Post-Treatment Assessment of ERDC Hydrilla Control Demonstration Project Tonawanda Creek/Erie Canal 2016

Contract No. W912P4-10-D-0002

March 2017

Prepared for:

UNITED STATES ARMY CORPS OF ENGINEERS
Buffalo District

Table of Contents

List of Tables

Table **Page**

List of Figures

List of Abbreviations and Acronyms

C	center of canal/creek
Canal Corp.	New York State Canal Corporation
cfs	cubic feet per second
E & E	Ecology and Environment, Inc.
ERDC	Engineer Research and Development Center
ft/s	feet per second
µg/L	micrograms per liter
NYPA	New York Power Authority
NYSDEC	New York State Department of Environmental Conservation
ppm	parts per million
Project	Tonawanda Creek/Erie Canal Hydrilla Demonstration Project
RM	river mile
SLM	SOLitude Lake Management, LLC
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

1 Introduction

The Tonawanda Creek/Erie Canal[1] Hydrilla Demonstration Project (the Project) is a field-scale demonstration of a technology developed under the United States Army Corps of Engineers (USACE) – Buffalo District and Engineer Research and Development Center (ERDC) Aquatic Plant Control Research Program to manage monoecious hydrilla (*Hydrilla verticillata;* Hydrilla) in a flowing water system.

This report contributes to the Year 3 post-treatment monitoring and assessment of herbicide efficacy on Hydrilla by summarizing field conditions before, during, and after the treatment; summarizing herbicide treatment methodology and contact time; and identifying lessons learned to benefit future work.

1.1 Background

Hydrilla is a very aggressive, submerged aquatic plant. The United States Fish and Wildlife Service (USFWS) first discovered this invasive plant in the Tonawanda Creek section of the Erie Canal in September 2012. Hydrilla infestations have been documented from just upstream of the creek/canal's outlet at the Niagara River, in the cities of North Tonawanda and Tonawanda, and upstream to the Lockport area, approximately 15 miles to the east. Hydrilla has been identified within a total area of approximately 359 acres. Hydrilla beds are currently patchy and limited to the shallow shoreline areas outside of the main navigation channel.

There is significant concern regarding the potential spread of Hydrilla to other areas of New York State and the Great Lakes as a whole. Hydrilla could spread because fragments of Hydrilla within the creek/canal are easily transported via waterflow, the creek/canal is located directly adjacent to the Niagara River, and the canal has heavy boat traffic. These concerns provided the impetus for implementation of the Project.

This year, to control and eradicate Hydrilla, the USACE conducted a third year of treatment for the Project within a 15-mile-long stretch of creek/canal that focused

[1] The Erie Canal and Tonawanda Creek are separate waterbodies until they merge in Pendleton, New York, just downstream of the East Canal Road/New Road bridge. From the confluence, the canal then follows the modified former channel of Tonawanda Creek. This document refers to this channel as the creek/canal.

on application of the aquatic herbicide endothall (Aquathol K™). The following two areas were treated (see Figures 1-1 and 1-2):

- **Western block primary treatment area**: 5.5 miles between the Route 384 Bridge in Tonawanda, New York, to West Canal Park in North Tonawanda, New York. Of this area, 2.6 miles was directly treated with herbicide and the remaining area received secondary treatment from flow in the creek/canal; and
- **Eastern block secondary treatment area**: 8 miles between West Canal Park and the Pendleton Guard Gate in Pendleton, New York, received secondary treatment from flow in the canal.

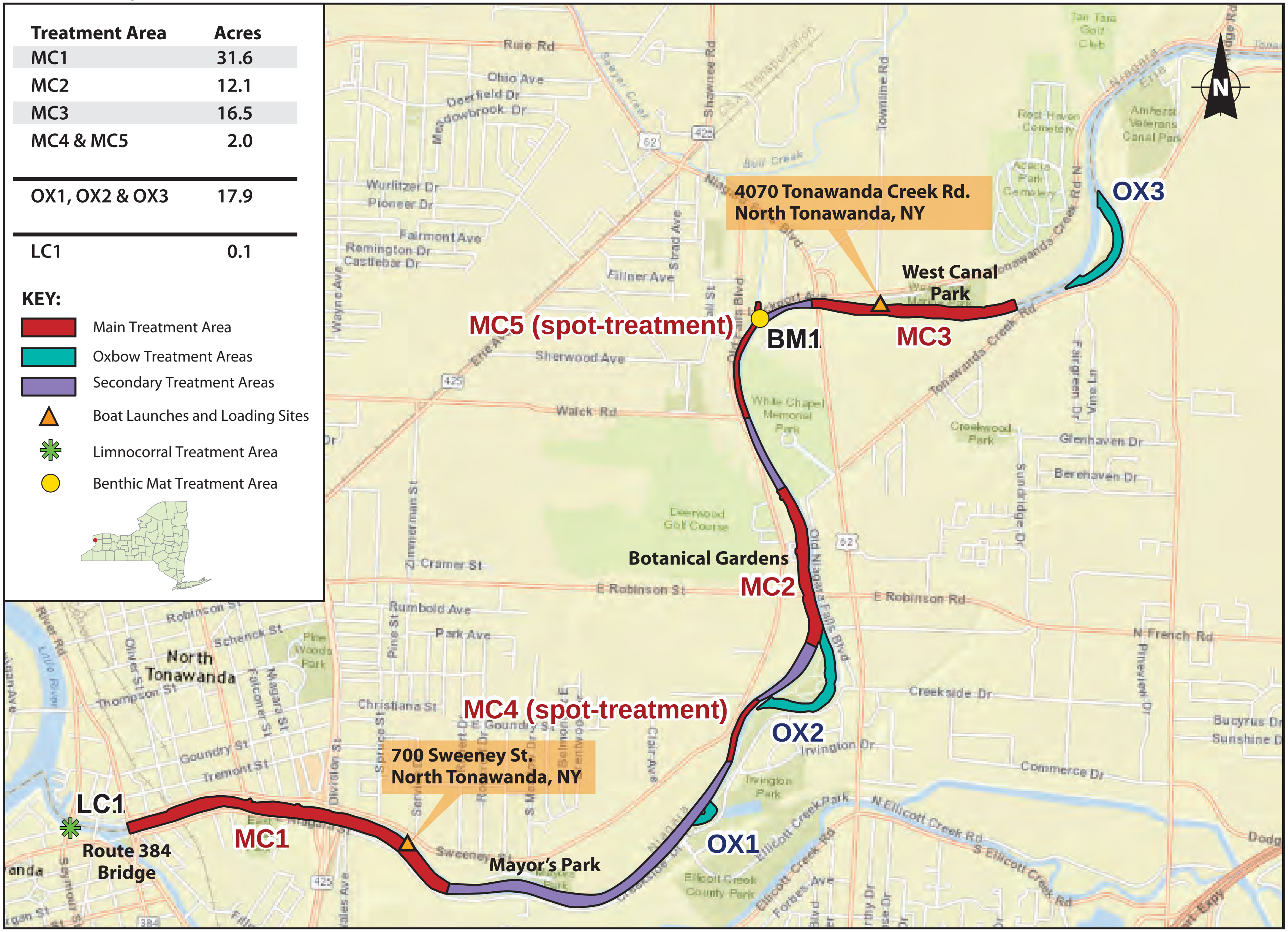
The identified treatment area, comprising both the primary and secondary treatment areas, is representative of the full 15-mile stretch of the canal in which Hydrilla beds were previously identified by the USFWS. The western block contains the majority of the Hydrilla beds, thus it continued to receive direct herbicide application.

Prior to treatment application, Hydrilla populations within the treatment areas were delineated via a point intercept survey. In July 2016, the USACE ERDC conducted supplementary mapping and plant delineation and identified two additional Hydrilla bed locations, one on the southeast side of the Seymour Street Bridge in Tonawanda (same as last year), and one at the confluence of Sawyer Creek and Tonawanda Creek, just west of West Canal Park (see Figure 1-1). The Seymour Street Bridge bed was isolated with a limnocorral (impermeable divider) and received direct endothall application. The Sawyer Creek bed was treated with a benthic mat (burlap barrier). Additionally, the following three oxbow treatment areas and two main channel spot treatment areas were included in the primary treatment area:

- East side of the small island along Creekside Drive at Ellicott Creek Park (OX1; see Figure 1-1);
- East side of Ellicott Island Park near Creekside Drive and Niagara Falls Boulevard (OX2; see Figure 1-1);
- East side of the island at Tonawanda Creek Road and Sweet Home Road (OX3; see Figure 1-1);
- West side of the creek/canal across from Ellicott Creek Park between Parkview Drive and Irvington Drive (MC4, see Figure 1-1); and
- West side of the creek/canal between Bull Creek and Walck Road (MC5, see Figure 1-1).

02:1003025.0025.06.04\Figure 1-1 Western Treatment Areas.ai-11/3/16

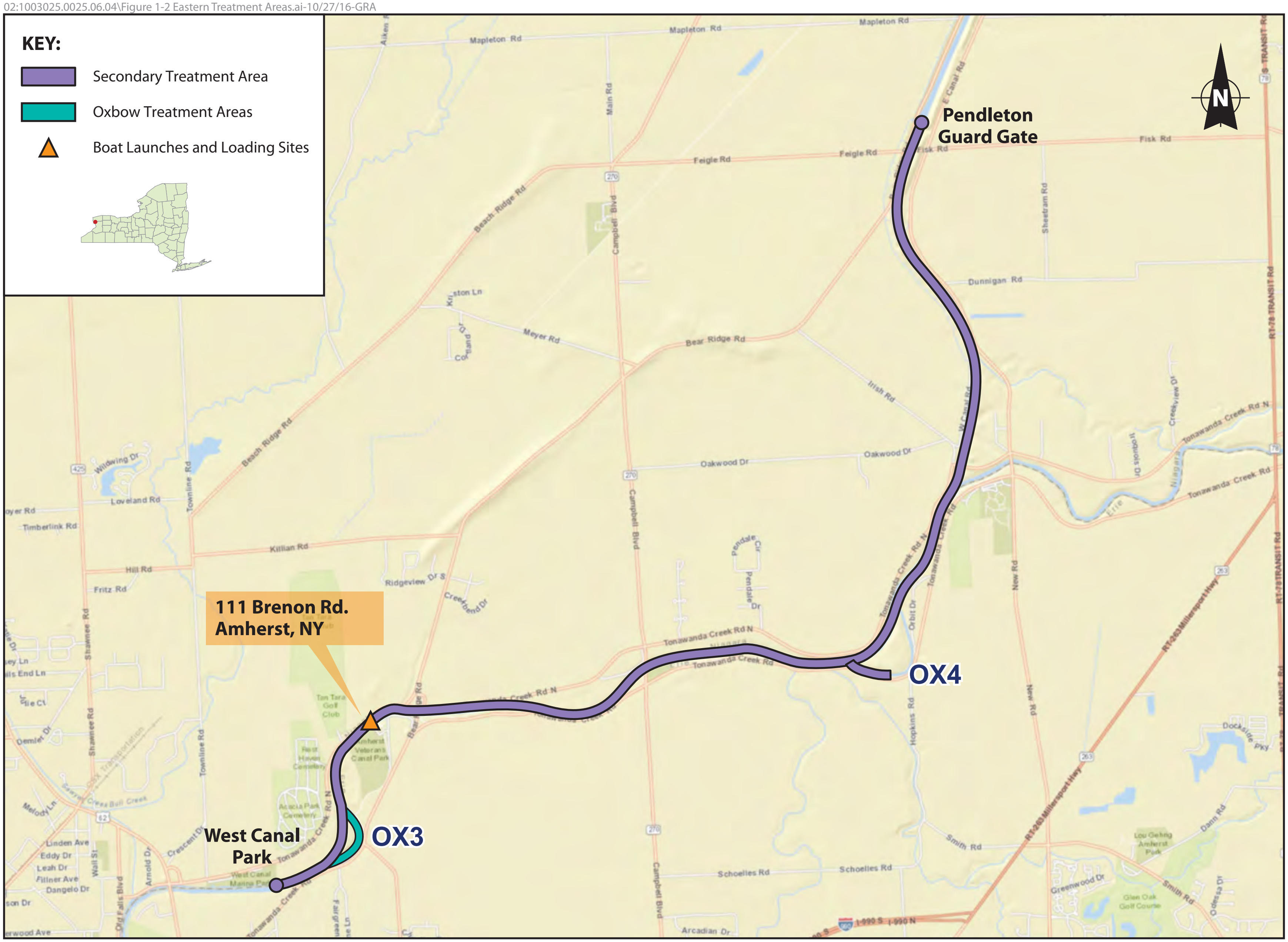
Treatment Area	Acres
MC1	31.6
MC2	12.1
MC3	16.5
MC4 & MC5	2.0
OX1, OX2 & OX3	17.9
LC1	0.1



SCALE 0 0.4 0.8 1.2 1.6 Miles

Figure 1-1 Western Block Treatment Areas
Tonawanda Creek/Erie Canal

02:1003025.0025.06.04\Figure 1-2 Eastern Treatment Areas.ai-10/27/16-GRA



Service Layer Credits: Sources: ESRI, HERE, DeLorme, USGS, Intermap, Increment P Corp., NRCAN, ESRI Japan, METI, ESRI China (Hong Kong), ESRI (Thailand), MapmyIndia, © OpenStreetMap Contributors, and the GIS User Community

SCALE
0 0.5 1.0 Mile

Figure 1-2 Eastern Block Treatment Areas
Tonawanda Creek/Erie Canal

Implementation of the Project was a collaborative effort between the ERDC; USACE; Ecology and Environment, Inc. (E & E); New York State Canal Corporation (Canal Corp.); New York State Department of Environmental Conservation (NYSDEC); USFWS; and the applicator, SOLitude Lake Management, LLC (SLM).

1.2 Purpose and Scope

The purpose of the Project is to develop and implement selective control methods to manage Hydrilla in a flowing water system, while limiting impacts on native vegetation. Prior to the Year 1 implementation of the Project in 2014, management of monoecious Hydrilla using an aquatic herbicide in a flowing water system had not been tested. Therefore, the results of this continued field-scale Project will provide valuable information for developing future guidance on how to manage this species in other flowing water systems throughout the northeastern United States.

The ERDC will use the findings in this report to support continued post-treatment monitoring to determine the success of each successive treatment program. Post-treatment monitoring will also be used to determine whether additional creek/canal-wide treatments will be needed in the future, or if direct targeting (limnocorrals/benthic mats) of individual Hydrilla beds would be a more effective way to remove small satellite populations that survive treatment or re-sprout from the bank of subsurface tubers.

This post-treatment report includes a summary of the herbicide treatment methodology, including quantity of herbicide/benthic mat used and total acreage treated; a discussion of herbicide contact time and dispersion through the system; and a discussion of the flow management and monitoring that accompanied the herbicide application. Lastly, conclusions are provided, in the form of lessons learned, to help shape future treatment projects.

2 Overview of Herbicide Treatment

Treatment of Hydrilla for this Project focused on the application of the aquatic herbicide endothall within the creek/canal. During treatment, the Canal Corp. minimized water flow in the creek/canal in order to achieve a maximum (or ideal) contact time at a target concentration. Minimizing water flow yielded greater contact time between the herbicide and Hydrilla. Normal flow during the July/August time period is 1,200 cubic feet per second (cfs) (Manns 2016). To minimize flow, a target flow rate of 200 cfs or less to the east was identified.

The following sections outline the public notification that preceded treatment; field conditions before, during, and after treatment; herbicide treatment methodology; quantity of herbicide used, and its dispersion; and details of the flow management and monitoring. (See Appendix A for photos of operations.)

2.1 Public Notification

Public awareness and understanding of the Project were important to its successful implementation. Although a State of New York Permit to Use a Pesticide for the Control or Elimination of Aquatic Vegetation (Article 1, Part 327) was not required for this Project, the notification requirements stipulated for the permit were adhered to (i.e., riparian owner and permitted user notification and use of warning signs). Six methods of public notification were used for the project:

1. Riparian (creekside) owners and permitted users were notified by E & E via U.S. certified mail;
2. Yellow warning signs were posted along the primary treatment areas at public access points;
3. Display advertisements were published in three local/regional newspapers on July 23, 2016 (*The Buffalo News*, *Lockport Journal*, and the *Niagara Gazette*) and re-printed in *The Buffalo News* on July 26, 2016;
4. Agency notification letters were distributed by U.S. certified mail; and
5. Project factsheets were distributed during Canal Fest (July 19 through 26) by Western New York Hydrilla Task Force members.

2.2 Field Conditions

Field conditions prior to (July 21 through July 25), during (July 26 through 27), and immediately following the treatment (July 29 through August 1) are summarized in Table 2-1. Conditions were primarily dry when the herbicide was applied.

Table 2-1 Field Conditions Preceding, During, and Following Herbicide Application

Date	Temperature Range (degrees Fahrenheit)	Precipitation (inches)	Other
July 21, 2016	Min: 60 Max: 87	0	No significant weather observed Average wind speed 11.7 mph with gusts up to 26 mph
July 22, 2016	Min: 75 Max: 85	Trace	Light rain, fog, haze Average wind speed 15.2 mph with gusts up to 34 mph
July 23, 2016	Min: 70 Max: 91	0	Fog Average wind speed 8.3 mph with gusts up to 26 mph Precipitation since June 1, 2016: 2.07 inches
July 24, 2016	Min: 66 Max: 89	0	No significant weather observed Average wind speed 4.9 mph with gusts up to 18 mph
July 25, 2016	Min: 71 Max: 80	1.04	Thunderstorms with heavy to light rain and fog Average wind speed 10.3 mph with gusts up to 29 mph
July 26, 2016 Treatment Day 1	Min: 66 Max: 81	0	No significant weather observed Average wind speed 9 mph with gusts up to 23 mph
July 27, 2016 Treatment Day 2	Min: 65 Max: 84	0	No significant weather observed Average wind speed 10.8 mph with gusts up to 27 mph
July 28, 2016	Min: 68 Max: 85	0	No significant weather observed Average wind speed 2.9 mph with gusts up to 15 mph
July 29, 2016	Min: 68 Max: 84	0	No significant weather observed Average wind speed 6.7 mph with gusts up to 22 mph
July 30, 2016	Min: 68 Max: 82	Trace	Light Rain Average wind speed 9.8 mph with gusts up to 23 mph
July 31, 2016	Min: 68 Max: 79	Trace	Thunderstorms and light rain Average wind speed 7.4 mph with gusts up to 21 mph. Total precipitation for July 1.80 inches
August 1, 2016	Min: 65 Max: 83	0	Fog Average wind speed 6.4 mph with gusts up to 20 mph

Source: National Weather Service 2016

2.3 Herbicide Treatment Methodology

The aquatic herbicide endothall (Aquathol K™) was applied in designated sections of the creek/canal on July 26 and 27, 2016 (see Figure 1-1). The herbicide was applied by SLM in accordance with the *Architect-Engineer Scope of Work (SOW) Aquatic Plant Control ERDC Demonstration Project Tonawanda Creek/Erie Canal* dated May 27, 2016 (USACE 2016).

Two boats were used for the herbicide application. The vessels were 18- and 20-foot, shallow-draft aluminum work skiffs powered by 50- and 90-horsepower conventional four-stroke outboard motors, respectively. The skiffs were used to treat the main channel of the creek/canal and shallow oxbows. The limnocorral area was treated from the shore by using a hand-held sprayer to apply the herbicide from shore (see photos in Appendix A).

2.3.1 Herbicide Transfer

An in-line herbicide injection system was used on the two conventional work skiffs. Each skiff was outfitted with a 225-gallon polyethylene tank. The liquid herbicide was pumped from 250-gallon totes in the chemical delivery box truck located onshore into the polyethylene tanks via 1.5-inch-diameter tubing by electric- and gasoline-powered transfer pumps. Personal protective equipment was worn by SLM staff and by the driver from the company that delivered the herbicide and assisted with the herbicide transfer to the skiffs.

2.3.2 Herbicide Application

The work skiffs were outfitted with either a 2-inch-diameter gasoline-powered water pump or a 12-volt electric chemical distribution pump. Water was drawn from the creek/canal and sprayed out beneath the water's surface through a boom and subsurface hose assembly mounted to the stern of each boat. The storage tanks and hoses were fitted with ball valves that could be closed to stop flow. Herbicide was drawn from the tanks in-line at a rate of approximately 8 gallons per minute. The tanks on the skiffs were filled at the designated loading areas. Herbicide was applied from west to east along the creek/canal. Boat passes were made parallel to the shorelines. The herbicide was applied in water less than 10 feet deep, which was generally within 50 feet of the shoreline. The quantity of herbicide needed for each section was initially determined by the total acreage and volume of the treatment areas (see Figure 1-1). Prior to the start of application the USACE made some necessary in-field modifications to account for additional treatment areas identified through USACE hydrilla surveys of the creek/cannel.

July 26, 2016: Day 1

SLM staff arrived at the City of North Tonawanda boat launch at 700 Sweeney Street at the foot of Service Road at 0900 hours, launched the two skiffs, and began assembling the treatment systems. Following on-site meetings with staff from the USACE, NYSDEC, and E & E; and confirmation that the creek/canal flow rate had slowed to the desired rate, SLM personnel began to transfer the herbicide at approximately 1130 hours. Each treatment crew consisted of a lead applicator and an assistant/technician. Once the two skiffs were loaded, the herbicide application began at approximately 1230 hours (see photos in Appendix A). Aside from brief breaks when the skiffs stopped to reload herbicide, the treatments continued uninterrupted until the operation was completed at approximately 1600 hours.

