Post-Treatment Assessment for Aquatic Plant Control ERDC Demonstration Project Tonawanda Creek/Erie Canal 2017

Contract No. W912P4-16-D-0002

February 2018

US Army Corps of Engineers®
Buffalo District
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Prepared for:

UNITED STATES ARMY CORPS OF ENGINEERS
Buffalo District

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List of Abbreviations and Acronyms

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
Hydrilla	*Hydrilla verticillata*
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
SOW	scope of work
USACE	United States Army Corps of Engineers (Buffalo District)
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 – Buffalo District's (USACE's) Aquatic Plant Control Research Program to manage monoecious hydrilla (*Hydrilla verticillata;* Hydrilla) in a flowing water system.

This report contributes to the Year 4 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 were 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 fourth year of treatment for the Project within a 15-mile-long stretch of creek/canal that focused on application of the aquatic herbicide endothall (Aquathol K™) (see Figure 1-1). Prior to treatment application, Hydrilla populations were delineated and mapped by the USACE using point-intercept and hydro-acoustic surveys. The 2017 treatment areas were designated as follows:

[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.

- **Western block treatment areas**: 5.5 miles between the Route 384 Bridge in Tonawanda, New York, to West Canal Park in North Tonawanda, New York. Of this area, 53.8 acres were directly treated with herbicide and the remaining area received secondary treatment from flow in the creek/canal; and
- **Eastern block treatment areas**: 8 miles between West Canal Park and the Pendleton Guard Gate in Pendleton, New York. Within this area, 11.3 acres of the creek were treated directly with herbicide. The remaining area 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 the majority of the direct herbicide application.

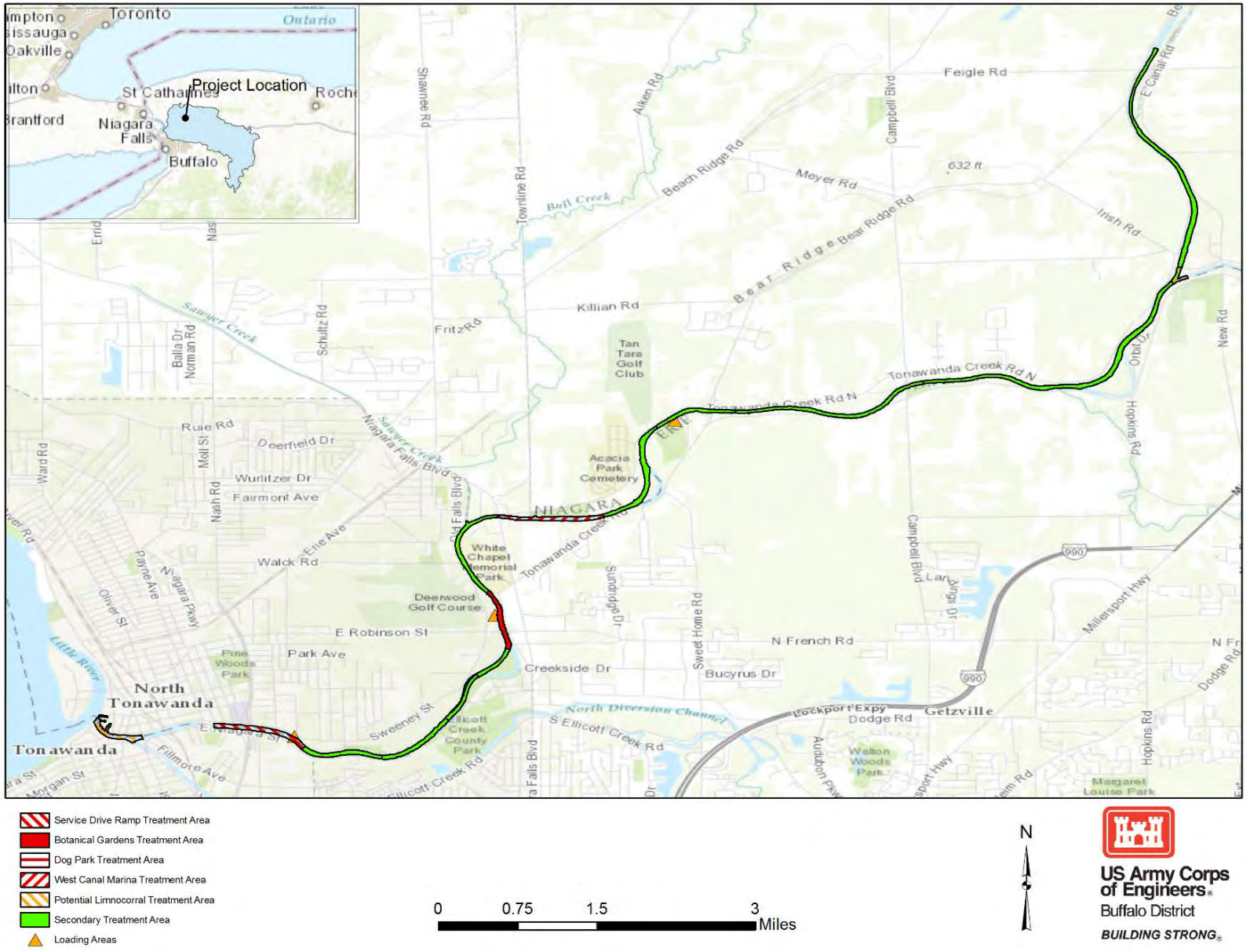
Implementation of the Project was a collaborative effort between the Engineer Research and Development Center (ERDC); USACE; Ecology and Environment, Inc. (E & E); New York State Canal Corporation (Canal Corp.); New York State Department of Environmental Conservation (NYSDEC); USFWS; and the applicator, 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.



SOURCE: USACE Buffalo Aquatic Plant Control ERDC Demonstration Project Tonawanda Creek/Erie Canal Scope of Work, May 2017

Figure 1-1 Hydrilla Treatment Areas for August 2017 in Tonawanda Creek/Erie Canal, NY

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. To minimize flow, a target flow rate of 50 cubic feet per second (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 photos in Appendix A).

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 that were stipulated for the permit were adhered to (i.e., riparian owner and permitted user notification and use of warning signs). Five 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 30 days prior to the application;
2. Yellow warning signs were posted along the primary treatment areas at public access points;
3. Display advertisements were published in two local/regional newspapers (*Lockport Journal* and the *Niagara Gazette*) and *The Buffalo News* on July 29, 2017;
4. Agency notification letters were distributed by U.S. certified mail 30 days prior to the application; and
5. Project factsheets were distributed during Canal Fest (July 16 through 23) by Western New York Hydrilla Task Force members.

2.2 Field Conditions

Field conditions prior to treatment (July 27 through July 31), during treatment (August 1 and 2), and immediately following the treatment (August 3 through August 7) 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 27, 2017	Min: 67 Max: 81	0.07	Light rain and fog Average wind speed 5.2 mph with gusts up to 17 mph
July 28, 2017	Min: 58 Max: 74	0	No significant weather observed Average wind speed 9.9 mph with gusts up to 28 mph
July 29, 2017	Min: 56 Max: 79	0	No significant weather observed Average wind speed 7.8 mph with gusts up to 26 mph
July 30, 2017	Min: 61 Max: 85	0	No significant weather observed Average wind speed 5.7 mph with gusts up to 19 mph
July 31, 2017	Min: 62 Max: 82	Trace	No significant weather observed Average wind speed 9.6 mph with gusts up to 22 mph. Total precipitation for July 4.65 inches
August 1, 2017 Treatment Day 1	Min: 65 Max: 83	0	No significant weather observed Average wind speed 7.3 mph with gusts up to 18 mph
August 2, 2017 Treatment Day 2	Min: 62 Max: 84	0	No significant weather observed Average wind speed 8.6 mph with gusts up to 23 mph
August 3, 2017	Min: 64 Max: 86	0.05	Thunderstorms and light rain Average wind speed 7.7 mph with gusts up to 33 mph
August 4, 2017	Min: 66 Max: 83	1.25	Thunderstorms, rain and fog Average wind speed 11.3 mph with gusts up to 53 mph
August 5, 2017	Min: 59 Max: 71	0.22	Light rain and fog Average wind speed 13.0 mph with gusts up to 34 mph
August 6, 2017	Min: 53 Max: 76	0	No significant weather observed Average wind speed 9.6 mph with gusts up to 26 mph
August 7, 2017	Min: 60 Max: 77	Trace	Light rain Average wind speed 3.9 mph with gusts up to 21 mph

Source: National Oceanic and Atmospheric Administration 2017

2.3 Herbicide Treatment Methodology

The aquatic herbicide endothall (Aquathol K™) was applied in designated sections of the creek/canal on August 1, 2, and spot treatments on August 9 and September 6, 2017 (see Figures 2-1 through 2-5). 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 June 12, 2017 (USACE 2017).

Two boats were used for the herbicide application. The vessels were an 18-foot, shallow-draft aluminum work skiff powered by a 40-horsepower conventional four-stroke outboard motor, and a 24-foot fiberglass skiff powered by a 90-horsepower four-stroke outboard motor. The skiffs were used to treat all treatment areas except the limnocorral and benthic mat areas. 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. The 24-foot skiff was outfitted with a 225-gallon polyethylene tank, while the 18-foot skiff was outfitted with a 100-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. Liquid herbicide was also delivered in 2.5-gallon jugs, which were triple rinsed and recycled after being emptied. The empty totes were taken back by the herbicide distributor and were returned to the manufacturer for reloading and reuse. 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 Treatment

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, at the City of Tonawanda boat launch at Service Drive, and the West Canal Marina Launch. 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 of the treatment areas. Each work skiff had a Global Positioning System navigation system with all of the treatment sections preloaded.

As stated in Section 1.1, the Project area was divided into two blocks: the western block encompassing approximately 4.9 miles between the East Niagara

Park in Tonawanda and the West Canal County Park in Niagara County; and the eastern block encompassing approximately 8 miles between West Canal County Park in Niagara County and the Pendleton Guard Gate. The western block contains the vast majority of large Hydrilla beds and received direct herbicide application in three main sections of the canal which total approximately 1.9 miles (see Figures 2-1, 2-2, and 2-3). Herbicide was applied in the littoral areas and allowed to disperse across the canal to bring herbicide concentrations to target levels. The two non-treated sections between Service Drive Ramp and Botanical Gardens, and Botanical Gardens and Niagara Falls Boulevard Bridge received exposure via the resumption of flow and direct spot treatment of large Hydrilla beds with endothall in the area of the dog park (see Figure 2-4). The non-treated eastern block of the Project area received exposure via the resumption of flow and direct spot treatment of large Hydrilla beds with endothall at the maximum label rate during the initial treatment.

In July and August 2017, the USACE ERDC conducted supplementary mapping and plant delineation and identified four additional Hydrilla bed locations: one on the southeast side of the Seymour Street Bridge (LC 1) in Tonawanda (same as last year), and one at the Wardell Boat Yard launch slip and marina (see Figure 2-5); one east of the confluence of Sawyer Creek and the creek/canal (BM 1); and another west of the Campbell Boulevard bridge (BM 2) (see Figure 2-6). The Seymour Street Bridge bed and the bed in the Wardell Boat Yard Marina launch slip was isolated with a limnocorral (impermeable divider) and received direct endothall application along with the side channel marina. The Sawyer Creek and Campbell Boulevard beds were treated with a benthic mat (burlap barrier).

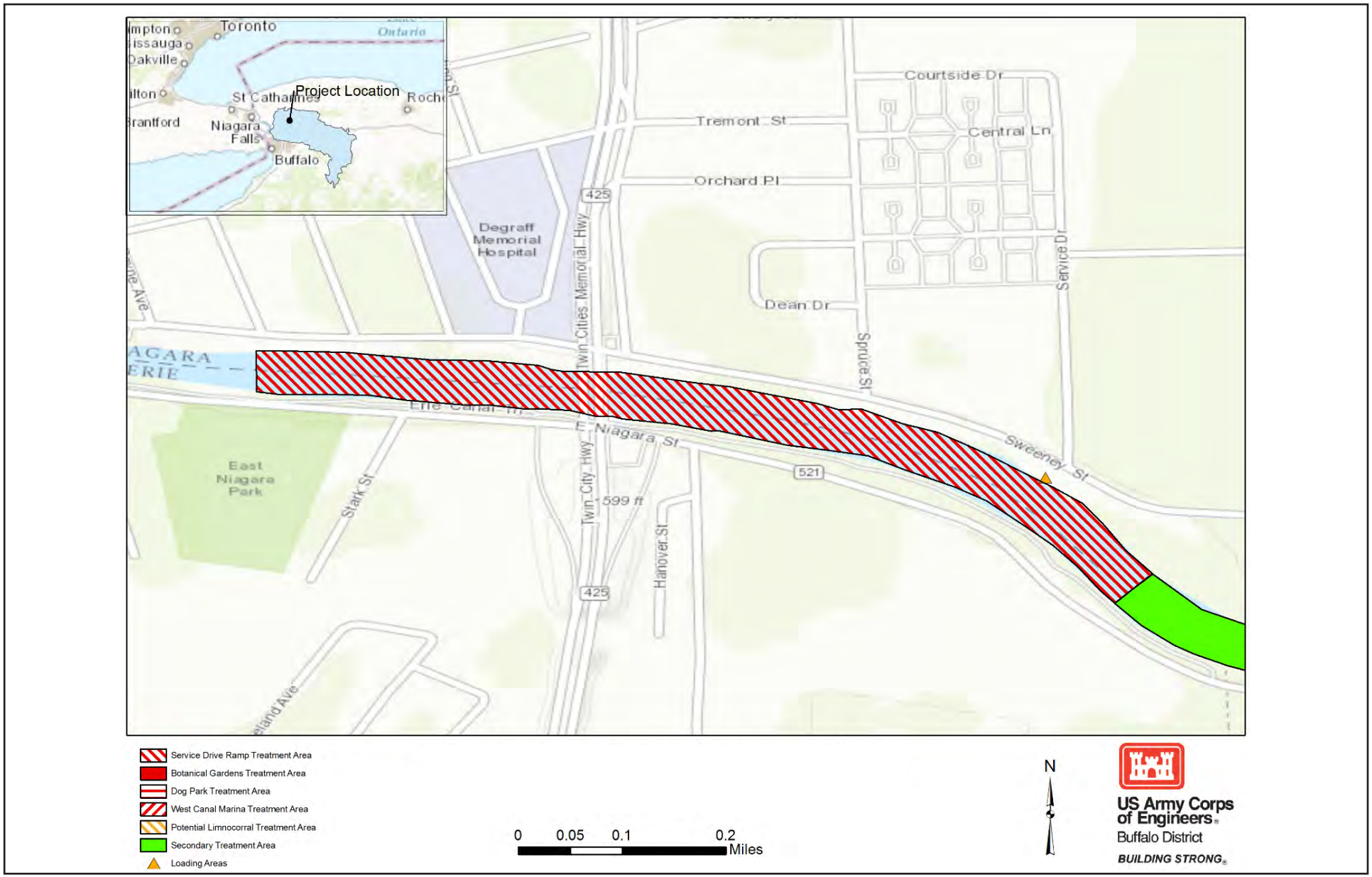
The following paragraphs summarize the 2017 treatment activities.

August 1, 2017: 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 both work 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 had slowed to the desired rate, SLM personnel began to transfer the herbicide at approximately 1145 hours. Each treatment crew consisted of a lead applicator and an assistant/technician. Treatment 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 1630 hours.

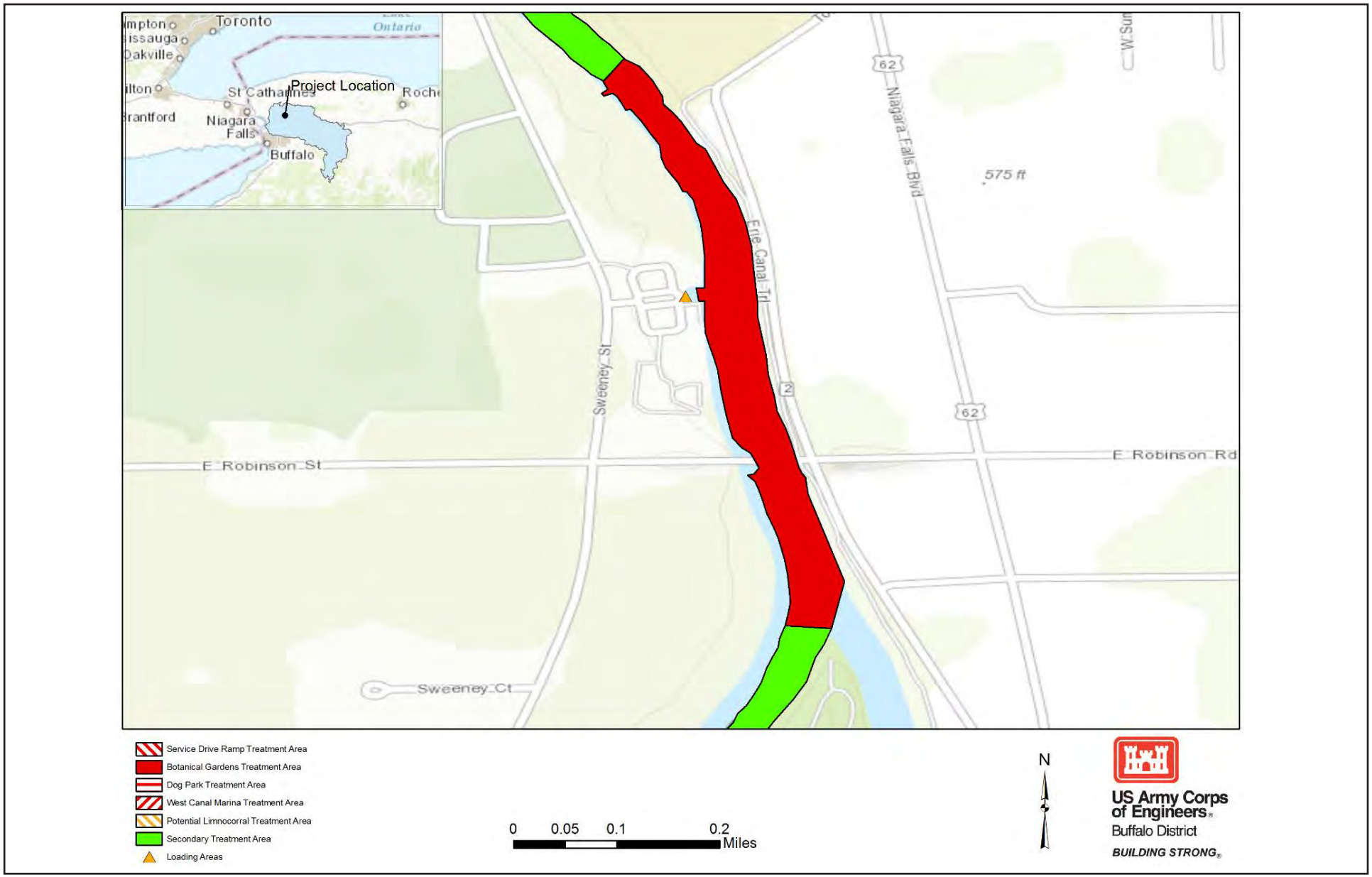
The following areas were treated on Day 1 (see Figure 2-6):

