6.13 Lake Erie

Ohio waters of Lake Erie (Google maps)

6.13.1 Status

The current condition of Lake Erie is best described as stressed. Lake Erie is subjected to more stress from urbanization, industrialization, and agriculture than any other Great Lake. About one-third of the total population of the Great Lakes basin resides within the Lake Erie watershed. Not surprising given the fact that the Lake Erie basin supports the largest population, it surpasses all the other Great Lakes in the amount of effluent received from sewage treatment plants (Lake Erie LaMP 2000). Lake Erie is the Great Lake most subjected to sediment loading. Intensive agricultural development, particularly in southwest Ontario and northwest Ohio, contributes huge sediment loads to the lake. The Lake Erie Basin also receives the most phosphorus of any Great Lake, and 44 percent of the total for the entire Great Lakes (NRCS 2011). Invasive species have entered Lake Erie in numbers via the Welland Canal, ballast water from commercial shipping, and intentional introductions.

6.13.2 Description

The Lake Erie habitat category applies to the 2.3 million acres of Ohio waters in Lake Erie, the 312 miles of Ohio shoreline, and Ohio's Lake Erie tributaries up to the first impediment to fish passage. It should be noted that while Lake Erie tributaries are treated as a separate habitat category (see Lake Erie Tributaries in the next section), the line of separation between the Lake Erie and Lake Erie Tributaries habitat categories is a biological one, rather than a line on a map. Riffles and dams provide some measure of biological separation between systems, and align themselves with how these habitat categories are managed. The Ohio waters of Lake Erie account for about 90 percent of Ohio's water area by acres.

Lake Erie is the second smallest (by area) of the Great Lakes, smallest by volume, shallowest, and the most biologically productive. Multiple jurisdictions share the lake including the states of New York, Pennsylvania, Ohio, Michigan, and the Canadian Province of Ontario. Lake Erie is divided into three basins - the western basin is very shallow with an average depth of 24 ft., the central basin is deeper with

the average depth of 60 ft., and the eastern basin is the deepest of the three with an average depth of 82 ft. Eighty percent of Lake Erie's total inflow comes from the Detroit River, and the Niagara River is the main outflow from the lake (Lake Erie LaMP 2000). The water volume of the western basin is approximately one-fifth of Lake Erie, but it drains about 65 percent of the Lake Erie watershed (Ohio EPA 2010c). Unlike the central and eastern basins, the western basin rarely thermally stratifies (Lake Erie LaMP 2011).

Lake Erie has undergone significant physical, chemical, and biological changes over time. These changes have primarily been a result of human influence on the lake itself, and in the basin. Overfishing, pollution, and habitat destruction began to take a toll in the late 1800s. Lake Erie was the first of the Great Lakes to experience problems with eutrophication. Its shallow basin made it the warmest and most biologically productive of the Great Lakes, however by the 1950's nutrient inputs finally pushed the trophic status of the lake to the point where algal blooms and turbidity reduced water quality and impacted aquatic species (Lake Erie LaMP 2000).

The Clean Water Act of 1972 started Lake Erie on the road to recovery relative to nutrient inputs, and by the 1990s the lake had essentially achieved the phosphorus levels established under the Great Lakes Water Quality Agreement as those needed to eliminate the effects of eutrophication. However, the models used to determine the maximum allowable annual phosphorus load did not account for the influence of such a major ecosystem disrupter as the zebra mussel. Attempting to manage the lake system by simply managing phosphorus inputs appears no longer workable, at least until more is understood about the internal dynamics of phosphorus cycling in the lake (Lake Erie LaMP 2000).

Recent summers on Lake Erie have been characterized by blue-green algal blooms similar to those seen in the 1960's. Water quality data shows increases in total, particulate, and dissolved reactive phosphorous loading since the mid 1990's. The summers of 2010 and 2011 brought massive algal blooms to Lake Erie. The Ohio Lake Erie Phosphorus Task Force concluded that while there are multiple contributors of phosphorus into Lake Erie, agriculture is the leading source due to the majority of the land use in agriculture (about 80%) in the Maumee River watershed (Ohio Lake Erie Phosphorus Task Force II Final Report 2013). Phosphorus delivered to rivers and streams in the Lake Erie Basin from cultivated cropland represented 61% of the total phosphorus load from all sources. Because of its location, high discharges, and high loads and concentrations of total and dissolved phosphorus, the Maumee River watershed is the primary driver of algal blooms in the Western Basin of Lake Erie (NRCS 2011). While agricultural practices have been identified as the primary culprit, the effects of other nutrient sources, climate change, and invasive species on nutrient cycling cannot be discounted (Lake Erie LaMP 2000).

Lake Erie has been the unfortunate recipient of many aquatic invasive species over the past century. Most of the major introductions prior to 1980 were fishes that entered the lake through the Welland Shipping Canal, such as the sea lamprey, alewife, and white perch. Other non-native fishes (rainbow smelt and common carp) were intentionally introduced. All of these species now have naturalized reproducing populations in Lake Erie. After 1980, the most important introductions of invasive species have occurred through ballast-water discharge from commercial freighters, including zebra and quagga mussels, the round and tubenose goby, spiny and fishhook water fleas, the bloody red shrimp, and a unique strain of viral hemorrhagic septicemia, all of which persist in Lake Erie today. The potential introduction of Asian carp into Lake Erie is the newest invasive species threat. The long-term impacts of invasive species on native fauna are highly uncertain, but are clearly not beneficial. Control programs have been implemented only for sea lamprey.

Changes in land use, development, and the construction of various shore structures have significantly altered the original habitat available along the Lake Erie shoreline. Many of the wetlands have been drained, filled, or altered so they no longer function naturally. Shore structures associated with development or built to protect shore property from high water levels have inhibited the natural flow of beach building materials along the shoreline, and consequently the natural habitat (Lake Erie LaMP 2000). From 2011-2013, Ohio EPA assessed nearshore fish communities from sites spread along Ohio's Lake Erie shoreline, including the islands. In general, areas assessed showed significant impairment due primarily to tributary loadings of nutrients and sediment, exacerbated by trophic disruptions caused by the

proliferation of exotic species, algal blooms, and shoreline habitat modifications. Of the 38 sites sampled, only 13 percent of fish community collections were assessed as fully attaining the designated EWH aquatic life use, 34 percent were assessed as partially attaining, and the remaining 53 percent were in non-attainment (Ohio EPA 2014a).

Land use practices and nutrient loading are the primary human activities affecting the future state of the Lake Erie ecosystem. Land use practices affect habitat, influence hydrology and sediment runoff, and contribute to inputs of nutrients and contaminants. Other issues of concern are the continued introduction of invasive species, the effects of climate change, and understanding the role and impacts of phosphorus management in the Lake Erie system (Lake Erie LaMP 2000).

The major priority for future sustainability of Lake Erie fish populations lies in the protection, enhancement, and restoration of critical habitat, especially spawning and nursery habitats that are created in large part by hydrological processes in the watershed and nearshore environments (Davies et al. 2005). As these processes were disrupted or degraded over the past century by human activities, native fish stocks/species (e.g., lake sturgeon, lake trout, sauger, blue-pike, lake herring), as well as other aquatic species (mussels, crayfish, invertebrates) were lost or suffered significant population declines. Healthy habitats will help buffer impacts to native species from severe weather patterns, such as storms or extended droughts, and potentially improve resiliency of the fish community against the impacts of invasive species.

6.13.3 Associated Species of Greatest Conservation Need

Lake Erie has a long history of natural and anthropogenic changes. The forests, grasslands, and wetlands that once comprised the Lake Erie watershed are largely gone. Urban, industrial, and agricultural lands now dominate the landscape. Tributary streams and rivers have experienced major changes in their hydrology owing to dams, channelization, tiling of agricultural fields, and an increase in hard surfaces that speed overland flow of water. The lake’s shorelines have been hardened and coastal wetlands drowned. River mouths have been dredged and turned into ports, at a loss of important estuarine habitat. Exotic species have been intentionally and unintentionally introduced.

All of these events have altered the lake's physical and chemical environment and produced changes in the aquatic community composition and abundance. Recent history indicates significant eutrophication throughout most of the 20th century, followed by a period of water quality improvement due to nutrient reductions/establishment of zebra mussels, and again followed by increasing phosphorous levels that today are causing severe blooms of diatoms and blue-green algae.

The Lake Erie species assemblage has, and will continue to shift with the physical and chemical environment of the lake. As the human influence on the lake is reduced, we can expect species composition and numbers reflective of what Lake Erie once was. At the other end of the scale, the deleterious effects of present day land-use will manifest themselves in an aquatic community able to tolerate the conditions. The most highly ranked species in terms of conservation need will always be the species on the fringe of tolerance relative to the existing physical and chemical environment in the lake.

The following species have been identified as Lake Erie species of greatest conservation need (conservation status rank in parentheses):

<u>Fish</u>

Spoonhead Sculpin (14)	*Cottus ricei*
Lake Sturgeon (17)	*Acipenser fulvescens*
Blacknose Shiner (22)	*Notropis heterolepis*
Mottled Sculpin (24)	*Cottus bairdi*
Silver Lamprey (26)	*Ichthyomyzon unicuspis*
Eastern Sand Darter (29)	*Ammocrypta pellucida*
Western Banded Killifish (30)	*Fundulus diaphanus menona*
Cisco (33)	*Coregonus artedi*
Burbot (36)	*Lota lota*

Silver Chub (36)	*Macrhybopsis storeriana*
Iowa Darter (38)	*Etheostoma exile*
Channel Darter (44)	*Percina copelandi*
Spotted Gar (45)	*Lepisosteus oculatus*
Longnose Sucker (47)	*Catostomus catostomus*
Black Redhorse (48)	*Moxostoma duquesnei*
Mooneye (50)	*Hiodon tergisus*
Lake Whitefish (57)	*Coregonus clupeaformis*
River Darter (58)	*Percina shumardi*

Crayfish

Northern Clearwater Crayfish (4)	*Orconectes propinquus*
Big Water Crayfish (7)	*Cambarus robustus*
Red Swamp Crayfish (13)	*Procambarus clarkii*

Mussels

Eastern Pondmussel (8)	*Ligumia nasuta*
Slippershell Mussel (16)	*Alasmidonta viridis*
Rayed Bean (21)	*Villosa fabalis*
Creek Heelsplitter (23)	*Lasmigona compressa*
Pondhorn (23)	*Uniomerus tetralasmus*
Threeridge (40)	*Amblema plicata*
Round Hickorynut (42)	*Obovaria subrotunda*
Kidneyshell (48)	*Ptychobranchus fasciolaris*
Northern Riffleshell (48)	*Epioblasma torulosa rangiana*
Rainbowshell (50)	*Villosa iris*
Round Pigtoe (50)	*Pleurobema sintoxia*
Elktoe (52)	*Alasmidonta marginata*
Deertoe (53)	*Truncilla truncata*
Fawnsfoot (53)	*Truncilla donaciformis*
Threehorn Wartyback (55)	*Obliquaria reflexa*
Cylindrical Papershell (56)	*Anodontiodes ferussacianus*

Table 35. CONSERVATION THREATS TO LAKE ERIE.
The following threats negatively impact or have the potential to negatively impact Lake Erie. Threat categories/classification from Salafsky et al. (2008), and threat impact rank calculations from Master et al. (2012).

ID	threats	2nd level threat classification(s)	threat impact rank
I	**residential and commercial development**		medium
A	Coastal development and its effect on nearshore habitat and species	housing & urban areas commercial & industrial areas tourism & recreation areas	medium medium low
B	Hydrological effects caused by hard surfaces such as roof tops, roads, parking lots, etc.	housing & urban areas commercial & industrial areas tourism & recreation areas	medium medium low

C	The market value of undeveloped land on the Lake Erie shoreline is exceptionally high, making land acquisition for protection purposes problematic	housing & urban areas commercial & industrial areas tourism & recreation areas	medium medium low
II	**agriculture and aquaculture**		medium
A	Watershed conversion to agriculture alters hydrology	annual & perennial non-timber crops livestock farming & ranching	high low
III	**energy production and mining**		low
A	Oil and gas extraction - can physically damage and destroy habitat, and cause negative impacts from chemical contamination	oil & gas drilling	negligible
B	Wind turbines can negatively impact birds and bats that utilize lake habitat	renewable energy	low
IV	**transportation and service corridors**		medium
A	Dredging/modification shipping lanes causes habitat loss, water quality impacts	shipping lanes	medium
B	Coastal development such as roads, bridges, causeways, utilities, etc. - impact shoreline/nearshore habitats	roads & railroads utility & service lines	low negligible
V	**biological resource use**		low
A	Fishing pressure and fishing gear impacts from recreational and commercial fishing	fishing & harvesting aquatic resources	low
VI	**human intrusions and disturbance**		low
A	Incompatible recreational activities	recreational activities	low
B	Creation of recreational facilities can alter/destroy nearshore habitat	recreational activities	low
C	Vessel impacts to fragile habitats and water quality	recreational activities work & other activities	low negligible
VII	**natural system modifications**		low
A	Loss of wetland function as spawning and nursery habitat due to wetlands being isolated from the lake by dikes/levees	dams & water management/use	low
B	Hardened shoreline structures such as dikes, seawalls, breakwaters, causeways, etc. that do not allow the shoreline to move naturally with fluctuating water levels	other ecosystem modifications	low
C	Natural sediment transport is disrupted by shoreline development	other ecosystem modifications	low
D	Some species populations have been reduced to levels below what is necessary to recover on their own	other ecosystem modifications	low
E	Lack of data for some species and habitats limits our ability to develop plans for threats like climate change	other ecosystem modifications	low
VIII	**invasive and other problematic species and genes**		high
A	Introduction and/or spread of invasive plants and animals	invasive non-native/alien species	high
B	Introduction and/or spread of nuisance plants and animals	problematic native species	low

C	Introduction and spread of diseases (plants and animals)	invasive non-native/alien species problematic native species	high low
IX	**pollution**		high
A	Urban effluent carries a variety of substances that impact water quality and aquatic species	household sewage & urban wastewater industrial & military effluents garbage & solid waste air-borne pollutants	high low low low
B	Agricultural effluent from row crops as well as confined animal operations impacts water quality and aquatic species	agricultural & forestry effluents	very high
C	Harmful algal blooms affect water quality, aquatic species, and can be toxic to terrestrial species	agricultural & forestry effluents	very high
D	Industrial spills impact water quality and aquatic species	industrial & military effluents	low
X	**geological events**		negligible
---	none	---	---
XI	**climate change and severe weather**		low
A	Climate change could impact habitats, water quality, and species	habitat shifting & alteration droughts temperature extremes storms & flooding	low low low medium
B	Climate change induced fluctuating lake levels could impact nearshore species and habitats	droughts temperature extremes storms & flooding	low low medium

Table 36. CONSERVATION ACTIONS FOR LAKE ERIE.
The following actions will help abate or have the potential to help abate threats to Lake Erie habitat. Action categories/classification from Salafsky et al. (2008), and action priority rank calculations from Georgia DNR (2005).

ID	actions	2nd level action classification(s)	action priority rank	threat(s) addressed*
I	**LAND/WATER PROTECTION**		med	
1	Protect coastal properties through acquisition, partnerships, conservation easements, etc.	site/area protection resource & habitat protection	low med	I, II, III-A, IV-B, VI-B, VII-A,B,C, XI-B

2	Quantify and map critical habitat areas in Cleveland Harbor for future protection	site/area protection	low	I-A, IV-A,B, VI-B,C, VII-B,C,
II	**LAND/WATER MANAGEMENT**		high	
1	Use physical enhancements in areas such as Maumee and Sandusky rivers and bays where human activities have permanently altered the natural hydrology	habitat & natural process restoration	high	I-A,B, II, IV, VI-B,C, VII-A,B, XI
2	Work to restore natural hydrological connections and flow regimes in tributary/near-shore areas	habitat & natural process restoration	high	I-A,B, IV-B, VI-B, VII-A,B,C, XI
3	Improve our understanding of the effects of manageable actions (e.g., dredging, energy generation, barriers to fish access, nutrient loading) and unmanageable/environmental factors (e.g., weather, climate change, land use practices, invasive species, etc.) on the Lake Erie ecosystem	habitat & natural process restoration	high	I-A,B, II, III, IV, V, VI, VII, VIII, IX, XI
4	Identify upland uses for dredge material and end open lake dumping of dredge spoil	habitat & natural process restoration	high	IV-A
5	Use lowest impact techniques and timing for dredging activities	habitat & natural process restoration	high	IV-A
6	Create and use wetlands for stormwater treatment	habitat & natural process restoration	high	I-A, IX-A
7	Establish an early-detection/rapid-response system for dealing with invasive and nuisance species	invasive/ problematic species control	high	VIII-A,B
8	Continue to work with federal and state Great Lakes partners to prevent the introduction of Asian Carp	invasive/ problematic species control	high	VIII-A
9	Develop a way to quantify habitat impacts caused by development so that they can be mitigated for	habitat & natural process restoration	high	I-A, III-A, IV, VI-B, VII-A,B,C,E
10	Develop a process for coordinating disparate data sources of distribution and abundance of aquatic SGCN	habitat & natural process restoration	high	I-A, III-B, IV-A,B, VI-B, VII-E, XI
11	Review existing species and habitat data to identify data gaps and needs for additional surveys, research, and management actions	habitat & natural process restoration	high	I, II, III, IV, V, VI, VII, VIII, IX, XI
12	Conduct comprehensive surveys of freshwater mussels	habitat & natural process restoration	high	IV-A,B, VI-B,C, VII-E, XI
13	Identify critical habitat areas (through research, literature, data mining) to help delineate management options for their protection/enhancement	site/area management habitat & natural process restoration	med high	I-A,B, II, III, IV, V, VI, VII, VIII-A, XI
14	Develop standardized nearshore monitoring programs for habitats and species	site/area management	med	I-A, III-B, IV-B, VI-B,C, VII-A,B,C,E, VIII-A,B, XI

III	**SPECIES MANAGEMENT**		low	
1	Determine if lake sturgeon sightings reported by the public can be used to monitor relative abundance	species management species recovery	low med	VII-D
2	Monitor the status of lake sturgeon through reported sightings from sport and commercial fisheries, fish assessment surveys, and the general public to assist with restoration efforts	species management species recovery	low med	VII-D
3	Assess population status, habitat suitability, and probability for restoration of lake sturgeon spawning stocks in Ohio tributaries	species management species recovery	low med	VII-D
4	Develop a restoration strategy for sauger in the Maumee and Sandusky Rivers	species reintroduction	low	VII-D
5	Assess spawning and nursery habitat suitability for lake trout at natural reefs in Ohio waters of the western and central basins of Lake Erie	species reintroduction	low	VII-D
6	Assess population status, habitat suitability, and probability for restoration of fish, mussels, and crayfish listed as SGCN	species reintroduction	High	VII-D, VII-E
7	Develop a restoration strategy for high priority fish, mussels, and crayfish	species reintroduction	High	VII-D, VII-E
IV	**EDUCATION AND AWARENESS**		medium	
1	Educate waterfront landowners and commercial pesticide/herbicide applicators on responsible chemical use, and the negative impacts to wildlife from toxic chemicals	training	high	I-A,C, IX-A
2	Promote conservation easements along shoreline habitat	training awareness & communic-ations	high med	I, II, IV-B, VI-B, VII-A,B,C, XI
3	Provide technical guidance on coastal development plans as relates to fish and wildlife interests	training	high	I, IV-B, VI-B, VII-A,B,C, XI
4	Support the Ohio Clean Lakes Initiative - educating and training farmers and other interested parties on agricultural nutrient management and stewardship	training	high	II, IX-B,C
5	Educate the public about the negative effects of exotic and nuisance animals – encourage responsible disposal of unwanted animals	awareness & communic-ations	med	VIII
V	**LAW AND POLICY**		high	
1	Support legislation promoting eco-friendly energy development and use	legislation	high	III
2	Support the ban on oil and gas drilling in Lake Erie	legislation policies & regulations	high high	III-A
3	Develop and implement a risk-assessment system in the approval process for importing or moving live animals and plants	legislation policies & regulations	high high	VIII
4	Support more stringent ballast water regulations to	legislation	high	VIII

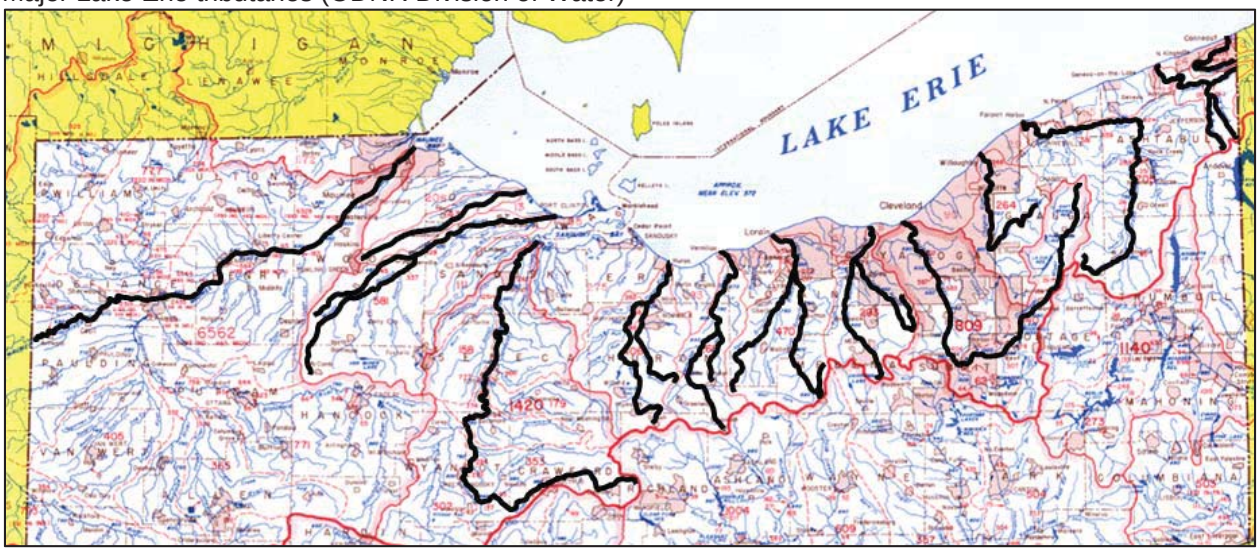
	stop the introduction of invasive species	policies & regulations	high	
5	Support legislation aimed at preventing Asian carp from entering the Great Lakes	legislation	high	VIII-A
6	Find innovative ways to mandate the inclusion of fish and wildlife interests in development plans	policies & regulations private sector standards & codes	high low	I, IV-B, VI-B, VII, XI
7	Increase enforcement of stormwater regulations	compliance & enforcement	med	I-B, IX-A
VI	**LIVELIHOOD, ECONOMIC AND OTHER INCENTIVES**		med	
1	Explore tying eligibility for grant money, loans, and cost-share programs to nutrient loading levels for agriculture – the lower the nutrient levels in their effluent, the more money they would be eligible for	market forces conservation payments	med med	IX-B,C, XI
2	Create incentives for vegetated buffers along all waterways to reduce nutrient loads and sediment	market forces conservation payments	med med	I-B, IX-A,B,C, IX-A
3	Create incentives to promote eco-friendly energy development and use	market forces conservation payments non-monetary values	med med low	III
4	Support the creation of incentives to protect coastal habitat	market forces conservation payments	med med	I-A,C, IV-B, VI-B, VII-A,B,C, XI
5	Support clean marina and clean vessel programs	market forces conservation payments	med med	VI-C
6	Develop incentives for municipalities to use stormwater management systems that minimize negative impacts to aquatic habitats	market forces conservation payments	med med	I-A, IX-A
7	Support incentives for development plans involving water frontage that take into account wildlife and habitat needs	market forces conservation payments non-monetary values	med med low	I, IV-B, VI-B, VII-A,B,C, XI
VII	**EXTERNAL CAPACITY BUILDING**		med	
1	Work with ODA and OEPA to minimize nutrients in runoff, and develop BMPs for pesticide/herbicide use	alliance & partnership development	high	IX
2	Create an interagency spill response team – update contacts and training on a regular basis	alliance & partnership	high	IX-D

		development		
3	Consider creating a multiagency invasive species prevention and control group that would handle all invasive species issues – include appropriate agencies from bordering states/provinces	alliance & partnership development	high	VIII
4	Through interagency coordination, work to assure that wildlife interests are taken into consideration in road, bridge, and causeway design, construction, and maintenance	alliance & partnership development	high	IV-B
5	Use interagency partnerships to augment data used to assess population status, habitat suitability, and probability for restoration of lake sturgeon spawning stocks in Ohio tributaries	alliance & partnership development	high	VII-D
6	Through partnerships with the U.S. and Ohio EPA, U.S. Dept. Agriculture, and the U.S. Army Corps, implement actions on manageable biotic and abiotic factors affecting Lake Erie, such as phosphorus regulation and dredging activities – include appropriate agencies from bordering states/provinces	alliance & partnership development	high	I-B, II, IV-A, IX-A,B
7	Use existing, and develop new partnerships with watershed managers, property owners, and funding/regulatory groups, etc. to affect land use practices in the Lake Erie basin	alliance & partnership development	high	I-B, II, IX-A,B,C, XI-A
8	Work with scientific community partners to understand longer-term trends in unmanageable environmental factors and their impacts on aquatic communities	institutional & civil society development alliance & partnership development	med high	XI
9	Increase personnel and expertise available for SGCN surveys/research through partnerships with other government agencies (including bordering states/provinces), universities, and conservation-minded NGO's	institutional & civil society development alliance & partnership development	med high	I, II, III, IV, V, VI, VII, VIII, IX, XI

*refers to the Lake Erie Habitat Conservation Threats in Table 35

6.14 Lake Erie Tributaries

Major Lake Erie tributaries (ODNR Division of Water)



6.14.1 Status

Stable to improving. Ohio Environmental Protection Agency (Ohio EPA) surveys indicate general improvement in the physical habitat, water quality, and biological communities of most of the streams in the Lake Erie watershed. Ohio's large rivers continue to show improvement as tracked over the last 20 years. The "100% full attainment by 2020" aquatic life goal statistic remains steady at 89.2% full attainment. Taken collectively since the 1980s, the quality of aquatic life in all of Ohio's large rivers has shown a remarkable improvement. Then, only 21% of the large rivers met water quality standards, increasing to 62% in the 1990s, to 89% today. Areas not meeting the standards have decreased from 79% in the 1980s to 38% in the 1990s to 11% today (Ohio EPA 2014a).

6.14.2 Description

In the upper third of Ohio, Lake Erie tributaries drain north across the 11,714 square mile Lake Erie watershed. The four largest tributaries include the Maumee River (drains 6,608 square miles), the Sandusky River (drains 1,420 square miles), the Cuyahoga River (drains 809 square miles), and the Grand River (drains 712 square miles). Tributary physical attributes, water quality, habitat, and biological communities tend to follow a west to east gradient across northern Ohio. This gradient results from geographical differences as well as changes in land use practices in the watersheds. The trend is from relatively flat watersheds dominated by agriculture in the west, to watersheds with more relief dominated by forests and urban/suburban land use in the east. Streams across this gradient reflect the impacts and impairments that result from land uses within the watershed.

Along Ohio's portion of the Lake Erie shoreline, 56 different streams empty directly into Lake Erie. From west to east, those tributary streams are: Halfway Creek, Ottawa River, Maumee River, Duck Creek, Swan Creek, Otter Creek, Wolf Creek, Cedar Creek, Crane Creek, Turtle Creek, Toussaint River, Lacarpe Creek, Portage River, Muddy Creek, Sandusky River, South Creek, Raccoon Creek, Pickerel Creek, Little Pickerel Creek, Cold Creek, Mills Creek, Pipe Creek, Plum Brook, Sawmill Creek, Huron River, Old Woman Creek, Cranberry Creek, Chapel Creek, Sugar Creek, Darby Creek, Sherod Creek, Vermilion River, Brownhelm Creek, Quarry Creek, Beaver Creek, Martin Run, Black River, Porter Creek, Cahoon Creek, Rocky River, Cuyahoga River, Doan Brook, Ninemile Creek, Euclid Creek, Chagrin River, Marsh Creek, Grand River, McKinley Creek, Big Creek, Wheeler Creek, Cowles Creek, Indian Creek, Red Brook, Ashtabula River, Conneaut Creek, and Turkey Creek (ODNR 2001).

Significant tributaries (watersheds >100 square miles) flowing directly into Lake Erie include the Ottawa River, Maumee River, Toussaint River, Portage River, Sandusky River, Huron River, Vermilion River, Black River, Rocky River, Cuyahoga River, Chagrin River, Grand River, Ashtabula River, and Conneaut Creek. A brief description of the habitat, water quality, and biological communities for each of these tributaries follows.

6.14.2.1 Ottawa River

The following information was assembled from *Biological and Water Quality Study of the Ottawa River Lower Nine Miles* (Ohio EPA 2007b) and *Biological and Water Quality Study of the Ottawa River and Principal Tributaries, 2010* (Ohio EPA 2013a).

The Ottawa River watershed is located in northwestern Ohio and drains into Maumee Bay in Lucas County. The 221 square mile watershed of the Ottawa River spans both sides of the Michigan-Ohio border. The western portion of the watershed is primarily crop land, while the eastern portion is almost entirely urban development. The watershed occupies two distinct ecoregions - the Eastern Corn Belt Plain (ECBP) and the Huron-Erie Lake Plains (HELP). The transition to the HELP ecoregion from the ECBP ecoregion occurs approximately at RM 17.5 on the Ottawa River mainstem.

The leading cause and source of aquatic life use impairments in the upper Ottawa River mainstem is nutrient enrichment/eutrophication from nonpoint source inputs (tile discharged to modified tributaries or surface runoff). In lower reaches of the Ottawa, the main causes of impairment are nutrient enrichment and organic enrichment from urban sewer overflow inputs, and municipal and industrial discharges. Recent surveys by the Ohio EPA however, indicate that pollution abatement efforts to date have yielded water quality improvements, and indicate that the Ottawa River has entered a phase of strong environmental recovery.

As measured by the Qualitative Habitat Evaluation Index (QHEI), the quality of near and in-stream macrohabitat throughout most of the Ottawa River appeared capable of supporting diverse, functionally organized, and well-structured assemblages of aquatic organisms, consistent with its respective ecoregional ECBP and HELP benchmarks. Most areas contain a complement of positive channel, substrate and riparian features at least minimally compatible with the river‘s Warmwater Habitat (WWH) aquatic life-use designation. However, conditions are not uniform, and the Ottawa River mainstem consists of a patchwork of high to moderate quality free-flowing reaches found largely within the rural portions of the ECBP, and lower quality channel with modified and/or impounded segments within the HELP ecoregion and the greater Lima area.

The river exists in a relatively natural or unmodified state upstream from Lima. Macrohabitat quality and resulting QHEI scores fall sharply as the Ottawa River enters the greater Lima area. Habitat quality metrics point to a predominance of modified features including historic channel modification, impoundment, and sedimentation. Progressing downstream into the heart of urban/industrial Lima, the Ottawa River enters a series of five dam pools contained within an approximately three mile river reach. Leaving the urban center of Lima, the Ottawa River is again free flowing and continues so for approximately ten river miles. Habitat metrics indicate WWH potential through this stretch, despite ample evidence of past channel modification. Before entering the lake plain proper (HELP ecoregion), the Ottawa River flows through approximately nine miles of lacustrine deposits contained in the ECBP ecoregion where stream gradient drops precipitously in comparison to upstream reaches. Habitat metrics reflect the change in topography and associated steam characteristics, but despite reduced stream power and diminished macrohabitat quality, most QHEI values remained within the WWH range. The lower 17 miles of the Ottawa River are contained within the HELP ecoregion. Gradients are further reduced through this segment and are typically half of that observed within the free-flowing reaches within the ECBP ecoregion. The increase in the level of sedimentation and diminishing channel form and function (through the loss of stream power) resulted in reduced QHEI scores for this stretch of river.

Ohio EPA surveys from 2010 indicated that about 76% (linear stream miles) of the mainstem were found to support an assemblage of fish at least minimally consistent with WWH biocriteria. The remaining 24.3% failed to support WWH assemblages; however, the magnitude of the departure was not great, as

community performance below the fair range was not observed. Compared against historical results, common stations in nearly every instance supported richer communities and a greater number of environmentally sensitive taxa in 2010.

Fifty fish species and four hybrids were collected from the Ottawa River during 2010 Ohio EPA surveys. Numerically predominant species were bluntnose minnow (33.7%), greenside darter/longear sunfish (~7.0%), white sucker/redfin shiner (~5.0%), and central stoneroller/spotfin shiner/bluegill sunfish (~4%). In terms of relative biomass, dominant species were common carp (25.3%), white sucker (17.6%), golden redhorse (8.5%), smallmouth bass (6.2%), and rock bass/channel catfish (5.2%). Over a quarter of the community, measured in terms of numerical abundance and biomass, was concentrated in two highly tolerant and ecological generalist species - bluntnose minnow and common carp, respectively. Nearly 47% of all fish and 51% of total fish biomass collected from the mainstem were pollution tolerant taxa. State listed species included only the greater redhorse. Other intolerant, rare, declining or otherwise ecologically significant species included mimic shiner and stonecat madtom.

The macroinvertebrate community in the Ottawa River mainstem was also assessed in the 2010 survey. Twenty-one of 26 Ottawa River mainstem survey sample sites (81%) attained the designated WWH aquatic life-use criterion. During this survey, the Ottawa River reach upstream from Lima and the lower 28.8 river miles of the Ottawa River mainstem met the WWH macroinvertebrate ecoregional biological performance criteria. The Invertebrate Community Index (ICI) scores attaining WWH status from the 2010 survey ranged from good to exceptional.

6.14.2.2 Maumee River

The following information was assembled from *Total Maximum Daily Loads for the Maumee River (lower) Tributaries and Lake Erie Tributaries Watershed* (Ohio EPA 2012e) and *Western Lake Erie Basin Study Upper Maumee Watershed Assessment* (U.S. Army Corps of Engineers 2009), except where otherwise noted.

The Maumee River is the largest tributary in the Great Lakes basin, draining all or part of 17 Ohio counties, five Indiana counties, and two Michigan counties. The entire watershed covers 8,316 square miles. The mainstem of the Maumee River is approximately 140 miles in length, the downstream 105 miles of which lie in Ohio. The Maumee drains a total of 5,024 square miles in Ohio before it empties into Lake Erie (Maumee Bay) at Toledo (Maumee RAP 2006).

The watershed is predominantly comprised of cultivated crops with some urban development, hay and pasture lands, and forest. The watershed covers a combination of Huron-Erie Lake Plain and Indiana and Ohio Till Plain ecoregions. The topography ranges from gently sloping glacial till plain to nearly level broad lake plains with some beach ridges and lower moraines. The gradient of the Maumee averages between 1-5 feet per mile throughout its length.

The 43-mile portion of the Maumee River extending from the Indiana/Ohio border to the Ohio Route 24 bridge (RM 68) near Defiance is designated as a State Scenic River. An additional 53 mile segment is designated as a State Recreational River from about RM 68 to RM 15. These two designated areas have special restrictions on development, permitted discharge, etc. within them. The lower 22.8 miles of the Maumee River is included in the Maumee River Area of Concern (Maumee RAP 2006).

The entire length of the Maumee River (in Ohio) has not been completely assessed since 1997. Ohio EPA surveys from the 1990's revealed that only about half of mainstem sites sampled met Warmwater Habitat (WWH) aquatic life-use criteria. Agricultural practices, stream channelization, and urbanization contributed to the loss and/or degredation of many landscape features that once attenuated flows, provided detention, and retained sediment. In general, negative impacts from agriculture are more prevalent in the upper Maumee River, while the effects of urbanization manifest themselves more so in the lower portion of the river.

Of note for the lower portion of the Maumee River is the fact that it supports a significant spring run of spawning walleyes and serves as important spawning habitat for a number of Lake Erie species. A more

detailed discussion of the Maumee River watershed is provided in Lake Erie Tributaries Conservation Opportunity Watersheds later in this section.

6.14.2.3 Toussaint River

The following information was assembled from *Biological and Water Quality Study of the Toussaint River and Rusha Creek Basins* (Ohio EPA 2005a) and *Total Maximum Daily Loads for the Toussaint River Watershed* (Ohio EPA 2006d).

The Toussaint River is a tributary to western Lake Erie, draining 143 square miles in Wood, Ottawa, and Sandusky counties.The mainstem of the river is 37 miles long and empties into Lake Erie in Ottawa County. Upstream from its confluence with Packer Creek, the Toussaint has historically been considered a creek. The Toussaint widens as it reaches lake elevation where the riverine habitat is affected by the intrusion of water levels from Lake Erie.

The watershed is located entirely in the Huron-Erie Lake Plains (HELP) ecoregion. The HELP ecoregion is a broad, fertile, nearly flat plain. Most of the area has been cleared and artificially drained for agricultural crop production. Stream habitat and water quality have been degraded by channelization and agricultural activities. Landcover data from 2003 show the watershed contains mixed row crops/open space/yards (56%), cultivated crop land (9%), forest (12%), developed land (11%), and grassland (8%).

Habitat (QHEI) scores for the Toussaint watershed indicate that the majority of very poor habitat areas are found in small tributary streams. Agricultural practices, including riparian cover removal, channelization, and dredging, as well as nutrient enrichment and siltation, have resulted in a degradation of available habitat to instream biological communities. Habitat quality modestly improves as drainage area increases, but in general, the highly modified conditions present throughout the majority of the watershed have resulted in a reduction in diversity and numbers of aquatic species.

2003 surveys of the resident fish community by the Ohio EPA produced a total of 18,076 fish, consisting of 46 species and 7 hybrids. No endangered or threatened species were collected during the sampling effort, though five moderately intolerant species, including smallmouth bass, brook silverside, sand shiner, logperch darter and greenside darter, were collected. Numerically predominant were tolerant fish species including bluntnose minnow (18.6%), fathead minnow (13.1%), and stoneroller minnow (10.6%). Species that dominated in biomass included common carp (52.9%), creek chub (7.5%) and largemouth bass (3.8%).

A total of 208 separate macroinvertebrate taxa were collected in the Toussaint watershed during 2003 sampling. Moderately intolerant or sensitive taxa comprised 27% of the total taxa collected. Pollution-tolerant taxa comprised approximately 22% of the total taxa collected. The lotic stream sites on Toussaint Creek mostly achieved the macroinvertebrate WWH biocriteria. Farther downstream, the lacustrine sites on the Toussaint River did not achieve minimum lacustrine performance expectations.

6.14.2.4 Portage River

The following information was assembled from *Biological and Water Quality Study of the Portage River Basin, Select Lake Erie Tributaries, and Select Maumee River Tributaries, 2006 - 2008* (Ohio EPA 2010a) and *Total Maximum Daily Loads for the Portage River Watershed* (Ohio EPA 2011c).

The Portage River is located in northwest Ohio, extending from headwaters near Findlay and Fostoria and emptying into Lake Erie at Port Clinton in Ottawa County. The watershed drains 585 square miles and encompasses parts of Wood, Hancock, Ottawa, Sandusky, and Seneca counties. The Portage River is fed by four major tributaries, the North Branch, the Middle Branch, the South Branch and the East Branch. The lower 30 miles of river is characterized by a single channel that meanders to Lake Erie, with its final reach from Oak Harbor to Port Clinton essentially an estuary controlled by Lake Erie. The majority of the watershed is located in the Huron-Erie Lake Plain (HELP) Ecoregion. The most upstream portion of the East Branch Portage River lies within the Eastern Corn Belt Plains (ECBP) ecoregion.

There is little topographic relief in the watershed. The overall stream gradient averages less than three feet per mile. Drainage practices (primarily drainage ditches) which faciliatated agricultural activities led to alteration of the landscape. Row crop agriculture is by far the dominant land use accounting for over 76% of the total Portage River watershed area. Developed land amounts to about 11% of the total. Forest and wetlands constitute 5.5% and 2.3% of the total, respectively.

Ohio EPA sampling indicated forty percent of the sites on the Portage River mainstem did not meet standards for aquatic life uses. The tributary streams showed slightly lower quality with a 47% overall impairment rate. Within all of the study area, most of the water quality impairments could be linked to nonpoint sources such as fertilizer and manure runoff, sedimentation from agricultural crop production, and failing home sewage systems. Agricultural practices such as the habitat alteration, channelization/maintenance of streams and ditches, and the drainage of farm fields through subsurface tiles caused habitat and flow alteration impairments. The average habitat (QHEI) score for the watershed was towards the low end of the “fair” range. This low average score reflects the low habitat quality throughout the study area which is a direct result of extensive channel modifications.

A total of 96,207 fish representing 66 species were collected from the study area between June 2006 and October 2008. Three very sensitive species were collected, though twelve tolerant species, often in high numbers, were also collected throughout the study area. Portage River mainstem sites sampled during 2008 achieved the applicable Warmwater Habitat (WWH) fish biocriteria at 64% of the locations evaluated.

Macroinvertebrate communities reflected habitat and water quality throughout the watershed. In less impacted areas of the Portage River and tributaries, macroinvertebrate communities were evaluated as good to exceptional in terms of number of individuals and taxa. In more heavily impacted areas – generally tributary headwaters and the lacustrine area of the lower Portage – communities did not meet WWH status. Macroinvertebrate communities in these areas were characterized by lower numbers of individuals, reduced diversity, and dominated by pollution tolerant species.

Thirteen species of freshwater mussels (Unionidae) were collected live or fresh-dead from the Portage River watershed. State listed species collected in this watershed were *Truncilla donaciformis* (Fawnsfoot-Threatened Species) from the Portage River, *Truncilla truncata* (Deertoe-Species of Concern) from the Portage River and Middle Branch Portage River, and *Uniomerus tetralasmus* (Pondhorn-Threatened Species) from the North Branch Portage River. The collection of *Uniomerus tetralasmus* during this study was the first time that species was recorded in the Portage River watershed.

6.14.2.5 Sandusky River

The following information was assembled from *Biological and Water Quality Study of the Sandusky River and Selected Tributaries 2001* (Ohio EPA 2003b), *Biological and Water Quality Study of the Lower Sandusky River Watershed 2009* (Ohio EPA 2011a), and *Total Maximum Daily Loads for the Sandusky River (lower) and Bay Tributaries Watershed* (Ohio EPA 2014b).

The Sandusky River drains 1,850 square miles from 12 counties in northwest Ohio before emptying into Lake Erie at Sandusky Bay. The Sandusky River mainstem is 133 miles long. The upper two-thirds of the river are relatively flat, characterized by broken ridges which are representative of end moraines deposited by glaciers. The northern one-third is flat to gently rolling and is characterized by shorelines from ancient lakes formed as glaciers receded. The Sandusky basin straddles the Eastern Corn Belt Plains (ECBP) ecoregion and Huron/Erie Lake Plain (HELP) ecoregion. Land use in the watershed is approximately 75% row crops, 10% developed land, 9% forest, 3% grassland/pasture/hay, and 2% wetlands. Approximately 70 miles of the Sandusky River between Upper Sandusky and Fremont is designated as a state scenic river.

The Sandusky basin, like other watersheds in north-central and northwest Ohio, is dominated by agricultural land use, including both cultivated row crops and pasture land for livestock grazing. Agricultural drain tiles were installed in the Sandusky basin to lower the water table for crop production and channels and ditches were installed to efficiently route water. Both practices significantly affect the

hydrology of the region and affect the water quality of the streams due to rapid delivery of excess nutrients. This area, along with other agricultural areas in northwestern Ohio, represents some of the most intensively tile-drained crop land in the United States.

The lower portion of the Sandusky River mainstem and small direct tributaries to Sandusky Bay and Lake Erie are lacustrine, meaning that waters from the streams and Lake Erie mix within an estuary. These lacustrine areas are slack water that can ebb and flow as lake seiches affect water levels, and are generally located between the farthest downstream riffle of the tributary and Lake Erie proper.

Ohio EPA sampled 21 sites on the upper Sandusky mainstem during 2001. Habitat, as reflected by QHEI scores generally met the Warmwater Habitat (WWH) minimum criteria at all sites. In terms of WWH aquatic life use, 66% of sites met minimal aquatic life use criteria, 24% were in partial attainment, and the remaining 10% did not meet minimum WWH criteria. Index of Biotic Integrity (IBI) scores met WWH criteria for fish communities at 71% of sites, and Modified Index of Well-being (MIwb) scores indicated healthy fish communities at 57% of sites. Macroinvertebrate communities achieved the minimum ICI scores for WWH at 85% of sites sampled. Health of biotic communities generally improved in a downstream direction on this section of the Sandusky mainstem.

Impediments to full attainment of designated aquatic life uses within the assessment area can be largely attributed to agricultural practices within the watershed. Sedimentation and substrate embeddedness were the most common impacts where aquatic life use attainment was not fully met. The channelizing of streams, removal of riparian trees, and field tiling to facilitate drainage have reduced the volume of water present during dry weather periods.

On the lower Sandusky River mainstem, the free-flowing reaches generally had good habitat and water quality. Of 18 sites sampled on the lower mainstem – 66% were in full attainment of WWH aquatic life use criteria, 6% were in partial attainment, and 28% were in non-attainment. The Sandusky River mainstem from Tymochtee Creek to Wolf Creek is impaired by sedimentation. Sources are individually permitted point sources, storm water from developed land, failing home septic systems, and agriculture. Model results indicate that the dominant source of sediment load is cultivated cropland (96%). The Sandusky mainstem from Wolf Creek to the mouth is impaired by sedimentation/siltation, nutrient/eutrophication, substrate embeddedness, and direct habitat alteration. The sources of pollutant loads are individually permitted point sources, storm water from developed land, failing home septic systems, and agriculture. Again, model results indicate that the dominant source of loading is cultivated cropland: 95% of total phosphorus loads, ~69% of nitrate/nitrite loads, and ~93% of sediment loads.

A more detailed discussion of the Sandusky River watershed is provided in the Lake Erie Tributaries Conservation Opportunity Watersheds later in this section.

6.14.2.6 Huron River

The following information was assembled from *Total Maximum Daily Loads for the Huron River Watershed* (Ohio EPA 2005b) except where otherwise noted.

The Huron River watershed is located on the south shore of Lake Erie between Toledo and Cleveland, in Huron, Erie, Seneca, Richland and Crawford counties. The Huron River is 59.7 miles long and drains 403 square miles. Land cover is primarily agricultural with approximately 74% cropland, 15% woodland, and 3-11% urban and other land uses.

Headwaters of the Huron River gather along the Fort Wayne and Defiance Moraines. The West Branch and East Branch of the Huron River flow relatively close to each other throughout much of the basin. From the confluence of West Branch and East Branch just west of Milan, the Huron River flows about 14 stream miles across the Lake Plain to its mouth in Lake Erie at Huron (Shiefer 2002).

The Huron River watershed spans the Eastern Corn Belt Plains (ECBP) and the Erie-Ontario Drift and Lake Plain (EODLP) ecoregions. The ECBP ecoregion is a rich agricultural area that covers approximately 70% of the watershed. Extensive grain and livestock production occurs in this ecoregion.

The turbid, low gradient streams in the ECBP ecoregion generally do not support exceptional fish communities. The EODLP ecoregion is a nearly level coastal strip of lacustrine deposits, and urban and industrial land use is more prevalent in this region of the Huron River watershed.

Despite the increase in conservation tillage practices on agricultural lands in recent years, the Huron River remains as having among the highest suspended sediment yields in the state of Ohio, and the second highest in the Lake Erie Basin. Many small streams have been channelized to assist drainage in the level, poorly drained soils of Huron and Seneca counties. With the exception of municipal sources, biological and water quality impairment in the Huron basin was most often associated with agricultural land use. The most common causes of impairment in these areas are siltation, channelization, and/or nutrient enrichment.

Despite past water quality issues, a 2002 Ohio EPA biological and water quality survey of the Huron River watershed found significant improvement in portions of the basin, particularly in the East and West Branches. Excluding the lacustrine segment, the Huron River mainstem and most of the East Branch and the West Branch are now in full attainment of Warmwater Habitat (WWH) aquatic life-use criteria. Approximately 80% of the over 80 free-flowing river miles in the mainstem and major branches met WWH criteria in 2002. With the exception of a few stream segments, fish and macroinvertebrate community performance was generally in the good to exceptional ranges. Not coincidentally, areas of high biological performance also tended to have intact physical habitats and riparian corridors. Based on QHEI habitat scores, attaining segments in the mainstem and major branches had good to exceptional physical habitat quality.

6.14.2.7 Vermilion River

The following information was assembled from *Biological and Water Quality Study of the Vermilion River, Old Woman Creek, Chappel Creek, Sugar Creek, and Select Lake Erie Tributaries 2002* (Ohio EPA 2004a), and *Total Maximum Daily Loads for the Vermilion River Watershed* (Ohio EPA 2005c).

The Vermilion River is 66.9 miles long and drains 269 square miles in north-central Ohio as it flows through Ashland, Erie, Huron, Lorain and Richland counties before emptying into Lake Erie at Vermilion. The predominant land cover within the Vermilion River basin is agriculture (72.8%) and forest (25.3%), with wetlands, open water, and urban areas accounting for the remaining 1.9%.

The upper portion of Vermilion River and its tributaries originate in the Erie-Ontario Drift and Lake Plain (EODLP) ecoregion consisting of low rolling hills and end moraines blanketed with low line drift and lacustrine deposits. The mid-section of the watershed in Erie, Huron and Lorain counties flows through the Eastern Corn Belt Plains (ECPB) ecoregion which is characterized by rolling till plains and end moraines. The lower portion of the watershed is located in the EODLP ecoregion, characterized by nearly level coastal lacustrine land with beach ridges and swales.

In a 2002 assessment by the Ohio EPA, habitat in the Vermilion mainstem and branches generally met Warmwater Habitat (WWH) criteria based upon QHEI scores. Sampling locations in the Vermilion mainstem and upper branches achieved minimum WWH criteria at 83% and 87% of sites, respectively. In the Vermilion watershed, most of the sites not meeting the QHEI habitat targets have drainage areas less than 30 square miles. QHEI scores tended to increase with drainage area for stream segments in the watershed. Primary causes of impairment were excess nutrients, siltation, and habitat and flow alteration. Similar to other watersheds in northwestern and north central Ohio, agriculture's influence on headwater and smaller tributary streams is reflected in the causes of impairment. The biological communities present in the headwater streams typically do not meet WWH criteria due to the historical and current habitat alterations, channelization, and nutrient enrichment.

A total of 26,103 fish, comprising 57 species and 4 hybrids were collected throughout the Vermilion basin during the 2002 Ohio EPA study. No endangered or threatened species were collected, though several intolerant species including the black redhorse, river chub, bigeye chub, silver shiner, rosyface shiner, mimic shiner and stonecat madtom were collected. Numerically predominant fish species included bluntnose minnows (18.2%), creek chub (15%), and stoneroller minnow (10.9%). Species that dominated

in biomass included common carp (32.5%), rock bass (10.9%), golden redhorse (8.7%), and white sucker (8.5%).

The fish community index for the upper Vermilion River ranged between very good and fair – the index improved in a downstream direction as sinuosity and stream cover improved. The fish community index for the middle portion of the Vermilion ranged between good and excellent. The higher quality fish assemblage found here was due to more natural stream conditions which offered diverse substrates, increased sinuosity, and high quality stream cover. The fish community index for the lower Vermilion ranged between good and excellent at sites outside of the lacustrine area. The lacustrine site index was fair to poor due to high percentage of exotic species and tolerant species. The lacustrine portion of the mainstem has exhibited poor biological performance from both fish and macroinvertebrate communities over time. The lacustrine area acts as a sink for silt and nutrients generated from upstream agricultural and development activities. In addition, the mouth of the mainstem is maintained for navigational purposes for both commercial and recreational use.

Uppermost sites on the Vermilion River reflected an improving trend in the condition of the macroinvertebrate community with increasing drainage area. Macroinvertebrate communities sampled in the majority of sites in the lotic portion of the Vermilion met WWH criteria. Impounded areas of the Vermilion supported lower diversity of macroinvertebrate fauna. Lacustrine sites also supported limited macroinvertebrate fauna. About half of the upstream tributaries in the watershed supported macroinvertebrate communities with indexes of marginally good to good. In the lower portion of the watershed about two-thirds of the macroinvertebrate communities met WWH criteria.

6.14.2.8 Black River

The following information was assembled from *Biological and Water Quality Study of The Black River Basin* (1999b), and *Total Maximum Daily Loads for the Black River Watershed* (Ohio EPA 2008) except where otherwise noted.

The Black River drains a 470 square mile watershed in Ashland, Huron, Medina, Cuyahoga and Lorain counties before emptying into Lake Erie in the City of Lorain. The East and West branches are about 42 and 30 miles long, respectively. The Black River watershed lies entirely within the Erie-Ontario Drift and Lake Plain (EODLP) ecoregion. The EODLP ecoregion is characterized by gently rolling plains from previous glaciation, unconsolidated glacial deposits, sandstone and shale bedrock, and glacial end moraines.

Headwaters of the Black River gather along the Defiance Moraine. The two main branches of the river, East Branch and West Branch, join at Elyria. From the confluence of East Branch and West Branch, the Black River flows about 16 stream miles to its mouth in Lake Erie at Lorain (Shiefer 2002).

Prominent land cover in the Black River watershed is 44% cropland, 25% forest, 18% residential/urban development, and 8% pasture. The subbasins of the greater Black River watershed exhibit distinctly different characters. The Black River mainstem area is urban and industrial in nature. In the French Creek sub-basin and the eastern areas of the northern East Branch, rapid suburban development is altering the formerly agricultural landscape. The southern regions of the watershed remain predominantly rural and agricultural, although extensive development has occurred in and around the Lodi area.

Because of a legacy of environmental impacts to water and habitat quality, the Black River was designated as a Great Lakes Area of Concern (AOC) and a remedial action plan (RAP) has been in place. Unique and diverse communities of fish, mussels and aquatic insects live in the streams of the Black River watershed, but recent studies confirm degraded water quality and stream habitat. In the agricultural upper watershed areas, the modification of stream channels (for drainage improvement), failing home sewage treatment facilities, and row crop/livestock production have resulted in habitat degradation, sedimentation, and high nutrient and pathogen loadings. In the Black River mainstem, major municipal and industrial discharges, combined sewer overflows, and urban runoff result in high nutrient and organic loads, poor habitat quality, siltation, and low dissolved oxygen concentrations. Among the most visible threats to the Black River today is the conversion of farm, forest and stream bank acreage to

suburban and commercial uses. Portions of the Black River watershed are experiencing unprecedented development. Ohio EPA studies of the overall watershed showed that 37% of sampled sites were meeting water quality goals, 30% were partially meeting the goals, and 38% were not meeting goals.

The free flowing reach of the Black River mainstem contains excellent habitat. The sinuous free flowing river combined with glacial tills and woody debris provide for habitat complexity, heterogeneity of the substrates, and good channel development. Habitat in the East Branch of the Black River is impacted by agriculture and encroachment into riparian areas – but despite these impacts, the habitat was sufficient to support warmwater communities. Habitat (QHEI) scores for West Branch sites were low.

Fish communities in the free flowing portion of the Black River mainstem have improved over time. The number of darter and sucker species, while improving slightly compared to previous surveys, remained below expectations. The absence of intolerant species, and the low numbers of darter and sucker species is a legacy of prior point source pollution, and an indication of continued watershed-scale habitat impairment. Nearly all sites sampled in the Black River lacustrine area remain in the poor to very poor range of Index of Biotic Integrity (IBI) scores. Some slight improvement was observed in the stream segment associated with contaminated sediment removal (from USS/Kobe outfalls), but IBI scores are still poor. This area as well as the rest of the lacustrine area remains strongly influenced by nutrient enrichment derived from point sources and nonpoint pollution. Within a mile of Lake Erie, the influx of cleaner water low in nutrients from the lake has created conditions more favorable to healthy fish communities. Nearer the lake, fish communities remain poor in response to habitat loss in the navigation channel. The Black River from approximately river mile 2.8 to Lake Erie is periodically dredged to support its use as a navigation channel. Vertical sheet piling and cement sea walls provide little habitat for fish.

As with the Black River mainstem, the legacy of nonpoint pollution and habitat degradation in the East Branch was evident in the absence of intolerant fish species, and low numbers of darter and sucker species. Habitat and water quality issues also limited fish communities in the West Branch. Macroinvertebrate communities in the Black River upstream from the Lake Erie lacustrine area were in the good to exceptional range in the 1997 study, but communities in the lacustrine area (below RM 5.6) scored below lacustrine criteria. In the East Branch, macroinvertebrate communities were very good to exceptional at all sites sampled.

6.14.2.9 Rocky River

The following information was assembled from *Biological and Water Quality Study of the Rocky River and Selected Tributaries* (Ohio EPA 1999c), and *Total Maximum Daily Loads for the Rocky River Basin* (Ohio EPA 2001) except where otherwise noted.

The Rocky River watershed drains a total of 265 square miles in all or parts of Cuyahoga, Summit, Medina, and Lorain Counties in northeastern Ohio. The Rocky empties into Lake Erie on the west side of Cleveland. Land cover within the watershed is primarily a mix of forest (44%), agriculture (40%), and urban areas (14%). The northern portion of the watershed is predominantly urban, while the southern half is dominated by forest and agriculture.

The Rocky River gathers headwaters in the hilly moraines that cross through Medina County into southern parts of Cuyahoga County. West Branch of the Rocky River originates south of Medina in the Wabash Moraine and flows through the Defiance Moraine along a northward course. East Branch of the Rocky River originates along the distal side of the Defiance Moraine in southern Cuyahoga County and flows southward to the Fort Wayne Moraine where it reverses course and flows back northward through the Defiance Moraine to its confluence with West Branch just north of Berea. From the confluence of East Branch and West Branch, the Rocky River flows about 12 stream miles to its mouth in Lake Erie on the west side of Cleveland (Shiefer 2002).

The watershed is located in the Erie-Ontario Drift and Lake Plain (EODLP) ecoregion. The EODLP ecoregion is characterized by northern hardwood vegetation (maple, birch, beech, hemlock) and glacial plains interspersed with high remnant beach ridges, drumlins, glacial till ridges, till plains, and outwash terraces. The Rocky River basin is a flat plateau with extremely narrow and dissected canyons.

The mainstem of the Rocky River is protected by the Cleveland Metroparks for almost its entire length. However, the area surrounding the metropark is heavily urbanized. For much of its mainstem, the Rocky River is fairly shallow and free flowing with good velocity and a fractured bedrock substrate. The mouth of the river has been modified to accommodate boating – Rocky River Harbor consists of the lower 4,200 feet of Rocky River.

Based on the performance of the biological communities, 71% of the surveyed reach of the Rocky River mainstem, including the lacustrine zone (the portion influenced by Lake Erie) were in partial attainment of the designated aquatic life use. The remaining 29% was in non-attainment. Attainment status, where both fish and invertebrates were sampled, was largely determined by the performance of the fish assemblage. While the macroinvertebrates at least marginally achieved ecoregional criteria, one or both fish indices (IBI and MIwb) performed at a fair to poor level throughout the mainstem.

The East and West branches of the Rocky River were assessed in 1997. Full attainment of Warmwater Habitat (WWH) aquatic life use was achieved for 66% of the East Branch and 70% of the West Branch. The remaining surveyed stretches of both branches partially met the designated aquatic life use. Departure from the WWH biocriteria was driven solely by fair fish community performance in both branches, as the macroinvertebrate community consistently exceeded ecoregional criteria. The North Branch of the Rocky River supported diverse biological communities, including good numbers of pollution sensitive taxa, and was found to be in full attainment of the WWH aquatic life use.

More recent studies of the Rocky mainstem and East Branch (Northeast Ohio Regional Sewer District 2012, 2013) indicated that habitat (QHEI scores), fish community (MIwb and IBI scores), and the macroinvertebrate community (ICI scores) met warmwater habitat aquatic life use criteria. Data collected was minimal compared to the previously referenced Ohio EPA studies, but suggests improvement in the water quality, habitat, and biological communities of the Rocky River in recent years.

6.14.2.10 Cuyahoga River

The following information was assembled from *Total Maximum Daily Loads for the Middle Cuyahoga River* (Ohio EPA 2000), *Total Maximum Daily Loads for the Lower Cuyahoga River* (Ohio EPA 2003a), and *Total Maximum Daily Loads for the Upper Cuyahoga River* (2004b).

