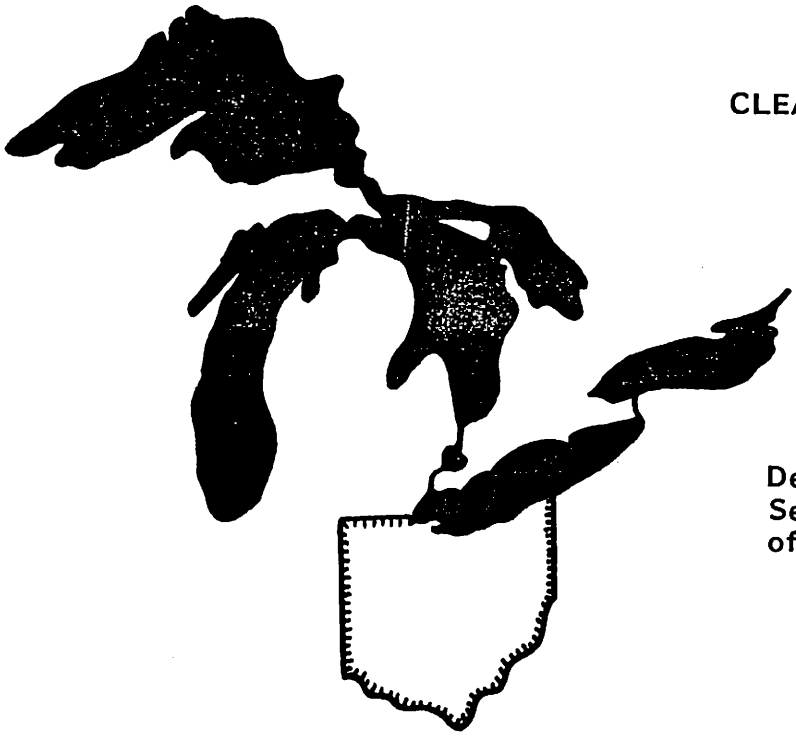

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Development of an Environmental Sensitivity Index for Coastal Areas of the North American Great Lakes

by

Charles E. Herdendorf

Prepared as a Background Document

for a Poster Session Presented at

XXIII SIL CONGRESS

Hamilton, New Zealand

8-14 February 1987

DEVELOPMENT OF AN ENVIRONMENTAL SENSITIVITY INDEX FOR COASTAL AREAS OF THE NORTH AMERICAN GREAT LAKES

by

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INTRODUCTION

The need for Environmental Sensitivity Index (ESI) mapping was initiated in Alaska in response to oil pipeline activity at the Lower Cook Inlet (Hayes et al. 1976). Since the initial study in the early 1970s, the National Oceanic and Atmospheric Administration (NOAA) has conducted several ESI projects along the sea coasts of the United States. Increased production and transport of oil and toxic substances around the Great Lakes, as well as oil discharges from commercial vessels and oil refineries, has created the need for an ESI mapping program for these freshwater environments. The development of a prototype index for the Great Lakes is discussed in this paper.

APPROACH

A shoreline classification scheme was needed which depicts the sensitivity of the coast on U. S. Geological Survey topographic maps and on which diverse resource data could be illustrated. In developing the sensitivity index a number of environmental factors were taken into consideration:

1. Geomorphic Factors
   a. Shoreline type
   b. Grain-size, shore profile and wave climate characteristics
2. Biologic Factors (location and seasonability of spill sensitive coastal wildlife)
   a. Fish spawning grounds and times
   b. Fish nursery areas and times
   c. Bird migration refuges/pathways and seasons
3. Socioeconomic Factors and Spill Response
   a. Sites of high socioeconomic importance
   b. Location of staging sites and equipment needs including landing strips, boom placements, inlet closures, and washovers

Once a preliminary scheme was developed, it was tested by attempting to map the shoreline of Lake Erie and connecting waterways (Lake St. Clair, St. Clair River, Detroit River and Niagara River). After appropriate modifications, the entire study area was mapped on 66 topographic maps utilizing low-altitude, overflight with a fixed-wing aircraft (Figure 1). The results of the mapping project was an atlas of coastal resources for use by the U. S. Coast Guard, Office of Marine Safety and NOAA, Hazardous Materials Response Branch in responding to oil spill events on Lake Erie (Appendix A). These maps will allow field personnel involved in decision-making and spill clean-up to observe all the significant variables at one time. The Lake Erie ESI was designed as a pilot program which eventually will be undertaken on the other Great Lakes.

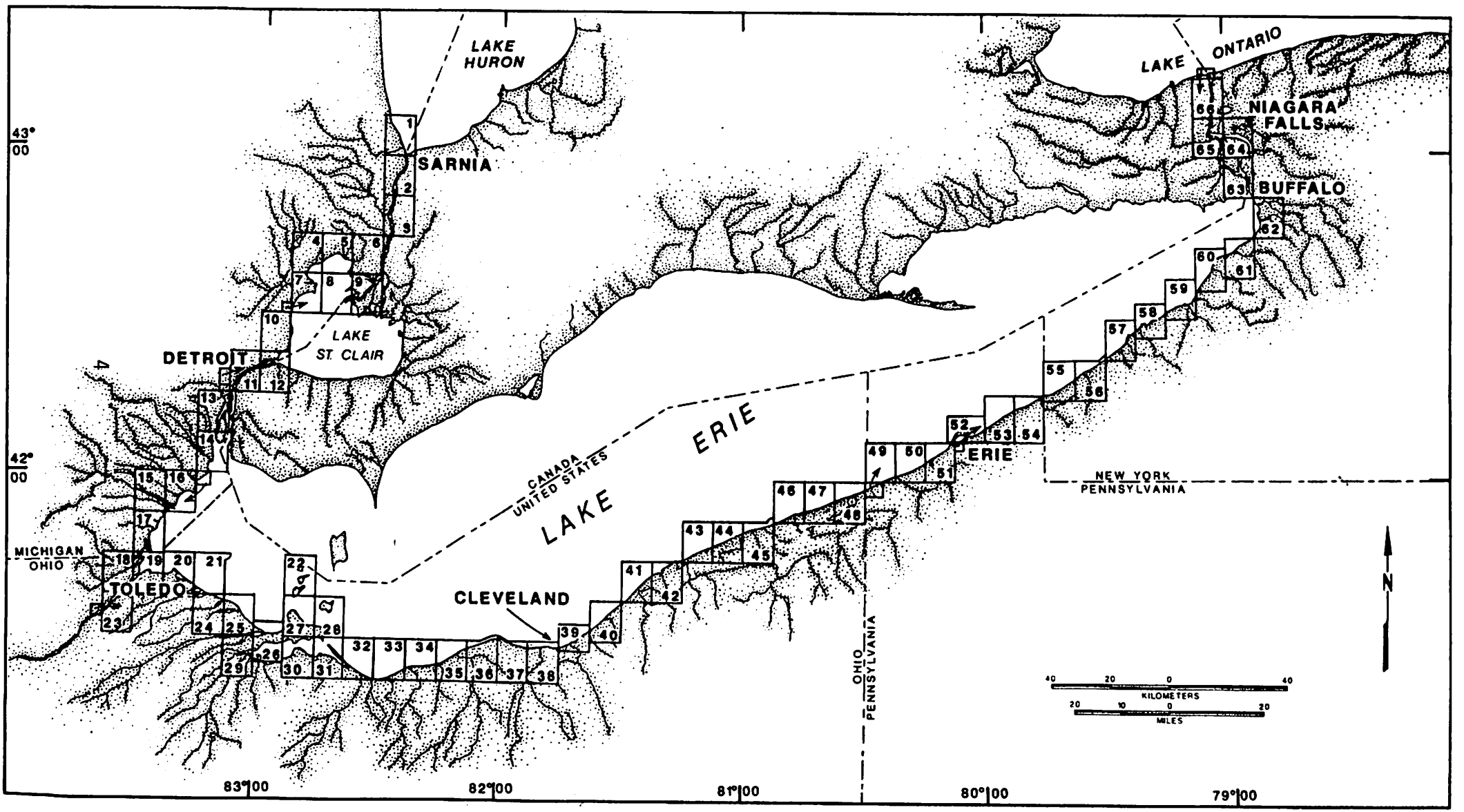
CLASSIFICATION SCHEME

An index was developed which incorporates geomorphological and sedimentological characteristics of the shoreline as well as biological and socioeconomic considerations. Based on the sensitivity of coastal areas to oil spills and discharges of other hazardous materials, ten sensitivity categories have been established. The categories range from least sensitive (Category 1, Exposed Bedrock Bluffs) to the most sensitive (Category 10, Coastal Wetlands):

Exposed Bedrock Bluffs (ESI-1)

This classification includes vertical or near vertical bedrock bluffs from 3 to 60 m in height. In the Lake Erie system this includes gray limestone and dolomite cliffs in the

FIGURE 1. Lake Erie and its connecting waterways, showing the location of the 66 ESI maps used to depict coastal classification and resources (Sexton et al. 1985).



islands region of the western basin, black and gray shale bluffs in the central basin from Vermilion to Cleveland, a brown sandstone cliff at Vermilion-on-the-Lake, gray and black shale in the eastern basin between Erie and Buffalo, gray dolomite and black shale cataracts and cliffs between Niagara Falls and the Niagara Escarpment, and red shale cliffs along the lower Niagara River. The bedrock shores are generally resistant to erosion and contribute little in the way of beach-building material. Landside access to the base of these bluffs is difficult at most locations. Beaches rarely occur in front of the bedrock cliffs, except where streams have cut small ravines or in coves between two headlands.

