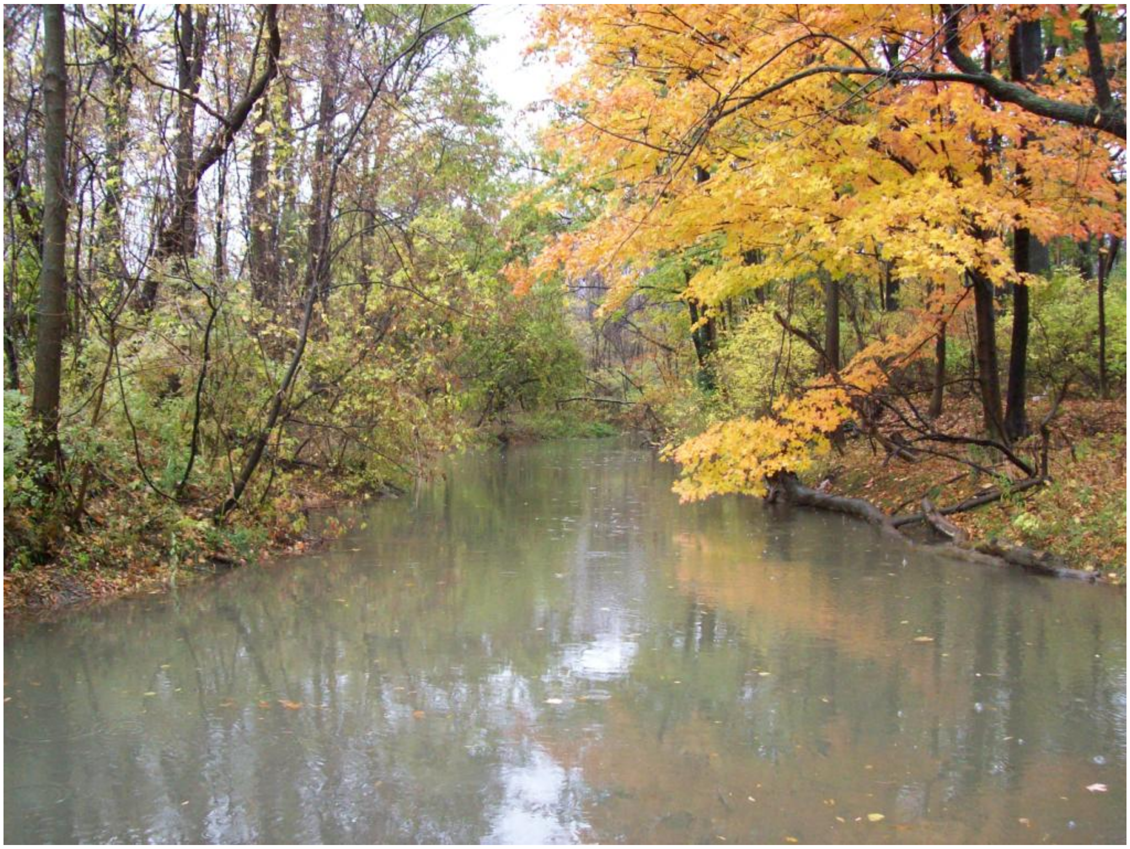
Cayuga Creek Watershed
Stream Visual Assessment Protocol (SVAP)



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In the Fall of 2008, as part of a class project for Watershed Analysis 421/521, students from Buffalo State College conducted a study using the NRCS Stream Visual Assessment Protocol (SVAP) (Natural Resources Conservation Service (NRCS), 1998) to assess the current geomorphological, water quality, and ecological conditions of Cayuga Creek in Niagara County, New York.

The objective of this project was to use a qualitative assessment tool (i.e., the SVAP) to describe the current conditions of Cayuga Creek. The purpose of this report is to provide a document to be used by planners and various stakeholders to identify potential rehabilitation areas within Cayuga Creek for possible project implementation.

Cayuga Creek in Niagara County, New York is a tributary to the upper Niagara River (Figure 1). The Niagara River was designated as one of 43 Areas of Concern (AOCs) in the Great Lakes Basin because of impaired beneficial uses (U.S. Environmental Protection Agency (USEPA), 2009). Environmental problems in the Niagara River AOC include: inactive hazardous waste sites, contaminated sediment, combined sewer overflows, habitat degradation, and nonpoint source pollution, including urban and rural runoff (USEPA, 2009).

