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

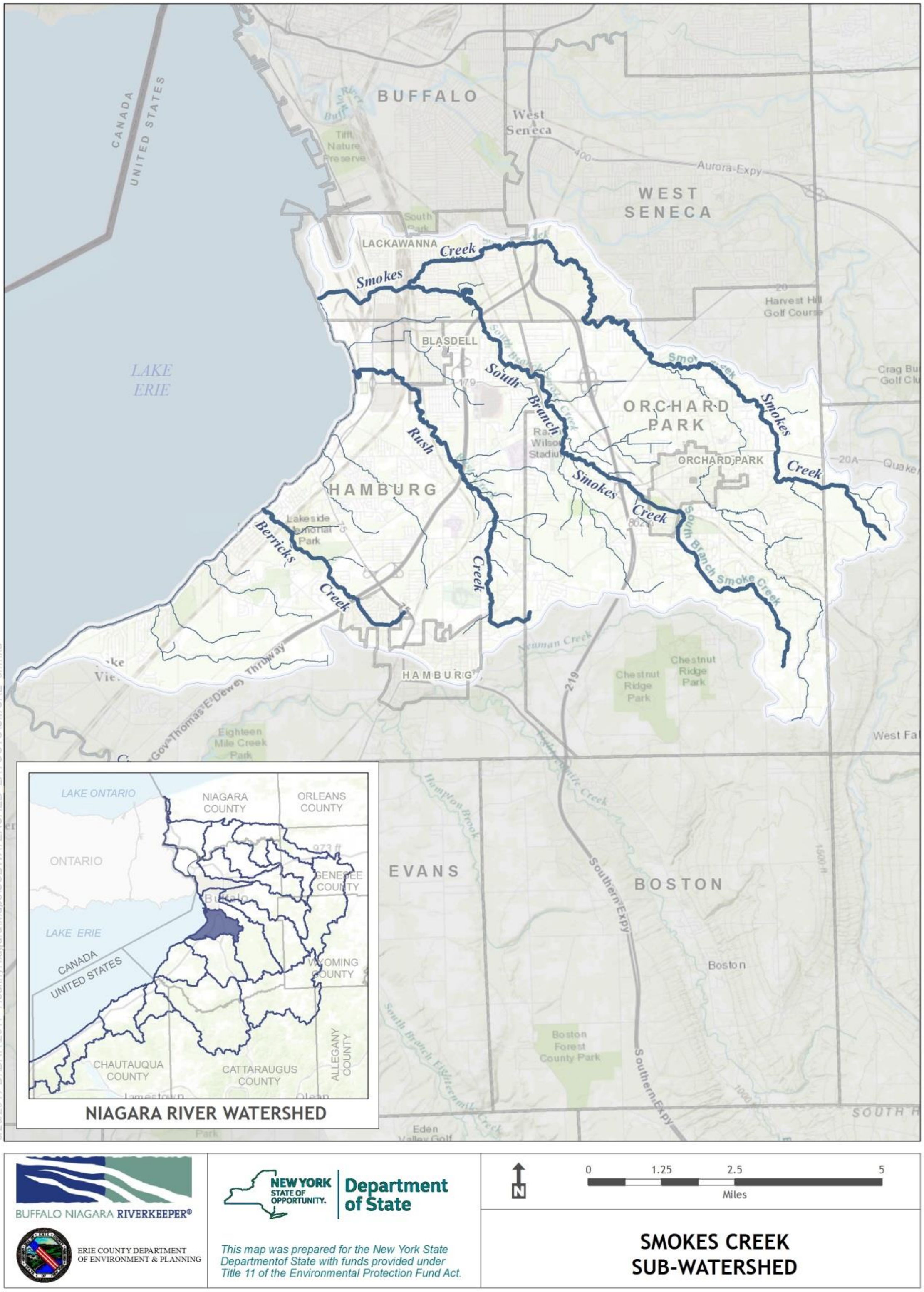
LULC Class	% by general LULC
Developed, High Intensity	Developed: 48.74%
Developed, Medium Intensity	
Developed, Low Intensity	
Developed, Open Space	
Cultivated Crops	Agriculture: 12.16%
Pasture/Hay	
Deciduous Forest	Forest: 24.27%
Evergreen Forest	
Mixed Forest	
Palustrine Forested Wetland	Wetland: 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