Predicted Oil Impact

a. An oil band will form at the rocky-shore/water interface, and if conditions are favorable, the entire lower portion of the bluff may be oiled
b. The persistence of oil would vary to the incoming wave energy; oil persistence would be short-lived during high-wave conditions
c. Birds that use the lower portion of the bluffs may be killed if oiled

Recommended Response Activity

a. Cleanup will be a low priority on most shorelines
b. Cleanup is very difficult because of poor access
c. If cleanup is warranted, the use of high-pressure water spraying is effective if the oil is still fresh

Exposed Unconsolidated Sediment Bluffs (ESI-2)

This classification includes vertical or steeply sloping bluffs of unconsolidated material ranging in height from 3 to 45 m. In the Lake Erie system this includes glacial till and lacustrine sediments. The till is generally the lower unit when the two occur together and its bluffs are often more nearly vertical. It is a gray mixture of compact silt, clay, sand and gravel with the finer particles predominating. Lacustrine bluffs are composed of brown, lake-deposited silt and fine sand. This material is not as compact and is permeable to ground-water; it erodes more easily. The shoreline of the central basin from Cleveland to Erie is dominated by a combination of these two bluff types. Because of their unconsolidated nature, till and lake deposit bluffs are among the most readily eroded shorelines on Lake Erie. Approximately 20% of the material eroded contributes sand and gravel to the littoral beaches. Like the bedrock areas, landside access to the base of these bluffs is difficult at most locations. Deep, "V" shaped ravines have been cut into these cliffs every few miles which afford some access routes. Beaches are normally narrow (15 m) and in many areas absent in front of till or lake sediment bluffs, except at stream mouths where widths approach 100 feet.

Predicted Oil Impact

a. Incoming oil will form a band along the swash line
b. Oil persistence will be limited to days or weeks, because of wave activity

Recommended Response Activity

a. In most cases, cleanup is not necessary because of the short residence time of the oil
b. Oil can usually be scraped off the surface of the sediment using manual labor
c. Removal of sediment should be avoided
d. The mechanical cleanup of the oil may be very difficult because of the steep slopes of the bluffs

Shelving Bedrock Shores (ESI-3)

This classification includes gently sloping bedrock surfaces that extend from the nearshore lake bottom to heights of up to 10 feet above lake level. In the Lake Erie system this includes the gray limestone and dolomites on the east shores of most of the western basin islands and the Marblehead Peninsula and black or gray shale in the central and eastern basins. In the islands region this exposure is normally a "dip-slope" of the bedrock and commonly contains glacial grooves. The width of these shores range from less than 3 m to over 30 m.

During the months of May through October dense mats of the filamentous green alga, Cladophora glomerata grow on the rock surfaces from the water down to a depth of approximately 3 m. Because of the gentle slope and hard surface of this type of shore, access is usually good. Beaches rarely occur in front of the bedrock except in small coves where beach material is generally gravel.

Predicted Oil Impact

a. Incoming oil will form a band along the swash line

b. The oil persistence is limited to days or weeks varying with the shore's exposure to wave action

Recommended Response Activity

a. In most wave-exposed areas, cleanup is not necessary

b. Other areas, having lower energy and high recreational use, may be cleaned effectively using high-pressure water spraying if oil is still fresh

Sand Shore (ESI-4)

This classification includes granular shores ranging in size from very fine sand to very coarse sand (0.1 to 2.0 mm in diameter). In the Lake Erie system, sand beaches are generally narrow to moderate in width (15-30 m), except at deltas, sand spits and on the updrift sides of large shore structures where wide beaches are found. Notable accumulations of sand occur at the delta of the St. Clair River, north of Monroe harbor at Sterling State Park, Woodtick Peninsula spit on the northwest side of Maumee Bay, Cedar Point and Bay Point spits at the entrance to Sandusky Bay, Headlands State Park west of Fairport Harbor, Walnut Beach west of Ashtabula harbor, Presque Isle spit surrounding Erie harbor and the beaches of Hanford, Sunset, Lotus, Grandview, and Evans bays between Dunkirk and Buffalo. Elsewhere, beaches are generally absent fronting bedrock areas, except at stream mouths and in small cover, or are relatively narrow at the base of unconsolidated bluffs. Because of the gentle slope of most of the larger beaches, small changes in water level can result in major changes in beach width; the narrower beaches are normally steeper and therefore show less

change with water level fluctuations. Access to the large accumulations are generally good, however landside approaches to the small beaches fronting high bluffs are difficult.

Predicted Oil Impact

a. Commonly, oil will be deposited on and become mixed into the sand along the swash line
b. Oil may become deeply buried into the beach sands; up to 12 inches in coarser-grained beaches
c. Organisms resident in the beach are likely to be killed under moderate oil concentrations

Recommended Response Activity

a. Cleanup may be difficult because of relatively soft sediments
b. Cleanup should concentrate on oil removal from the upper swash zone
c. Sand removal should be minimal to avoid erosion problems
d. Activity through the oiled sand should be limited to prevent grinding oil deeper into the beach sediments
e. Use of heavy equipment for oil/sand removal may result in the removal of excessive amounts of sand; manual cleanup may be more efficient

Mixed Sand and Gravel Shores (ESI-5)

This classification includes shorelines composed of sand, gravel and shell mixture which normally form narrow -- (<15 m) to moderate -- (<30 m) width beaches. The slope of the shorelines is generally greater than that for sand beaches but not as steep as that for gravel. These beaches are not wide spread, but they

often occur at the high, wave-energy end of sandy shores or in coves between headlands. Access to these beaches is normally good for those associated with larger sandy beaches and poor for those in isolated coves.

Predicted Oil Impact

a. Oil will be deposited along the swash zone
b. Oil may spread across the entire beach face under very heavy accumulations
c. The percolation of oil into the beach may be deep in well-sorted sediments
d. Biota present may be killed by the oil, either by smothering or by lethal concentration in the water column

Recommended Response Activity

a. Remove oil primarily from the upper swash lines
b. Removal of sediments should be kept to a minimum
c. Mechanical reworking of the sediment into the wave zone and/or high-pressure water spraying can effectively remove the oil; sorbent boom may be necessary to capture oil outflow

Gravel Shores (ESI-6)

This classification includes granular shores ranging in size from pebbles to boulders (2 to 4000 mm in diameter). In the Lake Erie system, gravel beaches are generally narrow (<15 m) and are usually associated with bedrock exposures. The most notable gravel beaches occur on Marblehead peninsula and the islands of the western basin. The most common component is pebble to cobble-sized gravel derived from the limestone and dolomite

cliffs. Isolated gravel beaches also occur in the central and eastern basins at the base of shale and glacial till cliffs, particularly in small coves. These beaches are typically composed of shale "shingle" and crystalline erratics from the glacial deposits. Landside access to gravel beaches is generally difficult because of the high, steep nature of the surrounding bluffs. In areas of shelving bedrock, access is normally good.

Predicted Oil Impact

a. The primary problem with oil pollution in this environment is related to the deep penetration of oil into the gravel beach
b. If oil is left uncleaned, it may become asphalt-like
c. Resident fauna and flora may be killed by the oil

Recommended Response Activity

a. Removal of sediment should be restricted
b. The use of high-pressure water spraying may be effective at removing oil while it is still fresh
c. Sorbent booms or pads should be used to capture oil outflowing during the cleaning process

Rip-rap and Harbor Structures (ESI-7)

This classification includes several types of man-placed material for shore protection and navigation. The variety of material used includes steel sheeting, large concrete blocks, wood, extraneous metallic and concrete debris and tires. A large portion of the St. Clair, Detroit and Niagara Rivers are reinforced by some type of added structure. The bluff areas between Cleveland and Erie are subject to intensive erosion and these areas have been covered by rip-rap materials.