The focus of this study is on the main-stem of Cayuga Creek. The headwaters of the 10-mile long Cayuga Creek start in the Town of Lewiston and from that point the creek flows south through the Tuscarora Nation and the Town of Wheatfield. The creek then crosses under Walmore Road onto the Niagara Falls International Airport and Air National Guard Base complex and continues south through the Town of Niagara, and the City of Niagara Falls where it joins the Little River adjacent to Cayuga Island (Figure 1).

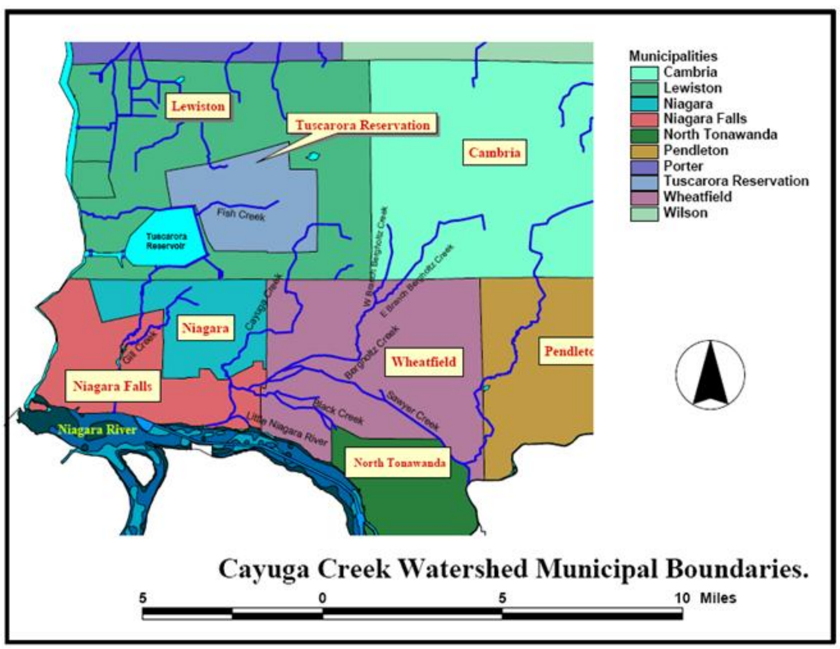

Figure 1. Map of the Cayuga Creek watershed municipal boundaries.

Land use in the Cayuga Creek watershed varies from rural, residential, agricultural, to commercial and industrial. North of the Airport and Air Base complex in the Town of Lewiston, the Tuscarora Nation, and the Town of Wheatfield, land uses consist of mixed residential and agriculture with some pockets of open land. In the southern portion of the watershed much of the land in the Town of Niagara and the City of Niagara Falls are mainly suburban, residential, and commercial development. Industrial activities are concentrated in the City of Niagara Falls.

Most of the watershed topography is relatively flat. Elevations range from approximately 625 feet at the headwaters to approximately 560 feet at the Niagara River confluence in the City of Niagara Falls. Fluctuations in the water levels of Cayuga Creek are directly affected by water levels in the Niagara River (U.S. Army Corps of Engineers (USACE), 2002). Water levels are also affected by the daily draw down of the New York Power Authority (NYPA) and Ontario Power Generation (OPG) (USACE, 2002). Other factors such as wind, natural flow variations and ice conditions, water levels of Lake Erie and Lake Ontario, also affect water levels of the creek (USACE, 2002).

The characteristic bedrock units underlying the basin are the Lockport Dolomitic Limestone and the Queenston and Rochester Shales. These are buried along much of Cayuga Creek, with the stream flowing through a clay-lined channel. The U.S. Department of Agriculture Soil Conservation Service has mapped these soils and classified them as to permeability (drainage) (Higgins et al., 1972). Most of the soils in the Cayuga Creek basin are derived from glacial lake sediments and are characterized by high density, poor tilth (tillability), and very poor drainage.

Historically, the primary function of Cayuga Creek has been that of flood control, as evident by human induced channel alterations, specifically channelization. An existing flood control structure located between Porter Road and Niagara Falls Boulevard consists of an earthen berm built along the creek to control flood waters and protect homes and structures in and around the Cayuga Village Trailer Park in the Town of Niagara (USACE, 2002).

