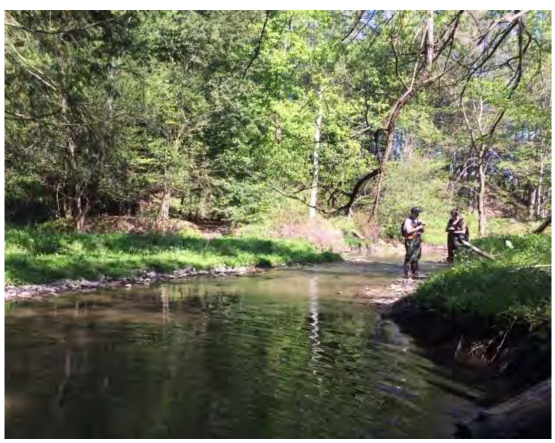
Healthy Niagara

Regional Niagara River/Lake Erie Watershed Management Plan (Phase 2)





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For more information of the Regional Niagara River/Lake Erie Watershed Management Plan (Phase 2), or to become involved in our regional watershed's protection and restoration, visit Buffalo Niagara RIVERKEEPER® online at www.bnriverkeeper.org. For more information regarding watershed plans in New York State, visit the NYS Department of State's website at https://www.dos.ny.gov/opd/programs/waterResourcesMgmt/watershedplansNY.html

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Table of Contents

Chapter 1: Introduction **1-1**

Chapter 2: Sub-watershed Implementation Plan – Eighteenmile Creek **2-1**

Chapter 3: Sub-watershed Implementation Plan – Buffalo River **3-1**

Chapter 4: Sub-watershed Implementation Plan – Smokes Creek **4-1**

Chapter 5: Sub-watershed Implementation Plan – Lower Tonawanda Creek **5-1**

Chapter 6: Sub-watershed Implementation Plan – Upper Tonawanda Creek **6-1**

Bibliography .... **B**

Appendices .... **A-J**

- TMDL Whitepaper .... A
- Stationary Sampling Sites .... B
- 2015 Technical Report C
- 2016 Technical Report .... D
- Eighteenmile Creek Sub-watershed Priority Projects .... E
- Buffalo River Sub-watershed Priority Projects .... F
- Smokes Creek Sub-watershed Priority Projects .... G
- Lower Tonawanda Creek Sub-watershed Priority Projects .... H
- Upper Tonawanda Creek Sub-watershed Priority Projects I
- Inventory of Municipal Tools .... J

Chapter 1: Introduction and Methodologies

This report is part of a multi-phased watershed planning process, and has been prepared to directly supplement previous work conducted by Buffalo Niagara Riverkeeper in Phase I of the Niagara River Watershed Management Plan (Healthy Niagara), and ongoing work by project partners Erie County Department of Environment and Planning, and the Lake Erie Watershed Protection Alliance. This project was prepared for the New York State Department of State with funds provided under Title 11 of the Environmental Protection Fund Act.

Phase I began the watershed planning process through assessment of current conditions, trends, and major contributors to regional water quality at a watershed-wide scale. This document builds on the priorities identified through the Phase I planning process, aims to provide a “snapshot in time” of water quality conditions throughout the Niagara River Watershed, and develop implementation plans to address specific concerns identified in five priority sub-watersheds.

For the purpose of this report, we collectively refer to four sub-basins (USGS HUC 8 level) as the Erie/Niagara Watershed: Chautauqua-Conneaut, Cattaraugus, Buffalo-Eighteenmile and Niagara River sub-basins. The first three sub-basins drain into eastern Lake Erie and the fourth is the connecting channel which drains Lake Erie into Lake Ontario. It is important to note that although the Chautauqua-Conneaut sub-basin spans both New York and Pennsylvania jurisdictions, we only describe NYS lands. Additionally, Canada is an equally important contributor to the Erie/Niagara Watershed; however, it is beyond the scope of this report.

Priority Sub-watersheds and Methodologies

Many rural, suburban, and urban settlements exist throughout the watershed, with each setting presenting its own unique set of impairments to ecological integrity. Although some deteriorations cause site-specific changes to water quality (such as livestock grazing eroding a streambank), it is imperative to note that these issues also influence the ecosystem at a much larger scale. Thus, a successful watershed management plan must carefully consider degradation at both small and large scales as well as across an urban to rural gradient. The approach taken is to identify priority areas to address impairments, conduct a thorough inventory of the most serious threats to water quality (through both modeling and data collection), and finally to highlight specific strategies which will have greatest potential for watershed-scale improvements. In this report we provide both short-term solutions for time-sensitive impairments, as well as long-term goals which have the greatest propensity to ensure long-term sustainability of healthy watershed conditions.

The Niagara River/Lake Erie Watershed is located in Western New York, which has a rich history and legacy of industrial pollution. Currently the Niagara and Buffalo Rivers are designated as Areas of Concern (AOCs) under the Great Lakes Water Quality Act, an agreement between the US and Canada to protect and restore the waters of the Great Lakes. Lake Erie is the shallowest and most ecologically productive of the Great Lakes, and also has the shortest water retention time of all five lakes. The Niagara River is the connecting channel between Lakes Erie and Ontario; essentially the mode of transportation for water from all of the other lakes into Lake Ontario. The Niagara River is a globally recognized Important Bird Area, the same designation given to areas such as the Galapagos Islands, which are able to support incredible populations and communities of migrating birds. The Lake Erie walleye fishery is unmatched elsewhere in the country and recreational fishing brings in considerable revenue to the region, as does tourism at Niagara Falls. Additionally, the Niagara River also supports one of two of the only self-sustaining, native musky populations in the Great Lakes, with the other location being in the St. Lawrence River.

The Niagara River/Lake Erie Watershed spans eight counties: all of Erie County, and portions of Allegheny, Cattaraugus, Chautauqua, Niagara, Orleans, Genesee, and Wyoming counties. The watershed also spans across a transect of rural to urban land use, with generally more rural regions in the upper reaches of the watershed, becoming increasingly urbanized downstream towards Lake Erie and the Niagara River. The three largest municipalities in this watershed are Buffalo, Niagara Falls, and Amherst. Sub-watersheds are shown in spatial context below in Map 1.1.

The Niagara River/Lake Erie Watershed is comprised of 18 sub-watersheds (USGS HUC 10 level) that cover 1,523,515.3 acres (2,380.5 square miles) of the eastern end of Lake Erie, including the full extent of the Eastern (US) side of the Niagara River Channel. The total area of each individual sub-watershed is listed above in Table 1.1.

Table 1.1: Sub-watershed Areas

10-Digit Hydrologic Unit	Acres	Square Miles
Big Sister Creek	62,363.00	97.4
Buffalo Creek	93,158.50	145.6
Buffalo River	105,367.80	164.6
Canadaway Creek	64,538.80	100.8
Cattaraugus Creek	197,523.20	308.6
Cayuga Creek	81,358.20	127.1
Chautauqua Creek	51,266.30	80.1
Eighteenmile Creek	76,834.00	120.1
Ellicott Creek	76,824.30	120
Headwaters Cattaraugus Creek	160,605.70	250.9
Lower Tonawanda Creek	78,788.80	123.1
Middle Tonawanda Creek	79,090.00	123.6
Murder Creek	46,666.40	72.9
Niagara River	102,812.10	160.6
Sixmile Creek	43,537.60	68
Smokes Creek	39,522.80	61.8
Upper Tonawanda Creek	127,237.90	198.8
Walnut Creek	36,019.90	56.3
Total	1,523,515.30	2,380.50

Map 1.1: Niagara River/Lake Erie Watershed

It is important to note that Phase I of this project, and the selection of priority sub-watersheds for Phase II considered only the 11 sub-watersheds of the Niagara River Watershed, the area referred to hereafter in this document as the “New Phase II Territory” is comprised of seven additional sub-watersheds, Big Sister Creek, Canadaway Creek, Chautauqua Creek, Cattaraugus Creek, Headwaters Cattaraugus Creek, Sixmile Creek, and Walnut Creek, that were outside of the scope of the previously completed Phase I work. These areas are included in this report as expanded territory of the Lake Erie Watershed, but, because this phase builds off of Phase I work, they were not selected for consideration as priority sub-watersheds for on-the-ground assessment. It should also be noted that roughly half of all inputs into this region of Lake Erie and the Niagara River are not included in this project, as they are part of the Niagara River Watershed in Canada.

As Phase II of the watershed management process was developed, it became increasingly clear that due to the size and scale of the Niagara River Watershed, a single study spanning only two to three years in total would not be able to effectively investigate and assess the 18 sub-watersheds individually. Because of this, a matrix was developed to rank and prioritize for further study, sub-watersheds as either a sub-watershed with high water quality and healthy habitat to be protected and preserved, or a sub-watershed with impaired water quality and habitat quality. The matrix assessment used to assess watershed prioritization in Phase I is shown below in Table 1.2.

Table 1.2: Watershed Prioritization Matrix

Sub-watershed Prioritizing Data Sets	Good Indication	Poor Indication
% of Impervious Cover	Low	High
% of Natural Areas	High	Low
% of Woodland Cover	High	Low
Predicted Biologic Assessment Profile Scores	High	Low
% Riparian Woodland (tracts greater than 50 Acres)	High	Low
Density of Stream Miles	High	Low
% of Industrial Use	Low	High
Urban Density	Low	High
# of Road/Bridge Crossings	Low	High
# of Hazardous Waste Sites	Low	High

Through this process, five sub-watersheds, Eighteenmile Creek, Buffalo River, Lower Tonawanda, Smokes Creek, and Upper Tonawanda, were identified as priorities for further investigation of water quality and physical characteristics in order to develop appropriate management actions for improving and protecting healthy conditions.

Priority Sub-watersheds to Protect & Preserve (Good Conditions):

- Buffalo River Sub-watershed
- Eighteenmile Creek Sub-watershed
- Upper Tonawanda Creek Sub-watershed

The three sub-watersheds above were chosen based on the priority to preserve and protect conditions leading to high water quality and healthy habitat. These watersheds are characterized by a large amount of forest cover, much of it in connected riparian corridors. They have low levels of urbanization and impervious cover. They are also currently found to have the best water quality characteristics in the Niagara River Watershed. By focusing on these sub-watersheds, tools can be developed and outcomes measured which will be most effective in protecting the health of sub-watersheds from common impairments moving forward. A summary of the Protect & Preserve assessment is provided in Table 1.3 below, with Phase II priority sub-watersheds highlighted in green.

Table 1.3: Sub-watershed Assessment by Potential to Protect and Preserve

Data/Indicator	Niagara	Lower Tonawanda	Middle Tonawanda	Upper Tonawanda	Ellicott	Murder	Cayuga	Buffalo Creek	Buffalo River	Smokes	Eighteenmile
Low Impervious Cover	1	3	5	5	2	5	4	5	3	2	5
Natural Areas	1	1	2	4	2	3	3	4	5	3	5
Woodland Cover	1	2	2	3	2	2	4	4	4	3	5
Water Quality – BAP	2	3	4	5	3	2	4	5	5	1	3
Riparian Woodland	3	1	2	3	2	4	4	4	5	3	4
Stream Miles	2	2	4	5	3	3	4	4	3	1	3
	10	**12**	**19**	**25**	**14**	**19**	**23**	**26**	**25**	**13**	**25**

It is important to note, that although Buffalo Creek Sub-watershed ranked highest on this scale, it was not chosen for further investigation through this project, as the Buffalo River Sub-watershed contains an EPA Area of Concern, has been previously studied, and is therefore already deemed a high priority for implementation of identified management actions.

Priority Sub-watersheds to Address Impairments (Poor Conditions):

- Smoke's Creek Sub-watershed
- Lower Tonawanda Creek Sub-watershed

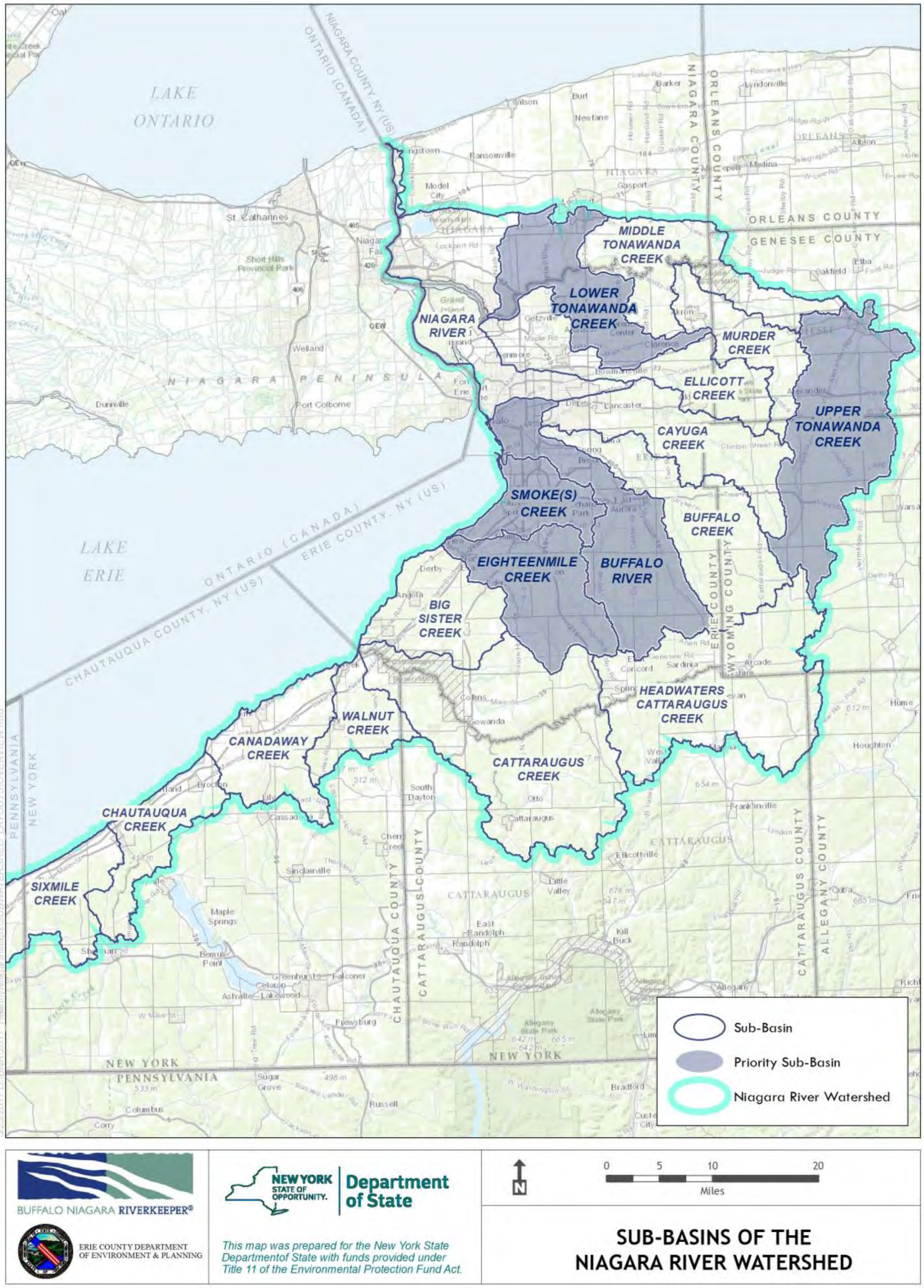
The two sub-watersheds were chosen the based on the potential to affect factors that currently contribute to the impairment of water quality and habitat conditions. These watersheds are characterized by high density urban development in the cities of Buffalo, Lackawanna, and the Tonawandas, along with high percentages of impervious cover. There are also high amounts of land and water impaired by legacy contamination within these sub-watersheds. Table 1.4 below summarizes the assessment, with Phase II priority sub-watersheds highlighted in yellow. While Ellicott Creek Sub-watershed ranks slightly higher on the matrix assessment for potential to address impairments, Lower Tonawanda was selected for further investigation due to higher regional interest in the waterbodies as expressed by stakeholders.

Table 1.4: Sub-watershed Assessment by Potential to Address Impairments

Data/Indicator	Niagara	Lower Tonawanda	Middle Tonawanda	Upper Tonawanda	Ellicott	Murder	Cayuga	Buffalo Creek	Buffalo River	Smokes	Eighteenmile
High Impervious Cover	5	3	1	1	4	1	2	1	3	4	1
Natural Areas – lack of	5	5	4	2	4	3	3	2	1	3	1
Woodland Cover – lack of	5	4	4	3	4	4	2	2	2	3	1
Water Quality - BAP	4	3	2	1	3	4	2	1	1	5	3
Industrial Use	4	3	0	2	2	1	1	1	1	5	0
High Density Urban	5	1	0	0	2	0	1	0	3	4	0
Road Crossings	4	2	1	4	3	3	3	2	1	5	1
Hazardous Waste Sites	5	3	1	1	3	1	2	4	1	3	1
	37	**24**	**13**	**14**	**25**	**11**	**16**	**14**	**13**	**32**	**8**

To identify these impairments on-the-ground stream visual assessments, water quality sampling, and nutrient and bacterial loading measurements were taken throughout the five priority sub-watersheds. Using the data collected, critical source areas, defined as those lands which serve as impairments sources within the sub-watershed, were identified by performing a combination of mathematical and GIS analysis.

Priority Sub-watersheds are shown as shaded sections Map 1.2.



Map 2.2: Prioritized Sub-Watersheds

EPA Nine Element Watershed Management Plan and TMDL

The long-term goal for the Regional Niagara River/Lake Erie Watershed Management Plan is to contribute to the drafting and implementation of a US EPA Nine Element Watershed Management Plan. While Phases 1 and 2 of the planning processes have contributed towards progress on a Nine Element Plan for the region, the complete process is expected to take another three to four phases of watershed planning efforts over the next several years. A complete and implemented nine element plan outlines strategies for restoration that are based on quantifiable metrics to enable ongoing tracking of watershed health and the effectiveness of restoration initiatives.

A related yet ancillary study completed through this effort was to analyze the feasibility of implementing a Total Maximum Daily Load (TMDL) for those waterbodies listed on the New York State List of Impaired water bodies, and is available as Appendix A. A summary chart comparing nine-element Plans and TMDLs is presented below in Table 1.5.

Table 1.5: Comparison of 9E plans and TMDLs

Attribute	9E Plan	TMDL
Pollutant sources	Better for nonpoint sources	Better for point sources
Implementation plan	Required	Optional*
Public comment period	No (public participation is conducted throughout plan development)	Required
Agency approval	NYS DEC	EPA
Funding eligibility	State and federal opportunities	State and federal opportunities

Of the five priority sub-watersheds studied, three contained water bodies or segments of waterbodies listed as impaired. This means they may require the state to set a TMDL for the water body limiting the amount of pollutants that can be discharged into a specific water body each day. This report identifies baseline indicators of pollution as well as best management practices for addressing identified impairments. Together these factors can be used to implement an alternative to a TMDL. TMDLs can be costly and difficult to implement. However, if the goals of the TMDL can be met through alternate means, then the listed water body can be taken off the impaired water body list. This report, through a holistic and science driven approach will identify the major sources and contributors of pollution and present strategies to combat those sources of pollution through mechanisms that include voluntary landowner actions, alternative land management regimes, maintenance, as well as other best management practices, policy and regulatory tools.

Land Use/Land Cover

Land Use/Land Cover (LULC) classifications were derived from 2010 National Oceanic Atmospheric Administration (NOAA) LULC data, and like classifications were consolidated into groups that reflect the overall LULC classification.[22]

Active River Area

This project was developed around measuring conditions in streams to determine impairments, and begin to understand the processes and areas that those impairments stem from during baseline conditions, i.e. not during storm events or extreme weather. Because of this, a need to understand which land the stream channels interact with during these baseline conditions became apparent.

Understanding the connectivity between land and water is crucial for implementing effective conservation, restoration, and management actions. The Active River Area (ARA) model, developed by the Nature Conservancy was utilized to determine the extent that stream channels within the priority sub-watersheds interacts with surrounding land. This model is composed of components that capture the natural processes and key attributes that define a stream's active components and interaction with surrounding land. Table 1.6 below displays an itemized list of features that the ARA model incorportates.

Table 1.6: Active River Area Components

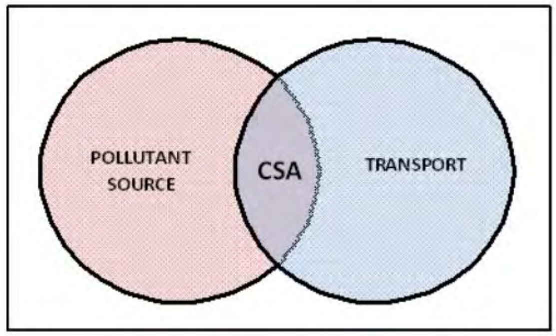
Active River Area Component	Typical Habitat Features
Material contribution areas	Seep or saturated source area Spring Wetland (forested, meadow, etc.) Forest canopy / overhanging vegetation Bluff, cliff and steep slopes
Meander belt	Step, riffle, run, pool, glide, dune, ripple Sediment & gravel bars (point, mid-channel, etc.) Hydraulic refugia from tributaries and oxbows Undercut bank Beaches and scour areas Physical refugia from LWD, debris jam, CPOM Forest canopy / overhanging vegetation
Floodplain	Oxbows Meander scar Floodplain lake Wetland Backwater swamp Island Natural levee Floodplain forest Forest canopy / overhanging vegetation Clay plug (filled oxbow)
Terraces	Wet meadow Ridges (old natural levee) Troughs (dry oxbow) Meander scars Prairie Remnant floodplain forest
Riparian wetlands	Forested, meadow, etc. Vernal pool Backwater swamp Beaver pond flowage

By modeling and identifying the sub-watershed's components, as seen above, which sustain the waterway's physical and ecological processes, the ARA of a stream or sub-watershed can be determined. The ARA model defines the area of land that is hydrologically connected to a waterway, and is an important tool to guide actions to improve water quality.

Critical Source Areas

Areas where priority contaminants–those prevalent in large spatial expanses of the sub-watershed or that consistently exceed water quality standards and guidance values are defined as Critical Source Areas (CSAs). These source areas are described in this study as discrete regions within the sub-watershed that contribute a disproportionate amount of pollutants relative to their spatial expanse. For example, a study conducted in Oklahoma by White et al. (2009)[32], found that only 5% of the land in the six watersheds studied contributed 50% of the sediment load and 34% of the measured phosphorus. Additionally, in watersheds with more agricultural land use, large portions of agricultural pollutants were found to enter waterways from an even smaller subset of land area. Figure 1.1 displays the study's definition of a CSA, and how it is developed from overlap between a pollutant source and transport.

Figure 1.1: Concept of Critical Source Areas



CSAs are also not intended to trackdown and pinpoint the exact location of a pollutant's source, but rather identify where pollutants are actively interacting with and influencing a stream. The National Institute of Food and Agriculture Conservation Effects Assessment Project states that, "pollutant sources in the watershed are usually, although not always, a function of land use and management."[17]

This report views CSAs through the lens of ARA and LULC. Critical sources that contribute to water quality impairments identified in this report were separated from noncritical sources that do not actively contribute to the impairments as identified in the sub-watershed. Critical sources were derived from agriculture and developed LULC within the ARA, while forest, wetland, water, and other land covers make up the noncritical sources of impairments to the sub-watershed. It is important however, to note that CSAs as defined in this project refer only to potential nonpoint pollution sources during baseline conditions (i.e. not storm event), and that point source pollution from sources such as CSO and CAFO complexes may be contributing to stream impairments from non CSAs.

Management actions and best management practices to address impairments to waterbodies are intended to be implemented sub-watershed-wide but by focusing these actions on the CSAs identified in each sub-watershed, project implementation may achieve more successful, sustainable, and cost effective results. Targeting management and implementation actions where CSAs indicate potential stream segments or baseline indicator impairment in the ARA can enable practitioners to more quickly address problems.

Field Methodologies

Stream Visual Assessment Protocol

The SVAP was used to conduct field assessments of streams in order to define baseline conditions. This tool, developed by the Natural Resources Conservation Service, allows efficient qualification of a stream's condition by assessing several elements indicative of overall stream health. The result provides a "snapshot in time" of qualitative stream conditions, which are helpful for gauging the apparent health of a stream. The protocol was modified to better reflect conditions within the assessment area. Scoring elements such as salinity were not included in assessment due to freshwater conditions. Many streams and segments of streams were unable to be assessed due to limitations of the SVAP protocol. For example, SVAP requires assessments to be taken from within a stream; therefore a stream must be wadeable, generally no more than a few feet in depth at baseflow conditions. In certain instances, segments of streams were not wadeable and therefore were not assessed.

The SVAP scores select components of a stream's physical attributes on a 1-10 scale. For this study, the SVAP included (if applicable) the following elements:

- Channel Conditions
- Riparian Zone (Left and Right Bank)
- Bank Stability (Left and Right Bank)
- Water Appearance
- Nutrient Enrichment
- Instream Fish Cover
- Pools
- Invertebrate Habitat
- Riffle Embeddedness
- Canopy Cover
- Manure Presence

Stream reaches were located a standard 200 feet apart from each other, and sampling was conducted while moving upstream in the stream segment. Each sub-watershed was broken down into segments, and each segment was then divided into reaches, where individual assessments occurred. Each reach received an SVAP score based on observed elements. Scores of individual elements are averaged to generate overall SVAP scores for different waterbodies. Numerical scores are then calculated and grouped into four different categories as listed below.

- Poor (1.0-6.0)
- Fair (6.1 – 7.4)
- Good (7.5 – 8.9)

- Excellent (9.0-10.0)

Assessment locations were determined by identifying stream segments with impairment thresholds, i.e. stream segments where a marked change in water quality, stream health, land use, or other predictive tools suggest that in-water conditions have changed.

Streams to be sampled were selected for assessment based on a rubric assessment, various physical characteristics, and land use types. Digital reconnaissance of the streams was conducted using a Geographic Information System (GIS) and various maps to determine the practicality of SVAP sampling. Ground truthing of the selected streams occurred prior to the field season. The target was to assess and characterize approximately 10% of the total stream miles in the sub-watershed.

In addition to standard SVAP elements, the presence of invasive vegetation, aquatic vegetation, and barriers to fish movement were noted. Photo documentation occurred at the end of each reach, looking downstream. Additional photos and notes were taken to record any stream features that may influence stream condition or health such as pipes, culverts, tributaries, etc.

General parameters (coordinates, stream depth, bankfull width, baseflow width, and dominate substrate type) were recorded at each stream reach.

Water Quality Sampling

General water quality measurements were recorded at every other stream reach where SVAP assessments occurred. Stationary water quality monitoring sites were also utilized to provide measurements over time.

Yellow Springs Instruments (YSI) Pro Plus Multiparameter Instruments were used to measure temperature, conductivity, total dissolved solids, dissolved oxygen, and pH. YSI's were calibrated no longer than 24 hours in advance of sampling, as per manufacture specifications.

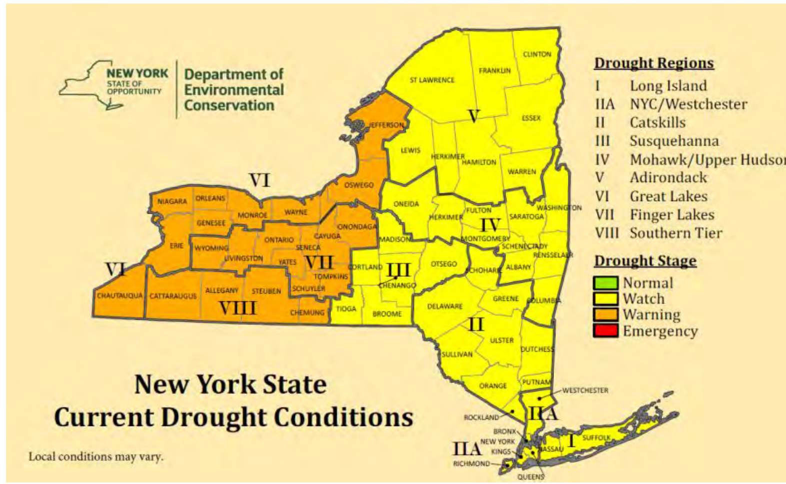
If water quality sampling was unable to be performed, due to equipment malfunction or dangerous conditions, it was noted on the field data sheets.

Grab samples were taken and stored on ice to later to analyze phosphorus, nitrate, and turbidity using a YSI 9500 Photometer and a Hach 2100Q Turbidimeter.

During the months of June to August, grab samples for *Escherichia coli* (*E. coli*) were collected and analyzed at the Erie County Health Department Lab. The sites were sampled regardless of weather or stream flow conditions.

Western New York experienced drought conditions during the spring and summer months of 2016. As of August 3rd, NYSDEC issued a drought warning for most of this region. The extent of the drought conditions can be seen in Figure 1.2. Samples collected during this time may not be representative of normal conditions in the watershed, as samples were still taken in the drought conditions.

Figure 1.2: Drought Conditions in NYS – As of August 3, 2016



Public and Municipal Input

Through the process of identifying impairments to water quality and developing management actions, it became increasingly important to gather input from municipal, agency, and public stakeholders. Riverkeeper held two municipal workshops, one in the northern portion of the Niagara River Watershed, and one in the southern portion, to present findings and recommendations to interested stakeholders, as well as solicit input on the development of the implementation plans. Additionally, a public presentation of the completed project was performed in Buffalo, NY to inform interested parties of the methods, results, and suggestions identified through the watershed planning process.

Additionally, a project advisory committee of technical experts was consulted for feedback and development of recommended management actions.

Figure 1.3: Riverkeeper staff member Elizabeth Robbe presenting to the public in Buffalo, NY

Chapter 2: Eighteenmile Creek

The Eighteenmile Creek Sub-watershed (EC) is located in the southernmost section of the Niagara River/Lake Erie Watershed. It has an area of 76,843.1 acres, or 120.1 square miles, and includes 273.8 miles of waterways. Located in Erie County, EC includes the Towns of Hamburg, Eden, Evans, North Collins, Orchard Park, Boston, Colden, and Concord. Also located within EC is the Village of Hamburg. The sub-watershed is shown in Map 2.1.

Eighteenmile Creek is a large, meandering stream with spring-fed headwater tributaries and upland forests. Its landscape consists of natural overhanging cover that provides material contribution in the form of woody debris and beneficial nutrients, all contributing to overall physical conditions. The creek's principal tributary, South Branch, flows through steep-sided, wooded gorges which remain mostly undeveloped. Cold springs and groundwater seeps are commonplace along the 70 to150-foot-tall shale cliffs. Making its way toward the eastern end of Lake Erie, the last half-mile is of low gradient, 75-100 feet wide, with a broad floodplain.

EC has the highest amount of non-impaired aquatic habitat in the Niagara River Watershed, due to large amounts of natural conditions. The NYS Coastal Management Program has designated the EC gorge in Hamburg as a 'significant coastal fish and wildlife habitat area,' the Town of Hamburg has designated it as a 'critical environmental area,' and Erie County has designated the area near the confluence of the North and South Branches as a conservation park.

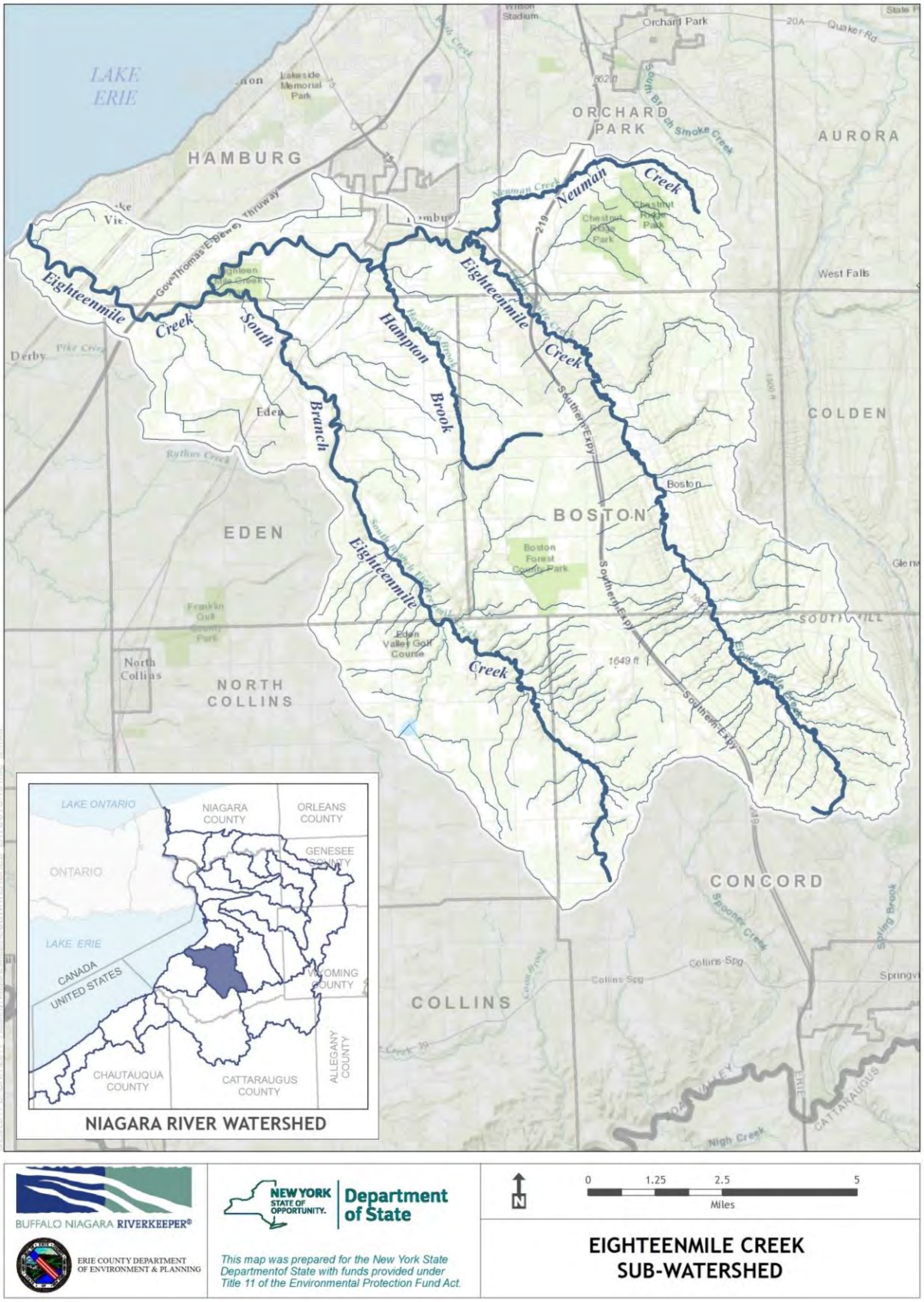
Land Use/Land Cover

Land Use/Land Cover (LULC) classifications for EC were derived from 2010 NOAA LULC data, and similar classifications were consolidated into groups that reflect the overall LULC classification.[22] The LULC groups can be seen below in Table 2.1.

Table 2.1: LULC Groups and percentages

LULC Class	% by general LULC
Developed, High Intensity	Developed: 6.06%
Developed, Medium Intensity	
Developed, Low Intensity	
Developed, Open Space	
Cultivated Crops	Agriculture: 38.13%
Pasture/Hay	
Deciduous Forest	Forest: 47.61%
Evergreen Forest	
Mixed Forest	
Palustrine Forested Wetland	Wetland: 5.88%
Palustrine Scrub/Shrub Wetland	
Palustrine Emergent Wetland	
Open Water	Water: 0.27%
Palustrine Aquatic Bed	
Grassland/Herbaceous	
Scrub/Shrub	
Unconsolidated Shore	
Bare Land	Other: 2.04%

As seen in Map 2.2, EC is characterized by high concentrations of undeveloped headwater forests, the most dominant land cover in EC is classified as forest (47.6%). The second highest classification is agriculture (38.1%). Together, these two classifications account for 85.7% of land use in EC.



Map 2.1: Eighteenmile Creek Sub-watershed

Active River Area

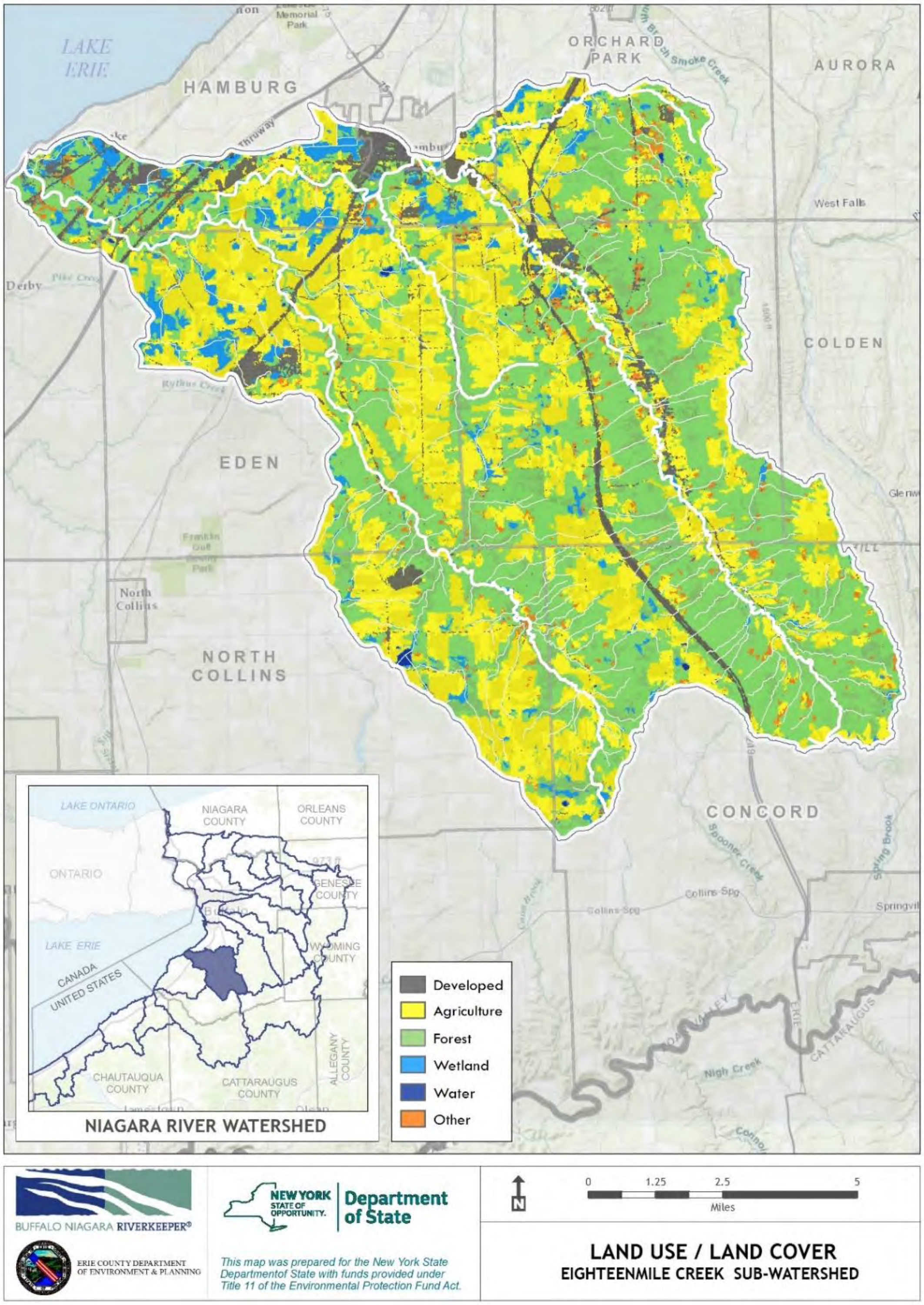
The Active River Area model, as discussed in Chapter 1, was applied to the sub-watershed to determine the extent of the ARA, and focus area for this project. The ARA within the EC sub-watershed is generally evenly distributed, encompassing narrow strips of land in the headwaters, where Eighteenmile Creek flows through the steep gorges, limiting its floodplain and in effect, the ARA. As the creek and tributary streams approach the northwestern portion of the sub-watershed, near Lake Erie, the ARA widens, mostly due to flatter topography and more wetland LULC that interacts directly with waterbodies.

The ARA within EC encompasses 24% of its total area, as seen in Map 2.3.

Land Use/Land Cover in the Active River Area

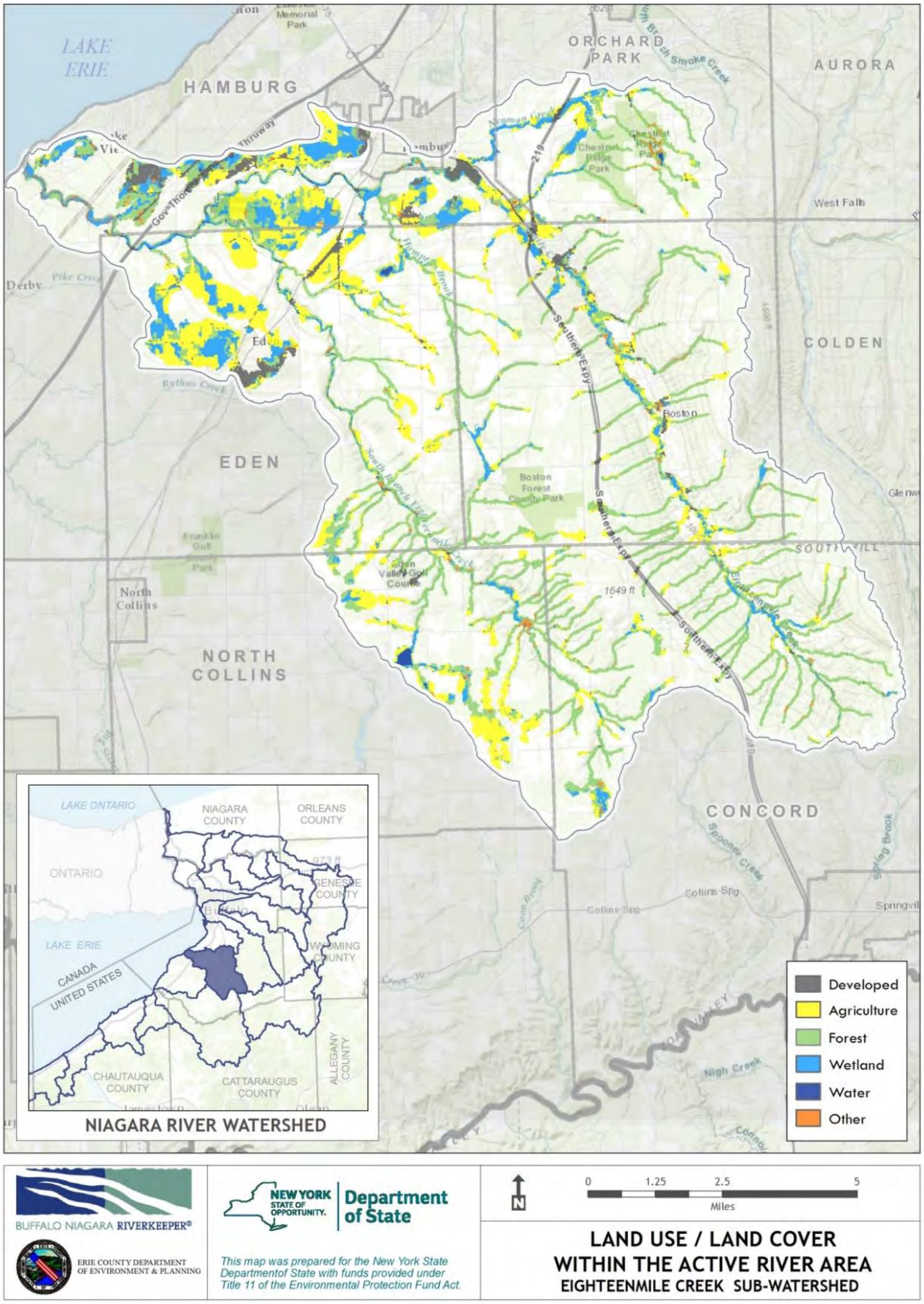
Potential sources of contaminants entering waterways from surrounding lands were identified by overlaying the ARA model on LULC data, to plot where specific land uses interact with streams through natural hydrologic mechanisms. Map 2.4 displays LULC limited to the bounds of the ARA, indicating where contaminants on land may have direct interaction with stream waters.

Tributaries to Eighteenmile Creek and South Branch Eighteenmile Creek flow through mostly forested LULC, as many sections of the creeks generally reside in gorges that drain steep topography. Because of an abundance of steep slopes in many sections of EC, development on lands adjacent to these water bodies is difficult or outright impossible, leaving pristine riparian forests that produce high value habitat and clean drinking water resources. While both Eighteenmile Creek and South Branch Eighteenmile Creek pass through agricultural, developed, and other LULC classifications, it isn’t until the waterbodies flow through the towns of Eden and Hamburg that agriculture and developed LULC becomes dominant, and runoff from agricultural and urban sources becomes concentrated in both main stream channels and tributaries.



Map 2.2: Eighteenmile Creek Sub-watershed Land Use/Land Cover

Map 2.3: Eighteenmile Creek Sub-watershed Active River Area



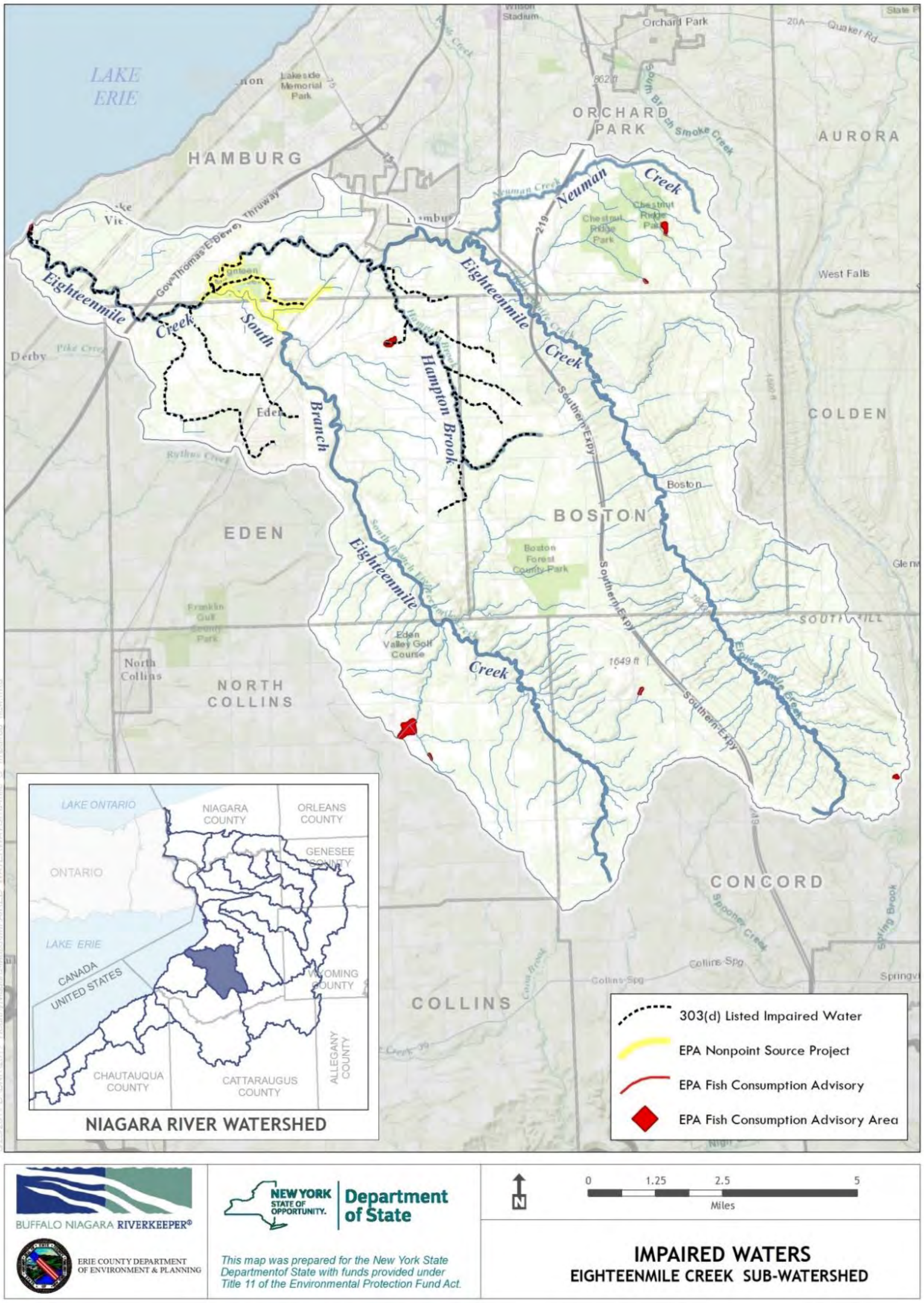
Map 2.4: LULC and ARA Interaction

Impaired Waters

The NYSDEC WI/PWL catalogs two waterbody segments within EC, encompassing 47.5 miles, or 17.4% under the 'Minor Impacts' classification. These segments include Eighteenmile Creek (Lower and minor tributaries) and Hampton Brook and its respective tributaries. The remaining waterbody segments within EC are cataloged as No Known Impact.

As depicted in Map 2.5, a portion of Eighteenmile Creek and Hampton Brook are listed on the 303(d) list, indicating impaired waterways, while several small tributaries are listed under EPA Fish Advisories. A small portion of Eighteenmile Creek (Main Stem and South Branch) are listed on the EPA Nonpoint Source Project, a program established under Section 319 of the Clean Water Act, and administered by the NYS Department of Environmental Conservation (NYS DEC), to "control pollution from nonpoint sources to the waters of the state and to protect, maintain, and restore waters of the state that are vulnerable to, or are impaired by nonpoint source pollution."[9]

NYS DEC categorizes waterways according to a class system related to uses.[12] Stream classifications for waterways assessed in this project are listed below in Table 2.2. Streams with AA or A classifications are suitable for use as drinking water sources, while streams classified as B, C, or D support descending numbers of uses. The addition of a (T) to a stream classification indicates that the stream may support trout populations, while a (TS) waterway may support trout spawning.