Other types of man-made structures along the lake are dredge disposal areas (a combination of both steel sheeting and concrete block) and wetlands maintained by earthen and rock covered dikes (i.e. Sandusky Bay).

The fauna and flora associated with this classification is also variable depending on the type of material utilized in the structure and the accessibility to the splash zone. Some of the structures provide fishery habitat and bird nesting sites. Harbor structures create a sheltered effect causing debris and oil to accumulate in slack water areas.

Predicted Oil Impact

a. Oil would percolate easily between the gravel and boulders of riprap structures
b. Biota would be damaged or killed under heavy accumulations

Recommended Response Activity

a. Along exposed structures, cleanup may not be necessary
b. Since riprap is often associated with developed, recreational beaches, cleanup would be advisable; sorbent materials should be used to capture the oil as it is cleaned
c. Structures may require high-pressure spraying:
    1) To remove oil
    2) To prepare substrate for recolonization of benthic communities
    3) For aesthetic reasons

Sheltered Bluffs (ESI-8)

This classification includes vertical or steeply sloping bluffs of bedrock or unconsolidated deposits which are not exposed to open lake conditions or torrent stream flow. These bluffs can range in height from 1 to 45 m and are often dissected by tributary ravines. In the Lake Erie systems sheltered bluffs occur along the St. Clair River, Anchor Bay of Lake St. Clair, Detroit River, Maumee Bay, Sandusky Bay, Presque Isle Bay, upper Niagara River, and the navigable portions of the major tributaries. Narrow sand and/or gravel beaches and wetlands are often associated with the edge of these bluffs. These shores are commonly developed for residential and commercial use. Because of this development, landside access is normally good. Natural areas are less accessible.

Predicted Oil Impact

a. Incoming oil will form a band along the swash line
b. Oil sediment interactions will vary with bluff composition with possible burial in sand and percolation down in the gravel
c. Biota present may be killed by the oil, either by smothering or by lethal concentrations in the water column

Recommended Response Activity

a. Removal of sediment should be limited
b. Cleanup should concentrate on oil removal from the upper swash zone
c. Since beach sediments are highly variable, refer to

specific sediment beach type (ESI number) for more detailed response activity

Low Banks (ESI-9)

This classification includes low banks (<1 m) of unconsolidated sediments (i.e. glacial till, lacustrine deposits, and stream alluvium) which are subject to frequent lake or stream flooding. Because of the longitudinal seiche activity which is typical of Lake Erie, areas subject to flooding are concentrated at the western and eastern extremities of the lake. Also, the lower reaches of most tributaries have a "drowned mouth" forming estuarine conditions where flooding from either the lake or the tributary can occur. These low shorelines are also associated with mud flats, sand bars, and wetlands. Because of the low nature of this type of shoreline, landside access is normally good but can be hampered by the soft or marshy nature of the shore material. Shore erosion in these areas can be extreme during high water storms.

Predicted Oil Impact

a. During low lake levels, oil will coat only the edge of the bank or the narrow beach at the toe of the bank
b. During high lake levels, oil can overtop the bank and cover the grasses or trees on the bank
c. Oil may kill the grasses and other vegetation present
d. Trees may become oiled but probably will not be killed unless oil concentrations within the base sediments are very high

Recommended Response Activity

a. Where possible, these areas should be boomed to prevent oil from entering
b. Raking oiled grasses may effectively remove light-to-moderate oil accumulations
c. High- and low-pressure spraying, with cutting only if necessary, will aid oil removal from exposed tree roots
d. Sorbent booms should be placed on the waterside of the cleanup operation to collect outflowing oil

Coastal Wetlands (ESI-10)

This classification includes shore areas with dense growths of primarily emergent or floating aquatic vegetation. The types of wetlands found in the Lake Erie system include the delta wetlands of the St. Clair River mouth, fringing wetlands which require sheltered shorelines such as those of Lake St. Clair and Buckhorn and Strawberry Islands in the upper Niagara River, coastal lagoon wetlands typified by those associated with Woodtick Peninsula and Presque Isle spits, diked wetlands of the Ohio and Michigan shores of the western basin and the upper reaches of Sandusky Bay, and estuarine wetlands which are prominent in the lower courses of several tributaries such as the Maumee River, Old Woman Creek, Mentor Marsh, and Arcola Creek (Herdendorf et al. 1981). Coastal wetlands can vary from a few acre plot in sheltered backwater areas within harbors to over 30 km^2 for the St. Clair River delta (Herdendorf et al. 1986). Landside access to coastal wetlands is normally good for inshore portions, however, offshore growths can be difficult to reach

because of the lack of suitable foundation for the movement of heavy equipment.

Predicted Oil Impact

a. Oil in heavy accumulations may persist for decades
b. Small quantities of oil will be deposited primarily along the other wetland fringe or along the upper wrack (debris) swash line
c. Resident biota, including bird life, are likely to be oiled and possibly killed

Recommended Response Activity

a. Under light oiling, the best practice is to let the wetland recover naturally
b. During winter months, surface ice commonly offers shoreline protection
c. Cutting of oiled grasses and low-pressure water spraying are effective, especially during the early part of the spring growing season
d. Heavy oil accumulations on the wetland surface should be removed manually; access across the wetland should be greatly restricted
e. Cleanup activities should be carefully supervised to avoid excessive damage to the area.

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APPENDIX A

EXCERPTS FROM:

"Sensitivity of Coastal Environments and Wildlife to Spilled Oil

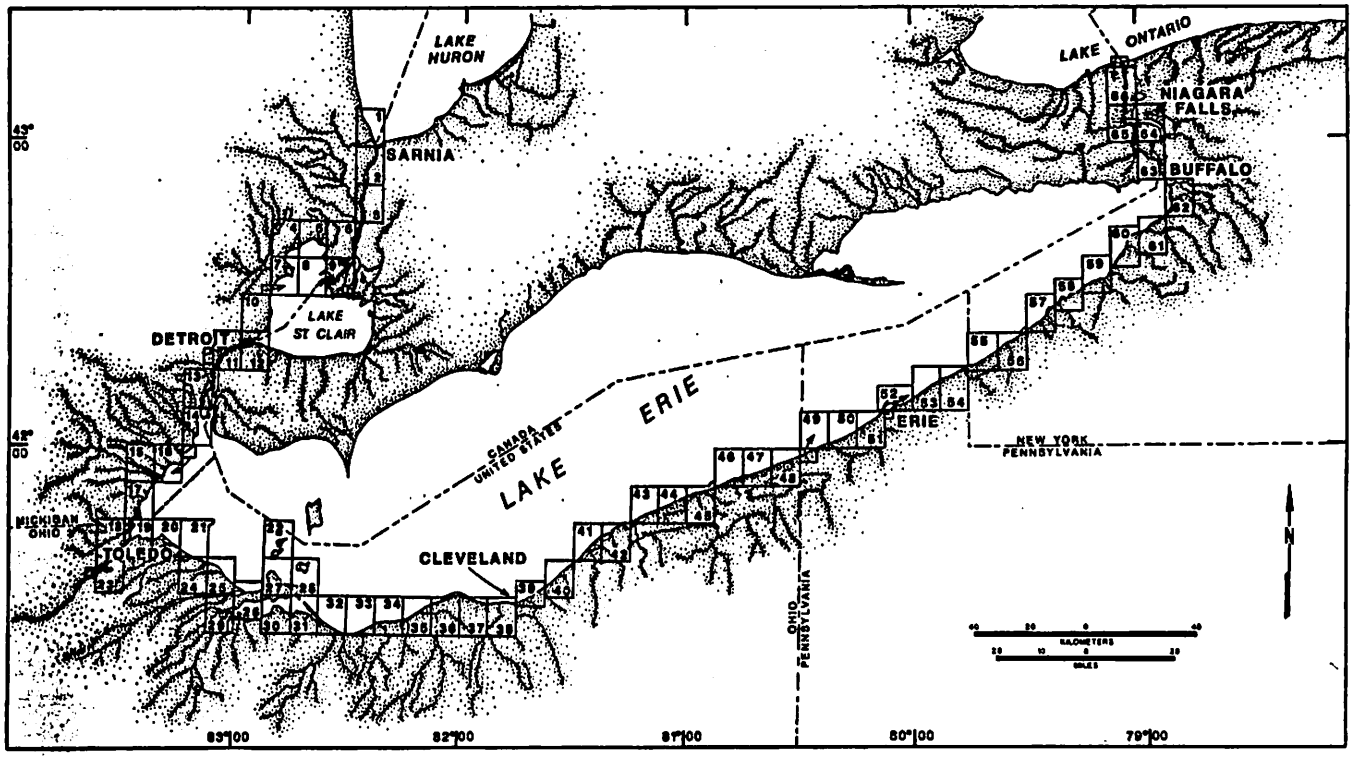
LAKE ERIE SYSTEM

An Atlas Of Coastal Resources"

SENSITIVITY OF COASTAL ENVIRONMENTS AND WILDLIFE TO SPILLED OIL

LAKE ERIE SYSTEM

AN ATLAS OF COASTAL RESOURCES



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1985

ENVIRONMENTAL SENSITIVITY INDEX—LAKE ERIE SYSTEM

SHORELINE TYPES

The shoreline of the Lake Erie system was classified during low-altitude, fixed-wing aerial surveys and ground station surveys. The list below, presented in order of increasing sensitivity to spilled oil, provides a summary of all shoreline types common to the Great Lakes region. All shoreline types are found within the study area. Wetland environments (ESI=10) are the most sensitive and deserve priority protection.