METHODS

STREAM VISUAL ASSESSMENT PROTOCOL

The Stream Visual Assessment Protocol (SVAP) is a qualitative field reconnaissance technique that assesses channel and floodplain conditions, riparian areas, water quality and aquatic habitat (NRCS, 1998). The SVAP elements assessed for this project consider fluvial geomorphological, water quality, and biological conditions (Table 1). The following elements were assessed: channel condition, bank stability, riparian zone, water appearance, nutrient enrichment, barriers to fish movement, instream fish cover, presence of pools in the stream, and canopy cover (Table 1).

Table 1. Description of SVAP Elements (after NRCS, 1998)

SVAP Element	Description
Channel Condition	Evidence of channelization or alteration of the stream and existence of dikes, levees, etc.
Bank Stability	Existence of or the potential for detachment of soil from the upper and lower stream banks and its movement into the stream.
Riparian Zone	Width of the natural vegetation zone from the edge of the active channel out onto the flood plain.
Nutrient Enrichment	Reflected by the types and amounts of aquatic vegetation in the water.
Water Appearance	Compares turbidity, color, and other visual characteristics with a healthy or reference stream.
Barriers to Fish Movement	Barriers that block the movement or deny access to fish or any other aquatic organism to other parts of the stream.
Instream Fish Cover	Measures availability of physical habitat for fish.
Pools	Pool abundance and diversity are evaluated.
Canopy Cover	Evaluates shading of the water surface area throughout the entire stream reach.

Cayuga Creek was divided into sections by road intersection (between Saunders Settlement Road and Niagara Falls Boulevard) and reaches were defined within each section. The sections of the stream that flow through the Tuscarora Nation and the Niagara Falls International Airport and Air National Guard Base complex were not assessed. Based on the SVAP protocol, a reach should be twelve times the active (i.e., bankfull) channel width and it should be representative of the stream through an area (NRCS, 1998). Within each reach, the elements outlined in Table 1 were individually ranked on a scale of 1 to 10, using the qualitative descriptions in the SVAP manual (NRCS, 1998). The mean of the individual scores was used to determine the overall condition of each reach. Reaches with an overall score of 6 or less are Poor; overall scores in the range of 6.1-7.4 are Fair; overall scores between 7.5-8.9 are Good; and overall scores greater than 9 are Excellent (NRCS, 1998).

In the field, a general description of each reach was documented and sketched. Channel width (lowflow and bankfull), depth (lowflow and bankfull), reach length, dominant substrate type, and GPS coordinates were recorded. A Manning's n roughness coefficient was estimated and digital photographs were taken at each reach.

STABILITY THRESHOLD ANALYSIS

Stability Threshold Analysis (STA) was used to determine what methods of bank stabilization techniques could be used to stabilize streambanks in reaches that had Poor bank stability element scores. In particular, the applicability of biotechnical bank stabilization techniques was considered. Biotechnical techniques use vegetation to stabilize streambanks. STA compares reach-averaged shear stress and velocity values to permissible shear stress and velocity values (Fischenich 2001) and it can be used to determine a range of possible bank stabilization solutions (Frothingham, 2008). Thus, STA is valuable in the planning stage of watershed management, as it is relatively easy and cost-effective to collect the data needed for the analysis.

Reach-averaged velocity for both low- and bankfull flow conditions were calculated using Manning's equation:

$$V= (1.49/n)\, D^{2/3} * S^{1/2}$$

where D=depth, S=slope, and n= Manning's number. Reach-averaged shear stress values for both low- and bankfull flow conditions were also calculated:

$$\tau = \gamma DS$$

where γ=specific weight of water, D=depth, and S=slope.

The calculated reach-averaged velocity and shear stress values in Poor bank stability score reaches were compared to permissible velocity and shear stress values for a variety of boundary conditions (Table 2).