- The creek/canal east and west of the Twin Cities Highway bridge (Twin Cities Hwy);
- Waters along the north bank of the creek/canal, south of the small island along Creekside Drive at Ellicott Creek Park (Dog Park);



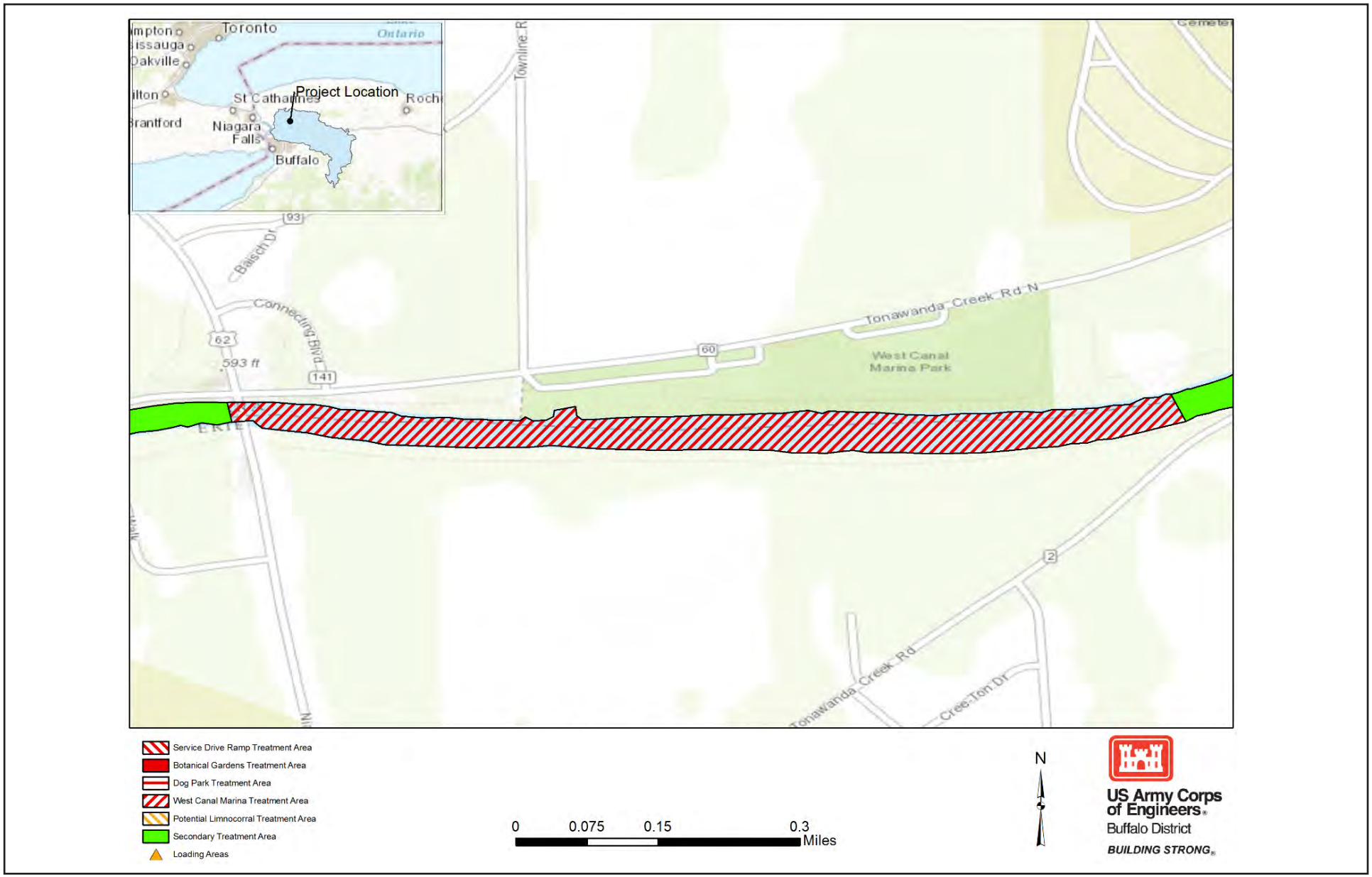
SOURCE: USACE Buffalo Aquatic Plant Control ERDC Demonstration Project Tonawanda Creek/Erie Canal Scope of Work, May 2017

Figure 2-1 Service Drive Ramp Treatment Area for August 2017 in Tonawanda Creek/Erie Canal, NY



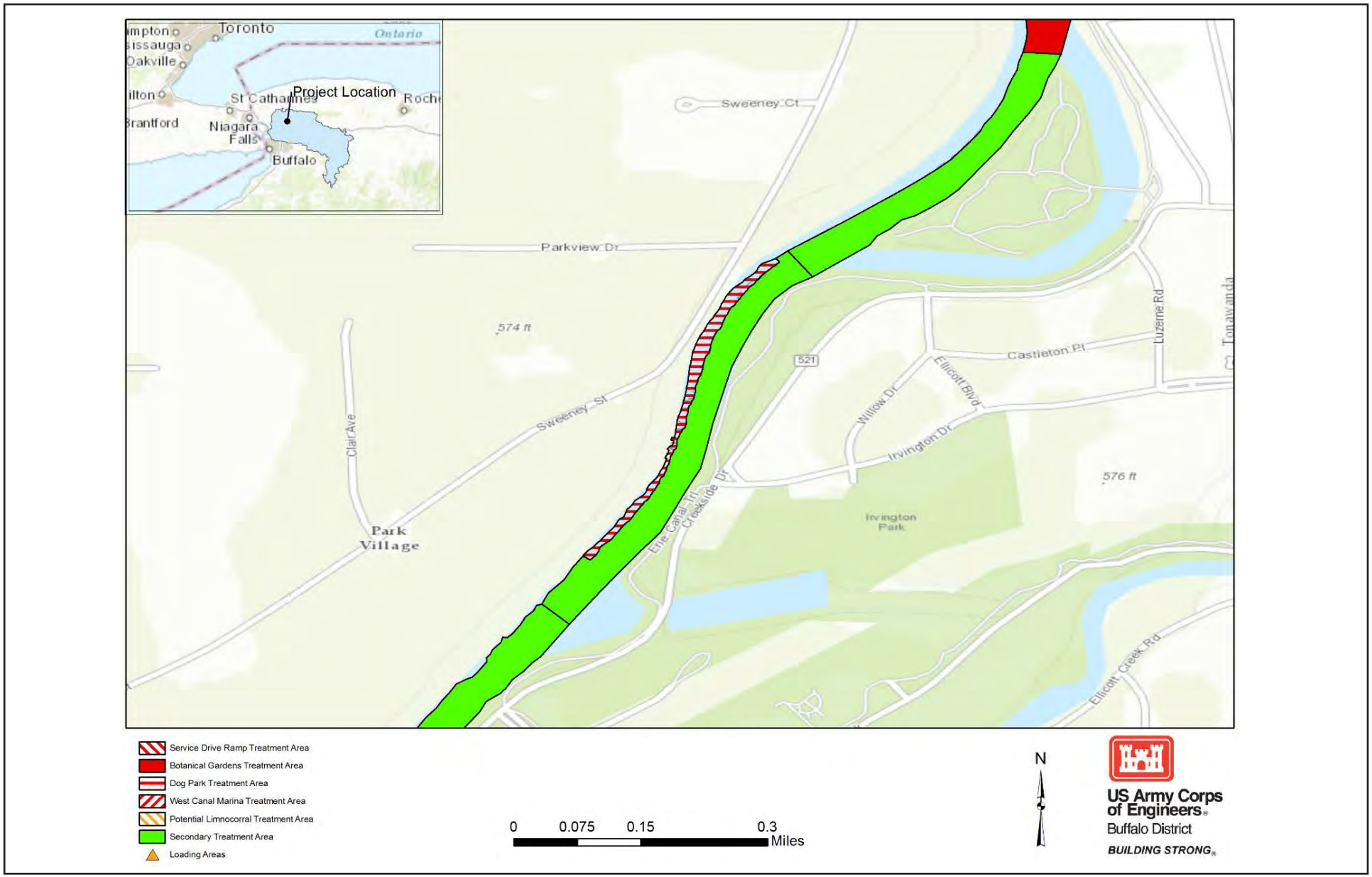
SOURCE: USACE Buffalo Aquatic Plant Control ERDC Demonstration Project Tonawanda Creek/Erie Canal Scope of Work, May 2017

Figure 2-2 Botanical Gardens Treatment Area for August 2017 in Tonawanda Creek/Erie Canal, NY



SOURCE: USACE Buffalo Aquatic Plant Control ERDC Demonstration Project Tonawanda Creek/Erie Canal Scope of Work, May 2017

Figure 2-3 West Canal Marina Treatment Area for August 2017 in Tonawanda Creek/Erie Canal, NY



SOURCE: USACE Buffalo Aquatic Plant Control ERDC Demonstration Project Tonawanda Creek/Erie Canal Scope of Work, May 2017

Figure 2-4 Dog Park Treatment Area for August 2017 in Tonawanda Creek/Erie Canal, NY

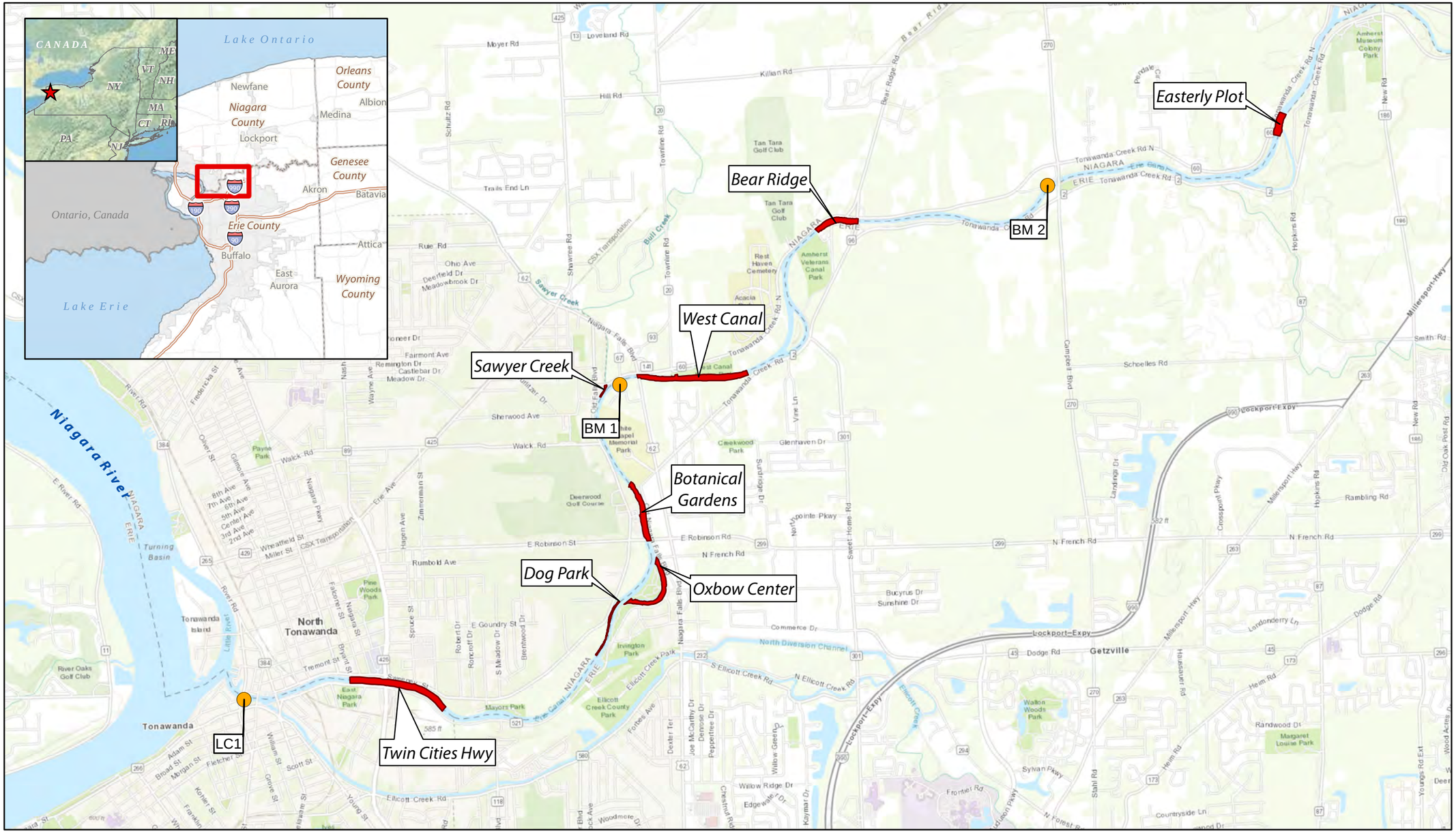
Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Figure 2-5 Wardell and Seymour Treatment Areas.mxd

SOURCE: ESRI 2018; Solitude 2017.

Figure 2-5 Wardell Boat Yard and Seymour Street, August 2018 Treatment Areas

Tonawanda Creek, Erie and Niagara Counties, New York

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Figure 2-6 TreatmentArea1_Overview_2018_Feb.mxd



SOURCE: ESRI 2010, 2012, 2018; Solitude 2017.

Figure 2-6 First Round, August 2018 Treatment Areas

Tonawanda Creek, Erie and Niagara Counties, New York

- The creek/canal at the oxbow southeast of the small island within Ellicott Creek Park (Oxbow Center);
- The creek/canal east and west of the North Tonawanda Botanical Gardens (Botanical Gardens);
- Waters long the north bank of the creek/canal at the confluence of Sawyer Creek and the creek/canal (Sawyer Creek);
- The creek/canal east and west of West Canal Marina and Park (West Canal);
- The creek/canal between Amherst Veterans Canal Park and the Bear Ridge Road bridge (Bear Ridge); and
- The creek/canal north of the island by Orbit Drive off Tonawanda Creek Road (Easterly Plot).

Immediately following treatment of these areas, the limnocorral was installed on the southeast side of the Seymour Street Bridge in Tonawanda and the area was treated using a hand-held spray gun (Area LC 1 on Figures 2-5 and 2-6). This area was isolated with 20-foot-long, floating limnocorrals secured to the bottom with cinder blocks and to the shoreline on each end. 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 E & E personnel removed it on September 11, 2017.

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. Day 1 treatment efforts were completed at 1800 hours, resulting in a total treatment time of approximately 6 hours (see Figure 2-6).

August 2, 2017: Day 2

All of the same treatment areas, except Bear Ridge, the Easterly Plots, and LC 1, were re-treated on Day 2 (as shown on Figure 2-6). SLM launched both work skiffs from the City of North Tonawanda boat launch at 700 Sweeney Street. The same herbicide transfer and application methods were used as Day 1. Treatment began at 0800 hours and was completed by 1330 hours for a total treatment time of approximately 5.5 hours.

August 9 and September 6, 2017: Second Round/Spot Treatments

The four areas listed below were re-treated on August 9 with the same herbicide transfer and application methods that were used on Days 1 and 2. This round of treatment re-treated the following areas (see Figure 2-7):

- Waters along the north bank of the creek/canal, south of the small island along Creekside Drive at Ellicott Creek Park (Dog Park);

- Waters along the North bank of the creek/canal at the confluence of Sawyer Creek and the creek/canal (Sawyer Creek);
- The creek/canal west of the Campbell Boulevard bridge; and
- Both banks of the creek/canal north of the island by Orbit Drive off Tonawanda Creek Road (Easterly Plots).

A limnocorral was installed across the launch slip of the Wardell Boat Yard Marina on September 6 and the area inside the slip and the adjacent marina area was treated using a hand-held spray gun that day. The corral was removed the next morning, providing a contact time of at least 12 hours. The limnocorral under the Seymour Street Bridge was re-treated on September 6 as well using a hand-held spray gun, and the limnocorral was removed on September 11.

August 3 through October 13, 2017: Benthic Mat Deployment/ Retrieval

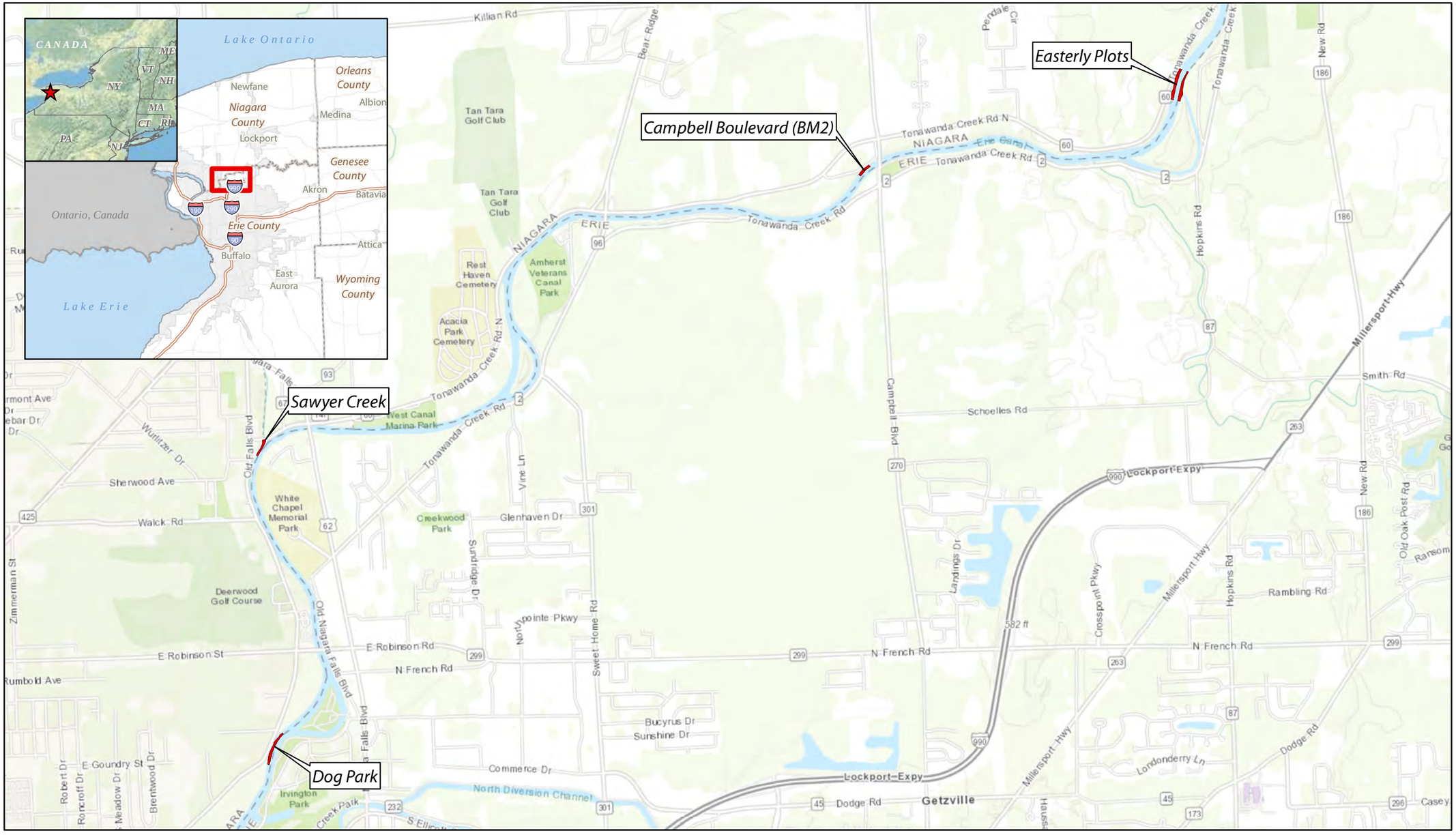
On August 3, 2017, two benthic mats were installed in the canal in approximately 18 to 48 inches of water: a 350–square-foot benthic mat was placed in the boat slip on the south side of the canal near Sawyer Creek (66 Admirals Walk); and a 250–square-foot mat placed west of the boat dock on the north side of the canal across from the Amherst Marine Center (marina near Campbell Boulevard bridge). The benthic mats consisted of 3-foot-wide strips of 17-pound burlap mat overlapped approximately 4 inches and tied together with zip ties to form a rectangular sheet of burlap. On August 17, the 350-square-foot benthic mat was removed from the boat slip at 66 Admirals Walk, and 250–square-foot of benthic mat was redeployed to additional hydrilla patches closer to the dock on the north side of the canal across from the Amherst Marine Center (marina near Campbell Boulevard bridge). On September 1, the 250-square-foot of benthic mat was moved to additional Hydrilla patches next to the dock on the north side of the canal across from the Amherst Marine Center (marina near Campbell Boulevard bridge). On September 15, the 250-square-foot benthic mat was moved to additional Hydrilla patches under dock and slip on north side of the canal across from the Amherst Marine Center (marina near Campbell Boulevard bridge). Lastly, the 250 square feet of benthic mat and anchors were removed from the creek/canal on October 13, 2017.

