Final Post-Treatment Assessment for Aquatic Plant Control ERDC Demonstration Project Tonawanda Creek/Erie Canal 2019

Contract No. W912P4-16-D-0002

May 2020

US Army Corps of Engineers
Buffalo District
BUILDING STRONG®

Prepared for:

UNITED STATES ARMY CORPS OF ENGINEERS
Buffalo District

Table of Contents

List of Tables

List of Figures

Figure **Page**

List of Abbreviations and Acronyms

Canal Corp.	New York State Canal Corporation
cfs	cubic feet per second
CET	concentration exposure time
E & E	Ecology and Environment, Inc., member of WSP
ERDC	Engineer Research and Development Center
ft/s	feet per second
GIS	Geographic Information System
GPS	Global Positioning System
HAT	hour after treatment
Hydrilla	*Hydrilla verticillata*
mg/L	milligrams 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	U.S. Army Corps of Engineers (Buffalo District)
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. 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 U.S. 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 6 post-treatment monitoring and assessment of herbicide efficacy on Hydrilla by summarizing field conditions before, during, and after 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 U.S. 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 was identified within a total area of approximately 359 acres when initially discovered, and USACE determined Hydrilla frequency to be at 31% in July 2014, prior to the initial large-scale herbicide application. Hydrilla beds were patchy and limited to the shallow shoreline areas outside of the main navigation channel. Based on USACE surveys of over 2,000 points within the canal conducted in 2015, 2016, 2017, and 2018, Hydrilla frequency was 1.65% based on September 2018 post-treatment surveys.

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.

In 2019, to control and eradicate Hydrilla, the USACE conducted a sixth year of treatment for the Project within an approximately 15-mile-long stretch of creek/canal that focused on application of the aquatic herbicide endothall

[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.

(Aquathol® K) and spot treatment with chelated copper (Harpoon®) and endothall (Aquathol® Super K) (see Figure 1-1a through 1-1e). Prior to treatment application, Hydrilla populations were delineated and mapped by the USACE using point-intercept and hydro-acoustic surveys. The 2019 endothall (Aquathol® K) treatment areas were designated as follows:

- **Western block treatment areas**: 4.9 miles between East Niagara Park in Tonawanda to the West Canal Park in Niagara County. Of this area, 24.2 acres were directly treated with endothall (Aquathol® K) and the remaining areas 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. Of this area, 78 acres were directly treated with endothall (Aquathol® K) and the remaining areas received secondary treatment from flow in the canal.

Additionally, for the second consecutive year, spot treatment with chelated copper occurred in various locations within the 15-mile stretch to control small, persistent beds of Hydrilla (see Figure 1-1a through 1-1e). In addition to spot treatment with copper, 2019 was the first year in which spot treatment with a granular formulation of endothall (Aquathol® Super K) was also conducted. Endothall (Aquathol® Super K) was added to the treatment plan for 2019 for evaluation of use in smaller treatment plots.

Implementation of the Project was a collaborative effort between the Engineer Research and Development Center (ERDC); USACE; Ecology and Environment, Inc., member of WSP (hereafter referred to as 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. In addition, this Project evaluates herbicide efficacy on a delineated stretch of Tonawanda Creek where Hydrilla is more problematic.

The USACE 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 treatments will be needed in the future, and the most

effective method(s) 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 herbicides 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.

