALS		245	604	2,123	1,388	2,368	1,992

(a) Observation dates were November 6-9, November 20-22, and November 26-29. Although coots are not in the waterfowl family (Anatidae), they are included due to their ecological similarity to waterfowl.

(b) Four marsh stations were near Pickerel Creek and the fifth marsh station was near Raccoon Creek (Figure 6.1.4.3.4). Data presented are for 11 days.

(c) Only 10 days of data are included for the five stations along Sandusky Bay. Rain prevented an accurate survey on November 28.

Almost 70 percent of the waterfowl observed at the Site were mergansers, while only 9 percent of the waterfowl observed in Bednarik's aerial surveys were mergansers (Table 2.7.6). This difference in the two surveys can be attributed to the fact that mergansers do not distribute themselves evenly in the Lake Erie area. Large flocks may be found way out on the lake on one day and may be concentrated close to shore on another (Bednarik, personal communication). Since the ground survey covered 11 days in November and the aerial survey only covered 3 days, there was a greater chance of including days when mergansers were close to shore during the ground survey.

Thirty-six non-waterfowl species of birds were observed during the fall survey (Table 2.7.7). The following nine species were observed more than 50 times during the 11-day survey period: great blue heron, killdeer, dunlin, herring gull, ring-billed gull, Bonaparte's gull, red-winged blackbird, rusty blackbird, and tree sparrow. Bald eagles were observed seven times during this survey period, but no other threatened species were observed.

Spring Survey. A total of 22 waterfowl species plus coots were observed during the spring survey (Table 2.7.8). This total includes the following 6 species which were not observed during the fall survey: whistling swan, white-fronted goose, pintail, blue-winged teal, canvasback, and common goldeneye. The blue-winged teal and wood duck were found in much greater numbers in the spring than they were in the fall survey. This was expected since their peak migration periods correspond more with the spring survey (Trautman and Trautman, 1968) than with the fall survey (Ohio Department of Natural Resources, 1971). Greater numbers of whistling swans normally stop over in the Lake Erie marshes in spring than they do in the fall (Campbell, 1968). This may be one of the reasons for the whistling swans absence during the fall survey.

The presence of the white-fronted goose in the spring survey was extremely unusual since this species normally migrates through the western United States (Robbins et al, 1966). Both Trautman and Trautman (1968) and Campbell (1968) consider the white-fronted goose a very irregular or accidental visitor to Ohio.

TABLE 2.7.6. A COMPARISON OF AERIAL SURVEYS OF LAKE ERIE MARSHES[a] TO GROUND SURVEYS AT THE SITE[b], NOVEMBER 1973

Common Name	Scientific Name	Percent of Total Birds Observed: Aerial[b] Survey	Ground Survey[c]: All 10 Stations	Ground Survey[c]: 5 Marsh Stations
Canada Goose	*Branta canadensis*	26	3	6
Snow Goose	*Chen caerulescens*	<1	0	0
Mallard	*Anas platyrhynchos*	44	16	65
Black Duck	*Anas rubripes*	12	3	7
Gadwall	*Anas strepera*	0	1	4
Pintail	*Anas acuta*	3	0	0
Green-winged Teal	*Anas crecca*	<1	<1	2
Blue-winged Teal	*Anas discors*	<1	0	0
American Wigeon	*Anas americana*	3	3	11
Northern Shoveler	*Anas clypeata*	<1	<1	1
Wood Duck	*Aix sponsa*	0	<1	0
Redhead	*Aythya americana*	0	<1	0
Scaup spp.	*Aythya marila* or *collaris*	1	<1	<1
Bufflehead	*Bucephala albeola*	0	<1	0
Ruddy Duck	*Oxyura jamaicensis*	0	1	<1
Mergansers	*Mergus* or *Lophodytes*	9	70	<1
American Coot	*Fulica americana*	1	3	<1
Unidentified Ducks		-	<1	2

(a) Revised from three aerial surveys made by K. Bednarik (unpublished data) on November 2, 16, and 30, 1973.
(b) Revised from Table 1.
(c) Includes birds observed flying over or on the water at five marsh stations and five stations on Sandusky Bay

TABLE 2.7.7. BIRDS OTHER THAN WATERFOWL OBSERVED DURING THE FALL WATERFOWL SURVEY AT THE SITE, NOVEMBER, 1973[a]

Common Name	Scientific Name	Frequency of Observation[b]
Horned Grebe	Podiceps auritus	VR
Cooper's Hawk	Accipiter cooperii	VR
Marsh Hawk	Circus cyaneus	R
Red-tailed Hawk	Buteo jamaicensis	R
Bald Eagle	Haliaeetus leucocephalus	R
American Kestrel	Falco sparverius	VR
Ring-necked Pheasant	Phasianus colchicus	U
Great Egret	Casmerodius albus	VR
Great Blue Heron	Ardea herodias	C
Killdeer	Charadrius vociferus	C
Greater Yellowlegs	Tringa melanoleucus	R
Dunlin	Calidris alpina	C
Common Snipe	Capella gallinago	VR
Herring Gull	Larus argentatus	VC
Ring-billed Gull	Larus delawarensis	A
Bonaparte's Gull	Larus philadelphia	VC
Mourning Dove	Zenaida macroura	U
Belted Kingfisher	Megaceryle alcyon	R
Common Flicker	Colaptes auratus	R
Red-headed Woodpecker	Melanerpes erythrocephalus	U
Hairy Woodpecker	Dendrocopos villosus	VR
Downy Woodpecker	Dendrocopos pubescens	R
Blue Jay	Cyanocitta cristata	VU
Common Crow	Corvus brachyrhynchos	VR
Tufted Titmouse	Parus bicolor	VR
White-breasted Nuthatch	Sitta carolinensis	VR
Golden-crowned Kinglet	Regulus satrapa	VR
Starling	Sturnus vulgaris	VR
House Sparrow	Passer domesticus	R
Red-winged Blackbird	Agelaius phoeniceus	A
Rusty Blackbird	Euphagus carolinus	C
Cardinal	Cardinalis cardinalis	U
American Goldfinch	Spinus tristis	R
Dark-eyed Junco	Junco hyemalis	VR
Tree Sparrow	Spizella arborea	C
Song Sparrow	Melospiza melodia	U

(a) The observation days were: November 6-9, November 20-22, and November 26-29.

(b) These birds were not censused, but records were kept during the waterfowl survey and general reconnaissance of White's Landing Site. The approximate number (11-day total) of observations is indicated as follows:

A = Abundant, 501 +
VC = Very common, 101-500
C = Common, 51-100
U = Uncommon, 11-50
R = Rare, 4-10
VR = Very rare, 1-3.

TABLE 2.7.8. SPRING MIGRATORY WATERFOWL SURVEY AT THE SITE ON 12 DAYS DURING MARCH 17 TO APRIL 5, 1974[(a)]

Common Name	Scientific Name	Total Waterflowl Observed During Survey Period: 5 Marsh Stations[(b)] On Water	5 Marsh Stations[(b)] Flying Over	5 Bay Stations[(c)] On Water	5 Bay Stations[(c)] Flying Over	all 10 stations On Water	all 10 stations Flying Over
Whistling Swan	*Olor columbianus*	13	14	0	11	13	25
Canada Goose	*Branta canadensis*	70	16	107	44	177	60
White-fronted Goose	*Anser albifrons*	0	0	18	0	18	0
Mallard	*Anas platyrhynchos*	592	369	207	74	799	443
Black Duck	*Anas rubripes*	258	94	306	33	564	127
Gadwall	*Anas strepera*	143	7	6	8	149	15
Pintail	*Anas acuta*	132	56	33	161	165	217
Green-winged Teal	*Anas crecca*	189	17	12	26	201	43
Blue-winged Teal	*Anas discors*	291	57	29	25	320	82
American Wigeon	*Anas americana*	420	167	261	91	681	258
Northern Shoveler	*Anas clypeata*	212	19	0	0	212	19
Wood Duck	*Aix sponsa*	101	79	2	2	103	81
Redhead	*Aythya americana*	22	2	28	10	50	12
Ring-necked Duck	*Aythya collaris*	45	5	2	10	47	15
Canvasback	*Aythya valisineria*	0	0	41	2	41	2
Lesser Scaup	*Aythya affinis*	20	9	32	16	52	25
Scaup spp.	*Aythya affinis* or *collaris*	0	0	5	0	5	0
Common Goldeneye	*Bucephala clangula*	0	0	0	1	0	1
Bufflehead	*Bucephala albeola*	12	0	10	3	22	3
Ruddy Duck	*Oxyura jamaicensis*	5	0	7	0	12	0
Hooded Merganser	*Lophodytes cucullatus*	151	43	0	11	151	54
Common Merganser	*Mergus merganser*	228	155	49	26	277	181
Red-breasted Merganser	*Mergus serrator*	2	0	137	36	139	36

TABLE 2.7.8. (continued)

		Total Waterfowl Observed During Survey Period					
		5 Marsh Stations(b)		5 Bay Stations(c)		All 10 Stations	
Common Name	Scientific Name	On Water	Flying Over	On Water	Flying Over	On Water	Flying Over
Merganser spp.	Lophodytes or Mergus	0	6	0	11	0	17
American Coot	Fulica americana	107	0	31	1	138	1
Unidentified Ducks		0	138	3	12	3	150
TOTALS		3,013	1,253	1,326	614	4,339	1,867

(a) Although coots are not in the waterfowl family (Anatidae), they are included due to their ecological similarity to waterfowl. Observation dates were March 17 to 24 and April 2 to 5. 1974.

(b) Four marsh sites were near Pickerel Creek and the fifth marsh station was near Raccoon Creek. (Figure 6.1.4).

(c) The five stations along Sandusky Bay were between Raccoon Creek and Sunset Harbor.

Two types of waterfowl concentration areas were not included as survey stations. Most of the puddle ducks (subfamily Anatinae) were observed in fields flooded by high water levels in Lake Erie. Ducks using the flooded fields were primarily mallards, black ducks, pintails, green-winged teal, blue-winged teal, American wigeons, and northern shovelers. Both the American wigeon and the Canada goose were frequently observed in large flocks feeding on winter wheat. These two species plus small numbers of other waterfowl were observed in the wheat fields east of Pickerel Creek. Sprunt et al (1961) report that wigeon graze like geese in fields of grain, although they normally feed on submerged vegetation (Meeks, personal communication).

The mallard and American wigeon were first and second in abundance during the spring survey at the five marsh stations (Table 2.7.9). The springtime abundance rank for these two ducks was the same as it was for the fall survey. Other species which individually accounted for more than 5 percent of the waterfowl at the marsh stations were the black duck, blue-winged teal, wood duck, and common merganser. Meeks (personal communication) thinks that the black duck was one of the most abundant ducks at Sandusky Bay during the portion of the spring migration which preceded this survey. He also observed that the American wigeon was much less common during this early migration than it was during the Site survey. During general reconnaissance surveys of the Site in January, the black duck was observed to be the most abundant species of waterfowl followed in abundance by the Canada goose and mallard.

The American wigeon was the most abundant waterfowl species at the five bay stations during the spring survey (Table 2.7.9). This was a big change from the fall survey where the mergansers accounted for 86 percent of the waterfowl observed at the bay stations. The black duck and mallard were second and third in abundance at the five bay stations during the spring survey. These two species, plus a few other ducks, were seen in the greatest numbers at the bay stations when the prevailing winds were from a southerly direction producing relatively quiet water near the shore. The three other waterfowl at the bay stations were the Canada goose, pintail, and red-breasted merganser.

TABLE 2.7.9. PERCENTAGES BY SPECIES OF TOTAL WATERFOWL OBSERVED DURING THE SPRING WATERFOWL SURVEY AT THE SITE[(a)]

	Percent of Total Birds Observed		
	5 Marsh stations	5 Bay Stations	All 10 Stations
Whistling Swan	< 1	< 1	< 1
Canada Goose	2	8	4
White-fronted Goose	0	< 1	< 1
Mallard	23	14	20
Black Duck	8	17	11
Gadwall	4	< 1	3
Pintail	4	10	6
Green-winged Teal	5	2	4
Blue-winged Teal	8	3	6
American Wigeon	14	18	15
Northern Shoveler	5	0	4
Wood Duck	7	< 1	3
Redhead	< 1	2	1
Ring-necked Duck	1	< 1	1
Canvasback	0	2	< 1
Lesser Scaup	< 1	2	1
Scaup spp.	0	< 1	< 1
Common Goldeneye	0	< 1	< 1
Bufflehead	< 1	< 1	< 1
Ruddy Duck	< 1	< 1	< 1
Hooded Merganser	5	< 1	3
Common Merganser	9	4	7
Red-breasted Merganser	< 1	9	3
Merganser spp.	< 1	< 1	< 1
American Coot	3	2	2
Unidentified Ducks	3	< 1	2

(a) Includes birds observed on the water and flying over the five marsh stations and five stations on Sandusky Bay. Revised from Table 2.7.8.

Forty-one non-waterfowl species of birds were observed during the spring survey (Table 2.7.10). The following 9 species were observed more than 50 times during the 12-day survey period: great blue heron, killdeer, dunlin, herring gull, ring-billed gull, Bonaparte's gull, red-winged blackbirds, rusty blackbird, and tree sparrow. Bald eagles were only observed twice on the Site, although the two known nesting sites were checked daily. Species associated with the woodlots, such as the red-headed woodpecker, downy woodpecker, and tufted titmouse, were undoubtedly more abundant than indicated in Table 2.7.10 since very little time was spent observing in the woodlots. As expected, no warblers or flycatchers were observed since these small passerines normally do not migrate until the last week of April through the first three weeks of May (Campbell, 1968).

Results of the Winter Bird Surveys

The woodlot survey (Table 2.7.11) was conducted in woods varying in size from 4.3 to 20 acres (Figure 6.1.5). Although Kolb (1965) suggests that plots under 20 acres may produce biased results, these small woodlots were the largest woodlots at the Site that were not standing in water. Dominant canopy trees in woodlot 12 were mature pin oaks, chestnut oaks, and shagbark hickorys. The understory is open due to previous grazing and is composed mainly of hawthorn, dogwood, and shagbark hickory.

Woodlot 6 (Figure 6.1.5) is a mature oak-hickory woodlot. The fairly open understory is composed mainly of dogwood, American elm, hawthorn, and ash.

Dominant canopy trees in the immature woodlot 1 (Figure 6.1.4.3.5) are silver maple and cottonwood. The dense understory includes mainly black locust, pin oak, dogwood, shagbark hickory, and multiflora rose. Only a few mature chestnut oaks surround the woods.

Woodlot 2 (Figure 6.1.5) is composed mainly of mature oaks with pin oak as the most dominant canopy tree. The fairly dense understory is mainly dogwood, wild grape, silver maple, American elm, and black locust. A statistical analysis of vegetation transects conducted in woodlot 2 and woodlot 6 are included in Appendix E.

TABLE 2.7.10. BIRDS OTHER THAN WATERFOWL OBSERVED DURING THE SPRING WATERFOWL SURVEY AT THE SITE, MARCH 17 TO APRIL 5, 1974[(a)]

Common Name	Scientific Name	Frequency of Observations at the Site[(b)]
Pied-billed Grebe	*Podilymbus podiceps*	U
Double-crested Cormorant	*Phalacrocorax auritus*	VR
Great Blue Heron	*Ardea herodias*	VC
Great Egret	*Casmerodius albus*	R
Turkey Vulture	*Cathartes aura*	VR
Cooper's Hawk	*Accipiter cooperii*	VR
Red-tailed Hawk	*Buteo jamaicensis*	R
Bald Eagle	*Haliaeetus leucocephalus*	VR
Marsh Hawk	*Circus cyaneus*	R
American Kestrel	*Falco sparverius*	R
Ring-necked Pheasant	*Phasianus colchicus*	U
Killdeer	*Charadrius vociferus*	VC
Common Snipe	*Capella gallinago*	VR
Herring Gull	*Larus argentatus*	VC
Ring-billed Gull	*Larus delawarensis*	VC
Bonaparte's Gull	*Larus philadelphia*	VR
Rock Dove	*Columba livia*	VR
Mourning Dove	*Zenaida macroura*	C
Short-eared Owl	*Asio flammeus*	VR
Belted Kingfisher	*Megaceryle alcyon*	VR
Common Flicker	*Colaptes auratus*	U
Red-headed Woodpecker	*Melanerpes erythrocephalus*	R
Downy Woodpecker	*Dendrocopos pubescens*	VR
Horned Lark	*Eremophila alpestris*	U
Blue Jay	*Cyanocitta cristata*	U
Tree Swallow	*Iridoprocne bicolor*	U
Purple Martin	*Progne subis*	R
Common Crow	*Corvus brachyrhynchos*	C
Tufted Titmouse	*Parus bicolor*	U
White-breasted Nuthatch	*Sitta carolinensis*	VR
American Robin	*Turdus migratorius*	VC

TABLE 2.7.10. (Continued)

Common Name	Scientific Name	Frequency of Observations at the Site(b)
Starling	_Sturnus vulgaris_	VC
House Sparrow	_Passer domesticus_	U
Eastern Meadowlark	_Sturnella magna_	U
Red-winged Blackbird	_Agelaius phoeniceus_	A
Rusty Blackbird	_Euphagus carolinus_	U
Common Grackle	_Quiscalus quiscula_	C
Cardinal	_Cardinalis cardinalis_	U
Dark-eyed Junco	_Junco hyemalis_	R
Tree Sparrow	_Spizella arborea_	C
Song Sparrow	_Melospiza melodia_	VC

(a) The observation days were: March 17 to 24 and April 2 to 5, 1974.
(b) These birds were not censused, but records were kept during the waterfowl survey and general reconnaissance of the Site. Approximate number (12-day) total of observations in indicated as follows:

A = Abundant, 501 +
VC = Very common, 101-500
C = Common, 51-100
U = Uncommon, 11-50
R = Rare, 4-10
VR = Very rare, 1-3.

TABLE 2.7.11. RESULTS OF AN 8-DAY[(a)] WINTER BIRD SURVEY AT FOUR WOODLOTS ON THE SITE (Figure 6.1.4.3.5)

Common Name	Scientific Name	Average Number of Birds Seen Per Trip[(b)] Woodlot 12 (20 Acres)	Woodlot 16 (11.3 Acres)	Woodlot 1 (4.3 Acres)	Woodlot 2 5.9 Acres
Marsh Hawk	Circus cyaneus	-	+	-	-
Red-tailed Hawk	Buteo jamaicensis	+	+	-	-
Ring-necked Pheasant	Phasianus colchicus	-	-	+	-
Mourning Dove	Zenaida macroura	-	+	+	+
Common Flicker	Colaptes auratus	-	-	+	-
Red-headed Woodpecker	Melanerpes erythrocephalus	11 (55)	7 (62)	+	1 (17)
Hairy Woodpecker	Dendrocopos villosus	+	+	-	-
Downy Woodpecker	Dendrocopos pubescens	1 (5)	1 (9)	+	1 (17)
Blue Jay	Cyanocitta cristata	3 (15)	2 (18)	-	1 (17)
Common Crow	Corvus brachyrhynchos	+	-	+	-
Tufted Titmouse	Parus bicolor	2 (10)	1 (9)	-	+
White-breasted Nuthatch	Sitta carolinensis	-	+	-	-
Brown Creeper	Certhia familiaris	+	+	+	-
Starling	Sturnus vulgaris	2 (10)	+	-	-
House Sparrow	Passer domesticus	+	2 (18)	-	-
Rusty Blackbird	Euphagus carolinus	+	-	-	-
Cardinal	Cardinalis cardinalis	1 (5)	-	+	1 (17)
Dark-eyed Junco	Junco hyemalis	-	1 (9)	-	+
Tree Sparrow	Spizella arborea	-	+	2 (47)	2 (34)
White-throated Sparrow	Zonotrichia albicollis	+	-	-	-
Song Sparrow	Melospiza melodia	-	-	+	+
	Average Totals	20 (100)	14 (124)	2 (47)	6 (102)

(a) January 16 to 18 and January 28 to February 1, 1974.

(b) Numbers in parentheses are density estimates for 100 acres of this type of woods. Plus sign indicates that the average observations per trip are less than 0.5 birds. Average hours per day required to survey each plot were as follows:

Woodlot 12 - 1-1/4
Woodlot 6 - 1
Woodlot 1 - 1/2
Woodlot 2 - 1/2.

Woodlots 6 and 12 had similar species of birds that were observed on an average of one or more per day (Table 2.7.11). However, woodlot 12 had more starlings and cardinals than woodlot 6, and woodlot 6 had more house sparrows and dark-eyed juncos than woodlot 12.

The most frequently observed species in both of these larger woods was the red-headed woodpecker (Table 2.7.11) which was observed on all of the 8 survey days. The blue jay, downy woodpecker, and tufted titmouse were also frequently observed in both woodlots and are considered by Campbell (1968) as common, permanent residents. The red-headed woodpecker is classed by Campbell as a summer resident which is uncommonly found in winter. However, he indicates that these woodpeckers prefer oak-hickory woodlots where they feed on acorns. This accounts for their abundance in the oak woodlots at the Site.

Very few birds were observed with any frequency or abundance in woodlot 1, which is very small. Woodpeckers were undoubtedly scarce because of a lack of large, dead trees. The only species observed in this woods with any significant abundance were tree sparrows. These common winter visitors were observed at the edge of the woodlot and were only recorded there on 2 of the 8 days. Since Campbell (1968) indicates that tree sparrows are normally associated with tall weeds and brush, these birds should not be considered regular inhabitants of woodlot 1. In fact, all of the species using woodlot 1 during the winter survey were only sporadically observed (species recorded on fewer than 3 of 8 trips).

The tree sparrow also had the highest average density of any bird species found in woodlot 2 (Table 2.7.11). However, this species was found near the edge of the woods on only 2 of 8 days. Both woodlots 1 and 2 had significant tree sparrow densities which probably reflects the bias resulting from the sampling of small woodlots. In surveys of small woods the species normally associated with the edge of the woods are more frequently recorded than they would be if a large woodlot were surveyed.

Species which were seen on at least 6 of the trips through woodlot 2 were the red-headed woodpecker (7 trips) and blue jay (6 trips). The presence of many mature oak trees in this woodlot probably accounted for the greater density of these two species than was observed in the woodlot 1. Martin et al (1951) indicate that red-headed woodpeckers and blue jays rely heavily on oak trees for food during the winter.

The two hedgerows (included some fencerows) surveyed were each about 1-mile long and 10-to 15-foot wide (Figure 6.1.5). About one-half of each row was adjacent to a ditch containing water. Hedgerow #1 was close to weedy fields and included more perennials in the row than hedgerow #2. About two-thirds of hedgerow #1 was composed of hawthorn, poison ivy, and staghorn sumac; the remaining one-third of the row was composed of dogwood with a few large silver maple, pin oak, and white ash trees, Hedgerow #2 was surrounded mainly by plowed fields. About one-third of this row was composed of dogwoods. The remaining two-thirds were composed of 15- to 20-foot high cottonwood and willow trees.

The two major bird species observed in the hedgerows were tree sparrows and song sparrows (Table 2.7.12). Eight other avian species were observed in these transects, but none of these birds were recorded on more than 2 of the 8 days. Evidently these 8 species were only making temporary use of this cover type.

The tree sparrow is a common, winter visitor normally found among tall weeds and brush (Campbell, 1968). Hedgerow # 1 was closer to weedy fields than hedgerow #2 which probably accounts for the higher average density per mile found for the tree sparrows using hedgerow #1 than for populations of the same species using hedgerow #2 (Table 2.7.12).

A total of 41 species of birds were observed during a general reconnaissance of the Site (Table 2.7.13). Eight of these species were waterfowl that moved into the area as soon as the ice melted in Sandusky Bay, Pickerel Creek, or marshes on the Site. Of the 41 species observed this winter, 23 are considered permanent residents, 13 are considered half-hardy (transients or summer residents which are found in winter on occasion), and 5 are considered winter visitors (Campbell, 1968).

Bald eagles were observed on the Site on 2 of 9 survey days. Two adults were seen in a tree at the edge of the woods on the west side of County Road 256 (near the Gowitzka residence). Another day one adult bald eagle was observed near the mouth of Scherz Ditch.

TABLE 2.7.12. RESULTS OF AN 8-DAY[a] BIRD SURVEY ALONG 2 MILES OF FENCE (HEDGE) ROWS AT THE SITE (FIGURE 6.1.5)

Common Name	Scientific Name	AVERAGE NUMBER OF BIRDS SEEN PER TRIP[b] Fence Row #1(1-mile)	Fence Row #2(1-mile)	Both Fence Rows (birds/mile)
Marsh hawk	Circus cyaneus	-	+	+
Ring-necked pheasant	Phasianus colchicus	+	+	+
Mourning dove	Zenaida macroura	-	+	+
Downy woodpecker	Dendrocopos pubescens	-	+	+
Blue jay	Cyanicutta cristata	+	+	1
Tufted titmouse	Parus bicolor	+	-	+
Red-winged blackbird	Agelaius phoeniceus	+	-	+
Cardinal	Cardinalis cardinalis	+	+	+
Tree sparrow	Spizella arborea	5	2	4
Song sparrow	Melospiza melodia	4	+	2

(a) January 16 to 18 and January 28 to February 1, 1974. Each fence row required an average of 3/4-hour each day to complete.