Immediately following treatment in the main channel and oxbow areas, the limnocorral was installed on the southeast side of the Seymour Street Bridge in Tonawanda. This location is designated as LC1 on Figure 1-1. The area was isolated with 20-foot-long, floating limnocorrals secured to the shoreline. The limnocorral extended from above the surface of the water to the creek/canal bed effectively isolating the Hydrilla bed from the surrounding flowing water. The limnocorral remained in place until SLM personnel removed it on August 17, 2016. The benthic mats are biodegradable, so they will remain in-place indefinitely.

The base of operations was moved upstream to the West Canal Park launch towards the end of Day 1 of the treatment. At both locations, the chemical delivery box truck was able to park adjacent to or on one side of the ramp, which still enabled each ramp to be used by other boaters, as necessary, during the herbicide transfer operations.

July 27, 2016: Day 2

All of the main channel areas except MC2 were re-treated on Day 2 (as shown on Figure 1-1). SLM launched both work skiffs from the City of North Tonawanda boat launch at Service Road. The same herbicide transfer and application methods were used as Day 1. Treatment began at 0830 hours and was complete by 1230 hours for a total treatment time of approximately 4 hours.

2.4 Quantity of Herbicide Used and Total Area Treated

The total quantity of endothall applied in designated sections of the creek/canal on July 26 and 27, 2016, was 1,250 gallons. This is the lowest quantity of endothall applied to the creek for this program, as 1,855 gallons were applied in 2014 and 2,091 gallons were applied in 2015. The planned treatment area was divided into distinct sections, the total amount of endothall to be applied to each section was calculated, and the product was then applied as described in Section 2.3.

The dosing was predetermined and calculated by the ERDC and SLM based on the treatment area acreages and volumes. The target concentration of endothall for all of the treated sections in the main creek/canal channel was 1.5 parts per million (ppm). This dose was calculated on the entire water volume of the creek/canal sections, but the herbicide was applied in the infested areas along the shoreline, resulting in higher concentrations at the time of application. Oxbows were treated with a concentration of 3.0 ppm. The limnocorral area (LC1) was treated once with a concentration of 4.0 ppm to comply with the herbicide label requirement of not applying more than a total of 5 ppm within a seven-day interval.

Table 2-2 summarizes herbicide application for each canal section as depicted on Figure 1-1.

Table 2-2 Herbicide Application Summary, by Canal Section

Date	Canal Section	Acres	Endothall Applied (gallons)	Targeted Concentration (ppm)	Notes
7/26/2016	MC1, MC2, MC3	60.2	612	1.5	
7/26/2016	OX1, OX2, OX3	17.9	121	3.0	
7/26/2016	MC4, MC5	2.0	20	1.5	
7/26/2016	LC1	0.1	0.2	4.0	
7/27/2016	MC1	31.6	307	1.5	Re-treatment
7/27/2016	MC3	16.5	174	1.5	Re-treatment
7/27/2016	MC4, MC5	2.0	15.8	1.5	Re-treatment
		Total Gallons	**1,250**		

Key:

LC = Limnocorral
MC = Main channel treatment area
OX = Oxbow treatment area
ppm = parts per million

2.5 Herbicide Contact Time and Dispersion

Herbicide was applied to sections of the creek/canal on July 26 and 27, 2016; these sections were determined as discussed in Section 2.4. ERDC and E & E performed water sampling to determine the endothall concentrations and dispersion of herbicide from the date of application through August 1, 2016.

2.5.1 Initial Sampling Results – First 48 Hours

ERDC performed endothall concentration sampling on the 7-mile western half of the creek/canal area at 0.5-mile intervals on Days 1 and 2 of treatment (July 26, and 27, 2016). E & E performed endothall concentration sampling on the entire 15-mile creek/canal area at 0.5-mile intervals on Days 3 and 4 (July 28 and 29, 2016) and sampled the entire 15-mile area at 1-mile intervals on Day 7 (August 1, 2016). E & E samples were collected in the same general locations as the samples collected by ERDC. These sample locations and denotations are provided in Appendix B. Sampling locations were established along Tonawanda Creek/Erie Canal beginning at the confluence of the creek/canal at the Niagara River in Tonawanda, New York (river mile [RM] 0) and ending at Lockport Road in Lockport, New York, approximately 15 miles to the northeast. Additional samples were taken at areas deemed significant, such as oxbows and the limnocorral area. These additional locations are summarized in Table 2-3. The start to end locations of treatment areas are listed by increasing river mile. For comparison, sample locations are provided in Appendix B and treatment areas are highlighted in Figure 1-1.

Table 2-3 Additional Sample Area Locations

Area Description	River Mile
Limnocorral	0.2
Start of Main Treatment Area MC1	0.4
Rail Bridge	0.6
Twin Cities Memorial Highway bridge	1.1
Mayor’s Park	2.2
Oxbow 1	2.8
End of Spot Treatment Area MC4	3.2
Oxbow 2	3.4, 3.5, 3.6
Botanical Gardens	3.8
End of Main Treatment Area MC2	4.1
400 feet south of start of Spot Treatment Area MC5	4.4
Confluence of Bull Creek	4.9
500 feet west of start of Main Treatment Area MC3	5.2
East end of West Canal Park	5.8
Oxbow 3	6.2, 6.3, 6.4
1,400 feet north of end of last treatment area at Oxbow 3	6.7
Bear Ridge Road	7.3
Oxbow 4	10.1

The samples were analyzed using an enzyme-linked immunoassay procedure specific for endothall. The standard operating procedures for use of the RaPID Assay® Endothall Test Kit were followed. The detection limit for this method is 7 micrograms per liter (µg/L). Samples were analyzed at a 10:1 dilution, with a detection limit of 70 µg/L, or as non-diluted samples with a detection limit of 7 µg/L. The sampling results analyzed and reported by ERDC indicate the concentrations of the active ingredient, dipotassium salt of endothall, in each sample. For every 10 samples, duplicate analyses were performed to determine the percent recovery of endothall. Each sample run incorporated the use of external standards at 500 and 1,000 µg/L.

The analytical results for samples collected during the initial 48 hours following application during the reduced flow period suggest movement of endothall to the east as anticipated based on normal creek/canal flow. The additional endothall application on July 27, 2016, was conducted between the morning and afternoon sampling in all of the main channel treatment areas, except MC2 by the Botanical Gardens, in order to maintain adequate herbicide concentrations (see Figure 1-1). These additional herbicide applications resulted in increased endothall concentrations noted between the morning sample and the afternoon sample on July 27 in all the primary treatment areas excepting MC2, with some increased concentrations in the oxbows and secondary treatment areas due to eastward movement of the endothall. Target endothall concentrations were maintained in the treatment areas between RMs 1 and 6 for 48 hours. Moreover, eastward movement of the herbicide was noted in RMs 6 through 8. RMs 8 through 10 received significant exposures to endothall on July 28, 2016. Herbicide concentrations sampled in the afternoon after application ranged from 84.5 to 2,110 µg/L (see Table 2-4). Table 2-4 summarizes results obtained through August 1, 2016, and emphasizes distribution of the treatment in relation to the target zone and clearance of the herbicide from the system.

Table 2-4 Summary of Water Sample Results Showing Treatment Distribution

River Mile	Location ID[2]	Endothall Concentration (µg/L)[3] Sampling Dates[1] 7/26/16 A[4]	7/26/16 B[4]	7/27/16 A[4]	7/27/16 B[4]	7/28/16	7/29/16	8/1/16
0.0	0.0 C					ND	ND	
0.2	0.2 LB / LC1					122.3	100.1	9.9
0.4	**0.4 RB**	**ND**	**ND**	**84.8**	**89.7**			
	0.4 LB	**ND**	**ND**	**ND**	**122.3**			
0.5	**0.5 LB**					**ND**	**ND**	**ND**
0.6	**0.6 RB**	**113.2**	**ND**	**180.9**	**155.9**			
	0.6 LB	**ND**	**ND**	**115.7**	**114.4**			
1.0	**1.0 RB**					**444.0**	**ND**	
1.1	**1.1 RB**	**2,104.8**	**1,446.1**	**1,253.8**	**1,184.9**			
	1.1 LB	**2,213.5**	**1,275.2**	**1,128.8**	**856.6**			
1.5	**1.5 RB**	**2,339.0**	**2,110.2**	**1,365.3**	**1,723.0**			
	1.5 C					**912.8**	**ND**	**ND**
	1.5 LB	**2,013.3**	**2,008.6**	**1,396.1**	**1,884.7**			
2.0	2.0 RB	ND	1,130.5	1,141.6	1,389.9	1,441.5	ND	
	2.0 LB	ND	1,096.9	1,084.9	1,760.5	1,432.6	ND	
2.2	2.2 RB	ND	798.9	738.2	1,549.7			
	2.2 LB	ND	921.7	667.4	1,567.5			
2.5	2.5 RB					1,321.0	ND	ND
2.8	**2.8 A**					**996.7**	**ND**	**ND**
3.0	**3.0 C**					**1,156.8**	**ND**	
3.2	**3.2 RB**	**158.3**	**ND**	**120.7**	**586.3**			
	3.2 LB	**79.1**	**ND**	**111.5**	**710.4**			
3.4	**3.4 A**	**218.8**	**647.3**	**313.0**	**296.7**			
3.5	**3.5 A**					**404.5**	**ND**	**ND**
	3.5 RB					802.9	ND	ND
	3.5 LB					834.1	78.9	ND
3.6	**3.6 A**	**1,969.4**	**1,216.7**	**1,443.6**	**256.9**			
3.8	**3.8 RB**	**2,145.2**	**956.1**	**559.3**	**446.1**			
	3.8 LB	**1,781.7**	**390.0**	**329.4**	**521.1**			
4.0	**4.0 RB**	**1,520.5**	**1,193.8**	**910.8**	**322.0**	**439.3**	**ND**	
	4.0 LB	**1,399.8**	**996.3**	**826.2**	**483.3**			

Table 2-4 Summary of Water Sample Results Showing Treatment Distribution

River Mile	Location ID[2]	Endothall Concentration (µg/L)[3] Sampling Dates[1] 7/26/16 A[4]	7/26/16 B[4]	7/27/16 A[4]	7/27/16 B[4]	7/28/16	7/29/16	8/1/16
4.1	**4.1 RB**	**2,174.4**	**1,574.2**	**1,210.5**	**497.8**			
	4.1 LB	**1,951.1**	**1,461.8**	**946.2**	**469.5**			
4.4	4.4 RB	ND	1,231.6	1,491.9	358.5			
	4.4 LB	ND	1,452.5	1,411.1	431.9			
4.5	**4.5 C**					**396.6**	**100.1**	**ND**
4.9	**4.9 RB**	**134.1**	**84.5**	**106.8**	**946.6**			
	4.9 LB	**ND**	**ND**	**138.2**	**770.2**			
5.0	5.0 LB					602.4	ND	
5.2	**5.2 RB**	**176.3**	**106.6**	**97.1**	**1,277.1**			
	5.2 LB	**149.5**	**162.5**	**ND**	**963.7**			
5.5	**5.5 RB**	**1,395.4**	**393.2**	**133.9**	**1,412.7**	**458.2**	**142.2**	**ND**
	5.5 LB	**1,333.9**	**526.6**	**109.3**	**1,206.5**			
5.8	**5.8 RB**	**2,026.2**	**1,088.6**	**368.2**	**1,760.7**			
	5.8 LB	**1,919.4**	**976.9**	**309.7**	**2,031.2**			
6.0	6.0 RB	2130.4	1369.8	567.0	1549.7			
	6.0 C					852.9	182.9	
	6.0 LB	1746.5	1277.8	422.3	1795.2			
6.2	**6.2 A**	**1,517.5**	**1,146.7**	**850.5**	**1,665.3**			
6.3	**6.3 A**	**1,163.9**	**1,101.2**	**732.2**	**1,354.5**	**1,234.6**	**459.7**	**9.9**
6.4	**6.4 A**	**1,014.3**	**1,092.8**	**600.8**	**641.4**			
6.5	6.5 LB					1,373.2	684.1	ND
6.7	6.7 RB	ND	297.6	741.5	663.2			
	6.7 LB	96.1	618.3	843.5	622.8			
7.0	7.0 RB					1,033.0	456.6	
7.3	7.3 C	ND	ND	175.9	790.5			
7.5	7.5 C					720.2	634.2	ND
8.0	8.0 LB					665.0	748.9	
8.5	8.5 RB					623.4	819.6	ND
9.0	9.0 C					989.4	840.1	
9.5	9.5 LB					281.5	873.4	ND
10.0	10.0 RB					211.2	617.3	
10.1	10.1 A					176.6	497.1	
10.5	10.5 C					144.2	670.0	ND
11.0	11.0 LB					ND	522.2	
11.5	11.5 RB					115.4	440.2	9.9
12.0	12.0 C					ND	447.3	
12.5	12.5 LB					ND	359.4	ND
13.0	13.0 RB					91.7	433.2	
13.5	13.5 C					ND	529.4	ND
14.0	14.0 LB					82.8	497.1	
14.5	14.5 RB					ND	651.0	

Table 2-4 Summary of Water Sample Results Showing Treatment Distribution

River Mile	Location ID[2]	Endothall Concentration (µg/L)[3] Sampling Dates[1]						
		7/26/16 A[4]	7/26/16 B[4]	7/27/16 A[4]	7/27/16 B[4]	7/28/16	7/29/16	8/1/16
15.0	15.0 C					100.1	708.3	

[1] Application occurred on July 26 and 27, 2016. Samples collected on July 26 and 27 were collected by ERDC; samples collected on July 28 and 29 and August 1, 2016, were collected by E & E.
[2] Location ID assigned by E & E. Number indicates river mile of location and letter indicates location within creek.
[3] Endothall results provided by ERDC for all samples.
[4] The letter "A" denotes first sampling event of the day and "B" denotes the second sampling event of the day. "A" samples were collected between 1530 and 1700 hours on 7/26 and between 0815 and 0945 hours on 7/27. "B" samples were collected between 1930 and 2030 hours on 7/26 and between 1730 and 1900 hours on 7/27.

Key:
C = center of canal/creek
ND = Non-detect (detection limit of 70 µg/L on July 26, 27, 28 and 29, 2016; and 7 µg/L on August 1, 2016)
RB = Right bank of creek/canal (when heading toward the Niagara River)
LB = Left bank of creek/canal (when heading toward the Niagara River)
Blank cell = no sample collected
Bold text = samples taken within the main treatment areas and oxbow treatment areas

Sampling conducted on the day of herbicide application also indicated an eastward movement of the herbicide. At the western edge of the treatment block, the herbicide was not detected in the second sampling event of the day, while concentrations increased from non-detects to hundreds of ppb during the second sampling event of the day in the area east of treatment area MC1.

Lateral Dispersion

Samples were collected at various locations on both banks of the creek/canal and in the center. Similar concentrations were measured in all in-creek/canal locations, indicating that the endothall was dispersed across the creek/canal.

2.5.2 Water Sampling Results Following Flow Resumption

As discussed in detail in Section 2.6.2, flows were managed by the Canal Corp. during the 48-hour application period and immediately after. On July 26, 2016, at approximately 0930 hours, flow gates were closed within the canal system, and flow was minimized prior to herbicide application (i.e., it was reported from Canal Corps that the Flight of Five Lock had about 40 cfs leakage, and the City Hall gate had about 20 cfs leakage). Canal Corp. resumed flows on the morning of July 28, 2016, at 1050 hours

As stated above, following the initial sampling effort by ERDC, E & E obtained grab water samples along Tonawanda Creek/Erie Canal on July 28, 29, and August 1, 2016 (see Table 2-4 for sampling results). Sampling locations were spaced approximately 0.5 miles apart. In addition, a sample was also collected at the limnocorral location and in both channels where the flow is divided at the following four locations:

- East side of the small island along Creekside Drive at Ellicott Creek Park (RM 2.8);

- East side of Three Mile Island near Creekside Drive and Niagara Falls Boulevard (RM 3.5);
- East side of the island at Tonawanda Creek Road and Sweet Home Road (RM 6.3); and
- The side channel along Tonawanda Creek Road just west of Hopkins Road (RM 10.1).

All sampling locations are indicated on Figures B1 through B23 in Appendix B.

The samples obtained by E & E were collected as grab samples from an approximate depth of 1 foot below the creek/canal surface at all locations using a peristaltic pump. A stainless-steel tube was attached to vinyl tubing and suspended to the collection depth. After purging the line with creek/canal water, the samples were then pumped directly into laboratory vials provided by ERDC. Two to three drops of hydrochloric acid were then added to preserve each sample. Each sample was labeled with a unique sample code and immediately placed into a cooler containing ice. Samples were not taken at RM 10.1 or 14.5 on August 1, 2016, because there was a shortage of laboratory vials.

Google Earth was used to navigate to the predetermined sampling locations. At the time of collection, a Bad Elf global positioning system receiver was used to obtain the actual sampling location coordinates. The accuracy of this unit varied depending on availability of satellites but was typically between 8 and 14 feet.

Half of the samples taken by E & E on July 28 were handed directly to the EDRC representative that day. The remaining samples from July 28 and all samples from July 29 and August 1 were shipped on ice to the ERDC laboratory at the University of Florida Center for Aquatic Plants for analysis and arrived at the laboratory on August 2. All samples were analyzed using an enzyme-linked immunoassay procedure specific for endothall (RaPID Assay® Endothall Test Kit).

Quality control samples collected in the field by E & E consisted of normal/ duplicate pairs collected from the same location at the rate of approximately 5%, and lateral sample pairs collected from opposing banks, also at the rate of approximately 5%. Five normal/duplicate pairs were collected over three days of sampling. The analytical results for two of the five pairs (both samples) were non-detect; the sample pairs collected at location 6.0 center of canal/creek (C) on July 28 and 29 and 1.5 C on July 28 had positive values and a relative percent difference of less than 5%, showing good correlation. Five lateral pairs were collected over three days of sampling. The analytical results for the sample pairs at RM 2.0 collected on July 29 and August 1 were non-detect; the two sample pairs collected at RMs 2.0 and 3.5 on July 28 had positive values and correlations less than 5%. The analytical results for the sample pair collected on July 29 at RM 2.0 were 79 µg/L on the left bank and non-detect on the right bank. Given that the detection limit was 70 µg/L, it is possible that these samples had good correlation at concentrations too low to quantify accurately.

The purpose of E & E's sampling effort was to determine the movement and degradation of endothall following the resumption of flow in the canal after the initial 48-hour application period (refer to Section 2.6.2 for a discussion of how flows were managed). Sample results from July 28, 2016, indicated the presence of endothall from RM 1.0 through RM 10.5 (with low detections at RMs 11.5 through 13.0, 14.0 and 15.0). Concentrations in this area ranged from 144.2 µg/L to 1,441.5 µg/L (see Table 2-4 and Figures B2 through B15 in Appendix B). On July 29, 2016, sample results indicated the presence of endothall from RM 3.5 to at least RM 15.0, which was the sampling location farthest to the east. Almost all results for the final day of sampling (August 1, 2016) were non-detects at an undiluted detection limit of 7 µg/L, except the very low detections at the oxbow at RM 6.3 and at RM 11.5. This suggests that all of the herbicide treatment dispersed outside of the sampling area or degraded to non-detect levels in a little over one week from initial treatment.

2.6 Flow Monitoring and Management

Flow monitoring and management were integral components of the Project. This section provides an overview of the flow monitoring methodology, management actions taken by Canal Corp., and general trends evident in the flow data collected during the monitoring period.

2.6.1 Flow Monitoring

E & E personnel programmed and installed flow meters prior to the application of the herbicide in order to help Canal Corp. manage the flows in the Erie Canal during the 48-hour treatment window. Prior to application, on July 19 and 21, 2016, E & E personnel set up a flow meter at each of the three following locations to test operations: Mayor's Park in Tonawanda, New York; near the East Canal Road/New Road Bridge in Pendleton, New York; and near the Stevens Street bridge in Lockport, New York (see photo of flow meter buoys at Stevens Street Bridge in Appendix A).

Flow in the creek/canal was measured prior to, during, and following herbicide application. Flow was calculated for each location as a function of the cross-sectional area and average cross-sectional velocity. Prior to deployment of flow sensors, E & E obtained measurements of the creek/canal depth and instantaneous velocity in a cross section perpendicular to the flow direction. In general, depth measurements were recorded every 10 feet across the channel, and at each location velocity measurements were recorded 6 inches below the surface and at approximately 25%, 50%, and 75% of the total creek/canal depth. These data were used to create a depth profile and velocity profile at each location (see Appendix C). Velocity readings were measured using a Hach FH950 Handheld Flow Meter with electromagnetic sensor with a resolution of 0.01 foot per second (ft/s), an accuracy of ±2%, and a zero stability of 0.05 ft/s.

The velocity data were then contoured using the Surfer software package version 13 by Golden Software. The Kriging method of data interpolation was used to grid the data obtained in the field and resulting grid nodes outside of the measured stream channel were removed. Surfer was used to calculate univariate statistics for the interpolated dataset, including the mean cross-sectional velocity. The area within the stream that represented the mean velocity ±20% was then highlighted to indicate areas within the stream where single, continuous velocity measurements could be obtained that would represent the approximate mean cross-sectional velocity (see Appendix C).

To continuously measure flow during the application period, single flow sensors were deployed at each monitoring location. Flow sensors were Hach Submerged AV, 1-megahertz acoustic Doppler flow sensors connected to a Hach FL900AV Flow Meter equipped with a Hach AV9000 Area-Velocity Analyzer Module. Each flow meter was equipped with a cellular modem to transmit data via Hach's Data Delivery Service for remote download and analysis. The flow sensors were positioned by E & E approximately 1 to 4 feet above the streambed using custom-made mounting systems. The sensors had a resolution of 0.01 ft/s, an accuracy of ±2%, a zero stability of 0.05 ft/s, and were capable of sensing both positive and negative velocities. They were oriented so that positive flow was recorded for the following conditions:

- West to east in Tonawanda Creek/Erie Canal at Mayor's Park, Tonawanda, New York;
- East to west in Tonawanda Creek at New Road, Pendleton, New York; and
- South to north in the Erie Canal at Stevens Street, Lockport, New York.