Map 2.5: Eighteenmile Creek Sub-watershed Impaired Waterways

Table 2.2: NYSDEC Priority Waterbody Classifications

Priority Waterbody	Stream Class	Designated Use(s) Not Supported by the Waterbody: Use(s) Impacted	Severity of Impact	Documentation	Pollutant(s) of Concern: Type of Pollutant	Documentation	Source(s) of Pollution: Source	Documentation
Eighteenmile Creek, Lower, minor tributaries	B(T); Tribs- B, C	Fish Consumption Recreation Habitat/Hydrology	Stressed Stressed Stressed	Possible Suspected Suspected	Silt/Sediment Priority Organics - PCBs Pathogens Thermal Changes	Suspected Suspected Suspected Possible	Streambank Erosion Urban Runoff Agriculture Hydrologic Modification Toxic/Contaminated Sediment	Suspected Suspected Suspected Suspected Suspected
Eighteenmile Creek, Middle, and tributaries	A	No Use Impairment	---	---	---	---	---	---
Eighteenmile Creek, Upper, and tributaries	A, A(T); Tribs- A	No Use Impairment	---	---	---	---	---	---
South Branch Eighteenmile Creek, Lower, and tributaries	B, B(T); Tribs- B	No Use Impairment	---	---	---	---	---	---
South Branch Eighteenmile Creek, Upper, and tributaries	C(TS); Tribs- C	No Use Impairment	---	---	---	---	---	---
Hampton Brook and tributaries	B	Aquatic Life	Stressed	Known	Nutrients (phosphorus) Dissolved Oxygen/Oxygen Demand Pathogens	Known Suspected Possible	Agriculture Urban Runoff	Suspected

Stream Visual Assessment & Water Quality Data Collection

In order to supplement existing data and fill in data gaps, BNR conducted water sampling and stream assessments throughout portions of the sub-watershed. Sampling took place along four streams in EC during the 2015 field season.

Waterways within EC were assessed from July 30, 2015 to September 1, 2015. Within three stream bodies, 331 reaches were assessed. The streams assessed were Eighteenmile Creek (Main and South Branches), Hampton Brook, and Neuman Creek. Each stream was broken up into segments, and assigned a unique identifier based on location (18S, 18W 18M, SB, SSB, HAM, NEU).

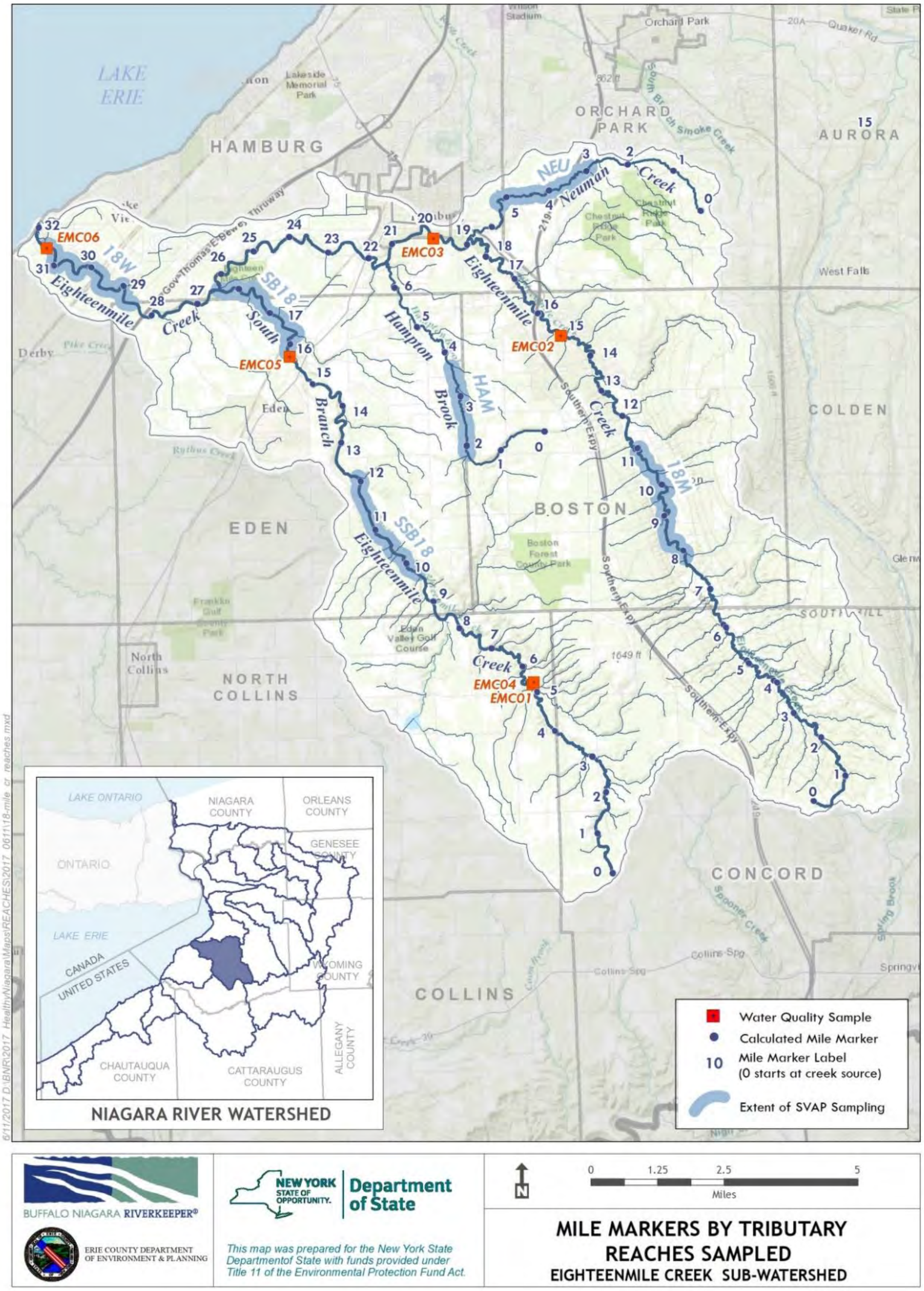
Within EC, 17 of the total 273.8 miles (6.2%) of waterways were assessed using a modified version of the Stream Visual Assessment Protocol (SVAP).[21] Table 2.3 presents the segments assessed.

Figure 2.1: Stream visual assessment in Eighteenmile Creek (BNR)

Stream miles were calculated using ArcGIS software so that stream segments and sample sites could be assigned a unique "mile marker" along each waterway for reference. Mapped segments with mile markers can be seen below in Map 2.6.

Table 2.3: Streams Assessed in Lower Tonawanda Creek Sub-watershed

Stream Assessed	Stream Class	Miles Assessed
Eighteenmile Creek - Main Stem	B(T), A	4.78
Eighteenmile Creek - South Branch	B	8.76
Hampton Brook	B	1.74
Neuman Creek	A	2.06



Map 2.6: Stream Segments Assessed

Physical Properties

As seen in Table 2.4, EC recorded an average depth of 9.8 inches for the four streams assessed. The sub-watershed recorded an average bankfull width of 55.7 feet and an average baseflow width of 32 feet.

Table 2.4: Eighteenmile Creek Sub-watershed Physical Properties

Stream	Average Depth (in.)	Average Bankfull Width (ft.)	Average Baseflow Width (ft.)
Eighteenmile Creek Main Stem	10.3	85	55.3
Eighteenmile Creek South Branch	6.8	81	44.9
Hampton Brook	9.6	34.8	14.1
Neuman Creek	12.5	22.1	13.7
Sub-watershed Average	**9.8**	**55.7**	**32**

Stream Visual Assessment and Water Quality Findings

During the Phase 1 process, EC was chosen based on the priority to preserve and protect conditions leading to good water quality and healthy habitat. Throughout the fieldwork process, it became apparent that while many stream segments were indeed in good overall health, there were several in poor condition. Overall SVAP findings from the four assessed water bodies within the sub-watershed resulted in a score of 'good' (7.8). Neuman Creek, which flows primarily through agricultural land and is a Class A stream, begins south of the hamlet of Ellicott and joins Eighteenmile Creek east of Hamburg, recorded the lowest average SVAP score in the sub-watershed of 'fair' (6.7). The other three assessed waterbodies, Hampton Creek (8.4), Eighteenmile Creek (7.6), and Eighteenmile Creek South Branch (8.2) all recorded 'good' scores.

Table 2.5 presents an SVAP score summary for EC, and a full SVAP summary is available in Appendix C.

Table 2.5: Eighteenmile Creek Sub-watershed SVAP Element Summary

	Channel Conditions	Riparian Zone Left Bank	Riparian Zone Right Bank	Bank Stability Left Bank	Bank Stability Right Bank	Water Appearance	Nutrient Enrichment
# of scores ***average***	329 9.6	330 8.7	330 9.2	330 7.6	330 7.8	330 7.6	331 6.4
	Instream Fish Cover	**Pools**	**Invertebrate Habitat**	**Canopy Cover**	**Manure Presence**	**Riffle Embeddedness**	
# of scores ***average***	331 5.8	326 5.9	331 8.9	237 5.2	1 1	301 9.4	

Substrate in EC is predominantly bedrock, with 39% of assessed reaches having a bedrock substrate. Cobble was observed to account for 32% of the sub-watershed's assessed substrate. Gravel comprised 23%, with sand, silt, silt/clay mix, and boulders making up only 6% of the substrate of assessed reaches, cumulatively.

Channel conditions throughout the sub-watershed were scored as 'excellent' (9.6+). Assessed stream channels were largely un-altered with limited channelization or use of rip-rap. These natural stream conditions have a positive impact on wildlife and overall stream health.

Japanese Knotweed was observed in 66% of assessed stream reaches in EC, and was evident in some capacity in every stream segment assessed within the sub-watershed. Purple Loosestrife was observed in 33% of assessed reaches, while Phragmites was observed in only 3% of all assessed reaches.

Figure 2.2: Japanese Knotweed growth along Eighteenmile Creek (BNR)

Japanese knotweed (*Polygonum cuspidatum)*, an invasive plant introduced to the US from Eastern Asia, was observed at 66% of reaches assessed in the sub-watershed. Historically, the plant was used for erosion control, and thick growths tend to mask poor bank conditions that would otherwise be assessed as eroding. It spreads very quickly via a rhizome (underground) root system, thriving in recently disturbed areas and forming monoculture stands. Resistant to drought and high temperatures, Japanese knotweed can out-compete native plant communities which are depended on by many wildlife species and important to the health and biodiversity of local habitats. As seen in Figure 2.2, large stands of Japanese knotweed were observed along the banks of Eighteenmile Creek.

Additional water quality sampling was performed at six sites within EC from June 25, 2015 to November 30, 2015. Of those six sites, three were sampled again from April 28, 2016 to November 15, 2016. It must be noted however, that as discussed above, 2016 sampling took place during drought conditions, and fewer storm events would have contributed to less runoff bringing nutrients into waterways.

Table 2.6 displays water quality parameters measured during SVAP, including the number of measurements performed, high and low values measured, and the average value recorded for each parameter. Full water quality parameter results can be found in Appendix C and D.

Table 2.6 Eighteenmile Creek Sub-watershed Water Quality Element Summary

	Temperature ºC	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)	Conductivity (uS/cm)	Total Dissolved Solids (mg/L)
# of meas.	119	118	118	119	119
low value	15.9	6.2	66.2	318	228.5
high value	29.0	15.2	184.1	781.9	403
average	21.0	9.6	107.6	495.8	347.2
	pH	**Turbidity (NTU)**	**Phosphorus (µg/L)**	**Nitrate (µg/L)**	
# of meas.	119	149	150	125	
low value	7.7	0.6	6.6	3,000	
high value	9.5	32.8	303.6	21,400	
average	8.18	5.4	79.2	10,300	

Baseline Indicators

Through the fieldwork portion of this project, parameters that either indicated pervasive impairments throughout the sub-watershed, or had high numbers of water quality parameters exceeding relevant standards or guidance values were isolated for further discussion. These baseline indicators begin to give us a picture of the sub-watershed's health or impairment status during normal, baseline conditions.

Baseline Indicators for the Eighteenmile Creek Sub-watershed are identified as:

- Land Use/Land Cover
    - LULC in EC directly affects water quality throughout the sub-watershed. Runoff from stormwater and agriculture is a major vector transporting contaminants from surrounding land into waterways. LULC also helps to determine suggested management actions, as those actions that are able to be performed on agricultural or forested land may not be appropriate for more developed land.
- Riparian Zone and Bank Stability
    - The riparian zone within EC was rated as 'good', but several individual reaches recorded fair and poor scores. A poor riparian zone allows stream banks to erode more readily, and for contaminants in runoff to flow uninterrupted into a water body. Bank stability is grouped with riparian zone, as a poor riparian zone generally coincides

with poor bank stability. While some reaches scored very high, erosion issues were prevalent throughout the sub-watershed, and 'poor' bank stability scores were recorded in every stream segment SVAP assessments occurred in.

- *E. coli*
  - *E. coli* measurements performed in the sub-watershed had levels greatly exceeding recommended levels for primary contact recreation.
- Nutrient Load
  - Phosphorus and nitrate within the sub-watershed are consistently high, indicating that elevated levels of these parameters are entering waterways.

Baseline Indicators Discussion

Land Use/Land Cover

EC contains extensive quantities of high quality of riparian forest, abundant canopy cover along waterways, and low overall impervious surface (3.45%). Land cover directly affects watershed health, making conservation of forested cover vital to maintain water quality. There have already been steps taken in this direction. Most recently, in 2015, Buffalo Niagara Riverkeeper (BNR), in partnership with The Nature Conservancy and Erie County Department of Parks, Recreation and Forestry, raised funds to acquire a 230-acre forest within the sub-watershed. This action connected a series of critical forested areas within the upper EC sub-watershed and can be used as a model for future land protection and partnership efforts.

EC contains approximately 3,595.3 acres (4.7%) of protected land, the smallest amount of any sub-watershed in the Niagara River Watershed. Land protection and conservation, including easements and regulatory protections (such as state parks, state forests, etc.), is a critical component in preserving water quality. With protection, these areas will not succumb to urban sprawl or development, which will assist in preserving water quality of nearby rivers and streams.

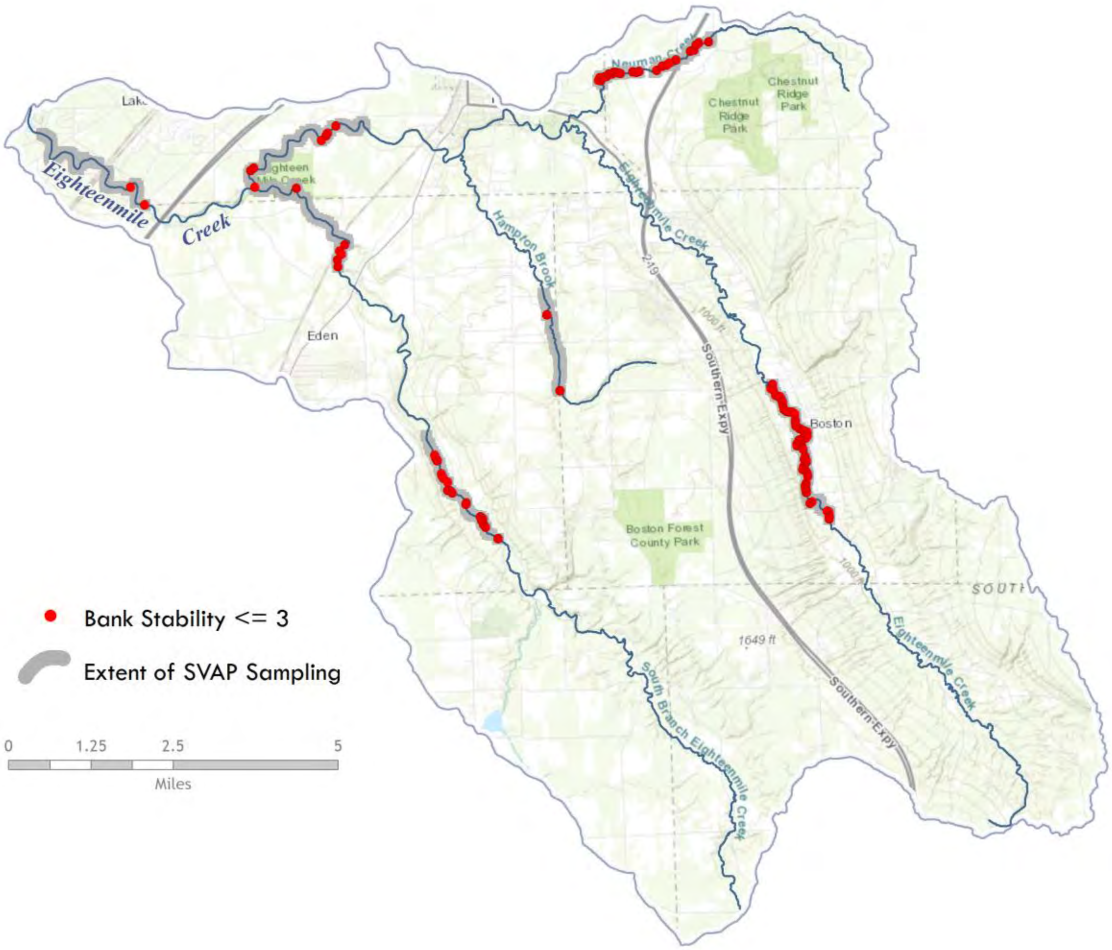
Figure 2.3: Eighteenmile Creek Riparian Zone (BNR)

Riparian Zone and Bank Stability

The riparian zone, or area of natural vegetation bordering waterbodies, along assessed stretches received either 'good' or 'excellent' average scores throughout the sub-watershed. Figure 2.3 presents an example of a healthy riparian zone observed along Eighteenmile Creek. Poor scores indicate a lack of riparian cover or a narrow riparian zone width in comparison to the stream's active channel. Excellent scores refer to a riparian zone extending at least two times the width of the stream's active channel. This zone is a vital component to a healthy water body, as the roots of riparian vegetation naturally stabilize banks and control erosion. This zone of vegetation also functions as a surface water filter, slowing and absorbing stormwater runoff and the various pollutants it may be transporting and provides natural shade helping to regulate water temperature. Neuman Creek received the lowest average score of 'good' (8.1). Characterized by abundant riparian vegetation, there were a few sites observed where the riparian zone was lacking due to residential mowing.

Figure 2.4: Neuman Creek Bank Erosion (BNR)

Coinciding with riparian zone scores, Neuman Creek also received the lowest average score for bank stability of 'poor' (4.1). Low scores indicate sites with a higher potential for stream bank erosion. Several sites with considerable stream bank erosion were observed, as seen in Figure 2.4. Assessed segments along Eighteenmile Creek and Hampton Creek recorded much higher average bank stability scores. For example, Eighteenmile Creek's South Branch recorded a bank stability average of 'good' (8.72). Bank stability scores under 3 for the sub-watershed are shown in Map 2.7 below. A score of 3 indicates that "banks are moderately unstable, typically high, actively eroding at bends; ~50% rip-rap; excessive erosion" while a score of 1 represents "Unstable high banks, actively eroding at bends throughout; dominated by rip-rap." It must be noted that large amounts of invasive species may mask eroding stream banks, and that SVAP did not assess reaches in the headwaters of EC. Main Stem and South Stem EC reaches assessed separately by Erie County Soil and Water Conservation District in 2000-2001 show 78 severely eroding sites, totaling 11,500 linear feet, and other assessments have shown similar erosion issues throughout EC.



Map 2.7: Bank Stability Score 1-3

E. coli

While manure presence was only observed at one location along Neuman Creek, other sampling locations throughout the sub-watershed recorded elevated *E. coli* levels. Samples were collected at six sites within EC during 2015 and 3 sites in 2016. Several results from both years recorded above the USEPA Beach Action Value (BAV) of 235 cfu/100mL as seen in Figure 2.5. The BAV is a tool often used to assist in making beach notifications and closures. [29]

Figure 2.5: *Escherichia coli* Monitoring Results

Cattle tracks were observed within the stream. Manure was also detected within this reach. As seen in Figure 2.6, a path used by cattle leads directly to the stream. Neuman Creek contained the reach that received the lowest overall score within the sub-watershed. The reach in question received a 'poor' score (4.2) and was located near a farm.

Figure 2.6: Livestock Access to Neuman Creek (BNR)

Nutrient Load

Livestock activity in the riparian zone of streams has the potential to degrade vegetation and escalate bank erosion. Manure can result in elevated pathogen and nutrient levels. Most samples collected to assess nutrient levels, both phosphorus and nitrate, displayed results well above the NYSDEC guidance and standard values. Eighteenmile Creek South Branch recorded average nitrate readings of 15,958.1 µg/L while the standard is 10,000 µg/L. Phosphorus levels were also elevated within the assessed waterbodies. Neuman Creek recorded the highest average phosphorus reading of 103.6 µg/L, well above the guidance value for Lake Erie Eastern basins of 10 µg/L.[6]

During monthly water quality sampling, phosphorus reached its highest measured levels in June 2015 with a sub-watershed average value of 471.9 µg/L, and the highest value in 2015 (of 765.6 µg/L) being measured at the South Branch Eighteenmile Creek site (EMC06). Phosphorus levels in 2015 trended downward from June through November, indicating that the bulk of phosphorus is entering waterways in the early summer seasons. In the 2016 sampling season, the sub-watershed's highest average phosphorus levels occurred in May, with measurements for that month averaging 110.0 µg/L.

Nitrogen and phosphorus are natural constituents of the environment, but can also be introduced into a water body via fertilizers and sewage inputs such as septic systems, which are prevalent in rural communities in this watershed. Most traditional fertilizers, used both for agricultural or residential purposes, contain nitrogen, phosphorus, and potassium (or potash). Animal manure and commercial fertilizer, used as a crop fertilizer, is a primary source of nitrogen and phosphorus to surface and groundwater via runoff or infiltration.[26]

While nitrogen and phosphorus are vital for a healthy stream, the correct balance is critical to sustain aquatic life. [18] High nutrient levels can fuel excessive growth of aquatic vegetation and algae which can congest streams. With elevated plant respiration and decomposition, dissolved oxygen levels become depleted. These-oxygen depleted environments can stress and have detrimental impacts on aquatic life. At times, algae will grow in large, expansive colonies often referred to as an algal bloom. Under the right conditions, some algal blooms will produce toxins that can be dangerous to both wildlife and human health.[1]

Eighteenmile Creek Critical Source Areas

CSAs in EC are depicted in Map 2.8, and displays CSAs using the methodology described on page 1-9.

The CSAs in EC are those areas which are thought to be actively contributing to impairments found through assessments. In EC, these "critical" or "contributing" areas are those agricultural, and developed land uses within the ARA. These critical areas represent the priority areas for intervention in the sub-watershed. Undeveloped, forested, or wetlands within the ARA are shown to be "Non-

Critical Areas", meaning that they are not actively contributing impairments, but and are priority areas for conservation and protection. These Non-Critical areas can generally be described as a large area which contains important riparian forest tracts, critical for preventing future pollutants from entering surrounding waterways.

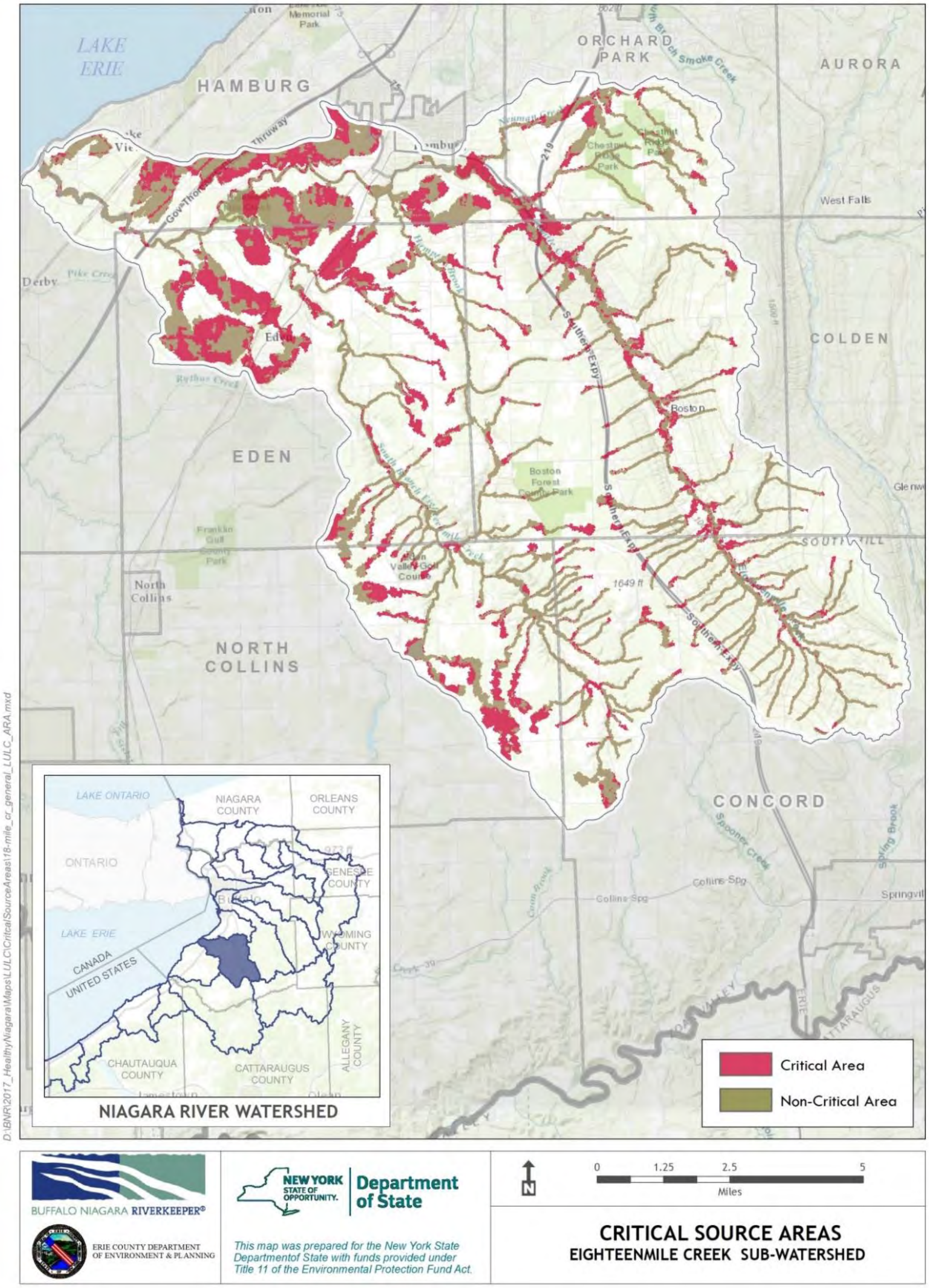
CSA Conservation Priorities

Three core forest areas are identified in the headwaters of the sub-watershed as protection priorities in order to maintain climate resiliency. These three core forest areas are located in headwaters of both the north and south branches of Eighteenmile Creek. Four potential fish barrier removal projects are identified in the headwaters of the sub-watershed. Two are located on the north branch of Eighteenmile Creek while two are located on the southern branch.

The Eighteenmile Creek Sub-watershed features several critical headwater forests and parks. Included in this list are Chestnut Ridge Park, Boston Forest County Park, and Fowlerville forest - a privately owned, 1,300-acre block which helps to mitigate downstream stream and bank erosion.

Many headwater streams in both branches of Eighteenmile Creek suffer from incorrect classifications which limit protections. For example, despite State-documented trout observations throughout these streams, the NYS DEC water quality classifications have not been updated to include protections appropriate for trout habitat and trout spawning streams. This prevents those streams from being adequately protected when bridge or culvert infrastructure is replaced. It is recommended that existing data be assessed to enact appropriate policy changes needed to update regional stream classifications.

Several conservation projects have been identified through Buffalo Niagara Riverkeeper's Niagara River Habitat Conservation Strategy, which are seen as priority projects for conservation lands that may directly address impairments in the sub-watershed. These projects are included as Appendix E.



Map 2.8: Critical Source Areas

Target Goals for Baseline Indicators

As specific management actions are carried out, baseline indicators can be used for comparison or to determine the effectiveness of implementation efforts. Suggested management actions are also developed to address baseline indicators, as these indicators can vary regionally and can be tuned to address a sub-watershed's unique characteristics.

Land Cover: Land cover can provide valuable information related to water quality and overall watershed health. With increased development and urbanization, areas with impervious cover will also increase. According to the Center for Watershed Protection, water quality can begin to degrade at 10% impervious cover.[1,3]

> **Future Goal:** Reduce the amount of impervious cover within the sub-watershed.
>
> **Target:** As of 2005, EC contains 3.45% impervious cover. This percentage should be analyzed in future years with a target of it remaining at or below 3.45%.
>
> **Future Goal:** Conserve and protect undeveloped land in the sub-watershed.
>
> **Target:** Engage communities in the sub-watershed to develop a cross-municipal land conservation strategy.

Riparian Zone and Bank Stability: Vegetation bordering waterways naturally stabilizes banks, controls erosion, functions as a natural filter for water runoff, and cools water temperatures via shading. The natural riparian zone should not be compromised during the course of new development or implementation of agricultural practices.

> **Future Goal:** Reduce erosion by increasing the length and width of riparian vegetation along streams within the sub-watershed, and incentivize and encourage riparian buffer ordinances.
>
> **Target:** Increase the width of riparian vegetation to two times the active channel or 300ft, whichever is greater.
>
> **Future Goal:** Work with communities, agencies, and municipalities to implement stream bank stabilization programs at actively eroding sites.
>
> **Target:** Stream stabilization at reaches scoring 3 and below in SVAP Bank Stability (Map 2.7).

***E. coli*:** As a bacterial indicator, *E. coli* is used to monitor the presence of human/animal waste in waterbodies. Sources may include fertilizer, livestock, sanitary discharges, or compromised septic systems.

Future Goal: Reduce access of livestock to streams and stream banks thereby limiting bacterial inputs.

Future Goal: Provide resources to communities to upgrade outdated and deteriorated septic systems.

Future Goal: Municipalities continue to prevent sanitary sewer overflows from discharging into waterways.

Target: Samples test at or below USEPA BAV throughout the sub-watershed, or reduce 30-day geometric mean value to meet USEPA recommended value of 126 cfu/100mL.

Nutrient load: Resulting from stormwater runoff, inputs from wastewater treatment plants, septic systems, and (possible) fertilizer use, high nutrient levels are commonplace throughout the sub-watershed.

Future Goal: Reduce loadings of nutrients, specifically phosphorus and nitrate.

Target: Meet NYS DEC guidance values

- Phosphorus NYS DEC guidance value for Lake Erie Eastern basins of 10 μg/L
- Nitrate NYSDEC standard value of 10,000 μg/L

Suggested Management Actions

The work performed during this project, along with the compilation of preceding data collection and inventory of watershed characteristics is intended to support the development of an action plan consisting of suggested management actions. Actions suggested below are intended to be part of an ongoing, dynamic process, in which management actions are periodically revisited to address changing conditions and management goals with the Niagara River/Lake Erie Watershed.

By implementing the general strategies and recommendations detailed here, the sub-watershed will be on track to meet the previously listed targets for various baseline indicators. These recommendations focus on key issues facing the sub-watershed that were identified through this effort and are not intended to act as a comprehensive list of everything that could be implemented. These suggested management actions apply to: homeowners, municipalities, volunteer groups, agricultural landowners, organizations and agencies working within the sub-watershed.

Land Use

Goal: Protect existing open space and headwater forested area from development

Benefit: According to the Center for Watershed Protection, water quality begins to degrade at 10% impervious cover, because of the loss of groundwater recharge through percolation, and the surge in runoff entering waterways, altering natural flow regimes and overwhelming sewer systems.[3] Currently, the sub-watershed has only 3.45% impervious cover, well below the suggested best practice. Eighteenmile Creek sub-watershed is almost half forested (47.6%) and about 87% of the entire sub-watershed is classified as forested or agricultural land yet only 4.7% of the sub-watershed is protected. Within the suburban population centers in the sub-watershed, efforts to retrofit existing spaces should include increasing pervious surface and decreasing overall imperviousness. In addition, because the sub-watershed has limited development, protecting the forested or open space in perpetuity would greatly benefit long-term water quality.

Best Management Practices

The actions outlined in the table below are organized into three broad categories: green and living infrastructure, land use policy changes, and community engagement.

Implement Green Infrastructure | Living Infrastructure

By incorporating simple living infrastructure practices such as bioswales or rain gardens into small-scale development plans or implementing broader techniques across a larger scale, the resulting effect will be to help to collect rain water before it is able to flow over impervious surfaces, collect pollution and enter bodies of water. In addition, the use of porous material in constructing roadways and parking lots beyond what is required by the NYS Stormwater Manual, rain barrels to disconnect rooftop runoff and incorporation of strategically preserved or placed green and living spaces into landscaping plans will reduce runoff from impervious surfaces directly into waterways and lessen the negative impacts of combined sewer overflows and stormwater discharges.

Land Use Policy

Recommended changes in land use policies include actions like updating a municipality's Comprehensive Plan or amending zoning codes. A Comprehensive Plan allows the municipality to clearly state its long-term goals and priorities for a community. While this document is not law, it does inform the law as a municipality would write zoning codes and ordinances that enable it to meet the goals outlined in the Comprehensive Plan. Conservation updates that can be made to code include: conservation overlay districts, steep slope requirements to limit erosion, minimum setback requirements from waterbodies (sometimes called a "waterfront yard" or "buffer" requirement) on new development, or requirements and standards for vegetated buffers along waterways on all lands.

Implementing conservation easements to protect existing open space, critical headwater forests, and prevent suburban sprawl, as well as farmland protection planning that restricts development on agricultural lands would have the greatest impact in this sub-watershed. For example, the Town of Eden has a codified conservation easement program enabling the town to purchase or request gifts or bequests of land for the protection of open space.[4] Similarly Riverkeeper helped to facilitate the purchase of property for inclusion into a County Forest, creating 1,000 acres of headwater forest in the Town of Concord protected in perpetuity.

Community Education and Engagement

While regulation through zoning codes forces those living in a municipality to abide by a certain set of laws, some practices are better implemented through landowner cooperation and collaboration. For example, almost 40% of the EC sub-watershed is classified as agricultural land and data analysis suggests that agricultural lands may be contributing to water quality impairments in places across the EC sub-watershed. Here, encouraging landowners to voluntarily participate in conservation initiatives can greatly benefit a community. These initiatives include landowner stewardship like utilizing a vegetated riparian buffer along a shoreline or installing a rain barrel to disconnect gutters and collect rainwater for reuse. Similarly, hosting town clean-ups or invasive species removal days can help people feel more connected to their environment, thereby fostering a greater sense of community ownership and stewardship. Invasive species, such as Japanese knotweed, were observed in the sub-watershed. Japanese knotweed requires a multi-step removal process in order to eradicate it and it will overtake as a nuisance weed without control. Implementing a community work day targeted towards removal of Japanese knotweed would be a great step towards achieving improved conditions in EC.

Recommended Actions to increase green space and protect existing open space:

Short Term	• Reclaim unused or underutilize impervious spaces and develop into "green" spaces like rain gardens or community gardens
	  o Cost: Medium
	• Host sustainable development workshops for municipalities and agricultural landowners
	  o Cost: Low
	• Promote recreational use of natural areas to increase land protection and awareness
	  o Cost: Low
	• Create agricultural and farmland protection easements and programs
	  o Cost: Low

	• Revise zoning regulations to limit expansion of impervious surfaces o Cost: Low • Revise zoning codes to include waterfront yard, buffers and increased setback requirements

Long Term	◦ Cost: Low • Creative incentive and educational programs for green and living infrastructure implementation ◦ Cost: Medium • Promote the conservation of open spaces through conservation easements and land acquisition. ◦ Cost: Medium to high • Develop vegetative buffer standards to protect stream quality ◦ Cost: Low

Riparian Zone and Bank Stability

Goal: Increase the length and width of riparian vegetated buffers along stream banks within the sub-watershed

Benefit: Native vegetation bordering waterways naturally stabilizes banks, controls erosion, functions as a natural filter for pollutants, and cools water temperature by providing shade over the water. As noted above, the riparian zone across this entire sub-watershed received average 'good-excellent' (8.7-9.2) SVAP scores, although many known areas of severe erosion exist. Increasing the width of vegetated riparian zones to twice the width of the stream channel or 300 feet, whichever is greater, would provide the greatest impact to the health of the waterway. Plating native vegetation and large trees to combat invasive species would also have beneficial effects on water health.

Best Management Practices

Stream Stabilization

Stabilization of actively eroding shorelines using living and natural infrastructure is recommended where appropriate. Other engineered stabilization techniques should be used only in extreme cases.

Add Vegetation

Hosting community tree planting days in a municipality can provide great benefit to the riparian corridor and improve waterway health with limited costs borne by the municipality. Trees can even be obtained at no cost through the NYS DEC "Trees for Tribs" Program.[5]

Invasive Species Control

Eradication and control invasive species in this sub-watershed is a priority issue that should be coordinated with local agencies and groups such as WNY PRISM.

Develop Ordinances

Including a vegetated buffer or setback requirements into a municipality's zoning code is one regulatory mechanism to ensure measures are taken to protect water health. Not all land can be regulated through laws so in some instances encouraging best management practices or utilizing incentive programs may be a more effective approach. Although located in the Lower Tonawanda sub-watershed, the town of Amherst provides a great example of a buffer ordinance. Goal 4-4 of The Bicentennial Comprehensive Plan for the Town of Amherst (amended Feb 2011) is: "To establish buffer/setback standards for new development to help protect streams of significance." This goal is then applied in the Town's zoning code as, "Lots abutting a watercourse."[16] This section requires that lots abutting a watercourse install a 50-foot wide riparian buffer on either side of a watercourse and further, any building must be set back another 10 feet from the buffer. Additionally, ordinances restricting development which encroaches on floodplains will benefit riparian zones and floodplain management.

Recommended Actions to increase the length and width of riparian zones:

Short Term	• Host tree plantings with volunteers
	  ○ Cost: Low
	• Develop programs to encourage the installation of riparian buffers
	  ○ Cost: Low to Medium
	• Implement stream and bank stability projects to stop erosion
	  ○ Cost: High

Long Term	• Develop vegetated buffer requirements for development in riparian areas
	  ○ Cost: Low
	• Develop setback ordinances for new development in riparian areas
	  ○ Cost: Medium
	• Encourage collaboration amongst municipalities and agencies to develop zoning codes to encourage conservation and best management practices across waterways that span municipalities
	  ○ Cost: Low

E. coli

Goal: Reduce bacterial inputs into streams throughout the sub-watershed

<u>Benefit:</u> *E. coli* is a fecal indicator bacteria used to monitor the presence of human/animal waste in water bodies. Because few strains of *E. coli* naturalize in the environment, the presence of *E. coli* almost certainly suggests that fecal matter is contaminating a body of water. Sources may include fertilizer, livestock, sanitary sewer discharges, or compromised septic systems. Water bodies with high levels of *E.coli* are not suitable for consumption or recreation and can result in a chain-reaction of negative human health and economic effects including beach closures. Reducing *E. coli* levels to meet USEPA's recommended value of 126 cfu/100ml (30 day geometric mean) would greatly improve water quality. Combating *E. coli* requires that the sources inputting the bacteria into waterways be mitigated, such as CSO/SSO outfalls and livestock exclusion.

Best Management Practices

Livestock

When livestock is able to freely roam in and across streams, they can produce a number of undesirable effects such as trampling banks, increasing erosion, and directly inputting sources of bacteria such as *E. coli* into water bodies through excrement. In addition, livestock fecal contamination releases a large amount of antibiotics into waterways, contributing to widespread naturalized antibiotic resistance. If livestock cannot be completely excluded from streams, then at a minimum, limit access by creating a designated crossing. Similarly, some lands have seen success by placing water troughs near the water body so that the cows can easily get to the stream water they may use for drinking but are not directly standing in the stream.

Update and Upgrade Septic Systems

Leaking septic systems are a direct input of bacteria into groundwater which can pollute drinking water and contaminate streams. It is important to recall that the presence of *E. coli* is not the only indicator species of biological pollution—it is just the simplest and most widely tested for. *E.coli* often occurs in tandem with other pathogenic bacteria, viruses and protozoans, such as those that cause cholera, dysentery, and Giardia. Upgrading septic systems with denitrification systems and fixing leaking systems is a necessary solution to mitigate this input.

Green and Living Infrastructure

In more populous areas, CSOs can be a large source of contaminants (particularly bacteria). CSOs occur where a municipality has combined storm and sanitary pipes and where rainfall inundates the system, resulting in more water than the pipes can handle. This results in an overflow situation where the pipes discharge excess untreated water directly into waterbodies. Implementing green and living infrastructure in both urban and suburban areas can drastically mitigate CSO events. By utilizing green and living infrastructure elements like rain barrels, raingardens, wetlands, and other installations meant to trap rainwater and runoff, less water goes into the sewer system resulting in fewer overflow events. In agricultural or suburban areas with larger swaths of open land, utilizing living infrastructure such as woodlands, meadows, and riparian buffers, and living shorelines to intercept stormwater and overland runoff can also help reduce runoff.

In addition to the modifications noted above, large-scale infrastructure improvement projects can be extremely beneficial as well as a catalyst for major change. For example, the completion of the Crescent Avenue Pumping Station in the Village of Hamburg was the final step to eliminate SSOs in the village. Over seven years, in partnership with Erie County, the village undertook four major grey infrastructure improvement projects to rehabilitate and/or replace aging portions of the sewer system. Immediately following the completion of the final stage, there were no recorded SSO events in either 2012 or 2013. The total cost to construct these projects was \$3.9 million. These upgrades had not only ecological benefits by eliminating overflows into Eighteenmile Creek, a designated Critical Environmental Area which boasts a NYS DEC fishing access point, but also helped the village to meet the goals stated in their Comprehensive Plan. As Mayor Moses stated,

> "By eliminating overflows into Eighteenmile Creek from the Village and removing a pump station from the creek bank these projects are not only helping the environment, they are also helping the Village to attain one of the strategies in our Comprehensive Plan- which is to increase access and recreational opportunities along 18 Mile Creek for residents and visitors so that we can all enjoy the natural resource that flows through our community."[13]

Recommended Actions to reduce bacterial inputs into streams:

Short Term	• Install livestock exclusion fencing to limit livestock access to and crossing of streams
	  ○ Cost: Medium
	• Disconnect gutters and install rain barrels to collect and reuse storm water
	  ○ Cost: Low
	• Build rain gardens
	  ○ Cost: Low
	• Develop and host septic system maintenance workshops
	  ○ Cost: Low
	• Install liquid manure retention and targeted spreading systems to prevent manure runoff from crop fields.
	  ○ Cost: High

Long Term	• Encourage the installation of wetland treatment systems or other living infrastructure to replace grey systems
	  ○ Cost: Low to Medium
	• Install vegetated bio-filtration systems such as bioswales and rain gardens
	  ○ Cost: Low
	• Install Living Shorelines along riparian land
	  ○ Cost: Low to High
	• Replace aging infrastructure and remove CSO/SSO outfalls from municipal sewer systems
	  ○ Cost: High

Nutrient Load

Goal: Reduce loadings of nutrients, specifically phosphorous

Benefit: Limiting phosphorus limits algae growth (including nuisance blue-green algae such as *Microcystis spp.)* and allows for more dissolved oxygen, resulting in better aquatic species health and cleaner water.

Best Management Practices

High levels of nutrients such as phosphorous and nitrates were found the in the creeks and streams sampled in the sub-watershed. Sources of nutrients include: stormwater runoff, wastewater treatment plants, CSOs, septic systems, fertilizers, agricultural runoff, and improper disposal of lawn debris. Two of the best ways to combat nutrient inputs are through improving land use practices and education.

Land Use

Making minor to moderate changes to the way in which a person or industry interacts with their land can have significant benefits to water body health. The actions outlined below provide examples of tactics both private homeowners and agricultural landowners can implement.

Education

Many of the changes that could result in the greatest improvement on the overall health of water bodies are behavioral. Encouraging changes in actions or promoting different protocols can be beneficial to combatting nutrient loadings along waterways. For instance, while in the field, the data collection team observed a number of piles of grass clippings abutting the stream and getting blown into the water. Inputs of grass clippings and yard waste into a waterway cause a direct increase in nutrients. Similar minor changes in farming practices or utilizing well known best practices can have significant impacts to the health of a waterbody. Suburban communities can benefit from individual small changes like using phosphorous-free fertilizer and consulting local town or village officials on lawn debris pick-up policies. Some towns, like Orchard Park, even have their own compost facilities where homeowners can bring yard waste.

Recommended Actions to reduce nutrient loadings:

Short Term	• Host educational workshops for riparian landowners pertaining to funding opportunities and financial assistance for implementing best management practices or runoff mitigation
	• Enact best management practices to reduce nutrients and sediments entering local waterbodies
	  o Agricultural Environmental Management Program
	  o NYS Agricultural Nonpoint Source abatement and Control Grant Program
	    o Cost: Low
	• Encourage no till farming practices
	    o Cost: Low
	• Provide educational stormwater management trainings for designers and highway officials to ensure stormwater law compliance
	    o Cost: Low
	• Implement "no mow" zones
	    o Cost: Low
	• Appropriately dispose of lawn debris – consult local town or village
	    o Cost: Low
	• Use phosphorous-free fertilizer
	    o Cost: Low

Long Term	• Develop and implement educational trainings for homeowners about lawn care techniques, debris disposal, native plant species etc.
	    o Cost: Low
	• Implement and enforce pesticide and fertilizer use standards and regulations
	    o Cost: Low
	• Increase watershed stewardship by installing markers and signage for things like storm drains
	    o Cost: Medium
	• Limit manure applications timeframes; i.e. not on frozen ground
	    o Cost: Low

Chapter 3: Buffalo River

The Buffalo River Sub-watershed (BR) is located on the southern section of the Niagara River Watershed. It has an area of 105,392 acres, or 164.7 square miles, and includes 312 miles of waterways, including Cazenovia Creek, Pipe Creek, the Buffalo River, along with many unnamed low-order tributaries and ephemeral headwater streams.

Located in Erie County, BR includes the following municipalities: The City of Buffalo, the Villages of East Aurora and Sloan, the Towns of West Seneca, Elma, Aurora, Colden, Holland, Concord, Cheektowaga, Boston, Wales, and Sardinia. The sub-watershed is shown in Map 3.1.

BR's varies across ecoregions – from high quality upland forests and streams down to the urban-industrial corridor and "Area of Concern" (AOC) approaching Lake Erie. The headwaters include the East and West Branches of Cazenovia Creek, which rise in the Towns of Sardinia and Concord respectively, and flow northwest to join in the Village of East Aurora. These upland landscapes are comprised of several protected areas including: Erie County Forests, eight NYS DEC Class 1 wetlands, and two large grassland areas (Knox Farm and Sprague Brook Park), and large open spaces such as Tifft Nature Preserve in Buffalo, and Emery Park in South Wales.

