Big Creek
Nonpoint Source Implementation Strategy

Version 1.1
May 27, 2017
Approved: June 9, 2017
Updated: March 2020 by West Creek Conservancy

Version 1.1 Approved: April 14, 2020

PRESENTED TO

Big Creek Connects
4352 Pearl Road, Suite C
Cleveland, OH 44109

West Creek Conservancy
1440 Rockside Road, Suite 329
Parma, OH 44134

PRESENTED BY

Tetra Tech, Inc.
1468 W. 9th Street, #620
Cleveland, OH 44113

(216) 861-2950
tetratech.com

(This page left intentionally blank.)

CONTENTS

TABLES

FIGURES

ABBREVIATIONS AND ACRONYMS

Acronyms/Abbreviations	Definition
ALU	aquatic life use
BCC	Big Creek Connects
BTU	building, transportation infrastructure, or utilities infrastructure
CM	Cleveland Metroparks
GLRI	Great Lakes Restoration Initiative
HUC	hydrologic unit code
IBI	Index of Biotic Integrity
ICI	Invertebrate Community Index
lb/yr	pounds per year
NEORSD	Northeast Ohio Regional Sewer District
NPS-IS	Nonpoint Source Implementation Strategy
Ohio EPA	Ohio Environmental Protection Agency
PSS	project summary sheet
QHEI	Qualitative Habitat Evaluation Index
TBD	to be determined
TSS	total suspended solids
U.S. EPA	U.S. Environmental Protection Agency
WAP	watershed action plan
WAU	watershed assessment unit
WCC	West Creek Conservancy
WWH	warmwater habitat

ACKNOWLEDGEMENTS

Big Creek Connects would like to thank all the organizations that contributed to this nonpoint source implementation strategy. Thanks are also given to: Tetra Tech, Inc., for compiling and evaluating data and for writing this plan. The following agencies, organizations, and contractors contributed to this project:

- Big Creek Connects
- Cleveland Metroparks
- City of Brook Park
- City of Brooklyn
- City of Cleveland
- City of Parma
- City of Parma Heights
- Northeast Ohio Regional Sewer District
- Ohio Environmental Protection Agency
- Tetra Tech, Inc.
- West Creek Conservancy

1 INTRODUCTION

Big Creek is a tributary to the Cuyahoga River in the *Big Creek* watershed assessment unit (WAU; hydrologic unit code [HUC] 04110002 06 03). The Big Creek subwatershed is 39 square miles, which is just below 5 percent of the Cuyahoga hydrologic unit (HUC 04110002). Big Creek discharges to the lower Cuyahoga River, within the Cuyahoga River large river assessment unit[1], within a sequence of WAUs[2] along the Cuyahoga River.

State and federal nonpoint source funding is now closely tied to strategic implementation-based planning that meets the U.S. Environmental Protection Agency's (U.S. EPA) nine minimum elements of a watershed plan for impaired waters. Big Creek Connects (BCC)[3] has taken the lead in authoring this NPS-IS. BCC is working with other watershed groups and municipalities to collaborate with the development of Nine-Element Nonpoint Source Implementation Strategic Plans several tributaries to the lower Cuyahoga River. This NPS-IS for the Big Creek watershed is one of four under development or being planned for the Cuyahoga River watershed.

Figure 1. Old Pear Road Bridge over Big Creek.

[1] The Cuyahoga River large river assessment unit (04110002 90 01) begins at the confluence of Brandywine Creek, at the upstream boundary of the *Willow Lake-Cuyahoga River* (HUC 04110002 05 05), and continues downstream to the mouth of the Cuyahoga River on Lake Erie, at the downstream boundary of *City of Cleveland-Cuyahoga River* (HUC 04110002 06 05).

[2] This WAU is downstream of *Cuyahoga Heights-Cuyahoga River* (HUC 04110002 06 04) and is upstream of *City of Cleveland-Cuyahoga River* (HUC 04110002 06 05).

[3] Big Creek Connects (BCC) is a 501(c)(3) non-profit organization that was formerly known as Friends of Big Creek.

1.1 REPORT BACKGROUND

This NPS-IS is the first document of its kind for the Big Creek watershed. No watershed action plan was previously developed for Big Creek. In 2010 BCC and the Cuyahoga River Community Planning Organization published a Balanced Growth Plan that was endorsed by the state in 2011. (CRCPO 2010). The plan identified *Priority Conservation Areas*, *Priority Development Areas*, and potential stormwater retrofits throughout the watershed. BCC has been actively investigating stormwater retrofits that were assessed further in two follow-up studies by Tetra Tech, Inc., hired by BCC. Several concept plans were developed in the Stormwater Retrofit Study and one of those, the Fern Hill Stormwater Treatment Wetland, was completed in 2015. Other retrofits are in the development process.

Figure 2. Colleda Branch (a tributary to West Branch).

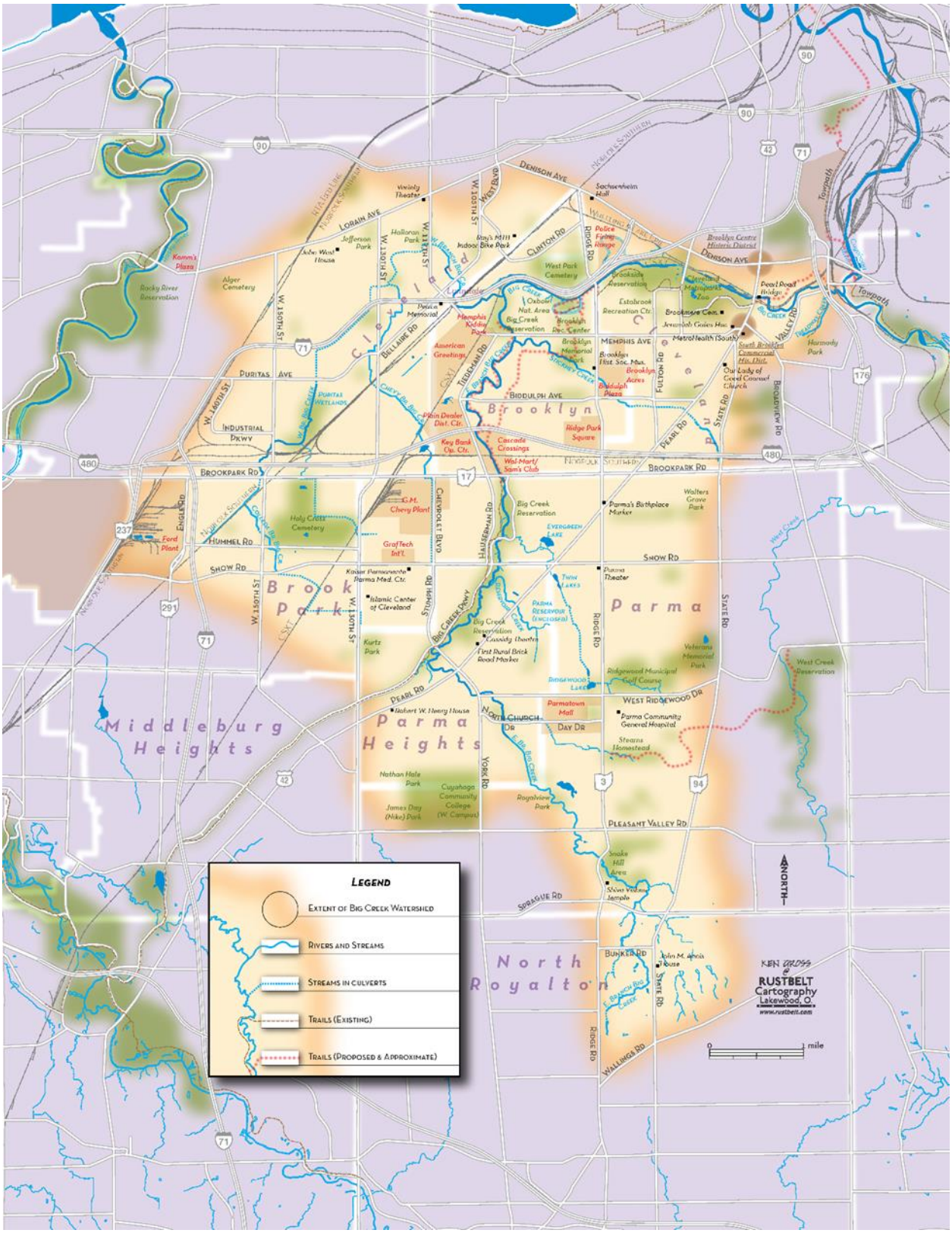
BCC protects local natural areas, open spaces, streams, and waterways; reclaims vacant urban land; restores streams, wetlands, woods, and natural habitats; and establishes trails and greenways to link people and neighborhoods to natural areas. BCC working with West Creek Conservancy acquired two riparian parcels along the East Branch of Big Creek in the city of Brooklyn identified in the Balanced Growth Plan and is continuing to work on acquiring adjacent parcels.

The growing impact of urbanization in Cuyahoga County and the need to increase focused implementation efforts drove the development of this NPS-IS. The hydrography and hydrology of the Big Creek watershed have been significantly altered over the past century as the watershed was developed. Streams were straightened and channelized (Figure 2) and many segments were culverted and piped underground. High levels of impervious cover and storm sewer systems that alter the natural hydrologic regime result in flashy flows with higher streamflow velocities and less baseflow. Altered hydrology combined with degraded habitat in the Big Creek watershed have impaired aquatic community health.

1.2 WATERSHED PROFILE AND HISTORY

Big Creek is 12 miles long and flows through the municipalities of Cleveland, Brooklyn, Linndale, Parma, Parma Heights, Brook Park and North Royalton (BCC 2010; Figure 3). The Big Creek Watershed encompasses seven (7) smaller sub-watersheds, including: Stickney Creek, Lower Big Creek, West Branch, Chevy Branch, East Branch, Colleda Branch, and Upper Big Creek. Big Creek is the northwestern portion of the Cuyahoga River watershed and is one of the most urbanized of the major tributaries to the Cuyahoga River. With a population of over 170,000, the Big Creek communities are largely residential with a mix of public open space, retail, and industrial land uses.

Big Creek is part of the Cuyahoga River Area of Concern, a designation resulting from decades of industrial impacts. At the same time, this helps to garner Federal and State commitments and cooperation with local entities to ensure action plans are developed and implemented. Approximately 1,570 acres of open space remains undeveloped within the Big Creek watershed. Many of these areas hold important watershed resources that area valuable examples of nature in the communities and offer opportunities for restoration. The keys to improving Big Creek include properly conserving these natural areas as communities continue to develop and also restoring areas that have been impacted in the past.



Source: BCC 2010.

Figure 3. Big Creek watershed.

1.3 PUBLIC PARTICIPATION AND INVOLVEMENT

It is important to have diverse involvement in the development of any restoration plan. This should include not only the public but businesses, academia, non-profit groups and organizations. In the Big Creek watershed there are lots of partners working to restore the watershed. Their focus varies from clean streams to neighborhood green space (Figure 4) and beautiful walking and biking trails.

Figure 4. 6th Annual Big Creek Balanced Growth Partnership Meeting.

The BCC works directly with citizens, businesses, governmental agencies, and other non-profit organizations who take local ownership in their rivers, streams, and lakes. BCC strives for clean, clear and safe waters by connecting organizational and individual partners through the protection of natural areas, restoration of streams, creation of recreational trails and greenways, and reclamation of vacant urban land. BCC is one of the principle authors of this NPS-IS for the Big Creek watershed.

Some of the other key partners working in the Big Creek watershed include: Cleveland Metroparks (CM), Cuyahoga County, Cuyahoga Soil and Water Conservation District, the Northeast Ohio Regional Sewer District (NEORSD), and West Creek Conservancy (WCC).

BCC published an overview of the NPS-IS process in the spring 2017 issue of its newsletter, *Big Creek Watershed News & Notes*. Additionally, representatives for BCC, WCC, and Tetra Tech, Inc., discussed the NPS-IS project during the *6th Annual Big Creek Balanced Growth Partnership Meeting* at CM's Watershed Stewardship Center on April 5, 2017. Representatives of BCC and WCC met with representatives from the following municipalities in the spring of 2017 to identify project needs for each municipality: Brook Park, Brooklyn, Cleveland, Parma, and Parma Heights.

This report was primarily authored by Tetra Tech, Inc. Chapters 1 and 2 were written using information from the balanced growth plan (CRCPO 2010) and information provided by BCC and WCC during several meetings. The development of Chapter 3 relied on information from the Balanced Growth Plan (CRCPO 2010) and the *Total Maximum Daily Loads for the Lower Cuyahoga River* (Ohio EPA 2003). Critical areas were delineated by BCC with the assistance of WCC, and NEORSD provided biological and habitat monitoring data that were summarized in Chapter 3. Project information in Chapter 4 was provided by BCC and WCC.

2 WATERSHED CHARACTERIZATION AND ASSESSMENT SUMMARY

2.1 SUMMARY OF WATERSHED CHARACTERIZATION

Big Creek is a wading-sized tributary of the Cuyahoga River that is in the northwest portion of the Cuyahoga hydrologic unit (HUC 04110002). The watershed, like much of the region, is highly developed. The Big Creek watershed is dominated by ageing residential suburbs.

2.1.1 Physical and Natural Features

The Big Creek watershed is an entire WAU (HUC 04110002 06 04). The Big Creek watershed is part of the larger *Big Creek-Cuyahoga River* (HUC 04110002 06) in the *Cuyahoga* subbasin (HUC 04110002). The mouth of Big Creek into the lower Cuyahoga River is about 4 miles downstream of the confluence of West Creek with the Cuyahoga River and about 7 miles upstream of the mouth of the Cuyahoga River on Lake Erie.

Big Creek drops a few hundred feet from 708 feet above mean sea level in the headwaters to 577 feet above mean sea level at the mouth on the Cuyahoga River (BCC 2010). The Big Creek WAU, along with the entire Cuyahoga River watershed, is within the Erie/Ontario Drift and Lake Plain (Woods et al. 2014; level III ecoregion #61), which is also known as the Erie/Ontario Lake Plain). The Big Creek watershed is composed of three level IV ecoregions: Lake Erie Plains (#61a), Low Lime Drift Plain (#61c), and Erie Gorges (#61d).

2.1.2 Land Use and Protection

The Big Creek watershed is predominantly developed (75 percent; Table 1 and Figure 5), followed by developed open space (16 percent) and deciduous forest (7 percent). No crop fields or pasture are present in the watershed anymore. BCC (2010) provides a more detailed distribution of land use (Table 2); over half of land use in the Big Creek watershed is residential. Much of the industrial and commercial/retail land use is along Brookpark Road (OH-17), Lorain Avenue (OH-10), Pearl Road (US-42), State Road (OH-94), and the Norfolk Southern rail lines. The history of development within the Big Creek watershed, including incorporation of communities and development of CM, is summarized in *History of Study Area* section of BCC (2015a).

Several notable landmarks lie within the Big Creek watershed including the Cleveland Metroparks Zoo, and the Brookside and Big Creek Reservations. Larger retail areas include the Shoppes at Parma, formerly Parmatown Mall, and Ridge Park Square in the city of Brooklyn. Notable industrial sites include both the Ford and Chevy plants in the communities of Brook Park and Parma, respectively.

Developed areas consist mostly of urban development with single family homes interspersed with areas of larger residential buildings, commercial and industrial development. Big Creek has been significantly altered to accommodate such development. The lower Cuyahoga River basin is among the most densely populated and industrialized urban areas in Ohio (Ohio EPA 2003). According to the 2000 Census, nearly 170,000 people resided in the Big Creek watershed and most census blocks contained 3,900 to 20,000 people per square mile (BCC 2010, p. A-4). The *Big Creek* hydrologic unit is 39 percent impervious cover with 14 percent canopy cover (Figure 6). Imperviousness varies by subwatershed (BCC 2010, p. 15):

- Chevy Branch (48 percent)
- Colleda Branch (47 percent)
- East Branch (32 percent)
- Lower Branch (41 percent)
- Stickney Creek (44 percent)
- Upper Branch (23 percent)
- West Branch (44 percent)

Table 1. Land cover in the Big Creek watershed, 2011 NLCD

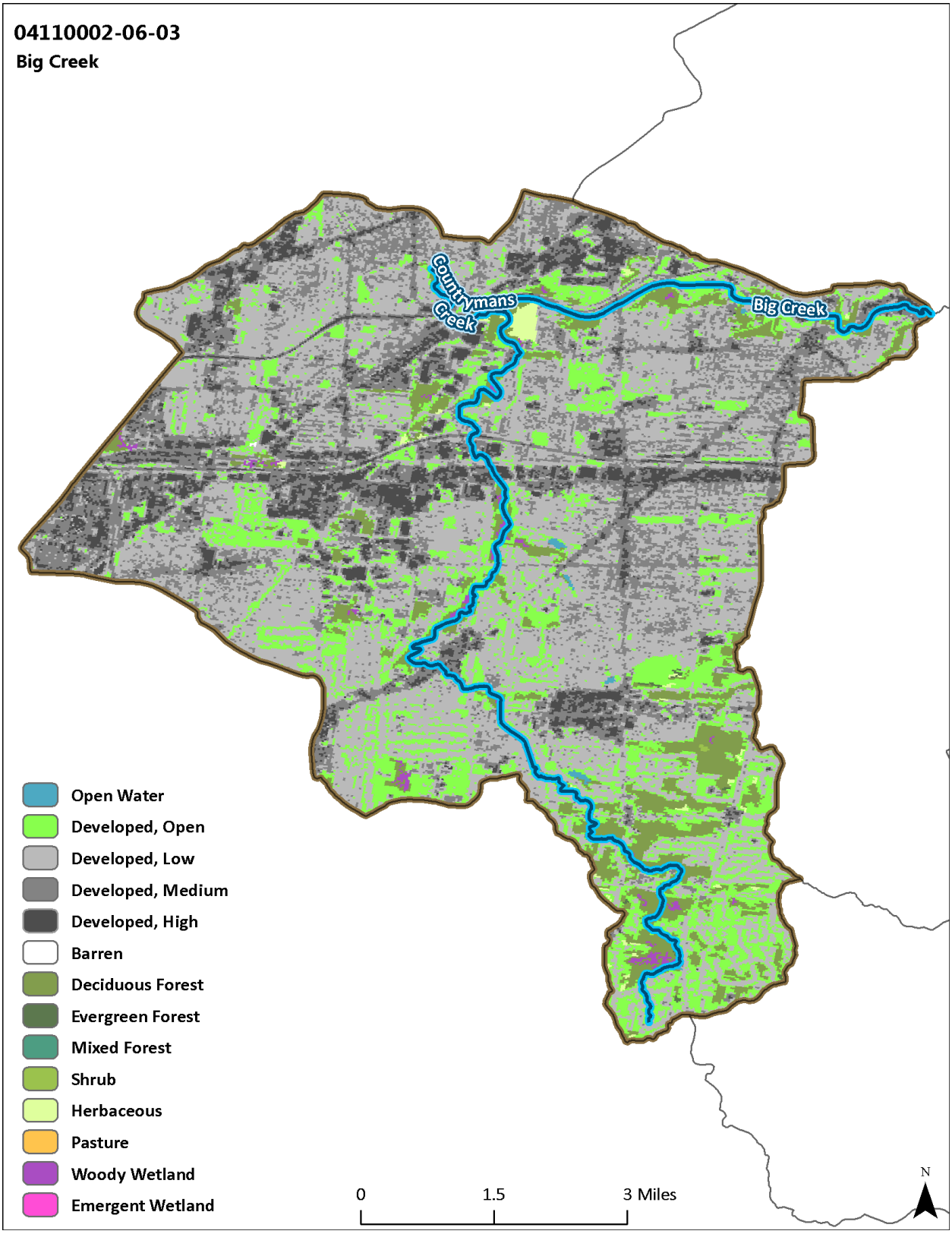
Land cover	*Big Creek* (HUC 04110002 06 03)	
	Area (acres)	Area (%)
Open water	24	<1%
Developed, open	3,909	16%
Developed, low intensity	10,482	44%
Developed, medium intensity	5,720	24%
Developed, high intensity	1,795	8%
Barren land	--	--
Deciduous forest	1,725	7%
Evergreen forest	15	<1%
Mixed forest	--	--
Shrub/scrub	5	<1%
Grassland / herbaceous	102	<1%
Pasture/hay	--	--
Cultivated crops	--	--
Woody wetlands	109	<1%
Emergent herbaceous wetlands	1	<1%
Total [a]	**23,889**	**100%**

Source of spatial data: Jin et al. 2013.
Notes
Areas rounded to the nearest acre or percentage point.
A double dash indicates that the land cover is not present.
a. Totals do not sum exactly due to rounding.