Table 2. Permissible Velocity and Shear Stress Values for Different Bank Stabilization Techniques (after Fischenich 2001)

Boundary category	Boundary type	Permissible shear stress (lb/ft^2)	Permissible velocity (ft/s)
Biotechnical streambank stabilization	Reed fascines	0.6-1.25	5
	Coir roll	3-5	8
	Vegetated coir mat	4-8	9.5
	Live brush mattress (initial)	0.4-4.1	4
	Live brush mattress (grown)	3.9-8.2	12
	Brush layering (initial/grown)	0.4-6.25	12
	Live fascine	1.25-3.10	6-8
	Live willow stakes	2.10-3.10	3-10
Non-degradable RECPs	Unvegetated	3.0	5-7
	Partially established	4.0-6.0	7.5-15
	Fully vegetated	8.0	8-21

RESULTS

A total of 67 reaches were assessed between Saunders Settlement Road and Niagara Falls Boulevard. The following contains a general description, including the number of reaches assessed, predominate land use, and the major impairments, by road intersection. Appendix A contains the individual SVAP scores for each reach and Appendix B contains the photo index of each reach.

Saunders Settlement Rd. to Walmore Rd.

This section included 20 reaches (Reach 1-20). The surrounding land use was a mix of residential and agricultural fields, with the latter being of the majority. Overall SVAP scores ranged from 3.3-6.6 (Poor, to the low end of Fair). Impairments included lack of pools, water appearance, nutrient enrichment, bank stability, and instream fish cover. Bank stability scores ranged from 1.5 to 7.5 (Poor to Good).

Walmore Rd. to Cory Rd.

This section included Reaches 21 through 24, with surrounding land use being a mix of residential and agricultural. The overall SVAP rating for all four reaches in this section was Poor. There was a large amount of bank erosion throughout this section and it lacked a significant riparian zone.

Cory Rd. to Walmore Rd.

This section was from Reach 25 through Reach 30, and it was a mix of residential and industrial land uses. The first two reaches (Reaches 25-26) in this section were industrial, flowing through a concrete mixing facility. The impairments in both reaches included lack of riparian zone and Reach 25 was overgrown with reeds to the point of becoming a complete barrier to fish movement. The remainder of this section (Reaches 27-30) was residential and impairments included lack of a riparian zone and there was some evidence of stream channelization. There also were reaches where there was little to no instream fish cover. It should also be noted that a resident of this section commented about concrete sediment washing downstream during and after storm events.

Walmore Rd. to Lockport Rd.

This section was from Reach 31 through Reach 44, and was combination of farmland, forest, and residential. This section was highly agricultural, and had a range of overall SVAP scores. For the most part this section was rated Fair to Good, with some reaches that are scored as Very Good. In the reaches that had Poor ratings, there were issues with bank stability, instream fish cover, and lack of riparian zone.

Lockport Rd. to Walmore Rd.

This section covered Reaches 45 through 52, and was a combination of forest, residential, commercial, and industrial land use. The first three reaches had Good overall SVAP scores. Reaches 48through 50 were surrounded by commercial/industrial land uses and impairments included channel condition, bank stability, riparian zone, barriers to fish movement, nutrient enrichment, and pools.

Porter Road to Niagara Falls Boulevard

A total of 15 reaches (Reaches 53-67) were assessed in this section of Cayuga Creek. All reaches fell within the boundary between Porter Road and Niagara Falls Boulevard and at no time did the creek cross under any roadway or structure; thus, several reaches with similar characteristics are described together.

Reaches 53-55

Reaches 53 through 55 were primarily surrounded by former agricultural lands that are currently forested. This section has been channelized from Porter Rd. to the Cayuga Village Trailer Park. Overall SVAP ratings for these reaches ranged from Poor to Fair. This section has some bank erosion, but overall it had an extensive riparian corridor and good canopy cover. The canopy cover has resulted in some large woody debris falling into the creek.

Reaches 56-58

Reaches 56 through 58 are in the Cayuga Village Trailer Park. Land use in this section is primarily residential on the left bank with forest on the right bank. This section of the creek has also been channelized to provide flood protection for the Cayuga Village Trailer Park. Overall SVAP ratings for these reaches are Poor and impairments include channel condition, riparian zone, bank stability, in-stream fish cover, and water appearance. At the beginning of Reach 56 the creek makes a 45-degree bend and slabs of concrete previously used for bank stabilization have fallen into the creek. The remaining portions of this ad hoc bank stabilization are in immediate danger of failure.

Reaches 59-62

Reaches 59 through 62 also run through and just downstream of the Cayuga Village Trailer Park. Land use in this section is primarily residential on both the left and right banks. Overall SVAP ratings for these reaches range from Poor to Fair. Impairments in this section are lack of a riparian zone, channel condition, bank stability, and water appearance. This section includes a tight bend (approximately 90 degrees) and additional ad hoc bank stabilization with no uniformity of material or construction.

