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.

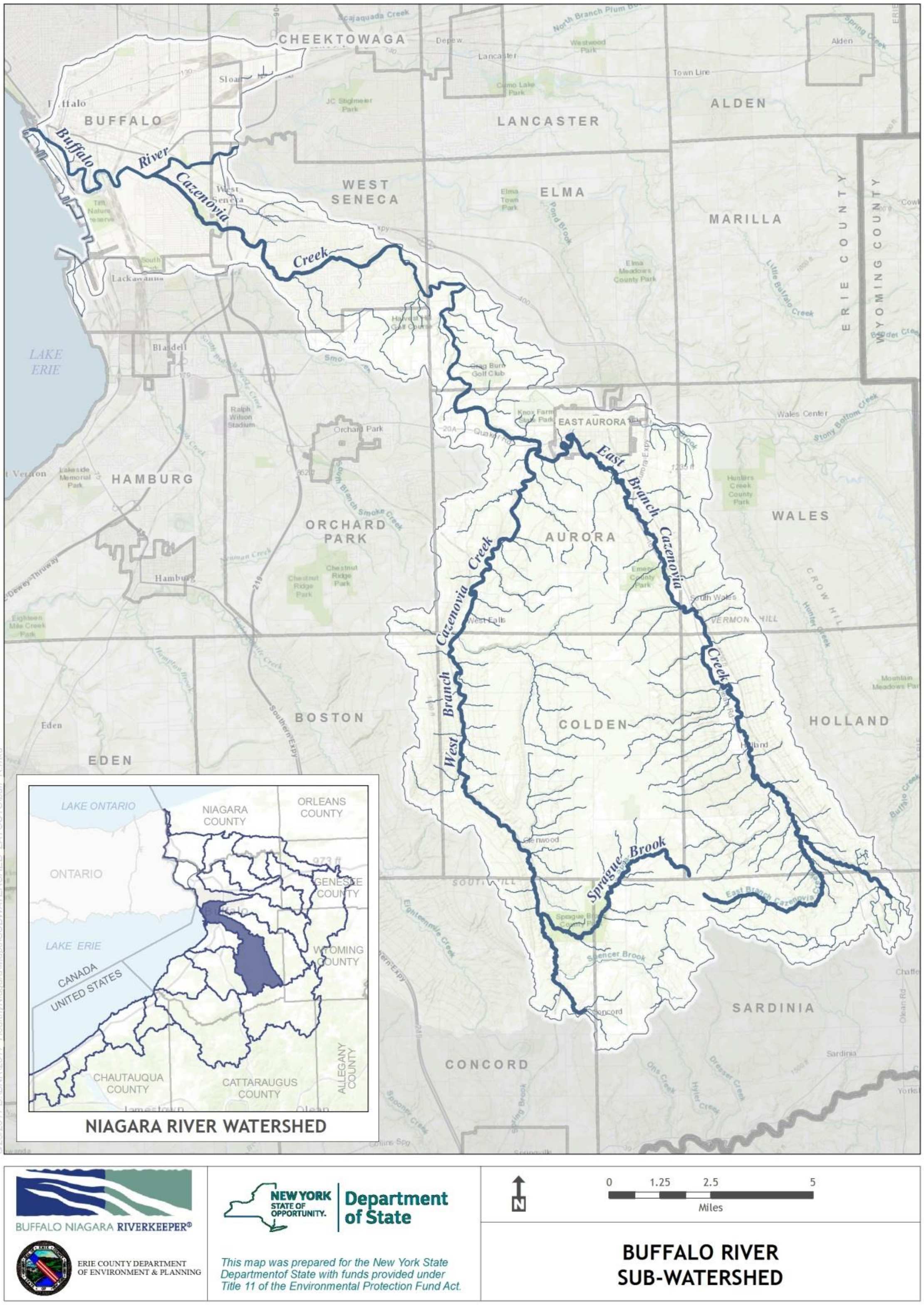
Table 3.1: LULC Groups and Percentages

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.