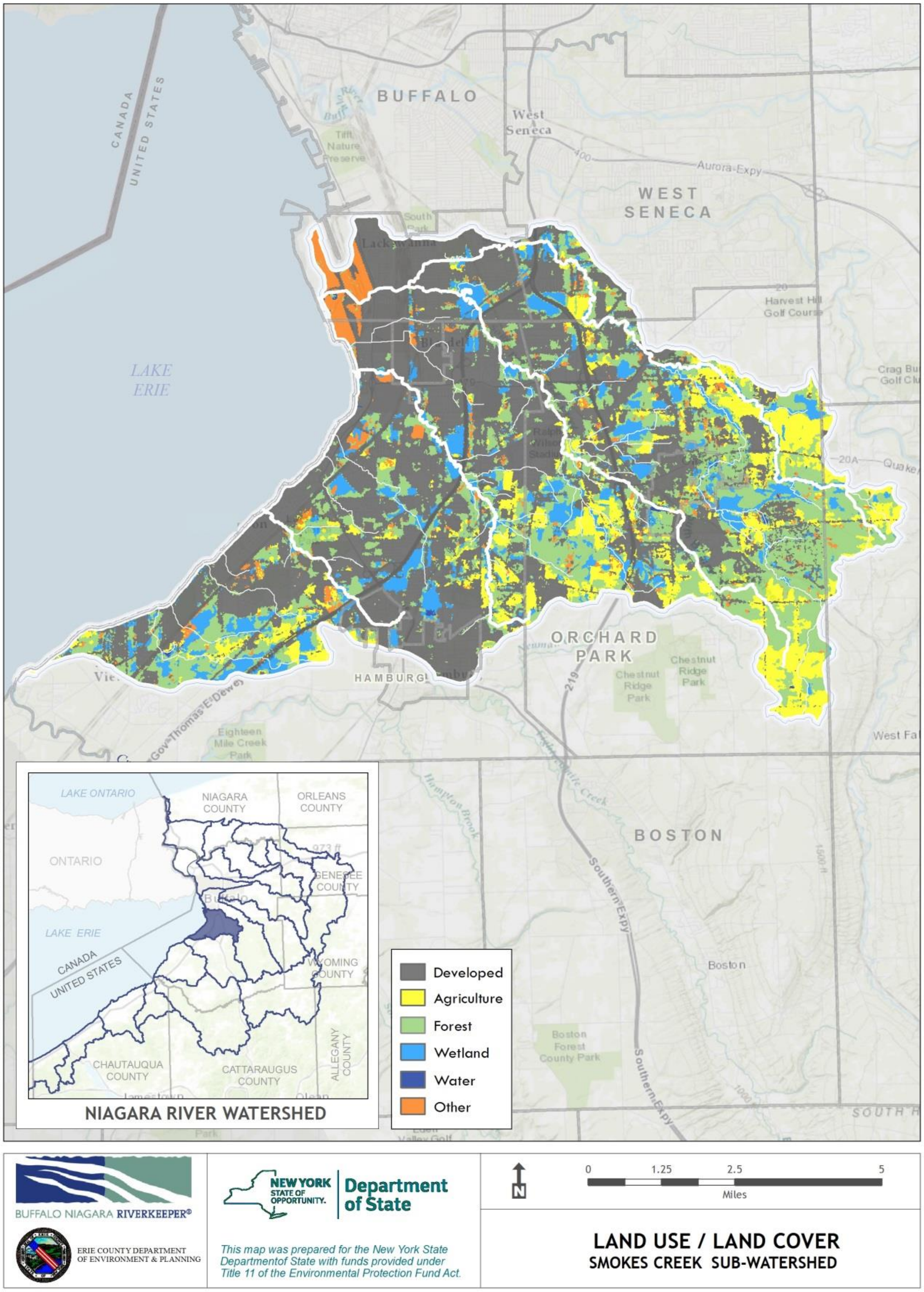
The Active River Area model, as discussed in Chapter 1, was applied to the sub-watershed to determine the extent of The ARA, and focus area for this project. The ARA within the sub-watershed is generally more constrained in the headwaters, becoming more expansive as the waterbodies approach Lake Erie,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