For each monitoring location, the cross-sectional area of the creek/canal was calculated using the depth measurements obtained prior to sensor deployment. The area of the stream below each sensor was calculated as a fixed area using Surfer software. The area above each sensor was calculated as a function of the water level (measured as height above the sensor) and stream bank geometry. Levels were measured using pressure transducers built into the flow sensors. The relationship between level above the sensor and cross-sectional area was determined using the depth measurements and a river profile area calculator provided by the equipment manufacturer. This calculator is based on simple trapezoidal sections of the river. The calculated areas were plotted against the levels and a line of linear interpolation was fit to the data using the basal area beneath the sensor as the intercept. The resulting formulas were used to calculate the total cross-sectional area based on the measured level. The relationships used for these calculations are depicted on the graphs in Appendix C.

Level and velocity measurements were recorded every 5 minutes. These data were saved in a spreadsheet format and the area was calculated as described herein. The product of the calculated area and measured velocity was then calculated to determine the average cross-sectional flow rate.

Some challenges were encountered with the original setup of the sensors, which resulted in the sensors tipping over after placement in the creek/canal. This challenge was realized and rectified with buoys prior to herbicide application. At the Mayor's Park monitoring station, the sensor tipped shortly after it was installed due to the uneven creek bottom. The sensor was then placed upright, and the buoys were adjusted to avoid further tipping. Flow was continuously monitored to detect tipped sensors before, during, and after treatment.

The Stevens Street monitoring station was removed from the water at 1750 hours on Monday, July 26, 2016, and a buoy was taken from the station. This was not detected until the following morning and the station was replaced in the water by 1255 hours on Tuesday, July 27. Flow at the other two stations indicated that there was little flow in the creek/canal during this time. This is reflected in the flow, velocity, and level graphs in Appendix D.

Hourly updates were provided to the USACE and Canal Corp. regarding flow conditions observed over the previous hour at each monitoring location. If necessary, specific direction was provided to Canal Corp. regarding any action required with respect to flow management.

2.6.2 Flow Management

Water passes through Canal Corp. Locks 34/35 in three ways: 1) through the bypass tunnel, 2) through the miter gates of Locks 34/35, and 3) through the Flight of Five lock gates, which are associated with Old Locks 67 and 71 and located immediately north of Locks 34/35 (Manns 2014). During herbicide application, Canal Corp. closed the bypass tunnel and operations of Locks 34/35 were kept to a minimum, leaving water to be directed through the Flight of Five gates. In order for Canal Corp. to control the amount of flow through Locks 34/35, the Brookfield Power Plant was taken off-line. In order for the Canal Corp. to control the water level between Lockport and the Genesee River, RG&E Power Plant at Station 26 on the Genesee River was taken off-line.

Prior to the 48-hour treatment period, Canal Corp. ceased flows out of Lockport by closing the bypass gate opening at approximately 0930 hrs on July 26, 2016. As stated above, Canal Corp. reported that the Flight of Five lock gates had about 40 cfs leakage, and the City Hall gate had about 20 cfs leakage). Canal Corp. minimized lock operations, which continued during the treatment period. Typically, when Locks 34/35 are filled, this causes a short-term increase in flow rate towards the locks at the Stevens Street Bridge (north) and a drop in water level. However, lock fills were not observed in the level data obtained near the Stevens Street Bridge and, therefore, had minimal effects on flow rates (see Appendix D). The bypass gate was reopened at approximately 1050 hours on July 28, 2016.

2.6.3 Flow Observations

As part of its relicensing studies, the New York Power Authority (NYPA) reviewed natural and man-made factors affecting water levels in the upper and lower Niagara River (URS Corporation et al. 2005a). In the upper river, the NYPA found that regulation of the river level in the Chippawa-Grass Island Pool (downstream from the northern tip of Grand Island) has a more pronounced effect on river levels during the tourist season (April 1 to October 31). This is because the pool level is cycled more fully between day and nighttime to maintain the required flows at Niagara Falls. During non-tourist hours (nighttime), the pool is generally maintained at a lower water level than during the day. However, the change in pool level is gradual, and on a typical day, the water level in the pool is at a maximum at 700 hours; it is drawn down during the day for power production and is generally lowest at 2100 hours. During the tourist season, the daily median water level fluctuation at Tonawanda Island was recorded at 0.55 feet (versus 0.43 feet during the non-tourist season). Water levels were generally higher in the Niagara River during the spring and summer due to generally higher natural outflow from Lake Erie.

The effects of Niagara River water level fluctuations on tributaries were also studied (URS Corporation et al. 2005b). Fluctuations in Niagara River water levels affect Tonawanda Creek/Erie Canal throughout the entire length of the study area, which extended from the confluence with the Niagara River to 10,570 feet upstream (modeling beyond this distance was not performed in this study). Based on the analysis of the creek/canal profile, this study suggests that the influences from the median Niagara River level extend approximately 13.7 miles upstream in Tonawanda Creek to two riffle areas (rocky or shallow parts of a stream or river with rough water), which act as hydraulic controls limiting the river's upstream influence.

The effects of the drawdown of the Niagara River level by the NYPA were somewhat evident in the water level data obtained during this project (see Appendix D). The water level at Mayor's Park exhibited a cyclic behavior on an approximately daily cycle. During 2015, the maximum water level occurred at approximately mid-day and minimum water level occurred near midnight, with a few fluctuations in timing. Measurements in 2016 showed that the water level in the creek/canal near the Niagara River was generally at its highest in the late morning (0900 to 1100 hours) and then decreased to a minimum between 2300 and 0600 hours, with a magnitude change of 0.25 to 0.7 feet. Fluctuations in water level did not appear to have significant effects on changes in flow rate. At Mayor's Park, the flow rate was generally on the order of 500 cfs or less, fluctuating in direction to the east and west during the day prior to, during, and following the days of application (see Appendix D). On July 22 and 23, flow fluctuated to higher values (2,500 cfs at maximum) to the east.

At the Stevens Street monitoring station, flow rates were generally below 500 cfs and to the south prior to the treatment period. During treatment, flows fluctuated in direction at levels below 200 cfs. Following resumption of flow at the locks and bypass gates on July 29, 2016, increases in velocity and flow rate were observed, with the direction alternating from towards the south to the locks (see Appendix D).

Flows out of and into the natural channel of Tonawanda Creek (near East Canal/New Road) were all low. The majority of the time flow was from the canal, likely due to backwater conditions moving up the creek/canal resulting from Niagara River level changes. However, flow direction fluctuated towards the canal as well, especially after the second day of treatment. During the days of the treatment period, flow rates were generally measured between 0 and 100 cfs, which corroborates the United States Geological Survey (USGS) gauging station data on Tonawanda Creek in Rapids, New York (USGS Station Number 04218000). USGS data for the week of treatment showed daily flow rates increasing and then decreasing throughout the week with a maximum daily flow of 72 cfs and minimum of 20 cfs (USGS 2016).

3 Study Improvements

The study improvements, summarized below, were based on lessons learned from the 2015 endothall application effort, coordination with the study partners during 2016 work plan development, and activities conducted during the 2016 herbicide application.

3.1 Herbicide Application and Analysis

Transfer of the herbicide from the shore-based areas to the skiffs and application of the herbicide in both 2015 and 2016 was smooth and efficient. The locations and number of staging areas adequately supported operations along the creek/canal. Public access to the boat ramps during use by the applicators was uninterrupted.

The immunoassay tests performed to determine endothall concentrations in both 2015 and 2016 were effective at detecting the herbicide and for tracking its movement and degradation.

3.2 Flow Monitoring and Management

Various improvements were implemented pertaining to flow monitoring and management as described below.

Flow Resolution and Fluctuation

Hach submerged AV, 1-megahertz acoustic Doppler flow sensors connected to Hach FL900AV flow meters equipped with Hach AV9000 area-velocity analyzer modules were deployed in 2015 and 2016. The sensors had a resolution of 0.01 ft/s, an accuracy of ±2%, a zero stability of 0.05 ft/s, and were capable of sensing both positive and negative velocities. This sensitivity of instrumentation allowed for a better flow rate resolution. However, the data would not transmit at a frequency higher than 15 minutes, which made it difficult to discern why velocity readings changed direction between readings. Since more frequent velocity changes would help E & E understand the flow dynamics, E & E will explore other flow monitoring options to use in 2017, looking for a higher data transmission rate with lower resolution requirements.

Canal Corp. Operations

After the initial demonstration in 2014, E & E determined that one of the most important aspects to maximize herbicide contact time was to reduce operations of the Lockport locks and bypass gate flow to the maximum extent practicable. By eliminating flow to the east through the locks, the only flow that would require management is the low input from the natural channel of Tonawanda Creek entering the canal in Rapids, New York (less than 68 cfs during the 2016 application period [USGS 2016]). This inflow rate can be matched at Lockport by operating the bypass gate at a comparably low flow rate.

3.3 2016 Lessons Learned

Treatment Areas

As more spot-treatment areas will likely be involved in future work, these areas will probably be added and modified according to the ERDC survey work before application. Modifying or adding treatment areas in the field on the day of treatment will require the applicator to be prepared to upload new information into the Global Positioning System units that are used for navigation to ensure accurate herbicide placement.

Herbicide Volumes

There is an uncertainty associated with the number of spot treatments needed and, as a result, the actual herbicide volume quantities needed for the first treatment. As the program evolves and presumably will require more spot-treatment work in the future, this issue will need to be addressed. The applicator will need to have enough herbicide on-hand to be able to target all areas that require treatment, but have the flexibility to return unused product to inventory. The best way to address this may be to assess a restocking charge if less herbicide than the amount purchased is required. Preliminary estimates of the anticipated and potential maximum quantities of herbicide to be applied will be needed to arrange for product delivery and to determine the preferred container size.

Flow Monitoring Locations

The flow meter at Mayor's Park was difficult to put in place before treatment and difficult to remove when sampling was completed. A shallower location with better access would work better for 2017. Two possible locations are across the creek from the Service Drive ramp, which is farther west than Mayor's Park, or near the Botanical Gardens ramp, farther east from Mayor's Park.

Sampling Locations

In 2015, longitudinal dispersion of endothall was documented by water samples taken on both banks and in the center of the creek in a few locations. Dispersion of endothall along the length of the creek could be tracked by a few additional sample locations aligned with the "upstream" and "downstream" ends of the treatment areas. It is recommended that sampling locations be picked to coordinate with the treatment area locations and to establish longitudinal dispersion of endothall within the treatment areas. Coordination between E & E and ERDC could be improved through shared sampling location maps.

4 References

Manns, Richard. 2014. Canal Engineering, New York State Canal Corporation. Personal communication with K. Dixon, Ecology and Environment, Inc. on October 15, 2014.

___________. 2016. Personal communication via email, December 16, 2016.

National Weather Service. 2016. Buffalo Weather Forecast Office: Accessed online at: http://w2.weather.gov/climate/index.php?wfo=buf, accessed on August 11, 2016.

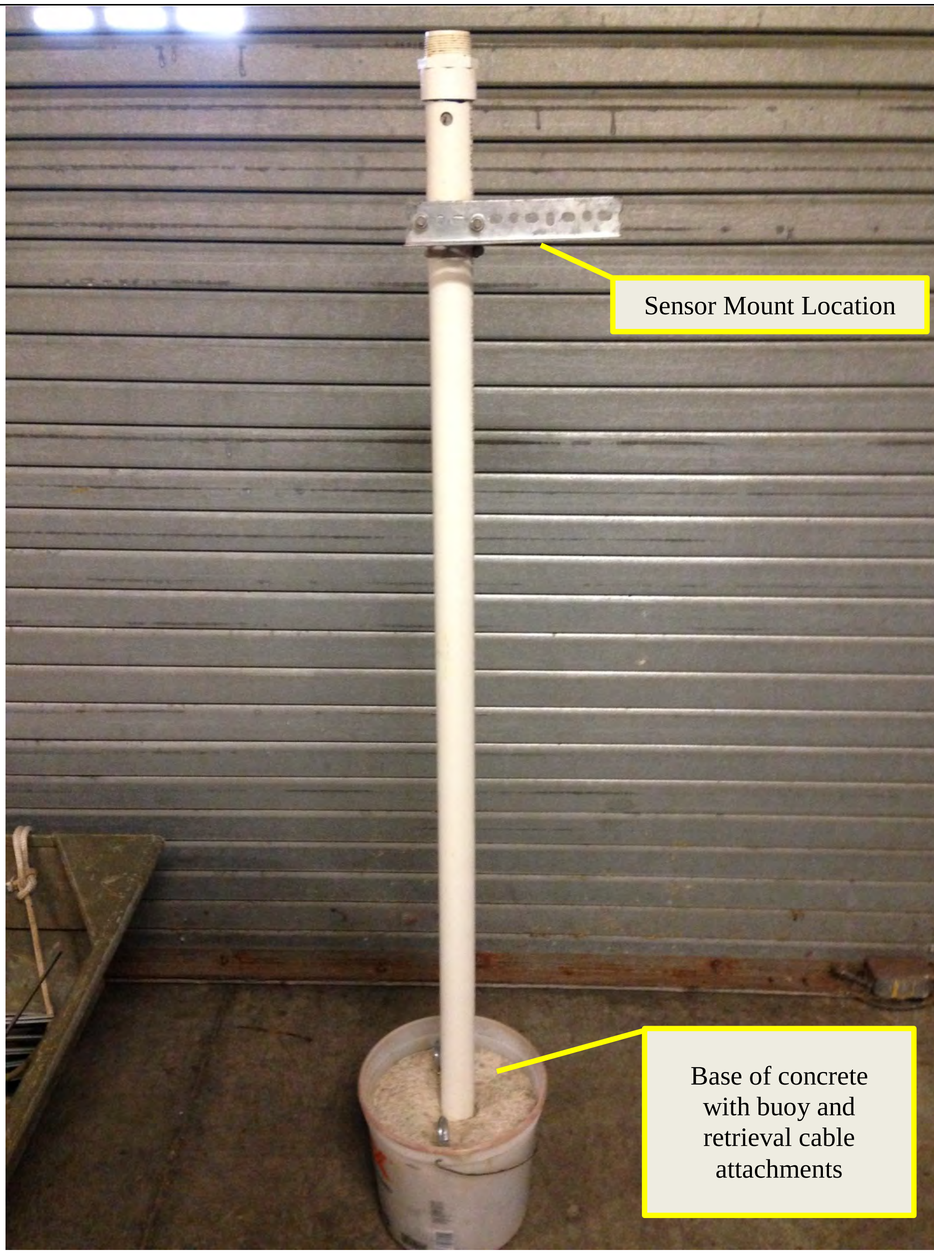
URS Corporation, Gomez and Sullivan Engineers, and E/PRO Engineering and Environmental Consulting. 2005a. *Niagara Power Project Relicensing, Niagara River Water Level and Flow Fluctuation Study Final Report*. Prepared for the New York Power Authority. http://niagara.nypa.gov/StudyReports/FinalReports.htm#WaterUseAndQuality.

___________. 2005b. *Niagara Power Project Relicensing, Upper Niagara River Tributary Backwater Study*. Prepared for the New York Power Authority. http://niagara.nypa.gov/StudyReports/FinalReports.htm#WaterUseAndQuality.

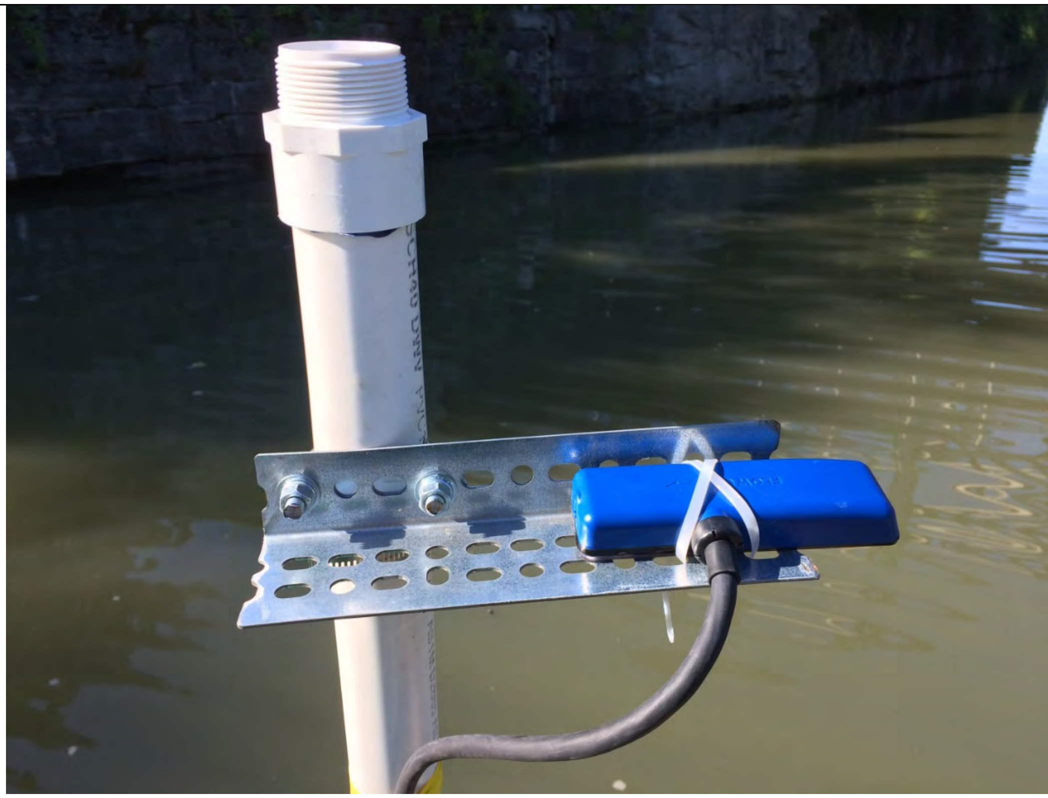
United States Army Corps of Engineers (USACE). 2016. *Architect-Engineer Scope of Work Aquatic Plant Control ERDC Demonstration Project Tonawanda Creek/Erie Canal.* May 27, 2016.

United States Geological Survey (USGS). 2016. Data for USGS 04218000 Tonawanda Creek at Rapids NY. National Water Information System. http://waterdata.usgs.gov/nwis/uv?site_no=04218000.

A Photolog



Subject:	Sensor Mount
Description:	Concrete bucket with attachments for retrieval cable, buoy ties and sensor cable. Sensor mount is adjustable to control for sensor height above creek bottom



Subject:	Mounted Sigma flow/velocity sensor
Description:	Sensor is mounted parallel to flow direction and can measure negative and positive flows

Date:	07/12/2016	**Direction of View:**	South from North shore of creek
Subject:	E&E employees at New Road Bridge in Pendleton		
Description:	E&E employees measuring flow at 6 inches, 25%, 50% and 75% of depth to determine the flow profile at New Road Bridge flow monitoring location.		

Date:	07/19/2016	**Direction of View:**	NW from SE shore of canal
Subject:	Buoys marking flow meter location		
Description:	Two buoys mark the location of the flow meter at Stevens St. Bridge in Lockport		

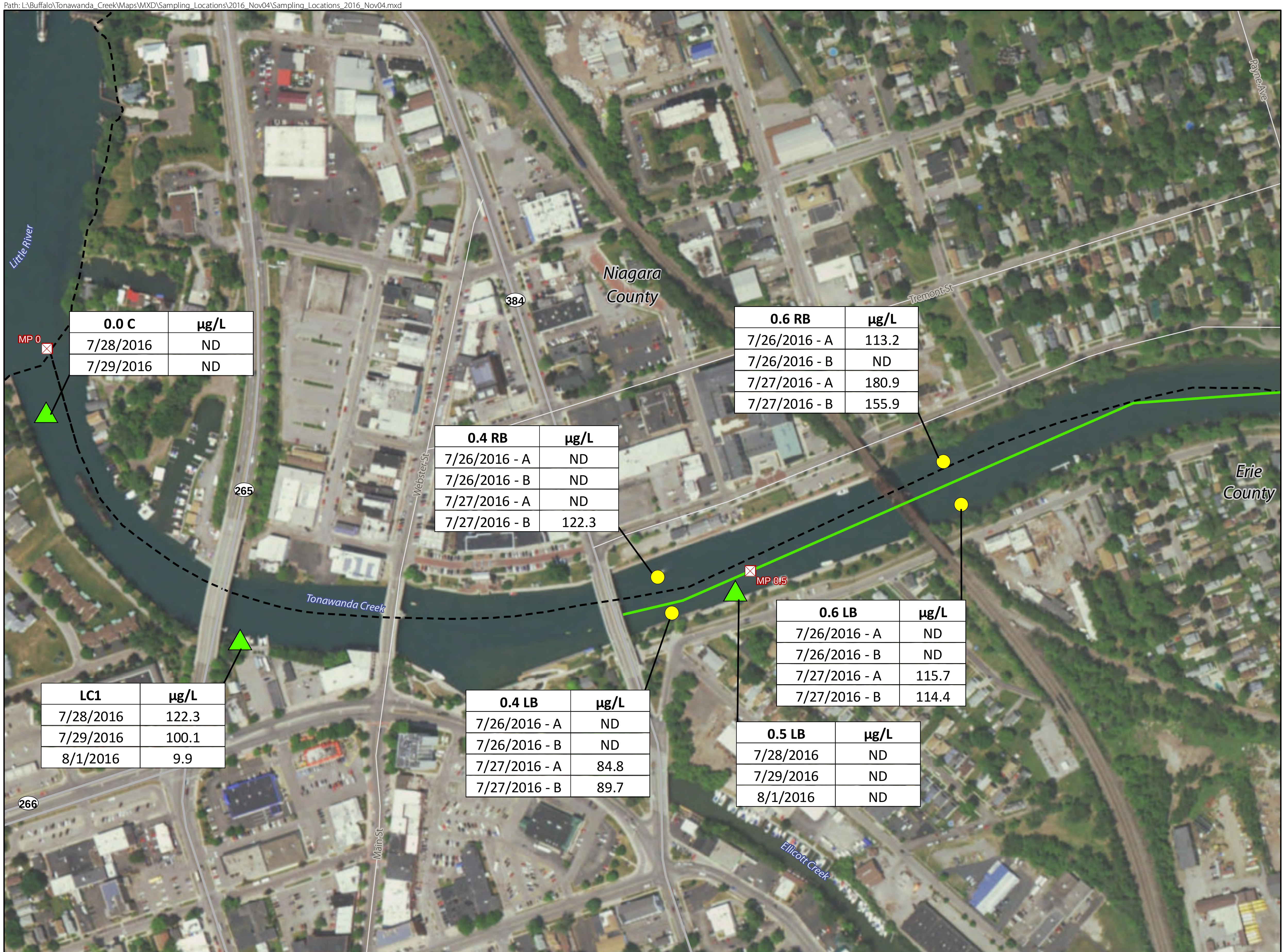
Date:	07/25/2016	**Direction of View:**	SE from North shore of canal
Subject:	US Army Corps of Engineers (USACE) employees surveying for Hydrilla		
Description:	USACE checked for additional hydrilla locations the day before endothall treatment		

Date:	07/26/2016	**Direction of View:**	West from North shore of creek
Subject:	Application boat set-up		
Description:	Endothall was placed in the tank and dispensed into the creek through PVC pipes on back of boat.		