Reaches 63-65

Reaches 63 through 65 are surrounded by primarily residential land use on the left bank with some wooded areas that have been partially cleared by property owners and heavily wooded land use on the right bank. Overall SVAP ratings for these reaches are Fair. These reaches the creek follow what appears to be a “natural” meandering course roughly paralleling Tuscarora Road.

Reaches 66-67

Reaches 66 through 67 are immediately upstream of Niagara Falls Boulevard. Land use in this section is primarily wooded on the left bank and commercial on the right bank. Overall SVAP ratings for these reaches are Fair. The right bank has been heavily armored with small stone to protect a capped “dump” site. In this section there is little to no riparian corridor and no canopy cover.

Stability threshold analysis (STA) was used to determine what methods of bank stabilization techniques could be used to stabilize streambanks in reaches that had Poor bank stability element scores. A total of 38 reaches had Poor bank stability scores. STA results indicate that biotechnical bank stabilization techniques could be used in all of those reaches (Tables 4 and 4); however, more detailed reach-scale analysis must occur before recommendations for specific bank stabilization techniques can be made. Based on STA results, we recommend further reach-scale study of the 38 reaches for several reasons:

1. Largely due to the shallow slope (0.0016) of Cayuga Creek, maximum calculated velocities rarely exceeded 8 ft/sec and maximum shear stress never exceeded 1.0 lbs/sq. ft. Biotechnical bank stabilization methods are recommended for use in streams with velocities ranging from 0 to 8 ft/sec, depending on which method is applied (Fischenich, 2001) (see Table 2).

2. Using biotechnical bank stabilization also addresses other problems observed in the reaches. Other problems that were common in the reaches included lack of fish cover, lack of pools, and poor general channel conditions (e.g., evidence of channelization). Biotechnical bank stabilization methods offer enhancement of channel condition by providing habitat, as well as bank stabilization.

3. Biotechnical bank stabilization methods are generally less expensive to install than traditional hard engineering methods. Traditional hard engineering methods, such as adding rock riprap, concrete, or cobble/gravel, do not usually enhance the in-stream fish cover, canopy cover, or habitat space for micro or macro invertebrates along the bank.

4. Most biotechnical bank stabilization methods, such as coir rolls, joint plantings, fascines, live brush mattresses, and RECPs, do not require the use of machinery and heavy equipment. The installation of these methods can be performed by hand using manual labor, which in turn is less damaging to the riparian and buffer zones. The clearing of trees and brush to make room for such equipment is not necessary for this process. A lack of heavy equipment also means less or no compaction of the surrounding soils, minimizing disturbance and excess sedimentation. On a scale such as that of Cayuga Creek, most of the possible biotechnical bank stabilization options could be accomplished with no more than a single truck and a few wheel barrows brought close to the streambank to deliver materials.

Table 3. Low Flow STA Results in Reaches with Poor Bank Stability Scores

Rd. Intersection	Reach number	Shear stress (lb/sq ft)	Velocity (ft/sec)	Applicable biotechnical techniques
Saunders Settlement. Rd to Walmore	1	0.02	0.61	any
	2	0.03	0.76	any
	3	0.06	1.30	any
	4	0.08	1.54	any
	5	0.06	1.12	any
	8	0.01	0.44	any
	9	0.03	0.68	any
	10	0.02	0.57	any
	11	0.02	0.52	any
	12	0.03	0.81	any
	13	0.05	1.34	any
	14	0.04	1.08	any
	17	0.01	0.20	any
Walmore Rd. to Cory Dr.	21	0.15	2.23	any
	22	0.05	1.07	any
	23	0.08	1.41	any
	24	0.10	1.70	any
Cory Dr. to Walmore Rd.	25	0.20	0.85	any
	26	0.08	0.44	any
	27	0.20	2.70	any
	30	0.10	1.70	any
Walmore Rd. to Lockport Rd.	31	0.10	2.06	any
	32	0.10	2.06	any
	38	0.08	0.95	any
	42	0.08	0.95	any
Lockport Rd. to Walmore Rd	48	0.15	0.70	any
	49	0.15	1.20	any
	50	0.15	1.66	any
	51	0.20	1.46	any
Porter Rd. to Niagara Falls Blvd.	54	0.20	2.70	any
	56	0.15	2.23	any
	57	0.30	2.96	any
	58	0.10	1.42	any
	60	0.20	3.26	any
	61	0.25	3.79	any
	62	0.30	3.54	any
	63	0.30	3.54	any
	64	0.20	2.70	any