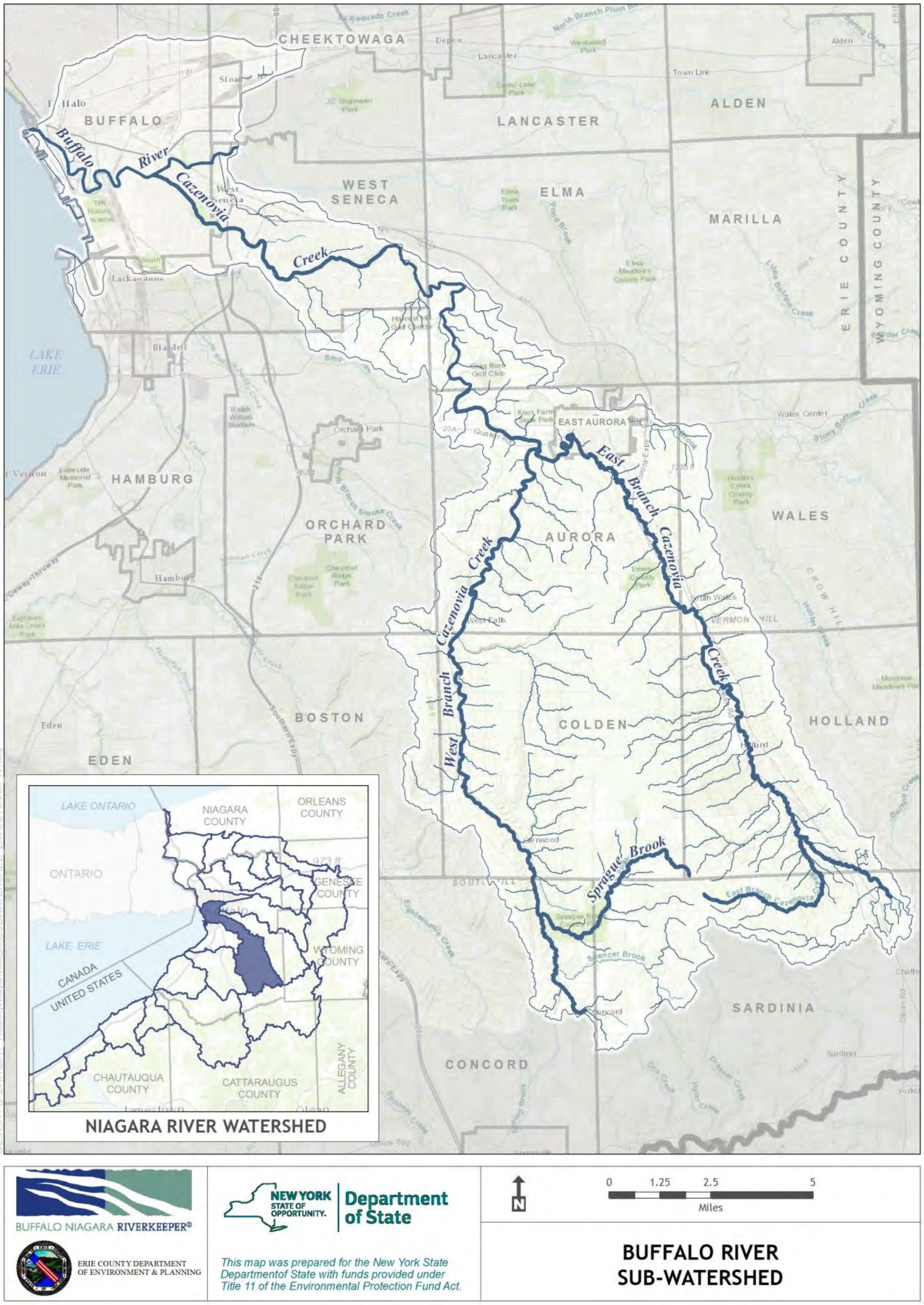
Table 3.1: LULC Groups and Percentages

LULC Class	% by general LULC
Developed, High Intensity	Developed: 21.89%
Developed, Medium Intensity	
Developed, Low Intensity	
Developed, Open Space	
Cultivated Crops	Agriculture: 22.09%
Pasture/Hay	
Deciduous Forest	Forest: 47.95%
Evergreen Forest	
Mixed Forest	
Palustrine Forested Wetland	Wetland: 4.53%
Palustrine Scrub/Shrub Wetland	
Palustrine Emergent Wetland	
Estuarine Emergent Wetland	
Open Water	Water: 0.61%
Palustrine Aquatic Bed	
Grassland/Herbaceous	
Scrub/Shrub	
Unconsolidated Shore	
Bare Land	Other: 2.93%

Land Use/Land Cover

Land Use/Land Cover (LULC) classifications for BR were derived from 2010 NOAA LULC data, and similar classifications were consolidated into groups that reflect the overall LULC classification.22 The LULC groups can be seen in Table 3.1.

Characterized by high concentrations of urban and suburban development, the most dominant land use in BR is residential (48%), followed by vacant land (22%). Vacant land is property either not in use, in temporary use, or lacking permanent improvement. This can be comprised of vacant industrial, residential, commercial, and rural or public utility lands. LULC within BR is shown in Map 3.2.



Map 3.1 Buffalo River Sub-watershed

Active River Area

The Active River Area model, as discussed in Chapter 1, was applied to the sub-watershed to determine the extent of The ARA, and focus area for this project. The ARA in BR is generally more constrained in the headwaters, becoming more expansive as waterbodies in the sub-watershed approach Lake Erie in the City of Buffalo.

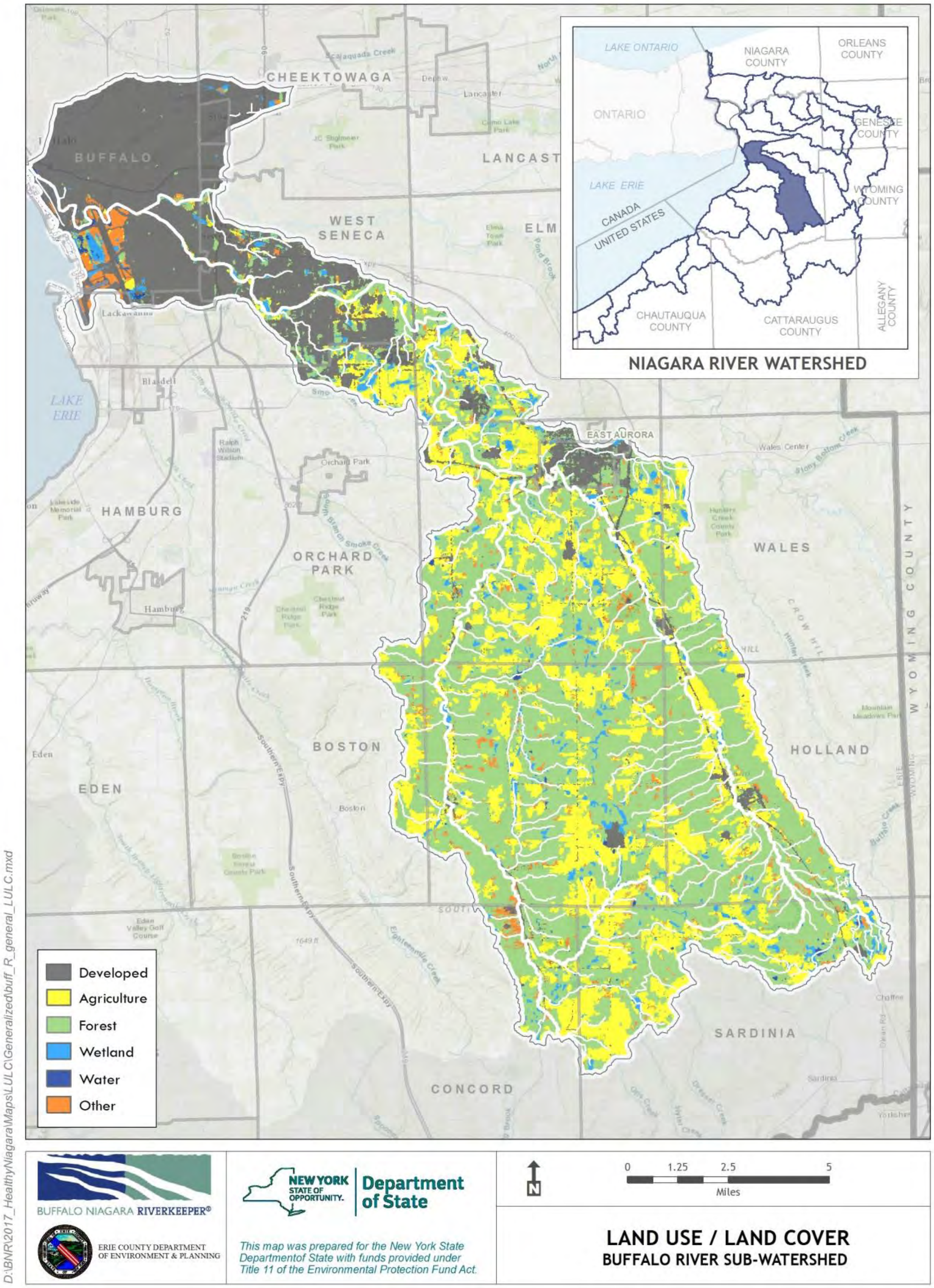
The ARA in BR encompasses 23% of its total area, as seen in Map 3.3.

Land Use/Land Cover in the Active River Area

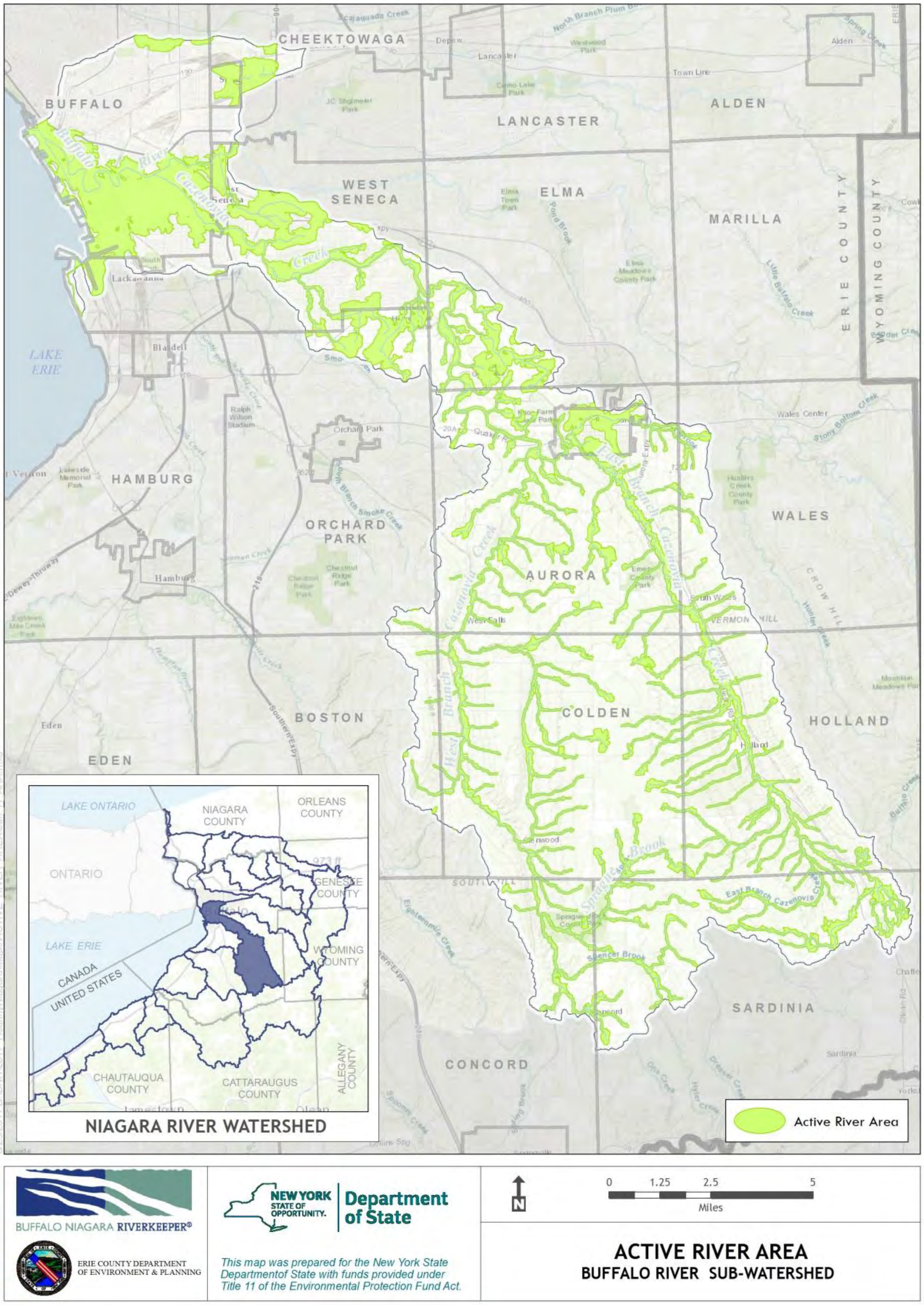
Potential sources of contaminants entering waterways from surrounding LULC were identified by overlaying the ARA model on LULC data, to plot where specific land uses interact with streams through hydrologic mechanisms. Map 3.4 displays LULC limited to the bounds of the ARA, indicating where contaminants on land may have direct interaction with stream waters.

Tributaries to the East and West Branch of Cazenovia Creek flow through mostly forest LULC, as many sections of the creeks generally reside in gorges that drain steep topography. Because of an abundance of steep slopes in many sections of BR, development on waterbody-adjacent lands is difficult or outright impossible, leaving pristine riparian forests that produce high value habitat and clean drinking water resources. Steep slopes, while keeping development off of streambanks, tend to push development away from streams into the larger floodplain, resulting in issues due to poor floodplain management.

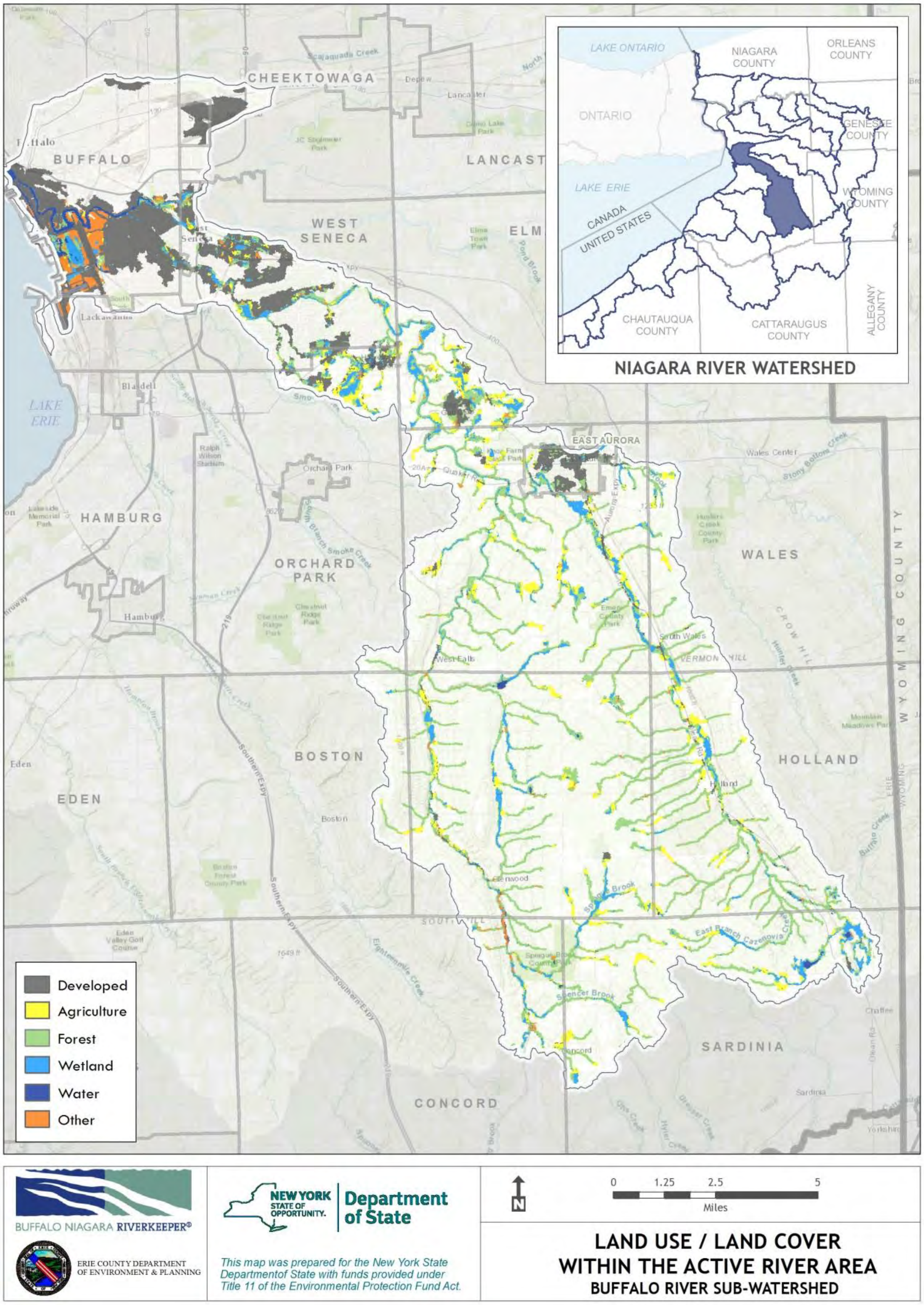
The East Branch of Cazenovia Creek flows through the developed Hamlet of Holland, the heavily developed Village of East Aurora before joining with the West Branch, and becoming Cazenovia Creek. Cazenovia Creek continues on through highly developed West Seneca, before joining Buffalo Creek within the City of Buffalo and becoming the Buffalo River, a highly modified and impaired urban waterway with adjoining industrial landscapes.



Map 3.2: Buffalo River Sub-watershed Land Use/Land Cover



Map 3.3: Buffalo River Sub-watershed Active River Area



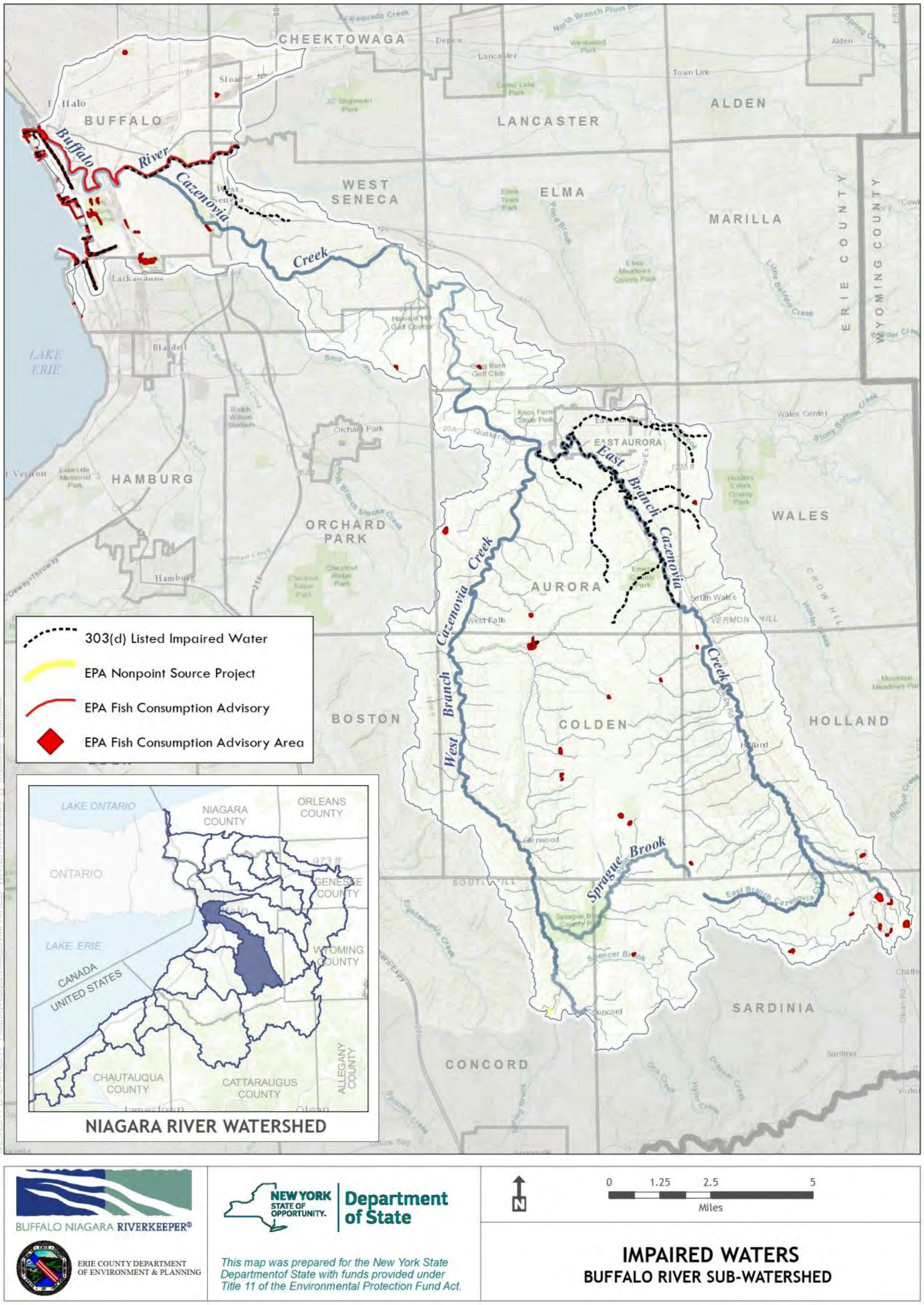
Map 3.4 LULC and ARA Interaction

Impaired Waters

The NYSDEC WI/PWL catalogs several waterbody segments within BR, encompassing 17.8 miles, or 5.7% as impaired. Impaired segments include the Outer Harbor (North and South) of Lake Erie and the main stem of the Buffalo River. Specifically, the 6.2 miles of the Lower Buffalo River to Lake Erie that comprises the AOC has a number of impairments. The health of an AOC is determined by impairments to designated beneficial uses or "BUIs." There are fourteen possible BUIs that can plague a body of water. Of those fourteen, the Buffalo River has nine impairments (two criteria are not applicable to the river): (1) Restrictions on Fish & Wildlife Consumption; (2) Tainting of Fish & Wildlife Flavor; (3) Degradation of Fish & Wildlife Populations; (4) Fish Tumors and Other Deformities; (5) Bird or Animal Deformities or Reproductive Problems; (6) Degradation of Benthos; (7) Restrictions on Dredging; (8) Degradation of Aesthetics; and (9) Loss of Fish and Wildlife Habitat. The habitat restoration, federally and state funded sampling and data collection, and massive dredging operations have been initiated in order to remedy theses impairments and ultimately "delist" the Buffalo River, in the hopes that one day it may be fishable, swimmable, and drinkable. The remaining waterbody segments within BR are cataloged as Minor Impacts or No Known Impacts.

As depicted in Map 3.5, many of the sub-watershed's streams including the Buffalo River, the East Branch Cazenovia Creek, and the Outer Harbor are listed on the 303(d) list, another indication of impaired waterways. Waterways in this sub-watershed may additionally be listed as EPA Fish Consumption Advisory Areas, or as part of the EPA Nonpoint Source Project, a program instituted by the EPA to provide funding opportunities through Section 319 of the Clean Water Act and administered by the NYS DEC to "control pollution from nonpoint sources to the waters of the state and to protect, maintain and restore waters of the state that are vulnerable to, or are impaired by nonpoint source pollution."[9]

NYSDEC categorizes waterways according to a class system related to uses.[12] Stream classifications for waterways assessed in this project are listed below in Table 3.2. Streams with AA or A classifications are suitable for drinking water sources, while streams classified as B, C, or D support descending numbers of uses. The addition of a (T) to a stream classification indicates that the stream may support trout populations, while a (TS) stream may support trout spawning.



Map 3.5: Buffalo River Sub-watershed Impaired Waterways

Table 3.2: NYSDEC Priority Waterbody Classifications

		Designated Use(s) Not Supported by the Waterbody			Pollutant(s) of Concern		Source(s) of Pollution	
Priority Waterbody	**Stream Class**	**Use(s) Impacted**	**Severity of Impact**	**Documentation**	**Type of Pollutant**	**Documentation**	**Source**	**Documentation**
Lake Erie (Outer Harbor, North)	B	Fish Consumption	Impaired	Known	Priority Organics - PCBs	Known	Toxic/Contaminated Sediment	Suspected
Lake Erie (Outer Harbor, South)	C	Fish Consumption	Impaired	Known	Priority Organics - PCBs	Known	Toxic/Contaminated Sediment	Suspected
Buffalo River, Main Stem	C	Fish Consumption Aquatic Life Recreation	Precluded Stressed Stressed	Known Suspected Known	Priority Organics - PCBs Dissolved Oxygen/Oxygen Demand Pathogens Silt/Sediment	Known Suspected Suspected Suspected	Toxic/Contaminated Sediment Habitat Modification Hydrologic Modification Urban Runoff Combined Sewer Overflow Industrial Landfill/Land Disposal Municipal Other Sanitary Discharge	Known Known Known Known Suspected Possible Possible Possible Possible
East Branch Cazenovia, Lower, and tributaries	B; Some tribs C (Including Tannery Brook)	Aquatic Life Recreation	Stressed Stressed	Known Suspected	Nutrients (phosphorus) Unknown Toxicity	Known	Urban Runoff	Known
East Branch Cazenovia, Upper, and tributaries	B, C(T); Tribs- B, C, C(T)	No Use Impairment	---	---	---	---	---	---
West Branch Cazenovia, Lower, and tributaries	B, A; Tribs- B	No Use Impairment	---	---	---	---	---	---
West Branch Cazenovia, Upper, and tributaries	B (Includes Crump Brook, Sprague Brook, Spencer Brook, Graff Brook)	No Use Impairment	---	---	---	---	---	---
Pipe Creek and tributaries	UNASSESSED	UNASSESSED	UNASSESSED	UNASSESSED	UNASSESSED	UNASSESSED	UNASSESSED	UNASSESSED
		Uses Evaluated		**Confidence**				
Cazenovia Creek and tributaries	B	Water Supply Public Bathing Recreation Aquatic Life Fish Consumption	Not Available Stressed Stressed Threatened Fully Supported	--- Suspected Suspected Suspected Unconfirmed	Pathogens	Known	Other Non-permitted Sanitary Discharge Urban Runoff	Known Suspected

Stream Visual Assessment & Water Quality Data Collection

Figure 3.1: Stream visual assessment in Cazenovia Creek (BNR)

In order to supplement existing data and fill in data gaps, BNR conducted water sampling and stream assessments throughout the sub-watershed. Sampling took place in five streams in BR during the 2015 field season.

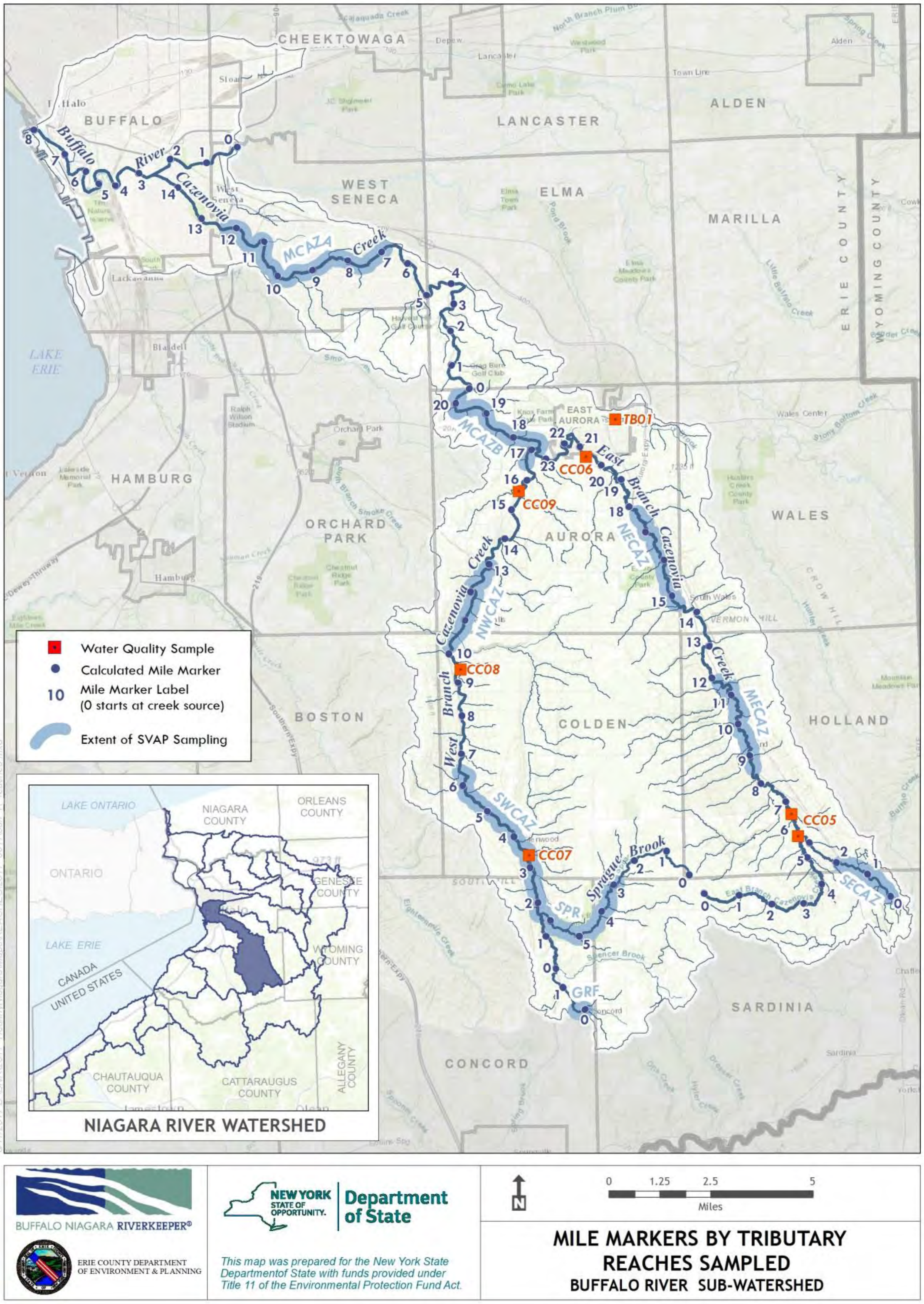
Waterways within BR were assessed from May 18, 2015 to August 4, 2015. Within five stream bodies, 525 reaches were assessed. The streams assessed were Graff Brook, Cazenovia Creek (main, west, and east branches), and Sprague Brook. Each stream was broken up into segments and assigned a unique identifier based on location (MCAZA, MCAZB, GRF, SECAZ, NWCAZ, NECAZ, MECAZ).

Table 3.3: Streams Assessed in Buffalo River Sub-watershed

Stream Assessed	Stream Class	Miles Assessed
Cazenovia Creek - Main Stem	B	8.7
Cazenovia Creek - West Branch	B	7.16
Cazenovia Creek - East Branch	B	7.13
Graff Brook	B	0.2
Sprague Brook	B	3.25

Within BR, 26 of the total 318.7 miles (8.15%) of waterways were assessed using a modified version of the Stream Visual Assessment Protocol (SVAP).[21] Table 3.3 presents the segments assessed.

Stream miles were calculated using ArcGIS software so that stream segments and sample sites could be assigned a unique "mile marker" within the waterways for reference. Mapped segments with mile markers can be seen below in Map 3.6. Additionally, the map shows stationary water quality sites.



Map 3.6: Stream Segments Assessed

Physical Properties

As seen in Table 3.4, the sub-watershed recorded an average depth of 8.7 inches for the five streams assessed. The average bankfull width of 50.1 feet and an average baseflow width of 38.4 feet.

Table 3.4: Buffalo River Sub-watershed Physical Properties

Stream	Average Depth (in.)	Average Bankfull Width (ft.)	Average Baseflow Width (ft.)
Cazenovia Creek Main Stem	11.1	102.6	83.3
Cazenovia Creek South Branch	8.1	58.7	40.1
Cazenovia Creek East Branch	13.4	47.2	28.2
Graff Brook	4.8	21.0	18.0
Sprague Brook	6.3	40.9	22.6
Sub-watershed Average	**8.7**	**50.1**	**38.4**

Stream Visual Assessment and Water Quality Findings

During the Phase 1 process, BR was chosen based on the priority to preserve and protect conditions leading to high water quality and healthy habitat.[1] Throughout the fieldwork process, it became apparent that while many stream segments were indeed in good overall health, many others were in poor condition, exhibiting impairments. Overall SVAP findings from the five assessed waterbodies within the sub-watershed resulted in an average score of 'fair' (7.3). The lowest assessed SVAP score for an individual reach was 'poor' (3.7) at MCAZA24 in Cazenovia Creek, while the highest score was 'excellent' (9.6) at SECAZ2 and SECAZ3 in the East Branch of Cazenovia Creek.

Within the sub-watershed, the MCAZB stream segment had the highest average SVAP score, 'good' (8.3). The lowest score recorded in the MCAZB stream segment was 'fair' (6.6) and the highest score was 'excellent' (9.3). The stream segment found to have the poorest health was the MCAZA segment in Cazenovia Creek with an average SVAP score of 'fair' (6.4), a low score of 'poor' (3.7), and a high score of 'good' (8.1).

Table 3.5 presents an SVAP score summary for BR, and a full SVAP summary is available in Appendix C.

Table 3.5: Buffalo River Sub-watershed SVAP Element Summary

	Channel Conditions	Riparian Zone Left Bank	Riparian Zone Right Bank	Bank Stability Left Bank	Bank Stability Right Bank	Water Appearance	Nutrient Enrichment
# of scores average	506 8.9	508 8.5	506 8.3	502 7.3	498 7.0	510 8.9	509 6.6
	Instream Fish Cover	**Pools**	**Invertebrate Habitat**	**Canopy Cover**	**Manure Presence**	**Riffle Embeddedness**	
# of scores average	510 4.8	504 5.1	508 8	316 4.7	4 5	431 9.1	

Substrate in BR is predominantly cobble, with 49% of assessed reaches having a cobble substrate. Bedrock was observed to cover 14% of BR's assessed substrate. Gravel comprised 10% of the assessed substrate, while sand, silt, and clay comprised 2%, and boulders made up 1% of BR's assessed substrate.

Japanese Knotweed was observed in 43% of all stream reaches, Phragmites (or Common Reed) was observed at 12% of sites, and Purple Loosestrife was observed at 7% of all assessed reaches.

All waterbodies assessed were found to have average channel condition scores of 'good' to 'excellent' (8.1-9.8). Assessed stream channels were generally un-altered with limited channelization or use of rip-rap. This lack of modification has a positive impact on wildlife and overall stream health. Areas of channel alteration were concentrated around areas of development or where infrastructure was located near streams, as seen in Figure 3.2. While channel conditions skewed towards good, many problems related to erosion in this area exist, as shown by inspections and erosion control projects undertaken by the Erie Wyoming County Joint Watershed Board. These areas are concentrated in the East Branch from Savage Road in Holland to East Aurora, and in the West Branch from Glenwood to Jewett Holmwood Road, among

Figure 3.2: Altered Stream Channel east of Orchard Park - Cazenovia Creek West Branch (BNR)

various other sites in the main stem such as intersections with Northrupp Road and Union Road. Additionally, heavily modified stream and fish barriers such as Legion Dam in East Aurora further degrade stream channels in BR.

Water appearance was also noted during assessments, and the sub-watershed recorded a 'good' (8.9) average SVAP score. This element takes into account the relative cloudiness, color, and other visual characteristics of the water including sheens, films, foam, or algal mats. Good scores indicate a lack of these characteristics.

Water quality data for the Buffalo River Sub-watershed was collected from May 18, 2015 to August 4, 2015. In Table 3.6 below, the data collected is compiled, along with number of measurements: lowest recorded value, highest recorded value, and overall average for each measured water quality criteria. Full water quality parameter results can be found in Appendix C and D.

Table 3.6: Buffalo River Sub-watershed Water Quality Element Summary

	Temperature ºC	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)	Conductivity (uS/cm)	Total Dissolved Solids (mg/L)
# of scores	136	111	111	120	120
low value	13.2	4.6	47.2	236.2	195
high value	25.9	12.8	154.6	409.5	409.5
average	19.5	10.0	109.6	422.2	304.2
	pH	**Turbidity (NTU)**	**Phosphorus (µg/L)**	**Nitrate (µg/L)**	
# of scores	120	242	236	235	
low value	7.4	0.2	33	500	
high value	8.7	20.9	1320	20,200	
average	8.2	1.5	264	10,200	

Baseline Indicators

Through the fieldwork portion of this project, parameters that either indicated pervasive impairments throughout the sub-watershed, or had high numbers of water quality parameters exceeding relevant standards or guidance values were isolated for further discussion. These so-called baseline indicators begin to develop a picture of the sub-watershed's health or impairment status during normal, baseline conditions.

Baseline indicators for the Buffalo River Sub-watershed are identified as:

- Land Use/Land Cover

    - LULC directly affects water quality throughout the sub-watershed, and stormwater and agricultural runoff is a major vector transporting contaminants from surrounding land into waterways. LULC also affects suggested management actions, as those actions that are able to be performed on agricultural or forested land may not be appropriate for more developed land.
- Riparian Zone and Bank Stability
    - The riparian zone, which measures the expanse of a natural vegetated strip, was rated as 'good', but many individual reaches recorded 'fair' and 'poor' scores. A 'poor' riparian zone allows stream banks to erode more readily, and for contaminants in runoff to flow uninterrupted into a waterbody. Bank stability is grouped with riparian zone, as a poor riparian zone generally coincides with poor bank stability. While some reaches scored very high, erosion issues were prevalent throughout the sub-watershed, and 'poor' bank stability scores were recorded in every stream segment SVAP assessments occurred in.
- E. coli
    - *E. coli* measurements performed in the sub-watershed had levels greatly exceeding recommended levels for recreational use.
- Nutrient Load
    - Phosphorus and Nitrate within the sub-watershed are consistently high, indicating that elevated levels of these parameters are entering waterways.

Baseline Indicators Discussion

Land Use/Land Cover

In contrast to the high amount of residential and vacant land, BR also contains nearly 8,500 acres of protected land. Land protection and conservation, including conservation easements and regulatory protections (such as state parks, forests, etc.), are critical components in preserving water quality. These areas will not succumb to urban sprawl or development and will assist in preserving water quality of nearby rivers and streams. However, there remains a high concentration of industry and infrastructure in closer proximity to the City of Buffalo. There are many facilities and sites such as CSOs, remediation sites, superfund sites, and hazardous waste sites that have the potential to negatively impact water quality.

Large amounts of developed LULC are concentrated in the northern region of the sub-watershed. Because BR reaches its terminus at the City of Buffalo's Lake Erie shoreline, the sub-watershed represents an archetypal rural to urban transect: tributaries begin in far off forested headwaters and traverse through agricultural regions before flowing through increasingly developed and populated land, including the industrial and downtown core of the City of Buffalo.

Riparian Zone and Bank Stability

The riparian zone, or area of natural vegetation bordering waterbodies, along assessed stretches of Cazenovia Creek, excluding the Main Stem, received average scores of 'good' to 'excellent' (8.4+). The Main Stem of Cazenovia Creek received the lowest average riparian zone score of 'fair' (7.3). As Cazenovia Creek flows toward the city of Buffalo, it meanders through many suburban areas with heightened residential and commercial development. In these areas, riparian vegetation along the creek is often compromised or removed as seen below in Figure 3.3. In these areas, the potential for urban stormwater runoff is elevated.

Figure 3.3: Compromised riparian vegetation along Cazenovia Creek, Main Stem (Google Maps)

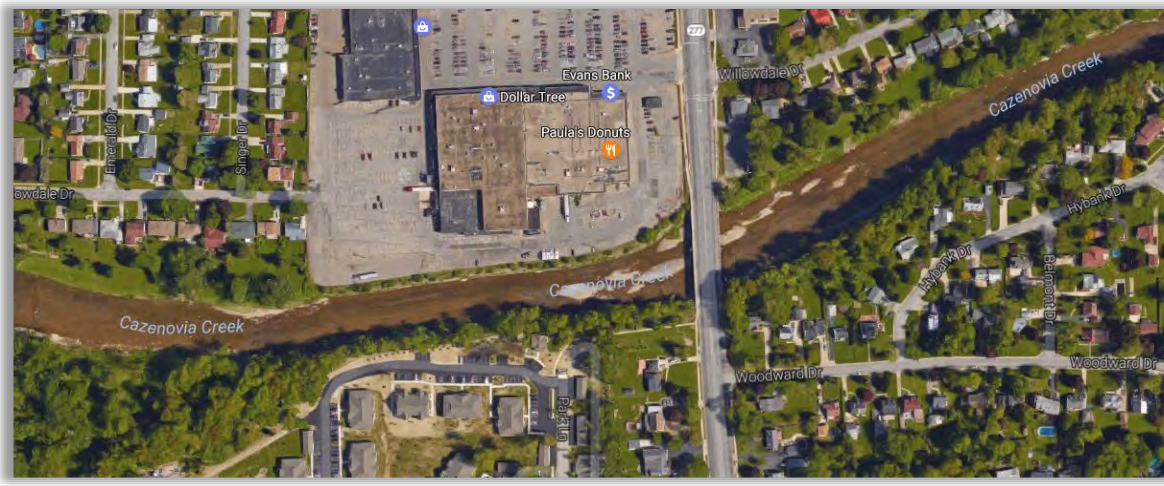


Figure 3.4: Riparian vegetation along Sprague Brook (BNR)

In areas closer to the headwaters, further removed from the pressures of development, riparian vegetation remains well intact. A segment of Sprague Brook over three miles long was assessed within the limits of Sprague Brook County Park. This segment received the highest average score for riparian zone within the entire sub-watershed of 'excellent' (9.9). This waterbody was characterized by extensive riparian vegetation, as seen in Figure 3.4.

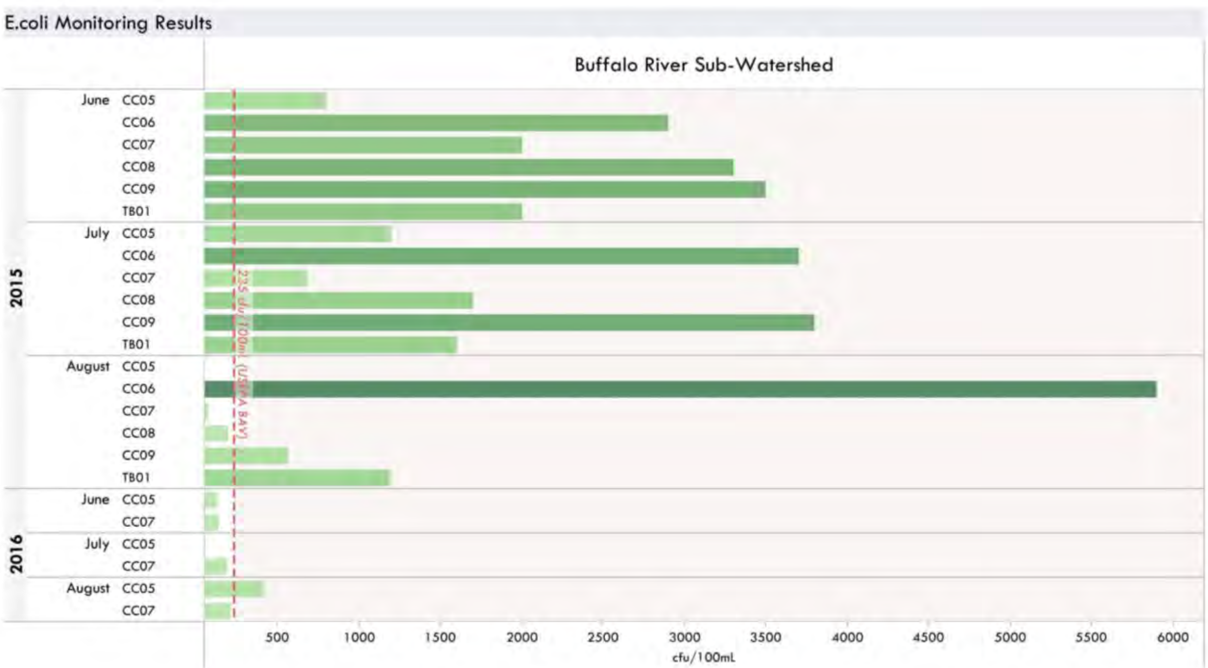
Bank stability within the sub-watershed recorded an average score of 'fair' (7.2). Bank stability scores can be impacted by the height of stream banks, current evidence or lack of erosion, and presence or absence of rip-rap. Bank stability was variable from reach to reach with 44% of reaches assessed recorded an 'excellent' score and 31% of reaches recorded a 'poor' score. Bank stability scores under 3 for the sub-watershed are shown in Map 3.7 below. A score of 3 indicates that "banks are moderately unstable, typically high, actively eroding at bends; ~50% rip-rap; excessive erosion" while a score of 1 represents "Unstable high banks, actively eroding at bends throughout; dominated by rip-rap." As noted prior, inspections and ongoing active bank management projects by the Erie Wyoming County Joint Watershed Board show heavy erosion at locations in the sub-watershed that may be masked by thick growths of invasive plants.

Map 3.7: Bank Stability Score 1-3

E. coli

Escherichia coli (*E. coli*) samples were collected within BR at six sites during 2015 and two sites during 2016. Results were frequently above the USEPA Beach Action Value (BAV) of 235 cfu/100mL as seen in Figure 3.5. The BAV is a tool often used to assist in making beach notifications and closures.[29] Extremely high *E. coli* levels seen at CC06 may be due to septic leakage from a nearby trailer park. The site is also downstream of the Town of Holland WWTP.

Figure 3.5: *Escherichia coli* Monitoring Results



Nutrient Load

Samples to assess nutrient levels (phosphorus and nitrate) within the sub-watershed were also collected and processed. All waterbody segments sampled within the Buffalo River Sub-watershed recorded average phosphorus readings above the NYS DEC guidance value for Lake Erie Eastern basins of 10 μg/L. Sprague Brook, portions of which are located in agricultural LULC, recorded the highest average phosphorus reading of 642.4 μg/L. Cazenovia Creek (Main, West and East branches) all recorded average nitrate readings above the NYSDEC standard value of 10,000 μg/L.

Nitrogen and phosphorus are natural constituents of the environment, but can also be introduced into the system via fertilizers and sewage inputs. Most traditional fertilizers, used both for agricultural or residential purposes, contain nitrogen, phosphorus, and potassium (or potash). Animal manure, sanitary discharges, combined sewer overflows, and stormwater runoff in urban areas can also contribute excess nutrients and pathogens into the system.

While nitrogen and phosphorus are vital for a healthy stream, the correct balance is critical to sustain aquatic life.[18] High nutrient levels can fuel growth of aquatic vegetation and algae which can congest streams, restricting water flow and fish movement. With elevated plant respiration and decomposition, dissolved oxygen levels become depleted. These oxygen-depleted environments can stress and have detrimental impacts on aquatic life. At times, algae will grow in large, expansive colonies often referred to as an algal bloom. Under the right conditions, some algal blooms will produce toxins that can be dangerous to wildlife and human health.[14]

Monthly water quality sampling of phosphorus reached its highest measured levels in June 2015 with a sub-watershed average value of 557.2 ug/L, with the highest value in 2015 (of 877.8 ug/L) being measured at a West Branch of Cazenovia Creek (CC09) site, well above the 10 ug/L EPA guidance values for. Phosphorus levels in 2015 trended downward from June through October, with a small spike at all sites in November, indicating that the bulk of phosphorus is entering waterways in the summer seasons, and levels are very dependent on rainfall amounts. In the 2016 sampling season, the sub-watershed's highest average phosphorus levels occurred in July, with measurements for that month averaging 140.3 ug/L. The highest individual value was recorded at CC07, at 161.7 ug/L. Overall levels in 2016 peaked in the summer and fall.

Nitrate levels during 2015 were measured only in June, due to equipment malfunctions, but averaged at a sub-watershed wide average of 2,666.7 for that month, well below the 10,000 ug/L NYS DEC standard value. Measurements performed in 2016 however, were extremely high, with measurements made in April averaging 17,300 ug/L, and a high reading at CC07 of 27,400 ug/L. All other nitrate levels measured in the sub-watershed were below the NYSDEC standard of 10,000 ug/L.

Buffalo River Critical Source Areas

CSAs in BR are depicted in Map 3.8 and displays CSAs using the methodology described in Chapter 1.

"Critical" source areas are those land uses known to contribute to impairments, and are designated as priority areas for intervention. "Non-Critical" sources are those passive land uses such as forested lands that do not actively contribute impairments.

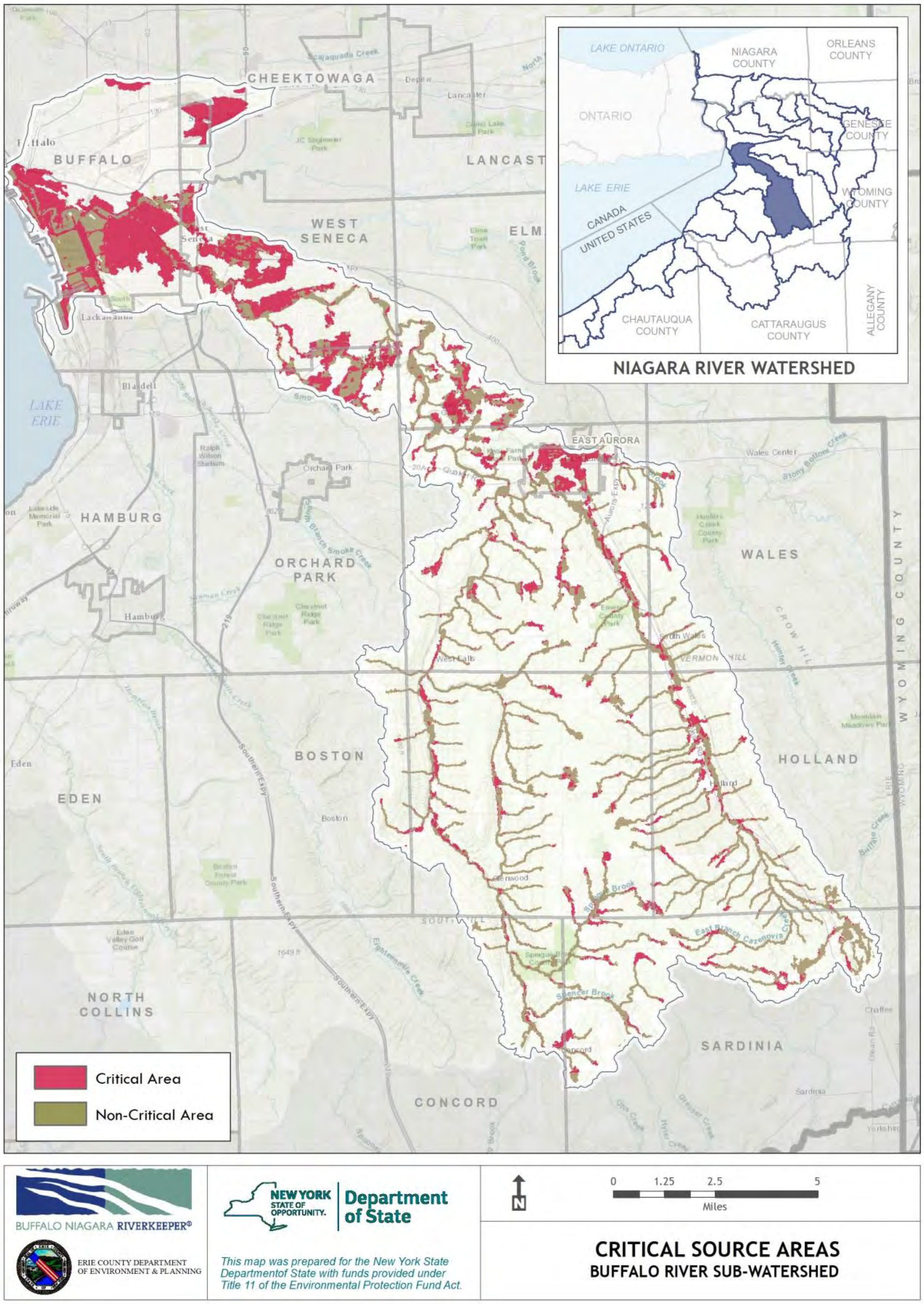
CSA Priorities

Sources of impairment and priority conservation areas in BR can generally be split into two main areas. These areas are best described as the southernmost headwater forests and the more developed downstream reaches to the north. The result of this split is two very different focus areas in which opportunities to address current impairments and prevent future impacts to water quality health can be identified.