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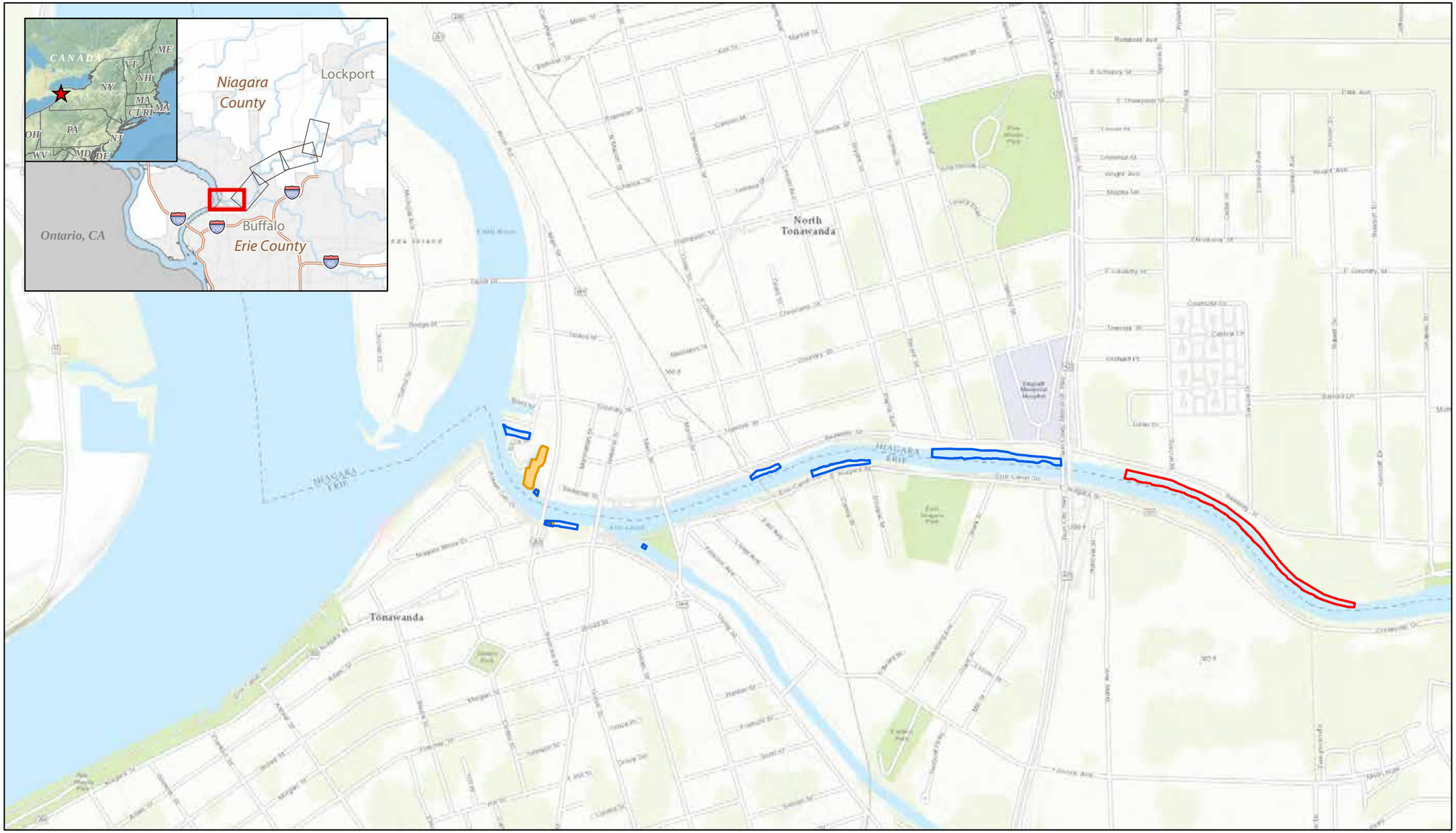

July Endothall (Aquathol®K) Treatment

August Endothall (Aquathol® Super K) Spot Treatment

August Copper (Harpoon®) Spot Treatment

August Endothall (Aquathol®K) Spot Treatment

0 0.25 0.5 Miles

N

Date: 2/25/2020

SOURCE: ESRI 2018; USACE ERDC 2018.

