CHAPTER 2

LAKE ERIE WATERSHED

The **Great Lakes**—Superior, Michigan, Huron, Erie and Ontario—are an interconnected series of lakes that make up the world's largest system of fresh water. Combined, the Great Lakes cover a total surface area of 94,250 square miles and contain roughly six quadrillion (6,000,000,000,000,000) gallons of fresh water, which is enough to submerge the entire contiguous United States in nearly ten feet of water. Twenty percent of the world's surface freshwater supply and about 95 percent of the United States' surface fresh water is contained in the Great Lakes and their connecting waterways. Only the polar ice caps and Lake Baikal in southern Siberia (Russia) hold more fresh water.

From a geologic standpoint, the Great Lakes are relatively young bodies of water on the North American continent. Formation of the Great Lakes is attributed to the movement of the massive ice sheets associated with the Wisconsinan glaciation. It is widely accepted that before the Ice Age, large river networks and valleys existed in the Great Lakes region. The southward advance of the glaciers—a process that commenced about one million years ago during the Pleistocene Epoch—drastically broadened and deepened these ancient river valleys. The Great Lakes began to take shape at the end of the last glacial period about 14,000 years ago. As the northward-trending ice sheets retreated, meltwater began to fill the expanded basins. Formation of the present-day Great Lakes was not instantaneous. Several early phases of each lake formed over the course of 12,000 years, as different drainage outlets were exposed and eventually closed off. Lakes Chicago (an early phase of Lake Michigan) and Maumee (an early phase of Lake Erie) originally drained to the south into the Mississippi River Watershed. Lake Erie was the first modern Great Lake to take its present shape about 10,000 years ago. Its drainage was ultimately directed to the Atlantic Ocean via Lake Iroquois, and later Early Lake Ontario (early phases of Lake Ontario), when the Niagara River outlet was breached.

The immense weight of the glacial ice had applied great pressure, which depressed the landscape. As a result, after the ice receded, the exposed land began to slowly rise through a process called "isostatic rebound." The post-glacial rebound process closed off drainage outlets and allowed the lakes' water levels to rise. The outflow of the upper

lakes was rerouted from a more northern passage through the present-day Ottawa River (Ontario) valley to the St. Clair and Detroit rivers to Lake Erie. Lake Ontario reached its present level about 7,000 years ago and lakes Superior, Michigan and Huron about 3,000 years ago. On Lake Erie's south shore, isostatic rebound continues at a rate of 0.2 to 0.3 feet every 100 years. See Chapter 9: Geology (page 204) for more information about the formation of Lake Erie and geologic history of Lake Erie's basin.

The Great Lakes border eight U.S. states (Minnesota, Wisconsin, Michigan, Illinois, Indiana, Ohio, Pennsylvania and New York) and the Canadian province of Ontario. Known as the United States' "fourth coast," the Great Lakes shore is more than 4,500 miles long and longer than the Atlantic coast. In total, the Great Lakes shore is about 11,000 miles long, including islands.

Lakes Superior, Michigan and Huron are known as the upper Great Lakes. **Lake Superior** is the largest of the Great Lakes by surface area (31,700 square miles) and volume (2,935 cubic miles). It is also the deepest (1,333 feet), northernmost, westernmost and coldest. **Lake Michigan**, the third largest by surface area (22,300 square miles) and second largest by volume (1,180 cubic miles), is the only Great Lake located entirely within the United States. **Lake Huron**, which includes the Georgian Bay, is the second largest of the Great Lakes by surface area (23,000 square miles) and third largest by volume (849 cubic miles). Lake Huron's shore, if considering its more than 30,000 islands, is 3,830 miles long, making it the longest shore of any lake in the world. Manitoulin Island (Canada) in northern Lake Huron is the largest freshwater island in the world (1,068 square miles).

Lakes Superior and Michigan flow into Lake Huron via the St. Marys River and Straits of Mackinac, respectively. Hydrologically, Lake Michigan and Lake Huron—separated by the five-mile-wide Straits of Mackinac—are two distinct lobes of the same waterbody and are collectively referred to as "Lake Michigan-Huron." Combined, the massive Lake Michigan-Huron makes up the largest body of fresh water in the world (45,300 square miles).

Lake Huron's primary outflow is the St. Clair River, which flows into Lake St. Clair. The St. Clair River mouth forms the largest freshwater delta in the world. The Detroit River links Lake St. Clair to Lake Erie. Approximately 80 percent of Lake Erie's water flows in from the Detroit River.

Lakes Erie and Ontario are known as the lower Great Lakes. **Lake Erie** is the second smallest Great Lake by surface area (9,910 square miles) and the smallest in terms of volume (116 cubic miles). Lake Erie contains approximately 127.7 trillion gallons of fresh water, which is three percent of the entire Great Lakes volume. Lake Erie is also the shallowest (average depth of 62 feet), southernmost and warmest of the Great Lakes. Its primary outflow is the Niagara River, which flows over Niagara Falls and through the Niagara Gorge into Lake Ontario. Lake Erie's water retention time is 2.6 years—the shortest duration of all the Great Lakes. **Lake Ontario** is the smallest of the Great Lakes

Berea Falls at Rocky River Reservation, Berea, Cuyahoga County

by surface area (7,340 square miles) and second smallest in terms of volume (393 cubic miles). It is also the easternmost lake. The St. Lawrence River flows from Lake Ontario to the Gulf of St. Lawrence and eventually into the Atlantic Ocean.

The distance between the western tip of Lake Superior at Duluth, Minnesota to the St. Lawrence River mouth at the Atlantic Ocean is nearly 2,200 miles. In that span, the Great Lakes and its connecting waterways descend about 600 feet in elevation. Lake Superior has a long-term surface level average of 601.7 feet (IGLD 1985). Lakes Michigan and Huron have long-term surface level averages of 578.8 feet (IGLD 1985). Lake Erie has a long-term surface level average of 571.3 feet (IGLD 1985). Lake Ontario has a long-term surface level average of 245.3 feet (IGLD 1985). The greatest change in elevation at one location is where the Niagara River plummets 167 feet over the Niagara Escarpment at Niagara Falls. The 744-mile St. Lawrence River gradually drops 245 feet from its source to sea level.

IGLD = *International Great Lakes Datum (an elevation positioning system specific to the Great Lakes region)*

Tuttle Creek waterfall at Columbia Park, Bay Village, Cuyahoga County

THE GREAT LAKES WATERSHED

The 295,710-square mile Great Lakes Basin consists of the Great Lakes themselves and the 201,360 square miles of surrounding lands that directly drain into them (see Great Lakes Watershed map on page 43). The greatest human population and industrial centers are concentrated around Lake Erie, Lake Ontario and southern Lake Michigan.

The Lake Superior Watershed drains 49,300 square miles of Michigan, Minnesota, Wisconsin and Ontario. It is primarily forested with little agriculture due to a cooler climate and poor soils. The basin is very rich with minerals. Iron ranges in the Lake Superior region are prevalent in Michigan, Minnesota, Wisconsin and Ontario. Extensive iron ore mining operations were once widespread. Today, taconite, silver, nickel and copper are primarily extracted from the region. Lake Superior is the least populated Great Lake watershed in the basin. Duluth's metropolitan area, which includes Superior, Wisconsin and Cloquet, Minnesota, is the largest population center on Lake Superior with approximately 280,000 people. Thunder Bay, Ontario is the most populated city on the lake with over 108,000 people*. Marquette, Michigan, the most populated city in Michigan's Upper Peninsula, has a population of 21,355†. The Nipigon River in Ontario is the largest river feeding into Lake Superior. It flows from Lake Nipigon—the largest secondary lake in the Great Lakes Watershed (1,872 square miles). The headwaters of the North River in northeastern Minnesota are considered the most distant source of the entire Great Lakes-St. Lawrence River system.

The Lake Michigan Watershed drains 45,500 square miles of Illinois, Indiana, Michigan and Wisconsin. The northern portion of the watershed is forested and sparsely populated, similar to Lake Superior's drainage basin. The Green Bay, Wisconsin metropolitan area includes Brown, Kewaunee and Oconto counties and is the most populous region in the northern part of the Lake Michigan Watershed with over 306,000 people†. In northern Michigan, Traverse City and surrounding area has a population of nearly 143,380 people†. The southern portion of Lake Michigan's watershed is among the most urbanized and populated areas in the Great Lakes region. It contains parts of the Chicago and Milwaukee metropolitan areas, which combined is home to over 11 million people. The watershed divide in Chicago was significantly altered in 1900, when the flow of the Chicago River was reversed away from its mouth at Lake Michigan to the Des Plaines River (in the adjacent Mississippi River Basin) via a 28-mile Sanitary and Ship Canal. The hydrologic change diverted industrial and commercial waste away from the lake, which was Chicago's drinking water source. The artificial linkage of major watersheds, while an engineering achievement, has opened the Great Lakes to potential waterborne invasive species, such as Asian carp.

The surrounding land comprising Lake Huron's drainage basin is the largest of all the Great Lakes, covering over 51,700 square miles. Its watershed drains portions of Michigan and Ontario. Much like the Superior and northern Michigan basins, Lake Huron's watershed is sparsely populated. The largest city on Lake Huron is Sarnia, Ontario with a population of over 72,000*, although a portion is in the Lake Erie Watershed. Bay City, which is located on Saginaw Bay, is the most populated city on the Michigan side of Lake Huron, with nearly 35,000 people†. The most populated metro area in the watershed is Flint, Michigan. It is home to over 425,000 people†. The Lake Huron shore is characterized by its shallow and sandy beaches, while the shores of Georgian Bay are rocky. Lumbering is a significant economic activity in the watershed.

The Lake Erie Watershed drains 30,140 square miles of Ohio, Indiana, Michigan, New York, Pennsylvania and Ontario. Of the five Great Lakes, Lake Erie is exposed to the greatest effects from urbanization and agriculture. The watershed is intensively farmed due to very fertile soils. The lake receives agricultural runoff from southwest Ontario and from parts of Ohio, Indiana and Michigan. The Maumee River has the largest drainage basin (6,570 square miles) of any other river system in the Great Lakes Watershed. It drains all or portions of 17 counties in Ohio, five counties in Indiana and two counties in Michigan. Other major tributaries feeding into Lake Erie include the Huron and Raisin rivers in Michigan, the Sandusky, Cuyahoga and Grand rivers in Ohio and the Grand River in Ontario. About 12 million people, or one-third of the Great Lakes Watershed total population, live in the Lake Erie Watershed. The largest metropolitan areas include Detroit, Michigan (over 4.2 million people), Cleveland, Ohio (over two million people)

	County	Land Area	Pct in LEWS
Coastal Counties	Ashtabula	702.7 sq mi	85%
	Cuyahoga	458.3 sq mi	100%
	Erie	254.5 sq mi	100%
	Lake	228.2 sq mi	100%
	Lorain	492.6 sq mi	100%
	Lucas	340.4 sq mi	100%
	Ottawa	255.1 sq mi	100%
	Sandusky	409.2 sq mi	100%
Non-Coastal Watershed Counties	Allen	405.5 sq mi	99%
	Ashland	424.4 sq mi	18%
	Auglaize	401.3 sq mi	77%
	Crawford	402.3 sq mi	77%
	Defiance	411.2 sq mi	100%
	Fulton	406.8 sq mi	100%
	Geauga	408.0 sq mi	99%
	Hancock	534.1 sq mi	100%
	Hardin	470.3 sq mi	44%
	Henry	420.1 sq mi	100%
	Huron	496.5 sq mi	100%
	Marion	403.9 sq mi	20%
	Medina	421.6 sq mi	67%
	Mercer	463.3 sq mi	42%
	Paulding	419.2 sq mi	100%
	Portage	492.4 sq mi	47%
	Putnam	484.5 sq mi	100%
	Richland	497.0 sq mi	11%
	Seneca	553.4 sq mi	100%
	Shelby	409.3 sq mi	6%
	Stark	576.2 sq mi	1%
	Summit	412.8 sq mi	62%
	Trumbull	615.8 sq mi	22%
	Van Wert	410.7 sq mi	100%
	Williams	423.5 sq mi	100%
	Wood	621.3 sq mi	100%
	Wyandot	408.0 sq mi	99%

LEWS = *Lake Erie Watershed*

and Buffalo, New York (over 1.1 million people). The basin is the second-most densely populated behind Lake Michigan's watershed.

The Lake Ontario Watershed drains 24,720 square miles of New York, Pennsylvania and Ontario. The Canadian portion of Lake Ontario's watershed is among the most urbanized and populated areas in the Great Lakes region. It contains parts the Toronto and Hamilton metropolitan areas, which combined are home to nearly seven million people. The Greater Toronto Area includes the city of Toronto and the four surrounding regional municipalities of Durham, Halton, Peel and York. It is the most populated metro area in Canada with over six million people. The U.S. shore is less urbanized. Rochester, New York is the largest American city on Lake Ontario with a population of over 201,000 people†. Syracuse, New York, located inland within the watershed, has a population of over 145,000 people†. Major tributaries include the Genesee, Oswego and Black rivers on the American side and the Trent River on the Canadian side. New York's Finger Lakes region is part of the Lake Ontario Watershed. Agricultural activity occurs in the broad plains of Ontario and along a narrow strip near the New York coast.