(b) Plus sign indicates that the average observations per trip are less than 0.5 birds.

TABLE 2.7.13. BIRDS OBSERVED OFF OF TRANSECT SITES (DURING 9 DAYS)[a] WHILE CONDUCTING A WINTER BIRD SURVEY AT THE SITE

Common Name	Scientific Name	Residency and Abundance Reported by Campbell (1968)[b]	Frequency of Observations at White's Landing[c]
Canada Goose	*Branta canadensis*	HH - LC	VC
Mallard	*Anas platyrhynchos*	P - C	VC
Black Duck	*Anas rubripes*	P - C	A
Redhead	*Aythya americana*	HH - FC	R
Canvasback	*Aythya valisineria*	HH - LC	R
Common Goldeneye	*Bucephala clangula*	WV - C	U
Ruddy Duck	*Oxyura jamaicensis*	HH - U	U
Common Merganser	*Mergus merganser*	WV - C	C
Marsh Hawk	*Circus cyaneus*	P - FC	U
Red-tailed Hawk	*Buteo jamaicensis*	P - C	U
Bald Eagle	*Haliaeetus leucocephalus*	P - U	R
American Kestrel	*Falco sparverius*	P - C	U
Bobwhite	*Colinus virginianus*	P - LC	U
Ring-necked Pheasant	*Phasianus colchicus*	P - C	R
Herring Gull	*Larus argentatus*	P - C	U
Rock Dove	*Columba livia*	P - C	R
Mourning Dove	*Zenaida macroura*	P - C	VR
Great Horned Owl	*Bubo virginianus*	P - FC	VR
Short-eared Owl	*Asio flammeus*	HH - FC	VR
Belted Kingfisher	*Megaceryle alcyon*	HH - U	VR
Common Flicker	*Colaptes auratus*	HH - FC	VR
Red-bellied Woodpecker	*Centurus carolinus*	HH - U	VR
Red-headed Woodpecker	*Melanerpes erythrocephalus*	HH - U	U
Hairy Woodpecker	*Dendrocopos villosus*	P - FC	R
Downy Woodpecker	*Dendrocopos pubescens*	P - C	U
Horned Lark	*Eremophila alpestris*	WV - FC	C
Blue Jay	*Cyanocitta cristata*	P - C	C
Common Crow	*Cornuus brachyrhynchos*	P - C	C
Tufted Titmouse	*Parus bicolor*	P - C	R
White-breasted Nuthatch	*Sitta carolinensis*	P - C	R
American Robin	*Turdus migratorius*	HH - R to C	VR
Starling	*Sturnus vulgaris*	P - A	A
House Sparrow	*Passer domesticus*	P - A	VC
Red-winged Blackbird	*Agelaius phoeniceus*	HH - U	VR
Rusty Blackbird	*Euphagus carolinus*	HH - U	VR
Cardinal	*Cardinalis cardinalis*	P - C	U
American Goldfinch	*Spinus tristis*	P - C	R
Dark-eyed Junco	*Junco hyemalis*	WV - C	U
Tree Sparrow	*Spizella arborea*	WV - C	VC
Field Sparrow	*Spizella pusilla*	HH - U	R
Song Sparrow	*Melospiza melodia*	P - C	C

(a) January 15-18 and January 28-February 1, 1974; 25 total hours of observation.

(b) Residency is given by the letters preceding the dash: P = Permanent resident (found regularly throughout the year), WV = Winter visitor (breeds north of the area and found most often in winter), HH = Half-Hardy (normally summer residents or transients, but found in winter on occasion). Abundance is given by the letters following the dash: A = Abundant, C = Common, FC = Fairly common, LC = Locally common, U = Uncommon, R = Rare. See Campbell (1968:23) for definition of the above terms.

(c) Records were made by two observers from a car and on foot. Most off-transect surveys were made during the afternoon. The approximate number of observations (9 days total) is indicated by the following letters: A = Abundant, 100+;, VC = Very common, 51-100; C = Common, 16-50; U = Uncommon, 6-15; R = Rare, 3-5; VR = Very rare, 1-2.

A comparison of raptor abundance indicated by Campbell (1968) in Table 2.7.12 and the frequency of observation noted during field studies could be confusing. Campbell (1968) has indicated relative abundance. Thus, observation of 8 to 20 individuals of one raptorial species may be equivalent to observing 50 to 100 individuals of a passerine species in the same length of time. This would explain Campbell's (1968) designation of common for the red-tailed hawk, when it was only observed 6 to 15 times during the winter survey at the Site.

Breeding Bird Survey Results

Plot Survey. Sixty-four territorial males (including two female cowbirds)(Table 2.7.14) were observed during nine visits to the 20-acre survey plot (Figure 6.1.6) in woodlot 12 (Figure 6.1.5) along Pickerel Creek. The eastern wood pewee and indigo bunting were the most abundant of the 24 territorial species recorded in this mature, oak-hickory, floodplain woodlot. These two species each had a density of 35 territorial males per 100 acres, which is much greater than their densities reported for a disturbed oak-hickory forest with a pine stand edge and pond (eastern wood pewee [14] and indigo bunting [+] per 100 acres) in Licking County, Ohio (Claugus, 1973), or a hickory-oak-ash floodplain forest in Maryland (eastern wood pewee [9] and indigo bunting [+]) (Robbins, 1973). When all territorial males are considered in woodlot 12, the number per 100 acres (320) is intermediate between the total density (420 territorial males) found by Robbins (1973) and the total density (274 territorial males) found by Claugus (1973).

Only 7 of the 24 territorial species found in woodlot 12 (Table 2.7.14) are considered by Kendeigh (1961) to be prominent in the deciduous forest biociation. However, 15 of the 24 species are commonly associated with the deciduous forest-edge biociation. This indicates that the survey plot contains two habitat types in spite of an attempt to restrict the survey plot to a uniform habitat. Almost 12 acres of woodlot 12 were excluded from the survey plot to avoid sampling oxbows, a powerline right-of-way, swamp forest, and hawthorn-edge habitats. Any future surveys of this plot will be comparable, but comparison with other plots is difficult due to the uniqueness of this plot.

TABLE 2.7.14. BREEDING-BIRD, PLOT SURVEY IN PICKEREL CREEK WOODLOT (WOODLOT 12 IN FIG. 2.7.1)[a]

Common Name	Territorial Males or Females	Density per km(b)	Density per 100 acres
Eastern Wood Pewee	7	87	35
Indigo Bunting	7	87	35
Great Crested Flycatcher	5	62	25
Acadian Flycatcher	5	62	25
Red-eyed Vireo	5	62	25
Cardinal	5	62	25
Mourning Dove	3	37	15
American Robin	3	37	15
Rufous-sided Towhee	3	37	15
Field Sparrow	3	37	15
Song Sparrow	3	37	15
Tufted Titmouse	2	I[2]	I
Gray Catbird	2	I	I
Brown-headed Cowbird	2 (females)	I	I
Yellow-billed Cuckoo	1	I	I
Common Flicker	1	I	I
Blue Jay	1	I	I
House Wren	1	I	I
Wood Thrush	1	I	I
Blue-grey Gnatcatcher	1	I	I
Yellow-throated Vireo	1	I	I
Yellow Warbler	1	I	I
Red-headed Woodpecker	0.5	I	I
Common Yellowthroat	0.5	I	I
TOTALS:	64	791	320

(a) Survey plot=20 acres (8.09 hectares) of mature, oak-hickory, floodplain woodlot, which was recently grazed. Survey dates were June 19 to 21 and June 24 to 28. Eight trips were made from 0528 to 0830 hours EDST, and one trip was made from 2009 to 2140 hours. Total manhours=20.4. Visitors: Bobwhite, Screech Owl, Chimney Swift, Ruby-Throated Hummingbird, Downy Woodpecker, Common Crow, Brown Trasher, Cerulean Warbler, Red-Winged Blackbird, Northern Oriole, Common Grackle, American Goldfinch.

(b) I=Insufficient population for projection to a larger area.

Four of the territorial species (cardinal, tufted titmouse, blue jay, and red-headed woodpecker) recorded in woodlot 12 during June (Table 2.7.14) were also present in the same woodlot during the winter bird survey (Table 2.7.11). Three species (downy woodpecker, common crow, and American goldfinch) visiting the woodlot in June were present during the January plot survey. Six of these 7 species are considered permanent residents; only the red-headed woodpecker is considered half-hardy (normally a summer resident, but found in winter on occasion)(Campbell, 1968). Three bird species considered permanent residents (red-tailed hawk, brown creeper, starling, and house sparrow) (Campbell, 1968) were recorded during the winter survey at woodlot 12, but were not observed during the breeding bird survey at that woodlot.

Breeding Bird Evidence. Searches for bird nests resulted in the location of 12 nests of 10 different species of birds (Table 2.7.15). As expected, most of these nests were found in woodlot 12 since most nest searching efforts were concentrated in this woods in connection with the plot survey of territorial males. All of the species found nesting or feeding fledglings on the Site are also indicated as breeding birds for the Ottawa National Wildlife Refuge Complex (see Appendix G).

Roadside Survey. A total of 45 species of birds were recorded during a 4-day roadside survey in June (Table 2.7.16). All 45 species are considered to be summer residents of the Ottawa National Wildlife Refuge Complex (see Appendix G). The three most abundant species are the starling, house sparrow, and red-winged blackbird. These same three species were also found to be the most abundant birds reported for a similar roadside survey made in 1972 which ran north from Bismark, Ohio (Chandler Robbins, unpublished data). All three of these birds are considered nuisance species. The starling is infamous for its habit of encroaching on the feeding and nesting grounds of native birds and for its habit of taking over cavities from hole-nesting species, such as flickers (Campbell, 1968) and wood ducks. The house sparrow is normally found close to buildings and is rarely seen in woods or thickets that are far from a dwelling. Red-winged blackbirds can be found breeding in such varied habitats as marshes, shrubs, low trees, and hay fields (Campbell, 1968).

TABLE 2.7.15. BREEDING-BIRD EVIDENCE OBTAINED DURING MAY AND JUNE AT THE SITE[a]

Common Name	# in Nest: Eggs[c]	# in Nest: Nestlings	Nest Height in Ft.	Number and (Size) of Fledglings	Date of Discovery
Pickerel Creek Woodlot[b]					
Acadian Flycatcher	2	--	10	--	6/24
Eastern Wood Peewee	Incubating	--	35	--	6/27
Gray Catbird	--	--	--	1 (2/3 Ad.)	6/28
Blue-gray Gnatcatcher	--	1+	30	--	6/25
Yellow-throated Vireo	--	3+	30	--	6/20
Red-eyed Vireo	--	3	6	gone by 6/28	6/18
Red-eyed Vireo	1 (+2 B.C.)	--	6	--	6/28
Brown-headed Cowbird	2 in R.V. Nest	--	6	--	6/28
Rufous-sided Towhee	--	--	--	2 (1/3 Ad.)	6/27

	# of Eggs	Area [d]	Nest Height in Ft.	Young	Date of Discovery
Remainder of Site					
Mallard	6	Salt Spray Survey Site(15a)	0	--	5/22
Mallard	8	Edge of Schlegel's Woodlot(6)	0	--	5/22
Mallard	--	W.S.S.(A)	--	3+ (Class Ia)[e]	6/18
Mallard	--	W.S.S.(K)	--	3 (Class IIa)	6/27
Red-Tailed Hawk	--	South of S.R. 6 near Strong Cr.(4)	35	1 juv.	6/27
Mourning Dove	--	Along Strong Cr.	6	1 (nestling)	6/27
Northern Oriole	--	Woodlot in NW corner(11)	25	1+ (nestling)	6/26

(a) Survey dates were 18 to 21 and 24 to 28 June 1974.

(b) B.C. = Brown-headed Cowbird; R.V. = Red-eyed Vireo.

(c) Woodlot number 12 on Figure 2.7.1.

(d) Numbers in parentheses refer to Figure 2.7.14. W.S.S. = Waterfowl Survey Site, see Section 6.1.4.3.

(e) Duckling classes after Gollop and Marshall (1954). Ia = 1-6 days old, IIa = 19-25 days old.

TABLE 2.7.16. SUMMARY OF ROADSIDE BREEDING BIRD SURVEY AT THE SITE (a)

Common Name	4-Day Totals	
	Total Individuals	Stops Per Species
Great Blue Heron	33	23
Green Heron	1	1
American Bittern	1	1
Mallard	21	4
Wood Duck	3	2
Bobwhite	15	15
Ring-necked Pheasant	17	16
Killdeer	37	26
Ring-billed Gull	1	1
Mourning Dove	49	27
Black-billed Cuckoo	1	1
Great Horned Owl	1	1
Chimney Swift	10	4
Belted Kingfisher	1	1
Willow Flycatcher	4	2
Eastern Wood Peewee	1	1
Tree Swallow	1	1
Barn Swallow	35	8
Purple Martin	6	4
Blue Jay	2	2
Common Crow	6	5
Tufted Titmouse	2	2
House Wren	5	4
Gray Catbird	18	12
Brown Thrasher	1	1
American Robin	61	37
Wood Thrush	3	3
Starling	436	44
Red-eyed Vireo	5	5
Yellow Warbler	15	13
Common Yellowthroat	1	1
House Sparrow	275	35
Red-winged Blackbird	538	51
Orchard Oriole	1	1
Northern Oriole	3	3
Common Grackle	117	32
Brown-headed Cowbird	6	4
Cardinal	4	4
Indigo Bunting	54	37
American Goldfinch	41	15
Rufous-sided Towhee	2	2
Vesper Sparrow	1	1
Chipping Sparrow	1	1
Field Sparrow	6	4
Song Sparrow	110	56

(a) Twenty 3-minute stops were made at 0.5 mile intervals beginning at 0.5 hour before sunrise on June 19, 20, 21, and 24, 1974. The route was reversed on 2 days. See Figure 6.1.7 for location of stops.

The number of stops per species (survey stations where one or more individuals of a species is observed) is considered to be an indication of distribution (Robbins and Van Velzen, 1969). Therefore, the song sparrow is the most widely distributed bird species on the Site, since it was seen on 56 of 80 stops made over the 4-day survey period (Table 2.7.16). Five other species were seen at more than 30 stops; these species were the American robin, starling, red-winged blackbird, common grackle, and indigo bunting. Campbell (1968) reports that the song sparrow is the most widely distributed bird species in the Toledo area.

Survey results provided by Chandler Robbins (unpublished data) for a 1972, roadside-survey route running north from Bismark, Ohio, indiate that the starling and common grackle are the most widespread along that route. The American robin, house sparrow, red-winged blackbird, and song sparrow were also widely distributed species in that survey. The major difference between the Bismark survey and the roadside survey at the Site is the number of stops where great blue herons were recorded; the number of stops for the Site was 23 out of 80, but the great blue heron was not seen on any of the 50 stops on the route running north of Bismark.

General Reconnaissance Surveys. A total of 71 species of birds were observed at the Site during 10 survey days on June 18 to 21 and June 24 to 28, 1974, involving a total of 55 man-hours of observation (Table 2.7.17). Most of these off-transect surveys were made between 9:00 a.m. and 4:00 p.m., but data from two evening roadside surveys and three early-morning marsh surveys are also included in Table 2.7.20. Data in this table indicate the frequency of observation of each species but should not be construed to indicate the abundance of a species at the Site. Abundance is more accurately described by the roadside survey data (Table 2.7.16) and by the literature (Appendix G).

Several Ohio rare and endangered species of birds (Smith et al, 1968) were observed during the June surveys. The bald eagle was the only Ohio endangered species observed on the Site during June. However, four bird species (great egret, least bittern, king rail, and orchard oriole)

TABLE 2.7.17. BIRDS OBSERVED DURING GENERAL RECONNAISSANCE SURVEYS IN JUNE(a) AT THE SITE

Common Name	Frequency of Observation2	Common Name	Frequency of Observation(b)
Great Blue Heron	A	Eastern Wood Pewee	U
Great Egret	VR	Tree Swallow	U
Green Heron	C	Barn Swallow	U
Black-crowned Night Heron	R	Purple Martin	U
American Bittern	VR	Blue Jay	C
Least Bittern	R	Common Crow	VR
Mallard	VC	Tufted Titmouse	U
Blue-winged Teal	U	House Wren	C
Wood Duck	U	Long-billed Marsh Wren	R
Turkey Vulture	R	Gray Catbird	C
Red-tailed Hawk	U	Brown Thrasher	U
Bald Eagle	VR	American Robin	VC
American Kestrel	VR	Wood Thrush	R
Bobwhite	U	Blue-gray Gnatcatcher	R
Ring-necked Pheasant	R	Cedar Waxwing	R
King Rail	VR	Starling	A
Common Gallinule	VR	Yellow-throated Vireo	VR
Killdeer	C	Red-eyed Vireo	C
American Woodcock	VR	Warbling Vireo	VR
Spotted Sandpiper	R	Yellow Warbler	C
Herring Gull	VR	Common Yellowthroat	C
Mourning Dove	VC	American Redstart	VR
Yellow-billed Cuckoo	VR	House Sparrow	C
Great Horned Owl	R	Bobolink	VR
Chimney Swift	R	Eastern Meadowlark	U
Ruby-throated Hummingbird	R	Red-winged Blackbird	A
Belted Kingfisher	U	Northeron Oriole	U
Common Flicker	U	Common Grackle	VC
Red-bellied Woodpecker	VR	Cardinal	C
Red-headed Woodpecker	R	Indigo Bunting	VC
Hairy Woodpecker	R	Dickcissel	R
Downy Woodpecker	U	American Goldfinch	VC
Eastern Kingbird	U	Rufous-sided Towhee	R
Great Crested Flycatcher	U	Vesper Sparrow	VR
Acadian Flycatcher	R	Chipping Sparrow	VR
Willow Flycatcher	U	Field Sparrow	C
		Song Sparrow	C

(a) June 18 to 21 and 24 to 28; 55 total man-hours of observation, with 35 of those hours by two observers working together. Most of these off-transect surveys were made between 0900 and 1600 hours, but it does include two evening roadside surveys and three early morning marsh surveys.

(b) The approximate number of observations (9 days total) is indicated by the following letters: A = Abundant, 100+; VC = Very Common, 51-100; C = Common, 16-50; U = Uncommon, 6-15; R = Rare, 3-5; VR = Very Rare, 1-2.

considered rare in Ohio were seen during one or more surveys in June. Ten bird species that have recently exhibited population declines in Ohio were seen during the June surveys; these species include the pied-billed grebe, American bittern, ring-necked pheasant, screech owl, purple martin, common crow, long-billed marsh wren, warbling vireo, bobolink, and northern oriole.

Waterfowl Brood Survey. Only one brood of 3 mallards was observed during 4 early-morning surveys at 5 marsh stations along Pickerel Creek. This Class IIa (19 to 25 days old) brood was seen on June 27, 1973. Adult waterfowl recorded at these survey stations (Figure 6.1.7) included 45 mallards, 4 blue-winged teals, and 6 wood ducks. An additional brood of at least 3 Class Ia (1 to 6 days old) mallards were seen on June 18 at survey station K, but this brood was not seen on the four survey days.

Although the mallard was the only waterfowl species observed with a brood or on a nest at the Site, other species are known to breed in the Sandusky Bay area. Campbell (1968) reported on the results of John Anderson's survey at the Winous Point marshes. In 1960, Anderson recorded the following numbers of nests or pairs of breeding ducks: mallard, 110; black duck, 20; pintail, 60; blue-winged teal, 80; and wood duck, 16, plus a green-winged teal nest and two male northern shovelers defending territory.

Campbell (1968) also reported on 15 years of waterfowl breeding pair surveys made by Karl Bednarik at Magee Marsh near Oak Harbor, Ohio. He recorded the following 14 species of waterfowl present as breeding pairs: mallard, black duck, blue-winged teal, green-winged teal, wood duck, gadwall, Canada goose, American wigeon, northern shoveler, pintail, mallard-black duck cross, redhead, ruddy duck, and hooded merganser. The four species with the greatest number of breeding pairs during each of the 15 years are the mallard, black duck, blue-winged teal, and wood duck.

Bird Impaction Studies

A total of 11 species of birds were collected below the meteorological tower on the Site from March 1 to June 28, 1974. The following species from 7 families were collected: (1) Rallidae-sora, (2) Corvidae-blue jay, (3) Mimidae-gray catbird, (4) Turdidae-wood thrush, (5) Vireonidae-red-eyed vireo and Philadelphia vireo, (6) Parulidae-cerulean warbler, blackburnian warbler, and bay-breasted warbler, and (7) Icteridae-bobolink and rusty blackbird. Seven of these eleven species are reported to breed in the area (U.S.D.I., 1970). A more complete picture of bird impacts with tall structures is described in Chapter 5.

Bald Eagles

Bald eagles use the northwestern portion of the Site for nesting, although the nests indicated in Figure 2.7.4 may not be used every year. In 1974, no eagles used the two nests in the northwestern portion of the Site, but a new nest was built about 0.5-mile east of the Site (Figure 2.7.5). The female at this latter nest appeared to be incubating, but no young were raised. Bald eagles used one of the nests in the northwest corner of the Site in 1973 and both of the nests in 1972. It is very possible that these two nests will be used in future years.

Present population estimates for bald eagles in the continental United States (which includes members of both subspecies) is 750 breeding pairs (Knoder, 1972). In the summer of 1973, only 627 active nests were found in the Lower 48 states (Laycock, 1974). The Lake Erie region, particularly around Sandusky Bay, is the only place in Ohio where bald eagles are known to nest. Laurel Van Camp, Naturalist, Crane Creek Wildlife Experiment Station (personal communication, 1974), reports that bald eagles nests are presently found in only the following 9 areas in Ohio: Sandusky County, 5 nests; Ottawa County, 2 nests; Erie County, 1 nest; and Lucas County, 1 nest.