Sensitivity ↓

- 1. Exposed bedrock bluffs
- 2. Exposed unconsolidated sediment bluffs
- 3. Shelving bedrock shores
- 4. Sand beaches
- 5. Mixed sand and gravel beaches
- 6. Gravel beaches
- 7. Riprap and harbor structures
- 8. Sheltered bluffs
- 9. Low banks
- 10. Coastal wetlands

(Unranked) Man-made structures

BIOLOGICAL RESOURCES

The biological resources found within the Lake Erie system are compiled from the literature and from direct contact with scientists knowledgeable about local species occurrence. Areas having resources should receive consideration when planning all spill-response activities. The symbols to indicate these resources are given below.

MAMMALS
- Coastal species

BIRDS
- Shorebirds
- Wading birds
- Diving birds
- Waterfowl
- Raptors
- Gulls

FISHES
- Salmonids
- Other gamefish

KEY TO SPECIES

BIRDS

4.	Great blue heron	*Ardea herodias*
5.	Green heron	*Butorides striatus*
6.	Virginia rail	*Rallus limicola*
7.	Sora rail	*Porzana caroline*
9.	Black-crowned night heron	*Nycticorax nycticorax*
10.	American bittern	*Botaurus lentiginosus*
11.	Belted kingfisher	*Megaceryle alcyon*
12.	Black tern	*Chlidonias niger*
17.	Canada goose	*Branta canadensis*
18.	Mallard	*Anas platyrhynchos*
19.	Black duck	*Anas rubripes*
20.	Green-winged teal	*Anas crecca*
24.	Redhead	*Aythya americana*
25.	Greater scaup	*Aythya marila*
26.	Common goldeneye	*Bucephala clangula*
27.	Bufflehead	*Bucephala albeola*
30.	Marsh hawk	*Circus cyaneus*
32.	Peregrine falcon	*Falco peregrinus*
40.	American coot	*Fulica americana*
41.	Pied-billed grebe	*Podilymbus podiceps*
43.	Whistling swan	*Olor columbianus*
45.	Lesser scaup	*Aythya affinis*
50.	Great egret	*Casmerodius albus*
54.	Yellow rail	*Coturnicops noveboracensis*
55.	Killdeer	*Charadrius vociferus*
56.	Spotted sandpiper	*Actitis macularia*
57.	Greater yellowlegs	*Tringa melanoleuca*
58.	Lesser yellowlegs	*Tringa flavipes*
61.	Dunlin	*Calidris alpina*
65.	Semipalmated sandpiper	*Calidris pusilla*
66.	Herring gull	*Larus argentatus*
67.	Ring-billed gull	*Larus delawerensis*
68	Common tern	*Sterna hirundo*
71.	Least bittern	*Ixobrychus exilis*
72.	Bonapartes gull	*Larus philadelphia*
74.	Southern bald eagle	*Haliaeetus leucocephalus*
75.	Forsters tern	*Sterna fosteri*
76.	King rail	*Rallus elegans*
82.	Upland sandpiper	*Bartramia longicauda*

FISH

1.	Alewife	*Alosa pseudoharengus*
2.	Rainbow smelt	*Osmerus mordax*
6.	Brown trout	*Salmo trutta*
9.	Chinook salmon	*Oncorhynchus tshawytscha*
10.	Coho salmon	*Oncorhynchus kisutch*
13.	Northern pike	*Esox lucius*
14.	Bluegill	*Lepomis macrochirus*
15.	White crappie	*Pomoxis annularis*
16	Black crappie	*Pomoxis nigromaculatus*
17.	Yellow perch	*Perca flavescens*
18.	Largemouth bass	*Micropterus salmoides*
19.	Smallmouth bass	*Micropterus dolomieui*
20.	Rock bass	*Ambloplites rupestris*
21.	Pumpkinseed	*Lepomis gibbosus*
22.	Walleye	*Stizostedion vitreum vitreum*
23.	White bass	*Morone chrysops*
26.	Channel catfish	*Ictalurus punctatus*
27.	Carp	*Cyprinus carpio*
28.	Gizzard shad	*Dorosoma cepedianum*
29.	Cisco	*Coregonus artedii*
30.	Brook trout	*Salvelinus fontinalis*
33.	Fathead minnow	*Pimephales promelas*
34.	Banded killifish	*Fundulus diaphanus*
35.	Shorthead redhorse	*Moxostoma macrolepidotum*
37.	White sucker	*Catostomus commersoni*
39.	Brown bullhead	*Ictalurus nebulosus*
40.	Green sunfish	*Lepomis cyanellus*
41.	Grass pickeral	*Esox americanus vermiculatus*
42.	Sauger	*Stizostedion canadense*
45.	Freshwater drum	*Aplodinotus grunniens*
46.	Lake sturgeon	*Acipenser fulvescens*

MAMMALS

3.	Muskrat	*Ondatra zibethicus*

SOCIOECONOMIC FEATURES

The following information is provided to highlight those areas having socio-economic importance in order to assist or direct the spill-response effort.

- Preserves and wildlife refuges
- Parks
- Recreational beaches
- Power plants
- Water intakes
- Marinas
- Submerged vegetation

PARKS AND PRESERVES

1. Sterling State Park
2. South Bass Island State Park
3. Crane Creek State Park
4. East Harbor State Park
5. Kelley's Island State Park
6. Headlands Beach State Park
7. Geneva State Park
8. Presque Isle State Park
9. Evangola State Park
10. Beaver Island State Park
11. Buckhorn Island State Park
12. Joseph Davis State Park
13. Point Mouillee State Game Area
14. Erie State Game Area
15. American Lotust Plant Preserve

SPILL-RESPONSE INFORMATION

The symbols below are used to indicate primary locations for the positioning of booms and open-water skimmers. Boat ramps to enable equipment access to the river are also indicated.

- Boat Ramps
- Hoists
- Airports

Description of Shoreline Types

EXPOSED BEDROCK BLUFFS — ESI=1

- Exposed bedrock bluffs are fairly common along the shoreline and vary from 10 to 200 feet in height
- These exposed rocky bluffs experience waves and strong currents
- Landside access to the base of these bluffs is difficult at most locations

Predicted Oil Impact

a. An oil band will form at the rocky-shore/water interface, and if conditions are favorable, the entire lower portion of the bluff may be oiled

b. The persistence of oil would vary to the incoming wave energy; oil persistence would be short-lived during high-wave conditions

c. Birds that use the lower portion of the bluffs may be killed if oiled

Recommended Response Activity

a. Cleanup will be a low priority on most shorelines

b. Cleanup is very difficult because of poor access

c. If cleanup is warranted, the use of high-pressure water spraying is effective if the oil is still fresh

EXPOSED UNCONSOLIDATED SEDIMENT BLUFFS — ESI=2

- The shoreline of the central basin from Cleveland to Erie is dominated by this shoreline type
- These bluffs are vertical to steeply sloping and composed of unconsolidated material 10 to 150 feet high (glacial or lacustrine)
- Beaches in front of the bluffs are narrow or absent
- Biological activity is low

Predicted Oil Impact

a. Incoming oil will form a band along the swash line

b. Oil persistence will be limited to days or weeks, because of wave activity

Recommended Response Activity

a. In most cases, cleanup is not necessary because of the short residence time of the oil

b. Oil can usually be scraped off the surface of the sediment using manual labor

c. Removal of sediment should be avoided

d. The mechanical cleanup of the oil may be very difficult because of the steep slopes of the bluffs