Table 2. Land cover in the Big Creek watershed, 2010

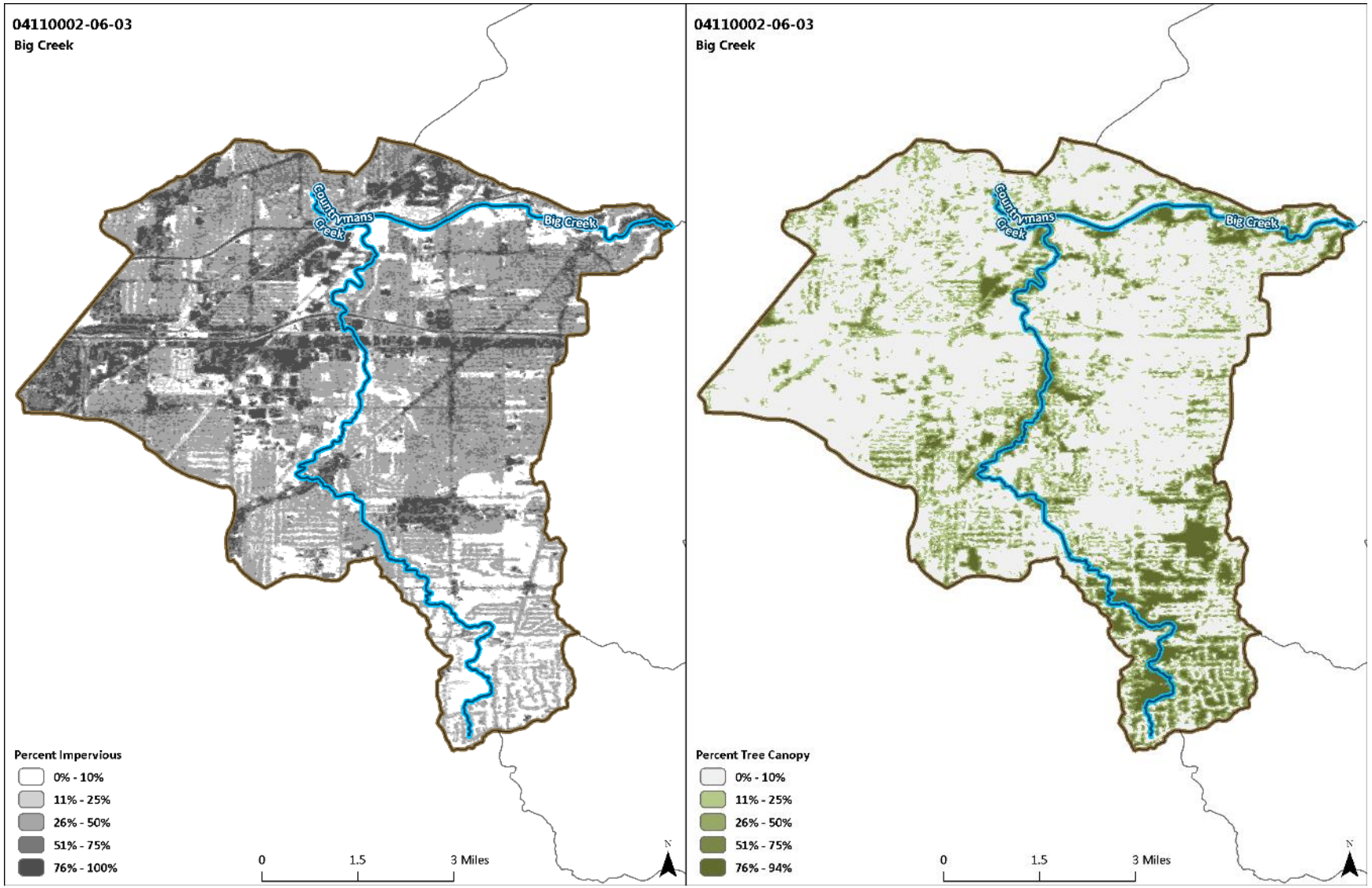
Land cover	*Cuyahoga Heights-Cuyahoga River* (HUC 04110002 06 04)	
	Area (acres)	Area (%)
Single-family residential	9,545	47%
Institutional	3,118	15%
Industrial	2,306	11%
Retail commercial	1,525	8%
Vacant land	966	5%
Utilities	652	3%
Multi-family residential	639	3%
Recreational, park, playground	557	3%
Two-family residential	489	2%
(unclassified)	258	1%
Office	197	1%
Railroad	49	<1%
Total [a]	**20,301**	**100%**

Source of spatial data: Jin et al. 2013.
Notes
Areas rounded to the nearest acre or percentage point.
A double dash indicates that the land cover is not present.
a. Totals do not sum exactly due to rounding.



Source of spatial data: Jin et al. 2013.

Figure 5. Land cover in *Big Creek* (HUC 04110002 06 03).



Source of spatial data: Jin et al. 2013.

Figure 6. Percent impervious cover (left) and canopy cover (right) in *Big Creek* (HUC 04110002 06 04).

Despite the high levels of urban development, the Big Creek watershed has considerable canopy cover in residential developments (especially in upper East Branch subwatershed) and park lands. The largest tracts of protected land in the Big Creek watershed are operated by CM: Big Creek Reservation, Brookside Reservation, and the zoo. Forested areas of Big Creek are generally located within Big Creek Reservation, directly along Big Creek and within the head waters in southern Parma and the northeast corner of North Royalton. These forested portions generally are comprised of second growth and mature forests with few remaining and scattered older forest patches.

BCC has identified several *Priority Conservation Area*s in the Big Creek watershed. *Priority Conservation Areas* are defined as sections of high-quality natural resources that should be preserved; if these areas were to be developed, they would have considerable impact on local water quality and hydrology. These areas can be acquired (e.g., purchase of parcels) and transferred to a public entity for protection in perpetuity or can be protected through conservation easements. Upland, riparian, and in-stream habitat can be enhanced or restored as necessary. *Priority Conservation Areas* are discussed throughout the Balanced Growth Plan (CRCPO 2010). Figure 7 presents an example of the types of assessments that were performed to develop the Balanced Growth Plan.

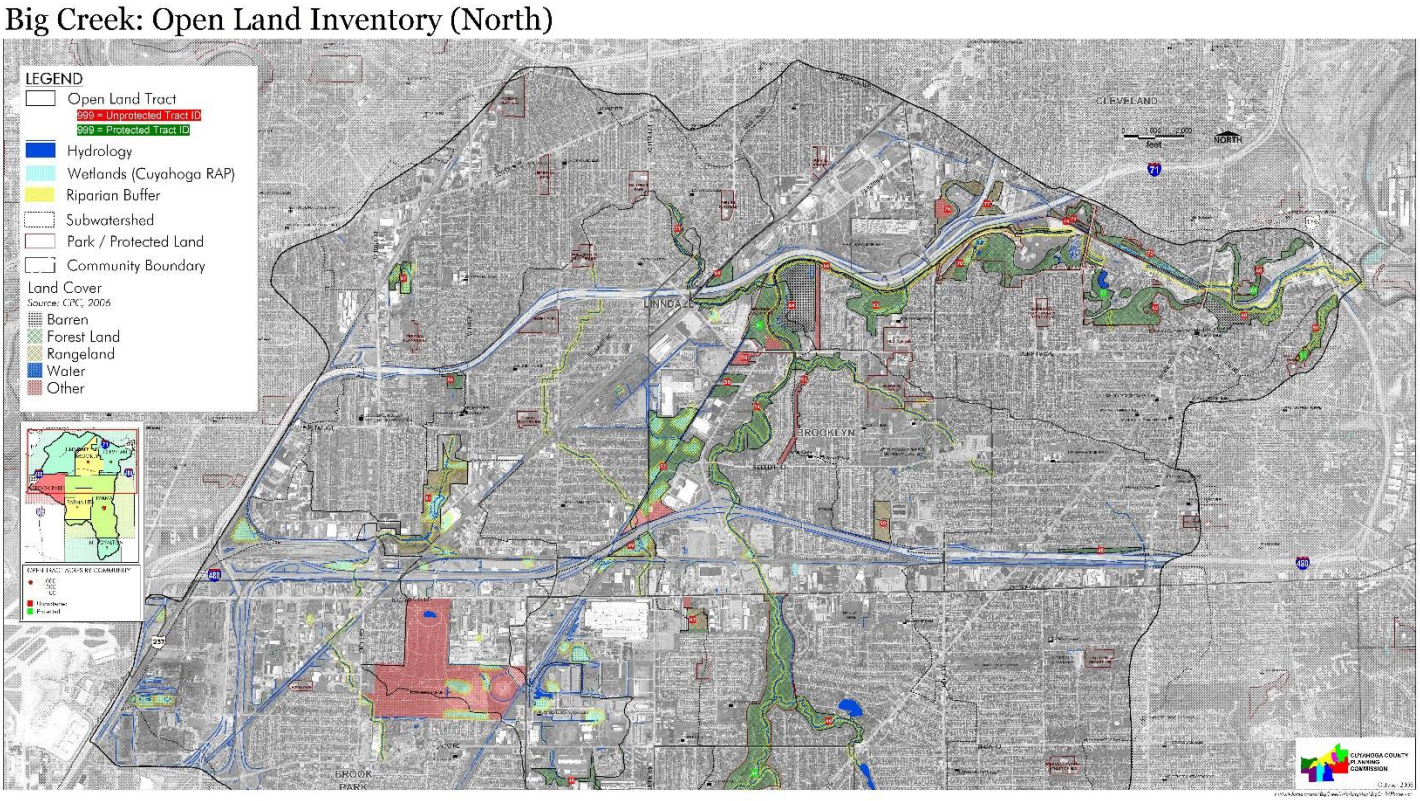


Figure 7. Open lands in the northern half of the Big Creek watershed.

2.2 SUMMARY OF BIOLOGICAL TRENDS

Much of Big Creek is in non-attainment of Ohio's biological criteria[4] for its designated aquatic life use (ALU) of warmwater habitat (WWH) in the Erie/Ontario Lake Plain ecoregion. Ohio EPA last collected biological and habitat data from the West Creek watershed as part of a comprehensive assessment in 1996 (Table 3) and is scheduled to collect data for another comprehensive assessment in the summer of 2018[5]. Since the 1996 assessment, NEORSD collected biological and habitat data from several locations on Big Creek and its tributaries during several years. The most recent data Ohio EPA and NEORSD collected at each assessment site are summarized in Table 4. Additional data are presented in Section 2.4. Figure 8 presents the attainment for the most recent monitoring event at each assessment site.

Table 3. Overall biological indices scores in the Big Creek watershed - Ohio EPA in 1996

RM (DA)	IBI	ICI	Status	QHEI	Site ID
7.8 H	28 / -- a	Fair	NON	64.5	not available
2.5 W	26 / 5.1	Poor	NON	50.5	F01S20
0.2 W	28 / 5.4	Poor	NON	53.0	502120

Source: Ohio EPA 2003. Data collected in 1996.
Notes
DA = drainage area, in square miles; H = headwaters site; IBI = Index of Biotic Integrity; ICI = Invertebrate Community Index; QHEI = Qualitative Habitat Evaluation Index; RM = river mile.
QHEI scores were rounded to the nearest one-tenth.
a. The MIwb is not applicable to headwaters streams, which are less than 20 square miles.

Table 4. Overall biological indices scores in the Big Creek watershed - Ohio EPA and NEORSD

RM (DA)	Year	IBI	ICI	Status [a]	QHEI	Site ID
Big Creek (WWH)						
9.80 (5.6) H	2016	30 / -- b	Poor	NON	69.5	303734
4.40 (19.3) H	2016	30 / -- b	MG	Partial	65.5	301193
2.40 (34.9) W	2015	26 / 6.7	--	NON	53.5	F01S20
1.30 (36.2) W	2015	30 / 7.0	--	NON	53.5	F01P01
0.23 (37.1) W	2016	27 / 7.6	Fair	NON	69.5	502120
Ford Branch [Big Creek RM 4.40] (LRW) [d]						
4.67 (4.3) H	2010	16 c / -- a	10 c	NON	62.0	301192
0.10 (11.9) H	2016	24 c / -- a	Poor	Full c	62.8	200072
unnamed tributary [Big Creek RM 4.91] (undesignated) e,f						
0.15 (4.9) H	2016	22 / -- a	28	NON	63.0	200073
unnamed tributary (Big Creek RM 7.78)(undesignated) e						
0.05 (2.5) H	2016	30 / -- a	32 *	Partial	67.0	302642
unnamed tributary (Big Creek RM 9.60)(undesignated) e,g						
0.05 (1.6) H	2012	28 / -- a	--	NON	70.0	302643

Notes
* = non-significant departure; DA = drainage area, in square miles; H = headwaters site; IBI = Index of Biotic Integrity; ICI = Invertebrate Community Index; MG = marginally good; QHEI = Qualitative Habitat Evaluation Index; RM = river mile.
Green scores meet the IBI or ICI biological criteria or QHEI target. Red scores do not meet the IBI or ICI biological criteria or QHEI target.
QHEI cores were rounded to the nearest one-tenth.
a. Attainment status is estimated for the 2015 and 2016 biological data. Ohio EPA has not evaluated these data or made an official attainment decision.
b. The MIwb is not applicable to headwaters streams, which are less than 20 square miles.
c. No numeric, biological criteria for LRW are codified in the Ohio Administrative Code. However, Ohio EPA uses thresholds to determine attainment. The EOLP headwaters IBI threshold is 18 and ICI threshold is 8. Failure to achieve either target results in nonattainment.
d. Big Creek Connects refers to this tributary as West Branch Big Creek.
e. No aquatic life use was designated for these tributaries in *OAC-3745-1-26*; therefore, they are assumed to be WWH.
f. Big Creek Connects refers to this tributary as Stickney Creek.
g. Big Creek Connects refers to this tributary as East Branch Big Creek.

[4] The biological criteria for headwaters WWH streams in the EOLP ecoregion are an IBI score of 40 and an ICI score of 34. The QHEI target is a score of 55 for a headwaters streams.
[5] Jeff DeShon, Manager of the Ecological Assessment Section, Ohio EPA, personnel communication via electronic mail, February 9, 2017.

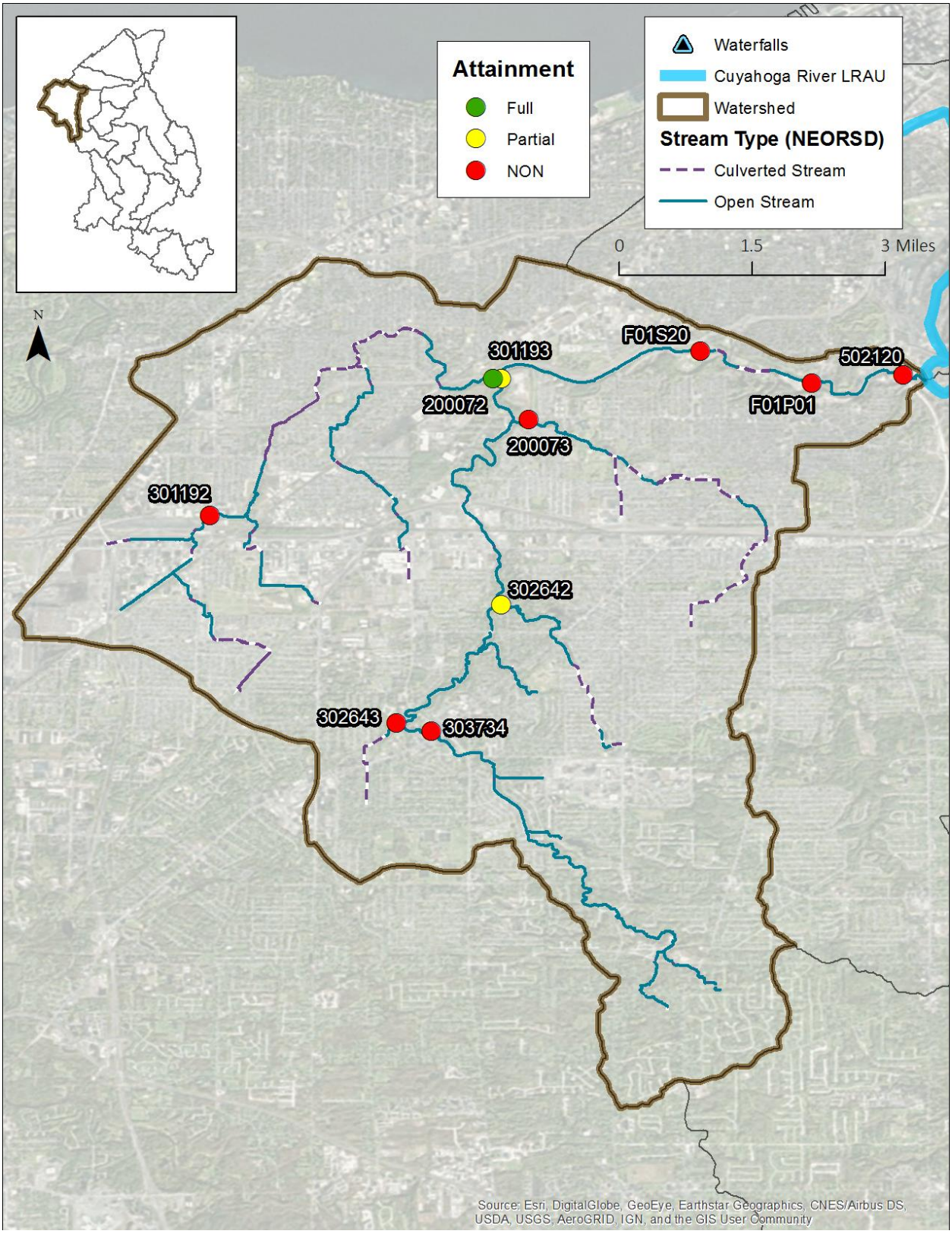


Figure 8. ALU attainment in the Big Creek watershed.

2.2.1 Fish Community Health

Fish data collected by Ohio EPA in 1996 and NEORSD in 1999 and 2007 through 2016 indicate that fish community health in the Big Creek watershed is impaired. Ohio EPA (2003, p. 22) collected fish data in 1996 and found that

> The fish communities lacked sensitive species, darters, insectivores and simple lithophils, implying habitat limitation and Stoneroller minnows dominated the catch at all sites. This combination of community attributes reflects habitat impacts, organic and nutrient enrichment related to urban storm water and CSOs.

Recent NEORSD data show that only five to eight fish species are present in much of Big Creek, except for the mouth where 13 to 19 fish species were often captured. Typically, only a few highly pollution tolerant fish species are captured frequently at most sites in the Big Creek watershed (Table 5; excluding the mouth of Big Creek).

Table 5. Fish species captured throughout Big Creek and its tributaries, except at the mouth of Big Creek

Code	Common name	Scientific name	Pollution tolerance
Captured at most or all sites in relatively large numbers			
40-016	Common white sucker	*Catostomus commersonii*	Highly tolerant
43-013	Creek chub	*Semotilus atromaculatus*	Highly tolerant
43-044	Central stoneroller minnow	*Campostoma anomalum*	--
Captured at most of all sites in relatively small numbers			
43-011	Blacknose dace (western)	*Rhinicthys atratulus*	Highly tolerant
43-043	Bluntnose minnow	*Pimephales notatus*	Highly tolerant
Captured at a few sites			
43-003	Golden shiner	*Notemigonus crysoleucas*	Highly tolerant
43-033	Bigmouth shiner	*Notropis dorsalis*	--
43-034	Sand shiner	*Notropis stramineus*	Moderately tolerant
47-004	Yellow bullhead	*Ictalurus natalis*	Highly tolerant
77-008	Green sunfish	*Lepomis cyanellus*	Highly tolerant
77-009	Northern bluegill sunfish	*Lepomis macrochirus*	Moderately tolerant
Captured at only one site			
43-026	Common shiner	*Notropis cornutus*	--
43-032	Spotfin shiner	*Cyprinella spiloptera*	--
43-042	Northern fathead minnow	*Pimephales promelas*	Highly tolerant
77-006	Largemouth bass	*Micropterus salmoides*	--
77-013	Pumpkinseed sunfish	*Lepomis gibbosus*	Moderately tolerant

Source: NEORSD (2017), sampling 2014-2016.

Lesions were identified on creek chub and yellow bullhead during a sampling event in 2014 in Big Creek (RM 1.00). DELTs were not identified during any other sampling events in 2014 through 2016, except for sampling events each year at the mouth of Big Creek. As most DELTs were observed on fish near the mouth of Big Creek, such DELTs may be representative of impacts outside of the Big Creek watershed.

Less fish in the East and West branches of Big Creek are likely due to multiple factors including barriers to fish passage (e.g., drop-structure, culverted segments), poor habitat (e.g., stream channelization), altered hydrologic regime (e.g., flashy flows), and poor water quality (e.g., contaminants in urban stormwater). Better fish community health at the mouth of Big Creek likely reflects the good fish community health in the Cuyahoga River.

2.2.2 Macroinvertebrate Community Health

Macroinvertebrate data collected by Ohio EPA in 1996 and NEORSD in 1995 through 1997 and 2002 through 2016 indicate that macroinvertebrate community health at many locations in the Big Creek watershed is impaired. Macroinvertebrate community health declined from fair in the headwaters to poor throughout the rest of Big Creek (Ohio EPA 1999).

NEORSD qualitative data from 2015 and 2016 generally indicate that macroinvertebrate community health in lower East Branch (Big Creek RM 4.40; 24-28 taxa, 6-7 EPT taxa) and Stickney Creek (28-31 taxa, 4-7 EPT taxa) is better than the

community health in lower West Branch (aka Ford Branch; 14-16 taxa, 1 EPT taxon). Additional sites on East Branch and its tributaries have somewhat fewer taxa (12-20) and EPT taxa (3-6) and lower East Branch, which are similar to the mainstem of Big Creek including near the mouth (2014-2016; 16-25 taxa, 3-8 EPT taxa).

2.2.3 Fish Habitat

Ohio EPA, NEORSD, and other entities assessed fish habitat at several locations in the Big Creek watershed. However, numerous segments of tributaries to Big Creek are culverted underground, lined with concrete, or channelized/straightened (Figure 9). Additionally, many intermittent or ephemeral drainages that have been developed (e.g., single family home residential subdivisions) have few surficial stream segments; most runoff is directed through storm sewers to Big Creek and a few of its larger tributaries. Many such small drainages have no surficial streams, and thus, no fish habitat.

As measured by the QHEI, fish habitat has been assessed at several locations along Big Creek and its tributaries. Fish habitat is generally *good* in Big Creek and its tributaries (Figure 9), as measured by the QHEI. However, a few locations have *excellent* or *fair* habitat. QHEI scores from the past decade are summarized in Table 9 in Section 2.4

Figure 9. Big Creek along I-71 (left) with poor fish habitat and East Branch (right) with good habitat.