Figure 1-1a Endothall (Aquathol®K) and Copper Hydrilla Treatment Areas - Summer 2019

Tonawanda Creek/Erie Canal, Erie and Niagara Counties, New York

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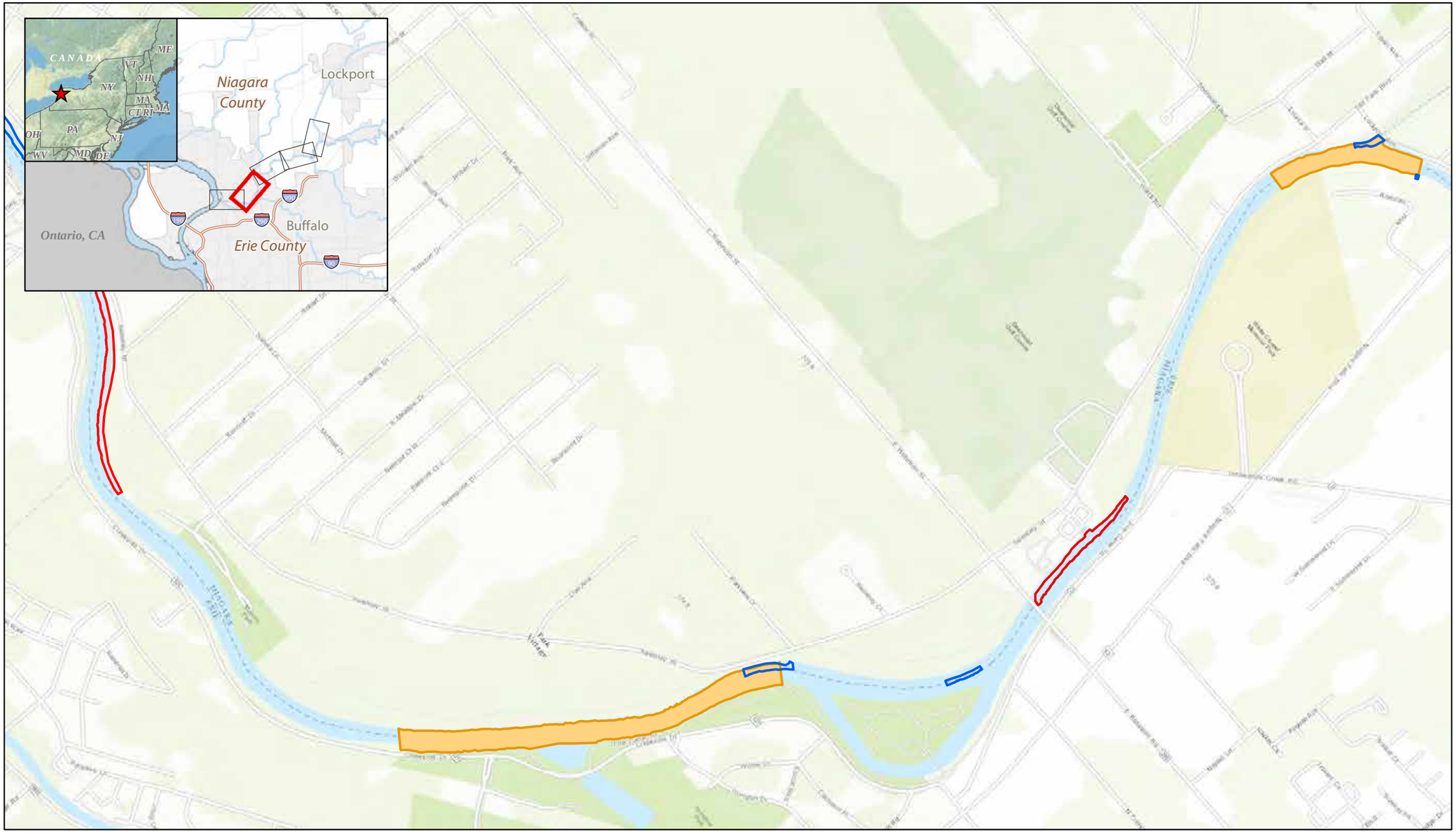

SOURCE: ESRI 2018; USACE ERDC 2018.