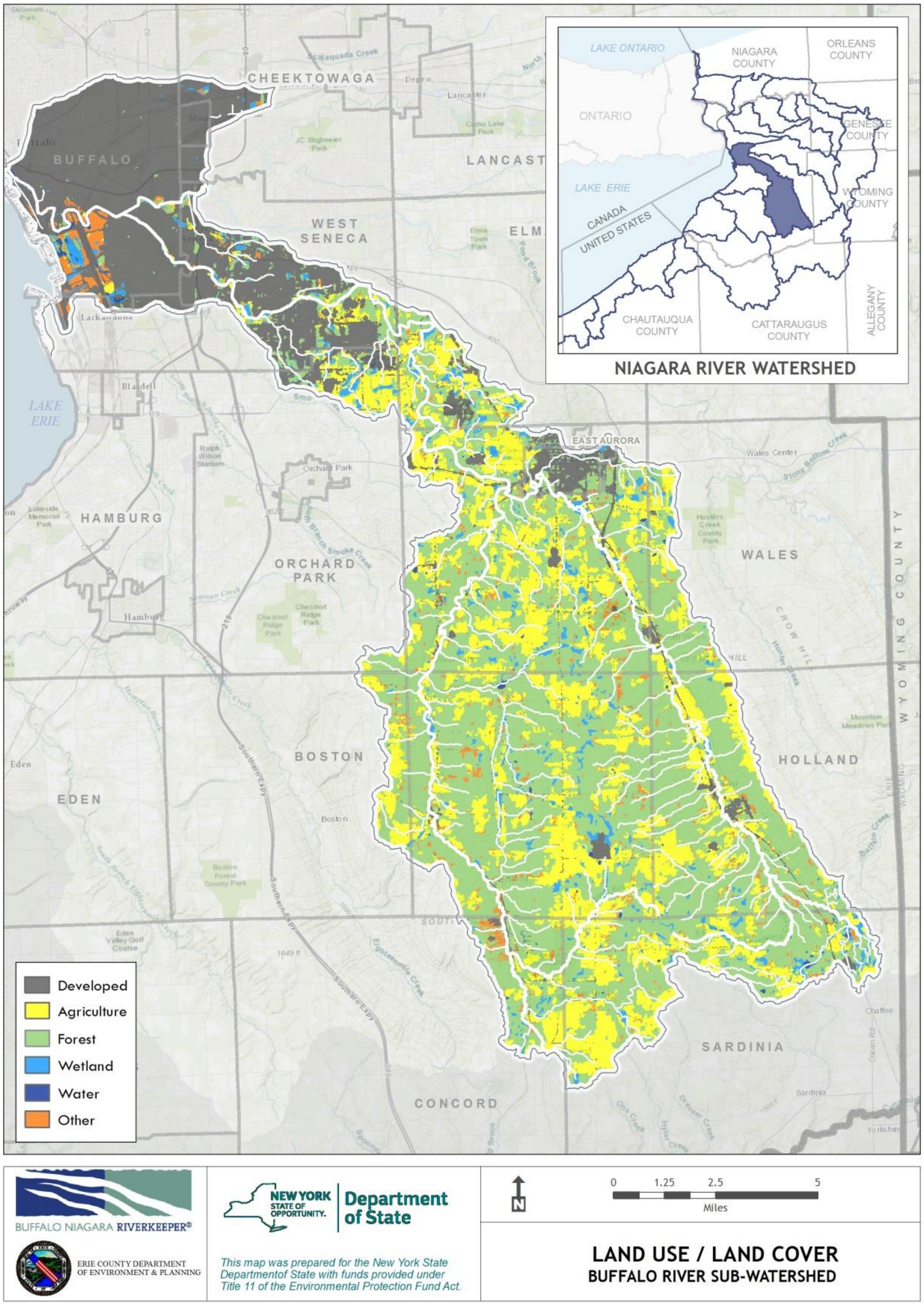
The ARA in BR encompasses 23% of its total area, as seen in Map 3.3.