Table 6. QHEI matrix with WWH and MWH attributes for - NEORSD 2016

Key QHEI component			WWH attributes											MWH attributes																				
														High influence						Moderate influence																
RM	QHEI score	Gradient (foot/mile)	Not channelized or Recovered	Boulder, Cobble, or Gravel substrates	Silt free substrates	Good/Excellent development	Moderate/High sinuosity	Extensive/Moderate cover	Fast current/Eddies	Low/Normal embeddedness	Maximum depth >40 centimeters	Low/Normal riffle embeddedness	No. of WWH attributes	Channelization or No recovery	Silt or Muck substrates	No sinuosity	Sparse/No cover	Maximum depth <40 centimeters	No. of high influence MWH attributes	Recovering channel	Heavy/Moderate silt cover	Sand substrate (boat)	Hardpan substrate origin	Fair/Poor development	Low sinuosity	Only 1 or 2 cover types	Intermediate/Poor pools	No fast current	High/Moderate embeddedness	High/Moderate riffle embeddedness	No riffle	No. of moderate influence MWH attributes
Big Creek																																		
9.80	69.5	21.2		●		●		●	●		●		5	●					1															0
4.40	65.5	17.6		●					●		●		3	●		●			2					●				●		●	3
0.20	69.5	17.6	●	●			●		●		●		5						0														0
Ford Branch (Big Creek RM 4.40), also known as West Branch																																		
0.02	62.8	14.5		●					●		●		3	●					1						●			●	●		3
unnamed tributary (Big Creek RM 4.70), also known as Stickney Creek																																		
0.15	63.0	22.2	●	●			●	●			●		5						0		●							●	●	●		4
unnamed tributary (Big Creek RM 7.78), also known as Snow & Pearl Branch																																		
0.02	67.0	51.3	●				●	●			●		4						0				●					●				2

Note: Green scores meet the QHEI target.

2.3 SUMMARY OF POLLUTION CAUSES AND ASSOCIATED SOURCES

Ohio EPA (2003) determined causes and sources of impairment for Big Creek and Ford Branch Big Creek from biological data collected in 1996 (Table 7). The only nonpoint source identified was urban runoff/storm sewers. Causes and sources are also reported on the interactive, online map for Ohio's 2016 Integrated Report (Ohio EPA 2016; shown in Table 8), which incorporate NEORSD data collected since TMDL development in 2003.

Table 7. Causes and sources of impairment to Big Creek and Ford Branch

Causes	Sources
Big Creek	
▪ Impairment unknown ▪ Oil and grease ▪ Organic enrichment / Dissolved oxygen	▪ Combined sewer overflows
Ford Branch	
▪ Flow alteration ▪ Siltation ▪ Unknown toxicity	▪ Industrial point sources ▪ Urban storms sewers

Source: Ohio EPA 2003, citing 1996 data.

Table 8. Causes and sources of impairment in the *Big Creek* WAU

Causes	Sources
▪ Direct habitat alteration ▪ Flow alteration ▪ Impairment unknown ▪ Metals ▪ Organic enrichment / Dissolved oxygen	▪ Combined sewer overflows ▪ Municipal (urbanized high density area) ▪ Spills ▪ Urban runoff/storm sewers

Source: Ohio EPA 2016.

The Big Creek watershed has a long history of impairment causes by combined sewer overflows, sanitary sewer overflows, and urban runoff. Ohio EPA and NEORSD had to frequently respond to sanitary waste discharges and remediate illicit connections to storm sewers (Ohio EPA 2003, p. 21). Point sources (including combined sewer overflows and sanitary sewer overflows) are beyond the scope of this NPS-IS because they are addressed through Ohio EPA's permitted point sources programs.

Causes and sources identified by Ohio EPA (2003, 2016) are consistent with the findings of BCC (2010, p. 14), in that "[t]he amount of impervious coverage in Big Creek, along with the long history of urban development, hinders the creek's ability to reach water quality attainment". The impacts of urbanization are the cumulative effect of multiple stressors in the watershed and stream environment resulting from urban development. A significant impact of urbanization is the alteration of natural hydrology that results in an urban flow regime with stormwater pulses (i.e., flashy flow). Habitat alteration due to flashy flows that impair fish communities were evident in lower Big Creek (Ohio EPA 1999, p. 111).

2.4 ADDITIONAL INFORMATION

Between 2007 and 2016, Ohio EPA, NEORSD, and Cuyahoga River Restoration collected biological and habitat data from several locations on Big Creek (Table 9). NEORSD collected data to support its numerous programs, while Cuyahoga River Restoration collected QHEIs to support the evaluation and eventual delisting of beneficial use impairments in the Cuyahoga Area of Concern.

Table 9. Recent indices scores in the Big Creek watershed (HUC 04110002 06 03)

RM (DA)	Year	IBI	ICI	QHEI	Site ID
Big Creek (WWH)					
9.80 (5.6) H	2015		20		303734
	2016	30 / -- b	Poor	69.5	
7.80 (--) H	2014	--	--	61.0	--
4.40 (19.3) H	2007	34 / -- a	--	60.8	301193
	2009	36* / -- a	Fair	61.8	
	2010	35 / -- a	38	60.5	
	2011	33 / -- a	Marginally good *	63.5	
	2015	28 / -- a	--	60.3	
	2016	30 / -- a	Marginally good *	65.5	
2.40 (34.9) W	2015	26 / 6.7	--	53.5	F01S20
1.30 (36.2) W	2014	26 / 6.1	28	65.3	F01P01
	2015	30 / 7.0	--	53.5	
0.23 (37.1) W	2007	28 / 5.2	--	68.8	502120
	2008	--	--	64.0	
	2009	26 / 5.6	28	73.3	
	2010	29 / 6.1	20	70.5	
	2011	30 / 6.1	--	69.5	
	2012	31 / 6.9	32 *	71.5	
	2013	32 / 5.4	24	73.5	
	2014	28 / 8.6	30 *	67.5	
	2015	29 / 6.2	18	72.5	
	2016	27 / 7.6	Fair	69.5	
Ford Branch (Big Creek RM 4.40) (LRW)					
4.67 (4.3) H	2007	16 b / -- a	--	51.0	301192
	2009	16 b / -- a	12 b	57.5	
	2010	16 b / -- a	10 b	62.0	
0.10 (11.9) H	2015	24 b / -- a	--	68.5	200072
	2016	24 b / -- a	Poor	62.8	
unnamed tributary (Big Creek RM 4.91)(undesignated)					
0.15 (4.9) H	2015	22 / -- a	38	65.0	200073
	2016	22 / -- a	28	63.0	
unnamed tributary (Big Creek RM 7.78)(undesignated)					
0.05 (2.5) H	2012	34 / -- a	--	73.5	302642
	2015	30 / -- a	--	67.3	
	2016	30 / -- a	32 *	67.0	
unnamed tributary (Big Creek RM 9.60)(undesignated)					
0.05 (1.6) H	2012	28 / -- a	--	70.0	302643

Notes

* = non-significant departure; DA = drainage area, in square miles; H = headwaters site; IBI = Index of Biotic Integrity; ICI = Invertebrate Community Index; QHEI = Qualitative Habitat Evaluation Index; RM = river mile.

Scores were rounded to the nearest one-tenth.

Green scores meet the IBI or ICI biological criteria or QHEI target. Red scores do not meet the IBI or ICI biological criteria or QHEI target.

a. The MIwb is not applicable to headwaters streams, which are less than 20 square miles.

b. No numeric, biological criteria for LRW are codified in the Ohio Administrative Code. However, Ohio EPA uses thresholds to determine attainment. The EOLP headwaters IBI threshold is 18 and the ICI threshold is 8.

Temporal analyses of the data at the mouth of Big Creek (site 502120; Figure 10) indicate that IBI and MIwb scores do not meet criteria but MIwb scores may be slowly improving, ICI scores do not usually meet criteria, and QHEI scores achieve targets.

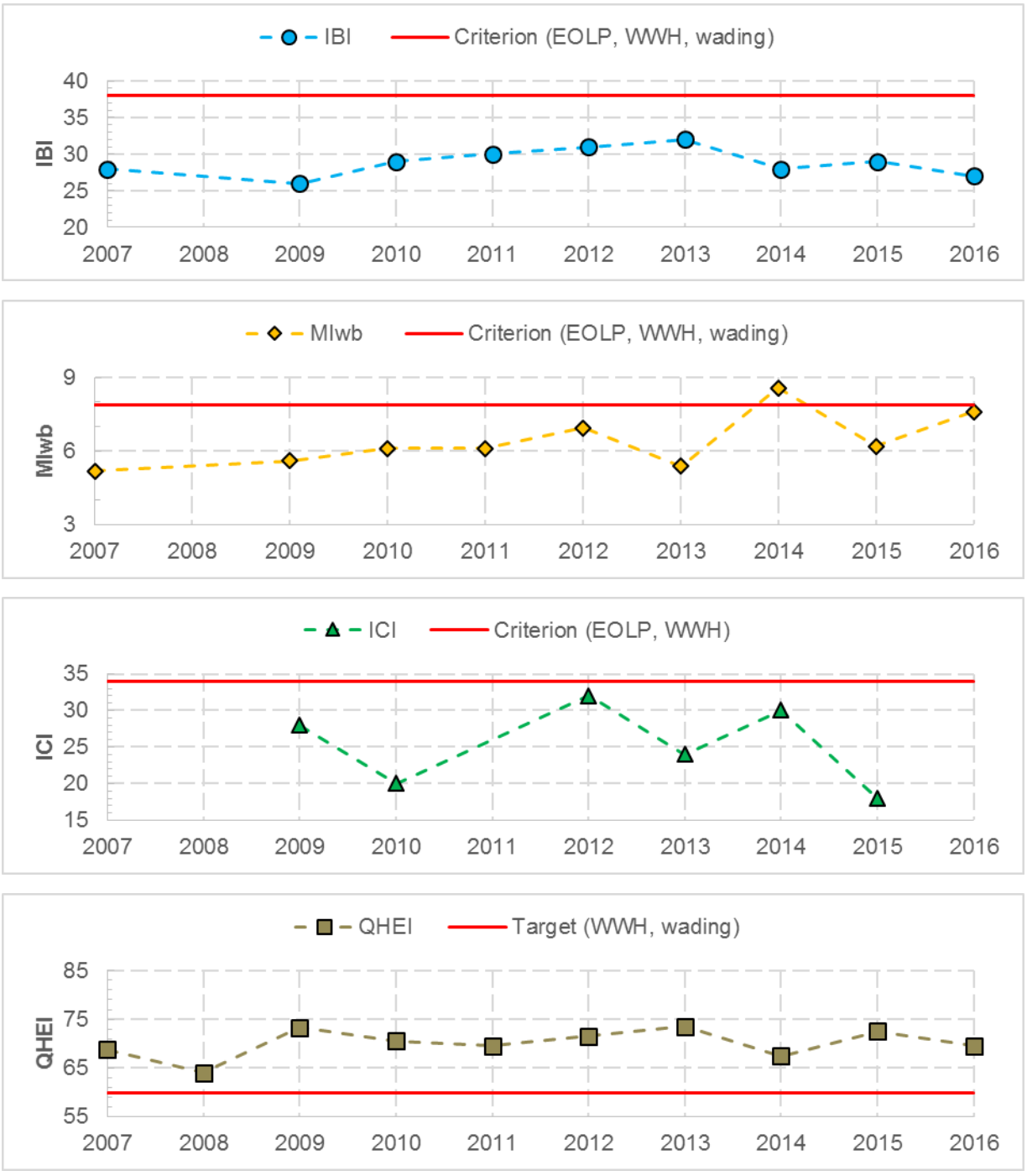


Figure 10. Temporal evaluation of biological and habitat scores.

NEORSD is developing stormwater master plans for its service area in northeast Ohio and the Big Creek watershed is within the *Cuyahoga River North* regional stormwater management area. As part of its stormwater master planning, NEORSD identifies buildings, transportation infrastructure, and utilities infrastructure (BTU) that are threatened by stormwater and associated issues. NEORSD staff identify BTUs in their online geographic information system and determine which BTUs are near streams and stormwater conveyances. BTUs that are near streams and stormwater conveyances are then assessed in the field. If NEORSD determines that a BTU is threatened by stormwater or related issues (e.g., stormwater caused erosion, stormwater infrastructure failure), then NEORSD prioritizes the threatened BTU in its stormwater management planning (Figure 12). NEORSD will implement a series of best management practices, capital improvements, and other projects to maintain its stormwater infrastructure. Capital improvements and projects that address threatened BTUs are higher priorities for funding and for implementation-scheduling.

Figure 11. Double barrel culvert of Big Creek at the Cleveland Metroparks Zoo.

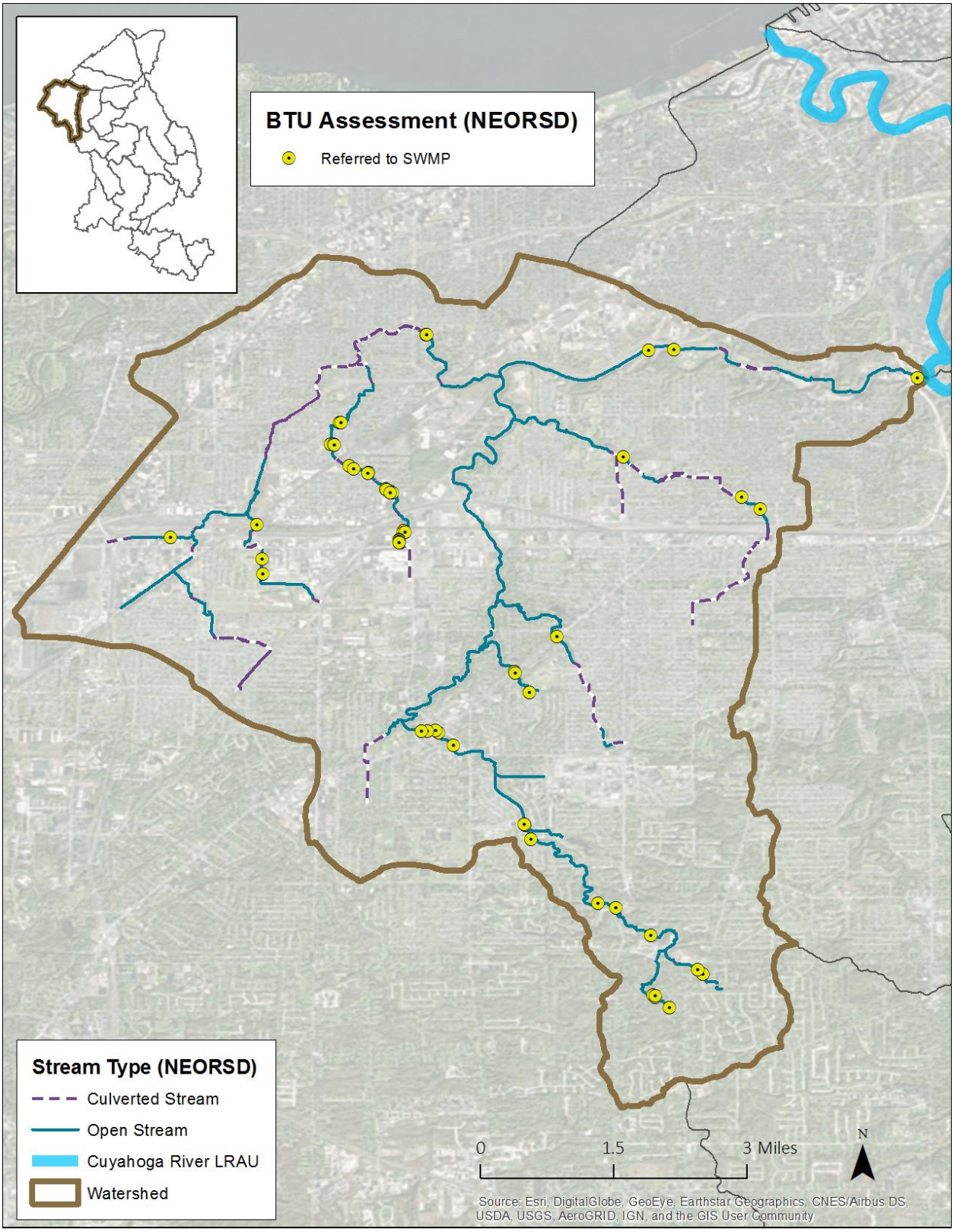


Figure 12. Threatened BTUs to be addressed by NEORSD during stormwater management planning.

3 CONDITIONS & RESTORATION STRATEGIES FOR THE BIG CREEK CRITICAL AREAS

3.1 OVERVIEW OF CRITICAL AREAS

Most sampling locations in the Big Creek WAU are not in full attainment of the designated aquatic life uses:

- **Big Creek:** Four sites (502120, F01P01, F01S20, and 303734) are in nonattainment of WWH criteria and one site is in partial attainment (301193).
- **Ford Branch[6]:** Both sites on Ford Branch (200072 and 301192) is in nonattainment LRW thresholds.
- **UT to Big Creek at RM 4.91[7]:** The only site (200073) is in non-attainment of WWH criteria.
- **UT to Big Creek at RM 7.78[8]:** The only site (302642) is in partial attainment of WWH criteria.
- **UT to Big Creek at RM 9.60[9]:** The only site (200074) is in non-attainment of WWH criteria.

Four critical areas have been identified to address the nonpoint source pollution issues that are believed to be causing the impairments (Figure 13).

[6] Ohio EPA refers to this branch as Ford Branch, while BCC refers to it as West Branch.

[7] Ohio EPA refers to this tributary as unnamed tributary at Big Creek RM 4.91, while BCC refers to it as Stickney Creek. No aquatic life use was designated for Stickney Creek in *OAC-3745-1-26*; therefore, it is assumed to be WWH.

[8] No aquatic life use was designated for this tributary in *OAC-3745-1-26*; therefore, it is assumed to be WWH.

[9] Ohio EPA refers to this tributary as unnamed tributary at Big Creek RM 9.60, while BCC refers to it as East Branch Big Creek. No aquatic life use was designated for this tributary in *OAC-3745-1-26*; therefore, it is assumed to be WWH.

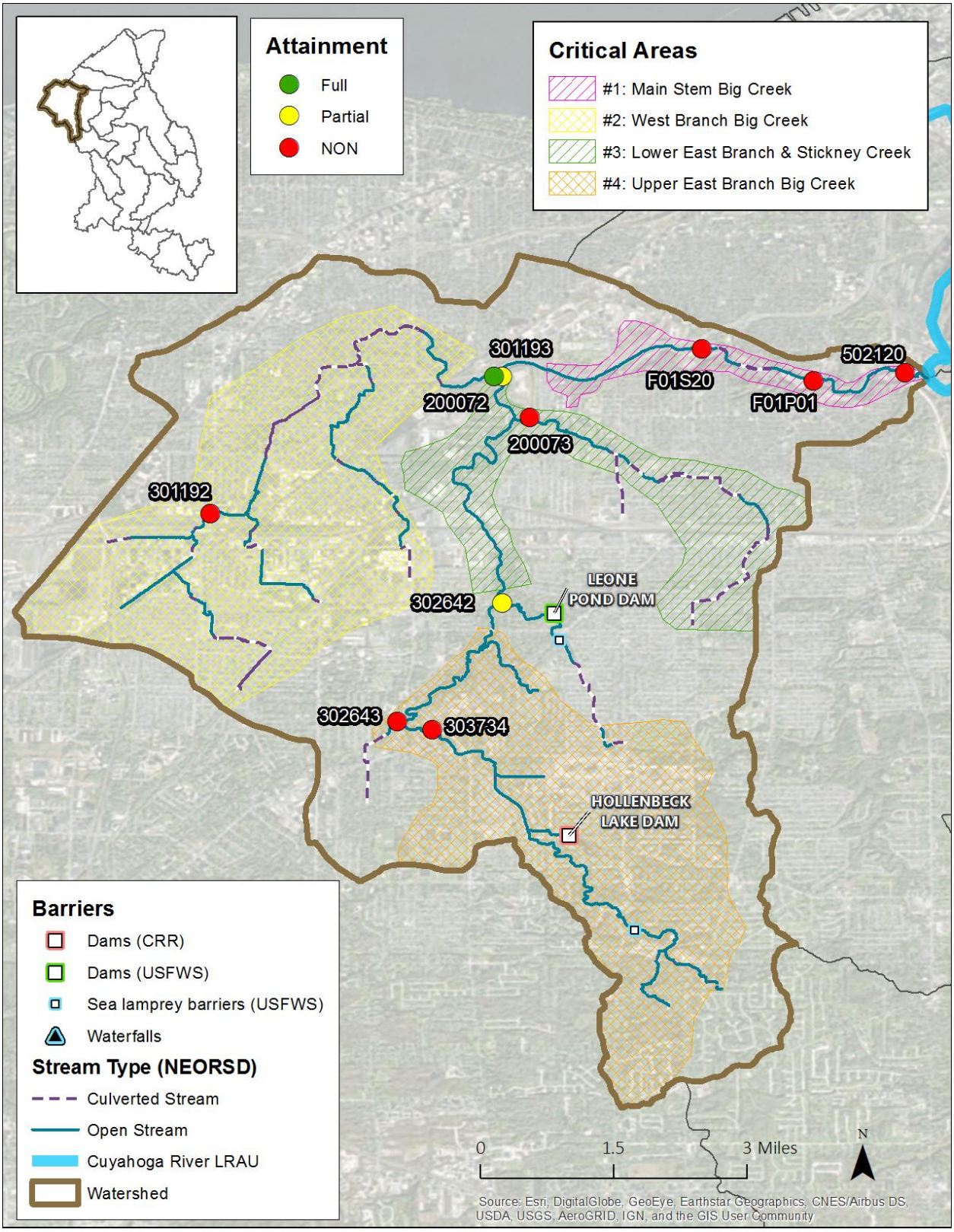


Figure 13. Critical areas in the Big Creek watershed.