SHELVING BEDROCK SHORES — ESI=3

- Shelving bedrock shores are scattered throughout the area
- They are gently sloping bedrock surfaces composed of carbonates or shale that extend to heights of up to 10 feet above normal lake level
- The shelving bedrock shore ranges from less than 10 feet to over 100 feet

Predicted Oil Impact

a. Incoming oil will form a band along the swash line

b. The oil persistence is limited to days or weeks varying with the shore's exposure to wave action

Recommended Response Activity

a. In most wave-exposed areas, cleanup is not necessary

b. Other areas, having lower energy and high recreational use, may be cleaned effectively using high-pressure water spraying if oil is still fresh

SAND BEACHES — ESI=4

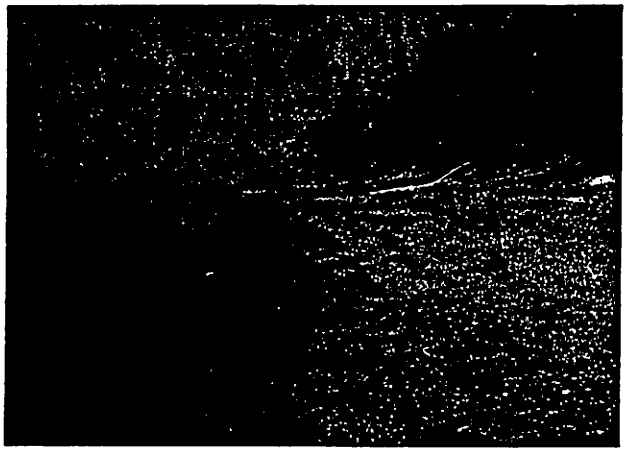
- Sand beaches are widespread throughout the area, often occurring in the vicinity of small delta and spits
- Sediments range from very fine- to coarse-grained sand with narrow to moderate width beaches (50-100 feet)
- Birds such as plovers, sandpipers, and gulls are common along the beaches

Predicted Oil Impact

- Commonly, oil will be deposited on and become mixed into the sand along the swash line
- Oil may become deeply buried into the beach sands; up to 12 inches in coarser-grained beaches
- Organisms resident in the beach are likely to be killed under moderate oil concentrations

Recommended Response Activity

- Cleanup may be difficult because of relatively soft sediments
- Cleanup should concentrate on oil removal from the upper swash zone
- Sand removal should be minimal to avoid erosion problems
- Activity through the oiled sand should be limited to prevent grinding oil deeper into the beach sediments
- Use of heavy equipment for oil/sand removal may result in the removal of excessive amounts of sand; manual cleanup may be more efficient



MIXED SAND AND GRAVEL BEACHES — ESI=5

- These beaches are not widespread but often occur in high wave-energy settings
- Generally, beach access is good
- Beach slopes are greater than the sand beaches but less than gravel beaches

Predicted Oil Impact

- Oil will be deposited along the swash zone
- Oil may spread across the entire beach face under very heavy accumulations
- The percolation of oil into the beach may be deep in well-sorted sediments
- Biota present may be killed by the oil, either by smothering or by lethal concentration in the water column

Recommended Response Activity

- Remove oil primarily from the upper swash lines
- Removal of sediments should be kept to a minimum
- Mechanical reworking of the sediment into the wave zone and/or high-pressure water spraying can effectively remove the oil; sorbent boom may be necessary to capture oil outflow

GRAVEL BEACHES — ESI=6

- Gravel beaches are not common within the study site
- These beaches are composed of pebbles and boulders with narrow beaches (< 50 feet) and are usually associated with bedrock exposures
- Beach access is highly variable

Predicted Oil Impact

- The primary problem with oil pollution in this environment is related to the deep penetration of oil into the gravel beach
- If oil is left uncleaned, it may become asphalt-like
- Resident fauna and flora may be killed by the oil

Recommended Response Activity

- Removal of sediment should be restricted
- The use of high-pressure water spraying may be effective at removing oil while it is still fresh
- Sorbent booms or pads should be used to capture oil outflowing during the cleaning process

RIPRAP AND HARBOR STRUCTURES — ESI=7

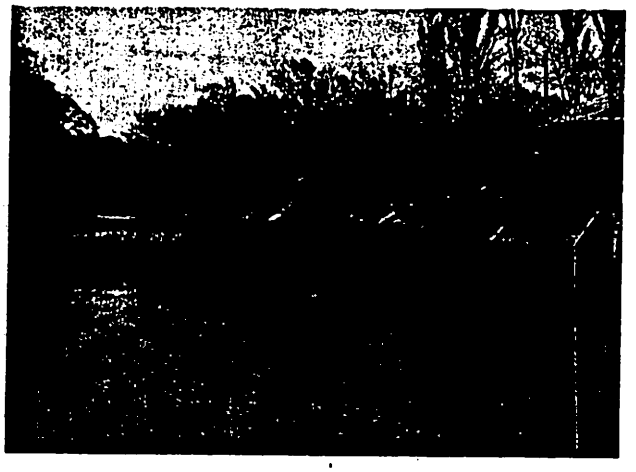
- Riprap and harbor structures are scattered throughout the area but common on the St. Clair, Detroit, and Niagara Rivers
- The bluff areas between Cleveland and Erie are covered by riprap (cobble- to boulder-sized material)
- A variety of material is used including steel sheet piles, concrete, wood, and old tires
- Biota along the upper structure are sparse, although gulls may be common
- Some fish, including yellow perch, darters, and sculpins, occupy portions of riprap structures
- Riprap is an important substrate for fish-food organisms and for the spawning of several species of fish

Predicted Oil Impact

- Oil would percolate easily between the gravel and boulders of riprap structures
- Biota would be damaged or killed under heavy accumulations
- Sheltered areas along harbor structures would enhance oil accumulation

Recommended Response Activity

- Along exposed structures, cleanup may not be necessary
- Since riprap is often associated with developed, recreational beaches, cleanup would be advisable; sorbent materials should be used to capture the oil as it is cleaned
- Structures may require high-pressure spraying:
  - To remove oil
  - To prepare substrate for recolonization of ~~barnacles and oyster~~ benthic communities
  - For aesthetic reasons



SHELTERED BLUFFS — ESI=8

- Sheltered bluffs are found most often associated with rivers or bays in the Lake Erie system
- The bluffs range in height from 5 to 150 feet and are composed of mixed bedrock and unconsolidated deposits
- Narrow sand and/or gravel beaches and wetlands are often associated with the edges of these bluffs
- Beach access is normally good except in lesser developed areas

Predicted Oil Impact

- Incoming oil will form a band along the swash line
- Oil sediment interactions will vary with bluff composition with possible burial in sand and percolation down in the gravel
- Biota present may be killed by the oil, either by smothering or by lethal concentrations in the water column

Recommended Response Activity

- Removal of sediment should be limited
- Cleanup should concentrate on oil removal from the upper swash zone
- Since beach sediments are highly variable, refer to specific sediment beach type (ESI number) for more detailed response activity

LOW BANKS — ESI=9

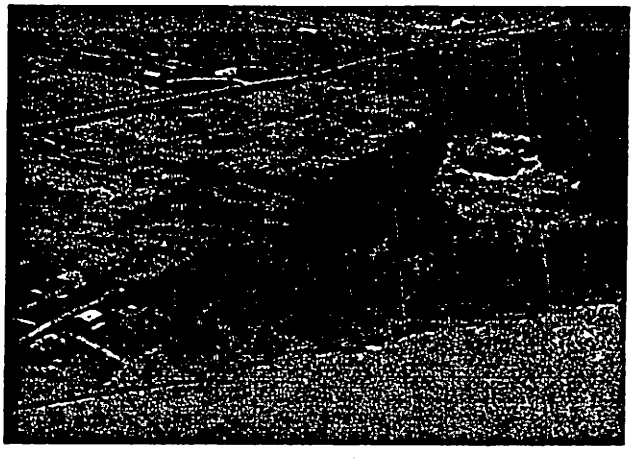
- Low banks are common on the western and eastern extremities of the lake and the lower reaches of tributaries
- These banks are less than 5 feet high and composed of unconsolidated sediments; glacial till, lacustrine, or stream deposits
- Land access is normally good
- Shore erosion can be extreme during high-water storms

Predicted Oil Impact

- During low lake levels, oil will coat only the edge of the bank or the narrow beach at the toe of the bank
- During high lake levels, oil can overtop the bank and cover the grasses or trees on the bank
- Oil may kill the grasses and other vegetation present
- Trees may become oiled but probably will not be killed unless oil concentrations within the base sediments are very high