Land Use/Land Cover in the Active River Area

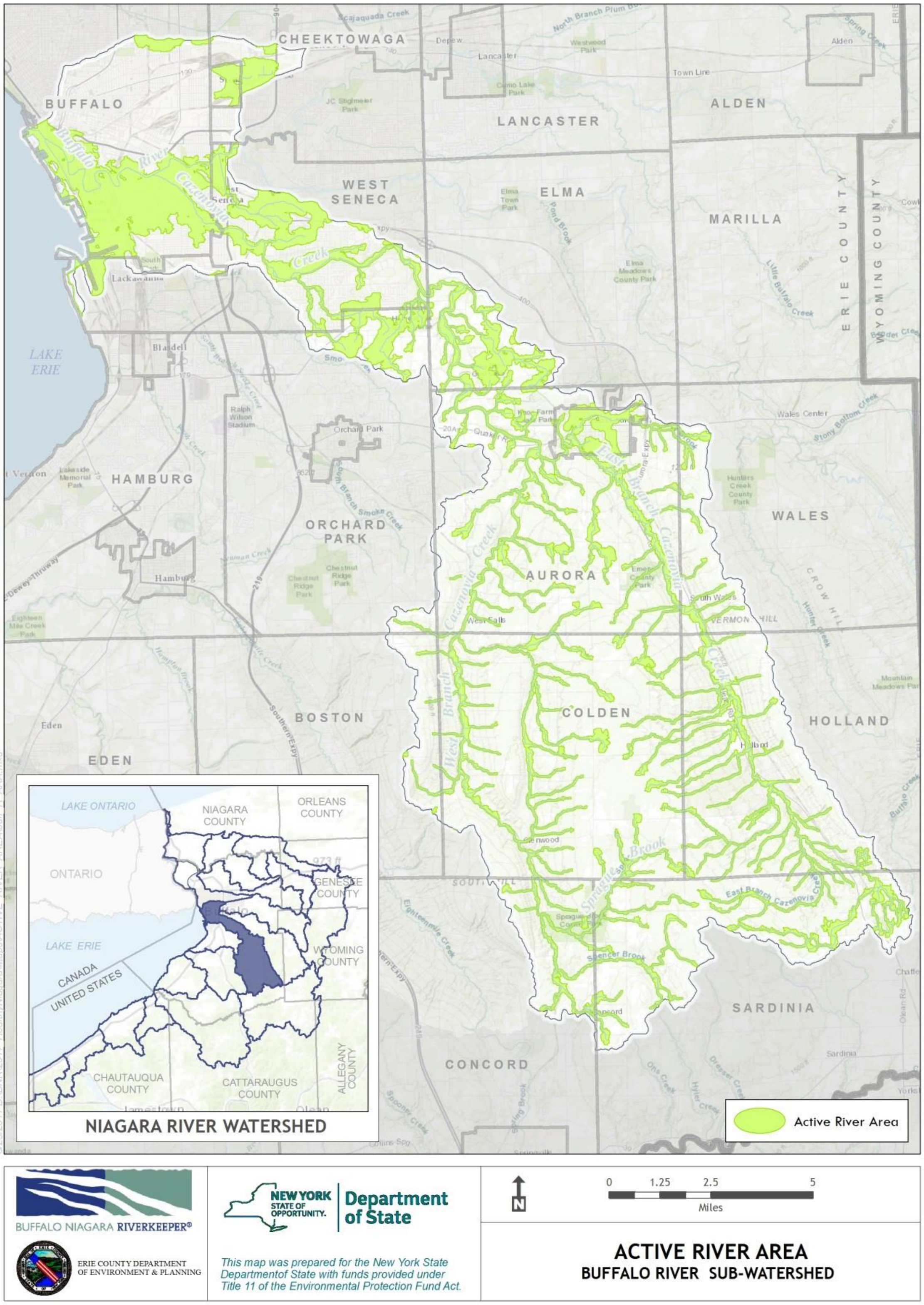
Potential sources of contaminants entering waterways from surrounding LULC were identified by overlaying the ARA model on LULC data, to plot where specific land uses interact with streams through hydrologic mechanisms. Map 3.4 displays LULC limited to the bounds of the ARA, indicating where contaminants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