Figure 1-1b Endothall (Aquathol®K) and Copper Hydrilla Treatment Areas - Summer 2019

Tonawanda Creek/Erie Canal, Erie and Niagara Counties, New York

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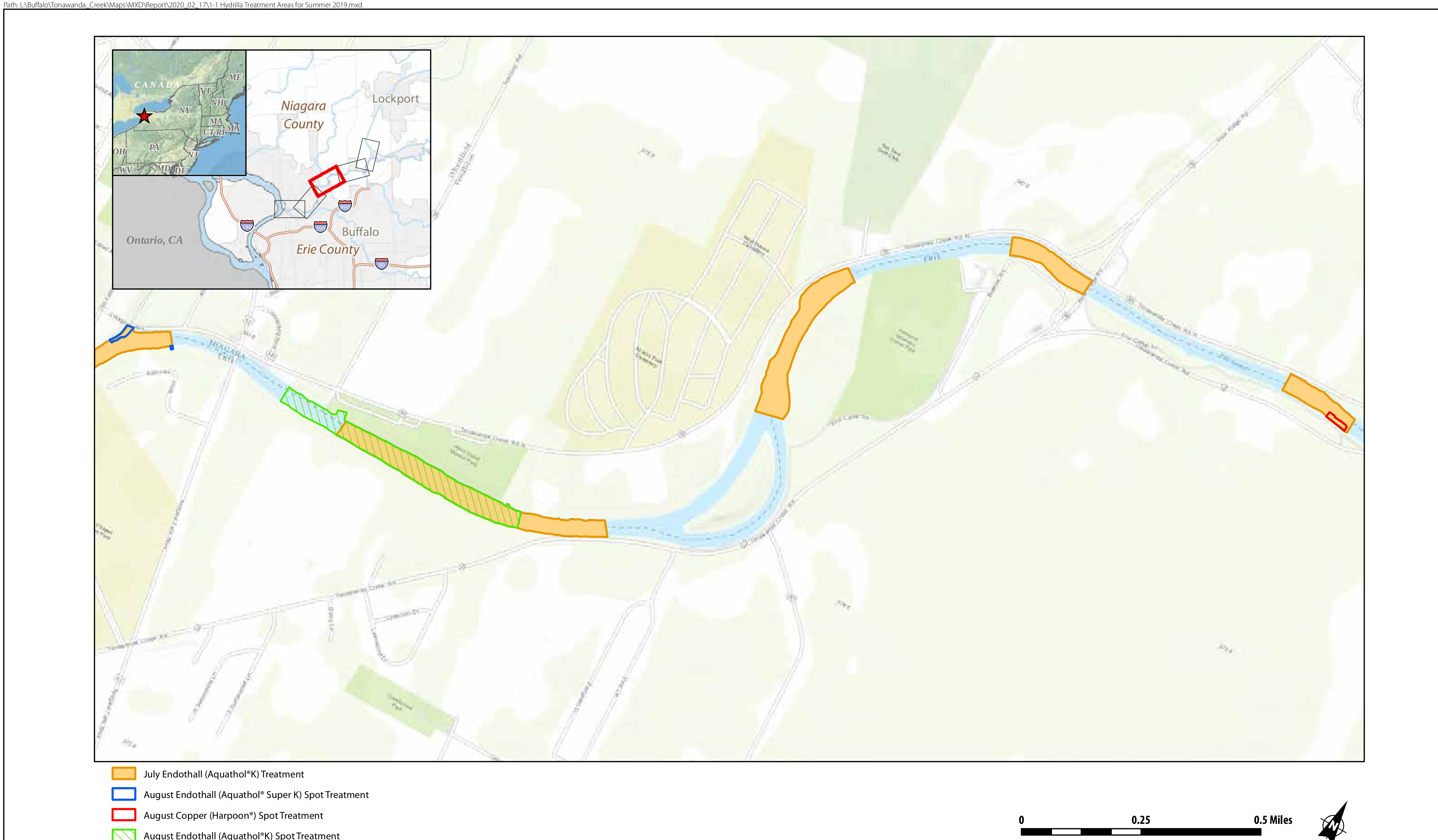

SOURCE: ESRI 2018; USACE ERDC 2018.