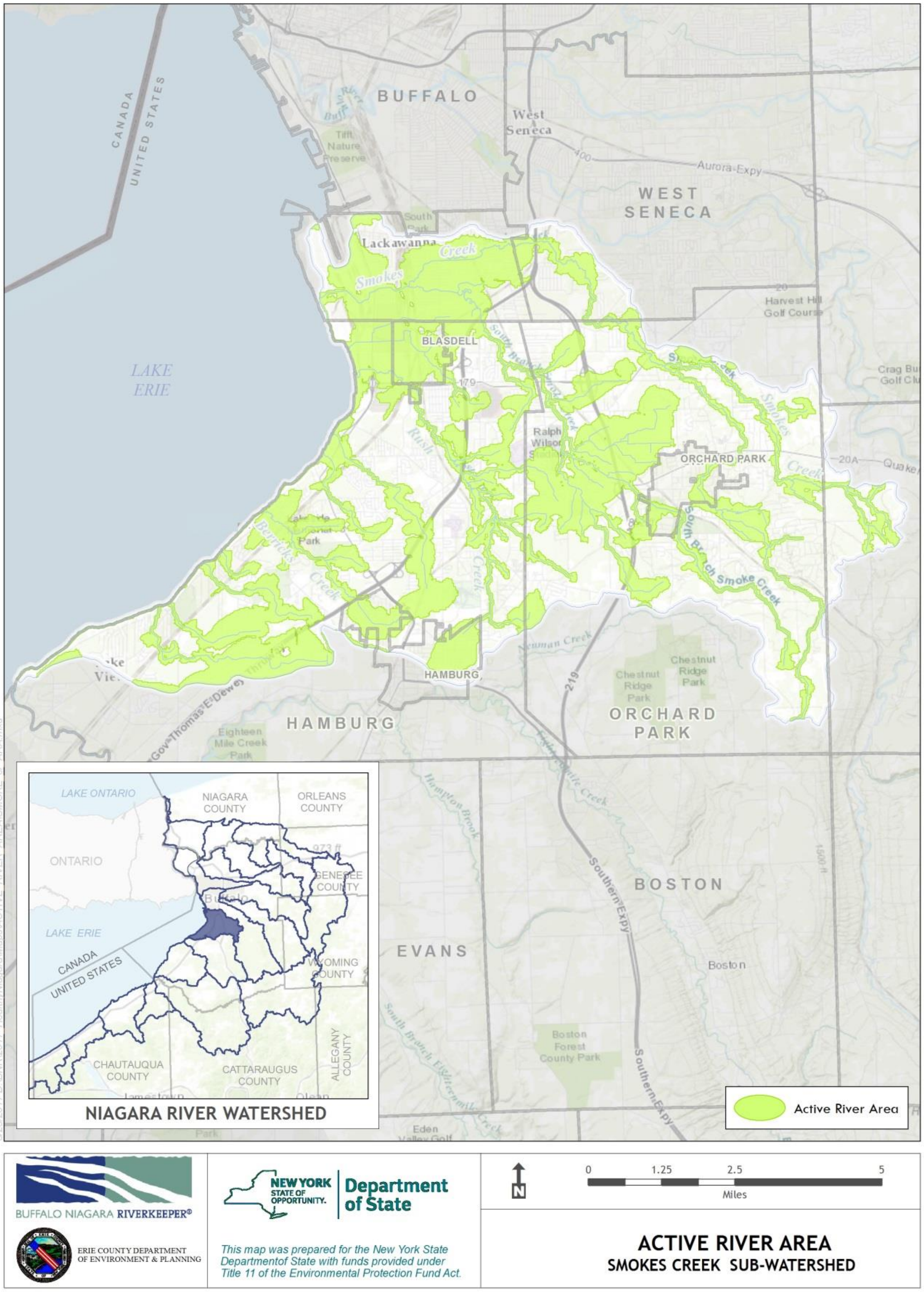
Land Use/Land Cover in the Active River Area

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.