Additional information about Lake Erie and the Lake Erie Watershed is presented throughout this chapter.

* *Canada 2011 Census*

† *2010 U.S. Census*

Learn more about the information presented in this chapter:

Great Lakes Information Network
www.great-lakes.net/lakes/ref/lakefact.html

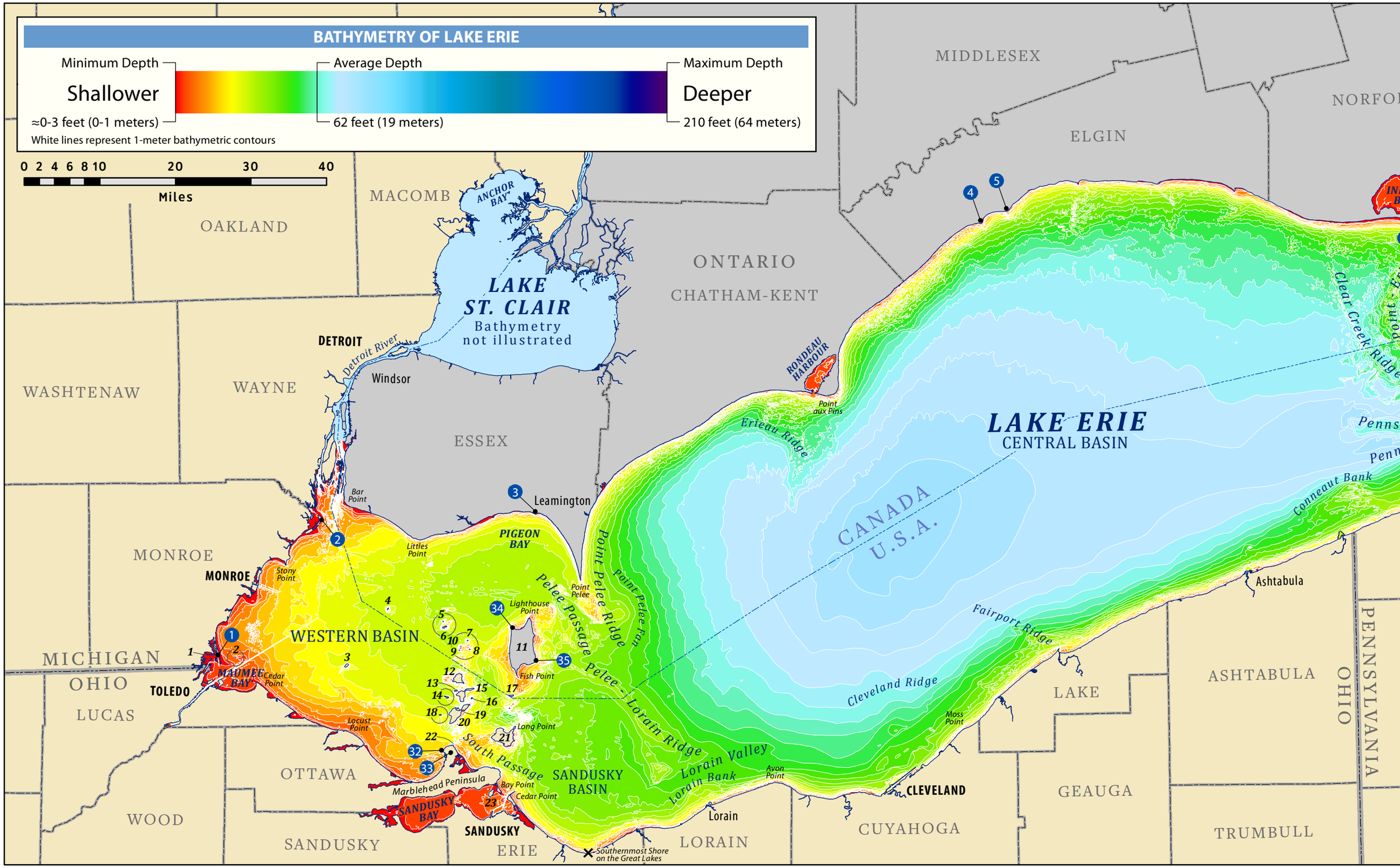
National Oceanic and Atmospheric Administration,
National Geophysical Data Center, Great Lakes Bathymetry
www.ngdc.noaa.gov/mgg/greatlakes/greatlakes.html

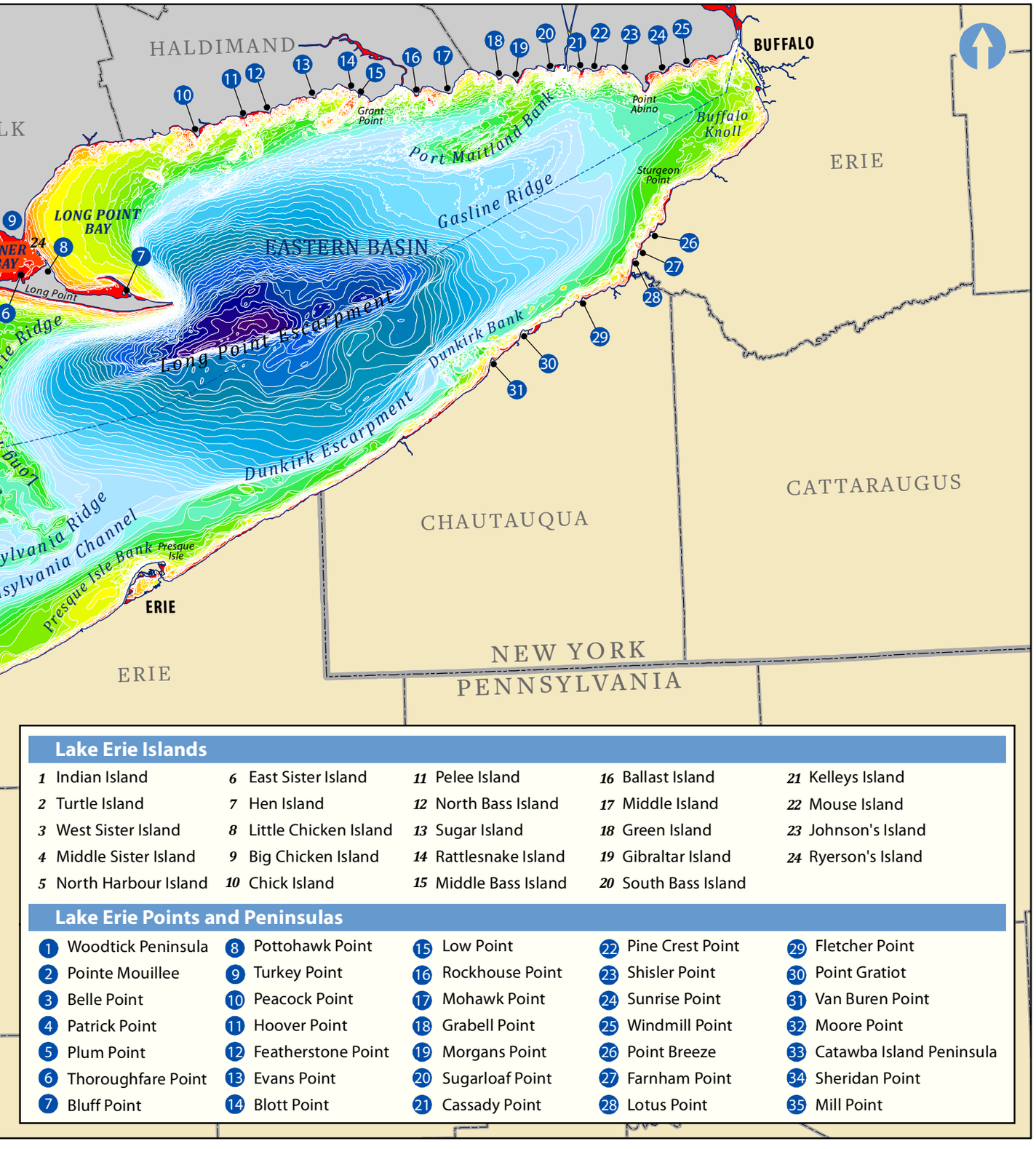
Ohio Department of Natural Resources,
Office of Coastal Management
coastal.ohiodnr.gov

A complete list of chapter sources is found in the Appendix.

Scheeff East Point Nature Preserve on South Bass Island, Ottawa County

LAKE ERIE BATHYMETRY AND LANDFORMS





Lake Erie Islands

1 Indian Island	6 East Sister Island	11 Pelee Island	16 Ballast Island	21 Kelleys Island
2 Turtle Island	7 Hen Island	12 North Bass Island	17 Middle Island	22 Mouse Island
3 West Sister Island	8 Little Chicken Island	13 Sugar Island	18 Green Island	23 Johnson's Island
4 Middle Sister Island	9 Big Chicken Island	14 Rattlesnake Island	19 Gibraltar Island	24 Ryerson's Island
5 North Harbour Island	10 Chick Island	15 Middle Bass Island	20 South Bass Island	

Lake Erie Points and Peninsulas

1 Woodtick Peninsula	8 Pottohawk Point	15 Low Point	22 Pine Crest Point	29 Fletcher Point
2 Pointe Mouillee	9 Turkey Point	16 Rockhouse Point	23 Shisler Point	30 Point Gratiot
3 Belle Point	10 Peacock Point	17 Mohawk Point	24 Sunrise Point	31 Van Buren Point
4 Patrick Point	11 Hoover Point	18 Grabell Point	25 Windmill Point	32 Moore Point
5 Plum Point	12 Featherstone Point	19 Morgans Point	26 Point Breeze	33 Catawba Island Peninsula
6 Thoroughfare Point	13 Evans Point	20 Sugarloaf Point	27 Farnham Point	34 Sheridan Point
7 Bluff Point	14 Blott Point	21 Cassady Point	28 Lotus Point	35 Mill Point

Lake Erie is the second smallest of the five Great Lakes by surface area (9,910 square miles) and the smallest in terms of volume (116 cubic miles). Lake Erie contains approximately 127.7 trillion gallons of fresh water, which is three percent of the entire Great Lakes' volume. The Lake Erie coast is 871 miles long (including natural islands) and borders Ohio, Michigan, Pennsylvania, New York, and the Canadian province of Ontario.

Lake Erie has three primary basins: Western, Central and Eastern. The Western Basin, which extends from Toledo to Sandusky, is the shallowest of the basins with an average depth of only 24 feet. The Central Basin, extending from Sandusky to Erie, Pennsylvania has an average depth of 60 feet. The Eastern Basin's average depth is 80 feet. Lake Erie's maximum depth is 210 feet in the Eastern Basin.