Figure 1-1c Endothall (Aquathol®K) and Copper Hydrilla Treatment Areas - Summer 2019

Tonawanda Creek/Erie Canal, Erie and Niagara Counties, New York

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July Endothall (Aquathol®K) Treatment

August Endothall (Aquathol® Super K) Spot Treatment

August Copper (Harpoon®) Spot Treatment

August Endothall (Aquathol®K) Spot Treatment

0 0.25 0.5 Miles

N

Date: 2/25/2020

SOURCE: ESRI 2018; USACE ERDC 2018.

Figure 1-1d Endothall (Aquathol®K) and Copper Hydrilla Treatment Areas - Summer 2019

Tonawanda Creek/Erie Canal, Erie and Niagara Counties, New York

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\1-1 Hydrilla Treatment Areas for Summer 2019.mxd

SOURCE: ESRI 2018; USACE ERDC 2018.

Figure 1-1e Endothall (Aquathol®K) and Copper Hydrilla Treatment Areas - Summer 2019

Tonawanda Creek/Erie Canal, Erie and Niagara Counties, New York

2 Overview of Herbicide Treatment and Monitoring

Treatment of Hydrilla for this Project focused on the application of the aquatic herbicides endothall and chelated copper within the creek/canal. Twenty-four hours before treatment, during treatment (48 hours), and immediately after treatment, the Canal Corp. minimized water flow in the creek/canal utilizing flow control structures on the canal in Lockport, New York, for a period of 101 hours 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 subsections outline the public notification that preceded treatment; field conditions before, during, and after treatment; herbicide treatment methodology; quantity of herbicide used, and its dispersion; details of the flow management and monitoring; and a summary of vegetative monitoring and overall treatment efficacy.

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). Five methods of public notification were used to announce the July 23 and 24, 2019, treatment:

1. Riparian (creekside) owners and permitted users were notified by E & E via U.S. certified mail approximately 21 days prior to the application and follow-up postcards were mailed out with online links for herbicide labels;
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, the *Lockport Journal* and *Niagara Gazette*, and *The Buffalo News* on July 20, 2019;

4. Agency notification letters were distributed by mail 10 days prior to the application; and
5. Project factsheets were distributed during Canal Fest (July 14 through 21, 2019) by staff from USACE, NYSDEC, and Western New York Partnership for Regional Invasive Species Management.

Additionally, in an effort to notify the public regarding the August 13 and 14, 2019, spot treatment, riparian owners and users were again notified via certified mail; mailings were sent out on August 5, 2019.

2.2 Field Conditions

Field conditions prior to treatment (July 18 through July 22, 2019), during treatment (July 23 and 24, 2019), and immediately following treatment (July 25 through July 28, 2019) are summarized in Table 2-1. As indicated in Table 2-1, a total of approximately 0.55 inches of rain fell in the four days immediately preceding treatment. During treatment, no significant inclement weather was observed, and conditions were dry. The first three days following treatment were generally dry. On the fourth day following treatment, approximately 1.53 inches of rain fell.

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

Date	Temperature Range (degrees Fahrenheit)	Precipitation (inches)	Other
July 18, 2019	Min: 69 Max: 85	0	Fog and mist Average wind speed 6.5 mph with gusts up to 16 mph
July 19, 2019	Min: 71 Max: 88	0.03	Thunder and rain Average wind speed 12.1 mph with gusts up to 31 mph
July 20, 2019	Min: 71 Max: 92	0.46	Thunder, rain, fog and mist Average wind speed 12.9 mph with gusts up to 40 mph
July 21, 2019	Min: 68 Max: 84	0.01	No significant weather observed Average wind speed 8.8 mph with gusts up to 20 mph
July 22, 2019	Min: 64 Max: 77	0.05	Rain Average wind speed 4.1 mph with gusts up to 18 mph.
July 23, 2019 Treatment Day 1	Min: 60 Max: 79	0	No significant weather observed Average wind speed 5.7 mph with gusts up to 20 mph
July 24, 2019 Treatment Day 2	Min: 54 Max: 79	0	No significant weather observed Average wind speed 5.4 mph with gusts up to 21 mph
July 25,2019	Min: 57 Max: 82	0	No significant weather observed Average wind speed 7.8 mph with gusts up to 23 mph