Opportunities to address impairments in the headwaters of the sub-watershed mostly focus around the protection of riparian forests. The area surrounding Sprague Brook, located just upstream from Sprague Brook County Park, has been identified as containing critical headwater forests of high priority for protection. The riparian forests surrounding Pipe Creek in Colden, NY are considered at risk for degradation and are also of increased importance in the headwater area of the Buffalo River Sub-watershed. Protection of these riparian forests is vital for stream structure, water quality, and health of riparian species throughout the entire sub-watershed. Multiple priority fish barriers are also identified throughout the upper portions of BR. Seven of these barriers occur on the West Branch of Cazenovia Creek and one occurs on the East Branch of Cazenovia Creek. Large agricultural areas where best management practices should be applied also occur sporadically throughout the BR headwaters. These agricultural best management practices limit impacts to streams related to bank stability and erosion, inputs of excess nutrients and pollutants, and additional discharges.

Further downstream in the more urbanized reaches of Cazenovia Creek, priority headwater forests occur in Elma, NY and West Seneca, NY. Due to the increased development in this area of the sub-watershed, these priority headwater forests are located directly adjacent to areas where high levels of impervious surfaces serve as sources of impairments, and therefore at risk for development.

Several projects have been identified through Buffalo Niagara Riverkeeper's Niagara River Habitat Conservation Strategy, which are seen as priority projects for conservation lands that may directly address impairments in the sub-watershed. These projects are included as Appendix F.



Map 3.8: Critical Source Areas

Target Goals for Baseline Indicators

As specific management actions are carried out, these indicators can be used for comparison or to determine the effectiveness of implementation efforts. Suggested management actions are also developed to address baseline indicators, as these indicators can vary regionally and can be tuned to address a sub-watershed's unique characteristics.

Land Cover: Land cover can provide valuable information related to water quality and overall watershed health. With increased development and urbanization, areas with impervious cover will also increase. According to the Center for Watershed Protection, water quality can begin to degrade at 10% impervious cover. [1,3]

> **Future Goal:** Reduce the amount of impervious cover within the sub-watershed.
>
> **Target:** As of 2005, the Buffalo River Sub-watershed contains 11.85% Impervious Cover .[22] This percentage should be analyzed in future years with a target of reducing it to below 10%.
>
> **Future Goal:** Conserve and protect undeveloped land in the sub-watershed.
>
> **Target:** Engage communities in the sub-watershed to develop a cross-municipal land conservation strategy.

Riparian Zone and Bank Stability: Vegetation bordering waterways naturally stabilizes banks, controls erosion, functions as a natural filter for runoff, and cools water temperatures via shading. The natural riparian zone has been removed or altered at several locations throughout the sub-watershed.

> **Future Goal:** To increase the length and width of riparian vegetation along streams within the sub-watershed, and incentivize and encourage riparian buffer ordinances.
>
> **Target:** Increase the width of riparian vegetation to two times the active channel or 300ft, whichever is greater.
>
> **Future Goal:** Work with communities, agencies, and municipalities to implement stream bank stabilization programs at actively eroding sites.
>
> **Target:** Stream stabilization at reaches scoring 3 and below in SVAP Bank Stability (Map 3.7).

***E. coli*:** As a bacterial indicator, *E. coli* is used to monitor the presence of human/animal waste in waterbodies. Sources may include fertilizer, livestock, sanitary discharges or compromised septic systems.

> ***Future Goal:*** Reduce access of livestock to streams and stream banks thereby limiting bacterial inputs.

Future Goal: Provide resources to communities to upgrade outdated and deteriorated septic systems.

Future Goal: Municipalities continue to disconnect sanitary sewer overflows from discharging into waterways.

Target: Samples at or below USEPA BAV throughout the sub-watershed or reduce 30-day geometric mean value to meet USEPA recommended value of 126 cfu/100mL.

Nutrient load: Resulting from stormwater runoff, discharges from wastewater treatment plants, septic systems, and fertilizers, high nutrient levels are commonplace throughout the sub-watershed.

Future Goal: Reduce loadings of nutrients, specifically phosphorus.

Target: Meet NYSDEC guidance values

- Phosphorus NYSDEC guidance value for Lake Erie Eastern basins of 10 μg/L
- Nitrate NYSDEC standard value of 10,000 μg/L

Suggested Management Actions

The work performed during this project, along with the compilation of preceding data collection and inventory of watershed characteristics is intended to support the development of an action plan consisting of suggested management actions. Actions suggested below are intended to be part of an ongoing, dynamic process, in which management actions are periodically revisited to address changing conditions and management goals with the Niagara River/Lake Erie Watershed.

By implementing the general strategies and recommendations detailed here, the sub-watershed will be on track to meet the previously listed targets for various baseline indicators. These recommendations focus on key issues facing the sub-watershed that were identified through this effort and are not intended to act as a comprehensive list of everything that could be implemented.

These suggested management actions apply to: homeowners, municipalities, volunteer groups, agricultural landowners, organizations and agencies working within the sub-watershed.

Land Use

Goal: Reduce the amount of impervious cover within the Buffalo River Sub-watershed from 11.9% to 10%.

Benefit: According to the Center for Watershed Protection, water quality begins to degrade at 10% impervious cover, because of the loss of groundwater recharge through percolation, and the surge in runoff entering waterways, altering natural flow regimes and overwhelming sewer systems.[3] Currently, the sub-watershed has 11.9% impervious cover, which is above the 10% threshold recommended above. Ideally, the sub-watershed impervious coverage should be decreased to <5% over the next ten years. Suggested techniques to achieve this goal include: using porous material in constructing roadways and parking lots, as well as including strategically placed green spaces like rain gardens and bioswales. These practices reduce direct run-off from impervious surfaces which would otherwise flow directly into waterways or trigger CSO/SSO events.

In addition, the use of porous material in constructing roadways and parking lots beyond what is required by the NYS Stormwater Manual, rain barrels to disconnect rooftop runoff and incorporation of strategically preserved or placed green and living spaces into landscaping plans will reduce runoff from impervious surfaces directly into waterways and lessen the negative impacts of combined sewer overflows and stormwater discharges.

Best Management Practices

The actions outlined in the table below are organized into three broad categories: green and living infrastructure, land use policy changes, and community engagement.

Implement Green Infrastructure | Living Infrastructure

By incorporating simple living infrastructure practices such as bioswales or rain gardens into small-scale development plans or implementing broader techniques across a larger scale, the resulting effect will be to help to collect rain water before it is able to flow over impervious surfaces, collect pollution and enter bodies of water. In addition, the use of porous material in constructing roadways and parking lots beyond what is required by the NYS Stormwater Manual, rain barrels to disconnect rooftop runoff and incorporation of strategically preserved or placed green and living spaces into landscaping plans will reduce runoff from impervious surfaces directly into waterways and lessen the negative impacts of combined sewer overflows and stormwater discharges.

As noted in the NYS DEC Stormwater Management Design Manual, a one-acre parking lot can produce 16 times more stormwater runoff than a one-acre meadow each year."[10] Because of this, in a sub-watershed such as the Buffalo River that extends into a once-industrialized urban area, many additional opportunities exist to increase the amount of green space by reclaiming abandoned buildings or parcels for reuse in green infrastructure designs.

Land Use Policy

Recommended changes in land use policies include actions such as updating a municipality's Comprehensive Plan or amending zoning codes. A Comprehensive Plan allows the municipality to clearly state its long-term goals and priorities for a community. While this document is not law, it does inform the law as a municipality would write zoning codes and ordinances that enable it to meet the goals outlined in the Comprehensive Plan. Conservation updates that can be made to code include: conservation overlay districts, steep slope requirements to limit erosion, minimum setback requirements from waterbodies (sometimes called a "waterfront yard" or "buffer" requirement) on new development, or requirements and standards for vegetated buffers along waterways on all lands.

In the less densely-developed southwestern portion of the sub-watershed, implementing conservation easements to protect existing open space, critical headwater forests, and prevent suburban sprawl would have the greatest impact in this sub-watershed. Additionally, agriculture and farmland protection, including the purchasing of development rights on agricultural lands is a strategy recommended to keep sprawl development from agricultural properties, and preserve open space.

In more urbanized sections, different approaches to land use policy can be undertaken. For example, the City of Buffalo has recently undergone a large multi-year effort to completely revise its zoning code and land use plan to reflect form-based code and some environmental protection features such as shoreline setbacks, other municipalities in the sub-watershed should follow suit.

<u>Community Education and Engagement</u>

While regulation through zoning codes forces those living in a municipality to abide by a certain set of laws, some practices are better implemented through landowner cooperation and collaboration. For example, nearly 20% of the sub-watershed is classified as agricultural land and data analysis suggests that agricultural lands may be contributing to water quality impairments in places across the sub-watershed. Here, encouraging landowners to voluntarily participate in conservation initiatives can greatly benefit a community. These initiatives include landowner stewardship like utilizing a vegetated riparian buffer along a shoreline, even if it isn't mandatory or installing a rain barrel on a property to collect rainwater for reuse. Similarly dedicating open space or hosting local clean-up or invasive species removal days can help people feel more connected to their environment thereby fostering a greater sense of community and stewardship.

Recommended Actions to reduce impervious land cover:

Short Term	• Utilize green and living infrastructure practices; rain barrels; no-mow areas; buffers and rain gardens
	  ○ Cost: Low
	• Reclaim unused or underutilized impervious spaces and develop into "green" spaces like meadowlands, rain gardens or community gardens
	  ○ Cost: Low to Medium
	• Host sustainable development workshops for municipalities and private landowners
	  ○ Cost: Low
	• Promote recreational use of natural areas to increase land protection and awareness
	  ○ Cost: Low
	• Create agricultural and farmland protection easements and programs to keep agricultural land undeveloped.
	  ○ Cost: Low

Long Term	• Improve/incorporate stormwater management on paved and unpaved roads/parking lots
	  ○ Cost: Medium to High
	• Reduce new parking lot sizes in urban areas
	  ○ Cost: Medium
	• Use pervious surfaces and materials when constructing new parking lots or updating existing parking lots beyond the percentage required by the New York State Stormwater Management Design Manual
	  ○ Cost: Medium
	• Develop vegetative buffer standards to protect stream quality
	  ○ Cost: Low
	• Creative incentive and educational programs for green infrastructure implementation
	  ○ Cost: Medium
	• Promote the conservation of open spaces through conversation easements and parks.
	  ○ Cost: Low

Riparian Zone

Goal: Increase the length and width of riparian vegetated buffers along stream banks within the sub-watershed

Benefit: Vegetation bordering waterways naturally stabilizes banks, controls erosion, functions as a natural filter for pollutants and cools water temperature by providing a shade over the water. The natural riparian zones in the lower portions of the Buffalo River sub-watershed have been affected by development and upstream, are subject to agricultural stressors. Increasing the width of vegetated riparian zones to twice the width of the stream channel or 300 feet, whichever is greater, would provide the greatest improvement to the health of the waterway.

Best Management Practices

Stream Stabilization

Stabilization of actively eroding shorelines using living and natural infrastructure is recommended where appropriate. Other engineered stabilization techniques should be used only in extreme cases.

Add Vegetation

Hosting community tree planting days in a municipality can provide great benefit to the riparian corridor and improve waterway health with limited costs borne by the municipality. Trees can even be obtained at no cost through the NYSDEC "Trees for Tribs" Program.[5] Similarly installing appropriately sized vegetated buffers in the more open and agricultural areas on the sub-watershed would be very beneficial.

Develop Ordinances

As noted above, including vegetated buffer or setback requirements into a municipality's zoning code is one regulatory mechanism to ensure measures are taken to protect water health. Not all land can be regulated through laws so in some instances encouraging best management practices or utilizing incentive programs may be a more effective approach. Located into the Lower Tonawanda sub-watershed, the Towns of Amherst and Pendleton both include language in their zoning codes for vegetated buffers. For example, Goal 4-4 of The Bicentennial Comprehensive Plan for the Town of Amherst (amended Feb 2011) sets a goal, "To establish buffer/setback standards for new development to help protect streams of significance." This goal is then applied in the town's zoning code in Chap. 204, Part 3 §3-5-6, "Lots abutting a watercourse." This sections requires that lots abutting a watercourse install a 50 foot wide riparian buffer on either side of a watercourse and further, any building be an additional 10 feet from the buffer. This type of ordinance could be applied in the upper reaches of the Buffalo River sub-watershed in order to limit runoff from yard waste, non-point sources of pollution, and development.

Recommended Actions to increase the length and width of riparian zones:

Short Term	• Host tree plantings with volunteers
	  ○ Cost: Low
	• Develop programs to encourage the installation of riparian buffer and cover crops
	  ○ Cost: Low to Medium
	• Invasive species eradication and control programs.
	  ○ Cost: Medium
	• Implement stream and bank stability projects to stop erosion
	  ○ Cost: High

Long Term	• Develop vegetated buffer requirements for development in riparian areas
	  ○ Cost: Low
	• Develop setback ordinances for new development in riparian areas
	  ○ Cost: Medium
	• Encourage collaboration amongst municipalities and agencies to develop zoning codes to encourage conservation and best management practices across waterways that span municipalities
	  ○ Cost: Low

E. coli

Goal: Reduce bacterial inputs into streams

Benefit: *E. coli* is a fecal indicator bacteria used to monitor the presence of human/animal waste in waterbodies. Because few strains of *E. coli* naturalize in the environment, the presence of *E. coli* almost certainly suggests that fecal matter is contaminating a body of water. Sources may include fertilizer, livestock, sanitary sewer discharges, or compromised septic systems. Waterbodies with high levels of *E.coli* are not suitable for consumption or recreating and can result in a chain-reaction of negative human health and economic effects. Reducing *E. coli* levels to meet USEPA's recommended value of 126 cfu/100ml (30 day geometric mean) would greatly improve water quality. Combating *E. coli* requires that the sources inputting the bacteria into waterways be mitigated, such as CSO/SSO outfall mitigation and livestock exclusion.

Best Management Practices

Livestock

When livestock is able to freely roam in and across streams, they can produce a number of undesirable effects such as trampling banks, increasing erosion, and directly inputting sources of bacteria such as *E. coli* into water bodies through excrement. In addition, livestock fecal contamination releases a large amount of antibiotics into waterways, contributing to widespread naturalized antibiotic resistance. If livestock cannot be completely excluded from streams, then at a minimum, limit access by creating a designated crossing. Similarly, some lands have seen success by placing water troughs near the water body so that the cows can easily get to the stream water they may use for drinking but are not directly standing in the stream.

Update and Upgrade Septic Systems

Leaking septic systems are a direct input of bacteria into groundwater which can pollute drinking water and contaminate streams. It is important to recall that the presence of *E. coli* is not the only indicator species of biological pollution—it is just the simplest and most widely tested for. *E.coli* often occurs in tandem with other pathogenic bacteria, viruses and protozoans, such as those that cause cholera, dysentery, and Giardia. Upgrading septic systems with denitrification systems and fixing leaking systems is a necessary solution to mitigate this input.

Green and Living Infrastructure

In more populous areas, CSOs can be a large source of contaminants (particularly bacteria). CSOs occur where a municipality has combined storm and sanitary pipes and where rainfall inundates the system, resulting in more water than the pipes can handle. This results in an overflow situation where the pipes discharge excess untreated water directly into waterbodies. Implementing green and living infrastructure in both urban and suburban areas can drastically mitigate CSO events. By utilizing green and living infrastructure elements like rain barrels, raingardens, wetlands, and other installations meant to trap rainwater and runoff, less water goes into the sewer system resulting in fewer overflow events. In agricultural or suburban areas with larger swaths of open land, utilizing living infrastructure such as woodlands, meadows, and riparian buffers, and living shorelines to intercept stormwater and overland runoff can also help reduce runoff. It is important to note that the City of Buffalo is currently undertaking a large scale rehabilitation of its sewer infrastructure and implementation of green infrastructure under a consent decree from United States Environmental protection Agency. The City has been exploring new and innovative ways to reduce inputs to the storm sewer system.

Recommended Actions to reduce bacterial inputs into streams :

Short Term	• Utilize livestock exclusion fencing to limit livestock access to and crossing of streams
	  ○ Cost: Medium
	• Install alternative watering facilities for livestock away from streams
	  ○ Cost: Medium
	• Install riparian buffers and covers crops to reduce stormwater runoff which can wash animal byproduct directly into waterways
	  ○ Cost: Medium
	• Install liquid manure retention and targeted spreading systems to prevent manure runoff from crop fields.
	  ○ Cost: High

Long Term	• Encourage the installation of wetland treatment systems or other living infrastructure to replace grey systems
	  ○ Cost: Low to Medium
	• Install vegetated bio-filtration systems such as bioswales and rain gardens
	  ○ Cost: Low
	• Install Living Shorelines along riparian land
	  ○ Cost: Low to High
	• Replace aging infrastructure and remove CSO/SSO outfalls from municipal sewer systems
	  ○ Cost: High

Nutrient Load

Goal: Reduce loadings of nutrients, specifically phosphorous

<u>Benefit</u>: Limiting phosphorus limits algae growth (including nuisance blue-green algae such as *Microcystis spp.)* and allows for more dissolved oxygen, resulting in better aquatic species health and therefore cleaner water.

Best Management Practices

High levels of nutrients such as phosphorous and nitrates were found in the waterbodies tested within the sub-watershed. As stated above, all the waterbody segments sampled within the Buffalo River Sub-watershed recorded average phosphorus readings above the NYSDEC guidance value for Lake Erie Eastern basins of 10 µg/L with Sprague Brook recording the highest average phosphorus Interestingly, as the map shows there is agricultural activity in the upper reaches of Sprague Brook. Although this may suggest correlation, it does not show causation. Similarly, nitrate measurements were also found to be above NYSDEC standard value of 10,000 µg/L. The prevalence of high nutrient levels is likely due to the number of sources or inputs including: storm water runoff, wastewater treatment plants, CSOs, septic systems, fertilizers, and improper disposal of lawn debris. Two of the best ways to combat nutrient inputs are through improving land use practices and education.

Land Use

Making minor to moderate changes to the way in which a person interacts with their land can have significant benefits to waterbody health. The actions outlined below provide examples of tactics both private homeowners and agricultural landowners can implement.

Education

Many of the changes that could result in the greatest improvement on the overall health of water bodies are behavioral. Encouraging changes in actions or promoting different protocols can be beneficial to combatting nutrient loadings along waterways. For instance, while in the field, the data collection team observed a number of piles of grass clippings abutting the stream and getting blown into the water. Inputs of grass clippings and yard waste into a waterway cause a direct increase in nutrients. Similar minor changes in farming practices or utilizing well known best practices can have significant impacts to the health of a waterbody. Suburban communities can benefit from individual small changes like using phosphorous-free fertilizer and consulting local town or village officials on lawn debris pick-up policies.

Recommended Actions to reduce nutrient loadings:

Short Term	• Agricultural landowners should coordinate with Erie County Soil and Water Conservation District to enact best management practices which reduce nutrient and sediment loading from entering local waterways.
	  o Cost: Low
	• Municipalities should host educational workshops for riparian landowners pertaining to funding opportunities and financial assistance for implementing best management practices for runoff mitigation
	  o Cost: Low
	• Encourage no till farming practices
	  o Cost: Low
	• Utilize cover crops to keep fertilizer laden soil in place
	  o Cost varies by crop planted and need to be addressed. For example, planting clover can be inexpensive and eliminate some nitrogen from the soil
	• Provide educational stormwater trainings for designers and highway officials to ensure stormwater law compliance
	  o Cost: Low
	• Implement “no mow” zones
	  o Cost: Low
	• Appropriately dispose of lawn debris
	  o Cost: Low
	• Use phosphorous-free fertilizer
	  o Cost: Low

Long Term	• Develop and implement educational trainings for homeowners about lawn care techniques, debris disposal, native plant species
	  o Cost: Low
	• Promote rotation grazing for livestock
	  o Cost: Low
	• Implement and enforce pesticide and fertilizer use standards and regulations.
	  o Cost: Low
	• Increase watershed stewardship by installing markers and signage for storm drains.
	  o Cost: Medium

Chapter 4: Smokes Creek

The Smokes Creek Sub-watershed (SC) is a sub-basin located in the southern portion of the Niagara River Watershed as seen in map 4.1. It has an area of 39,527 acres, or 61.8 square miles, and includes 120 miles of waterways, including Smokes Creek, Rush Creek, and Berricks Creek, along with many unnamed low-order tributaries and ephemeral headwater streams.

Located in Erie County, SC includes the Towns of Hamburg, Orchard Park, Aurora, and West Seneca. Also located within the sub-watershed are the City of Lackawanna and the Villages of Blasdell and Orchard Park. Smokes Creek rises emerges in the Town of Orchard Park and flows northwest for 15 miles to its mouth on Lake Erie. The creek has one principal tributary, South Branch, which is 12 miles long. Smokes Creek is a tributary to a New York State Department of State (NYS DOS) designated “significant coastal fish and wildlife habitat”- the 500-acre shallow water Smokes Creek Shoals, a spawning ground for important Lake Erie fish species like walleye and smallmouth bass. However, over the past decades, Smokes Creek itself was severely degraded from inputs of cyanide and other toxic waste from the Bethlehem Steel plant and inadequately treated sewage effluent. More recently, channelization and riparian buffer degradation have occurred along the last mile of the creek.

Table 4.1: LULC Groups and percentages

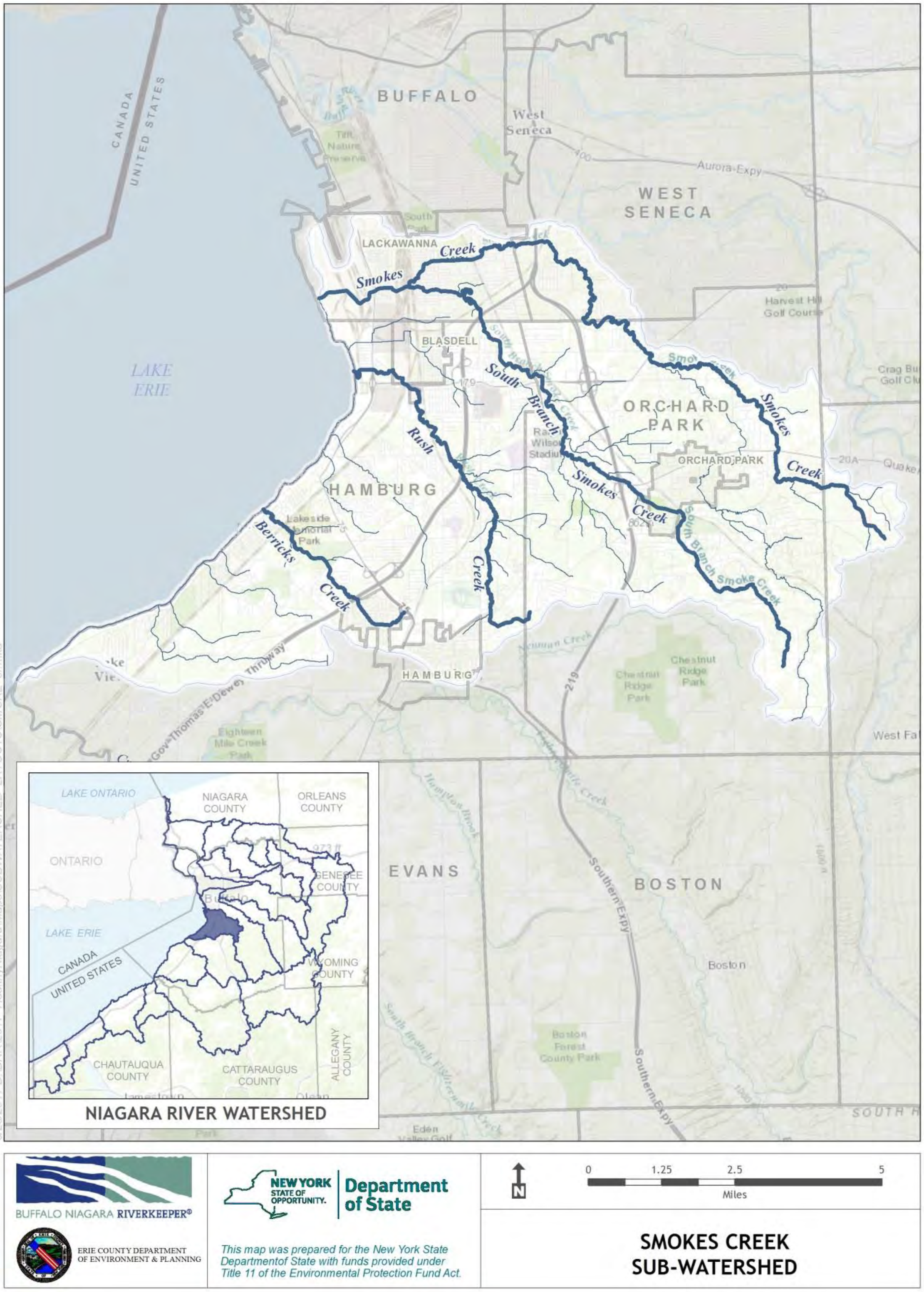
LULC Class	% by general LULC
Developed, High Intensity	Developed: 48.74%
Developed, Medium Intensity	
Developed, Low Intensity	
Developed, Open Space	
Cultivated Crops	Agriculture: 12.16%
Pasture/Hay	
Deciduous Forest	Forest: 24.27%
Evergreen Forest	
Mixed Forest	
Palustrine Forested Wetland	Wetland: 10.61%
Palustrine Scrub/Shrub Wetland	
Palustrine Emergent Wetland	
Open Water	Water: 0.46%
Palustrine Aquatic Bed	
Grassland/Herbaceous	
Scrub/Shrub	
Unconsolidated Shore	
Bare Land	Other: 3.76%

Smokes Creek in the City of Lackawanna suffers from extreme streambank erosion and flooding problems due to poor management and maintenance in the creek. Additionally, the construction and subsequent lack of maintenance of a flood control project the 1960’s and 1970’s also contributes heavily to flooding and erosion issues in Smokes Creek.

Land Use/Land Cover

The LULC groups can be seen in Table 4.1. Smokes Creek Sub-watershed is characterized by large concentrations of urban and suburban developed land, with the predominant LULC group being developed (48.7% of the sub-watershed). Interestingly, forest is ranked as the second highest LULC group at 24.5%, followed by agriculture (12.2%), wetland (10.6%), other (3.8%), and finally water (0.5%).

Smokes Creek's high levels of developed land are a function of communities with an industrial past, as the watershed contains some of the most urbanized and industrialized municipalities in the entire Niagara River Watershed. The LULC of SC can be seen in Map 4.2.



Map 4.1: Smokes Creek Sub-watershed

Active River Area

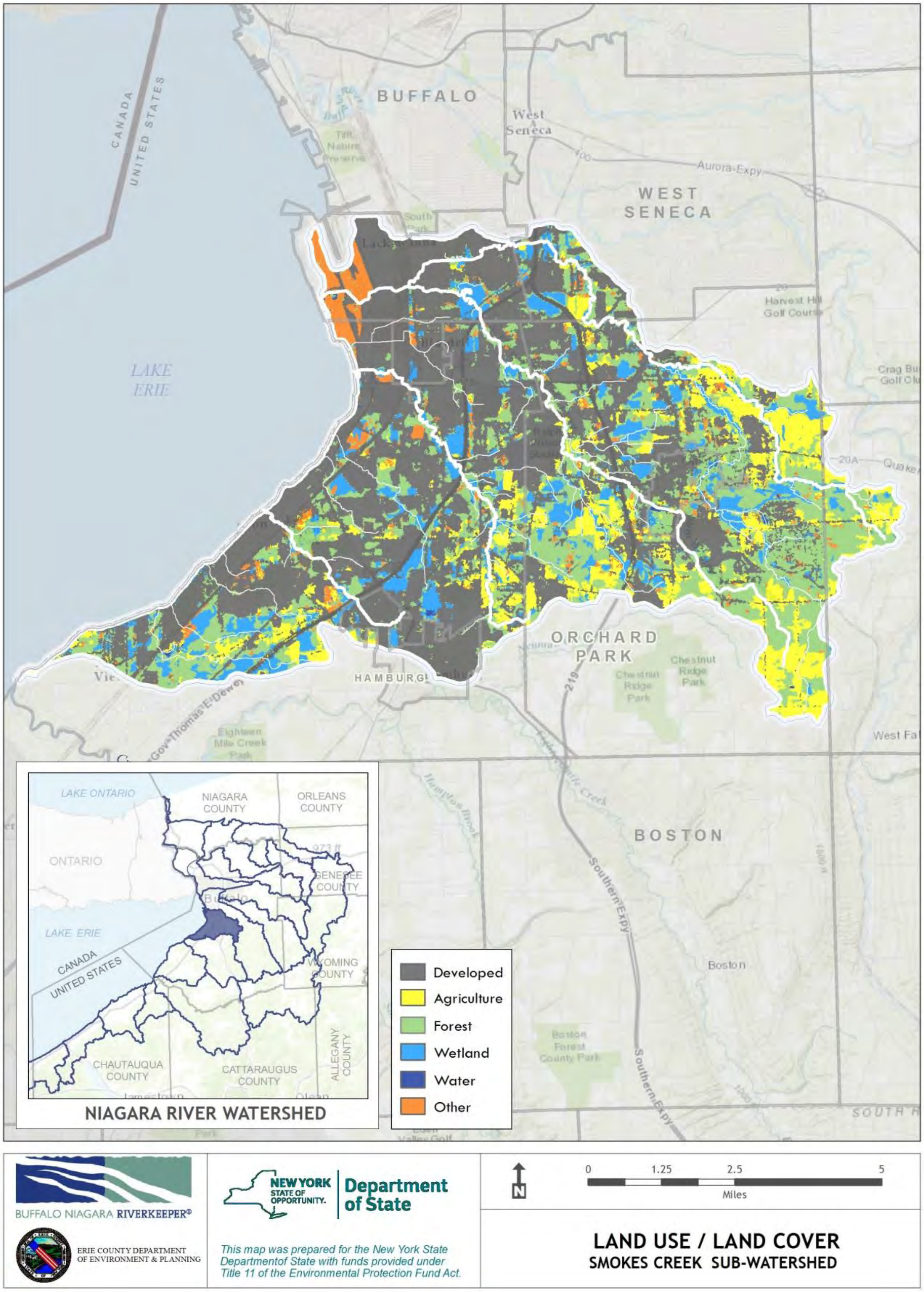
The Active River Area model, as discussed in Chapter 1, was applied to the sub-watershed to determine the extent of The ARA, and focus area for this project. The ARA within the sub-watershed is generally more constrained in the headwaters, becoming more expansive as the waterbodies approach Lake Erie, as well as two pockets of land in the Towns of Orchard Park and Hamburg.

The ARA in SC encompasses 39.7% of its total area, as seen in Map 4.3

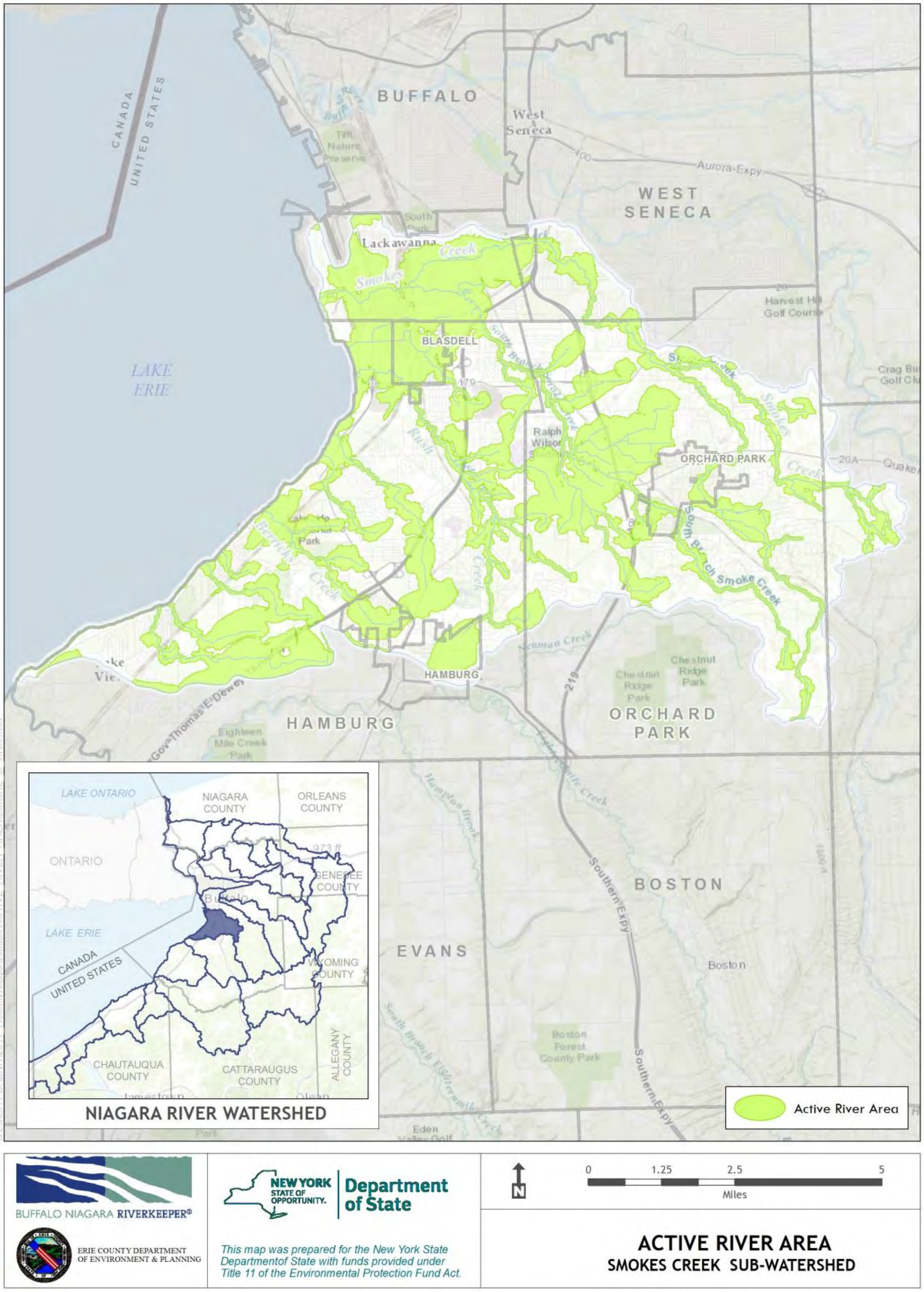
Land Use/Land Cover in the Active River Area

Potential sources of contaminants entering waterways from surrounding LULC were identified by overlaying the ARA model on LULC data, to plot where specific land uses interact with streams through hydrologic mechanisms. Map 4.4 displays LULC limited to the bounds of the ARA, indicating where contaminants on land may have direct interaction with stream waters.

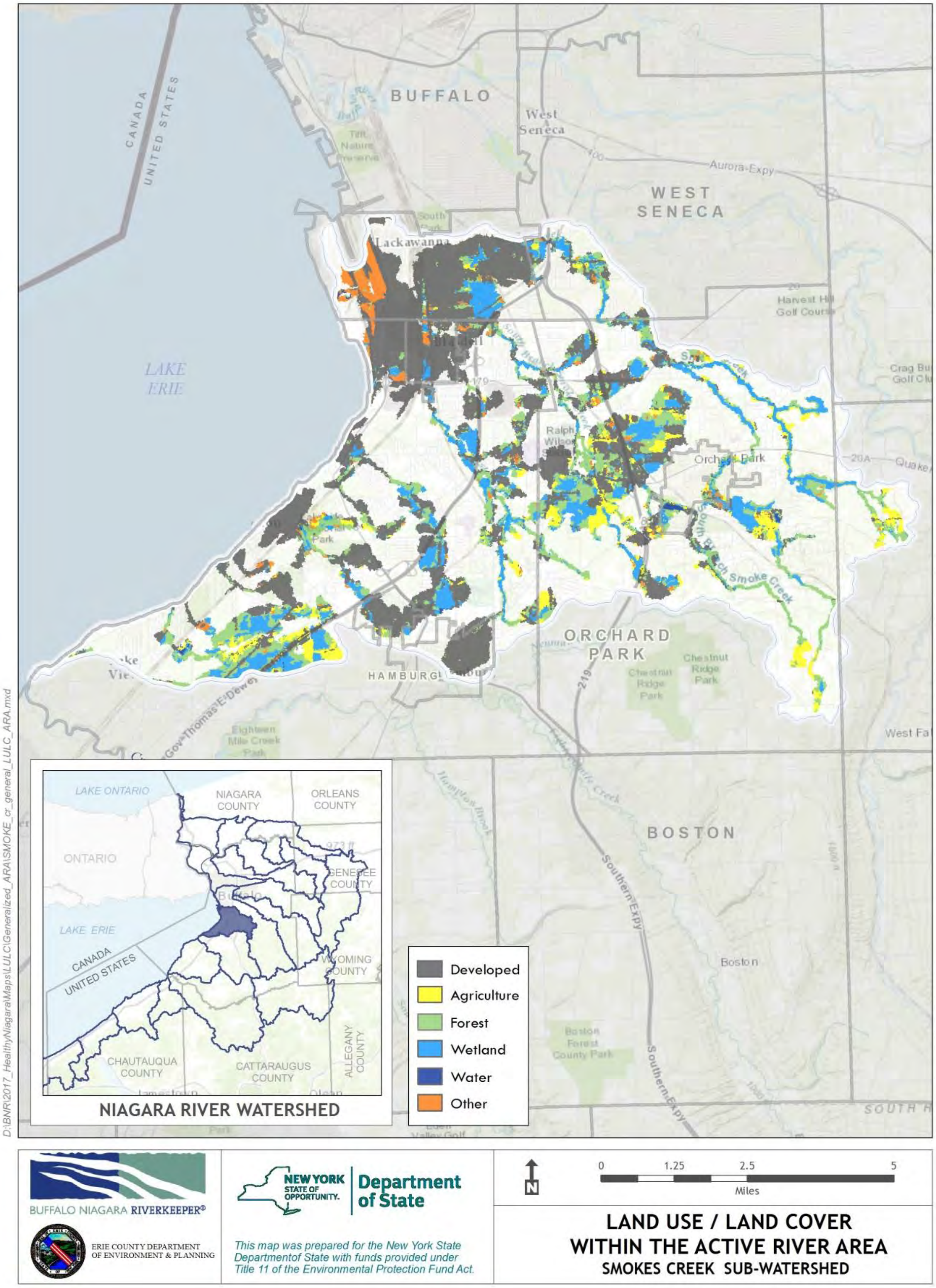
LULC within the ARA skews towards developed, as Smokes Creek remains the most urbanized and industrialized sub-watershed in the Niagara River Watershed, although limited stretches of forest, agriculture, and wetland LULC exist throughout. Coupled with the fact that the ARA is at its most expansive state where LULC is the most developed, Smokes Creek can be expected to contain impairments related to urban and suburban development: runoff, CSO/SSO events, and channelization remain priority concerns for this sub-watershed.



Map 4.2: Smokes Creek Sub-watershed Land Use/Land Cover



Map 4.3: Smokes Creek Sub-watershed Active River Area

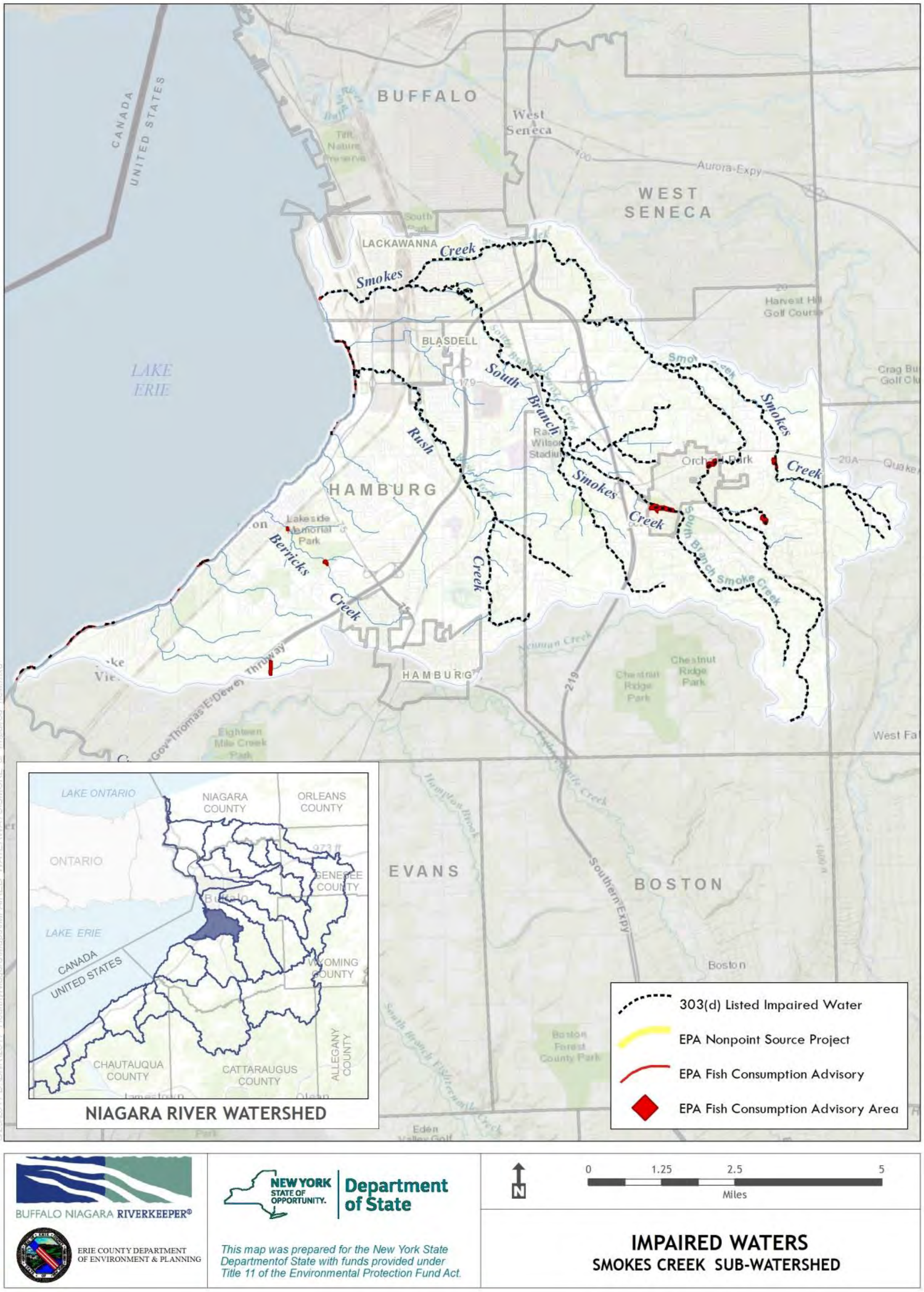


Map 4.4: LULC and ARA Interaction

Impaired Waters

The NYSDEC WI/PWL catalogs several water body segments within SC, encompassing 74.8 miles, or 68.6%, that are classified as impaired. As depicted in Map 4.5, much of the sub-watershed's main streams are listed on the 303(d) list, an additional indication of impaired waterways, while some areas are also listed under EPA Fish Advisories.

NYS DEC classifies waterways according to a class system related to uses.[12] Stream classifications for waterways assessed in this project are listed below in Table 4.2. Streams with AA or A classifications are suitable for drinking water sources, while streams classified as B, C, or D support descending numbers of uses. The addition of a (T) to a stream classification indicates that the stream may support trout populations, while a (TS) waterway may support trout spawning.



Map 4.5: Smokes Creek Sub-watershed Impaired Waterways

Table 6.2: NYSDEC Priority Waterbody Classifications

		Designated Use(s) Not Supported by the Waterbody			Pollutant(s) of Concern		Source(s) of Pollution	
Priority Waterbody	Stream Class	Use(s) Impacted	Severity of Impact	Documentation	Type of Pollutant	Documentation	Source	Documentation
Lake Erie (Upper Northeast Shoreline)	C	Fish Consumption	Impaired	Known	Priority Organics (PCBs)	Known	Toxic/Contaminated Sediment	Suspected
Lake Erie (Lower Northeast Shoreline)	B	Public Bathing Fish Consumption Recreation	Impaired Impaired Impaired	Known Known Known	Priority Organics (PCBs) Pathogens	Known Known	Toxic/Contaminated Sediment Urban Runoff On-Site/ Septic System	Suspected Suspected Possible
Smoke Creek, Lower, and minor tributaries	C	Aquatic Life Recreation Aesthetics	Stressed Stressed Stressed	Known Known Known	Aesthetics (sludge banks) Nutrients (phosphorus) Silt/Sediment Pathogens Dissolved Oxygen/Oxygen Demand Metals	Known Suspected Suspected Suspected Possible Possible	Urban Runoff Industrial Combined Sewer Overflow Municipal Other Sanitary Discharge Toxic Contaminated Sediment	Known Suspected Possible Possible Possible Possible
Smoke Creek, Upper, and tributaries	C	Aquatic Life Recreation	Stressed Stressed	Known Known	Nutrients (phophorus) Unknown Toxicity	Known Known	Urban Runoff Municipal Industrial	Urban Runoff Municipal Industrial
South Branch Smoke Creek, Lower, and tributaries	C	Aquatic Life Recreation Aesthetics	Impaired Impaired Stressed	Known Known Known	Nutrients (phosphorus) Silt/Sediment Aesthetics (sludge, debris) Pathogens	Known Known Known Possible	Streambank Erosion Urban Runoff Industrial Other Sanitary Discharge	Known Known Possible Possible
South Branch Smoke Creek, Upper, and tributaries	B	Aquatic Life Recreation	Stressed Stressed	Known Known	Nutrients (phosphorus) Pathogens	Known Suspected	Urban Runoff	Suspected
Rush Creek and tributaries	C, B; Tribs C	Public Bathing Aquatic Life Recreation Aesthetics	Impaired Impaired Impaired Stressed	Known Known Known Known	Pathogens Aesthetics (sludge banks, ordors) Oil and Grease Nutrients (phosphorus) Unknown Toxicity Dissolved Oxygen/Oxygen Demand Priority Organics	Known Known Known Suspected Suspected Possible Possible	Municipal (Hamburge, Blasdell Sanitary Sewer Overflows) Urban Runoff Other Sanitary Discharge On-Site/Septic Systems	Known Known Suspected Possible
Minor tributaries to Lake Erie	UNASSESSED	UNASSESSED	UNASSESSED	UNASSESSED	UNASSESSED	UNASSESSED	UNASSESSED	UNASSESSED

Stream Visual Assessment & Water Quality Data Collection

In order to supplement existing data and fill in data gaps, BNR conducted water sampling and stream assessments throughout the sub-watershed. Sampling took place in five stream bodies in SC during the 2015 field season.

Waterways within SC were assessed from May 18, 2015 to July 20, 2015. Within five stream bodies 352 reaches were assessed. The streams assessed were Smokes Creek, South Branch Smokes Creek, Rush Creek and two different unnamed tributaries. Each stream was broken up into segments and assigned a unique identifier based on location (SMK, SSMK, SBS, RSH, EKS, and LKS).