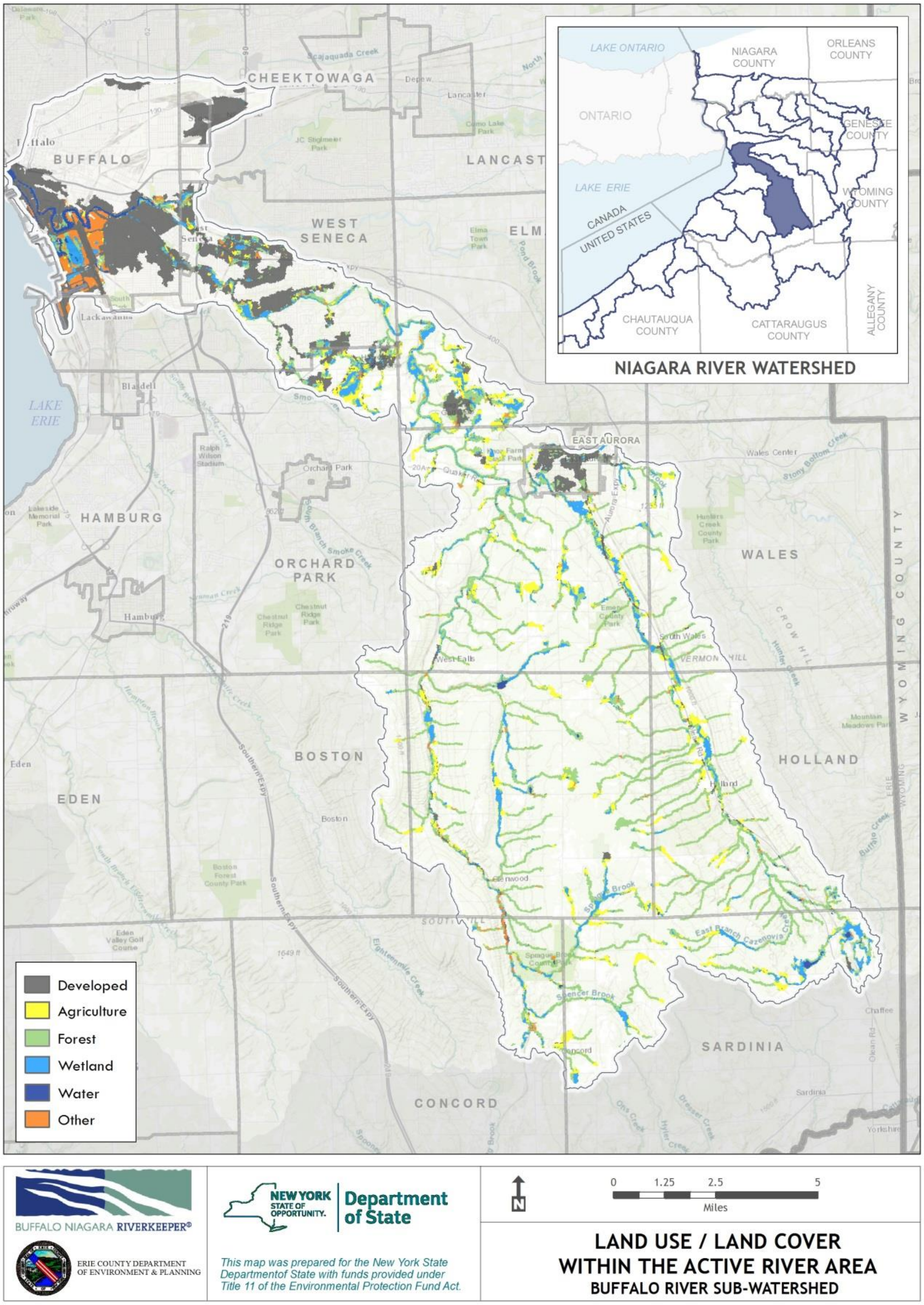
The East Branch of Cazenovia Creek flows through the developed Hamlet of Holland, the heavily developed Village of East Aurora before joining with the West Branch, and becoming Cazenovia Creek. Cazenovia Creek continues on through highly developed West Seneca, before joining Buffalo Creek within the 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