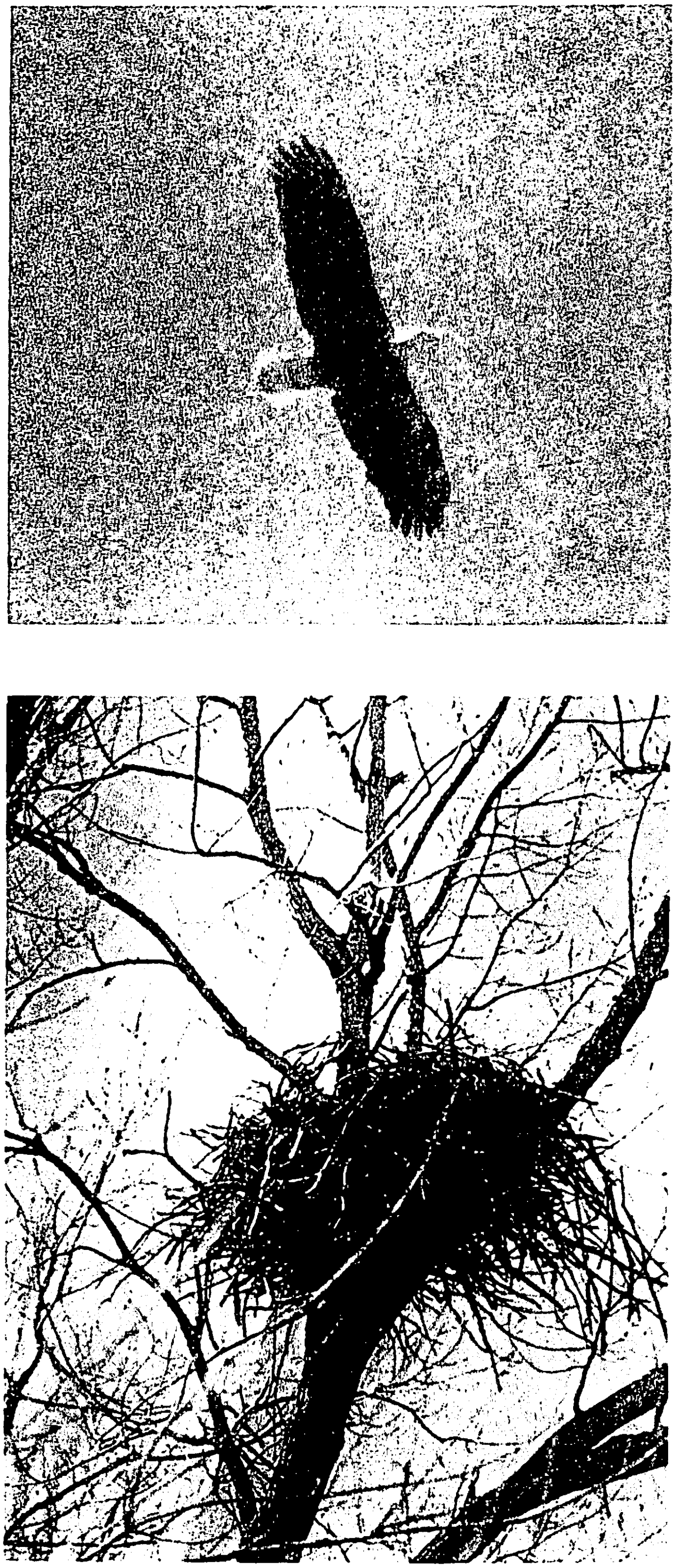


FIGURE 2.7.4 BALD EAGLE AND ITS STICK NEST TAKEN 0.5-mi. EAST OF THE SITE, APRIL, 1974

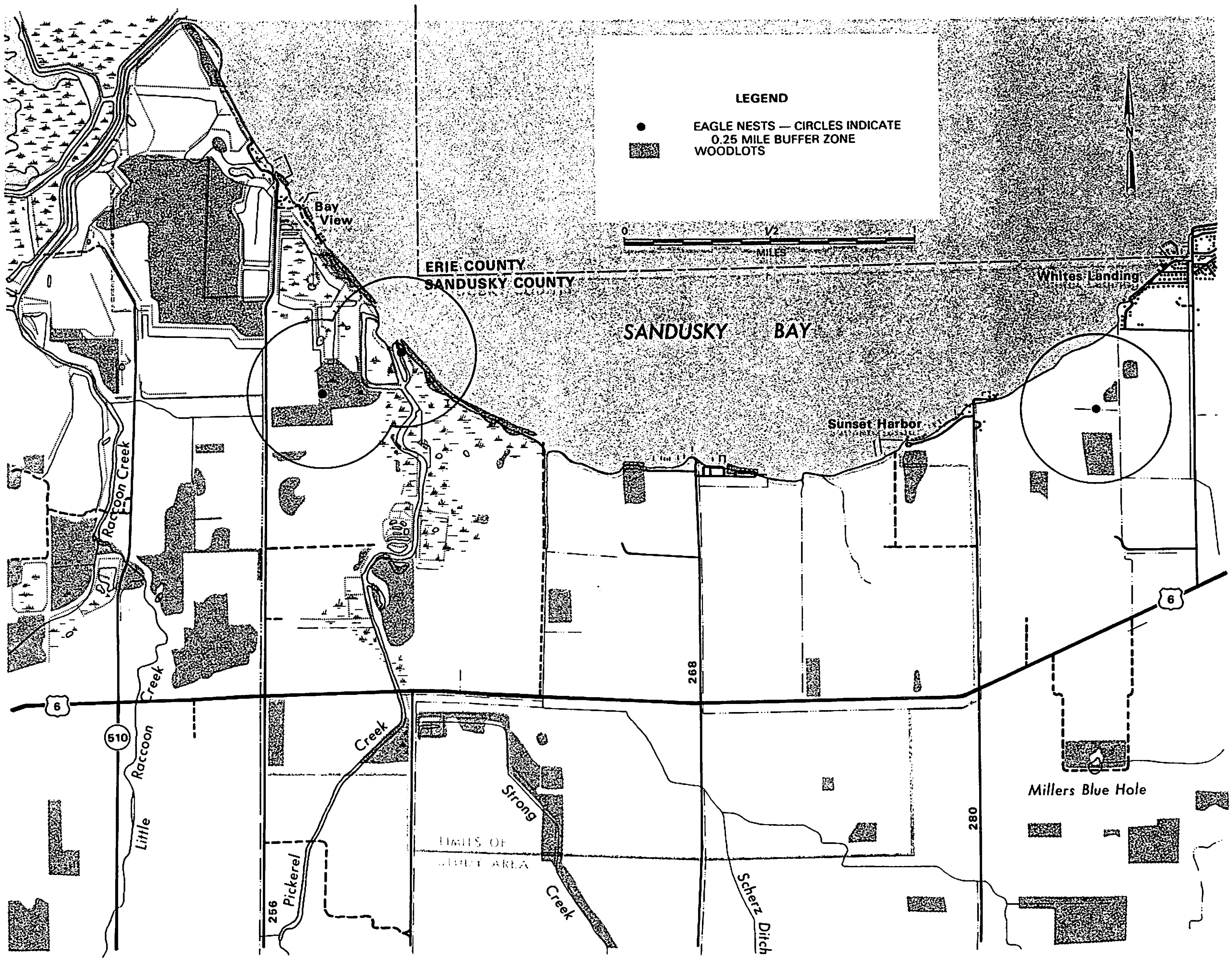


FIGURE 2.7.5 BALD EAGLE NEST LOCATIONS

Richard Branzell, U. S. Game Management Agent (personal communication, 1973), found 6 nesting pairs of bald eagles during his 1972 aerial surveys, but no young were produced. In 1973, he reported 7 nesting pairs which produced a total of 2 eaglets from one nest. The productive nest is about 2 miles east of the Site. Laurel Van Camp (personal communication, 1974) reports that a total of 2 eaglets from two successful nests were raised in 1974. However, the nest indicated in Figure 2.7.4 on the east side of the Site was not successful.

"Causes of (eagle) nesting failure are complex. Some leading authorities state the presence of humans and their interferences 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).

In spite of past declines in the bald eagle population, information obtained during the last 2 years has improved the outlook. "According to Paul Nickerson, both the percentage of successful nesting efforts and the number of young raised in active nests have increased slightly, coinciding with decreased use of DDT" (Laycock, 1974). Roger Thacker (personal communication, 1974) reports that the decline in bald eagle populations due to pesticides apparently has been stopped and that the Lake Erie colony, given proper management and protection, can become a viable population.

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 Chesepeake 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 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). Thacker (personal communication) reports that about 23 bald eagles have been shot in Ohio since 1956.

There are two subspecies of the bald eagle: Haliaeetus leucocephalus 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 (Smith et al, 1973).

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 ramification.

Two examples of successful eagle nests in the vicinity of heavy human disturbance have been 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).

> "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).

Although the preceding statement is old, the current interest in bald eagles nesting along Lake Erie is still high (Smith, Branzell, Sprunt, and Thacker, personal communication).

Bird Diversity in Comparison to Other Areas

Bird species observed at the Site represent a significant number of the bird species found in nearby areas and in the State of Ohio. For example, of the 288 bird species observed on the Ottawa National Wildlife Refuge Complex, over half (154) of those species have been seen during surveys at the Site (Appendix G). Also, 45 species were observed during a 4-day roadside breeding-bird survey at the Site (Table 2.7.16). This total is nearly half of all bird species (110) recorded during 2 years of roadside breeding-bird surveys throughout the State of Ohio (Robbins and Van Velzen, 1969). A 1-day roadside breeding-bird survey near Bismark, Ohio, resulted in the observation of 47 species at 50 stops, which is nearly equal to the number observed during the 4-day (20 stops repeated each day) roadside survey at the Site.

Many species of migratory waterfowl make use of the site during the spring and fall. Twenty-three of the 35 species of waterfowl observed at the Ottawa National Wildlife Refuge Complex have been seen on the Site (Appendix G). On a broader basis, the migratory waterfowl seen at the Site represent about 60 percent of the 38 species of waterfowl found in Eastern North America (Peterson, 1947).

2.7.1.4 Insects

The importance of insects in the energy flow of the food webs on the Site is due to the large number of insect consumers. Of the small mammals found on the Site, the moles, shrews and bats are known to live almost entirely on insects while other rodents feed on insects to a limited extent. The larger mammals, such as the opossum, raccoon, and skunk eat a smaller percentage of insects. The major food source for fish, reptiles, and amphibians is insects with only limited amounts of food obtained directly from plants

(Martin et al, 1961). A more detailed listing of site mammals, reptiles, and amphibians and their food habits is given in Section 2.7.1.2. Many of the marshbirds and shorebirds also include insects as part of their principal fare (Martin et al, 1961), but insects are less important fare for waterfowl. The vase majority of songbirds, i.e. tanagers, and orioles, rely wholly or partially on insects for food (Martin et al, 1961). Dowden and Mitchell (1966) also discuss the importance of insects in bird diets. Table 2.7.18 lists those groups of birds found on the Site that depend almost entirely on insects.

The discussion of important insect species is carried on at the family level since their habitats and relationship to their environment are shared throughout the family group. Ecological structure and function of the insects within the system can be sufficiently discussed on the family level. The main family groups found on the Site include both herbivores, detritivores, and predators/parasites. The main herbivorous families were found in the orders Homoptera, Hemiptera, and Coleoptera. Both the Homopterans and Hemipterans have piercing-sucking mouth parts. The major Hemipteran family was Lygaeidae with the largest number being found at station 12. The Lygaeids feed on many plants and their seeds. They overwinter as adults and have more than one generation a year. In agricultural areas they may migrate after the small grains dry up to other fields such as corn where the damage can be extensive. The major Homopteran family was the Cicadellidae or leaf-hoppers. The leafhoppers overwinter as adults or eggs usually having only one generation per year. Food preference in most species is quite specific making the habitats well defined. A few species in this family can be injurious to orchard and field crops by transmitting diseases while feeding. The principle herbivorous Coleopteran was the family Chrysomelidae or leaf beetles. The Chrysomelid adults are principally flower and foliage feeders while the larvae can feed on any part of the plant depending upon the species. Many species of leaf beetles are serious pests and do overwinter as adults (Borror and DeLong, 1971).

The main predators were also Coleopterans from the Coccinellid family. The Coccinellids or lady bird beetles are valued throughout the United States as beneficial insects. Several species of ladybird beetles were found on the Site. The adults and larvae feed on aphids chiefly, mites, scale insects, and other inuurious insects. They overwinter as adults frequently in aggregations, in debris or leaves. The main parasites found were Hymenopterans of the Ichneumonid and Braconid families. The life cycles

TABLE 2.7.18. COMMON NAME AND FAMILY OF INSECTIVOROUS BIRDS LIKELY TO BE FOUND AT SITE[a]

Common Name	Family
Cuckoos	Cuculidae
Goatsuckers	Caprimulgidae
Swifts	Apodidae
Woodpeckers	Picidae
Flycatchers	Tyrannidae
Swallows	Hirundinidae
Nuthatches	Sittidae
Creepers	Certhiidae
Wrens	Troglodytidae
Robin	Turdidae
Bluebirds	Turdidae
Thrushes	Turdidae
Gnatcatchers	Sylviidae
Kinglets	Sylviidae
Pipits	Motacillidae
Vireos	Vireonidae
Wood Warblers	Parulidae

(a) From Robbins et al, 1966.

of these wasps vary according to their host species. They parasitize almost all insect groups and are specific as to host. Parasitism from these two families decreases potential infestations of many harmful insects (Borror and DeLong, 1971).

The family that comprised more than half of the number of insects collected on the Site is the family Chironomidae, Order Diptera. The Chironomids or midges are detritivores and many of the larvae are aquatic. The midge larvae are often quite abundant and are an important food for many freshwater fish and other aquatic organisms (Borror and DeLong, 1971). They form an important link in the food chain and have a wide tolerance of environmental factors living in both clean and polluted water (Mason, 1968). As commented on by Usinger (1971), the Chironomid family forms one of the most important single groups in the ecology of aquatic environments.

The major and minor family groups were analyzed by the Shannon-Weiner Index (Odum, 1971), to determine species diversity of each sample station. Table 2.7.19 shows the number of orders, families, and species at each station. As seen in Table 2.7.20, station 6 a woodlot with medium to light underbrush has the highest diversity. Station 12 in the older woodlot had little brush under the canopy and the vegetation present was not climax vegetation due to the grazing in the past two years. Since only ground-level was sampled, the climax community of the canopy is not represented as indicated by the woodlot on station 6 having only the fourth highest diversity. Station 16a, a fencerow also included a ditch habitat, but the fencerow had a wide variety of woody shrubs present allowing for a more diverse community from lack of disturbance. Following Odum's premise (1971) of higher diversities being found on less disturbed areas or areas further along succession to climax, it would be expected that the oldfield would be the lowest in diversity, the marsh next in diversity, although less disturbed by man and more disturbed by nature, and the young woodlot the highest in diversity. The diversity indices from the insect data at the site corroborate with this premise.

TABLE 2.7.19. NUMBER OF ORDERS, FAMILIES, AND SPECIES AT SAMPLE STATIONS. 1974

Site	# Orders	# Families	# Species
1	8	21	26
6	7	29	52
12	8	40	74
17b	6	16	24
15a	7	18	29
16a	8	25	70

TABLE 2.7.20. TOTAL NUMBER OF INDIVIDUALS AND SPECIES DIVERSITY AT SAMPLE STATIONS. 1974

Site	Total No. Individuals	Diversity Index
1	114	3.776
6	229	4.619
12	754	4.046
17b	118	3.464
15a	215	3.242
16a	430	4.462

2.7.2 AQUATIC ECOLOGY

2.7.2.1 Benthos

Taxonomic and Qualitative Analysis of the Benthic Community

A list of the benthic invertebrates found in Sandusky Bay is shown in Table 2.7.21. The benthic invertebrate community of Sandusky Bay and tributaries is primarily composed of Oligochaete worms and Chironomid (Midge) larvae. Although twenty-nine genera were recorded from samples, some appeared in only one sample while others, such as mollusks, were identified from empty shells. Some of these organisms have been reported in the Bay, but it is not known whether they are denizens of the Bay or were washed into the Bay during high water. High water made it impossible to completely sample the littoral zone of the south shore where many species of aquatic insect larvae and crustaceans typically exist. Riprap stone along a section of the shore contains many niches which no doubt are filled with invertebrates that defy quantitative and qualitative routine sampling, particularly during periods of fluctuating water levels.

A complete list of aquatic organisms reported from Sandusky Bay is found in Appendix H. This list includes organisms reported in the literature and from the present study. This list also cites the decade the organisms were reported in Sandusky Bay.

Relative Abundance of Species in the Benthic Community

Table 2.7.22 summarizes the number of benthic organisms collected at each station per month. Included in Table 2.7.22 are the two saturation sampling periods, November, 1972, and July, 1973, in which all stations were sampled. The largest number of benthic organisms was collected in the mid-bay channel. The mean number of benthic organisms collected from all mid-bay stations (See Figure 2.7.6, Stations 33, 21, 35, 36, 38) was 2064/ m^2 as compared to 1160/ m^2 for all shore/near-shore stations (see Figure 2.7.7, Stations 5, 6, 8, 16, 17, 19, 29, 31). The least number of benthic organisms was collected at the shore stations (see Figure 2.7.7, Stations 1, 5, 16, 22, 28). The mean number of organisms collected at all shore

TABLE 2.7.21. BENTHIC INVERTEBRATES OBTAINED FROM SANDUSKY BAY, NOVEMBER, 1972 TO MARCH, 1974

Phylum Ectoprocta (Bryozoa)	
	Plumatella sp.
Phylum Annelida	
Class Oligochaeta	
Order Plesiopora	
Family Tubificidae	
	Branchiura sowerbyi
	Limnodrilus hoffmeisteri
	Peloscolex ferox
	Amphichaeta sp.
	Bothrioneurum sp.
Class Hirudinea	
Order Rhynchobdellidae	
Family Glossiphoniidae	
	Helobdella sp.
	Glossiphonia complanata
Phylum Arthropoda	
Class Insecta	
Order Diptera	
Family Culicidae	
	Chaoborus sp.
Family Ceratopogonidae	
	Palpomyia sp.
Family Chironomidae	
Subfamily Chironominae	
	Chironomus plumosus
	Polypedilum sp.
Subfamily Tanypodinae	
	Procladius culiciformis
	Coelotanypus sp.
	Clinotanypus sp.
	Anatopynia sp.
Phylum Mollusca	
Class Gastropoda	
Order Pulmonata	
Family Physidae	
	Physa sp.
Family Planorbidae	
	Planobula sp.
	Helisoma sp.
Family Anclyidae	
	Ferrissia sp.
Family Lymnaeidae	
	Bulimnaea sp.
Order Ctenobranchiata	
Family Amnicolidae	
	Amnicola sp.
Family Viviparidae	
	Viviparus sp.
Family Valvatidae	
	Valvata sp.
Family Pleuroceridae	
	Pleurocera sp.
	Goniobasis sp.
Class Pelecypoda	
Family Sphaeriidae	
	Pisidium sp.
	Sphaerium sp.
Family Unionidae	
	Anodouta grandis

FROM ALL STATIONS IN SANDUSKY BAY AND ADJACENT WATERS

November, 1972 to March, 1974

Station	November, 1972	March, 1973	May, 1973	June, 1973	July, 1973	August, 1973	September, 1973	October, 1973	November, 1973	December, 1973	January, 1974	February, 1974	March, 1974
1	819				402								
2	3,117												
3	3,808				210								
4	3,254				95								
5	918	1,815	344	286	114	191	535	689	728		824		1,035
6	2,601	3,526	1,415	497	707	496	535	632	670		825		929
7	2,373				573								
8	4,477	731	133	172	172	172	631	900	938		1,129		1,262
9	4,098				517								
10	421				306								
11	1,764				1,169								
12	3,271				364								
13	2,015				287								
14	818				211								
15	916				96								
16	172	172	495	612	96	153	536	1,015	1,035		1,243		1,359
17	976	5,977	822	572	937	421	707	1,110	1,225		1,435		1,549
18	1,072				306								
19	727	4,567	1,050	690	535	344	1,264	1,264	1,264		1,493		1,550
20	307				95								
21	632	923	1,242	593	498	229	785	1,147	1,167		1,646		1,667
22	57				19								
23	1,162				133								
24	732				517								
25	1,033				459								
26	1,033				267								
27	1,420				422								
28	57				305								
29	1,243	1,118	3,113	439	249	766	1,224	1,436	1,475		1,837		1,953
30	894				766								
31	632	215	6,724	3,024	478	440	1,244	1,339	1,378		1,704		1,702
32	497				287								
33	387	5,891	4,279	3,464	287	191	944	1,283	1,322		1,647		1,609
34	172												
35	1,506	645	6,475	4,249	613	478	881		1,339				
36	2,970	17,673	6,150	4,077	498	709	899	1,301	1,301				6,150
37					191	363	900	1,111	1,110		1,511		1,454
38	2,282	129	1,679	2,467	421		1,262	1,550	1,531				1,679
39					306	172	785	1,147	1,244				
40					114	57	613		1,187				
41						555	1,263	1,895	1,492				
43						57	229	325	211				
						57	172	230	344				
Mean	1,476	3,319	2,609	1,624	355	325	818	1,080	1,103		1,390		1,839

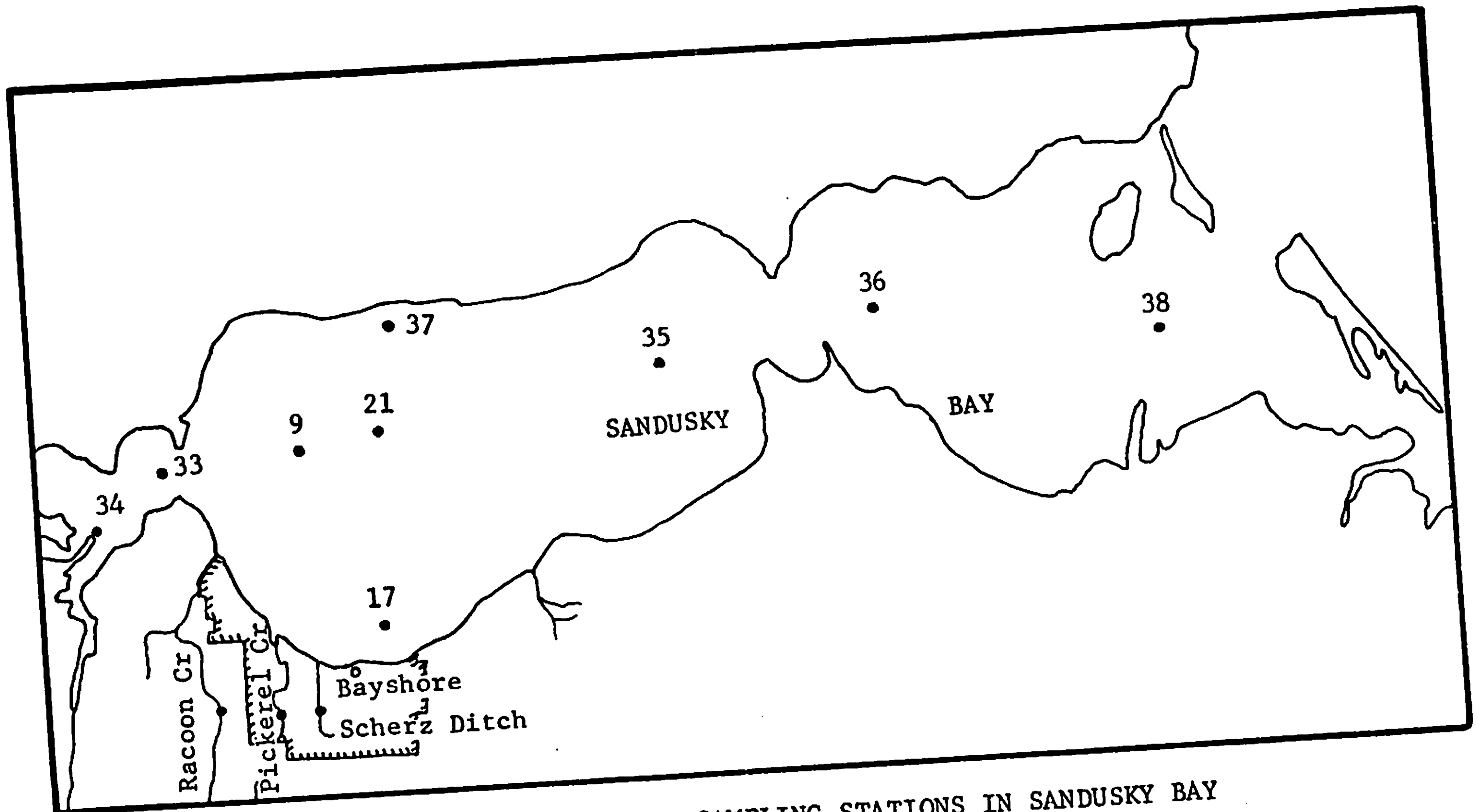


FIGURE 2.7.6. POSITION OF SAMPLING STATIONS IN SANDUSKY BAY

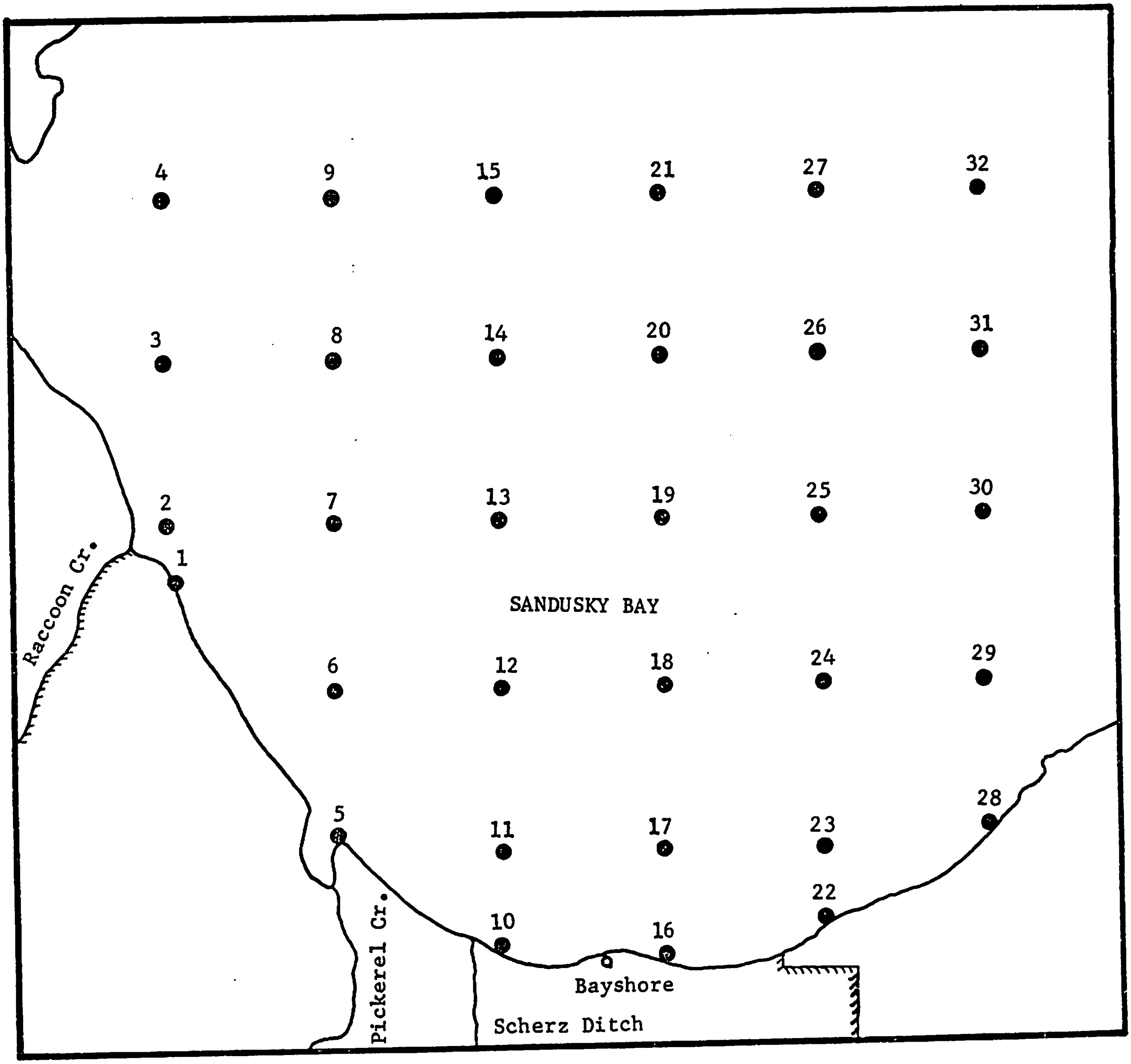


FIGURE 2.7.7 POSITIONS OF SANDUSKY BAY SAMPLING STATIONS ADJACENT TO PROPOSED SITE

stations (see Figure 2.7.7, Stations 1, 5, 16, 22, 28). The mean number of organisms collected at all shore stations was 83/ m^2. The larger standing crop of benthic organisms in the mid-bay area is probably the result of a more stable habitat. The shallower shore and near-shore area is more affected by wind and fluctuating water levels.