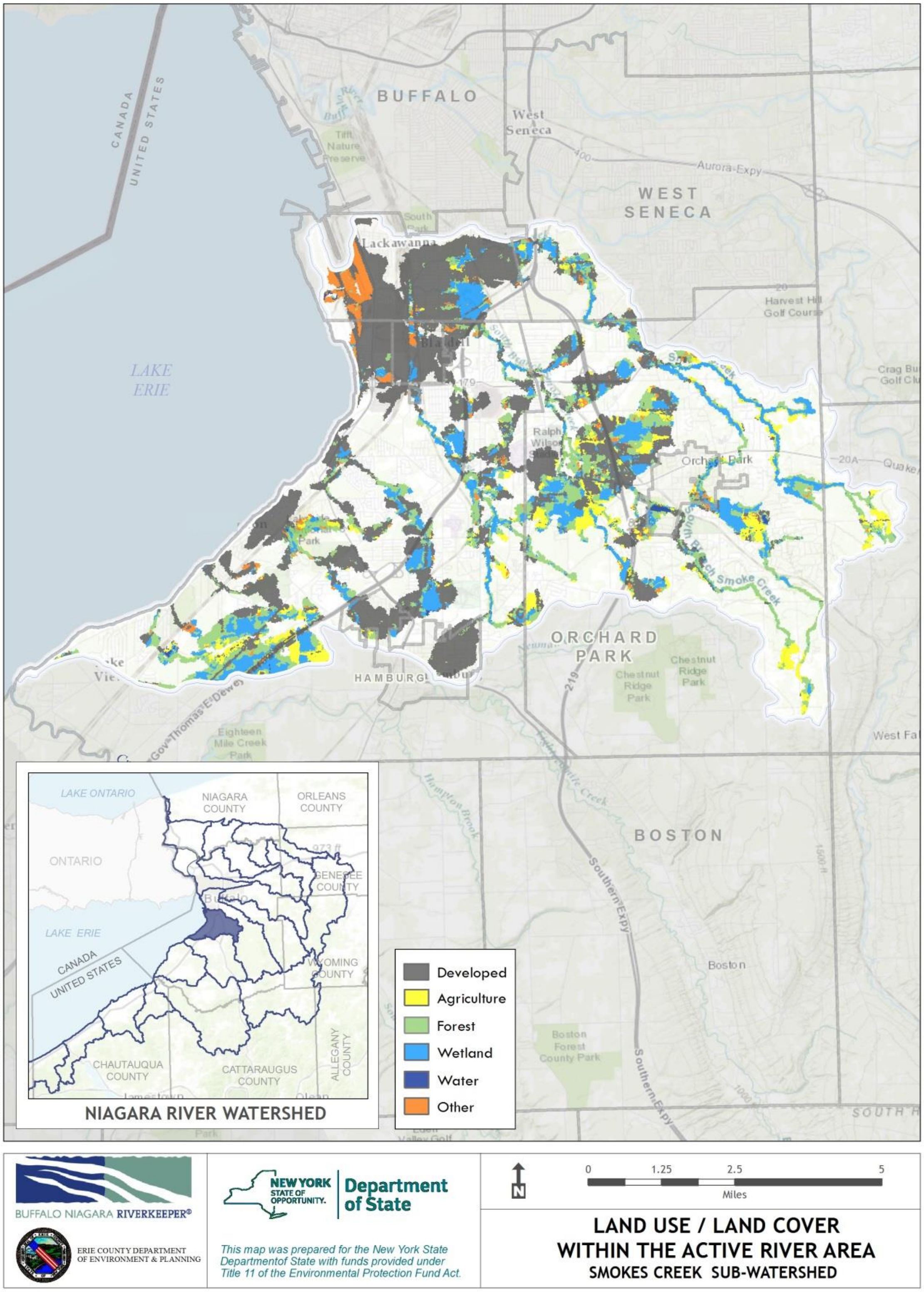
LULC within the ARA skews towards developed, as Smokes Creek remains the most urbanized and industrialized sub-watershed in the Niagara River Watershed, although limited stretches of forest, agriculture, and wetland LULC exist throughout. Coupled with the fact that the ARA is at its most expansive state 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