2.4 Quantity of Herbicide Used and Total Area Treated

The total quantity of endothall applied in designated sections of the creek/canal was 1,045 gallons, applied on the following dates:

- August 1 and August 2, 2017: 966 gallons total were applied, 906 gallons as originally planned for the western block treatment areas, and 60 gallons added for the spot treatment areas (two oxbows and a few other small patches identified by USACE the week before the treatment);

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Figure 2-7 TreatmentArea2_Overview_2017_Nov.mxd



Treatment 2 Areas

0 0.5 1 Miles

N

SOURCE: ESRI 2010, 2012, 2018; Solitude 2017.

Figure 2-7 Second Round, August 2018 Treatment Areas

Tonawanda Creek, Erie and Niagara Counties, New York

- August 9, 2017: 66 gallons for re-treatment of spot treatment areas; and
- September 6, 2017: 12.7 gallons total, 0.1 gallon in the Seymour Street Bridge limnocorral and 12.6 gallons in the Wardell Boat Yard Marina.

The planned treatment areas were divided into distinct sections using a geographic information system, 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 mg/L (milligrams per liter or 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. The limnocorral area (LC 1 and Wardell Boat Yard) was treated 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 Figures 1-1 through 1-3.

Table 2-2 Herbicide Application Summary, by Canal Section

Date	Canal Section	Figure Number	Acres	Endothall Applied (gallons)	Targeted Concentration (ppm)	Notes
8/1/2017	Twin Cities Hwy, Dog Park, Oxbow Center, Botanical Gardens, Sawyer Creek, West Canal, Bear Ridge, Easterly Plot	1-1	65.1	546	1.5	
8/1/2017	LC 1	1-1	0.1	0.2	4.0	
8/2/2017	Twin Cities Hwy, Dog Park, Oxbow Center, Botanical Gardens, Sawyer Creek, West Canal	1-1	53.8	420	1.5	Re-treatment
8/9/2017	Dog Park, Sawyer Creek, Campbell Boulevard, Easterly Plots	1-2	4.3	66	1.5	Re-treatment
9/6/2017	Wardell Boat Yard, LC 1	1-3	1.0	12.6 0.1	1.5-4.0	Re-treatment of LC 1
			Total Gallons	**1,045**		

Key:

LC = Limnocorral
ppm = parts per million

2.5 Herbicide Contact Time and Dispersion

Herbicide was applied to sections of the creek/canal on August 1, 2 and 9 and September 6, 2017; these sections were determined as discussed in Section 2.4. ERDC and E & E performed water sampling after the August 1 and 2 applications to determine the endothall concentrations and dispersion of herbicide from the date of application through August 5, 2017.

2.5.1 Initial Sampling Results – First 48 Hours

ERDC performed endothall concentration sampling between river mile 1.1 and 7.3 and river mile 10.6 (downstream side of the easterly treatment plots) of the creek/canal area at 0.5-mile intervals on Days 1, 2 and 3 of treatment and dispersion (August 1 through 3, 2017). E & E performed endothall concentration sampling on the entire 15-mile creek/canal area at 0.5-mile intervals on Day 4 (August 4, 2017) and sampled the entire 15-mile area at 1-mile intervals on Day 5 (August 5, 2016). E & E samples were collected in the same general locations as the samples collected by the 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/Robinson Road in Lockport, New York, approximately 15 miles to the northeast. Additional samples were taken at areas deemed significant, such as oxbows. These additional locations are summarized in Table 2-3. 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
Twin Cities Memorial Highway bridge	1.1
Oxbow 1	2.8
Dog Park Treatment Area	3.2
Oxbow 2	3.4, 3.5, 3.6
Botanical Gardens	3.8, 4.1
400 feet south of start of Sawyer Creek Treatment Area	4.4
Confluence of Sawyer Creek	4.9
500 feet west of start of West Canal Treatment Area	5.2
East end of West Canal Park	5.8
Oxbow 3	6.3
1,400 feet north of Oxbow 3	6.7
Bear Ridge Road	7.3
Oxbow 4	10.1
North end of Easterly Plot(s) Treatment Area	10.6

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 0.007 ppm). Samples were analyzed at dilutions of 10:1, 20:1, or 40:1, with

detection limits of 0.07 ppm, 0.14 ppm or 0.28 ppm, respectively, or as non-diluted samples with a detection limit of 0.007 ppm. 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 0.5 and 1 ppm.

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 August 2, 2017, was conducted between the morning and afternoon sampling in all of the treatment areas, 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 August 2 in almost all of the areas treated that day, with some increased concentrations in the secondary treatment areas due to eastward movement of the endothall. Target endothall concentrations were maintained in the treatment areas between miles 1 and 8 for 48 hours. Herbicide concentrations sampled in the afternoon after application ranged from 0.091 to 1.2 ppm (see Table 2-4). Table 2-4 summarizes results obtained through August 5, 2017, and emphasizes distribution of the treatment in relation to the target zone and clearance of the herbicide from the system.

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 Aug 1, 2017, at approximately 0800 hours, flow gates were closed within the canal system, and flow was minimized prior to herbicide application (i.e., it was reported from Canal Corp. that the Flight of Five Lock had about 40 cfs leakage, and the City Hall gate had about 10 cfs leakage). Canal Corp. resumed flows on the morning of August 4, 2017, at 0900 hours.

As stated above, following the initial sampling effort by ERDC, E & E obtained grab water samples along Tonawanda Creek/Erie Canal on August 4 and 5, 2017 (see Table 2-4 for sampling results). Sampling locations were spaced approximately 0.5 or 1 mile apart. In addition, samples were also collected 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 by hand as grab samples from an approximate depth of 1 foot below the creek/canal surface. After each sample was collected, two drops of 31.45% hydrochloric acid were added to the bottle 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 14.5 on August 5, 2017, due to dangerous boating weather.

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 5 and 10 feet.

Table 2-4 Summary of Post-treatment Canal/Creek Water Sample Results

River Mile	Location ID[2]	Endothall Concentrations in PPM[3] Sampling Dates[1] 8/1/17	8/2/17 A[4]	8/2/17 B[4]	8/3/17	8/4/17	8/5/17
0.0	0.0 C					ND	
0.5	0.5 LB					ND	ND
1.0	**1.0 RB**					**0.64**	
1.1	**1.1 C**	**0.83**$^{D.14}$	**0.92**$^{D.14}$	**2.9**$^{D.14}$	**0.90**		
1.5	**1.5 C**	**2.4**$^{D.14}$	**0.15**$^{D.007}$	**3.7**$^{D.28}$	**1.2**	**0.49**	**ND**
2.0	2.0 RB					0.24	
	2.0 C	ND$^{D.007}$	ND$^{D.007}$	0.11	0.58		
	2.0 LB					0.26	
2.5	2.5 C	ND$^{D.007}$	0.055$^{D.007}$	0.087	0.091		
	2.5 RB					0.20	ND
2.8	2.8 A					0.12	ND
3.0	**3.0 C**					**0.25**	
3.2	**3.2 RB**	**0.38**$^{D.14}$	**0.35**	**0.53**	**0.11**		
3.4	**3.4 A**	**0.76**$^{D.14}$	**0.87**	**0.55**	**0.22**		
3.5	**3.5 A**					**0.29**	**ND**
	3.5 RB					0.30	ND
	3.5 LB					0.24	ND
3.6	**3.6 A**	**0.71**$^{D.14}$	**1.5**	**0.89**	**0.63**		
3.8	**3.8 C**	**2.0**$^{D.14}$	**0.70**	**1.4**$^{D.14}$	**0.26**		
4.0	**4.0 RB**					**0.31**	
	4.0 C	**2.2**$^{D.14}$	**0.91**$^{D.14}$	**2.5**$^{D.14}$	**0.35**		
4.1	**4.1 C**	**1.9**$^{D.14}$	**0.85**$^{D.14}$	**2.7**$^{D.14}$	**0.39**		
4.4	4.4 C	0.0091$^{D.007}$	0.013$^{D.007}$	3.6$^{D.28}$	0.67		
4.5	4.5 C					527.9	440.5
4.9	**4.9 RB**	**0.0027** $^{D.007}$	**0.70**	**0.79**	**0.87**		
5.0	5.0 LB					0.58	
5.2	**5.2 C**	**2.6**$^{D.14}$	**1.3**$^{D.14}$	**2.0**$^{D.14}$	**1.1**		
5.5	**5.5 RB**					**0.83**	**0.25**

Table 2-4 Summary of Post-treatment Canal/Creek Water Sample Results

River Mile	Location ID[2]	Endothall Concentrations in PPM[3] Sampling Dates[1] 8/1/17	8/2/17 A[4]	8/2/17 B[4]	8/3/17	8/4/17	8/5/17
	5.5 C	**4.6$^{D.28}$**	**1.7$^{D.14}$**	**3.9$^{D.28}$**	**0.86**		
5.8	**5.8 C**	**2.5$^{D.14}$**	**0.53$^{D.14}$**	**3.8$^{D.28}$**	**1.1**		
6.0	6.0 C	ND$^{D.007}$	0.081	0.88	1.0	0.92	
6.3	6.3 A					1.1	ND
6.5	6.5 LB					0.95	0.070
6.7	6.7 C	ND$^{D.007}$	0.080$^{D.007}$	0.14	1.0		
7.0	7.0 RB					0.80	
7.3	**7.3 C**	**2.0$^{D.14}$**	**0.44$^{D.14}$**	**3.1$^{D.28}$**	**0.46**		
7.5	7.5 C					0.59	0.070
8.0	8.0 LB					0.28	
8.5	8.5 RB					0.41	0.15
9.0	9.0 C					0.27	
9.5	9.5 LB					0.32	0.19
10.0	10.0 RB					0.13	
10.1	10.1 A					ND	0.19
10.5	**10.5 C**					**ND**	**0.14**
10.6	**10.6 C**	**0.093$^{D.007}$**	**0.010$^{D.007}$**	**0.31**	**ND**		
11.0	11.0 LB					ND	
11.5	11.5 RB					ND	0.30
12.0	12.0 C					ND	
12.5	12.5 LB					0.073	0.32
13.0	13.0 RB					0.021$^{D.007}$	
13.5	13.5 C					0.042$^{D.007}$	0.089
14.0	14.0 LB					0.068$^{D.007}$	
14.5	14.5 RB					0.12$^{D.007}$	
15.0	15.0 C					0.11$^{D.007}$	

[1] Application occurred on August 1 and 2, 2017. Samples collected post-treatment on August 1, pre-and post-second treatment on August 2 (see note 4), and Post-treatment on August 3 were by ERDC; all samples collected on August 4 and 5, 2017 were post-treatment, and 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 pre-second treatment sampling on August 2, and the letter "B" denotes post-second treatment sampling on August 2.

D# This indicates the detection limit associated with the sample. For example, D.14 indicates a detection limit of 0.14 ppm. Concentration listed without a detection limit footnote had a detection limit of 0.07 ppm.

Key:

C = center of canal/creek
ND = Non-detect (detection limit of 0.07 ppm unless otherwise noted by footnote)
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

All samples collected by E & E from August 4 and 5 were shipped on ice to the ERDC laboratory at the University of Florida Center for Aquatic Plants for analysis. Samples arrived at the laboratory on the morning of August 7. 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%. Three normal/duplicate pairs were collected over two days of sampling. The analytical results for one of the three pairs (both samples) were non-detect; the sample pairs collected at location 1.5 C and 6.0 C on August 4 had positive values and a relative percent difference of less than 5%, showing good correlation. Three lateral pairs were collected over two days of sampling. The analytical results for the sample pair at RM 3.5 collected on August 5 were non-detect; the sample pair collected at RMs 2.0 and 3.5 on August 4 had positive values and correlations of 7.2% and 21.4%, both of which are acceptable values considering dispersion across the creek.

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 August 4, 2017, indicated the presence of endothall from RM 1.0 through RM 10.0 and RM 12.5 to at least RM 15.0. Concentrations in this area ranged from 0.021 ppm to 1.1 ppm (see Table 2-4 and Figures B2 through B14 and B18 through B23 in Appendix B). On August 5, 2017, sample results indicated the presence of endothall from RM 4.5 to at least RM 13.5, which was the sampling location farthest to the east. These concentrations clearly demonstrate the dispersion of endothall to the east after the resumption of normal flows in the creek/canal.

Due to mostly non-detect concentrations at an undiluted detection limit of 0.007 ppm measured on Day 7 of the 2016 monitoring effort, no sampling was conducted past Day 5. The endothall concentrations measured in Day 4 and Day 5 samples are the same magnitude of concentrations measured in Day 4 samples in 2016, suggesting 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.

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.

2.6 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, 2017, E & E personnel set up a flow meter at each of the three following locations to test operations: North Tonawanda Botanical Gardens; near the East Canal Road/New Road Bridge in Pendleton; and near the Stevens Street bridge in Lockport (see photos 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 North Tonawanda Botanical Gardens;
- East to west in Tonawanda Creek at New Road in Pendleton; and

- East to west in the Erie Canal at Stevens Street in Lockport.

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 New Road and Stevens Street monitoring stations, the sensors tipped over after installation due to high creek/canal velocity and heavy boat traffic, respectively. The sensors were replaced with the buoys adjusted to float just below the water surface to avoid further tipping. Flow was continuously monitored to detect tipped sensors before, during, and after treatment.

All monitoring stations successfully recorded flow before, during, and after treatment. During treatment, flow at the all 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 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 addition, the Canal Corp. controlled the water level between Lockport and the Genesee River by taking the RG&E Power Plant at Station 26 on the Genesee River off-line.

Prior to the 48-hour treatment period on August 1 and 2, Canal Corp. ceased flows out of Lockport by closing the bypass gate opening at approximately 0800 hrs on August 1, 2017. 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 10 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 (east) 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 0900 hours on August 4, 2017.

Canal Corps stopped flow again at 0800 hrs on August 9 for the spot treatment, and resumed flow at 0900 hrs on August 10.

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 North Tonawanda Botanical Gardens exhibited a cyclic behavior on an approximately daily cycle. During 2016, 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. Measurements in 2017 showed the maximum water level generally occurring in the late morning/early afternoon (1100 to 1400 hours) with the minimums happening overnight (2200 to 0600 hours), with a magnitude change between 0.4 and 0.6 feet. Anomalies in this pattern were likely due to heavy rains. Fluctuations in flow generally followed patterns of fluctuations in water level. At North Tonawanda Botanical Gardens, the flow rate was generally 1,000 cfs or less, primarily to the east with lower magnitude flow fluctuations to the west (see Appendix D). On July 28 through 30, flow fluctuated to higher values (2,760 cfs at maximum) to the west, likely due to high flows coming from the east in Tonawanda Creek.

At the Stevens Street monitoring station, flow rates were generally below 500 cfs, averaging 200 to 250 cfs to the west prior to the treatment period. During treatment, flows fluctuated in direction at levels below 300 cfs. Before and during treatment, there were a few instances of high flows towards the east (up to 1,690 cfs) likely due to lock filling at Locks 34/35 in Lockport and related boat traffic. Following resumption of flow at the locks and bypass gates on August 4, 2017, flow rates increased again to an average of 200 to 250 cfs to the west (see Appendix D).

Flows out of and into the natural channel of Tonawanda Creek (near East Canal/New Road) were high before the treatment period, due to heavy rains at the end of July 2017. 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 2017).

3 Study Improvements

The study improvements, summarized below, were based on lessons learned from the 2015 and 2016 endothall application efforts, coordination with the study partners during 2017 work plan development, and activities conducted during the 2017 herbicide application.

3.1 Herbicide Application and Analysis

There have been no issues with herbicide handling since the project's inception in 2014 at the public launch areas, and public access to the boat ramps continued to be uninterrupted while used by the applicators.

The immunoassay tests performed to determine endothall concentrations during the 2017 application 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, 2016, and 2017. 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. Issues with real time data transmission noted in 2016 did not affect data interpretation in 2017. The only issue with flow monitoring in 2017 was tipping over from vertical of some of the sensors. This was corrected by re-adjusting one of the buoys so that the buoy was slightly submerged resulting in a constant upward force on the sensor-mounted staff. Designing a heavier, flatter concrete base was considered, but the added weight will make deployment more difficult. Since the re-adjustment of one of the buoys rectified the issue, no concrete base reconfigurations are necessary for 2018.

Canal Corp. Operations

After the initial demonstration in 2014, it was 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.

After eliminating flow to the east through the locks, the only flow remaining is the input from the natural channel of Tonawanda Creek entering the canal in Rapids, New York (averaging 144 cfs during the 2017 application period [USGS 2017]). This inflow rate can be matched at Lockport by operating the bypass gate at a comparable flow rate.

Flow Monitoring Locations

In 2016, the flow meter at Mayor's Park was difficult to put in place before treatment and difficult to remove when sampling was completed. In 2017, a location on the south shore of the creek/canal near the Botanical Gardens ramp was chosen for the meter placement. No issues with meter tipping were noted and access to the location was easy from both boat and shoreline, making this location a better alternative for the former Mayor's Park meter location.