B Water Quality Sampling Location Maps

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2016_Nov04\Sampling_Locations_2016_Nov04.mxd

Sample Locations
Associated Endothall Concentration Values
Figure B1
Tonawanda Creek
Erie and Niagara Counties, New York



0.0 C	µg/L
7/28/2016	ND
7/29/2016	ND

0.6 RB	µg/L
7/26/2016 - A	113.2
7/26/2016 - B	ND
7/27/2016 - A	180.9
7/27/2016 - B	155.9

0.4 RB	µg/L
7/26/2016 - A	ND
7/26/2016 - B	ND
7/27/2016 - A	ND
7/27/2016 - B	122.3

0.6 LB	µg/L
7/26/2016 - A	ND
7/26/2016 - B	ND
7/27/2016 - A	115.7
7/27/2016 - B	114.4

LC1	µg/L
7/28/2016	122.3
7/29/2016	100.1
8/1/2016	9.9

0.4 LB	µg/L
7/26/2016 - A	ND
7/26/2016 - B	ND
7/27/2016 - A	84.8
7/27/2016 - B	89.7

0.5 LB	µg/L
7/28/2016	ND
7/29/2016	ND
8/1/2016	ND

Legend

- Milepost from Mouth of Creek/Canal
- ERDC Sampling Location*
- E&E Sampling Location*
- Primary Treatment Area
- Secondary Treatment Area
- County Boundary
- Secondary Road
- Local Road

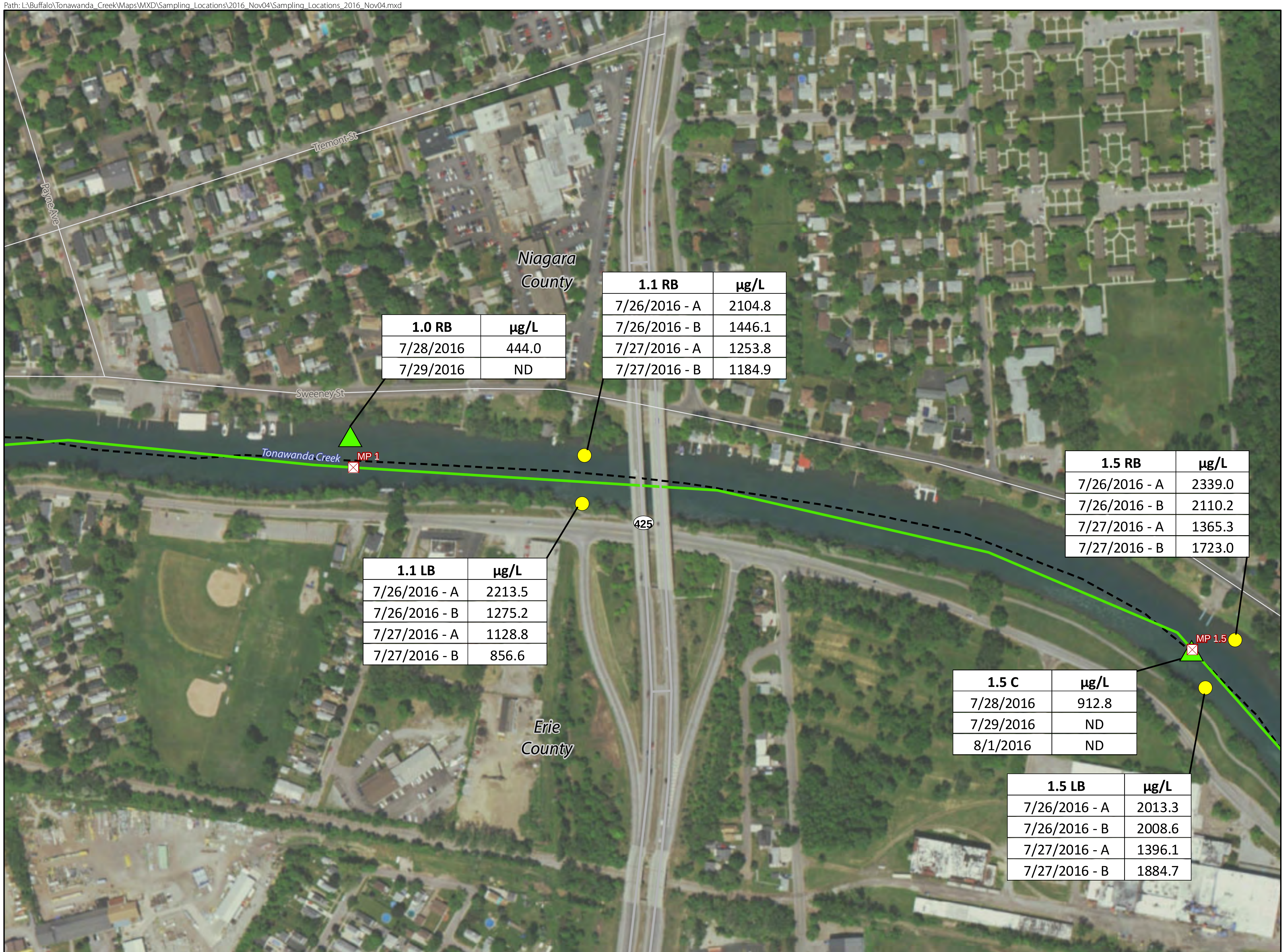
*Note: All Sample Locations are Approximate.

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2011; Ecology and Environment, Inc. 2016; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2016_Nov04\Sampling_Locations_2016_Nov04.mxd



1.0 RB	µg/L
7/28/2016	444.0
7/29/2016	ND

1.1 RB	µg/L
7/26/2016 - A	2104.8
7/26/2016 - B	1446.1
7/27/2016 - A	1253.8
7/27/2016 - B	1184.9

1.1 LB	µg/L
7/26/2016 - A	2213.5
7/26/2016 - B	1275.2
7/27/2016 - A	1128.8
7/27/2016 - B	856.6

1.5 RB	µg/L
7/26/2016 - A	2339.0
7/26/2016 - B	2110.2
7/27/2016 - A	1365.3
7/27/2016 - B	1723.0

1.5 C	µg/L
7/28/2016	912.8
7/29/2016	ND
8/1/2016	ND

1.5 LB	µg/L
7/26/2016 - A	2013.3
7/26/2016 - B	2008.6
7/27/2016 - A	1396.1
7/27/2016 - B	1884.7

Sample Locations
Associated Endothall Concentration Values
Figure B2
Tonawanda Creek
Erie and Niagara Counties, New York

Legend

- Milepost from Mouth of Creek/Canal
- ERDC Sampling Location*
- E&E Sampling Location*
- Primary Treatment Area
- Secondary Treatment Area
- County Boundary
- Secondary Road
- Local Road

*Note: All Sample Locations are Approximate.

SCALE
0 0.05 0.1 Miles

SOURCE: ESRI 2011; Ecology and Environment, Inc. 2016; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2016_Nov04\Sampling_Locations_2016_Nov04.mxd

2.0 RB	µg/L
7/26/2016 - A	ND
7/26/2016 - B	1130.5
7/27/2016 - A	1141.6
7/27/2016 - B	1389.9
7/28/2016	1441.5
7/29/2016	ND

2.2 RB	µg/L
7/26/2016 - A	ND
7/26/2016 - B	798.9
7/27/2016 - A	738.2
7/27/2016 - B	1549.7

2.0 LB	µg/L
7/26/2016 - A	ND
7/26/2016 - B	1096.9
7/27/2016 - A	1084.9
7/27/2016 - B	1760.5
7/28/2016	1432.6
7/29/2016	ND

2.2 LB	µg/L
7/26/2016 - A	ND
7/26/2016 - B	921.7
7/27/2016 - A	667.4
7/27/2016 - B	1567.5

Sample Locations
Associated Endothall Concentration Values
Figure B3

Tonawanda Creek
Erie and Niagara Counties, New York

Legend

- Milepost from Mouth of Creek/Canal
- ERDC Sampling Location*
- E&E Sampling Location*
- Primary Treatment Area
- Secondary Treatment Area
- County Boundary
- Local Road

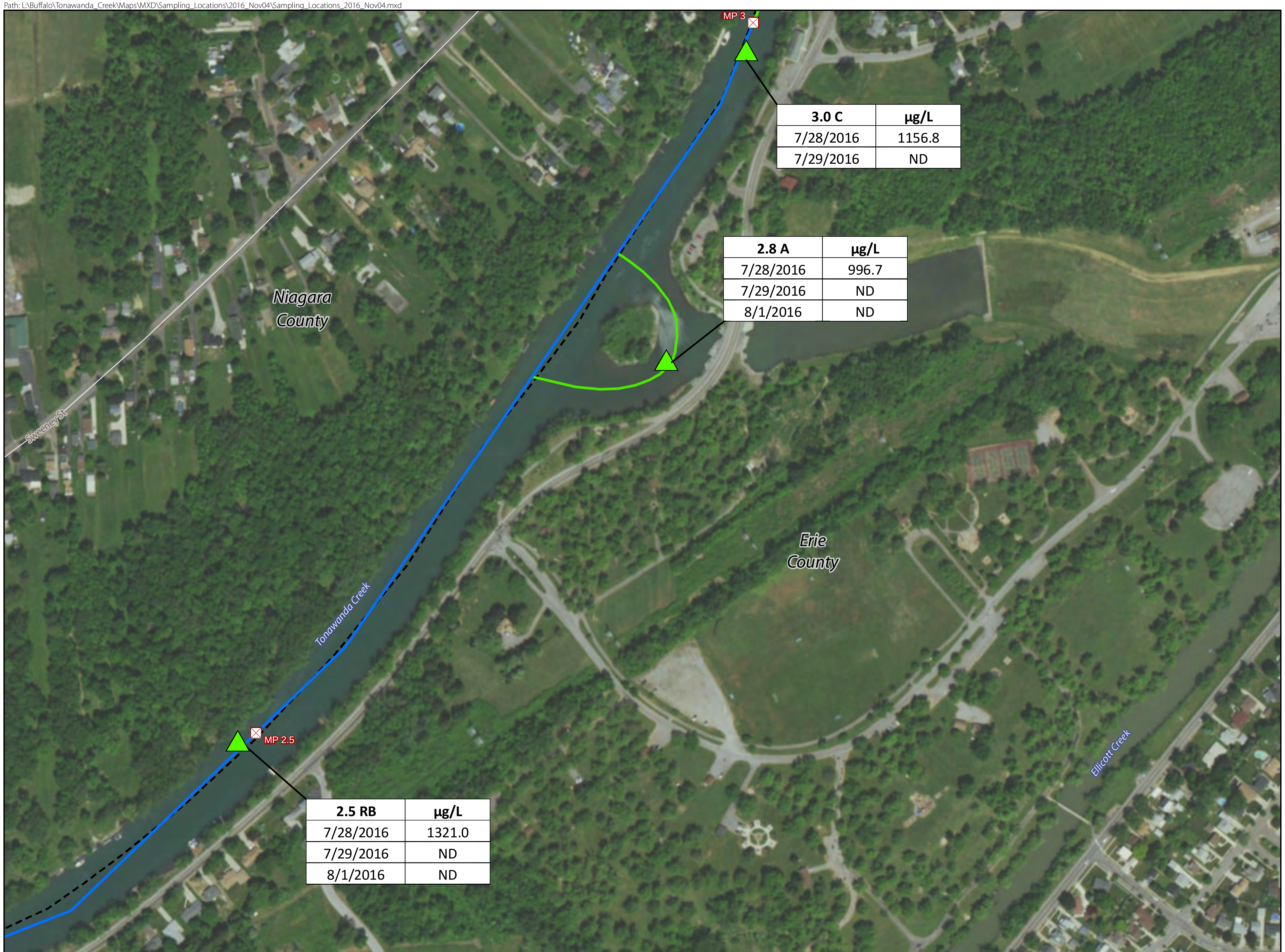
*Note: All Sample Locations are Approximate.

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2011; Ecology and Environment, Inc. 2016; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2016_Nov04\Sampling_Locations_2016_Nov04.mxd



3.0 C	µg/L
7/28/2016	1156.8
7/29/2016	ND

2.8 A	µg/L
7/28/2016	996.7
7/29/2016	ND
8/1/2016	ND

2.5 RB	µg/L
7/28/2016	1321.0
7/29/2016	ND
8/1/2016	ND

Sample Locations
Associated Endothall Concentration Values
Figure B4

Tonawanda Creek

Erie and Niagara Counties, New York

Legend

- Milepost from Mouth of Creek/Canal
- ERDC Sampling Location*
- E&E Sampling Location*
- Primary Treatment Area
- Secondary Treatment Area
- County Boundary
- Local Road

*Note: All Sample Locations are Approximate.

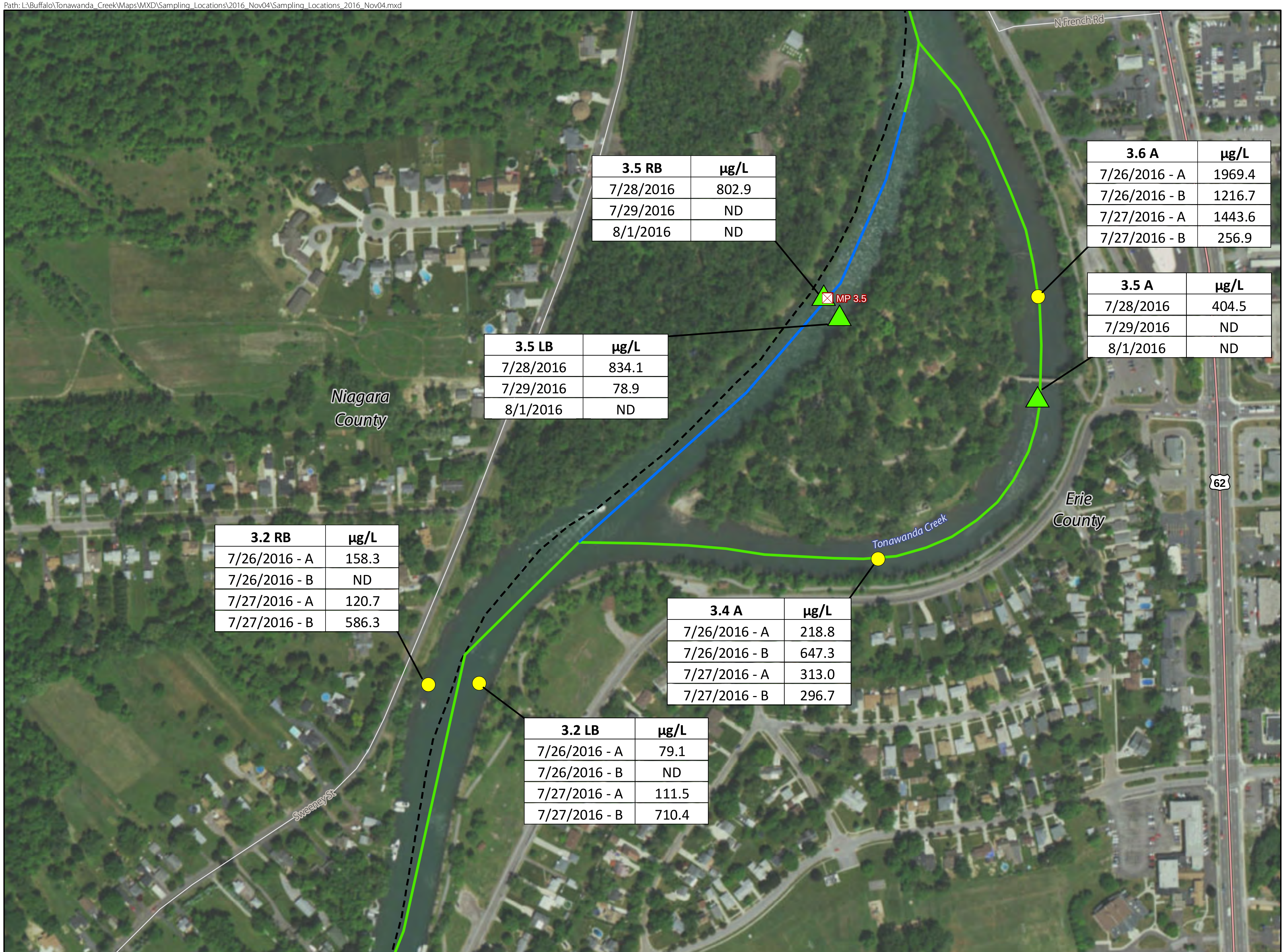
N

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2011; Ecology and Environment, Inc. 2016; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2016_Nov04\Sampling_Locations_2016_Nov04.mxd



3.5 RB	µg/L
7/28/2016	802.9
7/29/2016	ND
8/1/2016	ND

3.6 A	µg/L
7/26/2016 - A	1969.4
7/26/2016 - B	1216.7
7/27/2016 - A	1443.6
7/27/2016 - B	256.9

3.5 A	µg/L
7/28/2016	404.5
7/29/2016	ND
8/1/2016	ND

3.5 LB	µg/L
7/28/2016	834.1
7/29/2016	78.9
8/1/2016	ND

3.2 RB	µg/L
7/26/2016 - A	158.3
7/26/2016 - B	ND
7/27/2016 - A	120.7
7/27/2016 - B	586.3

3.4 A	µg/L
7/26/2016 - A	218.8
7/26/2016 - B	647.3
7/27/2016 - A	313.0
7/27/2016 - B	296.7

3.2 LB	µg/L
7/26/2016 - A	79.1
7/26/2016 - B	ND
7/27/2016 - A	111.5
7/27/2016 - B	710.4

Sample Locations
Associated Endothall Concentration Values
Figure B5

Tonawanda Creek

Erie and Niagara Counties, New York

Legend

- Milepost from Mouth of Creek/Canal
- ERDC Sampling Location*
- E&E Sampling Location*
- Primary Treatment Area
- Secondary Treatment Area
- County Boundary
- Major Road
- Local Road

*Note: All Sample Locations are Approximate.