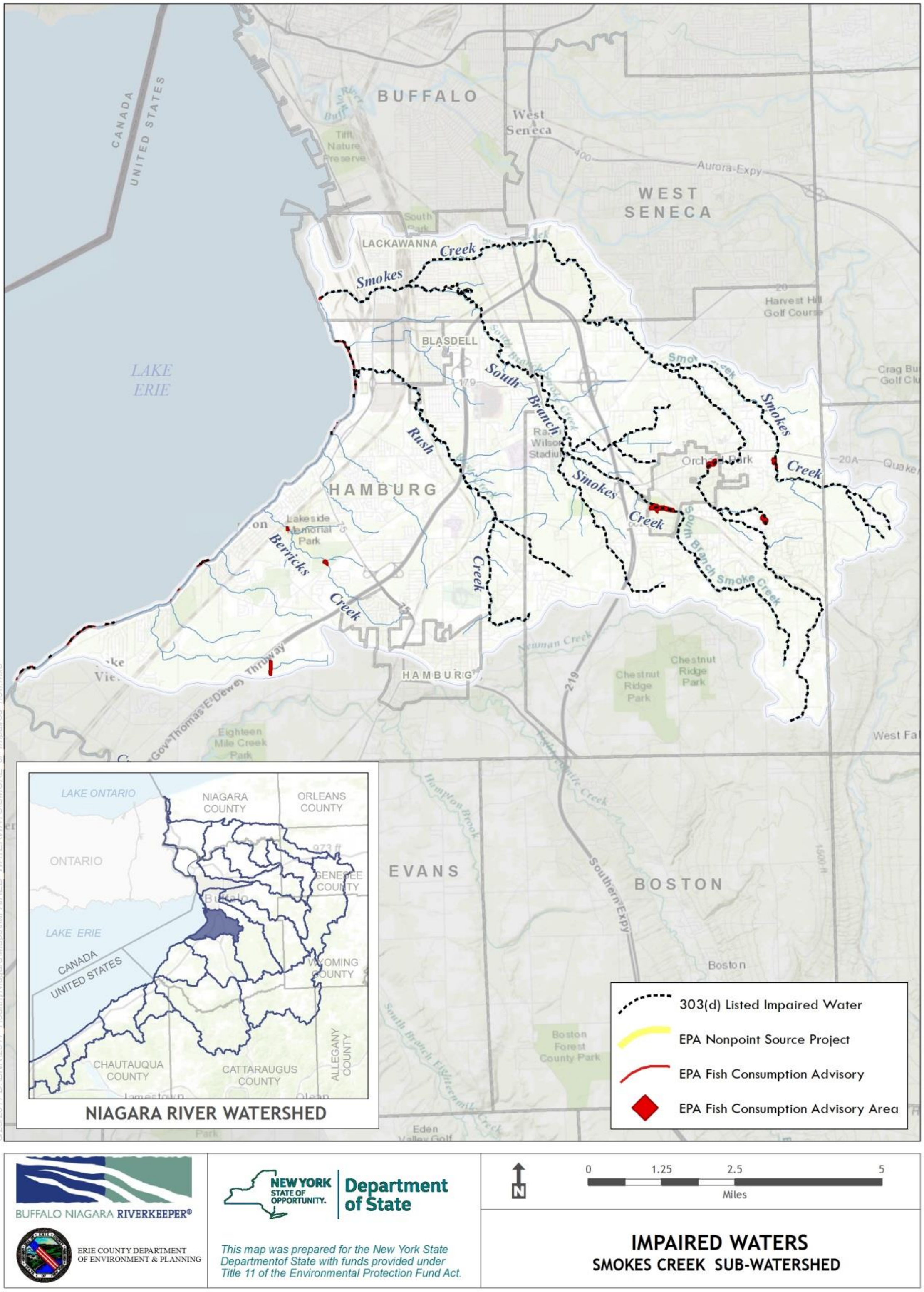


Map 4.4: LULC and ARA Interaction

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).