Table 4. Bankfull flow STA Results in Reaches with Poor Bank Stability Scores

Rd. Intersection	Reach number	Shear stress (lb/sq ft)	Velocity (ft/sec)	Applicable biotechnical techniques
Saunders Settlement. Rd to Walmore	1	0.30	4.13	any except initial live brush mattress
	2	0.28	3.82	any
	3	0.25	3.43	any
	4	0.28	3.70	any
	5	0.28	3.20	any
	8	0.24	3.05	any
	9	0.26	3.22	any
	10	0.19	2.86	any
	11	0.28	3.38	any
	12	0.28	3.38	any
	13	0.22	3.60	any
	14	0.26	3.64	any
	17	0.17	1.13	any
Walmore Rd. to Cory Dr.	21	0.28	3.34	any
	22	0.40	4.30	any except initial live brush mattress
	23	0.30	3.54	any
	24	0.40	4.29	any except initial live brush mattress
Cory Dr. to Walmore Rd.	25	0.45	1.45	any
	26	0.45	1.45	any
	27	0.50	4.50	any except initial live brush mattress
	30	0.40	4.29	any except initial live brush mattress
Walmore Rd. to Lockport Rd.	31	0.60	6.79	any except initial live brush mattress and reed facines
	32	0.50	6.01	any except initial live brush mattress and reed facines
	38	0.35	2.64	any
	42	0.21	1.82	any
Lockport Rd. to Walmore Rd	48	0.35	1.23	any
	49	0.90	4.26	any except initial live brush mattress
	50	0.35	2.92	any
	51	0.80	3.67	any
Porter Rd. to Niagara Falls Blvd.	54	0.50	4.98	any except initial live brush mattress and reed facines
	56	0.80	6.82	any except initial live brush mattress and reed facines
	57	0.60	4.69	any except initial live brush mattress and reed facines
	58	0.50	4.15	any except initial live brush mattress
	60	0.80	8.23	any except initial live brush mattress and reed facines
	61	0.80	8.23	any except initial live brush mattress and reed facines
	62	0.90	7.38	any except initial live brush mattress and reed facines
	63	0.80	6.82	any except initial live brush mattress and reed facines
	64	0.60	5.63	any except initial live brush mattress and reed facines

CONCLUSIONS

Streambank and channel erosion and the resulting suspension of sediment are significant and recognized problems throughout the watershed, particularly within the City of Niagara Falls. The constriction and concentration of creek flows, channel modification, concentrated point source discharges, loss of woody riparian vegetation, and altered hydrologic characteristics, and fluctuations in water levels associated with Power Authority of the State of New York management of the Niagara River are contributing causes to this problem. Streambank erosion continues to reduce the quantity and quality of the shoreline, the water column, vegetated shallows and the riparian corridor and overhanging trees and shrubs, which is subject to undercutting and deadfall (USACE, 2002).

Results from this study indicate that Cayuga Creek is generally in poor condition. The average SVAP score of all sixty-seven reaches analyzed is 5.7, and the median score is 5.8, which amounts to a Poor overall SVAP rating. Documented problems include: lack of riparian and buffer zones, eroding streambanks, lack of in stream habitat, mowed lawns right to the streambanks, lack of pools/riffles, commercial dumping, and nutrient enrichment.

Streambank erosion was documented in many of the reaches in Cayuga Creek Results of this study showed that biotechnical streambank stabilization methods are appropriate to use to remedy almost every instance of bank erosion. Biotechnical stream bank stabilization methods are appropriate and worth future study for four reasons: 1. The low energy nature of the stream; 2. The ability of biotechnical methods to address the habitat concerns in this watershed; 3.The cost of biotechnical methods are generally less than traditional heavy engineering; 4. The impact of installation on the stream corridor is less than that of traditional heavy engineering techniques.

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APPENDIX A – SVAP RESULTS FOR CAYUGA CREEK

APPENDIX B – REACH PHOTO INDEX FOR CAYUGA CREEK