2.10 COASTAL EROSION

Coastal erosion is defined as the gradual wearing away of the earth's surface by the natural forces of wind and water. The constant action of wind, waves, and ice flow has affected the coastline of Lake Erie[1]. Primarily, it is the waves and gravity that cause erosion. Waves undercut the land along the shore and gravity causes the land to slip into the water. As material from the bluff or bank slides into the lake, it too is eroded by waves. As this process continues, the shore moves farther landward[2]. Many natural factors affect erosion of the lakeshore, including shore and nearshore geology, shore relief, nearshore bathymetry, beaches, shoreline orientation, lake level fluctuations (long-term, annual, and storm surges), and climate changes (storm frequency, temperature, and precipitation)[3].

Lake Erie owes its fundamental existence to the presence of a basin or lowland that originated long before the Pleistocene Ice Age began 2 million years ago. This lowland was known as the valley of an east-flowing river, known as the Erigan River. This geology in the basin included Silurian and Devonian carbonates (limestone and dolomite) on the west and by Devonian shales on the east. Glacial ice was able to erode the less resistant shales (than the more resistant carbonate rocks) to a greater extent in the central basin and eastern basins. The first of the 4 major glacial advances during the Pleistocene obliterated this drainage system and deepened and enlarged the basin. Succeeding glaciations further deepened and enlarged it. Lake Erie, the southernmost of the Great Lakes, is also the shallowest because the ice was relatively thin (therefore lacking significant erosive power) when it reached so far south[4]. During the advancement of the glaciers, they eroded rock and soil and carried them with the flowing ice to the glacier edge where they were deposited as till released from melting ice. Laminated silt and clay were also deposited in proglacial lakes that formed along the margin of the glacier. These geologic materials are exposed in Lake Erie's bluffs and banks[5]. Upon final retreat of the glacier moving out of Ohio, the water started to discharge via the Niagara River. Glacial rebound raised the Niagara outlet and increased the water level in the Lake Erie basin. Due to a rapid glacial rebound in the upper Great Lakes, these lakes began to drain through the Lake Erie Basin [6]. There has been a continued slow rise following the rapid rise that has brought Lake Erie to its current mean level of 571 feet above sea level.

The geologic settings vary throughout the length of Ohio's coast. From the Ohio-Pennsylvania border to Huron, Ohio, moderate to high relief shore consists of bluffs and slopes composed of glaciolacustrine sands, silts, clay, till, and/or shale. From Huron around Sandusky Bay to Marblehead peninsula, the shore is

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[1] Lake Erie Coastal Erosion Areas, included with 1998 CEA Designation packet
[2] Questions and Answers Regarding Ohio's Coastal Erosion Areas
[3] Updating Lake Erie Coastal Erosion Area Maps, Donald E. Guy, Jr., July 2005
[4] The History of Lake Erie by Michael C. Hansen
[5] Erosion of Coastal Bluffs in the Great Lakes, Mickelson, Edil, and Guy, USGS Professional Paper 1693
[6] The History of Lake Erie by Michael C. Hansen

a low-relief plain composed of glaciolacustrine sediments and till, with shale exposed west of Huron and limestone exposed around Marblehead peninsula. At Sandusky Bay, two barrier beach complexes extend across the bay mouth. Around Marblehead Peninsula and Catawba Island, low to moderate banks/bluffs are composed of rock and till. West of Catawba Island, the landscape consists of low-relief lake plain and coastal wetlands (remnants of the Black Swamp). Nearshore slopes are generally gentle and are composed of the same materials in bluff or bank. Beaches are typically narrow (<50 feet per 15 meters wide) to non-existent along much of the shore. Man-made features have affected the longshore transport of sand trapping sand on the updrift side at harbor jetties, power plant intakes, and long groins. Shore parallel structures have altered sand transport as well[7].