The highest number of organisms was collected at Stations 36 (central basin) and 35 (eastern end of western basin). The mean number of benthic organisms collected at Station 36 was 4446/ m^2. Station 36 is probably the most sheltered and thus the most stable habit in the whole mid-channel of Sandusky Bay. In the western basin of the Bay, Station 35 yielded the most benthic organisms. The mean number of organisms collected at this station was 2023/ m^2.

The greatest relative abundance of benthic organisms was in the eastern sector of the western basin at Stations 17, 19, 29, and 31. The mean number of organisms collected at these eastern stations of the western basin was 1459/m^2 as compared to 940/sq mi for the western Stations 5, 6, and 8.

There was a definite seasonal variation in the number of organisms collected at all stations. Table 2.7.22 lists the mean number of organisms collected each month through the present study. The largest number of organisms were collected in March, with monthly decline in number to a low in August. From August to the next March there was a monthly increase in the number of organisms collected. The low density of organisms collected during July and August is probably the result of the emergence of Chironomids (midges) and the natural mortality of Oligochaetes. During the months of July and August, collections at all stations showed the absence of one or more of the dominant species of Oligochaetes and Chironomids. From September to March all such dominant populations were collected in each sample.

Oligochaetes dominate the benthic community of Sandusky Bay. Appendix I summarizes the species composition of all mid-bay and shore/near-shore stations. The sum total of all individuals collected from all stations in Sandusky Bay, from March to March, shows the following break-down by taxa and genera:

Oligochaetes	Chironomids
Branchiura - 23,728	Chironomus - 18,373
Limnodrelus - 17,775	Procladius - 14,307
Peloscolex - 16,209	Coelotanypus - 12,605
Immatures - 74,486	

The immature Oligochaetes are most abundant, particularly in the mid-bay stations. Adult Oligochaetes are likewise more abundant in the mid-bay area. Station 33 (mouth of Muddy Creek Bay) was the only mid-bay station in which the Chironomids outnumbered the Oligochaetes. The Chironomids dominated the samples collected at Station 33 from September to January. In the near-shore Stations 29 and 31 (see Figure 2.7.7), Chironomids outnumbered the Oligochaetes from July to November.

The data for the rest of the Bay stations do not indicate any geographic preference by any species. All species seem to be rather widely distributed throughout the western basin of Sandusky Bay. The data do not show any correlation between the density of one species against another, even seasonally.

The characteristics of the benthic fauna seem to be homogeneous for the western basin. Table 2.7.23 summarizes the benthic fauna from Station 37 on the north shore of the western basin. The data for this station are very similar to that from the south shore; the same populations are present and in approximately the same density relationship. The Oligochaetes dominate the community, and the total density of organisms is lowest in July and August.

Table 2.7.24 summarizes the benthic data for Station 39 located at the junction of Pickerel Creek and Route 6. For the purpose of defining a benthic community, this station can be considered as an inland extension of the Bay. A comparison of the total sample per month in Table 2.7.24 with the mean number of organisms collected in the Bay for the same month (Table 2.7.22), the results are very comparable.

Station 40, located in Scherz Ditch at Route 6 is another inland extension of the Bay. A comparison of the total number of benthic organisms collected per month at Station 40 (Table 2.7.25) with the mean number of similar organisms collected in the Bay indicate that the standing crop at Station 40 is less. During the month of August, there were no Chironomids collected at this station. The Chironomids reappeared in the September and November collections.

TABLE 2.7.23. BENTHOS - SANDUSKY BAY, STATION 37

Taxa	July			August			September			October			November			January			March		
	No./ sq m	% of Taxa	% of Total	No./ sq m	% of Taxa	% of Total	No./ sq m	% of Taxa	% of Total	No./ sq m	% of Taxa	% of Total	No./ sq m	% of Taxa	% of Total	No./ sq m	% of Taxa	% of Total	No./ sq m	% of Taxa	% of Total
Oligochaeta																					
Branchiura	38	24.8	19.9	38	19.9	10.5	287	44.1	31.9	306	38.0	27.5	287	36.6	25.9	344	34.6	22.8	306	31.4	21.0
Limnodrilus	96	62.7	50.3	38	19.9	10.5	115	17.7	12.8	134	16.7	12.1	172	21.9	15.5	211	21.2	14.0	211	21.6	14.5
Peloscolex	19	12.4	9.9	0	0.0	0.0	19	2.9	2.1	134	16.7	12.1	134	17.1	12.1	134	13.5	8.9	172	17.6	11.8
Immatures	0	0.0	0.0	115	60.2	31.7	230	35.3	25.6	230	28.6	20.7	191	24.4	17.2	306	30.8	20.3	287	29.4	19.7
		100			100			100			100			100			100			100	
Total	153			191			651			804			784			995			976		
Percent of total sample			80.1			52.6			72.3			72.4			70.6			65.9			67.1
Diptera																					
Chironomus	0	0.0	0.0	19	11.0	5.2	77	30.9	8.6	115	37.5	10.4	134	41.1	12.1	172	33.3	11.4	153	32.0	10.5
Procladius	19	50.0	9.9	57	33.2	15.7	38	15.3	4.2	77	25.9	6.9	96	29.4	8.6	153	29.7	10.1	153	32.0	10.5
Coelotanypus	19	50.0	9.9	96	55.9	26.4	134	53.9	14.9	115	37.5	10.4	96	29.4	8.6	191	37.0	12.6	172	36.0	11.8
		100			100			100			100			100			100			100	
Total	38			172			249			307			326			516			478		
Percent of total sample			19.9			47.9			27.7			27.6			29.4			34.1			32.9
Total sample	191			363			900			1,111			1,110			1,511			1,454		

TABLE 2.7.24. BENTHOS - SANDUSKY BAY, STATION 39

Taxa	July Number/ sq m	July Percent of Taxa	July Percent of Total	August Number/ sq m	August Percent of Taxa	August Percent of Total	September Number/ sq m	September Percent of Taxa	September Percent of Total	October Number/ sq m	October Percent of Taxa	October Percent of Total	November Number/ sq m	November Percent of Taxa	November Percent of Total
Oligochaeta															
Branchiura	0	0.0	0.0	0	0.0	0.0	153	42.1	19.5	191	31.2	16.7	191	29.3	15.6
Limnodrilus	38	14.2	12.4	19	12.4	11.4	134	37.0	17.0	191	31.2	16.7	211	32.4	17.0
Peloscolex	0	0.0	0.0	19	12.4	11.4	19	5.2	2.4	96	15.7	8.4	134	20.6	10.8
Immatures	230	85.8	75.6	115	75.6	66.9	57	15.7	7.2	134	21.9	11.7	115	17.7	9.2
		100			100			100			100			100	
Total	268			153			363			612			651		
Percent of total sample			87.6			89.0			46.2			53.4			52.3
Diptera															
Chironomus	19	50.0	6.2	0	0.0	0.0	211	50.0	26.9	191	35.7	16.7	191	29.3	15.6
Procladius	0	0.0	0.0	19	100	11.0	96	22.7	12.2	172	32.1	15.0	211	32.4	17.0
Coelotanypus	19	50.0	6.2	0	0.0	0.0	115	27.3	14.6	172	32.1	15.0	191	29.3	15.6
		100			100			100			100			100	
Total	38			19			422			535			593		
Percent of total sample			12.3			11.0			53.8			46.6			44.7
Total sample	306			172			785			1,147			1,244		

TABLE 2.7.25. BENTHOS - SANDUSKY BAY, STATION 40

Taxa	July Number/ sq.m.	July Percent of Taxa	July Percent of Total	August Number/ sq m	August Percent of Taxa	August Percent of Total	September Number/ sq m	September Percent of Taxa	September Percent of Total	November Number/ sq m	November Percent of Taxa	November Percent of Total
Oligochaeta												
Branchiura	0	0.0	0.0	0	0.0	0.0	134	31.8	21.9	211	33.3	17.8
Limnodrilus	57	60.0	50.0	0	0.0	0.0	191	45.4	31.2	211	33.3	17.8
Peloscolex	0	0.0	0.0	38	66.7	66.7	19	4.5	3.1	115	18.2	9.7
Immatures	38	40.0	33.3	19	33.3	33.3	77	18.3	12.6	96	15.2	8.1
		100			100			100			100	
Total	95			57			421			633		
Percent of total sample			83.3			100.0			68.7			53.3
Diptera												
Chironomus	0	0.0	0.0	0	0.0	0.0	96	50.0	15.7	191	34.5	16.1
Procladius	19	100	16.7	0	0.0	0.0	77	40.1	12.6	191	34.5	16.1
Coelotanypus	0	0.0	0.0	0	0.0	0.0	19	9.9	3.1	172	31.0	14.5
		100			100			100			100	
Total	19			0			192			554		
Percent of total sample			16.7			0.0			31.3			46.7
Total sample	114			57			613			1,187		

Station 41, located at the outflow of Millers Blue Hole, is different from the other Bay and inshore stations. The substratum is primarily calcareous marl (Taffa Rock) with small patches of field drained silt. Large masses of the filamentous alga, Cladophora are attached to the marl base rock. The dominant benthic species is the crustacean amphipod, Hyalella azteca, a common periphytic grazer. The benthic community is probably more extensive in species number than recorded due to the difficulty in dislodging organisms from the crevices in marl. Hand picking seems to be the only method that is satisfactory but difficult to quantify. Table 2.7.26 summarizes the quantitative benthic invertebrate data from this station.

TABLE 2.7.26. STATION 41 BENTHOS OF MILLERS BLUE HOLE OUTFLOW

	Aug.	Sept.	Oct.	Nov.
Hyalella azteca	459	746	1684	1148
Pseudochironomus sp.	96	421	0	0
Chrionomus plumosus	0	0	211	344

(all units - number m^2.)

Stations 43 and 44, located at the junction of Pickerel Creek -- Rt. 247 and Scherz Ditch -- Rt. 247 respectively, are inland (south) far enough that they are not influenced by Bay water. The substratum is shelving rock and silt laden pools, very characteristic of the small streams in the county. Both showed evidence of drying up, except for some pools, during the summer of 1973. Some immature Oligochaetes were recorded from Scherz Ditch in August but no adults were recorded. At Pickerel Creek there was a complete absence of Oligochaetes. All three species of Chironomids were present but in lower densities than those of the Bay. The Bryozoan animal, Plumatella sp., was found in both stations in August. Table 2.7.27 shows the qualitative and quantitative data for both stations.

TABLE 2.7.27. QUALITATIVE AND QUANTITATIVE SUMMARY OF BENTHIC INVERTEBRATES COLLECTED AT TWO ON-SHORE STATIONS AUGUST - NOVEMBER, 1973

(Number of Organisms/m^2)

	August	September	October	November
Station 43--Pickerel Creek at Route 247				
Chironomus	0	38	19	96
Procladius	0	0	134	0
Coelotanypus	38	191	172	115
Plumatella	19	0	0	0
Station 44--Bayshore Ditch at Route 247				
Immatures (Oligochaetes)	19	0	0	0
Chironomus	0	57	19	172
Procladius	0	0	77	19
Coelotanypus	19	115	134	153
Plumatella	19	0	0	0

Life History of Dominant Benthic Organisms

According to Brinkhurst (1971) the Oligochaetes, Limnodrilus hoffmeisteri and Branchiura sowerbyi are able to withstand a wider range of environmental conditions that all other freshwater tubificids (the family of Oligochaetes found in Sandusky Bay). These tubificids can withstand periods of oxygen deficiencies, including complete anaerobic conditions, for up to four weeks under laboratory conditions. They therefore have the ability to be faculative anaerobes for short periods of time.

All of these worms burrow into the sediment; some constructing tube cases. They ingest mud and extract both soluble nutrient material and microorganisms.

The Oligochaetes in Sandusky Bay have a one-year life cycle. Brinkhurst (1971) states, "the peak of breeding may take place when the water temperature reaches about 15 C." He also contends that this is highly variable because many species show a wide range of breeding behavior.

Brinkhurst (1971) states further that the species present in any particular habitat may be present the year-round both in the adult and juvenile form. This seems to be the case in Sandusky Bay. There is no evidence from the available data to indicate a preponderance of either adult or immature forms over one another.

Of the three most abundant species of Chironomids in Sandusky Bay, Procladius curiciformus and Coelotanypus sp. are carnivorous predators while Chironomus plumosus is a herbivore which constructs a definite burrow, (Johannsen, 1969). According to Oldroyd (1964), Chironomus will spin a cone of silk that projects into the water. Plankton and other organisms become stuck to the silk and are devoured along with the silk. The larvae then spins another cone and repeats the process. It may also merely extend from the burrow and graze on surrounding microorganisms. Body undulations by the larvae carry water down into the burrow-tube to the gills located in the posterior body segment. The genus Chironomus feeds primarily on planktonic diatoms, algae, aquatic plant tissue, and decaying organic matter.

Procladius and Coelotanypus belong to the subfamily Tanypodinae which, according to Johannsen, (1969), do not construct burrows. They may inhabit the burrows of those species that do construct. The members of this subfamily are predaceous, feeding largely on other Chironomids.

Both Oligochaetes and Chironomids are denizens of aquatic environments that are highly eutrophic. They require a substrate of mud and silt that contains a high amount of organic material. Sandusky Bay offers such suitable niches for these organisms.

Diversity Indices of the Benthic Community

The purpose of a diversity index is to attempt to provide some uniform statistic which will describe the distribution characteristics of a system of N organisms, divided into S categories, usually by species. The measure should be unique for each combination of N, S. and n_i, the number of organisms in each category. However, for most indices devised to date, there are a variety of widely differing sets of parameters which can give similar indices. Thus it is proposed that a set of index measures be applied to describe the system, each measure to describe a different facet of the distribution.

The indices in this report are from Wilhm (1967) and consist of community diversity, individual diversity, maximum diversity, observed diversity, and redundancy. An explanation of each indice is as follows:

Individual Diversity:

$$\bar{D} \text{ ind.} = -\sum_{i=1}^{s} \frac{n_i}{N} \ln \frac{n_i}{N} \quad .$$

This is the Shannon Index.

Community Diversity:

$$D \text{ com} = -\sum_{i=1}^{s} n_i \log \frac{n_i}{N} \quad .$$

This measure is an unnormalized Shannon Index which correlates better with the distribution of organisms than the $\bar{D}$ ind.

The following measures are a set of indices based on a theoretical consideration of the principles of combination analysis in information theory.

Maximum Diversity (theoretical):

$$D\ max. = \log \frac{N!}{\left(\frac{N}{s}!\right)^{s}} .$$

$N!$ is the number of permutations of N organisms. $\left(\frac{N}{s}!\right)^{s}$ is derived from the central limit theorem which states that assuming a random distribution process, the most probable distribution is the mean, i.e. $\frac{N}{s}$, $\frac{N}{s}$ is the permutations of the mean number of organisms in a species and this is raised to the s power to give the total permutations over all species. The ratio of these two is the maximum possible number of states the system could exist in. The log is taken for convenience since these numbers can be large.

Minimum Diversity:

$$D\ min = \log \frac{\frac{N!}{(N-s+1)!}}{\left(\frac{N}{s}!\right)^{s}} .$$

Minimum diversity would occur where there is only one representative in each of S-1 species, and N-S+1 in the remaining possible for the minimum diversity configuration.

Observed Diversity (Exact):

$$D\ obs - \log \frac{\frac{N!}{\prod_{i=1}^{s} \left(N_i!\right)}}{\left(\frac{N}{s}!\right)^{s}} .$$

The total number of permutations of the system as observed is simply the product of the permutations of the number of organisms in each species which equals $\prod_{i=1}^{s} \left(N_i!\right)$. This term is added to give the total number of states that could give the observed distribution.

Redundancy:

$$R = \frac{D\ max - D\ obs}{D\ max - D\ min} .$$

This measure ties the three previous measures together to give a measure of the dominance in a system. The range is 0 to 1.0 with dominance ranging from minimum to maximum. This occurs because maximum diversity occurs with perfectly even distribution, while minimum diversity occurs in the most dominant case. Thus the closer the observed diversity is to the maximum possible, the more even the distribution. As redundancy goes to one, the system is being dominated by one or a small number of species.

The index values given in Appendix J are useful to ascertain change in the benthic community. This data represents baseline data for future comparison. The Observed Diversity was closer to the Maximum Diversity in the mid-bay stations (33, 21, 35, 36, 38) and closer to the Minimum Diversity limit in the shore stations. Seasonally, the Observed Diversity was closer to the Minimum in August and rose sharply toward the Maximum in October, November, and March.

2.7.2.2 Phytoplankton and Periphyton

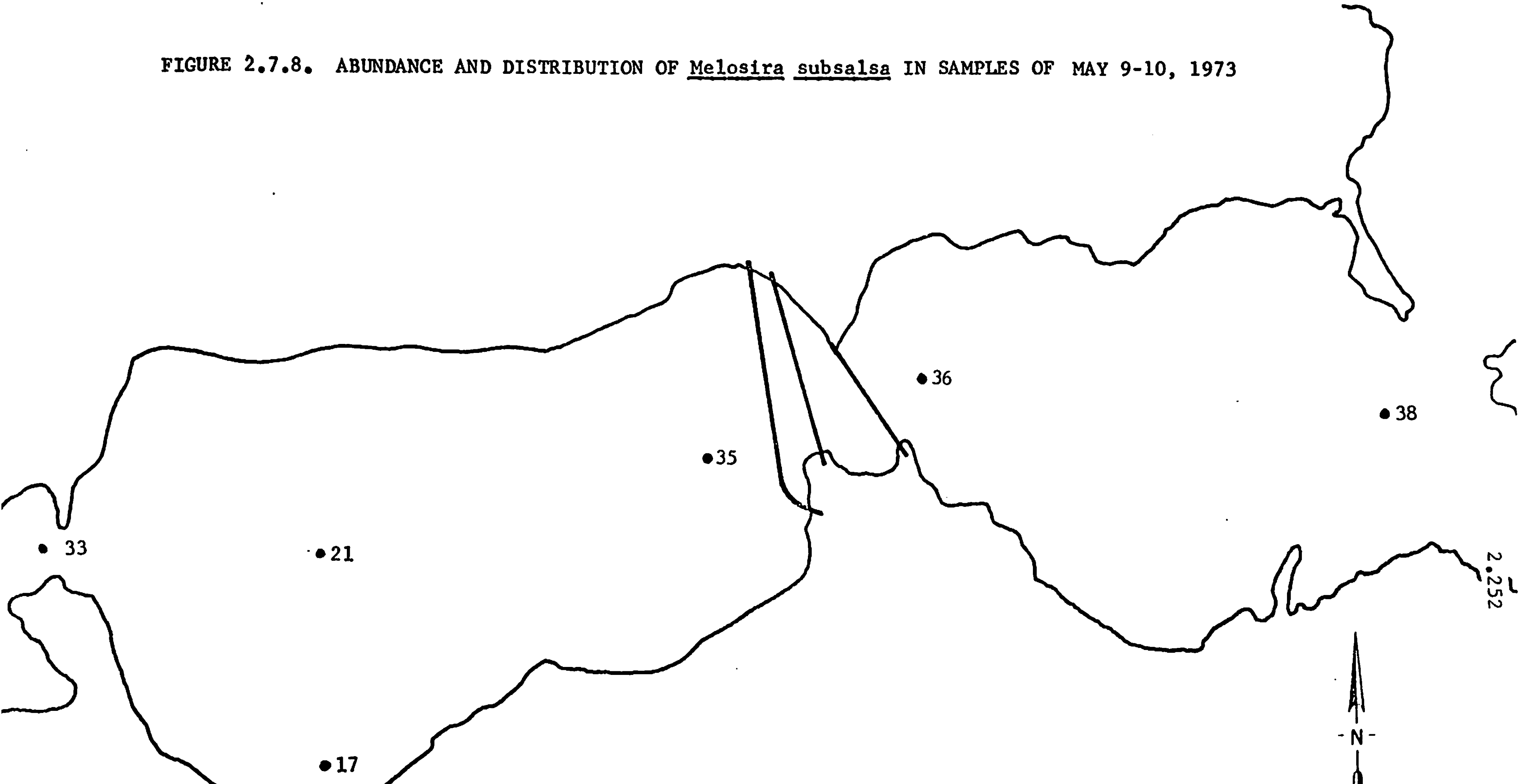
The western basin of Lake Erie, into which Sandusky Bay empties, is recognized as one of the most productive areas of the Great Lakes. Since the turn of the century, changes in the plankton community has reflected a considerable increase in productivity. Although a considerable number of investigations have shed light on the phytoplankton of western Lake Erie, little work has been done on these communities in Sandusky Bay. Based on this lack of data from previous years, it is not possible to make comparisons showing long-term trends in phytoplankton abundance and composition, and thus productivity in Sandusky Bay.

Seasonal variations. On March 24, 1973, 84.5 percent of the phytoplankton community was composed of diatoms with *Diatoma tenue* var. *elongatum*, *Melosira* spp., and small centrics dominant. Each of these taxa were found at about 2×10^5 units (colonies, filaments, cells) per liter with a total plankton community of 1×10^6 organisms per liter. Organisms of secondary importance were *Nitzschia* spp., *Coscinodiscus rothii* var. *subsalsa* and *lacustris*, *Dinobryon sertularia*, and *Codinella*/*Difflugia*. The existence of large numbers of *Codinella*/*Difflugia* in the sample may have indicated that the turbulent and high water conditions at the time resulted in the bottom being disturbed and benthic algae being suspended in the water column. The phytoplankton community on this date was characterized by diatoms at a moderately high abundance and of fairly high diversity.

Conditions of rough water and flooding with abnormally high water levels prohibited the collection of plankton samples in the Bay during the month of April.

Samples of May 9-10, 1973, showed an almost complete dominance of the phytoplankton community by diatoms of the genus *Melosira*. Composing up to 99+ percent of the community was the diatom *Melosira subsalsa*, A.Cl. This diatom has not been previously reported in the Great Lakes. It has probably been overlooked or has had its thinly silicified frustule destroyed by methods commonly used to clean diatoms. Difficult to observe and identify due to its very small size (3-4 um), weak silicification, and lack of sculptured valve, this diatom has been described as belonging to three separate genera: *Melosira* (Cleve-Euler, 1912), *Skeletonema* (Bethge, 1929), and *Stephanodiscus* (Hustedt, 1930). Abundance of *M. subsalsa* throughout Sandusky Bay (Figure 2.7.8)

FIGURE 2.7.8. ABUNDANCE AND DISTRIBUTION OF Melosira subsalsa IN SAMPLES OF MAY 9-10, 1973



Date	Station	Filaments/liter
9 May 73	33	7.9×10^6
9 May 73	21	37.6×10^6
9 May 73	17	65.3×10^6
10 May 73	35	32.9×10^6
10 May 73	36	43.2×10^6
9 May 73	38	369.2×10^6

was remarkable - reaching in excess of 369 X 10^6 filaments/liter at Station 38 opposite the City of Sandusky. Its minimum abundance in the Bay, 3 X 10^6 filaments/liter, was at Station 33 in the mouth of the Sandusky River. Stations in the Bay proper (17, 21, 35, and 36) showed intermediate figures with 32 to 65 X 10^6 organisms/liter. This taxon has been described by Hustedt (1930) as a planktonic diatom characteristic of eutrophic conditions. It appears that the development of M. subsalsa blooms on these dates reached its greatest extent near Sandusky where conditions may possibly be more eutrophic. The presence and abundance of this taxon in Lake Erie proper is unknown due to lack of samples.