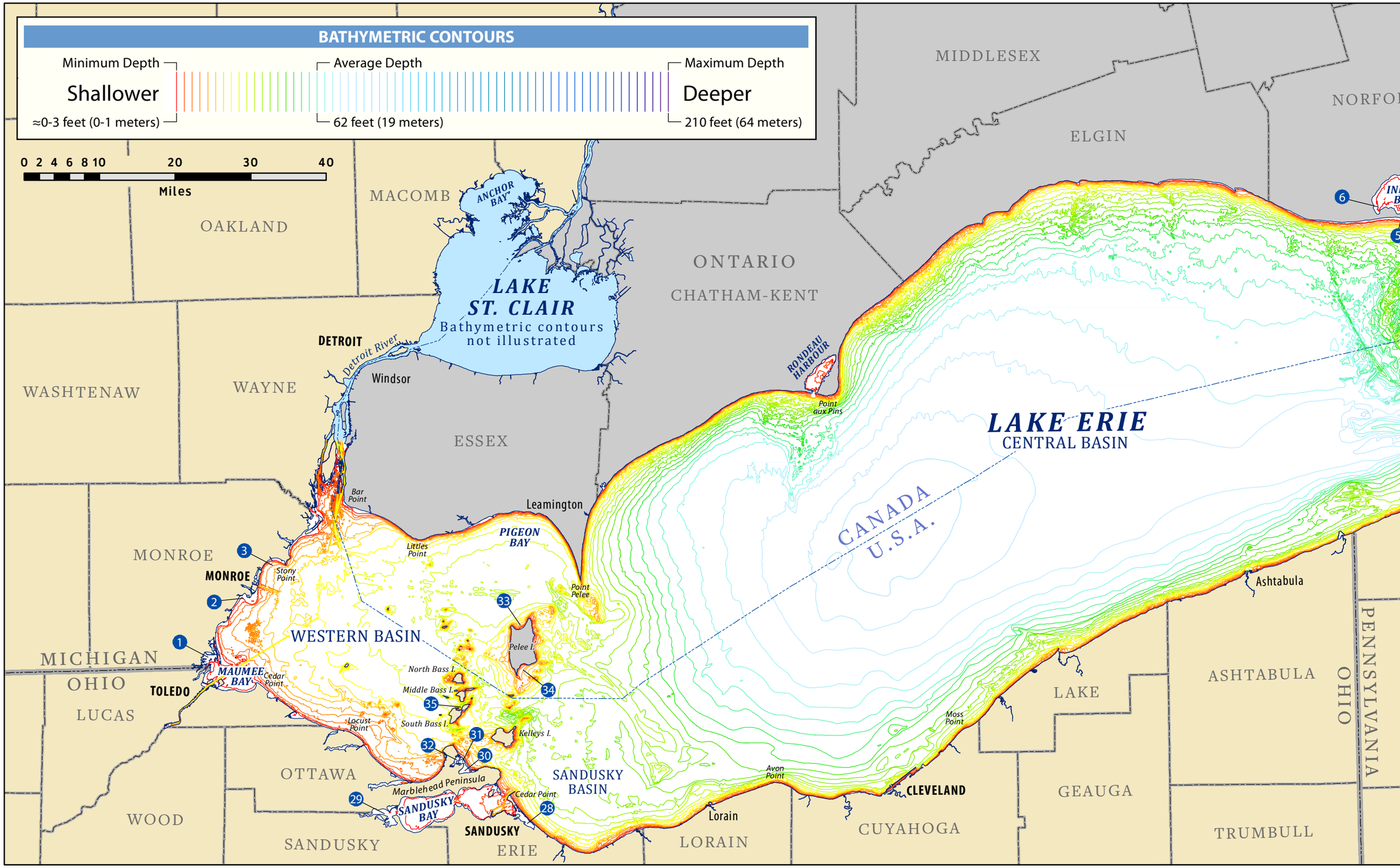
Bathymetry maps display the depths and submerged topographies of underwater terrain. Details of Lake Erie's bathymetry are illustrated in this map. Lake depths are represented using a red-to-navy color ramp; where red, orange and yellow show shallower depths and darker blues represent deeper areas. White contour lines (one-meter intervals) help further define bathymetric slopes and the steepness of submerged valleys and ridges. The closer together the contour lines are, the steeper the lakebed terrain is. This is evident with the Long Point Escarpment in the Eastern Basin, where Lake Erie's bathymetry drastically drops to its deepest point.

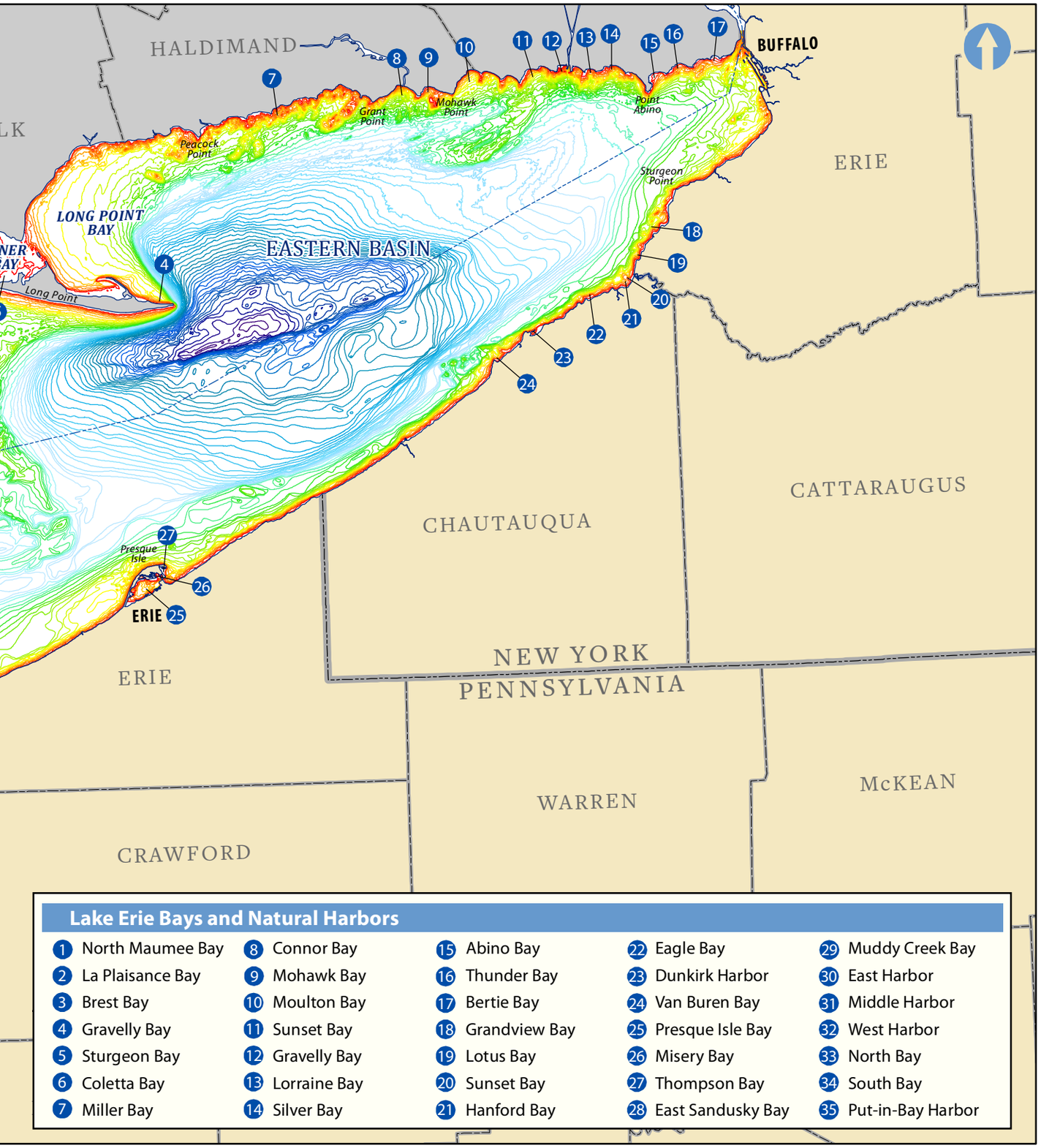
There are many notable bathymetric features in Lake Erie. The Pelee-Lorain Ridge and the Long Point-Erie Ridge are prominent submerged topographies that represent end moraines. These features likely formed during a transitory readvance of the Wisconsinan ice sheet during the last major glacial retreat. The Long Point Escarpment is an approximately 31-mile long, north-facing ridge that likely formed as the result of faulting or erosion. Several submerged promontories are located along the south shore of the Central Basin. These include, from west to east, the Lorain Bank, Cleveland Ridge, Fairport Ridge and Conneaut Bank.

The Western Basin geology is dominated by dolomite and limestone. These durable sedimentary rock types were considerably more resistant to the advancement and retreat of the last glacial ice sheet. The shallow depths of the Western Basin and its island archipelago can be attributed to the hardness and stratigraphy of these overlying rock types. In contrast, the geology of the Central and Eastern basins is composed of less-resistant shale, resulting in greater lake depths and more glacially-formed bathymetric features. The Eastern Basin's northern shore has many outcroppings (see "points" on map) because of relatively resistant bedrock. These irregular shoreline structures are continuous with the directional patterns of the ridges and valleys found offshore.

Map 2-1: Lake Erie Bathymetry and Landforms

LAKE ERIE BATHYMETRIC CONTOURS





Lake Erie Bays and Natural Harbors

1 North Maumee Bay	8 Connor Bay	15 Abino Bay	22 Eagle Bay	29 Muddy Creek Bay
2 La Plaisance Bay	9 Mohawk Bay	16 Thunder Bay	23 Dunkirk Harbor	30 East Harbor
3 Brest Bay	10 Moulton Bay	17 Bertie Bay	24 Van Buren Bay	31 Middle Harbor
4 Gravelly Bay	11 Sunset Bay	18 Grandview Bay	25 Presque Isle Bay	32 West Harbor
5 Sturgeon Bay	12 Gravelly Bay	19 Lotus Bay	26 Misery Bay	33 North Bay
6 Coletta Bay	13 Lorraine Bay	20 Sunset Bay	27 Thompson Bay	34 South Bay
7 Miller Bay	14 Silver Bay	21 Hanford Bay	28 East Sandusky Bay	35 Put-in-Bay Harbor

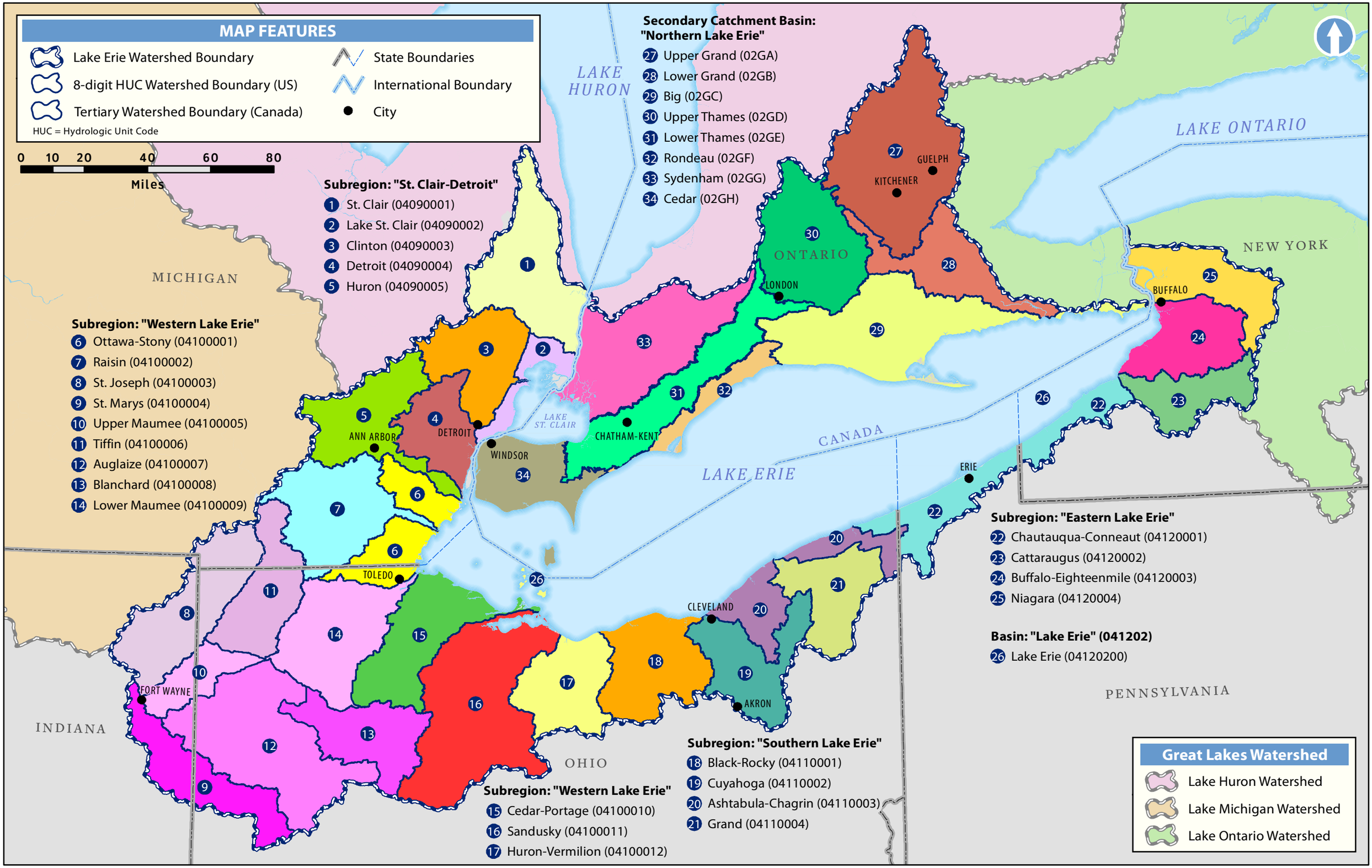
Bathymetry maps display the depths and submerged topographies of underwater terrain. Bathymetric contours, or depth contours, detailing Lake Erie's underwater terrain are illustrated in this map. Contours are lines on a map that connect points of equal elevation, which help illustrate topographic or submerged relief. The contour lines in this map are color-coded and mapped in one-meter intervals. Color coding provides a way to visualize and interpret underwater features. In this map, depth contours are displayed using a red-to-navy color ramp; where red, orange and yellow show shallower lake depths and darker blues represent deeper areas. Contours help further define flatter topographies, sloping terrain and the steepness of submerged valleys and ridges. The closer together the contour lines are, the steeper the lakebed terrain is. Colors easily help show the range of varying depths.