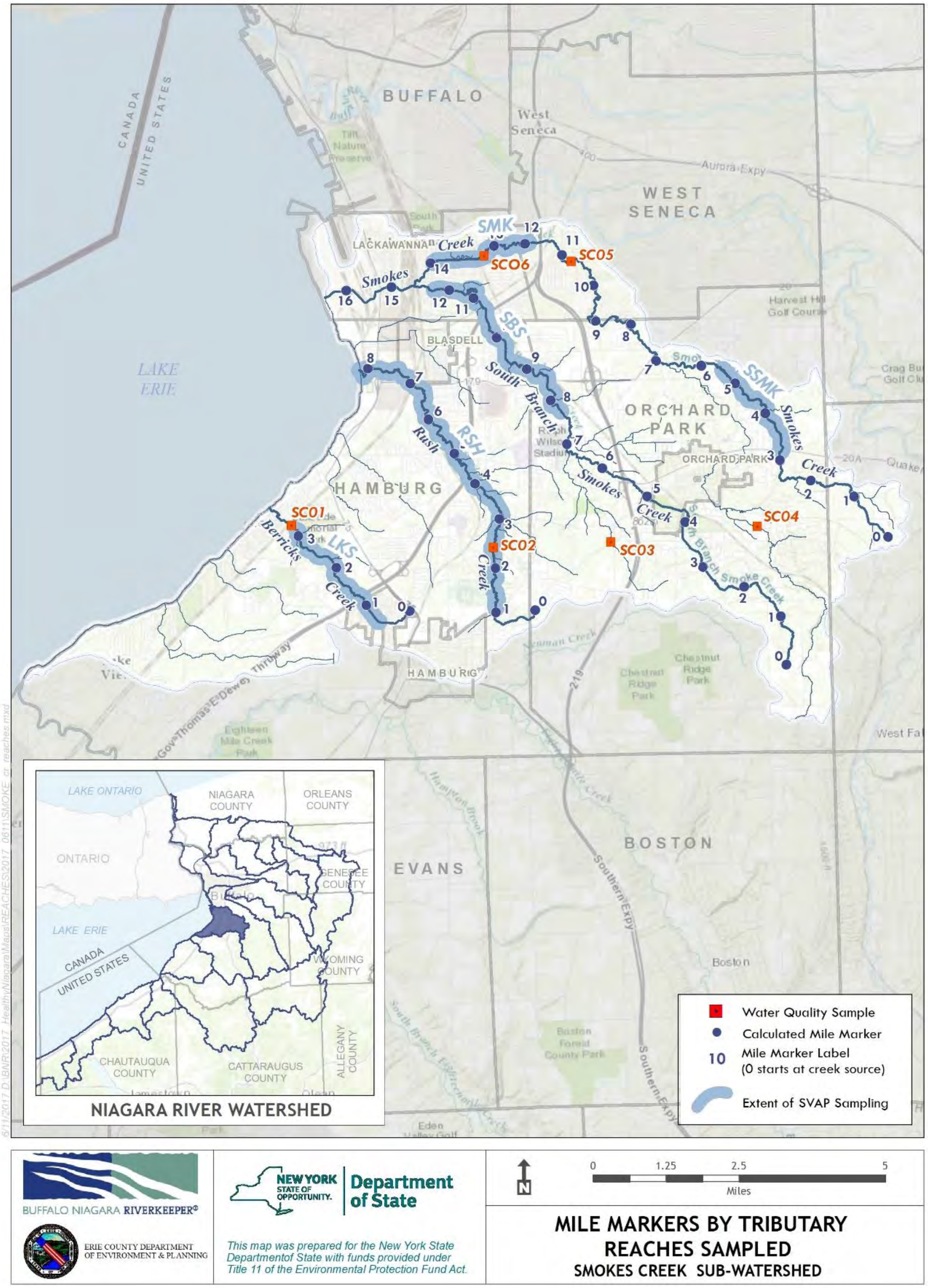
Table 4.3: Streams Assessed in Smokes Creek Sub-watershed

Stream Assessed	Stream Class	Miles Assessed
Smokes Creek	C	3.6
South Branch Smokes Creek	C	4.15
Rush Creek	C	4.92
Unnamed Tributary (LKS)	unassessed	1.97
Unnamed Tributary (EKS)	unassessed	0.3

Within SC, 15 of the total 120 miles (13%) of waterways were assessed using a modified version of the Stream Visual Assessment Protocol (SVAP).[21] Table 4.3 presents the segments assessed.

Stream miles were calculated using ArcGIS software so that stream segments and sample sites could be assigned a unique "mile marker" within the waterways for reference. Mapped segments with mile markers can be seen in Map 4.6.

Figure 4.1: Stream visual assessment in Smokes Creek (BNR)



Map 4.6: Stream Segments Assessed

Physical Properties

As seen in Table 4.4, SC recorded an average depth of 7.5 inches for the five streams assessed. The sub-watershed recorded an average bankfull width of 27.2 feet, and an average baseflow width of 16.4 feet.

Table 4.4: Smokes Creek Sub-watershed Physical Properties

Stream	Average Depth (in.)	Average Bankfull Width (ft.)	Average Baseflow Width (ft.)
Smokes Creek	10.9	32.3	19.5
South Branch Smokes Creek	7.7	39.8	25.9
LKS (Unnamed Tributary)	5.6	17.7	9.9
Rush Creek	8.5	23.3	14.3
EKS (Unnamed Tributary)	4.8	22.9	12.1
Sub-watershed Average	**7.5**	**27.2**	**16.4**

Stream Visual Assessment and Water Quality Findings

During the Phase 1 process, SC was chosen based on its impaired water quality and habitat conditions. Throughout the fieldwork process it became apparent that stream conditions varied greatly by individual reach. Overall SVAP findings from the five waterbodies within the sub-watershed resulted in a score of 'fair' (7.2). The lowest assessed SVAP score for an individual reach was 'poor' (1.5) at reach EKS8, located within an unnamed tributary. This reach suffered from degraded stream conditions due mainly to a large, long culvert located directly upstream of the sampled site. The highest SVAP score for a reach was 'excellent' (9.3) at reach SSMK09 in Smokes Creek. A standard deviation of 1.9 suggests that there is a fairly large variation in overall stream health throughout the sub-watershed system.

Within the sub-watershed, the SMK stream segment in Smokes Creek had the lowest average SVAP score, 'poor' (5.2). The lowest reach score recorded within the SMK stream segment was 'poor' (3.8) and the highest score was 'fair' (7.5). The stream segment with the highest average SVAP score was the SSMK segment in Smokes Creek, which recorded an average of 'good' (8.3). The lowest reach score recorded within the SSMK stream segment was 'poor' (3.9) and the highest score was 'excellent' (9.3).

Table 4.5 presents an SVAP score summary for SC, and a full SVAP summary is available in Appendix C.

Table 4.5: Smokes Creek Sub-watershed SVAP Element Summary

	Channel Conditions	Riparian Zone Left Bank	Riparian Zone Right Bank	Bank Stability Left Bank	Bank Stability Right Bank	Water Appearance	Nutrient Enrichment
# of score average	349 8.7	347 8.4	349 8.8	349 7.0	348 7.3	350 6.5	347 5.2
	Instream Fish Cover	**Pools**	**Invertebrate Habitat**	**Canopy Cover**	**Manure Presence**	**Riffle Embeddedness**	
# of scores average	352 5.9	345 6.2	352 8.5	344 6.3	NA NA	267 7.6	

Substrate within SC was highly variable, with no overarching type of substrate appearing dominant within the sub-watershed. Every stream was observed to have variable substrate particle size ranging from a silt/clay mix to boulder and cobble material.

Within the sub-watershed, the Main Stem of Smokes Creek recorded the lowest average channel condition score of 'good' (7.5). Channel conditions were lowest in areas where the stream cut through residential areas. Abundant use of rip-rap and other methods of hard engineered stream bank stabilization were observed, as seen in Figure 4.2.

SC had the fewest number of invasive species out of the five assessed sub-watersheds, with 82% of all assessed reaches having no observed invasive species. 17% of assessed reaches were observed to have growth of Japanese Knotweed, while the presence of Phragmites was only observed in one stream reach in Smokes Creek (SSMK01).

While water quality was sampled during SVAP, additional water quality sampling was performed at six sites within the sub-watershed at location in Berrick's Creek, Rush Creek, the South Branch of Smokes Creek, and Smokes Creek from June 2015 to November 2015. Three repeat sites located in Berrick's Creek, Rush Creek, and Smokes Creek were sampled from April 2016 to November 2016.

Figure 4.2: Altered Stream Channel with use of Rip-Rap (BNR)

Table 4.6 displays water quality parameters measured during SVAP, including the number of measurements performed, high

and low values measured, and the average value recorded for each parameter. Full water quality parameter results can be found in Appendix C and D.

Table 4.6 Smokes Creek Sub-watershed Water Quality Element Summary

	Temperature ºC	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)	Conductivity (uS/cm)	Total Dissolved Solids (mg/L)
# of scores	95	95	95	95	95
low value	14.4	2.4	26.1	231.6	171.6
high value	28.1	16.4	182.7	1398.0	1001.0
average	18.9	10.2	109.9	828.1	602.6
	pH	**Turbidity (NTU)**	**Phosphate (µg/L)**	**Nitrate (µg/L)**	
# of scores	95	165	155	156	
low value	7.6	0.7	23.1	200	
high value	8.6	112	1227.6	23,400	
average	8.1	6.0	442.2	8700	

Baseline Indicators

Through the fieldwork portion of this project, parameters that either indicated pervasive impairments throughout the sub-watershed, or had high numbers of water quality parameters exceeding relevant standards or guidance values were isolated for further discussion. These so-called baseline indicators begin to give us a picture of the sub-watershed's health or impairment status during normal, baseline conditions.

Baseline Indicators for the Smokes Creek Sub-watershed are identified as:

- Land Use/Land Cover
    - LULC in SC directly affects water quality throughout the sub-watershed, and stormwater and agricultural runoff is a major vector transporting contaminants from surrounding land into waterways. LULC also affects suggested management actions, as those actions that are able to be performed on agricultural or forested land may not be appropriate for more developed land.
- Riparian Zone and Bank Stability
    - The riparian zone, which measures the expanse of a natural vegetated strip, within SC was rated as 'good', but many individual reaches recorded fair and poor scores. A poor riparian zone allows stream banks to erode more readily, and for contaminants in runoff to flow uninterrupted into a waterbody. Bank stability is grouped with riparian zone, as a poor riparian zone generally coincides with poor bank stability. While some reaches scored very high, erosion issues were prevalent throughout the sub-

watershed, and 'poor' bank stability scores were recorded in every stream segment SVAP assessments occurred in.

- *E. coli*
    - *E. coli* measurements performed in the sub-watershed had levels greatly exceeding recommended levels for primary contact recreation.
- Nutrient Load
    - Phosphorus and nitrate within the sub-watershed are consistently high, indicating that elevated levels of these parameters are entering waterways.

Baseline Indicators Discussion

Land Use/Land Cover

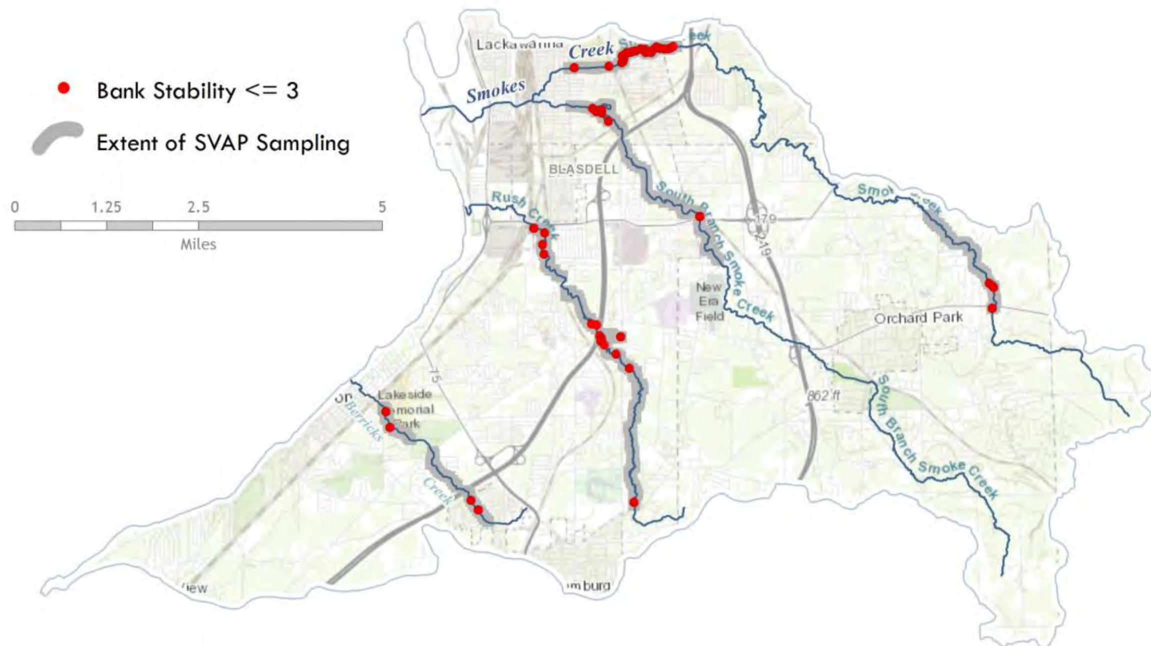
As discussed previously, high levels of developed LULC in Smokes Creek sub-watershed result in contributing urban runoff and industrial effluent into area waterways through direct inputs (runoff, industrial SPDES discharges), or overflow events (CSO/SSO events), and heavily modified stream channels.

Riparian Zone and Bank Stability

Figure 4.3: Limited riparian vegetation in unnamed tributary (BNR)

The riparian zone, or area of natural vegetation bordering a water body, received average scores of 'good-excellent' (7.7-9.4) within the sampled stream segments. Within the sub-watershed 72% of reaches recorded a score of 'excellent' (>9.0). This zone is a vital component to a healthy water body, as the roots of riparian vegetation naturally stabilize banks and control erosion. This zone of vegetation also functions as a surface water filter, slowing and absorbing stormwater runoff and the various pollutants it may be transporting. Excellent scores refer to a riparian zone extending at least two times the width of the streams active channel. However, there were several instances where poor riparian zone was observed. These areas often experience poor bank stability and increased erosion, as there are limited roots present to reinforce the bank as seen below in Figure 4.3.

The Main Stem of Smokes Creek recorded the lowest average bank stability score of all water body segments assessed, earning a score of 'fair' (6.5). Bank stability scores can be impacted by the height of stream banks, evidence of erosion, and presence or absence of rip-rap. Lower scores indicate unstable high banks, often dominated by rip-rap or other hardened materials. South Branch Smokes Creek recorded the highest average score of 'good' (8.2), indicating stream banks along this segment are more stable and are experiencing less erosion. Bank stability scores under 3 for the sub-watershed are shown in Map 4.7 below. A score of 3 indicates that "banks are moderately unstable, typically high, actively eroding at bends; ~50% rip-rap; excessive erosion" while a score of 1 represents "Unstable high banks, actively eroding at bends throughout; dominated by rip-rap." It is important to note that due to the subjective nature of SVAP, and because there is no data normalization applied to compare results between undeveloped and developed streams, scores in impaired streams may be inflated to appear better than otherwise expected. For example, a stream reach that would score poorly in an ideal natural stream corridor may be ranked higher when compared to other reaches in a highly impaired stream. For this reason, caution is advised when using non-site specific data in heavily developed sub-watersheds.

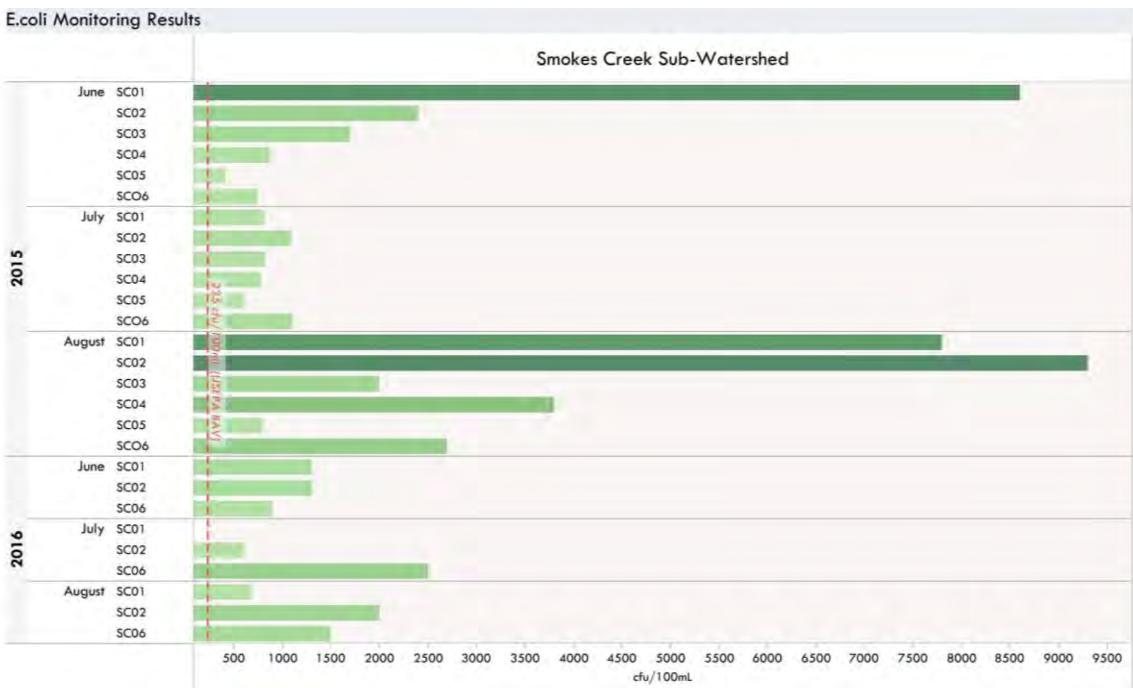


Map 4.7: Bank Stability Score 1-3

E. coli

Along with high nutrient levels, elevated *E. coli* levels throughout the sub-watershed were common. A variety of suspected sources present within the sub-watershed include inputs from municipal and sanitary sewer discharges, on-site septic systems, and combined sewer overflows.[11] Samples collected within Smokes Creek were regularly above the USEPA Beach Action Value (BAV) of 235 cfu/100mL as seen in Figure 4.4. The BAV is a tool often used to assist in making beach notifications and closures.[29] Only one out of 27 samples recorded below the BAV.

Figure 4.4: *Escherichia coli* Monitoring Results



Nutrient Load

Samples to assess nutrient levels (phosphorus and nitrate) were also collected and processed. With the sub-watershed having a dominant percentage of developed land cover, there is a greater potential for point source pollution with high concentrations of nutrients from wastewater treatment plant discharges, industrial discharges, and non-point source urban stormwater runoff.

Nutrient sampling from SC found the highest phosphate readings of all five prioritized sub-watersheds. The sub-watershed recorded an average of 442.5 µg/L of phosphorus, well above the NYS DEC guidance value of 10 µg/L for Lake Erie Eastern basins.[8] Rush Creek recorded the highest average phosphorus readings in comparison to other assessed stream segments at 609.3 µg/L. An unnamed tributary (LKS) to Lake Erie also recorded elevated phosphorus levels, with an average of 469.7 µg/L. This tributary flows through a small portion of the South Shore Country Club golf course as seen in Figure 4.5. Healthy riparian zones filter and prevent runoff from entering waterbodies. In contrast, average nitrate levels were below the NYS DEC standard value of 10,000 µg/L. The average for the sub-watershed was 8,734.6 µg/L of nitrate.

Nitrogen and phosphorus are natural constituents of the environment, but can also be introduced into the system via fertilizers and sewage inputs. Most traditional fertilizers, for residential or commercial purposes, contain nitrogen, phosphorus, and potassium (or potash). Commercial fertilizer, used as a fertilizer on golf courses and other heavily-maintained properties, are primary sources of nitrogen and phosphorus to surface and groundwater via runoff or infiltration.[26]

Figure 4.5: Unnamed tributary flowing through golf course (google maps)

While nitrogen and phosphorus are vital for a healthy stream, the correct balance is critical to sustain aquatic life.[18] High nutrient levels can fuel growth of aquatic vegetation and algae which can congest streams, restricting water flow and fish movement. Large quantities of long leaf pondweed, as seen in Figure 4.6 were observed in the Main Stem of Smokes Creek near a corn field. Potential non-point nutrient runoff could be contributing to this extensive plant growth. Large quantities of aquatic vegetation create elevated levels of plant respiration and decomposition, dissolved oxygen levels become depleted. These oxygen-depleted environments can stress and have detrimental impacts on aquatic life. At times, algae will grow in large, expansive colonies often referred to as an algal bloom. Under the right conditions, some algal blooms will produce toxins that can be dangerous to wildlife and human health.

Figure 4.6: Long-Leaf Pondweed (*Potamogeton nodosus*) (BNR)

A total of 69% of assessed stream reaches recorded scores of 'poor' (<6.0) for nutrient enrichment. Only three reaches received a score of 'excellent' (>9.0). These results indicate that the majority of the assessed waterbodies are slightly greenish in color, with high quantities of algal and/or macrophyte growth. These findings are also reflected in the WI/PWL findings.[11]

During Monthly water sampling, phosphorus reached its highest measured levels in June 2015 with a sub-watershed average value of 542.3 ug/L, with the highest value in 2015 (of 768.9 ug/L) being measured at the Rush Creek site. Phosphorus levels in 2015 trended downward from June through November, indicating that the bulk of phosphorus is entering waterways in the early summer seasons. In the 2016 sampling season, the sub-watershed's highest average phosphorus levels occurred in October, with measurements for that month averaging 155.1 ug/L.

Average dissolved oxygen for SC was measured as 10.18 mg/L, and 109.9%. Dissolved oxygen levels over 100% can be a function of photosynthesis, rapid aeration, water temperature, or a lack of aquatic respiration. Organisms producing oxygen through photosynthesis contribute to a stream's dissolved oxygen level. In addition, cold water has the ability to hold more dissolved oxygen than warm water. As water temperatures rise throughout the day, a stream may not quickly equalize its dissolved oxygen content with the atmosphere, resulting in a saturation level over 100%. The highest values recorded were 16.4 mg/L and 182.7%, while the lowest values recorded were 2.4 mg/L and 26.1%. Lower dissolved oxygen levels often correlate to areas with elevated plant respiration and decomposition, as previously discussed. These areas are more likely to succumb to algal blooms, creating harmful conditions for wildlife.

Smokes Creek Critical Source Areas

CSAs in Smokes Creek sub-watershed are depicted in Map 4.8, and displays CSAs using the methodology described on page 1-9.

“Critical” sources areas are those areas which are shown to be actively contributing to the sub-watershed’s impairments, and are seen as priority areas for intervention. “Non-critical” areas are those which are not actively contributing to impairments within he sub-watershed, and seen as priority areas for conservation or protection.

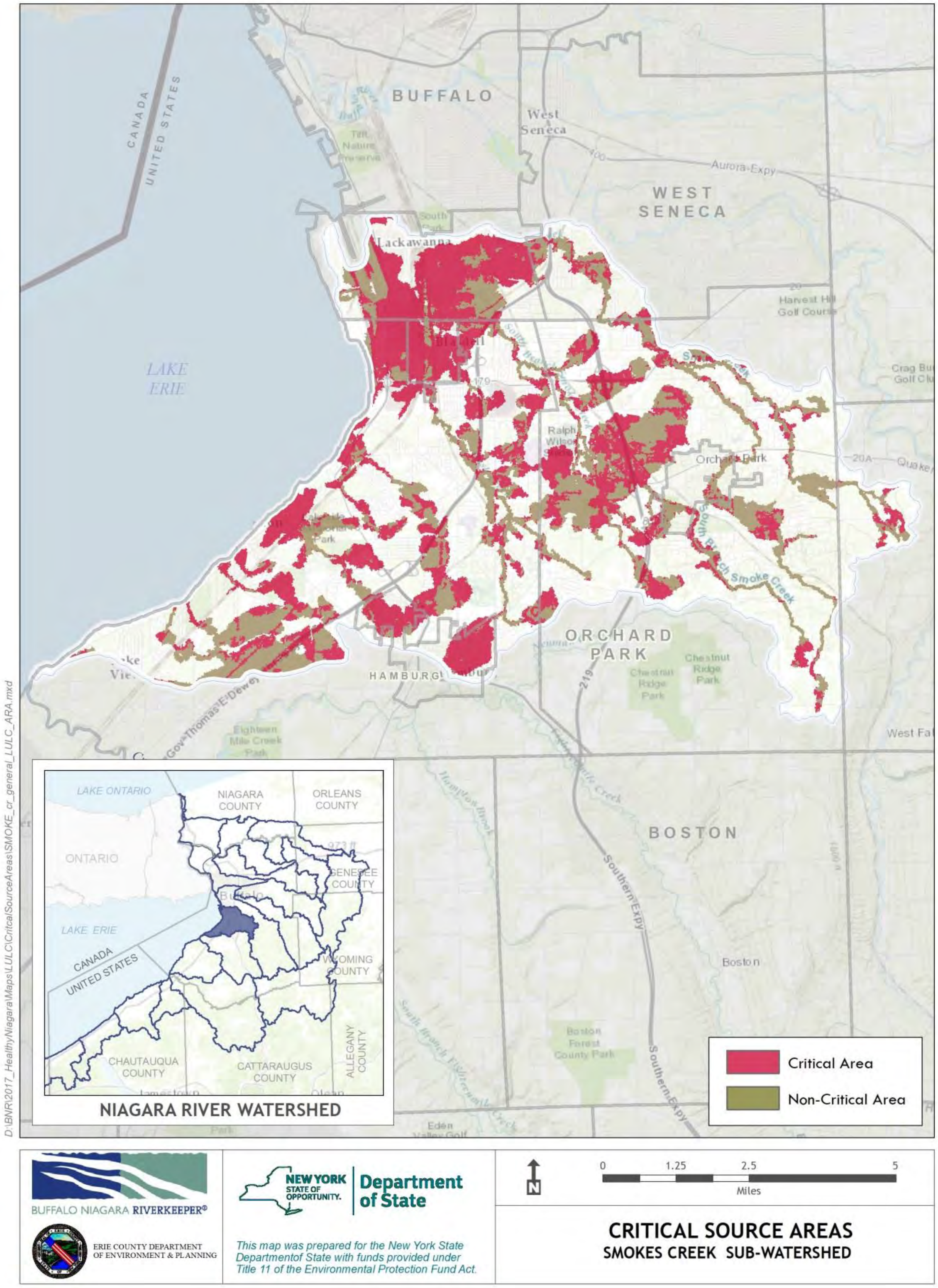
CSA Priorities

The Smokes Creek Sub-watershed is mostly comprised of developed areas in Lackawanna, Blasdell, Orchard Park, and Hamburg. This sub-watershed represents large source areas of legacy pollutants, due largely to its industrial history. Bethlehem Steel, a steel manufacturing plant closed in 1982 was a heavy polluter of Smokes Creek and the adjacent Lake Erie waters. Other industries in the City of Lackawanna continue to contribute pollutants to waterways in this sub-watershed, and are high priorities for intervention and management actions.

Smokes Creek has a high population density in comparison to the other Niagara River sub-watersheds. Common outcomes of this high density include building expansion, high percentages of impervious surfaces, increased water and sewer lines, and additional roads and sidewalks which can all contribute to non-point source pollution. Smokes Creek contains 18.26% of impervious cover, as indicated by 2005 NOAA land cover data, the second most of all sub-watersheds in the entire Niagara River Watershed.[1,22]

The sub-watershed has the greatest risk for increased future impervious cover by heavy development expansion through re-urbanization and suburban sprawl, therefore making the few remaining headwater forests of critical importance. Critical headwater forests occur in the lower reaches of Smokes Creek and are vital for protection due to the fact that they have the greatest effect on overall health of water quality, stream habitat, and resiliency to climate change throughout the sub-watershed.

Several projects have been identified through Buffalo Niagara Riverkeeper’s Niagara River Habitat Conservation Strategy, which are seen as priority projects for conservation lands that may directly address impairments in the sub-watershed. These projects are included as Appendix G.



Map 4.7: Critical Source Areas

Target Goals for Baseline Indicators

As specific management actions are carried out, these indicators can be used for comparison or to determine the effectiveness of implementation efforts. Suggested management actions are also developed to address baseline indicators, as these indicators can vary regionally and can be tuned to address a sub-watershed's unique characteristics.

Land Cover: Land cover can provide valuable information related to water quality and overall watershed health. With increased development and urbanization, areas with impervious cover will also increase. According to the Center for Watershed Protection, water quality can begin to degrade at 10% impervious cover. [1,3]

> **Future Goal:** Reduce the amount of impervious cover within the sub-watershed.
>
> **Target:** As of 2005, Smokes Creek Sub-watershed contains 18.26% impervious Cover. This percentage should be analyzed in future years with a target of it remaining at or below 10%.
>
> **Future Goal:** Conserve and protect undeveloped land in the sub-watershed.
>
> **Target:** Engage communities in the sub-watershed to develop a cross-municipal land conservation strategy.

Riparian Zone and Bank Stability: Vegetation bordering waterways naturally stabilizing banks, controls erosion, functions as a natural filter for water runoff, and cools water temperatures via shading. The natural riparian zone has been removed or altered at several locations throughout the sub-watershed.

> **Future Goal:** To increase the width of riparian vegetation along streams within the sub-watershed, especially in areas where easements exist along Smokes Creek, and incentivize and encourage riparian buffer ordinances.
>
> **Target:** Increase the width of riparian vegetation to 2 times the active channel or 300ft, whichever is greater.
>
> **Future Goal:** Work with communities, agencies, and municipalities to implement stream bank stabilization programs at actively eroding sites.
>
> **Target:** Stream stabilization at reaches scoring 3 and below in SVAP Bank Stability (Map 4.7).

***E. coli*:** As a bacterial indicator, *E. coli* is used to monitor the presence of human/animal waste in waterbodies. Sources may include fertilizer, livestock, municipal discharges, combined sewer overflows, or compromised septic systems.

Future Goal: Reduce the amount and volume of discharges throughout the sub-watershed.

Future Goal: Provide resources to communities to upgrade outdated and deteriorated septic systems.

Future Goal: Municipalities continue to prevent sanitary sewer overflows from discharging into waterways.

Target: Samples test at or below USEPA BAV throughout the sub-watershed, or reduce 30-day geometric mean value to meet USEPA recommended value of 126 cfu/100mL.

Nutrient load: Resulting from stormwater runoff, wastewater treatment plants, septic systems, and (possible) fertilizer use, high nutrient levels are commonplace throughout the sub-watershed.

Future Goal: Reduce loadings of nutrients, specifically phosphorus.

Target: Meet NYS DEC guidance values

- Phosphorus NYS DEC guidance value for Lake Erie Eastern basins of 10 μg/L
- Nitrate NYS DEC standard value of 10,000 μg/L

Suggested Management Actions

The work performed during this project, along with the compilation of preceding data collection and inventory of watershed characteristics is intended to support the development of an action plan consisting of suggested management actions. Actions suggested below are intended to be part of an ongoing, dynamic process, in which management actions are periodically revisited to address changing conditions and management goals with the Lake Erie/Niagara River Watershed.

By implementing the general strategies and recommendations detailed here, the sub-watershed will be on track to meet the previously listed targets for various baseline indicators. These recommendations focus on key issues facing the sub-watershed and are not intended to act as a comprehensive list of everything that could be implemented. These suggested management actions apply to: homeowners, municipalities, volunteer groups, agricultural landowners, organizations and agencies working within the sub-watershed.

This sub-watershed is predominately suburban, comprised of towns and village with mixed densities. Unlike some of the other sub-watersheds, SC has numerous tributaries and creeks that run through densely populated areas, resulting in a high number of riparian landowners. The major stressors on this system are CSO inputs, nutrients from nonpoint sources on private lands, with limited agriculture and septic system usage.

The following management actions and goals are derived from the baseline indicators developed through the field assessments performed for this sub-watershed, including SVAP assessments and WQ monitoring.

Land Cover

Goal: Reduce the 18.26% impervious cover in the Smokes Creek Sub-Watershed to achieve levels closer to 10%

Benefit: According to the Center for Watershed Protection, water quality begins to degrade at 10% impervious cover, because of the loss of groundwater recharge through percolation, and the surge in runoff entering waterways, altering natural flow regimes and overwhelming sewer systems.[3] The Smokes Creek Sub-watershed is almost double the suggested figure with an estimated 18.25% impervious cover.

Best Management Practices

The actions outlined in the table below are organized into three broad categories: green and living infrastructure, land use policy changes, and community engagement.

Implement Green Infrastructure | Living Infrastructure

By incorporating simple living infrastructure practices such as bioswales or rain gardens into small-scale development plans or implementing broader techniques across a larger scale, the resulting effect will be to help to collect rain water before it is able to flow over impervious surfaces, collect pollution and enter bodies of water. In addition, the use of porous material in constructing roadways and parking lots beyond what is required by the NYS Stormwater Manual, rain barrels to disconnect rooftop runoff and incorporation of strategically preserved or placed green and living spaces into landscaping plans will reduce runoff from impervious surfaces directly into waterways and lessen the negative impacts of combined sewer overflows and stormwater discharges.

Land Use Policy

Recommended changes in land use policies include actions like updating a municipality's Comprehensive Plan or amending zoning codes. A Comprehensive Plan allows the municipality to clearly state its long-term goals and priorities for a community. While this document is not law, it does inform the law as a municipality would write zoning codes and ordinances that enable it to meet the goals outlined in the Comprehensive Plan. Conservation updates that can be made to code include: conservation overlay districts, steep slope requirements to limit erosion, minimum setback requirements from waterbodies (sometimes called a "waterfront yard" or "buffer" requirement) on new development, or requirements and standards for vegetated buffers along waterways on all lands.

It is also recommended that large property owners in this sub-watershed such as the Bethlehem Steel site, New Era Stadium, and the City of Lackawanna be identified for priority project implementation.

Community Education and Engagement

While regulation through zoning codes forces those living in a municipality to abide by a certain set of laws, some practices are better implemented through landowner cooperation and collaboration. Encouraging landowners to voluntarily participate in conservation initiatives can greatly benefit a community. These initiatives include landowner stewardship like utilizing a vegetated riparian buffer along a shoreline or installing a rain barrel to disconnect gutters and collect rainwater for reuse. Similarly, hosting town clean-ups or invasive species removal days can help people feel more connected to their environment, thereby fostering a greater sense of community ownership and stewardship. Invasive species, such as Japanese knotweed, were observed in the sub-watershed. Japanese knotweed requires a multi-step removal process in order to eradicate it and it will overtake as a nuisance weed without control.

Recommended Actions to reduce impervious land cover:

Short Term	• Utilize green infrastructure practices; rain barrels; no-mow areas and buffers; rain gardens
	  ○ Cost: Low
	• Reclaim unused or underutilize impervious spaces and develop into “green” spaces like rain gardens or community gardens
	  ○ Cost: Medium
	• Host sustainable development workshops for municipalities and agricultural landowners
	  ○ Cost: Low
	• Identify landowners for potential open space projects
	  ○ Cost: Low

Long Term	• Improve/incorporate stormwater management on paved and unpaved roads/parking lots
	  ○ Cost: Medium
	• Reduce new parking lot sizes in urban areas
	  ○ Cost: Medium
	• Use pervious surfaces and materials when constructing new parking lots or updating existing parking lots beyond the percentage required by the New York State Stormwater Management Design Manual
	  ○ Cost: Medium
	• Revise zoning regulations to limit expansion of impervious surfaces
	  ○ Cost: Low
	• Revise zoning codes to include waterfront yard and setback requirements
	  ○ Cost: Low
	• Creative incentive and educational programs for green infrastructure implementation
	  ○ Cost: Medium

	• Promote the conservation of open spaces through conversation easements and parks etc.
	  ○ Cost: Low
	• Develop waterfront yard standards to require setbacks
	  ○ Cost: Low

Riparian Zone and Bank Stability

Goal: Increase the length and width of vegetated riparian buffers along stream banks within the sub-watershed

Benefit: Vegetation bordering waterways naturally stabilizes banks, controls erosions, functions as a natural filter for pollutants and cools water temperature by providing shade over the water. As noted above, the riparian zone across this entire sub-watershed received overall 'good-excellent' (7.7-9.4) scores within the sub-watershed. Some areas received an excellent score while hardened shoreline and rip-rap was observed elsewhere. Increasing the width of vegetated riparian zones to twice the width of the stream channel or 300 feet, whichever is greater, would provide the greatest impact to the health of waterways throughout the sub-watershed.

Best Management Practices

Stream Stabilization

Stabilization of actively eroding shorelines using living and natural infrastructure is recommended where appropriate. Other engineered stabilization techniques should be used only in extreme cases.

Add Vegetation

Hosting community tree planting days in a municipality can provide great benefit to the riparian corridor and waterway health with limited costs borne by the municipality. Trees can even be obtained at no cost through the NYS DEC "Trees for Tribs" Program.[5]

Develop Ordinances

Including vegetated buffer or setback requirements into a municipality's zoning code is one regulatory mechanism to ensure measures are taken to protect water health. Not all land can be regulated through laws so in some instances encouraging best management practices or utilizing incentive programs may be a more effective approach. Although located into the Lower Tonawanda sub-watershed, the town of Amherst provides a good example of a buffer ordinance: Goal 4-4 of The Bicentennial Comprehensive Plan for the Town of Amherst (amended Feb 2011) sets a goal, "To establish buffer/setback standards for new development to help protect streams of significance." This goal is then applied in the town's zoning code in Chap. 204, Part 3 §3-5-6, "Lots abutting a watercourse."[16] This section requires that lots abutting a watercourse install a 50 foot wide riparian buffer on either side of a watercourse and, further any building must be set back another 10 feet from the buffer.

Recommended Actions to increase the length and width of riparian zones:

Short Term	• Host tree plantings with volunteers
	  ○ Cost: Low
	• Develop programs to encourage the installation of riparian buffers
	  ○ Cost: Low to Medium
	• Implement stream and bank stability projects to stop erosion
	  ○ Cost: High

Long Term	• Develop vegetated buffer requirements for development in riparian areas
	  ○ Cost: Low
	• Develop setback ordinances for new development in riparian areas
	  ○ Cost: Medium
	• Encourage collaboration amongst municipalities and agencies to develop zoning codes to encourage conservation and best management practices across waterways that span municipalities
	  ○ Cost: Low

E. coli

Goal: Reduce bacterial inputs into streams throughout the sub-watershed

<u>Benefit:</u> *E. coli* is a fecal indicator bacteria used to monitor the presence of human/animal waste in water bodies. Because few strains of *E. coli* naturalize in the environment, the presence of *E. coli* almost certainly suggests that fecal matter is contaminating a body of water. Sources may include fertilizer, livestock, sanitary sewer discharges, or compromised septic systems. Water bodies with high levels of *E.coli* are not suitable for consumption or recreation and can result in a chain-reaction of negative human health and economic effects including beach closures. Reducing *E. coli* levels to meet USEPA's recommended value of 126 cfu/100ml (30 day geometric mean) would greatly improve water quality. Combating *E. coli* requires that the sources inputting the bacteria into waterways be mitigated, such as CSO/SSO outfalls and faulty septic systems.

Best Management Practices

<u>Green and Living Infrastructure</u>

In more populous areas, CSOs can be a large source of contaminants (particularly bacteria). CSOs occur where a municipality has combined storm and sanitary pipes and where rainfall inundates the system, resulting in more water than the pipes can handle. This results in an overflow situation where the pipes discharge excess untreated water directly into waterbodies. Implementing green and living infrastructure in both urban and suburban areas can drastically mitigate CSO events. By utilizing green and living infrastructure elements like rain barrels, raingardens, wetlands, and other installations meant to trap rainwater and runoff, less water goes into the sewer system resulting in fewer overflow events. In agricultural or suburban areas with larger swaths of open land, utilizing living infrastructure such as woodlands, meadows, and riparian buffers, and living shorelines to intercept stormwater and overland runoff can also help reduce runoff.

Recommended Actions to reduce bacterial inputs into streams:

Short Term	○ Disconnect gutters and install rain barrels to collect and reuse storm water • Cost: Low ○ Build rain gardens • Cost: Low ○ Develop and host septic system maintenance workshops • Cost: Low
Long Term	• Encourage the installation of wetland treatment systems or other living infrastructure to replace grey systems ○ Cost: Low to Medium • Install vegetated bio-filtration systems such as bioswales and rain gardens ○ Cost: Low • Install Living Shorelines along riparian land ○ Cost: Low to High • Replace aging infrastructure and remove CSO/SSO outfalls from municipal sewer systems ○ Cost: High

Nutrient Load

Goal: Reduce loadings of nutrients, specifically phosphorous

Benefit: Limiting phosphorus limits algae growth (including nuisance blue-green algae such as *Microcystis spp.)* and allows for more dissolved oxygen, resulting in better aquatic species health and cleaner water.

Best Management Practices

High levels of nutrients such as phosphorous and nitrates were found the waterbodies tested within the sub-watershed. In fact, Smokes Creek recorded the highest phosphate readings of all five prioritized sub-watersheds with an average of 442.5 μg/L of phosphorus, well above the NYS DEC guidance value of 10 μg/L for Lake Erie Eastern basin. The highest average phosphorous recording was in Rush Creek. The prevalence of high nutrient levels is likely due to the number of sources or inputs of both point and non-point pollutants and nutrients and the land use gradient of this sub-watershed from rural with light agriculture, into suburban and the urban areas. Sources of nutrients include: storm water runoff, wastewater treatment plants, CSOs, septic systems, fertilizers, and improper disposal of lawn debris. Two of the best ways to combat nutrient inputs are through land uses and education.

Land Use

Making minor to moderate changes to the way in which a person interacts with their land can have significant benefits to water body health. The actions outlined below provide examples of tactics both private homeowners and agricultural landowners can implement.

Education

Many of the changes that could result in the greatest improvement on the overall health of water bodies are behavioral. Encouraging changes in actions or promoting different protocols can be beneficial to combatting nutrient loadings along waterways. For instance, while in the field, the data collection team observed a number of piles of grass clippings abutting the stream and getting blown into the water. Inputs of grass clippings and yard waste into a waterway cause a direct increase in nutrients. Similar minor changes in farming practices or utilizing well known best practices can have significant impacts to the health of a waterbody. Suburban communities can benefit from individual small changes like using phosphorous-free fertilizer and consulting local town or village officials on lawn debris pick-up policies. Some towns, like Orchard Park, even have their own compost facilities where homeowners can bring yard waste. Some towns, like Orchard Park, even have their own compost which, in turn, can be used by residents

Recommended Actions to reduce nutrient loadings:

Short Term	• Host educational workshops for riparian landowners pertaining to funding opportunities and financial assistance for implementing best management practices or runoff mitigation
	• Enact best management practices to reduce nutrients and sediments entering local waterbodies
	  ○ Agricultural Environmental Management Program
	  ○ NYS Agricultural Nonpoint Source abatement and Control Grant Program
	    ○ Cost: Low
	• Encourage no till farming practices
	    ○ Cost: Low
	• Provide educational stormwater management trainings for designers and highway officials to ensure stormwater law compliance
	    ○ Cost: Low
	• Implement "no mow" zones
	    ○ Cost: Low
	• Appropriately dispose of lawn debris – consult local town or village
	    ○ Cost: Low
	• Use phosphorous-free fertilizer
	    ○ Cost: Low

Long Term	• Develop and implement educational trainings for homeowners about lawn care techniques, debris disposal, native plant species etc.
	    ○ Cost: Low
	• Implement and enforce pesticide and fertilizer use standards and regulations
	    ○ Cost: Low
	• Increase watershed stewardship by installing markers and signage for things like storm drains
	    ○ Cost: Medium
	• Limit manure applications timeframes; i.e. not on frozen ground
	    ○ Cost: Low

Chapter 5: Lower Tonawanda Creek

The Lower Tonawanda Creek Sub-watershed (LT) is located in the northern section of the Niagara River Watershed as seen in Map 5.1. It has an area of 78,802.6 acres, or 123.1 square miles, and includes 216.6 miles of waterways. Located in portions of Erie and Niagara Counties, LT includes the following municipalities: the towns of Cambria, Lockport, Wheatfield, Pendleton, Clarence, Amherst, Lancaster, and Newstead, and the cities of North Tonawanda and Lockport. The sub-watershed is shown in Map 5.1.

Tonawanda Creek is channelized and dredged from the Village of Pendleton to its mouth on the Niagara River to accommodate the Erie Canal. During the months of April to November, a lock diverts water causing the creek to flow backward for approximately 19 miles northeast through the canal to Lockport. This flow reversal and channelization limits habitat connectivity between the Niagara River and Tonawanda Creek and has likely impaired aquatic biodiversity in both systems. Water temperatures are affected by flow reversals and may be responsible for periodic fish die-offs in the creek.

Land Use/Land Cover

Land Use/Land Cover (LULC) classifications for LT were derived from 2010 National Oceanic Atmospheric Administration (NOAA) LULC data, and like classifications were consolidated into groups that reflect the overall LULC classification.[22] The LULC groups can be seen in Table 5.1.

As seen in Map 5.2, large concentrations of agricultural land exist in the northwestern expanse of the sub-watershed, especially in the northwest near Cambria, and Wheatfield Interspersed wetlands exist throughout, but are especially prevalent in the middle of the sub-watershed.

Table 5.1: LULC Groups

LULC Class	% by general LULC
Developed, High Intensity	Developed: 25.41%
Developed, Medium Intensity	
Developed, Low Intensity	
Developed, Open Space	
Cultivated Crops	Agriculture: 36.59%
Pasture/Hay	
Deciduous Forest	Forest: 16.14%
Evergreen Forest	
Mixed Forest	
Palustrine Forested Wetland	Wetland: 17.92%
Palustrine Scrub/Shrub Wetland	
Palustrine Emergent Wetland	
Estuarine Emergent Wetland	
Open Water	Water: 0.74%
Grassland/Herbaceous	
Palustrine Aquatic Bed	
Scrub/Shrub	
Unconsolidated Shore	
Bare Land	Other: 3.21%

Map 5.1: Lower Tonawanda Creek Sub-watershed

Active River Area

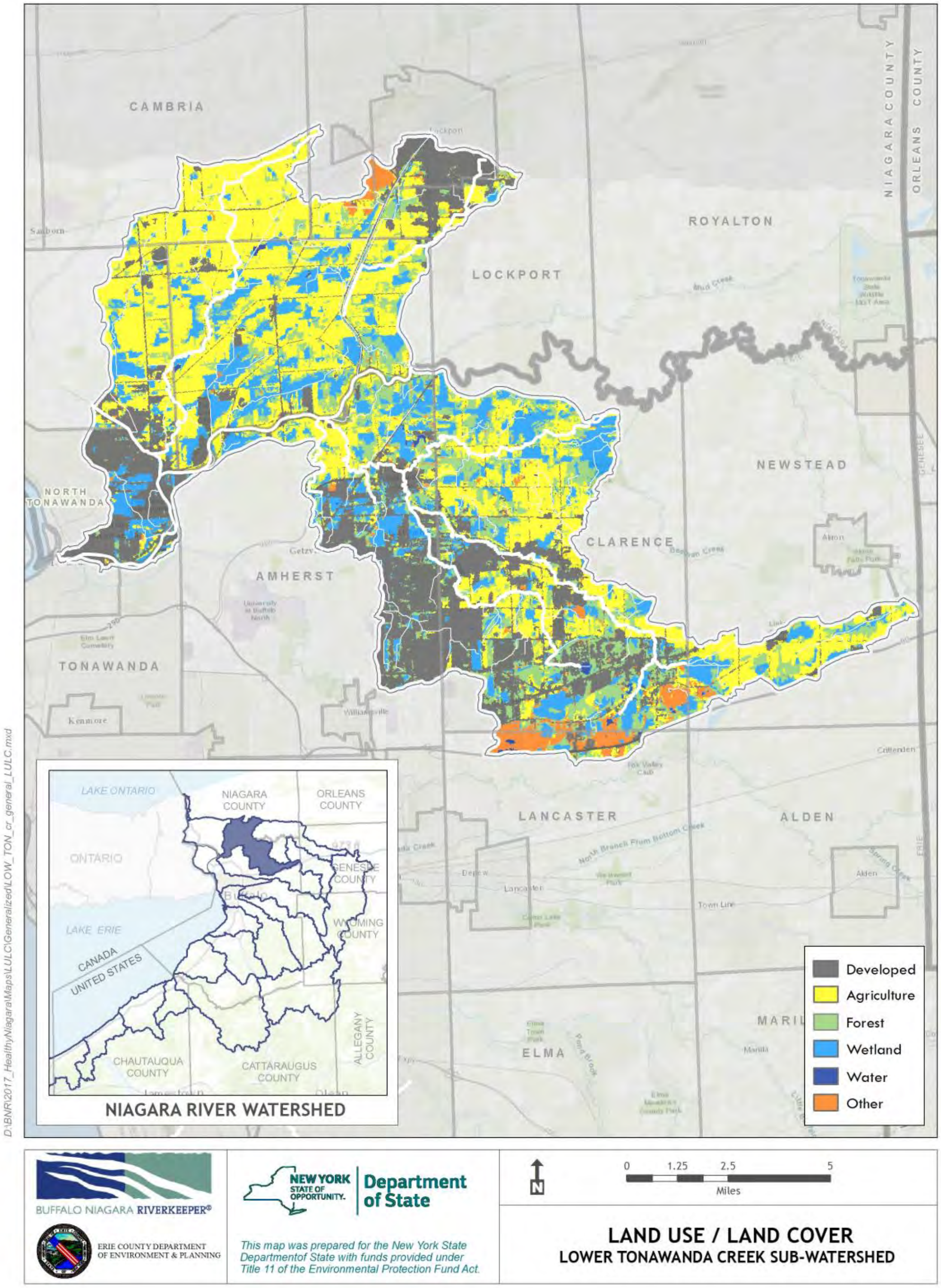
The Active River Area model, as discussed in Chapter 1, was applied to the sub-watershed to determine the extent of the ARA, and focus area for this project. The ARA within the LC is the most expansive of all sub-watersheds in the Niagara River sub-watershed due to flat topography and an abundance of wetlands and hydric soils.