The Cuyahoga River is 84.9 miles long and drains 813 square miles in Geauga, Portage, Summit and Cuyahoga counties before emptying into Lake Erie at Cleveland. The river is one of the few rivers in the world that changes flow direction and creates a u-shaped watershed. The basin is situated within the Erie-Ontario Drift and Lake Plain (EODLP) ecoregion, characterized by glacial formations that can have a significant local relief of up to 300 feet and exhibits a mosaic of cropland, pasture, woodland, and urban areas. Land use patterns vary greatly from the upper basin that is primarily forest/agricultural/rural, to the lower basin which is among the most densely populated and industrialized urban areas in the state. The Cuyahoga River, from the Ohio Edison Dam to the mouth and the nearshore area has been identified as an Area of Concern (AOC) by the International Joint Commission.

Upper River

The upper Cuyahoga River flows through Geauga and Portage counties. This portion of the watershed is predominately rural in nature with significant amounts of wetlands. Based on Ohio EPA's monitoring, a number of water bodies within this watershed appear on Ohio's list of impaired waters. The Ohio EPA identified the upper Cuyahoga River watershed as a priority impaired water in 2002. The primary causes of impairment in the upper Cuyahoga River watershed are hydromodification, nutrient enrichment, low dissolved oxygen, and habitat degradation.

Among mainstem stations evaluated within the upper Cuyahoga River, only 33% were found to support an assemblage of fish fully attaining the Warmwater Habitat (WWH) aquatic life use designation. The majority of the stream reaches in this segment were characterized by low stream gradient, historic channel modification, hydromodification, and influences from extensive natural wetland complexes. Fish and macroinvertebrate communities were in non and partial attainment of WWH in the upper reaches of

the mainstem downstream from East Branch reservoir. The stream reaches upstream from East Branch reservoir were found to be fully attaining Ohio's WWH biocriteria.

Much of the West Branch of the Cuyahoga is a low gradient swamp-marsh influenced stream with attendant habitat limitations, and consequently the fish community is limited by the habitat. Despite these limitations, excellent habitat features are present owing to light development in the watershed, and as a result, biological community health throughout most of the West Branch was quite good.

Middle River
The middle Cuyahoga River watershed covers portions of Portage, Summit and Stark Counties. The middle Cuyahoga River mainstem has been identified as a priority impaired water on Ohio's list of impaired waters. Biological and chemical stream surveys from 1989 through 1998 indicated that habitat alteration, excessive nutrient levels, and low dissolved oxygen were the primary causes of impairment in this stream segment. Index of Biotic Integrity (IBI) scores decrease downstream from Lake Rockwell relative to the free-flowing reach upstream primarily because the river is impounded, causing habitat loss and resulting in an increase in the relative abundance of tolerant fishes. Modified Index of Well-being (MIwb) scores also decreased in the reach downstream from Lake Rockwell. Consequently, neither fish index met the respective WWH criterion. The invertebrate community, being less dependent on habitat, was found to be in better condition than the fish community.

Lower River
The Lower Cuyahoga River watershed flows through Summit and Cuyahoga counties before emptying into Lake Erie. Historical pollution has occurred in this section of the river as a result of heavy industrial and urban centers located between the cities of Akron and Cleveland. Based on Ohio EPA's monitoring of the Lower Cuyahoga River watershed, a number of streams appear on Ohio's list of impaired waters. Organic enrichment, nutrients, bacteria, flow alteration, toxicity, and degraded habitats are cited as the primary causes of impairment. Physical habitat attributes in most of the mainstem and tributaries are generally of high quality and typically include natural stream channels, coarse substrates and wooded riparian corridors.

Biological impairment in the Cuyahoga River downstream from Akron was manifest most strongly in the fish. Fish communities were poor or very poor at nearly all sites between Akron and Cleveland. Both fish and macroinvertebrate communities were in the fair to very poor ranges downstream from the Akron. In contrast to the fish communities, macroinvertebrates gradually improved and reached very good to exceptional quality upstream from Cleveland. Biological community health declined below Akron but year 2000 results showed significant improvement over past surveys.

Sampling downstream from Tinkers Creek found the first Full attainment of WWH ever recorded by Ohio EPA in the Cuyahoga River downstream from Akron. Full attainment is believed to extend downstream to the confluence with Mill Creek. Downstream of Mill Creek the fish communities declined to the poor range. Fish improved to fair downstream from Southerly resulting in partial attainment.

The lower section of the Cuyahoga River contains a navigation channel. Ohio EPA sampling indicates that adult fish are able to utilize the navigation channel for passage upstream to suitable habitat. Cumulative loadings and flows from steel plant outfalls make it one of the largest point source discharges in the Cuyahoga River basin. Poor and very poor biological communities coincide with the lack of suitable habitat, low dissolved oxygen, and chronically elevated ammonia and zinc levels between the steel plant and Lake Erie.

A more detailed discussion of the Cuyahoga River watershed is provided in the Lake Erie Tributaries Conservation Opportunity Watersheds later in this section.

6.14.2.11 Chagrin River
The following information was assembled from *Biological and Water Quality Study of the Chagrin River and Selected Tributaries 2003-04* (Ohio EPA 2006b), and *Total Maximum Daily Loads for the Chagrin River Watershed* (Ohio EPA 2007d).

The Chagrin River is located in northeast Ohio, flowing through Portage, Geauga, Cuyahoga, and Lake Counties on its way to Lake Erie. The Chagrin River watershed is located in the Erie-Ontario Drift and Lake Plain (EODLP), which is formerly glaciated and characterized by low rounded hills, scattered end moraines, kettles, and areas of wetlands. The resulting soils and geologic deposits contribute to the high quality and varied habitats of the watershed. The Main Branch of the Chagrin River begins as the Upper Main Branch above Bass Lake in Geauga County, and flows over 49 miles before entering Lake Erie in the City of Eastlake, comprising a drainage area of 267 square miles.

The Chagrin River is deeply entrenched over the lower 25 miles of its length and flows on bedrock in narrow valleys through much of the watershed. The southern portion of the watershed is a mixture of urban development, agricultural land uses, and forest. The southern and western portions of the watershed are predominantly comprised of urban development. Primary land cover in the basin is forest 65.4%, commercial/industrial/residential 21.2%, crops 7.6%, pasture/urban/recreational grasses 3.2%, and wetlands 1.2%.

The Aurora Branch, East Branch, and Chagrin mainstem are included in the State of Ohio Scenic River system. Seventy-one miles of streams in the watershed are designated as a Scenic Rivers. Stream impacts are generally noted in the tributary streams, while the main stem is generally meets aquatic life-use designation. Although the watershed is experiencing significant development pressure from Cleveland's population migration to outlying suburbs, the majority of the river retains its riparian forest cover. The river valley offers a diversity of terrestrial and aquatic plant communities, wildlife, unique rock outcroppings, and extensive headwater wetlands.

Overall, habitat quality in the Chagrin River watershed is very good. Of the sites assessed, only 7.1% failed to meet the QHEI Warmwater Habitat (WWH) score minimum. However, the Ohio EPA identified the Chagrin River as a priority impaired water on the 2004 and 2006 lists of impaired waters. Studies show that organic enrichment, nutrients, flow alteration, and degraded habitats are the primary causes of impairment. Stream surveys conducted in 2003 and 2004 found impairments for some biological communities.

Upper River

The upper reaches of the Chagrin River do not completely meet applicable biocriteria. Fish communities in the upstream-most (upper 7.5 miles) sampling locations were all degraded by direct channelization, and by removal of riparian habitat. Macroinvertebrate communities also show signs of impact, but most sites sampled met WWH biological criteria. The river recovers to full attainment downstream of the headwaters, and maintains full attainment to downstream from the Aurora Branch confluence. Several sites in this area demonstrate exceptional biological communities. The section between Dewdale Creek and the Aurora Branch contained a very good to exceptional macroinvertebrate community.

The Aurora Branch shows impairments of both fish and macroinvertebrate indices. The fish community showed an elevated relative abundance of pollution tolerant species and omnivores. The stream generally recovers to full attainment farther downstream. Ninety-three percent of macroinvertebrate samples collected in the Aurora Branch of the Chagrin River met their aquatic performance expectations. The Aurora Branch and its tributaries, despite having the highest combined intensity of agricultural and residential land use in the basin, generally had good to excellent habitat. Approximately two-thirds of the tributaries sampled in this part of the Chagrin basin are designated Coldwater Habitat (CWH). Where habitat is intact and stable, brook trout reintroductions have been successful in a number of small tributaries in the upper Chagrin and Aurora Branch subwatersheds.

Lower River

The entire lower mainstem of the Chagrin River is in full attainment of its life-use biocriteria. Habitat quality in the mainstem of the Chagrin River downstream from the confluence with the Aurora Branch is good to excellent, and possesses all the necessary attributes to fully support a diverse and robust fish community. Overall, the lower mainstem macroinvertebrate community quality was generally very good with Invertebrate Community Index (ICI) scores ranging from good to exceptional.

The East Branch Chagrin River, due to habitat and flow alterations declined in the upstream reaches and did not meet its designated CWH aquatic life use in the lower mainstem. The East Branch is unique among Ohio streams in that it harbors a strong population of longnose dace, a coolwater/coldwater fish species with the southern limit of its distribution in Northeast Ohio. Most sites sampled in the East Branch and its tributaries harbored fish communities that met numeric water quality standards for biological integrity. The strong population of longnose dace and the presence of numerous young-of-the-year steelhead trout in the mainstem and tributaries indicate that the East Branch continues to maintain its coldwater character. The macroinvertebrate community in the East Branch was rated exceptional in upstream areas, with a very good macroinvertebrate community present downstream. There are several small cold-water tributaries to the Chagrin River that serve as some of the few remaining streams supporting naturally reproducing brook trout in Ohio.

A more detailed discussion of the Chagrin River watershed is provided in the Lake Erie Tributaries Conservation Opportunity Watersheds later in this section.

6.14.2.12 Grand River

The following information was assembled from *Biological and Water Quality Study of the Grand River Basin 2003-2004* (Ohio EPA 2006c), Biological *and Water Quality Study of the Grand River Basin* (Ohio EPA 2009a), *Total Maximum Daily Loads for the Grand River (lower) Watershed* (Ohio EPA 2012c), and *Total Maximum Daily Loads for the Grand River (upper) Watershed* (Ohio EPA 2013b).

The Grand River is located in northeastern Ohio and drains a total of 707 square miles as it flows through all or part of Ashtabula, Geauga, Lake, Portage, and Trumbull counties. The watershed is a mixture of forest, agricultural land (crops, pasture, hay), and urban land. The Grand River basin is contained within the Erie-Ontario Drift and Lake Plain (EODLP) ecoregion. Portions of the 102.7 mile long Grand River have Wild and Scenic River designations.

Upper River

The upper Grand River flows through Ashtabula, Geauga, Portage and Trumbull counties and drains 418 square miles. Land cover in the upper Grand River watershed is dominated by forest (41.5%), cultivated crops and pasture lands (36.1%), and wetlands (8.9%). A large complex of wetlands is located near the center of the watershed, and forest and agricultural lands are spread throughout the watershed. Developed land (6.3%) is primarily located in the northern portion of the upper watershed.

The condition of biological communities in the upper Grand River basin is governed principally by post-glacial physiography. The dominant feature of the basin is the glacial lake-plain and lacustrine deposits which have essentially resulted in three classes of streams: lowland streams, upland headwaters, and the Grand River mainstem. Because the lowland streams are sluggish and have fine-grained substrates, they cannot in all cases be reasonably expected to support biological communities typical of the ecoregion. At the other extreme, some of the headwaters drain areas where bedrock is very close to the surface, and consequently, flow is not sustained through the summer because the shallow soil horizon does not store water. Apart from these natural limitations, some of the sites evaluated in the upper watershed were impacted by pollution or loss of habitat.

Non and partial attainment of aquatic life-use criteria in the watershed tended to result from natural conditions (flow or habitat), excess nutrients, and organic enrichment. Sixty-three percent of sites assessed within the watershed by the Ohio EPA fully attained water quality standards, 23% partially attained, and 14% were in non-attainment. Overall habitat QHEI scores ranged from fair to excellent in the headwaters of the Grand River subwatershed. Where the topography is flat, and the substrates are composed primarily of lacustrine silts and clays, habitat quality was generally poor and not conducive to stream faunas typical of the ecoregion. The headwaters on the western side tend to have high gradients, and possess the energy to form well-developed channels through coarse substrates. Typically, the faunas in these headwaters were not limited by habitat quality.

Within the headwaters area, the Grand River transitions rapidly from a small upland coldwater stream, to a large lowland swamp stream. Near the northern subwatershed boundary, the river begins to support a

fauna typical of larger streams and rivers including redhorse suckers and walleye. Fish communities were sampled at several locations along the Grand River mainstem. Headwater sites above RM 88.5 did not meet applicable standards, but fish communities met criteria for Warmwater Habitat (WWH) from RM 88.5 downstream to RM 48.6. Northern brook lamprey ammocoetes and sand darters were found in the Grand River near RM 88.5. Starting at RM 44.5 the Grand River is designated Exceptional Warmwater Habitat (EWH). Functionally, the fish community at the site represents one of the closest approximations Ohio has to an intact, lowland, large river fish fauna. No other river in Ohio has native, naturally reproducing populations of muskellunge, northern pike and walleye occurring together.

Macroinvertebrate communities collected from the three most upstream stations on the Grand River (above RM 94.3) were performing at an exceptional level with high diversity and sensitive taxa. The remaining Grand River sites were located in a lowland area with low gradient (glacial Grand River Lake lacustrine deposits). Macroinvertebrate communities at these stations were performing at good to exceptional levels, with generally lower diversity and sensitive taxa.

Lower River

The lower Grand River flows through Lake, Ashtabula and Geauga counties and drains 287 square miles. The river empties into Lake Erie at Painesville. The Grand River downstream from Mill Creek transitions from a low-gradient swamp stream to a higher-gradient bedrock stream. Land use in the lower Grand River watershed transitions from urban/suburban on the western edge to rural and agricultural in the eastern two-thirds. The watershed is a mixture of forest (43%), agricultural land (29%), and urban land (16%).

The character and physical habitat of the Grand River changes abruptly near RM 44.5 where the river makes its westward turn toward Lake County and its eventual union with Lake Erie. Upstream from RM 44.5 the river flows through the lacustrine deposits of a former glacial lake. There, the river is a classic swamp-wetland type stream with low gradient (<1 ft/mi), fine sediments (typically small gravels to clay), and few riffles. Consequently, large woody debris, rootwads, rootmats, undercut banks and deep pools characterize the habitat. The fish fauna in this reach very much resembles a swamp-stream association: trout-perch, silver redhorse, sunfish and blackside darters are common. The wetland environs also provide spawning habitat for the Great Lakes muskellunge and northern pike. A native population of walleye exists as well. In short, the habitat in this reach of the Grand River supports one of the few intact type-locality faunal assemblages found anywhere in Ohio.

Downstream from RM 44.5 the gradient increases and the river flows in a series of pools, glides, runs, and riffles through a shale gorge. Long stretches of shallow bedrock alternate with aggregations of glacial till to form glides and riffles, and deeper pools exist where the river erodes former depositional areas. Water quality in the river is protected by the shale gorge that the river flows through and the scouring flows that formed it – the steep bluffs and regular flooding generally preclude development within the floodplain. Habitat quality in this reach of the river is among the best anywhere in Ohio.

In 2003 and 2004, the Ohio EPA evaluated the biological health and water quality of the lower Grand River watershed. The results of that survey show that the Grand River and its tributaries continue to harbor a rich and diverse biological assemblage containing many rare and threatened species, and several state endangered species. Fish communities in the Grand River have an exceptionally high degree of biological integrity. This is evident in the consistently high Index of Biotic Integrity (IBI) scores along the length of the mainstem and in the unusually high percent composition of pollution intolerant species. The population of Great Lakes muskellunge subspecies (*Esox masquinongy masquinongy*) in the Grand River may well be a truly endemic strain. As it stands, it is the last naturally reproducing muskellunge population found in any of Ohio's Lake Erie tributaries.

Aquatic life in the Grand River is fully attaining standards for EWH from RM 42.2 to RM 5.2, and is fully meeting standards for WWH downstream from there. The entire free-flowing Grand River mainstem sampled in this study from RM 44.0 to 6.1 was supporting exceptional macroinvertebrate communities. High numbers of sensitive taxa and sensitive taxa diversity existed throughout this reach. In addition, three lacusturine stations scored high on the lacustrine Invertebrate Community Index (ICI). The free

flowing lower Grand River has maintained exceptional macroinvertebrate communities since the late 1980s. ICI scores and sensitive taxa diversity in 2004 were as high or higher than previous years.

Twenty-three sensitive taxa (excluding freshwater mussels) found in this assessment unit are noteworthy because they are not commonly collected in statewide collections. In addition to these, the state listed Species of Concern crayfish *Orconectes propinquus* (Great Lakes Crayfish) was collected at 19 of the 35 stations in this assessment unit. Seventeen species of freshwater mussels (Unionidae) were collected from the lower Grand River. In total, this study found two state endangered species, three state Threatened species, and four state Species of Concern to be present in the lower Grand River basin. This assessment unit had an unusually high number of uncommonly collected sensitive taxa and state listed species, which is an indication of the exceptional resource quality in the lower Grand River basin.

A more detailed discussion of the Grand River watershed is provided in the Lake Erie Tributaries Conservation Opportunity Watersheds later in this section.

6.14.2.13 Ashtabula River

The following information was assembled from *Biological and Water Quality Study of The Grand and Ashtabula River Basins including Arcola Creek, Cowles Creek and Conneaut Creek* (Ohio EPA 1997), *Biological Study of the Lower Ashtabula River and Conneaut Creek* (Ohio EPA 2006a), and *Fish Community Aquatic Life Use Attainment Study Upper Mainstem Ashtabula River, 2007* (Ohio EPA 2007c).

The Ashtabula River is a tributary to Lake Erie that drains an area of about 137 square miles. The majority of the watershed is contained within Ashtabula County in Ohio, with 8.91 square miles located in Pennsylvania. The mainstem of the Ashtabula River is 27.55 miles long, beginning at the confluence of the East and West Branches, and discharging into Lake Erie in the City of Ashtabula. The lacustrine portion (where water levels vary with the elevation of Lake Erie) of the Ashtabula River extends to river mile 2.5. The Ashtabula River mainstem has an average gradient of 11.6 feet per mile. The Ashtabula River watershed is located within the Erie-Ontario Drift and Lake Plain ecoregion (EODLP).

The southern portion of the watershed is a mixture of agricultural land and forest. The northern portion of the watershed includes some urban development near the Lake Erie shoreline. The Ashtabula River is designated a State Scenic River and has 46 continuous designated river miles on three stream segments including the mainstem (25 miles), East Branch (12 miles), and West Branch (9 miles).

Upper River

Habitat quality as assessed by the Qualitative Habitat Evaluation Index (QHEI) was found to be more than suitable to support the Warmwater Habitat (WWH) aquatic life use throughout the monitored reach. Land cover within the study area is dominated by forest and mixed agricultural uses. The riparian corridor along the Ashtabula River within the study area was almost completely forested.

Fish community assessments were conducted in 2007 along the upper reaches of the Ashtabula River mainstem in Ashtabula County to determine the attainment status for the WWH aquatic life use. Survey results for both the Index of Biotic Integrity (IBI) and the Modified Index of Well-being (MIwb) were in Full attainment of the ecoregional criteria for the fish community. A total of 24 fish species were collected during the survey. Most notable among the species collected were the northern bigeye chub and the northern mimic shiner. Both are listed as declining fish species in Ohio. Healthy populations of both species were found at all three sampling locations. In addition, all three sites supported robust populations of rock bass and smallmouth bass. The presence of larval sea lamprey in the Ashtabula River study area indicates that the river is breeding habitat for this invasive species. The 2007 survey of the upper portion of the Ashtabula River did not include an assessment of macroinvertebrate communities.

Lower River
The lower Ashtabula River empties into Lake Erie at Ashtabula, where the mouth and immediate upstream area have been modified to accommodate commercial shipping. The bottom sediments, bank soils, and biota of Ashtabula tributary Fields Brook (approximately RM 1.6) have been severely contaminated by unregulated discharges of hazardous substances. Hazardous substances have migrated downstream from Fields Brook to the Ashtabula River and Harbor, contaminating bottom sediments, fish, and wildlife. The lower two miles of the Ashtabula River and its outer harbor were designated an Area of Concern due to severe pollution problems by U.S. EPA in 1988.

Fish and macroinvertebrate communities were sampled in the lacustrine areas of the Ashtabula River during 2003 and 2005 by the Ohio EPA and U.S. Fish and Wildlife Service. Partial attainment of the interim lacustrine Index of Biotic Integrity (IBI) and Modified Index of Well-being (MIwb) biocriteria for fish was noted in the Ashtabula River at RM 1.3 during 2005. Lacustrine IBI scores were in the fair to good range, and MIwb scores were reflective of fair to good conditions. Fish species considered moderately to highly intolerant of pollution were collected in this lacustrine area – these included included silver redhorse, black redhorse, golden redhorse, smallmouth bass, brook silverside, and logperch.

In the lower Ashtabula River, the macroinvertebrate community was exceptional to good at the upstream sites, but in the vicinity of Fields Brook the macroinvertebrate community was poor to very poor. The macroinvertebrate community improved downstream and returned to good condition at the most downstream sampling location. The macroinvertebrate community is impaired within the area where Fields Brook flow mixes with the Ashtabula River.

6.14.2.14 Conneaut Creek
The following information was assembled from *Biological and Water Quality Study of The Grand and Ashtabula River Basins including Arcola Creek, Cowles Creek and Conneaut Creek* (Ohio EPA 1997), and *Biological Study of the Lower Ashtabula River and Conneaut Creek* (Ohio EPA 2006a).

The Conneaut Creek basin drains an area of 38 square miles in extreme northeast Ohio. The entire watershed, including the portion in Ohio, encompasses about 190 square miles. The Conneaut Creek mainstem originates south of Conneautville in Crawford County, Pennsylvania. In general Conneaut Creek flows in a northwesterly direction to the town of Conneaut where it enters Lake Erie. The mainstem is 56.8 miles in length, (22.3 in miles in Ohio). The Conneaut Creek mainstem has an average gradient of 11.3 feet per mile. All principal tributaries to Conneaut Creek are located in Pennsylvania.

The lower portion of the watershed is a mixture of urban development and forest. The upper portion of the watershed is predominantly comprised of forest, with some hay and pasture lands and cultivated crops. The Conneaut Creek watershed is situated within the Erie-Ontario Drift and Lake Plain ecoregion. The Ohio portion of Conneaut Creek is designated a State Wild and Scenic River.

The lacustrine area (estuary) is impacted from urbanized municipal and industrial activities. Major coal handling operations have resulted in layers of coal dust in the substrate. There are no marinas in Conneaut Creek harbor, however, the west shore has been bulkheaded and embankment reshaping has occurred along the eastern embankment. Most of the banks of Conneaut Creek in the lower two miles have been extensively modified with rip-rap and sheet piling. Undisturbed shorelines exist upstream from RM 2.0.

In the lacustrine zone, predominant bottom substrates included sand, muck, hardpan, and cobble, with lesser amounts of boulder, gravel, bedrock, and silt. Aquatic vegetation included pond lilies, wild celery, waterweed, cattail, Eurasian milfoil, and algae mats. Conneaut Creek lacustrine fish communities were in the fair to good range during 2003 and 2005. Modified Index of Well-being scores were fully attaining the interim lacustrine biocriterion during 2003 and 2005. Interim lacustrine Index of Biotic Integrity (IBI) results revealed attainment of the biocriteria during 2005. Conneaut Creek biological monitoring documented full attainment of the interim Lacustrine Invertebrate Community Index (LICI) biocriterion at all macroinvertebrate sampling locations during 2003. LICI scores were reflective of good to exceptional biological conditions.

Upstream, excellent habitat quality was noted at all sites evaluated. Fractured bedrock and glacial tills provided substrates with a variety of sizes and high complexity, and channel development was excellent. Riffles were free of embedding silt, and silt in the slower channels was confined to depositional areas. Wide mature riparian vegetation covered the undeveloped flood plain, providing woody debris for in-stream cover. Upstream fish communities in Conneaut Creek met Exceptional Warmwater Habitat (EWH) criteria at all sampling locations. Fish species considered moderately to highly intolerant of pollution collected in Conneaut Creek included silver redhorse, black redhorse, golden redhorse, shorthead redhorse, northern hog sucker, rosyface shiner, and smallmouth bass. Upstream macroinvertebrate communities were consistently in the exceptional range at all sampling locations. Invertebrate Community Index (ICI) scores, and mayfly/stonefly/caddisfly taxa richness were consistently among the highest in the survey. Conneaut Creek has consistently been among the highest quality streams in the state of Ohio with regards to macroinvertebrate community performance.

6.14.3 Associated Species of Greatest Conservation Need

The characteristics of Ohio's Lake Erie tributaries change significantly from west to east, and with them the associated aquatic communities. Western tributary species tend to be more tolerant of degraded conditions, low stream gradient and velocity, turbidity, and compromised habitat. Eastern tributary aquatic communities contain species that require better habitat and water quality. All of Ohio's Lake Erie tributaries are utilized by a number of lake fish species at certain times of the year. Several of the western tributaries experience significant spring spawning runs, and a number of eastern tributaries are used by steelhead during the cold weather months. Overall, generalist species are found across the entire gradient of tributaries, and species less tolerant of human disturbance tend to be more abundant in eastern tributaries.

The following species have been identified as Lake Erie Tributary species of greatest conservation need (conservation status rank in parentheses):

<u>Fish</u>

Popeye Shiner (3)	*Notropis ariommus*
American Eel (5)	*Anguilla rostrata*
Lake Sturgeon (17)	*Acipenser fulvescens*
Blacknose Shiner (22)	*Notropis heterolepis*
Silver Lamprey (26)	*Ichthyomyzon unicuspis*
Eastern Sand Darter (29)	*Ammocrypta pellucida*
Western Banded Killifish (30)	*Fundulus diaphanus menona*
Silver Chub (36)	*Macrhybopsis storeriana*
Iowa Darter (38)	*Etheostoma exile*
Bigeye Chub (42)	*Hybopsis amblops*
Channel Darter (44)	*Percina copelandi*
Spotted Gar (45)	*Lepisosteus oculatus*
Black Redhorse (48)	*Moxostoma duquesnei*
Mooneye (50)	*Hiodon tergisus*
Silver Redhorse (52)	*Moxostoma anisurum*
Greater Redhorse (55)	*Moxostoma valenciennesi*
River Darter (61)	*Percina shumardi*

<u>Crayfish</u>

Northern Clearwater Crayfish (4)	*Orconectes propinquus*
Sanborn's Crayfish (6)	*Orconectes sanbornii*
Big Water Crayfish (7)	*Cambarus robustus*
Paintedhand Mudbug (8)	*Cambarus polychromatus*
Little Brown Mudbug (9)	*Cambarus thomai*
Papershell Crayfish (13)	*Orconectes immunis*
Virile Crayfish (13)	*Orconectes virilis*

Mussels

Snuffbox (5)	*Epioblasma triquetra*
Eastern Pondmussel (8)	*Ligumia nasuta*
Purple Lilliput (15)	*Toxolasma lividum*
Slippershell Mussel (16)	*Alasmidonta viridis*
Rayed Bean (21)	*Villosa fabalis*
Creek Heelsplitter (23)	*Lasmigona compressa*
Rabbitsfoot (25)	*Quadrula cylindrica*
Salamander Mussel (25)	*Simpsonaias ambigua*
Clubshell (35)	*Pleurobema clava*
Purple Wartyback (37)	*Cyclonaias tuberculata*
Threeridge (40)	*Amblema plicata*
Round Hickorynut (42)	*Obovaria subrotunda*
Black Sandshell (47)	*Ligumia recta*
Kidneyshell (48)	*Ptychobranchus fasciolaris*
Northern Riffleshell (48)	*Epioblasma torulosa rangiana*
Rainbowshell (50)	*Villosa iris*
Round Pigtoe (50)	*Pleurobema sintoxia*
Elktoe (52)	*Alasmidonta marginata*
Deertoe (53)	*Truncilla truncata*
Fawnsfoot (53)	*Truncilla donaciformis*
Threehorn Wartyback (55)	*Obliquaria reflexa*
Cylindrical Papershell (56)	*Anodontiodes ferussacianus*

Amphibians

Mudpuppy (14)	*Necturus maculosus maculosus*

Reptiles

Midland Smooth Softshell (7)	*Apalone mutica mutica*
Common Map Turtle (19)	*Graptemys geographica*
Ouachita Map Turtle (19)	*Graptemys ouachitensis*
Queen Snake (19)	*Regina septemvittata*

6.14.4 Lake Erie Tributaries Conservation Opportunity Watersheds

6.14.4.1 Maumee River CO Watershed (consists of HUC 04100003, HUC 04100004, HUC 04100005, HUC 04100006, HUC 04100007, HUC 04100008, and HUC 04100009)

The Maumee River forms at the confluence of the St. Joseph River and the St. Marys River and flows about 140 stream miles to its mouth in Maumee Bay. The St. Joseph River and the St. Marys River are both ice front streams that flow along the outer edge of the Fort Wayne Moraine. These rivers discharged to the west before retreat of the glacial ice allowed flow along the present day Maumee. Each river is about 100 miles long. Drainage area of the St. Joseph River at Fort Wayne is 1,085 square miles while that of the St. Marys is 839 square miles.

East Branch and West Branch of the St. Joseph River gather headwaters in the morainal hills of southern Michigan and flow into Ohio joining north of Montpelier. All of the larger tributaries to the St. Joseph lie northwest of the river and gather headwaters in the Wabash Moraine. The largest of these tributaries are Fish Creek with a drainage area of 109 square miles and Cedar Creek with a drainage area of 273 square miles.

Headwaters of the St. Marys River gather along the St. Johns Moraine and flow northward through the Wabash Moraine to the Fort Wayne Moraine. Numerous small tributaries gather along the Wabash Moraine and join the St. Marys as it flows toward Fort Wayne. The largest of these tributaries are Black Creek with a drainage area of 54 square miles and Blue Creek with a drainage area of 82 square miles.

The drainage area of the Maumee River increases from 1,924 square miles at Fort Wayne to 2,315 square miles at Defiance through addition of relatively small drainages along its course, the largest being Gordon Creek with 44 square miles of drainage area. At Defiance, the drainage area of the Maumee and the size of the river channel increase dramatically with the addition of the Tiffin River drainage of 777 square miles and the Auglaize River drainage of 2,435 square miles.

The Tiffin River originates in the morainal hills northwest of Morenci, Michigan in the same general area as the East Branch of the St. Joseph River. Bean Creek, as the Tiffin River is known in Michigan, enters Ohio near Powers in Fulton County and flows southwestward to its confluence with the Maumee River at Defiance. The larger tributaries to the Tiffin in downstream order are Beaver Creek, Brush Creek, Lick Creek, and Mud Creek with drainage areas of 45, 66, 106, and 59 square miles, respectively.

The Auglaize River originates along the St. Johns Moraine and flows westward along the distal side of the Wabash Moraine to Wapakoneta where it turns abruptly northward. The river crosses the Fort Wayne Moraine as it enters Allen County and is joined by Jennings Creek with a drainage area of 69 square miles just north of Delphos. In Putnam County the Ottawa River with a drainage area of 365 square miles joins the Auglaize doubling its drainage area to 703 square miles. Not far downstream, the Blanchard River with a drainage area of 771 square miles joins the Auglaize, doubling its drainage area to 1,496 square miles. Major tributaries to the Auglaize between the Blanchard and the Maumee in downstream order include Little Auglaize River, Blue Creek, Flatrock Creek, and Powell Creek with drainage areas of 405, 108, 195, and 98 square miles, respectively.

From the confluence with the Auglaize River, drainage area of the Maumee River increases from 5,528 square miles to 6,608 square miles at Maumee Bay. The largest tributaries contributing to the increase in downstream order are South Turkeyfoot Creek, North Turkeyfoot Creek, Bad Creek, Beaver Creek, and Swan Creek with drainage areas of 149, 75, 65, 186, and 204 square miles, respectively.

The Ottawa River (Ten Mile Creek) lies north of the Maumee River and drains 172 square miles directly to Lake Erie. Some of the land west of the Ottawa River drainage in northern Fulton County drains to the River Raisin in Michigan.

Removal of forest cover in the Maumee River Basin for agriculture has been so extensive that only about 3 to 5 percent of the land remains wooded. Scattered woodlots and river corridors account for most of the woodland. The largest contiguous woodlands are on the Sand Plains in the Oak Openings Metro Park and Maumee State Forest.

Surface and subsurface drainage works completed to eliminate the Black Swamp and facilitate farming operations in the Maumee River Basin are some of the most extensive works of this type that exist anywhere. Most of the headwater channels and tributaries of the major streams in the southern part of the basin are channelized. Extensive surface drainage modifications were completed before systematic stream flow measurements began in the 1920s. Historic observations of flow conditions before major drainage work in the basin are sparse.

Physiography

The central portion of the Maumee River Basin is in the Huron-Erie Lake Plains while peripheral areas are in the Till Plains. The Ottawa River and bordering tributaries to the River Raisin are in the Lake Plains.

Headwaters of the St. Joseph River and its western tributaries gather along the Wabash Moraine in the Steuben Till Plain, a hummocky terrain of moderately low relief with rolling hills, interspersed flats and closed depressions, wetlands, and deranged drainage. The main stem of the river flows in the Central Ohio Clayey Till Plain along a highly sinuous course at average gradient of about 1.5 feet per mile. Headwaters of the St. Marys River gather along the St. Johns Moraine in the Central Ohio Clayey Till Plain. The St. Marys flows across the Central Ohio Clayey Till Plain at an average gradient of about 2.5 feet per mile and joins the St. Joseph River at the western edge of the Maumee Lake Plain. The moraine along the southern boundary of the basin is gently rolling and more subdued than the hummocky moraine along the boundary in the Steuben Till Plain.

The Maumee River between Fort Wayne and Defiance meanders along a winding course with a very low gradient of about 1.2 feet per mile. The river flows onto the Paulding Clay Bottom not far inside Ohio and joins the Tiffin and Auglaize River at the eastern edge of the Paulding Plain in Defiance.

Headwaters of the Tiffin River gather in the hummocky terrain of the Steuben Till Plain and flow across the Central Ohio Clayey Till Plain onto the Maumee Lake Plain. The Tiffin flows across the Maumee Sand Plains in Fulton County as does Brush Creek, its major eastern tributary. Along its lower reaches, the Tiffin flows across the Paulding Clay Bottom.

Headwaters of the Auglaize River gather along the St. Johns Moraine in the Central Ohio Clayey Till Plain. The river flows along a winding course at average fall of about 3.2 feet per mile northward to its confluence with the Maumee. The Auglaize crosses from till plain to the lake plain in northern Allen County and enters the Paulding Clay Bottom in Putnam County. The largest tributary to the Auglaize, the Blanchard, originates in Hardin County on the Central Ohio Clayey Till Plain and flows north to the Findlay Embayment, a lacustrine plain with relatively coarse sediments. The Blanchard flows at average fall of about 1 foot per mile along the Findlay Embayment and Defiance Moraine onto the Paulding Clay Bottom in western Hancock County. Streams in the Auglaize River Basin have cut through thin till to bedrock in many locations. Channel bottoms of bedrock with shifting alluvial sediments are common along lower reaches of the Blanchard River.

The Maumee River between Defiance and Maumee Bay flows in a much more linear pattern than the reach between Fort Wayne and Defiance. Gradient of the river is very low averaging about 1.2 feet per mile, but the gradient varies considerably. Between Waterville and Maumee, the river flows on bedrock at gradient of about 5 feet per mile. North Turkeyfoot Creek, South Turkeyfoot Creek, and Beaver Creek are mainly confined to the Lake Plains while Bad Creek and Swan Creek flow across areas of the Sand Plains before joining the Maumee. Waters of the Ottawa River gather on the Lake Plains and flow across the Sand Plains to the lake.

Geology

The Maumee River Basin lies along the western flank of the Findlay Arch where Silurian, Devonian, and Mississippian-age rocks occur at or near the surface. Rocks in the eastern part of the basin along the axis of the arch are the oldest with successively younger rocks surfacing toward the northwestern part of the basin. The bedrock in the basin is relatively dense with limited ground water storage in rock fractures. Although rock exposures along streams in the basin are common, the effect of ground water discharge from the rock on base flows is not great.

Surficial deposits in the Lake Plains portion of the basin consist of wave-planed glacial till and lacustrine deposits of fine sand, silt, and clay. These deposits are of low permeability in most areas, but deep deposits of relatively permeable sand exist mainly in the sand plains. Beach ridges in the Lake Plains generally consist of shallow permeable sand with limited ground-water storage that is typically perched on top of low permeability till or lake clays.

Surficial deposits in the Till Plains portion of the basin consist of glacial drift and lacustrine deposits. The glacial drift is in the form of ground moraine with a series of end moraines superimposed as morainal belts. Thickness of the ground moraine atop the bedrock varies greatly within the basin and is generally of low permeability. Lens of permeable sand and gravel are common in much of the thicker ground moraine. Some lacustrine areas of relatively impermeable silt and clay exist amid the ground moraine in the southern portion of the basin.

Four morainal belts cross the southern portion of the basin including the Defiance, Fort Wayne, Wabash, and St. Johns. Portions of the St. Johns Moraine along the southern boundary of the basin contain permeable sands and gravel in the form of kames and eskers. The other moraines contain limited amounts of permeable deposits. The Fort Wayne and Wabash Moraines extend northward from Fort Wayne across extreme northwestern Ohio into southern Michigan. Deep permeable sands and gravel along these moraines store considerable ground water to sustain stream flows.

Soils
The Lake Plains in the central portion of the Maumee River Basin are dominated by Hoytville-Nappanee-Paulding-Toledo soils. The Till Plain portions of the basin are dominated by Blount-Pewamo-Glywood soils.

Slowly permeable Hoytville clay loam is the most wide spread soil in the Maumee Lake Plains. Toledo clay soils dominant the Paulding Clay Plain and lake plain areas in and around Toledo. The Sand Plains and beach ridges contain areas of moderate to rapidly permeable soils including Ottokee, Tedrow, and Oakville sandy loams and sands.

The extensive areas of slowly permeable soils and limited ground water storage that exist in most of the basin results in low volumes of ground water discharge to sustain base flows of streams. Streams that gather headwaters in the morainal hills along the northwestern part of the basin, however, receive substantial ground water discharge to sustain base flows.

Water Development
The relatively flat topography of the Maumee River Basin presents few good sites for development of on-stream reservoirs, and not many large ones have been constructed. Cedarville Reservoir on the St. Joseph River is an important on-stream reservoir that supplies Fort Wayne. At Defiance, there is a relatively large hydroelectric power dam on the Auglaize River. Grand Lake straddles the Lake Erie-Ohio River divide capturing water from tributaries of the Wabash River and St. Marys River for the Ohio-Erie Canal. There are three large low head dams of canal era vintage on the Maumee River at Independence and Grand Rapids.

Off-stream reservoirs are well suited for storage of water supply in the Maumee River Basin and are common. These reservoirs are created by enclosing land with earth embankments. Water is pumped from nearby streams during high flow periods to fill the impoundment. Communities in the basin with off-stream storage reservoirs include: Lima, Van Wert, Paulding, Findlay, Ottawa, Archbold, Wauseon, Delta, Swanton, and Metamora.

Many of the smaller communities in the Maumee Basin obtain adequate source of supply from bedrock aquifers, but development of large quantities of supply from these aquifers is generally restrained by dewatering conflicts and highly mineralized water at greater depths.

Abundant sand and gravel deposits in deep till in extreme northwestern Ohio and neighboring areas of Michigan and Indiana yield ground water for communities in the area. Auburn, located along Cedar Creek in Indiana, has the largest ground water supply system in the Maumee Basin. Wapakoneta with the second largest is situated over a sizeable outwash area along the Wabash Moraine.

Many industries in the Maumee Basin obtain part or all of their supply from ground water sources. Return flows from independent industrial supplies significantly augment stream flows at Fort Wayne and Lima.

Most communities located along the Maumee River downstream from Fort Wayne obtain supply from the river. Bowling Green, although not located along the river, obtains its supply from the river and discharges wastewater to the Portage River Basin. Toledo and Oregon obtain large quantities of water supply directly from Lake Erie. Toledo distributes water as far west as eastern Fulton County.

Flow Characteristics
The Maumee River Basin includes streams with some of the lowest mean annual flows in the state. Mean annual runoff of the Maumee River at Waterville equates to 10.7 inches, ranking at the low end of the range for Ohio streams. Mean annual precipitation is relatively low and fairly evenly distributed across the basin such that mean annual runoff of streams deviates little from that at Waterville.

Mean annual runoff is slightly higher in the northwestern part of the basin than elsewhere. Mean annual runoff of the St. Joseph River and Tiffin River each equate to about 11 inches. The Maumee River at Antwerp has mean annual flow of 10.9 inches, an amount that is representative of runoff from both the St.

Marys River and St. Joseph River. Mean annual runoff of streams in the southern portion of the basin is generally lower than those in the northwestern part of the basin. Mean annual flow of the Auglaize River near Defiance is 10.4 inches. Municipal and industrial water supply operations at Lima result in relatively high mean annual flow of 11.1 inches in the Ottawa River at Allentown. The Blanchard River at Findlay with 10.1 inches of runoff is the lowest registered in the basin. Mean annual runoff of the Ottawa River at Toledo and Swan Creek are probably at least as low as the Blanchard because of lower mean annual precipitation near the lake.

Base-flow characteristics of streams in the Maumee River Basin are much more variable than mean annual flow characteristics. Mean base-flow indices indicate that ground water may contribute as little as 25 percent of mean annual flow of streams in the southern till plains area of the basin while streams in the northwestern part may derive as much as 65 percent of mean annual flow from ground water discharge. Streams in the latter category include the St. Joseph River and Tiffin River that originate in the morainal hills of southern Michigan and receive ground-water contributions from abundant sand and gravel deposits. The relatively low mean base-flow index of Unnamed Tributary to Lost Creek at Farmer of 25.6 is noteworthy because it is indicative of the minimal ground water that tributaries to the lower Tiffin River receive from the inner flank of the Fort Wayne Moraine. Streams representative of the relatively low base-flow indices in the southern portion of the basin include Town Creek near Van Wert that originates on the inner flank of the Fort Wayne Moraine and Eagle Creek at Findlay that originates on the ground moraine south of Findlay. Swan Creek with a relatively high mean base-flow index of 50 apparently receives substantial ground-water contribution from the extensive deep sand deposits of the Maumee Sand Plains.

Fifty percent duration flows of streams in the Maumee River Basin vary in similar manner as the base-flow indices. The median flows for streams in the upper basin are moderate at about 0.3 cfs per square mile indicating moderate amounts of ground-water storage to sustain base flows. Fifty percent flows of streams in the southern till plain areas of the basin are relatively low, averaging about 0.2 cfs per square mile indicating minimal amounts of ground-water storage to sustain flows. The 50-percent duration flow of the Maumee River at Waterville of 0.27 cfs per square mile indicates moderate amounts of ground-water storage exist in the basin to sustain base flows. The 50-percent duration flow of 0.37 cfs per square mile for the Maumee River near Defiance is unusually high, but is the result of a relatively short and wetter period of record. The lowest 50-percent duration flows occur in the Blanchard River Basin. Eagle Creek with 50-percent duration flow of 0.11 cfs per square mile is very low.

Streams in the western and northwestern parts of the Maumee River Basin have higher 90-percent duration flows than those in other parts of the basin. Bean Creek at Powers with 90-percent duration flow of 0.08 cfs per square mile is highest in the basin. Tributaries downstream of Powers like Beaver Creek near Stryker with 90-percent duration flow of 0.03 cfs per square mile contribute relatively less ground water to sustain stream flow resulting in 90-percent duration flow for Tiffin River at Stryker of 0.06 cfs per square mile. East Branch of St. Joseph River near Pioneer with 90-percent duration flow of 0.06 cfs per square mile is representative of the St. Joseph Basin. The 90-percent duration flow of 0.07 cfs per square mile of the Maumee River at Antwerp reflects augmentation at Fort Wayne as the relative base flow in the St. Marys River is less than in the St. Joseph River.

The 90-percent duration flows of streams in the Auglaize River Basin are low compared to those in the upper part of the Maumee Basin. The 90-percent duration flow of the Auglaize River near Defiance of 0.017 cfs per square mile is representative of base-flow conditions in the basin. The Auglaize River at Uniopolis gathers along the St. Johns Moraine where it receives limited ground-water contribution to sustain 90-percent duration flow of 0.013 cfs per square mile. The 90-percent duration flow of the Auglaize River at Buckland reported in Bulletin 40 is 0.025 cfs per square mile. Ground-water contributions from outwash deposits at Wapakoneta and wastewater discharge add to base flow at the Buckland station. The 90-percent duration flow of the Auglaize River near Fort Jennings is relatively high at 0.05 cfs per square mile reflecting further contribution to base flow from Grand Lake canal diversions and wastewater discharge at Delphos. The 90-percent duration flow for Ottawa River at Allentown of 0.119 cfs per square mile is exceptionally high for the Maumee Basin and due primarily to wastewater discharge at Lima and return flows from independent industrial supplies. Smaller streams such as the Blanchard River at Mount Blanchard and Eagle Creek near Findlay have 90-percent duration flows of

zero or near zero. The 90-percent duration flow of the Blanchard River at Findlay of 0.025 cfs per square mile is relatively low despite the gage location directly downstream of the wastewater outfall for Findlay. The relatively low 90-percent duration flow of 0.008 cfs per square mile for North Turkeyfoot Creek near Liberty Center is typical of tributary streams in clayey areas of the Maumee Lake Plain.

The relatively high 90-percent duration flow of the Ottawa River at Toledo of 0.06 cfs per square mile is for a period of record that includes substantial upstream wastewater discharge at Sylvania. Bulletin 40 gives 90-percent duration flow of 0.008 cfs per square mile based on period of record before relatively large amounts of wastewater where discharged.

The 10-percent duration flows of streams in the Maumee River Basin are relatively low averaging about 2.2 cfs per square mile. Peak discharges for 2-year recurrence interval floods are also relatively low averaging about 8 cfs per square mile for the larger streams and proportionately more for smaller streams. Low permeability of soils in much of the basin favors direct surface runoff, but the flat topography tends to attenuate flood peaks. Areas of hummocky terrain in the northwestern parts of the basin contain large amounts of natural storage that attenuates flood peaks. Floods in the Maumee Basin are characterized by slowly rising flood stages of prolonged duration. Extensive channelization in the basin has resulted in many enlarged channels.

State Listed Species by County with Records of Occurrence from the Maumee River Watershed (from the Ohio Natural Heritage Database)
The following species are dependent upon aquatic habitats to complete their life cycle – this dependence may be for all or a portion of their life:

Williams County
Eastern cricket frog, blanding's turtle, spotted turtle, copperbelly watersnake, Canada darner, mottled darner, marsh bluet, plains clubtail, lilypad forktail, chalk-fronted corporal, frosted whiteface, blackchin shiner, pugnose minnow, lake chubsucker, Iowa darter, greater redhorse, eastern sand darter, wavyrayed lampmussel, creek heelsplitter, clubshell, round pigtoe, kidneyshell, rabbitsfoot, salamander mussel, purple lilliput, rayed bean, purple wartyback, white catspaw, northern riffleshell, black sandshell

Fulton County
Blanding's turtle, four-toed salamander, greater redhorse

Lucas County
Eastern cricket frog, spotted turtle, Blanding's turtle, Kirtland's snake, persius dusky wing, plains clubtail, frosted elfin, chalk-fronted corporal, frosted whiteface, Canada darner, channel darter, greater redhorse, lake sturgeon, muskellunge, round pigtoe, fawnsfoot, deertoe, rayed bean, eastern pondmussel, black sandshell, threehorn wartyback, purple wartyback, creek heelsplitter

Defiance County
Eastern cricket frog, marsh bluet, greater redhorse, elktoe, purple wartyback, northern riffleshell, black sandshell, threehorn wartyback, clubshell, round pigtoe, rabbitsfoot, fawnsfoot, deertoe

Henry County
Spotted turtle, Blanding's turtle, Kirtland's snake, four-toed salamander, greater redhorse, eastern sand darter, threehorn wartyback, creek heelsplitter, deertoe

Wood County
Eastern cricket frog, four-toed salamander, river redhorse, muskellunge, eastern sand darter, western banded killifish, threehorn wartyback, deertoe, creek heelsplitter

Paulding County
Four-toed salamander, marsh bluet, plains clubtail, deertoe, purple wartyback

Putnam County
Least darter, greater redhorse, pugnose minnow, elktoe, purple wartyback, white catspaw, wavyrayed lampmussel, creek heelsplitter, round pigtoe, rabbitsfoot, wartyback, purple lilliput, deertoe, rayed bean, clubshell

Hancock County
Eastern cricket frog, Kirtland's snake, four-toed salamander, plains clubtail, western banded killifish, northern crayfish, elktoe, creek heelsplitter, black sandshell, clubshell, round pigtoe, kidneyshell, salamander mussel, purple lilliput, deertoe, rayed bean

Allen County
Least darter, greater redhorse, purple wartyback, wavyrayed lampmussel, creek heelsplitter, clubshell, purple lilliput, deertoe

Hardin County
Four-toed salamander, least darter, creek heelsplitter, pondhorn, rayed bean

Mercer County
Eastern cricket frog, deertoe, pondhorn

Auglaize County
Least darter, greater redhorse, rayed bean

Shelby County
Least darter, purple wartyback

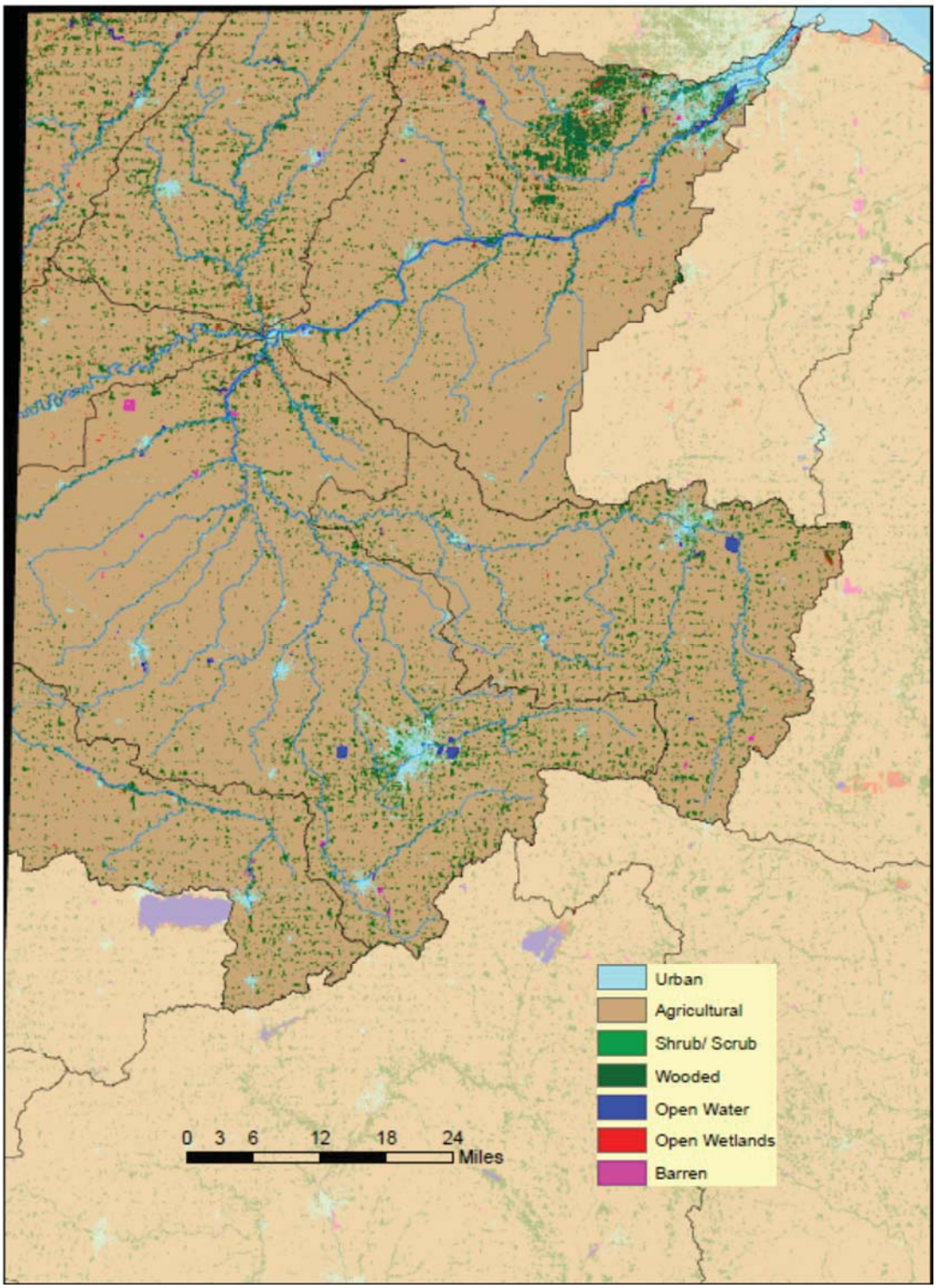


Figure 21. Maumee River Conservation Opportunity Watershed – Land Cover.

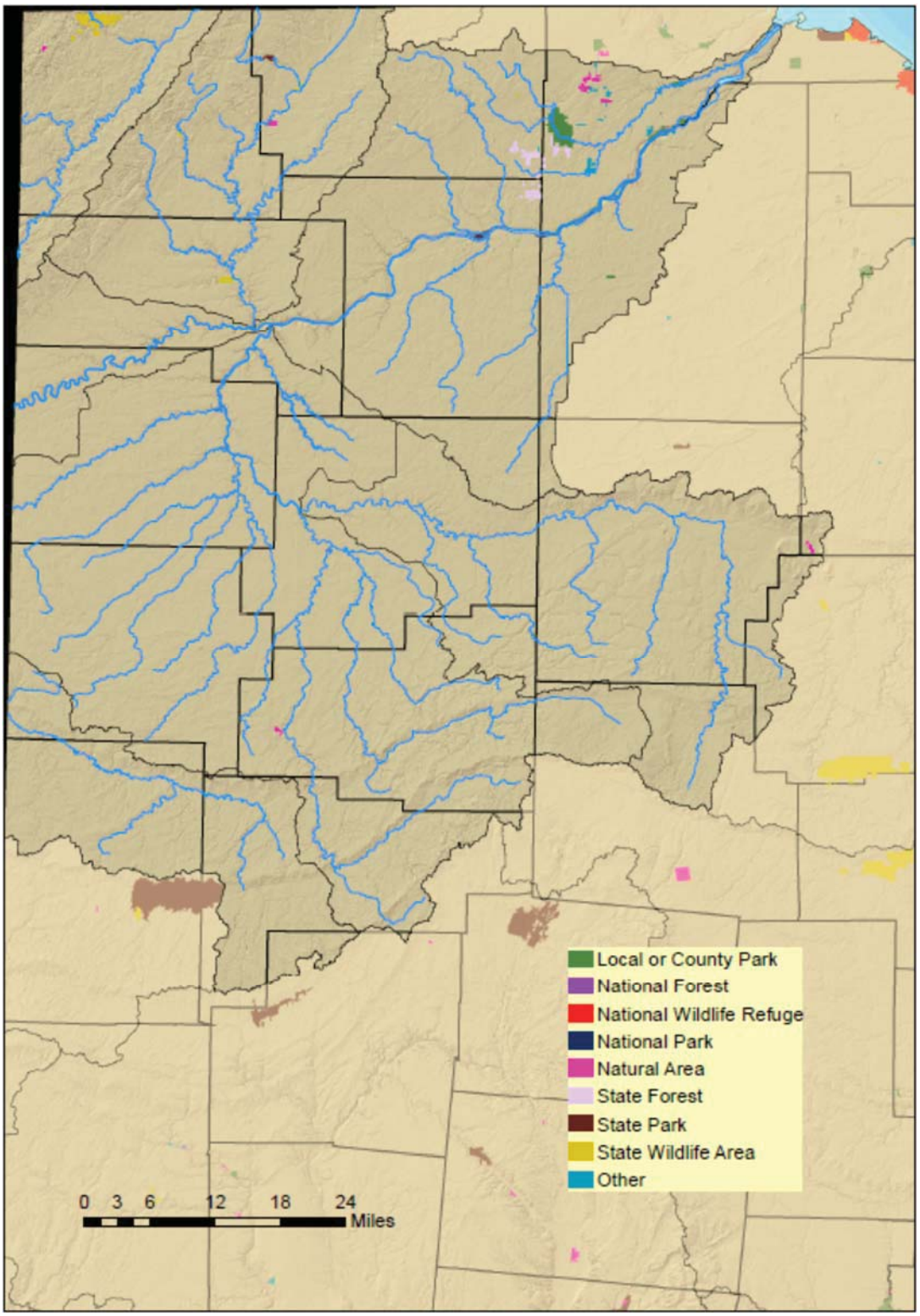


Figure 22. Maumee River Conservation Opportunity Watershed – Protected Lands.

6.14.4.2 Sandusky River CO Watershed (HUC 04100011)

The Sandusky River forms at the confluence of Paramour Creek and Allen Run winding through northwest Ohio to its mouth in Sandusky Bay. Paramour Creek gathers in morainal hills near Crestline. The Sandusky River is joined by Broken Sword Creek southwest of Nevada. The Broken Sword has drainage area of 95 square miles. Not far downstream, the Little Sandusky contributes 38 square miles of drainage area. Tymochtee Creek drains 302 square miles in the western part of the upper basin and joins the Sandusky about midway between Upper Sandusky and Tiffin.

Sycamore Creek, Honey Creek, and Rock Creek flow into the Sandusky from the east contributing 64, 179, and 35 square miles, respectively. Most of the western half of the lower basin is drained by Wolf Creek with a drainage area of 158 square miles. Muskellunge Creek drains 47 square miles of the lower western basin joining the Sandusky north of Fremont. Green Creek drains 81 square miles of the lower eastern part of the basin and joins the Sandusky at its mouth in Sandusky Bay.

Physiography

The Sandusky River Basin is about equally divided between the Till Plains and the Lake Plains. The upper portion of the basin is in the Central Ohio Clayey Till Plain while the lower portion is in the Maumee Lake Plains. Paramour Creek, at the head of the Sandusky River, gathers in the Galion Glaciated Low Plateau. From the confluence of Paramour Creek and Allen Run, the Sandusky flows southwestward along the outer margin of the Wabash End Moraine. At the Crawford-Wyandot county line, the river crosses the moraine and flows northwest toward Upper Sandusky crossing the Fort Wayne Moraine along the way. About midway between Upper Sandusky and Tiffin the river crosses the Defiance End Moraine. At Tiffin, it leaves the till plain and flows onto the lake plain.

The gradient of the Sandusky River is extremely variable. In some places the fall is 2 feet per mile and in other places, such as north of Tiffin, it is 25 feet per mile. The stream gradient reflects underlying substrates. Just north of Tiffin the substrate is thick erodible deltaic silt; near Fremont the stream flows directly on Silurian dolomite. In many places the river and its tributaries have cut through thin till to bedrock. Cobble and gravel substrate along its reaches consist of rounded granite and carbonate rock fragments. Upper reaches in the Galion Glaciated Low Plateaus contain sandstone and shale bed material. The Sandusky is a mildly entrenched river that meanders considerably along its course.

Geology

Nearly all the Sandusky River Basin consists of limestone, dolomite, and shale of Silurian and Devonian age. Headwater streams of the Sandusky are underlain with sandstone, limestone, and shale of Late Mississippian age. The bedrock is relatively dense and ground water storage is not great. The water table in the rock generally lies at or below drainage. The overburden of glacial drift and lacustrine deposits is generally thin and for the most part consists of materials with relatively low permeability. Sandy lacustrine deposits are generally shallow and underlain by material of low permeability. Fractures in till afford some passages for ground water recharge.