Lake Erie's three primary basins are bowl-shaped. The lake floor gradually and smoothly deepens from the shore to greater depths with minimal terrain variation, particularly in the Western and Central basins. This is likely the result of postglacial sediment deposition and sediment-smoothing caused by circulating water currents, known as "gyres," occurring independently in each basin (see the Lake Circulation map on page 170). This map shows widely-spaced contours in the Central Basin, and to a lesser degree also in the Western Basin, representing much flatter lake bottoms.

The Western Basin includes prominent features such as islands and reefs. Two primary north-south island archipelago bands occur in the eastern portion of the basin. The western band includes the Bass Islands, Catawba Island and the smaller Canadian islands. The eastern band includes the eastern tip of Marblehead Peninsula (including Johnson's Island), Kelleys Island and Pelee Island. Depth contours show the gradual sloping of the lake bottom in the islands region. Underwater reefs west of the Bass Islands are easily noticeable. Most reefs are conical in shape and elongated in a northeast-to-southwest direction (due to the trend of the retreating Wisconsinan ice sheet on the substrate structure). Reefs consist of bedrock exposures and associated rock, cobble and gravel. The Western Basin's reef complex provides important habitat to many fish species (see the Walleye Habitat map on page 156).

Bathymetry data for Lake Erie was compiled at a one-meter contour interval at scales ranging from 1:100,000 to 1:2,500. High-quality bathymetric data is valuable for geologic and limnologic studies, including modeling lake circulation and sediment transport, forecasting climate change effects and identifying contaminated sediment locations. Bathymetry of the Great Lakes has been collected for nautical charting purposes for at least 150 years by the U.S. Army Corps of Engineers (until 1970), the National Oceanic and Atmospheric Administration's National Ocean Service (after 1970) and the Canadian Hydrographic Service.

LAKE ERIE WATERSHED (INTERNATIONAL)



GREAT LAKES WATERSHED

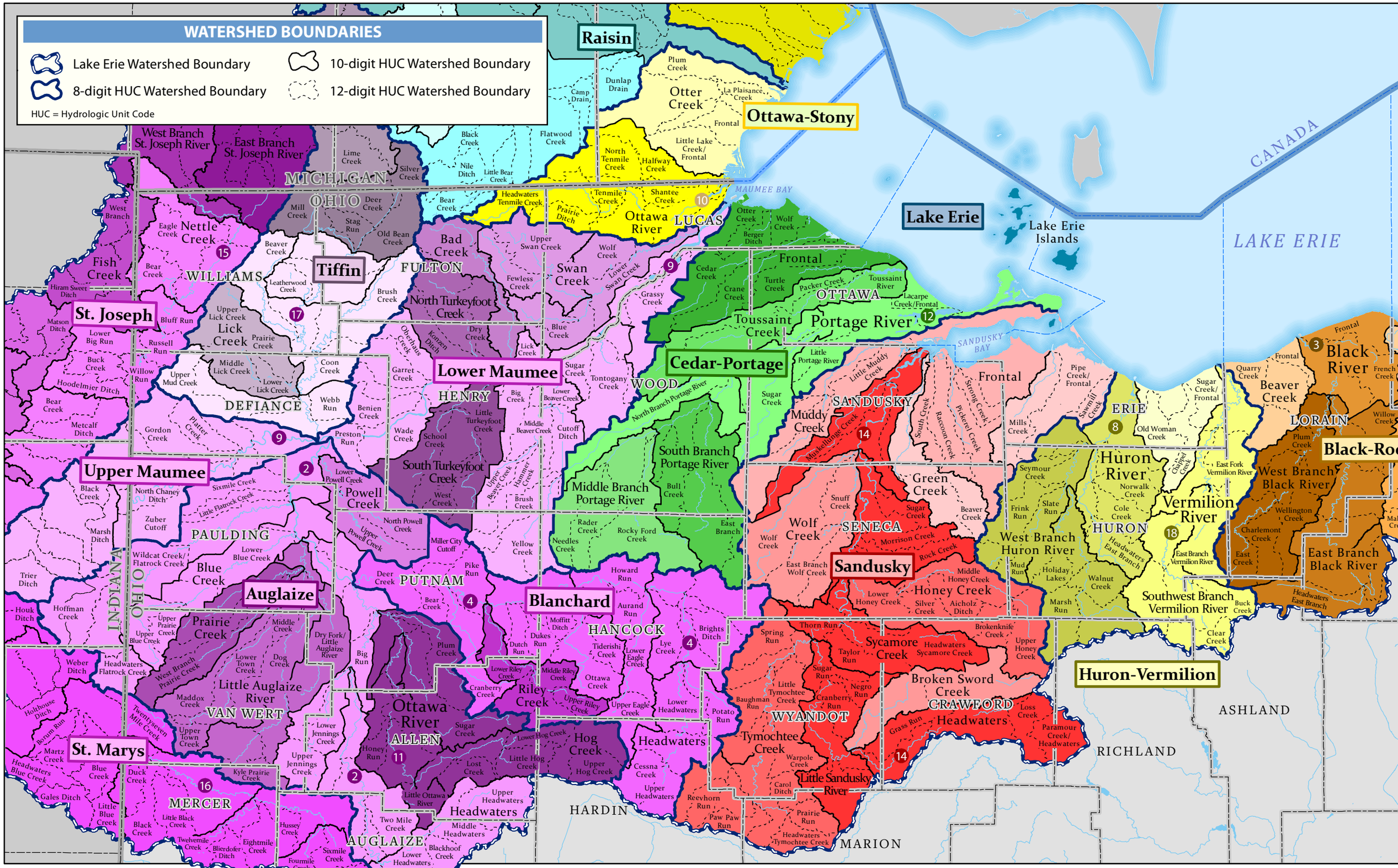
A **watershed** is an area of land that drains water from tributaries and rainfall to a common body of water, such as a larger tributary, pond, lake or ocean. The word "watershed" is often used interchangeably with the terms "basin" or "catchment." The line separating two adjacent watersheds is called a "drainage divide." Unaltered drainage divides follow natural physical features in the landscape, such as ridgelines, hills and mountains.

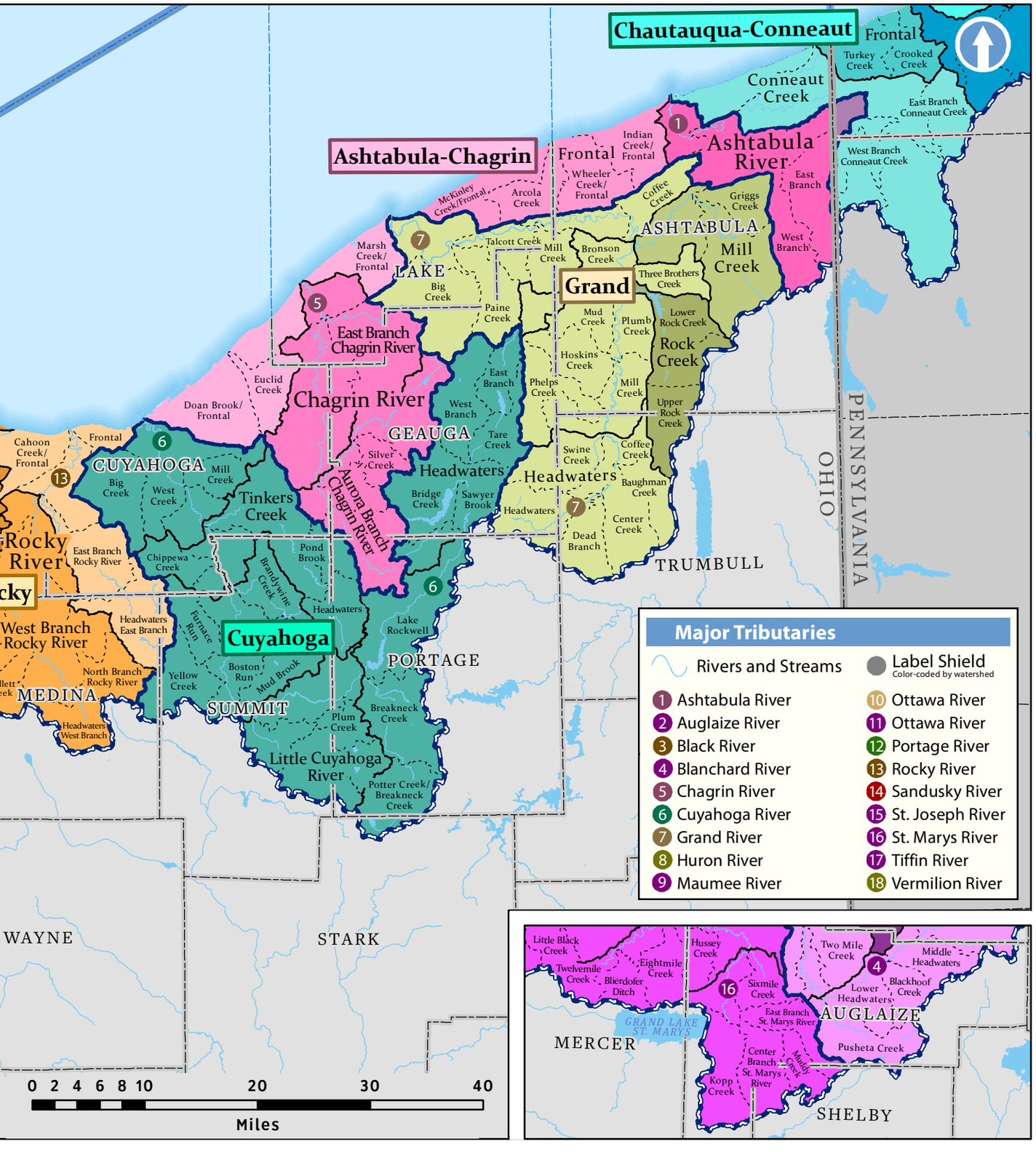
The Lake Erie Watershed (see map at left) drains portions of Ohio, Indiana, Michigan, Pennsylvania, New York, and the Canadian province of Ontario. It includes the Lake St. Clair Watershed. Lake Erie and its watershed are part of the Great Lakes Watershed (see map at right) and the St. Lawrence River Watershed, which feeds into the Atlantic Ocean (not mapped). Lakes Michigan and Superior flow into Lake Huron via the Straits of Mackinac and St. Marys River, respectively. Lake Huron's primary outflow is the St. Clair River, which flows into Lake St. Clair. The Detroit River links Lake St. Clair to Lake Erie. Approximately 80 percent of Lake Erie's water flows in from the Detroit River. Lake Erie's primary outflow is the Niagara River, which flows over Niagara Falls and through the Niagara Gorge into Lake Ontario. The St. Lawrence River flows from Lake Ontario to the Gulf of St. Lawrence and eventually into the Atlantic Ocean.

Watersheds in the U.S. are delineated into a six-level, nested hierarchal system of hydrologic units and cataloged using unique **hydrologic unit codes** (HUC). Developed by the U.S. Geological Survey, the six hierarchal levels include: regions (largest unit), subregions, basins, subbasins, watersheds and subwatersheds (smallest unit). The Great Lakes Watershed is a first-level region and represented with the 2-digit HUC, "04." Nested within the Great Lakes Watershed are the individual watersheds for each of the five Great Lakes. The Lake Erie Watershed is comprised of four second-level subregions: St. Clair-Detroit ("0409"), Western Lake Erie ("0410"), Southern Lake Erie ("0411") and Eastern Lake Erie ("0412"). The Northern Lake Erie "subregion" is delineated as a secondary basin in Canada's cataloging system.

The Lake Erie Watershed is further delineated into 26 fourth-level subbasins (and eight tertiary basins in Canada). In some cases, two or more major tributary networks are grouped into the same subregion, for instance the Huron-Vermilion, Black-Rocky and Ashtabula-Chagrin subregions. Conversely, some larger drainage basins within a second-level subregion are delineated into two or more subbasins, as is the case with the Maumee River Watershed in the Western Lake Erie subregion. The Maumee River Watershed is the largest drainage basin in the Great Lakes (6,570 square miles). It is broken into seven subbasin divisions, including the St. Joseph, St. Marys, Tiffin, Auglaize, Blanchard, Upper Maumee and Lower Maumee watersheds. For greater detail about HUC watershed delineations in Ohio's portion of the Lake Erie Watershed, see pages 46-47.

OHIO'S LAKE ERIE WATERSHED WITH WATERSHED NAMES





Ohio's portion of the Lake Erie Watershed covers 11,649 square miles and drains all or portions of 35 counties. Of this land, more than 65 percent is agricultural, 14 percent is developed, ten percent is forested and six percent is wetland. The remaining five percent consists of shrub/scrub, bare land or water (2010 NOAA C-CAP; see Land Cover map on page 52). The rest of Ohio—south of the watershed divide—drains to the Ohio River, which is part of the Mississippi River Watershed.