The diatom bloom of Melosira spp. in May began to be encroached upon by a blue-green alga, Aphanizomenon flos-aquae in the June 15-20, 1973, samples with an increase in water temperature. Melosira spp. made up from less than 1 percent to 85 percent of the phytoplankton communities of these samples, while Aphanizomenon flos-aquae composed from 0 percent to 96 percent of the community. Figure 2.7.9 shows the relative abundance of Melosira spp. and A. flos-aquae in samples with percent abundance and total number of organisms per liter collected on June 19-20, 1973. No clear distribution is observed, with blooms seen as very localized events. Two samples taken on June 29, 1973, show an increase in abundance of Aphanizomenon flos-aquae, composing 85-99 percent of the total phytoplankton community with Melosira spp. dropping to less than 10 percent.

The hot summer month of July resulted a development of extensive pea-green blooms of the blue-green alga, Aphanizomenon flos-aquae. On July 9, 1973, dominant phytoplankton taxa were A. flos-aquae and Melosira spp. with occasional subdominant species of Microcystis sp., Coscinodiscus rothii var. subsalsa, C. lacustris, and Ceratium hirundinella. Figure 2.7.10 shows Melosira spp. was still the dominant alga toward the center of the Bay with A. flos-aquae attaining blooms of greater than 23.5 X 10^6 filaments/liter along the Bay's southern shore. This distribution was the result of floating masses of A. flos-aquae being blown by northerly winds to the southern shore. Two samples collected on July 13, 1973, showed the same distribution with Melosira spp. the dominant taxa at Station 21 in the center of the Bay with some A. flos-aquae present. At Station 17 directly offshore from Bayshore, A. flos-aquae reached 23.5 X 10^6 filaments per liter.

July 18, 1973, showed blooms of A. flos-aquae throughout the Bay as shown in Figure 2.7.11 ranging from 2.96 X 10^6 filaments/liter at Station 27

FIGURE 2.7.9. ABUNDANCE AND DISTRIBUTION OF *Melosira* spp. AND *Aphanizomenon flos-aquae* IN SAMPLES OF JUNE 19-20, 1973

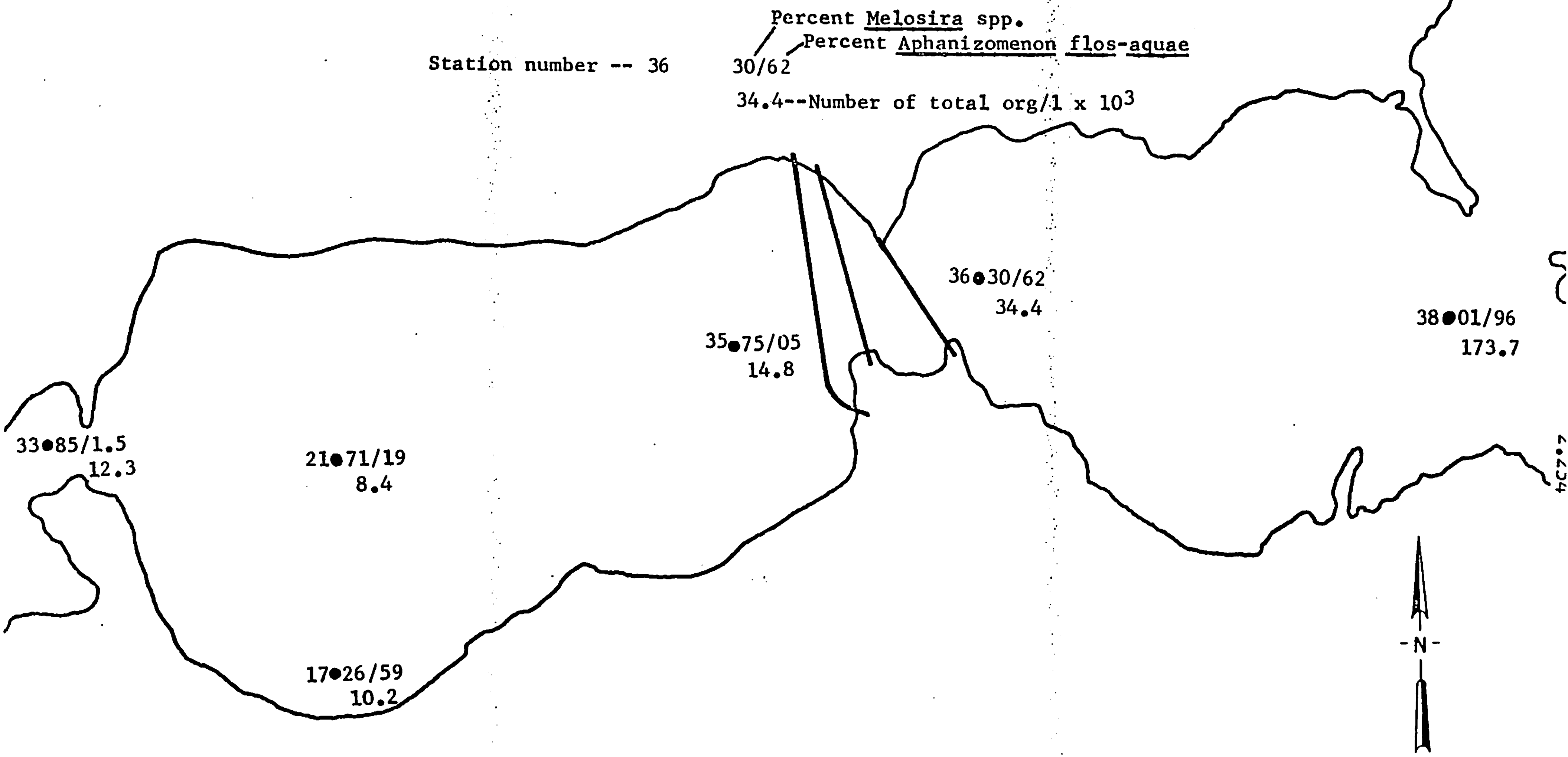
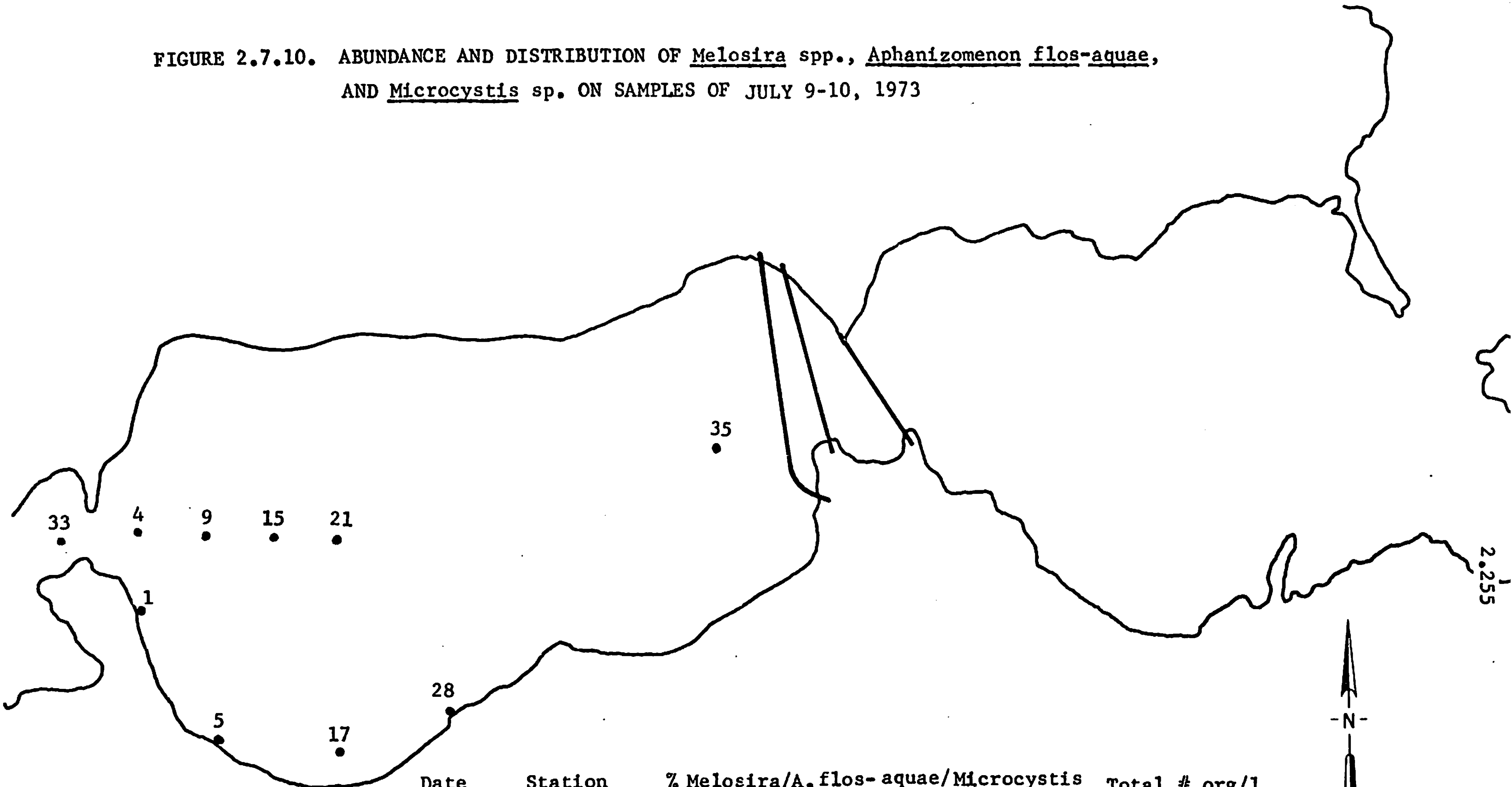
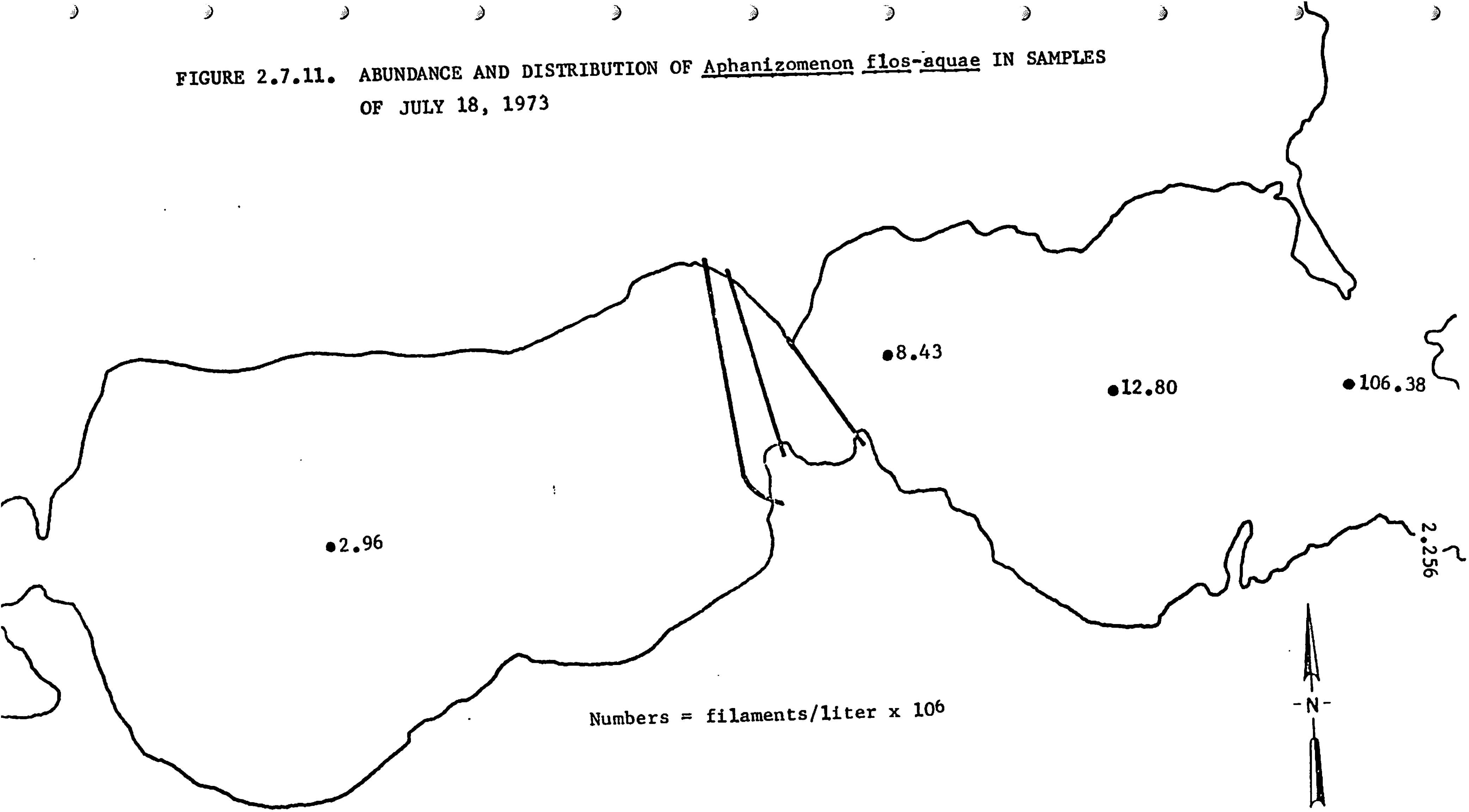


FIGURE 2.7.10. ABUNDANCE AND DISTRIBUTION OF Melosira spp., Aphanizomenon flos-aquae, AND Microcystis sp. ON SAMPLES OF JULY 9-10, 1973



Date	Station	% Melosira/A. flos-aquae/Microcystis	Total # org/l
9 July 73	01	07/56/07	10,726
9 July 73	04	46/14/00	6,512
10 July 73	05	03/80/00	56,856
10 July 73	09	50/07/02	8,096
10 July 73	15	41/43/00	7,007
10 July 73	17	01/98/00	23,884,103
10 July 73	21	74/15/01	6,232
9 July 73	28	00/99/00	1,951,692
9 July 73	33	54/11/00	4.680
9 July 73	35	90/89/00	40,050

FIGURE 2.7.11. ABUNDANCE AND DISTRIBUTION OF *Aphanizomenon flos-aquae* IN SAMPLES OF JULY 18, 1973



in the central western portion of the Bay to 106.4 X 10^6 filaments/liter at Station 38 near the Bay mouth off Sandusky. Samples collected on July 30, August 7, and August 28, 1973, show a gradual diminishing in the abundance of A. flos-aquae beginning in the western part of the Bay and spreading to the eastern portion to be replaced by species of Melosira.

By September, Melosira spp. regained a dominant position along with small centric diatoms, and the blue-green algae, Aphanizomenon flos-aquae, Oscillatoria sp., and Schizothrix sp. Phytoplankton populations during the month of September were considerably lower than during the summer months, with a maximum total of 13,439 organisms per liter occurring at Station 38 on September 10, 1973.

Oscillatoria sp. was dominant in October, ranging in abundance from 29 percent to 75 percent with a maximum of only 2,543 filaments per liter. Although dominant, phytoplankton populations were at such low levels that actual blooms did not occur. This rise of Oscillatoria sp. could be imparted by turbulence in the Bay causing this species, normally considered a benthic alga, to be found in the plankton.

The dynamics of the phytoplankton communities of Sandusky Bay, can be broken down into three phases based on data collected to this time. First, a diatom bloom of Melosira spp., particularly M. subsalsa, occurred during the spring month of May. Large populations of this alga were found in the Bay, with maximums occurring near Sandusky. The dominance of Melosira spp. was succeeded by a bloom of the blue-green alga, Aphanizomenon flos-aquae, during July. Overall high abundance of phytoplankters declined with the onset of fall with Melosira spp. and the blue-green alga, Oscillatoria sp. becoming the predominant taxa.

The phytoplankton of Stations 39, 40, and 41 (Pickerel Creek, Bayshore Ditch, and the stream draining Millers Blue Hole) is different from that of the Bay into which they drain. The phytoplankton was of low abundance throughout the sampling period, never reaching bloom proportions. Composition of Bay plankton was primarily of true Bay planktonic algae such as Melosira spp., Pediastrum simplex and duplex, and occasional Coscinodiscus spp. being swept into Pickerel Creek and Bayshore Ditch by high water. Many of these forms appeared in a deteriorated state with many cells of the colony dead or broken. They do not appear to be true plankton of the streams, just occasional species swept in from the Bay. Other planktonic organisms were benthic diatoms of streams such as Nitzschia spp., Navicula spp., and Gyrosigma scalproides churned up into the water by turbulence. The phytoplankton communities of Stations 39, 40, and 41 were unimportant in influencing changes or affecting plankton of Sandusky Bay.

Primary Productivity

Although numerous determinations of photosynthetic rates in western Lake Erie waters have been conducted (Cody, 1972: Glooschenko et al, 1974; and Verduin, 1956, 1960), only one previous study of primary productivity in Sandusky Bay has been made. McQuate (1954) examined phototrophic production and respiration by pelagic phytoplankton at one station in Sandusky Bay between February 2 and June 18, 1954. The station was located at Winous Point; however, during periods of high water, incubation was conducted at the Bay bridges (see Figure 2.7.12 for general location of these stations). McQuate (1954) found that (1) photosynthetic rates tended to increase sharply with decreasing standing crops of phytoplankton, (2) carbon fixation was inversely proportional to the phytoplankton population, and (3) maximum net production during the study period occurred between May 5 and June 18 and was approximately 594 mgC^{-3} day^{-1}. (McQuate's original value was 66.0 μMCO_2/liter per day and was based on the tenuous assumption that photosynthesis was constant throughout the day. The value for his 6-hr incubation period was 33.0 μMCO_2/liter per day which for purposes here was multiplied by 1.5 to give 49.5 μMCO_2/liter per day. This latter value was subsequently converted to milliequivalents of carbon/m^3 per day.) When this value is applied to the western basin of Sandusky Bay, the integral production equivalent is 1,485 mgC m^{-2} day^{-1}, assuming a water column depth of 2.5 meters.

During the past year, the measurements of primary productivity and nutrient concentrations in Sandusky Bay have been made. Table 2.7.28 lists maximum photosynthetic rates or carbon assimilation measured at 6 stations in the western basin of Sandusky Bay (see Figure 2.7.12 for station location). The highest carbon fixation rate recorded to date, 156.4 mgC m^{-3} hr^{-1}, occurred at Station 4 during mid-August. However, higher rates may occur. 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. (Primary productivity investigations will continue

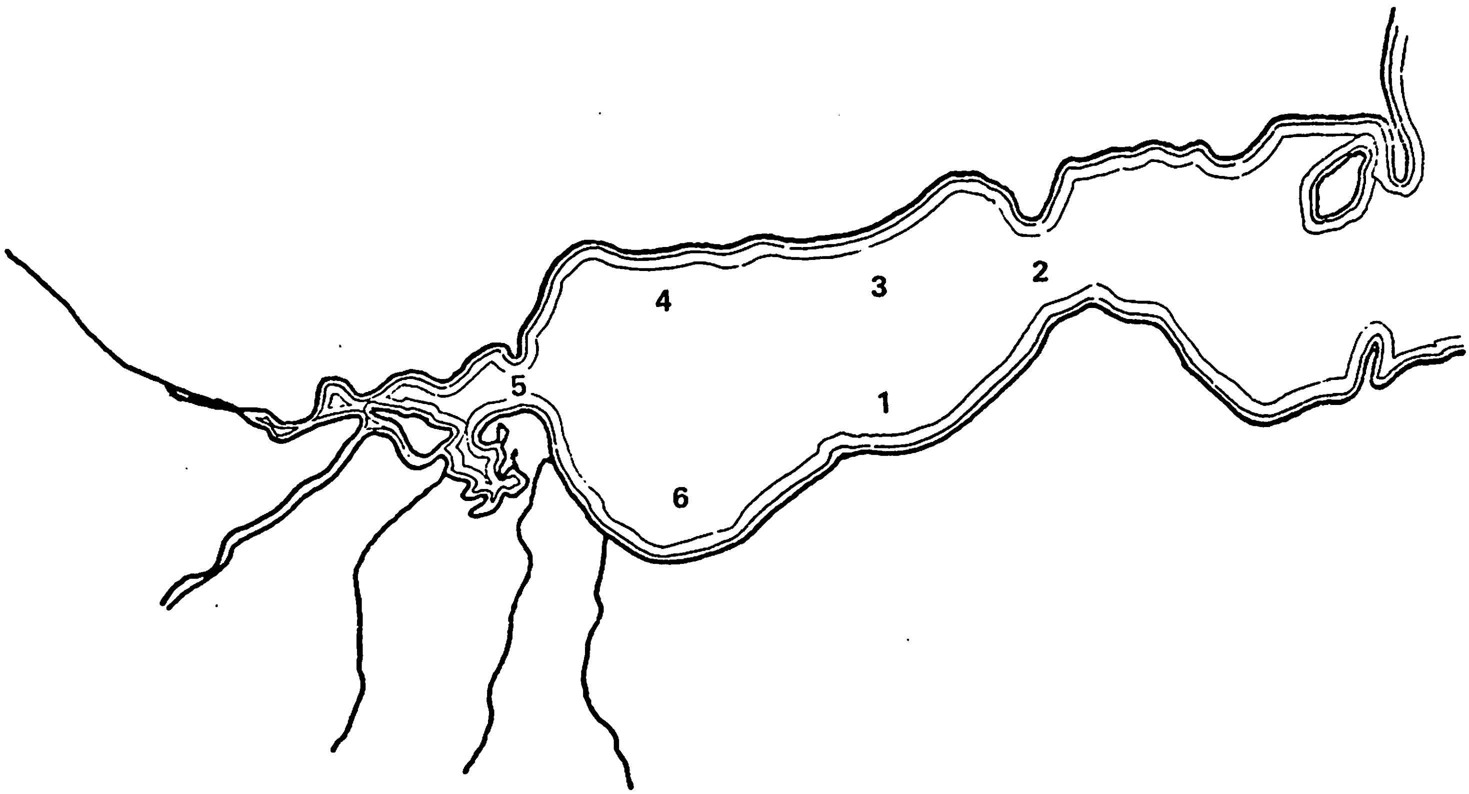


FIGURE 2.7.12. SANDUSKY BAY SHOWING STATIONS WHERE PRIMARY PRODUCTIVITY EXPERIMENTS WERE CONDUCTED

TABLE 2.7.28. MAXIMUM PRIMARY PRODUCTIVITY RATES IN SANDUSKY BAY

mgC m^{-3} hr^{-1}

Date	Station					
	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
9-25-73	15.3	14.9	20.0	22.9	13.2	18.6
10-10-73	13.2	16.2	14.2	13.5	24.3	19.3
10-24-73	9.7	7.6	8.5	5.3	6.8	8.4
11-7-73	4.8	3.7	4.8	5.4	7.8	7.4
3-20-74	1.0	1.5	2.5	0.3	<0.1	0.5
4-3-74	0.4	2.1	2.3	0.3	2.0	0.7
4-17-74	1.8	2.5	2.0	1.0	0.8	0.6
5-1-74	13.7	18.9	19.1	13.3	19.4	11.6
5-15-74	15.1	18.0	7.3	17.4	15.1	16.6
5-29-74	20.2	26.2	21.2	23.2	27.4	23.6
6-12-74	13.2	15.2	24.4	36.7	30.5	24.1
6-25-74	23.0	13.2	28.9	29.3	28.1	26.8

throughout the summer of 1974 to evaluate the extent of primary production during July and early August.) The lowest value recorded, < 0.1 mgC m^{-1} hr^{-1}, occurred at Station 5 during March. Excluding these extreme values, optimum primary productivity rates throughout Sandusky Bay appeared to be similar during any particular observational period. The production values listed in Table 2.7.28 represent, with few exceptions, maxima attained in surface waters where the influence of turbidity and transparency on phototrophic carbon fixation does not cause dramatic variability in photosynthetic rates. No inhibition of photosynthesis in surface waters has been observed on sunny days. However, with increasing depth the effect of turbidity on light penetration is accentuated and results in decreasing photosynthetic activity. The variability in optimum carbon assimilation which does exist between stations is probably due to the interplay of water transparency (as influenced by turbidity), allowing light to penetrate the water thus providing energy to drive the photosynthetic process, and to the availability of nutrients. A refined evaluation of the interaction between transparency and carbon assimilation can be made from determinations of integral carbon fixation rates throughout the western portion of Sandusky Bay.

Values for integral carbon fixation rates at each station represents the total amount of carbon fixed in the water column throughout a 12-hr period. Table 2.7.29 lists such values for Sandusky Bay. These data were obtained by integrating the maximum primary productivity rates measured at specific depths at each station. Determination of integral production rates incorporates the interrelated effects of water column depth and water transparency on phototrophic activity. For example, transparency was always lowest at Station 5 near the mouth of the Sandusky River (see Appendix K). The lowest integral productivity rates were at Station 5, even though this station was situated nearest to the principal input of nutrients (the Sandusky River accounts for 85 percent of the tributary waterflow into Sandusky Bay). The turbidity level at this station retarded photosynthetic activity there.

Stations 3 and 4 appear to be the most productive areas within that portion of the Bay studied. Perhaps a settling-out of suspended sediments combined with a close, direct-line positioning to the Bay's principal nutrient input, the Sandusky River, allows high carbon fixation rate in these areas.