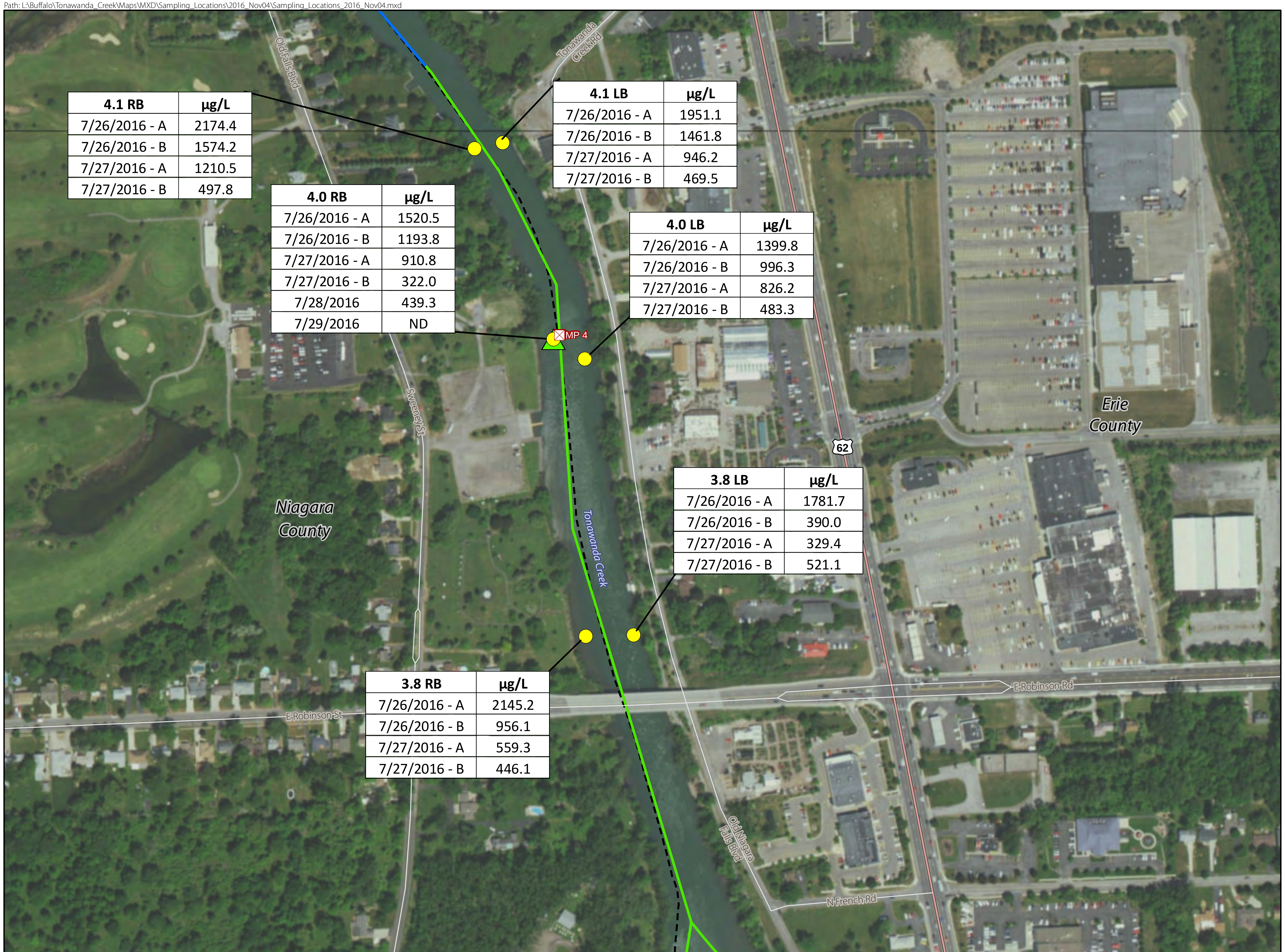
N

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2011; Ecology and Environment, Inc. 2016; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2016_Nov04\Sampling_Locations_2016_Nov04.mxd



4.1 RB	µg/L
7/26/2016 - A	2174.4
7/26/2016 - B	1574.2
7/27/2016 - A	1210.5
7/27/2016 - B	497.8

4.1 LB	µg/L
7/26/2016 - A	1951.1
7/26/2016 - B	1461.8
7/27/2016 - A	946.2
7/27/2016 - B	469.5

4.0 RB	µg/L
7/26/2016 - A	1520.5
7/26/2016 - B	1193.8
7/27/2016 - A	910.8
7/27/2016 - B	322.0
7/28/2016	439.3
7/29/2016	ND

4.0 LB	µg/L
7/26/2016 - A	1399.8
7/26/2016 - B	996.3
7/27/2016 - A	826.2
7/27/2016 - B	483.3

3.8 LB	µg/L
7/26/2016 - A	1781.7
7/26/2016 - B	390.0
7/27/2016 - A	329.4
7/27/2016 - B	521.1

3.8 RB	µg/L
7/26/2016 - A	2145.2
7/26/2016 - B	956.1
7/27/2016 - A	559.3
7/27/2016 - B	446.1

Sample Locations
Associated Endothall Concentration Values
Figure B6

Tonawanda Creek

Erie and Niagara Counties, New York

Legend

- Milepost from Mouth of Creek/Canal
- ERDC Sampling Location*
- E&E Sampling Location*
- Primary Treatment Area
- Secondary Treatment Area
- County Boundary
- Major Road
- Local Road

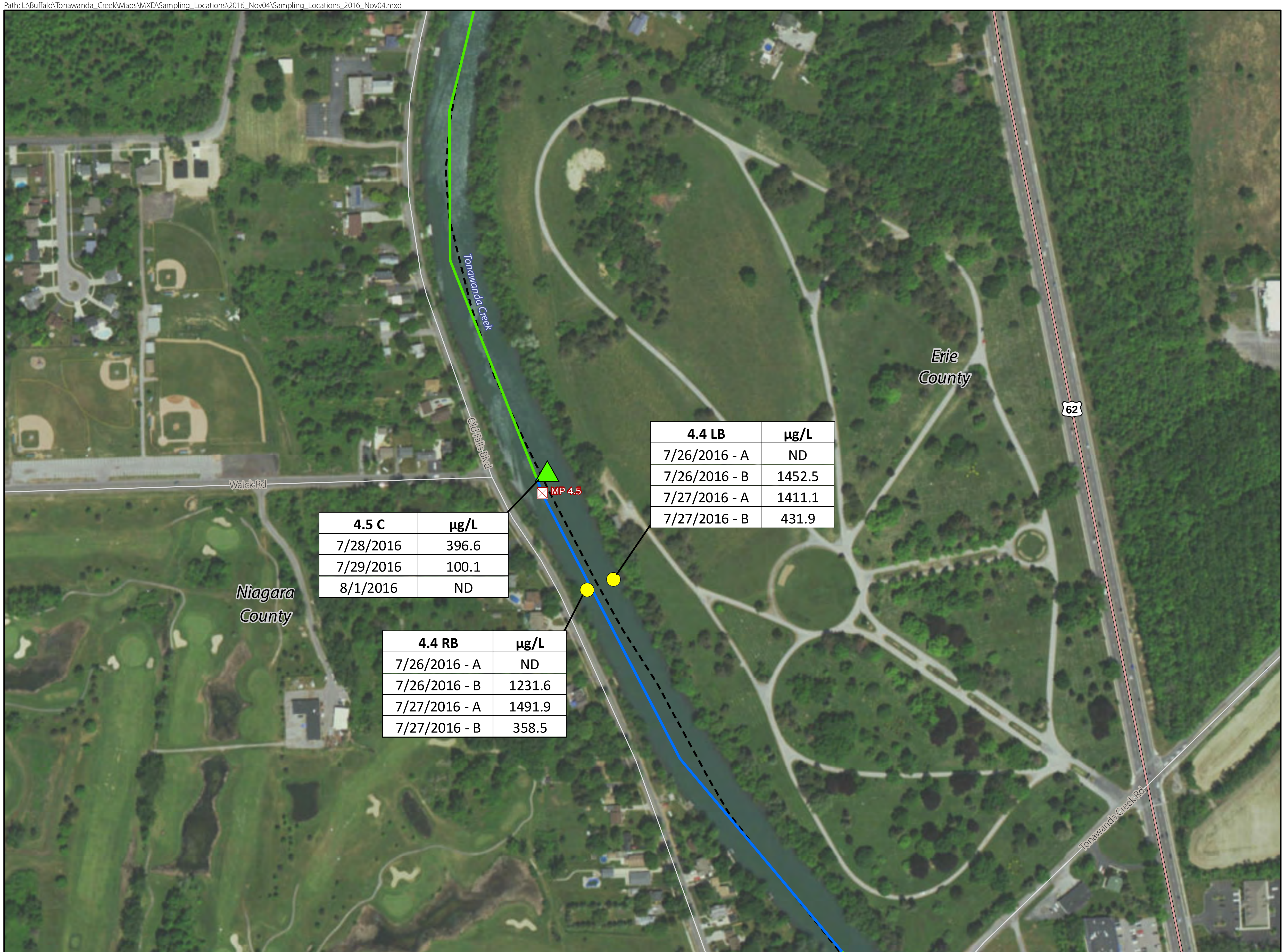
*Note: All Sample Locations are Approximate.

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2011; Ecology and Environment, Inc. 2016; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2016_Nov04\Sampling_Locations_2016_Nov04.mxd



4.5 C	µg/L
7/28/2016	396.6
7/29/2016	100.1
8/1/2016	ND

4.4 LB	µg/L
7/26/2016 - A	ND
7/26/2016 - B	1452.5
7/27/2016 - A	1411.1
7/27/2016 - B	431.9

4.4 RB	µg/L
7/26/2016 - A	ND
7/26/2016 - B	1231.6
7/27/2016 - A	1491.9
7/27/2016 - B	358.5

Sample Locations
Associated Endothall Concentration Values
Figure B7
Tonawanda Creek
Erie and Niagara Counties, New York

Legend

- Milepost from Mouth of Creek/Canal
- ERDC Sampling Location*
- E&E Sampling Location*
- Primary Treatment Area
- Secondary Treatment Area
- County Boundary
- Major Road
- Local Road

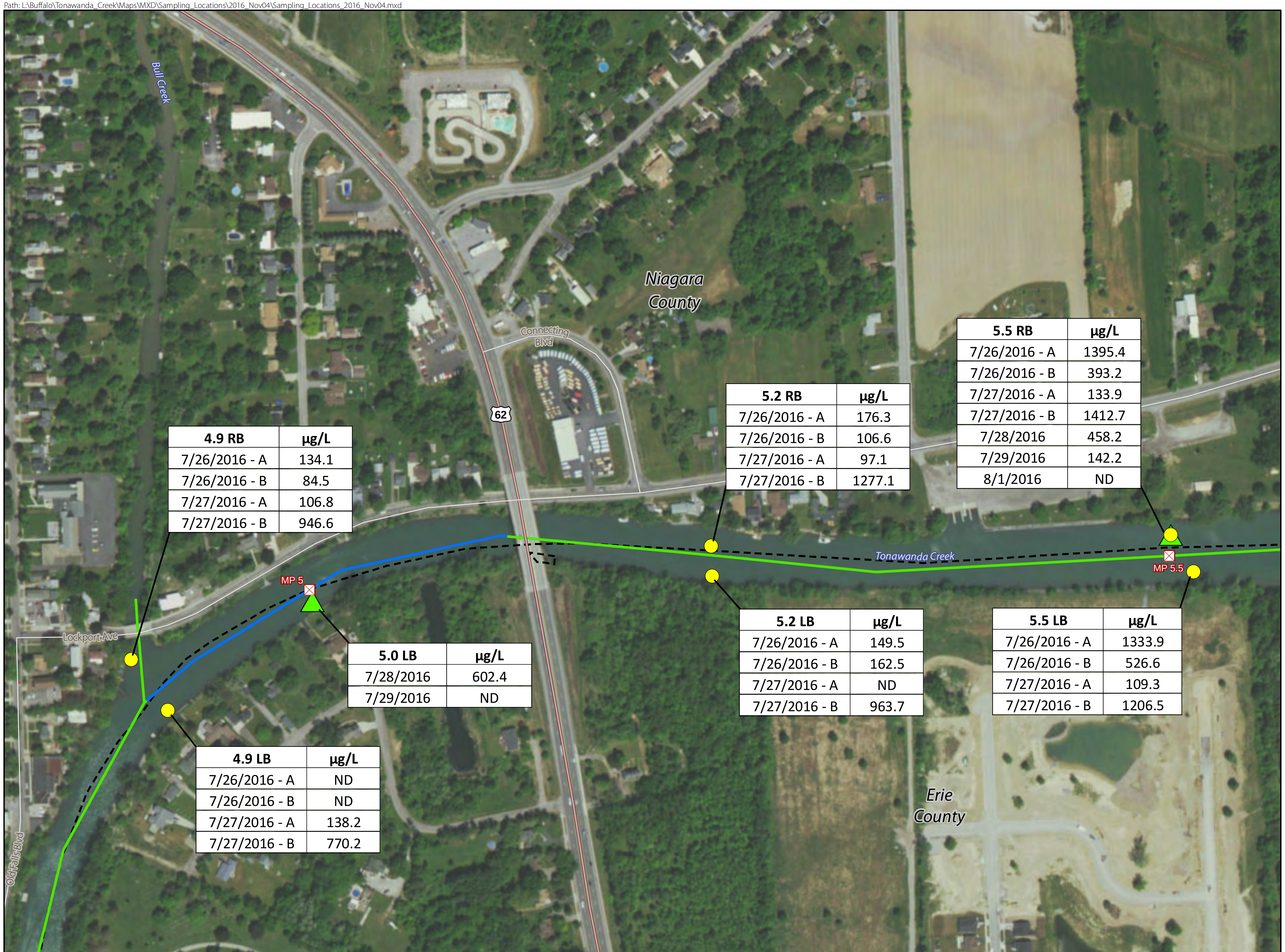
*Note: All Sample Locations are Approximate.

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2011; Ecology and Environment, Inc. 2016; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2016_Nov04\Sampling_Locations_2016_Nov04.mxd



4.9 RB	µg/L
7/26/2016 - A	134.1
7/26/2016 - B	84.5
7/27/2016 - A	106.8
7/27/2016 - B	946.6

4.9 LB	µg/L
7/26/2016 - A	ND
7/26/2016 - B	ND
7/27/2016 - A	138.2
7/27/2016 - B	770.2

5.0 LB	µg/L
7/28/2016	602.4
7/29/2016	ND

5.2 RB	µg/L
7/26/2016 - A	176.3
7/26/2016 - B	106.6
7/27/2016 - A	97.1
7/27/2016 - B	1277.1

5.2 LB	µg/L
7/26/2016 - A	149.5
7/26/2016 - B	162.5
7/27/2016 - A	ND
7/27/2016 - B	963.7

5.5 RB	µg/L
7/26/2016 - A	1395.4
7/26/2016 - B	393.2
7/27/2016 - A	133.9
7/27/2016 - B	1412.7
7/28/2016	458.2
7/29/2016	142.2
8/1/2016	ND

5.5 LB	µg/L
7/26/2016 - A	1333.9
7/26/2016 - B	526.6
7/27/2016 - A	109.3
7/27/2016 - B	1206.5

Sample Locations
Associated Endothall Concentration Values
Figure B8

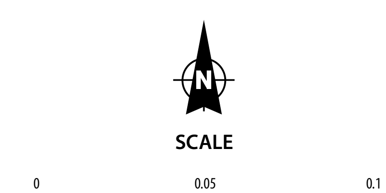
Tonawanda Creek

Erie and Niagara Counties, New York

Legend

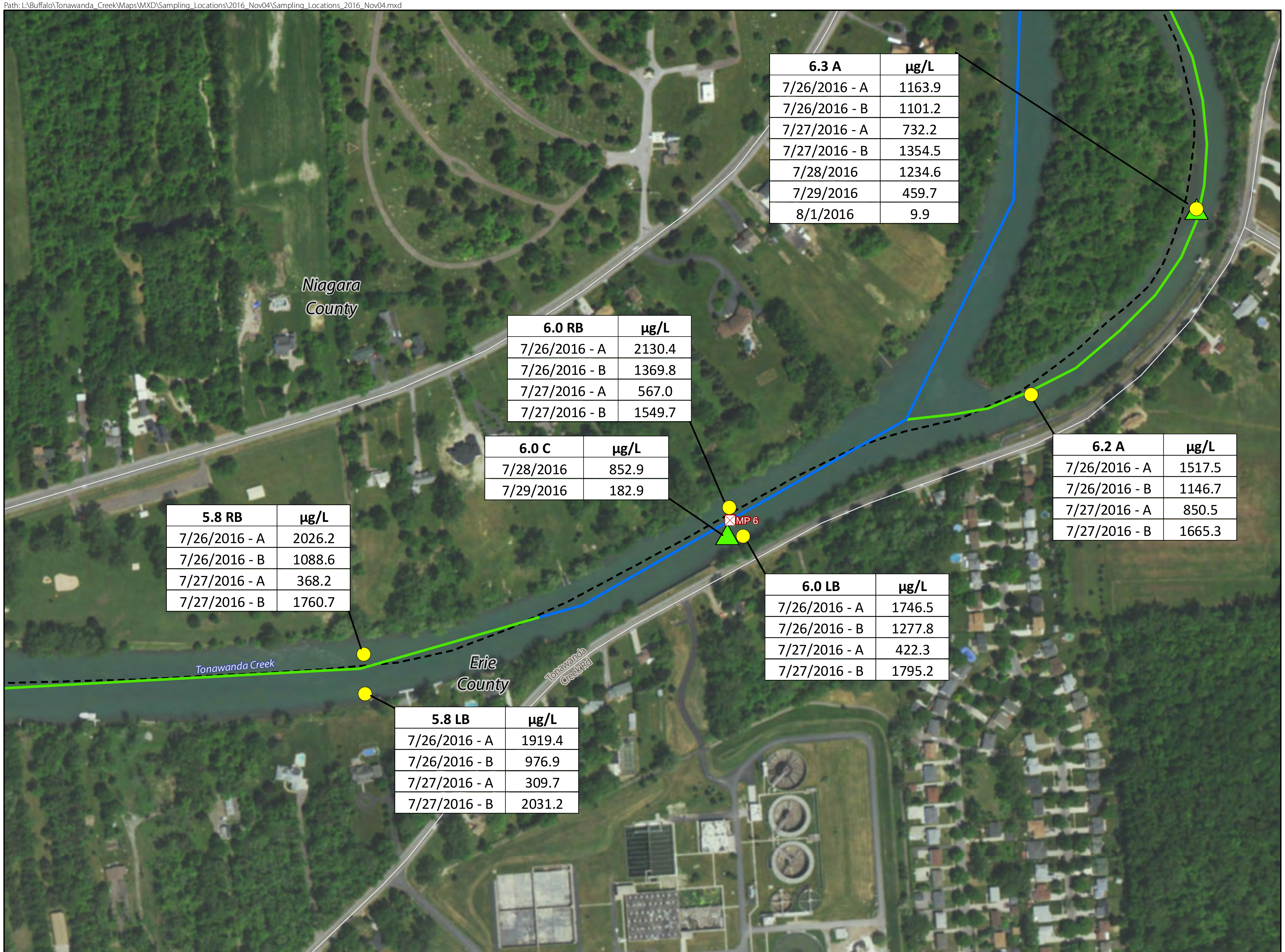
- Milepost from Mouth of Creek/Canal
- ERDC Sampling Location*
- E&E Sampling Location*
- Primary Treatment Area
- Secondary Treatment Area
- County Boundary
- Major Road
- Local Road

*Note: All Sample Locations are Approximate.



SOURCE: ESRI 2011; Ecology and Environment, Inc. 2016; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2016_Nov04\Sampling_Locations_2016_Nov04.mxd



6.3 A	µg/L
7/26/2016 - A	1163.9
7/26/2016 - B	1101.2
7/27/2016 - A	732.2
7/27/2016 - B	1354.5
7/28/2016	1234.6
7/29/2016	459.7
8/1/2016	9.9

6.0 RB	µg/L
7/26/2016 - A	2130.4
7/26/2016 - B	1369.8
7/27/2016 - A	567.0
7/27/2016 - B	1549.7

6.0 C	µg/L
7/28/2016	852.9
7/29/2016	182.9

6.2 A	µg/L
7/26/2016 - A	1517.5
7/26/2016 - B	1146.7
7/27/2016 - A	850.5
7/27/2016 - B	1665.3

5.8 RB	µg/L
7/26/2016 - A	2026.2
7/26/2016 - B	1088.6
7/27/2016 - A	368.2
7/27/2016 - B	1760.7

6.0 LB	µg/L
7/26/2016 - A	1746.5
7/26/2016 - B	1277.8
7/27/2016 - A	422.3
7/27/2016 - B	1795.2

5.8 LB	µg/L
7/26/2016 - A	1919.4
7/26/2016 - B	976.9
7/27/2016 - A	309.7
7/27/2016 - B	2031.2

Sample Locations
Associated Endothall Concentration Values
Figure B9

Tonawanda Creek
Erie and Niagara Counties, New York

Legend

- Milepost from Mouth of Creek/Canal
- ERDC Sampling Location*
- E&E Sampling Location*
- Primary Treatment Area
- Secondary Treatment Area
- County Boundary
- Local Road

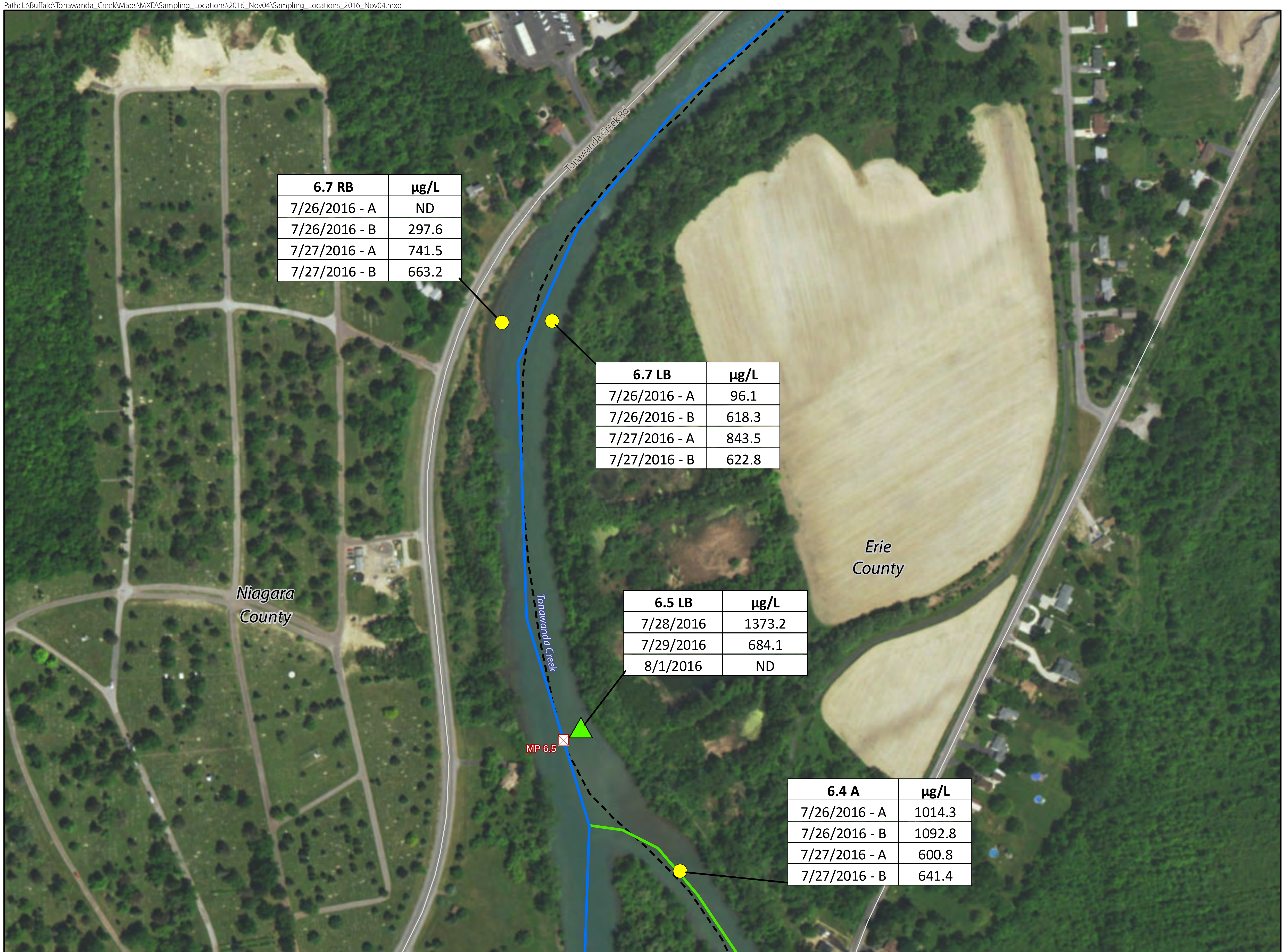
*Note: All Sample Locations are Approximate.