3.3 2017 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 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. Improved preliminary estimates of the anticipated and potential maximum quantities of herbicide to be applied help in arranging for product delivery and determining the preferred container size.

Sampling Locations

In previous years, 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.

Communication

As the Project enters its maintenance phase, it is critical to maintain one point of contact for the client and each subcontractor and project stakeholder for efficient communication of needs.

4 References

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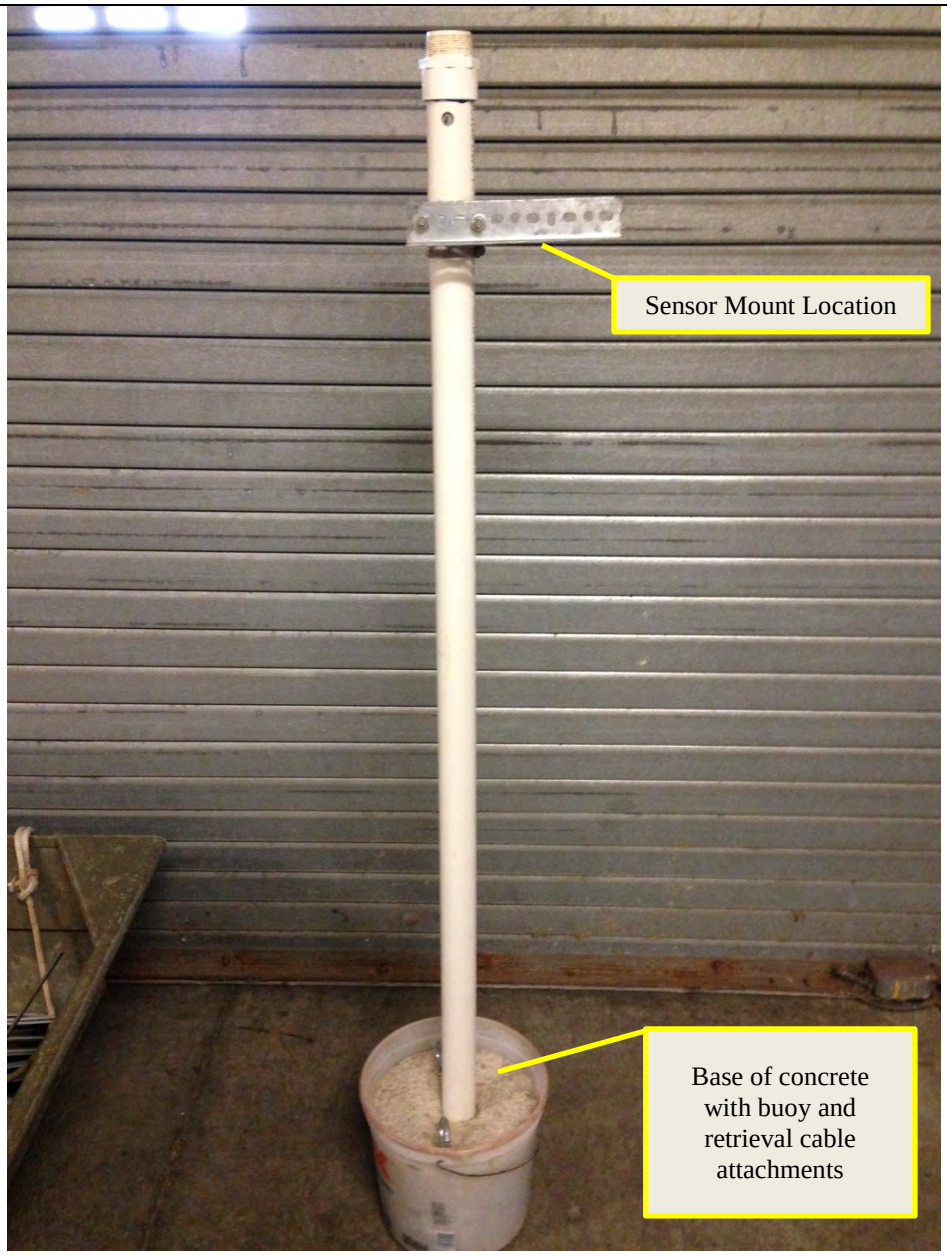
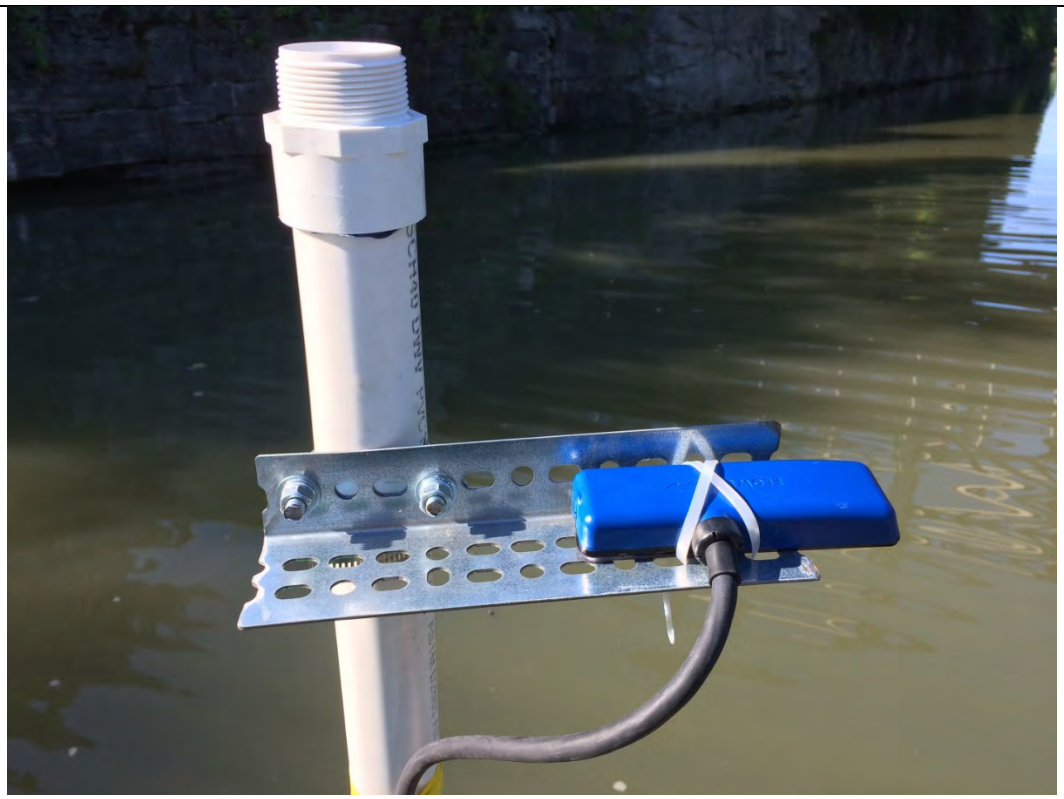
A Photolog



Subject: Typical Flow 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



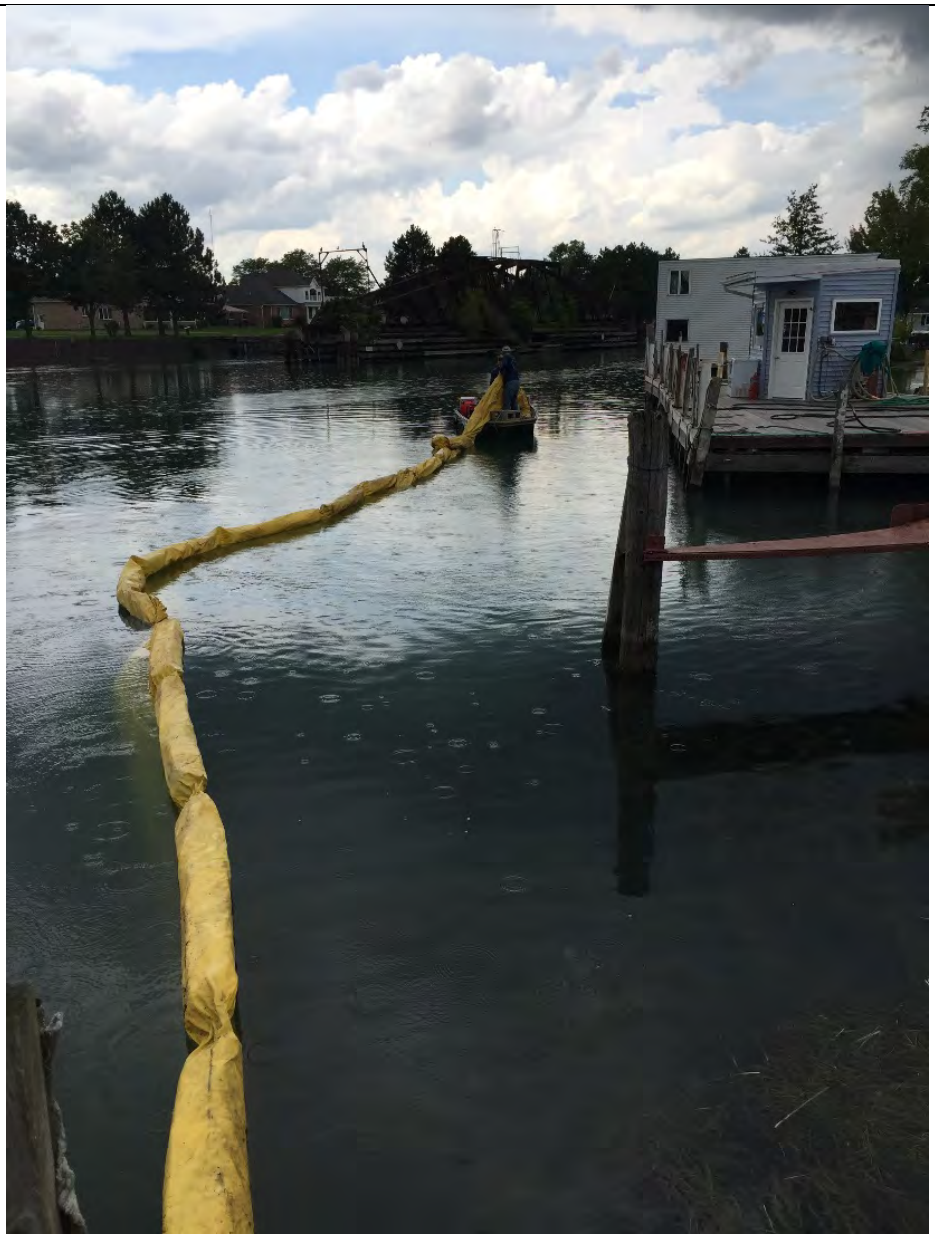
Subject:	Mounted Sigma flow/velocity sensor
Description:	Sensor is mounted parallel to flow direction and can measure negative and positive flows

Date:	07/11/2017	**Direction of View:**	East from West shore of creek/canal
Subject:	E&E employees at Stevens Street Bridge in Lockport, NY		
Description:	E&E employees measuring velocity at 6 inches, 25%, 50% and 75% of creek/canal depth to determine the velocity profile at Stevens Street Bridge flow monitoring location.		

Date:	08/11/2017	**Direction of View:**	SE from N side of creek
Subject:	Botanical Gardens meter location		
Description:	Two buoys mark the new location of the flow meter at the Botanical Gardens in North Tonawanda, NY		

Date:	08/01/2017	**Direction of View:**	West from North shore of creek
Subject:	SOLitude endothall application boat		
Description:	Endothall was placed in the tank and dispensed into the creek/canal through PVC pipes off of boat stern.		

Date:	08/02/2017	**Direction of View:**	NA
Subject:	Benthic mat		
Description:	Burlap benthic mat and associated brick weights.		



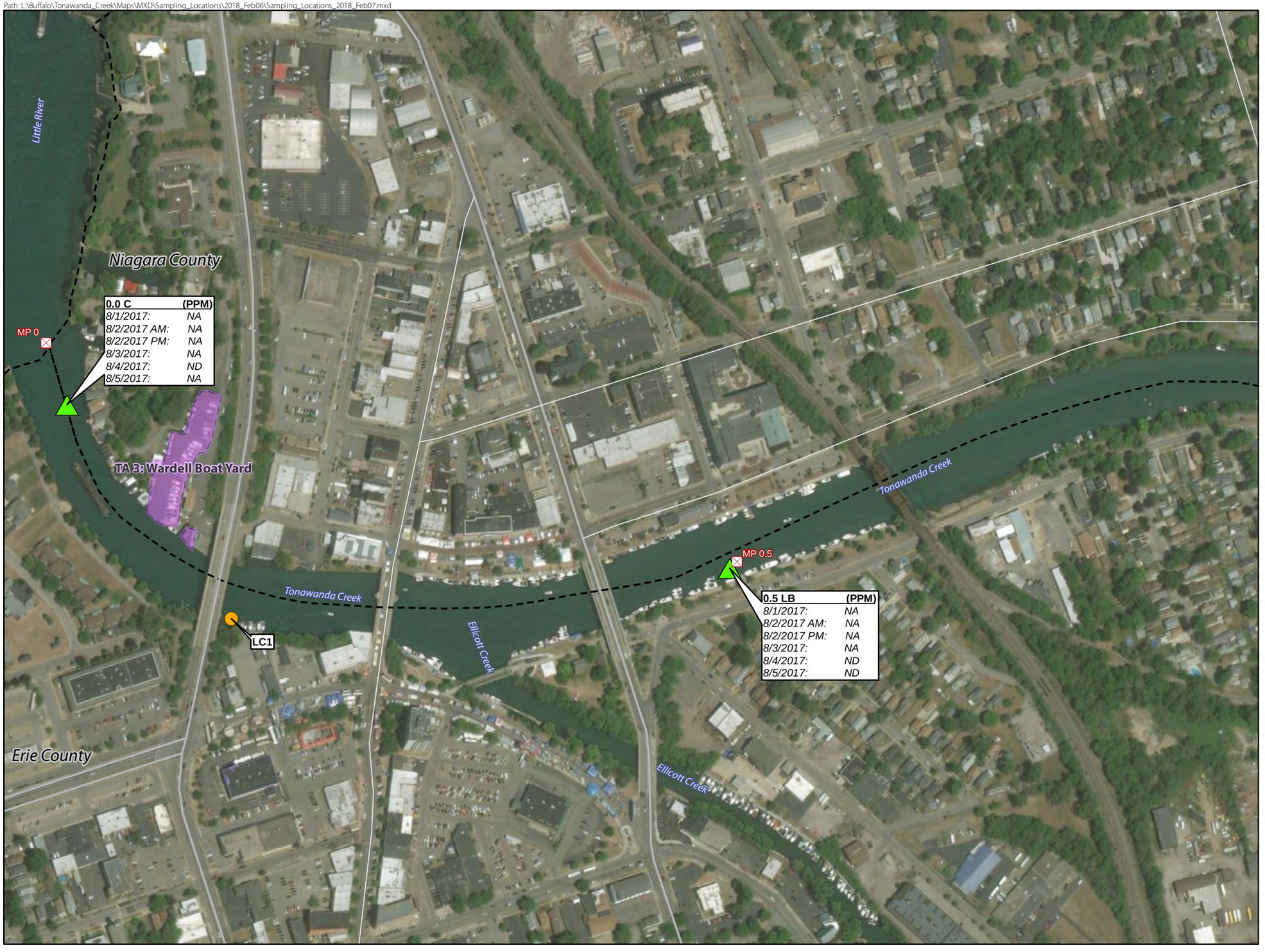
Date:	09/06/2017	**Direction of View:**	West from North shore of creek
Subject:	Limnocorral at Wardell Boat Yard Marina		
Description:	Installation of limnocorral at Wardell Boat Yard marina for isolated spraying of endothall from shore by backpack and from boat.		

Date:	09/06/2017	**Direction of View:**	West from North shore of creek
Subject:	SOLitude endothall sprayer application at Wardell Boat Yard Marina		
Description:	Endothall was placed in the backpack tank and sprayed into the area around the marina by hand.		

Date:	09/06/2017	**Direction of View:**	North from North shore of creek
Subject:	Wardell Boat Yard Marina		
Description:	Endothall application.		

B Water Quality Sampling Location Maps

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Sampling_Locations_2018_Feb07.mxd



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

Legend

- E&E
- Treatment Location
- Milepost from Mouth of Creek/Canal
- County Boundary
- Secondary Road
- Local Road
- Marina Treatment Area

*Note: All sample locations are approximate.