The ARA within LC encompasses 79% of LC's total area, as seen in map 5.3

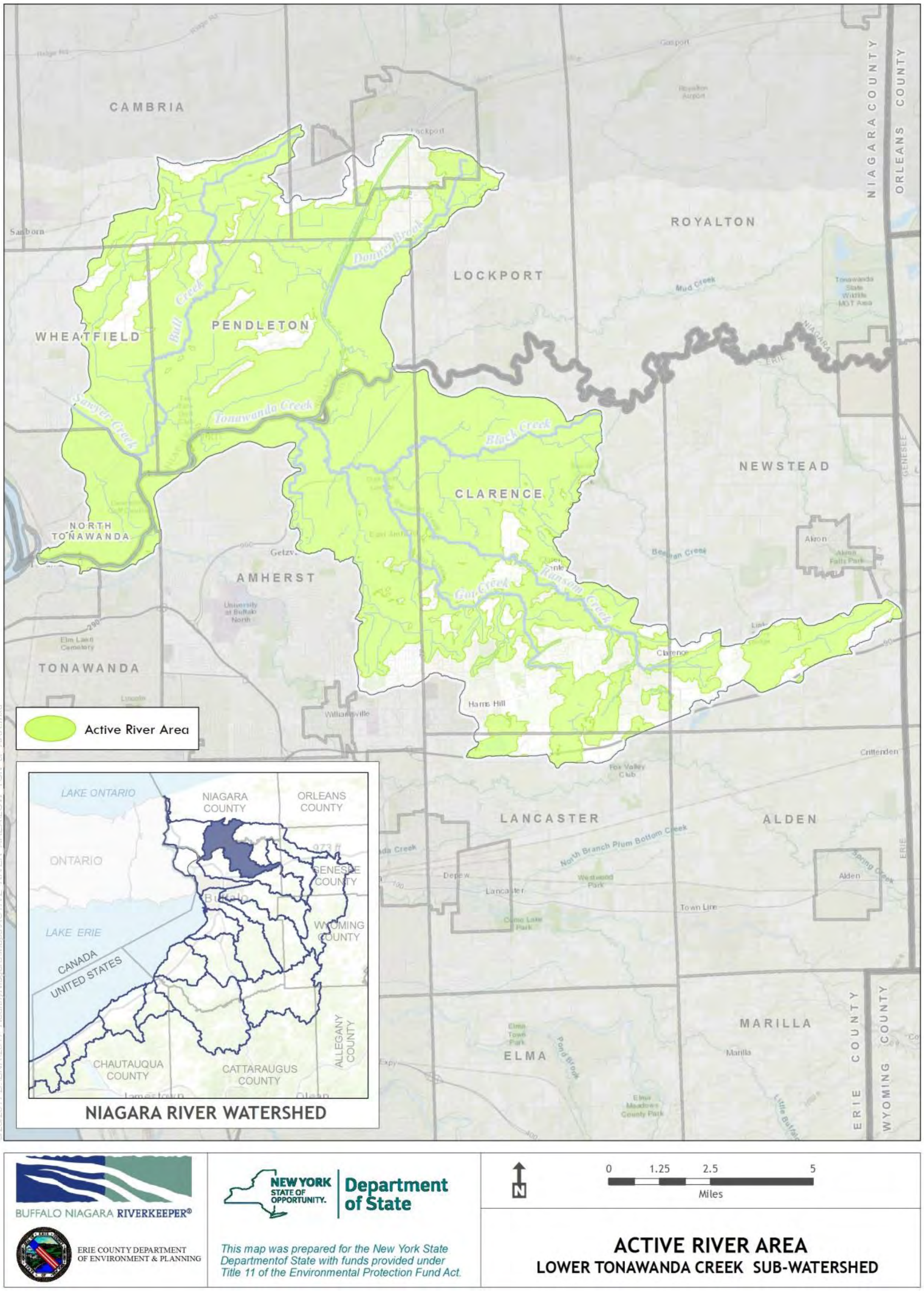
As the ARA in LT is expansive, and covers a majority of the sub-watershed, LULC within the sub-watershed likely has significant effects on overall waterbody health. The ARA in the southwestern headwaters of LT, encompassing the upper reaches of Ransom Creek, Gott Creek, and Black Creek interacts hydrologically with a variety of land uses such as forest, wetland/palustrine aquatic bed, and agriculture. Within the ARA's most expansive area, in the middle sections of the sub-watershed, the land-to-stream interaction becomes increasingly dominated by agricultural land use, suggesting that runoff occurs from these locations. However, this area also contains a large amount of wetland LULC. Additionally, in the lower reaches of LT, Tonawanda Creek and Sawyer Creek flow through lands with heavy urbanized development, where inputs into the creek, such as road runoff and industrial effluent, reflect developed land use and urban environments. Finally, the headwaters of Donner Brook, located in the northeastern reaches of the sub-watershed are also heavily developed in the Village of Lockport, where impervious surfaces contribute urban storm water runoff into streams.

Land Use/Land Cover in the Active River Area

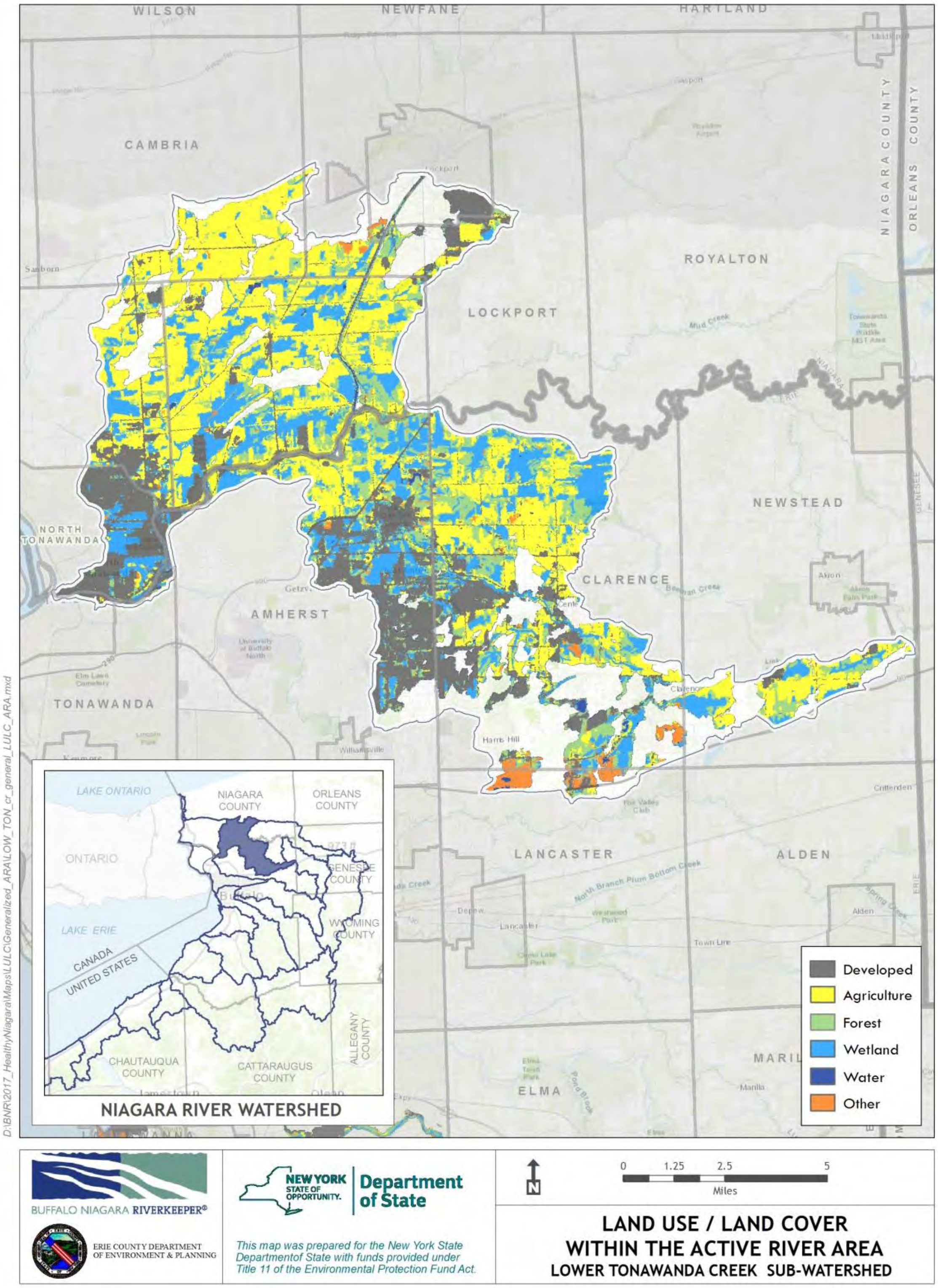
Potential sources of contaminants entering waterways from surrounding lands were identified by overlaying the ARA model on LULC data, to plot where specific land uses interact with streams through natural hydrologic mechanisms. Map 5.4 displays LULC limited to the bounds of the ARA, indicating where contaminants on land may have direct interaction with stream waters.



Map 5.2: Upper Tonawanda Creek Sub-watershed Land Use/Land Cover



Map 5.3: Lower Tonawanda Creek Sub-watershed Active River Area



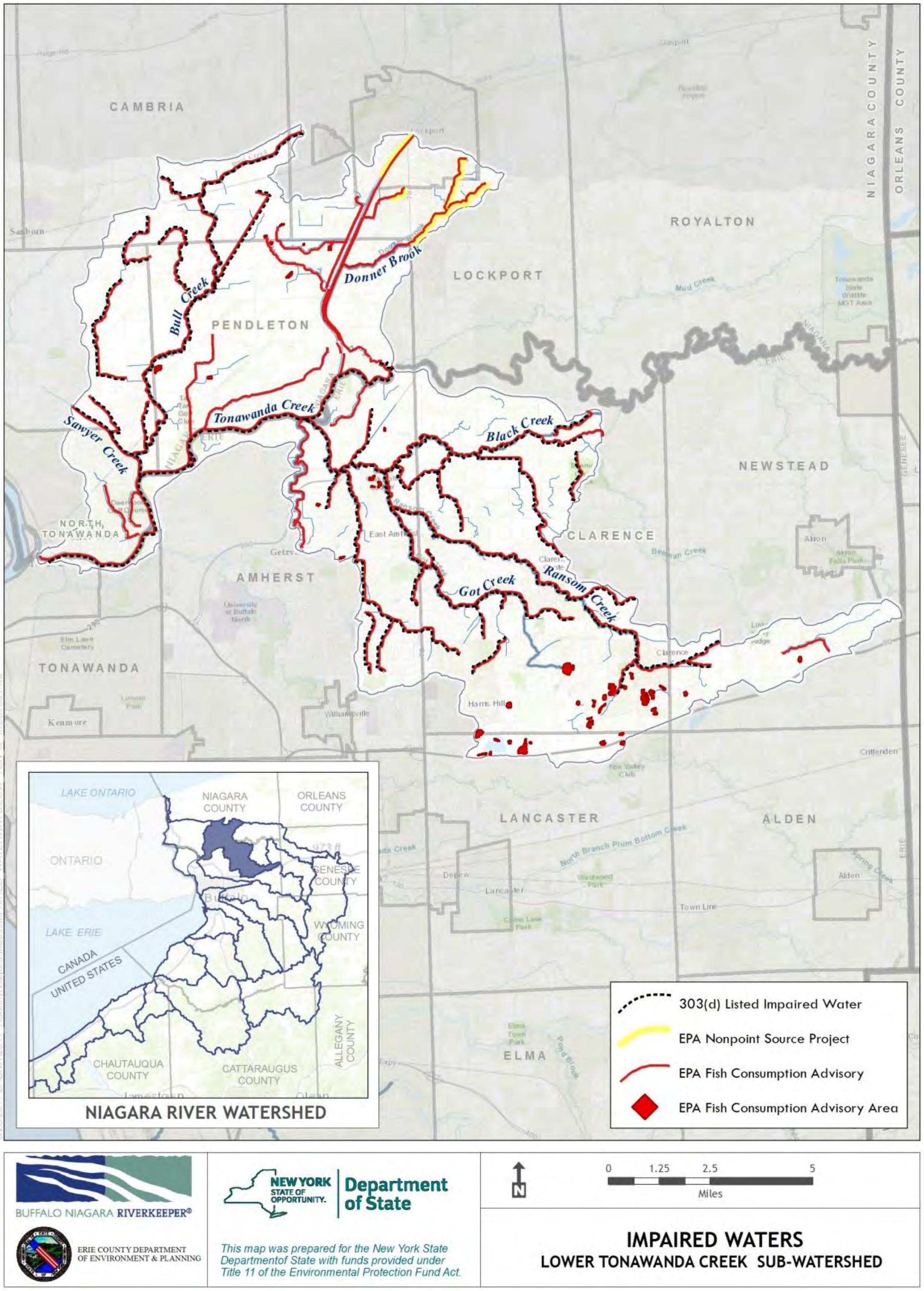
Map 5.4: LULC and ARA Interaction

Impaired Waters

The NYSDEC WI/PWL catalogs several waterbody segments within LT, encompassing 154.2 miles, or 71.2% as impaired. Impaired segments include the Lower Main Stem of the Niagara River, Bull Creek and its tributaries, and both Upper and Lower Ransom Creek and its tributaries. The minor tributaries to Lower Tonawanda Creek remain unassessed.

As depicted in Map 5.5, much of the sub-watershed's main streams, including Tonawanda Creek, Sawyer Creek, Bull Creek, Black Creek, Ransom Creek and Black Creek, are listed on the 303(d) list indicating impaired waterways, with a majority of streams are listed as being under EPA Fish Advisories. Portions of the northern reaches of the sub-watershed, including Donner Brook are listed as EPA Nonpoint Source Projects, a program established under Section 319 of the Clean Water Act, and administered by the NYSDEC to "control pollution from nonpoint sources to the waters of the state and to protect, maintain and restore waters of the state that are vulnerable to, or are impaired by nonpoint source pollution".[9]

NYSDEC classifies waterways according to a class system related to uses.[12] Stream classifications for waterways assessed in this project are listed below in Table 5.2. Streams with AA or A classifications are suitable for drinking water sources, while streams classified as B, C, or D support descending numbers of uses. The addition of a (T) to a stream classification indicates that the stream may support trout populations, while a (TS) waterway may support trout spawning.



Map 5.5: Lower Tonawanda Creek Sub-watershed Impaired Waterways

Table 5.2: NYSDEC Priority Waterbody Classifications

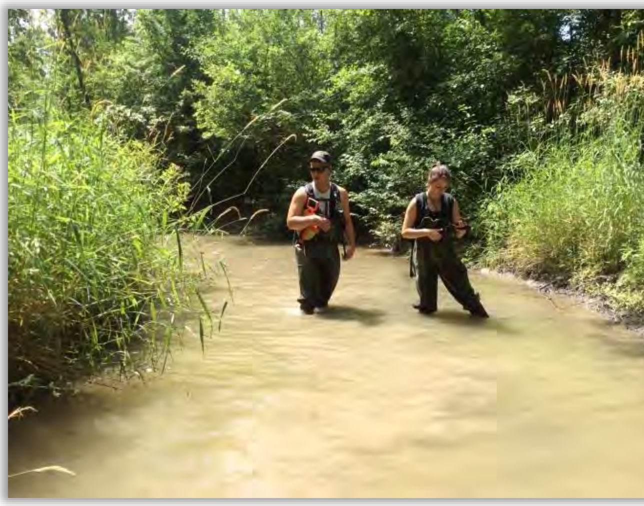
		Designated Use(s) Not Supported by the Waterbody			Pollutant(s) of Concern		Source(s) of Pollution	
Priority Waterbody	**Stream Class**	**Use(s) Impacted**	**Severity of Impact**	**Documentation**	**Type of Pollutant**	**Documentation**	**Source**	**Documentation**
Tonawanda Creek, Lower, Main Stem	C	Fish consumption Aquatic Life Recreation	Impaired Stressed Stressed	Known Suspected Suspected	Priority Organics - PCBs Nutrients Silt/Sediment	Known Suspected Suspected	Toxic/Contaminated Sediment Urban Runoff Other Sanitary Discharge Streambank Erosion Landfill/Land Disposal Municipal	Known Known Suspected Suspected Possible Possible
Bull Creek and tributaries	C	Aquatic Life	Impaired	Known	Unknown Toxicity Dissolved Oxygen/Oxygen Demand Nutrients	Suspected Suspected Suspected	Unknown Source Municipal Urban Runoff Industrial	Suspected Suspected Suspected Possible
Ransom Creek, Lower, and tributaries (includes Black Creek)	C	Aquatic Life Recreation Aesthetics	Impaired Impaired Stressed	Suspected Suspected Known	Dissolved Oxygen/Oxgyen Demand Pathogens Aesthetics (odors) Nutrients Silt/Sediment Ammonia	Known Known Known Suspected Suspected Possible	On-site Septic Systems Private/Community/Industrial (various residential) Urban Runoff	Known Known Suspected
Ransom Creek, Upper, and tributaries (includes Gott Creek)	C(T)	Aquatic Life Recreation Aesthetics	Impaired Impaired Stressed	Suspected Suspected Known	Dissolved Oxygen/Oxgyen Demand Pathogens Aesthetics (odors) Nutrients Silt/Sediment Ammonia	Known Known Known Suspected Suspected Possible	On-site Septic Systems Private/Community/Industrial (various residential) Urban Runoff	Known Known Suspected

Stream Visual Assessment & Water Quality Data Collection

In order to supplement existing data and fill in data gaps, Buffalo Niagara Riverkeeper (BNR) conducted water sampling and stream assessments throughout the sub-watershed. Sampling took place in eight stream bodies in LT during the 2016 field season.

Waterways within LT were assessed from June 20, 2016 to August 8, 2016. Within eight stream bodies, 825 reaches were assessed. Reaches refer to a length of stream 200 feet in length. The streams assessed were Sawyer Creek, Black Creek, Bull Creek, Ransom Creek, Gott Creek, a tributary of Ransom Creek, a tributary of Tonawanda Creek, and another minor tributary to Tonawanda Creek. Each stream was broken up into segments and assigned a unique identifier based on location (SAW, BLK, BUL, RSM, GOT, RT, TOND, EC).

Figure 5.1: Stream visual assessment in Bull Creek (BNR)



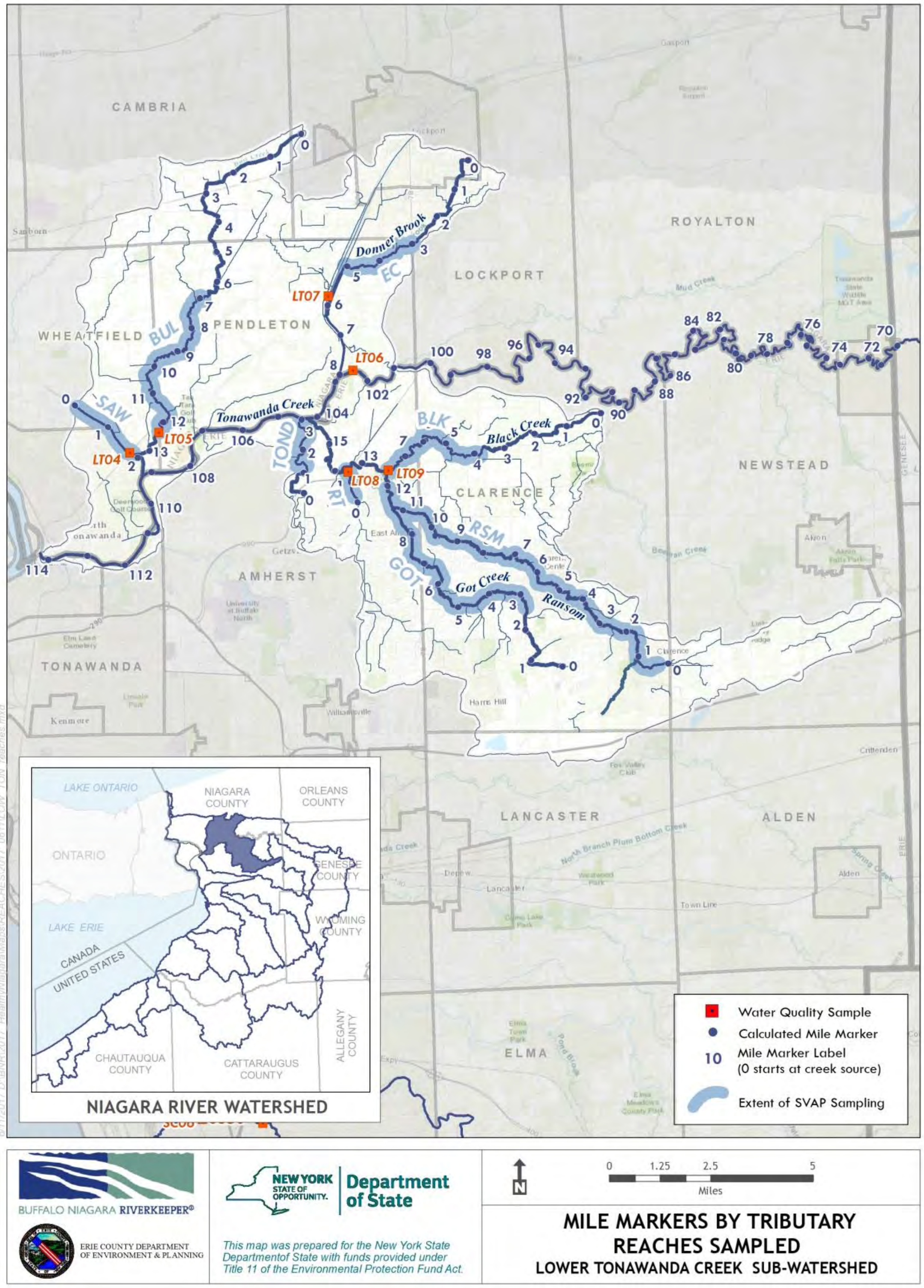
Within LT, 31 of the total 216 miles (14%) of waterways were assessed using a modified version of the Stream Visual Assessment Protocol (SVAP).[21] Field teams encountered numerous streams where water depth was too high or where drought conditions resulted in dry stream beds. In these locations, assessment was not possible.

As seen below in Table 5.3, segments assessed through SVAP were within the following streams: Sawyer Creek, Black Creek, Bull Creek, Ransom Creek and tributaries, Gott Creek, and two unnamed tributaries of Tonawanda Creek.

Table 5.3: Streams Assessed in Lower Tonawanda Creek Sub-watershed

Stream Assessed	Stream Class	Miles Assessed
Sawyer Creek	C	1.7
Black Creek	C	3.2
Bull Creek	C	5.5
Ransom Creek and tributaries	C, C(T)	11.86
Gott Creek	C(T)	5.8
Tributary of Tonawanda Creek		1.33
Minor Tributary to Tonawanda Creek		1.93

Stream miles were calculated using ArcGIS software so that stream segments and sample sites could be assigned a unique "mile marker" within the waterways for reference. Mapped segments with mile markers can be seen in Map 5.6.



Map 5.5 Stream Segments Assessed

Physical Properties

As seen in Table 5.4, LT recorded an average depth of 9.9 inches for the eight streams assessed. The sub-watershed recorded an average bankfull width of 23.7 feet and an average baseflow width of 13.4 feet.

Table 5.4: Lower Tonawanda Creek Sub-watershed Physical Properties

Stream	Average Depth (in.)	Average Bankfull Width (ft.)	Average Baseflow Width (ft.)
Sawyer Creek	13.2	29.4	21.9
Black Creek	6.5	25.5	11.0
Bull Creek	8.8	24.2	12.4
Ransom Creek	8.8	24.1	13.8
Gott Creek	9.5	22.9	14.4
Ransom Creek Tributary	12.9	17.4	8.2
TOND (Tonawanda Creek Tributary)	15	28.9	17.9
EC (Minor Tributary to Tonawanda Creek)	4.3	17.1	7.8
Sub-watershed Average	**9.9**	**23.7**	**13.4**

Stream Visual Assessment and Water Quality Findings

During the Phase 1 process, LT was chosen based on its impairment of water quality and habitat conditions. Throughout the fieldwork process, it became apparent that stream conditions varied greatly by individual reach. Overall SVAP findings from the eight assessed waterbodies within the sub-watershed resulted in a score of 'poor' (5.7).

Within the sub-watershed, the EC stream segment had the highest average SVAP score, 'fair' (6.9). The lowest score recorded in the EC stream segment was 'poor' (5.6) and the highest score was 'good' (7.9). The stream segment with the lowest average SVAP score was the SAW segment in Sawyer Creek, which recorded an average of 'poor' (3.1). The lowest SVAP score in the segment was 'poor' (2.1) and the highest score was also 'poor' (5.0).

Overall SVAP scores draw attention to Sawyer Creek, which recorded the lowest average score in LT. Sawyer Creek recorded an average score of 'poor' (3.1). Sawyer Creek runs closely parallel to Niagara Falls Boulevard in the city of North Tonawanda before the confluence at Tonawanda Creek, primarily a developed landscape. Characterized by a severely altered channel, the creek recorded an average score of 'poor' (1.0) for channel conditions. The creek is highly channelized. Straightening channels is often implemented for navigational purposes, or in the attempt to reduce flooding in a specific area. However, these drastic alterations create many ecological consequences. The straightening of stream channels can result in faster flow and deeper water which can lead to increased soil erosion.[19] In addition, the removal of riparian vegetation results in decreased bank stability and increased water temperatures due to reduction of shading.

Table 5.5 presents an SVAP score summary for LT, and a full SVAP summary is available in Appendix D.

Table 5.5: Lower Tonawanda Creek Sub-watershed SVAP Element Summary

	Channel Conditions	Riparian Zone Left Bank	Riparian Zone Right Bank	Bank Stability Left Bank	Bank Stability Right Bank	Water Appearance	Nutrient Enrichment
# of scores average	825 7.3	825 7.4	825 7.2	825 6.8	825 8.6	825 4.8	825 4.3
	Instream Fish Cover	**Pools**	**Invertebrate Habitat**	**Canopy Cover**	**Manure Presence**	**Riffle Embeddedness**	
# of scores average	825 3.5	825 2.7	825 5.5	823 6.5	83 5.0	104 4.3	

Substrate in LT is predominantly silt/clay, with 66% of assessed reaches having a silt/clay substrate. Cobble comprised 17% of the sub-watershed's assessed substrate. Gravel comprised 13%, with sand, boulders, and bedrock making up only 4% of the substrate of assessed reaches, cumulatively.

Hydrilla was observed in 15% of stream reaches assessed in the sub-watershed. Phragmites, or common reed was observed in 11%, Purple Loosestrife in 8%, and Japanese Knotweed in 3% of all assessed reaches.

These conditions impacted the extent of stream assessments and water quality sampling within Ransom, Bull, and Black Creeks. The upper reaches of Bull and Black were dry and water flow was intermittent. Flow at select mid-reaches within Ransom Creek was also dry and intermittent. During community presentations and outreach events, local landowners also anecdotally noted that water levels within Ransom Creek were unusually low. One unnamed tributary of Tonawanda Creek completely dried up from the time of reconnaissance in April 2016 to mid-July. It should be noted that assessments preformed in abnormal weather conditions may not be representative of a stream's typical conditions.

Additional water quality sampling was performed at six sites within LT from June 2015 to November 2015. Of those six sites, three were sampled again from April 2016 to November 2016. It must be noted however, that as discussed above, 2016 sampling took place during drought conditions, and fewer storm events would have contributed to runoff brining nutrients into waterways.

Table 5.6 displays water quality parameters measured, including the number of measurements performed, high and low values measured and the average value recorded for each parameter. Full water quality parameter results can be found in Appendix C and D.

Table 5.6: Lower Tonawanda Creek Sub-watershed Water Quality Element Summary

	Temperature ºC	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)	Conductivity (uS/cm)	Total Dissolved Solids (mg/L)
# of scores	194	172	172	194	194
low value	12.6	2.8	30	336.5	225.6
high value	29.2	15.1	178	1982	1670.5
average	20.77	7.37	83.32	1160.41	828.09
	pH	**Turbidity (NTU)**	**Phosphorus (µg/L)**	**Nitrate (µg/L)**	
# of scores	194	193	193	181	
low value	7.19	1.09	3.3	0	
high value	8.27	820	848.1	30,400	
average	7.72	52.35	128.7	6,310	

Baseline Indicators

Through the fieldwork portion of this project, parameters that either indicated pervasive impairments throughout the sub-watershed, or had high numbers of water quality parameters exceeding relevant standards or guidance values were isolated for further discussion. These baseline indicators are representative of the impairments that were identified through the field and analysis. Identifying and understanding the baseline indication and their sources is a crucial step for developing goals and actions to address stream impairments or act on conservation opportunities.

Baseline Indicators for the Lower Tonawanda Sub-watershed are identified as:

- Land Use/Land Cover
  - LULC in LT directly affects water quality throughout the sub-watershed, and stormwater and agricultural runoff is a major vector transporting contaminants from surrounding land into waterways. LULC also affects suggested management actions, as those actions that are able to be performed on agricultural or forested land may not be appropriate for more developed land.
- Turbidity
  - Turbidity as measured throughout the sub-watershed is consistently high. 69.8% of water quality samples performed during stream assessments had levels over the NYS DEC standard of 5 NTU.
- Riparian Zone and Bank Stability
  - The riparian zone, which measures the expanse of a natural vegetated strip, was rated as ‘fair’, but many waterbody segments recorded ‘poor’ scores. A ‘poor’ riparian zone allows stream banks to erode more readily, and for contaminants in runoff to flow uninterrupted into a waterbody. Bank stability is grouped with riparian zone, as a poor riparian zone generally coincides with poor bank stability. While some reaches scored very high, erosion issues were prevalent throughout the sub-watershed, and ‘poor’ bank stability scores were recorded in every stream segment SVAP assessments occurred in.
- *E. coli*
  - *E. coli* measurements performed in the sub-watershed had levels greatly exceeding recommended levels for recreational use.
- Nutrient Load
  - Phosphorus and Nitrate within the sub-watershed are consistently high, indicating that elevated levels of these constituents are entering waterways.
- Dissolved Oxygen
  - Dissolved Oxygen levels throughout the sub-watershed were very low, promoting excessive algae growth attributed to nutrient-laden stormwater runoff. Low dissolved oxygen directly affects stream health, as insufficient levels can lead to fish and aquatic die-offs.

Baseline Indicators Discussion

Land Use/Land Cover

As discussed previously, high levels of developed LULC in Lower Tonawanda Creek Sub-watershed, especially the southern portion, result in contributing urban runoff and industrial effluent into area waterways through direct inputs (runoff, industrial SPDES discharges), or overflow events (CSO/SSO events). Because some areas in the northern portion are heavily agricultural, impairments caused by runoff from fields and other operations is also prevalent.

Turbidity

High turbidity levels were common throughout LT in the 2016 field season. Of the samples collected, 70% read over the NYSDEC standard. Turbidity can be used an in indirect indicator of the concentration of suspended matter.

During monthly sampling, turbidity was measured in 2015 as an average of 42.9ntu throughout the six, with a high value of 222ntu recorded at Bull Creek in October 2015, and a low value of 1.8ntu recorded at Sawyer Creek in August 2015. In 2016, turbidity recorded an average of 62.2 NTU, with a low value of 13.2 NTU in May. A low value of 374 NTU was recorded in August at a tributary of Ransom Creek. Average Turbidity within the sub-watershed in 2015 and 2016 averaged above the NYSDEC standard value of 5 NTU, indicating that turbidity and sedimentation within the sub-watershed is prevailing concern.

Riparian Zone

The riparian zone, or area of natural vegetation bordering waterbodies, along assessed stretches of Sawyer Creek recorded an average score of ‘poor’ (3.0), the lowest of all waterbody segments assessed within LT. Poor scores indicate a lack of riparian zone or a narrow riparian zone in comparison to the streams active channel. This zone is vital component to a healthy waterbody, as the roots of riparian vegetation naturally stabilize banks and control erosion. This zone of vegetation also functions as a surface water filter, slowing and absorbing storm water

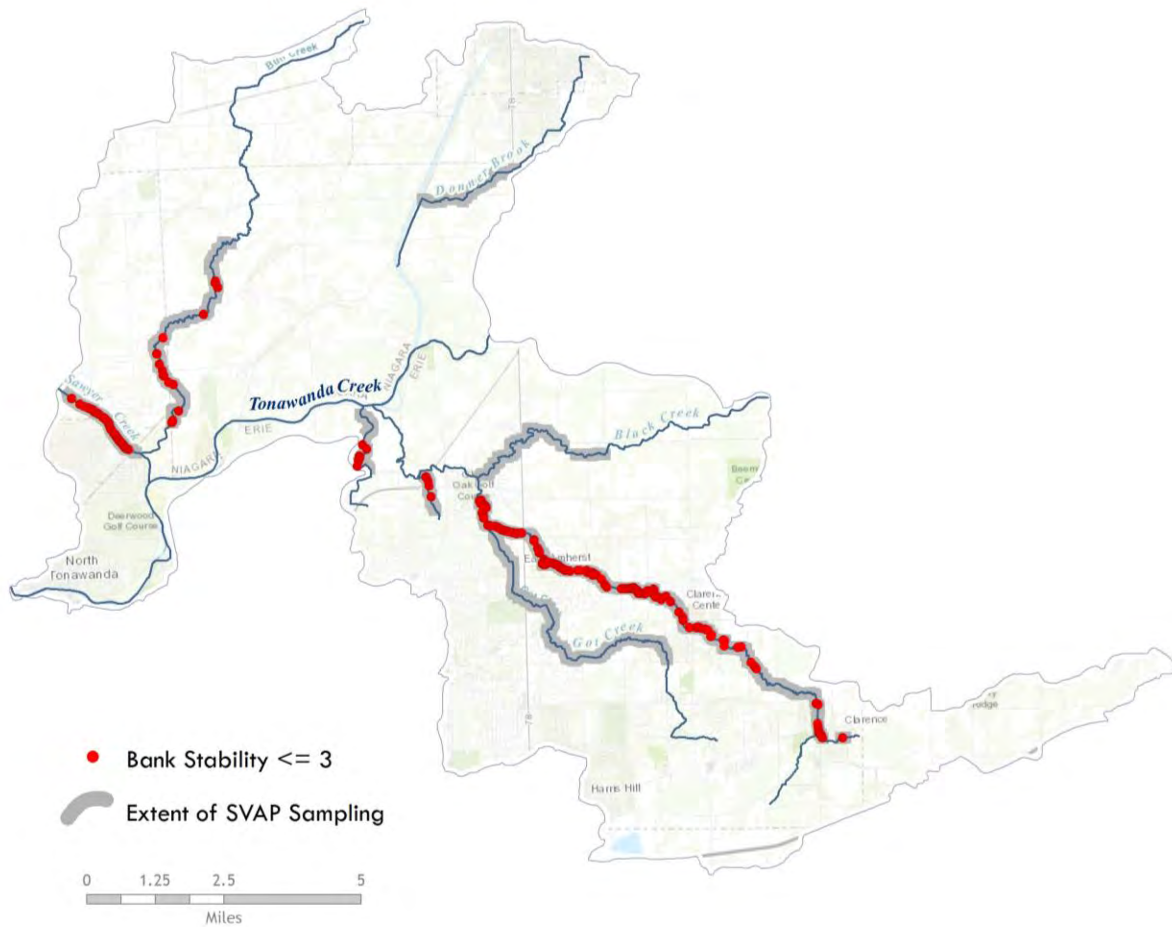
Figure 5.2: Lack of Riparian Vegetation along Sawyer Creek (BNR)

runoff and the various pollutants it transports. Due to the extent of development along Sawyer creek, the natural vegetation has been severely depleted as seen in Figure 5.2. Excellent scores (9.0+) refer to a riparian zone extending at least two times the width of the streams active channel.

In contrast, Bull Creek recorded a 'good' (8.8) score in regards to riparian zone. Bull Creek flows in a less developed area, primarily agricultural land, and its riparian vegetation has been less modified which can be seen in Figure 5.3.

Figure 5.3: Riparian Vegetation along Bull Creek (BNR)

Bank stability within the sub-watershed recorded an average score of 'fair' (6.8). Bank stability scores can be impacted by the height of stream banks, current evidence or lack of erosion, and presence or absence of rip-rap. Sawyer Creek recorded the lowest average bank stability score in the sub-watershed of 'poor' (4.0) due to its lack of natural riparian vegetation, which provides natural bank stabilization. Black Creek recorded the highest average bank stability score of 'good' (8.1). Bank stability scores under 3 for the sub-watershed are shown in Map 5.7 below. A score of 3 indicates that "banks are moderately unstable, typically high, actively eroding at bends; ~50% rip-rap; excessive erosion" while a score of 1 represents "Unstable high banks, actively eroding at bends throughout; dominated by rip-rap."



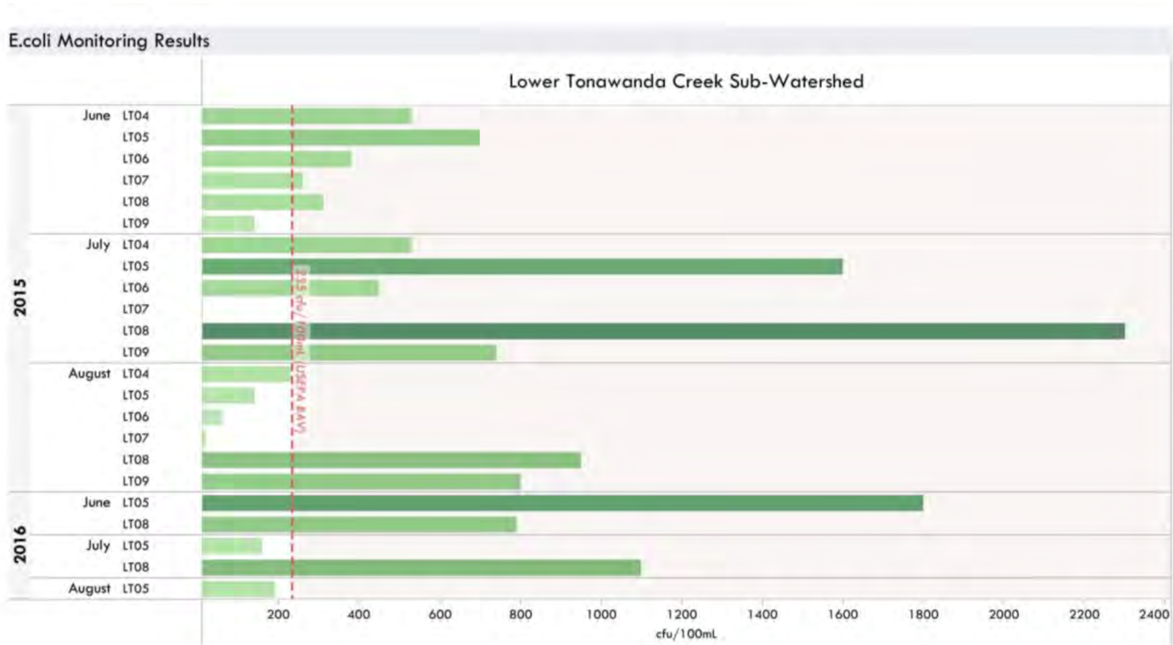
Map 5.7: Bank Stability Scores 1-3

E. coli

Manure presence was observed at 10% of the assessed stream reaches, with Ransom Creek accounting for the majority. A high amount of deer activity along the stream banks was observed.

Escherichia coli (*E. coli*) samples were collected within LT at six sites during 2015 and two sites during 2016. Results were frequently above the USEPA Beach Action Value (BAV) of 235 cfu/100mL as seen in Figure 5.4. The BAV is a tool often used to assist in making beach notifications and closures.[29] Overall higher levels of *E. coli* measured in 2015 can be partially explained by more precipitation during the sampling season than 2016, although the LT08 site in 2016 was also well above the recommended value, indicating input during non-storm event conditions.

Figure 5.4 *Escherichia coli* Monitoring Results



Nutrient Load

During stream assessment, scores for nutrient enrichment were recorded. LT recorded an average 'poor' (4.5) score indicating high levels of nutrients throughout the assessed waterbodies. Abundant macrophyte and algal growth was observed (Figure 5.5) in addition to abundant lawn debris in the streams or on the stream banks (Figure 5.6). This lawn debris contributes nutrients, including phosphorus, promoting the growth of algae and other aquatic vegetation. Samples to assess nutrient levels (phosphorus and nitrate) were also collected and processed. Phosphorus levels recorded an average of 129.7 µg/L, well above the NYSDEC guidance value of 10 µg/L for Lake Erie Eastern basins.[8] Sawyer Creek recorded the highest average phosphorus reading of 305.5 µg/L. All waterbody segments sampled recorded average nitrate readings below the NYSDEC standard value of 10,000 µg/L.[6]

Figure 5.5: Mowed Lawn Adjacent to Stream with Extensive Algal Growth (BNR)

Nitrogen and phosphorus are natural constituents of the environment, but can also be introduced into the system via fertilizers and sewage inputs. Most traditional fertilizers, used both for agricultural or residential purposes, contain nitrogen, phosphorus, and potassium (or potash). Animal manure and commercial fertilizer, used as a crop fertilizer, are primary sources of nitrogen and phosphorus to surface and groundwater via runoff or infiltration.[26]

While nitrogen and phosphorus are vital for a healthy stream, the correct balance is critical to sustain aquatic life.[18] High nutrient levels can fuel growth of aquatic vegetation and algae which can congest streams, restricting water flow and fish movement as seen in Figure 5.7. With elevated plant respiration and decomposition, dissolved oxygen levels become depleted. These oxygen-depleted environments can stress and have detrimental impacts on aquatic life. At times, algae will grow in large, expansive colonies often referred to as an algal bloom. Under the right conditions, some algal blooms will produce toxins that can be dangerous to wildlife and human health.[14]

Figure 5.6: Grass Clippings along Ransom Creek (BNR)

Figure 5.7: Abundant Growth of Aquatic Vegetation in Sawyer Creek (BNR)

Dissolved Oxygen

Average dissolved oxygen for the sub-watershed was measured at 7.37 mg/L and 83.3%. Dissolved oxygen levels over 100% can be a function of photosynthesis, rapid aeration, water temperature, or a lack of aquatic respiration. Organisms producing oxygen through photosynthesis contribute to a stream's dissolved oxygen level. In addition, cold water has the ability to hold more dissolved oxygen than warm water, and as water temperatures rise throughout the day, a stream may not quickly equalize its dissolved oxygen content with the atmosphere, resulting in a saturation level over 100%. The highest values recorded were 15.1 mg/L and 178%, while the lowest values recorded were 2.8 mg/L and 30%. Lower dissolved oxygen levels often correlate to areas with elevated plant respiration and decomposition, as previously discussed. These areas are more likely to succumb to algal blooms, creating harmful conditions for wildlife and potentially humans.

Dissolved oxygen during monthly water quality sampling was measured in 2015 to be highest in October, with an average sub-watershed wide measurement of 71.6%. 2016 however, had much higher levels, with the highest levels by sub-watershed average in April and May, with nearly identical measurements of 125.7% and 125.5% respectively. The highest individual reading in 2016 was recorded at the LT08 site in May.

Lower Tonawanda Critical Source Areas

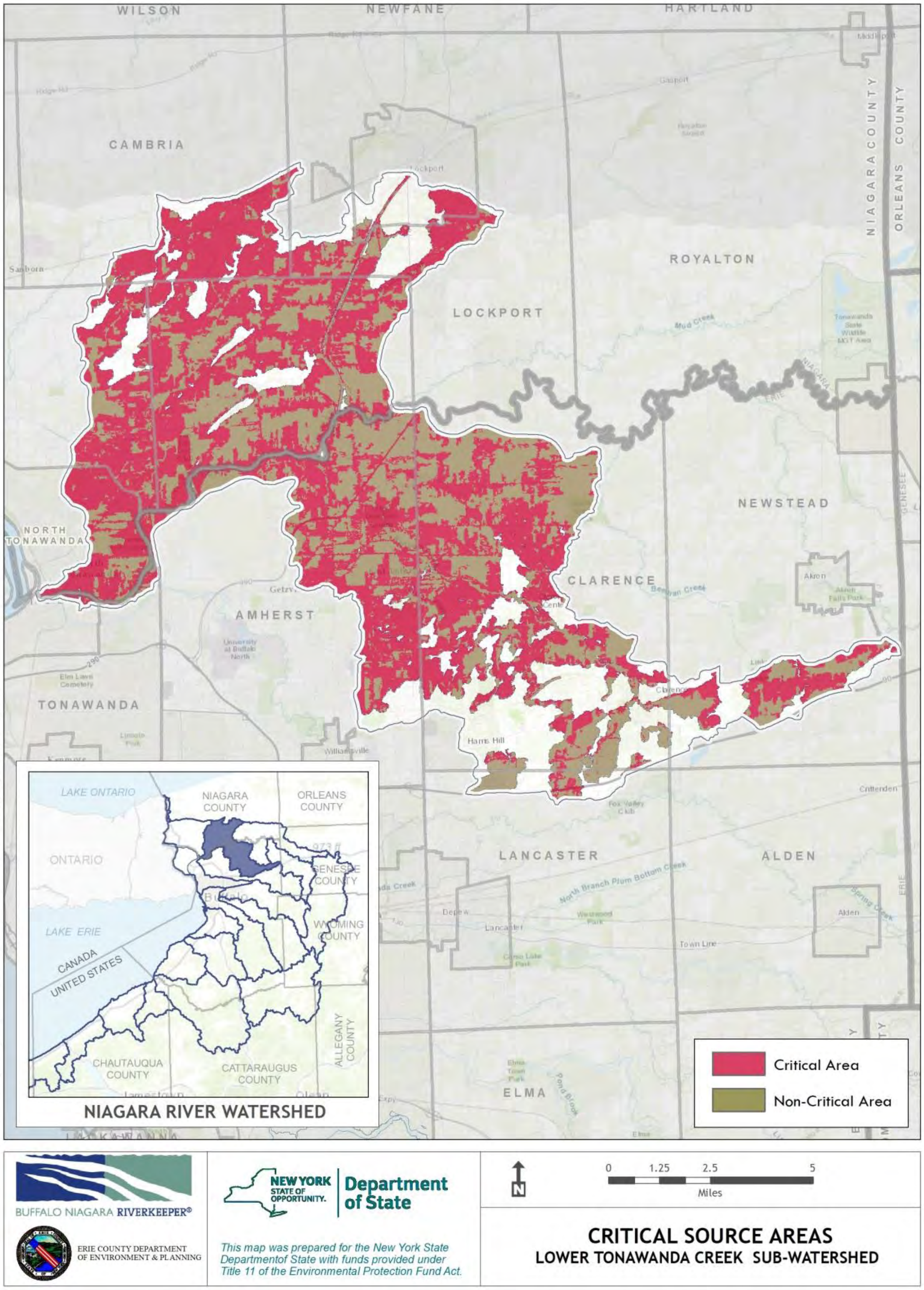
CSAs in LT are depicted in Map 5.8, and displays CSA using the methodology described on page 1-9.

The CSAs in LT are those areas which are thought to be actively contributing to impairments found through assessments. In LT, these "critical" or "contributing" areas are those agricultural, and developed land uses within the ARA. These critical areas represent the priority areas for intervention in the sub-watershed. Undeveloped, forested, or wetlands within the ARA are shown to be "Non-Critical Areas", meaning that they are not actively contributing impairments, but and are priority areas for conservation and protection. These Non-Critical areas can generally be described as a large area which contains important riparian forest tracts, critical for preventing future pollutants from entering surrounding waterways.

CSA Conservation Priorities

LT is dominated by critical source areas throughout and it is predicted that impervious cover in LT will rise from 8.4% to 35% in the near future. One of the most prominent features in the sub-watershed, the Erie Canal corridor, remains a priority for riparian buffer protection and restoration. Several critical headwater forests occur throughout the sub-watershed including multiple locations in Pendleton, Clarence, and Newstead. The headwaters of Ransom Creek, just north of Interstate 90, are identified as important riparian woodland to be protected in order to prevent further decline and future contribution as a source area. Large amounts of developed land generate a high percentage of impervious cover, making protection of remaining natural habitats even more vital. Sand and gravel quarries are frequent throughout the heart of sub-watershed and serve as good opportunities for long-term restoration and protection of groundwater.

Several projects have been identified through Buffalo Niagara Riverkeeper's Niagara River Habitat Conservation Strategy, which are seen as priority projects for conservation lands that may directly address impairments in the sub-watershed. These projects are included as Appendix H.



Map 5.7: Critical Source Areas

Target Goals for Baseline Indicators

As specific management actions are carried out, baseline indicators can be used for comparison or to determine the effectiveness of implementation efforts. Suggested management actions are also developed to address baseline indicators, as these indicators can vary regionally and can be tuned to address a sub-watershed's unique characteristics.

Land Cover: Land cover can provide valuable information related to water quality and overall watershed health. With increased development and urbanization, areas with impervious cover will also increase. According to the Center for Watershed Protection, water quality can begin to degrade at 10% impervious cover.[1,3]

> **Future Goal:** Reduce the amount of impervious cover within the sub-watershed.
>
> **Target:** In data compiled in 2005, LT contains 8.4% Impervious Cover. A target plant to reduce impervious cover to below 5% should be developed.
>
> **Future Goal:** Conserve and protect undeveloped land in the sub-watershed.
>
> **Target:** Engage communities in the sub-watershed to develop a cross-municipal land conservation strategy.

Turbidity: Erosion of shorelines contributes to turbidity and sedimentation of waterways. High turbidity levels were common throughout LT in the 2016 field season. Of the samples collected, 70% read over the NYSDEC standard. Turbidity can be used an in indirect indicator of the concentration of suspended matter.

> **Future Goal:** Restore steep and actively eroding shorelines to decrease erosion and sedimentation in streams.
>
> **Target:** Meet NYSDEC water quality standard or set a higher reachable level <25 NTU throughout the sub-watershed.

Riparian Zone and Bank Stability: Vegetation bordering waterways naturally stabilizes banks, controls erosion, functions as a natural filter for water runoff, and cools water temperatures via shading. The natural riparian zone has been removed or severely altered within this sub-watershed.

> **Future Goal:** To increase the length and width of riparian vegetation along streams within the sub-watershed, and incentivize and encourage riparian buffer ordinances.
>
> **Target:** Increase the width of riparian vegetation to two times the active channel or 300ft, whichever is greater.

Future Goal: Work with communities, agencies, and municipalities to implement stream bank stabilization programs at actively eroding sites.

Target: Stream stabilization at reaches scoring 3 and below in SVAP Bank Stability (Map 5.7).

***E. coli*:** As a bacterial indicator, *E. coli* is used to monitor the presence of human/animal waste in waterbodies. Sources may include fertilizer, livestock, sanitary discharges or compromised septic systems.

Future Goal: Reduce access of livestock to streams and stream banks thereby limiting bacterial inputs.

Future Goal: Provide resources to communities to upgrade outdated and deteriorated septic systems.