Headwater areas of the Sandusky River gather where drift thickens in end moraines with relatively greater amounts of permeable sand and gravel deposits. The portion of the Defiance End Moraine where the Sandusky crosses contains significant amounts of sand and gravel deposits, and there are buried valleys with permeable deposits in the area. Flowing springs near the river are indicative of a ground water discharge area. East of Fremont, a shallow buried valley exists along Green Creek. The buried valley contains sand and gravel deposits that yield considerable amounts of ground water.

Soils

Soils in the Sandusky River Basin are more varied than in the Portage River Basin. Hoytville silty clay loam dominates the lower Lake Plain portion of the basin with less extensive areas of Ottokee and Tedrow sandy loam. Blount-Pewamo-Glynwood soils dominate the upper western portion of the basin while Bennington-Cardington soils dominate the eastern part of the upper basin. Blount-Pewamo-Glynwood soils of the upper western basin have slow permeability similar to Hoytville soils of the lower basin. Bennington-Cardington soils are moderately to slowly permeable.

Water Development

The Sandusky River serves as source of water supply for Bucyrus, Upper Sandusky, Tiffin and Fremont. Bucyrus and Upper Sandusky pump water into off-stream storage while Tiffin and Fremont withdraw water directly from behind low-head dams. The Ballville low-head dam at Fremont has about 180 million gallons of storage. Attica and New Washington obtain source of supply from Honey Creek utilizing off-stream impoundments. An off-stream reservoir near Marseilles in Wyandot County is filled from Tymochtee Creek and supplies water for wetland management on the Killdeer Plains Wildlife Area. A number of communities obtain source of supply from ground water, the largest systems being at Crestline and Carey. Green Springs obtains water supply from wells. Wastewater return flows generated by water supply systems in the basin affect low-flow characteristics of streams to varying degrees. A number of rock quarries discharge ground water to tributaries of the Sandusky River.

Flow Characteristics

Mean annual flow of the Sandusky River at Fremont equates to 11.2 inches, typical runoff for most streams in the basin. Areas east of Bucyrus receive greater amounts of annual precipitation, and this is reflected in the higher mean annual flow of 13.2 inches at Bucyrus. The relatively low mean annual flow of 10.3 inches given in Table 2 for Sandusky River at Mexico is mainly due to differences in period of record rather than basin hydrology. Base flow in the Sandusky River generally accounts for about one-third of mean annual runoff. This amount of base flow is in the lower range for streams in Ohio. Fifty percent duration flows at gaging stations along the Sandusky average about 0.2 cfs per square mile, a relatively low value indicating that ground-water storage in the basin is not great.

The 90-percent duration flows at various stations along the Sandusky are uniformly low averaging about 0.03 cfs per square mile. The uniformity of low flows is somewhat contrary to what the physiology of the basin suggests as the till plain of the upper basin yields only modest ground-water accretions to streams and even less to the lake plain of the lower basin.. Low-flow augmentation from municipal wastewater discharges and dewatering flows from quarries contribute to the uniformity of low flows, but the basin geology remains the most important factor determining the low-flow regimen of streams. Paramour Creek at Leesville and the Sandusky River near North Robinson exhibit relatively high base-flow characteristics compared to those for the Sandusky River at downstream stations. Wastewater discharge at Crestline could account for the higher base flows, as might ground-water discharge from permeable materials in the morainal drift. Low flows of the Sandusky River at Bucyrus are affected by wastewater discharge that enters immediately upstream of the gage, but marked declines in effluent discharge during dry spells has historically lessened the direct impact on low flows.

Between Bucyrus and Upper Sandusky, the river may receive modest contributions of ground water from the end moraine and alluvial deposits bordering the channel. Baseflow characteristics of Broken Sword Creek and Tymochtee Creek are very low with 90- percent duration flow of 0.006 to 0.007 cfs per square mile. The Broken Sword receives little ground-water contribution from the Fort Wayne End Moraine that it flows along. Tymochtee Creek gathers in a lacustrine plain and flows across till plain neither yielding much ground water to sustain flows.

About half of the drainage area of the Sandusky River at Mexico is contained in the Broken Sword and Tymochtee drainages. That by itself should cause less favorable base flow at Mexico than observations reveal. Wastewater discharge at Upper Sandusky and Carey combined with dewatering flows from the rock quarry at Carey provide some augmentation flows but not of sufficient amount to explain the magnitude of base flows at Mexico. The Sandusky River apparently receives significant ground-water contribution as it crosses through the Defiance End Moraine in vicinity of McCutchenville.

Honey Creek at Melmore has base-flow characteristics slightly more favorable than Broken Sword Creek or Tymochtee Creek, but it receives little ground water to sustain flows from the Defiance Moraine that borders it. Rock Creek, that traverses the Defiance Moraine, has relatively high sustained flows, but the drainage area is too small to make much contribution to sustaining flows in the Sandusky.

Streams in the western portion of the lower basin contribute little base flow to sustain flows in the Sandusky River. The 90-percent duration flows of Wolf Creek and East Branch of Wolf Creek reported in

Bulletin 40 are zero or near zero flow. Ground-water discharge to sustain flows in lower reaches of the Sandusky below Tiffin may originate with tributaries draining from the east and from rock exposures along the river. Base flows of Green Creek near Fremont appear as an anomaly in the Sandusky River Basin. The 90-percent duration flow for Green Creek near Fremont equates to 0.18 cfs per square mile, an exceptionally high value for the Sandusky Basin. Base flow of Green Creek is sustained by ground-water discharge from artesian springs originating in the limestone bedrock in the Green Springs area.

The 10-percent duration flows for streams in the Sandusky River Basin are comparatively low averaging 2.2 cfs per square mile. The 2-year recurrence interval flood-peak discharges are also relatively low, ranging from about 40 cfs per square mile for smaller gaged streams to about 12 cfs per square mile for the largest streams. Flat to moderately rolling topography of the basin and the relatively mild gradient of streams allows floodwaters to rise at moderate rates and recede gradually. Violent flash floods are not common in the basin. Channel forming flows being relatively low, tend to favor channels with comparatively narrow bankfull widths. Accelerated runoff is common in headwater areas where streams have been channelized for drainage and flood control purposes.

State Listed Species by County with Records of Occurrence from the Sandusky River Watershed (from the Ohio Natural Heritage Database)
The following species are dependent upon aquatic habitats to complete their life cycle – this dependence may be for all or a portion of their life:

Ottawa County
Blanding's turtle, Lake Erie watersnake, Canada darner, lake sturgeon, eastern sand darter, muskellunge, western banded killifish, spotted gar, burbot, channel darter, eastern pondmussel, black sandshell, pocketbook, purple wartyback, northern riffleshell, snuffbox, threehorn wartyback, kidneyshell, fawnsfoot, deertoe, pondhorn, rayed bean

Erie County
Eastern cricket frog, spotted turtle, Blanding's turtle, Kirtland's snake, Lake Erie watersnake, marsh bluet, plains clubtail, lake sturgeon, longnose sucker, lake whitefish, muskellunge, channel darter, purple wartyback, eastern pondmussel, black sandshell, threehorn wartyback, fawnsfoot, deertoe

Sandusky County
Blanding's turtle, muskellunge, western banded killifish, river redhorse, greater redhorse, eastern pondmussel, threehorn wartyback, fawnsfoot, deertoe

Seneca County
Spotted turtle, Blanding's turtle, plains clubtail, river redhorse, greater redhorse, purple wartyback

Wyandot County
Kirtland's snake, plains clubtail, greater redhorse, elktoe, purple wartyback, northern riffleshell, creek heelsplitter, rayed bean

Crawford County
Pondhorn

Marion County
Snuffbox, wavy-rayed lampmussel, Ohio pigtoe, round pigtoe, pondhorn, rayed bean

Hardin County
Four-toed salamander, least darter, creek heelsplitter, pondhorn, rayed bean

Richland County
Least darter, greater redhorse, pugnose minnow, elktoe, purple wartyback, white catspaw, wavyrayed lampmussel, creek heelsplitter, clubshell, round pigtoe, rabbitsfoot, wartyback, purple lilliput, deertoe, rayed bean

Huron County
Pondhorn

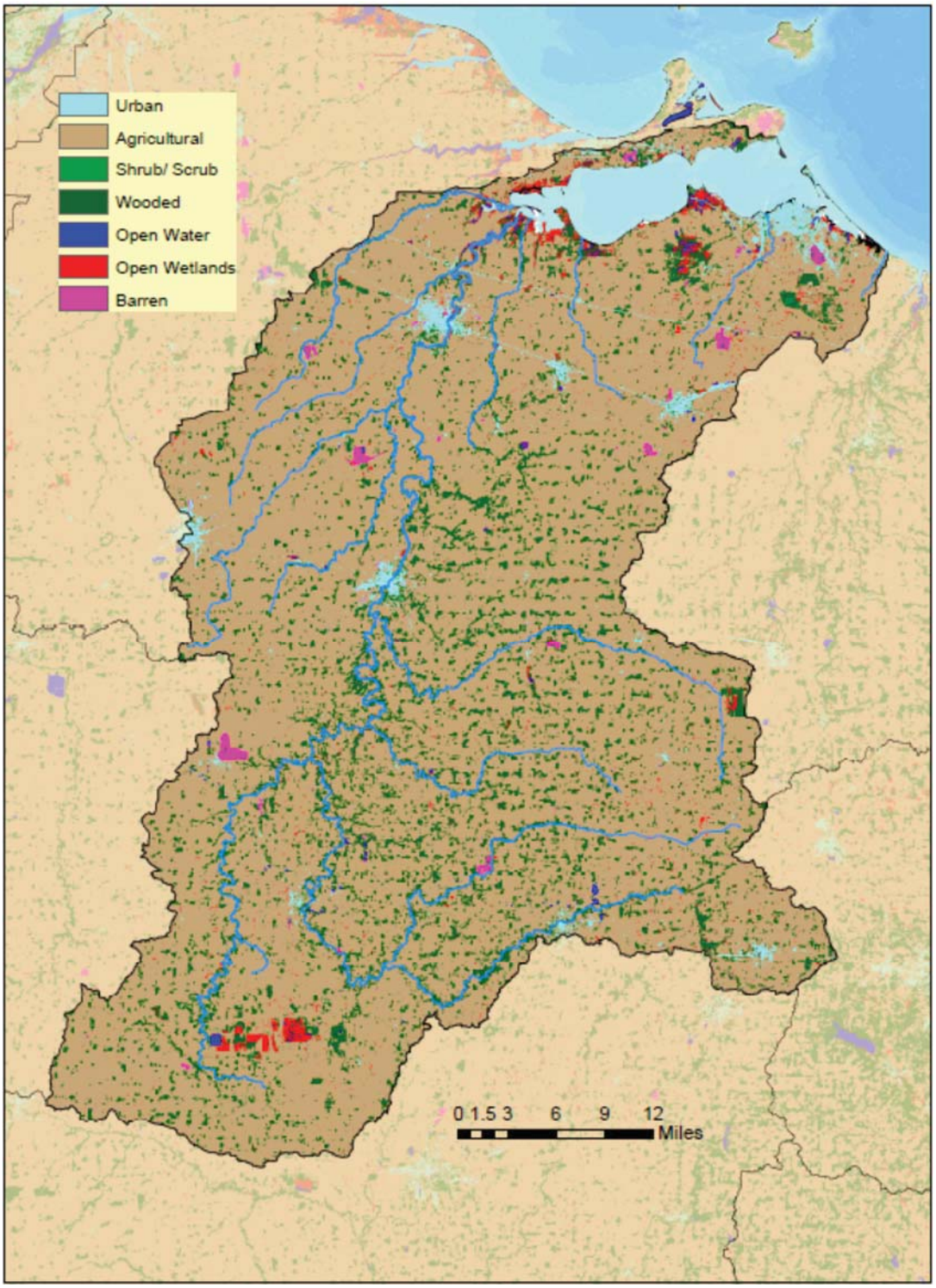


Figure 23. Sandusky River Conservation Opportunity Watershed – Land Cover.

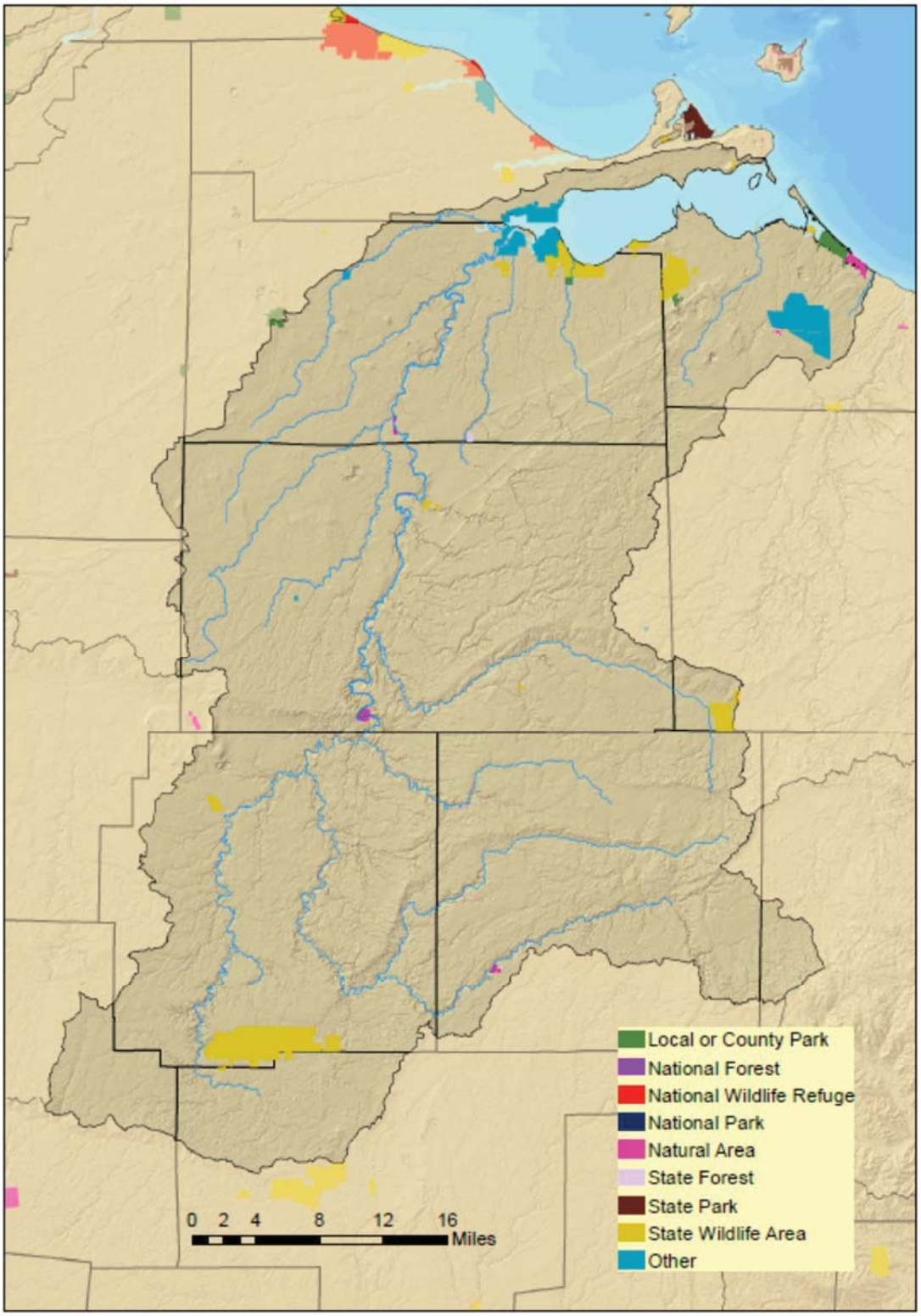


Figure 24. Sandusky River Conservation Opportunity Watershed – Protected Lands.

6.14.4.3 Cuyahoga River CO Watershed (HUC 04110002)

The Cuyahoga River originates in Geauga County in the extreme northern part of the Akron-Canton Interlobate Plateau. From its headwaters area, the river flows southwestward in a relatively long, narrow basin toward Akron. Downstream of Cuyahoga Falls, the river turns abruptly northward and flows in a wide, deep preglacial valley to Cleveland and its mouth in Lake Erie. The peculiar shape of the basin with its long eastern arm is the result of drainage changes brought about by glaciation.

In the upper part of the eastern basin near Burton, the East Branch, West Branch, and Bridge Creek converge to give the Cuyahoga River a drainage area of about 150 square miles. Downstream at Kent, Congress Lake Outlet adds about 79 square miles of drainage area. At Akron, the Little Cuyahoga joins the Cuyahoga River contributing 62 square miles of drainage area. North of Akron, a series of smaller tributaries drain into the Cuyahoga from both sides of the basin, the largest of these being, Mud Brook, Yellow Creek, Furnace Run, Brandywine Creek, and Chippewa Creek. Near Bedford, Tinkers Creek joins the Cuyahoga contributing 96 square miles of drainage area. Additional smaller tributaries flow into the Cuyahoga in Cleveland – the largest being Big Creek with 38 square miles of drainage area.

Physiography

The topography of the Cuyahoga River Basin varies from flat lake plain to relatively rough glaciated, dissected plateau. Most of the basin is in the Glaciated Allegheny Plateaus; only the extreme lower part lies in the Erie Lake Plain. Relief is generally moderate except where the river has cut a deep valley, and where there is local steepness created by smaller streams.

The northern part of the Akron-Canton Interlobate Plateau, where the eastern arm of the basin is located, is hummocky and dominated by kames, kame terraces, eskers, bogs, and natural lakes. The river flows in a relatively shallow channel cut in lacustrine deposits and drift at very low gradient of about 3 feet per mile. Kame terraces and outwash exist along most of the channel. The channel reach in Geauga County cuts through lacustrine deposits.

Congress Lake Outlet and the Little Cuyahoga River are in the central part of the interlobate area where considerable amounts of outwash material exists. The river flows north of the outwash area in a deep narrow gorge cut in Pennsylvanian-age sandstone dropping about 220 feet in 1.5 miles through a series of steep rapids and falls. Along the northward course, the river flows in a wide, deep preglacial valley that contains Pleistocene lacustrine deposits and alluvium of more recent time. The river meanders at moderately low gradient of about 6 feet per mile. Upland areas draining to the valley of the lower Cuyahoga are in areas of ground moraine and end moraine. Tinkers Creek gathers in lacustrine areas with extensive wetlands and flows northward along the Defiance End Moraine atop a buried valley before turning westward at Bedford and descending at steep gradient to the Cuyahoga River.

The Cuyahoga River flows across the Erie Lake Plain in a deep wide valley at Cleveland. Most of the lake plain tributary to the Cuyahoga on the west side of the river in Cleveland is drained by Big Creek.

Geology

The surface rocks in the Cuyahoga River Basin range in age from Devonian to Pennsylvanian. Devonian-age shales outcrop along the lower Cuyahoga Valley and lake plain area. Upland areas along the lower reach of the Cuyahoga are underlain with Mississippian sandstones and shales. Berea sandstone outcrops along Tinkers Creek just downstream of Bedford. Pennsylvanian-age sandstones and shales underlie much of the basin along the upper Cuyahoga. The narrow gorge at Cuyahoga Falls is cut in Sharon Conglomerate of Pennsylvanian age. As a whole, ground water from the rock strata has little effect on stream flow except locally where streams have cut through sandstone formations.

The glacial drift in the basin varies greatly in thickness and character, ranging from a few feet to as much as 200 feet in thickness and consisting of deep impermeable till in some places to highly permeable sand and gravel in other places. Deep buried valleys are present throughout the basin, but it is ground water from outwash material in high-level terraces, kames, and kame terraces that support the dry-weather flow of the Cuyahoga River.

The shales underlying the lake plain at Cleveland are thinly mantled with till and clayey lacustrine deposits. Uplands tributary to the lower reach of the Cuyahoga are generally covered with moderate amounts of clayey till except along the moraines where till thickness is greater and contains some permeable deposits. The Cuyahoga Valley is hundreds of feet deep to bedrock. The buried valley along the Cuyahoga between Newburg Heights and downtown Cleveland contains permeable deposits that yield substantial amounts of ground water to wells.

Pennsylvanian- and Mississippian-age sandstones and shales are covered with till and extensive amounts of sand and gravel deposits in the upper basin. Large deposits of permeable outwash material exist in the interlobate area between the Grand River and Killbuck Lobes of the Wisconsinan glaciation. Depths of these deposits vary from a few feet to as much as 100 feet in some places.

Soils

The Glaciated Allegheny Plateaus part of the Cuyahoga River Basin that comprises the vast majority of the basin is in the Mahoning-Canfiel-Rittman-Chili soil region. The narrow Erie Lake Plain part of the basin at Cleveland is in Conotton-Conneaut-Allis soil region.

Soils on the Erie Lake Plain at Cleveland are largely urban land complexes wherein imperious surfaces constitute a large percentage of the complex. Mahoning urban complex dominates the lake plain with lesser amounts of Oshtemo urban complex. The Mahoning soil developed from clay loam and clayey till and is slowly permeable. Oshtemo developed on sandy beach ridges and has rapid permeability.

The ground moraine and end moraines in the Killbuck-Pittsburgh Glaciated Plateau part of the basin are dominated by Mahoning and Rittman soils. Rittman developed from medium to fine textured till and has a fragipan that is slowly permeable. Soils developed from lacustrine deposits amid the end moraines have slow permeability.

Chili-Canfield soil associations dominate the interlobate area in the upper basin. Chili soil developed from loamy outwash on kames, kames terraces, and outwash fans common in the interlobate area. Chili is underlain with sand and gravel and has rapid permeability. Canfield soil developed from medium-textured till and has a fragipan that is slowly permeable.

Soil developed in alluvium along the lower Cuyahoga and upper reaches of Tinkers Creek are mostly Chagrin silt loams with moderate permeability. Permeability of soils on high-level terraces along the lower Cuyahoga vary from rapid to slow depending on the texture of the sediments.

Permeable outwash soils in the Cuyahoga Basin are limited in extent but highly significant ground water recharge areas for the ground water aquifers of the Cuyahoga Basin. Overall, however, most of the soils in the basin are slowly permeable.

Water Development

The City of Akron has several water supply reservoirs in the upper Cuyahoga River Basin. These include East Branch Reservoir, LaDue Reservoir, and Lake Rockwell. Water is released from East Branch and LaDue to maintain water levels in Lake Rockwell where the city water supply intakes are located. Wastewater return flows from Akron and enters the Cuyahoga below Old Portage several miles downstream of the confluence with the Little Cuyahoga.

Kent and Cuyahoga Falls obtain water supply from well fields located in sand and gravel deposits along the upper Cuyahoga. Some smaller communities in the upper basin including Burton obtain water supply from wells, but most obtain supply from either Akron or Cuyahoga Falls. Individual supply is generally available from sandstones of the Pottsville Group, mainly the Sharon Conglomerate, and from permeable deposits in buried valleys.

The city of Cleveland obtains water from Lake Erie and distributes it throughout Cuyahoga County and to some communities in neighboring counties. All of the communities in Cuyahoga County except Berea

obtain supply from Cleveland. Return flows enter the Cuyahoga though the Cleveland Southerly Wastewater Treatment Plant at Cuyahoga Heights.

Some water is diverted from the Tuscarawas River Basin to the Cuyahoga River Basin through the Ohio-Erie Canal system at Akron. Water from Portage Lakes is diverted to the Ohio Canal for industrial use and discharged through Summit Lake to the Little Cuyahoga River. Mogador Reservoir on the Little Cuyahoga River was built for industrial supply and recreation.

Flow Characteristics

Mean annual flows of streams in the Cuyahoga River Basin range from about 12 inches to 21 inches. Upper reaches of the Cuyahoga in Geauga County are in an area that receives some of the greatest amounts of mean annual precipitation in the state. This accounts for the relatively high mean annual flow of 20.2 inches at Hiram Rapids.

Tinkers Creek is also in an area receiving relatively high amounts of mean annual precipitation. This largely but not entirely accounts for the 21.7 inches of runoff recorded at Bedford. The flow of Tinkers Creek at the gage site is augmented by wastewater originating from wells and imported waters. The Little Cuyahoga River is in an area of lower mean annual precipitation averaging about 36 inches at Akron. Mean annual runoff of the Little Cuyahoga is correspondingly lower at about 12 inches. Mean annual flow of 14.9 inches for the Cuyahoga River at Old Portage excludes water diverted from Lake Rockwell for use at Akron and returned downstream of Old Portage. This diversion is partly offset by canal diversions from the Portage Lakes into the Cuyahoga River. On balance, mean annual flow at Old Portage without the diversions should be closer to 17 inches. Mean annual flow of the Cuyahoga at Independence of 16.4 inches represents the composite of mean annual flows of streams in the basin. The relatively high mean annual flow of Big Creek at Cleveland is due to industrial wastewater discharge and shorter, wetter period of record.

Base flows of the Cuyahoga River at all of the gaging stations are affected by regulation. Base flows at Hiram Rapids are affected by evaporative losses and releases from East Branch and LaDue. Base flows at Old Portage are largely a function of releases from Lake Rockwell and flows from Congress Lake Outlet and the Little Cuyahoga. The gaging records for Yellow Creek give some insight to the affect of permeable deposits on base flows. The basin upstream of Ghent is situated in an area of kames and outwash deposits. This accounts for the relatively high mean base-flow index of 68 and 90-percent duration flow of 0.213 cfs per square mile for Yellow Creek at Ghent. North Fork at Bath Center includes areas of ground moraine containing much less permeable material. The mean base-flow index of 44 and 90-percent duration flow of 0.072 cfs per square mile reflects this difference in geology. Yellow Creek at Boltzum with 90-percent duration flow of 0.16 cfs per square mile and mean base-flow index of 54 represents a composite of basin characteristics.

Tinkers Creek with mean base-flow index of 48 and 90-percent duration flow of 0.24 cfs per square mile contains some permeable deposits along the Defiance End Moraine but not to the same degree as Yellow Creek. Base flows in Tinkers Creek are augmented significantly by wastewater discharges from municipal and industrial plants.

The base-flow record for Cuyahoga River at Independence excludes water diverted into the Ohio Canal upstream at Brecksville. The 90-percent duration flow of 0.184 cfs per square mile and the 7-day, 2-year low-flow index of 0.153 are lower than they would be if the diversions were included. The relatively high base-flow indices for Big Creek are due to industrial wastewater discharge upstream of the gaging station.

The median flow or 50-percent duration flow of 0.69 cfs per square mile for the Cuyahoga River at Independence is representative of flow conditions at gaging sites along the Cuyahoga and its major tributaries. This median flow rate is at the high end of the range for Ohio streams and reflects the combination of relatively large amounts of ground-water storage, substantial artificial and natural surface-water storage, and significant flow regulation from water supply and wastewater operations in the basin. The 10-percent duration flows of streams in the Cuyahoga River Basin are at the high end of the range

for streams in Ohio. This indicates that although significant storage exists in the basin, it is limited as far as attenuation of larger floods. Relatively low 2-year recurrence interval flood-peak discharges characteristic of the streams in the basin indicate that basin storage nevertheless provides some attenuation of flood flows. The 10-percent duration flows at stations along the Little Cuyahoga River are relatively low because of the large reservoirs located upstream of the gaging sites.

State Listed Species by County with Records of Occurrence from the Cuyahoga River Watershed (from the Ohio Natural Heritage Database)
The following species are dependent upon aquatic habitats to complete their life cycle – this dependence may be for all or a portion of their life:

Cuyahoga County
Spotted turtle, tiger spiketail, *Chimarra socia* (caddisfly), muskellunge, bigmouth shiner, channel darter, longnose dace, great lakes crayfish

Geauga County
Blanding's turtle, spotted turtle, four-toed salamander, river jewelwing, tiger spiketail, American emerald, boreal bluet, northern bluet, marsh bluet, harlequin darner, riffle snaketail, *Litobrancha recurvate* (mayfly), *Psilotreta indecisa* (caddisfly), *Stenonema ithaca* (mayfly), lake chubsucker, Iowa darter, longnose dace, brook trout, creek heelsplitter, eastern pondmussel, great lakes crayfish, northern crayfish

Summit County
Spotted turtle, four-toed salamander, racket-tailed emerald, boreal bluet, marsh bluet, harlequin darner, chalk-fronted corporal, elfin skimmer, brush-tipped emerald, lake chubsucker, Iowa darter, western banded killifish, pugnose minnow, paddlefish

Portage County
Spotted turtle, four-toed salamander, American emerald, racket-tailed emerald, northern bluet, harlequin darner, frosted whiteface, brush-tipped emerald, *Psilotreta indecisa* (caddisfly), eastern sand darter, lake chubsucker, Iowa darter, least darter, mountain brook lamprey, creek heelsplitter, eastern pondmussel, Allegheny crayfish

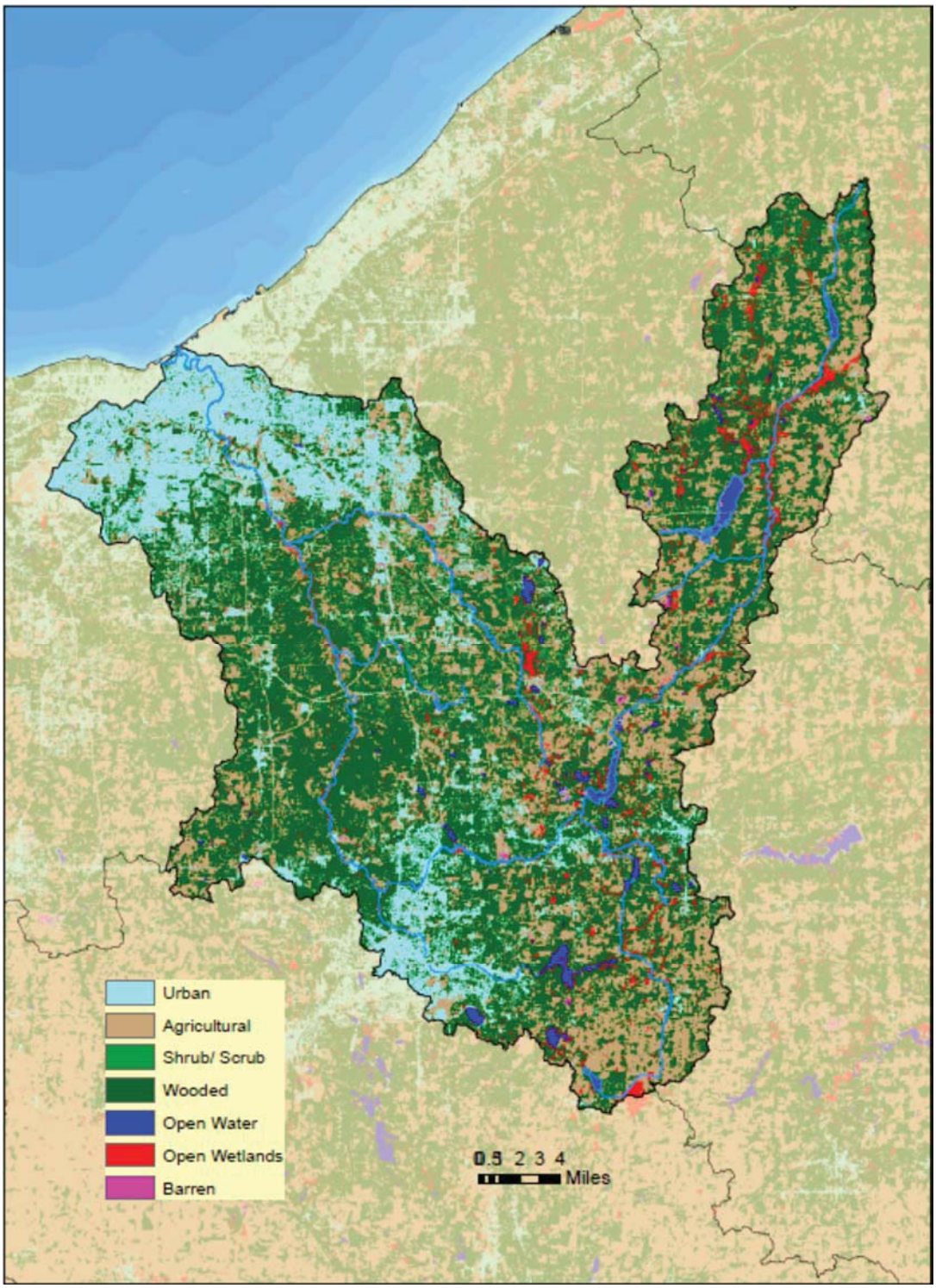


Figure 25. Cuyahoga River Conservation Opportunity Watershed – Land Cover.

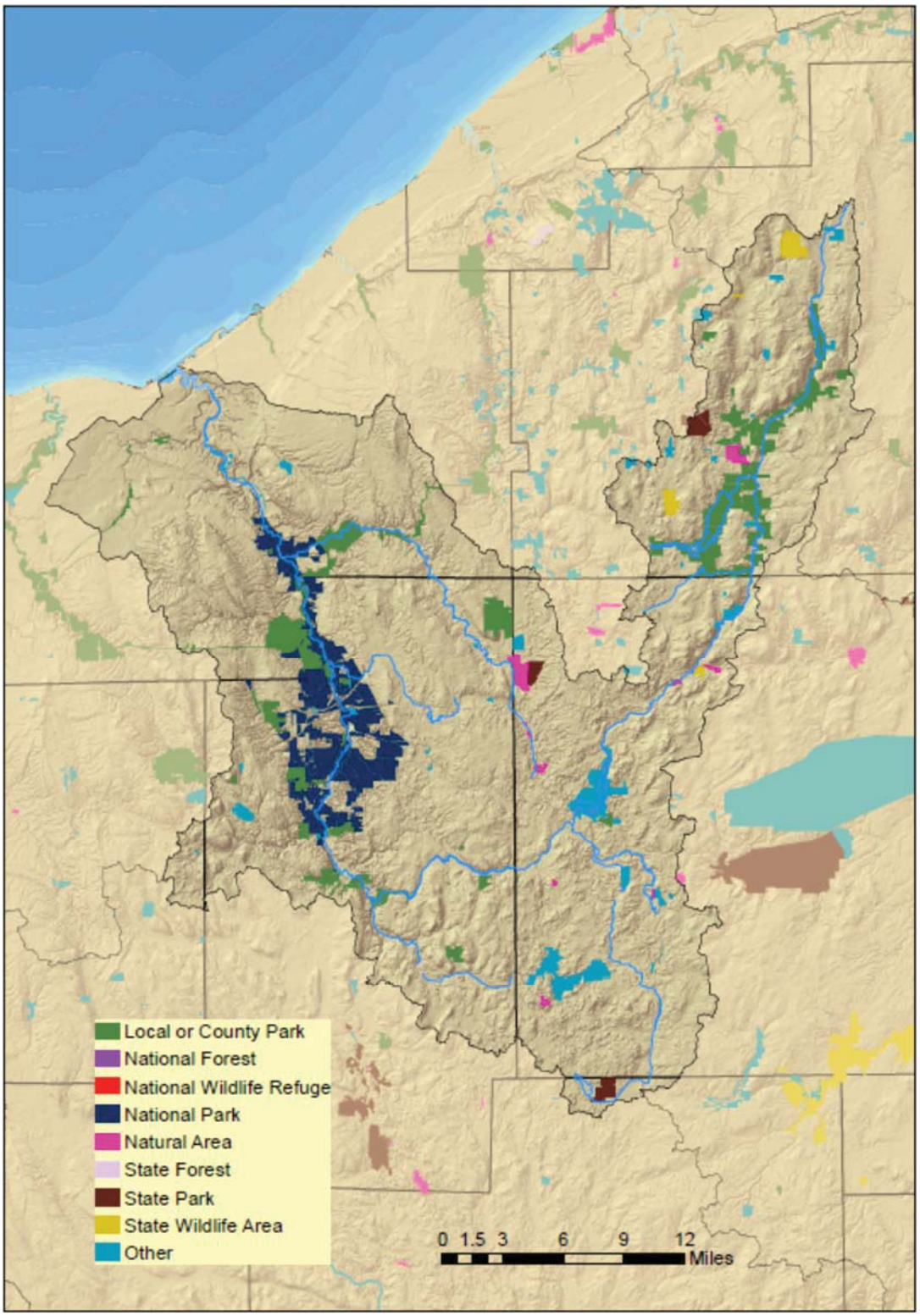


Figure 26. Cuyahoga River Conservation Opportunity Watershed – Protected Lands.

6.14.4.4 Chagrin River CO Watershed (consists of the southern ~ 75% of HUC 04110003)
The Chagrin River originates in Geauga County at Chardon and flows southwest to Chagrin Falls where its drainage area is 60.6 square miles. Just west of Chagrin Falls, Aurora Branch with 58.2 square miles of drainage area joins the river from the south. From the confluence with Aurora Branch, the Chagrin flows northward in a preglacial valley to Willoughby and its mouth in Lake Erie at Fairport Harbor. East Branch with drainage area of 51.1 square miles joins the river at Willoughby. The total drainage basin is approximately 264 square miles.

Physiography
The main tributaries to Lake Erie east of the Cuyahoga River lie mostly in the Glaciated Allegheny Plateaus with only the extreme lower reaches in the Erie Lake Plain. The Erie Lake Plain is separated from the Glaciated Allegheny Plateaus by the Portage Escarpment, an irregular slope 2 to 4 miles wide descending from elevation of about 1200 feet to 700 or 800 feet above mean sea level. The main tributaries have cut deep gorges in the Portage Escarpment. The smaller tributaries to the lake typically gather in and along the south side of the escarpment.

The Chagrin River Basin is mostly in the Killbuck Glaciated Pittsburgh Plateau and is rougher than that of the other main tributaries to the east. The terrain is rolling hills with moderate relief. The river flows on bedrock in some places and on valley fill of silts and clays in other places. Rock outcrops along the upper reaches of the Chagrin and its main tributaries are mainly that of Sharon Conglomerate. The upper reach between Chardon and Chagrin Falls flows at relatively steep gradient averaging about 25 feet per mile. At Chagrin Falls the river drops through a series of rapids about 100 feet over the course of a mile. Aurora Branch flows at average gradient of about 20 feet per mile and drops about 60 feet through a series of rapids near Chagrin Falls. The lower reach of the Chagrin River flows at relatively low gradient of about 4 feet per mile in a preglacial valley filled with silts and clays. The river flows in a deep gorge cut in Devonian-age shales at the Portage Escarpment. East Branch originates on the west side of Chardon and flows at relatively steep gradient averaging about 35 feet per mile to its confluence with the Chagrin River in the Portage Escarpment at Willoughby.

Geology
The surface rocks along the Erie Lake Plain are shales of Devonian age. These rocks continue at the surface south of the Portage Escarpment toward the midpoint of the basins. South and east, sandstone and shales of Mississippian age are at the surface. The Pennsylvanian-age Pottsville Group including the Sharon Conglomerate interfaces with the Mississippian-age rocks in upper parts of the Chagrin River Basin. The Berea sandstone of Mississippian age forms the falls at Chagrin Falls. A buried valley exists along the general course of Aurora Branch and the lower Chagrin River. Although the Berea sandstone yields some ground water to streams, it is the Sharon Conglomerate that yields large quantities. The shales yield little ground water to streams. The overburden of glacial drift covering the basin as a whole is relatively impermeable. Two recessional moraines cross the area, and there are some local deposits of outwash material.

Soils
Basins of the main tributaries to Lake Erie east of the Cuyahoga River are largely in the Mahoning-Canfield-Rittman-Chili soil region. Parts of the basin in the Erie Lake Plain and Portage Escarpment are in Conotton-Conneaut-Allis soil region.

Mahoning soil is dominant in the northern and eastern parts of the Grand River Low Plateau where the main tributaries east of the Cuyahoga River are located. Mahoning soil developed from clay loam and clayey till and has slow permeability. Platea soil is also common. It has a fragipan that is very slowly permeable. Soils in the Grand River Finger Lake Plain developed from medium- to fine-textured till and lacustrine deposits. They have slow permeability. Soils developed in loamy outwash at various places have rapid permeability. For the most part, however, soils in Grand River Low Plateau of the tributary basins have slow permeability that impeded ground water recharge. Conneaut soil is dominant in the Erie Lake Plain eastward from Cleveland. This slowly permeable soil developed from lacustrine deposits of lacustrine silt loam and silty glacial till. Rapidly permeable soils are on beach ridges. Conotton soil formed on beach ridges along the Portage Escarpment. Conotton is rapidly permeable.

Water Development
Communities along Lake Erie from Cleveland to Conneaut are supplied with water from Lake Erie. Source of supply for the communities distant from the lake includes both surface water and ground water. The Grand River is source of supply for Rock Creek. Roaming Rock Lake on Rock Creek serves as source of supply for Roaming Shores. Sand and gravel lens in glacial drift supply Orwell. Chardon has wells near Bass Lake at the head of the Chagrin River. Chagrin Falls obtains supply from Cleveland.

Flow Characteristics
The Chagrin River at Willoughby and Aurora Branch near Chagrin Falls have relatively high base flow largely due to discharges from the Sharon Conglomerate and some outwash deposits. Big Creek and Painsville Creek gather in outwash near Chardon like the Chagrin and have relatively high base flows. East Branch of the Chagrin River is characterized as cold-water habitat and likely has high base flow similar to the Chagrin River.

State Listed Species by County with Records of Occurrence from the Chagrin River Watershed (from the Ohio Natural Heritage Database)
The following species are dependent upon aquatic habitats to complete their life cycle – this dependence may be for all or a portion of their life:

Lake County
Spotted turtle, four-toed salamander, tiger spiketail, racket-tailed emerald, boreal bluet, northern bluet, marsh bluet, green-faced clubtail, Uhler's sundragon, riffle snaketail, *Chimarra social* (caddisfly), *Psilotreta indecisa* (caddisfly), *Rheopelopia acra* (midge), muskellunge, northern brook lamprey, eastern sand darter, river redhorse, pugnose minnow, longnose dace, great lakes crayfish, northern crayfish, elktoe, snuffbox, wavyrayed lampmussel, black sandshell, round pigtoe, kidneyshell, salamander mussel, fawnsfoot, deertoe

Cuyahoga County
Spotted turtle, tiger spiketail, *Chimarra socia* (caddisfly), muskellunge, bigmouth shiner, channel darter, longnose dace, great lakes crayfish

Geauga County
Blanding's turtle, spotted turtle, four-toed salamander, river jewelwing, tiger spiketail, American emerald, boreal bluet, northern bluet, marsh bluet, harlequin darner, riffle snaketail, *Litobrancha recurvate* (mayfly), *Psilotreta indecisa* (caddisfly), *Stenonema ithaca* (mayfly), lake chubsucker, Iowa darter, longnose dace, brook trout, creek heelsplitter, eastern pondmussel, great lakes crayfish, northern crayfish

Portage County
Spotted turtle, four-toed salamander, American emerald, racket-tailed emerald, northern bluet, harlequin darner, frosted whiteface, brush-tipped emerald, *Psilotreta indecisa* (caddisfly), eastern sand darter, lake chubsucker, Iowa darter, least darter, mountain brook lamprey, creek heelsplitter, eastern pondmussel, allegheny crayfish

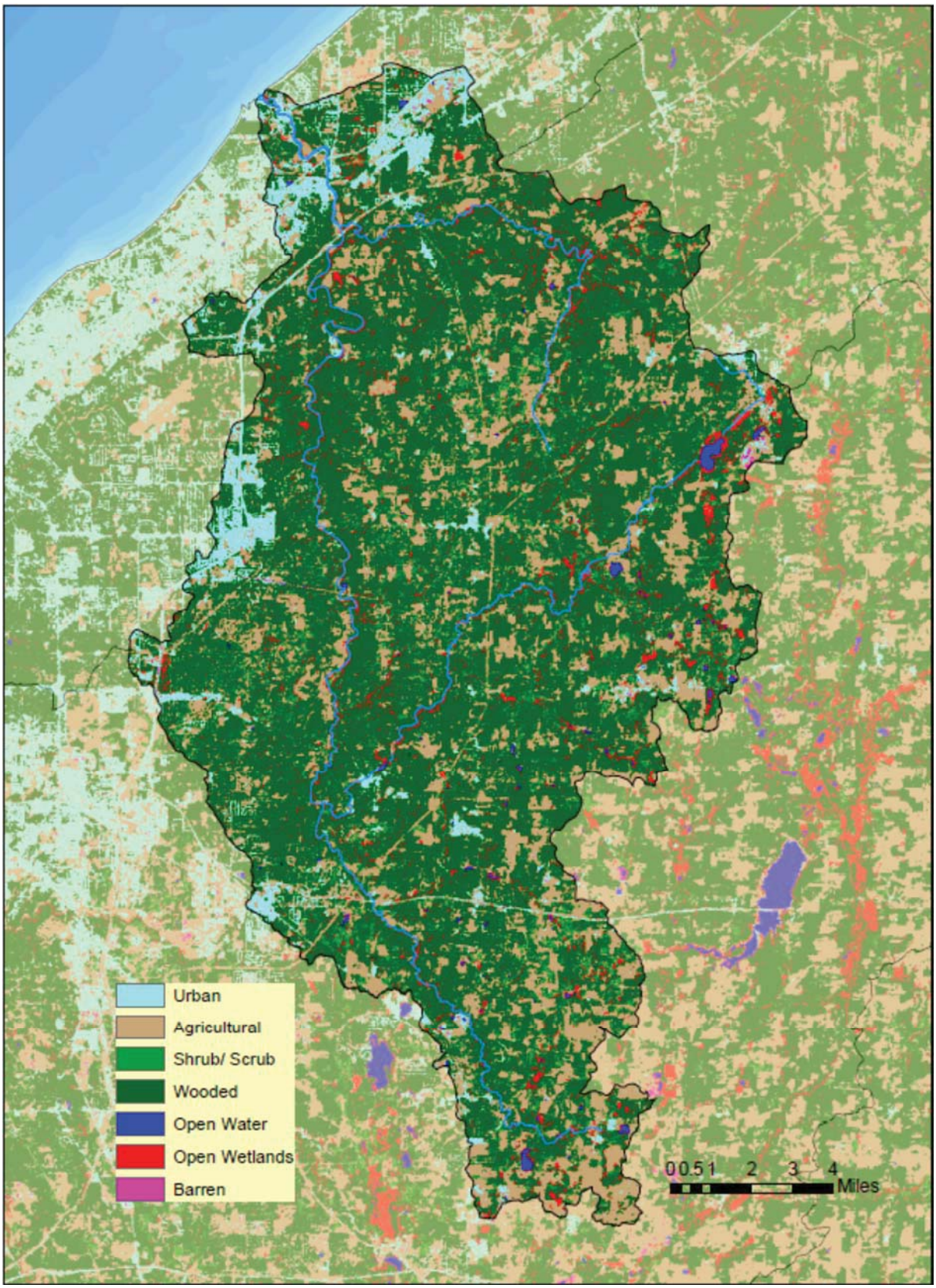


Figure 27. Chagrin River Conservation Opportunity Watershed – Land Cover.

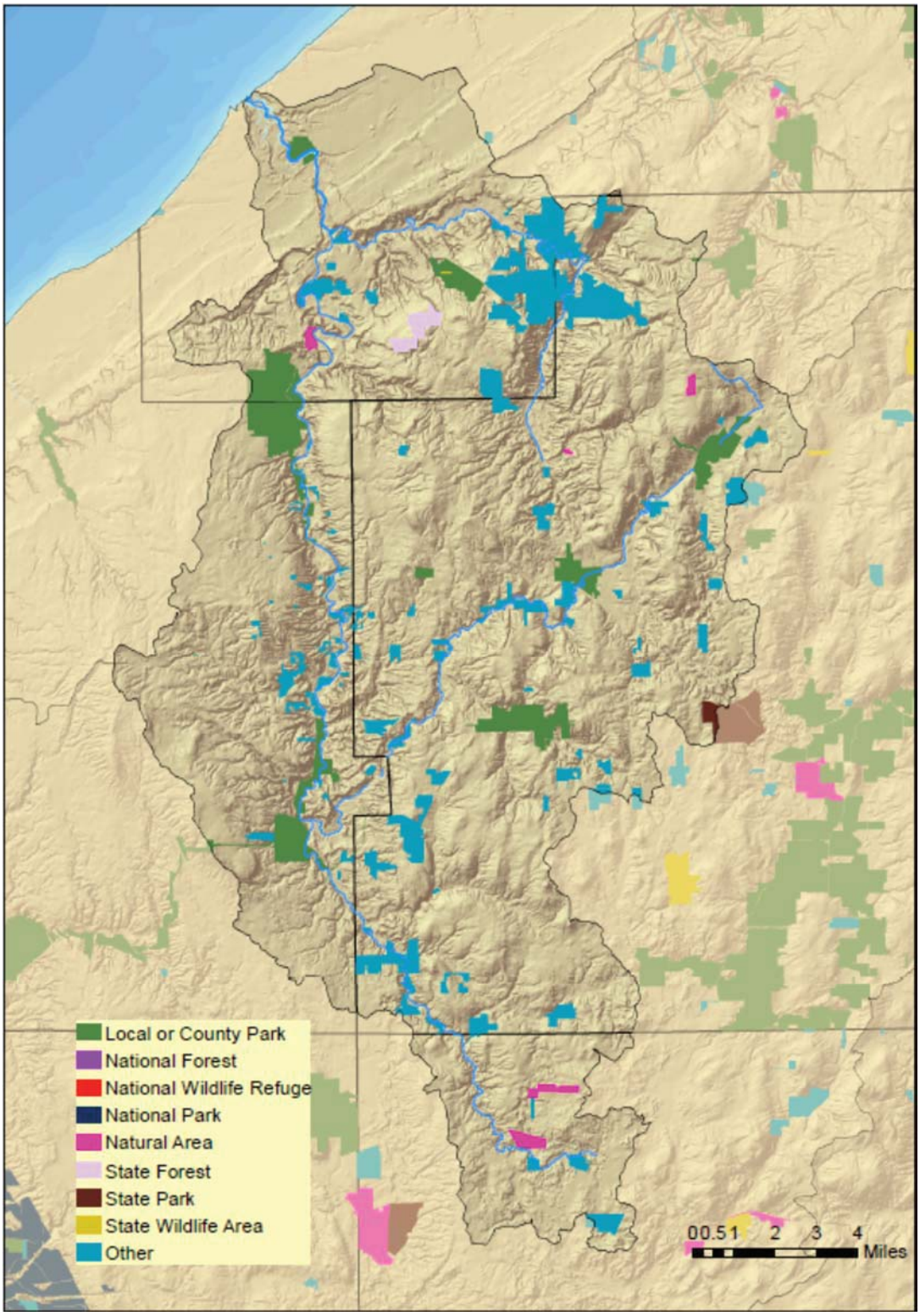


Figure 28. Chagrin River Conservation Opportunity Watershed – Protected Lands.

6.14.4.5 Grand River CO Watershed (HUC 04110004)
Draining 705 square miles, the Grand River gathers in morainal hills around the southern end of the Grand River Finger Lake Plain. The river meanders northward picking up drainage from relatively small tributaries to the west include Swine Creek, Phelps Creek, and Hoskins Creek with drainage areas of 30.9, 29.2, and 26.9 square miles, respectively. Larger tributaries join the Grand River from the east including Rock Creek with drainage area of 70.7 square miles and Mill Creek with drainage area of 103 square miles. At the north end of the Grand River Finger Lake Plain, the river turns west and meanders toward Painesville in a relatively deep, flat bottom valley in the Lake Escarpment. Paine Creek and Big Creek with drainage areas of 28.9 and 50.1 square miles flow into the river from the south along the Lake Escarpment. At Painesville, the river cuts north across the narrow Erie Lake Plain to its mouth in the lake.

Physiography
The Grand River Basin occupies nearly all of the Grand River Finger-Lake Plain located in the western part of the Grand River Low Plateau. The broad trough-like preglacial valley that the river flows north in is filled with surficial lacustrine deposits and till. Relief in the Finger-Lake Plain is very low as is the gradient of the river. Tributaries joining the Grand River from the west descend into the valley at relatively steep gradient while those flowing in from the east have more moderate gradient. The lower westward reach of the Grand River flows in a deep gorge along the Portage Escarpment to Painesville where it crosses the narrow Erie Lake Plain. Paine Creek and Big Creek that join the Grand River along its westward course, originate north of Chardon in the Killbuck Glaciated Pittsburgh Plateau.

Geology
The surface rocks along the Erie Lake Plain are shales of Devonian age. These rocks continue at the surface south of the Portage Escarpment toward the midpoint of the basins. South and east, sandstone and shales of Mississippian age are at the surface. Although the Berea sandstone yields some ground water to streams, it is the Sharon Conglomerate that yields large quantities. The shales yield little ground water to streams. The overburden of glacial drift covering the basin as a whole is relatively impermeable. Two recessional moraines cross the area, and there are some local deposits of outwash material.

Soils
Mahoning soil is dominant in the northern and eastern parts of the Grand River Low Plateau where the main tributaries east of the Cuyahoga River are located. Mahoning soil developed from clay loam and clayey till and has slow permeability. Platea soil is also common. It has a fragipan that is very slowly permeable. Soils in the Grand River Finger Lake Plain developed from medium- to fine-textured till and lacustrine deposits. They have slow permeability. Soils developed in loamy outwash at various places have rapid permeability. For the most part, however, soils in Grand River Low Plateau of the tributary basins have slow permeability that impeded ground water recharge.

Water Development
Communities along Lake Erie from Cleveland to Conneaut are supplies with water from the lake. Source of supply for the communities distant from the lake includes both surface water and ground water. The Grand River is source of supply for Rock Creek. Roaming Rock Lake on Rock Creek serves as source of supply for Roaming Shores. Sand and gravel lens in glacial drift supply Orwell. Chardon has wells near Bass Lake at the head of the Chagrin River. Chagrin Falls obtains supply from Cleveland.

Flow Characteristics
Actual mean annual runoff of the Grand River is likely around 18 inches. Areas with large amounts of snow pack and extensive wetlands present limitations for the hydrograph separation techniques used to derive mean base-flow indices. Overall, the Grand River has relatively low base flow.

The 10-percent duration flows of streams in the area are relatively high indicating that high water is not uncommon. The relatively low 2-year recurrence interval flood-peak discharge of 15 cfs per square mile for Grand River at Madison reflects the attenuating effects of the Finger Lake Plain. The watershed of Hoskins Creek upstream of Hartsgrove is a relatively flat till plain with extensive wetlands. This explains the 37.6 cfs per square mile peak discharge of Hoskins Creek versus 69.5 cfs per square mile for nearby Phelps Creek that gathers in the end moraine where the terrain is hilly and the relief is greater.

State Listed Species by County with Records of Occurrence from the Grand River Watershed (from the Ohio Natural Heritage Database)
The following species are dependent upon aquatic habitats to complete their life cycle – this dependence may be for all or a portion of their life:

Lake County
Spotted turtle, four-toed salamander, tiger spiketail, racket-tailed emerald, boreal bluet, northern bluet, marsh bluet, green-faced clubtail, Uhler's sundragon, riffle snaketail, *Chimarra social* (caddisfly), *Psilotreta indecisa* (caddisfly), *Rheopelopia acra* (midge), muskellunge, northern brook lamprey, eastern sand darter, river redhorse, pugnose minnow, longnose dace, great lakes crayfish, northern crayfish, elktoe, snuffbox, wavyrayed lampmussel, black sandshell, round pigtoe, kidneyshell, salamander mussel, fawnsfoot, deertoe

Ashtabula County
Spotted turtle, four-toed salamander, racket-tailed emerald, marsh bluet, green-faced clubtail, chalk-fronted corporal, brush-tipped emerald, *Chimarra socia* (caddisfly), *Rheopelopia acra* (midge), *Stenonema ithaca* (mayfly), eastern sand darter, muskellunge, northern brook lamprey, burbot, river redhorse, longnose dace, great lakes crayfish, elktoe, elephant-ear, snuffbox, wavyrayed lampmussel, creek heelsplitter, eastern pondmussel, black sandshell, clubshell, round pigtoe, kidneyshell, salamander mussel

Geauga County
Blanding's turtle, spotted turtle, four-toed salamander, river jewelwing, tiger spiketail, American emerald, boreal bluet, northern bluet, marsh bluet, harlequin darner, riffle snaketail, *Litobrancha recurvate* (mayfly), *Psilotreta indecisa* (caddisfly), *Stenonema ithaca* (mayfly), lake chubsucker, Iowa darter, longnose dace, brook trout, creek heelsplitter, eastern pondmussel, great lakes crayfish, northern crayfish

Trumbull County
Spotted turtle, four-toed salamander, *Psilotreta indecisa* (caddisfly), eastern sand darter, northern brook lamprey, mountain brook lamprey, great lakes crayfish, northern crayfish, creek heelsplitter, black sandshell, round pigtoe, salamander mussel

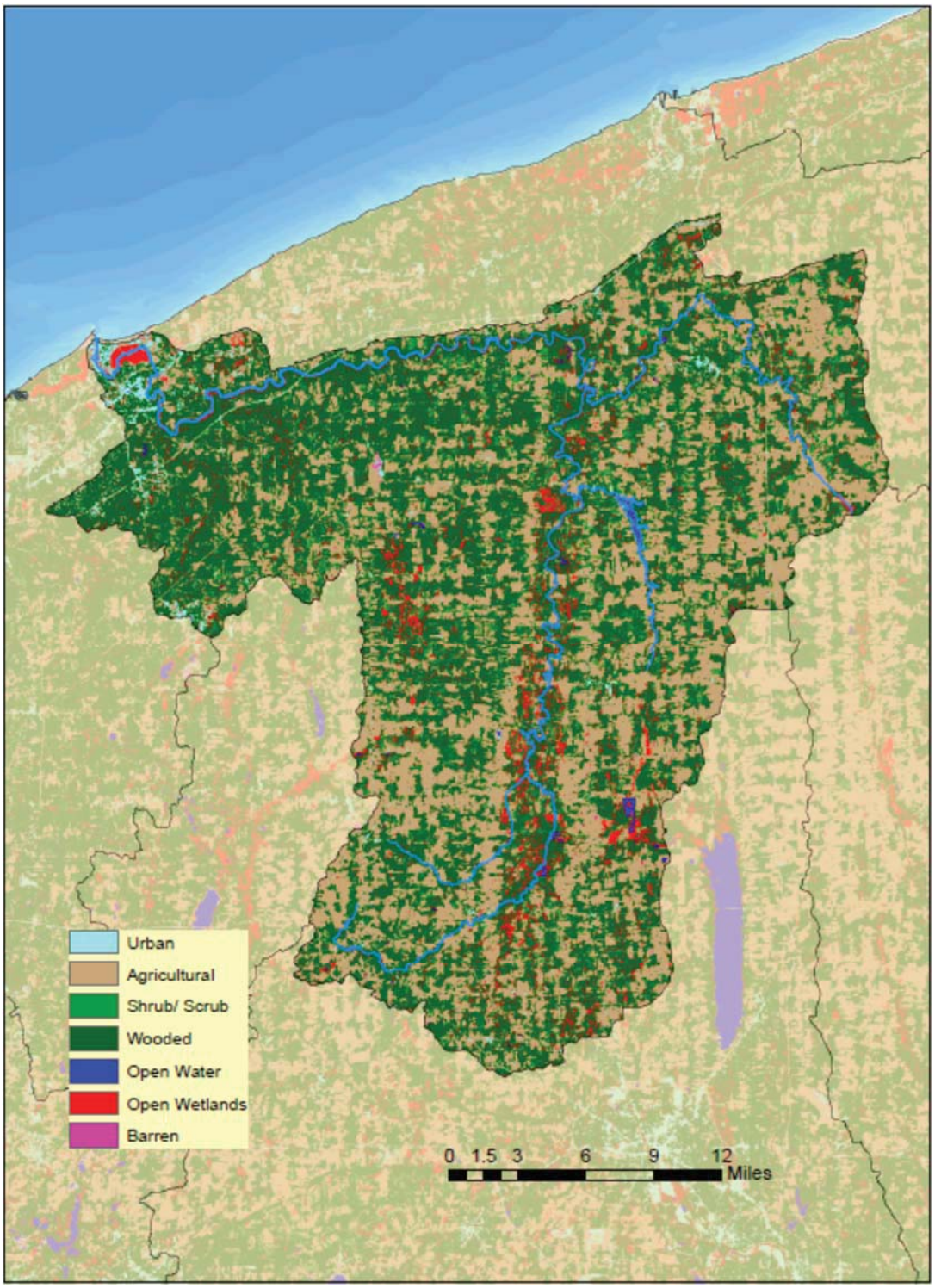


Figure 29. Grand River Conservation Opportunity Watershed – Land Cover.