N

SCALE

0 0.05 0.1 Miles

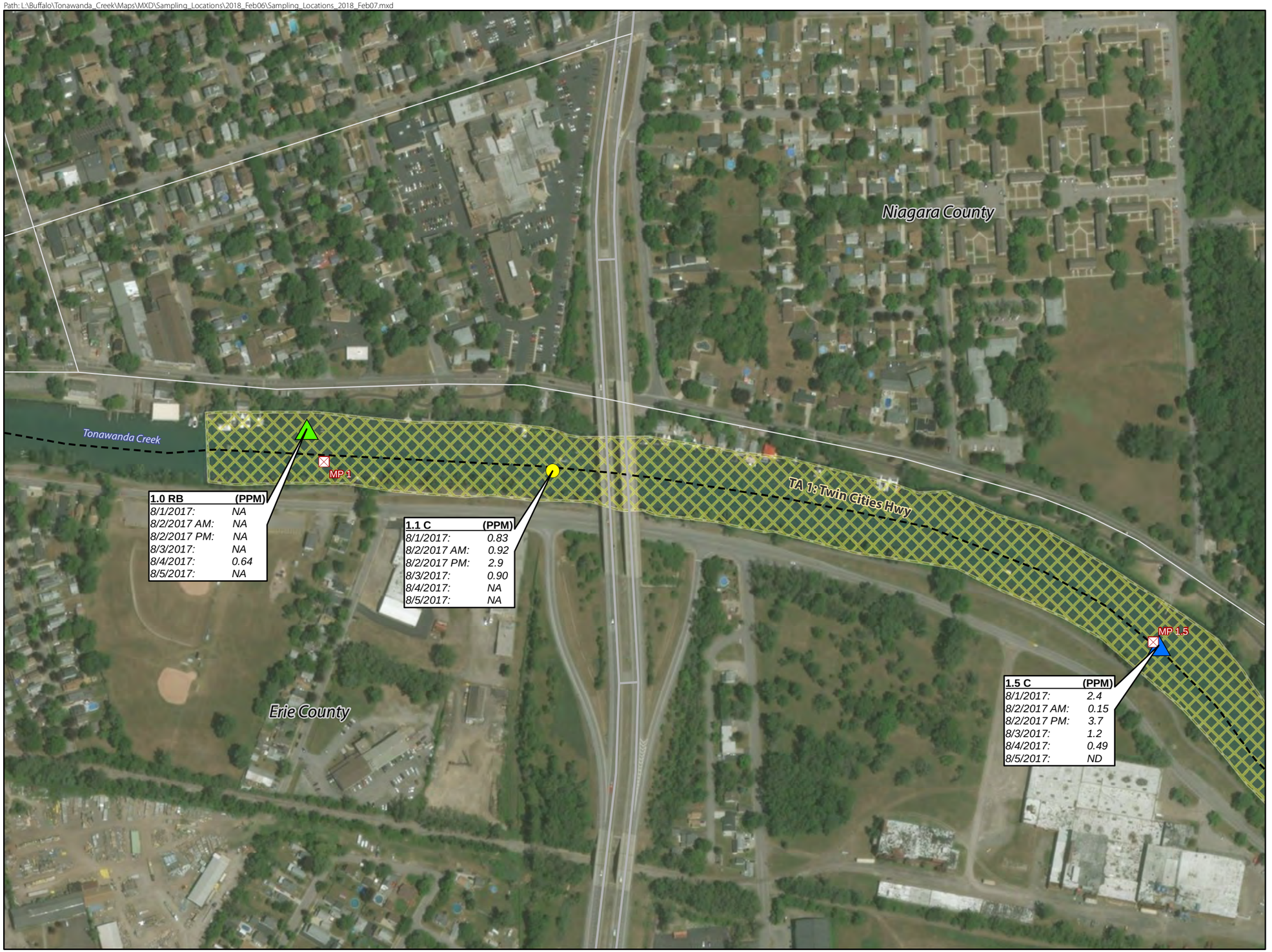
SOURCE: ESRI 2012; Ecology and Environment, Inc. 2018; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Sampling_Locations_2018_Feb07.mxd

Sample Locations
Associated Endothall Concentration Values
Figure B2

Tonawanda Creek/Erie Canal

Erie and Niagara Counties, New York



Legend

- E&E
- E&E/ERDC
- ERDC
- Milepost from Mouth of Creek/Canal
- County Boundary
- Secondary Road
- Local Road
- First Round Treatment Areas

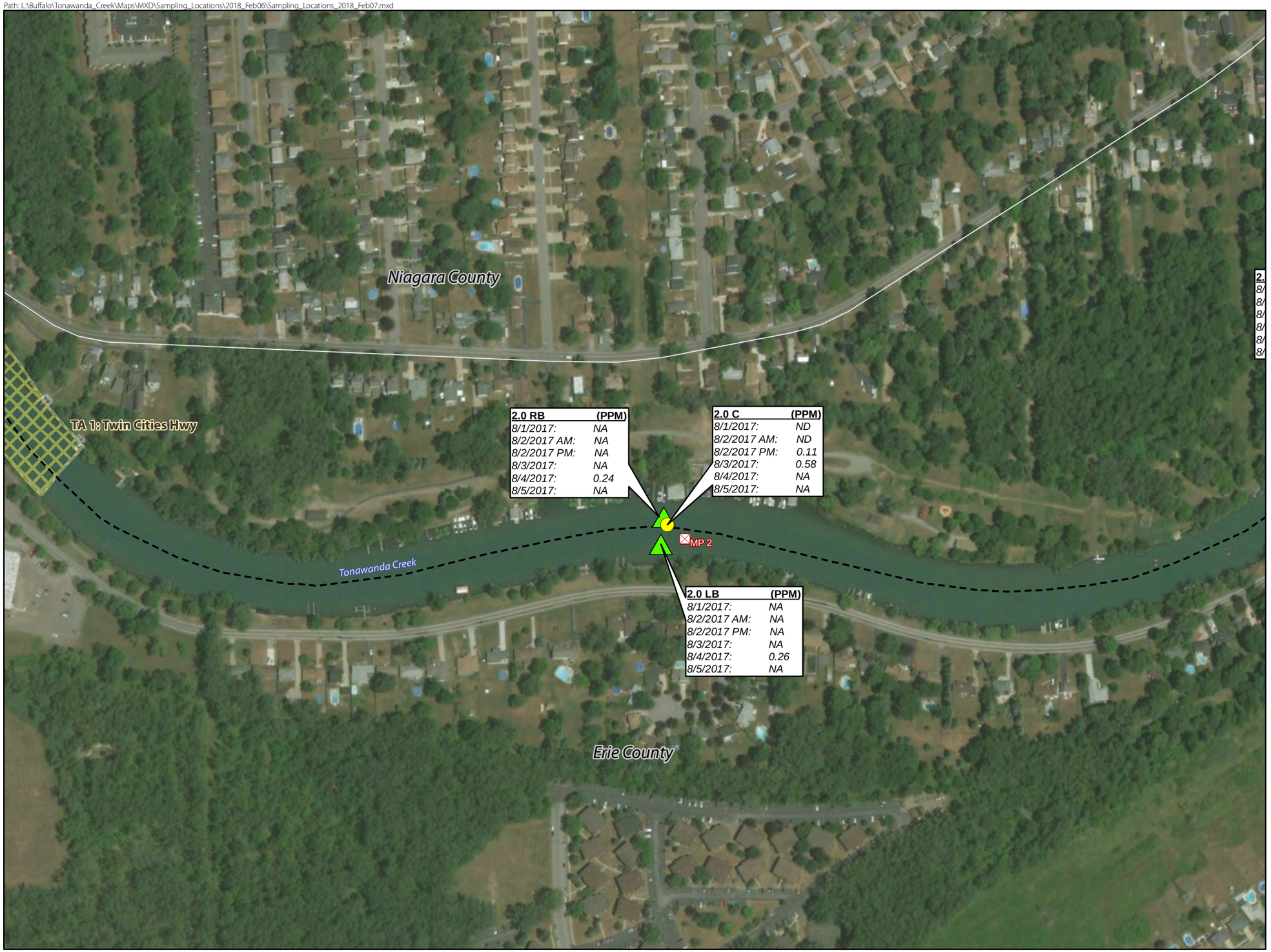
*Note: All sample locations are approximate.

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; Ecology and Environment, Inc. 2018; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Sampling_Locations_2018_Feb07.mxd



Sample Locations
Associated Endothall Concentration Values
Figure B3

Tonawanda Creek/Erie Canal

Erie and Niagara Counties, New York

Legend

- E&E
- ERDC
- Milepost from Mouth of Creek/Canal
- County Boundary
- Local Road
- First Round Treatment Areas

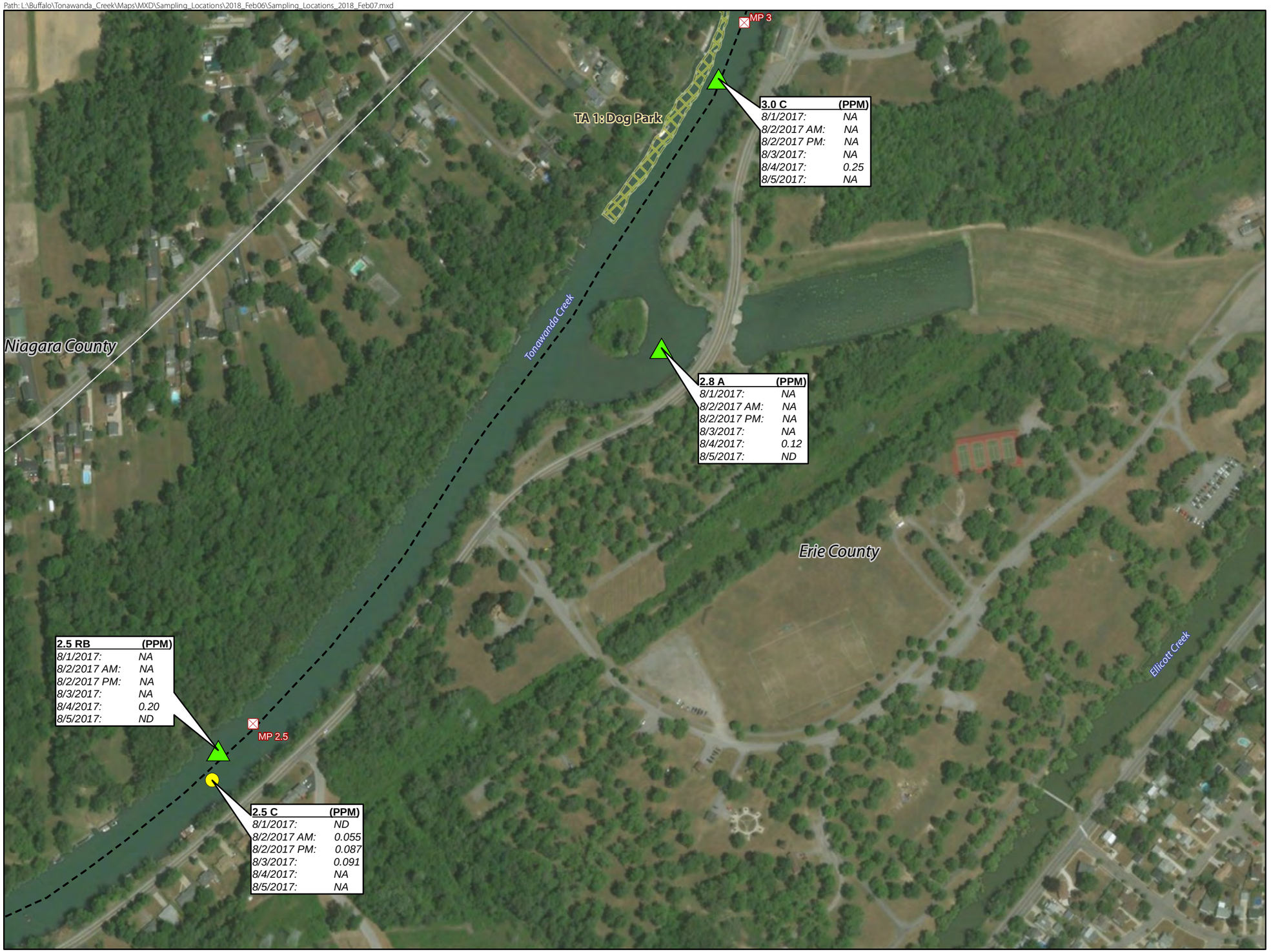
*Note: All sample locations are approximate.

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; Ecology and Environment, Inc. 2018; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Sampling_Locations_2018_Feb07.mxd



Sample Locations Associated Endothall Concentration Values Figure B4

Tonawanda Creek/Erie Canal

Erie and Niagara Counties, New York

Legend

- E&E
- ERDC
- Milepost from Mouth of Creek/Canal
- County Boundary
- Local Road
- First Round Treatment Areas

*Note: All sample locations are approximate.

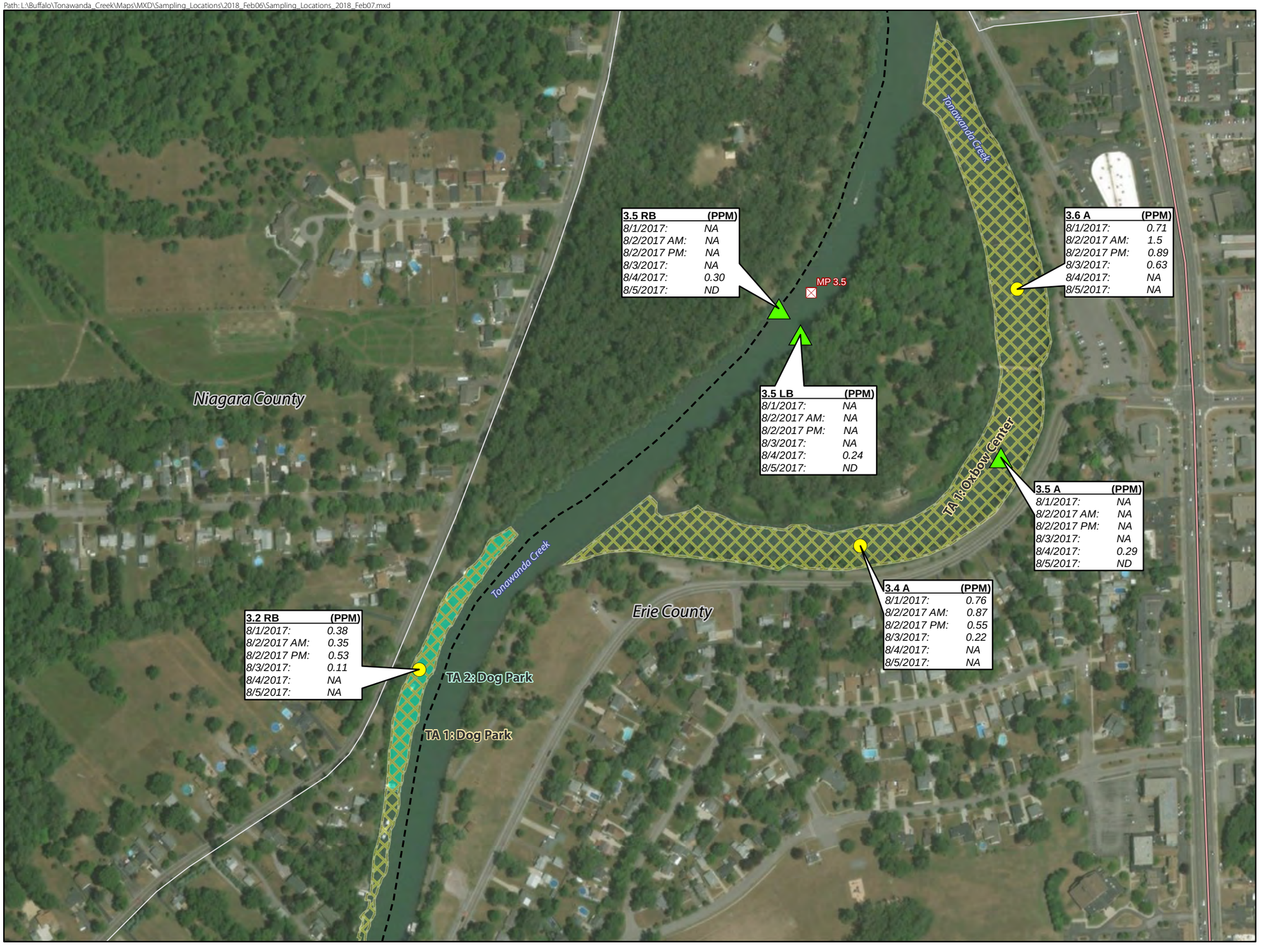
N

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; Ecology and Environment, Inc. 2018; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Sampling_Locations_2018_Feb07.mxd



Sample Locations
Associated Endothall Concentration Values
Figure B5

Tonawanda Creek/Erie Canal

Erie and Niagara Counties, New York

Legend

- E&E
- ERDC
- Milepost from Mouth of Creek/Canal
- County Boundary
- Major Road
- Local Road
- First Round Treatment Areas
- Second Round Treatment Areas

*Note: All sample locations are approximate.

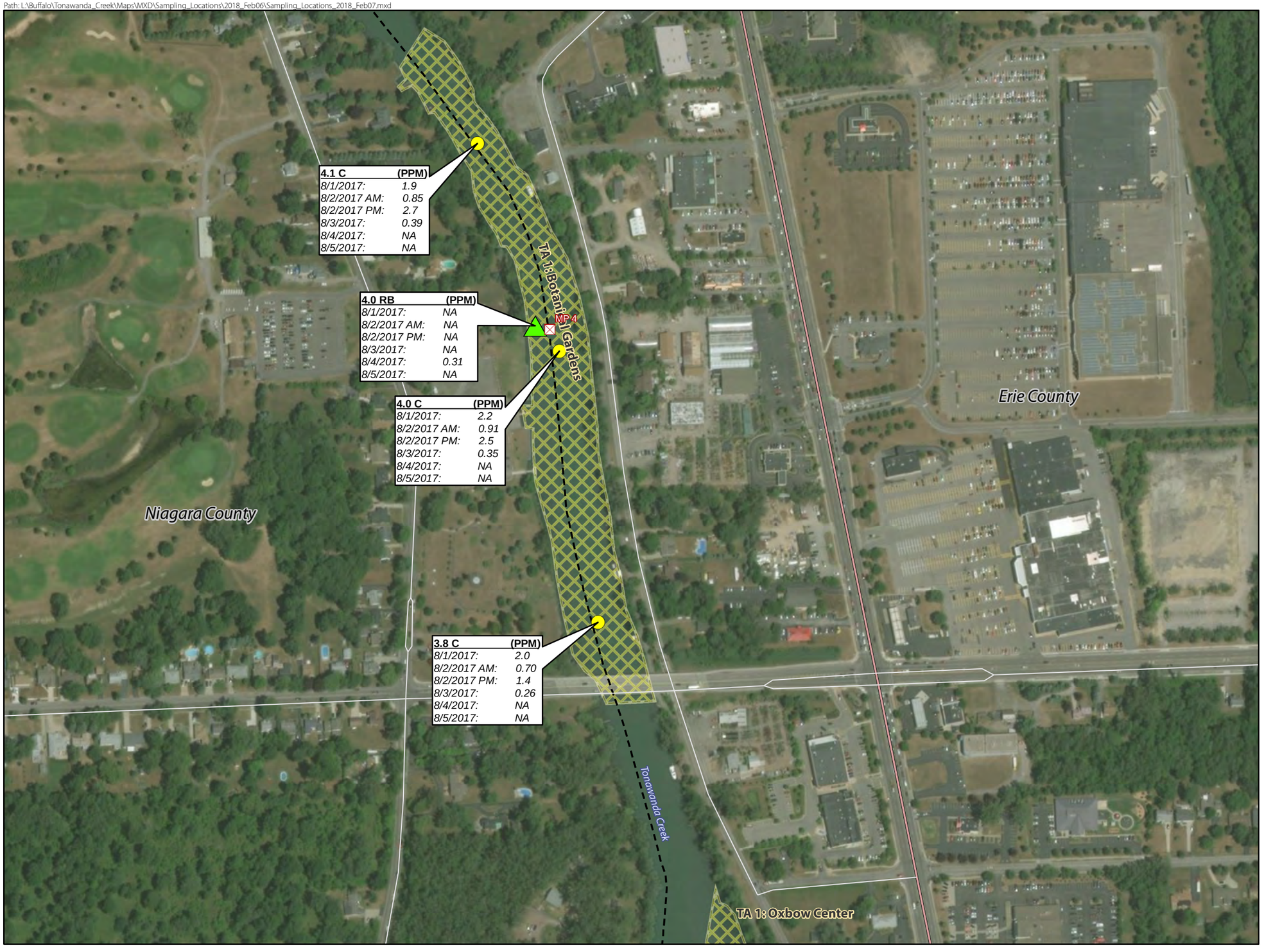
N

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; Ecology and Environment, Inc. 2018; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Sampling_Locations_2018_Feb07.mxd



Sample Locations
Associated Endothall Concentration Values
Figure B6

Tonawanda Creek/Erie Canal

Erie and Niagara Counties, New York

Legend

- E&E
- ERDC
- Milepost from Mouth of Creek/Canal
- County Boundary
- Major Road
- Local Road
- First Round Treatment Areas

*Note: All sample locations are approximate.

N

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; Ecology and Environment, Inc. 2018; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Sampling_Locations_2018_Feb07.mxd

Sample Locations
Associated Endothall Concentration Values
Figure B7

Tonawanda Creek/Erie Canal

Erie and Niagara Counties, New York

Legend

- E&E
- ERDC
- Milepost from Mouth of Creek/Canal
- County Boundary
- Major Road
- Local Road
- First Round Treatment Areas

*Note: All sample locations are approximate.