Recommended Response Activity

- Where possible, these areas should be boomed to prevent oil from entering
- Raking oiled grasses may effectively remove light-to-moderate oil accumulations
- High- and low-pressure spraying, with cutting only if necessary, will aid oil removal from exposed tree roots
- Sorbent booms should be placed on the waterside of the cleanup operation to collect outflowing oil



COASTAL WETLANDS ESI=10

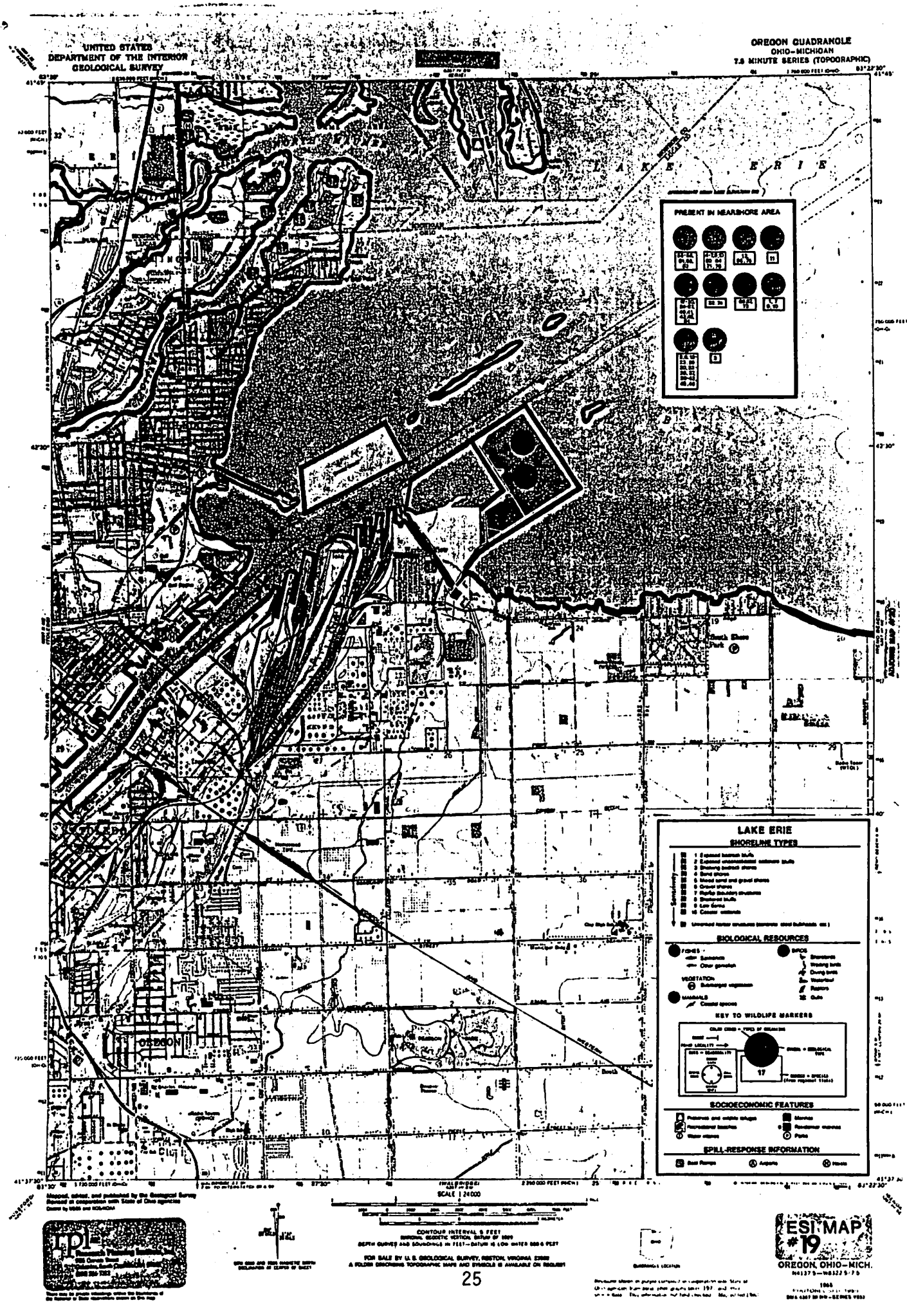
- Wetlands are most commonly associated with river mouths (St. Clair River, delta) and fringing wetlands in sheltered settings like tributary heads; Mentor Marsh and Arcola Creek
- Sheltered embayments or lagoonal wetlands such as Woodtick Peninsula and Presque Isle contain broad wetlands
- Wetlands are relatively sheltered from wave action
- Commonly composed of emergent to floating aquatic vegetation
- Wetlands are the most important wildlife habitat in the area, providing a nesting area for ducks, geese, herons, rails, kingfishers, some shorebirds, muskrats, and turtles; as well as a major nursery and spawning ground for many species of sport and forage fish

Predicted Oil Impact

- Oil in heavy accumulations may persist for decades
- Small quantities of oil will be deposited primarily along the other wetland fringe or along the upper wrack (debris) swash line
- Resident biota, including bird life, are likely to be oiled and possibly killed

Recommended Response Activity

- Under light oiling, the best practice is to let the wetland recover naturally
- During winter months, surface ice commonly offers shoreline protection
- Cutting of oiled grasses and low-pressure water spraying are effective, especially during the early part of the spring growing season
- Heavy oil accumulations on the wetland surface should be removed manually; access across the wetland should be greatly restricted
- Cleanup activities should be carefully supervised to avoid excessive damage to the area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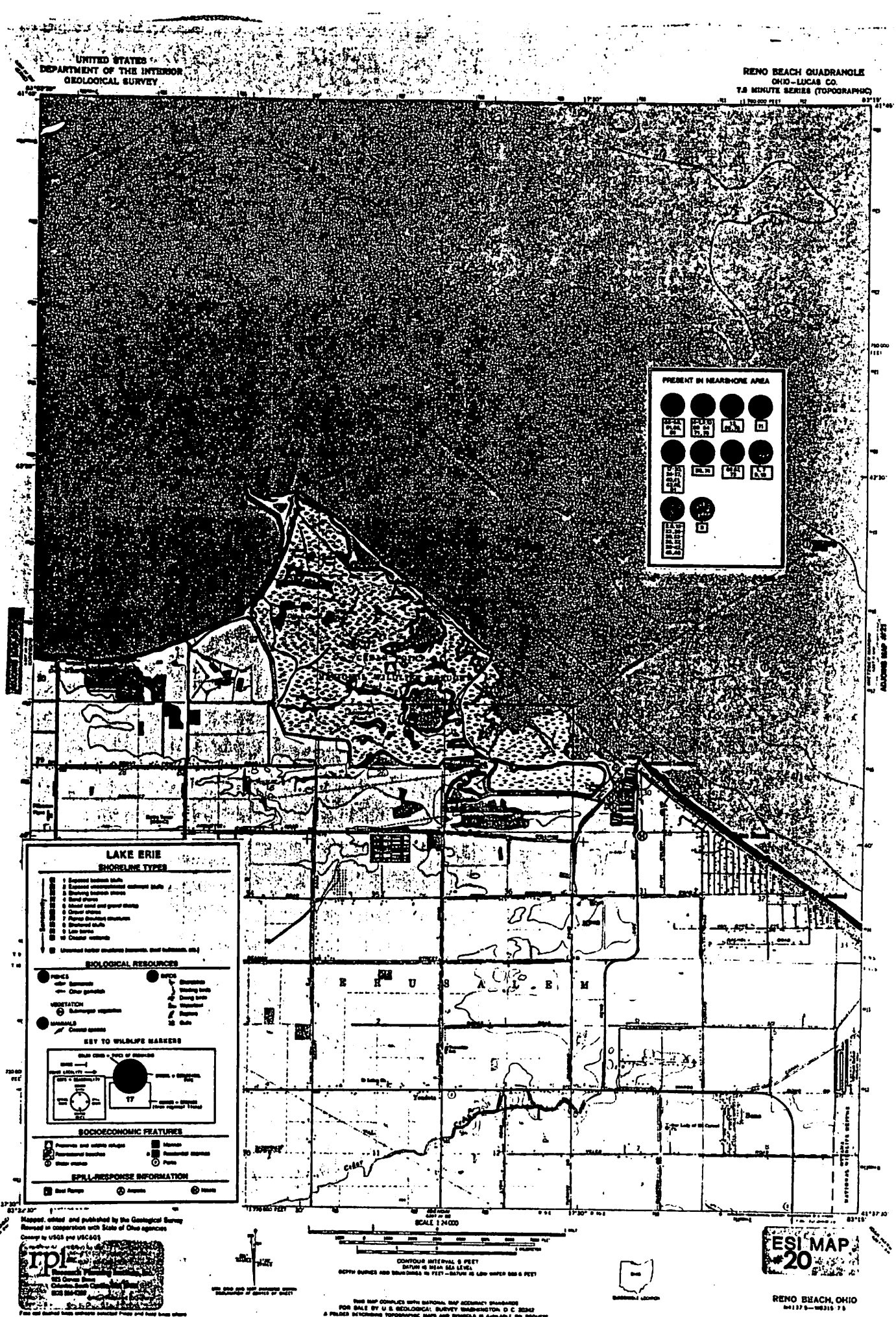
OREGON, OHIO–MICH.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ESI MAP #20
RENO BEACH, OHIO