TABLE 2.7.29. INTEGRAL PRIMARY PRODUCTIVITY RATES IN SANDUSKY BAY

	Station					
Date	1	2	3	4	5	6
8-16-73	311.6	743.6	827.2	1227.6	221.6	789.2
8-29-73	64.4	197.6	298.0	199.6	48.8	257.2
9-12-73	148.8	196.8	293.2	208.8	98.4	137.2
9-25-73	92.8	90.0	145.6	103.6	45.2	68.8
10-10-73	102.8	126.0	124.4	105.6	91.2	109.6
10-24-73	53.2	55.8	60.0	38.2	29.2	44.5
11-7-73	17.6	27.2	19.8	30.1	20.8	36.5
3-20-74	7.8	9.7	21.4	1.7	<0.1	2.4
4-3-74	3.9	14.1	13.4	2.4	11.0	4.8
4-17-74	7.5	9.4	7.4	4.1	4.7	2.4
5-1-74	54.6	97.0	78.4	85.2	109.2	59.6
5-15-74	64.7	74.9	30.4	68.0	47.2	65.2
5-29-74	112.4	137.4	108.2	94.8	118.4	127.7
6-12-74	56.0	74.3	93.3	151.9	145.7	105.1
6-25-74	203.6	160.2	247.7	265.1	176.7	215.0

That station nearest the Site (Station 6) is intermediate with respect to integral primary productivity rates there and elsewhere in Sandusky Bay.

The projected integral primary productivity rate determined from McQuate (1954) is slightly higher than the highest rate recorded during these recent investigations on Sandusky Bay; 1,485 mgC m^{-2} day^{-1} versus 1,228 mgC m^{-2} day^{-1}, respectively. It must be noted, however, that experiments have not yet been conducted during what is probably the most productive period for Sandusky Bay.

Primary productivity is strongly influenced by seasonal variation in temperature, solar radiation, and supplies of nutrients, especially phosphorus and nitrogen compounds (Table 2.7.30). Photosynthesis follows and is directed by seasonal patterns of the temperature and light regime. Supplies of dissolved orthophosphate (that phosphate fraction utilized by phytoplankton) and nitrate-nitrogen within the water is influenced by the photosynthetic rate and standing crop biomass of pelagic algae. When primary production is high, these nutrients are removed from the water and incorporated into algal biomass. When production is low, nutrient levels are high. Input of nutrients to the Bay from its tributaries is, of course, superimposed upon this trend.

Comparison of primary production in the eastern and western basins of Sandusky Bay, and in Sandusky Bay versus western Lake Erie is tenuous due to the differences in depth, transparency, and nutrient supplies of these areas. Moreover, the amount of data available for each area varies considerably. Some generalizations can be made, however.

Field observations made during July, 1973, indicated that algal bloom conditions were more extensive throughout the western basin as opposed to the eastern basin of Sandusky Bay. Nevertheless, optimum or maximum primary productivity rates in both basins may be similar throughout much of the year. On September 26, 1973, average production rates for both basins were nearly equal, 18 vs 20 mgC m^{-3} hr^{-1}. It is possible that the nutrient input from the Sandusky River and other tributaries is sufficient to enhance production throughout both basins.

Cody (1972) determined maximum carbon assimilation rates at several stations near the Bass Islands in western Lake Erie. The highest value obtained was 185.4 mgC m^{-3} hr^{-1} during August, 1970. This production

TABLE 2.7.30. SOLAR RADIATION AND MEANS OF TEMPERATURE, PRIMARY PRODUCTIVITY, AND ORTHOPHOSPHATE AND NITRATE-NITROGEN CONCENTRATIONS IN THE WESTERN BASIN OF SANDUSKY BAY

Date	Temperature, F	Solar Radiation, langleys/ day	Primary Productivity, mgC m^{-2} day^{-1}	Orthophosphate, mg/ℓ	NO_3 - N, mg/ℓ
8-16-73	75.6	517	686.8	0.073	0.13
8-29-73	80.1	345	177.6	0.021	<0.01
9-12-73	70.0	635	180.5	0.087	0.07
9-25-73	64.1	265	91.3	0.050	<0.01
10-10-73	65.3	285	109.9	0.255	0.01
10-24-73	55.3	281	46.8	0.648	0.02
11-7-73	42.7	333	25.3	0.066	0.05
3-20-74	38.5	404	7.2	0.128	4.37
4-3-74	44.1	195	8.3	0.124	3.89
4-17-74	49.3	464	5.9	0.129	3.33
5-1-74	59.9	535	81.0	0.040	3.12
5-15-74	59.4	297	58.4	0.015	1.41
5-29-74	63.2	243	116.5	0.021	0.74
6-12-74	67.9	578	104.4	0.068	0.16
6-25-74	67.5	524	211.7	0.041	0.02

rate is slightly higher than the 156.4 mgC m^{-3} hr^{-1} obtained for Sandusky Bay during August, 1973 (Table 2.7.28). Overall, however, Cody's (1972) data indicate lower maximum production rates for the western basin of Lake Erie when compared with the Sandusky Bay data listed in Table 2.7.28. However, integral production rates are greater in Lake Erie than in Sandusky Bay. Water transparency is greater in Lake Erie than in Sandusky Bay, thus allowing a deeper euphotic zone and consequently higher integral primary productivity rates.

2.7.2.3 Zooplankton

Zooplankton was classified into three major groups: rotifers, copepods, and cladocera and ostracods.

The rotifer community of Sandusky Bay was extensively studied by Kellicott (1896, 1897) during the 1890's. He recorded 106 species and varieties of rotifers in samples from every conceivable habitat. Since the present study was concerned with planktonic rotifers only, many forms were excluded by the sampling methods. Distortion of bdelloid and other aloricate rotifers caused by the formalin preservative made identification of many rotifers impossible. (This problem was overcome by Kellicott by the use of cocaine hydrochloride as a fixative!) During the course of the study, 26 rotifers of 12 genera were observed and are listed in Table 2.7.31.

The rotifer populations were rather large and diverse in samples collected during March and May, 1973. Most common taxa during these months were species of *Branchionus*, *Keratella cochlearis*, and species of *Polyarthra*. Total rotifer populations during these months was in excess of 6,000 organisms per liter. These population gradually declined and reached a low point during the month of July. September and October samples showed an increase in rotifer abundance and diversity with *Branchionus calycifloris*, *B. bundapestiensis*, and *B. havanaensis* and *Keratella cochlearis* dominant, but with populations less than 500 organisms per liter.

In Sandusky Bay, the calanoid copepods, *Diaptomis* spp. were considerably more abundant than the cyclopoid copepods, such as *Cyclops* spp. copepods, particularly nauplii, were very abundant in samples collected in March and May, attaining greater than 15,000 organisms per liter in May. Table 2.7.32 lists the copepods and cladocera found in plankton samples.

Spatial variation and seasonal changes for the major zooplankton

TABLE 2.7.31. LIST OF ROTIFER TAXA OBSERVED IN PLANKTON SAMPLES

Asplanchna	priodonta
Brachionus	angularis
	bidentatus
	budapestiensis
	calycifloris
	caudatus
	caudatus f. vulgaris
	havanaensis
	quadridentatus
	rubens
	sp.
Filinia	longiseta
Gastrophus	sp.
Kellicottia	longisdina
Keratella	cochlearis
	quadrata
Lecane	lunaris (luna)
Monostyla	bulla
Notholca	striata
Platyias	patulus
Polyarthra	euryptera
	sp.
	trigla
	vulgaris
Trichocerca	multicrinus
	similis
Unknown	

TABLE 2.7.32. COPEPODS AND CLADOCERA - SANDUSKY BAY

COPEPODS
Cyclops
bicuspidatus
sp.
Diaptomus
oregonensis
sanguineus
silicoides
sp.
Senecella
sp.
CLADOCERA
Alona
costata
Ceriodaphnia
Chydorus
sphaericus
Daphnia
pulex
retrocurva
sp.
Diaphanosoma
brachyurum
Eubosmina
coregoni
Leptodora
kindtii

taxa are shown on Table 2.7.33. Rotifers formed the dominant zooplankton population in the spring, but the populations were more balanced in the summer and fall. The highest population of all taxa were found at the extreme west end of Sandusky Bay and near-shore in the vicinity of the Site. Copepods were most abundant at Stations 17 and 35, near the southwest and eastern ends, respectively, of the western basin of the Bay. Cladocerans were the less abundant zooplankters with a minimum population in June at Station 17 near the Site. The wide variability of the data makes possible only these very general conclusions.

2.7.2.4 Fishes

Species Composition and Relative Abundance of Fishes Collected from Sandusky Bay

Table 2.7.34 lists the species composition of fishes taken from Sandusky Bay from November, 1972, to January, 1974. A total of 7,112 fishes were collected and the most abundant species taken was carp (*Cyprinus carpio*) with 2,190 individuals. It must be pointed out here that the effort to catch larger fish was much greater than the effort to capture the smaller fish. Several seine hauls along the shore captured more emerald shiners (*Notropis atherinoides*) than was feasible to preserve; thus, while the carp was most abundant in the data obtained, the density of the emerald shiner was probably greater. The third most abundant fish was the gizzard shad (*Dorosoma cepedianum*) followed by the goldfish (*Carassius auratus*), the white bass (*Morone chrysops*), the yellow perch (*Perca flavescens*), and the sheepshead or drum (*Aplodinotus grunniens*). Ten families and twenty species were collected from the Bay and adjacent inland tributaries.

Distribution of Fishes in Sandusky Bay

Probably due to the shallowness and homogeneous character of the whole western basin, no defined spatial pattern existed in the distribution of the dominant species in the Bay. Species like the carp, gizzard shad, perch, and freshwater drum are ubiquitous in the Bay. The emerald and spotfin shiners were captured only in the littoral zone of the shore but a selective mesh size net was used to capture them. Even the migratory walleye and white bass were captured along shore, near-shore, and in the center of the Bay.

TABLE 2.7.33. SEASONAL AND AREAL VARIATION IN ZOOPLANKTON POPULATIONS OF SANDUSKY BAY IN 1973

	May	June	July	August	September	October
Station 17						
Rotifers	30,964	167	704	176	--	39
Copepods	18,578	502	352	440	--	154
Cladocera	0	1,338	528	88	--	0
Station 21						
Rotifers	8,334	0	76	1,163	1,092	0
Copepods	0	772	228	342	437	375
Cladocera	0	515	76	76	219	54
Station 33						
Rotifers	25,081	372	1,670	557	1,905	--
Copepods	4,180	372	334	929	790	--
Cladocera	0	558	334	829	445	--
Station 35						
Rotifers	0	279	356	--	178	--
Copepods	15,482	418	0	--	218	--
Cladocera	0	279	178	--	72	--
Station 36						
Rotifers	5,992	279	--	--	132	437
Copepods	5,972	557	--	--	218	218
Cladocera	0	139	--	--	131	146
Station 38						
Rotifers	14,262	111	--	--	306	--
Copepods	2,194	557	--	--	256	--
Cladocera	0	223	--	--	102	--

TABLE 2.7.34. SPECIES COMPOSITION OF FISH TAKEN FROM SANDUSKY BAY

November 11, 1972 - January, 1974

Family	Genus and Species	Number	Percent of Total
Clupeidae	Dorosoma cepedianum (gizzard shad)	2,157	30.3
Cyprinidae	Cyprinus carpio (carp)	2,190	30.8
	Carassius auratus (goldfish)	1,099	15.5
	Carassius (hybrid)	3	0.04
	Notropis atherinoides (common emerald shiner)	674	9.5
	Notropis spilopterus (spotfin shiner)	6	0.08
Ictaluridae	Ictalurus punctatus (northern channel catfish)	28	0.4
	Ictalurus nebulosus (brown bullhead)	23	0.3
Esocidae	Esox lucuis (northern pike)	1	0.01
	Esox niger (chain pickerel)	2	0.03
	Esox m. masquinongy (muskellunge)	2	0.03
Serranidae	Morone chrysops (white bass)	365	5.1
Percidae	Perca flavescens (yellow perch)	322	4.5
	Stizostedion vitreum (walleye)	24	0.3
Centrarchidae	Pomoxis annularis (white crappie)	80	1.1
	Pomoxis nigromaculatus (black crappie)	3	0.04
Sciaenidae	Aplodinotus grunniens (freshwater drum)	128	1.8
Atherinidae	Labidesthes sicculus (brook silverside)	1	0.01
Castostomidae	Moxostoma breviceps (Ohio redhorse)	1	0.01
	Catostomus c. commersoni (common white sucker)	3	0.04
Total number of fish		7,112	

Table 2.7.35 summarizes the characteristics of fishes captured in the western basin of Sandusky Bay from May to September, 1973. The extremely high and rough water during May made capturing procedures difficult, and the results are probably not indicative of fishes present in the Bay.

From Table 2.7.35, perch (Perca flavescens) captured from June to September were very consistent in weight. The mean weights of perch caught from June to September were 86.5, 83.7 80.3 and 84.3 grams. The gizzard shad (Dorosoma cepedianum) on the other hand, increased in weight from May to August and then dropped down in weight in September. The mean weight of the white crappie (Pomoxis annularis) caught during July and August was low compared to those caught in June and September. No sheepshead or fresh-water drum (Aplodinotus grunniens) were caught in the September sampling. Monthly distribution of fishes taken from Sandusky Bay during the study period is listed in Appendix L.

Brief Life Histories of the Dominant Species of Fishes in Sandusky Bay

The following life histories are primarily taken from Trautman, 1957.

Carp (Cyprinus carpio): Since 1879, when the carp was introduced into Ohio water, this species has multiplied and spread into every county in Ohio. Carp thrive in a wide variety of habitats (euryoecious) characterized by low gradient conditions, warm waters possessing large concentrations of organic matter. Aquatic environments that are highly eutrophic make suitable habitats for the propagation and survival of carp. Carp populations in Ohio are most numerous in the western end of Lake Erie and its tributaries where the individuals may vary in size from less than a pound to as high as 60 pounds. Sandusky Bay is notable in this region for supporting one of the largest populations of this species.

Carp usually spawn in late April to June. They do not build a nest but deposit their eggs among vegetation, debris, and roots. They deposit their eggs in water ranging in depth from one to three feet. Shallow cattail marshes are particularly suited for the spawning of carp. A large female may lay from 100,000 to half-a-million eggs that hatch in 8 to 10 days. Young fry feed primarily on organic detritus and microplankton. According to Chapman (1955), carp move into and out of the Bay from Lake Erie.

TABLE 2.7.35. SUMMARY OF FISH CAPTURED IN SANDUSKY BAY

Species	May 15-16, 1973 Number Captured Station 17	Station 21	Station 5	Total	Mean St Length, cm	Mean Weight, g
leye	No sample - rough water	1		1	41.1	640
zard shad			21	21	30.0	60.2
nnel catfish						
llhead						
rch						
ite bass						
appie			1	1	30	400
erald shiner						
eat northern pike						
eshwater drum						
llback						
rp		1	4	5	41.2	289
ldfish						

Species	June 21-22, 1973 Number Captured Station 17	Station 21	Station 5	Total	Mean St Length, cm	Mean Weight, g
leye	1			1	21.8	138
zard shad	3	16		19	13.5	80.3
nnel catfish	1	3		4	18.1	121
llhead		1		1	19	142
rch	21	14		35	17.3	86.5
ite bass						
appie			5	5	19.2	180
erald shiner						
eat northern pike						
eshwater drum	3	7	1	11	15.4	71.1
llback						
rp	5	23		28	28.7	894
ldfish		3		3	14.9	171

Species	July 24-25, 1973 Number Captured Station 17	Station 21	Station 5	Total	Mean St Length, cm	Mean Weight, g
leye	1	2		3	30.2	355
zard shad		45	1	46	20	172.3
nnel catfish	6	6		12	18.7	103
llhead	1	1		2		97.5
rch	33	36		69	16.9	83.7
ite bass	8	4		12	22.2	268
appie	2	4		6	13.5	38
erald shiner						
eat northern pike						
eshwater drum	2	5	2	9	15.8	82.4
llback						
rp	13		1	14	28.8	542.9
ldfish	9			9	19	201

Species	August 10-11, 1973 Number Captured Station 17	Station 21	Station 5	Total	Mean St Length, cm	Mean Weight, g
leye	2	2		4	26.0	276
zard shad	14	35		49	20.3	189
nnel catfish	1	4		5	25.2	340
llhead						
rch	47	42		89	16.5	80.3
ite bass	6	4		10	21.6	298.1
appie	1	1		2	13.1	32
erald shiner						
eat northern pike	1			1	31.2	1206
eshwater drum	4			4	21.4	160
llback						
rp	12			12	28.4	846.5
ldfish	3	2		5	19.4	242

Species	September 2-3, 1973 Number Captured Station 17	Station 21	Station 5	Total	Mean St Length, cm	Mean Weight, g
leye		5		5	31.2	389
zard shad		9		9	13.1	41.2
nnel catfish	2	1		3	15.9	152
llhead			2	2	25.1	369
rch	16	20		36	17.3	84.3
ite bass	4	2		6	24.3	470
appie	3		2	5	20.2	192.6
erald shiner						
eat northern pike						
eshwater drum						
llback		1		1	24.1	332
rp		2	2	4	21.4	275
ldfish						

<u>Gizzard Shad</u> (<u>Dorosoma cepedianum</u>): This species is well distributed throughout Ohio's major river systems and Lake Erie and its tributaries. Adult shad may measure 18 inches long and attain weights to 3 pounds. The species is very tolerant of turbid waters with a low flow rate. Being primarily phytoplankton feeders, population density is often dependent on the abundance of phytoplankton. With the increasing abundance of phytoplankton in Lake Erie, shad populations have correspondingly increased.

Two-year old shad are able to reproduce; an adult female is capable of producing 25,000 to 50,000 eggs which are scattered during spawning. The species is relatively short-lived and extremely sensitive to changing environmental conditions, such as sudden changes in water temperature. Large numbers of shad are killed subsequent to the breaking up of ice and the warming of surface waters. These dead fish are well known to denizens of the shoreline of the Bay and Lake Erie.

The gizzard shad is an important forage species, occupying an important primary consumer tropic level. It is this population that transfers the material and energy from the photosynthetic primary producers to the more economically important secondary and tertiary consumers. Schools of small gizzard shad make easy targets for the larger more economically significant predator fishes such as the basses, crappies, walleye, pike, and perch.

Emerald Shiner (<u>Notropis atherinides</u>): This species is very abundant in Lake Erie and its tributaries. It prefers rather clear water but is tolerant of turbid conditions. It spends most of its time in midwater levels and near the surface and seldom comes in contact with the bottom, even during spawning. The species is known to surface at dark for small insects.

Mature emerald shiners rarely exceed 3 inches and are known to school in great numbers. In Lake Erie this shiner spawns from late June into August in open water and near the surface.

The emerald shiner is an important forage fish for larger predatory species.

Perch (<u>Perca flavescens</u>): Perch populations in Ohio are principally in Lake Erie and adjoining bays and harbors. The lake populations of perch contain some of the largest members known to the species. Perch as large as 2 pounds have been recorded in Lake Erie.

Perch prefer clear water where an abundance of rooted aquatic vegetation abounds. Adult animals are rather tolerant of periods of high turbidity; however, egg hatching success is severely decreased by heavy siltation upon the eggs.

Perch spawn in mid-April to middle May in three to eight feet of water. The average number of eggs in ripe females in Lake Erie is approximately 40,000, reaching a maximum of about 60,000 eggs.

According to Chapman (1955), successful spawning of perch is taking place in Sandusky Bay. Indications are that large yellow perch enter the Bay from the Lake in late summer and leave in the spring following spawning.

Factors which probably limit spawning of perch in the Bay are sparsity of aquatic vegetation, high turbidity of water, deposits of silt on the bottom, pollution, and predation from fishing and predatory fishes.

Chapman (1955), indicates that perch have a faster growth rate in the spring and early summer than the population in the western end of Lake Erie. This difference in growth rate is minimized by mid-summer when the Lake population catches up in size with the Sandusky Bay population.

Sheepshead or Freshwater Drum (Aplodinotus grunniens): This species is abundant in the larger rivers of Ohio but is most abundant in Lake Erie. Records (Trautman, 1957) indicate that the freshwater drum has attained sizes to 36 pounds in the Ohio River but their counterparts in Lake Erie seldom weigh more than 10 pounds.

Sheepshead are found in water ranging in depth from 2 feet to 60 feet. This species spawns in the spring; the females scattering their pelagic eggs. Large females normally produce from 100,000 to half-a-million eggs.

According to Daiber (1952), who analyzed the feeding habits of drum in Sandusky Bay, young-of-the year feed mostly upon Chironomid larvae, copepods, Amphipods, and Ostracods. Sheepshead continue to utilize insect larvae beyond the first year and add crayfish and small fishes to their diets.

Chapman (1955), states the sheepshead enter the Bay in early spring and that by late summer and early fall have returned to Lake Erie.

Both the work of Chapman and of this study indicate that successful spawning takes place in Sandusky Bay. Length/weight relationship checks for Sandusky Bay and Lake Erie drums show no appreciable differences.

White Bass (Morone chrysops): The greatest concentrations of this fish are in the western portion of Lake Erie. This freshwater, true bass is rather short-lived but shows high rates of growth during its short life. These fish may attain weights as high as three pounds in three years.

White Bass prefer large, open, clear water areas where the bottom is hard and low in silt. The species is primarily predatory in behavior, feeding on smaller forage species.

White Bass spawn in early April to May at which time they migrate to the tributaries and bays of Lake Erie. A mature female may possess up to a million eggs which are deposited and fertilized in mid-water. The eggs adhere to the substrate and hatch in 10 days to two weeks.

The Sandusky River is noted for its annual spawning "runs" of white bass in the vicinity of the City of Fremont. According to Chapman (1955), there are indications of successful spawning populations in Sandusky Bay. The Bay is a nursery ground for young-of-the-year of this species. Tagged bass show their migration into and out of the Bay from the Lake.

Walleye (Stizostedion v. vitreum): The walleye is a prime species for the sportsman and commercial fisherman. The walleye prefers clear or slightly turbid waters and are most prevalent over reefs and shoals of gravel, bedrock, or other firm bottoms. It is seldom found in or near aquatic vegetation. Walleyes in Lake Erie average from one to three pounds, reaching a maximum of 18 pounds.

The walleye spawns in April and May when the water temperature is between 40 and 52 degrees. Eggs are scattered, fertilized, and then fall to the bottom where they adhere to hatch in about 10 days. A female may average between 100,000 and 400,000 eggs depending on the size of the fish.

Walleyes in Lake Erie either spawn over reefs in the Lake or migrate into some of the tributaries. The Sandusky River spawning population is well known by the sport fisherman. According to Chapman (1955), tagged walleyes move into and out of Sandusky Bay and are migrants through the Bay in satisfying their behavior to spawn in the Sandusky River near the City of Fremont. He also suggests that some limited spawning might take place in the Bay. The presence of large numbers of fingerlings in the Bay does indicate that the area serves as an important nursery for the young before they migrate back to the Lake.

Channel Catfish (Ictalurus punctatus): This popular food and game species is well distributed throughout Ohio and is especially abundant in the western tributaries of Lake Erie and in Sandusky Bay.

The channel catfish is primarily a benthic feeder that may attain a weight of 15 pounds. The fish prefers water with some current, over gravel or rock bottoms, and can tolerate periods of high turbidity.

The channel catfish spawn from April through August and deposit their eggs in natural holes or depressions in bottom substrate. An adult female may lay up to 15,000 eggs which hatch in 10-15 days.

Chapman (1955), states that a large population of channel catfish is endemic to Sandusky Bay. Tagging studies show, however, that there is migration into and out of the Bay, thus intermingling of Bay and Lake populations.

Table 2.7.36 from an unpublished report by C. Willis (1974, Museum of Zoology, The Ohio State University) shows the relative abundance and population trends of Sandusky Bay fishes. From this summary, the only species collected during this study that is not abundant or common is the northern pike (*Esox lucius*). Most species are likewise increasing in abundance in the Bay.

The commercial harvests of fishes from Sandusky Bay are indicative of the relative abundance of various species if one analyzes the percent each species represents of the total harvest for that year. The market value dictates the effort and selectivity for certain species. Still, a general overview of abundance can be recognized. The commercial catch and most probable economic value has increased for such species as bullheads, carp, catfish, and perch. Table 2.7.37 summarizes the commercial harvest of fishes from 1961 to 1972.

Food Preferences of Fishes in the Bay

The analysis of stomach contents of all species of fishes caught in the Bay in 1973 indicate that Chironomid larvae occurred more often in the identifiable contents than any other item. The zooplanktonic Cladocerans and copepods were next in occurrence followed by fishes. It must be noted here that the organisms that possess calcareous or chitinous exoskeletal parts are more identifiable than soft-bodied organisms. The absence of Oligochaetes, which are soft-bodied, might be assumed to be part of the unidentifiable debris. Table 2.7.38 shows the frequency of occurrence of food items from all species caught in the Bay from May to August, 1973.