3.2 CRITICAL AREA #1: CONDITIONS, GOALS, & OBJECTIVES

3.2.1 Detailed Characterization

Lower Big Creek in the *Main Stem Big Creek* critical area is a wading-sized stream that flows along I-71, over a drop-structure (Figure 14), through CM's Brookside Reservation and through and under CM's Zoo, before passing under the Jennings Freeway (OH-176) and discharging to the Cuyahoga River (Figure 15). The lowest reaches of Big Creek in this critical area flow along railroad tracks and industrial properties. Long segments of Big Creek in the *Main Stem Big Creek* critical area are culverted underground.

Figure 14. Big Creek drop structure along I-71.

The *Main Stem Big Creek* critical area is 681 acres and is predominantly developed land (56 percent; Table 10). An evaluation of the percent imperviousness data from the 2011 National Land Cover Database indicated that a total of over a quarter (29 percent) of the critical area is impervious cover. This critical area also contains significant areas of developed open space (23 percent) in the CM Zoo and Brookside Reservation and forest (20 percent) in CM's Brookside Reservation. Canopy cover is over a quarter (30 percent) of the critical area.

Table 10. Land cover in the *Main Stem Big Creek* critical area of the Big Creek watershed

Land cover	Area (acres)	Area (%)
Open water	2	<1%
Developed, open	154	23%
Developed, low intensity	203	30%
Developed, medium intensity	155	23%
Developed, high intensity	23	3%
Barren land	--	--
Deciduous forest	137	20%
Evergreen forest	--	--
Mixed forest	--	--
Shrub/scrub	--	--
Grassland / herbaceous	--	--
Pasture/hay	--	--
Cultivated crops	--	--
Woody wetlands	4	1%
Emergent herbaceous wetlands	4	1%
Total [a]	**681**	**100%**

Source of spatial data: 2011 National Land Cover Database (Jin et al. 2013).
Notes
Areas rounded to the nearest acre or percentage point.
A double dash indicates that the land cover is not present.
a. Totals do not sum exactly due to rounding.

Figure 15. Critical Area #1: *Main Stem Big Creek*.

3.2.2 Detailed Biological Condition

Several sites sampled over the past few years indicated nonattainment of biological criteria. The most recent data were collected by NEORSD; the District evaluated fish and macroinvertebrate community health in 2016 at site 502120 (RM 0.23; Table 11 and Table 12). The IBI scores for two sample events in 2016 were 24 (*poor*) and 30 (*fair*); the MIwb scores were 8.0 (*fair*) and 7.2 (*fair*). Most species caught are highly tolerant of pollution. No DELT anomalies were observed.

Table 11. Fish community health and habitat data - Critical Area #2

RM	DA	QHEI	Total species	MIwb	IBI	Predominant species (percent of catch)	Narrative evaluation
0.23	37.1	69.5	14-19	7.6	27	sand shiner (16-19%), common emerald shiner (13-19%)	Fair

Notes
DA = drainage area, in square miles; IBI = Index of Biotic Integrity; MIwb = Modified Index of well-being; QHEI = Qualitative Habitat Evaluation Index; RM = river mile.
a. The MIwb is not applicable to headwaters streams, which are less than 20 square miles.
Green scores meet the IBI or MIwb biological criteria or QHEI target. Red scores do not meet the IBI or MIwb biological criteria or QHEI target.

Macroinvertebrate community health at site 502120 (RM 0.23) in 2016 was narratively scored as *poor* (Table 12). Over half of the qualitative macroinvertebrate taxa were facultative (7 taxon), while a few taxa were moderately tolerant (3 taxa) or tolerant (3 taxa). The predominance of flatworms (class *Tubellaria*) and freshwater crustaceans (order *Isopoda*) is often indicative of impaired community health. Baetid mayfilies (order *Ephemeroptera*, family *Baetidae*) and nonbiting midges (order *Diptera*, family *Chironomidae*) were also common.

Table 12. Macroinvertebrate community health qualitative data - Critical Area #2

RM	DA	No. of taxa			Predominant species	Narrative evaluation
		Total	EPT	Coldwater		
0.23	37.1	12	4	0	flatworms (common), freshwater crustaceans (common), baetid mayflies (common), nonbiting midges (common)	Poor

Notes
DA = drainage area, in square miles; EPT = *Ephemeroptera* (mayflies), *Plecoptera* (stoneflies), and *Trichoptera* (caddisflies); RM = river mile.
Red scores do not meet the ICI biological criteria.

In 2015, NEORSD deployed an in-stream modified Hester-Dendy substrate sampler. The *poor* ICI score from 2015 (18) was due to a lack of mayfly taxa (0 points for the *number of mayfly* and *percent mayflies* metrics), few EPT taxa (0 points for the *qualitative EPT taxa* metric), and the dominance of other insects (0 points for the *percent other diptera and non-insects* [97 percent] and *percent tolerant organisms* [88 percent] metrics). Only one metric scored the full 6 points (*number of dipteran taxa*).

3.2.3 Detailed Causes and Associated Sources

Lower Big Creek in the *Main Stem Big Creek* critical area has been significantly altered. The stream channel is concrete lined and straightened along I-71 (Figure 16) and spills over a large drop-structure upstream of the CM Zoo. Throughout much of the Zoo, Big Creek is culverted underground. The channel is straightened and heavily incised along railroad tracks downstream of the CM Zoo, with a narrow riparian corridor. The drop structure and culverted segments are barriers to fish passage. The concrete lining along the stream bottom and both banks is a complete lack of habitat for aquatic life, while the deeply incised channel with narrow riparian corridor is very poor habitat. Both fish and macroinvertebrate community health is impaired by the lack of good-quality stream-bottom and bank habitat.

While lower Big Creek was formerly a meandering stream, it has been straightened, lined, culverted, and disconnected from its floodplain to support the installation of interstate highways and railroads and to accommodate industrial and commercial development. In addition to physical alteration of the stream channel and floodplain, the hydrology of Big Creek has also been altered. Big Creek receives stormwater from transportation corridors and urban development.

Without floodplain connectivity and with straightened channels or culverted segments, stormwater results in very flashy flows in Big Creek. For a general review of the impacts of urbanization and references to additional resources, see the CADDIS Urbanization Module (U.S. EPA 2010) and *The Importance of Imperviousness* (Schueler 1994).The flashy flows (i.e., higher peak flows and volumes) associated with urban stormwater result in the following stressors on biological communities:

- Degraded habitat and siltation
- High stream flow velocities
- Erosion, channel scour, and bank failure
- Poor water quality
- Increased temperatures or rapid temperature flux
- Reduction in base flow

Urban development, with increases in impervious cover and storm sewers, typically degrades aquatic biological communities. Research generally shows that urbanization directly affects aquatic habitat and biota (Schueler 2004; Capiella et al. 2005; Shaver et al 2007; Cuffney et al. 2010). To briefly summarize (Shaver et al 2007, p. 4-98):

> [O]verall, there tends to be a decline in taxa richness or species diversity, a loss of sensitive species, and an increase in tolerant species […] due mainly to the cumulative impacts of watershed urbanization: altered hydrologic and sediment transport regimes, degradation of in-stream habitat quality and complexity, stream bed fine sediment deposition, poor water quality, and the loss of native riparian vegetation.

Figure 16. Lower Big Creek in the *Main Stem Big Creek* critical area.

Previous Ohio EPA technical support documents and the lower Cuyahoga River TMDL (Ohio EPA 2003) only briefly discuss attainment and causes and sources of impairment in the Big Creek watershed. Typical of surrounding, highly developed urban watersheds, lower Big Creek is impaired by barriers to fish passage (drop structure and culverts), flow regime alterations (urban runoff and storm sewers), and habitat alterations (channelization and loss of riparian habitat).

3.2.4 Goals and Objectives for Critical Area #1

As explained in detail above, *Critical Area #1* is primarily impaired by barriers to fish passage, flow regime alterations, and habitat alterations. Lower Big Creek has been modified to accommodate transportation infrastructure and commercial and industrial development. Removal or bypass of barriers to fish passage, stormwater retrofits, habitat restoration, and floodplain reconnection will be needed to improve aquatic community health.

3.2.4.1 Goals

The overall nonpoint source restoration goals of any NPS-IS plan is to improve IBI, MIwb, ICI, and QHEI scores such that a waterbody is brought into full attainment of the designated ALU. Non-attainment in this critical area is due to *fair* to *poor* IBI, MIwb, and ICI scores. Additionally, QHEI scores are above the wading target. Therefore, the goals for *Critical Area #1*

of the Big Creek watershed are to improve IBI, MIwb, and ICI scores at site 502120 (RM 0.23) [10] so that the site will improve from non-attainment to full attainment of the designated ALU. These goals are specifically to:

Goal 1. **Achieve an IBI score of 38 at site 502120 (RM 0.23) on Big Creek**

- Not Achieved: Site currently has a score of 27

Goal 2. **Achieve a MIwb score of 7.9 at site 502120 (RM 0.23) on Big Creek**

- Not Achieved: Site currently has a score of 7.6

Goal 3. **Achieve an ICI[11] score of 34 at site 502120 (RM 0.23) on Big Creek**

- Not Achieved: Site currently has a score of *fair*

Goal 4. **Achieve a QHEI score of 60 at site 502120 (RM 0.23) on Big Creek**

- ✓ Achieved: Site currently has a score of 69.5

3.2.4.2 Objectives

To achieve the overall nonpoint source restoration goal of full attainment, the following objectives need to be achieved within *Critical Area #1*:

Objective 1 Remove or bypass three barriers to fish passage

- The Big Creek drop structure is a major barrier that prevents fish passage to most of the Big Creek watershed, including the *West Branch*, *Lower East Branch and Stickney Creek*, and *Upper East Branch* critical areas.
- Two- and three-barrel culverts just downstream of the CM Zoo parking lot along with the long sections of Big Creek culverted under the Zoo are barriers to fish passage.

Objective 2 Restore 5,800 lineal feet of bank habitat along lower Big Creek

- Along I-71, Big Creek is a concrete channel. However, many concrete panels have begun to fail, exposing underlying shale.
- Big Creek is channelized throughout much of the *Main Stem Big Creek* critical area.

Objective 3 Create or restore 50 acres of wetland and upland habitat

Objective 4 Install green infrastructure retrofits at commercial, industrial, and institutional complexes to address 40 acres of buildings, driveways, walkways, and parking lots

- Disconnect downspouts from storm sewers and route roof runoff to newly installed bio-swales and water quality detention basins that discharge Big Creek.
- Install infiltration basins and route parking lot runoff through the infiltration basins before discharging to storm sewers.

As these objectives are implemented, water quality monitoring (both project-related and regularly scheduled monitoring) will be conducted to determine progress toward meeting the identified goals (i.e., water quality standards). These objectives will be reevaluated and modified, as necessary. When reevaluating, BCC will reference Ohio's *Nonpoint Source Management Plan Update* (Ohio EPA 2013), which has a complete listing of all eligible NPS management strategies.

[10] Goals are set for site 502120 (RM 0.23), and not the other sites, because NEORSD sampled site 502120 recently.

[11] If Big Creek is not suitable for placement of the in-stream modified Hester-Dendy substrate sampler, then Goal 3 is to achieve a qualitative EPT narrative score of *good*.

3.3 CRITICAL AREA #2: CONDITIONS, GOALS, & OBJECTIVES

3.3.1 Detailed Characterization

West Branch Big Creek is a headwaters-sized stream (Figure 17) in the most developed portion of the Big Creek watershed. The two main tributaries to the West Branch in this critical area are Ford Branch (western tributary) and Chevy Branch (eastern tributary). Ohio EPA refers to West Branch as Ford Branch, which the agency designates as LRW.

Significant portions of West, Ford, and Chevy branches are culverted underground, while the portions in open channels are straightened and with little to no riparian vegetative cover. Segments are straightened along railroads and city streets. Many commercial and industrial properties contain mowed lawns with occasional trees, in addition to buildings and parking lots. A few industrial properties are nearly, completely impervious cover. The residential subdivisions are composed of single family homes on straight streets (Figure 18); many homes in some subdivisions have detached garages. Most homes have small yards with at least one tree.

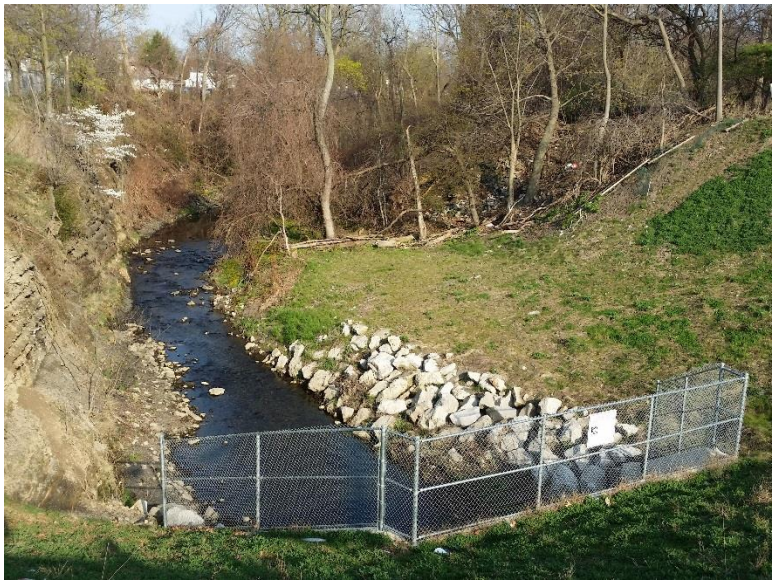


Figure 17. West Branch at Kensington Avenue.

The *West Branch* critical area is 5,653 acres and is predominantly developed land (89 percent; Table 13). An evaluation of the percent imperviousness data from the 2011 National Land Cover Database indicated that a total of one half of the critical area is impervious cover. This critical area also contains limited areas of developed open space (10 percent) in single family residential subdivisions and in manicured fields on commercial and industrial properties. Canopy cover is just a twentieth (5 percent) of the critical area.

Table 13. Land cover in the *West Branch* critical area of the Big Creek watershed

Land cover	Area (acres)	Area (%)
Open water	--	--
Developed, open	538	10%
Developed, low intensity	2,363	42%
Developed, medium intensity	1,971	35%
Developed, high intensity	702	12%
Barren land	--	--
Deciduous forest	68	1%
Evergreen forest	--	--
Mixed forest	--	--
Shrub/scrub	--	--
Grassland / herbaceous	4	<1%
Pasture/hay	--	--
Cultivated crops	--	--
Woody wetlands	7	<1%
Emergent herbaceous wetlands	1	<1%
Total [a]	**5,653**	**100%**

Source of spatial data: 2011 National Land Cover Database (Jin et al. 2013).
Notes
Areas rounded to the nearest acre or percentage point.
A double dash indicates that the land cover is not present.
a. Totals do not sum exactly due to rounding.

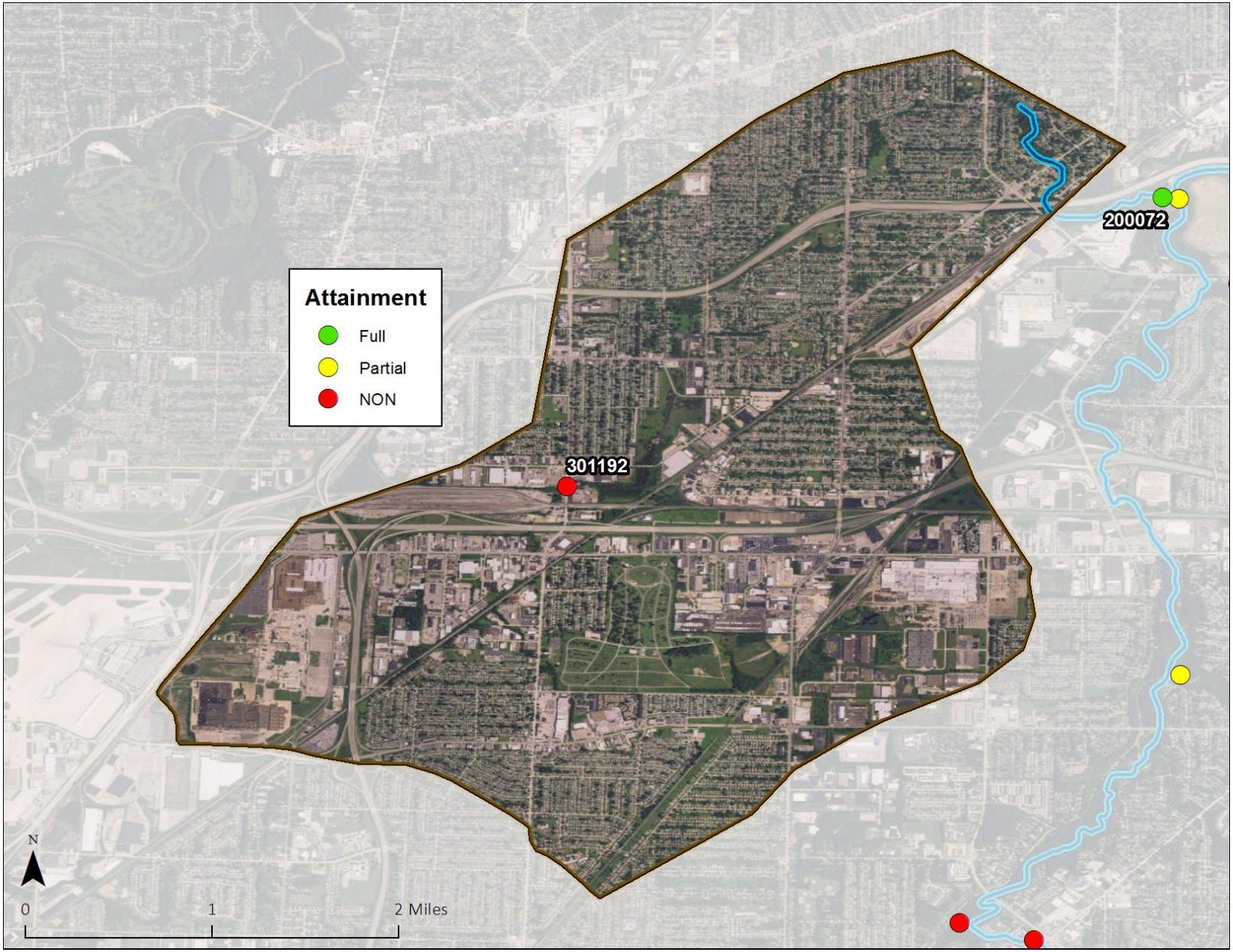


Figure 18. Critical Area #2: *West Branch Big Creek*.

3.3.2 Detailed Biological Condition

Two sites sampled over the past few years indicated attainment or nonattainment of biological thresholds. No numeric, biological criteria for LRW are codified in the Ohio Administrative Code. However, Ohio EPA uses thresholds to determine attainment.

The most recent data were collected by NEORSD; the District evaluated fish and macroinvertebrate community health in 2016 in West Branch Big Creek at site 200072 (RM 0.10; Table 14 and Table 15). Due to the lack of data in this critical area, NEORSD's sampling at site 200072 is included in this analysis even though the site is just downstream of the critical area; the data are believed to be representative of biological and habitat conditions in the *West Branch Big Creek* critical area. Ohio EPA previously collected data farther upstream at site 301192 (RM 4.67) in 2007, 2009, and 2010 (Table 9). The IBI score in 2016 was 24 (*poor*). Most species caught are highly tolerant of pollution. No DELT anomalies were observed.

Table 14. Fish community health and habitat data - Critical Area #2

RM	DA	QHEI	Total species	MIwb	IBI	Predominant species (percent of catch)	Narrative evaluation
0.10	11.9	62.8	8	--[a]	24	creek chub (35%), common white sucker (31%), central stoneroller minnow (25%)	Poor [b]

Notes
DA = drainage area, in square miles; IBI = Index of Biotic Integrity; MIwb = Modified Index of well-being; QHEI = Qualitative Habitat Evaluation Index; RM = river mile.
a. The MIwb is not applicable to headwaters streams, which are less than 20 square miles.
b. No numeric, biological criteria for LRW are codified in the Ohio Administrative Code. However, Ohio EPA uses thresholds to determine attainment. The EOLP headwaters IBI threshold is 18.
Green scores meet the IBI biological threshold or QHEI target.

NEORSD deployed an in-stream modified Hester-Dendy substrate samplers in 2016; however, the substrate sampler was not located during retrieval. Macroinvertebrate community health at this site was narratively scored as *poor* (Table 15) which achieves the threshold established for LRW. Just less than half of the qualitative taxa were tolerant (7 taxa) and just over a third of the taxa were facultative (7 taxon); a few taxa were moderately tolerant (2 taxa). Aquatic segmented-worms (class *Oligochaeta*), flatworms (class *Turbellaria*), and leeches (subclass *Hirudina*) were common, which is indicative of poor community health.

Table 15. Macroinvertebrate community health qualitative data - Critical Area #2

RM	DA	No. of taxa			Predominant species	Narrative evaluation
		Total	EPT	Coldwater		
0.10	11.9	16	1	0	aquatic segmented-worms (common), flatworms (common), leeches (common)	Poor

Notes
DA = drainage area, in square miles; EPT = *Ephemeroptera* (mayflies), *Plecoptera* (stoneflies), and *Trichoptera* (caddisflies); RM = river mile.
b. No numeric, biological criteria for LRW are codified in the Ohio Administrative Code. However, Ohio EPA uses thresholds to determine attainment. The EOLP headwaters IBI threshold is 18 and the ICI threshold is 8.
Green scores meet the ICI biological threshold.