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2011; Ecology and Environment, Inc. 2016; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2016_Nov04\Sampling_Locations_2016_Nov04.mxd



6.7 RB	µg/L
7/26/2016 - A	ND
7/26/2016 - B	297.6
7/27/2016 - A	741.5
7/27/2016 - B	663.2

6.7 LB	µg/L
7/26/2016 - A	96.1
7/26/2016 - B	618.3
7/27/2016 - A	843.5
7/27/2016 - B	622.8

6.5 LB	µg/L
7/28/2016	1373.2
7/29/2016	684.1
8/1/2016	ND

6.4 A	µg/L
7/26/2016 - A	1014.3
7/26/2016 - B	1092.8
7/27/2016 - A	600.8
7/27/2016 - B	641.4

Sample Locations
Associated Endothall Concentration Values
Figure B10

Tonawanda Creek
Erie and Niagara Counties, New York

Legend

- Milepost from Mouth of Creek/Canal
- ERDC Sampling Location*
- E&E Sampling Location*
- Primary Treatment Area
- Secondary Treatment Area
- County Boundary
- Local Road

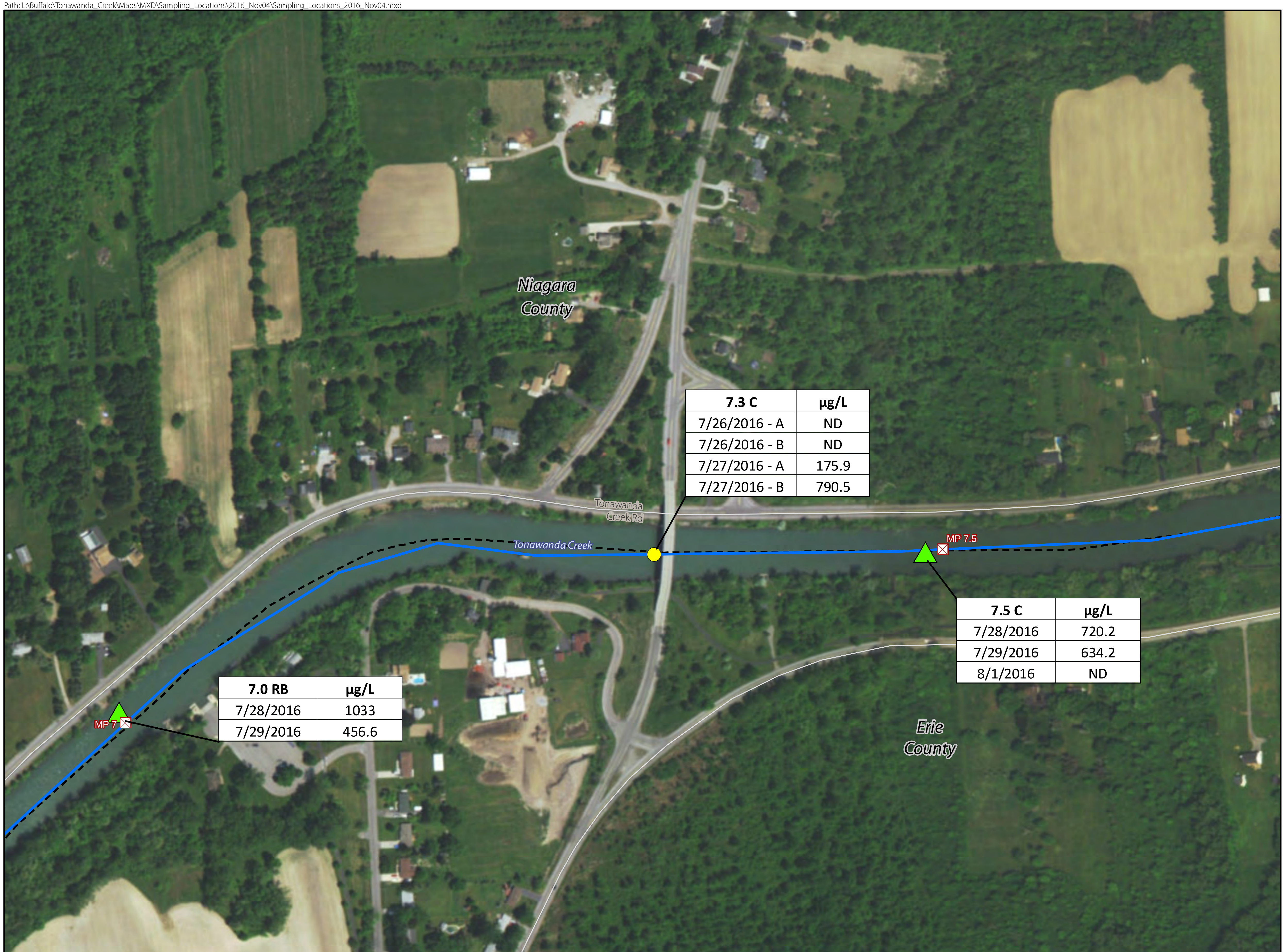
*Note: All Sample Locations are Approximate.

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2011; Ecology and Environment, Inc. 2016; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2016_Nov04\Sampling_Locations_2016_Nov04.mxd



7.3 C	µg/L
7/26/2016 - A	ND
7/26/2016 - B	ND
7/27/2016 - A	175.9
7/27/2016 - B	790.5

7.5 C	µg/L
7/28/2016	720.2
7/29/2016	634.2
8/1/2016	ND

7.0 RB	µg/L
7/28/2016	1033
7/29/2016	456.6

Sample Locations
Associated Endothall Concentration Values
Figure B11

Tonawanda Creek

Erie and Niagara Counties, New York

Legend

- Milepost from Mouth of Creek/Canal
- ERDC Sampling Location*
- E&E Sampling Location*
- Primary Treatment Area
- Secondary Treatment Area
- County Boundary
- Local Road

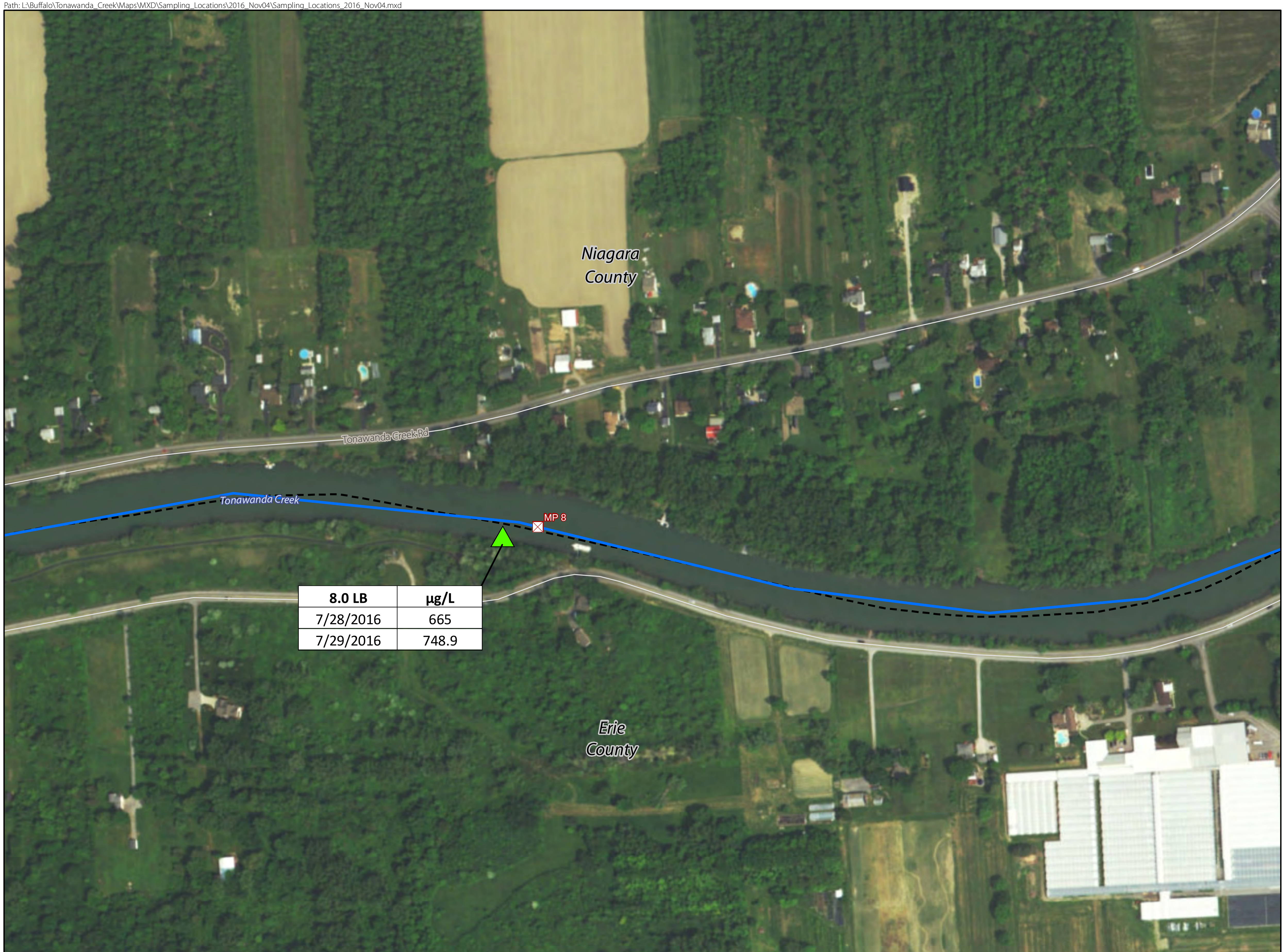
*Note: All Sample Locations are Approximate.

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2011; Ecology and Environment, Inc. 2016; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2016_Nov04\Sampling_Locations_2016_Nov04.mxd



8.0 LB	µg/L
7/28/2016	665
7/29/2016	748.9

Sample Locations
Associated Endothall Concentration Values
Figure B12
Tonawanda Creek
Erie and Niagara Counties, New York

Legend

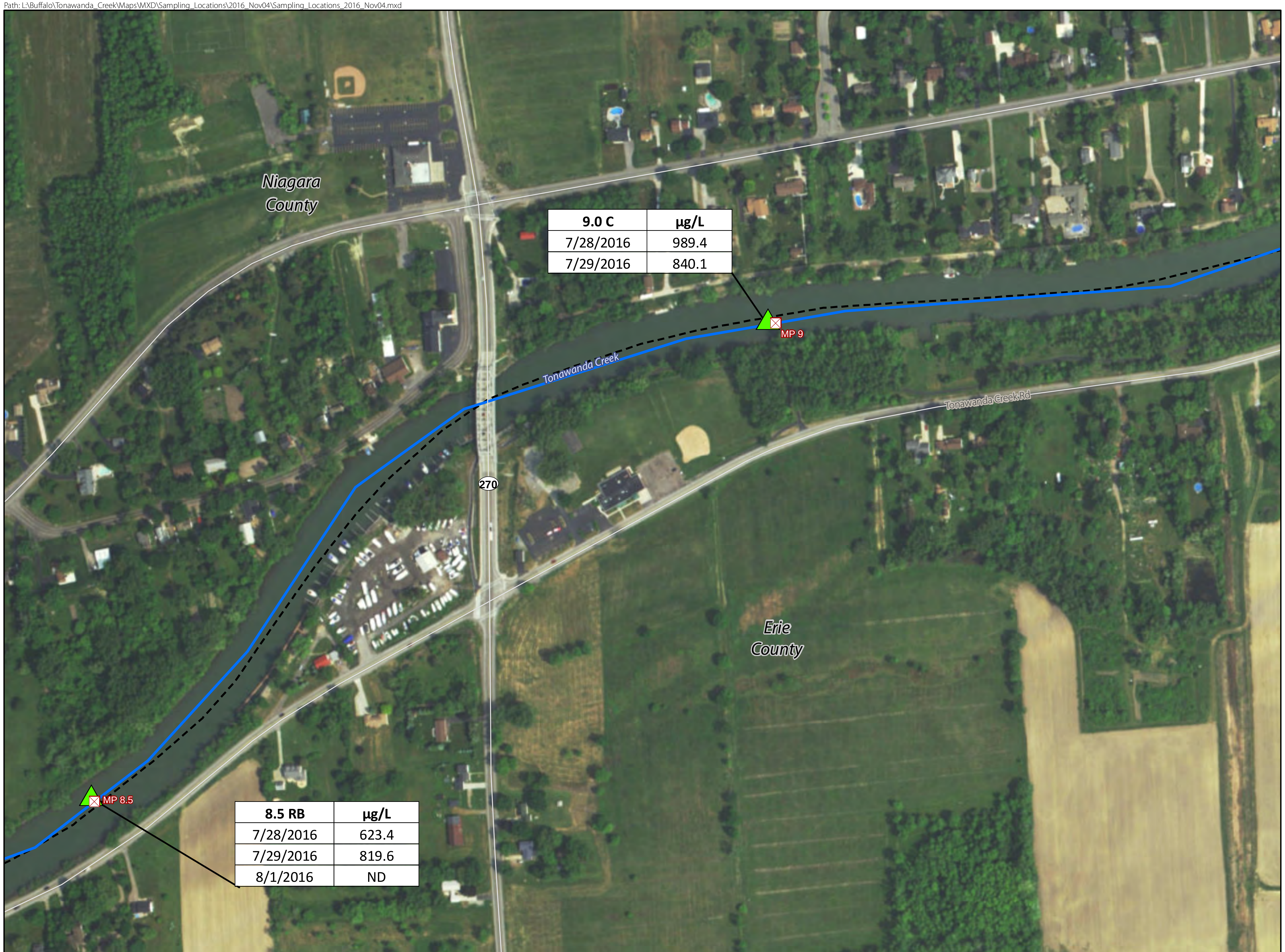
- Milepost from Mouth of Creek/Canal
- ERDC Sampling Location*
- E&E Sampling Location*
- Primary Treatment Area
- Secondary Treatment Area
- County Boundary
- Local Road

*Note: All Sample Locations are Approximate.

SCALE
0 0.05 0.1 Miles

SOURCE: ESRI 2011; Ecology and Environment, Inc. 2016; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2016_Nov04\Sampling_Locations_2016_Nov04.mxd



9.0 C	µg/L
7/28/2016	989.4
7/29/2016	840.1

8.5 RB	µg/L
7/28/2016	623.4
7/29/2016	819.6
8/1/2016	ND

Sample Locations
Associated Endothall Concentration Values
Figure B13
Tonawanda Creek
Erie and Niagara Counties, New York

Legend

- Milepost from Mouth of Creek/Canal
- ERDC Sampling Location*
- E&E Sampling Location*
- Primary Treatment Area
- Secondary Treatment Area
- County Boundary
- Local Road

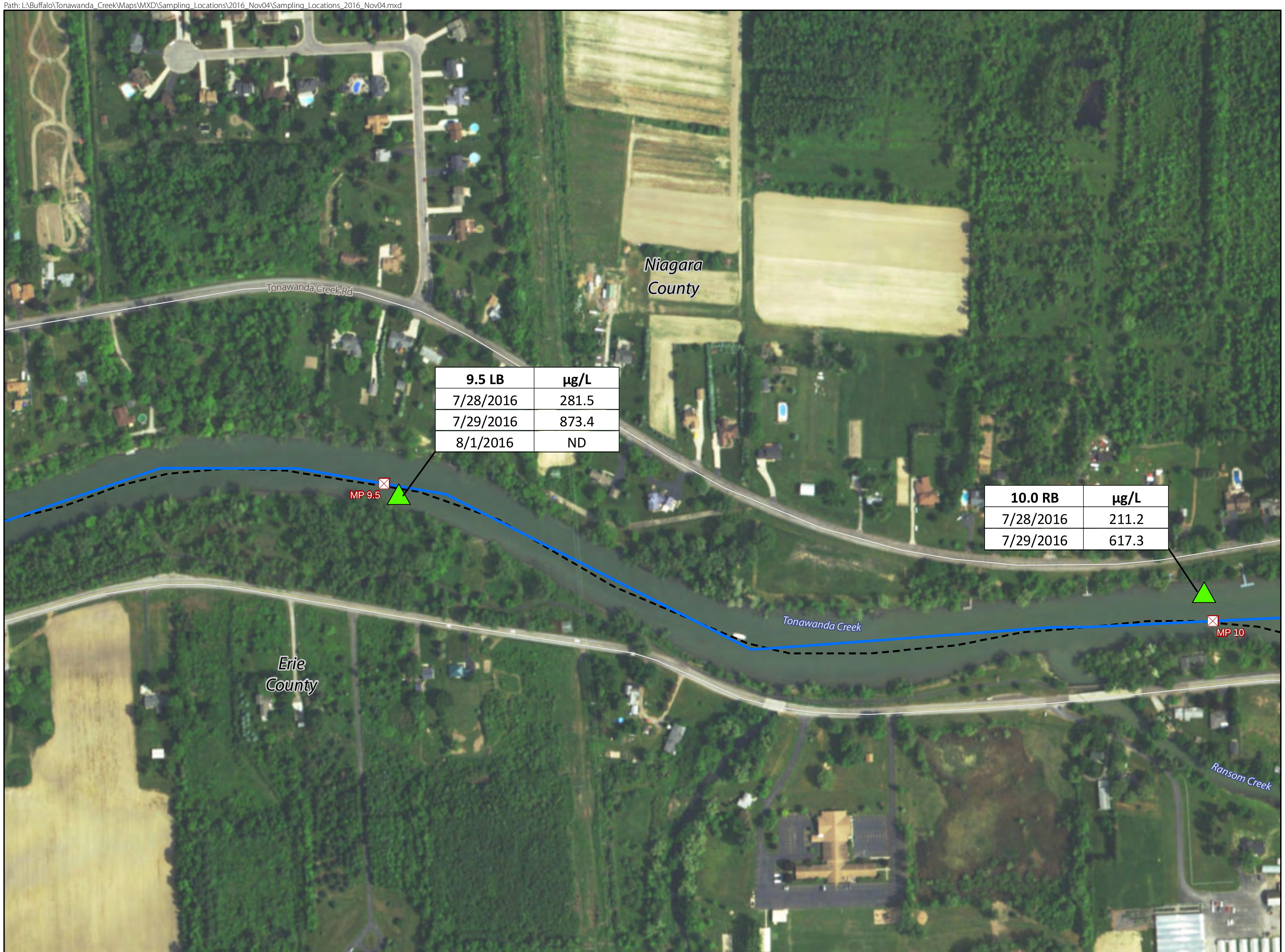
*Note: All Sample Locations are Approximate.