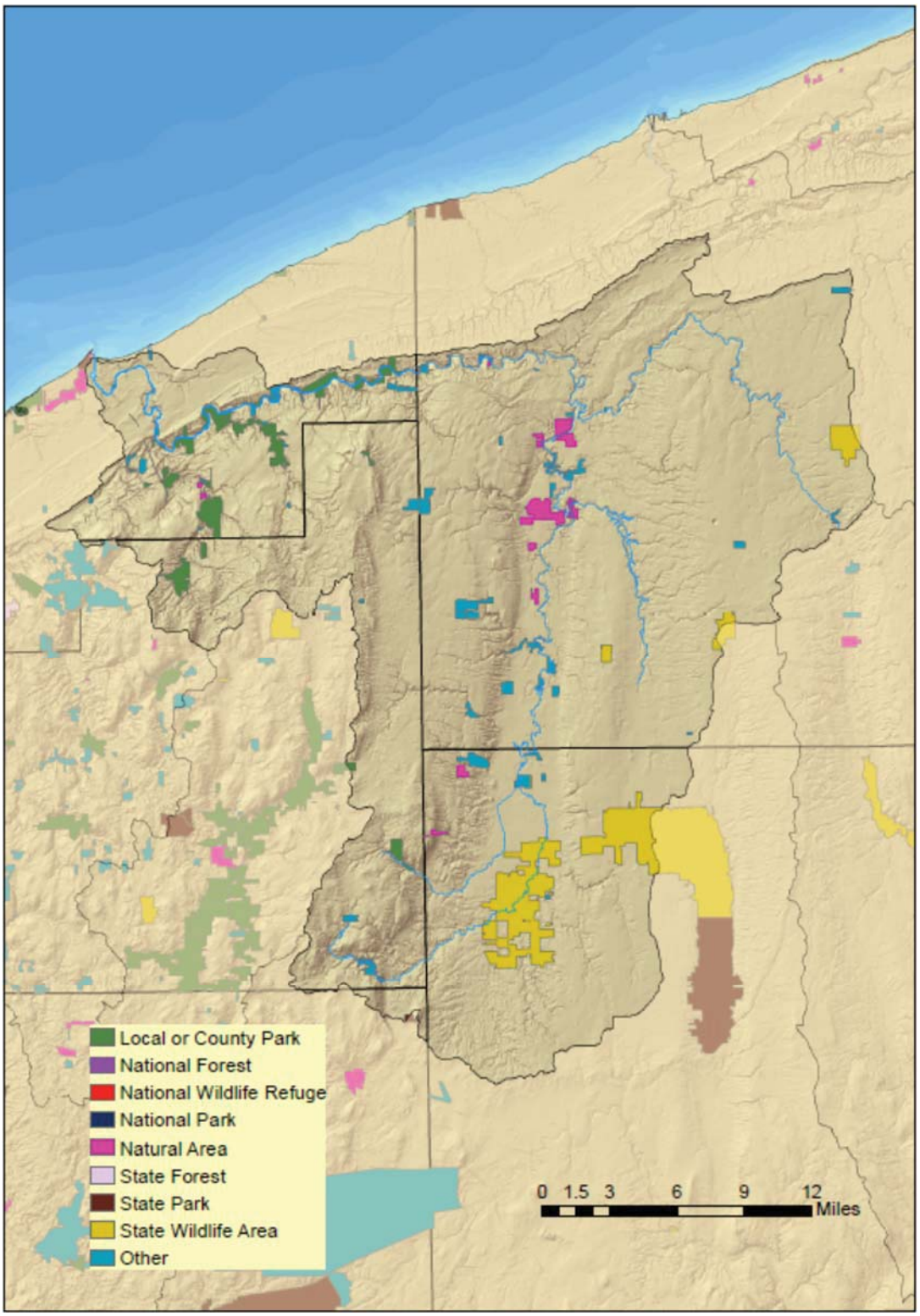


Figure 30. Grand River Conservation Opportunity Watershed – Protected Lands.

Table 37. CONSERVATION THREATS TO LAKE ERIE TRIBUTARIES.
The following threats negatively impact or have the potential to negatively impact Lake Erie Tributaries. Threat categories/classification from Salafsky et al. (2008), and threat impact rank calculations from Master et al. (2012).

ID	threats	2nd level threat classification(s)	threat impact rank
I	**residential and commercial development**		medium
A	Watershed conversion to urban/commercial development alters hydrology	housing & urban areas commercial & industrial areas	medium low
B	Riparian development and its negative effect on habitat and species	housing & urban areas commercial & industrial areas tourism & recreation areas	medium low low
C	Increasing land prices limit our ability to protect riparian corridors	housing & urban areas commercial & industrial areas tourism & recreation areas	medium low low
II	**agriculture and aquaculture**		medium
A	Loss of riparian corridor to agriculture	annual & perennial non-timber crops livestock farming & ranching	high low
B	Watershed conversion to agriculture alters hydrology	annual & perennial non-timber crops livestock farming & ranching	high low
III	**energy production and mining**		low
A	Oil and gas extraction - can have negative impacts by causing chemical contamination	oil & gas drilling	low
B	Hydropower facilities disrupt stream connectivity and kill aquatic species	renewable energy	low
C	Water withdrawal for fracking can alter hydrology	oil & gas drilling	low
D	Sand/gravel operations destroy habitat	mining & quarrying	low
IV	**transportation and service corridors**		medium
A	Channel modification, dredging river mouths - causes habitat loss, water quality impacts	shipping lanes	medium
B	Roads, bridges, causeways, utilities, impact shoreline/nearshore habitats	roads & railroads utility & service lines	low low
V	**biological resource use**		low
A	Fishing pressure and fishing gear impacts	fishing & harvesting aquatic resources	low
VI	**human intrusions and disturbance**		low
A	Incompatible recreational activities	recreational activities	low

B	Creation of recreational facilities can alter/destroy nearshore habitat	recreational activities	low
C	Vessel impacts to nearshore habitats and water quality	recreational activities work & other activities	low negligible
VII	**natural system modifications**		medium
A	Dams cause habitat loss, sedimentation, decreased water quality, reduced biodiversity, and reduce movement of aquatic species and species abundance	dams & water management/use	medium
B	Conflicting water control management objectives of controlling agencies (DOW – USACOE)	dams & water management/use	medium
C	Some species' populations have been reduced to levels below what is necessary to recover on their own	other ecosystem modifications	medium
D	Lack of data for some species and habitats limits our ability to develop plans for threats like climate change	other ecosystem modifications	medium
VIII	**invasive and other problematic species and genes**		high
A	Introduction and/or spread of invasive plants and animals	invasive non-native/alien species	high
B	Introduction and/or spread of nuisance plants and animals	problematic native species	low
C	Introduction and spread of diseases (plants and animals)	invasive non-native/alien species problematic native species	high low
IX	**pollution**		high
A	Urban effluent carries a variety of substances that impact water quality and aquatic species	household sewage & urban wastewater industrial & military effluents garbage & solid waste air-borne pollutants	high medium low low
B	Agricultural effluent from row crops as well as confined animal operations impacts water quality and aquatic species	agricultural & forestry effluents	very high
C	Harmful algal blooms affect water quality, aquatic species, and can be toxic to terrestrial species	agricultural & forestry effluents	very high
D	Industrial spills impact water quality and aquatic species	industrial & military effluents	medium
X	**geological events**		negligible
---	none	---	---
XI	**climate change and severe weather**		low
A	Climate change could impact habitats, water quality, and species	habitat shifting & alteration droughts temperature extremes storms & flooding	low low low medium

Table 38. CONSERVATION ACTIONS FOR LAKE ERIE TRIBUTARIES.
The following actions will help abate or have the potential to help abate threats to Lake Erie Tributaries habitat. Action categories/classification from Salafsky et al. (2008), and action priority rank calculations from Georgia DNR (2005).

ID	actions	2nd level action classification(s)	action priority rank	threat(s) addressed*
I	**LAND/WATER PROTECTION**		med	
1	Protect riparian corridors through acquisition, partnerships, conservation easements, etc.	site/area protection resource & habitat protection	low high	I, II, IV-B, VI-B
2	Quantify and map critical habitat areas in the Cuyahoga River for future protection	site/area protection	low	I-A, IV-A,B, VI-B,C, VII-C
II	**LAND/WATER MANAGEMENT**		high	
1	Work with OEPA, ODOT, USACE, and other government agencies to focus mitigation activities on riparian habitats in conservation opportunity watersheds	habitat & natural process restoration	high	I-A, II-A, IV-B, VI-B, XI
2	Work with landowners to develop and implement habitat improvement projects on private lands	habitat & natural process restoration	high	I, II, XI
3	Remove dams to restore stream connectivity and improve water quality	habitat & natural process restoration	high	VII-A, XI
4	Develop criteria for prioritizing candidate dams for removal – give extra emphasis to dams in conservation opportunity watersheds	habitat & natural process restoration	high	III-B, VII
5	Research fish passage improvements for dams that are not candidates for removal	habitat & natural process restoration	high	III-B, VII
6	Identify and prioritize restoration projects (channel restoration, floodplain and backwater reconnection, etc.) in conservation opportunity watersheds	habitat & natural process restoration	high	I-A,B, II, IV, VII-B, XI
7	Complete a geomorphological restoration project in each conservation opportunity watershed on an average of every 5 years beginning in 2016	habitat & natural process restoration	high	I-A,B, II, IV, VII, XI
8	Develop model stream protection guidelines aimed at slowing the overland flow of water into streams	habitat & natural process restoration	high	I-A, II-B, IX-A,B
9	Use lowest impact techniques and timing for dredging activities	habitat & natural process restoration	high	III-D, IV-A, VII-B
10	Create and use wetlands for stormwater treatment	habitat & natural process restoration	high	I-A, IX-A
11	Establish an early-detection/rapid-response system for dealing with invasive and nuisance species	invasive/ problematic species control	high	VIII-A,B

12	Develop ways to control invasive plant species in flowing waters	invasive/ problematic species control	high	VIII-A,B
13	Develop a process for coordinating disparate data sources of distribution and abundance of aquatic SGCN with special emphasis on conservation opportunity watersheds	habitat & natural process restoration	high	I-B, III-B,D, IV-A,B, VI-B, VII-A,D, XI
14	Review existing species and habitat data to identify data gaps and needs for additional surveys, research, and management actions	habitat & natural process restoration	high	I, II, III, IV, V, VI, VII, VIII, IX, XI
15	Conduct comprehensive surveys of freshwater mussels in all conservation opportunity watersheds	habitat & natural process restoration	high	I-B, III-C,D, IV-A,B, VI-B, VII, XI
16	Conduct watershed studies to identify and prioritize restoration opportunities	habitat & natural process restoration	high	I-B, II-A, IV-A, VI-B, VII, XI
17	Stabilize severely eroding streambanks with bio-engineering techniques	habitat & natural process restoration	high	I-A,B, II, VI-C
18	Reconnect stream channels with natural floodplains	habitat & natural process restoration	high	I-A,B, II, IV, VII-B, XI
19	Restore/stabilize riparian habitat by planting native grasses, shrubs, and trees	habitat & natural process restoration	high	I-B, II-A, IV-B
20	Develop GIS tools to archive and monitor the status of protected lands in conservation opportunity watersheds	site/area management	low	XI
III	**SPECIES MANAGEMENT**		low	
1	Assess population status, habitat suitability, and probability for restoration of lake sturgeon spawning stocks in Ohio tributaries to Lake Erie	species management species recovery	low med	VII-C
2	Develop a restoration strategy for sauger in the Maumee and Sandusky Rivers	species reintroduction	low	VII-C
3	Assess population status, habitat suitability, and probability for restoration of fish, mussels, crayfish, invertabrates, and amphibians listed as SGCN	species reintroduction	High	VII-C, VII-D
4	Develop a restoration strategy for high priority fish, mussels, crayfish, invertebrates, and amphibians	species reintroduction	High	VII-C, VII-D
IV	**EDUCATION AND AWARENESS**		high	
1	Educate waterfront landowners and commercial pesticide/herbicide applicators on responsible chemical use, and the negative impacts to wildlife from toxic chemicals	training	high	I-B,C, IX-A
2	Promote conservation easements to protect riparian habitat	training awareness & communic-ations	high high	I, II, IV-B, VI-B, XI
3	Conduct shoreline protection/stabilization workshops	training	high	I-B, II-A, IV-B, VI-B
4	Provide technical guidance on shoreline development plans as relates to fish and wildlife interests	training	high	I, IV-B, VI-B, XI
5	Support the Ohio Clean Lakes Initiative - educating	training	high	II, IX-B,C

	and training farmers and other interested parties on agricultural nutrient management and stewardship			
6	Educate the public about the negative effects of exotic and nuisance animals – encourage responsible disposal of unwanted animals	awareness & communic-ations	high	VIII
7	Provide training to road construction/maintenance personnel for runoff/sediment control	training	high	I-B, IV-B, VI-B
8	Educate the public and legislators on the benefits of dam removals	training awareness & communic-ations	high high	VII-A
9	Provide training in geomorphological, fluvial, and in-stream flow processes for DOW personnel	training	high	III-B,C,D, IV, VI-B, VII-A,B
10	Develop and provide streams/watersheds educational materials for landowners, schools, public officials, and the general public	training awareness & communic-ations	high high	I, II, IX-A,B, XI
11	Create and implement demonstration projects aimed at reducing urban effluent – such as rain gardens, bioretention, etc.	training awareness & communic-ations	high high	I-A,B, IX-A
12	Conduct outreach for landowners on private land management, conservation practices, and water quality	training awareness & communic-ations	high high	I, II, IX-A,B
V	**LAW AND POLICY**		high	
1	Support legislation promoting eco-friendly energy development and use	legislation	high	III-A,B,C
2	Support sewage sludge/animal manure disposal standards to regulate application rates and timing	policies & regulations	high	IX-A,B,C
3	Develop and implement a risk-assessment system in the approval process for importing or moving live animals and plants	legislation policies & regulations	high high	VIII
4	Support more stringent ballast water regulations to stop the introduction of invasive species	legislation policies & regulations	high high	VIII
5	Encourage and support minimum flow regulations that protect downstream aquatic habitats	policies & regulations	high	III-B, VII-A,B, IX-A,B
6	Support the creation of additional and/or increased enforcement of stormwater regulations	policies & regulations compliance & enforcement	high med	I-A, IX-A
7	Find innovative ways to mandate the inclusion of fish and wildlife interests in development plans	policies & regulations private sector	high low	I, III-B,C,D, IV-B, VI-B, VII-C, XI

		standards & codes		
8	Support the use of buffers between development and tributary shorelines	policies & regulations private sector standards & codes	high low	I-A,B, IV-B, IX-A
9	Promote riparian protection ordinances that prevent floodplain encroachment and riparian habitat removal	policies & regulations private sector standards & codes	high low	I, II, IV-B, VI-B
10	Support increased regulation of home sewage treatment systems	compliance & enforcement	med	IX-A
VI	**LIVELIHOOD, ECONOMIC AND OTHER INCENTIVES**		med	
1	Explore tying eligibility for grant money, loans, and cost-share programs to nutrient loading levels for agriculture – the lower the nutrient levels in their effluent, the more money they would be eligible for	market forces conservation payments	high high	IX-B,C, XI
2	Create incentives for vegetated buffers along all waterways to reduce nutrient loads and sediment	market forces conservation payments	high high	I, II, IX-A,B,C, XI
3	Create incentives to promote eco-friendly energy development and use	market forces conservation payments non-monetary values	high high low	III-A,B,C
4	Support the creation of incentives to protect riparian habitat	market forces conservation payments	high high	I, II, IV-B, VI-B, XI
5	Support clean marina and clean vessel programs	market forces conservation payments	high high	VI-C
6	Develop incentives for municipalities to use stormwater management systems that minimize negative impacts to aquatic habitats	market forces conservation payments	high high	I-A, IX-A
7	Support incentives for development plans involving water frontage that take into account wildlife and habitat needs	market forces conservation payments non-monetary values	high high low	I, IV-B, VI-B, XI
8	Support payments to offset losses (revenue from crops) resulting from implementation of conservation practices aimed at reducing sediment loads	conservation payments	high	IX-B,C

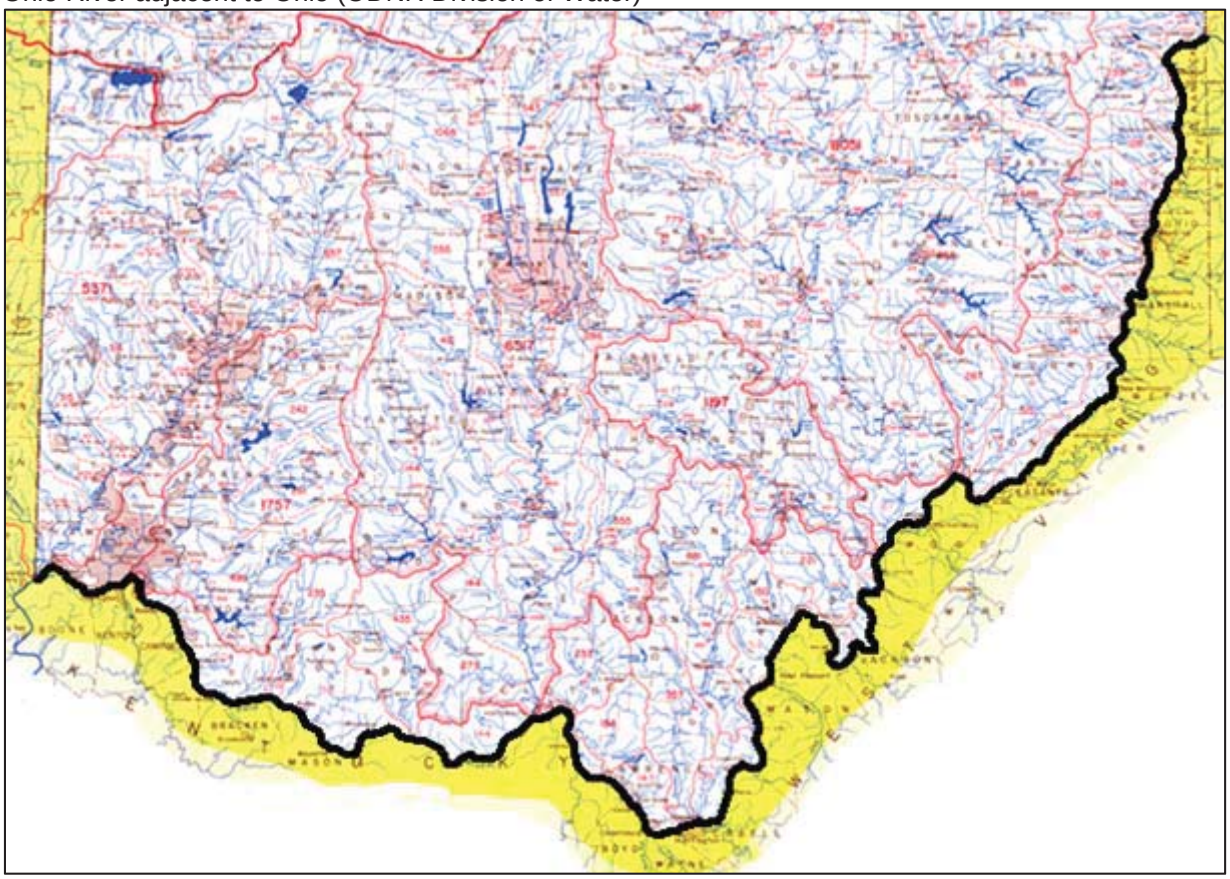
9	Create incentives to encourage the use of conservation tillage – especially in impaired watersheds	market forces conservation payments	high high	IX-B,C
10	Support incentives for conservation farming practices – including nutrient management plans and livestock waste management plans	market forces conservation payments	high high	IX-B,C
11	Encourage the use of cover crops for idle agricultural fields	market forces conservation payments	high high	IX-B,C
12	Promote drainage water management such as grassed waterways, 2-stage channels, and over-wide ditches	market forces conservation payments	high high	II, IX-B,C
13	Promote waterway conservation livestock practices such as exclusion fencing, livestock crossings, alternative water supplies, livestock access lanes	market forces conservation payments	high high	II-A, IX-B,C
VII	**EXTERNAL CAPACITY BUILDING**		med	
1	Work with ODA and OEPA to minimize nutrients in runoff, and develop BMPs for pesticide/herbicide use	alliance & partnership development	high	IX
2	Create an interagency spill response team – update contacts and training on a regular basis	alliance & partnership development	high	IX-D
3	Consider creating a multiagency invasive species prevention and control group that would handle all invasive species issues	alliance & partnership development	high	VIII
4	Through interagency coordination, work to assure that wildlife interests are taken into consideration in road, bridge, and causeway design, construction, and maintenance	alliance & partnership development	high	IV-B
5	Create a multi-agency dam removal task force	alliance & partnership development	high	VII
6	Use inter-agency cooperation to influence watershed health	alliance & partnership development	high	I, II, IX, XI
7	Pursue partnerships with local, state, and federal agencies to secure funding for projects benefitting streams and watersheds	alliance & partnership development conservation finance	high low	I, II, III, IV, VI, VII, VIII, IX, XI
8	Work with OEPA to encourage the reuse of point source discharge water	alliance & partnership development	high	IX-A
9	Work with OEPA and municipalities to eliminate CSO's and SSO's – especially in impaired watersheds	alliance & partnership development	high	I-A, IX-A
10	Work with OEPA to encourage completion of TMDL studies for all streams in the Lake Erie drainage	alliance & partnership development	high	IX-A,B,C

11	Work with OEPA and local watershed groups to remediate contaminated sediments, and restore habitat in conjunction with remediation	alliance & partnership development	high	I-B, IX-A
12	Work with regulatory agencies and local watershed groups on programs to restore natural stream and flood plain function	alliance & partnership development	high	I-A,B, II, IV, VII-A,B, XI
13	Develop partnerships with land trusts, watershed and conservation groups, and government agencies to guide acquisition and protection activities in each conservation opportunity watershed	institutional & civil society development alliance & partnership development	med high	I, II, III, IV, VI, XI
14	Increase personnel and expertise available for SGCN surveys and research through partnerships with other government agencies and, universities, and conservation-minded NGO's	institutional & civil society development alliance & partnership development	med high	I, II, III, IV, V, VI, VII, VIII, IX, XI
15	Encourage/facilitate the establishment of watershed groups & watershed coordinator to promote watershed improvement activities	institutional & civil society development	med	I, II, IX, XI

*refers to the Lake Erie Tributaries Habitat Conservation Threats in Table 37

6.15 Ohio River

Ohio River adjacent to Ohio (ODNR Division of Water)



6.15.1 Status

Generally good, and stable. All pools adjacent to Ohio met aquatic life-use designations. Water quality has improved over time, although industrial spills continue to occur. The percentage of pollution tolerant fishes has declined over time. Despite dams, hydropower facilities, and commercial navigation, the river supports a tremendous diversity of terrestrial and aquatic species – although this species assemblage has changed significantly since the river was modified to facilitate commercial navigation.

6.15.2 Description

The Ohio River is formed in Pittsburgh, Pennsylvania by the confluence of the Allegheny and Monongahela rivers and flows 981 miles to Cairo, Illinois where it enters the Mississippi River. The river forms the entire 451-mile southern boundary between Ohio and West Virginia/Kentucky. Adjacent to Ohio, the river comprises 91,300 surface acres of water. The U.S. Army Corps of Engineers began modifying the Ohio River to improve navigation in 1824 by dredging sandbars and removing snags. The first lock and dam was completed in 1885 about five miles below Pittsburgh, and 12 more were built in 1910. Channelization of the river was completed in 1929 with 50 lock and dam structures in operation. This system was later replaced by a high rise system of 20 dams. Nine navigational projects (locks and dams) are in operation today along the stretch of the Ohio River adjacent to Ohio (http://watercraft.ohiodnr.gov/ohioriver).

The nine locks and dams located on the 451-mile section of the Ohio River adjacent to Ohio are (from east to west): New Cumberland, Pike Island, Hannibal (hydro), Willow Island (hydro), Belleville, Racine

(hydro), RC Byrd, Greenup (hydro), and Meldahl. These locks and dams divide the river into a series of pools that provide adequate navigation depths and allow freight to be transported the length of the river. Freight on the river is primarily coal, aggregrates, and grain moved by barges.

This habitat chapter refers to the 451 miles of the Ohio River mainstem along Ohio's southern border, and its tributaries to the first riffle or dam. It should be noted that while Ohio River tributaries are treated as a separate habitat category (see Ohio River Tributaries in the next section), the line of separation between the Ohio River and Ohio River Tributaries habitat categories is a biological one, rather than a line on a map. Riffles and dams provide some measure of biological separation between systems, and align themselves with how these habitat categories are managed.

The Ohio River is an extremely altered system, due to the numerous dams, hydropower facilities, and commercial navigation. In spite of these perturbations, the river supports many unique wildlife populations, e.g., freshwater mussels, tiger beetles, paddlefish, waterfowl, ospreys and bald eagles. The Ohio River contains a diverse fish community that includes over 150 different species.

Shared ownership of the Ohio River with Kentucky along the Ohio-Kentucky border, and ownership of the Ohio River by West Virginia along the Ohio-West Virginia border, creates opportunities for cooperative management as well as unique inter-jurisdictional challenges. Fisheries management is conducted under the context of the Ohio River Fisheries Management Team, which is composed of natural resource personnel from the six states bordering the river. Shared jurisdiction necessitated cooperative management and led to the development of a Memorandum of Understanding among natural resource agencies that manage fisheries in Pennsylvania, West Virginia, Ohio, Kentucky, Indiana, and Illinois.

The following water quality, habitat, and biological assessment of the Ohio River comes from the Ohio River Valley Water Sanitation Commission (ORSANCO 2012). Ohio River pool assessments are from http://www.orsanco.org/biological-programs-55/10-mainpages/orsanco-programs/115-biological-surveys – and additional information can be found at www.orsanco.org.

ORSANCO is a water pollution control agency established in 1948 by an interstate Compact. The eight member states - Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, Virginia, and West Virginia - pledge to cooperate in the control of water pollution within the Ohio River Basin. ORSANCO coordinates activities and facilitates an exchange of information and technology among federal agencies and the water pollution control and natural resource agencies of the member states.

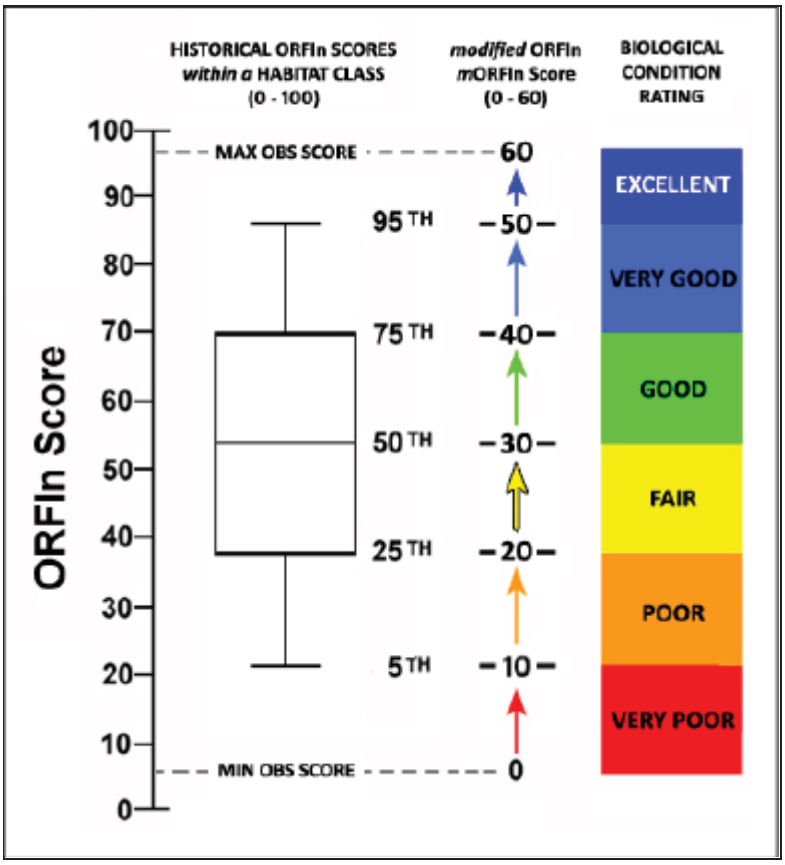
Maintaining the biological integrity of the Ohio River through the protection of aquatic life and habitat is a goal of both the Compact and the Clean Water Act. Chemical and physical parameters are monitored to assess pollution levels in the river. In addition, the effects of pollution on aquatic life monitored using biological assessment tools. Monitoring biological communities can reveal stressors, such as pollution or habitat degradation, which may not be detected by chemical or physical measurements.

Since 2004, aquatic life has been assessed on a pool-by-pool basis. For aquatic life assessments, the river has been divided into independent Assessment Units (AUs) based on the pools created by high-lift dams. These AUs are sampled each year on a rotating basis, such that complete coverage of the river every five years is achieved. ORSANCO evaluates biological condition using an index specifically designed for the Ohio River, the ORFIn, which has been updated recently and is now referred to as the *modified* Ohio River Fish Index (*m*ORFIn). The *m*ORFIn combines various attributes of the fish community to assign a score to the river based on biological characteristics.

The *m*ORFIn is comprised of metrics which serve as surrogate measures of more complicated processes. Examples of metrics include number of species, number of pollution tolerant individuals, and percent of top piscivores in the fish community. A *m*ORFIn score is calculated for each site by comparing observed ORFIn values to statistical thresholds in historical ORFIn scores within each habitat class. ORSANCO uses three distinct habitat classes in performing habitat assessments - designated as Class A, B, and C. Each class has a different expectation on the ORFIn scale, depending on the habitat composition. Habitat A sites contain coarse substrates such as boulders and cobble, provide the most cover and food, and

therefore score the highest. Habitat C sites contain smaller substrates such as sand, are less attractive to fish, and usually score at the lower end of the ORFIn scale. Habitat B sites have a combination of sand, cobble, and other substrates. Bottom substrate percentages reported for the individual pools are limited to "hard" materials (boulder, cobble, gravel, sand) – the remaining percentage generally consists of "soft" materials (silt, mud, muck).

ORFIn scores decrease significantly at locations influenced heavily by human activity and are higher at less-impacted sites. Higher scores indicate a more desirable fish community that is reflective of improved water quality. Biological condition ratings are then assigned to a pool based on the average *m*ORFIn score. Attainment is assessed as either "fully supporting" indicating no impairment, "partially supporting" meaning the segment is impaired due to violations of chemical water quality criteria for the protection of aquatic life or biological data, or "not supporting" meaning biological and water quality data indicate impairment. A description of *m*ORFIn scores and how they relate to biological condition ratings is shown in the figure below:



A brief synopsis of ORSANCO Ohio River pool descriptions and assessments (moving in a downstream direction from east to west) follows:

6.15.2.1 New Cumberland Pool (2011 data)

The New Cumberland pool is 22.7 miles long, averages 1439 feet wide and 22 feet deep, and has an average gradient of 0.2 feet per mile. The upper 9 miles of the pool flow within the state of Pennsylvania, while the remaining 13.7 miles are bordered by Ohio and West Virginia. The pool lies 31.7 miles downstream of the City of Pittsburgh in a portion of the Ohio River heavily influenced by industry. The pool receives water primarily from Little Beaver Creek and Yellow Creek. The pool's watershed is primarily forested (>65%), with some agriculture and urban influences. In unmodified sections of the pool the shoreline consists of coarse substrates. Cobble/gravel/sand make up over 75% of the bottom substrate. ORSANCO sampling indicated the following families dominated the fish species composition of the pool: Cyprinids 48.5%, Clupeids 22.6%, Centrarchids 8.6%, Catostomids 8.4%, Ictalurids 4.5%.

New Cumberland Pool - Results Overview

Sampling Results

Environmental Measures

Dominant Habitat Class: C – equal mix of coarse and fines

Notable Measures: relatively high percentage of coarse shoreline

Biological Measures

Total No. of Fish Species: 39

Average No. of Individuals: 149

Dominant Family (*minus herring/shad)*: Minnows/Carp

Dominant Species (*minus shad/shiners*): golden redhorse

Threatened & Endangered Species: mooneye, silver chub (PA)

Rare Ohio River Mainstem Species: channel darter

Notable Catch: abundant game fishes (sm. bass and bluegill)

Assessment Results

Highest scoring ORFIn metric (*minus DELTs*): % Non-natives

Lowest scoring ORFIn metric: % Piscivores

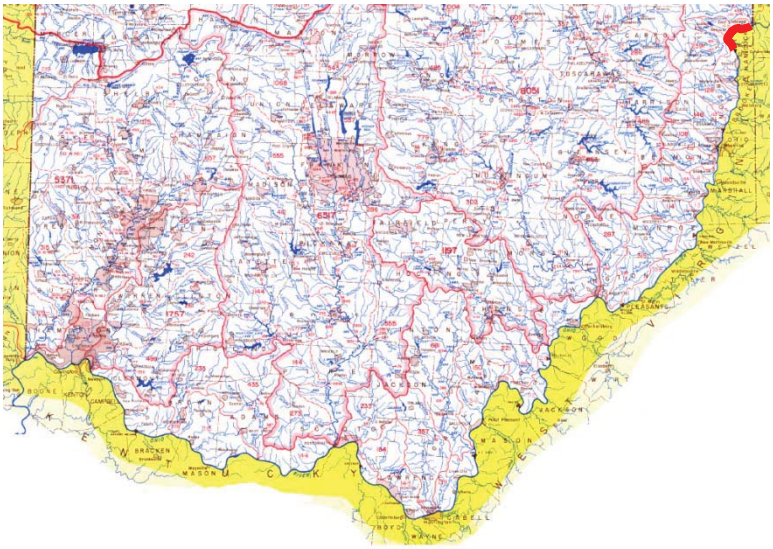
Sites Above 25th percentile (i.e. *m*ORFIn Score = 20): 9

Sites Below 25th percentile (i.e. *m*ORFIn Score = 20): 6

Aquatic Life-Use Designation: Met

Overall Biological Condition Rating: Fair

New Cumberland Pool



6.15.2.2 Pike Island Pool (2012 data)

The Pike Island pool is 29.8 miles long, averages 1338 feet wide and 19 feet deep, and has an average gradient of 0.4 feet per mile. The pool is located in a portion of the Ohio River heavily influenced by industry, with significant barge activity. The pool receives water primarily from Buffalo Creek (WV) and Short Creek. The pool's watershed is primarily forested (>64%), with some agriculture and urban influences. The shorelines of this pool support a moderate degree of aquatic vegetation, and littoral zones are dominated by invasive species (Hydrilla spp.). Boulder/cobble/gravel/sand make up about 75% of the bottom substrate. ORSANCO sampling indicated the following families dominated the fish species composition of the pool: Clupeids 62.8%, Cyprinids 18.6%, Centrarchids 8.5%, Catostomids 3.1%.

Pike Island Pool - Results Overview

Sampling Results

Environmental Measures

- Dominant Habitat Class: C - equal mix of coarse and fines
- Notable Measures: abundant aquatic vegetation (15 of 15 sites)

Biological Measures

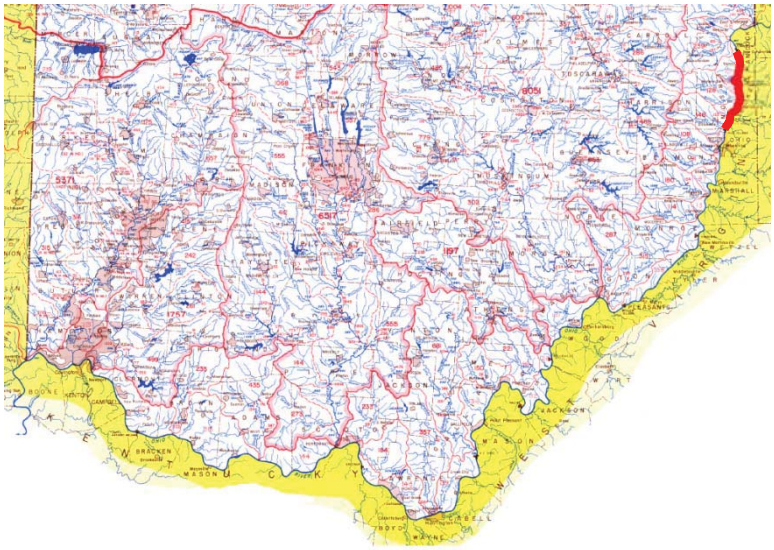
- Total No. of Fish Species: 42
- Average No. of Individuals: 137
- Dominant Family (*minus herring/shad)*: Minnows/Carp
- Dominant Species (*minus shad/shiners*): smallmouth bass
- Species of Concern: river redhorse (OH)
- Rare Ohio River Mainstem Species: rainbow darter
- Notable Catch: northern pike

Assessment Results

- Highest scoring ORFIn metric (*minus DELTs*): % Non-natives
- Lowest scoring ORFIn metric: Great River Species
- Sites Above 25th percentile (i.e. *m*ORFIn Score = 20): 12
- Sites Below 25th percentile (i.e. *m*ORFIn Score = 20): 3
- Aquatic Life-Use Designation: Met

Overall Biological Condition Rating: Good

Pike Island Pool



6.15.2.3 Hannibal Pool (2013 data)

The Hannibal pool is 42.2 miles long, averages 1133 feet wide and 21 feet deep, and has an average gradient of 0.5 feet per mile. The pool is located in a portion of the Ohio River heavily influenced by industry with significant barge activity. The pool receives water primarily from Wheeling Creek (OH), Wheeling Creek (WV), McMahon Creek, Grave Creek (WV), Captina Creek, Fish Creek (WV), and Sunfish Creek. The pool's watershed is primarily forested (>64%), with some agriculture and urban influences. The shorelines of this pool support a moderate degree of aquatic vegetation, and littoral zones are dominated by invasive species (Hydrilla spp.). Boulder/cobble/gravel/sand make up about 65% of the bottom substrate. ORSANCO sampling indicated the following families dominated the fish species composition of the pool: Centrarchids 44.3%, Catostomids 18.6%, Cyprinids 16.4%, Percids 9.1%, Ictalurids 4.3%.

Hannibal Pool - Results Overview

Sampling Results

Environmental Measures

- Dominant Habitat Class: C - equal mix of coarse and fines
- Notable Measures: Above average flows and poor water clarity were observed during the sampling period

Biological Measures

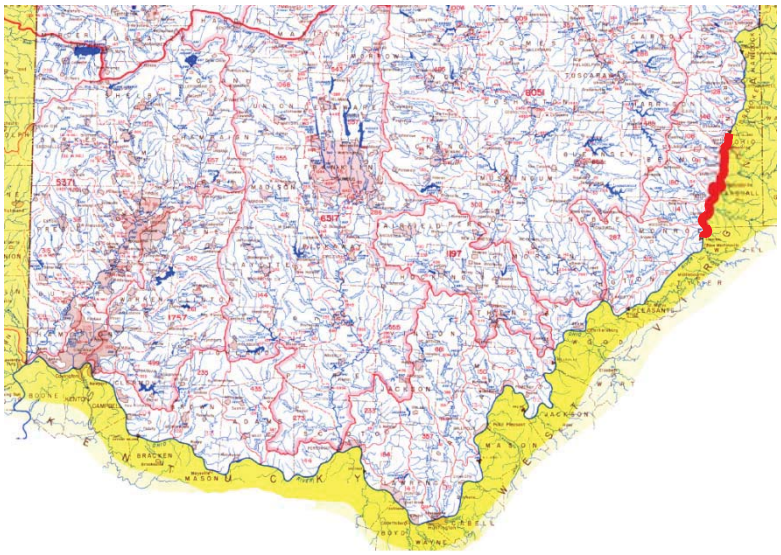
- Total No. of Fish Species: 48
- Average No. of Individuals: 169
- Dominant Family (*minus herring/shad*): Sunfishes/Black Bass
- Dominant Species (*minus shad/shiners*): bluegill
- Species of Concern (WV): highfin carpsucker
- Rare Ohio River Mainstem Species: greenside darter
- Notable Catch: river darter & channel darter (threatened in OH)

Assessment Results

- Highest scoring ORFIn metric (*minus DELTs*): % Non-natives
- Lowest scoring ORFIn metric (*minus GR Species*): % Lithophils
- Sites Above 25th percentile (i.e. *m*ORFIn Score = 20): 13
- Sites Below 25th percentile (i.e. *m*ORFIn Score = 20): 2
- Aquatic Life-Use Designation: Met

Overall Biological Condition Rating: Good

Hannibal Pool



6.15.2.4 Willow Island Pool (2011 data)

The Willow Island pool is 35.3 miles long, averages 1194 feet wide and 21 feet deep, and has an average gradient of 0.6 feet per mile. The pool receives water primarily from Fishing Creek (WV), Middle Island Creek (WV), and the Little Muskingum River. The pool's watershed is primarily forested (>65%), with some agriculture and urban influences. Almost the entire Ohio shoreline is federally protected national forest (Wayne National Forest). Boulder/cobble/gravel/sand make up about 54% of the bottom substrate. ORSANCO sampling indicated the following families dominated the fish species composition of the pool: Cyprinids 42.3%, Centrarchids 27.3%, Clupeids 9.4%, Catostomids 4.4%.

Willow Island Pool - Results Overview

Sampling Results

Environmental Measures

Dominant Habitat Class: D - shallow sand/fines

Notable Measures: abundant inshore structure and vegetation

Biological Measures

Total No. of Fish Species: 48

Average No. of Individuals: 182

Dominant Family (*minus herring/shad)*: Minnows/Carp

Dominant Species (*minus shad/shiners*): bluegill

Endangered Species: banded killifish (OH)

Rare Ohio River Mainstem Species: yellow bullhead

Notable Catch: abundant game fishes (bass and bluegill)

Assessment Results

Highest scoring ORFIn metric (*minus DELTs*): Centrarchid score

Lowest scoring ORFIn metric: % Lithophils

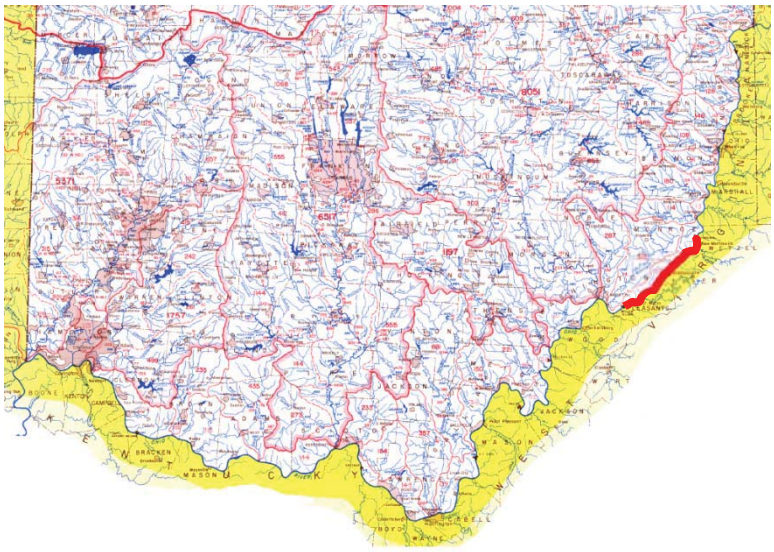
Sites Above 25th percentile (i.e. *m*ORFIn Score = 20): 13

Sites Below 25th percentile (i.e. *m*ORFIn Score = 20): 2

Aquatic Life-Use Designation: Met

Overall Biological Condition Rating: Fair

Willow Island Pool



6.15.2.5 Belleville Pool (2009 data)

The Belleville pool is 42.2 miles long, averages 1327 feet wide and 24 feet deep, and has an average gradient of 0.5 feet per mile. The pool is located in a portion of the basin moderately influenced by industry and barge activity. The pool receives water primarily from Duck Creek, Muskingum River, Little Kanawha River (WV), Little Hocking River, and the Hocking River. The pool's watershed is primarily forested (>65%), with some agriculture and urban influences. The pool has multiple islands scattered throughout its reach. Boulder/cobble/gravel/sand make up about 77% of the bottom substrate. ORSANCO sampling indicated the following families dominated the fish species composition of the pool: Cyprinids 46.7%, Centrarchids 17.3%, Clupeids 12.3%, Catostomids 10.4%, Percids 5.3%.

Belleville Pool - Results Overview

Sampling Results

Environmental Measures

Dominant Habitat Class: C - mix of coarse and fine substrates

Notable Measures: rocky shorelines were still to be found, woody debris and aquatic vegetation were both very common

Biological Measures

Total No. of Fish Species: 52

Average No. of Individuals: 167

Dominant Family (*minus herring/shad)*: Minnows/Carp

Dominant Species (*minus shad/shiners*): mimic shiner

Threatened/Endangered: Ohio lamprey (E) & river darter (T)

Rare Ohio River Mainstem Species: rainbow darter

Notable Catch: muskellunge and large flathead catfish

Assessment Results

Highest scoring ORFIn metric (*minus DELTs*): % Non-Natives

Lowest scoring ORFIn metric: % Piscivores & Great River Species

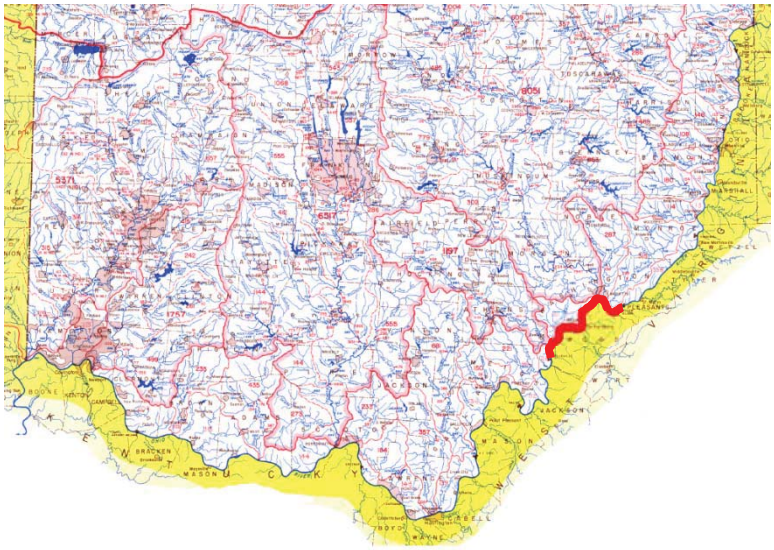
Sites Above 25th percentile (i.e. *m*ORFIn Score = 20): 14

Sites Below 25th percentile (i.e. *m*ORFIn Score = 20): 1

Aquatic Life-Use Designation: Met

Overall Biological Condition Rating: Good

Belleville Pool



6.15.2.6 Racine Pool (2010 data)

The Racine pool is 33.6 miles long, averages 1275 feet wide and 24 feet deep, and has an average gradient of 0.5 feet per mile. The pool is located in a relatively undeveloped portion of the basin with little influence of industry. The pool receives water primarily from the Shade River, Shady Creek (WV), and Mill Creek (WV). The pool's watershed is primarily forested (>65%), with some agriculture and residential influences. The shoreline conditions are conducive to the growth of aquatic vegetation, which is found in large quantities throughout the pool. Boulder/cobble/gravel/sand make up about 65% of the bottom substrate. ORSANCO sampling indicated the following families dominated the fish species composition of the pool: Clupeids 35.1%, Cyprinids 17.9%, Centrarchids 14.9%, Sciaenids 8.5%, Serranids 8.4%.

Racine Pool - Results Overview

Sampling Results

Environmental Measures

Dominant Habitat Class: D - shallow sand/fines

Notable Measures: aquatic vegetation found at 100% of sites

Biological Measures

Total No. of Fish Species: 42

Average No. of Individuals: 97

Dominant Family (*minus herring/shad)*: Minnows/Carp

Dominant Species (*minus gizzard shad)*: bluegill sunfish

Threatened & Endangered: banded killifish (OH)

Rare Ohio River Mainstem Species: yellow bullhead

Notable Catch: spotted sucker

Assessment Results

Highest scoring ORFIn metric: Centrarchid species

Lowest scoring ORFIn metric: Great River species

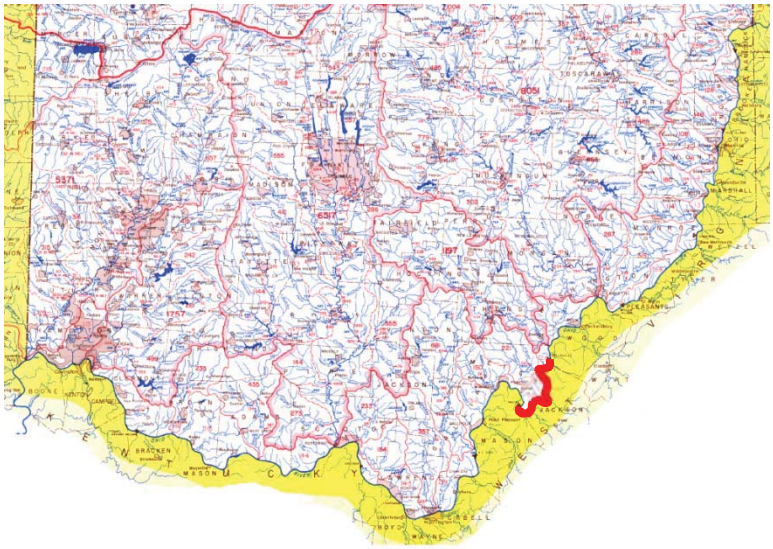
Sites Above 25th percentile (i.e. *m*ORFIn Score = 20): 8

Sites Below 25th percentile (i.e. *m*ORFIn Score = 20): 7

Aquatic Life-Use Designation: Met

Overall Biological Condition Rating: Fair

Racine Pool



6.15.2.7 R.C. Byrd Pool (2013 data)

The R. C. Byrd pool is 41.7 miles long, averages 1154 feet wide and 26 feet deep, and has an average gradient of 0.6 feet per mile. The pool is located in a portion of the basin heavily influenced by industry, with significant barge activity. The pool receives water primarily from Leading Creek, Kanawha River (WV), and Raccoon Creek. The pool's watershed is primarily forested (>65%), with some agriculture and residential influences. Littoral zones are dominated by invasive aquatic vegetation species (Hydrilla spp.). Boulder/cobble/gravel/sand make up about 57% of the bottom substrate. ORSANCO sampling indicated the following families dominated the fish species composition of the pool:, Cyprinids 41.2%, Centrarchids 20.4%, Catostomids 8.1%, Clupeids 8.0%, Ictalurids 7.0%.

R. C. Byrd Pool - Results Overview

Sampling Results

Environmental Measures

Dominant Habitat Class: C - equal mix of coarse and fines

Notable Measures: The lowest performing sites were found downstream of the confluence of the Kanawha River

Biological Measures

Total No. of Fish Species: 33

Average No. of Individuals: 121

Dominant Family (*minus herring/shad*): Minnows/Carp

Dominant Species (*minus shad/shiners*): bluegill

Species of Concern: highfin carpsucker (WV) & river redhorse (OH)

Rare Ohio River Mainstem Species: spottail shiner

Notable Catch: striped bass (common in reservoirs & lower OH R.)

Assessment Results

Highest scoring ORFIn metric (*minus DELTs*): % Tolerants

Lowest scoring ORFIn metric (*minus GR Species*): CPUE

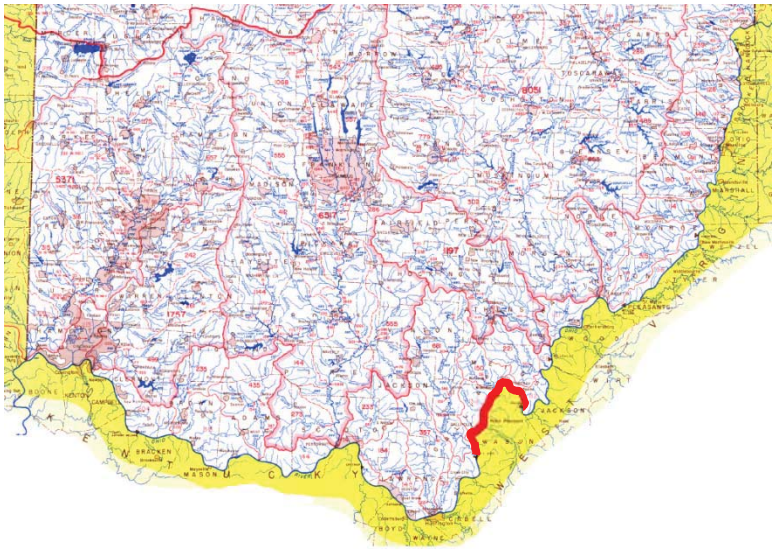
Sites Above 25th percentile (i.e. *m*ORFIn Score = 20): 10

Sites Below 25th percentile (i.e. *m*ORFIn Score = 20): 5

Aquatic Life-Use Designation: Met

Overall Biological Condition Rating: Good

R.C. Byrd Pool



6.15.2.8 Greenup Pool (2011 data)

The Greenup pool is 61.8 miles long, averages 1111 feet wide and 26 feet deep, and has an average gradient of 0.4 feet per mile. The pool is located in a portion of the basin heavily influenced by industry, with significant barge activity. The pool receives water primarily from the Guyandotte River (WV), Symmes Creek, Twelvepole Creek (WV), Big Sandy River (WV) and Little Sandy River (KY). The pool's watershed is primarily forested (>65%), with some agriculture and urban influences. Boulder/cobble/gravel/sand make up about 67% of the bottom substrate. ORSANCO sampling indicated the following families dominated the fish species composition of the pool: Cyprinids 59.4%, Centrarchids 13.6%, Ictalurids 7.5%, Sciaenids 7.4%, Catostomids 4.5%.

Greenup Pool - Results Overview

Sampling Results

Environmental Measures

Dominant Habitat Class: C – equal mix of coarse and fines

Notable Measures: relatively high percentage of barge traffic

Biological Measures

Total No. of Fish Species: 47

Average No. of Individuals: 183

Dominant Family (*minus herring/shad)*: Minnows/Carp

Dominant Species (*minus shad/shiners*): bluegill

Species of Concern: river redhorse (OH), black buffalo (KY)

Rare Ohio River Mainstem Species: bowfin

Notable Catch: river redhorse, numerous catfish and basses

Assessment Results

Highest scoring ORFIn metric (*minus DELTs*): % Tolerants

Lowest scoring ORFIn metric: % Lithophils

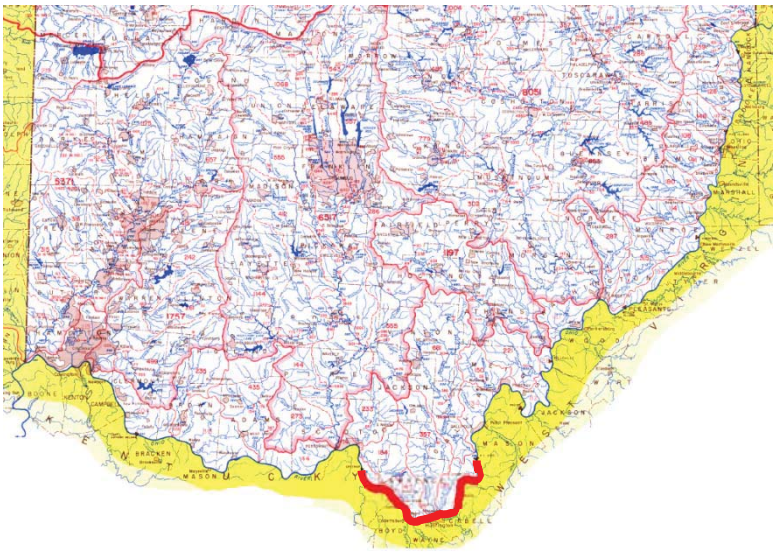
Sites Above 25th percentile (i.e. *m*ORFIn Score = 20): 15

Sites Below 25th percentile (i.e. *m*ORFIn Score = 20): 0

Aquatic Life-Use Designation: Met

Overall Biological Condition Rating: Good

Greenup Pool



6.15.2.9 Meldahl Pool (2012 data)

The Meldahl pool is 95.2 miles long, averages 1603 feet wide and 23 feet deep, and has an average gradient of 0.3 feet per mile. The pool receives water primarily from Pine Creek, Little Scioto River, Tygarts Creek, Scioto River, Kinniconnick Creek, Ohio Brush Creek, Eagle Creek, and Whiteoak Creek. The shorelines support a moderate degree of aquatic vegetation. The pool's watershed is primarily forested (>65%), with significant agricultural influence. Historically, Meldahl is consistently rated as one of the better pools on the Ohio River. Boulder/cobble/gravel/sand make up about 72% of the bottom substrate. ORSANCO sampling indicated the following families dominated the fish species composition of the pool: Clupeids 79%, Cyprinids 11.8%, Sciaenids 3.1%, Centrarchids 2.3%, Catostomids 1.4%.

Meldahl Pool - Results Overview

Sampling Results

Environmental Measures

Dominant Habitat Class: E - deep sand/fines

Notable Measures: high occurance of woody structure

Biological Measures

Total No. of Fish Species: 41

Average No. of Individuals: 191

Dominant Family (*minus herring/shad)*: Minnows/Carp

Dominant Species (*minus shad/shiners*): freshwater drum

Threatened and Endangered Species: channel darter (T)

Rare Ohio River Mainstem Species: slenderhead darter

Notable Catch: walleye (more common upstream)

Assessment Results

Highest scoring ORFIn metric (*minus DELTs*): % Non-natives

Lowest scoring ORFIn metric: % Lithophils

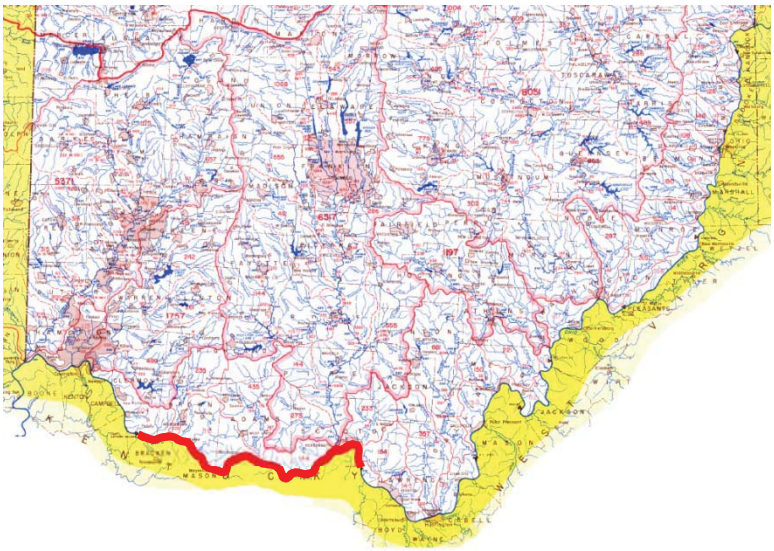
Sites Above 25th percentile (i.e. *m*ORFIn Score = 20): 14

Sites Below 25th percentile (i.e. *m*ORFIn Score = 20): 1

Aquatic Life-Use Designation: Met

Overall Biological Condition Rating: Good

Meldahl Pool



6.15.2.10 Markland Pool (2009)

The Markland pool is 95.3 miles long, averages 1594 feet wide and 31 feet deep, and has an average gradient of 0.4 feet per mile. The lower 39 miles of the pool are bordered by Indiana and Kentucky. The pool is located in a portion of the basin heavily influenced by industry, with significant barge activity. The pool receives water primarily from the Little Miami River (OH), Great Miami River (OH), and Licking River (KY) – as well as several smaller tributaries. The pool's watershed is primarily forested (>50%), with significant agriculture and urban influence. Boulder/cobble/gravel/sand make up about 58% of the bottom substrate. ORSANCO sampling indicated the following families dominated the fish species composition of the pool: Cyprinids 21.6%, Sciaenids 18.4%, Centrarchids 17.1%, Catostomids 15.4%, Percids 13.7%.