Climate affects overall physical setting in the nearshore, beach, and shore zones. Long-term and annual fluctuations in lake level are due to changes in the volume of the lake resulting from changes in precipitation in the Great Lakes Basin. Short-term fluctuations are due to wind-driven storm surges, changes in barometric pressure, or inertial surges of water (seiches) that occur after lake level has been set up by either of the two previous agents. The greatest storm surges occur when the wind blows parallel to the long axis of the lake. Under extreme conditions, lake level at the confined ends of the lake may rise or fall more than six feet from pre-storm levels. Passage of storm systems through the Great Lakes can cause lake levels at the ends of the lake to fluctuate 10 to 11 feet over a period of several days. The most important storm surges along the western part of the Central Basin and all of the Western Basin are those generated by northeast winds because these storm surges are accompanied by large storm waves[8].

The size of wind-generated waves depends upon wind speed and duration, open-water fetch distance, and water depth. The largest waves affecting the Ohio lakeshore are those generated by storm winds from the west through the northeast. Wave energy is highest from late fall through spring; however, lake level is at its lowest and shorefast ice typically forms a barrier between the waves and erodible shore material. Most wave erosion occurs during storms in early spring when the greatest amount of wave energy is expended on the shore. The largest waves to strike the shore are generated by onshore storms winds from the west to the northeast[9]. Wave erosion causes undercutting of the bluff or bank, mass wasting including block falls, rotational slumps, and debris flows, and lakebed downcutting of cohesive materials. Bedrock is not as easily eroded as the cohesive glacial sediments.

[7] Geologic Setting and Processes Along Lake Erie From Fairport Harbor to Marblehead, Ohio, D. Guy and L. Moore, 2006

[8] Geologic Setting and Processes Along Lake Erie From Fairport Harbor to Marblehead, Ohio, D. Guy and L. Moore, 2006

[9] Geologic Setting and Processes Along Lake Erie From Fairport Harbor to Marblehead, Ohio, D. Guy and L. Moore, 2006

Although erosion of the bluff is necessary to sustain beaches, excessive erosion of the Lake Erie shoreline can be considered a hazard exposure.

Risk MAP (Mapping, Assessment and Planning)

In March 2013, FEMA published a basin-wide Discovery Report of Lake Erie as part of a Great Lakes Coastal Flood Study. This report was the result of several stakeholder meetings that involved three states (Ohio, Michigan and Pennsylvania), eleven counties (eight in Ohio) and numerous jurisdictions (44 in Ohio) that have Lake Erie shores. The Lake Erie stakeholder group includes representatives from FEMA, other Federal agencies, State agencies, local government, and several other technical focus groups.

The Lake Erie Discovery Report provides users with a comprehensive understanding of historical flood risk, existing coastal data, and current flood mitigation activities within the Lake Erie basin. The report also summarizes FEMA's intent to proceed with a coastal flood hazard study under FEMA's Risk Mapping, Assessment, and Planning (Risk MAP) program and the Great Lakes Coastal Flood Study (GLCFS) project.

Data collection efforts in the Discovery phase include base map data, coastal data, historic flood data, risk assessment, flood mitigation information, community plans, projects along the shoreline, and other comments based on local knowledge of flood risk. Additionally, certain useful datasets are being developed for use in this study. These datasets include oblique imagery, topography and bathymetry data, a shoreline feature dataset to classify shoreline characteristics, a draft transect layout, and a storm surge and wave study, all of which will feed into the coastal flood hazard analysis for Lake Erie.

In addition to identifying and assessing flood risk along the Great Lakes, the GLCFS project will provide communities with tools and information that encourage identification and implementation of mitigation actions to reduce risk. Mitigation is a critical foundation on which to reduce loss of life and property by avoiding or reducing the impact of hazard events, and it is an essential part of this coastal flood study process.

As part of the Discovery process, local Hazard Mitigation Plans were reviewed to better understand existing flood risk within the Lake Erie communities, as well as the strategies and actions that have already been developed as part of the local planning processes to mitigate that risk. By first obtaining a better understanding of existing local risk and mitigation actions during this Discovery phase, FEMA intends to begin working with communities to identify new mitigation actions and strengthen existing actions throughout the coastal flood study.