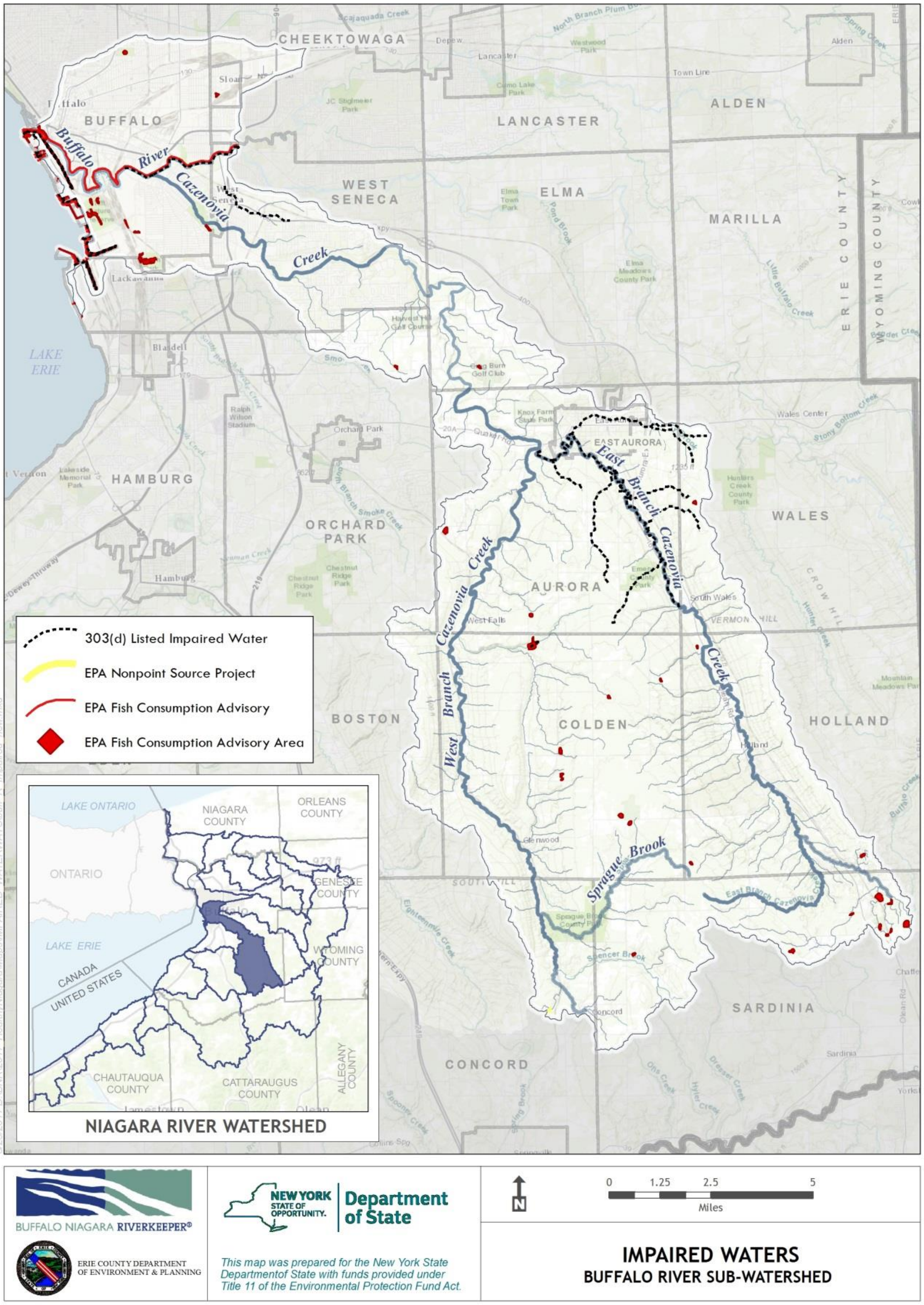
Map 3.4 LULC and ARA Interaction

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

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.