This map illustrates three hydrologic unit levels of the Lake Erie Watershed: fourth-level subbasins (8-digit HUC), fifth-level watersheds (10-digit HUC) and sixth-level subwatersheds (12-digit HUC). Eighteen of Lake Erie's 26 subbasins are partially or completely located in Ohio. Subbasins are outlined on the map with thick navy blue lines and highlighted using varying shades of a specific color. The Maumee River Basin's seven subbasins are each represented in shades of purple. Fifth-level watershed boundaries are displayed with thin black lines. Watershed units that are part of the direct flow to Lake Erie are highlighted in a distinct color, whereas drainage areas that are removed from the direct flow are presented in various shades of that color. For example, in the Sandusky River Watershed, the fifth-level units that are directly associated with the main branch of the Sandusky River (e.g. the Little Sandusky River and Sycamore Creek) are highlighted in the same shade of red. In contrast, the Broken Sword, Tymochtee, Honey, Wolf and Green creek drainage areas have different shades of red to show they are not directly part of the primary drainage. Sixth-level subwatersheds are delineated using thin, dashed black lines.

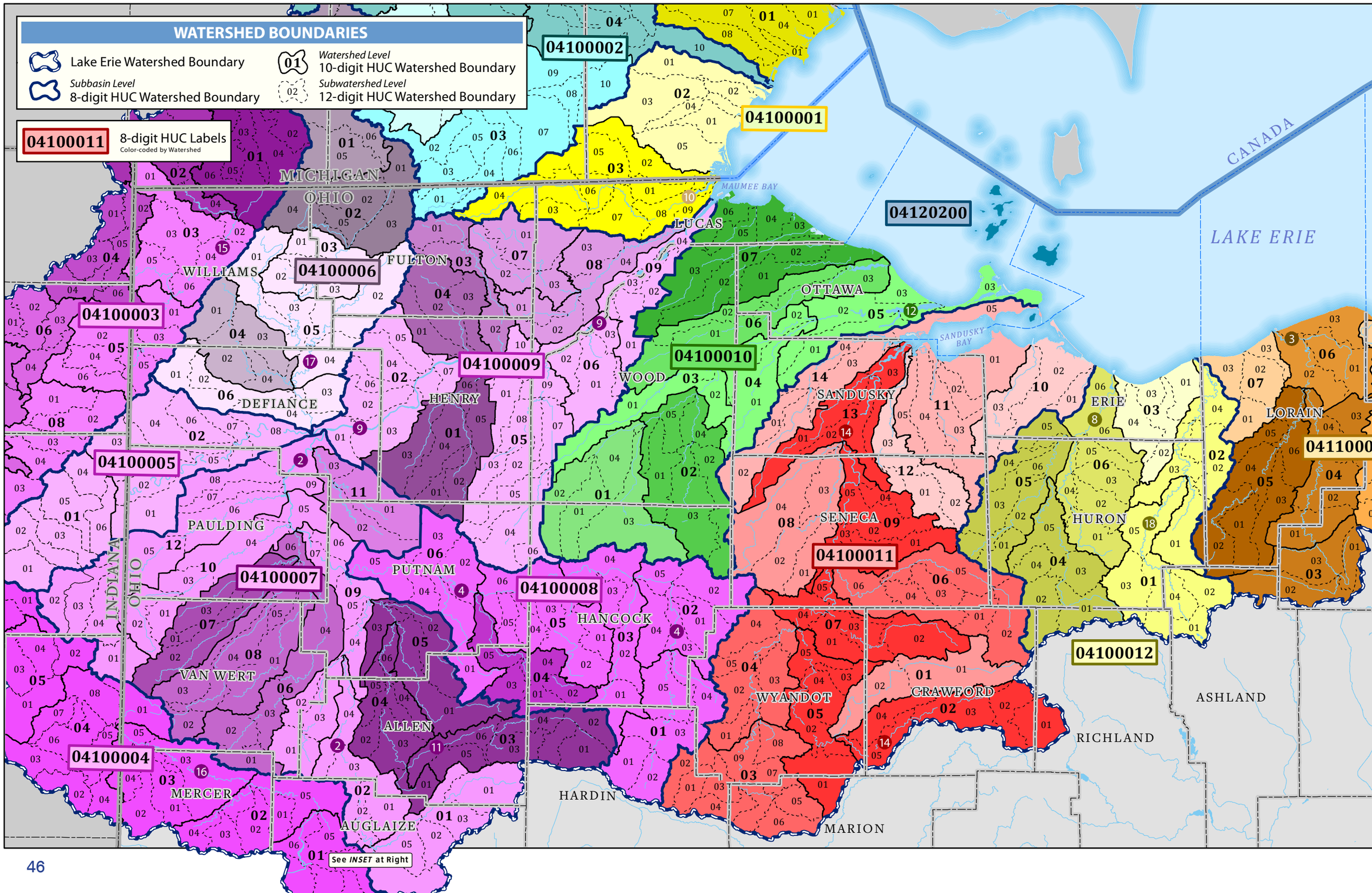
Assigned fourth-level subbasin labels are found inside color-coordinating boxes, e.g. "Huron-Vermilion." Additional watershed labelling corresponds with the nested drainage areas within each subbasin. For example, the "Huron River" label comprises an entire fifth-level watershed area, whereas for ease of understanding, the "West Branch Huron River" label represents two unlabeled watershed units. Shading helps identify the delineation of watersheds and accompanying labels. Subwatersheds are labelled individually (smallest text) where appropriate, such as "Old Woman Creek."

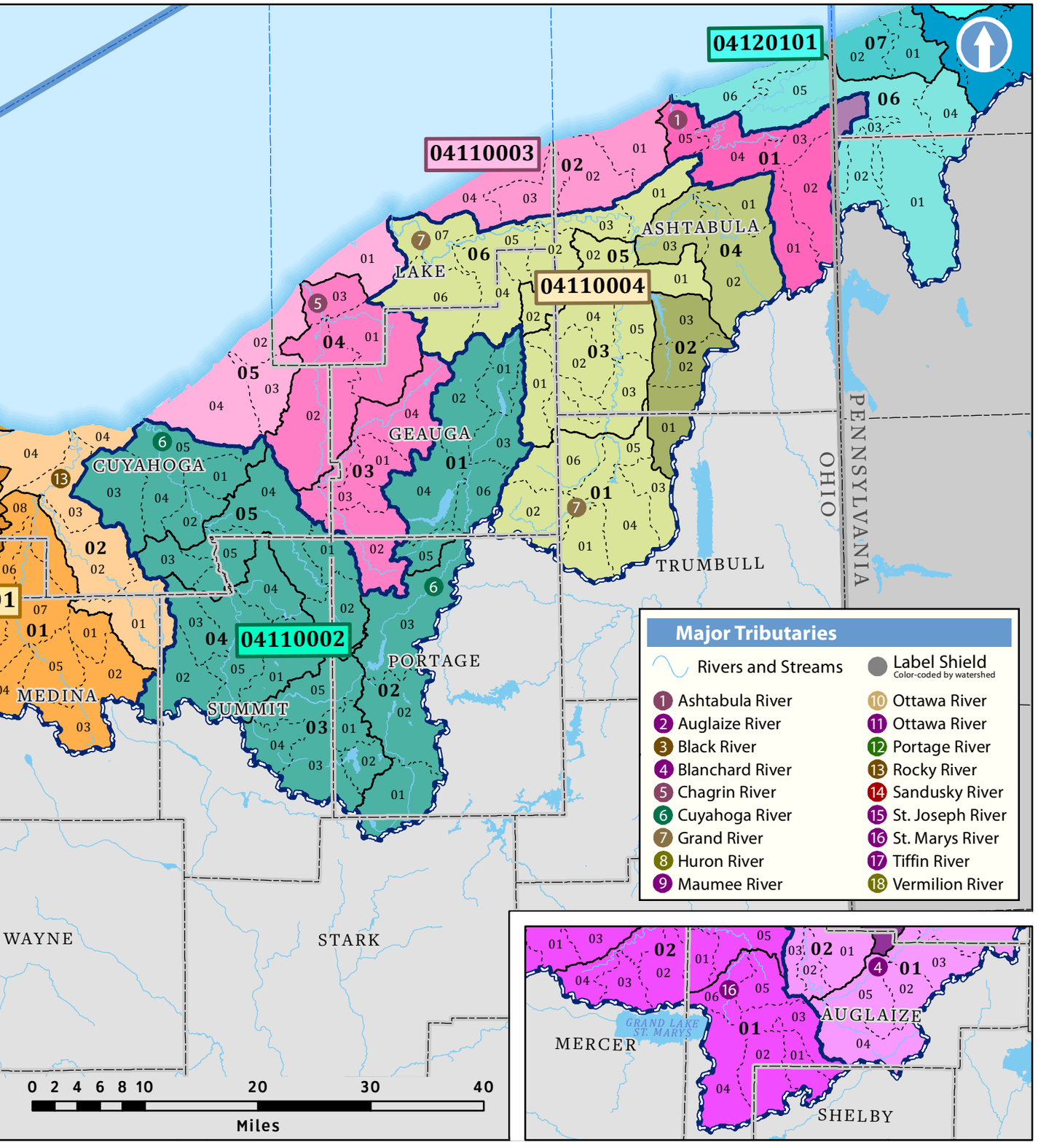
Drainage units labelled "Frontal" represent coastal areas where multiple minor tributaries, too small to be delineated into distinctive subdivisions, are combined. Frontal drainage areas, also known as "remnant areas," are unique because they have more than one outlet. For example, the frontal watershed east of the Black River mouth in Lorain County includes many small tributaries that flow into Lake Erie, including Sheffield Creek, Schumaker Creek, Powdermaker Ditch and Heider Ditch (not mapped or labelled).

Identification and delineation of 8-digit, 10-digit and 12-digit hydrologic units in the Lake Erie Watershed is further explained and mapped on the next page.

Map 2-5: Ohio's Lake Erie Watershed with Watershed Names

OHIO'S LAKE ERIE WATERSHED WITH HYDROLOGIC UNIT CODES





All watersheds in the United States are delineated into a standard six-level, nested hierarchal system of hydrologic units and cataloged using unique hydrologic unit codes (HUC). Developed by the U.S. Geological Survey, the six hierarchal levels include: regions (largest unit), subregions, basins, subbasins, watersheds and subwatersheds (smallest unit). This map illustrates three hydrologic unit levels of the Lake Erie Watershed: fourth-level subbasins (8-digit HUC), fifth-level watersheds (10-digit HUC) and sixth-level subwatersheds (12-digit HUC). Watershed delineation provides a geographic boundary that is based upon local hydrology and is used to assess, plan, monitor and manage water resources.

Subbasins are outlined on the map with thick navy blue lines and highlighted using varying shades of a specific color. Below is a sequential listing of Ohio's subbasins by 8-digit HUC in the Lake Erie Watershed. The number of 10-digit HUC watersheds and 12-digit HUC subwatersheds within each 8-digit HUC is included in brackets and parentheses, respectively (Ohio portion only):

04100001 – Ottawa-Stony [1] (10)
04100002 – Raisin [1] (4)
04100003 – St. Joseph [5] (18)
04100004 – St. Marys [4] (19)
04100005 – Upper Maumee [1] (9)
04100006 – Tiffin [5] (20)
04100007 – Auglaize [12] (60)
04100008 – Blanchard [6] (30)
04100009 – Lower Maumee [9] (42)
04100010 – Cedar-Portage [7] (25)
04100011 – Sandusky [14] (66)
04100012 – Huron-Vermilion [6] (30)
04110001 – Black-Rocky [7] (32)
04110002 – Cuyahoga [6] (29)
04110003 – Ashtabula-Chagrin [5] (20)
04110004 – Grand [6] (26)
04120101 – Chautauqua-Conneaut [2] (4)
04120200 – Lake Erie, including islands

Nationally, the average size of a subbasin is 700 square miles. In some cases, to ensure that all subbasins are relatively equal in size, two or more major tributary networks are often grouped into the same subregion, e.g. the Huron-Vermilion, Black-Rocky and Ashtabula-Chagrin. Conversely, larger drainage basins may be delineated into two or more subbasins, as is the case with the Maumee River Watershed. The Maumee basin is broken into seven subbasin divisions, including the St. Joseph, St. Marys, Tiffin, Auglaize, Blanchard, Upper Maumee and Lower Maumee.