RISK ASSESSMENT

Location

Lake Erie comprises 312 miles of the northern coast of Ohio bordering Lucas, Ottawa, Sandusky (Sandusky Bay), Erie, Lorain, Cuyahoga, Lake, and Ashtabula Counties. Lake Erie, the 12th largest (area) lake in the world, is about 210 miles long, 57 miles wide, and has a shoreline length of 871 miles (including the islands). With the exclusion of government-owned park and reserve areas, the coast is highly prized for commercial and residential development. In many cases, human activity has disrupted the natural function of beach formation and aquatic habitats. According to the Ohio Geological Survey, 95 percent of Ohio's Lake Erie shoreline is eroding.

LHMP Data

All of the LHMPs for the counties that border Lake Erie (Ashtabula, Cuyahoga, Erie, Lake, Lorain, Lucas, Ottawa, and Sandusky), indicate that coastal erosion is a recognized hazard and ranked them either fourth or fifth for their county. Almost all of the plans reference the same data (Figure 2.10.a) provided by the Ohio Geological Survey. Erie County's LHMP indicated that they had completed a structural inventory in the late 1990's; but those data were not available to them at the time of writing their plan.

Ashtabula County. The HIRA of the Ashtabula County Countywide All Natural Hazards Mitigation Plan of August 2012 describes that 28 miles of Lake Erie coastline form the northern border of the County. The HIRA also explains that factors such as high lake levels, long shore currents, high winds, water runoff over cliffs, bluff recession and seasonal fluctuations are driving forces that lead to coastal erosion. The risk is classified as a Moderate Probability and Moderate Impact. The plan's vulnerability analysis determined 2,619 structures would be affected with a loss estimate of $78,295,582.

Cuyahoga County. The Cuyahoga County Countywide All Natural Hazards Mitigation Plan of 2011 lists there are 22.4 miles of shoreline in the County. There are seven jurisdictions that share this coastline with Bay Village and Euclid having the two longest lengths of coastline. Records on coastline recess have been maintained since 1973. Within the past 24 years, it has been estimated that 4.4 acres have been lost to coastal erosion, with half in Bay Village and Euclid. The average anticipated recession distance is estimated to be over a 3.1 foot distance. However, the Maximum recession distance is anticipated to be over a 31 foot distance.

Lucas County. According to the Lucas County Countywide All Natural Hazards Mitigation Plan of March 2013, lake surges (also referred to as storm surges) are associated with extreme weather events and are responsible for coastal flooding and erosion along Lake Erie within Lucas County. The storms that generate the large waves of lake surges can develop year-round, however within Lucas County, these events have typically occurred in the early spring and late fall months. Storm surges inundate coastal floodplains by dune over-wash, the rise in water levels in inland bays and harbors, and backwater flooding through river mouths. Coastal erosion is generally associated with storm surges, windstorms, and flooding hazards, and may be exacerbated by human activities such as boat wakes, shoreline hardening, and dredging. Conversely, actions to supplement natural coastal processes, such as beach nourishment, dune stabilization, and construction of shore protection structures can greatly modify and reduce erosion trends within an area.

SHARPP. Hazard identification data were queried from SHARPP to evaluate each hazard and its frequency. Only two counties (Lake and Ashtabula) provided data for coastal erosion. This limited amount of data reflects that there are a few counties who have yet to populate their HIRA in SHARPP. Once these are populated, Ohio EMA will be better able to assess the local risks associated with this hazard. Even given limited data, coastal erosion ranked the highest for response duration, requiring between one week and one month for response. For all other factors, this hazard ranked in the lower 50 percent, which resulted in an overall ranking of eighth out of 15 hazards. These and additional HIRA data queried from SHARPP can be found in Append J.