Markland Pool - Results Overview

Sampling Results

Environmental Measures

Dominant Habitat Class: D - shallow sand/fines

Notable Measures: some degree of woody cover was observed at each of the 15 sites

Biological Measures

Total No. of Fish Species: 45

Average No. of Individuals: 207

Dominant Family (*minus herring/shad*): Drum

Dominant Species (*minus shad/shiners*): freshwater drum

Species of Concern (OH): black buffalo

Rare Ohio River Mainstem Species: warmouth

Notable Catch: river darter & channel darter (threatened in OH)

Assessment Results

Highest scoring ORFIn metric (*minus DELTs*): % Tolerants

Lowest scoring ORFIn metric (*minus GR Species*): CPUE (i.e. total catch)

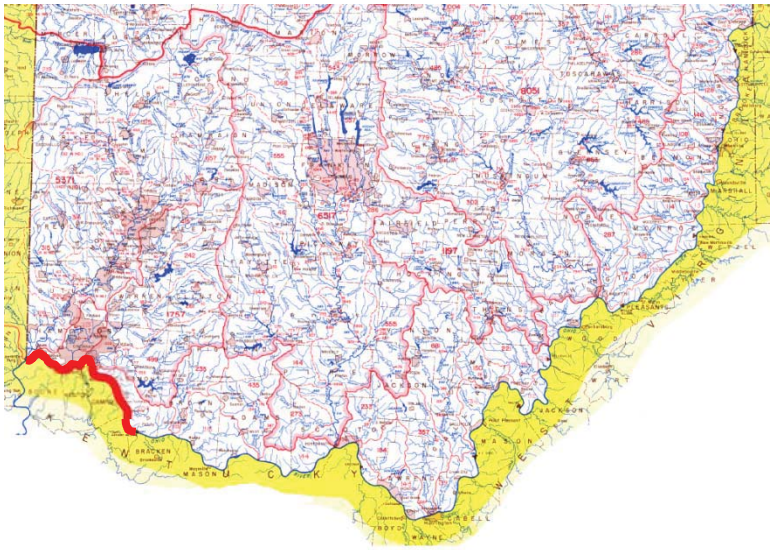
Sites Above 25th percentile (i.e. *m*ORFIn Score = 20): 15

Sites Below 25th percentile (i.e. *m*ORFIn Score = 20): 0

Aquatic Life-Use Designation: Met

Overall Biological Condition Rating: Very Good

Markland Pool



6.15.3 Associated Species of Greatest Conservation Need

Considering that the Ohio River today bears no resemblance to the river that existed in pre-settlement days, the river still supports tremendous numbers and diversity of aquatic species. The riffles, pools, and runs that were the Ohio River are long gone – covered by water of adequate depth to support commercial navigation. A number of aquatic species that existed in the pre-dams Ohio are also gone. Today the river has more in common with large southern reservoirs than it does with the free flowing stream that it once was. The species found in the river today are a reflection of that. Improved water quality in recent years has been mirrored by a shift in the species assemblage – in the direction of species characteristic of better quality lakes/streams. Owing to the reduction in gradient in a downstream direction, the lower pools of the Ohio are longer, wider, warmer, and generally contain softer substrates than their upstream counterparts. As the physical and chemical environment of the river changes, shifts in species composition and abundance are apparent.

The following species have been identified as Ohio River species of greatest conservation need (conservation status rank in parentheses):

<u>Fish</u>

Diamond Darter (2)	*Crystallaria cincotta*
American Eel (5)	*Anguilla rostrata*
Gilt Darter (6)	*Percina evides*
Paddlefish (9)	*Polyodon spathula*
Shoal Chub (11)	*Macrhybopsis hyostoma*
Ohio Lamprey (13)	*Ichthyomyzon bdellium*
Alligator Gar (15)	*Lepisosteus spatula*
Lake Sturgeon (17)	*Acipenser fulvescens*
Blue Sucker (18)	*Cycleptus elongatus*
Shovelnose Sturgeon (19)	*Scaphirhynchus platorynchus*
Bluebreast Darter (25)	*Etheostoma camurum*
Eastern Sand Darter (29)	*Ammocrypta pellucida*
Silver Chub (36)	*Macrhybopsis storeriana*
Goldeye (39)	*Hiodon alosoides*
Channel Darter (44)	*Percina copelandi*
Black Redhorse (48)	*Moxostoma duquesnei*
Mooneye (50)	*Hiodon tergisus*
Silver Redhorse (52)	*Moxostoma anisurum*
Black Buffalo (56)	*Ictiobus niger*
Dusky Darter (58)	*Percina sciera*
Shortnose Gar (60)	*Lepisosteus platostomus*
River Darter (61)	*Percina shumardi*
Mississippi Silvery Minnow (62)	*Hybognathus nuchalis*
River Redhorse (63)	*Moxostoma carinatum*
Smallmouth Redhorse (63)	*Moxostoma breviceps*

<u>Mussels</u>

White Wartyback (1)	*Plethobasus cicatricosus*
Pink Mucket (3)	*Lampsilis abrupta*
Long Solid (6)	*Fusconaia subrotunda*
Ebonyshell (8)	*Fusconaia ebena*
Elephantear (8)	*Elliptio crassidens*
Pyramid Pigtoe (8)	*Pleurobema rubrum*
Orange-foot Pimpleback (12)	*Plethobasus cooperianus*
Ohio Pigtoe (13)	*Pleurobema cordatum*
Sheepnose (13)	*Plethobasus cyphyus*
Monkeyface (16)	*Quadrula metanevra*
Slippershell Mussel (16)	*Alasmidonta viridis*
Ring Pink (18)	*Obovaria retusa*

Scaleshell (18)	*Leptodea leptodon*
Winged Mapleleaf (18)	*Quadrula fragosa*
Butterfly (21)	*Ellipsaria lineolata*
Fanshell (25)	*Cyprogenia stegaria*
Wartyback (25)	*Quadrula nodulata*
Rough Pigtoe (35)	*Pleurobema plenum*
Yellow Sandshell (37)	*Lampsilis teres*
Spectaclecase (39)	*Cumberlandia monodonta*
Threeridge (40)	*Amblema plicata*
Washboard (40)	*Megalonaias nervosa*
Cracking Pearlymussel (42)	*Hemistena lata*
Pocketbook (42)	*Lampsilis ovata*
Northern Riffleshell (48)	*Epioblasma torulosa rangiana*
Round Pigtoe (50)	*Pleurobema sintoxia*
Elktoe (52)	*Alasmidonta marginata*
Deertoe (53)	*Truncilla truncata*
Fawnsfoot (53)	*Truncilla donaciformis*
Threehorn Wartyback (55)	*Obliquaria reflexa*
Fat Pocketbook (56)	*Potamilus capax*

Table 39. CONSERVATION THREATS TO THE OHIO RIVER.
The following threats negatively impact or have the potential to negatively impact the Ohio River. Threat categories/classification from Salafsky et al. (2008), and threat impact rank calculations from Master et al. (2012).

ID	threats	2nd level threat classification(s)	threat impact rank
I	**residential and commercial development**		low
A	Watershed conversion to urban/commercial development alters hydrology	housing & urban areas commercial & industrial areas	low low
B	Shoreline development and its negative effect on habitat and species	housing & urban areas commercial & industrial areas tourism & recreation areas	low low low
C	Increasing land prices limit our ability to protect riparian corridors	housing & urban areas commercial & industrial areas tourism & recreation areas	low low low
II	**agriculture and aquaculture**		low
A	Loss of riparian corridor to agriculture	annual & perennial non-timber crops livestock farming & ranching	low low

B	Watershed conversion to agriculture alters hydrology	annual & perennial non-timber crops livestock farming & ranching	low low
III	**energy production and mining**		low
A	Oil and gas extraction - can have negative impacts by causing chemical contamination	oil & gas drilling	low
B	Hydropower facilities disrupt stream connectivity and kill aquatic species	renewable energy	low
C	Sand/gravel operations destroy habitat	mining & quarrying	low
IV	**transportation and service corridors**		medium
A	Channel modification, dredging shipping lanes - causes habitat loss, water quality impacts	shipping lanes	medium
B	Roads, bridges, causeways, utilities, impact shoreline/nearshore habitats	roads & railroads utilities & service lines	low low
C	Barge traffic impacts water quality, nearshore habitat, and aquatic species	shipping lanes	medium
V	**biological resource use**		low
A	Fishing pressure and fishing gear impacts from recreational and commercial fishing	fishing & harvesting aquatic resources	low
B	Exploitation of Ohio listed species by sport/commercial fisheries in other Ohio River states	fishing & harvesting aquatic resources	low
VI	**human intrusions and disturbance**		low
A	Incompatible recreational activities	recreational activities	low
B	Creation of recreational facilities can alter/destroy nearshore habitat	recreational activities	low
C	Creation of commercial facilities can alter/destroy nearshore habitat	work & other activities	low
D	Vessel impacts to nearshore habitats and water quality	recreational activities work & other activities	low low
VII	**natural system modifications**		high
A	The interjurisdictional nature, conflicting priorities, overlapping regulatory responsibilities and limited Ohio ownership complicates management	other ecosystem modifications	low
B	Dam operations can affect movement of aquatic species, impact water quality, and impact habitat (through changing water levels)	dams & water management/use	high
C	Conflicting water control management objectives of controlling agencies (DOW – USACOE)	dams & water management/use	high
D	Some species' polulations have been reduced to levels below what is necessary to recover on their own	other ecosystem modifications	low
E	Lack of data for some species and habitats limits our ability to develop plans for threats like climate change	other ecosystem modifications	low
VIII	**invasive and other problematic species and genes**		high
A	Introduction and/or spread of invasive plants and animals	invasive non-native/alien species	high
B	Introduction and/or spread of nuisance plants and animals	problematic native species	low

C	Introduction and spread of diseases (plants and animals)	invasive non-native/alien species problematic native species	high low
D	Possible genetic contamination of native fish stocks from introduced hybrid fishes	introduced genetic material	low
IX	**pollution**		high
A	Urban effluent carries a variety of substances that impact water quality and aquatic species	household sewage & urban wastewater industrial & military effluents garbage & solid waste air-borne pollutants	high medium low low
B	Agricultural effluent from row crops as well as confined animal operations impacts water quality and aquatic species	Agricultural & forestry effluents	high
C	Industrial spills impact water quality and aquatic species	industrial & military effluents	medium
X	**geological events**		negligible
---	none	---	---
XI	**climate change and severe weather**		low
A	Climate change could impact habitats, water quality, and species	habitat shifting & alteration droughts temperature extremes storms & flooding	low low low medium

Table 40. CONSERVATION ACTIONS FOR THE OHIO RIVER.
The following actions will help abate or have the potential to help abate threats to Ohio River habitat. Action categories/classification from Salafsky et al. (2008), and action priority rank calculations from Georgia DNR (2005).

ID	actions	2nd level action classification(s)	action priority rank	threat(s) addressed*
I	**LAND/WATER PROTECTION**		high	
1	Protect shoreline habitats through acquisition, partnerships, conservation easements, etc.	site/area protection resource & habitat protection	med high	I, II, IV-B, VI-B,C, XI
II	**LAND/WATER MANAGEMENT**		high	
1	Increase habitat diversity in the Ohio River (construct riffles and “T” dikes, dredge embayments, connect backwaters to the mainstem, build islands and wetlands, etc.)	habitat & natural process restoration	high	III-C, IV, V, VI-B,C,D, VII, XI

2	Work with USACOE to minimize negative impacts to fish and wildlife species from dam operations	habitat & natural process restoration	high	III-B, VII-B,C
3	Use lowest impact techniques and timing for dredging activities	habitat & natural process restoration	high	III-C, IV-A, VII-A
4	Work with the USACOE on upland disposal sites for dredge material, or develop innovative ways to create habitat	habitat & natural process restoration	high	IV-A
5	Create and use wetlands for stormwater treatment	habitat & natural process restoration	high	I-A, IX-A
6	Establish an early-detection/rapid-response system for dealing with invasive and nuisance species	invasive/ problematic species control	high	VIII-A,B
7	Develop a process for coordinating disparate data sources of distribution and abundance of aquatic SGCN with special emphasis on conservation opportunity watersheds	habitat & natural process restoration	high	I-B, III-B,C, IV, V-B, VI-B, C, VII-B,E, XI
8	Review existing species and habitat data to identify data gaps and needs for additional surveys, research, and management actions	habitat & natural process restoration	high	I, II, III, IV, V, VI, VII, VIII, IX, XI
9	Conduct comprehensive surveys of freshwater mussels	habitat & natural process restoration	high	I-B, III-C, IV, VI-B,C,D, VII, XI
10	Compile Ohio River hydrological/limnological datasets and assess the potential these data may have to explain variations in Ohio River fish populations	habitat & natural process restoration	high	V, VII-B,D,E, VIII-D
11	Evaluate the efficacy of alternative sampling gears for providing accurate and precise estimates of population metrics for important fishes	habitat & natural process restoration	high	V, VII-D,E, VIII-D
III	**SPECIES MANAGEMENT**		low	
1	Determine the genetic structure of Ohio River *Sander* spp. populations	species management	med	VIII-D
2	Monitor for the presence of Asian carp in pools adjacent to Ohio	species management	med	VIII-A
3	Assess population status, habitat suitability, and probability for restoration of fish, mussels, crayfish, invertabrates, and amphibians listed as SGCN	species reintroduction	High	VII-D, VII-E
4	Develop a restoration strategy for high priority fish, mussels, crayfish, invertebrates, and amphibians	species reintroduction	High	VII-D, VII-E
IV	**EDUCATION AND AWARENESS**		med	
1	Educate waterfront landowners and commercial pesticide/herbicide applicators on responsible chemical use, and the negative impacts to wildlife from toxic chemicals	training	high	I-B,C, IX-A
2	Promote conservation easements along important shoreline habitat (backwaters, embayments, etc.)	training awareness & communic-ations	high med	I, II, IV-B, VI-B,C, XI
3	Provide technical guidance on shoreline development plans as relates to fish and wildlife interests	training	high	I, IV-B, VI-B,C, XI
4	Provide training to road construction/maintenance personnel for runoff/sediment control	training	high	I-B, IV-B, VI-B,C

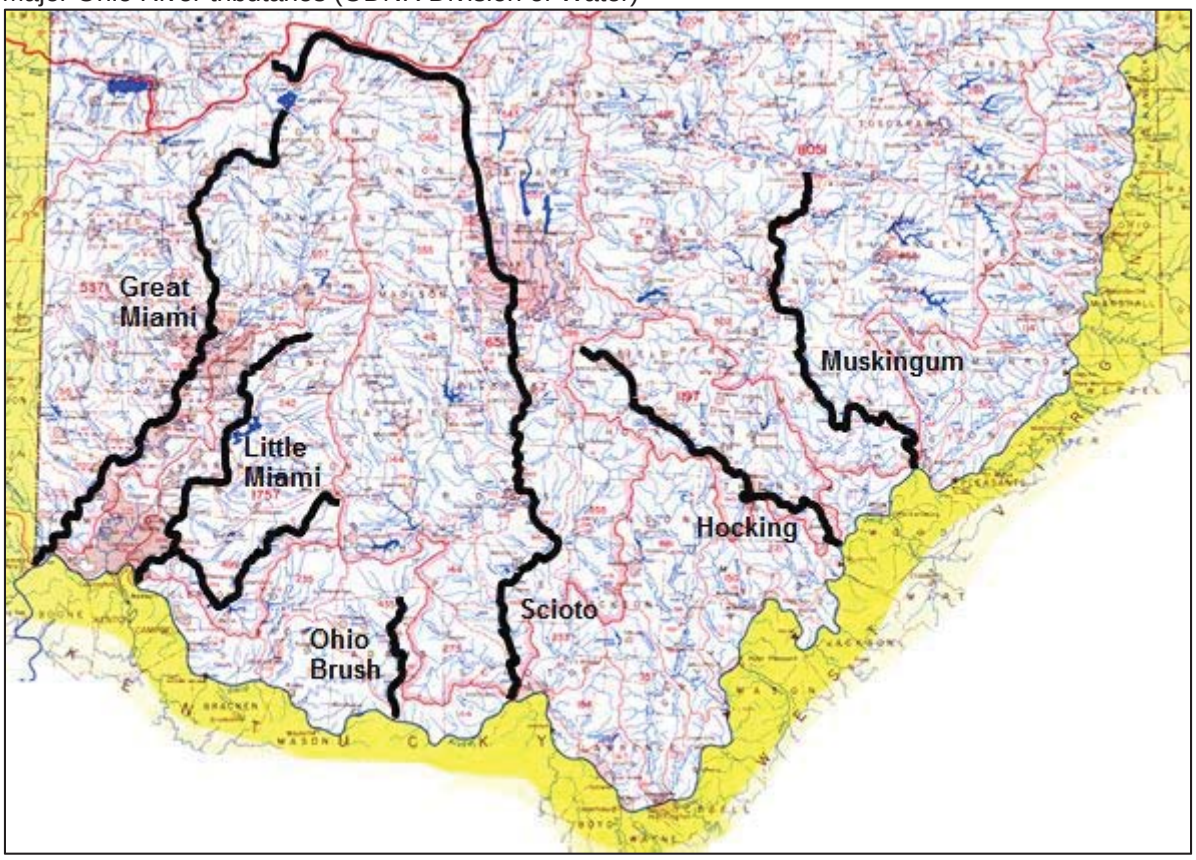
5	Educate the public about the negative effects of exotic and nuisance animals – encourage responsible disposal of unwanted animals	awareness & communic-ations	med	VIII-A,B,C
V	**LAW AND POLICY**		med	
1	Support legislation promoting eco-friendly energy development and use	legislation	med	III-A,B
2	Develop and implement a risk-assessment system in the approval process for importing or moving live animals and plants	legislation policies & regulations	med med	VIII
3	Find innovative ways to mandate the inclusion of fish and wildlife interests in development plans	policies & regulations private sector standards & codes	med low	I, III-B,C, IV-B, VI-B,C, VII-D, XI
4	Support the use of buffers between development and tributary shorelines	policies & regulations private sector standards & codes	med low	I-A,B, IV-B, IX-A
5	Support the creation of additional and/or increase enforcement of stormwater regulations	compliance & enforcement	low	I-A, IX-A
VI	**LIVELIHOOD, ECONOMIC AND OTHER INCENTIVES**		med	
1	Explore tying eligibility for grant money, loans, and cost-share programs to nutrient loading levels for agriculture – the lower the nutrient levels in their effluent, the more money they would be eligible for	market forces conservation payments	med med	IX-B,C, XI
2	Create incentives for vegetated buffers along all waterways to reduce nutrient loads and sediment	market forces conservation payments	med med	I, II, IX-A,B,C, XI
3	Create incentives to promote eco-friendly energy development and use	market forces conservation payments non-monetary values	med med low	III-A,B
4	Support the creation of incentives to protect shoreline habitat	market forces conservation payments	med med	I, II, IV-B, VI-B,C, XI
5	Support clean marina and clean vessel programs	market forces conservation payments	med med	VI-D
6	Develop incentives for municipalities to use stormwater management systems that minimize negative impacts to aquatic habitats	market forces conservation payments	med med	I-A, IX-A

7	Support incentives for development plans involving water frontage that take into account wildlife and habitat needs	market forces conservation payments non-monetary values	med med low	I, IV-B, VI-B,C, XI
VII	**EXTERNAL CAPACITY BUILDING**		med	
1	Work with ODA and OEPA to minimize nutrients in runoff, and develop BMPs for pesticide/herbicide use	alliance & partnership development	high	IX
2	Create an interagency spill response team – update contacts and training on a regular basis	alliance & partnership development	high	IX-C
3	Consider creating a multiagency invasive species prevention and control group that would handle all invasive species issues	alliance & partnership development	high	VIII-A,B,C
4	Through interagency coordination, work to assure that wildlife interests are taken into consideration in road, bridge, and causeway design, construction, and maintenance	alliance & partnership development	high	IV-B
5	Improve inter-jurisdictional relationships within the Ohio River Fisheries Management Team – share data and data gathering	alliance & partnership development	high	I-B, III-B, IV, V, VI, VII, VIII, IX-C, XI
6	Use inter-agency cooperation to influence watershed health, reduce in-stream habitat degradation, and implement projects to improve habitats	alliance & partnership development	high	I, II, III-C, IV, VI-B,C,D, VII-D, IX, XI
7	Collaborate on interjurisdictional management strategies that benefit the resource and constituents, unify regulations, and meet statutory responsibilities	alliance & partnership development	high	VII-A,C
8	Develop or improve reciprocal agreements with Kentucky and West Virginia for fish and wildlife management and wildlife law enforcement	alliance & partnership development	high	VII-A
9	Work with OEPA to encourage completion of TMDL studies for all streams in the Ohio River drainage	alliance & partnership development	high	IX-A,B
10	Encourage/facilitate the establishment of watershed groups and watershed coordinator to promote watershed improvement activities	institutional & civil society development alliance & partnership development	low high	I, II, IX, XI
11	Increase personnel and expertise available for SGCN surveys and research through partnerships with other government agencies and, universities, and conservation-minded NGO's	institutional & civil society development alliance & partnership development	low high	I, II, III, IV, V, VI, VII, VIII, IX, XI

*refers to the Ohio River Habitat Conservation Threats in Table 39

6.16 Ohio River Tributaries

Major Ohio River tributaries (ODNR Division of Water)



6.16.1 Status

Stable to improving. Ohio Environmental Protection Agency (Ohio EPA) surveys indicate general improvement in the physical habitat, water quality, and biological communities of most of the streams in the Ohio River watershed. Ohio's large rivers continue to show improvement as tracked over the last 20 years. The "100% full attainment by 2020" aquatic life goal statistic remains steady at 89.2% full attainment. Taken collectively since the 1980s, the quality of aquatic life in all of Ohio's large rivers has shown a remarkable improvement. Then, only 21% of the large rivers met water quality standards, increasing to 62% in the 1990s, to 89% today. Areas not meeting the standards have decreased from 79% in the 1980s to 38% in the 1990s to 11% today (Ohio EPA 2014a).

6.16.2 Description

In the southern two-thirds of Ohio, tributaries drain south across the 34,361 square mile Ohio River watershed. The five largest tributaries include the Muskingum River (drains 8051 square miles), the Scioto River (drains 6517 square miles), the Great Miami River (drains 5371 square miles), the Little Miami River (drains 1757 square miles), and the Hocking River (drains 1197 square miles). Tributary physical attributes, water quality, habitat, and biological communities tend to follow a west to east gradient across southern Ohio. This gradient results from geographical differences as well as changes in land use practices in the watersheds. The trend is for relief in watersheds to increase from west to east as a result of past glaciation. In the western third of Ohio, the upper reaches of tributary watersheds tend to be relatively flat, with stream gradients increasing as they enter the Ohio River valley. Land use in this part of the state is dominated by urban/suburban development and agriculture. In the unglatiated eastern two-thirds of Ohio, relief is greater, watersheds are smaller, and stream gradients higher. The

predominant land cover in this part of the state is forest, and agriculture is the dominant land use. Streams across this gradient reflect the impacts and impairments that result from land uses within the watershed.

Along Ohio's portion of the Ohio River shoreline, 204 different streams empty directly into the Ohio River. From west to east, those tributary streams are: Great Miami River, Muddy Creek, Rapid Run, Mill Creek, Little Miami River, Fivemile Creek, Eightmile Creek, Tenmile Creek, Pond Run, Twelvemile Creek, Little Indian Creek, Boat Run, Indian Creek, Little Indian Creek, Ray Run, Maple Creek, Bear Creek, Crooked Run, Ryan Run, Bullskin Creek, Moon Hollow Run, Miranda Run, Hog Run, Whiteoak Creek, Straight Creek, Levanna Branch, Cornick Run, Redoak Creek, Eagle Creek, Threemile Creek, Fishing Gut Creek, Little Threemile Creek, Buzzardroost Creek, Elk Run, McClelland Run, Isaacs Creek, Island Creek, Lindsey Creek, Donaldson Run, Cummings Creek, Upper Sister Creek, Spring Run, Ohio Brush Creek, Alex Run, Smokey Creek, Stout Run, Long Lick Run, Wikoff Run, Sulphur Creek, Little Sulphur Creek, Gilpen Run, McCall Run, Rock Run, Lower Twin Creek, Upper Twin Creek, Moore Run, Spencer Run, McAtee Run, Old Pond Run, Pond Run, Nace Run, Turkey Creek, Carey Run, Slab Run, Scioto River, Munn Run, Little Scioto River, Pine Creek, Patton Run, Ginat Creek, Gervais Run, Norman Run, Osburn Run, Storms Creek, Ice Creek, Lick Creek, Salliday Creek, Buffalo Creek, Symmes Creek, Indian Guyan Creek, Paddy Creek, Twomile Creek, Federal Creek, Stillhouse Branch, Swan Creek, Hildebrand Run, Teens Run, Burrels Run, Raccoon Creek, Sardis Run, Long Run, Clark Run, Evans Run, Chickamauga Creek, Mill Creek, George Creek, Campaign Creek, Kyger Creek, Stores Run, Leading Creek, Forest Run, Jesse Run, Bowman Run, Wolf Run, Dunham Run, Tupper Run, Johns Run, Mill Run, Tanner Run, Toms Run, Oldtown Creek, Granny Run, Silver Creek, Savers Run, Groundhog Creek, Dry Run, Locks Run, Wells Run, DeWitt Run, Long Run, Shade River, Guyan Run, Forked Run, Little Forked Run, Sugarcamp Run, Indian Run, Hocking River, Swan Run, Dunfee Run, Sawyer Run, Little Hocking River, Davis Creek, Congress Run, Crooked Run, Mile Run, Muskingum River, Duck Creek, Little Muskingum River, Sheets Run, Allen Run, Bells Run, Newell Run, Danas Run, Reynolds Run, Davis Run, Reas Run, Leith Run, Sheets Run, Collins Run, Mill Creek, Jims Run, Miller Run, Deadhorse Run, Parker Run, Barnes Run, Narrows Run, Patton Run, Pool Run, Havely Run, Texas Creek, Bares Run, Fisher Run, Ueltsch Run, Narrows Run, Litman Run, Muhleman Run, Opossum Creek, Bishop Creek, Sunfish Creek, Gardner Run, Stillhouse Run, Blair Run, Big Run, Captina Creek, Little Captina Creek, Pipe Creek, Big Run, Wegee Creek, McMahon Creek, Indian Run, Whiskey Run, Moore Run, Wheeling Creek, Glenns Run, Patton Run, Deep Run, Short Creek, Little Rush Run, Rush Run, Salt Run, Tarrs Run, Cross Creek, Wells Run, Wills Creek, Island Creek, Croxton Run, Jeremy Run, Goose Run, Brimstone Run, Yellow Creek, McQueen Run, Little Yellow Creek, Wells Run, California Hollow (ODNR 2001).

A brief description of the habitat, water quality, and biological communities for six of the seven largest tributaries to the Ohio River follows (Raccoon Creek is not included at this time because recent data is not available).

6.16.2.1 Great Miami River

The following information was assembled from *Total Maximum Daily Loads for the Great Miami River (upper) Watershed* (Ohio EPA 2012d) except where otherwise noted.

The Great Miami River watershed is located in southwestern Ohio and southeastern Indiana and includes all or part of 15 Ohio counties. The river's headwaters begin near Indian Lake, and the Great Miami flows 170 miles in a southweaterly direction before it empties into the Ohio River west of Cincinnati. Most of the Great Miami River Watershed lies within the Eastern Corn Belt Plains Ecoregion which is characterized by rolling till plains with local moraines. Extreme southern portions of the watershed lie within the Northern Bluegrass Ecoregion characterized by more rugged and deeply dissected terrain (Miami Conservancy District 2012).

In general, the northern portion of the watershed is more agricultural while the southern portion is more urban and suburban developed land. Land cover in the upper Great Miami River watershed is comprised of 71% cultivated crops, 8% pasture/hay, 9% forest and 9% developed land. Land cover in the middle section of the watershed is dominated by cultivated crops (65%) and developed land (20%), with an

additional 8% forest and 5% pasture/hay. Land cover in the lower portion of the watershed is dominated by developed urban and residential land (nearly 40%), agricultural land (28%) and forest (19%).

In 2008, Ohio EPA sampled 78 sites on streams in the upper Great Miami River watershed. Overall the watershed met criteria for aquatic life use at 64% of sites, partially met at 26%, and did not meet aquatic life use criteria at 10% of the sites. The causes of impairments included habitat alteration, excess nutrients, silt, flow alteration, organic enrichment, low dissolved oxygen, excess dissolved solids, and bacteria. In the 2008 survey, 79% of sites evaluated for habitat quality had experienced some form of channelization and 62% were still negatively influenced by channelization. Eighteen percent of sites have recovered from historical modification, and only 21% of site channels were considered natural and unmodified.

Bacteriological impairment was pervasive throughout the upper watershed. Primary Contact Recreation criteria were exceeded at 73% of sites. Row crop agriculture was a suspected source of contamination at all of the impaired sites. Normal row crop agricultural activity may also include manure application to farm fields – and portions of the Great Miami basin drain some of the highest manure-producing counties in the state. Biosolids from the larger local municipal wastewater treatment plants are also spread on area fields near the facilities. The lower watershed shows similar causes of impairment, although due to the increasingly urban nature of the watershed in this area, sources of impairment shift to a variety of runoff and discharges from municipalities.

A more detailed discussion of the Great Miami River watershed is provided in the Ohio River Tributaries Conservation Opportunity Watersheds later in this section.

6.16.2.2 Little Miami River

The following information was assembled from *Total Maximum Daily Loads for the Upper Little Miami River* (Ohio EPA 2002), and *Lower Little Miami River Watershed Draft TMDL Report* (Ohio EPA 2010b).

The Little Miami River watershed is located in southwestern Ohio and drains a total of 1,758 square miles as it flows through all or part of 11 counties. The 110-mile-long river joins the Ohio River in Hamilton County on the east side of Cincinnati. The eastern portion of the watershed is predominantly comprised of cultivated crops with pockets of forest and pasture/hay lands. The western portion of the watershed is a mixture of forest, pasture/hay lands and urban development. The majority of the watershed is located within the Eastern Corn Belt Plains ecoregion, which is characterized by level to gently sloping land. Designated a State and National Scenic River, the Little Miami River mainstem contains some of Ohio's most scenic and diverse riverine habitat.

Upper River

The upper Little Miami River watershed covers portions of six counties and drains approximately 657 square miles. The topography of this northern section has been influenced by glaciation which left distinctive land forms and thick deposits of silt, sand, and gravel.

The habitat quality in the upper Little Miami watershed ranges from poor to excellent. For the mainstem, detailed results from Ohio EPA studies show that two patterns are apparent. First, the headwaters upstream from Clifton possess a greater number of human derived habitat attributes than natural attributes. Row crop agriculture strongly influences this part of the basin. Habitat attributes associated with impaired biological performance included sparse cover, no sinuosity, and channelization. The other pattern evident is that the riffles are at least moderately embedded with fine gravel, sand and silt. These two patterns are related – the practices resulting in modified habitat attributes in the headwaters and tributaries result in the bedload of sediment that infiltrates the riffles throughout the mainstem. Two other pervasive sources of sediment loads affecting the mainstem are eroding banks, especially where the riparian buffers have been removed, and suburban development. Downstream from Clifton, the habitat is capable of supporting Exceptional Warmwater Habitat (EWH) communities, with the habitat characterized by natural features derived from a free flowing channel interacting with glacial till and a mature riparian corridor.

Lower River
The lower Little Miami River watershed covers portions of 5 counties and drains about 1100 square miles. Land cover in the watershed is predominantly agriculture (40% cropland, 11% pasture) and forest (30%). About 17% of the watershed is developed or urban land, mostly in the southern portion when current land development is most rapid.

In 2007, the Ohio EPA collected biological, chemical, and physical data in the lower watershed. The mainstem of the Little Miami River showed exceptional quality, as twenty-four of twenty-five locations achieved the State's highest standards for aquatic life. The smaller tributary streams met goals for aquatic communities at 57% of the sites, partially met at 35%, and dis not meet at 12% of the sites. The reason for not meeting aquatic life goals at over half of the impaired sites was low stream flow due to an unusually dry year. The other impaired sites were most impacted by wastewater discharges, where nutrients and organic substances are the pollutants of concern. An excessive amount of fine sediment on the streambed was a problem at some survey sites. This was likely the result of surface or stream bank erosion in cropland areas due to exposed soil, changes in hydrology, and ditch maintenance.

The following information was assembled from *Biological and Water Quality Study of Little Miami River and Tributaries 2012* (Midwest Biodiversity Institute 2013).

Seventeen Little Miami R. mainstem sites were evaluated under the Warmwater Habitat (WWH) suite of uses and biocriteria. Of these, 24% were in full attainment of EWH biocriteria, and the remaining 76% were in partial attainment. The 2012 results represent a decline in attainment status compared to the most recent 2007 Ohio EPA results. The decline was the result of the failure of the fish Index of Biotic Integrity (IBI) to meet the EWH biocriterion. The reduction in the quality of the fish assemblage was substantial and widespread. A total of eight fish species that were present in 2007 were missing in 2012, and 16 additional species exhibited marked declines in distribution and abundance. Fifteen of these 24 species are classified as highly intolerant to pollution. Seven species increased in distribution and abundance and four of these are classified as moderately to highly tolerant of pollution.

Eleven mainstem sites on the East Fork of the Little Miami River were evaluated under the WWH suite of uses and biocriteria. Of these, 1 site was in full attainment of the EWH use and the remaining 10 in partial attainment. Causes of impairment included flow fluctuations, low dissolved oxygen, organic enrichment, habitat modifications, and siltation.

A number of sites on tributaries to the Little Miami River were also evaluated. In general, the majority of sites either did not meet the warmwater habitat aquatic life use criteria, or only partially attained it. The partial and non-attainment of WWH was mostly due to poor quality fish assemblages, and at some locations, poor quality macroinvertebrate assemblages also. The water quality in these tributary streams was typical of watersheds with a high degree of urban development, and urban effluents were the primary source of causes of impairment.

A more detailed discussion of the Little Miami River watershed is provided in the Ohio River Tributaries Conservation Opportunity Watersheds later in this section.

6.16.2.3 Ohio Brush Creek
The following information was assembled from *Biological and Water Quality Study of Ohio Brush Creek and Selected Tributaries 2007* (Ohio EPA 2011b).

Ohio Brush Creek is a moderate sized Ohio River tributary in south central Ohio, draining 435 square miles in portions of 5 counties before it empties into the Ohio River in Adams County just downstream of the town of Rome. The average mainstem gradient is 8.7 ft./mile. The West Fork is the only significant Ohio Brush tributary. Smaller tributaries are numerous, with gradients frequently exceeding 40 ft./mile. These steep gradients are a result of the high relative relief of the uplands.

Ohio Brush Creek watershed is located in the Interior Plateau (IP) Ecoregion. Land cover in the IP varies with topography, but is primarily livestock, pasture, cropland, and forest. Most of the basin is sparsely

populated, and within the heart of the watershed (Adams County) land use is roughly split between agriculture and forest. Due to a diverse geology creating diverse habitat types, Adams County supports some of the highest numbers of State listed species in Ohio.

By and large, the channel configuration of the Ohio Brush Creek mainstem is in a natural state, displaying adequate sinuosity and development. Dominant substrates are coarse, consisting of a mixture of native limestone, dolomite, shale, sandstone, and tills. Riparian areas at most sites are vegetated, more often wooded, attenuating sunlight and providing in-stream structure in the form of woody debris and rootwad formations. As measured by the Qualitative Habitat Evaluation Index, the quality of near and in-stream macrohabitat through the length of Ohio Brush Creek appeared capable of supporting diverse, functionally organized, and well-structured assemblages of aquatic organisms, consistent with its existing Exceptional Warmwater Habitat aquatic life use.

Surface flow or stream discharge of Ohio Brush Creek fluctuates widely. Runoff is rapid in the hill county and peak flows generally follow shortly after heavy precipitation. In contrast, during extended dry periods, surface flows often go intermittent or very low, due to a paucity of sustained ground water input. The latter was directly observed during the 2007 Ohio EPA survey which coincided with an extreme drought.

Of the 152 aggregate linear stream miles of the Ohio Brush Creek watershed assessed in 2007, 59.9% were found to fully support existing and recommended aquatic life uses. Partial attainment was indicated for 38.1%, and non-attainment for the remaining 2.0%. By far the leading associated cause and source of the aquatic life use impairments throughout the basin was the significant reduction, diminution and at times elimination of surface flow, due to an extreme drought experienced throughout south-central Ohio in 2007. Nearly all (98.4%) of the impaired stream miles had as their primary cause and source of impairment “low flow” resulting from a prolonged regional drought. Although other stressors were identified for many waterbodies, nearly all of these factors had as their antecedent, diminished surface flow due to an exceptionally dry summer.

The effects of the drought on the fish and macroinvertebrate indices were largely the cause of the low attainment percentages. It is uncommon to find such a high percentage of impaired river miles within a rural and relatively undeveloped watershed, as that observed for Ohio Brush Creek in 2007. The vast majority of fish stations were found to support a diverse and well organized assemblage of fish, showing high species richness and a good representation of sensitive taxa. In contrast, the performance of macroinvertebrates at the same locations typically performed no better than fair, and in almost every instance were the organism group driving attainment status.

A more detailed discussion of the Ohio Brush Creek watershed is provided in the Ohio River Tributaries Conservation Opportunity Watersheds later in this section.

6.16.2.4 Scioto River

The following information was assembled from *Biological and Water Quality Study of the Middle Scioto River and Select Tributaries, 2010* (Ohio EPA 2012a), *Biological and Water Quality Study of the Upper Scioto River Watershed 2009 & 2011* (Ohio EPA 2012b), and *Ohio 2014 Integrated Water Quality Monitoring and Assessment Report* (Ohio EPA 2014a).

The Scioto River watershed is located in central and south central Ohio and drains a total of 6,513 square miles in all or part of 31 counties. The Scioto River flows into the Ohio River at Portsmouth in Scioto County. The main stem of the Scioto River is over 236 miles long and has an average gradient of 2.3 feet per mile. The watershed is located in the Eastern Corn Belt Plains (ECBP) ecoregion. The northern portion of the watershed is predominantly comprised of cultivated crops with some areas of substantial urban development. The southern portion of the watershed is primarily comprised of forest with pockets of agricultural lands.

Upper River
The upper Scioto River watershed is located in the northwestern portion of central Ohio. The predominant land cover in this part watershed is cultivated crops at 80%. Other relatively common land cover types include developed land (8%), forest (6%) and pasture/hay (4%).

In 2009, 23 streams in the upper Scioto River watershed were assessed by the Ohio EPA. Scioto River mainstem habitat quality was highly variable and ranged from very poor to excellent. The average Qualitative Habitat Evaluation Index (QHEI) score for the upper Scioto River mainstem reflected overall good habitat quality. However, for more than sixteen miles the mainstem is severely modified from channelization, and habitats scored in the poor to fair range. Excellent physical habitat was scored outside of this reach, which helped increase the diversity and biological recruitment potential in the fish communities. High quality tributaries were rarely encountered in the upper Scioto River basin and a majority of samples reflected degraded or marginal quality. As a result of widespread impairment encountered in the upper Scioto basin, high quality biological communities were rarely found.

Fish sampling was conducted during the upper Scioto River watershed assessment in 2009 and 2011. The upper Scioto River headwater site was the only biologically exceptional fish community sampled and had five darter species in the community. The Scioto River downstream of Kenton scored very good, while 40% of mainstem sites scored good and the other 47% were found to have only marginally good or fair quality fish communities.

Macroinvertebrates were sampled at 14 locations along the upper Scioto River mainstem in 2009. Scioto River mainstem sites achieved the applicable Warmwater Habitat (WWH) macroinvertebrate biocriterion at all sites evaluated. The average Invertebrate Community Index (ICI) score was generally reflective of good to very good biological quality. Communities maintained good to exceptional quality from Kenton to the Little Scioto River confluence.

Throughout the study area, channelization and nutrient enrichment associated with agriculture were considered the most common and widespread stressors at these lower quality sites. For macroinvertebrates, the negative effects of these activities were manifest in low total taxa, low sensitive taxa richness, and a predominance of facultative, nutrient and silt tolerant populations. These mostly facultative populations included a number of flatworms, blackflies, midges and riffle beetles, along with several common varieties of baetid mayflies and net-spinning caddisflies.

Middle River
The middle Scioto River watershed is located in central Ohio. Forty-five percent of the basin is developed to some degree (ranging from high to low density development) while cropland by itself accounts for another forty percent of the area. Forest and pastureland account for an additional six and five percent respectively. The middle Scioto River mainstem has a designated aquatic life use of WWH throughout the study area, except for the 2.5 miles impounded by the Greenlawn Avenue dam. In addition, two stretches of the middle Scioto River are impounded by reservoirs: O'Shaugnessy Reservoir (6.6 miles) and Griggs Reservoir (5.9 miles).

Nearly half of the sites within the middle Scioto River basin did not meet the biological integrity goal, as only 58% were in full attainment of the WWH aquatic life use designation. The remaining sites were in partial (19%) or non-attainment (19%) of WWH criteria. Full attainment of a reduced-goal aquatic life use was achieved at the remaining 4%. While 84.6% of the Scioto River mainstem from the Little Scioto River to Big Darby Creek were in full attainment of the designated aquatic life use, organic enrichment downstream of Columbus contributed to 8.1% of partial attainment in the lower reach of the river.

Excellent stream habitat was noted at 39% of sites sampled, good stream habitat was recorded at another 39% of sites, fair habitat was noted at 18% of locations, and poor habitat accounted for the remaining 4%. The average QHEI score for the watershed reflected generally good habitat quality throughout the study area. The Scioto River mainstem had excellent to good habitat quality at 88% of sampling locations. Two sites scored within the fair range as a result of impounded conditions caused by dams.

A total of 82 species of fish were collected from the study area between June 2009 and September 2010. Fourteen very sensitive species were collected, reflecting the overall integrity of the middle Scioto River basin. Scioto River mainstem sites sampled achieved the applicable WWH biocriteria at all sites with this aquatic life use designation. Exceptional fish communities were recorded at all but two sites sampled.

The macroinvertebrate communities from 18 locations in the middle Scioto River and 20 locations in tributaries to the middle Scioto River watershed were sampled in 2009 and 2010. The middle Scioto River mainstem achieved the WWH macroinvertebrate biocriterion at 78% of sites sampled. The average ICI score for the Scioto River mainstem was reflective of overall good biological quality. The four sites that did not meet WWH criteria were impacted by either dams or by the influence urban/suburban effluent.

Lower River
The lower Scioto River watershed is located in south central Ohio. Predominant land cover in this part of the watershed includes forest (47%), cultivated crops (26%) and pasture/hay (13%). Approximately 7.5% of the watershed is developed land. The lower Scioto River from the confluence of Big Darby Creek to the mouth at the Ohio River (101 miles) was in 100% attainment of aquatic life use.

A more detailed discussion of the Scioto River watershed is provided in the Ohio River Tributaries Conservation Opportunity Watersheds later in this section.

6.16.2.5 Hocking River
The following information was assembled from *Total Maximum Daily Loads for the Hocking River Watershed* (Ohio EPA 2009b).

The Hocking River watershed, including Sunday and Monday creeks, is located in southeastern Ohio and drains a total of 1,196 square miles in all or part of seven counties. The Hocking River mainstem is over 102 miles long, emptying into the Ohio River at Hockingport. The northern portion of the watershed is predominantly comprised of cultivated crops. The southern portion of the watershed is predominantly forest, with some hay and pasture lands, and pockets of urban development. Overall, land cover in the watershed is predominantly forest (62%) and agricultural lands (27%). About 9% of the watershed is developed or urban land.

The Hocking River watershed is located within parts of the three different ecoregions: the Eastern Corn Belt Plains (ECBP), the Erie-Ontario Lake Plains (EOLP), and the Western Allegheny Plateau (WAP). The ECBP ecoregion consists primarily of rolling till plains with local end moraines. Corn, soybean, and livestock production is widespread. The EOLP ecoregion is characterized by low lime drift overlying rolling to level terrain with scattered end moraines and kettles. The WAP has a more rugged, unglaciated terrain with local relief up to 500 feet. The underlying strata of the WAP contain significant coal, oil, and gas deposits. Extraction of coal, oil, and gas has had and continues to have a major effect on the ecology of the region. Steep slopes in the region limit crop and cattle production to valley floors that reduces riparian corridors and concentrates animal wastes near the stream.

Ohio EPA conducted a comprehensive physical, chemical, and biological survey in portions of the Hocking River watershed from 2003 to 2005. Aquatic life uses were fully met at nearly 70% of sampling sites throughout the watershed. Just over 20% of the sites sampled were found to be in partial attainment where one or two of the three biological indices (habitat, fish, invertebrates) were met. About 10% of the sites failed to meet any of the biological criteria. The Upper Rush Creek assessment unit is severely impacted by acid mine drainage (AMD) along the mainstem of Rush Creek and some of its small tributaries. These streams are essentially devoid of fish and macroinvertebrates. Due to the overwhelming impact from the AMD, some streams and stream segments are designated as limited resource waters. Primary sources of non-attainment in the watershed were excess nutrients/organic enrichment, sedimentation, habitat alteration, and acid mine drainage.

Based upon Qualitative Habitat Evaluation Index (QHEI) scores, the Hocking River mainstem had good to excellent habitat quality at 66% of sampling locations. In general, habitat quality improved in a downstream direction. Habitat scores in tributary streams were good to excellent in areas not impacted by

agriculture or mine drainage. Impacted stream sampling sites generally did not meet Warmwater Habitat (WWH) criteria.

Fish communities met WWH or Exceptional Warmwater Habitat (EWH) criteria at about 70% of sites sampled on the Hocking mainstem. Community scores improved in a downstream direction. Fish community scores in tributary streams usually met WWH or EWH unless impacted by mine drainage. Macroinvertebrate communities met WWH criteria or better at about 90% of Hocking mainstem sites. Macroinvertebrate communities from tributary streams were rated moderately good or better at about 80% of sites sampled.

6.16.2.6 Muskingum River

The following information was assembled from *2006 Biological and Water Quality Study of the Muskingum River* (Ohio EPA 2007a).

Located in eastern Ohio, the Muskingum River drains the largest watershed in the state, encompassing 8,051 square miles in all or part of 27 counties. The mainstem is 112 miles long and enters the Ohio River near Marietta. The Muskingum River is located in the Western Allegheny Plateau (WAP) ecoregion. The northern portion of the watershed is a mixture of urban development, agricultural land, and forest. The southern portion of the watershed is predominantly comprised of forest, with some hay and pasture lands and pockets of urban development.

Ten locks and dams are currently located on the mainstem of the lower 85 miles of the Muskingum River. This system of dams and locks, built to allow commercial use of the river, was one of the earliest slack water systems in the United States. The Muskingum River is no longer used for commercial navigation. Today, recreational boaters use the river, with more than 5,800 boats “locking through” the river’s navigation system annually.

Biological sampling in the Muskingum River during 2006 demonstrated that the entire length of river is fully attaining the Warmwater Habitat (WWH) aquatic life-use designation. Surveys of the fish and macroinvertebrate communities of the Muskingum River revealed healthy populations of numerous pollution sensitive species, along with localized populations of rare, threatened, and endangered species. Most of the free-flowing and tailwater sites supported exceptional biological communities, and chemical water testing results were generally reflective of good water quality.

A total of 65 species of fish were collected from the Muskingum River during 2006 surveys. Muskingum River fish communities at 93% of sampling locations achieved the WWH biocriterion. Index of Biotic Integrity (IBI) scores and Modified Index of Well-being scores were all within the marginally good to exceptional range. An evaluation of fish communities by habitat type (free-flowing upper section, tailwaters, and impounded sections) reveals that the free-flowing and tailwater sites were largely reflective of very good to exceptional conditions, and at or approaching Exceptional Warmwater Habitat (EWH) levels of biological integrity. Physical habitat features at the free-flowing and tailwater sections were adequate for supporting the EWH aquatic life-use designation.

Ohio threatened (T), or species of concern (SC) fish collected during this survey included blue sucker (T), mountain madtom (T), river redhorse (SC), and eastern sand darter (SC). Fish species collected which are intolerant of water pollution included mooneye, blue sucker, river redhorse, bigeye chub, streamline chub, silver shiner, rosyface shiner, mimic shiner, stonecat madtom, mountain madtom, slenderhead darter, eastern sand darter, banded darter, variegate darter, and bluebreast darter. River redhorse and mimic shiner, two species intolerant of water pollution, were recorded at a number of sampling sites on the Muskingum River. Mimic shiners were recorded from impounded and freeflowing (including tailwater) sites, with fish collected from 22 of 28 sampling locations. River redhorse, a fish species which prefers moderate to swift water habitat, were recorded from 15 of 16 free-flowing sites.

Macroinvertebrate sampling results from 2006 indicate that all sampled sites were in full attainment of the WWH biocriterion. A more detailed discussion of the Muskingum River watershed is provided in the Ohio River Tributaries Conservation Opportunity Watersheds later in this section.

6.15.3 Associated Species of Greatest Conservation Need

The physical and chemical characteristics of Ohio River tributaries change as you move from unglaciated eastern Ohio and transition to the glaciated western part of the state. Changes in gradient and land cover drive changes in stream characteristics from east to west. The eastern portion of the Ohio River watershed is predominantly comprised of forest with some areas of crops, pasture, and hay lands. The central portion of the watershed is a more even mixture of crops, pasture and hay lands, and forest. The western portion of the watershed is primarily comprised of urban development and agriculture. The aquatic communities of Ohio River tributaries are a reflection of the glaciated versus unglaciated differences in the watershed.

The following species have been identified as Ohio River Tributary species of greatest conservation need (conservation status rank in parentheses):

<u>Fish</u>

Diamond Darter (2)	*Crystallaria cincotta*
American Eel (5)	*Anguilla rostrata*
Paddlefish (9)	*Polyodon spathula*
Shoal Chub (11)	*Macrhybopsis hyostoma*
Ohio Lamprey (13)	*Ichthyomyzon bdellium*
Alligator Gar (15)	*Lepisosteus spatula*
Lake Sturgeon (17)	*Acipenser fulvescens*
Blue Sucker (18)	*Cycleptus elongatus*
Shovelnose Sturgeon (19)	*Scaphirhynchus platorynchus*
Tippecanoe Darter (20)	*Etheostoma tippecanoe*
Bluebreast Darter (25)	*Etheostoma camurum*
Eastern Sand Darter (29)	*Ammocrypta pellucida*
Gravel Chub (32)	*Erimystax x-punctatus*
Silver Chub (36)	*Macrhybopsis storeriana*
Goldeye (39)	*Hiodon alosoides*
Streamline Chub (41)	*Erimystax dissimilis*
Bigeye Chub (42)	*Hybopsis amblops*
Channel Darter (44)	*Percina copelandi*
Black Redhorse (48)	*Moxostoma duquesnei*
Mooneye (50)	*Hiodon tergisus*
Silver Redhorse (52)	*Moxostoma anisurum*
Variegate Darter (53)	*Etheostoma variatum*
Black Buffalo (56)	*Ictiobus niger*
Dusky Darter (58)	*Percina sciera*
Shortnose Gar (60)	*Lepisosteus platostomus*
River Darter (61)	*Percina shumardi*
Mississippi Silvery Minnow (62)	*Hybognathus nuchalis*
River Redhorse (63)	*Moxostoma carinatum*
Smallmouth Redhorse (63)	*Moxostoma breviceps*

<u>Crayfish</u>

Teays River Crayfish (1)	*Cambarus sciotensis*
Norwood River Crayfish (2)	*Orconectes raymondi*
Sanborn's Crayfish (6)	*Orconectes sanbornii*
Big Water Crayfish (7)	*Cambarus robustus*
Paintedhand Mudbug (8)	*Cambarus polychromatus*
Little Brown Mudbug (9)	*Cambarus thomai*
Spiney Stream Crayfish (11)	*Orconectes cristavarius*
Papershell Crayfish (13)	*Orconectes immunis*
Red Swamp Crayfish (13)	*Procambarus clarkii*
Virile Crayfish (13)	*Orconectes virilis*

Mussels

White Wartyback (1)	*Plethobasus cicatricosus*
Snuffbox (5)	*Epioblasma triquetra*
Long Solid (6)	*Fusconaia subrotunda*
Ebonyshell (8)	*Fusconaia ebena*
Elephantear (8)	*Elliptio crassidens*
Pyramid Pigtoe (8)	*Pleurobema rubrum*
Orange-foot Pimpleback (12)	*Plethobasus cooperianus*
Ohio Pigtoe (13)	*Pleurobema cordatum*
Sheepnose (13)	*Plethobasus cyphyus*
Monkeyface (16)	*Quadrula metanevra*
Slippershell Mussel (16)	*Alasmidonta viridis*
Ring Pink (18)	*Obovaria retusa*
Scaleshell (18)	*Leptodea leptodon*
Winged Mapleleaf (18)	*Quadrula fragosa*
Butterfly (21)	*Ellipsaria lineolata*
Rayed Bean (21)	*Villosa fabalis*
Creek Heelsplitter (23)	*Lasmigona compressa*
Pondhorn (23)	*Uniomerus tetralasmus*
Fanshell (25)	*Cyprogenia stegaria*
Rabbitsfoot (25)	*Quadrula cylindrica*
Salamander Mussel (25)	*Simpsonaias ambigua*
Wartyback (25)	*Quadrula nodulata*
Clubshell (35)	*Pleurobema clava*
Rough Pigtoe (35)	*Pleurobema plenum*
Purple Wartyback (37)	*Cyclonaias tuberculata*
Yellow Sandshell (37)	*Lampsilis teres*
Spectaclecase (39)	*Cumberlandia monodonta*
Threeridge (40)	*Amblema plicata*
Washboard (40)	*Megalonaias nervosa*
Cracking Pearlymussel (42)	*Hemistena lata*
Pocketbook (42)	*Lampsilis ovata*
Round Hickorynut (42)	*Obovaria subrotunda*
Black Sandshell (47)	*Ligumia recta*
Kidneyshell (48)	*Ptychobranchus fasciolaris*
Northern Riffleshell (48)	*Epioblasma torulosa rangiana*
Rainbowshell (50)	*Villosa iris*
Round Pigtoe (50)	*Pleurobema sintoxia*
Elktoe (52)	*Alasmidonta marginata*
Deertoe (53)	*Truncilla truncata*
Fawnsfoot (53)	*Truncilla donaciformis*
Threehorn Wartyback (55)	*Obliquaria reflexa*
Cylindrical Papershell (56)	*Anodontiodes ferussacianus*
Fat Pocketbook (56)	*Potamilus capax*

Amphibians

Mudpuppy (14)	*Necturus maculosus maculosus*

Reptiles

Rough Green Snake (3)	*Opheodrys aestivus*
Midland Smooth Softshell (7)	*Apalone mutica mutica*
Common Map Turtle (19)	*Graptemys geographica*
Ouachita Map Turtle (19)	*Graptemys ouachitensis*
Queen Snake (19)	*Regina septemvittata*

6.15.4 Ohio River Tributaries Conservation Opportunity Watersheds

6.15.4.1 Great Miami River Watershed (consists of HUC 05080001 and HUC 05080002)

The Miami River drains 5,385 square miles, of which 1,437 square miles are in Indiana, mainly in the Whitewater River Basin. The highest point in Ohio (1,550 feet above mean sea level) is in the Miami River drainage near Bellefontaine, and the lowest point in the state (about 430 feet above mean sea level, low water level in the Ohio River at the Indiana line) is just below the mouth of the Miami River.

Physiography

The entire basin is in the Till Plains. The level to gently rolling plain is broken by the wide valleys of the major streams. Toward Cincinnati the topography is hilly and more dissected, but is not as rugged as some other parts of southern and southeastern Ohio. The principal terrain features north of Middletown are the kames, eskers, and end moraines left by the glaciers.

Geology

The bedrock units exposed in the basin consist of limestone, dolomite, and shale of Ordovician and Silurian age. These strata are relatively dense and do not allow for the storage of large volumes of ground water. In the northern part of the basin, where the Silurian dolomites prevail, ground-water storage may influence streamflow to a minor degree.

The glacial drift is deep over the upper part of the basin, exceeding 300 feet in places, but thinning toward the south. The glaciers left extensive deposits of washed material, particularly outwash, valley-train deposits, kames, eskers, and kame moraines. Many deep preglacial or interglacial stream valleys are filled with permeable sands and gravels.

Soils

The soils in the basin are derived from glacial deposits of both early and late Wisconsin age. Miamian, Celina, Crosby, and Kokomo are the dominant soils of the late Wisconsin till area, and Russell, Xenia, and Fincastle are the principal soils of the early Wisconsin area. Classification of these soils depends on the drainage condition under which they developed. The less well-drained soils are relatively impermeable. Rather extensive terrace and alluvial soils occur, generally with good drainage and high permeability. Eldean, Ockley, and associated soils are prevalent on the terraces. Genesee soils are the dominant alluvial soils.

Water Development

Flood-control works of the Miami Conservancy District include five detention dams (dry reservoirs except during flood periods) that have automatic outlets. The dams provide flood protection for Dayton and other cities along the Miami River. In 1972, the Corps of Engineers completed Buck Creek Reservoir on Buck Creek at Springfield. The City of Dayton obtains its water supply from large well fields along the Miami River and Mad River.

Flow Characteristics

The amount of ground-water storage, the controlling factor influencing the low-flow characteristics of streams, is greatest in the upper part of the Miami River Basin, and diminishes toward the south. It is of interest to note that as early as 1896 a geologist with the U. S. Geological Survey (Leverett) recognized the influence of ground-water discharge on streamflow. Leverett states (in U. S. Geological Survey, Monogram 41, 1902) that "The streams in this basin (Miami River Basin) seldom reach a very low stage in seasons of drouth, for the valleys are usually filled with gravelly or sandy deposits which furnish strong springs. Even in the small tributaries, water bearing beds outcrop along the banks or bluffs."

Above Dayton three principal streams, Stillwater River, Miami River, and Mad River, all of which converge at Dayton to form the main valley, drain the basin. Of the three branches, Stillwater River has the lowest index of dry-weather flow and Mad River the highest. Throughout most of its course, Stillwater River follows a preglacial valley containing moderately permeable outwash deposits. Above Covington the Stillwater lies between two moraines, and although it flows through a till plain, its tributaries extend into

the morainal areas to the north and south. The morainal material is largely till but sufficiently extensive sand and gravel deposits are present to support the fairly good sustained flow in the Stillwater River.

The effects of morainal deposits are clearly shown on Greenville Creek. This stream is of ice-front origin and parallels the southern edge of the Union Moraine from Covington to the Indiana line. The dry-weather flow index at Bradford is double that of the Stillwater River above the mouth of Greenville Creek.

Below Covington the chief source of the sustained flow in the Stillwater River is the outwash and valley train deposits in the valley. Ground-water contribution from the limestone and dolomite that form the valley walls is relatively small. Above Dayton the sustained flow in the Miami River is relatively high. With the exception of a short reach above Piqua, the channel is cut into valley fill of glacial origin. At the col above Piqua, the channel is cut into the bedrock. The sustained flow is maintained largely from ground-water flow originating in the extensive kame moraine, end moraine, and kame terrace deposits above Quincy in Logan County. Downstream from Piqua the chief source is form high-level terrace deposits.

The tributary, Loramie Creek, has a poor sustained flow. The area drained is till plain in which most of the surface materials are dense and impermeable. It is believed that Loramie Reservoir has little effect on the flow of Loramie Creek. The same holds true for Indian Lake at the head of the Miami River.

The greatest contribution to the sustained flow of the Miami River is received from the Mad River. The Mad River occupies a broad trough-like valley of preglacial and interglacial origin and most of its course lies between the morainal ridges deposited by the Miami and Scioto lobes of the Wisconsin glacier. The surface material in the interlobate area consists of extensive permeable drift such as kames, kame terraces and end moraines accompanied by high-level outwash in the uplands and valley train in the main valleys. At no other place in the state is there such an accumulation of permeable material and, as a result, the Mad River has some of the highest median- and low-flow indices of all the streams in Ohio. Similar conditions prevail in the area drained by Buck Creek and Beaver Creek although glacial drift in this area is less gravelly in nature and tends to be more dominantly till. Regional discharge from limestone contributes some ground water to sustain base flows of the Mad River.