3.3.3 Detailed Causes and Associated Sources

West Branch Big Creek drains an area of dense industrial and commercial development and several subdivisions of single family residences. Much of West Branch is culverted underground. Open channel segments of Ford Branch and Chevy Branch are straightened and have little to no riparian vegetative cover. Ohio EPA designated West Branch Big Creek as a LRW due to significant modification of the stream and lack of riparian and in-stream habitat.

The lack of floodplain connectivity, culverted segments, and stormwater from industrial, commercial, and residential developments results in the altered hydrologic regime and flashy flows previously discussed in Section 3.2.3. With regards

to urbanization, stormwater, aquatic habitat, and biota, the information provided for the *Main Stem Big Creek* critical area (Section 3.2.3) applies to the *West Branch Big Creek* critical area too.

Previous Ohio EPA technical support documents and the lower Cuyahoga River TMDL (Ohio EPA 2003) only briefly discuss attainment and causes and sources of impairment in the Big Creek watershed. Typical of surrounding, highly developed urban watersheds, West Branch Big Creek is impaired by barriers to fish passage (culverted segments), flow regime alterations (urban runoff and storm sewers), and habitat alterations (channelization and loss of riparian habitat).

Figure 19. Chevy Branch (a tributary to West Branch) in the city of Cleveland.

3.3.4 Goals and Objectives for Critical Area #2

As explained in detail above, *Critical Area #2* is primarily impaired by barriers to fish passage, flow regime alterations, and habitat alterations. West Branch Big Creek has been modified to accommodate commercial and industrial development, residential subdivisions, and transportation infrastructure. As a LRW in a watershed dominated by impervious cover, improving aquatic community health will be difficult. Stormwater retrofits and daylighting culverted segments may improve the hydrologic condition. Industrial and commercial properties likely prohibit the establishment of a vegetated riparian corridor and connection to the floodplain.

3.3.4.1 Goals

The overall nonpoint source restoration goals of any NPS-IS plan is to improve IBI, MIwb, ICI, and QHEI scores such that a waterbody is brought into full attainment of the designated ALU. Nonattainment in this critical area is due to *very poor* IBI scores. Additionally, QHEI scores are above the headwaters target. Therefore, the goals for *Critical Area #4* of the Big Creek watershed are to improve IBI scores so that the site will improve to full attainment. These goals are specifically to:

Goal 1. **Achieve an IBI score of 18 at site 301192 (RM 4.67) on West Branch Big Creek**

- Not Achieved: Site currently has a score of 16

Goal 2. **Achieve an ICI[12] score of 8 at site 301192 (RM 4.67) on West Branch Big Creek**

- ✓ Achieved: Site currently has a score of 10

Goal 3. **Achieve a QHEI score of 55 at site 301192 (RM 4.67) on West Branch Big Creek**

- ✓ Achieved: Site currently has a score of 62.0

3.3.4.2 Objectives

To achieve the overall nonpoint source restoration goal of full attainment, the following objectives need to be achieved within *Critical Area #2*:

Objective 1 Install green infrastructure retrofits at commercial and industrial complexes to address 80 acres of impervious cover

- Disconnect downspouts from storm sewers and route roof runoff to newly installed bio-swales and water quality detention basins that discharge Big Creek.
- Install infiltration basins and route parking lot runoff through the infiltration basins before discharging to storm sewers.

Objective 2 Install green infrastructure retrofits on residential streets in Brook Park and Cleveland to reduce flooding of residential properties

- Downspout disconnects, rain gardens, and curb-cut bio-swales
- *Brook Park*: Wengler, Robert, Doris, Shelby, part of Ashland, and Harrison drives
- *Cleveland*: Cooley, Harold, Milligan, and Liala avenues and West 117th Street

Objective 3 Daylight 1,000 lineal feet of culverted West Branch to provide habitat for aquatic life

Objective 4 Restore 1,200 lineal feet of the banks and channel of West Branch and its tributaries Ford and Chevy branches

As these objectives are implemented, water quality monitoring (both project-related and regularly scheduled monitoring) will be conducted to determine progress toward meeting the identified goals (i.e., water quality standards). These objectives will be reevaluated and modified, as necessary. When reevaluating, BCC will reference Ohio's *Nonpoint Source Management Plan Update* (Ohio EPA 2013), which has a complete listing of all eligible NPS management strategies.

[12] If West Branch Big Creek is not suitable for placement of the in-stream modified Hester-Dendy substrate sampler, then Goal 2 is to achieve a qualitative EPT narrative score of *poor*.

3.4 CRITICAL AREA #3: CONDITIONS, GOALS, & OBJECTIVES

3.4.1 Detailed Characterization

The *Lower East Branch and Stickney Creek* critical area is composed of (1) the lowest East Branch of Big Creek from just downstream of an unnamed tributary (Big Creek RM 7.78) downstream to the confluence with the West Branch of Big Creek and (2) Stickney Creek, excluding a culverted, unnamed tributary (Figure 21). The lower East Branch in this critical area begins in CM's Big Creek Reservation and then flows north by commercial properties, including big box stores like Walmart and Sam's Club (Figure 20), before flowing under I-480. These segments have narrow riparian corridors. Downstream of I-480, East Branch meanders through wider, forested riparian cover with residential subdivisions to the east and industrial facilities with forested lots to the west. East Branch continues to flow north through Big Creek Reservation before its confluence with Big Creek near I-71 after flowing by an apartment complex and near rail lines.

Figure 20. East Branch Big Creek near Sam's Club.

Stickney Creek is a headwaters-sized tributary of the East Branch of Big Creek. Much of upper Stickney Creek is culverted underground within residential subdivisions composed of single family homes on straight, gridded streets. Downstream (west) of Ridge Road, Stickney Creek flows through an open channel in Memorial Park. Downstream of the park, Stickney Creek flows through a wooded, riparian corridor north of another residential subdivision before the stream discharges to East Branch.

The *Lower East Branch and Stickney Creek* critical area is 2,216 acres and is predominantly developed land (75 percent; Table 16). An evaluation of the percent imperviousness data from the 2011 National Land Cover Database indicated that a total of over a third (39 percent) of the critical area is impervious cover. This critical area also contains considerable developed open space (16 percent) in single family residential subdivisions and limited forest (8 percent) in Big Creek Reservation. Canopy cover is less than a fifth (16 percent) of the critical area.

Table 16. Land cover in the *Lower East Branch and Stickney Creek* critical area of the Big Creek watershed

Land cover	Area (acres)	Area (%)
Open water	--	--
Developed, open	357	16%
Developed, low intensity	957	43%
Developed, medium intensity	550	25%
Developed, high intensity	152	7%
Barren land	--	--
Deciduous forest	179	8%
Evergreen forest	1	<1%
Mixed forest	--	--
Shrub/scrub	--	--
Grassland / herbaceous	5	<1%
Pasture/hay	--	--
Cultivated crops	--	--
Woody wetlands	14	1%
Emergent herbaceous wetlands	--	--
Total [a]	**2,216**	**100%**

Source of spatial data: 2011 National Land Cover Database (Jin et al. 2013).
Notes
Areas rounded to the nearest acre or percentage point.
A double dash indicates that the land cover is not present.
a. Totals do not sum exactly due to rounding.

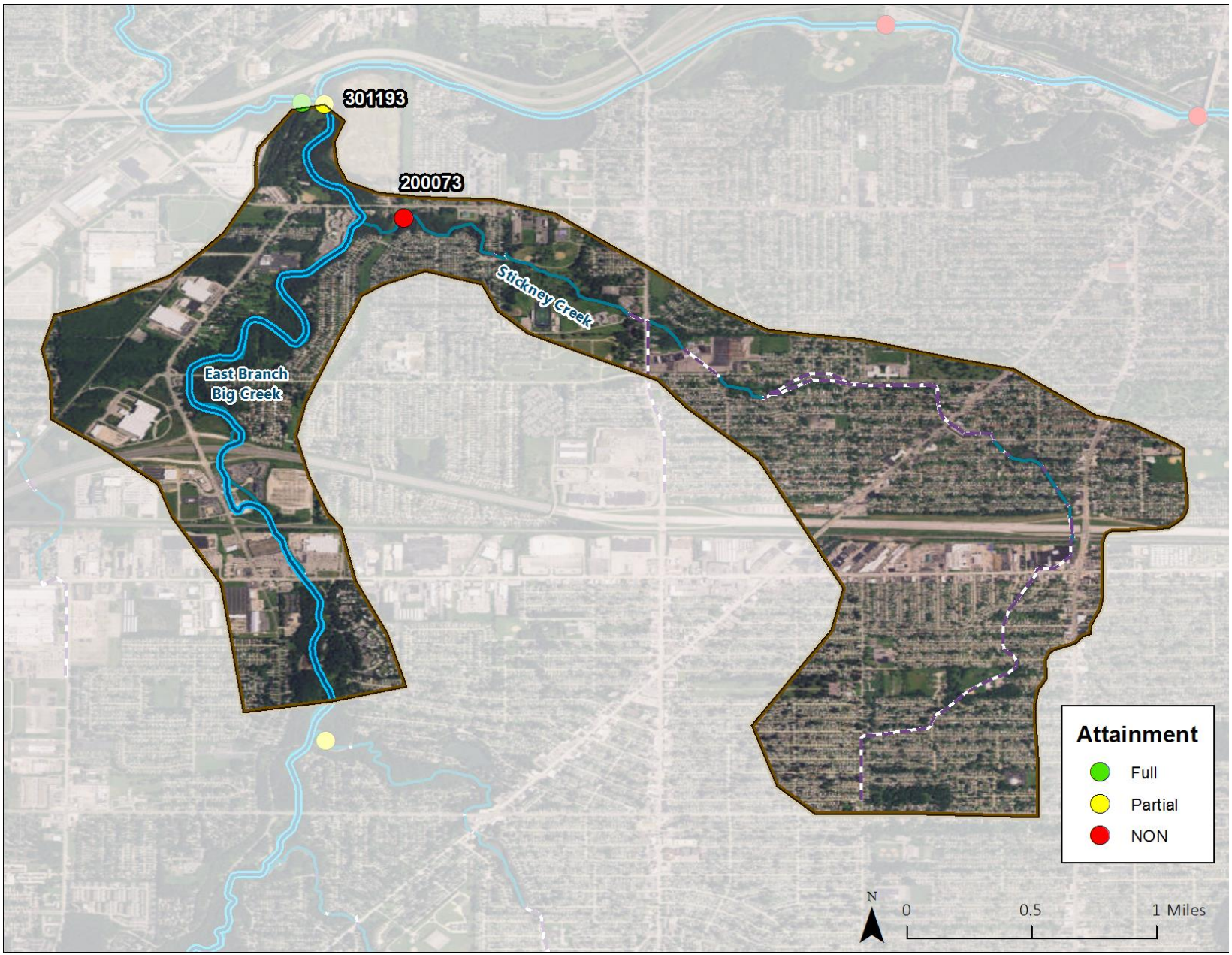


Figure 21. Critical Area #3: *Lower East Branch and Stickney Creek*.

3.4.2 Detailed Biological Condition

Several sites sampled over the past few years indicated partial or nonattainment of biological criteria. The most recent data were collected by NEORSD. The District evaluated fish and macroinvertebrate community health in 2016 in East Branch Big Creek at site 301193 (RM 4.40) and Stickney Creek at site 200073 (RM 0.15; Table 17 and Table 18). The IBI scores for two sample events in 2016 were 22 (*poor*) and 30 (*fair*). Most species caught are highly tolerant of pollution. No DELT anomalies were observed.

Table 17. Fish community health and habitat data - Critical Area #3

RM	DA	QHEI	Total species	MIwb	IBI	Predominant species (percent of catch)	Narrative evaluation
East Branch Big Creek							
4.40	19.3	65.5	8	--[a]	30	western blacknose dace (44%), creek chub (25%), central stoneroller minnow (21%)	Fair
Stickney Creek (aka unnamed tributary to Big Creek at RM 4.91)							
0.15	4.9	63.0	5	--[a]	22	creek chub (42%), western blacknose dace (24%)	Poor

Notes
DA = drainage area, in square miles; IBI = Index of Biotic Integrity; MIwb = Modified Index of well-being; QHEI = Qualitative Habitat Evaluation Index; RM = river mile.
a. The MIwb is not applicable to headwaters streams, which are less than 20 square miles.
Green scores meet the IBI biological criteria or QHEI target. Red scores do not meet the IBI biological criteria or QHEI target.

NEORSD deployed an in-stream modified Hester-Dendy substrate samplers in 2016 at both sites. The substrate sampler on Big Creek was not located during retrieval. The predominant species from quantitative sampling (with modified Hester-Dendy substrate samplers) in Stickney Creek were non-biting midges: *Tanytarsus glabrescens*, which are moderately intolerant gathering collectors, and *Thienemannimyia* group, which are facultative predators. Twenty-one quantitative taxa were identified. NEORSD calculated an ICI score of 28, which is less than the biological criterion (40).

Figure 22. Stickney Creek in Brooklyn Memorial Park.

Macroinvertebrate community health was also qualitatively assessed at sites 301193 (*marginally good*) and 200073 (*poor*). In Big Creek, over half of the qualitative taxa were facultative (16 taxa), while a few taxa were moderately intolerant (3 taxa), moderately tolerant (4 taxa) or tolerant (4 taxa)[13]. One coldwater taxon was observed at site 301193: *Polypedilum (Uresipedilum) aviceps*. The predominance of flatworms (class *Tubellaria*) and leeches (subclass *Hirudinea*) is often indicative of impaired community health. The qualitative assessment of macroinvertebrate community health at site 200073 was narratively scored as *poor* (Table 18).

[13] One taxon of *Corduliidae* or *Libellulidae* was identified but its pollution tolerance is not classified.

Table 18. Macroinvertebrate community health qualitative data - Critical Area #3

RM	DA	No. of taxa			Predominant species	Narrative evaluation
		Total	EPT	Coldwater		
East Branch Big Creek						
4.40	19.3	28	7	1	flatworms (common), leeches (common), baetid mayflies (common), dragonflies (common) hydropsychid caddisflies (common), nonbiting midges (common)	Marginally good
Stickney Creek (aka unnamed tributary to Big Creek at RM 4.91)						
0.15	4.9	28	7	0	flatworms (common), leeches (abundant), amphipods (common), baetid mayflies (common), hydropsychid caddisflies (common), nonbiting midges (common)	Poor

Notes
DA = drainage area, in square miles; EPT = *Ephemeroptera* (mayflies), *Plecoptera* (stoneflies), and *Trichoptera* (caddisflies); RM = river mile.
Green scores meet the ICI biological criteria. Red scores do not meet the ICI biological criteria.

3.4.3 Detailed Causes and Associated Sources

East Branch Big Creek and Stickney Creek drain an area of several residential subdivisions with some light industrial and commercial developments. Considerable sections of Stickney Creek are culverted underground, whereas East Branch is an open, meandering channel that flows through Big Creek Reservation. Open channels of Stickney Creek tend to have limited riparian cover and no connectivity to the floodplain, except in the lower reaches near the confluence with East Branch.

The lack of floodplain connectivity, culverted segments, and stormwater from residential developments results in the altered hydrologic regime and flashy flows previously discussed in Section 3.2.3. With regards to urbanization, stormwater, aquatic habitat, and biota, the information provided for the *Main Stem Big Creek* critical area (Section 3.2.3) applies to the *East Branch and Stickney Creek* critical area too.

Previous Ohio EPA technical support documents and the lower Cuyahoga River TMDL (Ohio EPA 2003) only briefly discuss attainment and causes and sources of impairment in the Big Creek watershed. Typical of surrounding, highly developed urban watersheds, East Branch Big Creek is impaired by flow regime alterations (urban runoff and storm sewers) and habitat alterations (loss of riparian habitat and lack of floodplain connection), while Stickney Creek is impaired by barriers to fish passage (culverted segments), flow regime alterations (urban runoff and storm sewers), and habitat alterations (channelization and loss of riparian habitat).

3.4.4 Goals and Objectives for Critical Area #3

As explained in detail above, *Critical Area #3* is primarily impaired by barriers to fish passage, flow regime alterations, and habitat alterations. Stickney Creek has been modified to accommodate residential and institutional development, while East Branch has been modified to accommodate commercial and industrial development and transportation infrastructure. Removal of barriers to fish passage (e.g., stream daylighting, culvert modification), stormwater retrofits, habitat restoration, and floodplain reconnection will be needed to improve aquatic community health.

3.4.4.1 Goals

The overall nonpoint source restoration goals of any NPS-IS plan is to improve IBI, MIwb, ICI, and QHEI scores such that a waterbody is brought into full attainment of the designated ALU. Partial and nonattainment in this critical area is due to *fair* to *poor* IBI and ICI scores. Additionally, QHEI scores are above the headwaters target. Therefore, the goals for *Critical Area #2* of the Big Creek watershed are to improve IBI and ICI scores at (1) site 301193 (RM 4.10) so that the site will

improve from partial attainment to full attainment and (2) site 200073 (RM 0.15) so that the site will improve from non-attainment to full attainment. These goals are specifically to:

Goal 1. **Achieve an IBI score of 40 at site 301193 (RM 4.10) on East Branch Big Creek**
- Not Achieved: Site currently has a score of 30

Goal 2. **Achieve an ICI[14] score of 34 at site 301193 (RM 4.10) on East Branch Big Creek**
- Not Achieved: Site currently has a score of *marginally good*

Goal 3. **Achieve a QHEI score of 55 at site 301193 (RM 4.10) on East Branch Big Creek**
- ✓ Achieved: Site currently has a score of 65.5

Goal 4. **Achieve an IBI score of 40 at site 200073 (RM 0.15) on Stickney Creek**
- Not Achieved: Site currently has a score of 22

Goal 5. **Achieve an ICI[15] score of 34 at site 200073 (RM 0.15) on Stickney Creek**
- Not Achieved: Site currently has a score of 28

Goal 6. **Achieve a QHEI score of 55 at site 200073 (RM 0.15) on Stickney Creek**
- ✓ Achieved: Site currently has a score of 63.0

3.4.4.2 Objectives

To achieve the overall nonpoint source restoration goal of full attainment, the following objectives need to be achieved within *Critical Area #3*:

Objective 1 Install green infrastructure retrofits on residential streets in Parma to improve water quality and reduce flooding of residential properties
- Downspout disconnects, rain gardens, and curb-cub bio-swales
- Forest Avenue and adjacent streets (300 residential units)

Objective 2 Daylight 1,500 lineal feet of culverted segments of East Branch in Cleveland and Parma to provide habitat for aquatic life
- *Cleveland*: Between Biddulph and Oak Park avenues
- *Parma*: Walters Grove Park and adjacent streets

Objective 3 Restore 1,000 lineal feet of banks and channel of East Branch Big Creek and Stickney Creek

Objective 4 Acquire and protect 30 acres adjacent to East Branch Big Creek in high-quality, wooded floodplain

As these objectives are implemented, water quality monitoring (both project-related and regularly scheduled monitoring) will be conducted to determine progress toward meeting the identified goals (i.e., water quality standards). These objectives will be reevaluated and modified, as necessary. When reevaluating, WCC will reference Ohio's *Nonpoint Source Management Plan Update* (Ohio EPA 2013), which has a complete listing of all eligible NPS management strategies.

[14] If East Branch Big Creek is not suitable for placement of the in-stream modified Hester-Dendy substrate sampler, then Goal 2 is to achieve a qualitative EPT narrative score of *good*.

[15] If Stickney Creek is not suitable for placement of the in-stream modified Hester-Dendy substrate sampler, then Goal 2 is to achieve a qualitative EPT narrative score of *good*.

3.5 CRITICAL AREA #4: CONDITIONS, GOALS, & OBJECTIVES

3.5.1 Detailed Characterization

Upper East Branch Big Creek (Figure 23) is the headwaters of the East Branch. This critical area is dominated by residential developments of single family homes. Large commercial developments are along Ridgewood Road and Ridge Road (OH-3) and the Ridgewood Country Club is nearby. There are also apartment complexes in this area.

Figure 23. East Branch Big Creek in Big Creek Reservation.

The *Upper East Branch* critical area is 4,905 acres and is predominantly developed land (54 percent; Table 19). An evaluation of the percent imperviousness data from the 2011 National Land Cover Database indicated that a total of one quarter of the critical area is impervious cover. This critical area also contains significant areas of developed open space (26 percent) in single family residential subdivisions and forest (18 percent) in small parks (e.g., Royalview Park, Selwick Park).

Table 19. Land cover in the *Upper East Branch* critical area of the Big Creek watershed

Land cover	Area (acres)	Area (%)
Open water	12	<1%
Developed, open	1,280	26%
Developed, low intensity	1,996	41%
Developed, medium intensity	489	10%
Developed, high intensity	156	3%
Barren land	--	--
Deciduous forest	876	18%
Evergreen forest	12	<1%
Mixed forest	--	--
Shrub/scrub	5	<1%
Grassland / herbaceous	28	1%
Pasture/hay	--	--
Cultivated crops	--	--
Woody wetlands	52	1%
Emergent herbaceous wetlands	--	--
Total [a]	**4,905**	**100%**

Source of spatial data: 2011 National Land Cover Database (Jin et al. 2013).
Notes
Areas rounded to the nearest acre or percentage point.
A double dash indicates that the land cover is not present.
a. Totals do not sum exactly due to rounding.

Figure 24. Critical Area #4: *Upper East Branch*

3.5.2 Detailed Biological Condition

Several sites sampled over the past few years indicated partial or nonattainment of biological criteria. The most recent data were collected by NEORSD; the District evaluated fish and macroinvertebrate community health in 2016 in East Branch Big Creek at site 303734 (RM 9.80) and an unnamed tributary to Big Creek at site 302642 (RM 0.05; Table 20 and Table 21). The IBI scores in 2016 were both 30 (*fair*). Most species caught are highly or moderately tolerant of pollution. One largemouth bass (*Micropterus salmoides*) was collected at RM 9.80. No DELT anomalies were observed.