Unlike many of the other hazards affecting Ohio, Lake Erie is consistently undergoing coastal erosion. Although particular storms or development creates periods of increased occurrence, the shore is eroding slowly every day. To easure erosion, the net landward movement of the shore over a specific time is calculated. The position of characteristic shore features such as bluff lines can be determined from maps and aerial photographs. By analyzing the position of

Table 2.10.a

Ohio Lake Erie Erosion Statistics by County

Long and Short-term Recession Data by County
Long-term: 1877 to 1973 Short-term: 1973 to 1990

County	Long-term Distance (ft.)	Long-term Rate (ft/yr)	Short-term Distance (ft.)	Short-term Rate (ft./yr.)
Ashtabula	82	0.9	28	1.6
Lake	160	1.7	32	1.9
Cuyahoga	60	0.6	8	0.4
Lorain	80	0.8	12	0.7
Erie (lake)	103	1.6	42	2.5
Ottawa (lake)	208	2.0	27	1.6
Lucas	520	5.4	46	2.7
Erie (bay)	241	2.8	32	1.9
Ottawa (bay)	61	2.0	21	1.2

Source: Ohio Division of Geological Survey http://dnr/state.oh.us/geosurvey/

these features (recession lines) through time, the amount of recession can be determined and rates of recession can be calculated. Long-term and short-term recession data have been developed for each county (see table 2.10.a).

During 1929-30, the mid-1940s, 1952, the fall of 1972, the spring of 1973, and 1985, storms and high lake levels caused property damage along the low-lying areas, such as low glacial till bluffs, low glaciolacustrine banks, and barrier beaches and eroded high glacial till or glaciolacustrine bluffs inducing mass wasting in Erie, Lake, Cuyahoga, and Ashtabula counties. The short-term and long-term rates indicate that the low-lying areas have been extremely affected.

Probability of Future Events

With shore structures increasing along the coastline, the shoreline becomes increasingly modified. Reports and studies suggest that wave erosion and mass wasting caused by Lake Erie will continue to erode the Ohio shore for the foreseeable future. Damage to the built environment is inevitable without intervention and will warrant the full understanding of coastal processes within each stretch to rehabilitate the shoreline.

VULNERABILITY ANALYSIS & LOSS ESTIMATION

Methodology

The Ohio Geological Survey continues the process of reassessing Ohio's vulnerability to coastal erosion. According to the Ohio Revised Code, coastal erosion area designation must be conducted every 10 years and parcels at risk must be listed as Coastal Erosion Areas. The initial evaluation utilized 1973 and 1990 data and the results were published in 1998. Researchers utilize aerial photography to delineate exposure based on observed shoreline characteristics.

Once the preliminary designations of the coastal erosion areas are determined with extensive quality checking and ground proofing support, GIS layers are reated and preliminary maps generated. Impacted property owners are contacted by mail of their inclusion and public meetings are held to provide an opportunity to see the risk assessment. Property owners may dispute the determination, if they believe that the shore features were not picked correctly and with proof that erosion did not occur. After all comments have been addressed, final maps are generated and final notifications are sent by mail to the coastal erosion area property owners.

Results

After examining limited data in county hazard mitigation plans and in SHARPP, the following vulnerability estimates are provided. As more of the plans are revised and assessments are updated, then more accurate vulnerability assessments can be projected.

Estimated Vulnerability Assessment		
Structure Type	**Structures at Risk**	**Damage in Dollars**
Residential	14,200	$734,378,954
Non-Residential	372	$62,836,701
Critical Facilities	43	$4,925,596
Total	14,615	$802,141,251

STATE-OWNED AND STATE-LEASED CRITICAL FACILITIES VULNERABILITY ANALYSIS & LOSS ESTIMATION

Previous versions of this plan indicated that coastal erosion had limited potential to affect any state-owned structures or critical facilities. All state facilities near the Lake Erie Coast were evaluated for their proximity to coastal erosion areas using the DAS data within a GIS. No state-owned or state-leased facilities were located in the coastal erosion areas, which represents no change since the last plan update.