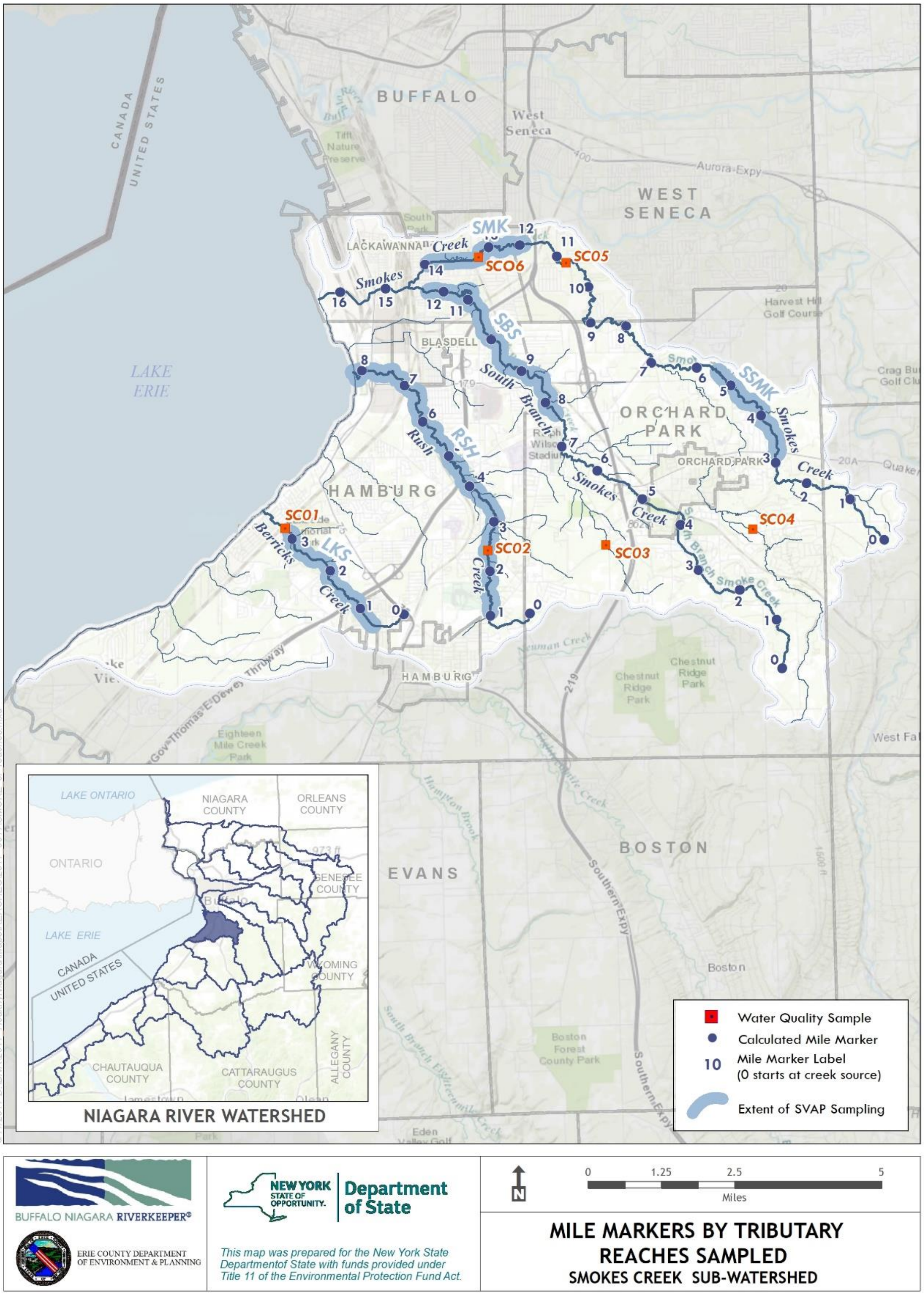
Table 4.3: Streams Assessed in Smokes Creek Sub-watershed

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

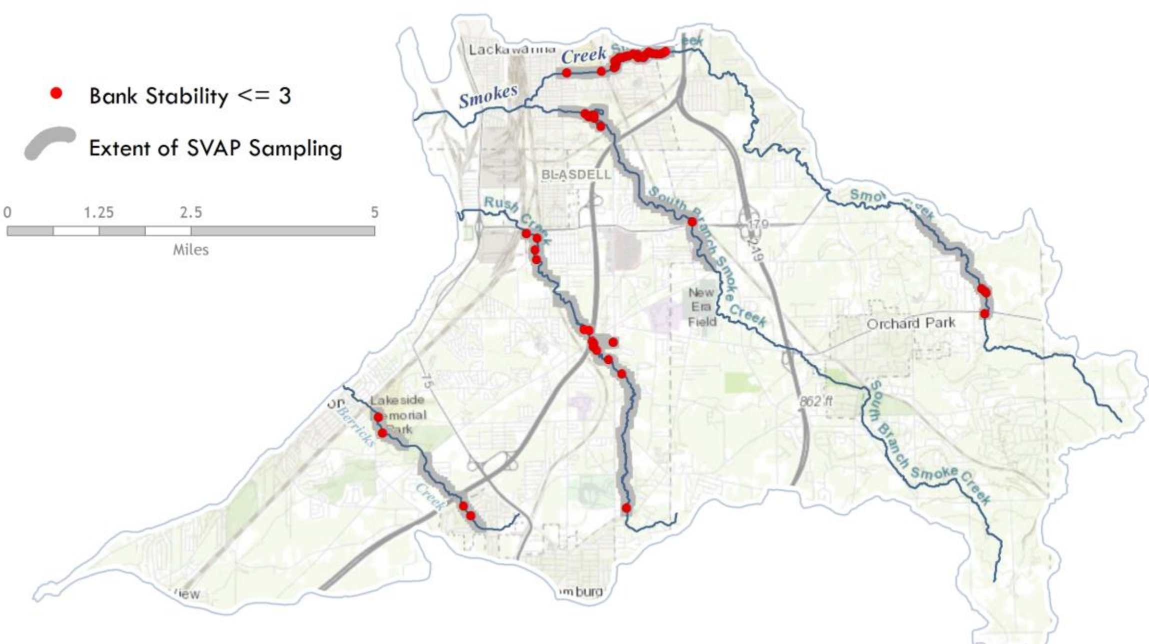
As discussed previously, high levels of developed LULC in Smokes Creek sub-watershed result in contributing urban runoff and industrial effluent into area waterways through direct inputs (runoff, industrial SPDES discharges), or overflow events (CSO/SSO events), and heavily modified stream channels.