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2011; Ecology and Environment, Inc. 2016; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2016_Nov04\Sampling_Locations_2016_Nov04.mxd



9.5 LB	µg/L
7/28/2016	281.5
7/29/2016	873.4
8/1/2016	ND

10.0 RB	µg/L
7/28/2016	211.2
7/29/2016	617.3

Sample Locations
Associated Endothall Concentration Values
Figure B14
Tonawanda Creek
Erie and Niagara Counties, New York

Legend

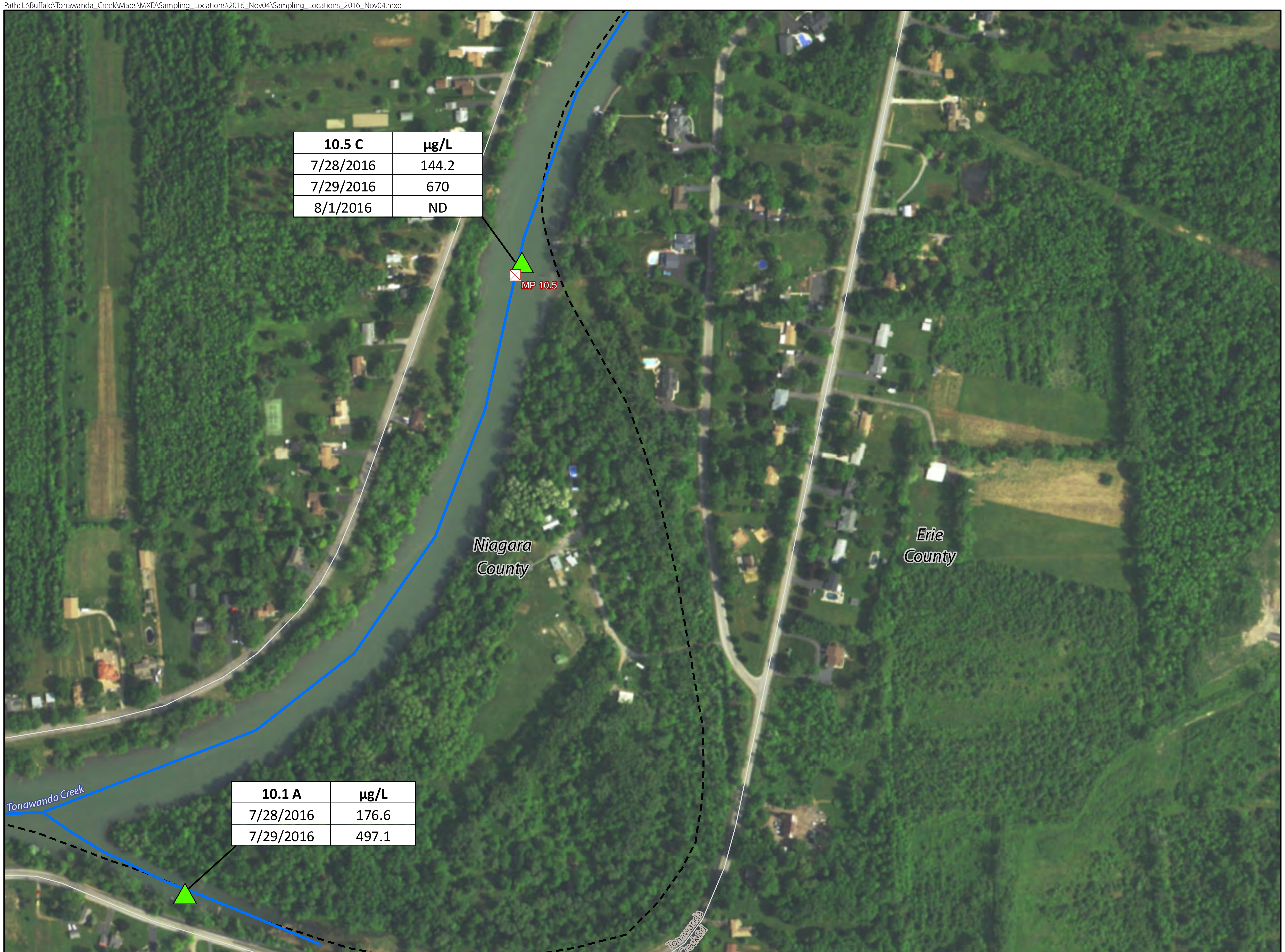
- Milepost from Mouth of Creek/Canal
- ERDC Sampling Location*
- E&E Sampling Location*
- Primary Treatment Area
- Secondary Treatment Area
- County Boundary
- Local Road

*Note: All Sample Locations are Approximate.

SCALE
0 0.05 0.1 Miles

SOURCE: ESRI 2011; Ecology and Environment, Inc. 2016; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2016_Nov04\Sampling_Locations_2016_Nov04.mxd



Sample Locations
Associated Endothall Concentration Values
Figure B15
Tonawanda Creek
Erie and Niagara Counties, New York

Legend

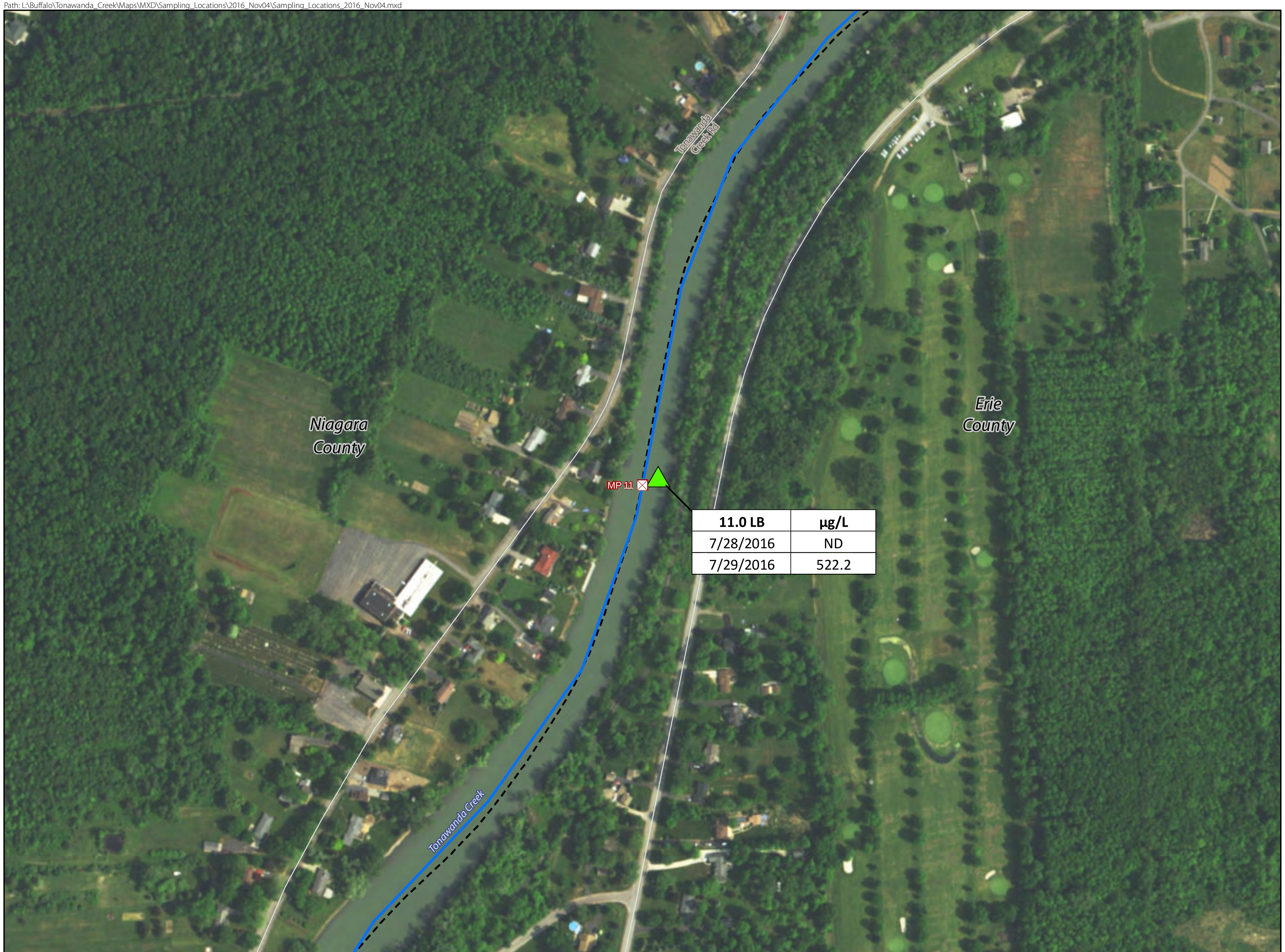
Milepost from Mouth of Creek/Canal
ERDC Sampling Location*
E&E Sampling Location*
Primary Treatment Area
Secondary Treatment Area
County Boundary
Local Road

*Note: All Sample Locations are Approximate.

SCALE
0 0.05 0.1 Miles

SOURCE: ESRI 2011; Ecology and Environment, Inc. 2016; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2016_Nov04\Sampling_Locations_2016_Nov04.mxd



11.0 LB	µg/L
7/28/2016	ND
7/29/2016	522.2

Sample Locations
Associated Endothall Concentration Values
Figure B16

Tonawanda Creek

Erie and Niagara Counties, New York

Legend

- Milepost from Mouth of Creek/Canal
- ERDC Sampling Location*
- E&E Sampling Location*
- Primary Treatment Area
- Secondary Treatment Area
- County Boundary
- Local Road

*Note: All Sample Locations are Approximate.

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2011; Ecology and Environment, Inc. 2016; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2016_Nov04\Sampling_Locations_2016_Nov04.mxd

11.5 RB	µg/L
7/28/2016	115.4
7/29/2016	440.2
8/1/2016	9.9

Sample Locations
Associated Endothall Concentration Values
Figure B17

Tonawanda Creek

Erie and Niagara Counties, New York

Legend

- Milepost from Mouth of Creek/Canal
- ERDC Sampling Location*
- E&E Sampling Location*
- Primary Treatment Area
- Secondary Treatment Area
- County Boundary
- Local Road

*Note: All Sample Locations are Approximate.

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2011; Ecology and Environment, Inc. 2016; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2016_Nov04\Sampling_Locations_2016_Nov04.mxd

12.0 C	µg/L
7/28/2016	ND
7/29/2016	447.3

Sample Locations
Associated Endothall Concentration Values
Figure B18
Tonawanda Creek
Erie and Niagara Counties, New York

Legend

- Milepost from Mouth of Creek/Canal
- ERDC Sampling Location*
- E&E Sampling Location*
- Primary Treatment Area
- Secondary Treatment Area
- County Boundary

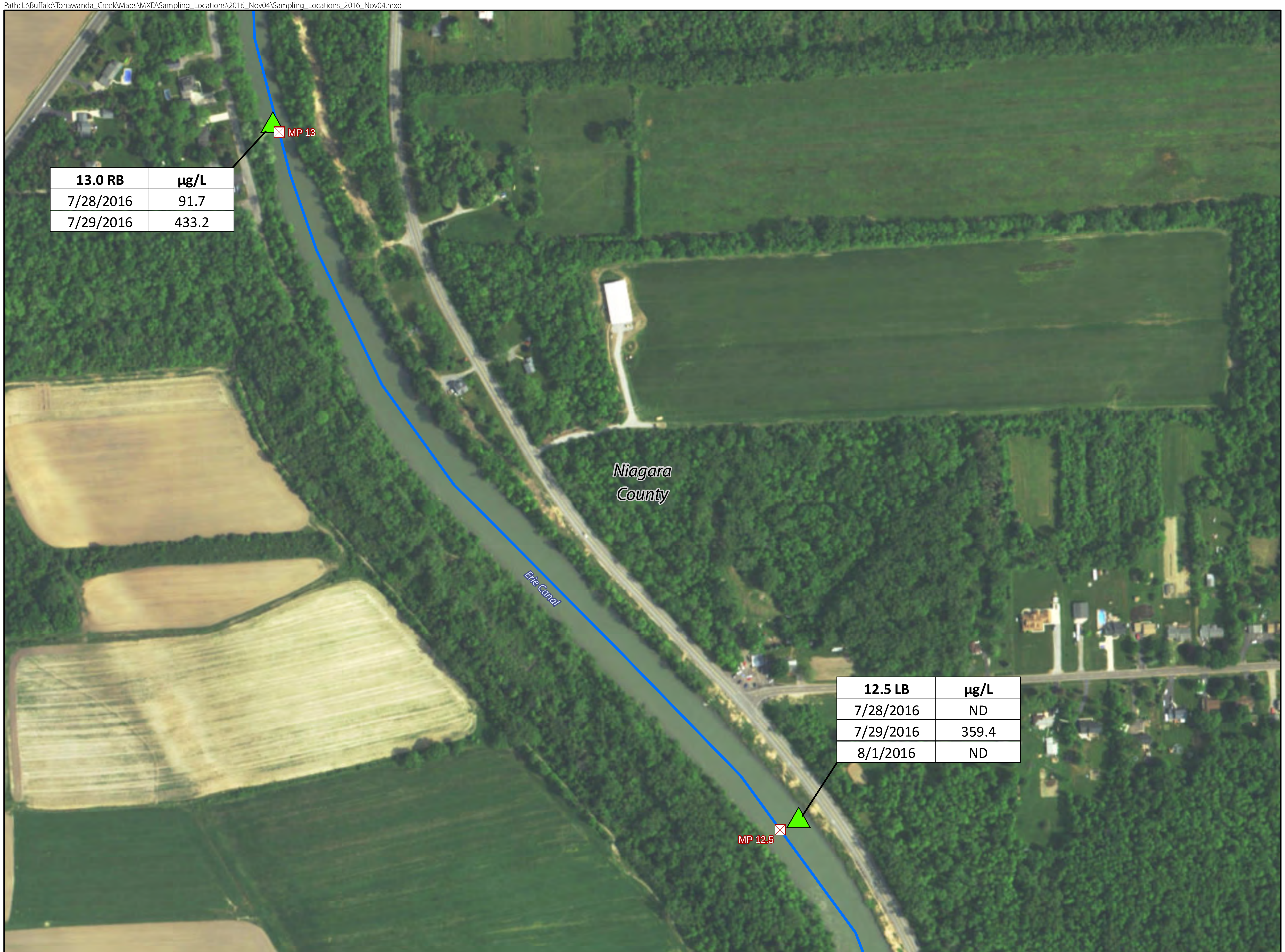
*Note: All Sample Locations are Approximate.

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2011; Ecology and Environment, Inc. 2016; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2016_Nov04\Sampling_Locations_2016_Nov04.mxd



13.0 RB	µg/L
7/28/2016	91.7
7/29/2016	433.2

12.5 LB	µg/L
7/28/2016	ND
7/29/2016	359.4
8/1/2016	ND

Sample Locations
Associated Endothall Concentration Values
Figure B19
Tonawanda Creek
Erie and Niagara Counties, New York

Legend

- Milepost from Mouth of Creek/Canal
- ERDC Sampling Location*
- E&E Sampling Location*
- Primary Treatment Area
- Secondary Treatment Area
- County Boundary

*Note: All Sample Locations are Approximate.

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2011; Ecology and Environment, Inc. 2016; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2016_Nov04\Sampling_Locations_2016_Nov04.mxd

13.5 C	µg/L
7/28/2016	ND
7/29/2016	529.4
8/1/2016	ND

Sample Locations
Associated Endothall Concentration Values
Figure B20
Tonawanda Creek
Erie and Niagara Counties, New York

Legend

- Milepost from Mouth of Creek/Canal
- ERDC Sampling Location*
- E&E Sampling Location*
- Primary Treatment Area
- Secondary Treatment Area
- County Boundary

*Note: All Sample Locations are Approximate.

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2011; Ecology and Environment, Inc. 2016; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2016_Nov04\Sampling_Locations_2016_Nov04.mxd

14.0 LB	µg/L
7/28/2016	82.8
7/29/2016	497.1

Sample Locations
Associated Endothall Concentration Values
Figure B21
Tonawanda Creek
Erie and Niagara Counties, New York

Legend

- Milepost from Mouth of Creek/Canal
- ERDC Sampling Location*
- E&E Sampling Location*
- Primary Treatment Area
- Secondary Treatment Area
- County Boundary

*Note: All Sample Locations are Approximate.

SCALE
0 0.05 0.1 Miles

SOURCE: ESRI 2011; Ecology and Environment, Inc. 2016; US Army CORPS of Engineers 2016.

14.5 RB	µg/L
7/28/2016	ND
7/29/2016	651

Sample Locations
Associated Endothall Concentration Values
Figure B22
Tonawanda Creek
Erie and Niagara Counties, New York

Legend

- Milepost from Mouth of Creek/Canal
- ERDC Sampling Location*
- E&E Sampling Location*
- Primary Treatment Area
- Secondary Treatment Area
- County Boundary

*Note: All Sample Locations are Approximate.

SCALE
0 0.05 0.1 Miles

SOURCE: ESRI 2011; Ecology and Environment, Inc. 2016; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2016_Nov04\Sampling_Locations_2016_Nov04.mxd

15.0 C	µg/L
7/28/2016	100.1
7/29/2016	708.3

Sample Locations
Associated Endothall Concentration Values
Figure B23
Tonawanda Creek
Erie and Niagara Counties, New York

Legend

- Milepost from Mouth of Creek/Canal
- ERDC Sampling Location*
- E&E Sampling Location*
- Primary Treatment Area
- Secondary Treatment Area
- County Boundary

*Note: All Sample Locations are Approximate.

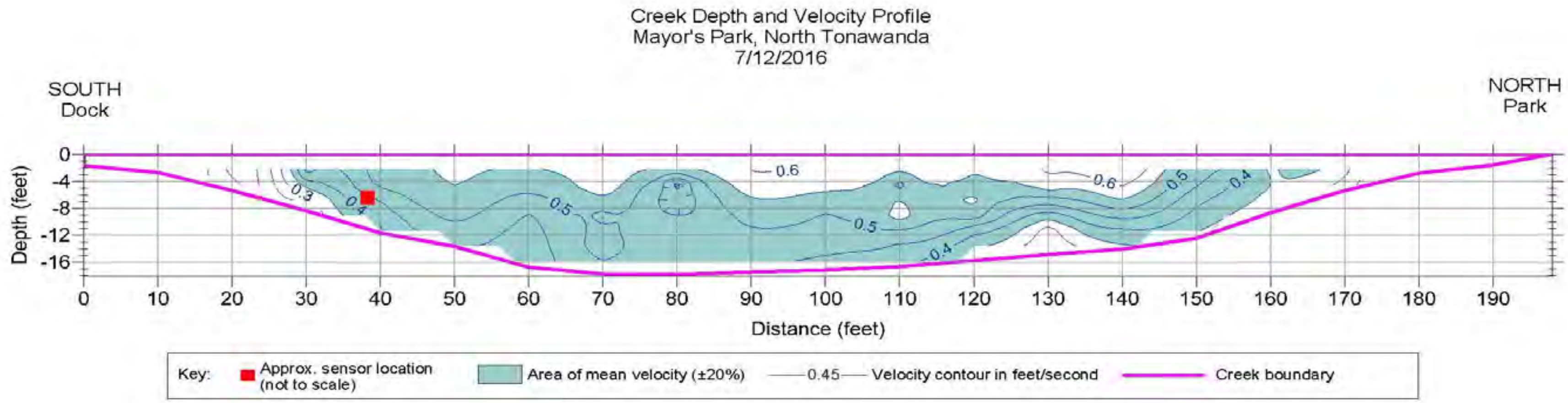
SCALE

0 0.05 0.1 Miles

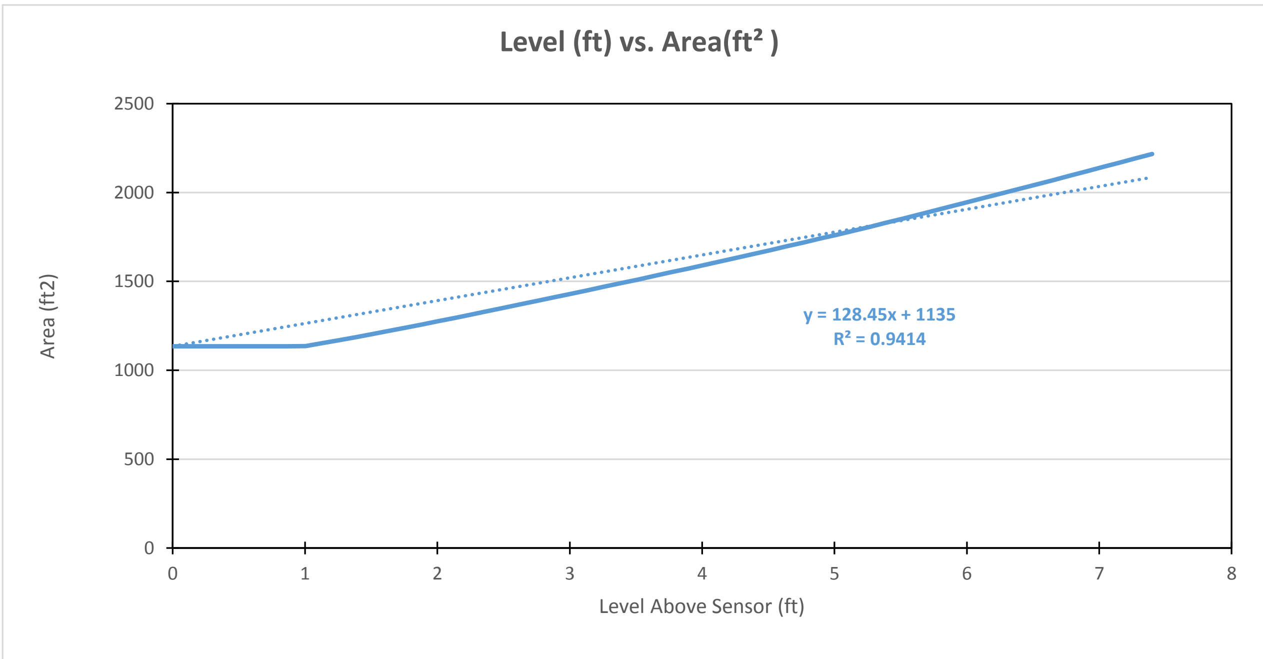
SOURCE: ESRI 2011; Ecology and Environment, Inc. 2016; US Army CORPS of Engineers 2016.