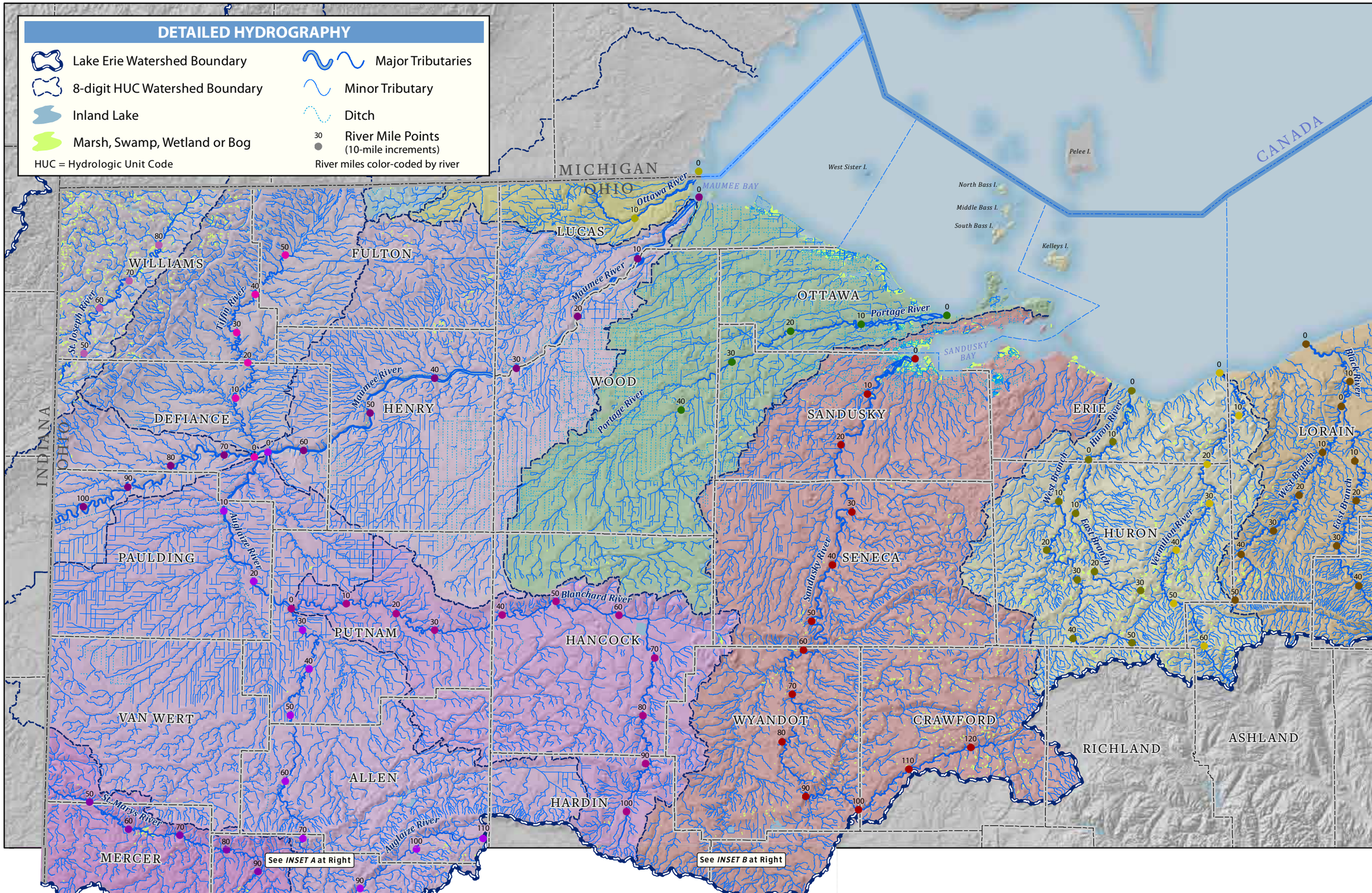
The average size of a fifth-level watershed is 227 square miles. To identify the HUC value associated with the watershed unit, locate the accompanying bold, two-digit label and add it to the subbasin's 8-digit HUC. For example, the Sandusky River Watershed has 14 fifth-level watershed units, labeled "01" through "14." The watershed for the Honey Creek, nested within the Sandusky basin, is labeled "06." Therefore, its full 10-digit HUC value is "0410001106" ("04100011"+"06").

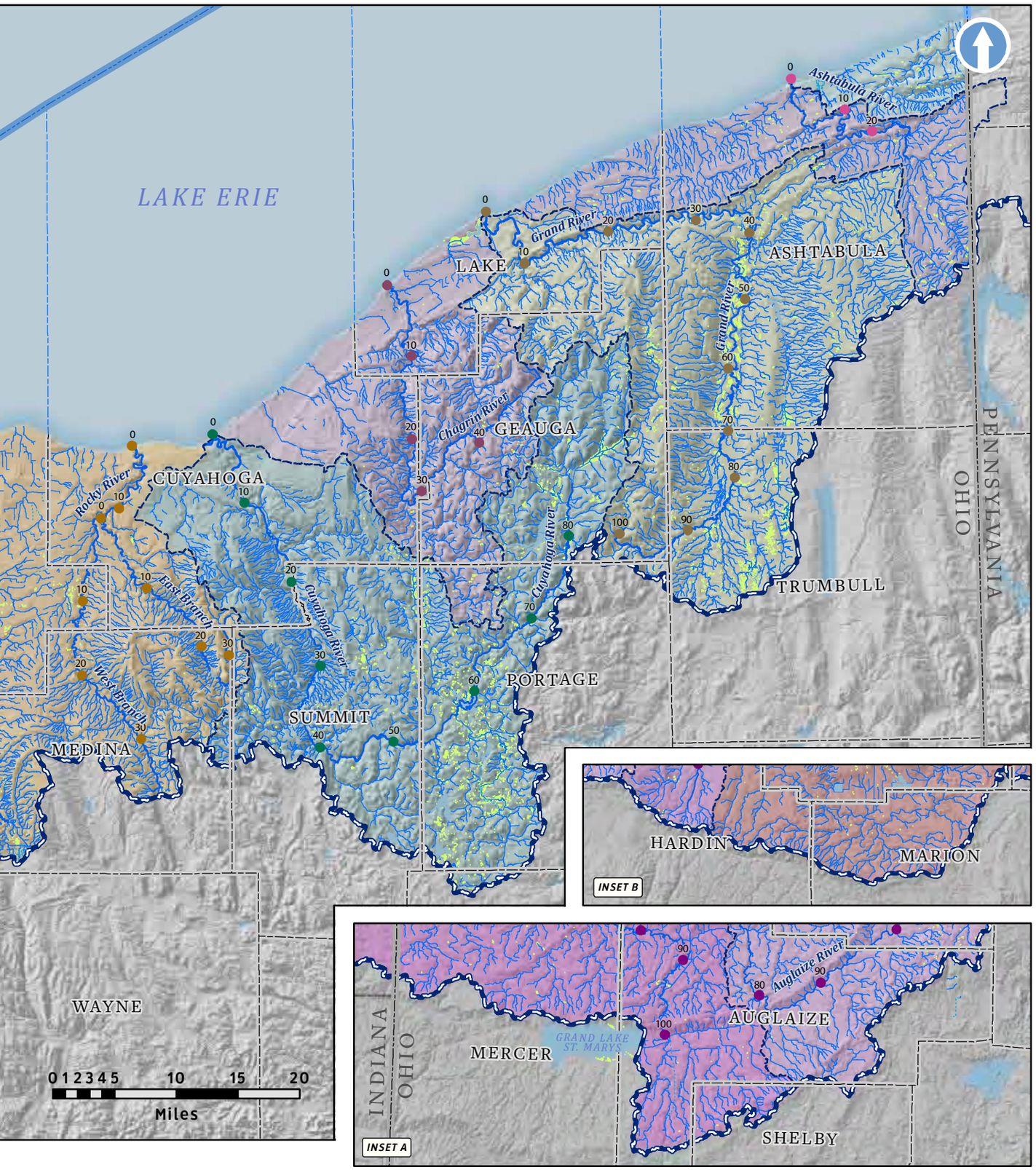
The average size of a sixth-level subwatershed is 40 square miles. To identify the HUC value associated with these units, locate the accompanying two-digit label and add it to the watershed's 10-digit HUC value. For example, Brokenknife Creek Watershed, nested within the Honey Creek basin, is labeled "01." Therefore, its 12-digit HUC value is "041000110601" ("04100011"+"06"+"01").

Watershed names are labelled on the previous page.

Map 2-6: Ohio's Lake Erie Watershed with Hydrologic Unit Codes

DETAILED HYDROGRAPHY AND RIVER MILES





Hydrography is the science and mapping of surface water. This map highlights the detailed drainage network of the Lake Erie Watershed using data from the National Hydrography Dataset (NHD). The NHD was developed at a scale of 1:24,000 by the U.S. Geological Survey to define the spatial locations of surface water. Hydrographic features shown on this map include major tributaries, minor tributaries, drainage ditches, inland lakes, ponds, reservoirs, marshes, swamps and bogs.

The glacially-influenced landscape of the Lake Erie Watershed ranges from low, flat topography of the lake plains, prevalent in northwest Ohio (and along the edge of the shore), to rolling hills and elevated highlands in north-central and northeast Ohio. Rivers in northwest Ohio traverse extensive tracts of highly fertile land that were once part of the Great Black Swamp. In north-central Ohio, headwater streams wind through gently sloping moraines (rolling hills made from glacial deposits) before flowing into their main branches and Lake Erie. The meandering rivers of northeast Ohio originate in higher elevations (greater than 1,000 feet above sea level) and follow bedrock-influenced courses.

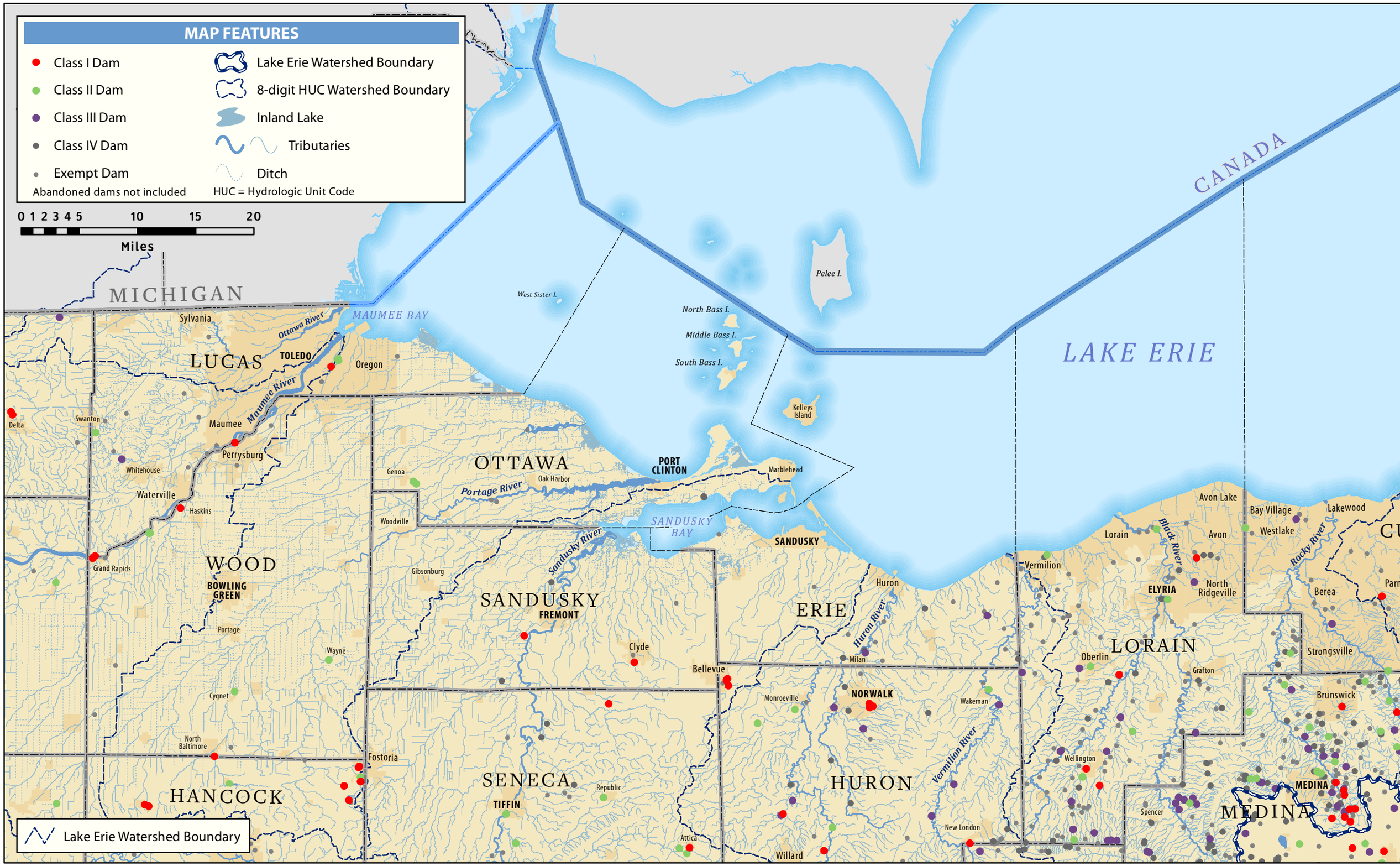
In Ohio, there are 12 principal rivers that flow into Lake Erie. From west to east, they include the Ottawa (mouth in Michigan), Maumee, Portage, Sandusky, Huron, Vermilion, Black, Rocky, Cuyahoga, Chagrin, Grand and Ashtabula. Many smaller tributaries flow into Lake Erie as well, including, but not limited to, the Toussaint River in Ottawa County, Pipe and Old Woman creeks in Erie County, Beaver Creek in Lorain County, Euclid Creek in Cuyahoga County, Arcola Creek in Lake County and Conneaut Creek in Ashtabula County. Within the Maumee River Watershed, there are more than 3,900 miles of rivers and streams that flow into the Maumee, including the St. Joseph, St. Marys, Auglaize, Blanchard (via the Auglaize) and Tiffin rivers.