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

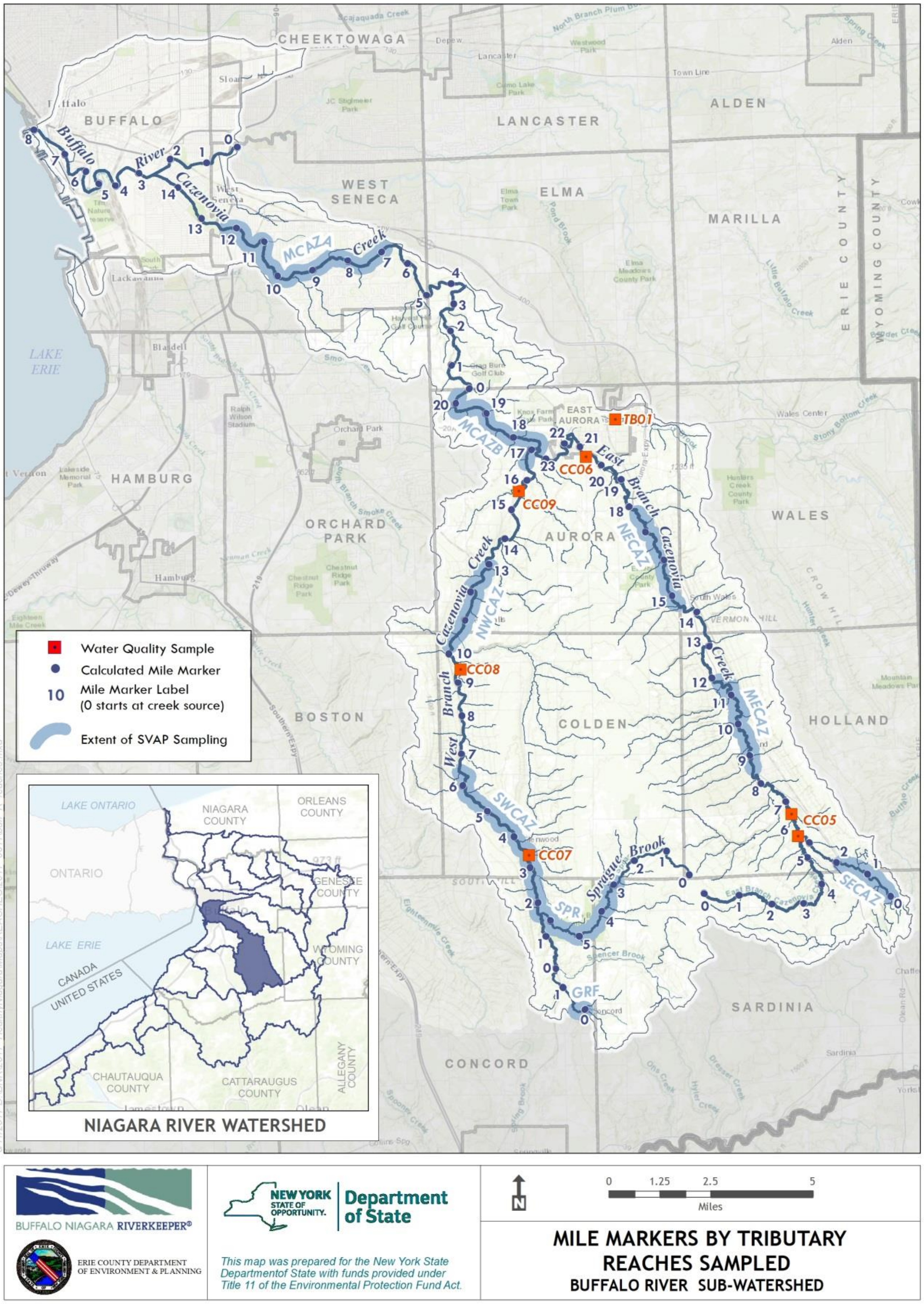
Waterways within BR were assessed from May 18, 2015 to August 4, 2015. Within five stream bodies, 525 reaches were assessed. The streams assessed were Graff Brook, Cazenovia Creek (main, west, and east branches), and Sprague Brook. Each stream was broken up into segments and assigned a unique identifier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