C

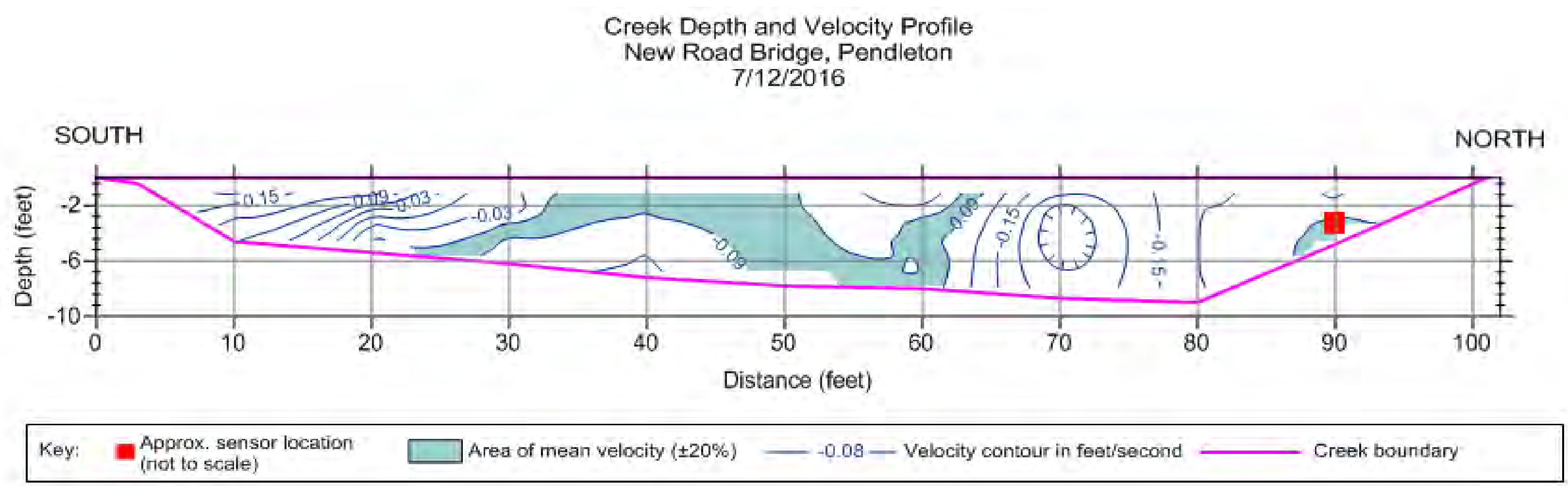
Creek Cross Sections at Monitoring Locations

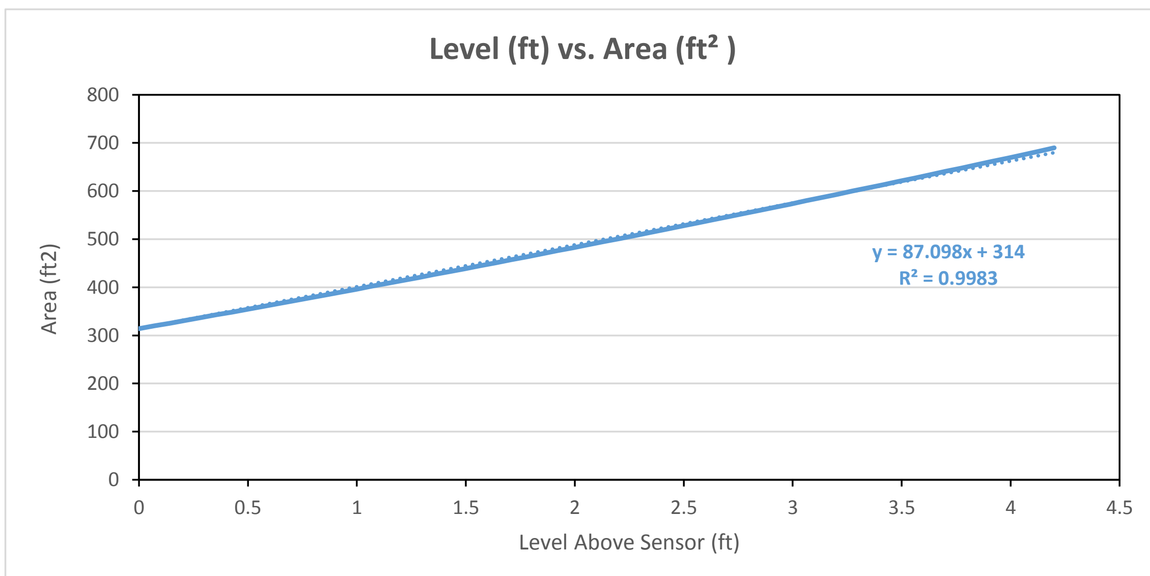


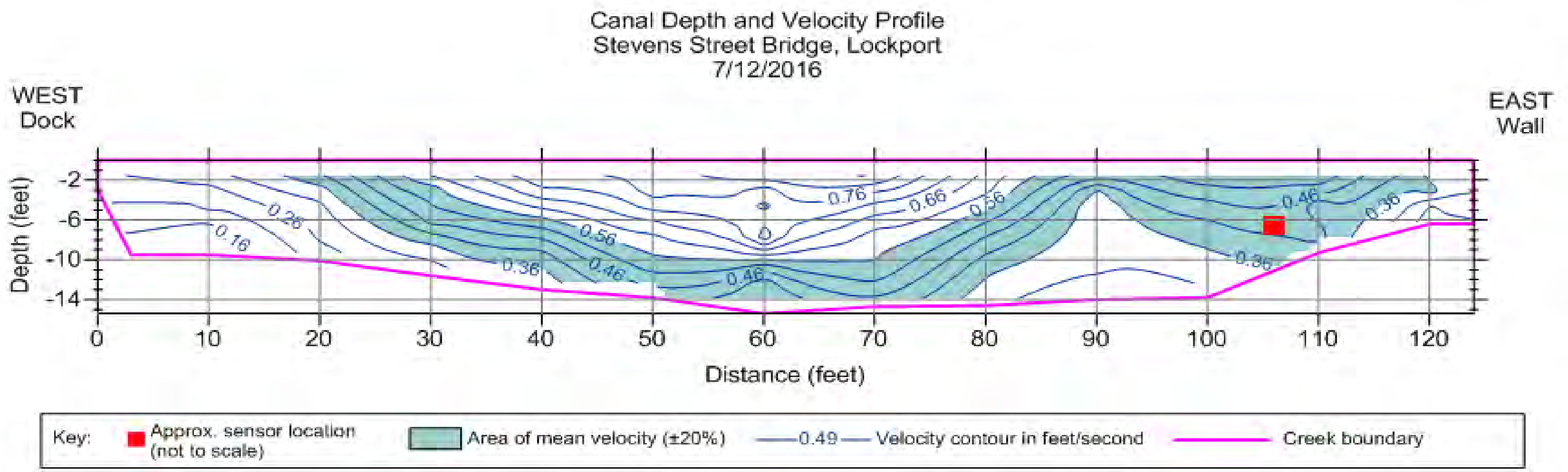
Creek Depth and Velocity Profile
Mayor's Park, North Tonawanda
7/12/2016
SOUTH
Dock
NORTH
Park
Depth (feet)
Distance (feet)
0
-4
-8
-12
-16
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
0.3
0.4
0.5
0.6
Key:
Approx. sensor location (not to scale)
Area of mean velocity (±20%)
0.45
Velocity contour in feet/second
Creek boundary



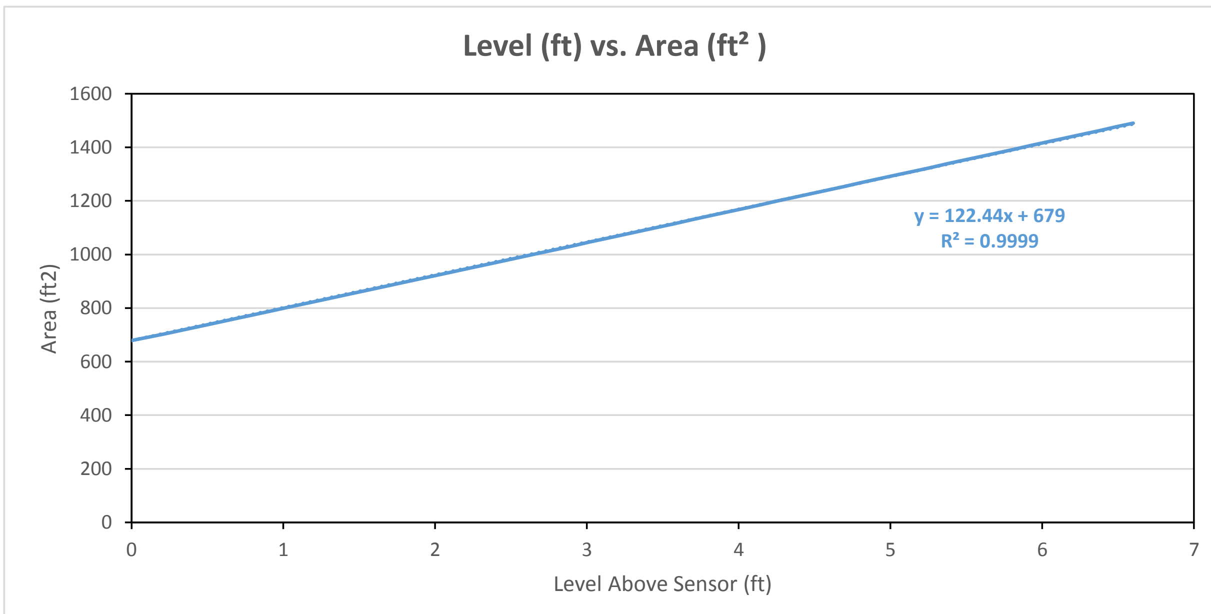
Level (ft) vs. Area(ft²)
Area (ft2)
Level Above Sensor (ft)
2500
2000
1500
1000
500
0
1
2
3
4
5
6
7
8
y = 128.45x + 1135
R² = 0.9414


Creek Depth and Velocity Profile
New Road Bridge, Pendleton
7/12/2016
SOUTH
NORTH
Depth (feet)
-2
-6
-10
0
10
20
30
40
50
60
70
80
90
100
Distance (feet)
Key:
Approx. sensor location (not to scale)
Area of mean velocity (±20%)
-0.08
Velocity contour in feet/second
Creek boundary


Level (ft) vs. Area (ft²)
Area (ft2)
Level Above Sensor (ft)
y = 87.098x + 314
R² = 0.9983

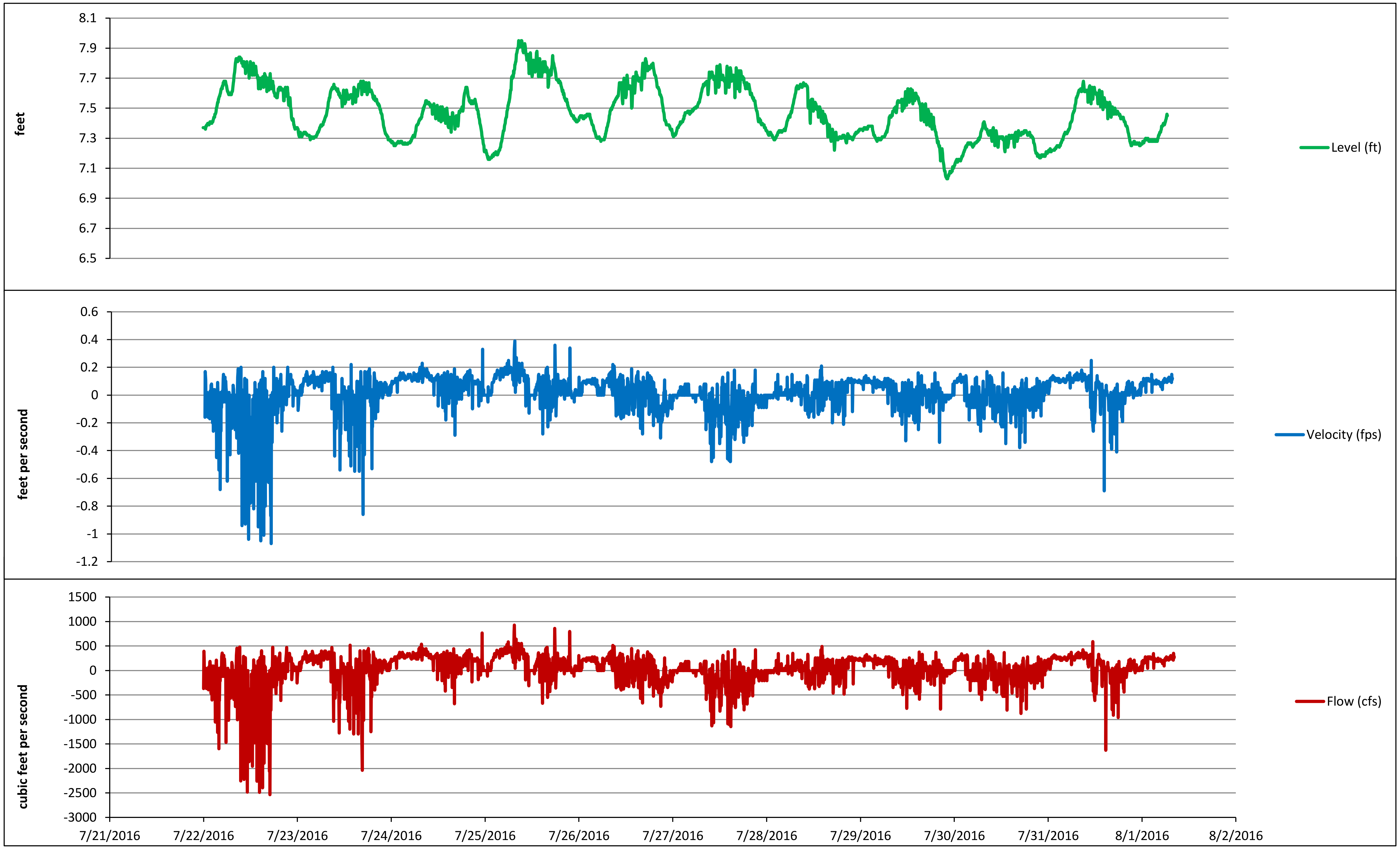


Canal Depth and Velocity Profile
Stevens Street Bridge, Lockport
7/12/2016
WEST
Dock
EAST
Wall
Depth (feet)
-2
-6
-10
-14
0
10
20
30
40
50
60
70
80
90
100
110
120
Distance (feet)
0.26
0.16
0.36
0.56
0.46
0.46
0.76
0.66
0.56
0.46
0.36
0.36
Key:
Approx. sensor location
(not to scale)
Area of mean velocity (±20%)
0.49 Velocity contour in feet/second
Creek boundary

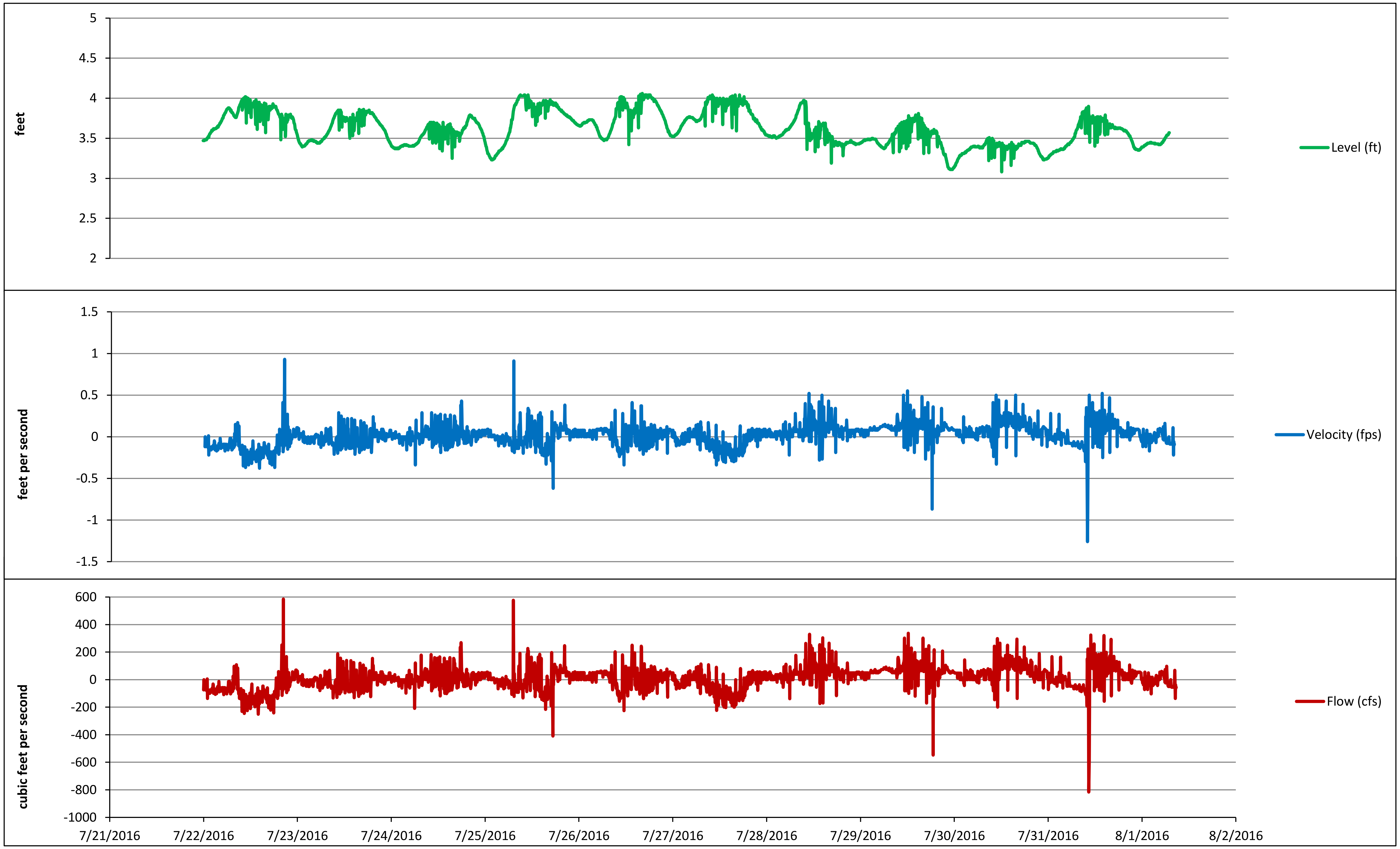


Level (ft) vs. Area (ft²)
Area (ft2)
1600
1400
1200
1000
800
600
400
200
0
0
1
2
3
4
5
6
7
Level Above Sensor (ft)
y = 122.44x + 679
R² = 0.9999

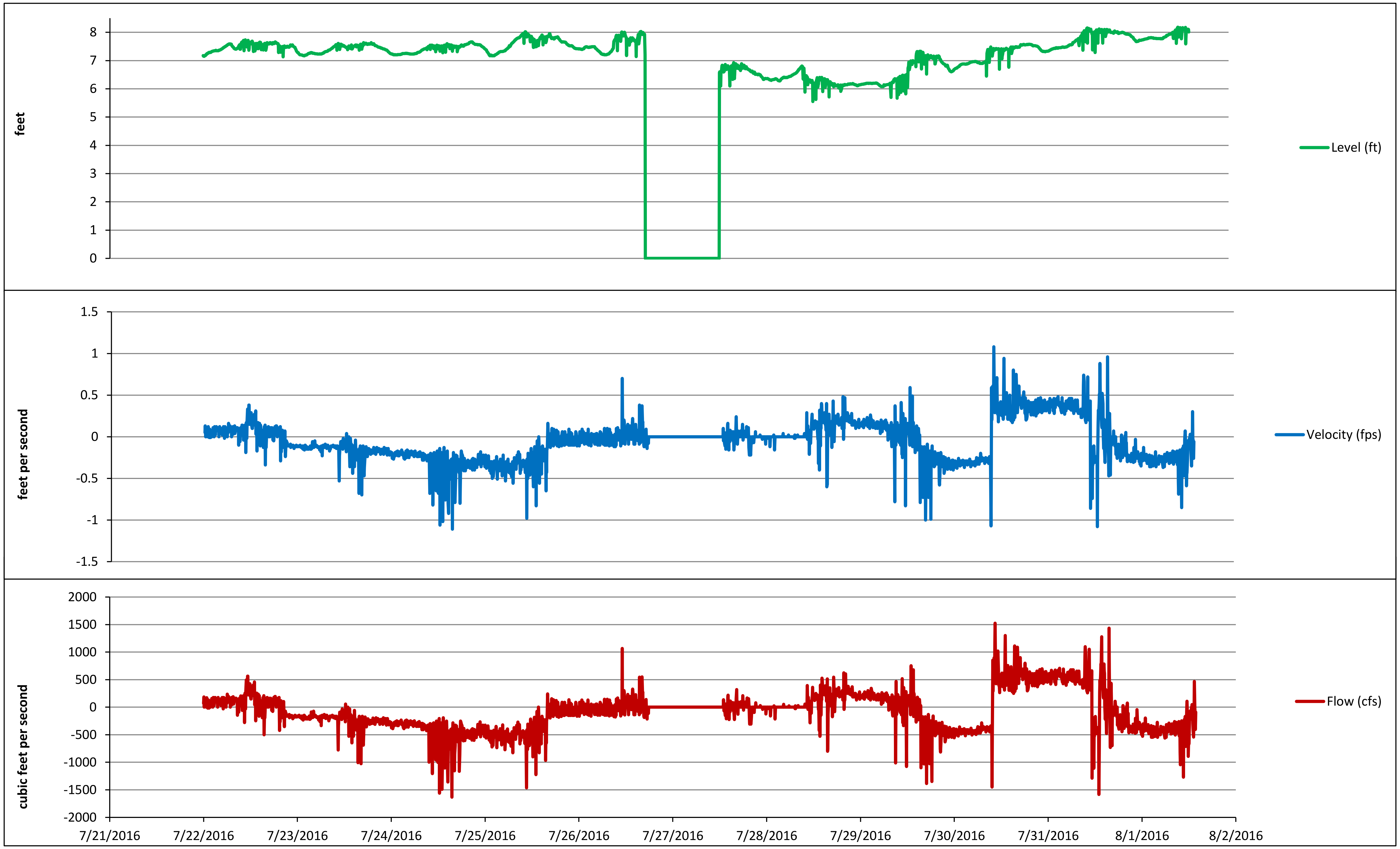
D Flow Meter Data and Water Level Graphs



Summary Flow Data and Water Levels for Tonawanda Creek at Mayor's Park (July 22nd-August 1st, 2016)



Summary Flow Data and Water Levels for Tonawanda Creek at New Road (July 22st-August 1st, 2016)



Summary Flow Data and Water Levels for Tonawanda Creek at Stevens St (July 22nd-August 1st, 2016)