Analyses of the gaging records for the Mad River show that the greatest influx of ground water occurs between Urbana and Springfield. This is due mainly to flow from Buck Creek and partly from greater ground-water influx along the river between Urbana and Springfield. The Mad River (similar to the Miami River at Piqua) has a short reach where it is shallow to limestone just west of Springfield. Between Springfield and Dayton there is a decrease in the index of flow. Miscellaneous discharge measurements made in this area in 1948 revealed that many of the tributary streams are dry during dry weather periods.

From Dayton to Hamilton there is a general decrease in the dry-weather flow indices of the Miami River except at Miamisburg where the effects of municipal and industrial wastewater return flows from Dayton are noticeable. Municipal and industrial water supplies are derived from gravel deposits along the Miami River and Mad River in Dayton and discharged as wastewater upstream of the Miamisburg gage. Part of the water supply is diverted to the Little Miami River through the wastewater system. Tributaries such as Wolf Creek and Twin Creek have moderate sustained flows and tend to maintain the low flow in the Miami River.

<u>State Listed Species by County with Records of Occurrence from the Great Miami River Watershed</u> (from the Ohio Natural Heritage Database)
The following species are dependent upon aquatic habitats to complete their life cycle – this dependence may be for all or a portion of their life:

Hamilton County
Kirtland's snake, cobblestone tiger beetle, plains clubtail, lake sturgeon, eastern sand darter, blue sucker, burbot, river redhorse, bigeye shiner, mountain madtom, northern madtom, channel darter, river darter, paddlefish, Sloan's crayfish, elktoe, purple wartyback, butterfly, elephantear, snuffbox, ebonyshell, washboard, threehorn wartyback, sheepnose, Ohio pigtoe, monkeyface, wartyback, fawnsfoot, deertoe

Butler County
Kirtland's snake, cave salamander, plains clubtail, blue corporal, tonguetied minnow, Sloan's crayfish

Warren County
Spotted turtle, Kirtland's snake, blue corporal, goldeye, river redhorse, bigeye shiner, paddlefish, Sloan's crayfish, elktoe, snuffbox, washboard, threehorn wartyback, round pigtoe, purple lilliput, fawnsfoot, deertoe, rayed bean

Preble County
Kirtland's snake, least darter, Sloan's crayfish

Montgomery County
Kirtland's snake, seepage dancer, plains clubtail, eastern sand darter, least darter, burbot, river redhorse, Sloan's crayfish, elktoe, snuffbox, wavyrayed lampmussel, pondhorn, rayed bean

Greene County
Spotted turtle, Kirtland's snake, seepage dancer, tonguetied minnow, snuffbox, wavyrayed lampmussel, creek heelsplitter, clubshell, fawnsfoot

Darke County
Plains clubtail, least darter, Sloan's crayfish, wavyrayed lampmussel, creek heelsplitter

Miami County
Iowa darter, least darter, creek heelsplitter

Clark County
Spotted turtle, Kirtland's snake, seepage dancer, Iowa darter, least darter, tonguetied minnow

Champaign County
Spotted turtle, Kirtland's snake, seepage dancer, elfin skimmer, *Litobrancha recurvata* (mayfly), *Radotanypus florens* (midge), lake chubsucker, least darter, tonguetied minnow, clubshell, rayed bean

Shelby County
Least darter, purple wartyback

Mercer County
Eastern cricket frog, deertoe, pondhorn

Logan County
Spotted turtle, eastern hellbender, swamp metalmark, lake chubsucker, Iowa darter, tonguetied minnow, elktoe, purple wartyback, wavyrayed lampmussel, creek heelsplitter, kidneyshell, rayed bean

Auglaize County
Least darter, greater redhorse, rayed bean

Hardin County
Four-toed salamander, least darter, creek heelsplitter, pondhorn, rayed bean

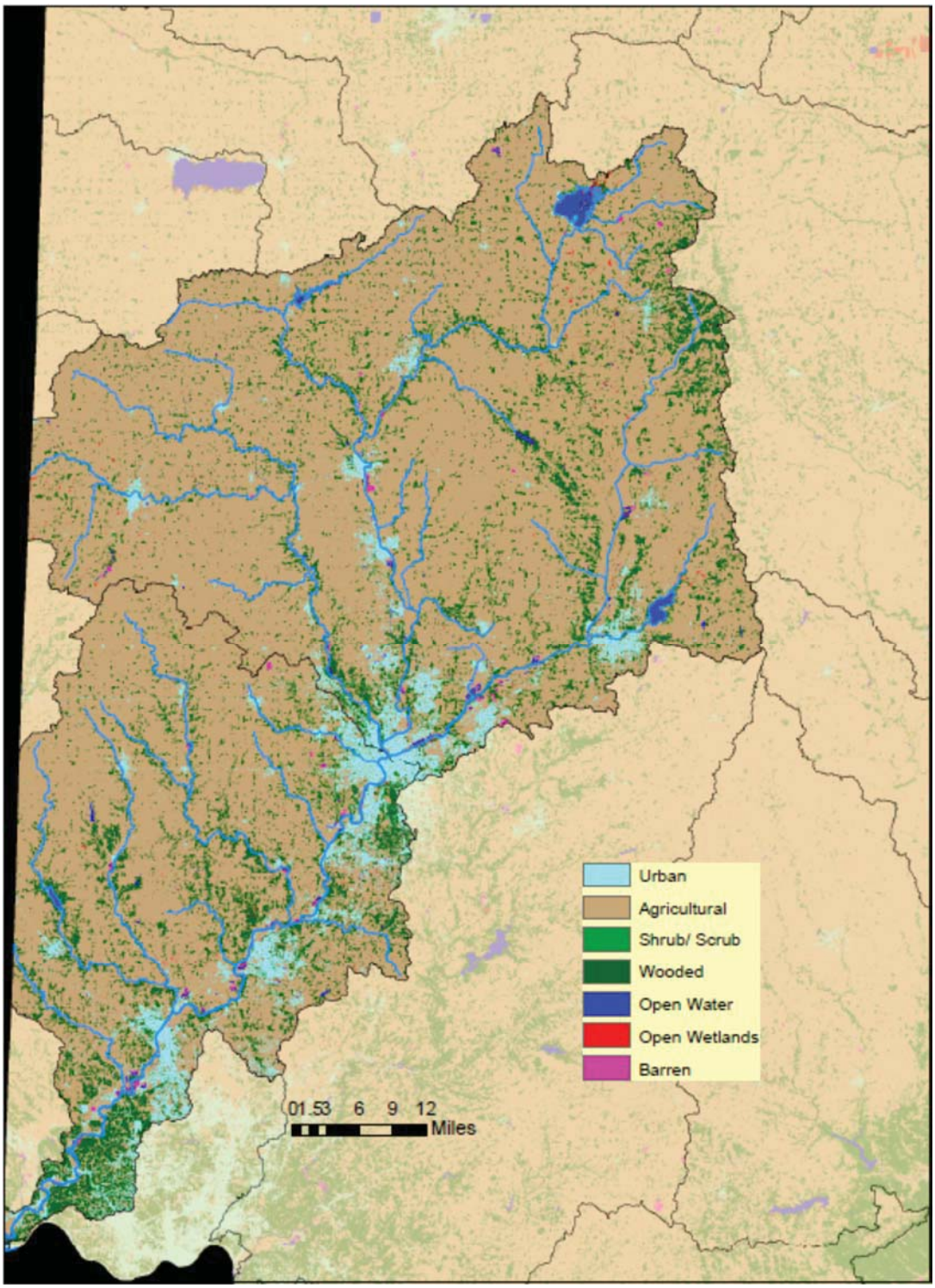


Figure 31. Great Miami River Conservation Opportunity Watershed – Land Cover.

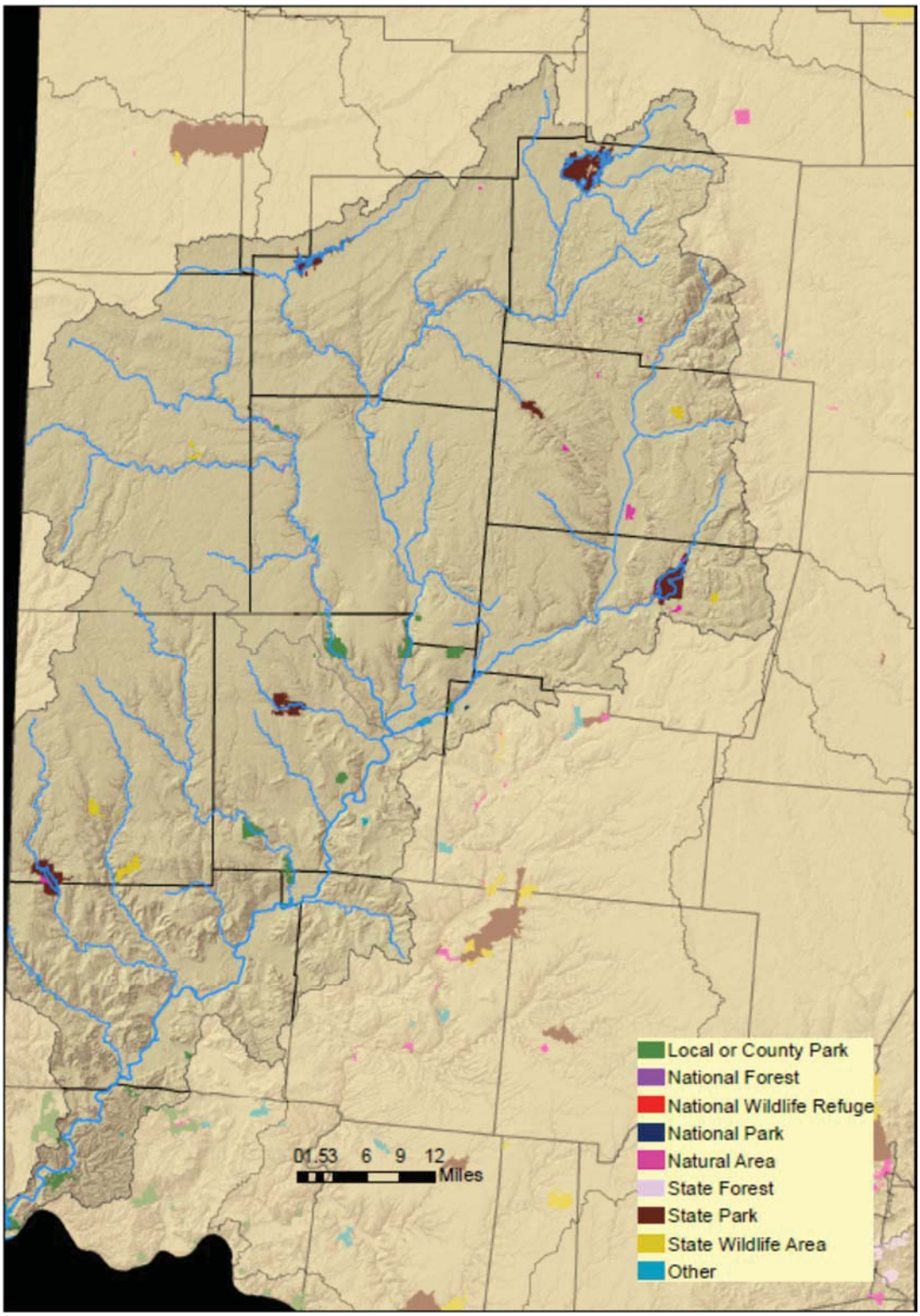


Figure 32. Great Miami River Conservation Opportunity Watershed – Protected Lands.

6.15.4.2 Little Miami River CO Watershed (HUC 05090202)

The Little Miami River Basin drains an area of 1,755 square miles. The source of the main stream is a few miles southeast of Springfield, and the mouth is just east of Cincinnati. East Fork, its principal tributary, originates near Hillsboro and joins the main stream about 12 miles above the mouth. East Fork drains 501 square miles of the total area comprising the Little Miami Basin.

Physiography

The entire basin lies within the Till Plains. The northern part of the area is flat to gently rolling but with occasional deep gorges, such as Clifton Gorge near Yellow Springs. Generally to the south the relief is greater, although a large area in the East Fork drainage is flat swampland. The valleys are generally relatively narrow and bordered by rock buffs. At places where the streams traverse preglacial drainage lines, the valleys are broad and flat-bottomed.

Geology

Dense calcareous shale, dolomite, and limestones of Ordovician and Silurian age underlie the basin. There is minor karst sinkhole terrain in the Silurian limestone, but it is poorly developed. Although there are springs and spring lines where a relatively permeable limestone outcrops over impermeable shale, their effect on streamflow is negligible. Glacial deposits of two ice advances occupy the area of the Little Miami Basin. Approximately the upper half of the basin is covered by drift of Wisconsinan age and the lower half by Illinoian deposits.

Soils

The soils in this basin vary widely. In areas of late Wisconsin drift are Miamian, Celina, Crosby, Kokomo, Birkbeck, Reesville, and Ragsdale soils. They range from very poorly drained to well drained and are for the most part slowly permeable. The moderately to slowly permeable Russell, Xenia, and Fincastle are the important soils series in areas of early Wisconsin drift. Rossmoyne, Clermont, and Avonburg are the dominant soils in the Illinoian drift area. The well-drained Bonnell and Jessup soils are common in areas in the southern part of the basin where the Illinoian till deposits are thin. These soils are slowly permeable. There are also terrace and alluvial soils with good drainage but these are rather limited in extent.

Water Development

The Corps of Engineers completed Caesar Creek Reservoir on Caesar Creek in 1973 and East Fork Reservoir on East Fork Little Miami River in 1977.

Flow Characteristics

There is a wide range of difference in the flow characteristics of the streams in this basin. The effects of glacial material on flow characteristics are manifest in this area. As the drift thins toward the south and changes from dominantly gravel terrain to till cover, the dry-weather flow decreases in relative magnitude from the source to the mouth. The gaging station on the Little Miami at Spring Valley shows an exceptionally high sustained flow as a result of the widespread gravel deposits that lie above drainage in the headwater area of the basin. High-level outwash materials in the form of valley fill, terraces, and kame terraces are present in northern Greene county and southern Clark County. These materials, which are highly permeable, absorb large quantities of rainfall and release it rather uniformly throughout the year. In addition to the ground water contribution from the glacial deposits, a minor amount is contributed by the limestone and dolomite formations.

The record of flow at the Oldtown gage on the Little Miami River indicates a relatively high index of median flow in the upper part of the Little Miami valley. Fifty percent of the time the flow exceeded about 0.5 cubic feet per second per square mile which is above average for an uncontrolled stream. The record at the Spring Valley station has an even higher median-flow index although augmented by wastewater discharges. Between Spring Valley and Fort Ancient, the Little Miami follows the course of a preglacial valley in which more than 100 feet of unconsolidated valley fill is present. However, there are no high-level glaciofluvial deposits that greatly affect streamflow. The relatively high base-flow index at the Fort Ancient is a reflection of the influence of ground-water discharge in the headwater area above Spring Valley and flow augmentation from wastewater discharges. Caesar Creek that is the principal tributary

above Fort Ancient is cut into the shale bedrock throughout much of its course and the unregulated flow relatively low during dry periods.

The record of flow at the Milford gaging station shows a high dry-weather flow index. This is still a reflection of the influence of conditions in the headwater area, although some additional flow is contributed by terrace deposits in the valley north of Milford and releases from Caesar Creek Reservoir.

Cowan Creek drains an area in which impervious shale and dense till predominate. This accounts for the very low indices of flow indicated by the records near Wilmington and at Clinton County Air Force Base.

The index of flow of East Fork of Little Miami River should be similar to that of Whiteoak Creek because of the similarity of geologic conditions in the two basins. East Fork drains an area in which the surface material is almost entirely glacial till of Illinoian.

State Listed Species by County with Records of Occurrence from the Little Miami River Watershed (from the Ohio Natural Heritage Database)
The following species are dependent upon aquatic habitats to complete their life cycle – this dependence may be for all or a portion of their life:

Brown County
Bigeye shiner, channel darter, river darter, purple wartyback, butterfly, elephantear, ebonyshell, yellow sandshell, washboard, threehorn wartyback, sheepnose, Ohio pigtoe, monkeyface, wartyback, salamander mussel, fawnsfoot, deertoe, rayed bean, little spectaclecase

Highland County
Tiger spiketail, bigeye shiner

Clinton County
Cobblestone tiger beetle

Greene County
Spotted turtle, Kirtland's snake, seepage dancer, tonguetied minnow, snuffbox, wavyrayed lampmussel, creek heelsplitter, clubshell, fawnsfoot

Clark County
Spotted turtle, Kirtland's snake, seepage dancer, Iowa darter, least darter, tonguetied minnow

Montgomery County
Kirtland's snake, seepage dancer, plains clubtail, eastern sand darter, least darter, burbot, river redhorse, Sloan's crayfish, elktoe, snuffbox, wavyrayed lampmussel, pondhorn, rayed bean

Warren County
Spotted turtle, kirtland's snake, blue corporal, goldeye, river redhorse, bigeye shiner, paddlefish, Sloan’s crayfish, elktoe, snuffbox, washboard, threehorn wartyback, round pigtoe, purple lilliput, fawnsfoot, deertoe, rayed bean

Clermont County
Kirtland's snake, goldeye, blue catfish, shortnose gar, river redhorse, bigeye shiner, mountain madtom, northern madtom, channel darter, paddlefish, elktoe, purple wartyback, butterfly, elephantear, snuffbox, ebonyshell, wavyrayed lampmussel, black sandshell, threehorn wartyback, sheepnose, Ohio pigtoe, monkeyface, wartyback, salamander mussel, fawnsfoot, deertoe, rayed bean, little spectaclecase

Hamilton County
Kirtland's snake, cobblestone tiger beetle, plains clubtail, lake sturgeon, eastern sand darter, blue sucker, burbot, river redhorse, bigeye shiner, mountain madtom, northern madtom, channel darter, river darter,

paddlefish, Sloan's crayfish, elktoe, purple wartyback, butterfly, elephantear, snuffbox, ebonyshell, washboard, threehorn wartyback, sheepnose, Ohio pigtoe, monkeyface, wartyback, fawnsfoot, deertoe

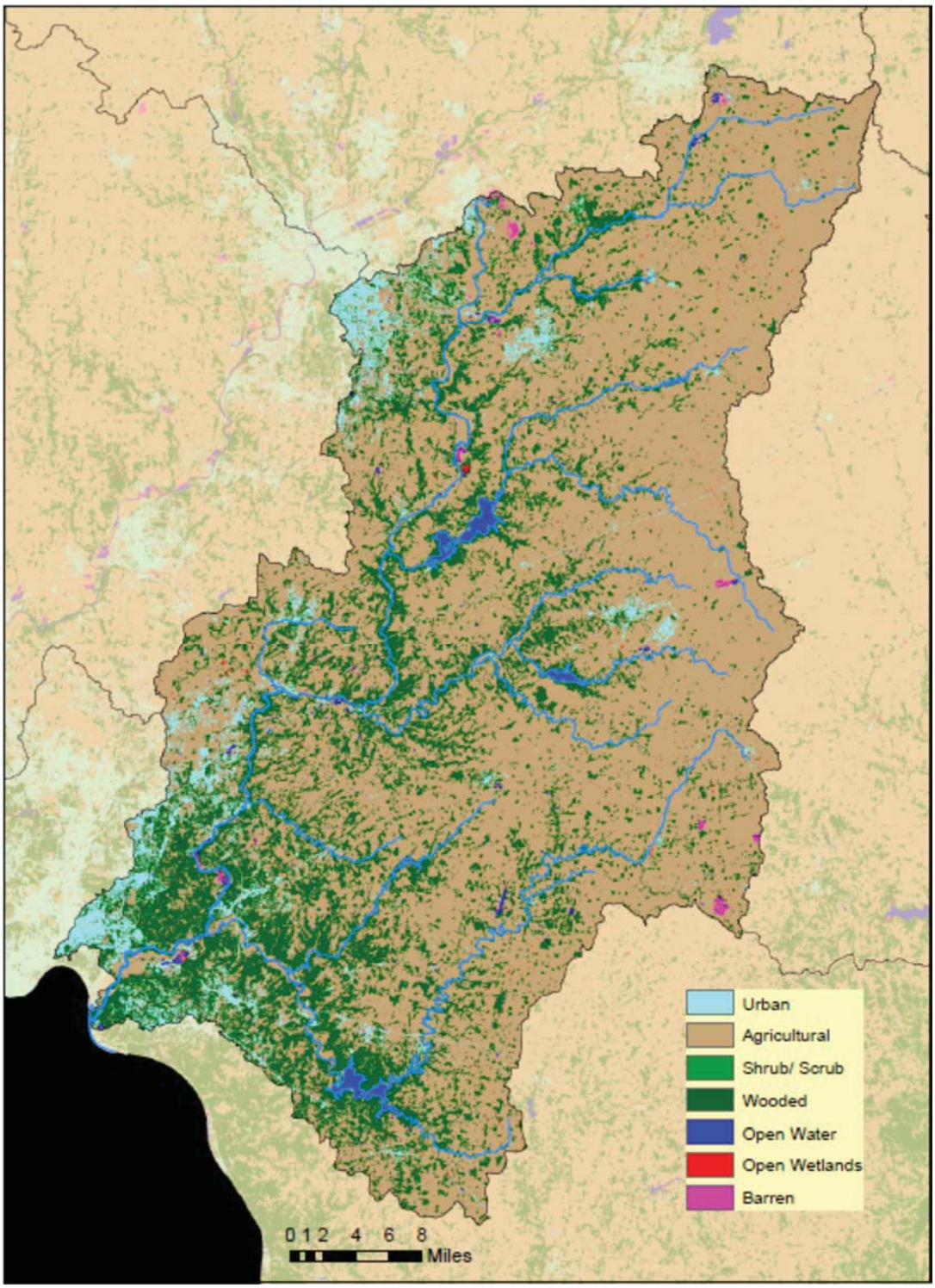


Figure 33. Little Miami River Conservation Opportunity Watershed – Land Cover.

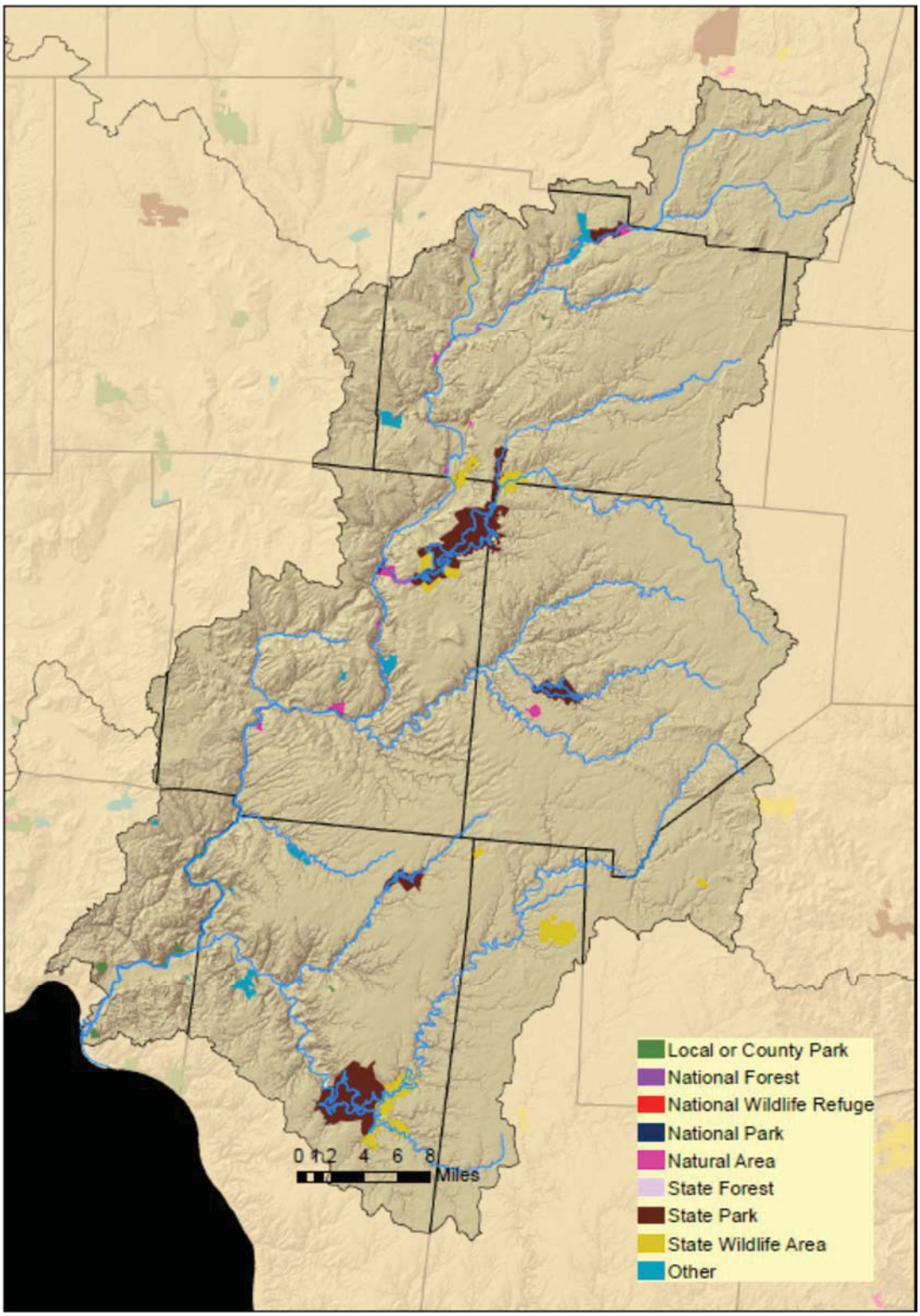


Figure 34. Little Miami River Conservation Opportunity Watershed – Protected Lands.

6.15.4.3 Ohio Brush Creek CO Watershed (consists of the central 33% of HUC 05090201)
There are 1,336 square miles contributing to the Ohio River drainage between the Scioto and Little Miami rivers; Ohio Brush Creek drains 435 square miles of this area.

Physiography
Most of Adams County is an unglaciated limestone area, considered physiographically to be part of the Bluegrass Section of the Interior Low Plateau Province, but the soils are thin, the topography rough, and there is little resemblance to the fertile Kentucky Bluegrass region. North and west of Adams County the area is in the Till Plains, but the terrain is rugged and the drift relatively thin.

Geology
The surface rocks are extremely variable, ranging from sandstone and shale in the eastern part to dolomite and limestone in the central part and to calcareous shale in the western sector. The western part of the area is covered with Illinoian drift, generally thin, but with some local areas of thick and relatively impermeable deposits. The glaciated area has lower dry-weather streamflow than the unglaciated, but not as low as in the Little Miami River Basin.

Soils
The soils of this area may be placed in three groups according to their parent materials and physiographic relationship: (1) those derived from limestone and shale that are generally shallow and occur on steep, hilly topography; (2) those derived from relatively shallow Illinoian glacial till on undulating to gently rolling relief; and (3) soils derived from sandstone and shale on steep, hilly topography. Principal soils in the first group are the Eden, Bratton, Brushcreek, and Cedarville. The permeability of these soils is generally moderate to slow. Soils of the second group include the moderately slow to slowly permeable Jessup, Bonnell, and Rossmoyne soils series. In the third group, the principal soils are the steep phases of Shelocta, Latham, and Rarden. There are some alluvial soils, but the valleys are narrow and of limited extent, except along the Ohio River where there are areas of moderately permeable soils.

Water Development
There are no large inland water developments in the watershed.

Flow Characteristics
Ohio Brush Creek has relatively low sustained flow. With the exception of a small area in the headwaters, Ohio Brush Creek drains an unglaciated area. Some alluvium and glacial outwash is present under the valley floor. The Brassfield limestone of Silurian age, which is a notable spring horizon, is exposed along the valley of Ohio Brush Creek throughout a large portion of its course. The spring water and possibly some discharge from the alluvium support the rather low dry-weather flow.

State Listed Species by County with Records of Occurrence from the Ohio Brush Creek Watershed (from the Ohio Natural Heritage Database)
The following species are dependent upon aquatic habitats to complete their life cycle – this dependence may be for all or a portion of their life:

Adams County
Green salamander, cave salamander, four-toed salamander, tiger spiketail, green-faced clubtail, Uhler's sundragon, blue corporal, goldeye, river redhorse, channel darter, river darter, paddlefish, purple wartyback, yellow sandshell, black sandshell, washboard, threehorn wartyback, clubshell, rabbitsfoot, wartyback, salamander mussel, fawnsfoot, deertoe

Pike County
Seepage dancer, plains clubtail, yellow-sided skimmer, blue sucker, goldeye, shortnose gar, river redhorse, bigeye shiner, paddlefish, shovelnose sturgeon, snuffbox, ebonyshell, yellow sandshell, creek heelsplitter, washboard, threehorn wartyback, sheepnose, fawnsfoot, deertoe

Highland County
Tiger spiketail, bigeye shiner

Brown County
Bigeye shiner, channel darter, river darter, purple wartyback, butterfly, elephantear, ebonyshell, yellow sandshell, washboard, threehorn wartyback, sheepnose, Ohio pigtoe, monkeyface, wartyback, salamander mussel, fawnsfoot, deertoe, rayed bean, little spectaclecase

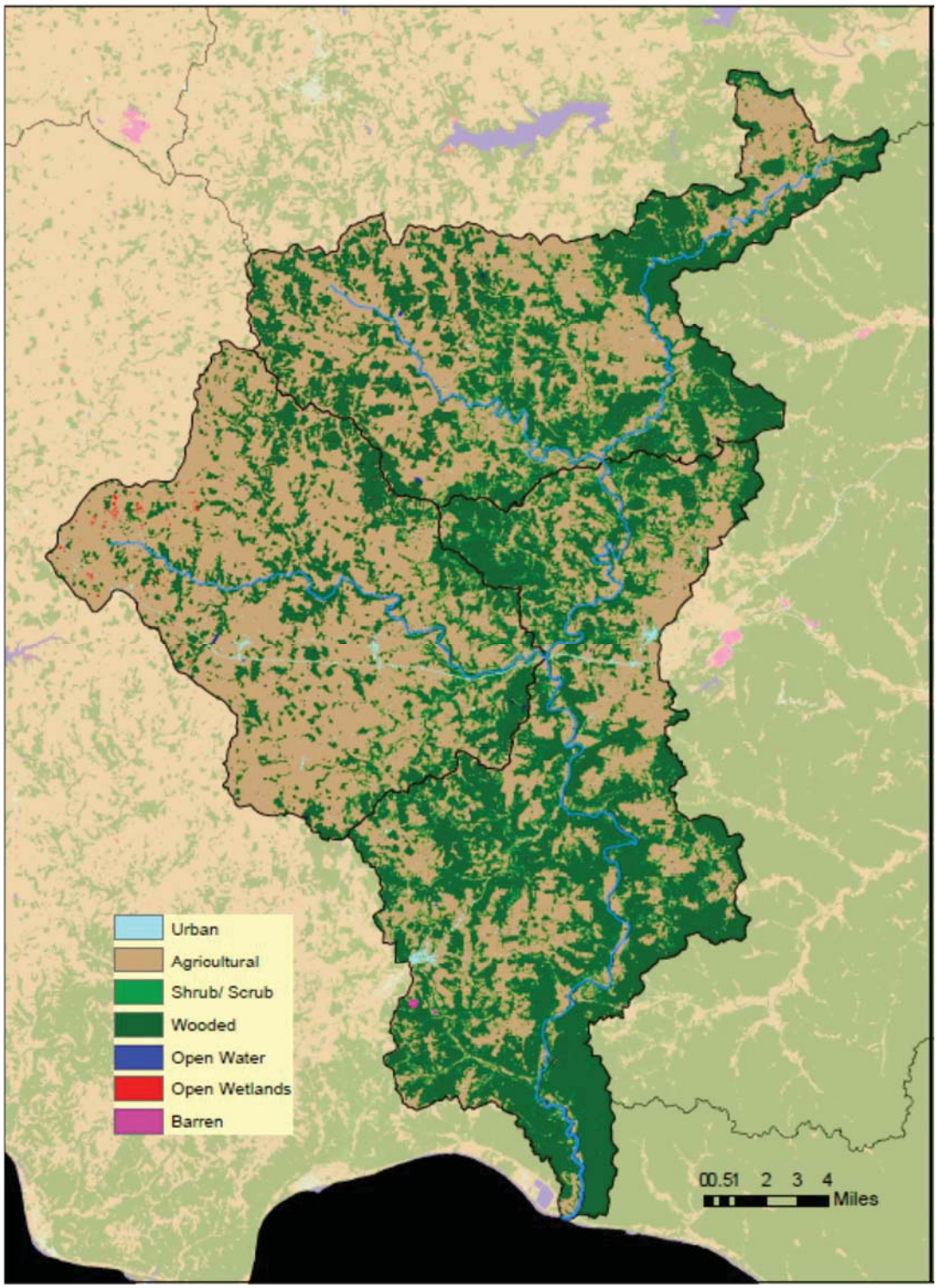


Figure 35. Ohio Brush Creek Conservation Opportunity Watershed – Land Cover.

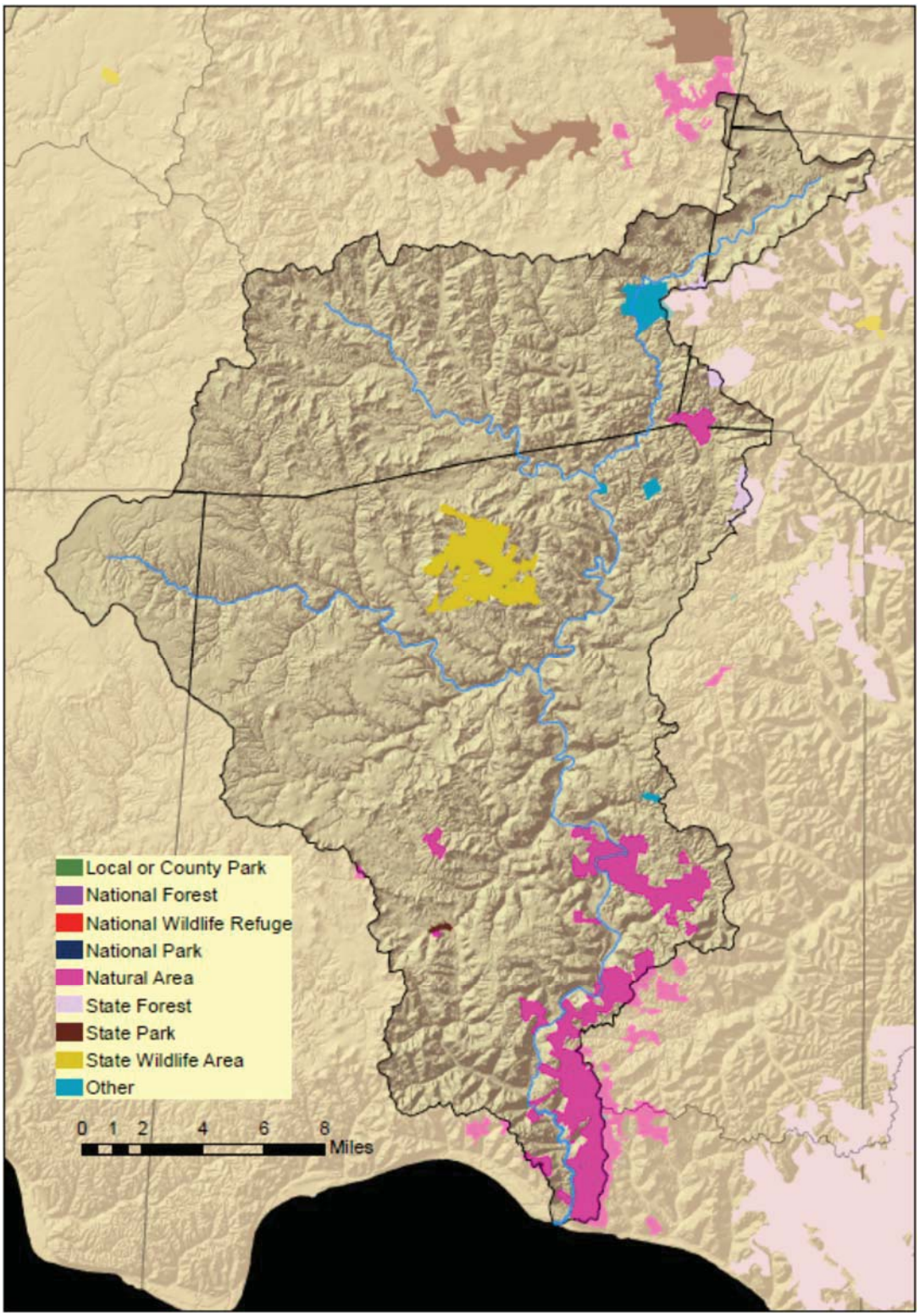


Figure 36. Ohio Brush Creek Conservation Opportunity Watershed – Protected Lands.

6.15.4.4 Scioto River CO Watershed (consists of HUC 05060001, HUC 05060002, and HUC 05060003)

The Scioto River drains 6,510 square miles and has the third largest drainage basin in the state. It is about 240 miles in length. The topography of the basin is extremely varied, from flat swamplands near the source to the rugged terrain of the unglaciated plateau near the mouth.

Physiography

Three physiographic sections are represented in the basin. About 65 percent of the area is in the Till Plains Section of the Central Lowlands Province. This northern part of the basin varies from an almost level plain to gently rolling terrain with thick glacial drift mantling the bedrock and filling the preglacial valleys. The streams flow in wide valleys, and a part of the area is swampy. The eastern margin of the basin from Chillicothe north is in the Glaciated Allegheny Plateaus Section of the Appalachian Plateaus Province. Here the topography is more rolling, with rounded hills and with valleys filled with glacial deposits. The southern and southeastern quarter of the basin is in the unglaciated Allegheny Plateaus Section with steep slopes and rugged topography.

The profile of the river is peculiar because of glaciation. The upper reaches are swampy and flat. From Marion County to Columbus the gradient is steeper, averaging 4 feet fall per mile, and the river is confined in a narrow gorge. South of Columbus the river flows in a wide preglacial or interglacial valley, and the gradient averages 1.7 feet per mile. The valley width in this lower section is about 1.5 miles.

Geology

The rock strata underlying the Scioto Basin ranges in age from Silurian to Pennsylvanian. East of an approximate north-south line through Columbus, the bedrock is predominantly dense, impervious shale. West of this line the rocks are dolomite and limestone that contain relatively large quantities of ground water in solution channels and joint systems. South of the Pickaway-Ross County line the dominant rock types become interbedded Mississippian and Pennsylvanian shales, siltstones, and sandstones.

Despite the fact that the underlying rocks store appreciable quantities of ground water in most of the basin, the effect of the bedrock character on streamflow is relatively unimportant. The glacial drift, particularly the melt-water deposits such as outwash, valley train, kame, and esker sands and gravels, store huge quantities of water and markedly affect low-water streamflow. The greatest influences occur where a present day stream flows in a preglacial valley over deep sand and gravel. Some of the till plain drift is relatively impermeable, and in these areas there is little sustained flow in streams.

Soils

Soils of glacial origin cover most of this area. The principal soils are those of the Miamian and Blount catenas in the glacial limestone area, and the Bennington catena of soils in the glacial sandstone and shale area. Generally, the till soils are moderately slow to slowly permeable; however, some moderately permeable soils occur. Terrace and alluvial soils are generally more permeable. The predominant soils are the Eldean and Genesee. There are some muck soils in the basin. South of the glacial boundary the soils are residual. The dominant soils include the Shelocta, Brownsville, and Latham soil series. Alluvial and terrace soils in this area include some well-drained permeable soils, but generally, permeability of the soils in the basin is moderate to slow.

Water Development

The City of Columbus has two water supply reservoirs on the Scioto River, Griggs Reservoir built in 1905 and O'Shaughnesy Reservoir built in 1925. Hoover Reservoir on Big Walnut Creek was added to the municipal supply system in 1954.

The Corps of Engineers completed construction of Delaware Reservoir on the Olentangy River near Delaware in 1951, Deer Creek Reservoir on Deer Creek in 1968, Paint Creek Reservoir on Paint Creek in 1971, and Alum Creek Reservoir on Alum Creek in 1973.

Flow Characteristics

There are wide differences in streamflow characteristics in adjacent areas, or even within the same subbasin. For example, Big Walnut Creek has about four times the sustained flow, in cubic feet per second per square mile, at the downstream station as compared with the upstream station. This is caused apparently by the presence of thick and permeable glacial deposits in the lower reach of the stream, the upper station being in an area of predominantly shallow till overlying dense shale. Alum Creek at Columbus is similarly affected by the heavy overburden of glacial drift east and northeast of Columbus. Another anomaly is the sustained flow of Rocky Fork, that is much greater that of adjacent areas of equal size. A major portion of this flow is derived from its tributary, Clear Creek, which has its headwater in the Cuba Moraine, and flows on glacial outwash material throughout most of its course.

Generally, the streams in the northern part of the Scioto River Basin above Columbus have lower sustained flows than those in the southern part. There is a remarkable consistency in the sustained flows at stations in the upper half of the basin. The bedrock in the above areas contributes a negligible amount of ground water to streamflow, and the overburden of glacial drift consists mainly of impervious till.

The Scioto River above Prospect is an ice-front stream in origin and derives its low flow from morainal masses both to the north and south. Rock exposures are few in this area. The channel is in glacial drift throughout practically its entire course and the morainal hills rise from 50 to 100 feet above the valley floor. Although the sustained flow above Prospect is not great, it clearly shows the effect of the relatively permeable morainal hills in contrast with flow of streams in strictly till areas.

Darby Creek and Deer Creek drain areas that have very similar surface features. Both streams flow through areas in which the glacial drift is relatively thick but variable in its physical characteristics. Deer Creek is influenced somewhat by the moraine south and west of Marysville.

The dry-weather flow index of Paint Creek at Bourneville prior to completion of Paint Creek Reservoir was three times that at Greenfield and remains about the same. Above Greenfield the stream drains an area of thin till that yields little ground water to sustain streamflow. Ground-water discharge from the buried valley deposits that underlie the floodplain of Paint Creek in the area between Bainbridge and Bourneville and contributions made by Rocky Fork apparently account for the higher dry-weather flow at Bourneville.

At first glance, the low-flow index for Rocky Fork at Barretts Mills appears abnormally high. As mentioned above, the high sustained flow is attributable to storage in the glacial deposits, particularly on Clear Creek, but it appears probable that storage in the cavernous limestone and dolomite may be a contributing factor. Also, the average annual precipitation in Highland and Clinton counties is greater than any other place in the state.

The low-flow index of Salt Creek at Londonderry is slightly greater than that of Little Salt Creek at Richmond. A considerable volume of permeable outwash material may be present along Salt Creek in the vicinity of Laurelville and south of the Pine Cottage col where a drainage reversal occurred during glacial times. Little Salt Creek drains an area underlain by lower Pennsylvanian strata that as a whole are quite impermeable. Mine drainage may contribute somewhat to the flow.

In the Scioto River Basin there are areas of both relatively high and relatively low dryweather flow indices. On the average, the indices are lower than those of other large tributaries to the Ohio River, but higher than those of most Lake Erie tributaries. The median-flow indices and the high-flow indices are below the average for the state. The Scioto River is not as much of a flood-producing stream as some others, although large floods have occurred at intervals.

State Listed Species by County with Records of Occurrence from the Scioto River Watershed (from the Ohio Natural Heritage Database)

The following species are dependent upon aquatic habitats to complete their life cycle – this dependence may be for all or a portion of their life:

Pickaway County
Plains clubtail, eastern sand darter, lake chubsucker, spotted darter, Tippecanoe darter, goldeye, northern brook lamprey, blue catfish, shortnose gar, river redhorse, northern madtom, Scioto madtom, paddlefish, elktoe, purple wartyback, elephantear, northern riffleshell, snuffbox, longsolid, wavyrayed lampmussel, pocketbook, black sandshell, washboard, threehorn wartyback, clubshell, Ohio pigtoe, round pigtoe, kidneyshell, rabbitsfoot, salamander mussel, fawnsfoot, deertoe, rayed bean

Fairfield County
Tiger spiketail, blue corporal, eastern sand darter, popeye shiner, northern brook lamprey, creek heelsplitter, clubshell, round pigtoe, kidneyshell, rabbitsfoot

Madison County
Riffle snaketail, least darter, Tippecanoe darter, river redhorse, elktoe, purple wartyback, elephantear, northern riffleshell, snuffbox, wavyrayed lampmussel, creek heelsplitter, clubshell, round pigtoe, kidneyshell, rabbitsfoot, rayed bean

Franklin County
Four-toed salamander, spotted darter, Tippecanoe darter, goldeye, northern brook lamprey, shortnose gar, river redhorse, paddlefish, elktoe, purple wartyback, elephantear, northern riffleshell, snuffbox, wavyrayed lampmussel, pocketbook, black sandshell, washboard, threehorn wartyback, clubshell, round pigtoe, kidneyshell, rabbitsfoot, salamander mussel, fawnsfoot, deertoe, pondhorn, rayed bean

Licking County
Spotted turtle, eastern hellbender, four-toed salamander, tiger spiketail, green-faced clubtail, eastern sand darter, lake chubsucker, longsolid, sheepnose, pondhorn

Champaign County
Spotted turtle, Kirtland's snake, seepage dancer, elfin skimmer, *Litobrancha recurvata* (mayfly), *Radotanypus florens* (midge), lake chubsucker, least darter, tonguetied minnow, clubshell, rayed bean

Union County
River redhorse, purple wartyback, snuffbox, wavyrayed lampmussel, creek heelsplitter, clubshell, round pigtoe, kidneyshell, rabbitsfoot, rayed bean

Delaware County
Marsh bluet, elktoe, purple wartyback, snuffbox, wavyrayed lampmussel, clubshell, kidneyshell, rabbitsfoot, salamander mussel, pondhorn, rayed bean

Logan County
Spotted turtle, eastern hellbender, swamp metalmark, lake chubsucker, Iowa darter, tonguetied minnow, elktoe, purple wartyback, wavyrayed lampmussel, creek heelsplitter, kidneyshell, rayed bean

Hardin County
Four-toed salamander, least darter, creek heelsplitter, pondhorn, rayed bean

Marion County
Snuffbox, wavyrayed lampmussel, Ohio pigtoe, round pigtoe, pondhorn, rayed bean

Crawford County
Pondhorn

Morrow County
Snuffbox, creek heelsplitter, rayed bean

Scioto County
Eastern hellbender, four-toed salamander, blue corporal, eastern sand darter, blue sucker, muskellunge, goldeye, shortnose gar, river redhorse, popeye shiner, bigeye shiner, mountain madtom, northern madtom, channel darter, river darter, purple wartyback, butterfly, elephantear, snuffbox, ebonyshell, pocketbook, yellow sandshell, black sandshell, washboard, threehorn wartyback, sheepnose, Ohio pigtoe, monkeyface, wartyback, salamander mussel, fawnsfoot, deertoe, rayed bean, little spectaclecase

Adams County
Green salamander, cave salamander, four-toed salamander, tiger spiketail, green-faced clubtail, Uhler's sundragon, blue corporal, goldeye, river redhorse, channel darter, river darter, paddlefish, purple wartyback, yellow sandshell, black sandshell, washboard, threehorn wartyback, clubshell, rabbitsfoot, wartyback, salamander mussel, fawnsfoot, deertoe

Pike County
Seepage dancer, plains clubtail, yellow-sided skimmer, blue sucker, goldeye, shortnose gar, river redhorse, bigeye shiner, paddlefish, shovelnose sturgeon, snuffbox, ebonyshell, yellow sandshell, creek heelsplitter, washboard, threehorn wartyback, sheepnose, fawnsfoot, deertoe

Jackson County
Kirtland's snake, four-toed salamander, lake chubsucker, pondhorn, little spectaclecase

Vinton County
Eastern hellbender, four-toed salamander, Uhler's sundragon, blue corporal, eastern sand darter, Ohio lamprey, northern brook lamprey, pocketbook, little spectaclecase

Hocking County
Kirtland's snake, four-toed salamander, tiger spiketail, Uhler's sundragon, blue corporal, eastern sand darter, tonguetied minnow, northern brook lamprey, pocketbook, clubshell

Ross County
Spotted turtle, eastern hellbender, tiger spiketail, plains clubtail, cobblestone tiger beetle, eastern sand darter, blue sucker, spotted darter, tippecanoe darter, goldeye, shortnose gar, river redhorse, northern madtom, elephantear, snuffbox, yellow sandshell, washboard, threehorn wartyback, clubshell, winged mapleleaf, salamander mussel, fawnsfoot, rayed bean, little spectaclecase

Highland County
Tiger spiketail, bigeye shiner

Fayette County
Least darter, river redhorse, clubshell

Clinton County
Cobblestone tiger beetle

Greene County
Spotted turtle, Kirtland's snake, seepage dancer, tonguetied minnow, snuffbox, wavyrayed lampmussel, creek heelsplitter, clubshell, fawnsfoot

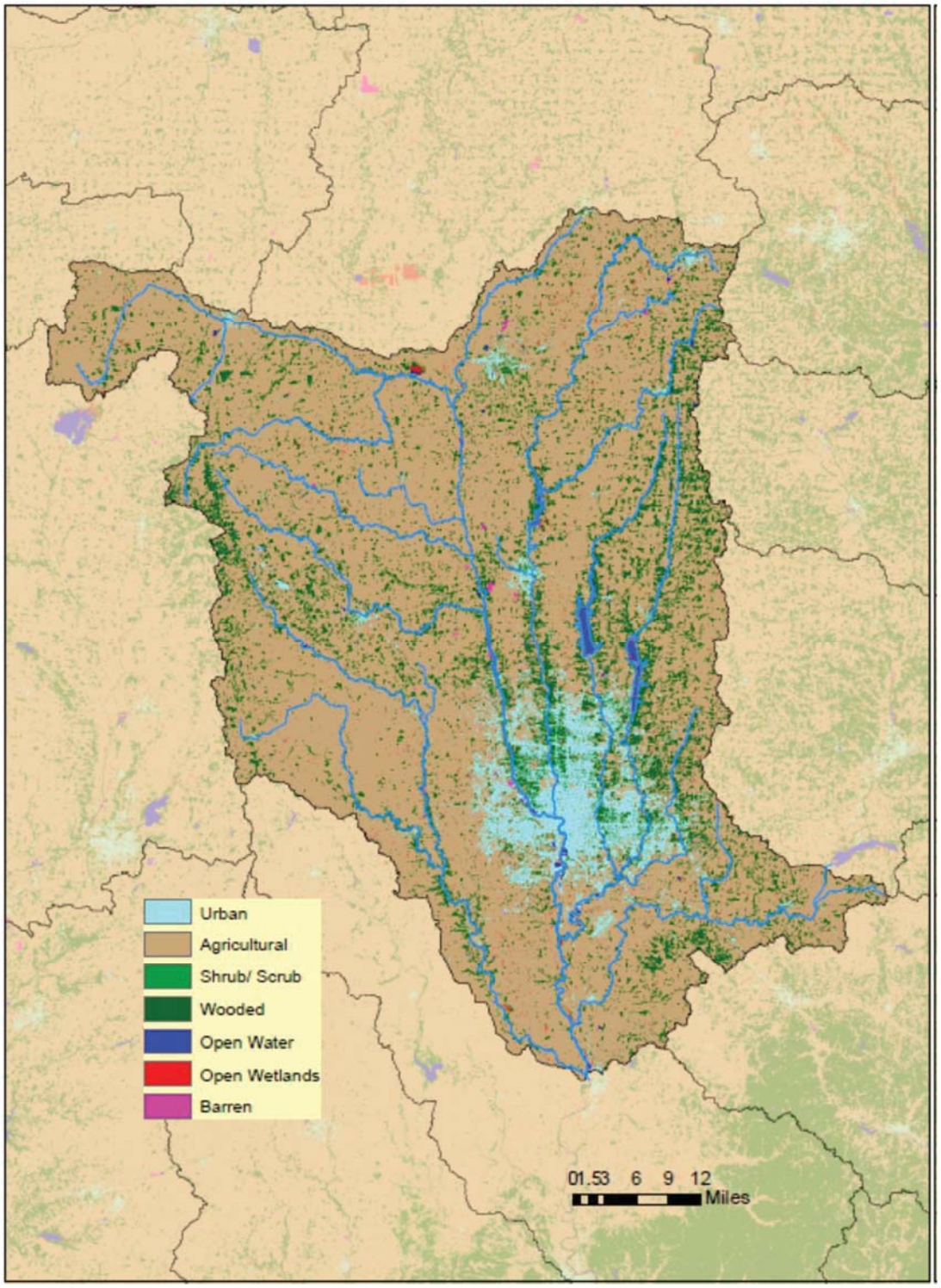


Figure 37. Upper Scioto River Conservation Opportunity Watershed – Land Cover.

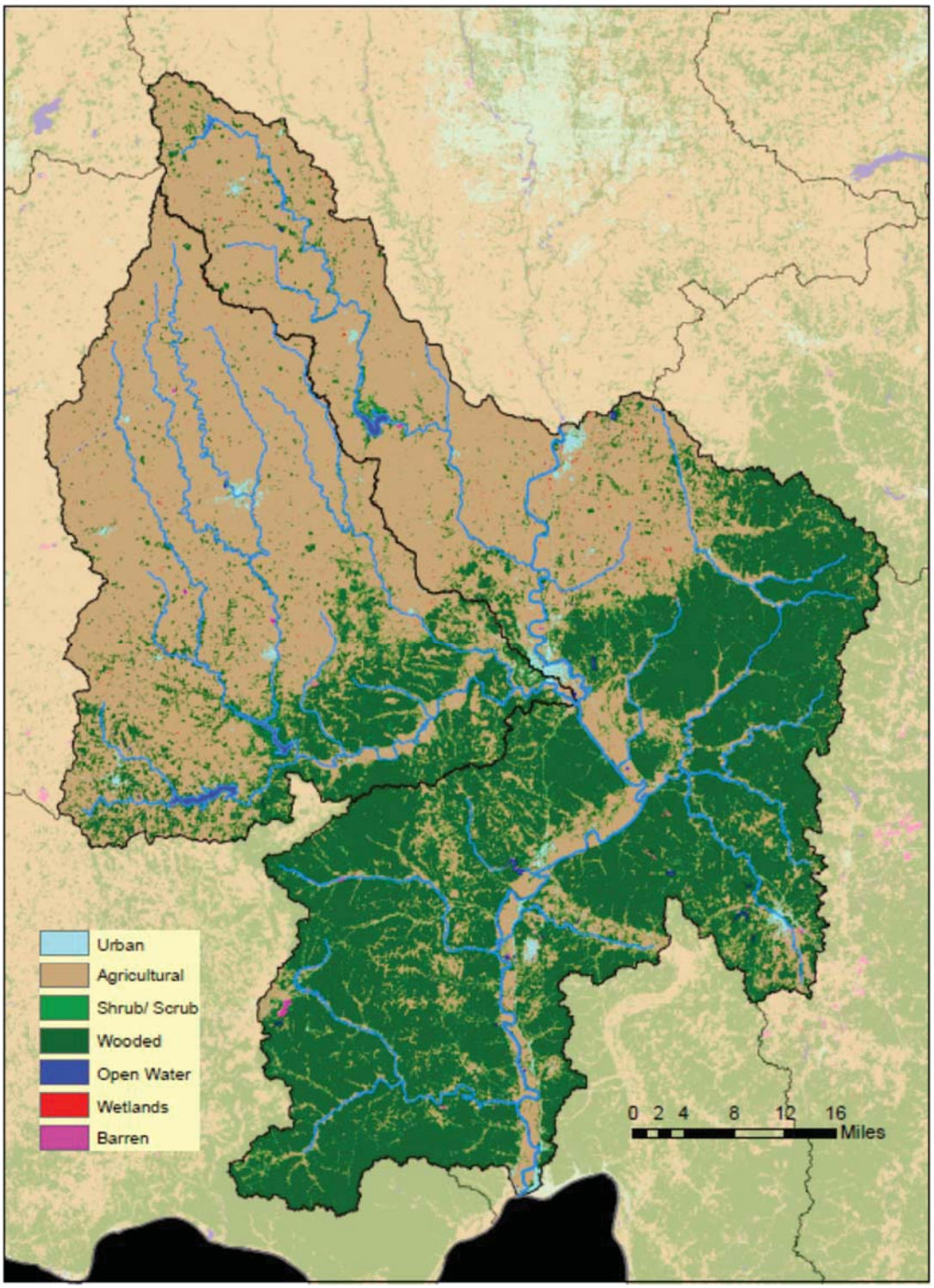


Figure 38. Lower Scioto River Conservation Opportunity Watershed – Land Cover.

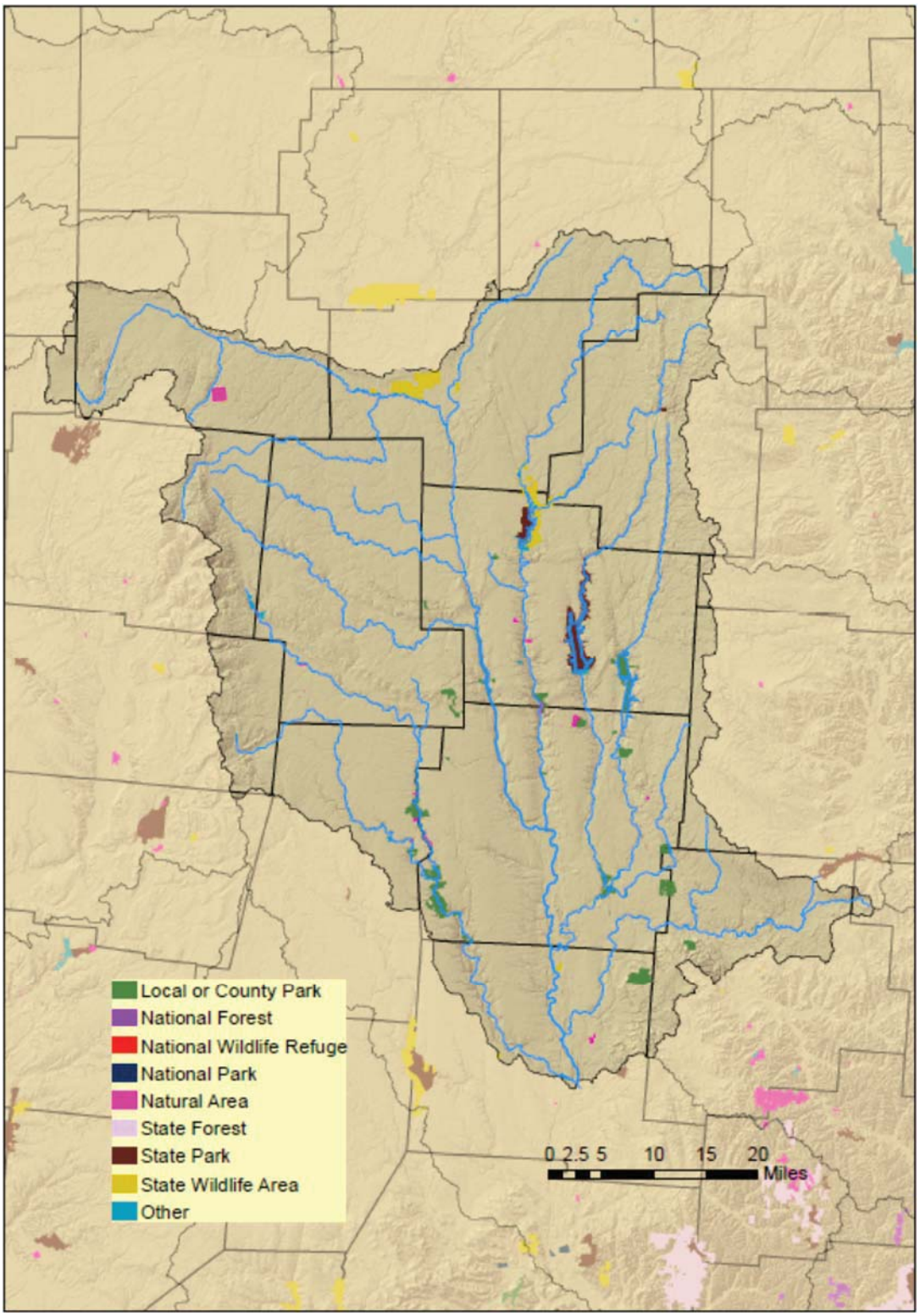


Figure 39. Upper Scioto River Conservation Opportunity Watershed – Protected Lands.