Table 20. Fish community health and habitat data - Critical Area #4

RM	DA	QHEI	Total species	MIwb	IBI	Predominant species (percent of catch)	Narrative evaluation
East Branch Big Creek							
9.80	5.6	69.5	8	--[a]	30	central stoneroller minnow (46%), creek chub (32%)	Fair
unnamed tributary to Big Creek at RM 7.78							
0.05	2.5	67.0	7	--[a]	30	creek chub (27%), western blacknose dace (25%), central stoneroller minnow (19%)	Fair

Notes
DA = drainage area, in square miles; IBI = Index of Biotic Integrity; MIwb = Modified Index of well-being; QHEI = Qualitative Habitat Evaluation Index; RM = river mile.
a. The MIwb is not applicable to headwaters streams, which are less than 20 square miles.
Green scores meet the IBI biological criteria or QHEI target. Red scores do not meet the IBI biological criteria or QHEI target.

NEORSD deployed an in-stream modified Hester-Dendy substrate sampler in 2016 at site 302642 (RM 0.05) on the unnamed tributary to Big Creek. The predominant species from quantitative sampling (with modified Hester-Dendy substrate samplers) in the unnamed creek at site 302642 were aquatic segmented-worms (class *Oligochaeta*), which are pollution-tolerant gathering collectors that burrow; they are indicative of poor macroinvertebrate community health (Table 21). *Corynoneura lobate* (moderately intolerant, gathering collector), *Tanytarsus* species (moderately intolerant, gathering collector), and *Polypedilum* (*Uresipedilum*) *flavum* (facultative, gathering collector) were also common. Thirty-two quantitative taxa were identified and 20 qualitative taxa were identified. NEORSD calculated an ICI score of 32, which is less than the biological criterion (40).

Macroinvertebrate community health was qualitatively assessed at sites 303734 (*poor*) and 302642 (*poor*). In Big Creek, over half of the qualitative taxa were facultative (7 taxa), while a few taxa were, moderately tolerant (1 taxon) or tolerant (4 taxa). No coldwater taxon were observed at site 303734. In the unnamed tributary at RM 7.78 of Big Creek, 20 taxa were identified (Table 21).

Table 21. Macroinvertebrate community health qualitative data - Critical Area #4

RM	DA	No. of taxa			Predominant species	Narrative evaluation
		Total	EPT	Coldwater		
0.05	2.5	20	6	0	freshwater crustaceans (common), damselflies (common), hydropsychid caddisflies (common)	Poor

Notes
DA = drainage area, in square miles; EPT = *Ephemeroptera* (mayflies), *Plecoptera* (stoneflies), and *Trichoptera* (caddisflies); RM = river mile.
Red scores do not meet the ICI biological criteria.

In 2015, NEORSD deployed an in-stream modified Hester-Dendy substrate sampler in East Branch (Big Creek RM 9.80). The *poor* ICI score from 2015 (20) was due to a lack of mayfly taxa (0 points for the *number of mayfly* and *percent mayflies* metrics), few EPT taxa (0 points for the *qualitative EPT taxa* metric [3 taxa]), and the dominance of other insects (0 points for the *percent other diptera and non-insects* metric [79 percent]). Only one metric scored the full 6 points (*percent Tanytarsini midges*).

3.5.3 Detailed Causes and Associated Sources

Upper East Branch Big Creek drains an area of several residential subdivisions with a few commercial complexes. East Branch is culverted under roadways only. Residential development discharges stormwater to East Branch via public storm sewers and the creek is often disconnected from the floodplain. This critical area was also established to help address flooding in residential developments and to protect larger tracts of less developed riparian areas.

The lack of floodplain connectivity, culverted segments, and stormwater from residential developments results in the altered hydrologic regime and flashy flows previously discussed in Section 3.2.3. With regards to urbanization, stormwater, aquatic habitat, and biota, the information provided for the *Main Stem Big Creek* critical area (Section 3.2.3) applies to the *East Branch and Stickney Creek* critical area too.

Previous Ohio EPA technical support documents and the lower Cuyahoga River TMDL (Ohio EPA 2003) only briefly discuss attainment and causes and sources of impairment in the Big Creek watershed. Typical of surrounding, highly developed urban watersheds, East Branch Big Creek is impaired by flow regime alterations (urban runoff and storm sewers) and habitat alterations (channelization and loss of riparian habitat).

During biological sampling, NEORSD observed untreated sanitary waste in the upper East Branch of Big Creek, which is likely derived from CSOs. However, CSOs are point sources and beyond the scope of this NPS-IS.

3.5.4 Goals and Objectives for Critical Area #4

As explained in detail above, *Critical Area #4* is primarily impaired by barriers flow regime alterations and habitat alterations. Big Creek has been modified to accommodate residential and institutional development. Stormwater retrofits, habitat restoration, and floodplain reconnection will be needed to improve aquatic community health.

3.5.4.1 Goals

The overall nonpoint source restoration goals of any NPS-IS plan is to improve IBI, MIwb, ICI, and QHEI scores such that a waterbody is brought into full attainment of the designated ALU. Non-attainment in this critical area is due to a *fair* to *poor* IBI and ICI scores. Additionally, QHEI scores are above the headwaters target. Therefore, the goals for *Critical Area #3* of the Big Creek watershed are to improve IBI and ICI scores at site 303734 (RM 9.80) [16] so that the site will improve from non-attainment to full attainment of the designated ALU. These goals are specifically to:

Goal 1. **Achieve an IBI score of 40 at site 303734 (RM 9.80) on East Branch Big Creek**

- Not Achieved: Site currently has a score of 30

Goal 2. **Achieve an ICI[17] score of 34 at site 303734 (RM 9.80) on East Branch Big Creek**

- Not Achieved: Site currently has a score of *poor*

Goal 3. **Achieve a QHEI score of 55 at site 303734 (RM 9.80) on East Branch Big Creek**

- ✓ Achieved: Site currently has a score of 69.5

[16] Goals are set for site 303734 (RM 9.80), and not site 303642, because site 303734 is downstream of both the residential developments that flood and priority conservation areas that are the focus of the objectives (i.e., site 303734 may be more representative of *Critical Area #3*). Additionally, much of the subwatershed draining to site 303734 is culverted and upstream of the Leone Pond Dam.

[17] If East Branch Big Creek is not suitable for placement of the in-stream modified Hester-Dendy substrate sampler, then Goal 2 is to achieve a qualitative EPT narrative score of *good*.

3.5.4.2 Objectives

To achieve the overall nonpoint source restoration goal of full attainment, the following objectives need to be achieved within *Critical Area #4*:

Objective 1 Install green infrastructure retrofits at commercial, industrial, and institutional properties with 30 acres of impervious cover

- Disconnect downspouts from storm sewers and route roof runoff to newly installed bio-swales and water quality detention basins that discharge Big Creek.
- Install infiltration basins and route parking lot runoff through the infiltration basins before discharging to storm sewers.

Objective 2 Install green infrastructure retrofits on residential streets in Parma to improve water quality in upper East Branch Big Creek and to reduce flooding of nearby residential properties

- Downspout disconnects, rain gardens, and curb-cub bio-swales
- Hauserman Road area (150 residential units)
- Hollenbeck Lake area (100 residential units)
- Powers Boulevard area (50 residential units)
- Improve stormwater treatment at the Ridgewood Lake by installing pretreatment cells and increasing lake capacity.

Objective 3 Create or re-connect 20 acres of floodplain

Objective 4 Restore 1,000 lineal feet of stream channel

Objective 5 Acquire and protect (or establish conservation easements) on 30 acres of habitat adjacent to East Branch Big Creek

As these objectives are implemented, water quality monitoring (both project-related and regularly scheduled monitoring) will be conducted to determine progress toward meeting the identified goals (i.e., water quality standards). These objectives will be reevaluated and modified, as necessary. When reevaluating, BCC will reference Ohio's *Nonpoint Source Management Plan Update* (Ohio EPA 2013), which has a complete listing of all eligible NPS management strategies.

4 PROJECTS AND IMPLEMENTATION STRATEGY

Projects and evaluations believed to be necessary to address the causes and sources of impairments to the Big Creek watershed are presented by critical area in this section. As Ohio assesses attainment using numeric biological criteria, periodic re-evaluation of biological condition will be necessary to determine if the implemented projects restore the critical areas.

Figure 25. Completed stormwater project in the Big Creek Reservation.

Time is an important factor to consider when measuring project success and overall status. Biological systems in some cases can show response fairly quickly (e.g., one season); other systems may take longer (e.g., several seasons, years) to show recovery. There may also be reasons other than nonpoint source pollution for the impairment. Those issues will need to be addressed under different initiatives, authorities or programs which may or may not be accomplished by the same implementers addressing the nonpoint source pollution issues.

The Big Creek watershed was delineated into four critical areas to address causes and sources of impairment. An overview table is presented for each critical area in the following subsections (4.1.1, 4.2.1, 4.3.1, and 4.3.3). Projects in each of the three critical areas were prioritized using the following process:

Highest priority	Directly addresses one or more of the critical area's objectives
	Indirectly or directly affect one or more upstream critical areas' objectives
	Landowner support
	Provides additional benefits to the community (e.g., reduces residential flooding)
Higher priority	Directly address one or more of the critical area's objectives
	Landowner support
Lower priority	Indirectly address one or more of the critical area's objectives
	Landowner support
Lowest priority	Indirectly address one or more of the critical area's objectives

If additional NPS impairments are identified for an existing critical area, the critical area's overview table will be updated. If a new impairment is determined that is not within an existing critical area, then a new critical area will be delineated and a new summary table will be created. Limited information is available for many of the medium- and long-term projects; unavailable information is identified as *to be determined* (TBD).

Project Summary Sheets (PSS) are in Sections 4.1.2, 4.2.2, 4.3.2, and 4.3.4. These PSS provide the essential nine elements for short-term and/or next step projects that are in development and/or in need of funding. As projects are implemented and new projects developed these sheets will be updated. Any new PPS created will be submitted to the state of Ohio for funding eligibility verification (i.e., all nine elements are included).

Load reductions for stormwater projects were calculated by Tetra Tech (2014). Total suspended solids (TSS) load reductions for stream restoration projects were calculated using U.S. EPA's Spreadsheet Tool for Estimating Pollutant Load. The selection of slight or moderate bank recession rates was based upon review of aerial imagery and best professional judgment.

4.1 CRITICAL AREA #1: OVERVIEW TABLE AND PROJECT SHEETS

The information included in Table 22 is a condensed overview of all identified projects needed for nonpoint source restoration of the *Main Stem Big Creek* critical area. PSSs are included for short term projects or any project that is considering seeking funding in the near future. Only those projects with complete PSS will be considered for state and federal nonpoint source program funding.

4.1.1 Critical Area #1: Project Implementation Strategy Overview Table

The *Main Stem Big Creek* critical area is based upon non-attainment at sampling site 502120 (RM 0.23). The overview table (Table 22) provides a quick summary of what needs to be done, where and what problem (cause/source) will be addressed. The table includes projects at all levels of development (e.g., concept, in progress), and the table is intended to show a prioritized path toward restoration of the *Main Stem Big Creek* critical area in the Big Creek watershed. Figure 26 presents an area near two projects shown in the overview table (Table 22) and Figure 27 presents a map of the critical area with the projects from the overview table.

Figure 26. Brooklyn Oxbow Wetland (near the sites of projects #10 and #11 in Table 22).

Table 22. Critical Area #1: Overview table for *Main Stem Big Creek*

Goal	Objective	Project	Project title	Lead organization (criteria d)	Timeframe (criteria f)	Estimated cost (criteria d)	Potential/actual funding sources (criteria d)
Urban sediment and nutrient reduction strategies							
none identified (yet)							
Altered stream and habitat restoration strategies							
1, 2, 3	1	1	Big Creek drop-structure rehabilitation (asset BC00032)	NEORSD	Medium	$6,000,000	NEORSD (funded)
1, 2	2	2	Big Creek bank stabilization below Jennings Road (asset BC00004; project SWD2014-003)	NEORSD	Medium	*not available*	NEORSD (funded)
1, 2	2	3	Big Creek bank stabilization above Jennings Road (asset BC00010; project SWD2014-003)	NEORSD	Medium	*not available*	NEORSD (funded)
1, 2, 3	3	4	Auto salvage acquisition and reclamation at Brooklyn Auto Parts	BCC, Cleveland, WCC	Long	TBD	WRRSP
3	3	5	Henninger Landfill Restoration (after soil remediation)	WRLC	Medium	TBD	Clean Ohio, GLRI
1, 2, 3	3	6	Wetland restoration between CSX and Norfolk Southern railroad lines	CSX Norfolk Southern	Long	TBD	CSX
1, 2	1	7	Ramp-up to culvert outlet downstream of CM Zoo parking lot to allow fish passage	BCC	Medium	TBD	CM, SOGL, Ohio EPA §319
1, 2	1	8	Ramp-up to culvert outlet downstream of Brookside Road at CM Zoo entrance to allow fish passage	BCC	Medium	TBD	CM, SOGL, Ohio EPA §319
1, 2, 3	1, 2, 3	9	Big Creek Channel and Drop Structure Enhancement	Brooklyn, Cleveland, ODOT	Long	$85,000,000	ODOT, NOACA, etc.
1, 2, 3	3	10	Brooklyn Oxbow Lower Wetland Restoration	BCC, Brooklyn, CM	Medium	TBD	Ohio EPA §319, GLRI
1, 2, 3	3	11	Brooklyn Oxbow Upper Wetland Restoration	BCC, Brooklyn	Medium	TBD	Ohio EPA §319, GLRI
Agricultural nonpoint source reduction strategies							
not applicable							
High quality waters protection strategies							
none identified (yet)							
Other NPS causes and associated sources of impairment							
1, 2, 3	4	12	Cleveland Metroparks Zoo parking lot retrofit	BCC, CM	Medium	TBD	GLRI, NEORSD
1, 2, 3	4	13	Dave's Market parking lot retrofit	BCC, NEORSD, Dave's Market, Neighborhood Family Practice	Short	$230,000	NEORSD, etc.

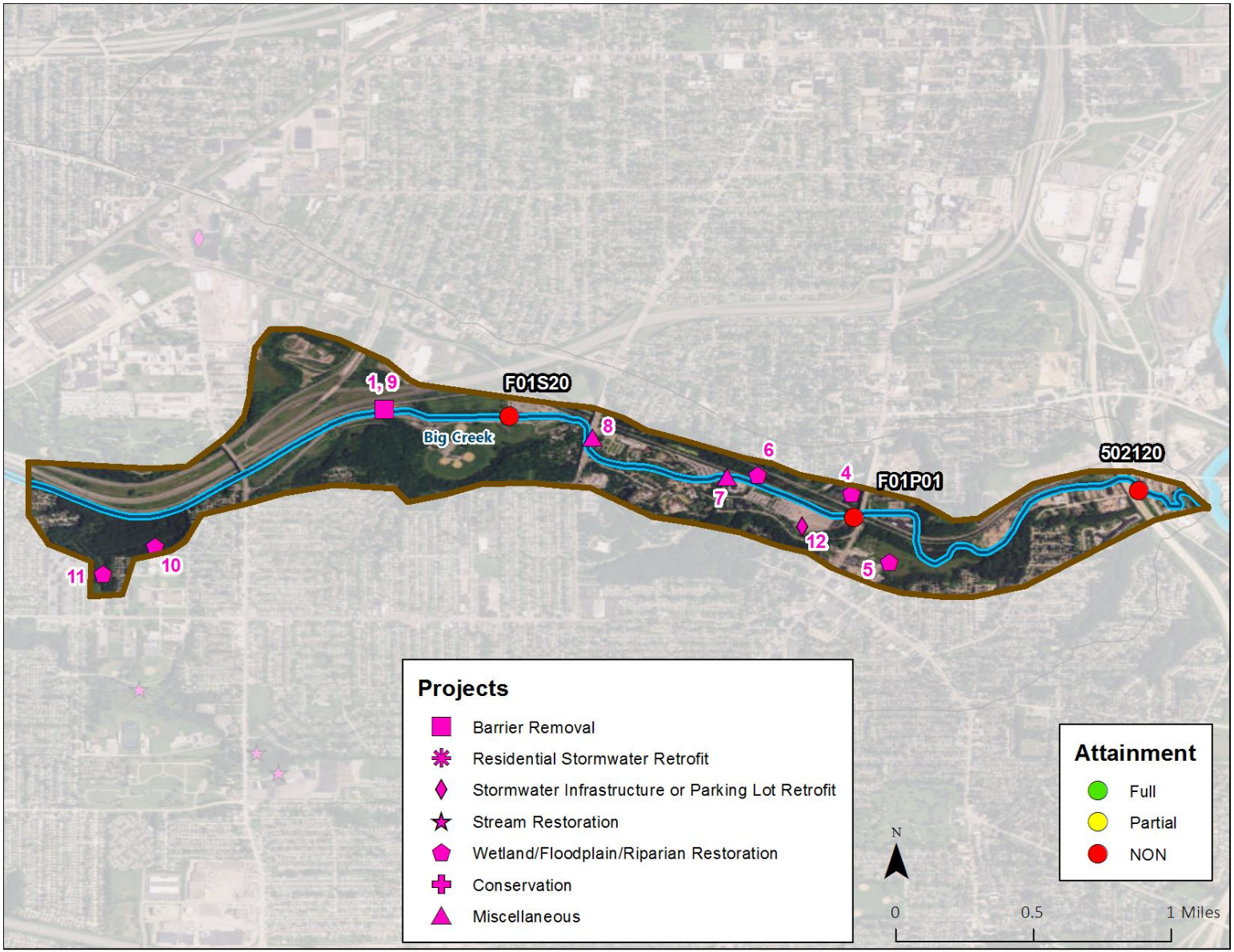


Figure 27. Projects for the *Main Stem Big Creek* critical area.

4.1.2 Critical Area #1: Project Summary Sheets

The PSSs provided below were developed based on the actions or activities needed to restore sampling site 502120 (RM 0.23) to attainment of the ALU designation. These projects are considered next step or priority/short term projects. Medium and long-term projects are not presented in PSSs since they are not yet ready for implementation.

Critical Area 1: Project 13		
Nine Element Criteria	**Information Needed**	**Explanation**
n/a	Title	Dave's Market parking lot retrofit
criterion d	Project Lead Organization and Partners	BCC, Dave's Market, Neighborhood Family Practice, & NEORSD
criterion c	HUC-12 & Critical Area	*Big Creek* (HUC 04110002 06 04) & *Main Stem Big Creek*
criterion c	Project Location	Parking lots along Denison Avenue and Ridge Road, behind Dave's Market and Neighborhood Family Practice
n/a	Which strategy is being addressed by this project?	Altered stream and habitat restoration strategies
criterion f	Time Frame	Short
criterion g	Short Description	Install permeable pavement sidewalk, s
criterion g	Project Narrative	A permeable pavement sidewalk will be installed to connect parking lots along Ridge Road to Dennison Avenue. Beneath the sidewalk gravel storage will be installed and connected via underdrains to storm sewers that receive runoff from the parking lots. The proposed permeable sidewalk will intercept over three acres of parking lot and provide storage for the 0.8 inch rainfall event. Trees will be planted along the sidewalk to delineate the pedestrian walkway and to shade (and thus cool) the paved surfaces.
criterion d	Estimated Total Cost	$190,000 to $230,000
criterion d	Possible Funding Source	Ohio EPA §319, GLRI
criterion a	Identified Causes and Sources	Causes: Flow regime alteration Sources: Urban runoff/storm sewers
Criteria b & h	Part 1: How much improvement is needed to remove the NPS impairment associated with this Critical Area?	Significant improvement is necessary for the IBI score of 27 to be increased to 40 to meet water quality standards and small improvement is necessary for the MIwb score of 7.3 to be increased to 7.6. Modest improvement is necessary for the ICI score of *fair* to be increased to 34 (or *good*) to meet water quality standards.
	Part 2: How much of the needed improvement for the whole Critical Area is estimated to be accomplished by this project?	This project will achieve about 9% of Objective 4 (about 3.5 acres of the 40 acre objective) but will not address Objective 1, Objective 2, or Objective 3.
	Part 3: Load reduced?	Annual load reduction: 1,130 lb/yr TSS
criterion i	How will the effectiveness of this project in addressing the NPS impairment be measured?	IBI, ICI, and QHEI will be assessed before and after project implementation. If this project is funded through §319, Ohio EPA DSW EAU will perform the monitoring. NEORSD is another potential entity that can perform the monitoring.
criterion e	Information and Education	Signage will be installed at the project site. BCC will discuss the project in its newsletters and post about the project on its website and social media.

4.2 CRITICAL AREA #2: OVERVIEW TABLE AND PROJECT SHEETS

The information included in Table 23 is a condensed overview of all identified projects needed for nonpoint source restoration of the *West Branch* critical area. PSSs are included for short term projects or any project that is considering seeking funding in the near future. Only those projects with complete PSSs will be considered for state and federal nonpoint source program funding.

4.2.1 Critical Area #2: Project Implementation Strategy Overview Table

The *Lower West Branch* critical area is based upon full attainment of LRW thresholds at sampling site 200072 (RM 0.10) and nonattainment at site 301192 (RM 4.67). The overview table (Table 23) provides a quick summary of what needs to be done where and what problem (cause/source) will be addressed. The table includes projects at all levels of development (e.g., concept, in progress), and the table is intended to show a prioritized path toward restoration of the *West Branch* critical area in the Big Creek watershed. Figure 28 presents an example project from the overview table, and Figure 29 presents a map of the critical area with the projects from the overview table.

Figure 28. Project #6 in Table 23 propose to install a detention basin in Wedo Park.