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.

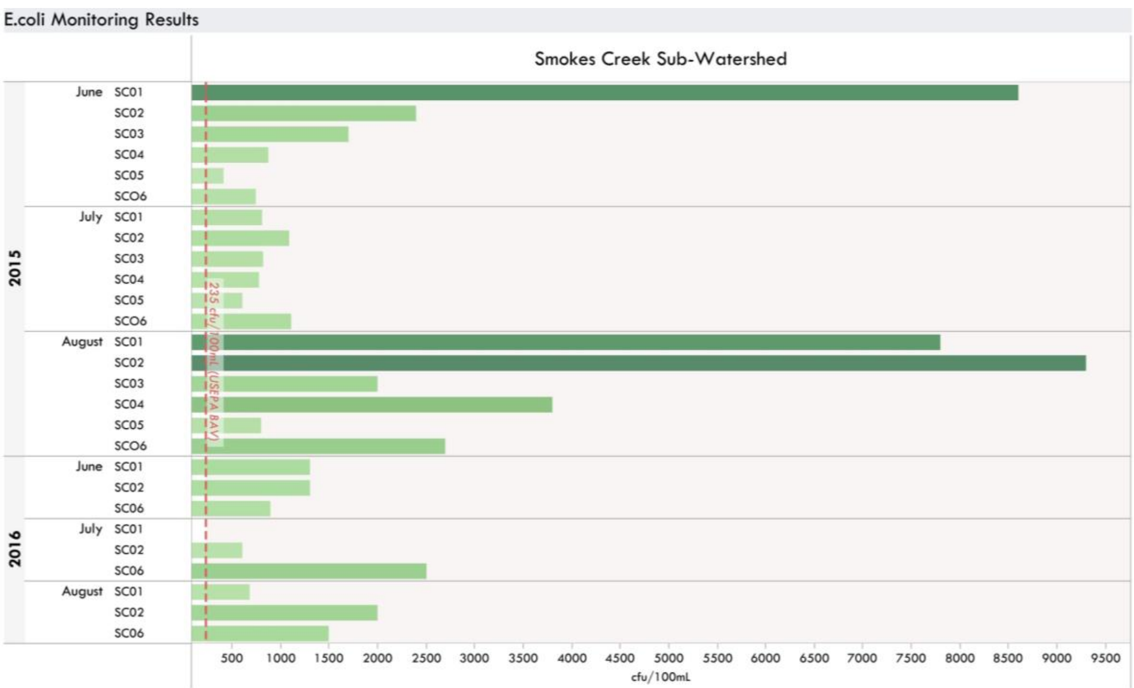


Map 4.7: Bank Stability Score 1-3

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.

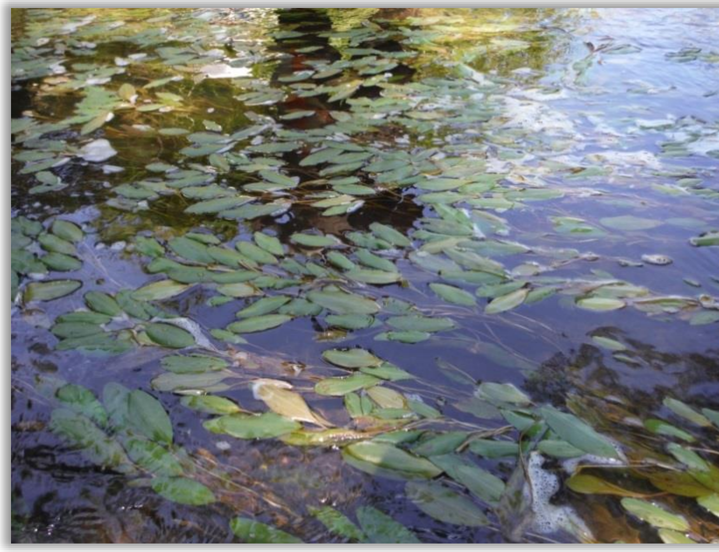
Nutrient sampling from SC found the highest phosphate readings of all five prioritized sub-watersheds. The sub-watershed recorded an average of 442.5 µg/L of phosphorus, well above the NYS DEC guidance value of 10 µg/L for Lake Erie Eastern basins.[8] Rush Creek recorded the highest average phosphorus 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.