TABLE 2.7.36. ABUNDANCE AND POPULATION TRENDS OF SANDUSKY BAY FISHES

(C. Willis, 1974)

Family	Genus and Species	Abundance	Population Trend
Clupeidae	Dorosoma cepedianum (gizzard shad)	Abundant	Increasing
Cyprinidae	Cypinus carpio (carp)	Abundant	Increasing
	Carassius auratus (goldfish)	Abundant	Increasing
	Carassius (hybrid)	N.A.	N.A.
	Notropis antherinoides (common emerald shiner)	Abundant	Increasing
	Notropis spilopterus (spotfin shiner)	Abundant	Increasing
Ictaluridae	Ictalurus punctatus (northern channel catfish)	Abundant	Increasing
	Ictalurus nebulosus (brown bullhead catfish)	Common	Decreasing
Esocidae	Esox lucius (northern pike)	Rare	Decreasing
	Esox niger (chain pickerel)	N.A.	N.A.
	Esox m. masquinongy (muskellunge)	Uncommon	Decreasing
Serranidae	Morone chrysops (white bass)	Abundant	Increasing
Percidae	Perca flavescens (yellow perch)	Abundant	Increasing
	Stizostedion vitreum (walleye)	Uncommon	Increasing
Centrarchidae	Pomoxis annularis (white crappie)	Abundant	Increasing
	Pomoxis nigromaculatus (black crappie)	Common	Decreasing
Sciaenidae	Aplodinotus grunniens (freshwater drum)	Abundant	Increasing
Atherinidae	Labidesthes sicculus (brook silverside)	Common	Decreasing
Castostomidae	Moxostoma breviceps (Ohio redhorse)	N.A.	N.A.
	Catostomus c. commersoni (common white sucker)	Common	Decreasing

TABLE 2.7.37. A SUMMARY OF COMMERCIAL HARVEST OF FISHES FROM SANDUSKY BAY FROM 1961-1972* (IN POUNDS)

Species	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Buffalo	6,059	12,293	9,778	23,206	12,849	8,845	8,619	18,312	7,813	7,267	2,347	494
Bullheads	42,942	59,138	78,892	79,377	55,424	41,778	20,941	8,983	22,249	17,164	21,657	9,185
Carp	860,673	1,088,836	936,892	1,006,333	838,603	889,978	647,371	752,478	972,835	1,470,322	912,211	802,754
Catfish	484,887	383,846	334,937	331,560	266,955	218,581	239,382	291,298	276,529	176,898	193,518	149,319
Goldfish	285,036	258,655	159,292	151,099	167,621	134,966	94,050	91,459	82,712	156,390	76,281	30,690
Mooneye	1,242	588	657	214	56			37	17			
Gizzard shad	3,522	2,324	150	255	1,140	5,375						
Drum	2,489,845	1,853,836	2,745,371	2,076,114	1,800,486	1,259,514	1,595,028	2,540,353	1,584,554	659,822	441,982	319,596
Suckers	6,453	14,846	21,689	15,160	10,286	6,961	9,682	28,146	23,605	43,326	31,020	25,555
White bass	304,976	159,452	180,769	188,495	46,702	193,077	332,703	156,887	394,846	294,970	184,949	55,662
Yellow perch	39,128	24,238	62,874	28,841	14,468	33,906	18,703	27,113	53,772	32,238	27,395	5,564
Walleye	44,696	24,978	25,865	15,773	13,668		27,437	35,845	17,949	7,998		
Smelt			40									
Burbot				15	129							
Saugers				5								
White fish				69	1,521	25	33	186				
Sturgeon						43						
Herring-Cisco					286							
Shad							3,618	269	440	2,350		
Quillback												1,144
Total	4,529,442	3,883,030	4,557,066	3,916,486	2,464,343	2,793,049	2,972,877	4,116,366	3,437,321	2,868,745	1,981,360	1,399,963

* Ohio Division of Wildlife, "Commercial Fish Landings for Lake Erie, Ohio"; Years 1961-1972.

TABLE 2.7.38. FREQUENCY OF OCCURRENCE OF FOOD ITEMS FROM SANDUSKY BAY FISHES MAY 15, 1973 TO AUGUST 10, 1973

Food Item	Percent of 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

Tubb (1973) studied the food habits of four species of fishes in Sandusky Bay. He compared his data with a previous study (Price, 1959) and found certain fishes have significantly changed their feeding habits in the 14-year span. In the four species studied the greatest changes in feeding habits occurred in the freshwater drum and perch populations, while the channel catfish and the white bass habits remained relatively unchanged, except for the demise of the mayfly (Ephemeroptera) population and the resultant absence in the 1973 study. Table 2.7.39 summarizes the findings of Tubb on the food habits of the four species.

Fish Parasite Burdens

The results of parasitological examinations (see Section 6.1) of the fish fauna of Sandusky Bay, Pickerel Creek, and Raccoon Creek are presented in Table 2.7.40.

In addition to sample collections, a literature survey was also conducted concerning fish parasites in Sandusky Bay and western Lake Erie. Bangham and Hunter (1939) surveyed the distribution of fish parasites in the eastern and western ends of Lake Erie. The authors found that host species from the western region (Sandusky Bay included) harbored a larger number of infecting forms and had a greater degree of infection than the same host species from the eastern region.

Bangham (1972) resurveyed western Lake Erie in 1957 for fish parasites. Of the 1,987 fishes belonging to 66 species examined, 1,589 or 94.2 percent were found to be parasitized as compared to 64.9 percent parasitization in the 1939 survey. It must be noted, however, that more host organs were examined during the 1957 survey. In the earlier survey most of the parasites were taken from the digestive tract, coelom, gills, and muscles. Data from the 1939 and the 1957 survey are presented in Appendix K.

Dechtiar (1972) recorded some new parasite records for Lake Erie fishes taken from the Wheatley and Port Dover areas in the western and eastern ends, respectively, of Lake Erie. Data from this study are included in Appendix M. These data have not been recorded by Bangham and Hunter (1939) or Bangham (1972). The results of this study imply, at least, that changes in the aquatic environment and in the fish fauna of Lake Erie have probably resulted in major and relatively rapid changes in the parasite fauna. Such will probably continue to be the case.

TABLE 2.7.39. PERCENTAGE COMPOSITION OF FOOD ITEMS FOUND IN STOMACHS OF FOUR SPECIES OF FISH FROM SANDUSKY BAY, 1971-1972

(Modified From Tubb, 1973)

Food Items	Ictalurus punctatus (Catfish)	Apoldinotus grunniens (Drum)	Perca flavescens (Perch)	Morone chrysops (White Bass)
Unidentified	9.9	14.9	8.5	11.2
Annelida (Oligochaetes)	2.7	2.8		
Diptera (Chironomids)	39.6	36.5	45.8	15.1
Crustacea	1.8	0.9		
Cladoceran	31.9	31.2	15.1	36.6
Pelecypoda	7.2			
Amphipoda	1.7	2.5	0.5	
Odonata	0.1			
Ephemeroptera	0.2			7.4
Hemiptera	3.3			0.1
Coleoptera	4.1			
Orthoptera	0.4			
Fish	23.0	33.6	19.2	66.9
Fish eggs	0.1			
Gastropoda	10.0	0.5		
Algae	0.9			
Nematode	5.6			
Copepoda		0.71	10.6	0.4
Ostracoda				1.2

TABLE 2.7.40. PARASITES OF FISH FROM SANDUSKY BAY, PICKEREL CREEK, AND RACCOON CREEK

Fish Host	Number Examined	Number Infested	Parasite Species
Pomoxis nigromaculatus (Black crappie)	1	1	Camallanus oxycephalus
Pomoxis annularis (White crappie)	7	0	None
Lepomis macrochirus (Bluegill)	2	2	Metacercariae
Lepomis cyanellus (Green sunfish)	3	1	Proteocephalus amblopitis
Carassius auratus (Goldfish)	12	0	None
Cyprinus carpio (Carp)	6	0	None
Dorosoma cepedianum (Gizzard shad)	11	0	None
Moxostoma macrolepidotum (Shorthead redhorse)	1	0	None
Roccus chrysops (White bass)	8	8	Camallanus oxycephalus Crepidostomum cooperi, Triaenophorus nodulosus (larvae), Bucephalus elegans
Ictalurus nebulosus (Brown bullhead)	4	0	None
Perca flavescens (Yellow perch)	3	0	Single hydracarina specimen in intestine

The frequency and abundance of a parasite within a host population depends on the host diet, behavior, physiological resistance, and the availability of infective larvae. Parasite abundance directly depends on the density of the host population. When the latter is high, the parasite's invasive phase has more chance of coming in contact with the host (Bauer, 1962; Kennedy, 1970). These factors are subject to direct or indirect environmental stresses, biotic and/or abiotic, in the aquatic media.

For endoparasitic species transmitted through a food web, host diet is extremely important. A high density of infective agents may increase the likelihood of host-parasite contact, but feeding habits ultimately determine the rate of contact. During a study of the ecology of *Camallanus oxycephalus*, the parasitic "red worm" found hanging out of the anus of fishes in Lake Erie, Stromberg (1973) found that the highest infection frequencies and greatest increases of *Camallanus* have occurred in adult, piscivorous fishes. These fishes become infected by consuming smaller, infected plankton-feeding species. His study revealed that the great increase of *C. oxycephalus* in western Lake Erie appears to be related to the rise in the abundance of gizzard shad and alewife (planktivorous species). Exploitation of such species has resulted in an increase flow of *Camallanus* to the adult, piscivorous portion of the fish community. If there is no regulation of worm numbers, the greater parasite frequency and perhaps greater infection intensities increase the probability of stress and disease within the fish community. Increased water temperatures can contribute to increased worm numbers because of the influence of temperature on parasite development. The generalized life cycle of *Camallanus oxycephalus*:

Piscivorous fish	Planktivorous fish	Copepods
(white bass, yellow perch, crappies)	(gizzard shad, alewife)	

shows that significant changes in that life cycle could affect the fish hosts (intermediate and definitive) positively or negatively.

The effect of temperature on the physiology of fish parasites has been frequently referred to in the literature. Arme and Walkey (1970) indicate that high temperatures have stimulatory effects on fish parasites, particularly for maturation. This correlates very well with Bauer's (1959,

1962) summary of some of the effects of water temperature on the reproduction of various fish parasites:

(1) Temperature increases generally shorten the length of embryonic development and promote more synchronized hatching. According to M. N. Dubinina (1953), Ligula intestinalis coracidia hatch very synchronously at 24-28 C; the same phenomenon occurs in Triaenophorus nodulosus, Bothriocephalus scorpii, and many other parasites. (2) All processes of parasitic protozoan reproduction are accelerated by temperature increases within certain limits.

(3) Invasive-phase activity of freshwater fish parasites (Ichthyophthirius sp. ciliospores, digenetic trematode miracidia and cercariae, monogenetic trematode free-swimming larvae, cestode coracidia, and various invasive larvae of parasitic crustaceans, e.g., Lernaea cyprinacea) depends on temperature. The activity of thermophilic forms is maximal at high temperatures. An example is the activity of Bucephalus elegans cercariae which increases from zero caudal contractions to 102 per minute with a temperature increase of 0-28 C. The miracidia of a known thermophobic form, Phyllodistomum megalorchis, parasitizing the urinary bladder of the burdot (Lota lota) are most active at 5-9 C. (4) Water temperature essentially affects the developmental rate of larval phases in the first intermediate host and the development of parthenogenetic generations of digenetic trematodes in mollusks. The larvae generally become invasive more rapidly at higher than at low temperatures. Leptorhynchoides thecatus larval development, e.g., in the amphipod Hyallela aztheca lasts for two months at 13-15 C, while at 20-25 C it lasts only one month (De Giusti,1949). (5) The last developmental phases of fish parasites are also subject to temperature effects; that is, when parasitism on or in the fish body occurs. Ichthyophthirius sp., living in the subepithelial skin layer of various freshwater fishes, attains maturity and leaves its host on the fourth day at 28-30 C, on the seventh at 19-21 C, on the tenth to eleventh at 13-15 C, and on the thirty-fifth to fortieth day at 8-9 C. The higher the water temperature surrounding the fishes, the faster the parasite grows, its abundance increasing accordingly (Bauer, 1955). (6) The oviposition rate of mongenetic trematodes increases with increased water temperatures, e.g., Dactylogyrus vastator. (7) Water temperature increases speed the rate of development and sexual maturity of some protozoa and all helminths in the definitive host. (8) Sexually mature fish parasites are very sensitive to abrupt fluctuations of water temperature. Carp fry heavily infected

with Dactylogyrus sp. transferred from pond water to 18 C to strongly flowing water with temperature never above 12 C were rid of the parasites after several days. Similar results were obtained with leeches, Piscicola geometrica, when infected fishes were transferred from warm to cool water.

Among species parasitic to fishes, there exists variable sensitivity to temperature in the temperate zone. These species fall into three ecological groups: (1) Those parasites which can develop within fairly wide temperature limits (eurythermic), e.g., Triaenophorus nodulosus, Camallanus lacustris. Their optimal temperature is about 20 C and their development does not stop at temperatures near zero. (2) Those parasites which can develop within narrower temperature limits but need a certain, very high minimum of heat (stenothermic-thermophilic or thermophilic), e.g., Lernaea cyprinacea, Ligula intestinalis, Ergasilus sieboldi, Dactylogyrus vastator, and Ichthyophthirius sp. The latter two species are causative agents of epizootics among fishes during the hottest periods of the year. The optimal temperatures for development in this group is about 25-26 C; they will not develop at temperatures near zero. (3) Those parasites, the development of which proceeds at a temperature near zero but which are suppressed at temperatures from 20 C or more (stenothermic-thermophobic). Optimum temperatures lie within the limits of about 10-15 C, sometimes even less. Examples are Chilodonella cyprini, Dactylogyrus solidus, Achtheres coregonorum.

Freshwater fish parasites are also highly sensitive to salinity. There are, however, those species whose free-swimming phases are tolerant of salinities higher than normally found in freshwater. Examples of such euryhaline species include Triaenophorus nodulosus and several myxosporidians. The eggs of T. nodulosus can incubate at salinities up to 5-6 percent; the coracidia can also live in water with a salinity not greater than 7 percent but do die much faster than at lower salinities. The most salinity-sensitive freshwater fish parasites include the dactylogyruses, leeches, and larvae of bivalve mollusks (glochidia).

The salts dissolved in water affect the freshwater fish parasites unequally. They are most sensitive to chlorides and sulfates and especially a mixture of both. Carbonates have not been implicated in the killing of freshwater fish parasites (Bauer, 1962).

Several of the parasites occurring on or in fishes from Sandusky Bay and other regions of western Lake Erie are pathogenic. Environmental and ichthyofaunal changes suggest the possibility of epizootics. Those species most frequently implicated in causing epizootics fall into the thermophilic and eurythermic ecological groups. Dechtiar (1972) indicates that a heavy infestation of Ichthyophthirius multifiliis was suspected as the cause for considerable mortality among yearling yellow perch and freshwater drum in Lake Erie in 1963. According to Bauer (1962) parasite infectivity has not been observed to be affected by the age of the host. Fishes of all ages may be carriers with an increase in infection very well correlated with temperature increases. This parasitic protozoan (infusorian) can be found on almost any species of freshwater fishes and is typically associated with gizzard shad (Dorosoma cepedianum) and white bass (Roccus chrysops). I. multifiliis is highly pathogenic, with death resulting from the parasites devouring many epithelial and blood cells. Infected fishes behave normally at first. As the number of parasites increase the fishes show signs of restlessness, swimming rapidly from the lower to the upper layers of water. The fishes have numerous white or greyish-colored spots on the fins and skin, looking as if dotted with grains of semolina. When parasites settle in the cornea of the eye, complete or partial blindness results. Dying fishes turn white and stay near the banks hardly reacting to stimuli. This is especially true of carp (Bauer, 1962; van Duijn, 1967; Petrushevski and Shulman, 1958).

The microsporidian, Glugea hertwigi, is believed to have caused extensive mortalities of young smelt in 1969. G. hertwigi produces knot disease in smelt (Osmerus) and has been found to be the most abundant parasite in Lake Erie smelt. Its incidence is high in fishes of all ages including young-of-the-year. Severe infection with this parasite causes inflammation and functional disturbances in the majority of the organs, leading to serious loss of condition, retardation of growth, decline in fertility and occasional mass mortality (Dechtiar, 1972; Petrushevski and Shulman, 1958; van Duijn, 1967). Dechtiar (1972) draws attention to the significance of the pathogens Myxosoma scleroperca and Henneguya doori on yellow perch and Thelohanellus sp. on sand shiners. Infections of M. scleroperca heavy enough to seriously affect the eyes of yellow perch were recorded in the Canadian waters of Lake Erie by Dechtiar (1965). This constitutes a new distribution record and that this organism can become quite significant in western Lake Erie is by no means an impossibility.

The pathogenic monogeneans detected in Lake Erie are Neodiscocotyle carpioditis, Dactylogyrus spp., and Gyrodactylus spp. (Dechtiar, 1972).

According to Davis (1953) Dactylogyrus does not multiply as fast as Gyrodactylus and is much less likely to cause epizootics. However, Dactylogyrus may be much more injurious since it attacks more important organs. Detailed studies of the ecology of D. vastator indicate that this is a very important species in terms of epizootics because of its response to increases in water temperature and its pathogenicity (Bauer, 1962; Dechtiar, 1972; Williams, 1967). Dactylogyrus spp. occur on the gills of cyprinids. In the U.S.A., several species occur on the gills of bass and sunfish where they cause serious injury by rupturing the gill epithelium and producing lesions which may bleed profusely. The epithelium then becomes thickened and, in places, may be destroyed (Davis, 1953).

Fishes with gyrodactylosis become very pale; the fins droop and fold and become gradually torn while the skin becomes more slimy than normal and shows small blood spots; and the frequency of breathing is generally increased (van Duijn, 1967).

The larval stages of several digenetic trematodes occurring in Lake Erie are pathogenic: Diplostomulum spp., Posthodiplostomulum minimum minimum, P.m. centrarchi, Tetracotyle spp., and Sanguinicola spp. Sanguinicola occidentalis and several other species were detected in walleye, freshwater drum, white sucker, shorthead redhorse, spottail shiner, and yellow perch in Lake Erie (Dechtiar, 1972). Diplostomatosis or parasitic cataract is said to be caused by Diplostomulum spathaceum metacerariae living in the vitreous humor or more often the lens of a large variety of freshwater fishes, the Cyprinidae being their most common hosts. The hosts of the adult parasites are the piscivorous birds (Petrushevski and Shulman, 1958). Diplostomum flexicaudum cercariae reported from Lake Erie fishes by Dechtiar (1972) have been found to be able to penetrate the eye and grow in the lens of amphibians, reptiles, birds, and mammals and to have similar appearance and behavior to those found in the eyes of fishes (Ferguson, 1942).

Black spot disease resulting from the infestation of the skin and fins of fishes by the metacercariae of Posthdiplostomulum is manifested by the appearance of black spots due to the deposition of black pigment around them. If a few parasites are present on a big fish they will not do much harm, but if there are many, or if the fish is small, the disease is serious, and in such cases the scales may also be damaged. In serious cases of the disease the fishes suffer from severe deformation of the body, muscular injuries, spinal deformities, and severe retardation of growth (Petrushevski and Shulman, 1958; van Duijn).

Tetracotylosis caused by metacercariae of Tetracotyle spp. results in a severe deterioration of fishes (Petrushevski and Shulman, 1958).

Sanguinicolosis caused by trematodes in the circulatory system of fishes results in the death of fry and yearlings because the blood capillaries are blocked by parasite eggs. In older fishes a chronic, kidney form of the disease develops. Blockage of kidney blood vessels by eggs causes water imbalance. Exudata accumulates in the fishes resulting in dropsy, exophthalmus, and puckering of scales (Bauer, 1958a; Bauer, 1962).

Species of cestodes considered pathogenic include larval stages of Triaenophorus nodulosus, Proteocephalus ambloplitis and Ligula intestinalis. Plerocercoids of those species have been recorded to cause fish mortalities and have been suspected to have caused mortalities in Lake Erie (Dechtiar, 1972). The pleroceroids of Triaenophorus cause the degeneration of internal organs, especially the liver, possibly causing the mass death of fishes (Bauer, 1962). White bass livers and mesenteries taken from Sandusky Bay and its tributaries on May 22 and 23, 1974, were riddled with encysted, larval Triaenophorus. The fish, however, appeared to be quite healthy. The adult of Triaenophorus nodulosus lives in the intestine of Esox lucius.

Ligulosis caused by ligulid worms including Ligula intestinalis ranks as a very common and dangerous disease. The adult worm lives in piscivorous birds. The plerocercoids of Ligula use part of the host's food and due to their considerable size, displace the internal organs of the fishes causing extensive functional disturbances. The liver develops pigmented spots; the gonads degenerate, leading to the complete atrophy of these organs. The condition of the fishes rapidly deteriorates as a consequence of retarded growth and loss of fat and weight (van Duijn, 1967); Petrushevski and Shulman, 1958). The degree of infection by this pathogen depends mainly on the concentration of birds (grebes, gulls, ducks) in the area as well as the water temperature for development of the coracidia and the body temperature of the definitive host. The higher the temperature in both cases, the faster development proceeds (Bauer, 1962; Williams, 1967). Proteocephalus ambloplitis plerocercoids frequently invade the liver, mesenteries, and gonads of their fish hosts. Many bass were apparently rendered sterile due to adhesions in the gonad tissue resulting from invasions of the P. amblopIitis plerocercoids (Bangham, 1972).

Some of the nematodes (Contracaecum spp. Eustrongylides sp., and Philometra cylindracea) are also pathogenic. The changing perch population in Lake Erie has been correlated with the recent increase in the abundance of the latter two nematode species (Dechtiar, 1972).

Very little information is available on the pathogenic effects of nematodes. This area is one of the most neglected fields in fisheries helminathology. Philometra americana larvae have been found to escape their fish hosts by rupturing the body wall. According to Bauer (1958), Eustrogylides sp. larvae, parasitic in fishes, caused a hypertrophy of connective tissue resulting in the encapsulation of the parasite in round, somewhat flattened cysts. In a review of the literature Sprinkle (1973) notes cases of mortalities of the great blue heron, the American egret, red-breasted mergansers, and other waterfowl caused by larval and adult Eustrongylides sp. Bangham (1972) encountered this large, red nematode larva in the body cavities and flesh of the hosts: yellow perch, northern logperch, freshwater drum, and central redfin sculpin. It has been reported to be a seasonal economic factor because its presence in the flesh caused fillets of yellow perch to be rejected. Bauer (1958b) states that Contracaecum sp. larvae, parasitic in fishes, cause hypertrophy of connective tissue resulting in sheath-like membranes sometimes colored bright green. Larvae remaining in the body of the host for a long time are eventually killed by the process of calcium deposition (petrification). Philometra cylindracea has been taken from cysts in the eye sockets of the hosts, most often sheepshead. It frequently invades the mesenteries of the coelom, especially in yellow perch (Bangham, 1972).

The pathogenic acanthocephalan considered to be particularly dangerous to catostomids and cyprinids in Lake Erie is Pomphorhynchus bulbocolli (Dechtiar, 1972).

The crustacean parasites Argulus spp. and Lernaea cyprinacea are considered by Dechtiar (1972) to be serious pathogens having caused extensive mortalities in North America and Europe. Argulus spp. have a poison gland, the secretion of which, in cases of mass infestation, may kill small fishes. Lernaea cyprinacea form swellings and hematomata on the bodies of fishes, rendering the flesh unsuitable for consumption. At and around the point of penetration of the parasite the scales of the host are destroyed (Bauer, 1958b).

In summary, the future stability and/or increase of the parasite fauna of Sandusky Bay fishes is dependent on abiotic and biotic factors in the environment -- temperature, salinity, host abundance, and host diet.

Several of the parasite species found in the Sandusky Bay fishes are pathogenic and can cause epizooties of very significant proportions given the appropriate environmental conditions. Even if epizootics do not occur, the pathogenic species have the ability to infect the host species such that their flesh is rendered unsuitable for human consumption.

Ichthyoplankton

In 1966 the Ohio Division of Wildlife (Baker, 1967) conducted a study of ichthyoplankton in Sandusky Bay at 15 stations. Twenty-four 5-minute fry net tows were made during the period May 10 to May 24, resulting in the capture of only 27 yellow perch (Perca flavescens) and one American smelt (Osmerus mordax). The fry nets used for this study were of two sizes: (1) No. 00 mesh monofilament net mounted on a 0.5 meter iron ring and (2) No. 000 mesh monofilament net mounted on a 1.0 meter iron ring. An average of only 1.1 fry per 5-minute fry net tow was captured in Sandusky Bay. The first perch fry were taken on May 10 and averaged 7.0 mm in length.