N

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; Ecology and Environment, Inc. 2018; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Sampling_Locations_2018_Feb07.mxd

Sample Locations
Associated Endothall Concentration Values
Figure B8

Tonawanda Creek/Erie Canal

Erie and Niagara Counties, New York

Legend

- E&E
- ERDC
- Treatment Location
- Milepost from Mouth of Creek/Canal
- County Boundary
- Major Road
- Local Road
- First Round Treatment Areas
- Second Round Treatment Areas

*Note: All sample locations are approximate.

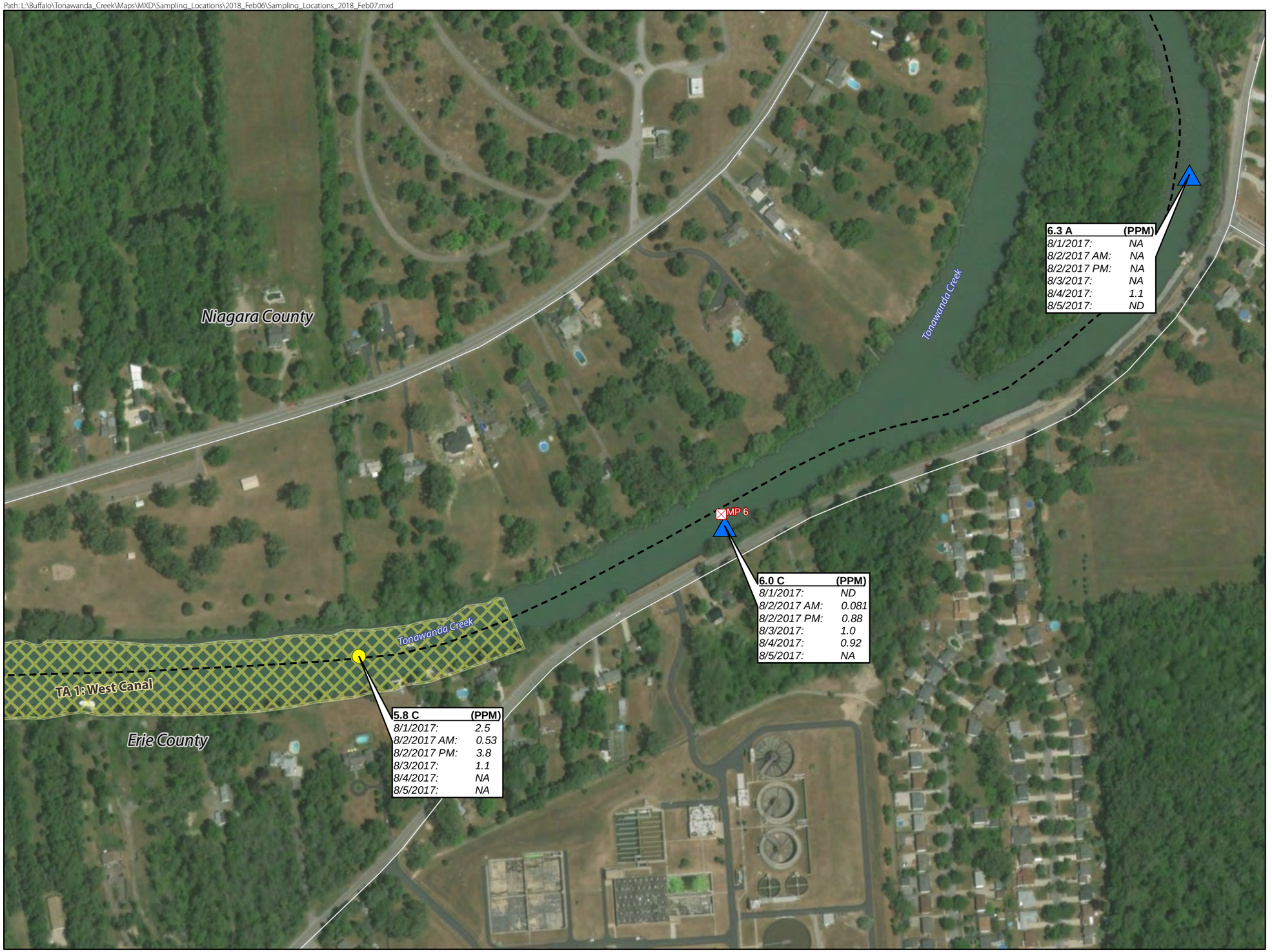
N

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; Ecology and Environment, Inc. 2018; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Sampling_Locations_2018_Feb07.mxd



Sample Locations
Associated Endothall Concentration Values
Figure B9

Tonawanda Creek/Erie Canal

Erie and Niagara Counties, New York

Legend

- E&E/ERDC
- ERDC
- Milepost from Mouth of Creek/Canal
- County Boundary
- Local Road
- First Round Treatment Areas

*Note: All sample locations are approximate.

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; Ecology and Environment, Inc. 2018; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Sampling_Locations_2018_Feb07.mxd

Sample Locations
Associated Endothall Concentration Values
Figure B10

Tonawanda Creek/Erie Canal

Erie and Niagara Counties, New York

Legend

- E&E
- ERDC
- Milepost from Mouth of Creek/Canal
- County Boundary
- Local Road

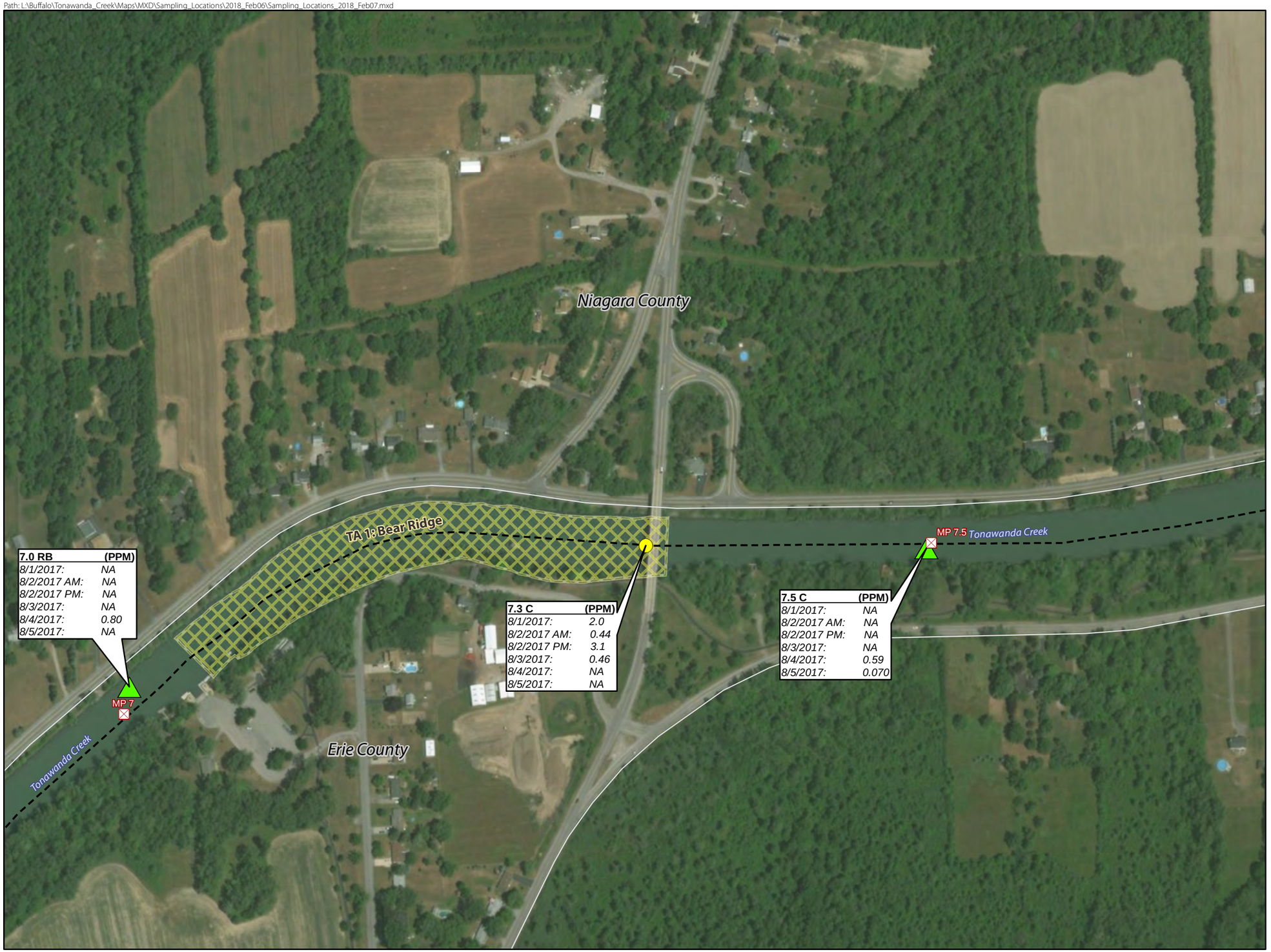
*Note: All sample locations are approximate.

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; Ecology and Environment, Inc. 2018; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Sampling_Locations_2018_Feb07.mxd



Sample Locations
Associated Endothall Concentration Values
Figure B11

Tonawanda Creek/Erie Canal

Erie and Niagara Counties, New York

Legend

- E&E
- ERDC
- Milepost from Mouth of Creek/Canal
- County Boundary
- Local Road
- First Round Treatment Areas

*Note: All sample locations are approximate.

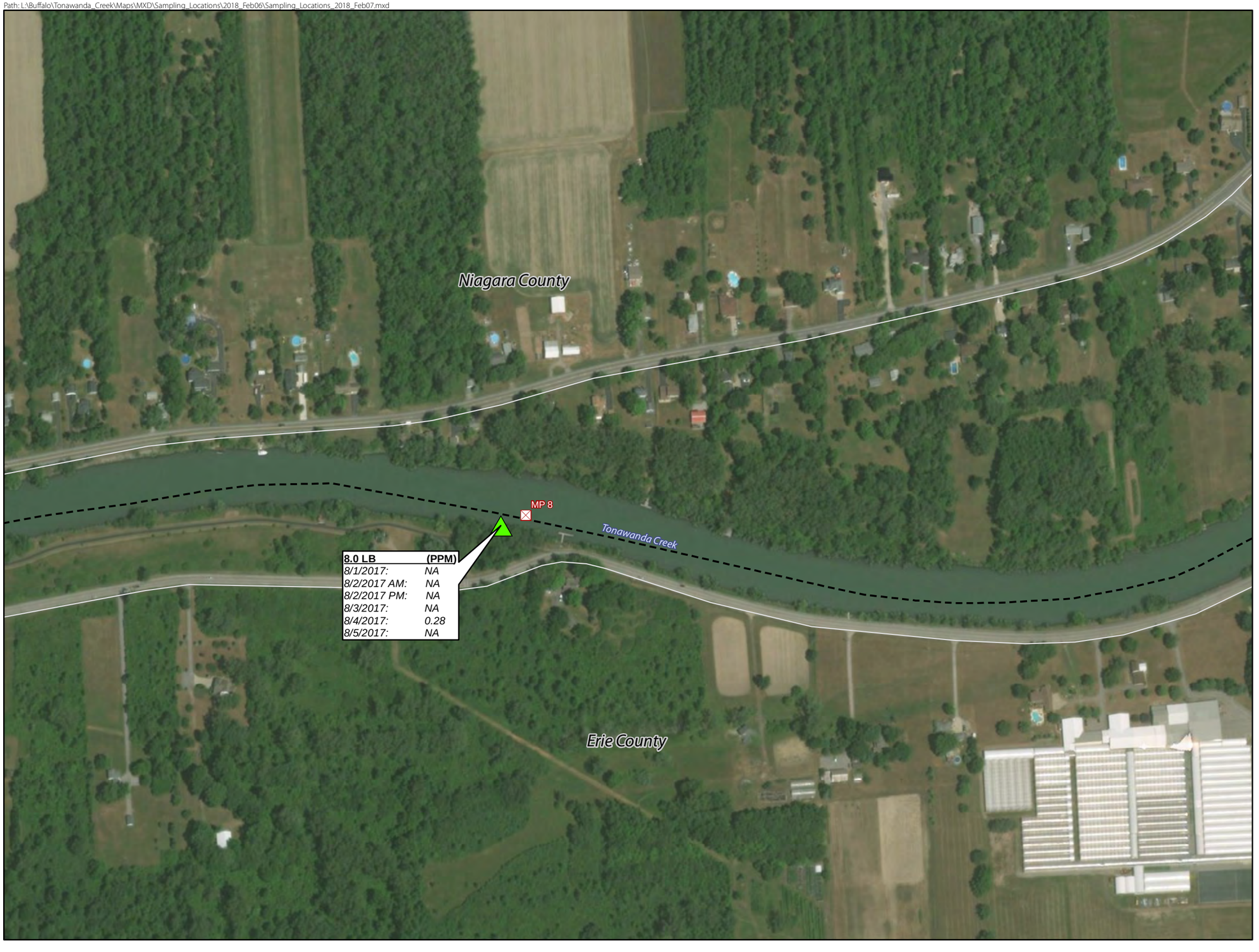
N

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; Ecology and Environment, Inc. 2018; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Sampling_Locations_2018_Feb07.mxd



Sample Locations
Associated Endothall Concentration Values
Figure B12

Tonawanda Creek/Erie Canal

Erie and Niagara Counties, New York

Legend

- E&E
- Milepost from Mouth of Creek/Canal
- County Boundary
- Local Road

*Note: All sample locations are approximate.

N

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; Ecology and Environment, Inc. 2018; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Sampling_Locations_2018_Feb07.mxd

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

Legend

- E&E
- Treatment Location
- Milepost from Mouth of Creek/Canal
- County Boundary
- Local Road
- Second Round Treatment Areas

*Note: All sample locations are approximate.

N

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; Ecology and Environment, Inc. 2018; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Sampling_Locations_2018_Feb07.mxd

Sample Locations
Associated Endothall Concentration Values
Figure B14

Tonawanda Creek/Erie Canal

Erie and Niagara Counties, New York

Legend

- E&E
- Milepost from Mouth of Creek/Canal
- County Boundary
- Local Road

*Note: All sample locations are approximate.

N

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; Ecology and Environment, Inc. 2018; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Sampling_Locations_2018_Feb07.mxd

Sample Locations
Associated Endothall Concentration Values
Figure B15

Tonawanda Creek/Erie Canal

Erie and Niagara Counties, New York

Legend

- E&E
- ERDC
- Milepost from Mouth of Creek/Canal
- County Boundary
- Local Road
- First Round Treatment Areas
- Second Round Treatment Areas

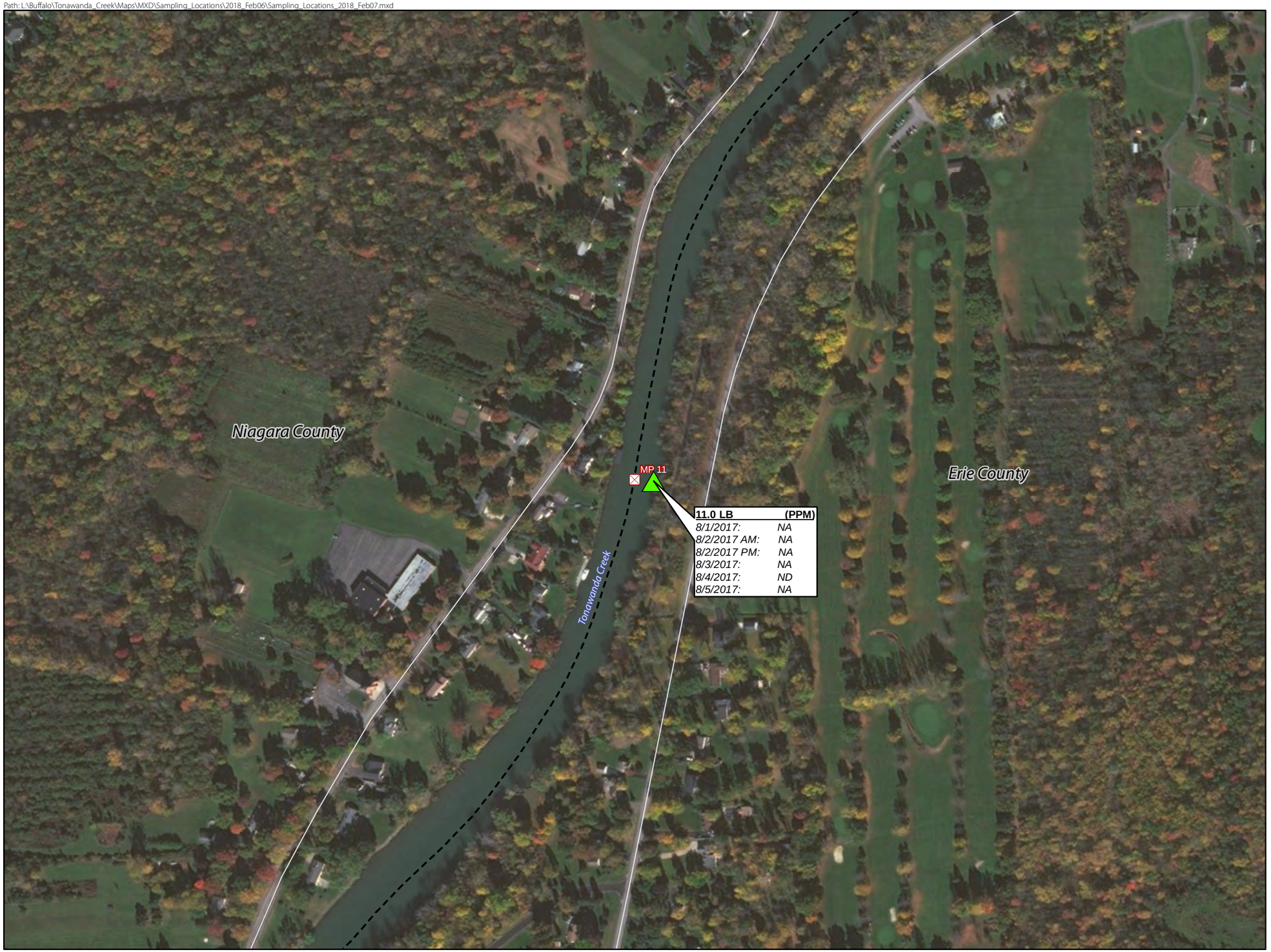
*Note: All sample locations are approximate.

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; Ecology and Environment, Inc. 2018; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Sampling_Locations_2018_Feb07.mxd



Sample Locations
Associated Endothall Concentration Values
Figure B16
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- E&E
- Milepost from Mouth of Creek/Canal
- County Boundary
- Local Road

*Note: All sample locations are approximate.