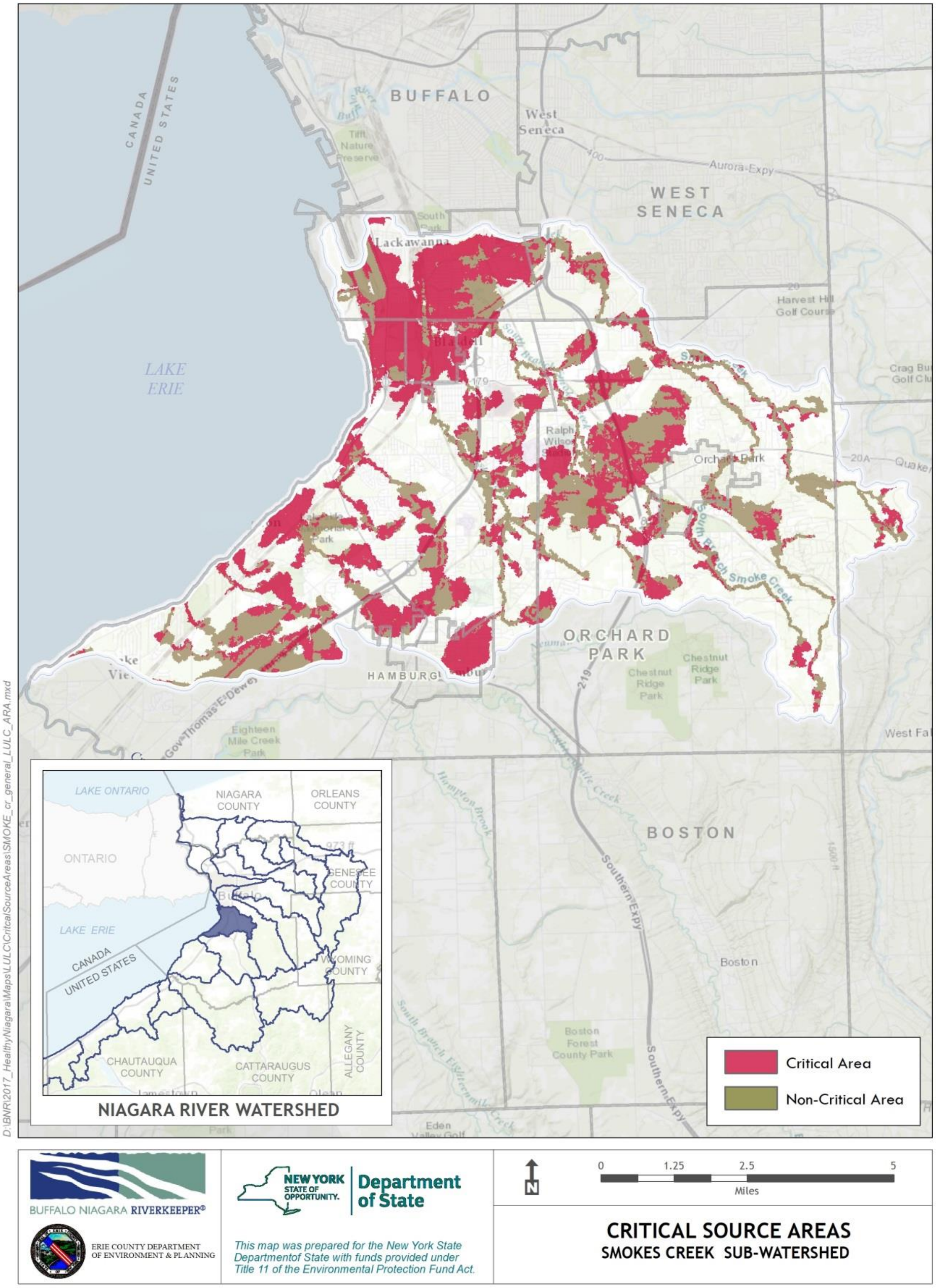
CSA Priorities

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

Benefit: *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

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.

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