Future Goal: Municipalities continue to prevent sanitary sewers from overflowing into waterways.

Target: Samples at or below USEPA BAV throughout the sub-watershed or reduce 30-day geometric mean value to meet USEPA recommended value of 126 cfu/100mL.

Nutrient load: Resulting from stormwater runoff, wastewater treatment plants, septic systems, fertilizers, and improper lawn debris disposal, high nutrient levels are common throughout the sub-watershed.

Future Goal: Reduce loadings of nutrients, specifically phosphorus

Target: Meet NYSDEC guidance values

- Phosphorus NYSDEC guidance value for Lake Erie Eastern basins of 10 µg/L
- Nitrate NYSDEC standard value of 10,000 µg/L

Dissolved Oxygen: Dissolved oxygen levels can be influenced by water temperature, flow rates, the presence of aquatic plants and animals, and inputs from stormwater and wastewater. Low dissolved oxygen levels can create harmful conditions for wildlife and potentially humans.

Future Goal: Increase shading along streams, to help lower water temperatures thereby increasing the potential to hold higher levels of dissolved oxygen.

Target: Meet NYSDEC standard value of no less than 4.0 mg/L

Suggested Management Actions

The work performed during this project, along with the compilation of preceding data collection and inventory of watershed characteristics is intended to support the development of an action plan consisting of suggested management actions. Actions suggested below are intended to be part of an ongoing, dynamic process, in which management actions are periodically revisited to address changing conditions and management goals with the Niagara River/Lake Erie Watershed.

By implementing the general strategies and recommendations detailed here, the sub-watershed will be on track to meet the previously listed targets for various baseline indicators. These recommendations focus on key issues facing the sub-watershed that were identified through this effort and are not intended to act as a comprehensive list of everything that could be implemented.

These suggested management actions apply to: homeowners, municipalities, volunteer groups, agricultural landowners, organizations and agencies working within the sub-watershed.

Land Use

Goal: Reduce the amount of impervious cover within the Lower Tonawanda sub-watershed from 8.4% to <5%

Benefit: According to the Center for Watershed Protection, water quality begins to degrade at 10% impervious cover, because of the loss of groundwater recharge through percolation, and the surge in runoff entering waterways, altering natural flow regimes and overwhelming sewer systems.[3] Lower Tonawanda sub-watershed population has steadily increased (by over 9,000 people between 2000-2010), and consequently so has the impervious surface coverage which negatively impacts water quality. Currently, the Lower Tonawanda sub-watershed has an estimated 8.4% impervious cover, which is approaching the 10% threshold. Ideally, the sub-watershed impervious coverage should be decreased to <5%.

Best Management Practices

The actions outlined in the table below are organized into three broad categories: green and living infrastructure, land use policy changes and community engagement.

Implement Green Infrastructure | Living Infrastructure

By incorporating simple living infrastructure practices such as bioswales or rain gardens into small-scale development plans or implementing broader techniques across a larger scale, the resulting effect will be to help to collect rain water before it is able to flow over impervious surfaces, collect pollution and enter bodies of water. In addition, the use of porous material in constructing roadways and parking lots beyond what is required by the NYS Stormwater Manual, rain barrels to disconnect rooftop runoff and incorporation of strategically preserved or placed green and living spaces into landscaping plans will reduce runoff from impervious surfaces directly into waterways and lessen the negative impacts of combined sewer overflows and stormwater discharges. As noted in the NYSDEC Stormwater Management Design Manual, a one-acre parking lot can produce 16 times more stormwater runoff than a one-acre meadow each year".[10]

Land Use Policy

Recommended changes in land use policies include actions like updating a municipality's Comprehensive Plan or amending zoning codes. A Comprehensive Plan allows the municipality to clearly state its long-term goals and priorities for a community. While this document is not law, it does inform the law as a municipality would write zoning codes and ordinances that enable it to meet the goals outlined in the Comprehensive Plan. Conservation updates that can be made to code include: conservation overlay districts, steep slope requirements to limit erosion, minimum setback requirements from waterbodies (sometimes called a "waterfront yard" or "buffer" requirement) on new development, or requirements and standards for vegetated buffers along waterways on all lands.

Community Education and Engagement

While regulation through zoning codes forces those living in a municipality to abide by a certain set of laws, some practices are better implemented through landowner cooperation and collaboration. For example, almost 40% of the EC sub-watershed is classified as agricultural land and data analysis suggests that agricultural lands may be contributing to water quality impairments in places across the EC sub-watershed. Here, encouraging landowners to voluntarily participate in conservation initiatives can greatly benefit a community. These initiatives include landowner stewardship like utilizing a vegetated riparian buffer along a shoreline or installing a rain barrel to disconnect gutters and collect rainwater for reuse. Similarly, hosting town clean-ups or invasive species removal days can help people feel more connected to their environment, thereby fostering a greater sense of community ownership and stewardship. Invasive species, such as Japanese knotweed, were observed in the sub-watershed. Japanese knotweed requires a multi-step removal process in order to eradicate it and it will overtake as a nuisance weed without control.

Recommended Actions to reduce impervious land cover:

Short Term	• Encourage municipalities to utilize pervious surfaces or living infrastructure in new developments and redevelop traditional grey infrastructure beyond the percentage requirements of the New York State Stormwater Management Design Manual for impervious cover.
	  ○ Cost: Medium
	• Reclaim and develop unused or underutilized impervious surfaces into "green spaces"
	  ○ Cost: Low to Medium
	• Host sustainable development workshops targeted at municipalities and agricultural operations
	  ○ Cost: Low
	• Create educations programs for green and living infrastructure solutions
	  ○ Cost: Low to Medium
	• Develop and implement educational outreach materials for waterfront landowners that address better yard management practices, riparian buffer design and erosion control and Living Shoreline implementation
	  ○ Cost: Low to Medium
	• Promote recreational use of natural areas to increase land protection and awareness through placemaking
	  ○ Cost: Low
	• Implement vegetated riparian buffers along stream corridors and on agricultural land
	  ○ Cost: Low (no mow) to Medium (erosion control structures)

Long Term	• Improve/incorporate stormwater management on paved and unpaved roads/parking lots
	  ○ Cost: Medium
	• Reduce new parking lot sizes in urban areas
	  ○ Cost: Medium
	• Use pervious surfaces and materials when constructing new parking lots or updating existing parking lots beyond the percentage required by the New York State Stormwater Management Design Manual
	  ○ Cost: Medium

Turbidity

Goal: Restore steep and actively eroding shorelines to decrease erosion and sedimentation in streams such that stream quality, at a minimum, meets the NYSDEC water quality standard for turbidity

Benefit: Levels of high turbidity were prevalent in the waters surveyed and tested throughout the Upper Tonawanda sub-watershed. High turbidity in waterways can be an indicator of concentrations of suspended matter. Cloudy or turbid water affects light penetration through increasing light scattering, which typically leads to warmer water temperatures (with lower dissolved oxygen capacity). The effects of turbidity on light penetration also directly affect plant growth, further lowering the dissolved oxygen in water. Typically, lowering turbidity can improve plant growth and benthic communities, which are the basis for the aquatic food chain.

Best Management Practices

High turbidity levels were common throughout the Lower Tonawanda sub-watershed. High water velocity rates have a higher carrying capacity for sediment increasing the travel distance before the particles fall out of suspension. This process is exacerbated by high levels of erosion which causes more sediment to go into waterways and creates excessively turbid water. Combating erosion and offsetting elevated velocity and water levels from runoff is one good way to reduce turbidity.

Land Use

Any number of actions that limit erosion and lessen sediment loading into waterways will help to combat turbidity. For example, instituting steep slope ordinances, where appropriate, into zoning codes can limit the amount of sediment that enters into waterways from highly erodible banks. Specifically, in the Upper Tonawanda Sub-watershed, this would be useful tool for Town of Orangeville. The town of Cortlandt, downstate in Westchester County, provides a good example of a steep slope ordinance. The ordinance states the following as one of the reasons for the protection of steep slopes:

> "The Town's experience with past development has shown that the improperly managed disturbance of steep slopes can aggravate erosion and sedimentation beyond rates experienced in natural geomorphological processes. Erosion and sedimentation often include the loss of topsoil, a valuable natural resource, and can result in the disturbance of habitats, degradation of the quality of surface water, the silting of wetlands, alteration of drainage patterns…"

Similarly requiring setbacks and requiring or encouraging vegetated buffers can help to anchor soil to the banks. Installing a Living Shoreline or vegetated buffer of either shrubs and grasses or tall trees can all help sediment remain in place.

Recommended Actions to combat turbidity:

Short Term	• Landowners should replant and reshape failing streambanks with stabilizing vegetation to reduce erosion and sediment deposition
	  ○ Cost: Low to High
	• Development of restoration plans for severely altered waterways
	  ○ Cost: Medium

Long Term	• Develop vegetated buffer standards for all waterfront development that ensure a protected, stabilized shoreline.
	  ○ Cost: Low
	• Identify and mitigate or replace improperly installed road/stream crossings and stream barriers
	  ○ Cost: Medium to High
	• Cost: Medium to High Implement Living Shoreline restoration projects to remove hardened shorelines and naturalize shorelines and slopes
	  ○ Cost: Medium to High

Riparian Zone and Bank Stability

Goal: Increase the length and width of riparian vegetated buffers along stream banks within the sub-watershed

Benefit: Vegetation bordering waterways naturally stabilizes banks, controls erosion, functions as a natural filter for pollutants and cools water temperature by providing a shade over the water. The natural riparian zones in the lower portions of BR have been affected by development and upstream, are subject to agricultural stressors. Increasing the width of vegetated riparian zones to twice the width of the stream channel or 300 feet, whichever is greater, would provide the greatest improvement to the health of the waterway.

Best Management Practices

Stream Stabilization

Stabilization of actively eroding shorelines using living and natural infrastructure is recommended where appropriate. Other engineered stabilization techniques should be used only in extreme cases

Add Vegetation

Hosting community tree planting days in a municipality can provide great benefit to the riparian corridor and improve waterway health with limited costs borne by the municipality. Trees can even be obtained at no cost through the NYSDEC "Trees for Tribs" Program.[5] Similarly installing appropriately sized vegetated buffers in the more open and agricultural areas on the sub-watershed would be very beneficial.

Develop Ordinances

As noted above, including vegetated buffer or setback requirements into a municipality's zoning code is one regulatory mechanism to ensure measures are taken to protect water health. Not all land can be regulated through laws so in some instances encouraging best management practices or utilizing incentive programs may be a more effective approach. Towns of Amherst and Pendleton both include language in their zoning codes for vegetated buffers. For example, Goal 4-4 of The Bicentennial Comprehensive Plan for the Town of Amherst (amended Feb 2011) sets a goal, "To establish buffer/setback standards for new development to help protect streams of significance." This goal is then applied in the town's zoning code in Chap. 204, Part 3 §3-5-6, "Lots abutting a watercourse." This sections requires that lots abutting a watercourse install a 50-foot-wide riparian buffer on either side of a watercourse and further, any building be an additional 10 feet from the buffer.

Recommended Actions to increase the length and width of riparian zones:

Short Term	• Host tree plantings with volunteers
	  ○ Cost: Low
	• Develop programs to encourage the installation of riparian buffer and cover crops
	  ○ Cost: Low to Medium
	• Implement stream and bank stability projects to stop erosion
	  ○ Cost: High

Long Term	• Develop vegetated buffer requirements for development in riparian areas
	  ○ Cost: Low
	• Develop setback ordinances for new development in riparian areas
	  ○ Cost: Medium
	• Encourage collaboration amongst municipalities and agencies to develop zoning codes to encourage conservation and best management practices across waterways that span municipalities
	  ○ Cost: Low

E. coli

Goal: Reduce bacterial inputs into streams throughout the sub-watershed

Benefit: *E. coli* is a fecal indicator bacteria used to monitor the presence of human/animal waste in waterbodies. Because few strains of *E. coli* naturalize in the environment, the presence of *E. coli* almost certainly suggests that fecal matter is contaminating a body of water. Sources may include fertilizer, livestock, sanitary sewer discharges, or compromised septic systems. Waterbodies with high levels of *E.coli* are not suitable for consumption or recreating and can result in a chain-reaction of negative human health and economic effects. Reducing *E. coli* levels to meet USEPA's recommended value of 126 cfu/100ml (30 day geometric mean) would greatly improve water quality. Combating *E. coli* requires that the sources inputting the bacteria into waterways be mitigated, such as CSO/SSO outfall mitigation and livestock exclusion.

Best Management Practices

Livestock

When livestock is able to freely roam in and across streams, they can produce a number of undesirable effects such as trampling banks, increasing erosion, and directly inputting sources of bacteria such as *E. coli* into water bodies through excrement. In addition, livestock fecal contamination releases a large amount of antibiotics into waterways, contributing to widespread naturalized antibiotic resistance. If livestock cannot be completely excluded from streams, then at a minimum, limit access by creating a designated crossing. Similarly, some lands have seen success by placing water troughs near the water body so that the cows can easily get to the stream water they may use for drinking but are not directly standing in the stream.

Update and Upgrade Septic Systems

Leaking septic systems are a direct input of bacteria into groundwater which can pollute drinking water and contaminate streams. It is important to recall that the presence of *E. coli* is not the only indicator species of biological pollution—it is just the simplest and most widely tested for. *E.coli* often occurs in tandem with other pathogenic bacteria, viruses and protozoans, such as those that cause cholera, dysentery, and Giardia. Upgrading septic systems with denitrification systems and fixing leaking systems is a necessary solution to mitigate this input.

Green and Living Infrastructure

In more populous areas, CSOs can be a large source of contaminants (particularly bacteria). CSOs occur where a municipality has combined storm and sanitary pipes and where rainfall inundates the system, resulting in more water than the pipes can handle. This results in an overflow situation where the pipes discharge excess untreated water directly into waterbodies. Implementing green and living infrastructure in both urban and suburban areas can drastically mitigate CSO events. By utilizing green and living infrastructure elements like rain barrels, raingardens, wetlands, and other installations meant to trap rainwater and runoff, less water goes into the sewer system resulting in fewer overflow events. In agricultural or suburban areas with larger swaths of open land, utilizing living infrastructure such as woodlands, meadows, and riparian buffers, and living shorelines to intercept stormwater and overland runoff can also help reduce runoff. In agricultural or suburban areas which larger swaths of open land, natural or constructed wetlands and bio-filtration systems can also be beneficial.

Recommended Actions to reduce bacterial inputs into streams:

Short Term	• Utilize livestock exclusion fencing to limit livestock access to and crossing of streams
	  ○ Cost: Medium
	• Install alternative watering facilities for livestock away from streams
	  ○ Cost: Medium
	• Install riparian buffers and covers crops to reduce stormwater runoff which can wash animal byproduct directly into waterways
	  ○ Cost: Medium
	• Install liquid manure retention and targeted spreading systems to prevent manure runoff from crop fields.
	  ○ Cost: Medium

Long Term	• Encourage the installation of wetland treatment systems or other living infrastructure to replace grey systems
	  ○ Cost: Low to Medium
	• Install vegetated bio-filtration systems such as bioswales and rain gardens
	  ○ Cost: Low
	• Install Living Shorelines along riparian land
	  ○ Cost: Low to High
	• Replace aging infrastructure and remove CSO/SSO outfalls from municipal sewer systems
	  ○ Cost: High

Nutrient Load

Goal: Reduce loadings of nutrients, specifically phosphorous

Benefit: Limiting phosphorus limits algae growth (including nuisance blue-green algae such as *Microcystis spp.)* and allows for more dissolved oxygen in a waterbody. In turn, this results in better aquatic species health and overall cleaner water.

Best Management Practices

High levels of nutrients such as phosphorous and nitrates were found in the waterbodies tested within the sub-watershed. As stated above, all the waterbody segments sampled within the Buffalo River Sub-watershed recorded average phosphorus readings above the NYSDEC guidance value for Lake Erie Eastern basins of 10 μg/L with Sprague Brook recording the highest average phosphorus Interestingly, as the map shows there is agricultural activity in the upper reaches of Sprague Brook. Although this may suggest correlation, it does not show causation. Similarly, nitrate measurements were also found to be above NYSDEC standard value of 10,000 μg/L. The prevalence of high nutrient levels is likely due to the number of sources or inputs including: storm water runoff, wastewater treatment plants, CSOs, septic systems, fertilizers, and improper disposal of lawn debris. Two of the best ways to combat nutrient inputs are through improving land use practices and education.

Land Use

Making minor to moderate changes to the way in which a person interacts with their land can have significant benefits to waterbody health. The actions outlined below provide examples of tactics both private homeowners and agricultural landowners can implement.

Education

Many of the changes that could result in the greatest improvement on the overall health of water bodies are behavioral. Encouraging changes in actions or promoting different protocols can be beneficial to combatting nutrient loadings along waterways. For instance, while in the field, the data collection team observed a number of piles of grass clippings abutting the stream and getting blown into the water. Inputs of grass clippings and yard waste into a waterway cause a direct increase in nutrients. Similar minor changes in farming practices or utilizing well known best practices can have significant impacts to the health of a waterbody. Suburban communities can benefit from individual small changes like using phosphorous-free fertilizer and consulting local town or village officials on lawn debris pick-up policies.

Recommended Actions to reduce nutrient loadings:

<table>
<tr><td>Short Term</td><td>

Agricultural landowners should coordinate with Erie County Soil and Water Conservation District to enact best management practices which reduce nutrient and sediment loading from entering local waterways.
Cost: Low
Municipalities should host educational workshops for riparian landowners pertaining to funding opportunities and financial assistance for implementing best management practices for runoff mitigation
Cost: Low
Encourage no till farming practices
Cost: Low
Utilize cover crops to keep fertilizer laden soil in place
Cost varies by crop planted and need to be addressed. For example, planting clover can be inexpensive and eliminate some nitrogen from the soil
Provide educational stormwater trainings for designers and highway officials to ensure stormwater law compliance
Cost: Low
Implement “no mow” zones
Cost: Low
Appropriately dispose of lawn debris
Cost: Low
Use phosphorous-free fertilizer
Cost: Low

</td></tr>
<tr><td>Long Term</td><td>

Development and implement direct-application fertilizer techniques and educational programs
Cost: High
Develop and implement educational trainings for homeowners about lawn care techniques, debris disposal, native plant species
Cost: Low
Promote rotation grazing for livestock
Cost: Low
Implement and enforce pesticide and fertilizer use standards and regulations.
Cost: Low
Increase watershed stewardship by installing markers and signage for storm drains.
Cost: Medium

</td></tr>
</table>

Dissolved Oxygen

Goal: Meet NYSDEC standard value of no less than 4.0mg/L

Benefit: Proper levels of dissolved oxygen create healthier aquatic environments to prevent adverse impacts to fish and wildlife.

Best Management Practices

Since dissolved oxygen levels can be influenced by water temperature, flow rates, the presence of aquatic plants and animals, and inputs from stormwater and wastewater, all of the best management practices outlined above would also have positive effects on dissolved oxygen levels. The Lower Tonawanda sub-watershed had the lowest average levels of dissolved oxygen out of the five priority sub watersheds studied. Moreover, 2015 data collected by Riverkeeper through monthly sampling also showed low levels of dissolved oxygen. As noted above, the Lower Tonawanda sub-watershed is nearing the 10% threshold for impervious cover. This can have drastic effects on water temperature. For instance, data suggests that changes in the level of impervious cover in drainage areas can increase stream temperature by between five to twelve degrees Fahrenheit.

Limiting nutrient inputs, such as from lawn fertilizer, can help address low dissolved oxygen. Efforts to decrease fertilizer inputs are particularly important in the Lower Tonawanda sub-watershed as the team observed grass cuttings and animal access directly abutting the stream.

Recommended Actions to increase dissolved oxygen:

Short Term	○ Plant riparian trees and riparian buffers for shade canopy and to prevent nutrient-laden stormwater runoff from entering waterbodies. • Cost: Low to Medium ○ Limit streambank erosion that carries excess solids into waterbodies. • Cost: Medium to High ○ Limit and educate landowners on proper lawn clipping disposal. • Cost: Low
Long Term	• Install Living Shorelines along riparian lands, especially near recreational uses such as golf courses ○ Cost: Low to High • Reduce fertilizer runoff from lawns by using phosphorus-free fertilizers ○ Cost: Low • Reduce stormwater inputs into waterways that bring warm water into streams, and raise temperatures, allowing for algal growth. ○ Medium to High • Naturalize stream channels that have been channelized or heavy modified to restore stream flow. ○ High

Chapter 6: Upper Tonawanda Creek

The Upper Tonawanda Creek Sub-watershed (UT) is located in the eastern edge of the Niagara River Watershed. It has an area of 127,308.6 acres, or 198.9 square miles, and includes 589.2 miles of waterways. Located in portions of Genesee and Wyoming Counties, UT includes 14 municipalities: Alexander, Attica, the Town of Batavia, the City of Batavia, Bennington, Bethany, Darien, Java, Middlebury, Orangeville, Sheldon, Stafford, Warsaw, and Wethersfield. Also located within the sub-watershed are the villages of Alexander and Attica. The sub-watershed is shown in Map 6.1.

UT's main tributaries, Tonawanda Creek and Little Tonawanda Creek, originate on the Allegheny Plateau and flow northeast through steep wooded ravines to the village of Attica. Both creeks then meander through wetlands and farmed mucklands. Just south of the City of Batavia, the two branches join on the Onondaga Escarpment and take a sharp left turn, flowing west into the Middle Tonawanda Creek Sub-watershed.

Land Use/Land Cover

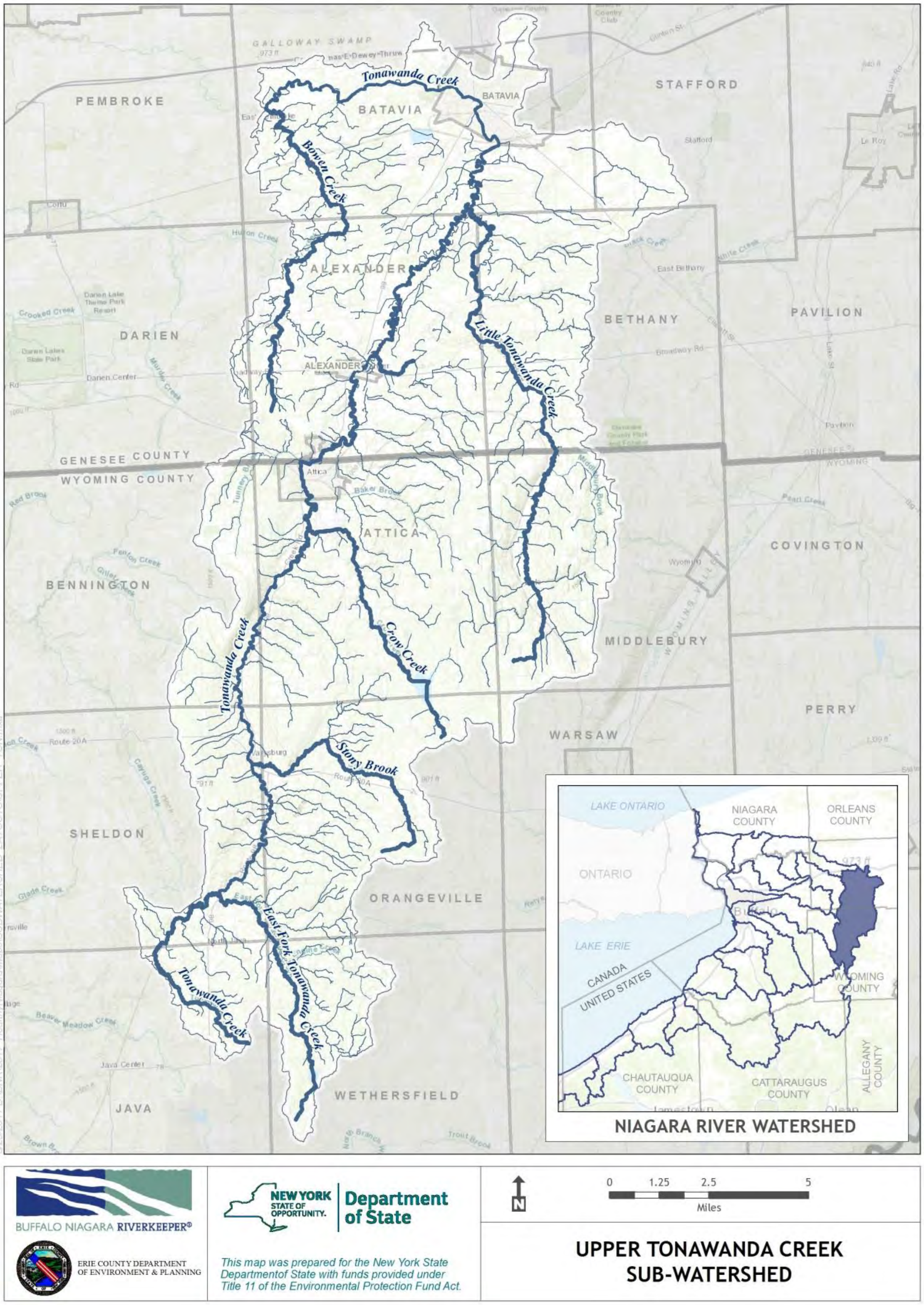
Land Use/Land Cover (LULC) classifications for UT were derived from 2010 National Oceanic Atmospheric Administration (NOAA) LULC data, and like classifications were consolidated into groups that reflect the overall LULC classification.[22] The LULC groups can be seen in Table 6.1.

Table 6.1: LULC Groups and percentages

LULC Class	% by general LULC
Developed, High Intensity	Developed: 4.23%
Developed, Medium Intensity	
Developed, Low Intensity	
Developed, Open Space	
Cultivated Crops	Agriculture: 49.05%
Pasture/Hay	
Deciduous Forest	Forest: 31.80%
Evergreen Forest	
Mixed Forest	
Palustrine Forested Wetland	Wetland: 9.95%
Palustrine Scrub/Shrub Wetland	
Palustrine Emergent Wetland	
Open Water	Water: 0.59%
Palustrine Aquatic Bed	
Grassland/Herbaceous	
Scrub/Shrub	
Unconsolidated Shore	
Bare Land	Other: 4.38%

Characterized by high concentrations of agricultural activities, the most dominant land cover in the sub-watershed is agriculture (41.9%) followed by forest (25.1%), wetland (22.7%), developed land (6.1%), other (3%), and water (1.2%).

Shown in Map 6.2, large amounts of agriculture LULC exist throughout the watershed, with the northern region of the sub-watershed near Batavia becoming increasingly urbanized and developed, while the southern region remains predominately agriculture and forested land.



Map 6.1: Upper Tonawanda Creek Sub-watershed

Active River Area

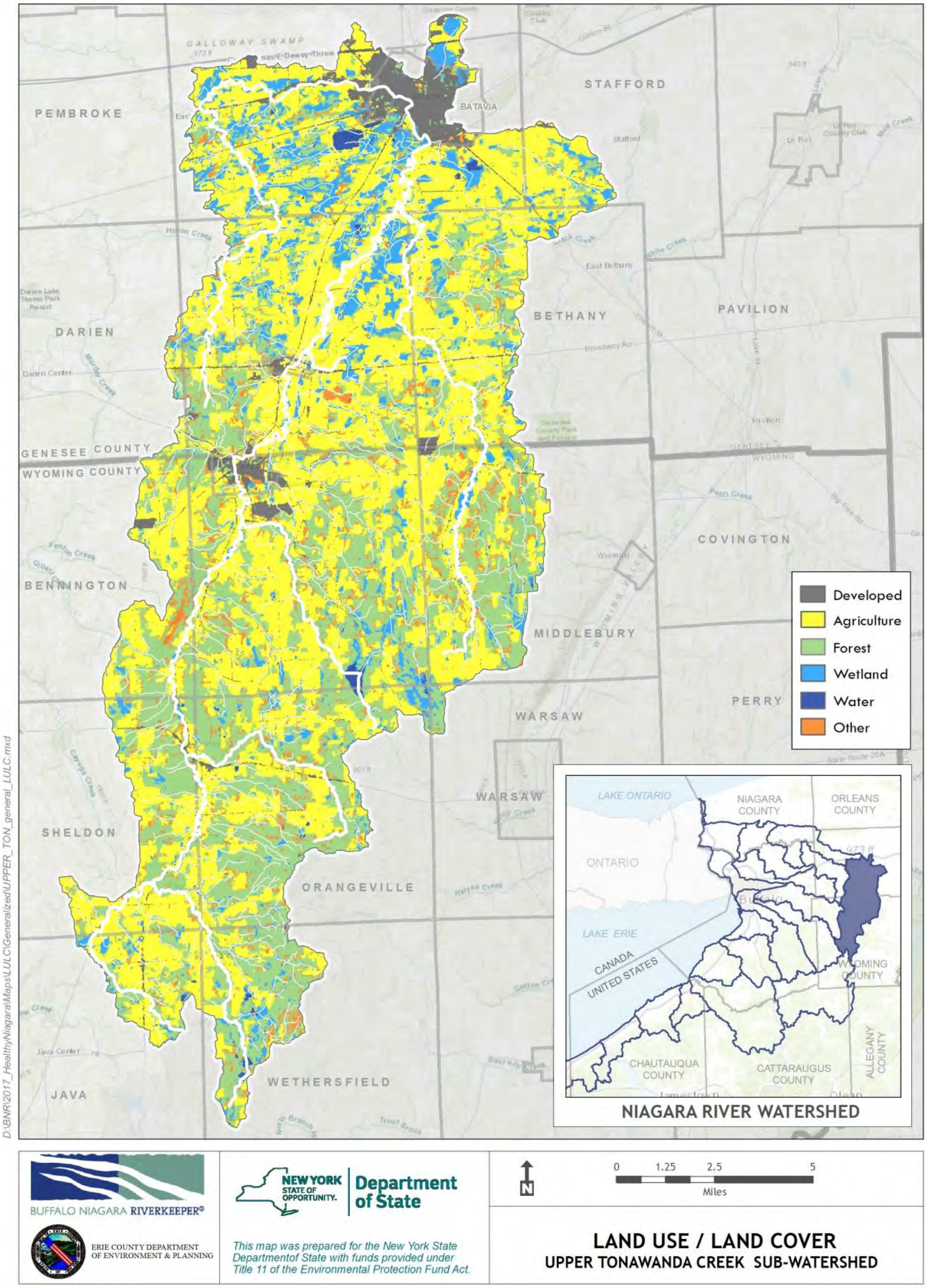
The Active River Area model, as discussed in Chapter 1, was applied to the sub-watershed to determine the extent of the ARA and focus area for this project. The ARA within UT is generally more constrained in the headwaters, becoming more expansive as the waterbodies approach the Town and City of Batavia.

The ARA within UT encompasses 33% of its total area, as seen in Map 6.3.

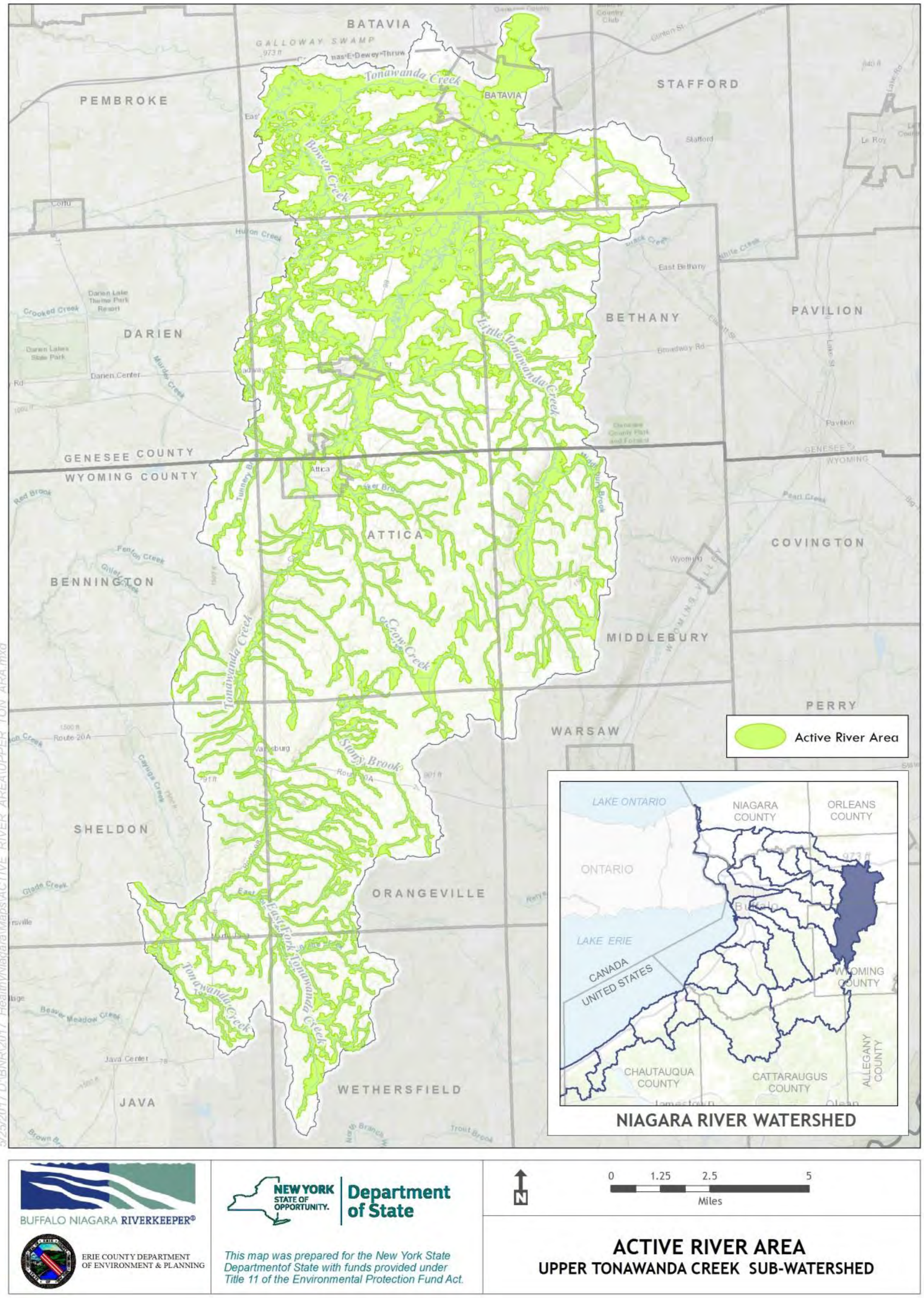
Land Use/Land Cover in the Active River Area

Potential sources of contaminants entering waterways from surrounding lands were identified by overlaying the ARA model on LULC data, to plot where specific land uses interact with streams through natural hydrologic mechanisms. Map 6.4 displays LULC limited to the bounds of the ARA, indicating where contaminants on land may have direct interaction with stream waters.

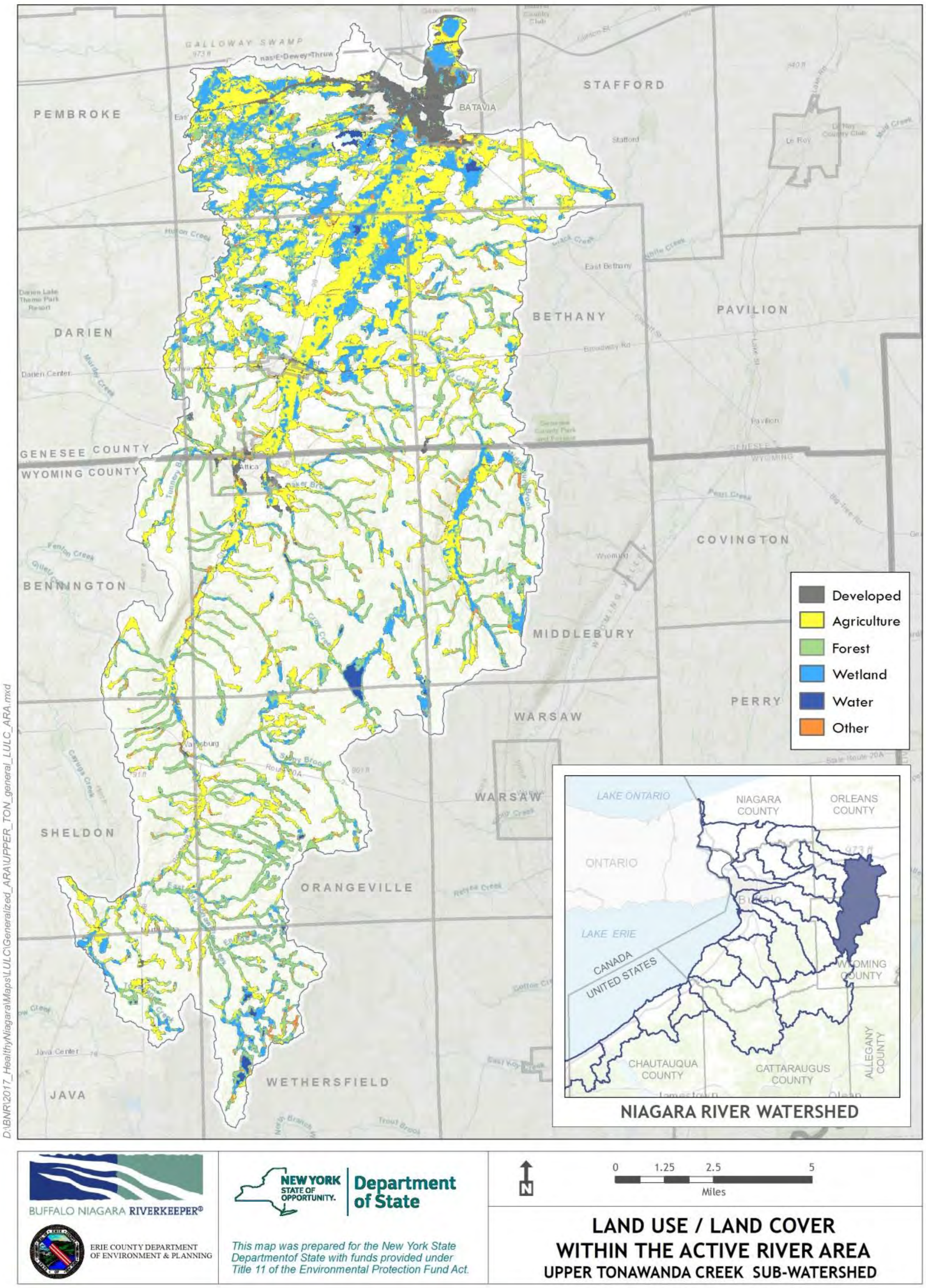
Sections within the ARA in the headwaters of UT interact hydrologically with a variety of land uses such as forest, wetland/palustrine aquatic bed, and agriculture. As the ARA widens flowing downstream, the land-to-stream interaction becomes increasingly dominated by agricultural land use, suggesting that runoff occurs from more homogenous plots of land. Additionally, in the lower reaches of UT, as Tonawanda Creek enters Batavia, land use gives way to urbanized development, where inputs into the creek, such as road runoff and industrial effluent, reflect developed land use and urban environments.



Map 6.1: Upper Tonawanda Creek Sub-watershed Land Use/Land Cover



Map 6.2: Upper Tonawanda Sub-watershed Active River Area



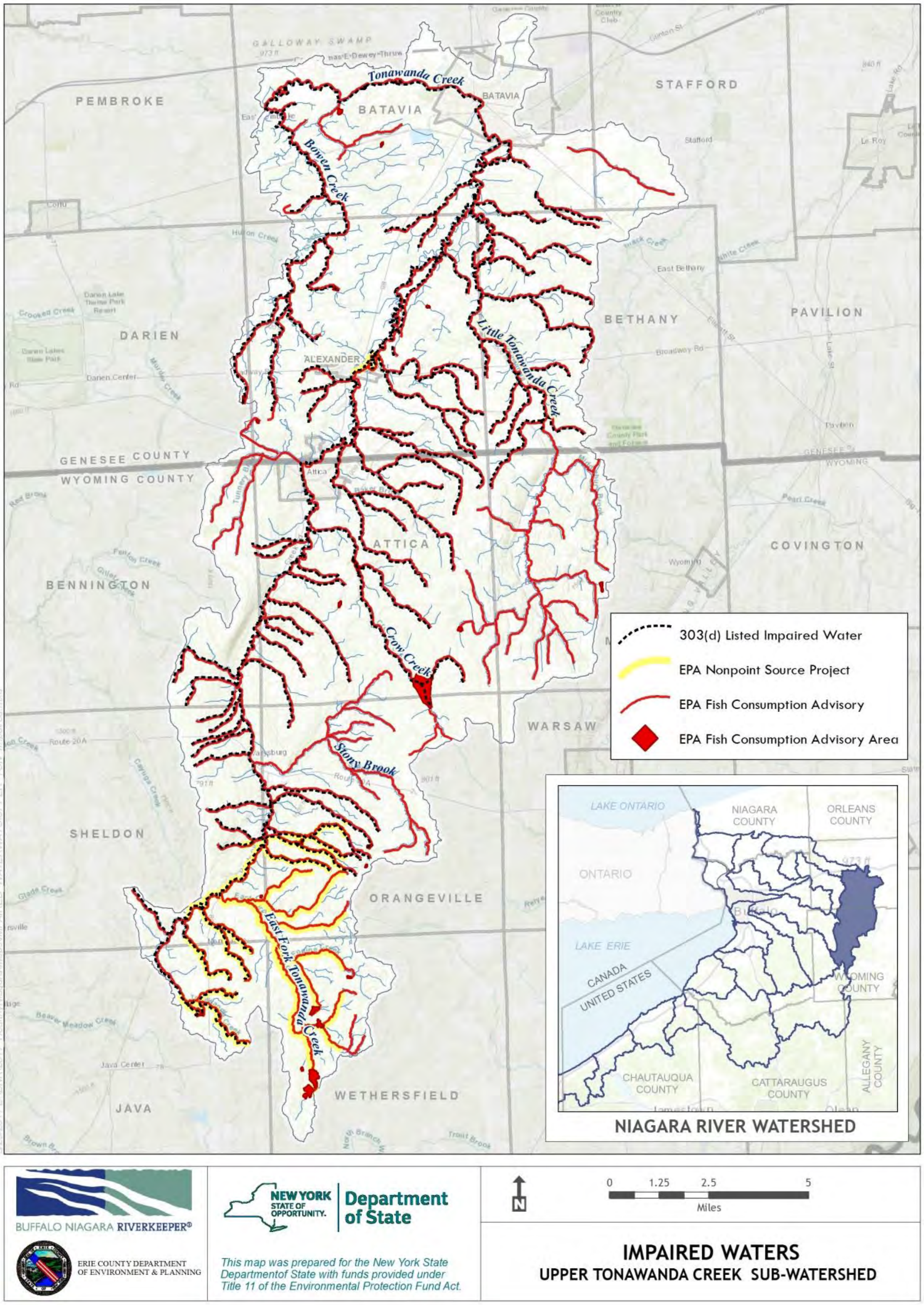
Map 6.4: LULC and ARA Interaction

Impaired Waters

The NYSDEC WI/PWL catalogs several waterbody segments within UT, encompassing 83.5 miles, or 14.2%, as impaired. These segments include East Fork Tonawanda Creek, Little Tonawanda Creek, Stony Brook, Crow Creek, Bowen Creek, Tonawanda Creek and its respective tributaries.

As depicted in Map 6.5, much of the sub-watershed's main streams, Tonawanda Creek, Little Tonawanda Creek, Bowen Creek, and Crow Creek, are listed on the 303(d) list, indicating impaired waterways, while a majority of streams are listed as being under EPA Fish Advisories, including some waterbodies throughout the sub-watershed, such as the Attica Reservoir. The southern tip of the sub-watershed, including the East Fork of Tonawanda Creek, is listed as an area under the EPA Nonpoint Source Project, a program established under Section 319 of the Clean Water Act, and administered by the NYS DEC to "control pollution from nonpoint sources to the waters of the state and to protect, maintain and restore waters of the state that are vulnerable to, or are impaired by nonpoint source pollution"[6].

NYS DEC classifies waterways according to a class system related to uses.[9] Stream classifications for waterways assessed in this project are listed below in Table 6.2. Streams with AA or A classifications are suitable for use as drinking water sources, while streams classified as B, C, or D support descending numbers of uses. The addition of a (T) to a stream classification indicates that the stream may support trout populations, while a (TS) waterway may support trout spawning populations.



Map 6.5: Upper Tonawanda Creek Sub-watershed Impaired Waterways

Table 6.2: NYSDEC Priority Waterbody Classifications

Priority Waterbody	Stream Class	Designated Use(s) Not Supported by the Waterbody			Pollutant(s) of Concern		Source(s) of Pollution	
		Use(s) Impacted	Severity of Impact	Documentation	Type of Pollutant	Documentation	Source	Documentation
Tonawanda Creek, Lower, Main Stem	C	Fish Consumption Aquatic Life Recreation	Impaired Stressed Stressed	Known Suspected Suspected	Priority Organics- PCBs Nutrients Silt/Sediment	Known Suspected Suspected	Toxic/Contaminated Sediment Urban Runoff Sanitary Discharge Streambank Erosion Landfill/Land Disposal Municipal	Known Known Suspected Suspected Possible Possible
Tonawanda Creek, Middle, Main Stem	C	Aquatic Life Recreation Aesthetics	Impaired Impaired Stressed	Known Known Suspected	Nutrients- phosphorus Dissolved Oxygen Silt/Sediment Metals Pathogens	Known Suspected Suspected Possible Possible	Sanitary Discharges Urban Runoff Streambank Erosion Agriculture Municipal-Batavia WWTP On-site/ Septic Systems Landfill/Land Disposal	Known Known Known Suspected Suspected Suspected Possible
Tonawanda Creek, Upper, and minor tributaries	A; Tribs primarily A, A(T), A(TS)	Water Suppy Aquatic Life Recreation	Stressed Stressed Stressed	Known Known Known	Silt/Sediment Nutrients Dissolved Oxygen Thermal Changes Pathogens	Known Known Suspected Suspected Possible	Agriculture Streambank Erosion Hydro Modification Municipal (Attica WWTP) Other Sanitary Disharge On-site/ Septic Systems	Known Known Suspected Suspected Suspected Possible
Bowen Brook & tributaries	C; Tribs primarily C, some B	Aquatic Life Recreation	Impaired	Known	Dissolved Oxygen Nutrients Pathogens	Suspected	On-site Septic Systems	Possible
Crow Creek & tributaries	A	Water Supply	Threatened	Suspected	Pathogens	Suspected	Agriculture	Suspected
Little Tonawanda Creek, Lower & tributaries	A, A(T); Tribs-A	Water Supply Public Bathing Recreation	Stressed Stressed Stressed	Known Known Known	Silt/Sediment Nutrients Dissolved Oxygen Pathogens Salts	Known Known Suspected Possible Possible	Agriculture Streambank Erosion On-site/ Septic Systems	Known Known Possible
Little Tonawanda Creek, Upper & tributaries	A(T); Tribs-A, A(T)	No Use Impairment	---	---	---	---	---	---
Stony Brook & tributaries	A	No Use Impairment	---	---	---	---	---	---
Tannery Brook & tributaries	A	No Use Impairment	---	---	---	---	---	---

Stream Visual Assessment & Water Quality Data Collection

In order to supplement existing data and fill in data gaps, Buffalo Niagara Riverkeeper (BNR) conducted water sampling and stream assessments throughout the sub-watershed. Sampling took place in seven stream bodies in UT during the 2016 field season.

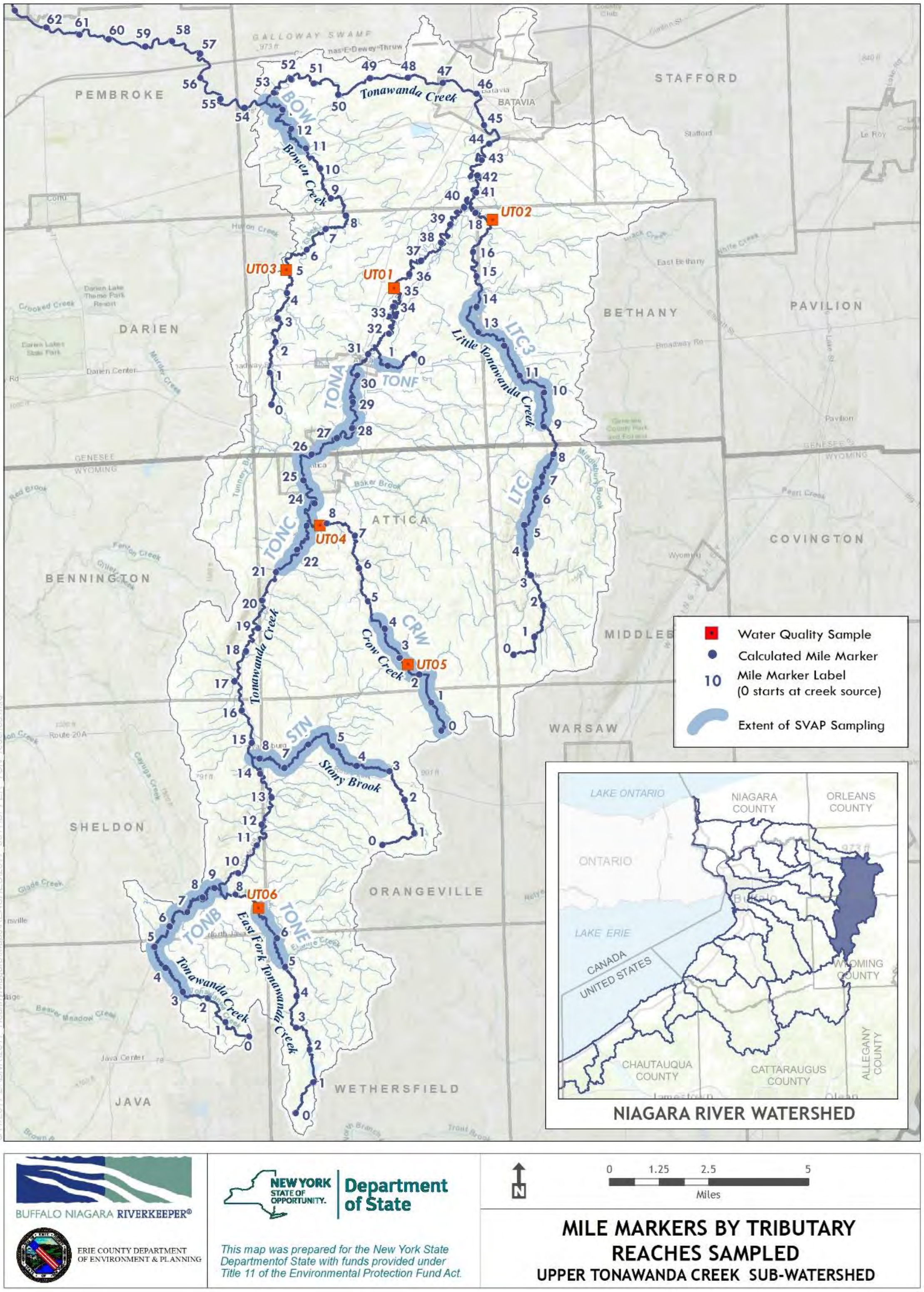
Waterways within UT were assessed from May 23, 2016 to August 3, 2016. Within seven stream bodies, 784 reaches were assessed. Reaches refer to a length of stream 200 feet in length. The streams assessed were Tonawanda Creek, East Fork Tonawanda Creek, Little Tonawanda Creek, Stony Brook, Bowen Creek, Crow Creek, and one unnamed minor tributary. Each stream was broken up into segments and assigned a unique identifier based on location (BOW, CRW, LTC, LTC3, STN, TONA, TONB, TONC, TONE, and TONF).