In addition to the fry net, a 16-foot otter trawl with a 1.8 inch bobbinet cod end was also used to capture young fishes in Sandusky Bay during the period June 2 through August 4. A total of 800 young-of-the-year fishes were captured in 29 5-minute tows at 14 sampling stations. The species distribution included 510 yellow perch (Perca flavescens), 208 spottail shiners (Notropis hudsonius), 52 troutperch (Percopsis omiscomoycus), 12 log perch (Percina c. caprodes), 6 gizzard shad (Dorosoma cepedianum), 5 alewife (Pomolobus pseudoharengus), 3 white bass (Morone chrysops), 2 freshwater drum (Aplodinotus grunniens), 1 goldfish (Carassius auratus), and 1 walleye (Stizostedion v. vitreum).

During the period of June 2-14, an average of 21.0 yellow perch were captured per tow. This number decreased to only 1.0 per tow by June 27. Baker (1967) concluded that the perch in Sandusky Bay grew slightly faster than those in Lake Erie for the same period of time; however, he believed that growth rates equalized by midsummer.

On August 4 one tow was made in Sandusky Bay with a 35-foot trawl fitted with a 1/4 inch mesh cod end for a period of 15 minutes. The 331 young fishes captured consisted of 156 gizzard shad, 90 spottail shiners. 31 freshwater drum, 30 yellow perch, 15 white bass, 7 troutperch, 1 white crappie (Pomoxis annularius), and 1 channel catfish (Ictalurus punctatus).

The results of these investigations are summarized in Tables 2.7.41, 2.7.42, and 2.7.43 and sampling stations are shown on Figure 2.7.13. Subsequent studies by the Ohio Division of Wildlife in May and June, 1967, yielded 102 yellow perch, 60 American smelt, and 79 gizzard shad from 47 fry net tows at 19 stations in Sandusky Bay while studies in May, 1968, yielded 272 yellow perch fry and one American smelt fry from tows at 13 stations in Sandusky Bay. The average number of fry captured per 5-minute tow was 11.9 with a mean length of 11.0 mm (Baker, 1969).

1974 investigations of Sandusky Bay included ichthyoplankton sampling at Stations 2,5,17,29 (Figure 2.7.7). Five-minute surface and bottom tows were taken at these stations on May 1, May 31, and June 26, 1974. A 0.75 meter, no. 00 mesh fry net was used to obtain fish eggs and fry. The results of these surveys are given in Table 2.7.44.

In late May the length of yellow perch ranged from 12.0-18.0 mm, gizzard shad ranged from 9.0-19.0 mm, and freshwater frum ranged from 6.0-11.0 mm. In late June the length of yellow perch fry ranged from 18.0-25.0 mm, gizzard shad ranged from 9.0-29.0 mm, freshwater drum ranged from 9.0-13.0 mm, and white bass ranged from 9.0-15.0 mm.

The data gathered by the Ohio Division of Wildlife and the present study indicate that Sandusky Bay provides spawning and nursery grounds and/or migratory corridors for such fish species as yellow perch, gizzard shad, freshwater drum, troutperch, log perch, white bass, walleye, American smelt, goldfish, alewife, and spottail shiner. The Division of Wildlife study was designed specifically to capture important commercial species such as walleye and yellow perch. Young-of-the-year walleye were found to be rare but perch fry were moderate in abundance. The 1974 study was designed to be more comprehensive. No walleyes were captured, but gizzard shad were very abundant and perch remained moderate. These data show that the western end of Sandusky Bay is not an important spawning ground for many of the sport and commercial fish species found in Lake Erie. With the exception of moderate numbers of yellow perch, fry captured during the ichthyoplankton surveys were either rough or forage species.

TABLE 2.7.41. YOUNG-OF-THE-YEAR FISH CAPTURED BY FRY NETS IN SANDUSKY BAY DURING MAY, 1966*

Station	Number of Tows	Number of Fry	Length, mm Range	Length, mm Mean	Species
A	1	0			
A-1	2	0			
A-2	1	0			
B	1	0			
B-1	0	--			
C	2	2	9.0 10.0	9.0 10.0	Perch Smelt
C-1	0	--			
C-2	0	--			
C-3	0	--			
D	1	0			
D-1	1	3	8.0 - 10.0	9.0	Perch
E	1	0			
E-1	1	0			
F	1	5	10.0 - 12.0	11.0	Perch
F-1	1	1	10.0	10.0	Perch
G	2	1	9.0	9.0	Perch
G-1	4	6	6.0 - 8.0	7.0	Perch
G-2	1	5	11.0 - 12.0	11.2	Perch
J	2	0			

* Source: Ohio Division of Wildlife (Baker, 1967).

TABLE 2.7.42. YOUNG-OF-THE-YEAR FISH CAPTURED BY 1/8-INCH MESH TRAWL IN SANDUSKY BAY DURING JUNE, 1966*

Station	Species	Number of Tows	Number of Fish	Length, mm Range	Mean
A	Troutperch	1	1	15.0	15.0
B	Perch	2	99	14.0 - 22.0	17.1
	Troutperch		2	14.0 - 15.0	14.5
B-1	Perch	2	97	13.0 - 26.0	20.0
	White Bass		2	13.0 - 14.0	13.5
	Spottail Shiner		2	17.0	17.0
	Troutperch		8	13.0 - 19.0	16.2
	Log Perch		6	18.0 - 23.0	20.5
C	Perch	2	22	16.0 - 27.0	22.0
	Troutperch		3	16.0 - 26.0	20.7
	Log Perch		5	22.0 - 30.0	25.6
	Goldfish		1	11.0	11.0
C-1	Perch	2	39	13.0 - 19.0	16.6
	Gizzard Shad		1	12.0	12.0
C-2	Perch	2	31	15.0 - 29.0	22.0
	Spottail Shiner		8	12.0 - 17.0	14.9
	Gizzard Shad		1	17.0	17.0
C-3	Perch	1	12	13.0 - 17.0	15.6
D	Perch	3	6	13.0 - 25.0	19.0
	Alewife		5	27.0 - 41.0	34.6
	Troutperch		1	13.0	13.0
	Spottail Shiner		56	13.0 - 25.0	16.0
D-1	Perch	3	74	13.0 - 30.0	25.0
	Troutperch		4	13.0 - 25.0	21.0
	White Bass		1	15.0	15.0
	Spottail Shiner		70	14.0 - 25.0	17.0
	Gizzard Shad		4	16.0 - 21.0	19.8
E	Perch	3	3	14.0 - 24.0	18.0
	Walleye		1	18.0	18.0
	Troutperch		3	12.0 - 14.0	13.3
	Spottail Shiner		52	13.0 - 29.0	16.5
	Freshwater Drum		2	21.0 - 27.0	24.3
E-1	Perch	2	106	18.0 - 39.0	27.0
	Spottail Shiner		12	13.0 - 18.0	15.4
	Troutperch		13	17.0 - 24.0	21.5
	Log Perch		1	26.0	26.0
F	Perch	2	12	19.0 - 38.0	27.5
	Troutperch		8	14.0 - 28.0	21.0
	Spottail Shiner		7	18.0 - 37.0	26.5
G	Perch	2	9	17.0 - 26.0	21.8
	Troutperch		4	18.0 - 22.0	20.3
J	Perch	1	7	17.0 - 26.0	20.9
	Troutperch		4	12.0 - 24.0	18.3

* Source: Ohio Division of Wildlife (Baker, 1967).

TABLE 2.7.44. ICHTHYOPLANKTON SURVEY OF SANDUSKY BAY

Date/Species	Station 2		Station 5		Station 17		Station 29	
	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
May 1, 1974								
Yellow Perch			0		0		0	
Gizzard Shad			0		0		0	
Freshwater Drum			0		0		0	
Eggs			0		0		0	
May 31, 1974								
Yellow Perch	13	45	9	50	35	18	13	62
Gizzard Shad	1,361	369	10,218	13,613	1,174	133	124	43
Freshwater Drum	36	17	79	327	16	3	0	0
Eggs	554	72	27	103	1,027	493	1,062	1,231
June 26, 1974								
Yellow Perch	1	6						
Gizzard Shad	92	6						
Freshwater Drum	0	9						
Eggs	2,048	1,626						
White Bass	236	43						
Goldfish	0	2						

Chapman (1955) also investigated fry in Sandusky Bay and found essentially the same results: forage fishes, 61.0 percent; rough fishes, 16 percent; and game fishes, 23 percent of the hatch-of-the-year population. From shore seining he concluded that there was a successful spawning population of the following species listed in order of decreasing numbers: (1) yellow perch, (2) black and white crappies, (3) white bass, (4) bullheads, (5) bluegills, and (6) catfish for the game species; (1) gizzard shad, (2) goldfish, (3) freshwater drum, and (4) carp for the rough fishes. Other species that spawned successfully, but to a lesser extent, were largemouth bass, walleye, smallmouth bass, pumpkinseed sunfish, rock bass, quillback, alewife, and longnose gar. The most widely distributed species in the ichthyoplankton were yellow perch, crappies, bluegill, white bass and gizzard shad, these being found throughout the Bay. Bullheads, catfish, carp, and goldfish were found over the most of the Bay, but particularly in protected water, tributary estuaries, and in areas of aquatic vegetation. The time of spawning for yellow perch, white bass, bullheads, catfish, carp, crappies, goldfish, walleye, and freshwater drum was spring and early summer. Bluegill spawned through the summer. Chapman concluded that factors which limit spawning in Sandusky Bay compared to Lake Erie are sparsity of aquatic vegetation, high turbidity of the water, drag seine grounds which are constantly disturbed during the spawning season, currents, deposits of silt on the bottom, pollution from domestic and industrial sewage, and predation from fishing and predatory fishes.

TABLE 2.7.43. YOUNG-OF-THE-YEAR FISH CAPTURED BY 1/4-INCH MESH TRAWL IN SANDUSKY BAY DURING AUGUST, 1966*

Station	Species	Number of Tows	Number of Fish	Length, mm Range	Mean
G	Perch	1	30	58.4 - 73.7	65.8
	Troutperch		7	48.3 - 61.0	54.9
	White Bass		15	38.1 - 104.6	71.5
	Spottail Shiner		90	28.4 - 66.0	49.3
	Freshwater Drum		31	38.1 - 88.9	66.4
	Gizzard Shad		156	40.6 - 79.2	59.0
	Channel Catfish		1	66.0	66.0
	White Crappie		1	43.2	43.2

* Source: Ohio Division of Wildlife (Baker, 1967)

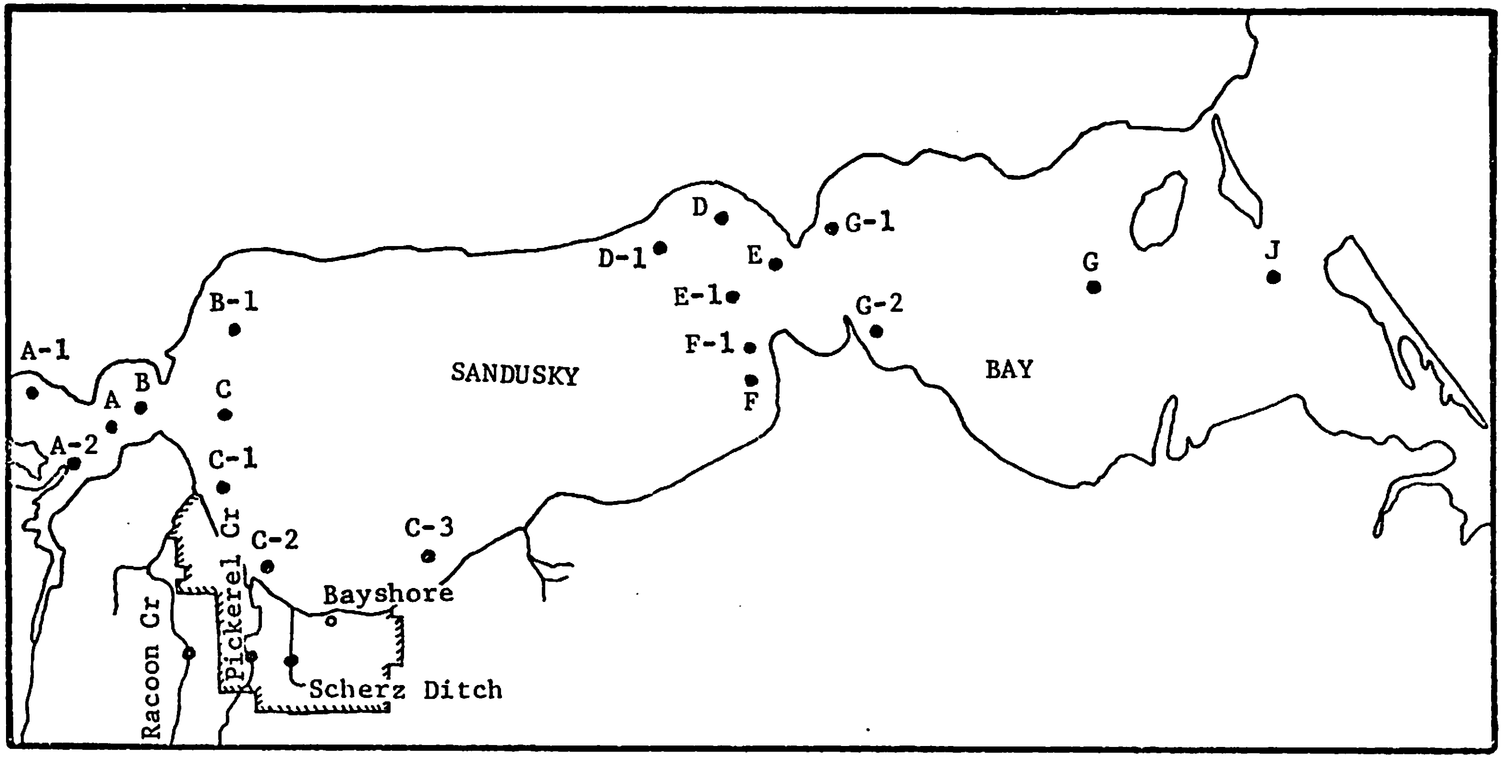


FIGURE 2.7.13. POSITION OF OHIO DIVISION OF WILDLIFE FISH FRY SAMPLING STATIONS IN SANDUSKY BAY

TABLE 2.7.44. ICHTHYOPLANKTON SURVEY OF SANDUSKY BAY

Date/Species	Station 2		Station 5		Station 17		Station 29	
	Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
<u>May 1, 1974</u>								
Yellow Perch			0		0		0	
Gizzard Shad			0		0		0	
Freshwater Drum			0		0		0	
Eggs			0		0		0	
<u>May 31, 1974</u>								
Yellow Perch	13	45	9	50	35	18	13	62
Gizzard Shad	1,361	369	10,218	13,613	1,174	133	124	43
Freshwater Drum	36	17	79	327	16	3	0	0
Eggs	554	72	27	103	1,027	493	1,062	1,231
<u>June 26, 1974</u>								
Yellow Perch	1	6						
Gizzard Shad	92	6						
Freshwater Drum	0	9						
Eggs	2,048	1,626						
White Bass	236	43						
Goldfish	0	2						

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CHAPTER 3

THE PLANT
(To be prepared by AEPSC)

CHAPTER 4

ENVIRONMENTAL EFFECTS OF SITE PREPARATION; PLANT AND TRANSMISSION FACILITIES CONSTRUCTION

4.1 SITE PREPARATION AND PLANT CONSTRUCTION

4.1.1 LAND USE

4.1.1.1 Terrestrial Ecology

Vegetation

Construction of the facility will have an impact upon the vegetation. This will result in the elimination of three small woodlots (1, 2, and 13) (see Figure 2.7.1), several fencerows, fields, and approximately 850 acres which will be removed from cultivation. Destruction of vegetation will have an effect on the animals in the immediate area which depend on the plants for food and cover.

Wildlife

The woodlots are utilized by rabbits, deer, and fox squirrels for food and cover. Fields and fencerows are utilized by rabbits, woodchucks, deer, skunk, and foxes. Mice and shrews occur throughout the construction area. Elimination of the woodlots will remove sources of food and cover for the deer and squirrels; on-Site activity will also likely impede the movement of deer across the area. Construction and land clearing will result in reduced populations of rabbits and other small mammals by destroying their habitat as well as decreased utilization of the area by predators such as fox, skunk, raccoon, opossum, etc. A general reduction in the quality of habitat in the immediate construction area will occur and it is therefore expected that there will be a decline in the use of the construction area by most, if not all, mammals.

Construction will also cause a decline in the amphibians and reptiles inhabiting the area where the facilities will be built, as these animals are also dependent on the vegetation for cover and food, either directly or indirectly. They usually are not very mobile and may not be able to emigrate to safer areas.

Construction on the Site property will also include armoring the shore to prevent further erosion and loss of land plus repairing and rebuilding the existing dike system to reduce flooding in fields and woodlots. These construction activities may reduce animal activity while work is actively taking place, and some individuals may leave the area. This construction will result in an improved habitat for deer, squirrel, rabbit, muskrat, and most other animals utilizing the western portion of the Site. This improvement will more than offset habitat destruction caused by construction of the plant facilities.

Birds

Site preparation and construction will disturb both migrating and breeding birds due to construction traffic and noise. In particular, upland gamebird and songbird feeding and nesting habitat will be destroyed where permanent facilities are constructed. Permanent facilities will require about 25 acres for two reactors, two cooling towers, a visitors center, and associated transportation facilities, such as roads, parking lots, and a railroad spur. An additional 225 acres will be required for holding ponds. After completion of the facility a total of about 250 acres will have been altered; however, marsh habitat will be protected and preserved along Pickerel Creek creating a positive impact on marsh birds, especially migratory waterfowl. The area of protected marsh habitat will include the two bald eagle nesting sites on the property.

Habitat. Most of the construction activities will take place on about 800 acres, located less than 1,000 feet west of Scherz Ditch and north of Route 6. This area is mainly agricultural fields where soybeans and winter wheat are grown. Birds, such as red-winged blackbirds, killdeer, and vesper sparrows, will lose nesting habitat as buildings and roads are built. Gamebirds, such as bobwhite and ring-necked pheasant, and songbirds, such as bobolinks, eastern meadowlarks, dickcissels, vesper sparrows, and field sparrows, will lose nesting habitat where hayfields and abandoned fields are covered by foundations and roads.

The winter wheat fields, especially when flooded, are used by a few species of waterfowl as feeding areas during the spring migration. Therefore, birds such as Canada geese and American wigeon will graze in surrounding fields as those on the Site are removed from agricultural status.

A few of the extremely small woodlots and a small orchard, probably less than 20 acres in total, will be cut down. This will decrease nesting area for such species as the eastern wood pewee, indigo bunting, great crested flycatcher, acadian flycatcher, red-eyed vireo, cardinal, mourning dove, American robin, and other species observed during the June surveys. Wintering species which would lose feeding areas include the red-headed woodpecker, downy woodpecker, blue jay, and cardinal.

Some of the fencerows and hedgerows will be leveled during construction, but this will probably be less than 5 miles of 10-to-15-foot wide brushy habitat. This habitat provides nesting sites for small numbers of the following species: bobwhite, ring-necked pheasant, mourning dove, yellow warbler, gray catbird, brown thrasher, cardinal, American goldfinch, indigo bunting, song sparrow, and field sparrow. During winter these hedgerows are used as cover by ring-necked pheasant and tree sparrows.

The marshes along both sides of Pickerel Creek and on the east side of Raccoon Creek are heavily used by waterfowl during both the spring and fall migration. This area also includes two bald eagle nesting sites. Therefore, the Applicant will preserve and protect these marshes by the following actions: (1) dikes around these marshes which are presently in disrepair will be rebuilt and the entire bay shoreline will be armored with rip-rap to retard erosion during late summer to avoid interference with nesting and migratory waterfowl, (2) the dikes will be maintained to allow marsh management for lush stands of aquatic plants, such as smartweed, which are important food sources for most of the dabbling ducks, (3) hunting will be prohibited and construction will be kept out of marsh areas, (4) water pumps and control structures such as sliding steel gates or wooden risers will be installed to facilitate water level control, (5) wood duck nesting boxes will be erected to offset the destruction of some cavity-bearing trees where construction is planned, (6) the swamp forests will be maintained by appropriate water level control to provide wood duck nesting habitat, and (7) an arrangement with the United States Fish and Wildlife Service will be worked out, allowing them to manage all of the Site west of a line running 1,000 feet west of and parallel to Scherz Ditch and north of Route 6. This area will be managed primarily for migratory waterfowl and bald eagles.

The potential for bald eagle nesting will be maintained by following a plan similar to the ones suggested by Alexander Sprunt and Roger Thacker (personal communication), and Snow (1973). Sprunt recommends the two following strategies:

(1) Establish a refuge of at least a 0.25-mile radus 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-mile 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. Thacker suggests that a buffer of 0.5-mile radius be protected throughout the year, since destruction of nest trees outside the nesting season has been recorded.

Establishment of the wildlife refuge will benefit most species of marsh birds. The net impact on bald eagles may be beneficial or zero, if construction noise and traffic can be kept to a minimum during the nesting season. Although some upland gamebird habitat will be permanently lost, the restriction of all hunting should more than offset this loss. The holding ponds are likely to attract some waterfowl, particularly during the winter when other bodies of water are frozen. Campbell (1968) reports that warm water from power houses has been responsible for keeping waterfowl and other water birds in the Toledo area that normally would have migrated farther south.

4.1.1.2 Transportation

Access to the Site is along U.S. Highway 6. Small developments of about 25 houses each exist near the southwest and northeast corners of the Site, and access may be complicated temporarily by Site preparation and plant construction.

4.1.2. WATER USE

The effect of Site preparation and plant construction on the aquatic biota of the western basin of Sandusky Bay should be minimal. All reasonable measures will be taken to: (1) control the discharge of trash spoil, both physical and chemical, (2) protect and preserve the wetlands along Pickerel Creek, (3) reconstruct a littoral zone that is erosion stabilized while still conducive to biological productivity, and (4) reduce to a minimum the processes of erosion and siltation in the construction of intake systems, discharge canals, holding ponds, etc.

The total area effected by construction will not be large enough to affect a large area of the Bay's biota. Data show a rather homogeneous distribution of Bay organisms: no specific localities in the Bay seem to be significantly more important than others, with the possible exception of the wetland areas. While natural resources, both biotic and abiotic, will be committed during construction, it is likely that the unaffected biotic resources possess enough reproductive flexibility to reestablish their numbers in any affected areas.

Temporary periods of heavy siltation and turbidity are not uncommon to denizens of the Bay. Strong winds acting upon the silt laden shallow water of the Bay produce periods of very low transparency or high turbidity.

Although the western basin of Sandusky Bay is considered a spawning and nursery area for several Bay species of fishes, most of these species spawn in the of the year. The success of spawning and hatching of the eggs will not be affected since offshore construction will be curtailed during In a positive sense, the commercial and sport fisheries in the western basin may improve due to the benefit of a stabilized shoreline, since sedimentation rates would be reduced. However, site preparation, including construction of intake and discharge structures plus shoreline revetment, will have a temporary effect of increasing suspended sediment, turbidity, in Sandusky Bay near the Site and/or construction activity.

Increasing turbidity has the effect of reducing the depth to which light can penetrate the water column. The lowest depth at which photosynthesis can occur is related directly to light attenuation. When turbidity is increased, the amount of light present at all water column depths is reduced.

The relationship between primary productivity and water transparency in Sandusky Bay was discussed in Section 2.7. Throughout the western basin of Sandusky Bay, that station which has the lowest transparency or highest turbidity, Station 5, also exhibits the lowest integral primary production. Therefore, primary productivity in the vicinity of near-shore and/or open-water construction operations is expected to be reduced due to elevated turbidity caused by disruption of the bottom sediments on and near the Site. The impact of this forecasted effect is judged as minimal, relative to the overall area of the western basin of Sandusky Bay and to the primary production which occurs there.

Primary productivity in discharge holding ponds and canals is not expected to be similar to that which occurs in the Bay. These ponds will receive blowdown water containing chlorine and high levels of total dissolved solids, which, acting in concert, will probably retard photosynthetic capability of entrained phytoplankters. The basis for this prediction is developed in Section 5.4.

4.2. TRANSMISSION FACILITIES CONSTRUCTION

(To be prepared by AEPSC.)

4.3. RESOURCES COMMITTED

Construction will result in the commitment of approximately 250 acres of land along with the associated vegetational habitat. The utilization of land for roads, buildings, ponds, and other facilities will cause a loss of vegetation and subsequent loss of cover, nesting, and feeding sites for species utilizing that area. This may result in a population decline for these species up to the number of those individuals inhabiting the area to be used for construction.

The impact on the total mammal populations will likely be minor. The area involved for Site preparation and construction is presently of low value to wildlife. The small size of the woodlots prevents them from being heavily utilized by deer or squirrels as areas for food or cover. Movement of deer through the area will be altered, but no significant impact is expected. Rabbit and small mammal losses will not be significant. Skunks, raccoons, and opossums will likely continue to forage over the construction area, except for that area cleared or covered by structures.

Since amphibians and reptiles are not very mobile, facility preparation and construction will likely eliminate those in the construction area. Those animals affected will primarily be garter and fox snakes which prey upon mice and insects.

No significant irreversible or irretrievable commitments of land, water, biological, mineral, or man-made resources are anticipated as a result of construction activities on the Site.