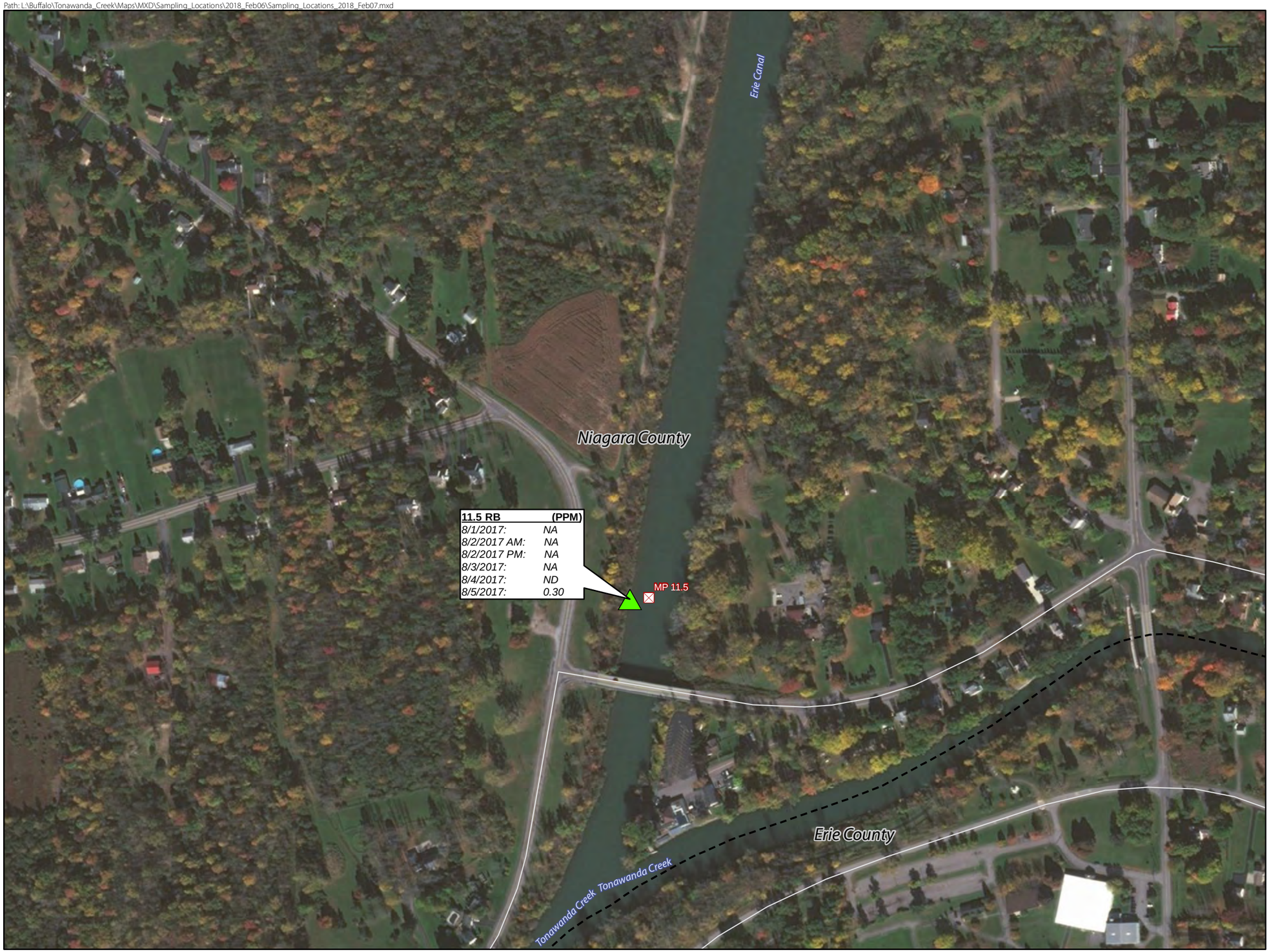
N

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; Ecology and Environment, Inc. 2018; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Sampling_Locations_2018_Feb07.mxd



Sample Locations
Associated Endothall Concentration Values
Figure B17

Tonawanda Creek/Erie Canal

Erie and Niagara Counties, New York

Legend

- E&E
- Milepost from Mouth of Creek/Canal
- County Boundary
- Local Road

*Note: All sample locations are approximate.

N

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; Ecology and Environment, Inc. 2018; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Sampling_Locations_2018_Feb07.mxd

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

Legend

E&E

Milepost from Mouth of Creek/Canal

*Note: All sample locations are approximate.

N

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; Ecology and Environment, Inc. 2018; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Sampling_Locations_2018_Feb07.mxd

Sample Locations
Associated Endothall Concentration Values
Figure B19

Tonawanda Creek/Erie Canal

Erie and Niagara Counties, New York

Legend

- E&E
- Milepost from Mouth of Creek/Canal

*Note: All sample locations are approximate.

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; Ecology and Environment, Inc. 2018; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Sampling_Locations_2018_Feb07.mxd

Sample Locations
Associated Endothall Concentration Values
Figure B20

Tonawanda Creek/Erie Canal

Erie and Niagara Counties, New York

Legend

E&E

Milepost from Mouth of Creek/Canal

*Note: All sample locations are approximate.

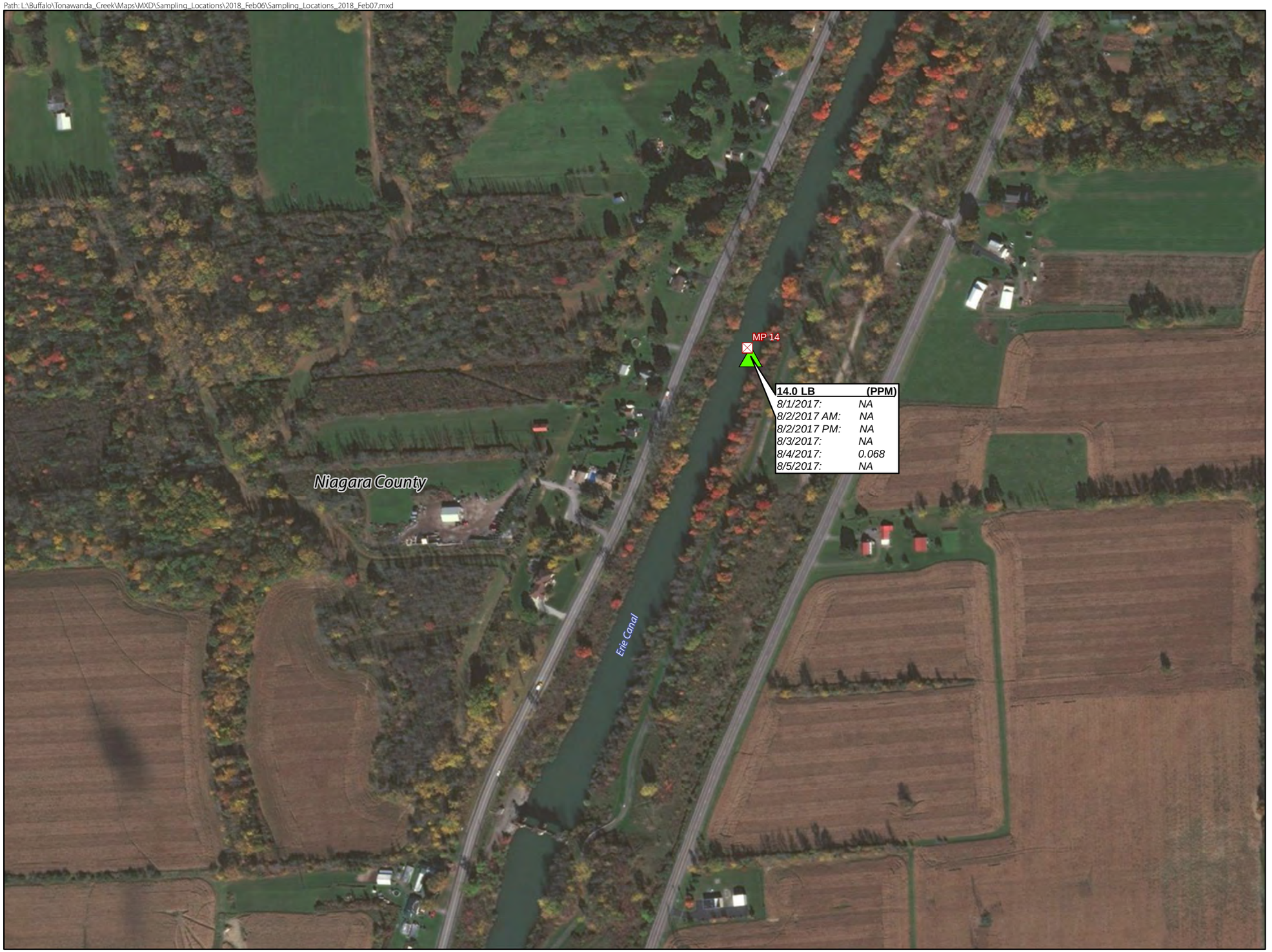
N

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; Ecology and Environment, Inc. 2018; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Sampling_Locations_2018_Feb07.mxd



Sample Locations
Associated Endothall Concentration Values
Figure B21

Tonawanda Creek/Erie Canal

Erie and Niagara Counties, New York

Legend

E&E

Milepost from Mouth of Creek/Canal

*Note: All sample locations are approximate.

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; Ecology and Environment, Inc. 2018; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Sampling_Locations_2018_Feb07.mxd

Sample Locations
Associated Endothall Concentration Values
Figure B22

Tonawanda Creek/Erie Canal

Erie and Niagara Counties, New York

Legend

E&E

Milepost from Mouth of Creek/Canal

*Note: All sample locations are approximate.

N

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; Ecology and Environment, Inc. 2018; US Army CORPS of Engineers 2016.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Sampling_Locations\2018_Feb06\Sampling_Locations_2018_Feb07.mxd

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

Legend

E&E

Milepost from Mouth of Creek/Canal

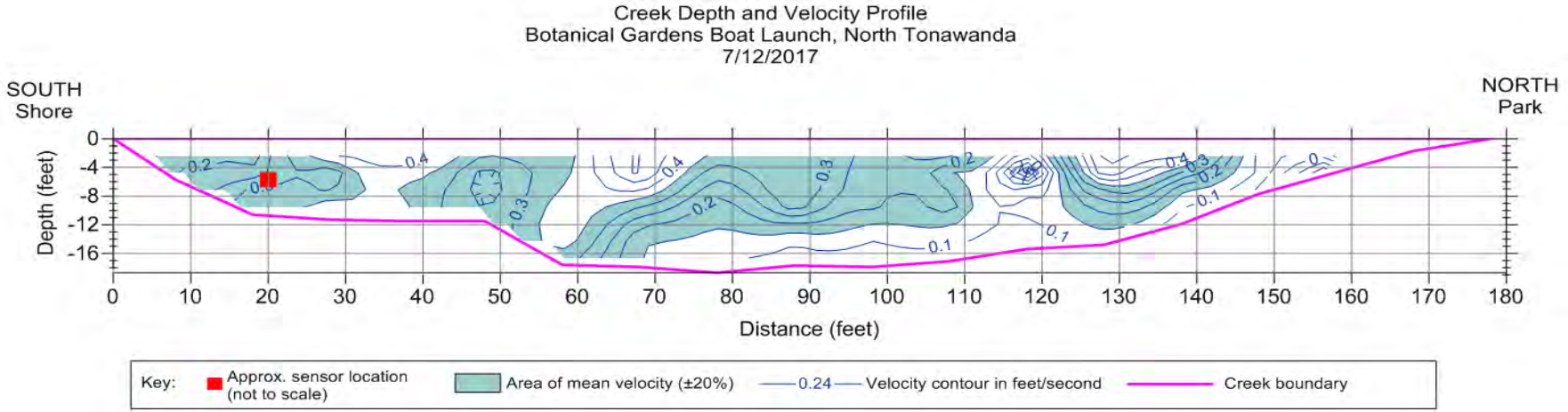
*Note: All sample locations are approximate.

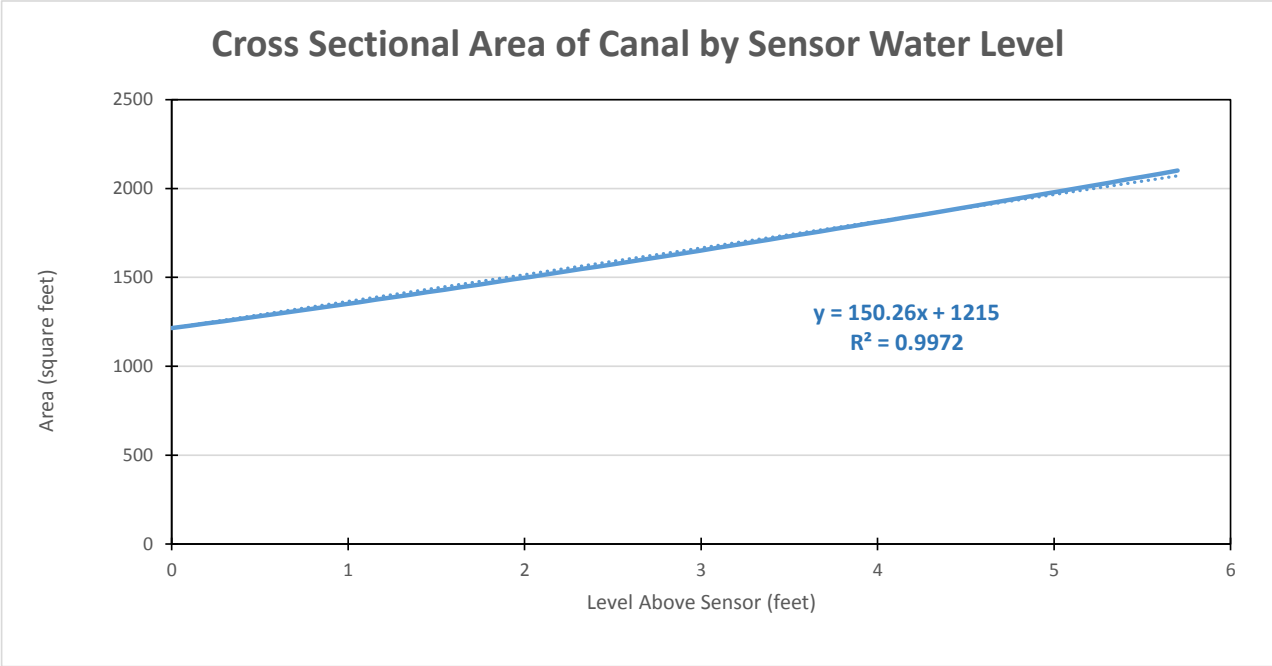
SCALE

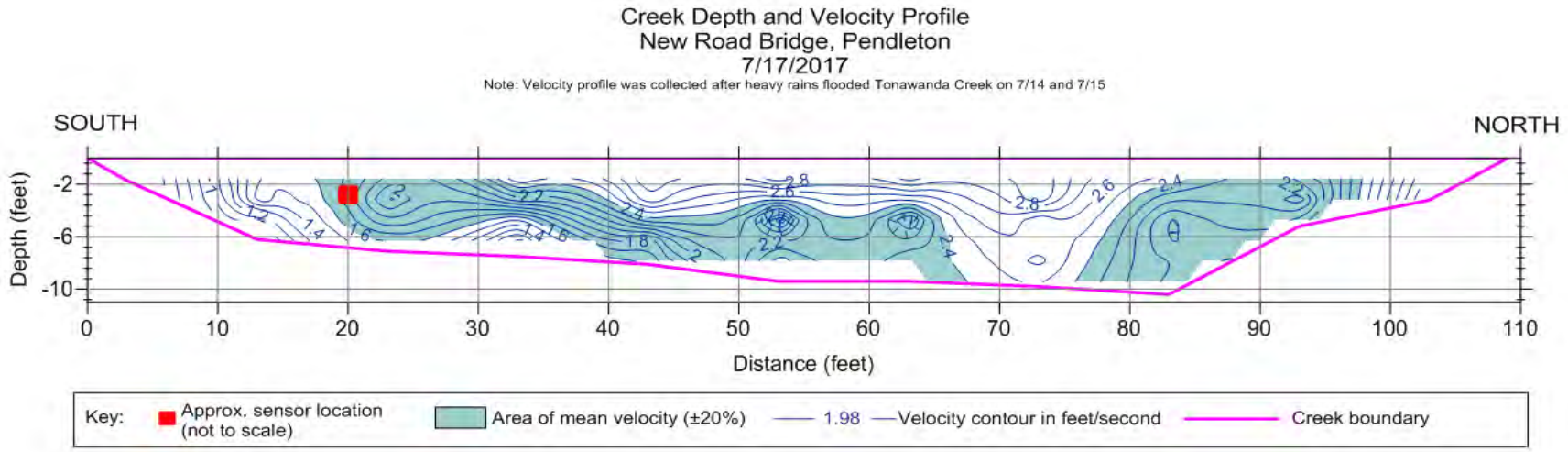
0 0.05 0.1 Miles

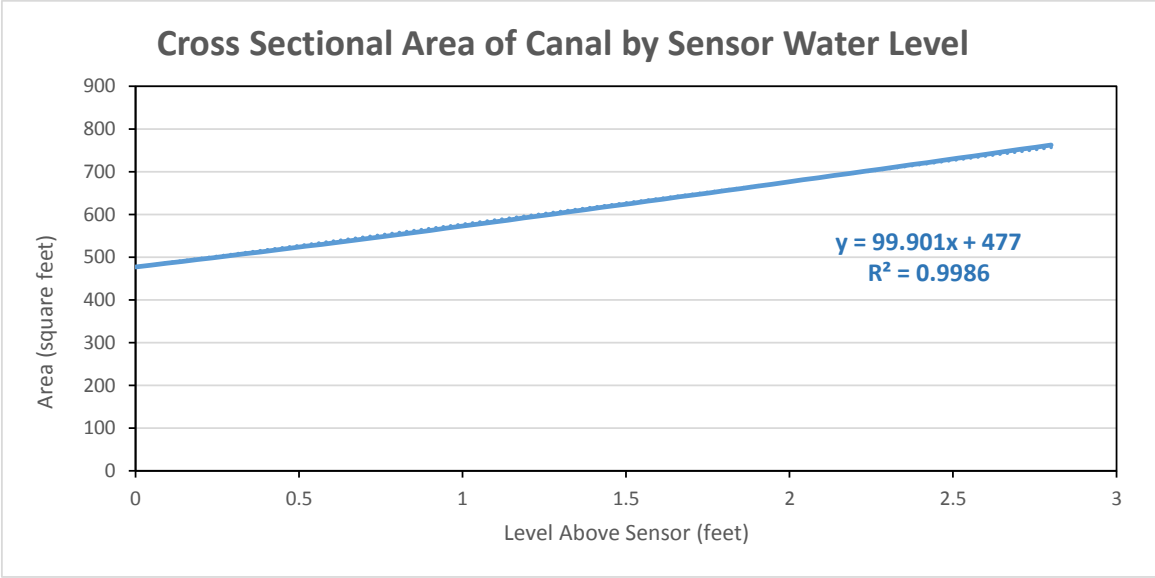
SOURCE: ESRI 2012; Ecology and Environment, Inc. 2018; US Army CORPS of Engineers 2016.