Table 6.3: Streams Assessed in Upper Tonawanda Creek Sub-watershed

Stream Assessed	Stream Class	Miles Assessed
Tonawanda Creek - Upper and minor tributaries	A	10.9
East Fork Tonawanda Creek	A	1.9
Little Tonawanda Creek	A, A(T)	7.9
Stony Brook	A	4.6
Bowen Creek	C	2.1
Crow Creek	A	2.3

Within UT, 29.75 of the total 589.2 miles (5%) of waterways were assessed using a modified version of the Stream Visual Assessment Protocol (SVAP).[15] Table 6.3 presents the segments assessed.

Stream miles were calculated using ArcGIS software so that stream segments and sample sites could be assigned a unique "mile marker" within the waterways for reference. Mapped segments with mile markers can be seen below in Map 6.6.



Map 6.6: Stream Segments Assessed

Physical Properties

As seen in Table 6.4, UT recorded an average depth of 8.7 inches for the seven streams assessed. The sub-watershed recorded an average bankfull width of 34.0 feet and an average baseflow width of 19.3 feet.

Table 6.4: Upper Tonawanda Creek Sub-watershed Physical Properties

Stream	Average Depth (in.)	Average Bankfull Width (ft.)	Average Baseflow Width (ft.)
Tonawanda Creek	14.3	50.0	33.4
East Fork Tonawanda Creek	8.2	46.8	25.4
Little Tonawanda Creek	10.3	38.4	23.3
Stony Brook	6.8	39.4	18.2
Bowen Creek	9.7	28.8	12.3
Crow Creek	6.7	23.8	13.5
TONF (minor tributary)	4.6	11.1	8.8
Sub-watershed Average	**8.7**	**34.0**	**19.3**

Stream Visual Assessment and Water Quality Findings

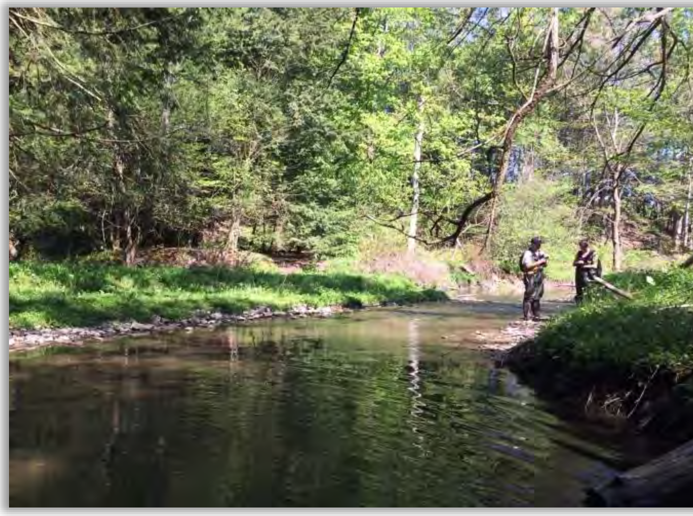
During the Phase 1 process, UT was chosen based on a priority to preserve and protect conditions leading to high water quality and healthy habitat. Throughout the fieldwork process, it became apparent that while many stream segments were indeed in good overall health, many others were in poor condition, exhibiting impairments. Overall SVAP findings from the seven assessed waterbodies within the sub-watershed resulted in an average score of 'fair' (7.0). Within the sub-watershed, the STN stream segment in Stony Brook had the highest average SVAP score, 'good' (7.8). The stream segment with the lowest average SVAP score was the TONA segment in Tonawanda Creek, which recorded an average of 'poor' (5.6).

Table 6.5 presents an SVAP score summary for UT, and a full SVAP summary is available in Appendix D.

Table 6.5: Upper Tonawanda Creek Sub-Watershed SVAP Element Summary

	Channel Conditions	Riparian Zone Left Bank	Riparian Zone Right Bank	Bank Stability Left Bank	Bank Stability Right Bank	Water Appearance	Nutrient Enrichment
# of scores	784	784	784	784	784	784	784
average	9.4	8.5	8.4	7.3	7.5	7.5	6.7
	Instream Fish Cover	**Pools**	**Invertebrate Habitat**	**Canopy Cover**	**Manure Presence**	**Riffle Embeddedness**	
# of scores	784	784	784	784	88	527	
average	4.9	4.5	7.2	5.3	4.5	6.6	

Figure 6.1: Stream visual assessment in Tonawanda Creek (BNR)

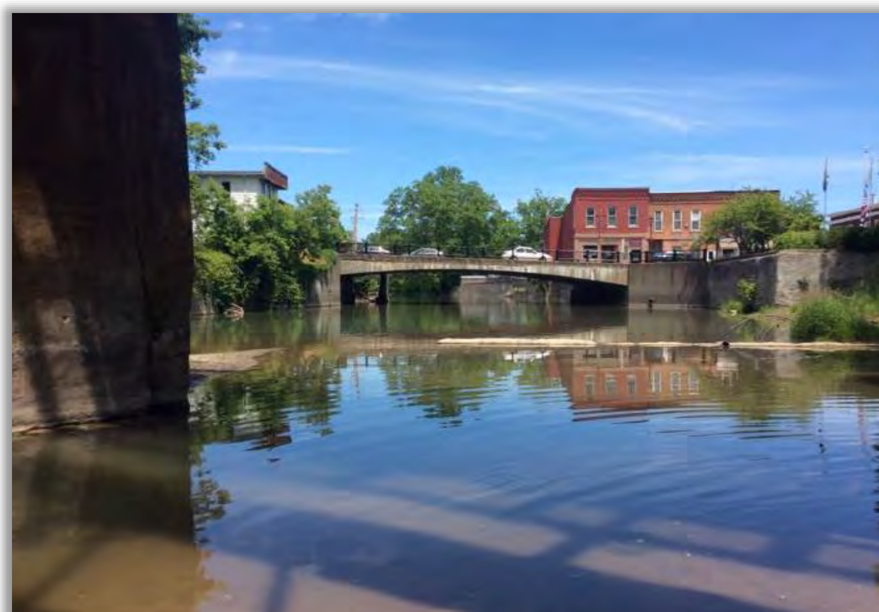


Substrate in UT is predominantly cobble, with 45% of assessed reaches having a cobble substrate. Silt/clay was observed to account for 22% of the sub-watershed's assessed substrate. Gravel comprised 20%, bedrock 8%, boulder 4%, and sand 2% of the sub-watershed's assessed substrate.

All assessed stretches within the sub-watershed received 'good' or 'excellent' average channel condition scores (8.7+). Stream channels are generally unaltered with limited channelization or use of rip-rap. These natural stream conditions have a positive impact on wildlife and overall stream health. Areas of channel alteration were concentrated around more urban areas, such as the town of Attica. This stretch of stream received the lowest average SVAP score within Tonawanda Creek of 'poor' (2.2), partly due to the level of channelization.

Overall SVAP scores draw attention to Tonawanda Creek, which recorded the lowest average score in UT. Recording an average score of 'poor' (6.0), Tonawanda Creek runs the full expanse of UT from the southern end of the sub-watershed near the town of Java, through the towns of Attica and Alexander, and reaches the city of Batavia in the northernmost section. The creek passes through a variety of different land uses including agricultural, residential, and conservation lands. In contrast, Stony Brook recorded the highest average SVAP score in UT of 'good' (7.8). Stony Brook is a tributary of Tonawanda Creek, and cuts predominately through forested LULC.

Figure 6.2: Altered Stream Channel in Attica - Tonawanda Creek (BNR)



Japanese Knotweed was observed in 9% of assessed stream reaches in UT. Hydrilla was observed in 3%, Phragmites was observed in 2%, and Purple Loosestrife was observed in 1% of all assessed reaches.

In addition to being performed during SVAP, water quality sampling at stationary sites was performed monthly at six sites within the sub-watershed at locations in Bowen Creek, Tonawanda Creek, Little Tonawanda Creek, and Crow Creek from April 25, 2016 to November 15, 2016. It must be noted however, that as discussed above, 2016 sampling took place during drought conditions, and fewer storm events would have contributed to runoff bringing nutrients into waterways.

Table 6.6 displays water quality parameters measured, including the number of measurements performed, high and low values measured, and the average value recorded for each parameter. Full water quality parameter results can be found in Appendix C and D.

Table 6.6: Upper Tonawanda Creek Sub-watershed Water Quality Element Summary

	Temperature ºC	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)	Conductivity (uS/cm)	Total Dissolved Solids (mg/L)
# of scores	187	187	187	186	186
low value	8.6	6.57	66.9	193.8	166.4
high value	27.5	17.05	193.2	854	617.5
average	17.1	11.3	119.3	409.5	311.9
	pH	**Turbidity (NTU)**	**Phosphorus (µg/L)**	**Nitrate (µg/L)**	
# of scores	187	182	181	183	
low value	7.48	0.7	0	400	
high value	8.81	94.2	214.5	34,600	
average	8.1	8.1	33	10,000	

Baseline Indicators

Through the fieldwork portion of this project, parameters that either indicated pervasive impairments throughout the sub-watershed, or had high numbers of water quality parameters exceeding relevant standards or guidance values were isolated for further discussion. These baseline indicators begin to give us a picture of the sub-watershed's health or impairment status during normal, baseline conditions.

Baseline indicators for Upper Tonawanda Sub-watershed are identified as:

- Land Use/Land Cover
  - LULC in UT directly affects water quality throughout the sub-watershed, and stormwater and agricultural runoff is a major vector transporting contaminants from

surrounding land into waterways. LULC also affects suggested management actions, as those actions that are able to be performed on agricultural or forested land may not be appropriate for more developed land.

- Turbidity
    - Turbidity as measured throughout the sub-watershed is consistently high. 51% of water quality samples performed during stream assessments had levels over the NYS DEC standard of 5 NTU.
- Riparian Zone
    - The riparian zone, which measures the expanse of a natural vegetated strip along a waterway, was rated as 'good', but many individual reaches recorded fair and poor scores. A poor riparian zone places stream banks at risk for erosion, and increases the likelihood of contaminant runoff to enter a waterbody. Bank stability is grouped with riparian zone, as a poor riparian zone generally coincides with poor bank stability. While some reaches scored very high, erosion issues were prevalent throughout the sub-watershed, and 'poor' bank stability scores were recorded in every stream segment SVAP assessments occurred in.
- *E. coli*
    - *E. coli* measurements performed in the sub-watershed had levels greatly exceeding recommended levels for recreational use, but as many of the waterways in the sub-watershed are class A, with drinking water uses, *E. coli* inputs must be addressed.
- Nutrient Load
    - Phosphorus and nitrate within the sub-watershed are consistently high, indicating that elevated levels of these parameters are entering waterways.

Baseline Indicators Discussion

Land Use/Land Cover

In relation to the high amount of agricultural land in the sub-watershed, UT features an abundance of farmland of statewide importance[14], a classification established by the NRCS Farmland Protection Policy Act as land "that is of statewide or local importance for the production of food feed, fiber, forage, or oilseed crops."[11] Additionally, the sub-watershed contains nearly 20,000 acres (15.5% of total land) of protected land, the second most in the Niagara River Watershed falling second to only Middle Tonawanda Creek. Land protection and conservation, including easements and regulatory protections (such as state parks, forests, etc.) are critical tools in preserving water quality. If protected these areas will not succumb to urban sprawl or development and will help to preserve the water quality of nearby rivers and streams. This is especially important in such areas where drinking water supplies stem from surface water (Town and City of Batavia), reservoirs (Attica) or underlying aquifers (Alexander).

Turbidity

Figure 6.3: Tonawanda Creek Bank Erosion (BNR)

Tonawanda Creek recorded an average bank stability score of 'fair' (6.1), the lowest of all waterbody segments assessed. All other assessed waterbody segments recorded 'good' average bank stability scores (7.9-8.8). The low bank stability scores along Tonawanda Creek indicate that reaches have a higher existence of, or potential for bank erosion. Several sites with significant stream bank erosion were observed as seen in Figure 6.3. Stream banks with limited riparian vegetation have a greater potential to erode and would receive a poor SVAP score.

A total of 182 water samples from assessed stream segments were collected and analyzed for turbidity. Turbidity refers to the clarity of a liquid. Suspended solids stemming from stream bank erosion, stormwater runoff, and/or other pollutants contribute to turbidity. Cloudy water containing an abundance of suspended solids would record 'high' turbidity. Turbidity readings over the NYSDEC standard of 5.0 NTU were common within UT. Of the 182 samples collected, 92 read over the standard. The assessed segment in Bowen Creek recorded an average turbidity reading of 45.8 NTU, the highest in the sub-watershed.

Riparian Zone and Bank Stability

The riparian zone, or area of natural vegetation bordering waterbodies, along assessed stretches of Tonawanda Creek recorded an average score of 'fair' (6.5), the lowest of all waterbody segments assessed. Poor scores indicate a lack of riparian zone or a narrow riparian zone width in comparison to the stream's active channel. This zone is a vital component to a healthy waterbody, as the roots of riparian vegetation naturally stabilize banks and control erosion. This zone of vegetation also functions as a surface water filter, slowing and absorbing storm water runoff and the various pollutants it may be transporting as well as provides natural shade helping to regulate water temperature.[17]

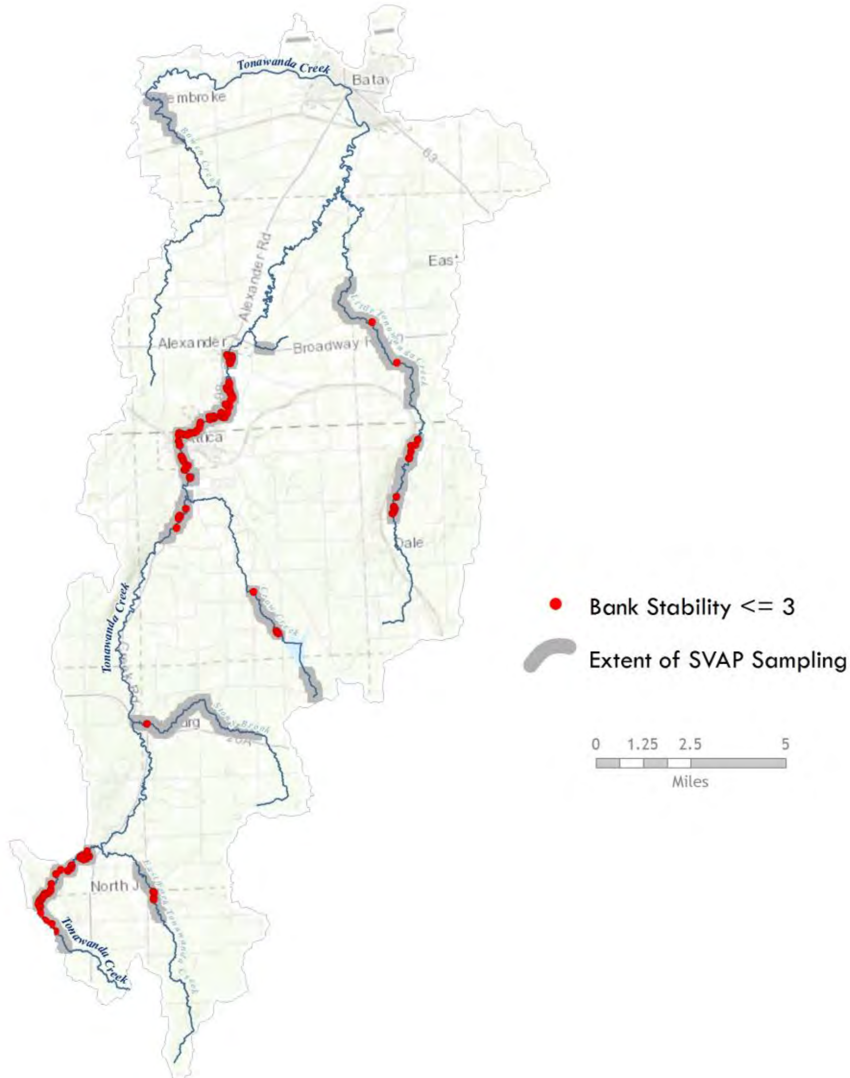
Figure 6.4: Riparian Zone -Tonawanda Creek (Google Maps)

Several sites, many occurring in agricultural areas, were observed along Tonawanda Creek that lacked a riparian zone. The location depicted in Figure 6.4, in particular received poor scores for bank stability and riparian zone (one side), as the stream bank's natural vegetation had been completely removed. The bank was actively eroding, and heightened levels of turbidity and phosphorus were recorded just downstream.

Figure 6.5: Stony Brook Riparian Zone (BNR)

Bank stability scores under 3 for the sub-watershed are shown in Map 6.7 below. A score of 3 indicates that "banks are moderately unstable, typically high, actively eroding at bends; ~50% rip-rap; excessive erosion" while a score of 1 represents "Unstable high banks, actively eroding at bends throughout; dominated by rip-rap."

All other assessed segments within UT recorded 'good' or 'excellent' (8.8+) average riparian zone scores. Excellent scores refer to a riparian zone extending at least two times the width of the stream's active channel. Stony Brook received the highest average score for riparian zone of 'excellent' (9.87). This waterbody was characterized by extensive riparian vegetation as seen in Figure 6.5. This vegetation provides ample shade, which helps maintain cool water temperatures.



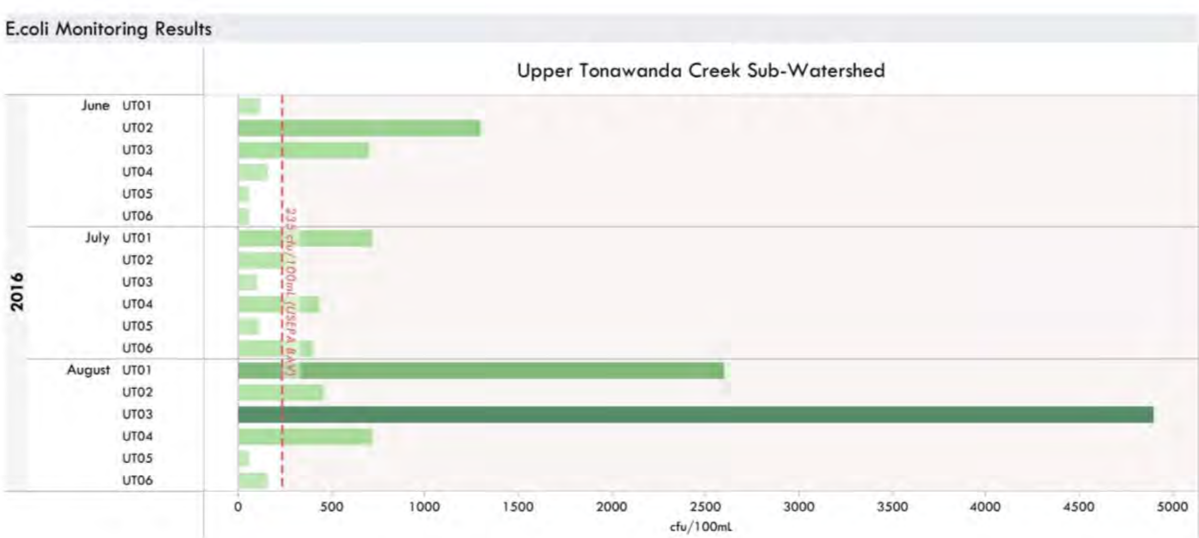
Map 6.7: Bank Stability Scores 1-3

E. coli

Concentrations of livestock activity were observed along Tonawanda Creek as seen in Figure 6.6 (a) and (b). Along some streams, livestock appeared to have unlimited access. Livestock activity can degrade riparian vegetation and escalate bank erosion, and the presence of manure in streams can increase nutrient and bacteria levels. *E. coli* samples collected at 6 various sites within UT frequently exceeded the United States Environmental Protection Agency (USEPA) Beach Action Value (BAV) of 235 cfu/100mL as seen in Figure 6.7. The BAV is a tool often used to assist in making beach notifications and closures.[29]

Figure 6.6 (a) and (b): In-stream Cattle Crossing (BNR)

Figure 6.7: *Escherichia coli* Monitoring Results 2016



Nutrient Load

Samples to assess nutrient levels (phosphorus and nitrate) were also collected and processed. With the sub-watershed having a dominant percentage of agricultural land cover, there is a higher potential for non-point source pollution with high concentrations of nutrients from fertilizers, pathogens, and pesticide chemicals. Phosphorus readings for the sub-watershed recorded an average of 34.64 µg/L, well above the NYSDEC guidance value of 10 µg/L for Lake Erie Eastern basins.[8] Bowen Creek recorded the highest average phosphorus readings in comparison to other assessed stream segments at 72.6 µg/L. Tonawanda Creek recorded the highest average nitrate readings at 13,115.49 µg/L, falling above the NYSDEC standard value of 10,000 µg/L.[6]

Figure 6.8: Abundant growth of aquatic vegetation within Bowen Creek (BNR)

Nitrogen and phosphorus are natural constituents of the environment, but can also be introduced into the system via fertilizers and sewage inputs. Most traditional fertilizers, used both for agricultural or residential purposes, contain nitrogen, phosphorus, and potassium (or potash). Animal manure and commercial fertilizer, used as a crop fertilizer, are primary sources of nitrogen and phosphorus to surface and groundwater via runoff or infiltration.[26]

While nitrogen and phosphorus are vital for a healthy stream, the correct balance is critical to sustain aquatic life.[18] High nutrient levels can fuel growth of aquatic vegetation and algae which can congest streams, restricting water flow and fish movement as seen in Figure 6.8. With elevated plant respiration and decomposition, dissolved oxygen levels become depleted. These oxygen-depleted environments can stress and have detrimental impacts on aquatic life. At times, algae will grow in large, expansive colonies often referred to as an algal bloom. Under the right conditions, some algal blooms will produce toxins that can be dangerous to wildlife and human health.[14]

During monthly sampling phosphorus levels measured at the same stationary sites ranged from 0 µg/L measured in June, to a high level 148.5 µg/L measured in August. While the high value recorded at UT02 is well above the range of other measurements within the sub-watershed, it is in line with observations made in other sub-watersheds where agricultural land use is prevalent. UT02 is located between active farm fields, and is also directly downstream of a registered medium Consolidated Agricultural Feeding Operation (CAFO), so high levels of pollutants related to agriculture and livestock operations are to be expected.

Nitrate samples collected at the six sites generally fell below the NYS DEC standard value of 10,000 µg/L, but some high values were recorded, especially in the spring. Agricultural fertilizers, often applied in the early spring before planting occurs, are susceptible to runoff. This may explain the nitrate spikes observed in at UT01, UT02, UT03, and UT05 in April during monthly water quality sampling.

Eighteenmile Creek Critical Source Areas

CSAs in UT are depicted in Map 6.8, and displays CSAs using the methodology described on page 1-9.

“Critical” source areas are those land uses known to contribute to impairments, and are designated as priority areas for intervention. “Non-Critical” sources are those passive land uses such as forested lands that do not actively contribute impairments.

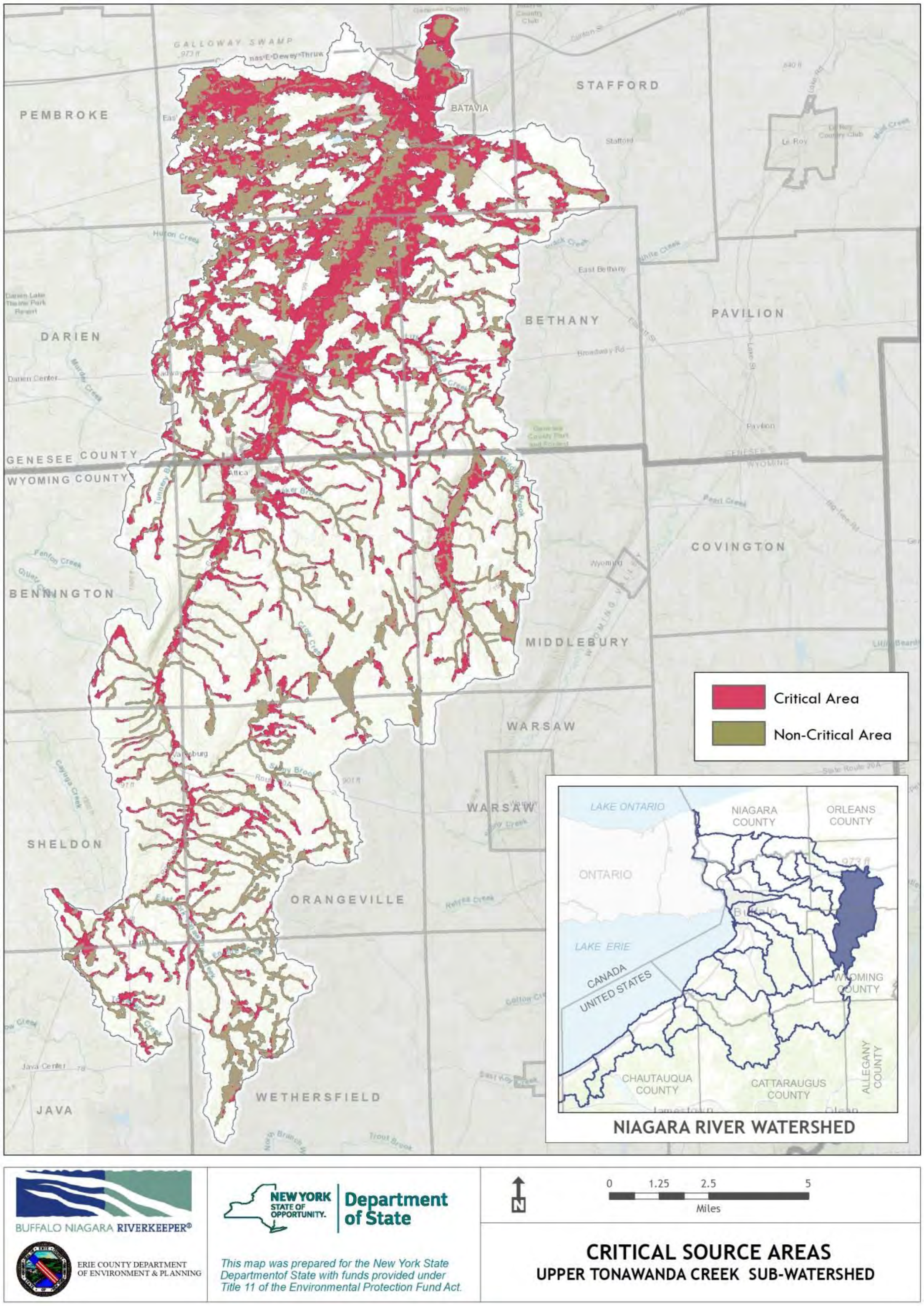
CSA Conservation Priorities

As noted previously, agricultural land use is dominant in the Upper Tonawanda Creek Sub-watershed. High percentage of agricultural land use leads to numerous targeted areas throughout the watershed where agricultural best management practices need to be applied in order to limit impacts to stream health and maintain climate resiliency. Three core forest areas are identified as protection priorities. These areas include riparian forests surrounding Tonawanda Creek near the Village of Attica, the headwater forests of Crow Creek, and headwater forests of the East Fork of Tonawanda Creek at the southernmost end of the sub-watershed.

Three potential, high priority fish barrier removal projects are also located in the southernmost headwaters of Tonawanda Creek. Removal of fish barriers at these locations will increase fish passage and therefore increase the number of stream miles suitable as fish habitat in the sub-watershed. Due to the sub-watershed’s agriculturally dominated land use, critical source areas due to impervious cover are not frequent but those that do occur throughout should be addressed.

Several headwater streams of Tonawanda Creek would benefit from re-classification in order to better reflect and protect current conditions. Trout observations have been documented in these locations but current stream classifications do not include the trout habitat (t) and trout spawning (s) designations. Updating stream classifications in locations where data knowingly supports adult and spawning trout habitat would increase protections for sensitive native species like eastern brook trout.

Several projects have been through Buffalo Niagara Riverkeeper's Niagara River Habitat Conservation Strategy, which are seen as priority projects for conservation lands that may directly address impairments in the sub-watershed. These projects are included as Appendix I.



Map 6.8: Critical Source Areas

Target Goals for Baseline Indicators

As specific management actions are carried out, baseline indicators can be used for comparison or to determine the effectiveness of implementation efforts. Suggested management actions are also developed to address baseline indicators, as these indicators can vary regionally and can be tuned to address a sub-watershed's unique characteristics.

Land Cover: Land cover can provide valuable information related to water quality and overall watershed health. With increased development and urbanization, areas with impervious cover will also increase. According to the Center for Watershed Protection, water quality can begin to degrade at 10% impervious cover. [3]

> **Future Goal:** Reduce the amount of impervious cover within the sub-watershed.
>
> **Target:** In data compiled in 2005, UT contains 3.3% Impervious Cover. This percentage should be analyzed in future years with a target of it remaining at or below 3.3%.
>
> **Future Goal:** Conserve and protect undeveloped land in the sub-watershed.
>
> **Target:** Engage communities in the sub-watershed to develop a cross-municipal land conservation strategy.

Turbidity: Erosion of shorelines contributes to turbidity and sedimentation of waterways. High turbidity levels were common throughout UT in the 2016 field season. Turbidity can be used as an indirect indicator of the concentration of suspended matter.

> **Future Goal:** Restore steep and actively eroding shorelines to decrease erosion and sedimentation in streams.
>
> **Target:** Meet NYSDEC water quality standard or set a higher reachable level <25 NTU throughout the sub-watershed.

Riparian Zone and Bank Stability: Vegetation bordering waterways naturally stabilizes banks, controls erosion, functions as a natural filter for water runoff, and cools water temperatures via shading. The natural riparian zone has been removed or severely altered within the sub-watershed.

> **Future Goal:** To increase the length and width of riparian vegetation along streams within the sub-watershed, and incentivize and encourage riparian buffer ordinances.
>
> **Target:** Increase the width of riparian vegetation to 2 times the active channel or 300ft, whichever is greater.

Future Goal: Work with communities, agencies, and municipalities to implement stream bank stabilization programs at actively eroding sites.

Target: Stream stabilization at reaches scoring 3 and below in SVAP Bank Stability (Map 4.7).

***E. coli*:** As a bacterial indicator, *E. coli* is used to monitor the presence of human/animal waste in waterbodies. Sources may include fertilizer, livestock, sanitary discharges, or compromised septic systems.

Future Goal: Reduce access of livestock to streams and stream banks thereby limiting bacterial inputs.

Future Goal: Provide resources to communities to upgrade outdated and deteriorated septic systems.

Future Goal: Municipalities continue to disconnect sanitary sewer overflows from discharging into waterways.

Target: Samples test at or below USEPA BAV throughout the sub-watershed, or reduce 30-day geometric mean value to meet USEPA recommended value of 126 cfu/100mL.

Nutrient load: Resulting from stormwater runoff, wastewater treatment plants, septic systems, and (possible) fertilizer use, high nutrient levels are commonplace throughout the sub-watershed.

Future Goal: Reduce loadings of nutrients, specifically phosphorus.

Target: Meet NYSDEC guidance values

- Phosphorus NYSDEC guidance value for Lake Erie Eastern basins of 10 µg/L
- Nitrate NYSDEC standard value of 10,000 µg/L

Suggested Management Actions

The work performed during this project, along with the compilation of preceding data collection and inventory of watershed characteristics, is intended to support the development of an action plan consisting of suggested management actions. Actions suggested below are intended to be part of an ongoing, dynamic process, in which management actions are periodically revisited to address changing conditions and management goals with the Lake Erie/Niagara River Watershed.

By implementing the general strategies and recommendations detailed here, the sub-watershed will be on track to meet the previously listed targets for various baseline indicators. These recommendations focus on key issues facing the sub-watershed and are not intended to act as a comprehensive list of everything that could be implemented.

The following management actions and goals are derived from the baseline indicators developed through the field assessments performed for this sub-watershed, including SVAP assessments and WQ monitoring.

These suggested management actions apply to: homeowners, municipalities, volunteer groups, agricultural landowners, organizations and agencies working within the sub-watershed.

Land Use

Goal: Maintain, or reduce, the amount of impervious cover within the Upper Tonawanda sub-watershed below current level of 3.3%

<u>Benefit:</u> According to the Center for Watershed protection, water quality begins to degrade at 10% impervious cover. The Upper Tonawanda sub-watershed has an estimated 3.3% impervious cover. Due to the low amount of impervious cover within the sub-watershed making changes and updates to existing spaces will likely have the greatest impact. Ideas for retrofitting existing spaces include increasing pervious surface by using porous material in constructing roadways and parking lots beyond what may be required by the NYS Stormwater Manual. Similarly, strategically integrating green and living infrastructure such as rain gardens, green roofs and natural or constructed wetlands into existing landscaping can reduce the volume of run-off from impervious surfaces, therefore lessening the frequency of combined sewer overflow (CSO) events which negatively impact waterways. Reducing the frequency and magnitude of CSO events, will in turn improve turbidity, fecal contamination and nutrient loadings, three of the other identified impaired indicators.

Best Management Practices

The actions outlined in the table below are organized into three broad categories: green and living infrastructure, land use policy changes and community engagement.

<u>Implement Green Infrastructure | Living Infrastructure</u>

By incorporating simple living infrastructure practices such as bioswales or rain gardens into small-scale development plans or implementing broader techniques across a larger scale, the resulting effect will be to help to collect rain water before it is able to flow over impervious surfaces, collect pollution and enter bodies of water. In addition, the use of porous material in constructing roadways and parking lots beyond what is required by the NYS Stormwater Manual, rain barrels to disconnect rooftop runoff and incorporation of strategically preserved or placed green and living spaces into landscaping plans will reduce runoff from impervious surfaces directly into waterways and lessen the negative impacts of combined sewer overflows and stormwater discharges.

As noted in the NYS DEC Stormwater Management Design Manual, a one-acre parking lot can produce 16 times more stormwater runoff than a one-acre meadow each year."[10] Because of this, in a sub-watershed such as the Buffalo River that extends into a once-industrialized urban area, many additional opportunities exist to increase the amount of green space by reclaiming abandoned buildings or parcels for reuse in green infrastructure designs.

Land Use Policy

Recommended changes in land use policies include actions such as updating a municipality's Comprehensive Plan or amending zoning codes. A Comprehensive Plan allows the municipality to clearly state its long-term goals and priorities for a community. While this document is not law, it does inform the law as a municipality would write zoning codes and ordinances that enable it to meet the goals outlined in the Comprehensive Plan. Conservation updates that can be made to code include: conservation overlay districts, steep slope requirements to limit erosion, minimum setback requirements from waterbodies (sometimes called a "waterfront yard" or "buffer" requirement) on new development, or requirements and standards for vegetated buffers along waterways on all lands.

Community Education and Engagement

While regulation through zoning codes forces those living in a municipality to abide by a certain set of laws, some practices are better implemented through landowner cooperation and collaboration. For example, nearly 20% of the sub-watershed is classified as agricultural land and data analysis suggests that agricultural lands may be contributing to water quality impairments in places across the sub-watershed. Here, encouraging landowners to voluntarily participate in conservation initiatives can greatly benefit a community. These initiatives include landowner stewardship like utilizing a vegetated riparian buffer along a shoreline, even if it isn't mandatory or installing a rain barrel on a property to collect rainwater for reuse. Similarly dedicating open space or hosting local clean-up or invasive species removal days can help people feel more connected to their environment thereby fostering a greater sense of community and stewardship.

Recommended Actions to reduce impervious land cover:

Short Term	• Utilize green and living infrastructure practices; rain barrels; no-mow areas; buffers and rain gardens ○ Cost: Low • Reclaim unused or underutilized impervious spaces and develop into "green" spaces like meadowlands, rain gardens or community gardens ○ Cost: Low to Medium • Host sustainable development workshops for municipalities and private landowners ○ Cost: Low • Promote recreational use of natural areas to increase land protection and awareness ○ Cost: Low
Long Term	• Improve/incorporate stormwater management on paved and unpaved roads/parking lots ○ Cost: Medium to High • Reduce new parking lot sizes in urban areas ○ Cost: Medium • Use pervious surfaces and materials when constructing new parking lots or updating existing parking lots beyond the percentage required by the New York State Stormwater Management Design Manual ○ Cost: Medium • Develop vegetative buffer standards to protect stream quality ○ Cost: Low • Creative incentive and educational programs for green infrastructure implementation ○ Cost: Medium • Promote the conservation of open spaces through conversation easements and parks. ○ Cost: Low

Turbidity

Goal: Restore steep and actively eroding shorelines to decrease erosion and sedimentation in streams such that stream quality, at a minimum, meets the NYSDEC water quality standard for turbidity

Benefit: Levels of high turbidity were prevalent in the waters surveyed and tested throughout the Upper Tonawanda sub-watershed. High turbidity in waterways can be an indicator of concentrations of suspended matter. Cloudy or turbid water affects light penetration through increasing light scattering, which typically leads to warmer water temperatures (with lower dissolved oxygen capacity). The effects of turbidity on light penetration also directly affect plant growth, further lowering the dissolved oxygen in water. Typically, lowering turbidity can improve plant growth and benthic communities, which are the basis for the aquatic food chain.

Best Management Practices

Land Use

Any number of actions that limit erosion and lessen sediment loading into waterways will help to combat turbidity. For example, instituting steep slope ordinances, where appropriate, into zoning codes can limit the amount of sediment that enters into waterways from highly erodible banks. Specifically, in the Upper Tonawanda this would be useful tool for Town of Orangeville. The town of Cortlandt, downstate in Westchester County, provides a good example of a steep slope ordinance. The ordinance states the following as one of the reasons for the protection of steep slopes:

> "The Town's experience with past development has shown that the improperly managed disturbance of steep slopes can aggravate erosion and sedimentation beyond rates experienced in natural geomorphological processes. Erosion and sedimentation often include the loss of topsoil, a valuable natural resource, and can result in the disturbance of habitats, degradation of the quality of surface water, the silting of wetlands, alteration of drainage patterns…"

Similarly requiring setbacks and requiring or encouraging vegetated buffers can help to anchor soil to the banks. Installing a Living Shoreline or vegetated buffer of either shrubs and grasses or tall trees can all help sediment remain in place.

Recommended Actions to combat turbidity:

Short Term	• Landowners should replant and reshape failing streambanks with stabilizing vegetation to reduce erosion and sediment deposition ○ Cost: Low to High

Long Term	• Develop restoration plans for severely failing waterways such as Tonawanda Creek and Bowen Creek.
	  ○ Cost: Medium
	• Develop vegetated buffer standards for all waterfront development that ensure a protected, stabilized shoreline.
	  ○ Cost: Low
	• Identify and mitigate or replace improperly installed road/stream crossings and stream barriers
	  ○ Cost: Medium to High

Riparian Zone and Bank Stability

Goal: Increase the length and width of riparian vegetated buffers along stream banks within the sub-watershed

Benefit: Vegetation bordering waterways naturally stabilizes banks, controls erosion, functions as a natural filter for pollutants and cools water temperature by providing a shade over the water. The natural riparian zones in the lower portions of the Buffalo River sub-watershed have been affected by development and upstream, are subject to agricultural stressors. Increasing the width of vegetated riparian zones to twice the width of the stream channel or 300 feet, whichever is greater, would provide the greatest improvement to the health of the waterway.

Best Management Practices

Stream Stabilization

Stabilization of actively eroding shorelines using living and natural infrastructure is recommended where appropriate. Other engineered stabilization techniques should be used only in extreme cases.

Add Vegetation

Hosting community tree planting days in a municipality can provide great benefit to the riparian corridor and improve waterway health with limited costs borne by the municipality. Trees can even be obtained at no cost through the NYSDEC "Trees for Tribs" Program.[5] Similarly installing appropriately sized vegetated buffers in the more open and agricultural areas on the sub-watershed would be very beneficial.

Develop Ordinances

As noted above, including vegetated buffer or setback requirements into a municipality's zoning code is one regulatory mechanism to ensure measures are taken to protect water health. Not all land can be regulated through laws so in some instances encouraging best management practices or utilizing incentive programs may be a more effective approach. Located in the Lower Tonawanda sub-watershed, the Towns of Amherst and Pendleton both include language in their zoning codes for vegetated buffers. For example, Goal 4-4 of The Bicentennial Comprehensive Plan for the Town of Amherst (amended Feb 2011) sets a goal, "To establish buffer/setback standards for new development to help protect streams of significance." This goal is then applied in the town's zoning code in Chap. 204, Part 3 §3-5-6, "Lots abutting a watercourse." This sections requires that lots abutting a watercourse install a 50-foot-wide riparian buffer on either side of a watercourse and further, any building be an additional 10 feet from the buffer.

Recommended Actions to increase the length and width of riparian zones:

Short Term	• Host tree plantings with volunteers
	  ○ Cost: Low
	• Develop programs to encourage the installation of riparian buffer and cover crops
	  ○ Cost: Low to Medium
	• Implement stream and bank stability projects to stop erosion
	  ○ Cost: High

Long Term	• Develop vegetated buffer requirements for development in riparian areas
	  ○ Cost: Low
	• Develop setback ordinances for new development in riparian areas
	  ○ Cost: Medium
	• Encourage collaboration amongst municipalities and agencies to develop zoning codes to encourage conservation and best management practices across waterways that span municipalities
	  ○ Cost: Low

E. coli

Goal: Reduce bacterial inputs into streams

Benefit: *E. coli* is a fecal indicator bacteria used to monitor the presence of human/animal waste in waterbodies. Because few strains of *E. coli* naturalize in the environment, the presence of *E. coli* almost certainly suggests that fecal matter is contaminating a body of water. Sources may include fertilizer, livestock, sanitary sewer discharges, or compromised septic systems. Waterbodies with high levels of *E.coli* are not suitable for consumption or recreating and can result in a chain-reaction of negative human health and economic effects. Reducing *E. coli* levels to meet USEPA's recommended value of 126 cfu/100ml (30 day geometric mean) would greatly improve water quality. Combating *E. coli* requires that the sources inputting the bacteria into waterways be mitigated, such as CSO/SSO outfall mitigation and livestock exclusion.

Best Management Practices

Livestock

When livestock is able to freely roam in and across streams, they can produce a number of undesirable effects such as trampling banks, increasing erosion, and directly inputting sources of bacteria such as *E. coli* into water bodies through excrement. In addition, livestock fecal contamination releases a large amount of antibiotics into waterways, contributing to widespread naturalized antibiotic resistance. If livestock cannot be completely excluded from streams, then at a minimum, limit access by creating a designated crossing. Similarly, some lands have seen success by placing water troughs near the water body so that the cows can easily get to the stream water they may use for drinking but are not directly standing in the stream.

Update and Upgrade Septic Systems

Leaking septic systems are a direct input of bacteria into groundwater which can pollute drinking water and contaminate streams. It is important to recall that the presence of *E. coli* is not the only indicator species of biological pollution—it is just the simplest and most widely tested for. *E.coli* often occurs in tandem with other pathogenic bacteria, viruses and protozoans, such as those that cause cholera, dysentery, and Giardia. Upgrading septic systems with denitrification systems and fixing leaking systems is a necessary solution to mitigate this input.

Green and Living Infrastructure

In more populous areas, CSOs can be a large source of contaminants (particularly bacteria). CSOs occur where a municipality has combined storm and sanitary pipes and where rainfall inundates the system, resulting in more water than the pipes can handle. This results in an overflow situation where the pipes discharge excess untreated water directly into waterbodies. Implementing green and living infrastructure in both urban and suburban areas can drastically mitigate CSO events. By utilizing green and living infrastructure elements like rain barrels, raingardens, wetlands, and other installations meant to trap rainwater and runoff, less water goes into the sewer system resulting in fewer overflow events. In agricultural or suburban areas with larger swaths of open land, utilizing living infrastructure such as woodlands, meadows, and riparian buffers, and living shorelines to intercept stormwater and overland runoff can also help reduce runoff. In agricultural or suburban areas which larger swaths of open land, natural or constructed wetlands and bio-filtration systems can also be beneficial.

Recommended Actions to reduce bacterial inputs into streams:

Short Term	• Utilize livestock exclusion fencing to limit livestock access to and crossing of streams
	  ○ Cost: Medium
	• Install alternative watering facilities for livestock away from streams
	  ○ Cost: Medium
	• Install riparian buffers and covers crops to reduce stormwater runoff which can wash animal byproduct directly into waterways
	  ○ Cost: Medium
	• Install liquid manure retention and targeted spreading systems to prevent manure runoff from crop fields.
	  ○ Cost: High

Long Term	• Encourage the installation of wetland treatment systems or other living infrastructure to replace grey systems
	  ○ Cost: Low to Medium
	• Install vegetated bio-filtration systems such as bioswales and rain gardens
	  ○ Cost: Low
	• Install Living Shorelines along riparian land
	  ○ Cost: Low to High
	• Replace aging infrastructure and remove CSO/SSO outfalls from municipal sewer systems
	  ○ Cost: High

Nutrient Load

Goal: Reduce loadings of nutrients, specifically phosphorous

Benefit: Limiting phosphorus limits algae growth (including nuisance blue-green algae such as *Microcystis spp.)* and allows for more dissolved oxygen in a waterbody. In turn, this results in better aquatic species health and overall cleaner water.

Best Management Practices

High levels of nutrients such as phosphorous and nitrates were found in the waterbodies tested within the sub-watershed. As stated above, all the waterbody segments sampled within the Buffalo River Sub-watershed recorded average phosphorus readings above the NYSDEC guidance value for Lake Erie Eastern basins of 10 µg/L with Sprague Brook recording the highest average phosphorus Interestingly, as the map shows there is agricultural activity in the upper reaches of Sprague Brook. Although this may suggest correlation, it does not show causation. Similarly, nitrate measurements were also found to be above NYSDEC standard value of 10,000 µg/L. The prevalence of high nutrient levels is likely due to the number of sources or inputs including: storm water runoff, wastewater treatment plants, CSOs, septic systems, fertilizers, and improper disposal of lawn debris. Two of the best ways to combat nutrient inputs are through improving land use practices and education.

Land Use

Making minor to moderate changes to the way in which a person interacts with their land can have significant benefits to waterbody health. The actions outlined below provide examples of tactics both private homeowners and agricultural landowners can implement.

Education

Many of the changes that could result in the greatest improvement on the overall health of water bodies are behavioral. Encouraging changes in actions or promoting different protocols can be beneficial to combatting nutrient loadings along waterways. For instance, while in the field, the data collection team observed a number of piles of grass clippings abutting the stream and getting blown into the water. Inputs of grass clippings and yard waste into a waterway cause a direct increase in nutrients. Similar minor changes in farming practices or utilizing well known best practices can have significant impacts to the health of a waterbody. Suburban communities can benefit from individual small changes like using phosphorous-free fertilizer and consulting local town or village officials on lawn debris pick-up policies.

Recommended Actions to reduce nutrient loadings

Short Term	• Agricultural landowners should coordinate with Erie County Soil and Water Conservation District to enact best management practices which reduce nutrient and sediment loading from entering local waterways. ○ Cost: Low • Municipalities should host educational workshops for riparian landowners pertaining to funding opportunities and financial assistance for implementing best management practices for runoff mitigation ○ Cost: Low • Encourage no till farming practices ○ Cost: Low • Utilize cover crops to keep fertilizer laden soil in place ○ Cost varies by crop planted and need to be addressed. For example, planting clover can be inexpensive and eliminate some nitrogen from the soil • Provide educational stormwater trainings for designers and highway officials to ensure stormwater law compliance ○ Cost: Low • Implement "no mow" zones ○ Cost: Low • Appropriately dispose of lawn debris ○ Cost: Low • Use phosphorous-free fertilizer ○ Cost: Low
Long Term	• Develop and implement educational trainings for homeowners about lawn care techniques, debris disposal, native plant species ○ Cost: Low • Promote rotation grazing for livestock ○ Cost: Low • Implement and enforce pesticide and fertilizer use standards and regulations. ○ Cost: Low • Increase watershed stewardship by installing markers and signage for storm drains. ○ Cost: Medium

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