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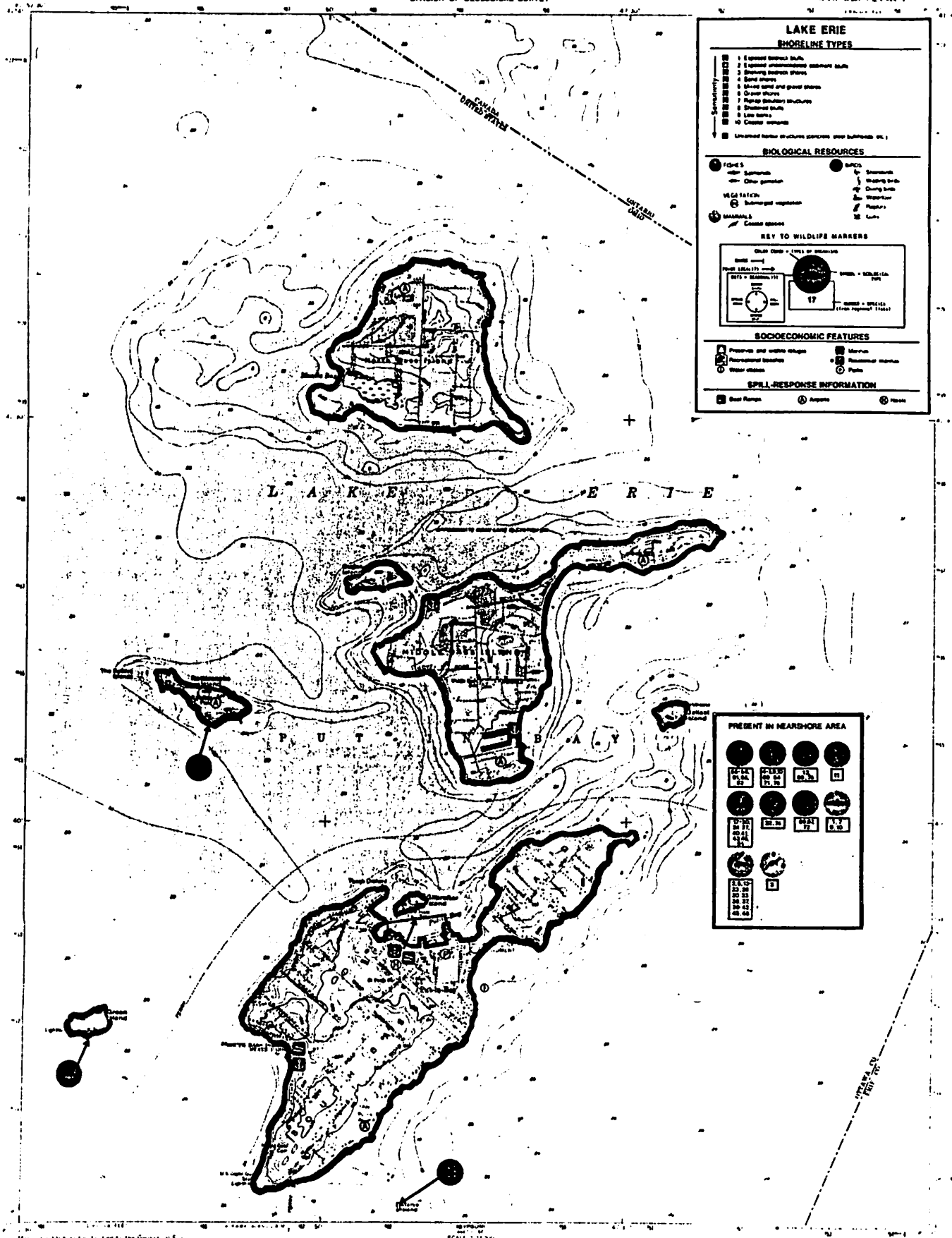