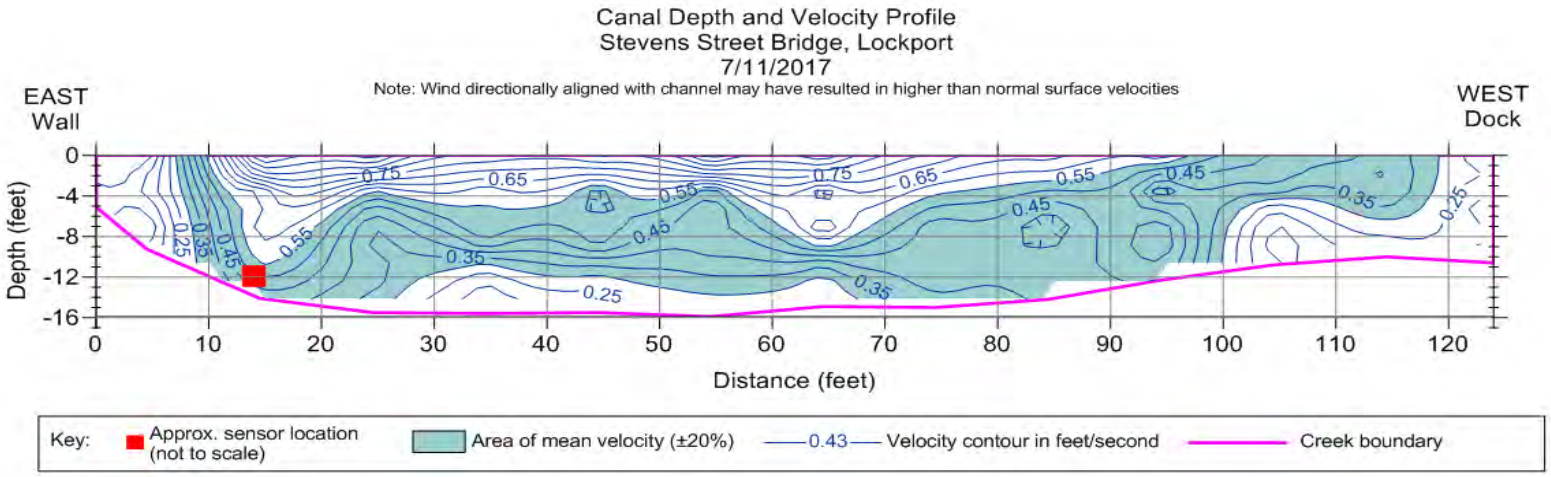
C Creek Cross Sections at Monitoring Locations

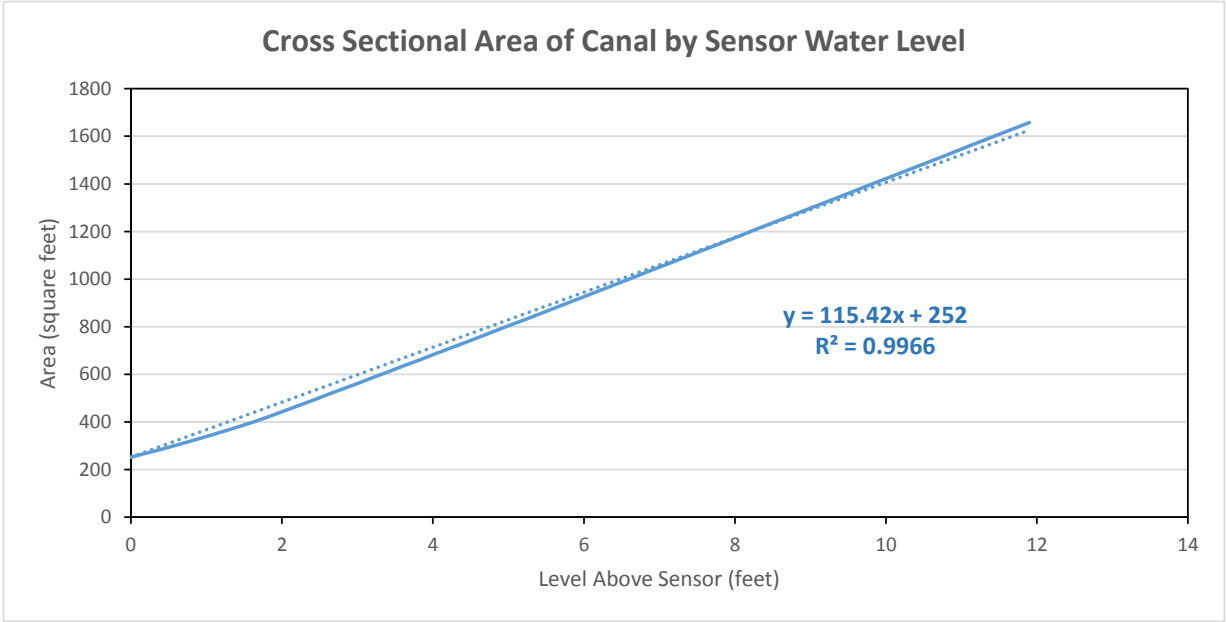

Creek Depth and Velocity Profile
Botanical Gardens Boat Launch, North Tonawanda
7/12/2017
SOUTH
Shore
NORTH
Park
Depth (feet)
0
-4
-8
-12
-16
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
Distance (feet)
Key:
Approx. sensor location
(not to scale)
Area of mean velocity (±20%)
0.24
Velocity contour in feet/second
Creek boundary


Cross Sectional Area of Canal by Sensor Water Level
Area (square feet)
2500
2000
1500
1000
500
0
0
1
2
3
4
5
6
Level Above Sensor (feet)
y = 150.26x + 1215
R² = 0.9972


Creek Depth and Velocity Profile
New Road Bridge, Pendleton
7/17/2017
Note: Velocity profile was collected after heavy rains flooded Tonawanda Creek on 7/14 and 7/15
SOUTH
NORTH
Depth (feet)
-2
-6
-10
0
10
20
30
40
50
60
70
80
90
100
110
Distance (feet)
Key:
Approx. sensor location (not to scale)
Area of mean velocity (±20%)
1.98
Velocity contour in feet/second
Creek boundary

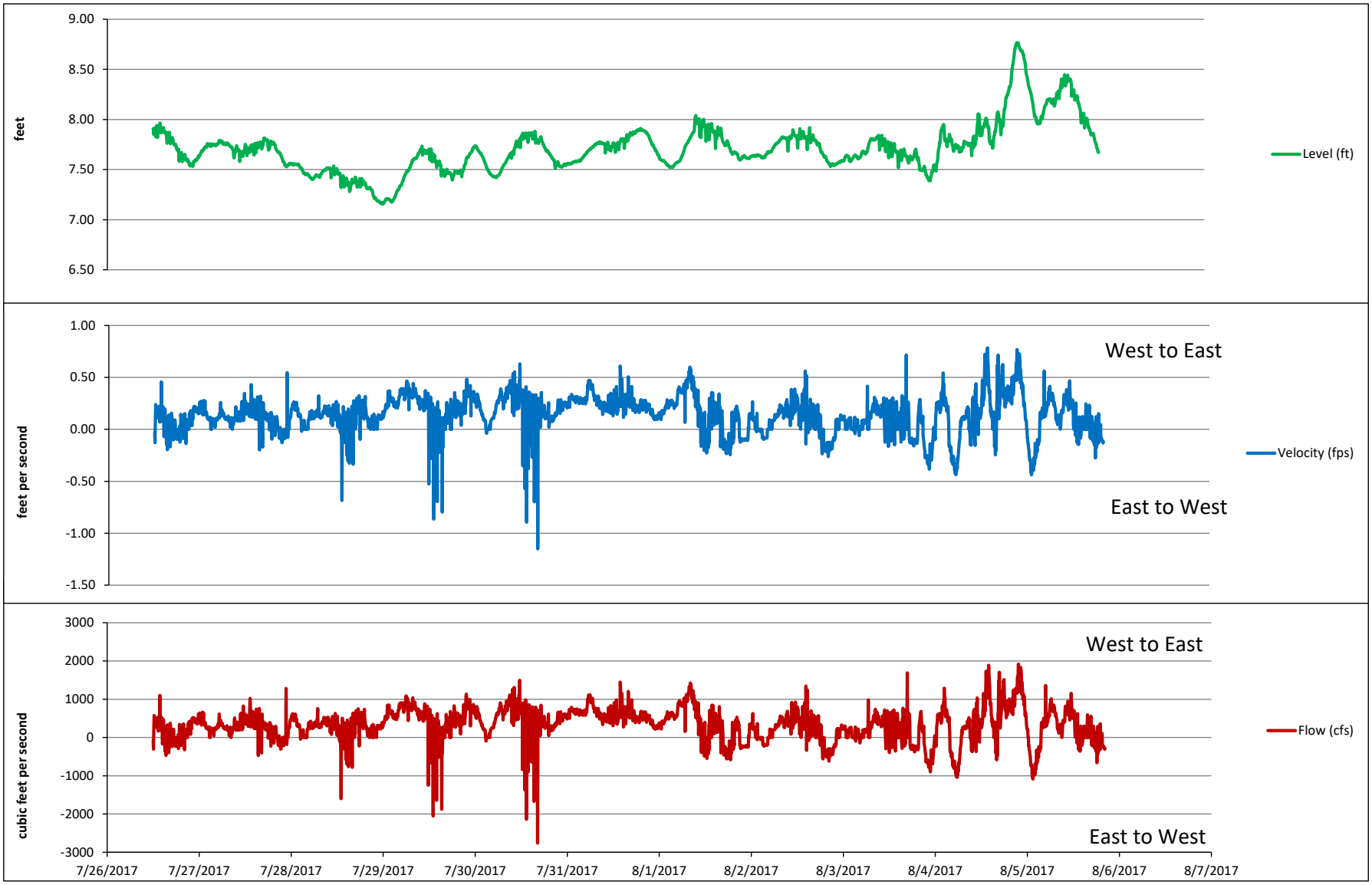

Cross Sectional Area of Canal by Sensor Water Level
Area (square feet)
900
800
700
600
500
400
300
200
100
0
0
0.5
1
1.5
2
2.5
3
Level Above Sensor (feet)
y = 99.901x + 477
R² = 0.9986


Canal Depth and Velocity Profile
Stevens Street Bridge, Lockport
7/11/2017
Note: Wind directionally aligned with channel may have resulted in higher than normal surface velocities
EAST
Wall
WEST
Dock
Depth (feet)
0
-4
-8
-12
-16
0
10
20
30
40
50
60
70
80
90
100
110
120
Distance (feet)
0.75
0.65
0.55
0.45
0.35
0.25
Key:
Approx. sensor location
(not to scale)
Area of mean velocity (±20%)
0.43
Velocity contour in feet/second
Creek boundary

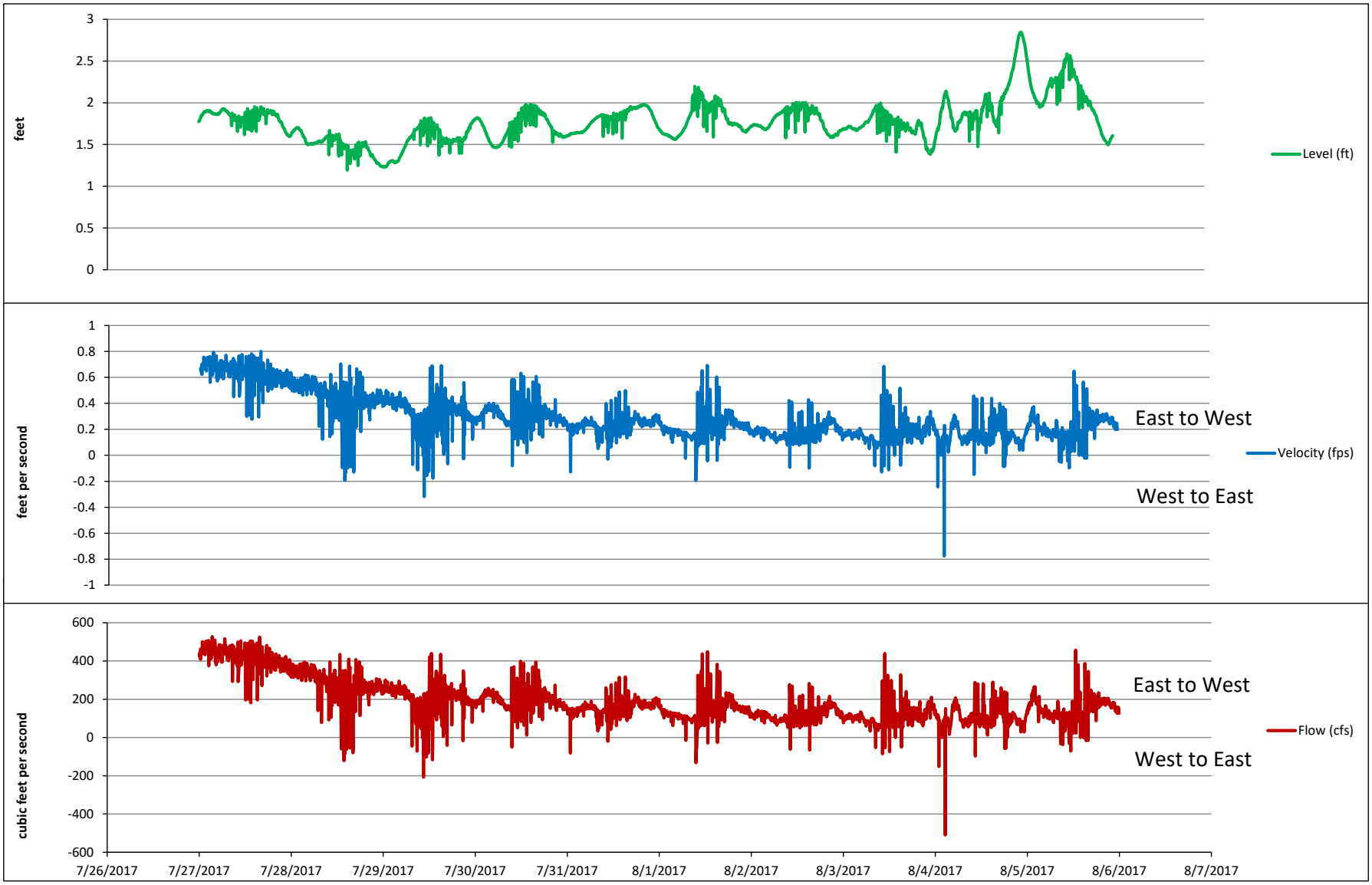

Cross Sectional Area of Canal by Sensor Water Level
Area (square feet)
1800
1600
1400
1200
1000
800
600
400
200
0
0
2
4
6
8
10
12
14
Level Above Sensor (feet)
y = 115.42x + 252
R² = 0.9966

D

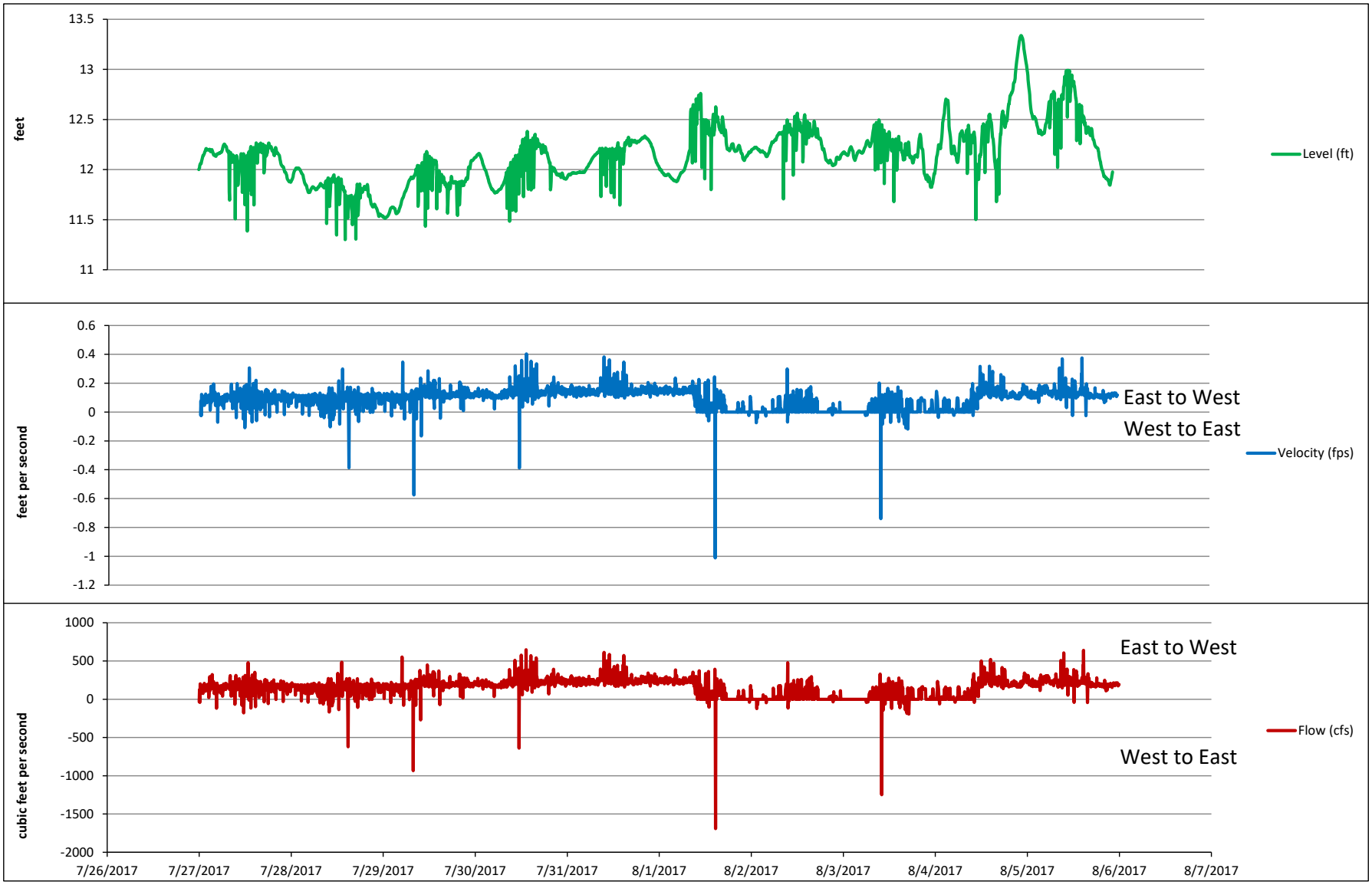
Flow Meter Data and Water Level Graphs



Summary of Flow Data and Water Levels for Tonawanda Creek at North Tonawanda Botanical Gardens (July 26th-August 5th, 2017)



Summary of Flow Data and Water Levels for Tonawanda Creek at New Road (July 27th-August 5th, 2017)



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