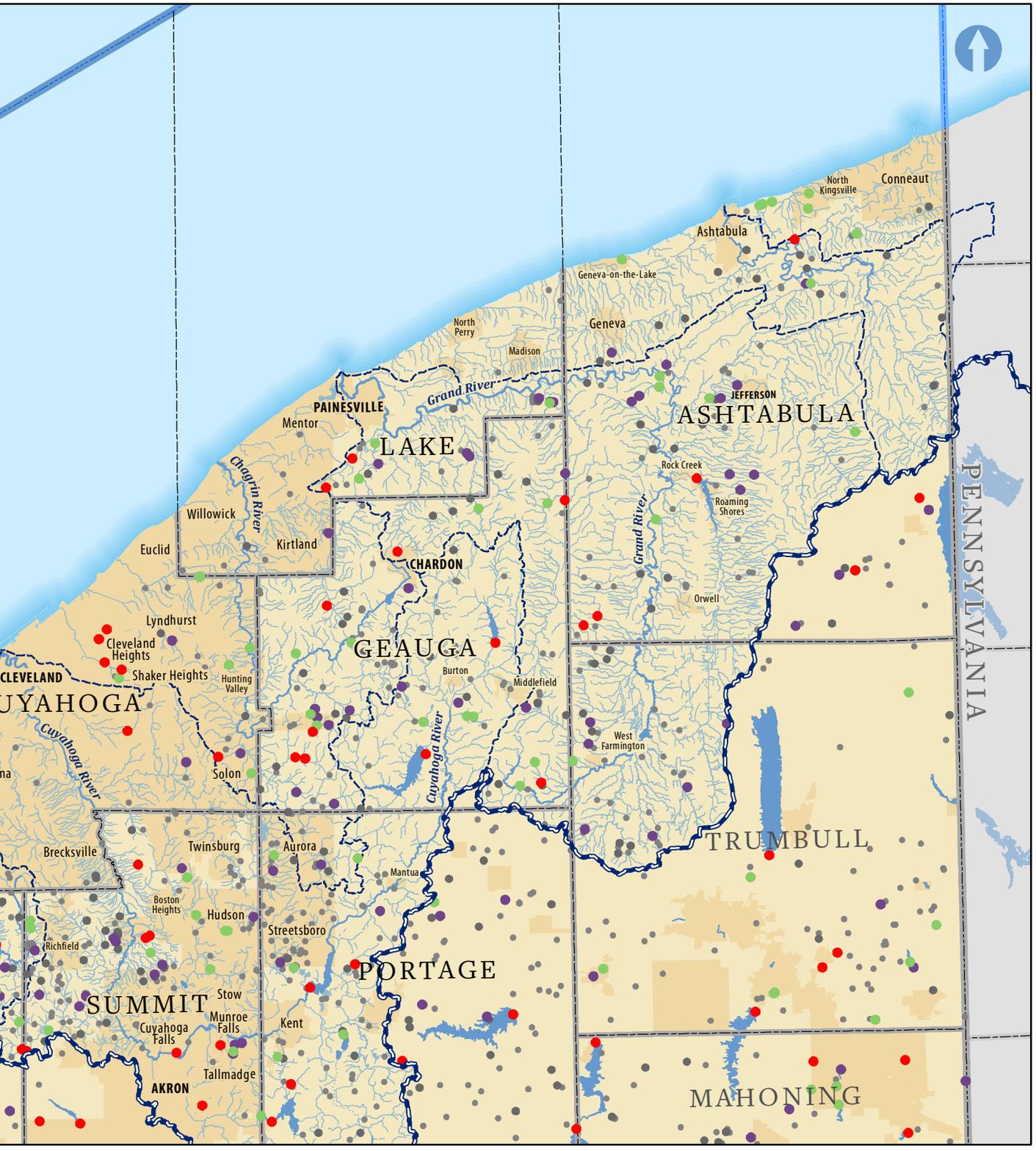
Drainage ditches are also represented in the map. Extensive ditch systems were dug in both the Maumee and Cedar-Portage watersheds in the 1850s to drain the Great Black Swamp. More than 16,000 miles of drainage ditches are in the Maumee River Watershed.

This map also shows river mile points in ten-mile increments along main water courses. The river mile system is a linear measure developed by the Ohio Environmental Protection Agency to index locations along a river or stream in Ohio. River mile values increase in an upriver direction, starting with zero at the mouth. River mile values help locate physical or cultural features along a tributary course in relation to its mouth, such a dam, wastewater treatment facility or paddling access site. The convergence of two river branches share the same river mile "zero," as is the case with the East and West branches of the Huron, Black and Rocky rivers.

Map 2-7: Detailed Hydrography and River Miles

DAMS


MAP FEATURES
Class I Dam
Class II Dam
Class III Dam
Class IV Dam
Exempt Dam
Abandoned dams not included
Lake Erie Watershed Boundary
8-digit HUC Watershed Boundary
Inland Lake
Tributaries
Ditch
HUC = Hydrologic Unit Code
0 1 2 3 4 5 10 15 20
Miles
MICHIGAN
LUCAS
WOOD
OTTAWA
SANDUSKY
ERIE
HURON
LORAIN
MEDINA
SENECA
HANCOCK
CANADA
LAKE ERIE
MAUMEE BAY
SANDUSKY BAY
West Sister I.
Pelee I.
North Bass I.
Middle Bass I.
South Bass I.
Kelleys Island
Sylvania
TOLEDO
Oregon
Ottawa River
Maumee River
Delta
Swanton
Maumee
Perrysburg
Whitehouse
Waterville
Haskins
Grand Rapids
BOWLING GREEN
Portage
Cygnet
North Baltimore
Wayne
Genoa
Oak Harbor
PORT CLINTON
Marblehead
Portage River
Woodville
Gibsonburg
Sandusky River
FREMONT
Clyde
Fostoria
TIFFIN
Republic
Attica
SANDUSKY
Huron
Huron River
Milan
Bellevue
Monroeville
NORWALK
Wakeman
Willard
Vermilion
Vermilion River
New London
Lorain
Black River
Avon
Avon Lake
Bay Village
Westlake
Lakewood
Rocky River
ELYRIA
North Ridgeville
Berea
Oberlin
Grafton
Strongsville
Brunswick
Wellington
Spencer
MEDINA
Lake Erie Watershed Boundary



A dam is a man-made structure that is typically constructed across a tributary channel to impound water. Dams are mostly built for: drinking water and wastewater storage; power generation; flood control; irrigation; river navigation for transporting goods; wildlife habitat, and; recreation (boating, swimming and fishing). They are often made of timber, rock, concrete, earth, steel, or a combination of these materials. Dams provide many economic and social benefits; however, they also cause a range of adverse environmental consequences. For example, dams can disrupt the natural flow, connectivity and seasonal fluctuations of a river or stream. Consequently, the movement and diversity of fish is impacted, and habitat and spawning areas become limited. Riverine ecosystems are affected by dams because they block the natural movement of sediment. The loss of sediment in downstream areas limits feeding, spawning and breeding habitat for many fish species. Dams can also pose various health and safety hazards.

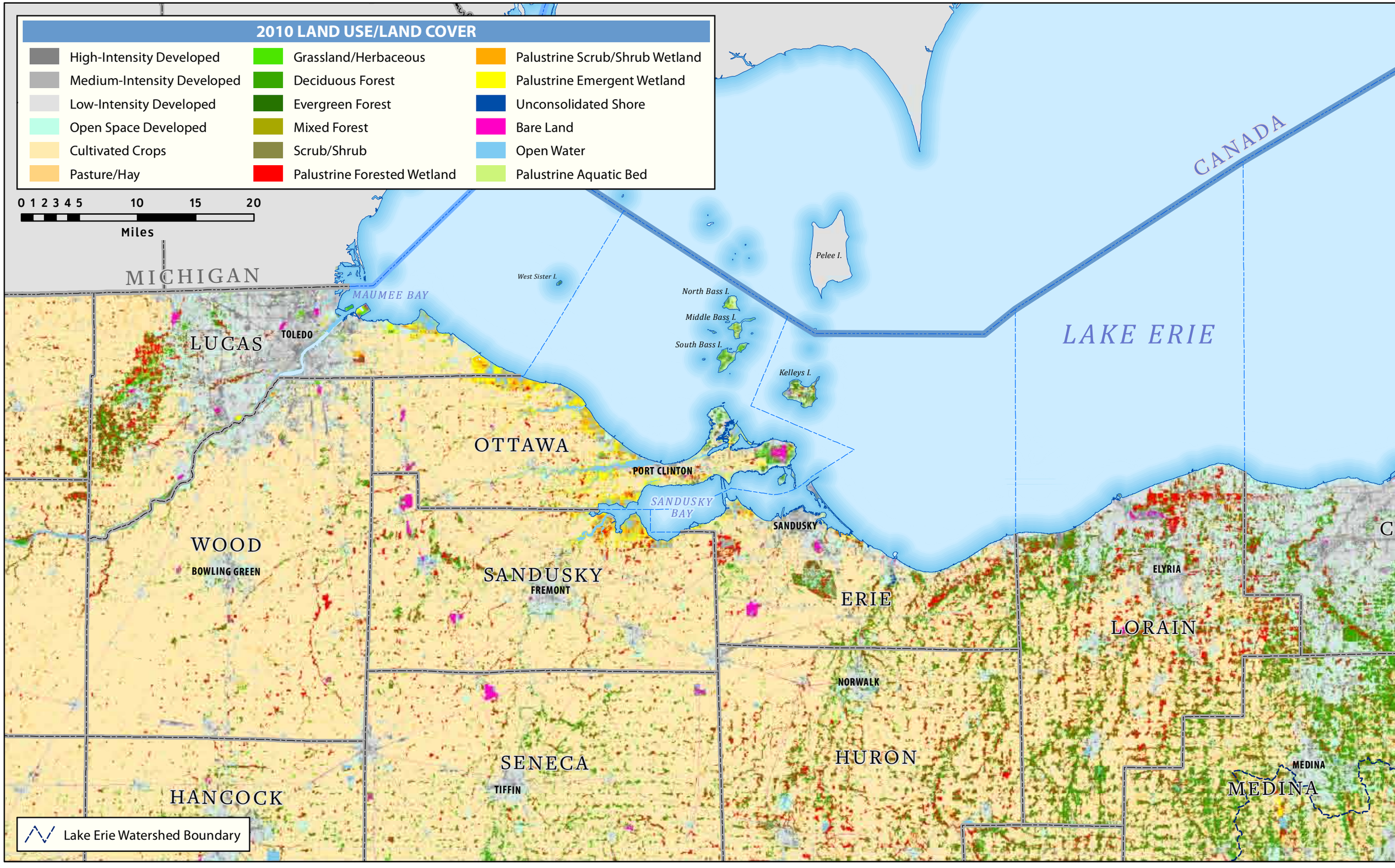
Efforts to remove outdated dams that no longer serve their intended purpose(s) have occurred throughout the Lake Erie Watershed. Dam removals are intended to help improve water quality, restore natural river conditions and reestablish fish habitat. Deconstruction and bypassing examples include the Kent (2004), Munroe Falls (2006), Sheraton Mill (2013) and LaFever Powerhouse (2013) dams on the Cuyahoga River, and the Ballville Dam (2018) on the Sandusky River.