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#22

PUT-IN-BAY, OHIO

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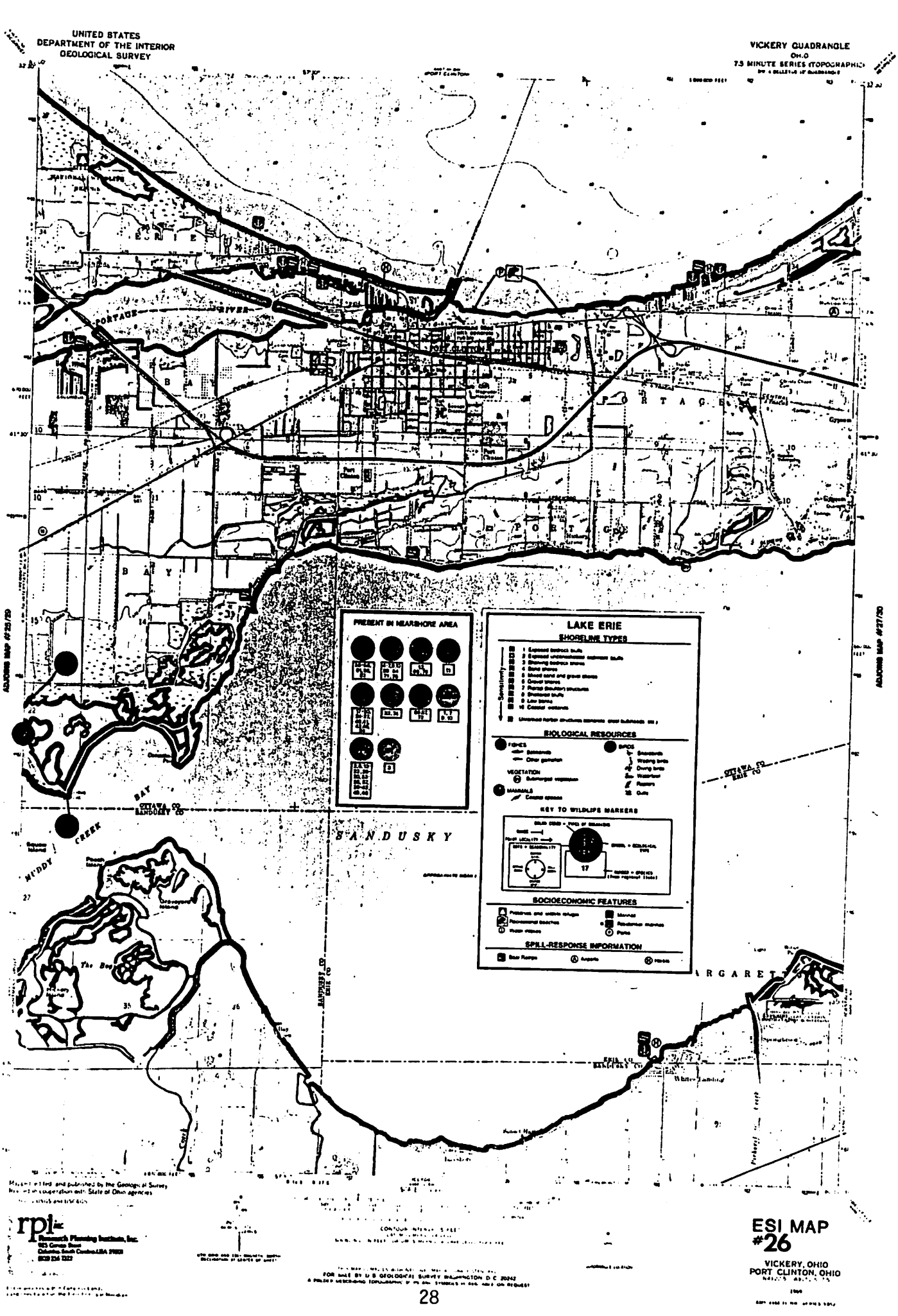
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VICKERY QUADRANGLE
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PORTAGE RIVER
PRESENT IN NEARSHORE AREA
LAKE ERIE
SHORELINE TYPES
BIOLOGICAL RESOURCES
KEY TO WILDLIFE MARKERS
SOCIOECONOMIC FEATURES
SPILL-RESPONSE INFORMATION
SANDUSKY BAY
MUDDY CREEK
ADJOINS MAP #25/30
ADJOINS MAP #27/30
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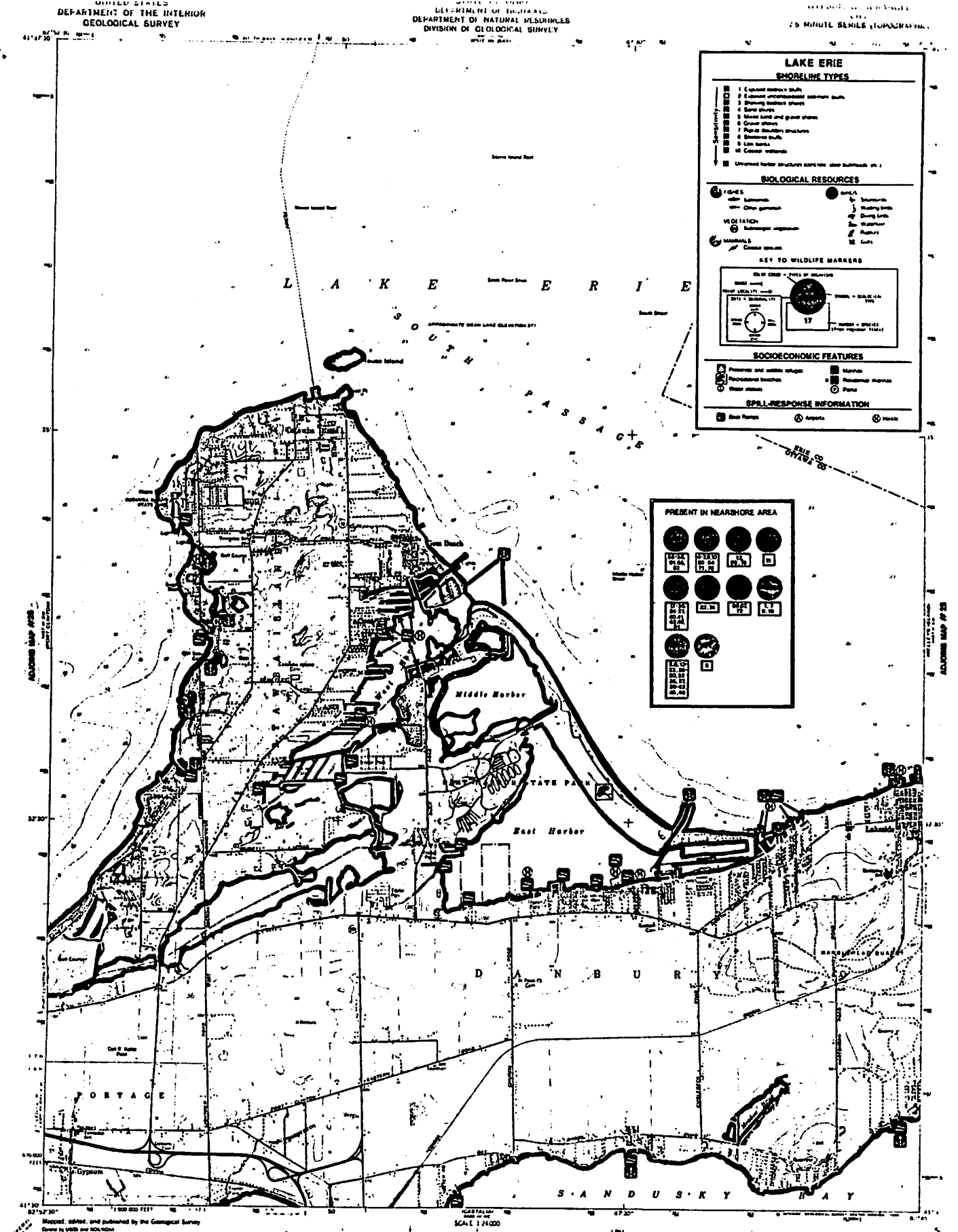
ESI MAP
#26
VICKERY, OHIO
PORT CLINTON, OHIO



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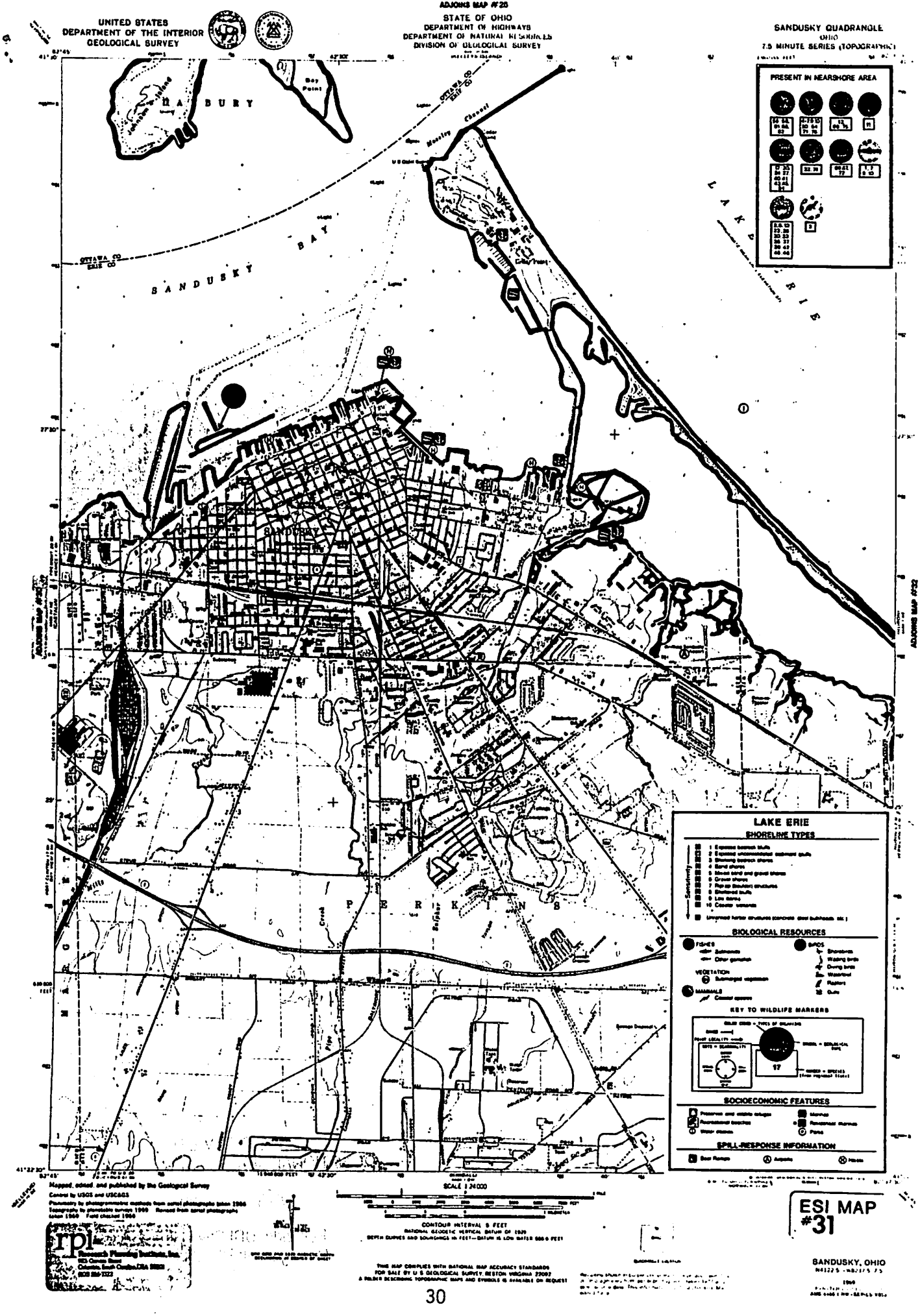
ESI MAP #27

GYPSUM, OHIO

1979


ADJOINS MAP #25
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SPILL-RESPONSE INFORMATION
ADJOINS MAP #32
SCALE 1:24000
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ESI MAP #31
SANDUSKY, OHIO
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