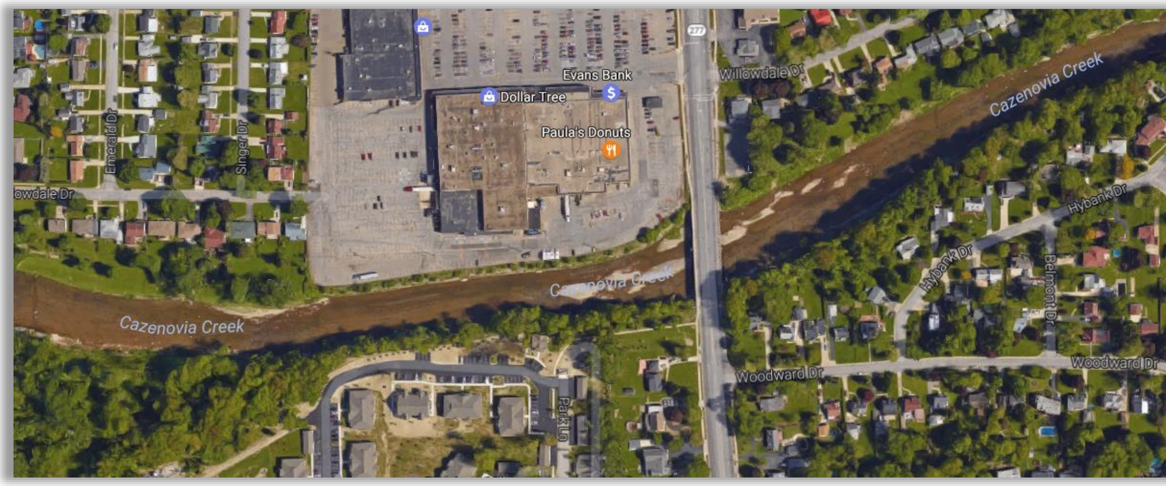
In contrast to the high amount of residential and vacant land, BR also contains nearly 8,500 acres of protected land. Land protection and conservation, including conservation easements and regulatory protections (such as state parks, forests, etc.), are critical components in preserving water quality. 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)



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

Figure 3.4: Riparian vegetation along Sprague Brook (BNR)

seen in Figure 3.4.

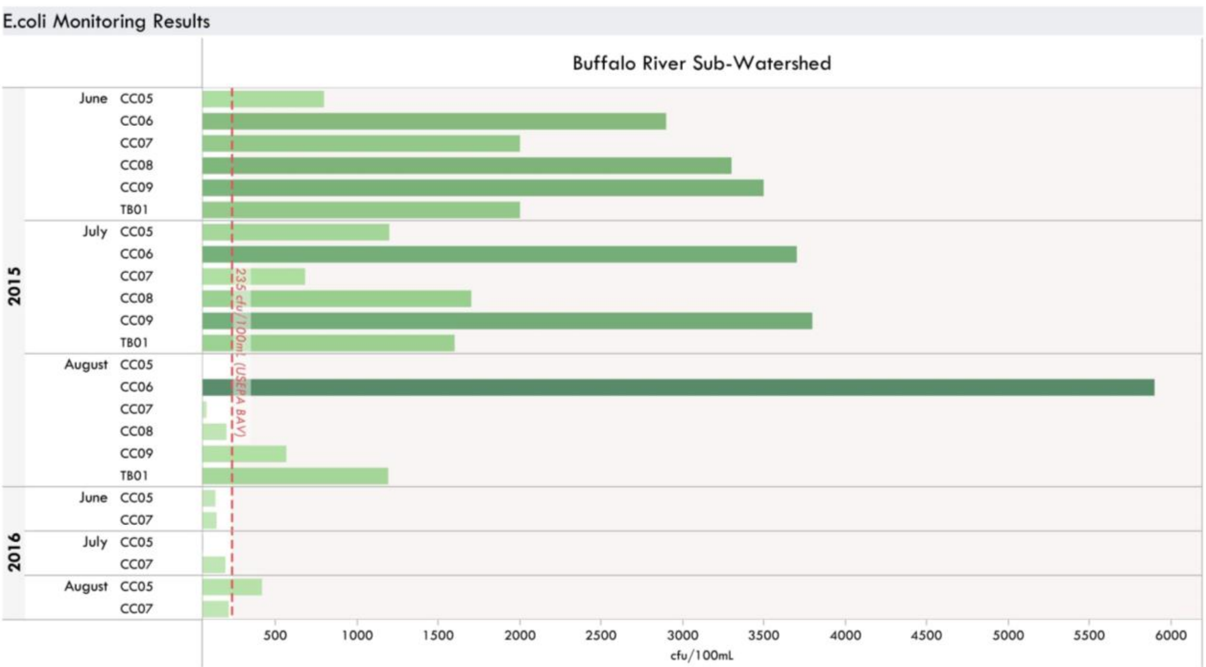
Bank stability within the sub-watershed recorded an average score of ‘fair’ (7.2). Bank stability scores can be impacted by the height of stream banks, current evidence or lack of erosion, and presence or absence of rip-rap. Bank stability was variable from reach to reach with 44% of reaches assessed 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.