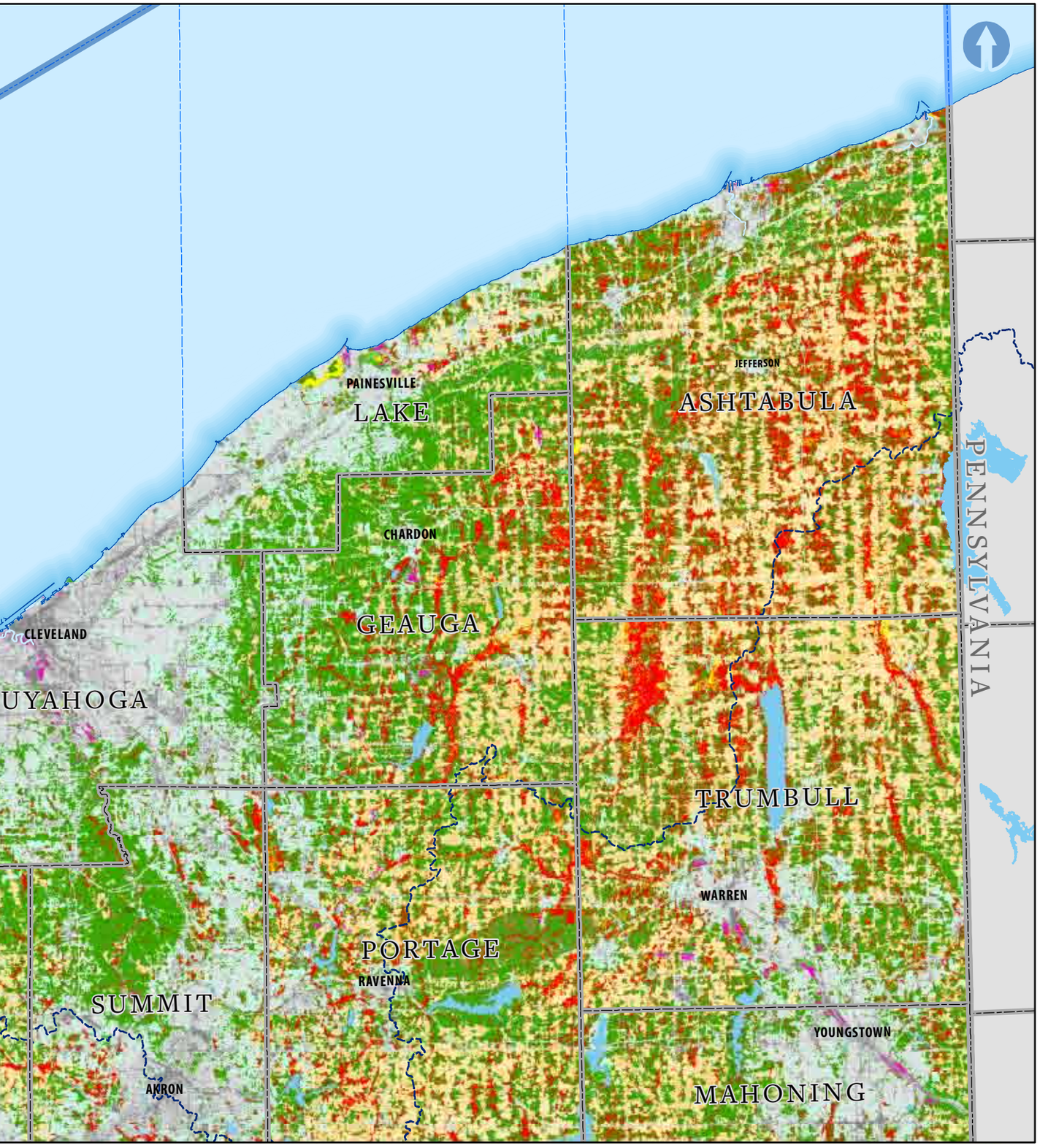
Dams under the jurisdiction of the Ohio Department of Natural Resources (ODNR), Division of Water Resources are categorized using a four-tier classification system. The classes include: Class I (largest), Class II, Class III and Class IV (smallest). Classifications are based on height, storage capacity and potential downstream hazard. Storage capacity is the total amount of impounded water when the pool level has reached the top of the dam, or immediately before overtopping the crest. A dam is categorized as “Class I” if its storage capacity is more than 5,000 acre-feet*, or if its height is greater than 60 feet, or if sudden failure would result in the probable loss of life. A dam is categorized as “Class II” if its storage capacity is more than 500 acre-feet*, or if its height is greater than 40 feet, or if sudden failure would result in flooding of high-value property. A dam is categorized as “Class III” if its storage capacity is more than 50 acre-feet*, or if its height is greater than 25 feet, or if sudden failure would result in flooding of rural buildings and local roads. Class IV dams are 25 feet or less in height and have a total storage capacity of 50 acre-feet* or less. The sudden failure of a Class IV would result in property losses restricted mainly to the dam and rural lands.

Dams are exempt from ODNR jurisdiction if they are six feet or less in height, regardless of total storage; less than ten feet in height with not more than 50 acre-feet of storage, or; not more than 15 acre-feet of total storage, regardless of height.

** One acre-foot equals approximately 326,000 gallons (the volume of water necessary to cover one acre of surface area to a depth of one foot).*

LAND COVER (2010)





This map shows 2010 land cover data from the National Oceanic and Atmospheric Administration's Coastal Change Analysis Program (C-CAP). Land cover is the vegetation and man-made features that occur on the surface of the earth.

Developed Land: "High-Intensity Developed" land contains heavily built-up urban centers and large constructed surfaces in suburban and rural areas. "Medium-Intensity Developed" land generally comprises multi- and single-family homes, especially in suburban and rural areas. "Low-Intensity Developed" land commonly includes single-family housing areas, especially in rural neighborhoods. In highly developed lands, impervious surfaces make up 80 to 100 percent of the total land cover. Vegetation and/or other cover types are increasingly prevalent in medium- and low-intensity developed lands. "Open Space Developed" mostly consists of managed grasslands or low-lying vegetation planted in developed areas for recreation, erosion control or aesthetic purposes.

Agricultural Land: "Cultivated Crops" includes lands that are actively being tilled and lands that are intensely managed to produce annual crops, such as corn, soybeans, fruits and vegetables. "Pasture/Hay" contains areas of grasses and legumes (or both) planted for livestock grazing or the production of seed or hay crops.

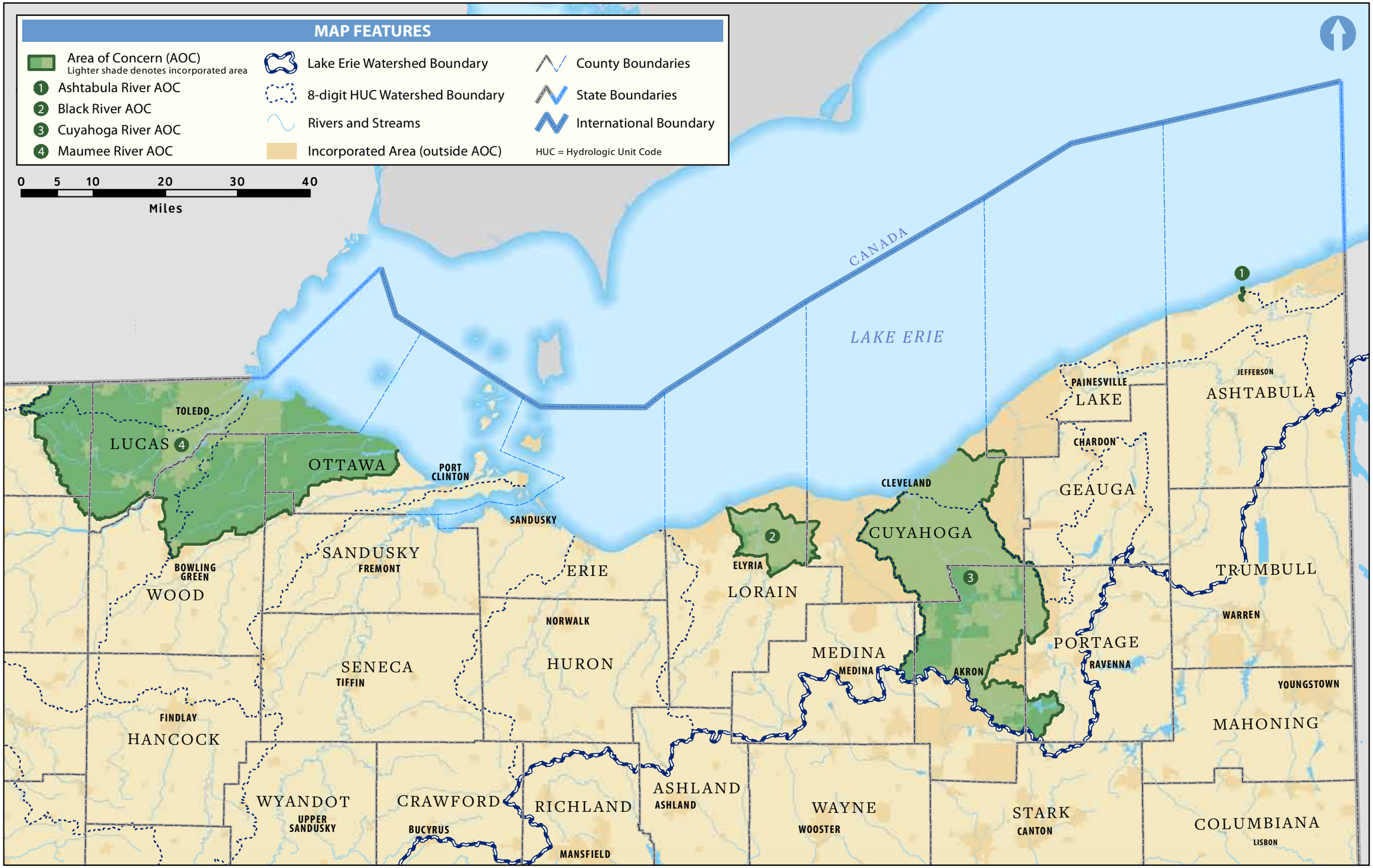
Grassland and Scrub Land: The "Grassland/Herbaceous" class contains areas dominated by herbaceous vegetation. These areas include prairies, meadows and other lands with naturally-occurring grasses. Grassland areas are not subject to intensive management (i.e. tilling) but can be utilized for grazing. "Scrub/Shrub" contains areas dominated by shrubs less than 16 feet tall with shrub canopy and includes tree shrubs, young trees or underdeveloped trees.

Forested Land: These lands contain areas dominated by trees that are greater than 16 feet tall and exceed 20 percent of the total vegetation cover. More than 75 percent of deciduous tree species (e.g. maple, hickory and oak) shed foliage in the fall, while over 75 percent of evergreen tree species (e.g. pine, fir and spruce) maintain leaves all year. Evergreen canopy is never without green foliage. "Mixed Forest" includes both deciduous and evergreen trees—neither of which is predominant.

Palustrine Wetlands: Wetlands are lands that are seasonally or permanently covered by shallow, standing water. Vegetation is adapted to withstand long-term saturation and oxygen-depleted soils. Forested wetlands include woody vegetation greater than or equal to 16 feet in height (e.g. cottonwood, American elm and ash), while shrub/scrub wetlands contain woody vegetation less than 16 feet in height. Emergent plants, mosses and/or lichens are common in emergent wetlands. These plants generally remain standing until the next growing season.

"Bare land" consists of exposed bedrock, dunes, quarries, strip mines, gravel pits and other buildups of earth material. Vegetation accounts for less than ten percent of the total bare land cover type.

AREAS OF CONCERN



In the 18th and 19th centuries, dumping industrial waste, raw sewage and animal remains into waterways and lakes without any regard to contamination, water quality or the environment was commonplace. It was presumed that industrial runoff and pollutants would be sufficiently diluted. Despite changing practices and the implementation of new environmental laws and regulations in the 20th century to reduce the discharge of pollutants, many waterways in the Great Lakes Basin continued to experience severe environmental degradation.

In 1985, the International Joint Commission (IJC) identified several Great Lakes locations in the United States and Canada as Areas of Concern (AOC). AOCs are designated watershed areas, or portions of a watershed within the Great Lakes Basin that exhibit significant environmental degradation from historic and continuing pollution. In addition to AOC designation, the IJC also recommended the development of site-specific, comprehensive remedial action plans to help guide remedying of known resource impairments.

AOC designation is a requirement of the 1987 Great Lakes Water Quality Agreement between the United States and Canada and is based on the presence of beneficial use impairments (BUI). Anthropogenic practices that change the chemical, physical or biological integrity of the Great Lakes system lead to the impairment of beneficial uses. AOCs must have at least one of the following BUIs present: (1) restrictions on fish and wildlife consumption; (2) tainting of fish and wildlife flavor; (3) degraded fish and wildlife populations; (4) fish tumors or other deformities; (5) bird or animal deformities or reproductive problems; (6) degradation of benthos; (7) restrictions on dredging activities; (8) eutrophication or undesirable algae; (9) restrictions on drinking water consumption or taste and odor problems; (10) beach closings; (11) degradation of aesthetics; (12) added costs to agriculture or industry; (13) degradation of phytoplankton and zooplankton populations, and; (14) loss of fish and wildlife habitat.

There are 36 Areas of Concern in the Great Lakes region—22 in the U.S., nine in Canada and five that are binational. The map on the right shows the geographic locations and extents of all Great Lakes AOCs. The map on the left shows Ohio's four AOCs: from west to east—Maumee River AOC, Black River AOC, Cuyahoga River AOC and Ashtabula River AOC. As of 2017, four AOCs in the United States and three in Canada have been delisted (not mapped), including two Lake Erie AOCs: Presque Isle Bay in Erie, Pennsylvania and Wheatley Harbor in Ontario. In 2013, two dredging projects and a large habitat restoration project were completed within the Ashtabula River AOC, and in 2014, the following three BUIs were removed: restrictions on fish and wildlife consumption, degradation of fish and wildlife populations and loss of fish and wildlife habitat.

Maps 2-10 and 2-11: Ohio's Areas of Concern and the Great Lakes Areas of Concern