Table 23. Critical Area #2: Overview table for *West Branch*

Goal	Objective	Project	Project title	Lead organization (criteria d)	Timeframe (criteria f)	Estimated cost (criteria d)	Potential/actual funding sources (criteria d)
Urban sediment and nutrient reduction strategies							
none identified (yet)							
Altered stream and habitat restoration strategies							
1	4	1	West Branch Stream Restoration along Kensington Avenue	Cleveland, WCC	Medium	~$400,000	Clean Ohio, GLRI
1	3	2	Daylighting and restoring West Branch along Cooley Avenue	BCC, Cleveland, WCC	Long	TBD	Clean Ohio, GLRI
1	3	3	Daylighting and restoring sections of Chevy Branch along Harold, Lena, and Milligan Avenues	BCC, Cleveland, WCC	Medium	~$1,000,000	Clean Ohio, GLRI
--[a]	--[a]	-- [a]	Project to address erosion and bank failure (asset WB00108; project SWD2016-018)	NEORSD	Medium	TBD	NEORSD
--[a]	--[a]	-- [a]	Projects to stabilize banks (multiple sites) (assets WB00072, WB00104; project SWD2016-033)	NEORSD	Medium	TBD	NEORSD
Agricultural nonpoint source reduction strategies							
not applicable							
High quality waters protection strategies							
none identified (yet)							
Other NPS causes and associates sources of impairment							
1	2	4	Chevy Branch Stormwater Source Controls to along Harold, Liala, and Milligan Avenues	BCC, Cleveland	Medium	TBD	TBD
1	1	5	General Motors East Parking Lot Retrofit	BCC, General Motors	Short	$7,000,000	Ohio EPA §319, GLRI, General Motors
1	2	6	Wedo Park Detention Basin Construction to Address Flooding	Brook Park, NEORSD	Medium	TBD	NEORSD
1	1	7	Ford Motor Basin Retrofit	BCC, Ford, NEORSD	Long	TBD	TBD
1	2	8	Brook Park Stormwater Source Controls along Wengler, Robert, Doris, Shelby, Ashland, and Harrison Drives	BCC, Brook Park	Medium	TBD	TBD

Note a.: NEORSD is in the early planning stages for several projects for locations in the *West Branch* critical area. These projects will begin in 2018 or later and may benefit fish populations (goal #1).

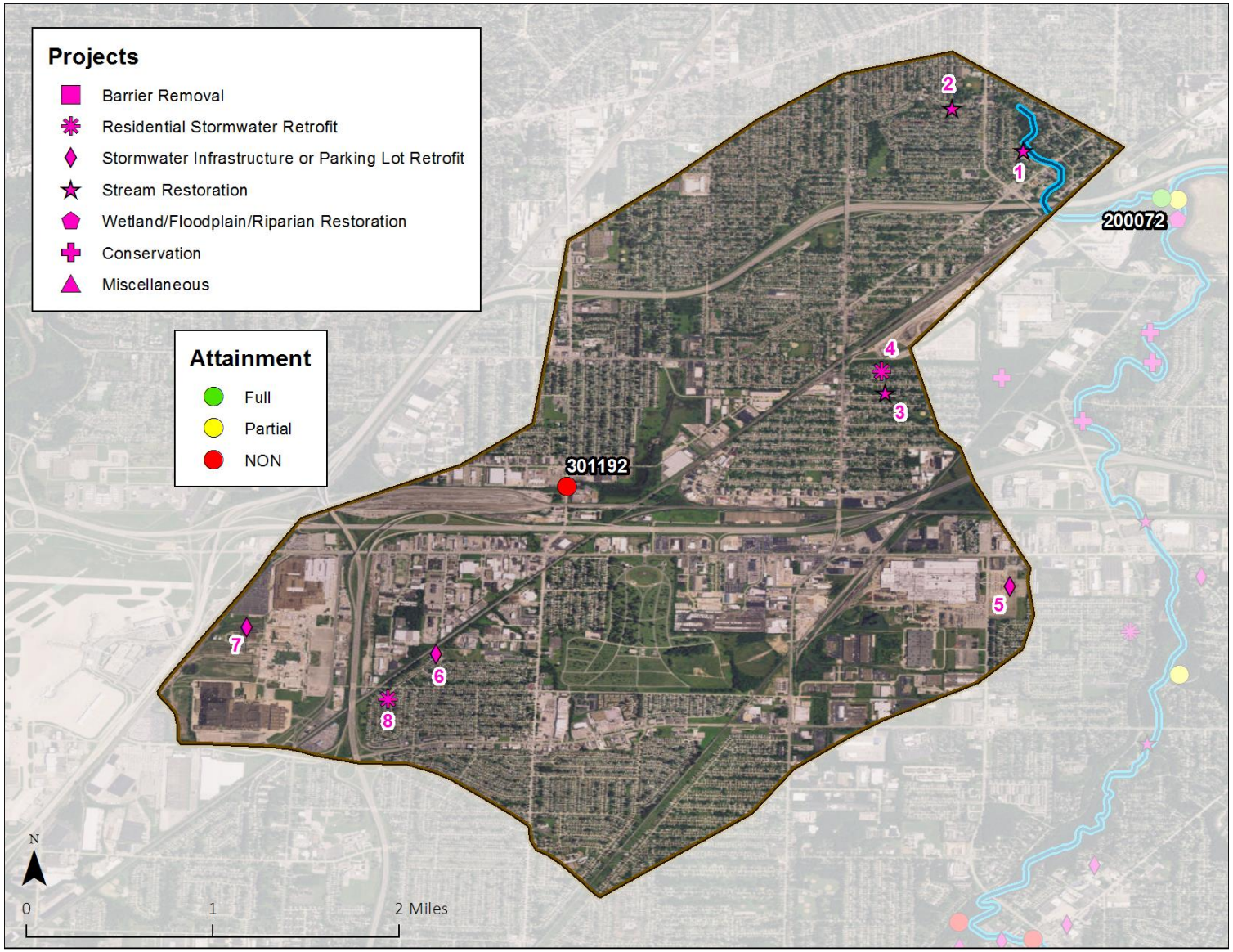


Figure 29. Projects for the *West Branch Big Creek* critical area.

4.2.2 Critical Area #2: Project Summary Sheets

The PSS provided below was developed based on the actions or activities needed to restore sampling sites 200072 (RM 0.10) and nonattainment at site 301192 (RM 4.67) to attainment of their ALU designations. This PSS is considered next step or priority/short term projects. Medium and long-term projects are not presented in PSSs since they are not yet ready for implementation.

Critical Area 2: Project 5		
Nine Element Criteria	**Information Needed**	**Explanation**
n/a	Title	General Motors East Parking Lot Retrofit
criterion d	Project Lead Organization and Partners	BCC & General Motors
criterion c	HUC-12 & Critical Area	*Big Creek* (HUC 04110002 06 04) & *West Branch*
criterion c	Project Location	General Motors parking lot on the east side of Chevrolet Boulevard just south of Brookpark Road
n/a	Which strategy is being addressed by this project?	Urban sediment and nutrient reduction strategies
criterion f	Time Frame	Short
criterion g	Short Description	Parking lot retrofit with the installation of bioswales, bioretention, and pervious pavers
criterion g	Project Narrative	The parking spaces will be aligned to improve safety for workers as they enter the facility. Bioswales, lined with trees and located between parking spaces, will guide stormwater runoff into numerous bioretention areas. The rear section of the parking lot will be surfaced with green pavers, allowing water to percolate directly into the ground. The proposed site includes over 800 parking spaces.
criterion d	Estimated Total Cost	$5,500,000 to $7,000,000
criterion d	Possible Funding Source	Ohio EPA §319, GLRI, General Motors
criterion a	Identified Causes and Sources	Causes: Flow regime alteration Sources: Urban runoff/storm sewers
Criteria b & h	Part 1: How much improvement is needed to remove the NPS impairment associated with this Critical Area?	Minor improvement is necessary for the IBI score of 16 to be increased to 18 to meet water quality standards.
	Part 2: How much of the needed improvement for the whole Critical Area is estimated to be accomplished by this project?	This project will achieve about 25% of Objective 1 (about 20 acres of the 80 acre objective) but will not address Objective 2, Objective 3, or Objective 4.
	Part 3: Load reduced?	Annual load reductions: 10,973 lb/yr TSS, 20.5 lb/yr total phosphorus, and 59.7lb/yr total nitrogen
criterion i	How will the effectiveness of this project in addressing the NPS impairment be measured?	IBI, ICI, and QHEI will be assessed before and after project implementation. If this project is funded through §319, Ohio EPA DSW EAU will perform the monitoring.
criterion e	Information and Education	Signage will be installed at the project site. BCC will present project results to General Motors staff. BCC will discuss the project in its newsletters and post about the project on its website.

4.3 CRITICAL AREA #3: OVERVIEW TABLE AND PROJECT SHEETS

The information included in the Table 24 is a condensed overview of all identified projects needed for nonpoint source restoration of the *Lower East Branch and Stickney Creek* critical area. PSSs are included for short term projects or any project that is considering seeking funding in the near future. Only those projects with complete PSSs will be considered for state and federal nonpoint source program funding.

4.3.1 Critical Area #3: Project Implementation Strategy Overview Table

The *Lower East Branch and Stickney Creek* critical area is based upon partial attainment at sampling site 301193 (RM 4.10) and nonattainment at site 200073 (RM 0.15). The overview table (Table 24) provides a quick summary of what needs to be done where and what problem (cause/source) will be addressed. The table includes projects at all levels of development (e.g., concept, in progress), and the table is intended to show a prioritized path toward restoration of the *Lower East Branch and Stickney Creek* critical area in the Big Creek watershed. Figure 30 presents a map of the critical area with the projects from the overview table.

Table 24. Critical Area #3: Overview table for *Lower East Branch and Stickney Creek*

Goal	Objective	Project	Project title	Lead organization (criteria d)	Timeframe (criteria f)	Estimated cost (criteria d)	Potential/actual funding sources (criteria d)
Urban sediment and nutrient reduction strategies							
none identified (yet)							
Altered stream and habitat restoration strategies							
4, 5	3	1	Ridge Road (Stickney Creek) Bank Stabilization and Utility Repair (asset ST00209; project SWC2016-003)	NEORSD	Medium	$1,000,000	NEORSD (funded)
1, 2	3	2	Cleveland Metroparks Memphis Picnic Area Floodplain Reconnection	BCC, CM	Medium	TBD	Ohio EPA §319, CM, GLRI
1, 2	3	3	Sam's Club Stream Channel Restoration and Bridge Replacement to Reduce Flooding	BCC, TBD	Medium-Long	TBD	TBD
4, 5	3	4	Stickney Creek Floodplain Restoration in Veterans Memorial Park	BCC, WCC, Brooklyn	Short	$761,175	Ohio EPA §319, GLRI
4, 5	2, 3	5	Biddulph Plaza Stream Daylighting	BCC, NEORSD	Long	TBD	TBD
4, 5	2, 3	6	Old Brooklyn Stream Daylighting and Restoration	BCC, Cleveland, WCC	Long	TBD	GLRI
4, 5	2, 3	7	Walters Grove Stream Daylighting and Restoration	BCC, Parma, WCC	Long	TBD	GLRI
Agricultural nonpoint source reduction strategies							
not applicable							
High quality waters protection strategies							
1, 2	3, 4	8	Floodplain Conservation and Restoration of Cleveland Baptist Church	BCC, WCC	Medium	TBD	TBD
1, 2	3, 4	9	Floodplain Conservation and Restoration of Teideman Road Parcel	BCC, WCC	Medium	TBD	TBD
1, 2	3, 4	10	Floodplain Conservation and Restoration of Biddulph Avenue Parcel	BCC, WCC	Medium	TBD	TBD
1, 2	3, 4	11	Floodplain Conservation and Restoration of Brooklyn Wetlands (American Greetings)	BCC, WCC	Long	TBD	TBD
Other NPS causes and associates sources of impairment							
4, 5	1	12	Walters Grove Stormwater Source Controls	BCC, Parma	Medium	TBD	TBD
1, 2	1	13	Knollwood Apartments Parking Lot Retrofits	BCC, Parma	Medium-Long	TBD	319, SOGL, NEORSD GIG
4,5,6	1	14	Ridge Park Square Green Infrastructure Phase 1	WCC, BCC, RPS	Short	200,000	319, SOGL

Funded and Completed

Funded Being Completed 2020/2021

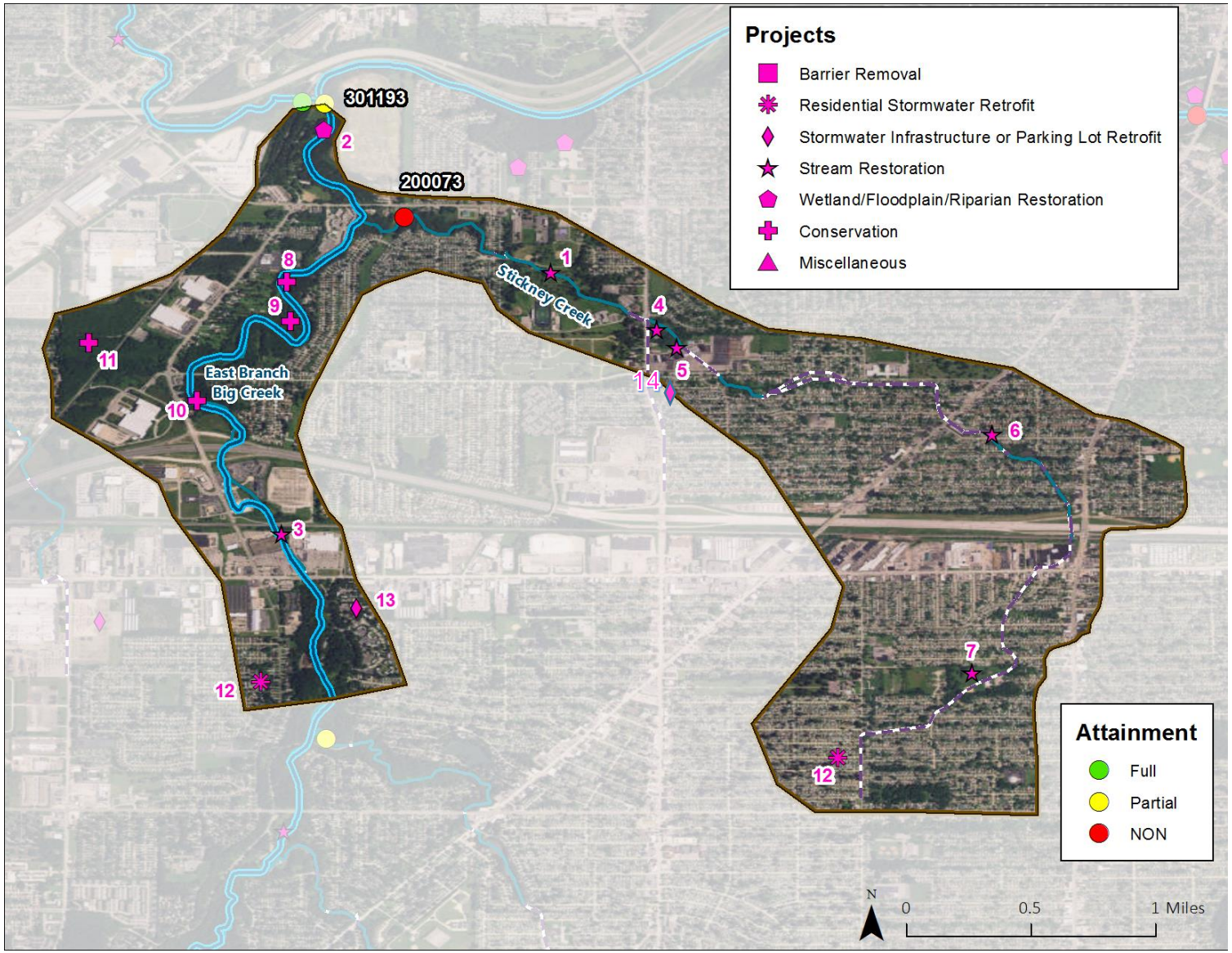


Figure 30. Projects for the *East Branch and Stickney Creek* critical area.

4.3.2 Critical Area #3: Project Summary Sheets

The PSS provided below was developed based on the actions or activities needed to restore sampling sites 301193 (RM 4.10) and 200073 (RM 0.15) to attainment of their ALU designations. These PSS are considered next step or priority/short term projects. Medium and long-term projects are not presented in PSSs since they are not yet ready for implementation.

Critical Area 3: Project 4		
Nine Element Criteria	**Information Needed**	**Explanation**
n/a	Title	Stickney Creek Floodplain Restoration in Veterans Memorial Park
criterion d	Project Lead Organization and Partners	BCC, WCC, Brooklyn
criterion c	HUC-12 & Critical Area	*Big Creek* (HUC 04110002 06 04) & *East Branch and Stickney Creek*
criterion c	Project Location	7619 Memphis Ave, Brooklyn, OH 44144 (owned by Brooklyn)
n/a	Which strategy is being addressed by this project?	Altered Stream and Habitat Restoration Strategy
criterion f	Time Frame	Short
criterion g	Short Description	Floodplain reconnection, bank stabilization, Infrastructure Removal
criterion g	Project Narrative	This will restore 0.5 miles of Stickney Creek. Minor channel realignment and additional floodplain excavation may be explored in future design efforts when soil depths and bedrock elevations are better understood. Approximately six acres of riparian floodplain will be planted. Most of the gabion baskets lining the channel will be removed. The remaining gabion rock will be reused in the channel restoration. The ford will be removed from the stream, and 1,500 feet of asphalt trail will be removed from the floodplain. the sediment/nutrient load was estimated using STEPL, USEPA 2018. The project would prevent approx. 3.3 tons of sediment and approx. 3.3 pounds of Phosphorus and 6.6 pounds of Nitrogen, annually.
criterion d	Estimated Total Cost	$761,175
criterion d	Possible Funding Source	Ohio EPA §319, GLRI
criterion a	Identified Causes and Sources	Cause: Flow regime alteration, Habitat alteration Source: Urban runoff/storm sewers, Loss of riparian habitat
Criteria b & h	Part 1: How much improvement is needed to remove the NPS impairment associated with this Critical Area?	Significant improvement is necessary for the IBI score of 30 to be increased to 40. Minimal improvement is necessary for the ICI score of *marginally good* to be increased to 34 (or *good*) to meet water quality standards.
	Part 2: How much of the needed improvement for the whole Critical Area is estimated to be accomplished by this project?	This project will achieve about 150% of Objective 3 (about 2,500 feet of the 1,000 foot objective) but will not address Objective 1, Objective 2, or Objective 4.
	Part 3: Load reduced?	The stream restoration should increase the IBI and ICI by several points. Annual load reduction: 8.6 tons/year TSS.
criterion i	How will the effectiveness of this project in addressing the NPS impairment be measured?	IBI, ICI, and QHEI will be assessed before and after project implementation. If this project is funded through §319, Ohio EPA DSW EAU will perform the monitoring. NEORSD is another potential entity that can perform the monitoring.
criterion e	Information and Education	Signage will be installed at the project site. BCC will discuss the project in its newsletters and post about the project on its website. BCC will work with Brooklyn to use this site as a “working classroom” for the city schools.

Critical Area 3: Project 14		
Nine Element Criteria	**Information Needed**	**Explanation**
n/a	Title	Ridge Park Square Green Infrastructure Phase 1
criterion d	Project Lead Organization and Partners	WCC, BCC, and Ridge Park Square
criterion c	HUC-12 & Critical Area	*Big Creek* (HUC 04110002 06 04) & Critical Area 3 *Stickney Creek*
criterion c	Project Location	7325 Northcliff Avenue, Brooklyn, OH 44144
n/a	Which strategy is being addressed by this project?	Urban sediment and nutrient reduction strategies
criterion f	Time Frame	Short
criterion g	Short Description	The retrofitting of an existing, inefficient Retention basin with an increase of capacity to an additional 350,000 gallons and the disconnecting of downspouts of another section, creating a Public Rain Garden as a functioning demonstration plot.
criterion g	Project Narrative	The current conditions of the Ridge Park square area of interest include a 1980-90s stormwater basin on the North West end corner of the property that currently has an outlet structure retraining retention to under 37,000 gallons and no nutrient reduction strategies (inundated with some invasives). There is an area notated on the North East corner of the property that is currently manicured lawn that the landowner is willing to disconnect building downspouts to, create a community raingarden, and incorporate publicly accessible areas with pervious pavers to be utilized as a “demonstration plot” for the community on Best Management Practices for Stormwater Management. Nutrient reduction numbers came to approx. 1.5lb/yr of N and P respectively via StepL, but those numbers, taking the Phosphorus capture capability of the proposed MetaMateria PO4 sponge filtration strategy could feasibly be higher depending on field calculations of nutrient loading from the property. Ridgepark Square (that drains into the project area) is approx. 20 acres of impervious surface at an 85% ratio to greenspace. The increase in retention capability of this basin and the increase of retention at the Raingarden will increase the current rate of 37,000 gallons to over 400,000 gallons. This is a combined inclusion of the increased area within the basin as well as the roof area redirected from downspouts on Ridgepark Square into the RainGarden. The process of execution of this Stormwater Management Project will begin with West Creek Conservancy putting out a design/build RFP with details on the specifics to the desired outcome. When a proposal is awarded, the WCC team will work with the team and Ridge Park Square to work through the best possible strategies for executing this project. WCC will manage every step of the way for continuance and conformity of results to completion. It is proposed to do a retrofit of the current outlet structure of the retention basin (which is currently allowing for minimal stormwater retention) to one that takes advantage of the large surface area available within it’s boundaries. We will also be including a MetaMateria PO4 sponge for orthophosphate capture that will reduce the nutrient loading from this site by an estimated 80%.