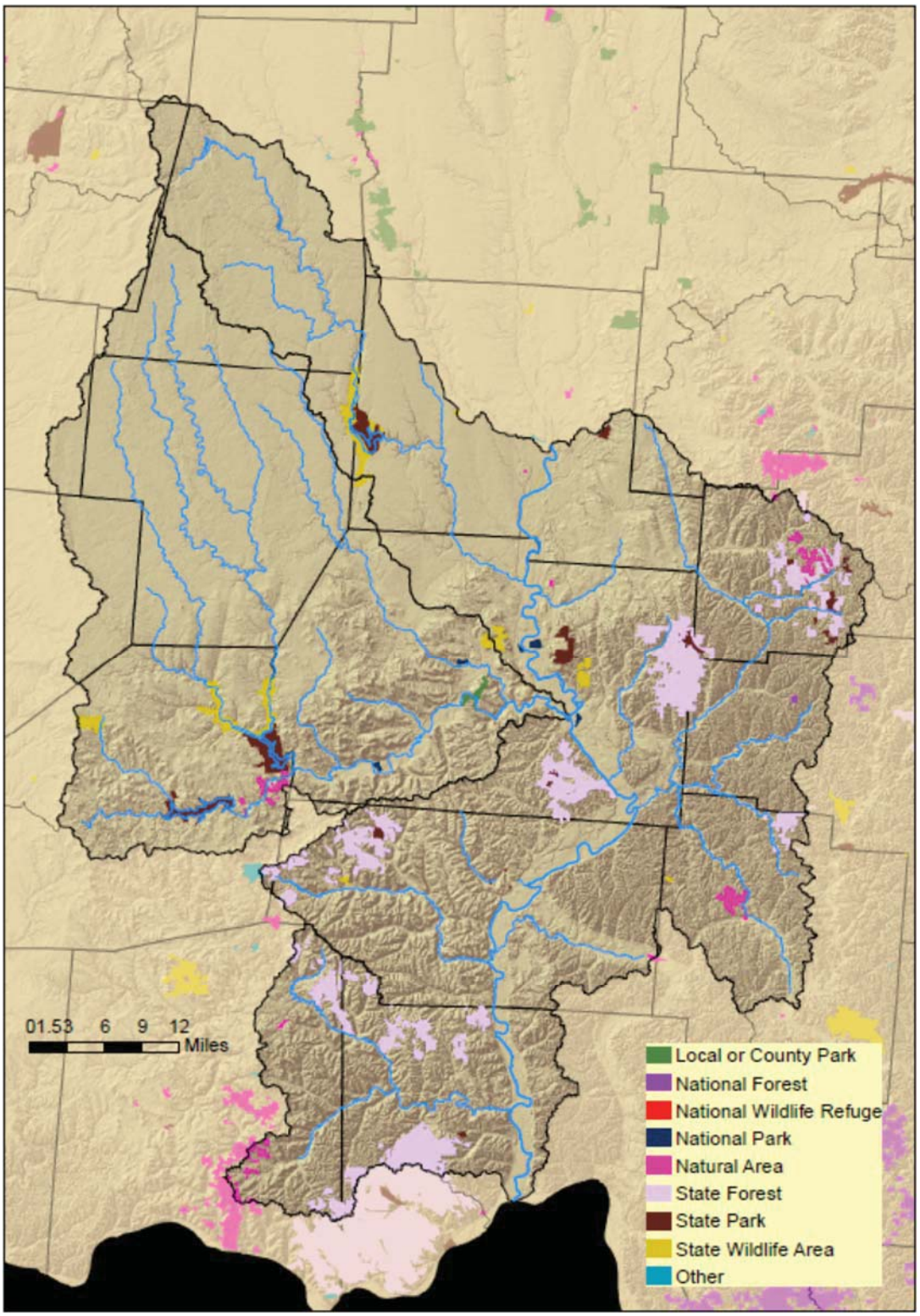


Figure 40. Lower Scioto River Conservation Opportunity Watershed – Protected Lands.

6.15.4.5 Muskingum River CO Watershed (consists of HUC 05040001, HUC 05040002, HUC 05040003, HUC 05040004, HUC 05040005, and HUC 05040006)

The Muskingum River is the largest stream in the state and drains 8,038 square miles, or about one-fifth of Ohio. Within the basin, the physiographic, geologic, and soil conditions vary greatly. The Muskingum River forms at the junction of the Walhonding and Tuscarawas rivers near Coshocton, and flows 109 miles to the south and east to enter the Ohio River at Marietta. The northern and western edges of the basin are glaciated.

Physiography

The basin is entirely within the Allegheny Plateaus province. The line of glaciation marking the farthest southward advance of the ice sheets extends west from northern Tuscarawas County to the vicinity of Loudonville, thence almost directly south, leaving the basin in Perry County. The glaciated area is generally gently rolling with some flat topography, and the unglaciated plateau is generally rough and well dissected.

Geology

The bedrock formations dip generally to the southeast about 20 to 40 feet to the mile. The rocks are of Mississippian, Pennsylvanian, and Permian ages, and consist of interbedded sandstones and shales, with some coal and clay beds and occasional thin limestone formations. Several of the sandstone beds are important sources of ground water, but generally the rocks have little direct influence upon streamflow. The productive sandstones are at depth below stream drainage.

The glacial deposits vary from thin and relatively impermeable till to thick sand and gravel beds. The melt water deposits, such as valley train deposits, kames and kame terraces are generally well sorted and permeable. Such beds, where extensive, have a profound influence on streamflow particularly in buried valleys filled with permeable material with a present-day stream flowing over the top of the ancient valley. The valleys of Sandy Creek and Nimishillen Creek in the vicinity of Canton, for example, have enormous ground-water storage in the thick permeable gravels and are one of the best areas in the state from this standpoint. In nearby areas the till is thin and impervious, and there is little natural storage in the ground. Every county that is in the glaciated part of the Muskingum River Basin has some thick valley deposits, but detailed surveys are required to determine the extent of such fills.

Soils

The soils in the glaciated area of this basin are generally developed from late Wisconsin drift. Over large areas of the upland in the north the soils are predominantly the well drained and moderately permeable Wooster and the moderately well drained, slowly permeable Canfield. Moderately large areas of slowly permeable Rittman and Wadsworth silt loams occur in the northern part of the glaciated area. Amanda and Alexandria silt loams and associated soils are prevalent along the western part of the glaciated area. The permeability of these soils varies from moderate to slow. More permeable soils are found in the valleys. Chili, Chagrin, and Tioga loams and silt loams are the more important soils there. Below the glacial boundary, the principal upland soils are the Gilpin, Brownsville, Berks, Westmoreland, Coshocton, Keene, and Wellston loams and silt loams, with Upshur in some areas of reddish clay shale in the southern part of the basin. These are moderately deep or deep residual soils developed on a variety of contrasting bedrock. Their profile characteristics depend almost entirely on the kind of parent rock on which the soils developed. Generally these soils are moderately to slowly permeable. In the broader valleys, there are areas of alluvial and terrace soils which are well drained and permeable.

Water Development

In 1938, the Corps of Engineers completed 14 flood control reservoirs in the Muskingum River Basin for the Muskingum Conservancy District. This system of reservoirs is the most important water development in the basin. In 1960, the Corps of Engineers completed Dillon Reservoir on the Licking River for flood protection at Zanesville. Canal Era locks and dams on the Muskingum River facilitated commercial navigation as far as Dresden, 91 miles above the mouth, but now serve recreational watercraft needs. Some flow from the upper reaches of the Tuscarawas River (Portage Lakes) is diverted into the Cuyahoga River by a feeder canal. Buckeye Lake, in Licking River drainage, was formed to provide water for the summit level of the old Ohio Canal, but it is now used for recreational purposes only.

Flow Characteristics

The gaging stations on the Tuscarawas River at Clinton and Massillon have high indices of dry-weather flow. The effect of the Portage Lakes during the low-flow period is probably small. The effect of the Barberton Reservoir on Wolf Creek is negligible on the overall flow of Tuscarawas River above Massillon. It is believed that the high sustained flow in this part of the basin is derived from the kame moraine area east of the Portage Lakes. The morainal material is highly permeable and absorbs large quantities of rainfall. Associated with the morainal material are buried valley deposits and high-level outwash material. Discharge of ground water in this area supports the dry-weather flow in the Tuscarawas River. As a whole the Tuscarawas River flows over relatively thick glacial deposits. A buried valley that contains about 200 feet of fill underlies the flood plain between Clinton and Massillon. This valley extends to the northwest under Chippewa Creek. Although Chippewa Creek may contribute some flow to the sustained flow of the Tuscarawas, it is quite likely that the high index of flow of the Tuscarawas is the result of ground-water contribution from glacial deposits associated with the Tuscarawas valley in Summit and Stark counties.

Analysis of flow in Sandy Creek reveals the effect of the sands and gravels on dryweather flow. For the most part the Sandy Creek basin lies below the glacial boundary; only the extreme upper part drains the terminal moraine area. However, the floodplain of Sandy Creek and several of its tributaries such as Little Sandy Creek, Hugle Run, and Middle Branch are underlain by sand and gravel deposits of outwash origin. The gaging stations at Waynesburg and Sandyville show indices of dry-weather flow well above average.

There is a wide difference in the indices of flow between Middle Branch of Nimishillen Creek at Canton and Nimishillen Creek at North Industry. The entire area is glaciated, the drift consisting of end moraine that varies from tight till to gravel, ground moraine of varying character, kames and kame terraces and outwash and valley train gravel. With such surface features, high sustained flows should be expected. The discrepancy between the two stations is the result of ground-water pumpage at the Canton northeast well field where up to 11 million gallons per day has been pumped from the gravel formation underlying the flood plain of Middle Branch. Field studies have shown that recharge to the well field is derived from river infiltration.

Below Massillon, the gaging stations on the Tuscarawas River are affected by regulation of the Muskingum Watershed Conservancy District reservoirs. Prior to the regulation, however, records indicate a high sustained flow. Throughout most of its course, the Tuscarawas River flows on extensive valley train gravels.

The record on Home Creek near New Philadelphia is significant in that it shows the small influence of ground-water storage in bedrock on streamflow in the basin. Home Creek is in the unglaciated area and flows on bedrock of Pennsylvanian age.

Stillwater Creek at Uhrichsville, although regulated at present, has a low index of dryweather flow as determined by the record from 1923 to 1936, prior to regulation. Ground-water contribution from the rock strata is almost negligible in this basin. Underlying the floodplain of Stillwater Creek is 100 feet or more of valley fill. This material is largely silt, clay, or fine sand and thus adds little to streamflow. Similar conditions prevail in Wills Creek.

The Walhonding River and all of its major tributaries have high indices of dry-weather flow. The tributary system in this basin follows essentially the Deep Stage drainage system, which was inaugurated in interglacial times. Thus, the Walhonding and its principal tributaries flow through valleys that are underlain by deep valley fill. Headwaters of the Kokosing River, Mohican River, and Killbuck Creek extend well into the glaciated area where a variety of surface conditions prevail. End moraines of Wisconsin and Illinoian glacial stages are present and the material ranges from tight till to porous gravel. The ground moraine is chiefly till although locally it may be sandy or gravelly. High-level outwash gravels are present locally and some areas have extensive kame and kame terrace deposits. As a whole the Walhonding Basin has a high percent of permeable glacial deposits capable of absorbing and releasing large quantities of water. Furthermore, the extensive sandstone of the Blackhand formation of Mississippian age lays at or near the

surface in places in Knox and Richland counties and undoubtedly contributes ground water to the flow of the Kokosing and Mohican tributaries.

Of the records available in the Walhonding Basin, two streams, Mill Creek near Coshocton and Jerome Fork at Jeromesville, show relatively low indices compared with other streams in the basin. Mill Creek is cut into impermeable Pennsylvanian strata except in the lower three miles of its course where it flows on unconsolidated valley fill. Above Jeromesville, Jerome Fork drains an area in which the surface materials are chiefly dense ground moraine.

The moderately sustained flow of Wakatomika Creek near Frazeysburg is influenced by conditions in both glacial deposits and bedrock. Wakatomika Creek had its inception during Illinoian glaciation and it has not changed greatly since that time. The stream in places flows over deep valley fill and over bedrock in other portions of its course. It drains an area partly occupied by the terminal moraine of Illinoian age. The morainal material varies from dense till to loose porous gravel. Additional sand and gravel deposits are present in the form of valley train and high-level outwash. Underlying the drift cover in the headwater area is the sandstone of the Blackhand formation that has a large ground-water storage capacity and undoubtedly contributes somewhat to the flow of Wakatomika Creek.

The Licking River is formed by the confluence of North Fork, Raccoon Creek, and South Fork at Newark. The flows equaled or exceeded 90 percent of the time in North Fork at Utica and Raccoon Creek at Granville are both about 0.05 cubic feet per second per square mile. Flow equaled or exceeded 90 percent of the time in South Fork near Millersport is about 0.06 cubic feet per second per square mile. Flow equaled or exceeded 90 percent of the time in the Licking River at Newark, however, is about 0.13 cubic feet per second per square mile. Miscellaneous measurements at low water indicate varying rates of increase in flow below the North Fork gage at Utica, and the 90 percent of the time flow in North Fork near Newark is about 0.12 cubic feet per second per square mile.

Study of glacial geology in the Newark area, aided by soil maps, provides an explanation for the streamflow characteristics. The tributaries forming the Licking River flow through areas of ground moraine and end moraine largely composed of till. The lower part of North Fork and the main stem of the Licking River at Newark flow through an area of kame terraces, valley train, and outwash plains. A marked increase in flow at Vanatta north of Newark is explained by the presence of a low outwash fan upon the main valley train.

On average, the dry-weather flow of streams in the Muskingum River Basin is higher than that of any other large area in the state, equaling the Miami River average. Median flow indices are also relatively high. High-flow indices are correspondingly low, on average, but large floods have occurred at intervals in the basin. The reservoir system significantly attenuates floods on the major streams, but tends to increase the 10-percent duration flow indices, by increasing the duration of medium high flows.

State Listed Species by County with Records of Occurrence from the Muskingum River Watershed (from the Ohio Natural Heritage Database)
The following species are dependent upon aquatic habitats to complete their life cycle – this dependence may be for all or a portion of their life:

Washington County
Eastern hellbender, eastern spadefoot, green-faced clubtail, Uhler's sundragon, blue corporal, eastern sand darter, Tippecanoe darter, goldeye, Ohio lamprey, river redhorse, mountain madtom, northern madtom, pugnose minnow, channel darter, river darter, paddlefish, purple wartyback, fanshell, butterfly, elephantear, snuffbox, longsolid, pink mucket, pocketbook, black sandshell, washboard, threehorn wartyback, sheepnose, Ohio pigtoe, rough pigtoe, pyramid pigtoe, round pigtoe, monkeyface, salamander mussel, fawnsfoot, deertoe

Noble County
Creek heelsplitter

Morgan County
Eastern spadefoot, eastern sand darter, goldeye, river redhorse, mountain madtom, northern madtom, pugnose minnow, purple wartyback, fanshell, butterfly, elephantear, snuffbox, longsolid, black sandshell, threehorn wartyback, sheepnose, Ohio pigtoe, pyramid pigtoe, round pigtoe, salamander mussel, fawnsfoot

Monroe County
Green-faced clubtail, blue corporal, eastern sand darter, Ohio lamprey, channel darter

Perry County
None reported

Muskingum County
Eastern hellbender, eastern spadefoot, tiger spiketail, plains clubtail, eastern sand darter, river redhorse, mountain madtom, northern madtom, purple wartyback, snuffbox, longsolid, pocketbook, creek heelsplitter, black sandshell, threehorn wartyback, pyramid pigtoe, rabbitsfoot, fawnsfoot, rayed bean

Guernsey County
None reported

Licking County
Spotted turtle, eastern hellbender, four-toed salamander, tiger spiketail, green-faced clubtail, eastern sand darter, lake chubsucker, longsolid, sheepnose, pondhorn

Coshocton County
Eastern hellbender, eastern spadefoot, plains clubtail, eastern sand darter, spotted darter, Tippecanoe darter, river redhorse, mountain madtom, elktoe, purple wartyback, fanshell, purple catspaw, snuffbox, longsolid, wavyrayed lampmussel, pocketbook, creek heelsplitter, black sandshell, sheepnose, clubshell, Ohio pigtoe, round pigtoe, kidneyshell, rabbitsfoot, salamander mussel, rayed bean

Tuscarawas County
Eastern hellbender, eastern spadefoot, plains clubtail, eastern sand darter, mountain madtom, northern madtom, clubshell

Belmont County
Eastern hellbender, tiger spiketail, river redhorse, paddlefish, wavyrayed lampmussel

Harrison County
None reported

Carroll County
Four-toed salamander, *Brachycentrus numerosus* (caddisfly), *Psilotreta indecisa* (caddisfly)

Stark County
Spotted turtle, four-toed salamander, brush-tipped emerald, seepage dancer, Iowa darter

Columbiana County
Spotted turtle, eastern hellbender, tiger spiketail, riffle snaketail, *Psilotreta indecisa* (caddisfly), *Stenonema ithaca* (mayfly), channel darter, wavyrayed lampmussel, creek heelsplitter

Summit County
Spotted turtle, four-toed salamander, racket-tailed emerald, boreal bluet, marsh bluet, harlequin darner, chalk-fronted corporal, elfin skimmer, brush-tipped emerald, lake chubsucker, Iowa darter, western banded killifish, pugnose minnow, paddlefish

Medina County
Tiger spiketail, bigmouth shiner

Wayne County
Kirtland's snake, four-toed salamander, riffle snaketail, lake chubsucker, creek heelsplitter

Holmes County
Iowa darter, creek heelsplitter, kidneyshell

Knox County
Eastern hellbender, eastern sand darter, spotted darter, mountain brook lamprey, speckled chub, purple wartyback, northern riffleshell, longsolid, black sandshell, clubshell, round pigtoe, kidneyshell, rabbitsfoot

Ashland County
Least darter, greater redhorse, purple wartyback, wavyrayed lampmussel, creek heelsplitter, clubshell, purple lilliput, deertoe

Richland County
Least darter, greater redhorse, pugnose minnow, elktoe, purple wartyback, white catspaw, wavyrayed lampmussel, creek heelsplitter, clubshell, round pigtoe, rabbitsfoot, wartyback, purple lilliput, deertoe, rayed bean

Morrow County
Snuffbox, creek heelsplitter, rayed bean

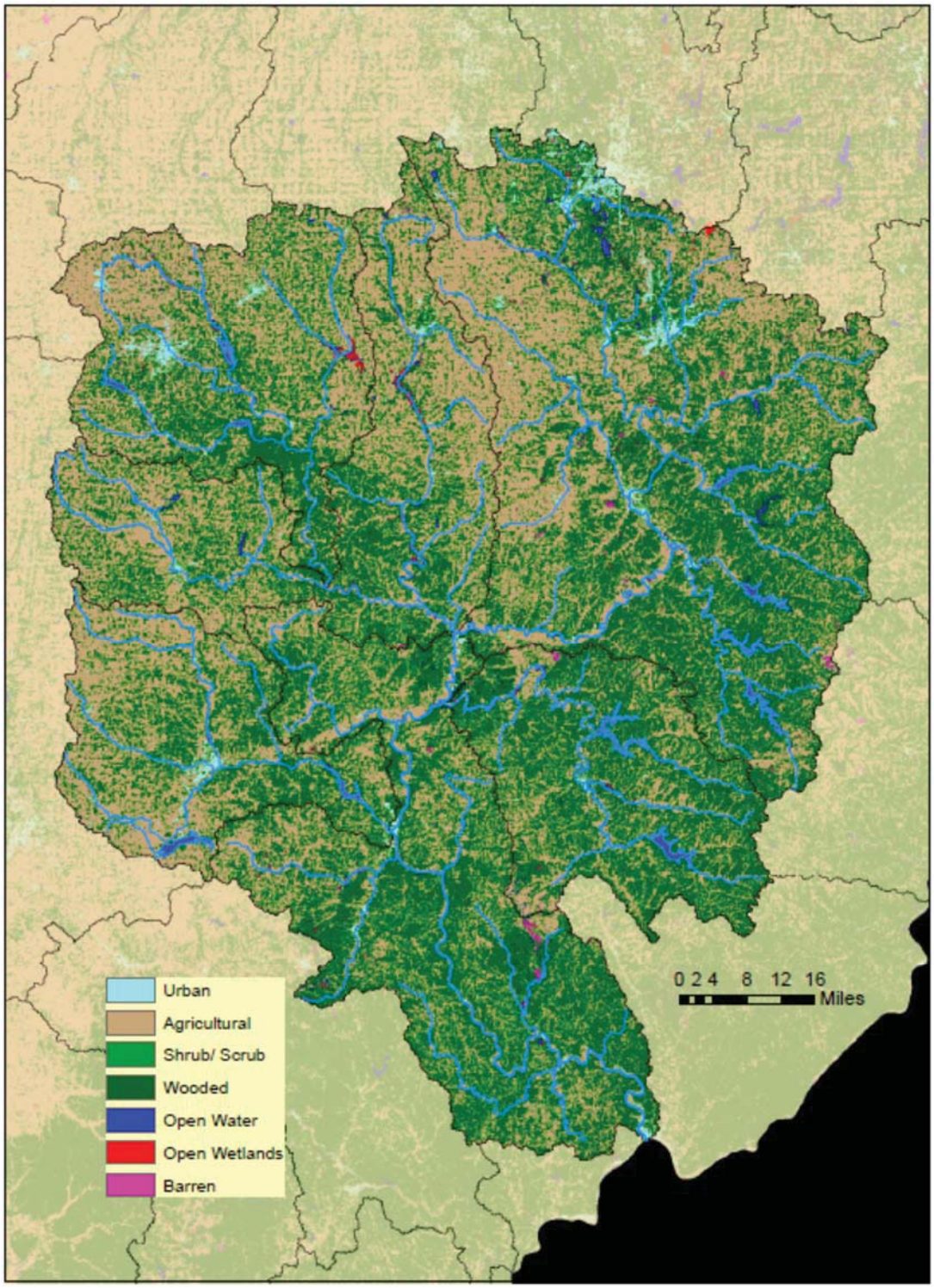


Figure 41. Muskingum River Conservation Opportunity Watershed – Land Cover.

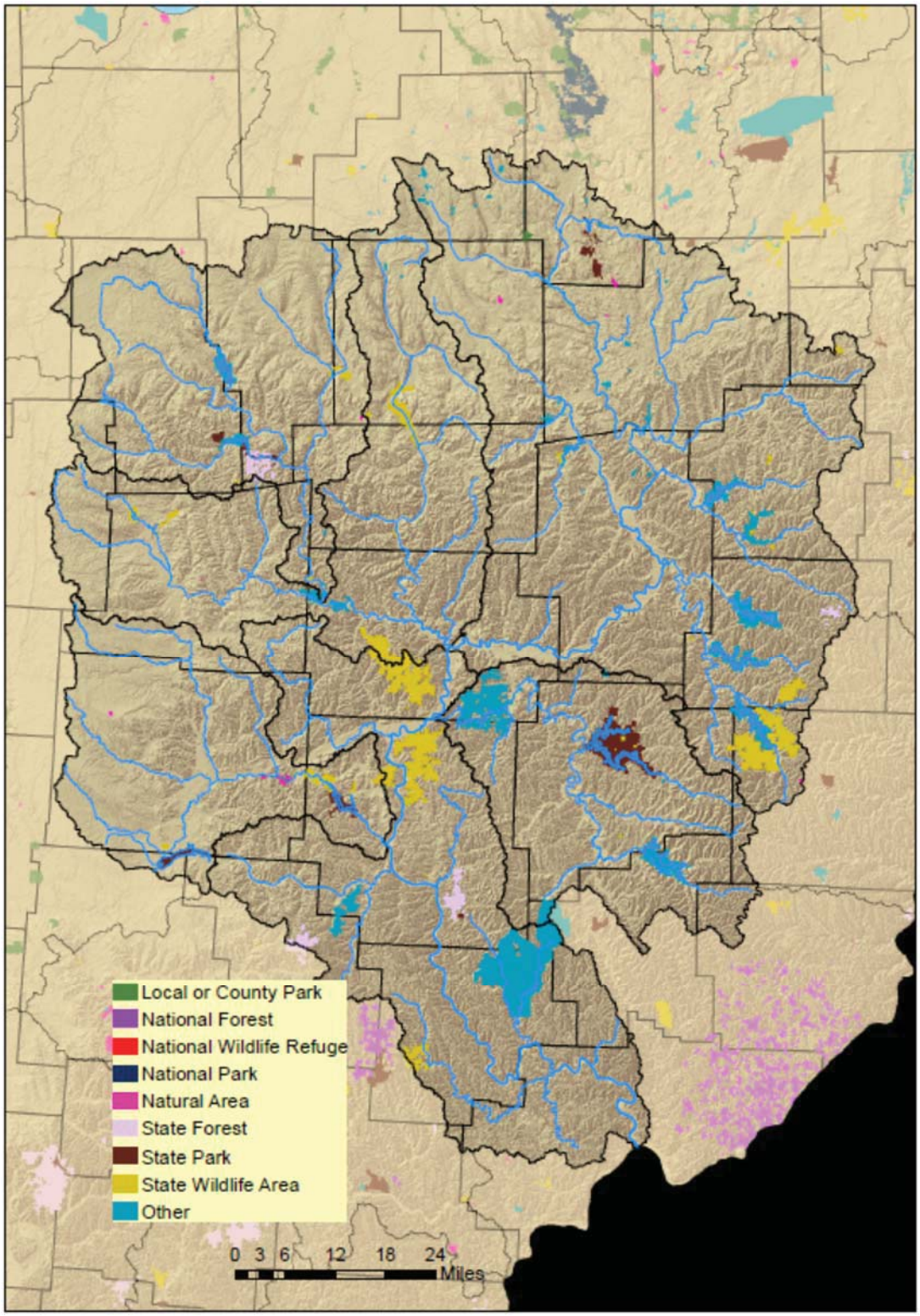


Figure 42. Muskingum River Conservation Opportunity Watershed – Protected Lands.

6.15.4.6 Little Beaver Creek CO Watershed (consists of the northern half of HUC 05030101)
Between the Mahoning River and the Muskingum River in southeastern Ohio is an area of about 2,500 square miles drained by several small tributaries of the Ohio River. The largest stream is Little Beaver Creek, with an area of 510 square miles.

Physiography
Most of the Little Beaver Creek Basin is glaciated but the remainder of the area is part of the unglaciated Allegheny Plateau. The plateau is well dissected and the topography is rough, with the steepest slopes near the Ohio River. The northern part of Columbiana County, in the Little Beaver Creek drainage, is a broken glacial plain. South of this area is a belt of terminal moraines, with generally thin till but with occasional hills and lobes of thick drift.

The unglaciated plateau is decidedly hilly, with deep valleys, and in the lower ends of several streams, narrow gorges. The thick sandstone formations are resistant and form steep cliffs, particularly toward the Ohio River. The lower courses of Short Creek and Yellow Creek, for example, are entrenched, narrow and sinuous. The upland areas are flatter, but rough terrain predominates.

Geology
The rocks exposed in this area dip toward the southeast and consist of sandstones, shales, coal, and clay with occasional thin calcareous formations. The rocks are of Pennsylvanian and Permian age.

The glacial drift and outwash has some appreciable effect on the flow characteristics of Little Beaver Creek. South of the glacial boundary the soils are thin, and there is relatively little natural storage in the bedrock. The sandstones are permeable and contribute toward sustained dry-weather flow of streams, but generally storage is small. Many of the coarser sandstone units are well above stream drainage. There are large areas denuded by strip mining.

Soils
The soils of the glaciated part of this area are predominantly the well-drained, moderately permeable Wooster and the moderately well drained, slowly permeable Canfield soils series. These soils developed from Wisconsin medium-textured glacial till on sandstone and shale. South of the glacial boundary the soils are shallow, with thin fill even in the valleys. Steep topography and erosion have prevented the normal development of soil profiles. Over large areas the soils are classified as the Gilpin, Berks, Hazleton, Westmoreland, Lowell, and Upshur series, with surface textures ranging from gravelly loam to silty clay loam. These are residual soils, and differences in their profile characteristics are due almost entirely to the underlying rock on which they developed. Permeability of the soils is generally moderate to slow.

Water Development
The only significant water development in the watershed is Guilford Lake. Completed in 1932, Guilford Lake was impounded by an earth-filled dam constructed across the West Fork Branch of Little Beaver Creek. The water level of the 361 acre lake is controlled by a concrete spillway and valve. Smaller impoundments in the watershed include Salem Reservoir and Lake Tomahawk.

Flow Characteristics
In the northern part of the area the streams are affected somewhat by glacial deposits.
The higher low-flow index for Little Beaver Creek indicates the additional increment of ground water furnished by the glacial deposits. North Fork and Middle Fork contribute the major portion of the dry-weather flow of Little Beaver Creek. These tributaries extend into the glaciated area and their main channels are underlain with glacial outwash deposits.

State Listed Species by County with Records of Occurrence from the Little Beaver Creek Watershed
(from the Ohio Natural Heritage Database)
The following species are dependent upon aquatic habitats to complete their life cycle – this dependence may be for all or a portion of their life:

Mahoning County
Allegheny crayfish

Columbiana County
Spotted turtle, eastern hellbender, tiger spiketail, riffle snaketail, *Psilotreta indecisa* (caddisfly), *Stenonema ithaca* (mayfly), channel darter, wavyrayed lampmussel, creek heelsplitter

Carroll County
Four-toed salamander, *Brachycentrus numerosus* (caddisfly), *Psilotreta indecisa* (caddisfly)

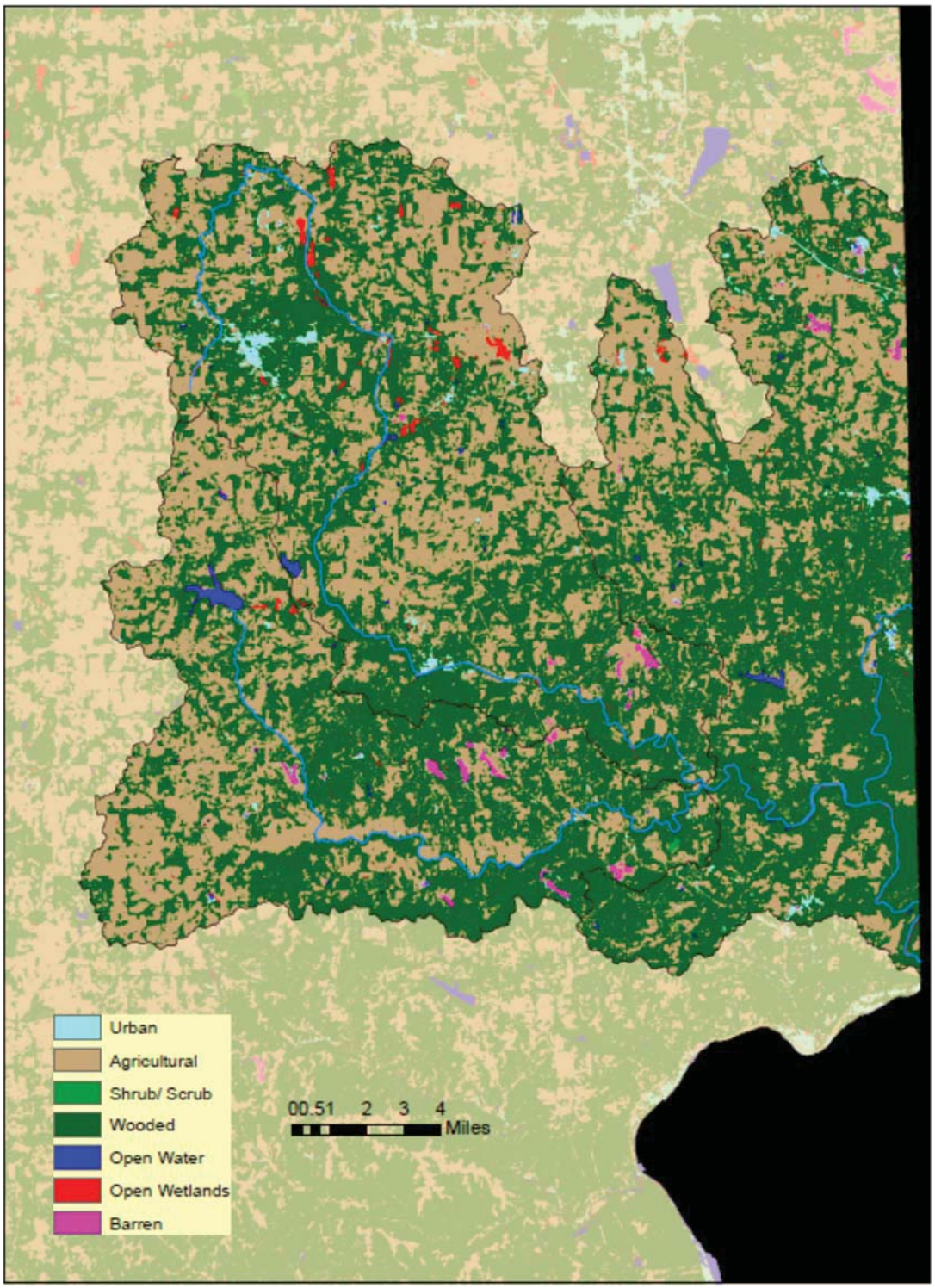


Figure 43. Little Beaver Creek Conservation Opportunity Watershed – Land Cover.

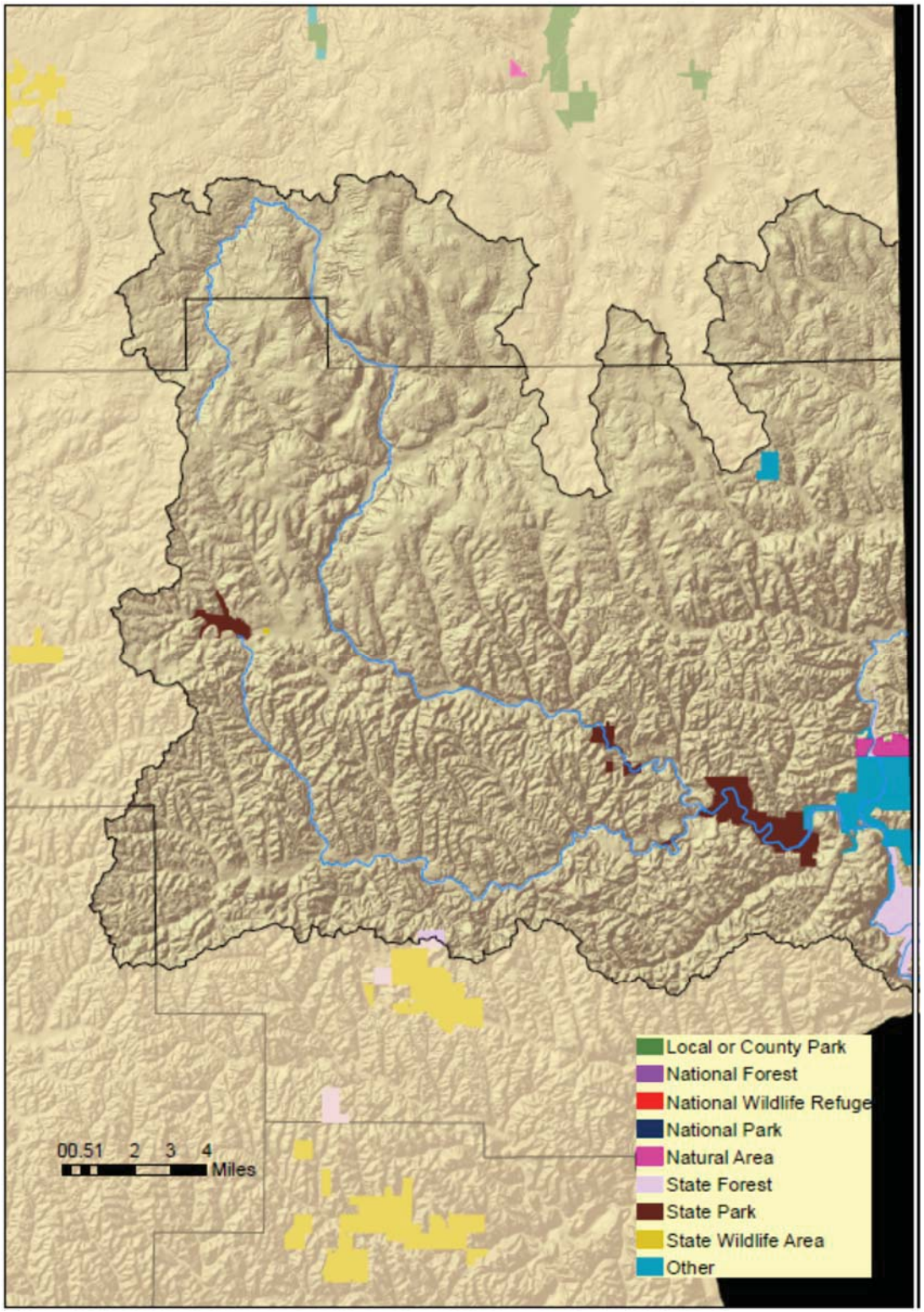


Figure 44. Little Beaver Creek Conservation Opportunity Watershed – Protected Lands.

Table 41. CONSERVATION THREATS TO OHIO RIVER TRIBUTARIES.
The following threats negatively impact or have the potential to negatively impact Ohio River Tributaries. Threat categories/classification from Salafsky et al. (2008), and threat impact rank calculations from Master et al. (2012).

ID	threats	2nd level threat classification(s)	threat impact rank
I	**residential and commercial development**		medium
A	Watershed conversion to urban/commercial development alters hydrology	housing & urban areas commercial & industrial areas	medium low
B	Shoreline development and its effect on habitat and species	housing and urban areas commercial & industrial areas tourism & recreation areas	medium low low
C	Increasing land prices limits our ability to protect riparian corridors	housing and urban areas commercial & industrial areas tourism & recreation areas	medium low low
II	**agriculture and aquaculture**		medium
A	Loss of riparian corridor to agriculture	annual & perennial non-timber crops livestock farming & ranching	high low
B	Watershed conversion to agriculture alters hydrology	annual & perennial non-timber crops livestock farming & ranching	high low
III	**energy production and mining**		low
A	Oil and gas extraction - can have negative impacts by causing chemical contamination	oil & gas drilling	low
B	Hydropower facilities disrupt stream connectivity and kill aquatic species	renewable energy	low
C	Water withdrawal for fracking alters hydrology	oil & gas drilling	low
D	Instream sand/gravel operations destroy habitat	mining & quarrying	low
E	Coal mining can result in acid mine drainage	mining & quarrying	low
IV	**transportation and service corridors**		low
A	Channel modification/dredging causes habitat loss, water quality impacts	shipping lanes	negligible
B	Roads, bridges, causeways, utilities, impact shoreline/nearshore habitats	roads & railroads utility & service lines	low low

V	**biological resource use**		low
A	Fishing pressure and fishing gear impacts	fishing & harvesting aquatic resources	low
VI	**human intrusions and disturbance**		low
A	Incompatible recreational activities	recreational activities	low
B	Creation of recreational facilities can alter/destroy nearshore habitat	recreational activities	low
C	Vessel impacts to nearshore habitats and water quality	recreational activities work & other activities	low negligible
VII	**natural system modifications**		medium
A	Dams cause habitat loss, sedimentation, decreased water quality, reduced biodiversity, and reduce movement of aquatic species and species abundance	dams & water management/use	medium
B	Conflicting water control management objectives of controlling agencies (DOW – USACOE)	dams & water management/use	medium
C	Lack of data for some species and habitats limits our ability to develop plans for threats like climate change	other ecosystem modifications	medium
D	Some species' polulations have been reduced to levels below what is necessary to recover on their own	other ecosystem modifications	Low
VIII	**invasive and other problematic species and genes**		high
A	Introduction and/or spread of invasive plants and animals	invasive non-native/alien species	high
B	Introduction and/or spread of nuisance plants and animals	problematic native species	low
C	Introduction and spread of diseases (plants and animals)	invasive non-native/alien species problematic native species	high low
D	Possible genetic contamination of native fish stocks from introduced hybrid fishes	introduced genetic material	low
IX	**pollution**		high
A	Urban effluent carries a variety of substances that impact water quality and aquatic species	household sewage & urban wastewater industrial & military effluents garbage & solid waste air-borne pollutants	high medium low low
B	Agricultural effluent from row crops as well as confined animal operations impacts water quality and aquatic species	agricultural & forestry effluents	very high
C	Industrial spills impact water quality and aquatic species	industrial & military effluents	medium
X	**geological events**		negligible
---	none	---	---

XI	**climate change and severe weather**		low
A	Climate change could impact habitats, water quality, and species	habitat shifting & alteration droughts temperature extremes storms & flooding	low low low medium

Table 42. CONSERVATION ACTIONS FOR OHIO RIVER TRIBUTARIES.
The following actions will help abate or have the potential to help abate threats to Ohio River Tributaries habitat. Action categories/classification from Salafsky et al. (2008), and action priority rank calculations from Georgia DNR (2005).

ID	actions	2nd level action classification(s)	action priority rank	threat(s) addressed*
I	**LAND/WATER PROTECTION**		med	
1	Protect riparian corridors through acquisition, partnerships, conservation easements, etc.	site/area protection resource & habitat protection	low high	I, II, IV-B, VI-B
II	**LAND/WATER MANAGEMENT**		high	
1	Work with OEPA, ODOT, USACE, and other government agencies to focus mitigation activities on riparian habitats in conservation opportunity watersheds	habitat & natural process restoration	high	I-A, II-A, IV-B, VI-B, XI
2	Work with landowners to develop and implement habitat improvement projects on private lands	habitat & natural process restoration	high	I, II, XI
3	Remove dams to restore stream connectivity and improve water quality	habitat & natural process restoration	high	VII-A, XI
4	Develop criteria for prioritizing candidate dams for removal – give extra emphasis to dams in conservation opportunity watersheds	habitat & natural process restoration	high	III-B, VII
5	Research fish passage improvements for dams that are not candidates for removal	habitat & natural process restoration	high	III-B, VII
6	Identify and prioritize restoration projects (channel restoration, floodplain and backwater reconnection, etc.) in conservation opportunity watersheds	habitat & natural process restoration	high	I-A,B, II, IV, VII-B, XI
7	Complete one geomorphological restoration project in each conservation opportunity watershed every 5 years	habitat & natural process restoration	high	I-A,B, II, IV, VII, XI
8	Develop model stream protection guidelines aimed at slowing the overland flow of water into streams	habitat & natural process restoration	high	I-A, II-B, IX-A,B
9	Use lowest impact techniques and timing for dredging activities	habitat & natural process restoration	high	III-D, IV-A, VII-B

10	Create and use wetlands for stormwater treatment	habitat & natural process restoration	high	I-A, IX-A
11	Establish an early-detection/rapid-response system for dealing with invasive and nuisance species	invasive/ problematic species control	high	VIII-A,B
12	Develop ways to control invasive plant species in flowing waters	invasive/ problematic species control	high	VIII-A,B
13	Develop a process for coordinating disparate data sources of distribution and abundance of aquatic SGCN with special emphasis on conservation opportunity watersheds	habitat & natural process restoration	high	I-B, III-B,D, IV-A,B, VI-B, VII-A,C, XI
14	Review existing species and habitat data to identify data gaps and needs for additional surveys, research, and management actions	habitat & natural process restoration	high	I, II, III, IV, V, VI, VII, VIII, IX, XI
15	Conduct comprehensive surveys of freshwater mussels in all conservation opportunity watersheds	habitat & natural process restoration	high	I-B, III-C,D, IV-A,B, VI-B, VII, XI
16	Conduct watershed studies to identify and prioritize restoration opportunities	habitat & natural process restoration	high	I-B, II-A, III-E, IV-A, VI-B, VII, XI
17	Stabilize severely eroding streambanks with bio-engineering techniques	habitat & natural process restoration	high	I-A,B, II, VI-C
18	Reconnect stream channels with natural floodplains	habitat & natural process restoration	high	I-A,B, II, IV, VII-B, XI
19	Restore/stabilize riparian habitat by planting native grasses, shrubs, and trees	habitat & natural process restoration	high	I-B, II-A, IV-B
20	Use treatment techniques to control the pH of effluent on abandoned mine lands	habitat & natural process restoration	high	III-E
21	Develop GIS tools to archive and monitor the status of protected lands in conservation opportunity watersheds	site/area management	low	XI
III	**SPECIES MANAGEMENT**		low	
1	Monitor for the presence of Asian carp in the lower portions of large tributaries	species management	med	VIII-A
2	Assess population status, habitat suitability, and probability for restoration of fish, mussels, crayfish, invertabrates, and amphibians listed as SGCN	species reintroduction	High	VII-C, VII-D
3	Develop a restoration strategy for high priority fish, mussels, crayfish, invertebrates, and amphibians	species reintroduction	High	VII-C, VII-D
IV	**EDUCATION AND AWARENESS**		high	
1	Educate waterfront landowners and commercial pesticide/herbicide applicators on responsible chemical use, and the negative impacts to wildlife from toxic chemicals	training	high	I-B,C, IX-A

2	Promote conservation easements to protect riparian habitat	training awareness & communic-ations	high high	I, II, IV-B, VI-B, XI
3	Conduct shoreline protection/stabilization workshops	training	high	I-B, II-A, IV-B, VI-B
4	Provide technical guidance on shoreline development plans as relates to fish and wildlife interests	training	high	I, IV-B, VI-B, XI
5	Educate the public about the negative effects of exotic and nuisance animals – encourage responsible disposal of unwanted animals	awareness & communic-ations	high	VIII
6	Provide training to road construction/maintenance personnel for runoff/ sediment control	training	high	I-B, IV-B, VI-B
7	Educate the public and legislators on the benefits of dam removals	training awareness & communic-ations	high high	VII-A
8	Provide training in geomorphological, fluvial, and in-stream flow processes for DOW personnel	training	high	III-B,C,D, IV, VI-B, VII-A,B
9	Develop and provide streams/watersheds educational materials for landowners, schools, public officials, and the general public	training awareness & communic-ations	high high	I, II, IX-A,B, XI
10	Create and implement demonstration projects aimed at reducing urban effluent – such as rain gardens, bioretention, etc.	training awareness & communic-ations	high high	I-A,B, IX-A
11	Conduct outreach for landowners on private land management, conservation practices, and water quality	training awareness & communic-ations	high high	I, II, IX-A,B
V	**LAW AND POLICY**		high	
1	Support legislation promoting eco-friendly energy development and use	legislation	high	III-A,B,C,E
2	Develop and implement a risk-assessment system in the approval process for importing or moving live animals and plants	legislation policies & regulations	high high	VIII
3	Support sewage sludge/animal manure disposal standards to regulate application rates and timing	policies & regulations	high	IX-A,B
4	Encourage and support minimum flow regulations that protect downstream aquatic habitats	policies & regulations	high	III-B, VII-A,B, IX-A,B
5	Support the creation of additional and/or increased enforcement of stormwater regulations	policies & regulations compliance & enforcement	high med	I-A, IX-A
6	Find innovative ways to mandate the inclusion of fish and wildlife interests in development plans	policies & regulations	high	I, III-B,C,D,E, IV-

		private sector standards & codes	low	B, VI-B, XI
7	Support the use of buffers between development and tributary shorelines	policies & regulations private sector standards & codes	high low	I-A,B, IV-B, IX-A
8	Promote riparian protection ordinances that prevent floodplain encroachment and riparian habitat removal	policies & regulations private sector standards & codes	high low	I, II, IV-B, VI-B
9	Support increased regulation of home sewage treatment systems	compliance & enforcement	med	IX-A
VI	**LIVELIHOOD, ECONOMIC AND OTHER INCENTIVES**		med	
1	Explore tying eligibility for grant money, loans, and cost-share programs to nutrient loading levels for agriculture – the lower the nutrient levels in their effluent, the more money they would be eligible for	market forces conservation payments	high high	IX-B, XI
2	Create incentives for vegetated buffers along all waterways to reduce nutrient loads and sediment	market forces conservation payments	high high	I, II, IX-A,B, XI
3	Create incentives to promote eco-friendly energy development and use	market forces conservation payments non-monetary values	high high low	III-A,B,C,E
4	Support the creation of incentives to protect riparian habitat	market forces conservation payments	high high	I, II, IV-B, VI-B, XI
5	Support clean marina and clean vessel programs	market forces conservation payments	high high	VI-C
6	Develop incentives for municipalities to use stormwater management systems that minimize negative impacts to aquatic habitats	market forces conservation payments	high high	I-A, IX-A
7	Support incentives for development plans involving water frontage that take into account wildlife and habitat needs	market forces conservation payments non-monetary values	high high low	I, IV-B, VI-B, XI
8	Support payments to offset losses (revenue from	conservation	high	IX-B

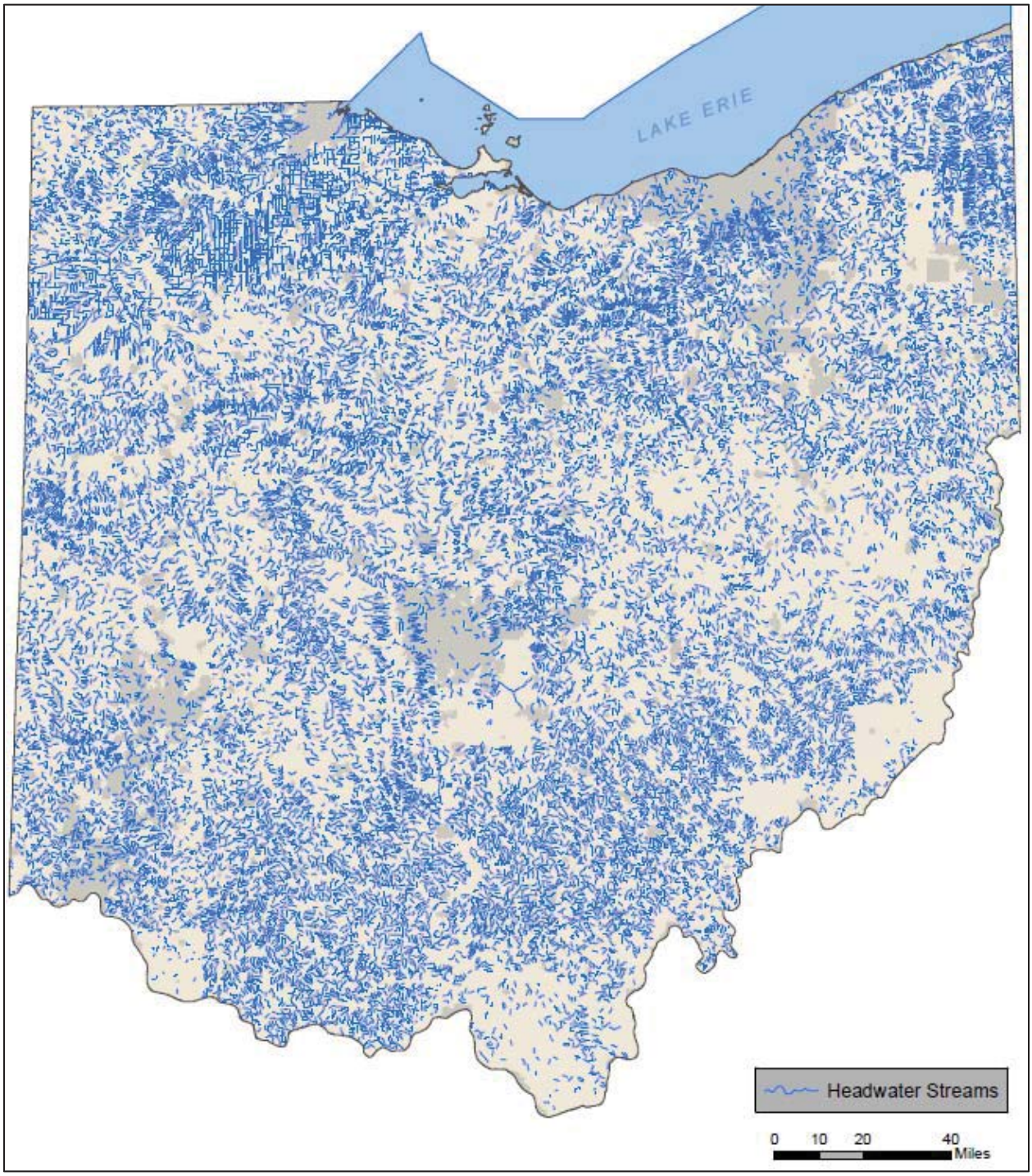
	crops) resulting from implementation of conservation practices aimed at reducing sediment loads	payments		
9	Create incentives to encourage the use of conservation tillage – especially in impaired watersheds	market forces conservation payments	high high	IX-B
10	Support incentives for conservation farming practices – including nutrient management plans and livestock waste management plans	market forces conservation payments	high high	IX-B
11	Encourage the use of cover crops for idle agricultural fields	market forces conservation payments	high high	IX-B
12	Promote drainage water management such as grassed waterways, 2-stage channels, and over-wide ditches	market forces conservation payments	high high	II, IX-B
13	Promote waterway conservation livestock practices such as exclusion fencing, livestock crossings, alternative water supplies, livestock access lanes	market forces conservation payments	high high	II-A, IX-B
VII	**EXTERNAL CAPACITY BUILDING**		med	
1	Work with ODA and OEPA to minimize nutrients in runoff, and develop BMPs for pesticide/herbicide use	alliance & partnership development	high	IX
2	Create an interagency spill response team – update contacts and training on a regular basis	alliance & partnership development	high	IX-C
3	Consider creating a multiagency invasive species prevention and control group that would handle all invasive species issues	alliance & partnership development	high	VIII
4	Through interagency coordination, work to assure that wildlife interests are taken into consideration in road, bridge, and causeway design, construction, and maintenance	alliance & partnership development	high	IV-B
5	Create a multi-agency dam removal task force	alliance & partnership development	high	VII
6	Use inter-agency cooperation to influence watershed health	alliance & partnership development	high	I, II, IX, XI
7	Pursue partnerships with local, state, and federal agencies to secure funding for projects benefitting streams and watersheds	alliance & partnership development conservation finance	high low	I, II, III, IV, VI, VII, VIII, IX, XI
8	Work with OEPA to encourage the reuse of point source discharge water	alliance & partnership development	high	IX-A
9	Work with OEPA and municipalities to eliminate CSO's and SSO's – especially in impaired watersheds	alliance & partnership development	high	I-A, IX-A
10	Work with OEPA to encourage completion of TMDL	alliance &	high	IX-A,B

	studies for all streams in the Ohio River drainage	partnership development		
11	Work with OEPA and local watershed groups to remediate contaminated sediments and restore habitat in conjunction with remediation	alliance & partnership development	high	I-B, IX-A
12	Work with regulatory agencies and local watershed groups on programs to restore natural stream and flood plain function	alliance & partnership development	high	I-A,B, II, IV, VII-A,B, XI
14	Develop partnerships with land trusts, watershed and conservation groups, and government agencies to guide acquisition and protection activities in each conservation opportunity watershed	alliance & partnership development	high	I, II, III, IV, VI, XI
15	Increase personnel and expertise available for SGCN surveys and research through partnerships with other government agencies, universities, and conservation-minded NGO's	institutional & civil society development alliance & partnership development	med high	I, II, III, IV, V, VI, VII, VIII, IX, XI
13	Encourage/facilitate the establishment of watershed groups & watershed coordinator to promote watershed improvement activities	institutional & civil society development	med	I, II, IX, XI

*refers to the Ohio River Tributaries Habitat Conservation Threats in Table 41

6.17 Headwater and Small Inland Streams

Ohio Headwater/Inland Streams



6.17.1 Status

Improving. State and federal legislation have created water quality standards, new technologies, stricter enforcement, and successful permitting and monitoring programs. Point source pollution has been

significantly reduced and the quality of many streams has markedly improved as a result. Biological communities in these streams generally show improvement commensurate with improvements to habitat and water quality.

In general, the percent of stream miles in attainment of their aquatic life use designations tends to increase from north to south in Ohio. Recent data indicates that unhealthy fish and aquatic insect populations are more common for smaller streams. For headwater streams (<20 sq. mi. drainage), 54% of sites sampled during 2003-2012 were in full attainment of their aquatic life use designation, compared to moderate sized streams (20-50 sq. mi. drainage) at 60%, and principal streams (50-500 sq. mi. drainage) at 67%. The larger the drainage area (and usually the larger the stream), the more likely the stream is to be healthy. This phenomenon correlates well with the most widespread causes associated with the aquatic life impairment in these watersheds. Habitat alteration and non-point source pollution remain issues today – new abatement efforts are increasingly focused on nonpoint sources such as runoff from urban and agricultural lands (Ohio EPA 2014a).

6.17.2 Description

Ohio rivers and streams represent more than 60,000 mi of flowing waters. Fifteen of the 3,300 named streams in Ohio have watersheds larger than 1,000 square miles (Sanders 2000). In the upper one-third of Ohio these streams drain north across the 11,714 square mile Lake Erie watershed, whereas in the lower two-thirds of Ohio they drain south across the 34,361 square mile Ohio River watershed. This aquatic habitat chapter focuses on the inland tributary streams that combine to form direct tributaries to Lake Erie and the Ohio River. The differentiation between this habitat category and the Lake Erie Tributaries and Ohio River Tributaries habitat categories is one of stream order. This habitat category contains primarily 1st and 2nd order streams.

Approximately 28,900 miles of the over 58,000 miles of stream channels digitally mapped in Ohio are headwater streams. However, the digital maps currently available for Ohio do not include the smallest of headwater channels. Results of a special study of primary headwater streams (drainage areas less than 1 sq. mi.) place the estimate of primary headwaters between 146,000 to almost 250,000 miles. Some of these primary headwater streams are in fact perennial habitats for aquatic life, and supply base flow to larger streams (Ohio EPA 2014a).

More than 75% of the streams in Ohio are first- or second-order streams - small headwater streams with drainage areas of less than 5 square miles (see the list from Ward et al. (2008) below). Many of the headwater streams in the Midwest region of the United States are constructed agricultural ditches or are natural streams that have been straightened and deepened to facilitate the removal of excess water from agricultural fields.

Stream Order	Drainage Area (square miles)	Total Length (miles)	Percentage of stream miles	Cumulative % of stream mi.
1	0.2 – 1.0	67,530	51.5	51.5
2	1.0 – 4.7	33,138	25.3	76.8
3	4.7 – 23	15,963	12.2	89.0
4	23 – 109	7803	6.0	95.0
5	109 – 518	3810	2.9	97.9
6	518 – 2460	1861	1.4	99.3
7	2460 – 11,700	908	0.7	100.0

Ohio's generally low gradient landscape results in the majority of headwater streams being Rosgen type C and E streams. Type C streams are slightly entrenched, meandering systems characterized by well-developed floodplains with riffle-pool bed forms that are typically wider than they are deep. Type E streams have a low width-to-depth ratio and exhibit a wide range of sinuosity with well developed floodplains. Less than 10 percent of Ohio's first and second order streams are of the Rosgen type A or B – typically steep, entrenched, confined channels found in narrow valleys of rolling hill landforms with channel beds consisting of a series of rapids and cascades with irregular scour pools (think mountain streams/brooks) (Ward et al. 2008).

The importance of headwater streams and their protection
As discussed in *Association between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (Ohio EPA 1999a), headwater streams represent a significant source of assimilative capacity for the protection of downstream reaches. The aggregate condition of headwater streams is correlated with the quality of water and aquatic life resources in larger streams, and reflects the integrity of the watershed as a whole. Headwaters represent the primary interface between the landscape and aquatic ecosystems, and are the initial entry points for energy and nutrients into lotic ecosystems. The form, manner, and rate at which nutrients are delivered to headwaters and eventually transported downstream profoundly affect the ecological integrity of the larger streams and rivers. While headwater streams are proportionally smaller in terms of physical size and volume, their sheer numbers imply importance in cumulative terms for downstream water bodies.