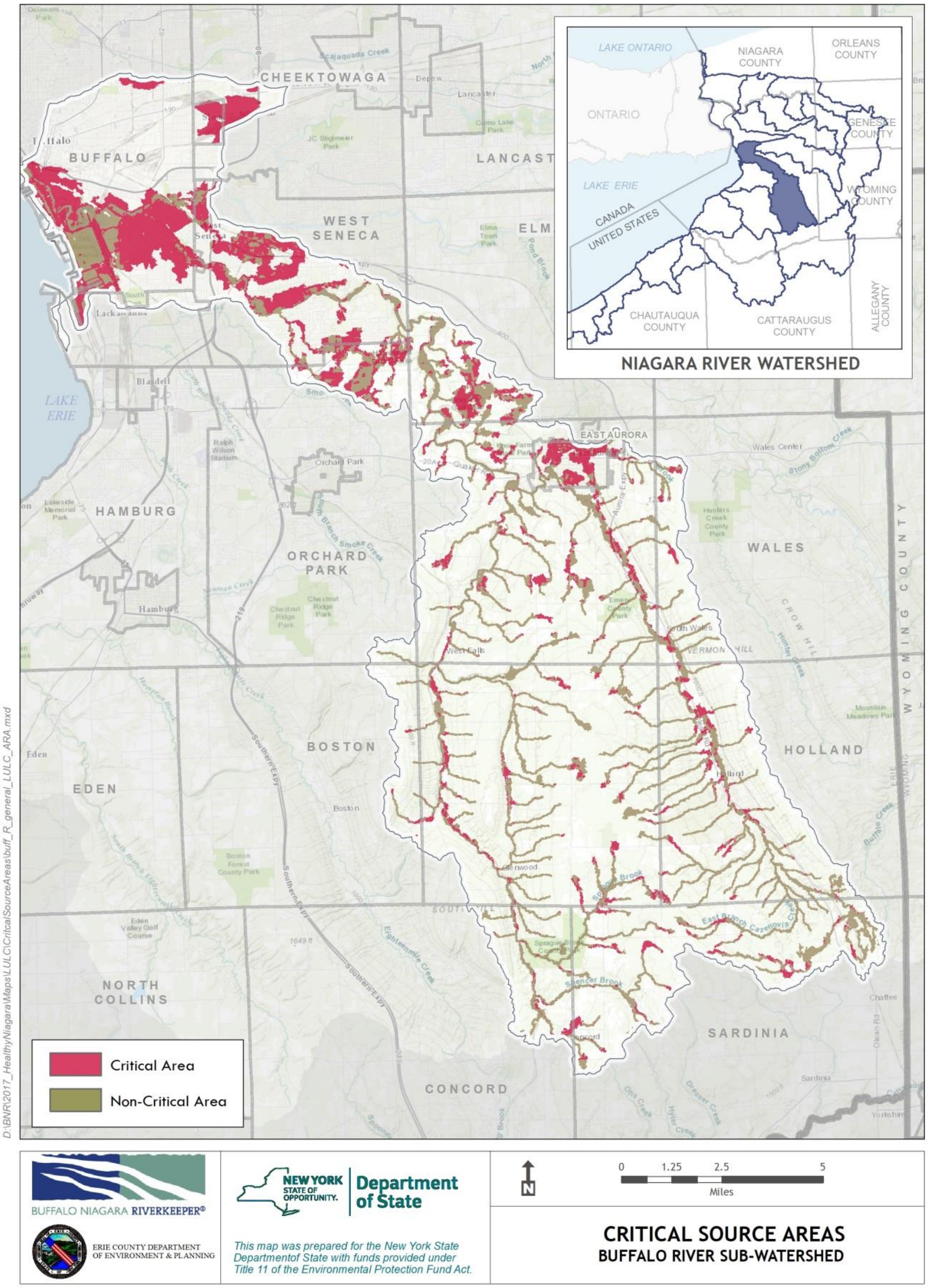
CSA Priorities

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.

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
	• 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

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 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.
	    ○ 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