		Within that suite of products, there is a BioLair biofilter option that can also treat the basin if nutrients are retained for longer periods of time (not included in this proposal but noted for nutrient reduction). There will be some native plantings, seed mixes standard to retention basins, and strategies for uptake of nutrients beyond as well. The North East corner's Rain Garden will be diverting 3 downspouts into a community raingarden with publicly accessible pervious paver paths and interpretive signage that will serve as a working demo plot for the public.
criterion d	Estimated Total Cost	200,000
criterion d	Possible Funding Source	Ohio EPA §319, SOGL
criterion a	Identified Causes and Sources	Causes: Flow regime alteration Sources: Urban runoff/storm sewers
Criteria b & h	Part 1: How much improvement is needed to remove the NPS impairment associated with this Critical Area?	Minor improvement is necessary for the IBI score of 22 to be increased to 40 and ICI from 28 to 34
	Part 2: How much of the needed improvement for the whole Critical Area is estimated to be accomplished by this project?	This project will fulfill 3 of the downspouts noted in Objective 1, but also will be making large strides in the reduction of Stormwater Pressure in the Stickney Creek by 350,000 gallons in first flush, and will have nutrient mitigation strategies installed with the Biofilters proposed.
	Part 3: Load reduced?	Annual load reductions: 1.5 lb/yr total phosphorus, and 1.5lb/yr total nitrogen
criterion i	How will the effectiveness of this project in addressing the NPS impairment be measured?	Downstream IBI, ICI, and QHEI will be assessed before and after project implementation.
criterion e	Information and Education	Signage will be installed at the project site. WCC will present project results to Ridgepark Square. WCC will discuss the project in its newsletters and post about the project on its website. The City of Brooklyn will transmit success findings via city outreach and media outlets.

Critical Area #4: Overview Table and Project Sheets

The information included in the Table 25 is a condensed overview of all identified projects needed for nonpoint source restoration of the *Upper East Branch* critical area. PSSs are included for short term projects or any project that is considering seeking funding in the near future. Only those projects with complete PSSs will be considered for state and federal nonpoint source program funding.

4.3.3 Critical Area #4: Project Implementation Strategy Overview Table

The *Upper East Branch* critical area is based upon non-attainment at sampling site 302643 (RM 0.05) and 303734 (RM 9.80) and partial attainment at sampling site 302642 (RM 0.05). The overview table (Table 25) provides a quick summary of what needs to be done where and what problem (cause/source) will be addressed. The table includes projects at all levels of development (e.g., concept, in progress), and the table is intended to show a prioritized path toward restoration of the *Upper East Branch* critical area in the Big Creek watershed. Figure 31 presents an example project from the overview table (Table 25), and Figure 32 presents a map of the critical area with the projects from the overview table.

Figure 31. Big Creek in the Big Creek Reservation near Snow Road (site of project #2 in Table 25).

Table 25. Critical Area #4: Overview table for the *Upper East Branch*

Goal	Objective	Project	Project title	Lead organization (criteria d)	Timeframe (criteria f)	Estimated cost (criteria d)	Potential/actual funding sources (criteria d)
Urban sediment and nutrient reduction strategies							
1, 2	3	1	Ridgewood Lake Retrofit	BCC, Parma, WCC	Short	$1,900,000	TBD
Altered stream and habitat restoration strategies							
1, 2	4	-- [a]	Columbo Park Stream Restoration (asset BC00299)	NEORSD	Medium	*not available*	NEORSD (funded)
1, 2	4	2	Cleveland Metroparks Snow Road Picnic Area Stream Restoration/ Floodplain Connectivity	BCC, CM, WCC	Short	$778,637	Ohio EPA §319, GLRI AOC
1, 2	3, 4	3	Ridgewood Golf Course stream restoration and floodplain reconnection	Parma, WCC	Medium	TBD	Ohio EPA §319, GLRI
1, 2	3	4	York/Ridgewood Floodplain Restoration	BCC, WCC	Medium	TBD	Ohio EPA §319, GLRI
1, 2	3	5	Ridgewood Drive Stream Restoration and Creation of Floodplain Wetlands	BCC, Private, WCC	Medium	TBD	Ohio EPA §319, GLRI
1, 2	1, 3	6	Drifter Sports Parking Lot Retrofit and Floodplain Creation	BCC, NEORSD, Private	Medium	TBD	TBD
1, 2	3	7	Snake Hill Floodplain Creation	WCC	Medium-Long	TBD	Ohio EPA §319, GLRI
1, 2	3	8	Streambank Restoration along Ridge Road	WCC	Medium	TBD	Ohio EPA §319, GLRI
--[b]	--[b]	--[b]	Project to stabilize banks (asset BC00351; project SWD2016-033)	NEORSD	Medium	TBD	NEORSD
Agricultural nonpoint source reduction strategies							
not applicable							
High quality waters protection strategies							
1, 2	5	9	Shiva Vishnu Temple	BCC, Private, WCC	Medium-Long	TBD	TBD
1, 2	5	10	Between Sprague Road and Bunker Road in North Royalton	BCC, Private, WCC	Medium-Long	TBD	TBD
1, 2	5	11	Between Bunker Road and Wallings Road in North Royalton	BCC, Private, WCC	Medium-Long	TBD	TBD
Other NPS causes and associates sources of impairment							
1, 2	2	12	Hauserman Road Area Residential Stormwater Retrofits	BCC, Parma	Medium-Long	TBD	TBD

Goal	Objective	Project	Project title	Lead organization (criteria d)	Timeframe (criteria f)	Estimated cost (criteria d)	Potential/actual funding sources (criteria d)
1, 2	2	13	Powders Boulevard Residential Stormwater Retrofits	BCC, Parma, WCC	Medium-Long	TBD	TBD
1, 2	1	14	St. John Bosco Church parking lot retrofit	TBD	Long	TBD	TBD
1, 2	1	15	Pearl Road Stormwater Retrofits	NEORSD, Parma Heights	Long	TBD	Ohio EPA §319, GLRI, NEORSD
1, 2	1	16	Greenbrier Commons Parking Lot Retrofit	Parma Heights	Medium	TBD	TBD
1, 2	1	17	Tri-C Parking Lot Retrofits	BCC, NEORSD, Tri-C	Short	$325,000	Ohio EPA §319, GLRI, NEORSD
1, 2	2	18	Hollenbeck Lake Area Stormwater Source Controls	BCC, Parma	Medium	TBD	TBD

Notes

a. The Columbo Park Stream restoration will be implemented at Ohio EPA monitoring site 303734, which is shown on Figure 32.

b. NEORSD is in the early planning stages for a project in the *Upper East Branch* critical area. This projects will begin in 2018 or later and may benefit fish or macroinvertebrate populations.

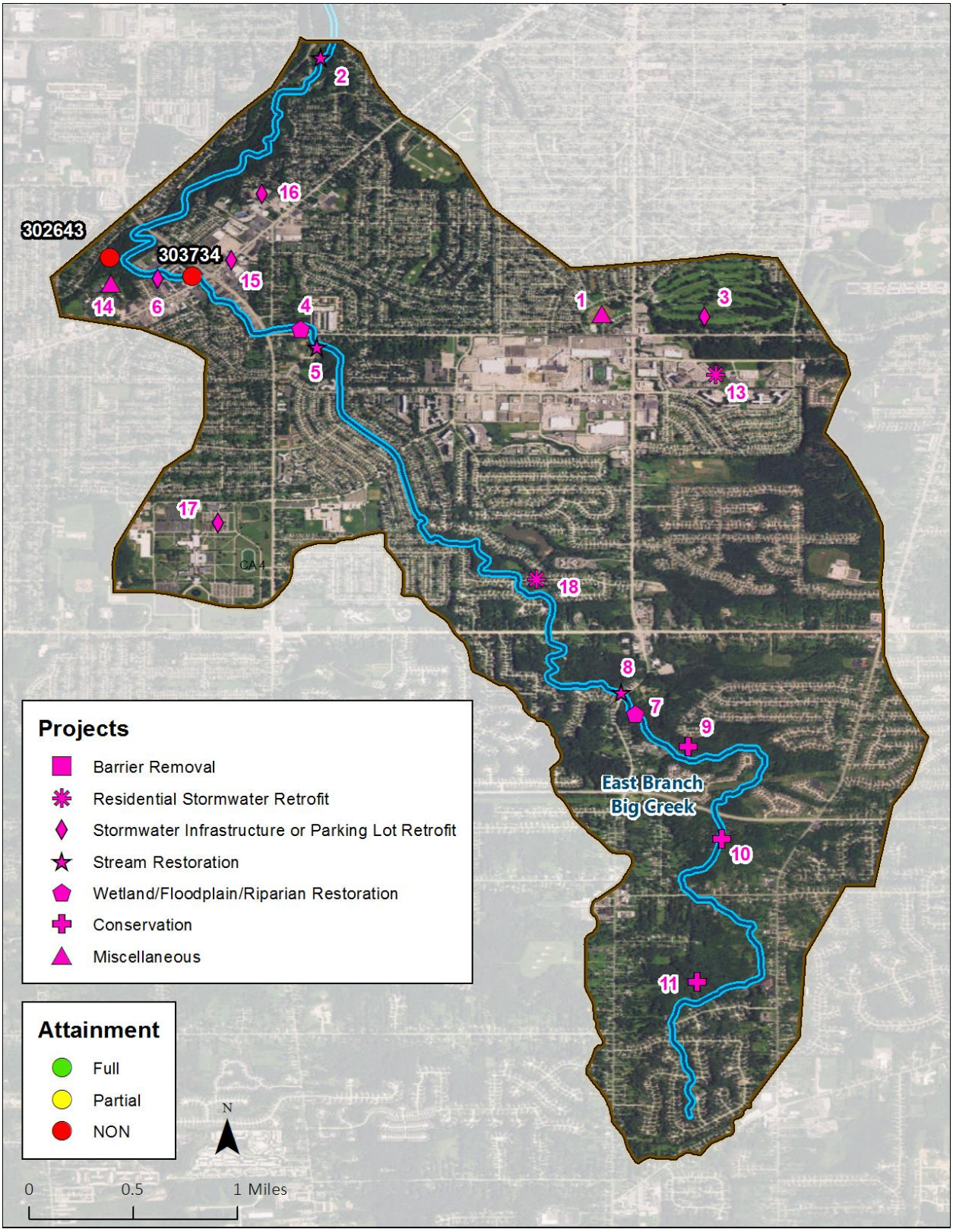


Figure 32. Projects for the *Upper East Branch Big Creek* critical area.

4.3.4 Critical Area #4: Project Summary Sheets

The PSS provided below was developed based on the actions or activities needed to restore sampling site 303734 (RM 9.80) to attainment of its ALU designation. This project is considered next step or priority/short term projects. Medium and long-term projects are not presented in PSS since they are not yet ready for implementation.

Critical Area 4: Project 1		
Nine Element Criteria	**Information Needed**	**Explanation**
n/a	Title	Ridgewood Lake Retrofit
criterion d	Project Lead Organization and Partners	BCC, Parma, & WCC
criterion c	HUC-12 & Critical Area	*Big Creek* (HUC 04110002 06 04) & *Upper East Branch*
criterion c	Project Location	Along Ridgewood Lake Road between East Ridgewood Drive and Ridge Road in Parma
n/a	Which strategy is being addressed by this project?	Urban sediment and nutrient reduction strategies
criterion f	Time Frame	Short
criterion g	Short Description	Installation of pretreatment cells and aquatic benches to support wetland vegetation, and modification of the outlet structure
criterion g	Project Narrative	Pretreatment cells will be installed at the two stormwater inlets to Ridgewood Lake that will allow for sediment to settle. The concrete steps will be replaced with a smooth, earthen gradient and installation of aquatic benches that will support wetland vegetation. The pond will be excavated and the outlet structure modified to lower the permanent pond elevation while providing 2 to 4 feet of depth and preserving the functionality of the overflow spillway.
criterion d	Estimated Total Cost	$1,100,000 to $1,900,000
criterion d	Possible Funding Source	Ohio EPA §319, GLRI
criterion a	Identified Causes and Sources	Cause: Flow regime alteration, Habitat alteration Source: Urban runoff/storm sewers, Loss of riparian habitat
Criteria b & h	Part 1: How much improvement is needed to remove the NPS impairment associated with this Critical Area?	Significant improvement is necessary for the IBI score of 30 to be increased to 40 and for the ICI score of *poor* to be increased to 34 (or *good*) to meet water quality standards.
	Part 2: How much of the needed improvement for the whole Critical Area is estimated to be accomplished by this project?	This project will achieve one of the five criteria of Objective 2 but will not address Objective 1, Objective 3, Objective 4, or Objective 5.
	Part 3: Load reduced?	An additional 11,017 lb/yr TSS
criterion i	How will the effectiveness of this project in addressing the NPS impairment be measured?	IBI, ICI, and QHEI will be assessed before and after project implementation. If this project is funded through §319, Ohio EPA DSW EAU will perform the monitoring.
criterion e	Information and Education	Signage will be installed at the project site. BCC will discuss the project in its newsletters and post about the project on its website.

Critical Area 4: Project 2		
Nine Element Criteria	**Information Needed**	**Explanation**
n/a	Title	Cleveland Metroparks Snow Road Picnic Area Stream Restoration/ Floodplain Connectivity
criterion d	Project Lead Organization and Partners	Cleveland Metroparks
criterion c	HUC-12 & Critical Area	*Big Creek* (HUC 04110002 06 04) & *Upper East Branch*
criterion c	Project Location	Snow Road picnic area in the Big Creek Reservation of the Cleveland Metroparks
n/a	Which strategy is being addressed by this project?	Altered Stream and Habitat Restoration Strategy
criterion f	Time Frame	Short (1-3 years)
criterion g	850-foot stream restoration	850-foot stream restoration
criterion g	Project Narrative	Streambank restoration upstream of Snow Road in the Big Creek Reservation. Banks and steep slopes will be cleared, backfilled, and replanted. Failed gabion basket shore protection and several fallen trees will be removed. Riprap shore protection and erosion control measures will be installed.
criterion d	Estimated Total Cost	$778,637
criterion d	Possible Funding Source	Ohio EPA §319, GLRI
criterion a	Identified Causes and Sources	Causes: Habitat alteration Sources: Urban runoff/storm sewers
Criteria b & h	Part 1: How much improvement is needed to remove the NPS impairment associated with this Critical Area?	Significant improvement is necessary for the IBI score of 22 to be increased to 40 to meet water quality standards. Modest improvement is necessary for the ICI score of 28 to be increased to 34 to meet water quality standards.
	Part 2: How much of the needed improvement for the whole Critical Area is estimated to be accomplished by this project?	This project will achieve about 87% of Objective 4 (about 870 feet of the 1,000 foot objective) but will not address Objective 1, Objective 2, Objective 3, or Objective 5.
	Part 3: Load reduced?	The stream restoration should increase the IBI and ICI by several points. Annual load reduction: 4.8 tons/year TSS.
criterion i	How will the effectiveness of this project in addressing the NPS impairment be measured?	IBI, ICI, and QHEI will be assessed before and after project implementation. If this project is funded through §319, Ohio EPA DSW EAU will perform the monitoring. Cleveland Metroparks is another potential entity that can perform the monitoring.
criterion e	Information and Education	Signage will be installed at the project site. BCC and Cleveland Metroparks will discuss the project in their newsletters and post about the project on their websites and social media.

Critical Area 4: Project 17		
Nine Element Criteria	**Information Needed**	**Explanation**
n/a	Title	Tri-C Parking Lot Retrofits
criterion d	Project Lead Organization and Partners	BCC, NEORSD, & Tri-C
criterion c	HUC-12 & Critical Area	*Big Creek* (HUC 04110002 06 04) & *Upper East Branch*
criterion c	Project Location	Cuyahoga Community College's Western Campus parking lot on the west side of York Road, north of West Pleasant Valley Road
n/a	Which strategy is being addressed by this project?	Urban sediment and nutrient reduction strategies
criterion f	Time Frame	Short
criterion g	Short Description	Parking lot retrofit with the installation of bioretention
criterion g	Project Narrative	Ten existing grassed medians will be converted to bioretention areas. Depressions will be 1-foot deep maximum, allowing 6-inches of ponded water. Runoff will be routed to bioretention areas through new curb cuts. New outlet structures will be used to connect bioretention areas and existing catch basins. A planting plan that is prominently herbaceous native plants that are water tolerant is recommended. Costs assume volunteers planting the vegetation.
criterion d	Estimated Total Cost	$280,000 to $325,000
criterion d	Possible Funding Source	Ohio EPA §319, GLRI
criterion a	Identified Causes and Sources	Causes: Flow regime alteration Sources: Urban runoff/storm sewers
Criteria b & h	Part 1: How much improvement is needed to remove the NPS impairment associated with this Critical Area?	Significant improvement is necessary for the IBI score of 30 to be increased to 40 and for the ICI score of poor to be increased to 34 (or *good*) to meet water quality standards.
	Part 2: How much of the needed improvement for the whole Critical Area is estimated to be accomplished by this project?	This project will achieve about 8% of Objective 1 (about 2.3 acres of the 30 acre objective) but will not address Objective 2, Objective 3, or Objective 4.
	Part 3: Load reduced?	Annual load reduction: 740 lb/yr TSS
criterion i	How will the effectiveness of this project in addressing the NPS impairment be measured?	IBI, ICI, and QHEI will be assessed before and after project implementation. If this project is funded through §319, Ohio EPA DSW EAU will perform the monitoring. NEORSD is another potential entity that can perform the monitoring.
criterion e	Information and Education	Signage will be installed at the project site. BCC and Tri-C will present project results at a meeting for Tri-C staff and students. BCC and Tri-C will discuss the project in their newsletters and post about the project on their websites.

5 REFERENCES

BCC (Big Creek Connects). 2015a. *Big Creek / I-71 Relocation & Restoration Initiative.* March 2015. http://www.friendsofbigcreek.org/BC_I-71/BigCreek_I-71_Initiative.pdf. Accessed February 16, 2017.

———. 2015b. *Bylaws. Friends of Big Creek dba Big Creek Connects*. October 14, 2015. http://www.friendsofbigcreek.org/organization/FOBCbylaws_Amended_Oct2015.pdf. Accessed February 16, 2017.

Cappiella, K., T. Schueler, and T. Wright. 2005. Urban Watershed Forestry Manual. Part 1 of a 3-Part Manual Series on Using Trees to Protect and Restore Urban Watersheds. Prepared by the Center for Watershed Protection for the U.S. Department of Agriculture, Forest Service.

Cuffney, T., R. Brightbill, J. May, and I. Waite. 2010. Responses of Benthic Macroinvertebrates to Environmental Changes Associated with Urbanization in Nine Metropolitan Areas. Pre-Print. Ecological Society of America.

CRCPO (Cuyahoga River Community Planning Organization). 2010. *Big Creek Watershed Plan. Balancing Growth and Watershed Stewardship.* Prepared in cooperation with Big Creek Watershed Planning Partnership. http://www.friendsofbigcreek.org/BalancedGrowthPlan/BigCreekBalGroPlan.pdf. Accessed February 16, 2017.

Jin, S., Yang, L., Danielson, P., Homer, C., Fry, J., and Xian, G. 2013. *A comprehensive change detection method for updating the National Land Cover Database to circa 2011*. Remote Sensing of Environment, 132: 159 – 175. Downloaded from Geospatial Data Gateway. USDA, NRCS. http://datagateway.nrcs.usda.gov/. Accessed March 20, 2017.

Natural Resources Conservation Service. 2011. *Soil Data Viewer 6.0 User Guide.* U.S. Department of Agriculture, NRCS. 62 pp.

NEORSD (Northeast Ohio Regional Sewer District). 2017. IBI, ICI, and QHEI data [15 PDF files]. Provided by Seth Hothem (NEORSD Supervisor of Environmental Assessment) via electronic mail on February 17, 2017.

Ohio EPA (Ohio Environmental Protection Agency). 2003. *Total Maximum Daily Loads for the Lower Cuyahoga River*. Final Report. Ohio EPA, Division of Surface Water. September 2003. http://www.epa.ohio.gov/dsw/tmdl/CuyahogaRiver.aspx. Accessed February 8, 2017.

———. 2013. *Nonpoint Source Management Plan Update*. Ohoi EPA, Division of Surface Water, Nonpoint Source Program. http://epa.ohio.gov/Portals/35/nps/NPS_Mgmt_Plan.pdf. Accessed April 21, 2017.

———. 2016. *Water Quality Summary - 2016 Integrated Report*. Ohio EPA. http://wwwapp.epa.ohio.gov/gis/mapportal/IR2016.html. Accessed February 8, 2017.

Schueler, T. 1994. The Importance of Imperviousness. *Watershed Protection Techniques* 1(3):100–111.

———. 2004. Urban Subwatershed Restoration Manual 1. An Integrated Framework to Restore Small Urban Watersheds. Prepared by the Center for Watershed Protection, Ellicott City, MD, for the U.S. Environmental Protection Agency, Office of Water Management, Washington, DC.

Shaver, E., R. Horner, J. Skupien, C. May, and G. Ridley. 2007. *Fundamentals of Urban Runoff Management: Technical and Institutional Issues*. North American Lake Management Society, Madison, WI.

Tetra Tech, Inc. 2014. *Stormwater Retrofit and Ranking Project, Phase 2 Summary Report.* Memorandum transmitted by Jennifer Olson and Jon Stein (Tetra Tech, Inc.) to Bob Gardin (BCC) on September 22, 2014.

U.S. EPA. 2010. Causal Analysis/Diagnosis Decision Information System (CADDIS). U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC. http://www.epa.gov/caddis. Accessed April 12, 2017.

Woods, A., J. Omernik, C. Brockman, T. Gerber, W. Hosteter, and S. Azevedo. 2014. *Ecoregions of Indiana and Ohio*. [shapefile]. http://www.epa.gov/wed/pages/ecoregions/ohin_eco.htm. Accessed October 16, 2014.