For watersheds, most impairment is related to modification of the landscape – and these impairments have the greatest impact on smaller streams. The top five aquatic life impairment causes for the period 2003 through 2012 are: siltation/sedimentation, excess nutrients, habitat modification, hydromodification, and organic enrichment/dissolved oxygen. Most of the impaired watershed units with current data had at least one of these causes contributing to impairment and many had two or more of the top five causes listed (Ohio EPA 2014a).

Headwater stream protection approaches should be focused on the improved management of riparian zones in attempts to reduce sediment and nutrient delivery (*i.e.*, encouraging sediment and nutrient interception, processing, and storage within the riparian areas of headwater streams). Vegetated riparian buffers are a vital functional component of the stream ecosystem and are instrumental in the detention, removal and assimilation of nutrients from or by the water column. The riparian zone is essentially a component of instream habitat. It contributes food and nutrients in forms that desirable aquatic assemblages are adapted for, and contributes to the habitat heterogeneity by influencing channel morphology via large woody debris and bank stabilization (Ohio EPA 1999a).

Illustrating the importance of the riparian zone to headwater stream ecology is the fact that biological community performance in headwaters and wadable streams has been found to be highest (based upon Index of Biotic Integrity [IBI] or Invertebrate Community Index [ICI] values) where total phosphorous (TP) concentrations are lowest. The quality of the riparian corridor influences TP levels in the stream by its ability to detain, remove, and assimilate P before it enters the stream. The lowest TP concentrations were also associated with the highest quality stream habitats (based upon Qualitative Habitat Evaluation Index [QHEI] scores). The correlation of low TP with high quality lotic habitat is thought to be the result of TP being sequestered by the well-organized, diverse, and trophically dynamic aquatic assemblages that are typically associated with high quality habitat (Ohio EPA 1999a).

Excess nutrients can have negative effects by altering trophic dynamics, increasing algal production, increasing turbidity, decreasing dissolved oxygen (D.O.) concentrations, and increasing daily fluctuations in D.O. and pH. Changes caused by excessive nutrient concentrations result in shifts in species composition away from functional assemblages of intolerant species, benthic insectivores and top carnivores (*e.g.,* darters, insectivorous minnows, redhorse, sunfish, and black basses) typical of high quality warmwater streams, towards less desirable assemblages of tolerant species, niche generalists, omnivores, and detritivores (*e.g.,* creek chub, bluntnose minnow, white sucker, carp, green sunfish) typical of degraded warmwater streams (Ohio EPA 1999a).

Since more than 88 percent of Ohio is privately or locally owned, the well-being of Ohio's streams and watersheds is very dependent upon the attitudes and conservation stewardship of landowners and local communities. Increasingly, community-based watershed groups and partnerships comprised of many stakeholders are collectively working to protect and restore their local streams and watersheds. As water resources become increasingly important, it will be the willingness of private landowners and these groups to practice voluntary conservation on private and local lands that will determine the need for future regulations related to the health of streams and watersheds throughout Ohio (Sanders 2000).

6.17.3 Associated Species of Greatest Conservation Need

With more than 1,200 species, aquatic insects are the largest group of Ohio stream wildlife. An amazing number of fish – historically over 160 species – have also been recorded from Ohio streams. Ohio's least impacted streams are characterized free-flowing diverse aquatic habitats, forested riparian corridors, islands, associated wetlands, unregulated flow regimes, and sparsely populated watersheds. These streams contain diverse and abundant biological assemblages that include pollution-sensitive, rare, and endangered species (Sanders 2000). Headwater and small inland streams however, are very succeptible to natural and anthropogenic influences due to their small size. In many of Ohio's watersheds, biological communities improve as stream size increases. Size can buffer the impacts of issues such as variable flows, pollution, land-use practices, and climate. Headwater and small inland streams are fragile systems who's aquatic species assemblages can be severly impacted by events that would have little effect upon larger systems. At any point in time, the aquatic community present in a small inland stream may be a reflection of the condition/activities in the watershed, a recent event that negatively impacted the stream (e.g., chemical spill), or both.

The following species have been identified as Headwater and Small Inland Streams species of greatest conservation need (conservation status rank in parentheses):

<u>Aquatic Invertebrates</u>

Hines Emerald Dragonfly	*Somatochlora hineana*
Eastern Red Damsel	*Amphiagrion sauclum*
Aurora Damsel	*Chromagrion conditum*
Arrowhead Spiketail Dragonfly	*Cordulegastor obliqua*

<u>Fish</u>

Scioto Madtom (1)	*Noturus trautmani*
Longhead Darter (4)	*Percina macrocephala*
Western Tonguetied Minnow (7)	*Exoglossum laurae*
Spotted Darter (8)	*Etheostoma maculatum*
Northern Madtom (10)	*Noturus stigmosus*
Bigeye Shiner (12)	*Notropis boops*
Ohio Lamprey (13)	*Ichthyomyzon bdellium*
Mountain Brook Lamprey (16)	*Ichthyomyzon greeleyi*
Tippecanoe Darter (20)	*Etheostoma tippecanoe*
Mountain Madtom (21)	*Noturus eleutherus*
Blacknose Shiner (22)	*Notropis heterolepis*
Northern Brook Lamprey (23)	*Ichthyomyzon fossor*
Mottled Sculpin (24)	*Cottus bairdi*
Bluebreast Darter (25)	*Etheostoma camurum*
Silver Lamprey (26)	*Ichthyomyzon unicuspis*
Pugnose Minnow (27)	*Opsopoeodus emiliae*
American Brook Lamprey (28)	*Lampetra appendix*
Eastern Sand Darter (29)	*Ammocrypta pellucida*
Western Banded Killifish (30)	*Fundulus diaphanus menona*
Redside Dace (31)	*Clinostomus elongatus*
Gravel Chub (32)	*Erimystax x-punctatus*
Least Darter (33)	*Etheostoma microperca*
Least Brook Lamprey (35)	*Lampetra aepyptera*
Iowa Darter (38)	*Etheostoma exile*
Rosyside Dace (39)	*Clinostomus funduloides*
Streamline Chub (41)	*Erimystax dissimilis*
Bigeye Chub (42)	*Hybopsis amblops*
Central Mudminnow (43)	*Umbra limi*
Lake Chubsucker (46)	*Erimyzon sucetta*
Bigmouth Shiner (48)	*Notropis dorsalis*
Black Redhorse (48)	*Moxostoma duquesnei*

Pirate Perch (51)	*Aphredoderus sayanus*
Silver Redhorse (52)	*Moxostoma anisurum*
Variegate Darter (53)	*Etheostoma variatum*
Southern Redbelly Dace (54)	*Phoxinus erythrogaster*
Greater Redhorse (55)	*Moxostoma valenciennesi*
Creek Chubsucker (58)	*Erimyzon claviformis*
Dusky Darter (58)	*Percina sciera*
Smallmouth Redhorse (63)	*Moxostoma breviceps*

Crayfish

Devil Crayfish (3)	*Cambarus diogenes*
Northern Clearwater Crayfish (4)	*Orconectes propinquus*
Sanborn's Crayfish (6)	*Orconectes sanbornii*
Paintedhand Mudbug (8)	*Cambarus polychromatus*
Little Brown Mudbug (9)	*Cambarus thomai*
Ortman's Mudbug (10)	*Cambarus ortmanni*
Spiney Stream Crayfish (11)	*Orconectes cristavarius*
Cave Spring Crayfish (12)	*Cambarus tenebrosus*
Papershell Crayfish (13)	*Orconectes immunis*
Virile Crayfish (13)	*Orconectes virilis*

Mussels

White Catspaw (2)	*Epioblasma obliquata perobliqa*
Purple Catspaw (3)	*Epioblasma obliquata obliquata*
Little Spectaclecase (7)	*Villosa lienosa*
Purple Lilliput (15)	*Toxolasma lividum*
Slippershell Mussel (16)	*Alasmidonta viridis*
Rayed Bean (21)	*Villosa fabalis*
Creek Heelsplitter (23)	*Lasmigona compressa*
Rabbitsfoot (25)	*Quadrula cylindrica*
Salamander Mussel (25)	*Simpsonaias ambigua*
Clubshell (35)	*Pleurobema clava*
Purple Wartyback (37)	*Cyclonaias tuberculata*
Threeridge (40)	*Amblema plicata*
Round Hickorynut (42)	*Obovaria subrotunda*
Black Sandshell (47)	*Ligumia recta*
Kidneyshell (48)	*Ptychobranchus fasciolaris*
Rainbowshell (50)	*Villosa iris*
Round Pigtoe (50)	*Pleurobema sintoxia*
Cylindrical Papershell (56)	*Anodontiodes ferussacianus*

Amphibians

Mudpuppy (14)	*Necturus maculosus maculosus*
Cave Salamander (15)	*Eurycea lucifuga*

Reptiles

Rough Green Snake (3)	*Opheodrys aestivus*
Midland Smooth Softshell (7)	*Apalone mutica mutica*
Common Map Turtle (19)	*Graptemys geographica*
Ouachita Map Turtle (19)	*Graptemys ouachitensis*
Queen Snake (19)	*Regina septemvittata*

Table 43. CONSERVATION THREATS TO HEADWATER AND SMALL INLAND STREAMS.
The following threats negatively impact or have the potential to negatively impact Headwater and Small Inland Streams. Threat categories/classification from Salafsky et al. (2008), and threat impact rank calculations from Master et al. (2012).

ID	threats	2nd level threat classification(s)	threat impact rank
I	**residential and commercial development**		high
A	Watershed conversion to urban/commercial development alters hydrology	housing & urban areas commercial & industrial areas	high medium
B	Shoreline development and its effect on habitat and species	housing & urban areas commercial & industrial areas	high medium
C	Increasing land prices limit our ability to protect riparian corridors	housing & urban areas commercial & industrial areas	high medium
II	**agriculture and aquaculture**		high
A	Loss of riparian corridor to agriculture	annual & perennial non-timber crops livestock farming & ranching	high low
B	Watershed conversion to agriculture alters hydrology	annual & perennial non-timber crops livestock farming & ranching	high low
III	**energy production and mining**		high
A	Oil and gas extraction - can have negative impacts by causing chemical contamination	oil & gas drilling	high
B	Water withdrawal for fracking alters hydrology	oil & gas drilling	high
C	Coal mining can result in acid mine drainage	mining & quarrying	low
IV	**transportation and service corridors**		medium
A	Roads/bridges/causeways and utilities can destroy habitat, alter hydrology	roads & railroads utility & service lines	high low
V	**biological resource use**		low
A	Fishing pressure and fishing gear impacts	fishing & harvesting aquatic resources	negligible
B	Removal of trees from streambanks and the watershed impacts water quality	logging & wood harvesting	high
VI	**human intrusions and disturbance**		low
A	Incompatible recreational activities	recreational activities	negligible
VII	**natural system modifications**		high
A	Forestry practices can negatively impact water quality	other ecosystem modifications	low
B	Altering channel morphology to facilitate agriculture impacts habitat and species	dams & water management/use	high
C	Dams cause habitat loss, sedimentation, decreased water quality, reduced biodiversity, and reduce movement of aquatic species and species abundance	dams & water management/use	high

D	Lack of data for some species and habitats limits our ability to develop plans for threats like climate change	other ecosystem modifications	low
E	Some species' polulations have been reduced to levels below what is necessary to recover on their own	other ecosystem modifications	Low
VIII	**invasive and other problematic species and genes**		low
A	Introduction and/or spread of invasive plants and animals	invasive non-native/alien species	low
B	Introduction and/or spread of nuisance plants and animals	problematic native species	negligible
C	Introduction and spread of diseases (plants and animals)	invasive non-native/alien species problematic native species	low negligible
IX	**pollution**		medium
A	Urban effluent carries a variety of substances that impact water quality & aquatic species	household sewage & urban wastewater industrial & military effluents garbage & solid waste air-borne pollutants	low low low low
B	Agricultural effluent from row crops as well as confined animal operations impacts water quality & aquatic species	agricultural & forestry effluents	high
C	Pesticides/herbicides from waterfront property owners impacts water quality	household sewage & urban wastewater	low
D	Mine drainage negatively impacts water quality and reduces species & species abundance	industrial & military effluents	low
X	**geological events**		negligible
---	none	---	---
XI	**climate change and severe weather**		medium
A	Climate change could impact habitats, water quality, and species	habitat shifting & alteration droughts temperature extremes storms & flooding	high low low low

Table 44. CONSERVATION ACTIONS FOR HEADWATER AND SMALL INLAND STREAMS.
The following actions will help abate or have the potential to help abate threats to Headwater and Small Inland Streams habitat. Action categories/classification from Salafsky et al. (2008), and action priority rank calculations from Georgia DNR (2005).

ID	actions	2nd level action classification(s)	action priority rank	threat(s) addressed*
I	**LAND/WATER PROTECTION**		high	
1	Protect riparian corridors through acquisition, partnerships, conservation easements, etc.	site/area protection resource & habitat protection	high high	I, II, IV, V-B, VII-B
II	**LAND/WATER MANAGEMENT**		med	
1	Work with OEPA, ODOT, USACE, and other government agencies to focus mitigation activities on riparian habitats in conservation opportunity watersheds	habitat & natural process restoration	high	I-A, II-A, IV, XI
2	Work with landowners to develop and implement habitat improvement projects on private lands	habitat & natural process restoration	high	I, II, IX-C, XI
3	Remove dams to restore stream connectivity and improve water quality	habitat & natural process restoration	high	VII-C, XI
4	Develop criteria for prioritizing candidate dams for removal – give extra emphasis to dams in conservation opportunity watersheds	habitat & natural process restoration	high	VII-C
5	Research fish passage improvements for dams that are not candidates for removal	habitat & natural process restoration	high	VII-C
6	Identify and prioritize restoration projects (channel restoration, floodplain and backwater reconnection, etc.) in conservation opportunity watersheds	habitat & natural process restoration	high	I-A,B, II, IV, VII-B, XI
7	Complete one geomorphological restoration project in each conservation opportunity watershed every 5 years	habitat & natural process restoration	high	I-A,B, II, IV, VII-B,C, XI
8	Develop model stream protection guidelines aimed at slowing the overland flow of water into streams	habitat & natural process restoration	high	I-A, II-B, IX-A,B
9	Create and use wetlands for stormwater treatment	habitat & natural process restoration	high	I-A, IX-A
10	Develop a process for coordinating disparate data sources of distribution and abundance of aquatic SGCN with special emphasis on conservation opportunity watersheds	habitat & natural process restoration	high	I-B, IV, VII-B,C,D, XI
11	Review existing species and habitat data to identify data gaps and needs for additional surveys, research, and management actions	habitat & natural process restoration	high	I, II, III, IV, V, VI, VII, VIII, IX, XI
12	Conduct comprehensive surveys of freshwater mussels in all conservation opportunity watersheds	habitat & natural process restoration	high	I-B, III-B,C, IV, VII, XI

13	Expand the DOW livestock exclusion fencing program to SWCDs in all counties in conservation opportunity watersheds	habitat & natural process restoration	high	II-A, VII-B, IX-B
14	Conduct watershed studies to identify and prioritize restoration opportunities	habitat & natural process restoration	high	I-B, II-A, III-C, IV, V-B, VII, XI
15	Reconnect stream channels with natural floodplains	habitat & natural process restoration	high	I-A,B, II, IV, VII-B, XI
16	Restore/stabilize riparian habitat by planting native grasses, shrubs, and trees	habitat & natural process restoration	high	I-B, II-A, V-B, VII-B
17	Use treatment techniques to control the pH of effluent on abandoned mine lands	habitat & natural process restoration	high	III-C
18	Develop GIS tools to archive and monitor the status of protected lands in conservation opportunity watersheds	site/area management	low	XI
19	Sample fish assemblages and assess aquatic habitat in currently non-assessed tributaries	site/area management	low	I, II, III, IV, V, VI, VII, VIII, IX, XI
20	Establish an early-detection/rapid-response system for dealing with invasive and nuisance species	invasive/ problematic species control	low	VIII-A,B
21	Develop ways to control invasive plant species in flowing waters	invasive/ problematic species control	low	VIII-A,B
III	**SPECIES MANAGEMENT**		med	
1	Assess population status, habitat suitability, and probability for restoration of fish, mussels, crayfish, invertabrates, and amphibians listed as SGCN	species reintroduction	High	VII-D, VII-E
2	Develop a restoration strategy for high priority fish, mussels, crayfish, invertebrates, and amphibians	species reintroduction	High	VII-D, VII-E
IV	**EDUCATION AND AWARENESS**		high	
1	Educate waterfront landowners and commercial pesticide/herbicide applicators on responsible chemical use, and the negative impacts to wildlife from toxic chemicals	training	high	I-B,C, IX-A
2	Conduct shoreline protection/stabilization workshops	training	high	I-B, II-A, IV, V-B, XI
3	Provide technical guidance on shoreline development plans as relates to fish and wildlife interests	training	high	I, IV, XI
4	Provide training to road construction/maintenance personnel for runoff/sediment control	training	high	I-B, IV
5	Conduct stream-related demonstrations or presentations to schools, watershed groups, and the general public	training	high	I, II, IX-A,B,C, XI
6	Provide training in geomorphological, fluvial, and in-stream flow processes for DOW personnel	training	high	III-B, IV, V-B, VII-B,C
7	Promote conservation easements to protect riparian habitat	training awareness & communic-ations	high med	I, II, IV, V-B, IX, XI

8	Educate the public and legislators on the benefits of dam removals	training awareness & communic-ations	high med	VII-C
9	Develop and provide streams/watersheds educational materials for landowners, schools, public officials, and the general public	training awareness & communic-ations	high med	I, II, IX-A,B,C, XI
10	Educate the public about the negative effects of exotic and nuisance animals – encourage responsible disposal of unwanted animals	awareness & communic-ations	med	VIII
V	**LAW AND POLICY**		high	
1	Support legislation promoting eco-friendly energy development and use	legislation	high	III
2	Develop and implement a risk-assessment system in the approval process for importing or moving live animals and plants	legislation policies & regulations	high med	VIII
3	Find innovative ways to mandate the inclusion of fish and wildlife interests in development plans	policies & regulations private sector standards & codes	med high	I, III-B,C, IV, IX-A, XI
4	Promote riparian protection ordinances that prevent floodplain encroachment and riparian habitat removal	policies & regulations private sector standards & codes	med high	I, II, IV, V-B, VII-A,B
5	Support the use of buffers between development and stream shorelines	policies & regulations private sector standards & codes	med high	I-A,B, IV, IX-A
6	Support the creation of additional and/or increased enforcement of stormwater regulations	policies & regulations compliance & enforcement	med med	I-A, IX-A
7	Support groundwater protection efforts	policies & regulations	med	III-B, VII-C, IX
8	Support sewage sludge/animal manure disposal standards to regulate application rates and timing	policies & regulations	med	IX-A,B
9	Encourage and support minimum flow regulations that protect downstream aquatic habitats	policies & regulations	med	III-B, VII-C, IX
VI	**LIVELIHOOD, ECONOMIC AND OTHER INCENTIVES**		med	
1	Explore tying eligibility for grant money, loans, and cost-share programs to nutrient loading levels for agriculture – the lower the nutrient levels in their effluent, the more money they would be eligible for	conservation payments	med	IX-B, XI

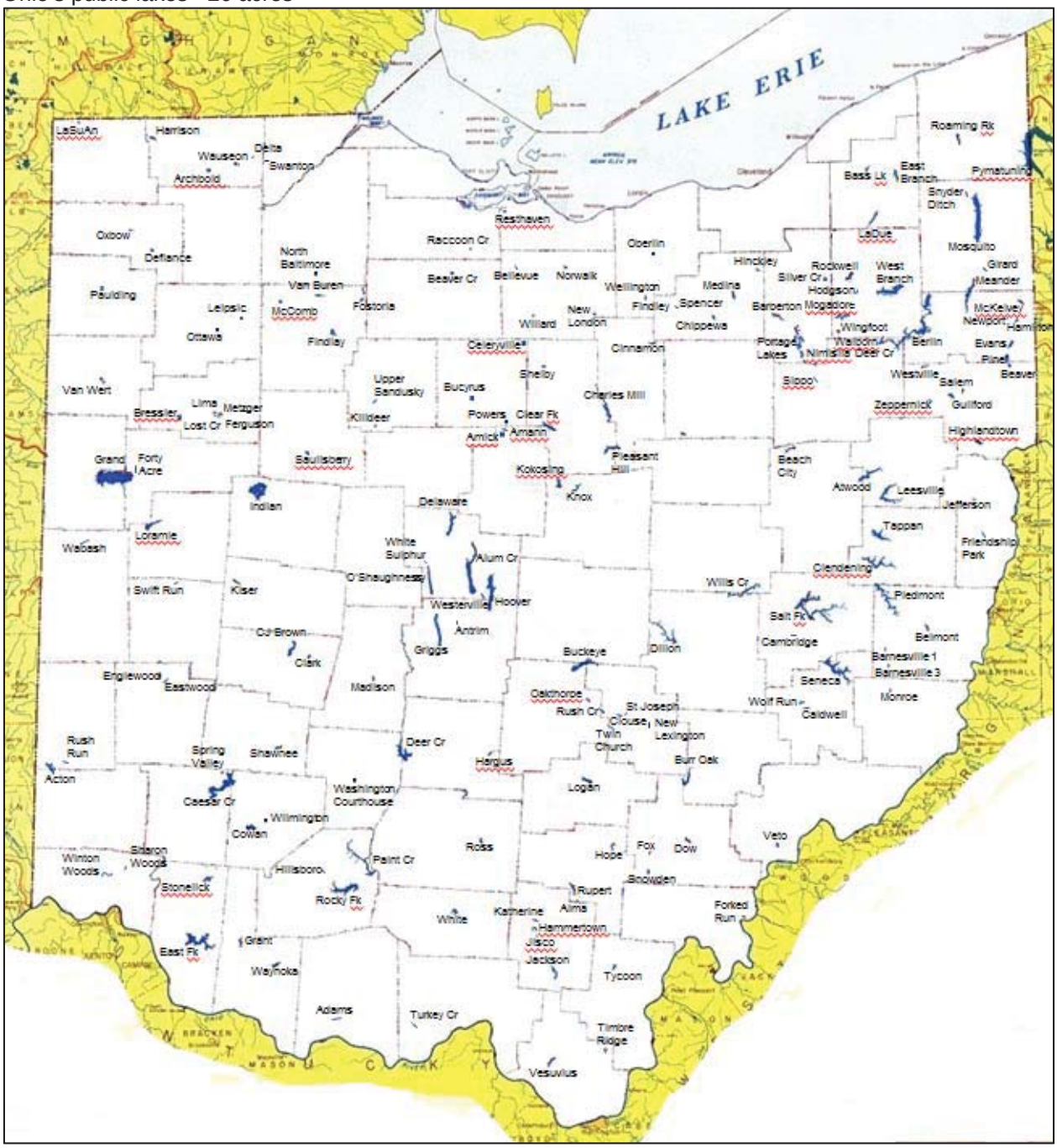
2	Support payments to offset losses (revenue from crops) resulting from implementation of conservation practices aimed at reducing sediment loads	conservation payments	med	IX-B
3	Create incentives for vegetated buffers along all waterways to reduce nutrient loads and sediment	market forces conservation payments	low med	I, II, V-B, VII-A,B, IX-A,B, XI
4	Create incentives to promote eco-friendly energy development and use	market forces conservation payments non-monetary values	low med high	III
5	Support the creation of incentives to protect riparian habitat	market forces conservation payments	low med	I, II, IV, V-B, VII-A,B, XI
6	Create/support programs that encourage buffers between development and inland streams	market forces conservation payments	low med	I-A,B, IV, IX-A
7	Develop incentives for municipalities to use stormwater management systems that minimize negative impacts to aquatic habitats	market forces conservation payments	low med	I-A, IX-A
8	Create incentives to encourage the use of conservation tillage – especially in impaired watersheds	market forces conservation payments	low med	IX-B
9	Support incentives for conservation farming practices – including nutrient management plans and livestock waste management plans	market forces conservation payments	low med	IX-B
10	Encourage the use of cover crops for idle agricultural fields	market forces conservation payments	low med	IX-B
11	Promote drainage water management such as grassed waterways, 2-stage channels, and over-wide ditches	market forces conservation payments	low med	II, VII-B, IX-B
12	Promote waterway conservation livestock practices such as exclusion fencing, livestock crossings, alternative water supplies, livestock access lanes	market forces conservation payments	low med	II-A, IX-B
VII	**EXTERNAL CAPACITY BUILDING**		high	
1	Pursue partnerships with local, state, and federal agencies to secure funding for projects benefitting streams and watersheds	alliance & partnership development conservation finance	med high	I, II, III, IV, V-B, VII, VIII, IX, XI
2	Work with ODA and OEPA to minimize nutrients in runoff, and develop BMPs for pesticide/herbicide use	alliance & partnership	med	IX

		development		
3	Create an interagency spill response team – update contacts and training on a regular basis	alliance & partnership development	med	IX-A,B
4	Consider creating a multiagency invasive species prevention and control group that would handle all invasive species issues	alliance & partnership development	med	VIII
5	Develop a multi-agency group to design wildlife/habitat friendly stream crossings	alliance & partnership development	med	I-B, II-A, IV, VI
6	Through interagency coordination, work to assure that wildlife interests are taken into consideration in road, bridge, and causeway design, construction, and maintenance	alliance & partnership development	med	IV
7	Create a multi-agency dam removal task force	alliance & partnership development	med	VII-C
8	Use inter-agency cooperation to influence watershed health	alliance & partnership development	med	I, II, V-B, VII-A,B, IX, XI
9	Attend and actively collaborate with watershed partnerships	institutional & civil society development alliance & partnership development	med med	I, II, III, IV, V-B, VI, VII, VIII, IX, XI
10	Develop partnerships with land trusts, watershed and conservation groups, and government agencies to guide acquisition and protection activities in each conservation opportunity watershed	alliance & partnership development	med	I, II, III, IV, V-B, VII-A,B, XI
11	Increase personnel and expertise available for SGCN surveys and research through partnerships with other government agencies, universities, and conservation-minded NGO's	institutional & civil society development alliance & partnership development	med med	I, II, III, IV, V, VI, VII, VIII, IX, XI

*refers to the Headwater and Small Inland Streams Habitat Conservation Threats in Table 43

6.18 Man-made Lakes and Ponds

Ohio's public lakes >20 acres



6.18.1 Status

Assessment data for this habitat category is limited and lagging behind assessment of rivers and streams. Inputs from the surrounding watershed as well as tributary streams affect habitat and water quality of lentic systems. Ohio's largest lakes/reservoirs are heavily influenced by sedimentation, nutrient enrichment, and turbidity. Canal lakes are extremely productive systems, but due to degraded habitat and

water quality, are dominated by tolerant species. Overall, ponds provide the best combination of water quality and habitat primarily because of the landcover in their smaller drainage areas.

6.18.2 Description

Ohio is estimated to have 2,293 lakes and reservoirs >5 acres, totaling 142,006 acres (ODNR 1980). Considering smaller waters, the US Environmental Protection Agency (EPA) estimated that Ohio has 5,130 lakes, reservoirs and ponds totaling 188,461 acres, whereas the ODNR estimated over 50,000 water bodies totaling 200,000 acres during this same time. Numerous small ponds counted by the ODNR were not identified by the US EPA due to differences in methods (Davic et al. 1996). The most recent estimate of all inland lentic waters, regardless of size, is over 52,000 ponds, lakes, and reservoirs statewide (Miami University 2005). Maintaining a current inventory of lakes, reservoirs, and ponds is challenging, as new waters are periodically constructed, while others are occasionally “decommissioned” by draining or breaching the dam.

Ohio’s man-made lakes and ponds fall into three categories related to construction. On-stream reservoirs (dammed impoundments) are constructed by placement of a dam across a stream or creek to impound water. Upground reservoirs are constructed in flat terrain by constructing an earthen levee above ground level, and then pumping water into the basin that is created. The third category (dug-out lakes) is created by excavating a hole and allowing it to fill with water.

Of the 422 man-made public lakes discussed in this section, 279 (66.1%) are dammed impoundments, 86 (20.4%) are upground reservoirs, and 57 (13.5%) are dug-out lakes. Three lakes are more than 5000 acres: Grand Lake St. Marys at 12,700 acres, Mosquito Creek Reservoir at 7,850 acres, and Indian Lake at 5,104 acres (Pymatuning Lake is 14,658 acres, but the majority lies in Pennsylvania). An additional 27 lakes range between 1,000 and 5,000 acres. Together, the 30 lakes larger than 1000 acres represent 84,336 (71%) of the total acres of inland public lake water in Ohio. A large number of public lakes (282) are from 5 to 50 acres in size, but these lakes collectively represent only 3.9 % (4,657 acres) of the total acres of public water (Davic et al. 1996). All of these waters have become important multi-use resources and provide important habitat for a number of aquatic and terrestrial species.

Ohio reservoirs are generally shallow (median depth 13.5 feet), and fertile. Ohio’s deepest reservoirs are East Fork and Caesar Creek, with maximum depths of nearly 121 feet, but all other reservoirs have maximum depths of less than 72 feet. Sixty percent of Ohio reservoirs are eutrophic, 19% are mesotrophic, 17% are hypereutrophic, and less than 5% are oligotrophic based on Carlson Trophic State Indicators (Davic et al. 1996). The range of productivity can vary greatly statewide depending upon landcover in the watershed. Knoll et al. (2003) found ranges of phosphorus from 27-153 ug/l, and chlorophyll-a from 5-56 ug/l in 12 tributary reservoirs with watersheds that spanned a gradient of 29% to 89% agricultural land use. Trophic state values do not differ substantially statewide by lake type except for lower values in upground reservoirs, that because of their morphology, control runoff. Another pattern that emerges is the distribution of low trophic state scores in the relatively nutrient poor Western Allegheny Plateau ecoregion and the higher scores in the intensively farmed Huron Erie Lake Plain. This pattern matches that observed for streams and rivers in Ohio (Davic et al. 1996).

Land cover across Ohio is 59% agricultural, 31% forest, 6% urban, and 3% wetland, with the balance in other cover types, but reservoir watersheds are predominately agriculture (64%) with very little urban use (3%) (Renwick and Andereck 2005). Agricultural land use can cause significant soil erosion and sedimentation, resulting in increased nitrogen and phosphorus loading, reduced storage capacity, and shortened reservoir life expectancy. Renwick and Andereck (2005) found reservoir sedimentation rates in 68 Ohio reservoirs to be highly variable, ranging from 2.4-23.8 yd^3/ac/y – values typical in Midwestern reservoirs. Extensive sedimentation often occurs in reservoirs with rapid exchange of water volume resulting from large watershed area to reservoir storage volume ratios. Ohio reservoirs with high watershed area to reservoir volume ratios can completely exchange total reservoir volume in less than three weeks (e.g. Dillon, Delaware, O’Shaughnessy, Paint Creek, Charles Mill, and Stonelick reservoirs). However, the median time to complete replacement of volume is 155 days (ODNR unpublished data). Throughout the Midwest, sedimentation rates have been reduced through improved agricultural practices

(Renwick and Andereck 2005; Renwick et al. 2005), suggesting that land management may be more important than land use in addressing sedimentation.

Of the 136 public lakes/ponds/reservoirs assessed by the Ohio EPA relative to aquatic life use attainment, 93 (68%) fully met, 30 (22%) partially met, and 13 (10%) did not meet designated life-use criteria. Major and moderate sources of non-attainment are primarily nonpoint in origin. Agricultural nonpoint sources are by far having the greatest influence with major and moderate effects on over 12,000 acres and threatening over 28,000 more. Other significant nonpoint sources with major and moderate magnitude impacts include hydromodification (> 4,000 acres), construction (>2,000 acres), urban runoff (>1,000 acres) and septic systems (1,400 acres). Point sources (all categories) have major or moderate impacts on greater than 7,000 acres of Ohio lakes. These sources of impact mirror those in Ohio rivers and streams (i.e., the predominance of nonpoint sources) and support a movement toward a watershed approach to water resource restoration in Ohio (Davic et al. 1996).

Most (probably all) Ohio lakes/reservoirs/ponds have been altered due to management and/or restoration activities. Primary alterations result from activities that (1) affect the biological community (fish stocking, nuisance fish removal, aquatic plant and algae control), and/or (2) influence productivity (nutrient addition or nutrient reduction), and alter physical habitat (dredging, shoreline alteration, drawdowns, artificial structure additions).

6.18.3 Associated Species of Greatest Conservation Need

The water bodies that comprise this habitat category were for the most part not constructed with aquatic species in mind. Man-made reservoirs/lakes/ponds serve a number of purposes, with water supply and flood control topping the list. Recreational opportunities vary with the size of the water body, but are rarely the primary intended purpose. Consequently, little to no regard for aquatic habitat goes into the construction and subsequent management of these waters. What habitat exists is to a large degree influenced by the watershed to surface acres ratio of a given body of water. On-stream impoundments in particular tend to serve as settling basins for sediment transported by source streams. The result after several years of existence is a homogenization of habitats from silt/sediment deposition. In addition, fluctuating water levels negatively impact littoral habitats and aquatic species throughout the year.

Despite the issues described above, a number of aquatic species survive and flourish in these systems. While species diversity is not extremely high, and threatened/rare species are not usually represented, these waters still provide significant habitat for a number of warm and cool water species. Man-made reservoirs/lakes/ponds are the primary habitat for sunfish species (Centrarchidae), and constitute a significant portion of habitat for catfishes (Ictaluridae), minnows (Cyprinidae), suckers (Catostomidae), a handful of mussel species, and the mudpuppy. Overall, the fish and invertebrate community tends to be a combination of resident species from the impounded stream that can tolerate the lentic conditions of the reservoir that has been created, and introduced species (both natural and stocked).

The following species have been identified as Man-made Lakes and Ponds species of greatest conservation need (conservation status rank in parentheses):

<u>Fish</u>

Lake Chubsucker (46)	*Erimyzon sucetta*

<u>Amphibians</u>

Mudpuppy (14)	*Necturus maculosus maculosus*
Red-spotted Newt (20)	***Notophthalmus viridescens viridescens***

Table 45. CONSERVATION THREATS TO MAN-MADE LAKES AND PONDS.
The following threats negatively impact or have the potential to negatively impact Man-made Lakes and Ponds. Threat categories/classification from Salafsky et al. (2008), and threat impact rank calculations from Master et al. (2012).

ID	threats	2nd level threat classification(s)	threat impact rank
I	**residential and commercial development**		low
A	Watershed conversion to urban/commercial development alters hydrology	housing & urban areas commercial & industrial areas	low low
B	Waterfront development and its effect on nearshore habitat and species	housing & urban areas tourism & recreation areas	low low
C	Increasing land prices limit our ability to protect riparian corridors - which affects water quality and habitat in lakes	housing & urban areas commercial & industrial areas	low low
II	**agriculture and aquaculture**		low
A	Loss of riparian corridor to agriculture - which affects water quality and habitat	annual & perennial non-timber crops livestock farming & ranching	low low
B	Watershed conversion to agriculture alters hydrology	annual & perennial non-timber crops livestock farming & ranching	low low
III	**energy production and mining**		medium
A	Oil and gas extraction - can have negative impacts by causing chemical contamination	oil & gas drilling	medium
B	Water withdrawal for fracking alters hydrology	oil & gas drilling	medium
IV	**transportation and service corridors**		low
A	Roads/bridges/causeways and utilities can destroy habitat, alter hydrology	roads & railroads utility & service lines	low low
B	Dredging to accommodate recreational watercraft can destroy habitat and affect water quality	shipping lanes	low
V	**biological resource use**		low
A	Fishing pressure and fishing gear impacts	fishing & harvesting aquatic resources	low
VI	**human intrusions and disturbance**		medium
A	Incompatible recreational activities	recreational activities	medium
B	Creation of recreational facilities can alter/destroy nearshore habitat	recreational activities	medium
C	Negative impacts of recreational watercraft on water quality and nearshore habitat	recreational activities	medium
VII	**natural system modifications**		high
A	Aging of reservoirs and the sediment they have collected destroys habitat and reduces species diversity and abundance	dams & water management/use	high

B	Dam operations affect habitat and species by changing water levels	dams & water management/use	high
C	Conflicting water control management objectives of controlling agencies (DOW – USACOE)	dams & water management/use	high
D	Seasonal hypolimnetic hypoxia and anoxia in many Ohio lakes and reservoirs substantially reduces deepwater habitat available to aquatic species	other ecosystem modifications	low
E	Chemical treatments applied to upground reservoirs to reduce algal production, for the purpose of maintaining the quality of municipal drinking water, can retard the production of the zooplankton needed to support the feeding of fish early life stages	other ecosystem modifications	low
F	Lack of data for some species and habitats limits our ability to develop plans for threats like climate change	other ecosystem modifications	low
VIII	**invasive and other problematic species and genes**		medium
A	Introduction and/or spread of invasive plants and animals	invasive non-native/alien species	medium
B	Introduction and/or spread of nuisance plants and animals	problematic native species	low
C	Introduction and spread of diseases (plants and animals)	invasive non-native/alien species problematic native species	medium low
IX	**pollution**		medium
A	Urban effluent carries a variety of substances that impact water quality and aquatic species	household sewage & urban wastewater industrial & military effluents garbage & solid waste air-borne pollutants	low low low low
B	Agricultural effluent from row crops as well as confined animal operations impacts water quality and aquatic species	agricultural & forestry effluents	high
C	Pesticides/herbicides from waterfront property owners impact water quality	household sewage & urban wastewater	low
D	Harmful algal blooms affect water quality, aquatic species, and can be toxic to terrestrial species	agricultural & forestry effluents	high
X	**geological events**		negligible
---	none	---	---
XI	**climate change and severe weather**		low
A	Climate change could impact habitats, water quality, and species	habitat shifting & alteration droughts temperature extremes storms & flooding	low low low low

Table 46. CONSERVATION ACTIONS FOR MAN-MADE LAKES AND PONDS.
The following actions will help abate or have the potential to help abate threats to Man-made Lakes and Ponds. Action categories/classification from Salafsky et al. (2008), and action priority rank calculations from Georgia DNR (2005).

ID	actions	2nd level action classification(s)	action priority rank	threat(s) addressed*
I	**LAND/WATER PROTECTION**		high	
1	Protect shoreline habitat and upstream riparian habitat through acquisition, partnerships, conservation easements, etc.	site/area protection resource & habitat protection	med high	I, II, IV-A, VI-B
II	**LAND/WATER MANAGEMENT**		med	
1	Identify the watershed characteristics that have the strongest influence on the quality of lake and reservoir habitats	habitat & natural process restoration	high	I-A, II-B, VII-A, IX
2	Develop a protocol for the collection and analysis of physical habitat data using high-frequency side scan sonar	habitat & natural process restoration	high	IV-B, VI-C, VII-A
3	Support and encourage efforts by the Ohio EPA and other agencies to assess the overall condition of Ohio's lakes	habitat & natural process restoration	high	I, II, III, IV, V, VI, VII, VIII, IX, XI
4	Annually collect lower trophic data to understand watershed impacts on fish communities, and how changes in land use may influence lake/reservoir productivity	habitat & natural process restoration	high	I-A, II-B, VII-A, IX
5	Research how reservoir aging affects productivity and influences abundance and condition of aquatic species	habitat & natural process restoration	high	VII-A
6	Complete development of a reservoir classification system that improves our understanding of the physical, chemical, and biological characteristics of reservoirs in a way that allows us to better manage aquatic species	habitat & natural process restoration	high	I, II, III, IV, V, VI, VII, VIII, IX, XI
7	Create and use wetlands for stormwater treatment	habitat & natural process restoration	high	I-A, IX-A
8	Develop a process for coordinating disparate data sources of distribution and abundance of aquatic SGCN with special emphasis on conservation opportunity watersheds	habitat & natural process restoration	high	I-B, IV, VI-B, VII-A,B,C,F, XI
9	Review existing species and habitat data to identify data gaps and needs for additional surveys, research, and management actions	habitat & natural process restoration	high	I, II, III, IV, V, VI, VII, VIII, IX, XI
10	Conduct comprehensive surveys of freshwater mussels in all conservation opportunity watersheds	habitat & natural process restoration	high	I-B, III-B, IV, VII-A,B,C,D,F, XI
11	Establish an early-detection/rapid-response system for dealing with invasive and nuisance species	invasive/ problematic species control	med	VIII-A,B

12	Determine the effect that spatial and temporal variations in water temperature and dissolved oxygen have on the quantity and quality of habitat	site/area management	low	VII-B,C,D
13	Evaluate the affect of common water level management practices and control structure type on in-lake habitat	site/area management	low	VII-B,C,D
14	Research how hydrologic pulsing influences aquatic species, as well as reservoir productivity	site/area management	low	VII-B,C
15	Develop compatible recreational activities criteria that can be used to evaluate impacts to habitat/species from recreational activities	site/area management	low	VI
III	**SPECIES MANAGEMENT**		low	
---	none	---	---	---
IV	**EDUCATION AND AWARENESS**		med	
1	Educate waterfront landowners and commercial pesticide/herbicide applicators on responsible chemical use, and the negative impacts to wildlife from toxic chemicals	training	med	I-B,C, IX-A,C
2	Promote conservation easements to protect riparian habitat of inlet streams	training awareness & communic-ations	med med	I, II, IV-A, VI-B, VII-A,D, IX, XI
3	Provide technical guidance on shoreline development plans as relates to fish and wildlife interests	training	med	I, IV-A, VI-B, XI
4	Educate the public about the negative effects of exotic and nuisance animals – encourage responsible disposal of unwanted animals	awareness & communic-ations	med	VIII
5	Provide training to road construction/maintenance personnel for runoff/sediment control	training	med	I-B, IV-A
6	Educate boaters about the negative impacts power boats can have on aquatic habitats	training awareness & communic-ations	med med	VI-A,C
V	**LAW AND POLICY**		med	
1	Support legislation promoting eco-friendly energy development and use	legislation	med	III
2	Find innovative ways to mandate the inclusion of fish and wildlife interests in development plans	policies & regulations private sector standards & codes	med med	I, III, IV, VI-B, IX-A, XI
3	Support the creation of additional and/or increased enforcement of stormwater regulations	policies & regulations compliance & enforcement	med med	I-A, IX-A
4	Develop and implement a risk-assessment system in the approval process for importing or moving live animals and plants	legislation policies & regulations	med med	VIII
5	Encourage and support minimum flow regulations that protect downstream aquatic habitats	policies & regulations	med	III-B, VII-C, IX

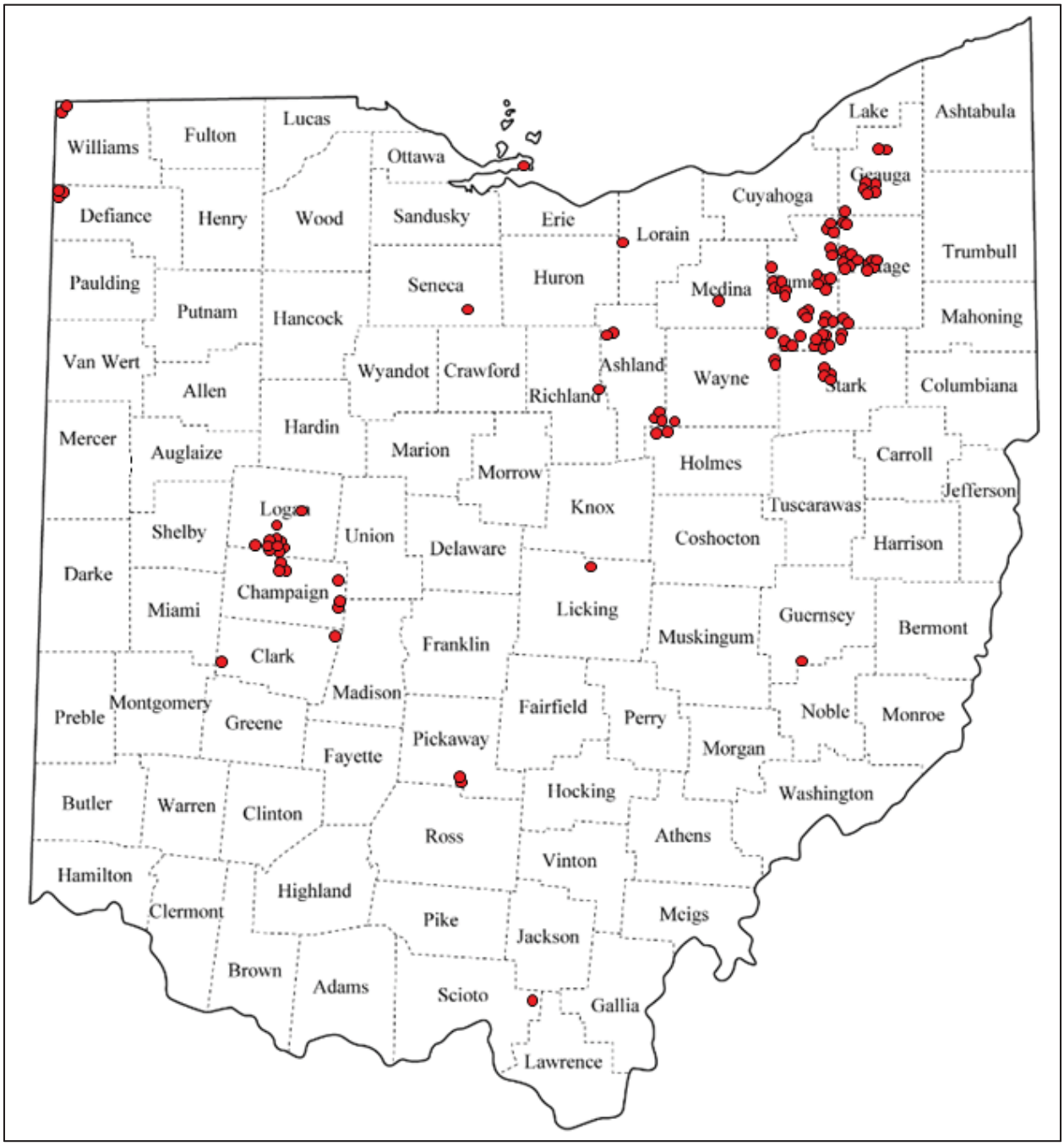
6	Support increased regulation of home sewage treatment systems	compliance & enforcement	med	IX-A
VI	**LIVELIHOOD, ECONOMIC AND OTHER INCENTIVES**		med	
1	Explore tying eligibility for grant money, loans, and cost-share programs to nutrient loading levels for agriculture – the lower the nutrient levels in their effluent, the more money they would be eligible for	market forces conservation payments	med med	IX-B, XI
2	Create incentives for vegetated buffers along all waterways to reduce nutrient loads and sediment	market forces conservation payments	med med	I, II, VII-A,D, IX, XI
3	Create incentives to promote eco-friendly energy development and use	market forces conservation payments non-monetary values	med med low	III
4	Support the creation of incentives to protect shoreline habitat	market forces conservation payments	med med	I, II, IV-A, VI, XI
5	Develop incentives for municipalities to use stormwater management systems that minimize negative impacts to aquatic habitats	market forces conservation payments	med med	I-A, IX-A
6	Support incentives for development plans involving water frontage that take into account wildlife and habitat needs	market forces conservation payments non-monetary values	med med low	I-B, IV-A, VI-B, IX-A,C
7	Support clean marina and clean vessel programs	market forces conservation payments	med med	VI-C
VII	**EXTERNAL CAPACITY BUILDING**		med	
1	Work with ODA and OEPA to minimize nutrients in runoff, and develop BMPs for pesticide/herbicide use	alliance & partnership development	high	IX
2	Consider creating a multiagency invasive species prevention and control group that would handle all invasive species issues	alliance & partnership development	high	VIII
3	Through interagency coordination, work to assure that wildlife interests are taken into consideration in road, bridge, and causeway design, construction, and maintenance	alliance & partnership development	high	IV-A
4	Through interagency coordination work to establish an inland lake monitoring program to collect baseline and long-term chemical, physical, and biological data for all of Ohio's public lakes	alliance & partnership development	high	I, II, III, IV, V, VI, VII, VIII, IX, XI

5	Use inter-agency cooperation to influence watershed health	alliance & partnership development	high	I, II, VII-A,D, IX, XI
6	Work with controlling authorities (i.e., US Army Corps of Engineers) to develop water management plans that are conducive to sustaining reservoir aquatic species populations and habitats	alliance & partnership development	high	IV-B, VI, VII-B,C,D
7	Attend and actively collaborate with watershed partnerships	institutional & civil society development alliance & partnership development	med high	I, II, III, IV-A, VI-A,B, VII-A,D, IX, XI
8	Increase personnel and expertise available for SGCN surveys and research through partnerships with other government agencies, universities, and conservation-minded NGO's	institutional & civil society development alliance & partnership development	med high	I, II, III, IV, V, VI, VII, VIII, IX, XI

*refers to the Man-made Lakes and Ponds Habitat Conservation Threats in Table 45

6.19 Natural Lakes

Ohio's Natural Lakes >5 acres



6.19.1 Status

Generally good, although much like man-made lakes and ponds, assessment data is limited. Aquatic life use data available for natural lakes indicated a high degree of attainment.

6.19.2 Description

The following information was assembled from *Natural Lakes in Ohio* (Black 1991).

There are 110 natural lakes in Ohio larger than five acres, covering a total surface area of 4,658 acres. These lakes occur in 21 of Ohio's 88 counties. Summit County has the most natural lakes with 34, followed by Portage County with 16, and Geauga County with 9.

Many (probably most) of Ohio's natural lakes have been altered to some degree by human activities. Some lakes have been drained, others completely inundated by manmade reservoirs. Some lakes have been enlarged by the addition of levees or dikes. Some lakes have had outlet control structures installed or outlet streams enlarged, thereby controlling lake levels. The vast majority of Ohio's natural lakes formed in the aftermath of the most recent ice age. A few are post-glacial in origin, created from cutoff stream oxbows.

The 20 largest natural lakes in Ohio are:
1. Aurora Pond, Portage County 345 acres
2. Chippewa Lake, Medina County 324 acres
3. Turkeyfoot Lake, Summit County 318 acres
4. Wingfoot Lake, Portage County 262 acres
5. Congress Lake, Stark County 200 acres
6. Springfield Lake, Summit County 200 acres
7. Lake Hodgson, Portage County 190 acres
8. Lake Pippen, Portage County 143 acres
9. Meyers Lake, Stark County 134 acres
10. Bass Lake, Geauga County 128 acres
11. Odell Lake, Holmes County 107 acres
12. Punderson Lake, Geauga County 101 acres
13. Summit Lake, Summit County 100 acres
14. Nettle Lake, Williams County 94 acres
15. West Twin Lake, Portage County 91 acres
16. Silver Lake, Summit County 91 acres
17. Sandy Lake, Portage County 90 acres
18. Sippo Lake, Stark County 88 acres
19. Muzzy Lake, Portage County 82 acres
20. Lake Nesmith, Summit County 80 acres

6.19.3 Associated Species of Greatest Conservation Need

While natural lakes do not constitute a large portion of Ohio's aquatic habitats, either numerically or from an acreage standpoint, they are home to some of Ohio's rare species. State listed (endangered) western banded killifish, Iowa darters, and pirate perch for example, have been found in natural lakes – primarily in the northern part of the state.

The following species have been identified as Natural Lakes species of greatest conservation need (conservation status rank in parentheses):

<u>Amphibians</u>	
Red-spotted Newt (20)	***Notophthalmus viridescens viridescens***
<u>Fish</u>	
Blacknose Shiner (22)	*Notropis heterolepis*
Western Banded Killifish (30)	*Fundulus diaphanus menona*
Iowa Darter (38)	*Etheostoma exile*
Pirate Perch (51)	*Aphredoderus sayanus*

Table 47. CONSERVATION THREATS TO NATURAL LAKES.
The following threats negatively impact or have the potential to negatively impact Natural Lakes. Threat categories/classification from Salafsky et al. (2008), and threat impact rank calculations from Master et al. (2012).

ID	threats	2nd level threat classification(s)	threat impact rank
I	**residential and commercial development**		high
A	Watershed conversion to urban/commercial development alters hydrology	housing & urban areas commercial & industrial areas	very high low
B	Waterfront development and its effect on nearshore habitat and species	housing & urban areas tourism & recreation areas	very high low
C	Increasing land prices limit our ability to protect riparian corridors - which affects water quality and habitat in lakes	housing & urban areas commercial & industrial areas	very high low
II	**agriculture and aquaculture**		medium
A	Loss of riparian corridor to agriculture - which affects water quality and habitat	annual & perennial non-timber crops livestock farming & ranching	medium medium
B	Watershed conversion to agriculture alters hydrology	annual & perennial non-timber crops livestock farming & ranching	medium medium
III	**energy production and mining**		low
A	Oil and gas extraction - can have negative impacts by causing chemical contamination	oil & gas drilling	low
B	Water withdrawal for fracking alters hydrology	oil & gas drilling	low
IV	**transportation and service corridors**		low
A	Roads/bridges/causeways and utilities can destroy habitat, alter hydrology	roads & railroads utility & service lines	low low
V	**biological resource use**		low
A	Fishing pressure and fishing gear impacts	fishing & harvesting aquatic resources	negligible
VI	**human intrusions and disturbance**		low
A	Incompatible recreational activities	recreational activities	negligible
B	Creation of recreational facilities can alter/destroy nearshore habitat	recreational activities	negligible
C	Negative impacts of recreational watercraft on water quality and nearshore habitat	recreational activities	negligible
VII	**natural system modifications**		medium
A	Seasonal hypolimnetic hypoxia and anoxia can substantially reduce deepwater habitat available to aquatic species	other ecosystem modifications	high
B	Lack of data for some species and habitats limits our ability to develop plans for threats like climate change	other ecosystem modifications	high

C	Some species' polulations have been reduced to levels below what is necessary to recover on their own	other ecosystem modifications	Low
VIII	**invasive and other problematic species and genes**		high
A	Introduction and/or spread of invasive plants and animals	invasive non-native/alien species	high
B	Introduction and/or spread of nuisance plants and animals	problematic native species	low
C	Introduction and spread of diseases (plants and animals)	invasive non-native/alien species problematic native species	high low
IX	**pollution**		high
A	Urban effluent carries a variety of substances that impact water quality and aquatic species	household sewage & urban wastewater industrial & military effluents garbage & solid waste air-borne pollutants	high low low low
B	Agricultural effluent from row crops as well as confined animal operations impacts water quality and aquatic species	agricultural & forestry effluents	high
C	Pesticides/herbicides from waterfront property owners impact water quality	household sewage & urban wastewater	high
D	Harmful algal blooms affect water quality, aquatic species, and can be toxic to terrestrial species	agricultural & forestry effluents	high
X	**geological events**		negligible
---	none	---	---
XI	**climate change and severe weather**		high
A	Climate change could impact habitats, water quality, and species	habitat shifting & alteration droughts temperature extremes storms & flooding	very high low negligible negligible

Table 48. CONSERVATION ACTIONS FOR NATURAL LAKES.
The following actions will help abate or have the potential to help abate threats to Natural Lakes. Action categories/classification from Salafsky et al. (2008), and action priority rank calculations from Georgia DNR (2005).

ID	actions	2nd level action classification(s)	action priority rank	threat(s) addressed*
I	**LAND/WATER PROTECTION**		high	
1	Protect shoreline habitat and upstream riparian habitat through acquisition, partnerships, conservation easements, etc.	site/area protection resource &	high high	I, II, IV, VI-B

		habitat protection		
II	**LAND/WATER MANAGEMENT**		med	
1	Develop a process for coordinating disparate data sources of distribution and abundance of aquatic SGCN with special emphasis on conservation opportunity watersheds	habitat & natural process restoration	high	I-B, IV, VI-B, VII, XI
2	Review existing species and habitat data to identify data gaps and needs for additional surveys, research, and management actions	habitat & natural process restoration	high	I, II, III, IV, V, VI, VII, VIII, IX, XI
3	Conduct comprehensive surveys of freshwater mussels in all conservation opportunity watersheds	habitat & natural process restoration	high	I-B, III-B, IV, VII, XI
4	Annually collect lower trophic data to understand watershed impacts on fish communities, and how changes in land use may influence lake/reservoir productivity	habitat & natural process restoration	high	I-A, II-B, VII-A, IX
5	Create and use wetlands for stormwater treatment	habitat & natural process restoration	high	I-A, IX-A
6	Support and encourage efforts by the Ohio EPA and other agencies to assess the overall condition of Ohio's lakes	habitat & natural process restoration	high	I, II, III, IV, V, VI, VII, VIII, IX, XI
7	Establish an early-detection rapid-response system for dealing with invasive and nuisance species	invasive/ problematic species control	med	VIII
8	Develop compatible recreational activities criteria that can be used to evaluate impacts to habitat/species from recreational activities	site/area management	med	VI
III	**SPECIES MANAGEMENT**		med	
1	Assess population status, habitat suitability, and probability for restoration of fish, mussels, crayfish, invertabrates, and amphibians listed as SGCN	species reintroduction	High	VII-B, VII-C
2	Develop a restoration strategy for high priority fish, mussels, crayfish, invertebrates, and amphibians	species reintroduction	High	VII-B, VII-C
IV	**EDUCATION AND AWARENESS**		high	
1	Educate waterfront landowners and commercial pesticide/herbicide applicators on responsible chemical use, and the negative impacts to wildlife from toxic chemicals	training	high	I-B,C, IX-A,C
2	Provide training to road construction/maintenance personnel for runoff/sediment control	training	high	I-B, IV
3	Promote conservation easements along shoreline habitat and riparian habitat of inlet streams	training awareness & communic-ations	high med	I, II, IV, VI-B, VII, IX, XI
4	Educate boaters about the negative impacts power boats can have on aquatic habitats	training awareness & communic-ations	high med	VI-A,C
5	Educate the public about the negative effects of exotic and nuisance animals – encourage responsible disposal of unwanted animals	awareness & communic-ations	med	VIII

V	**LAW AND POLICY**		med	
1	Support legislation promoting eco-friendly energy development and use	legislation	med	III
2	Develop and implement a risk-assessment system in the approval process for importing or moving live animals and plants	legislation policies & regulations	med med	VIII
3	Find innovative ways to mandate the inclusion of fish and wildlife interests in development plans	policies & regulations private sector standards & codes	med low	I, III, IV, VI-B, IX-A, XI
4	Support the creation of additional and/or increased enforcement of stormwater regulations	policies & regulations compliance & enforcement	med low	I-A, IX-A
VI	**LIVELIHOOD, ECONOMIC AND OTHER INCENTIVES**		low	
1	Explore tying eligibility for grant money, loans, and cost-share programs to nutrient loading levels for agriculture – the lower the nutrient levels in their effluent, the more money they would be eligible for	market forces conservation payments	low low	IX-B, XI
2	Create incentives for vegetated buffers along all waterways to reduce nutrient loads and sediment	market forces conservation payments	low low	I, II, VII, IX, XI
3	Create incentives to promote eco-friendly energy development and use	market forces conservation payments non-monetary incentives	low low low	III
4	Support the creation of incentives to protect shoreline habitat	market forces conservation payments	low low	I, II, IV, VI, XI
5	Develop incentives for municipalities to use stormwater management systems that minimize negative impacts to aquatic habitats	market forces conservation payments	low low	I-A, IX-A
6	Support incentives for development plans involving water frontage that take into account wildlife and habitat needs	market forces conservation payments non-monetary values	low low low	I-B, IV, VI-B, IX-A,C

VII	EXTERNAL CAPACITY BUILDING		med	
1	Attend and actively collaborate with watershed partnerships	institutional & civil society development alliance & partnership development	med low	I, II, III, IV, VI-A,B, VII, IX, XI
2	Increase personnel and expertise available for SGCN surveys and research through partnerships with other government agencies, universities, and conservation-minded NGO's	institutional & civil society development alliance & partnership development	med low	I, II, III, IV, V, VI, VII, VIII, IX, XI
3	Work with ODA and OEPA to minimize nutrients in runoff, and develop BMPs for pesticide/herbicide use	alliance & partnership development	low	IX
4	Consider creating a multiagency invasive species prevention and control group that would handle all invasive species issues	alliance & partnership development	low	VIII
5	Through interagency coordination, work to assure that wildlife interests are taken into consideration in road, bridge, and causeway design, construction, and maintenance	alliance & partnership development	low	IV
6	Use inter-agency cooperation to influence watershed health	alliance & partnership development	low	I, II, VII, IX, XI

*refers to the Natural Lakes Habitat Conservation Threats in Table 47