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

Date	Temperature Range (degrees Fahrenheit)	Precipitation (inches)	Other
July 26, 2019	Min: 65 Max: 85	0	Thunder Average wind speed 7.5 mph with gusts up to 25 mph
July 27, 2019	Min: 62 Max: 86	Trace	No significant weather observed Average wind speed 9.4 mph with gusts up to 28 mph
July 28, 2019	Min: 69 Max: 85	1.53	Thunder, rain and mist Average wind speed 12.1 mph with gusts up to 59 mph

Source: National Oceanic and Atmospheric Administration 2019

Key:
mph = miles per hour

2.3 Herbicide Treatment Methodology

The aquatic herbicide endothall (Aquathol® K) was applied in designated sections of the creek/canal on July 23 and 24, 2019, and spot treatment using chelated copper (Komeen Crystal™) occurred on July 24, 2019 (see Figures 2-1a through 2-1e). [Note: As discussed below, the Komeen treatment was cancelled due to a defective batch of the herbicide.] Additional spot treatments occurred on August 13 and 14, 2019, and utilized endothall (both Aquathol® K and Aquathol® Super K) and chelated copper (Harpoon®). The herbicides were 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 21, 2019, and the modification to that SOW dated August 8, 2019 (USACE 2019).

Two boats were utilized during the July treatments: a 20-foot, shallow-draft aluminum work skiff powered by a 40-horsepower conventional four-stroke outboard motor; and a 24-foot, aluminum airboat with a small-block Chevy engine.

2.3.1 Herbicide Transfer

An in-line herbicide injection system was used on the skiff and airboat. Both were outfitted with a 100-gallon polyethylene tank. The airboat was outfitted with adjustable granular spreaders. 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 they were emptied. The empty totes were taken back by the herbicide distributor and were returned to the manufacturer for reloading and reuse. The granular herbicide was carried in company work trucks from the New York warehouse to the site in 20-pound bags. These bags were triple rinsed and then disposed of as solid waste. 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 Endothall (Aquathol® K) Treatment

The work skiff and airboat were outfitted with a 2-inch-diameter gasoline-powered water 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 North Tonawanda Botanical Gardens and Veterans Park. 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 12 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 boat had a Global Positioning System (GPS) navigation system and all of the treatment section locations were preloaded.

As stated in Section 1.1, for the July 2019 treatment, the Project area was divided into two blocks for endothall (Aquathol® K) treatment: the western block encompassing approximately 4.9 miles between East Niagara Park in Tonawanda to West Canal Park in Niagara County; and the eastern block encompassing approximately 8 miles between West Canal Park in Niagara County and the Pendleton Guard Gate. Herbicide was applied in the littoral areas and allowed to disperse across the canal to bring herbicide concentrations to target levels.

In July 2019, the USACE conducted supplementary mapping and plant delineation and identified multiple treatment areas, as discussed below (see Figures 1-1a through 1-1e, 2-1a through 2-1e, and 2-2). Limnocorrals were used in two areas to isolate Hydrilla beds for treatment: near the Route 265 bridge, between the bridge and the boat dock on the canal, and on the eastern side of the dock on the canal, immediately downstream from the first limnocorral.

2.3.3 Chelated Copper Treatment

The original treatment plan called for application of chelated copper (Komeen Crystal™) on July 25, 2019. However, due to a defective batch of herbicide, the application of copper was cancelled and chelated copper in an alternate form, Harpoon®, was applied using granular spreaders during the spot treatment on August 13, 2019. The spreader systems were calibrated by SLM before use to accurately apply the amount of product to each treatment area. Chelated copper was loaded onto the boats from the city of North Tonawanda boat launch at Service Drive, as well as the North Tonawanda Botanical Gardens boat launch. Boat passes were made parallel to shore in water that was less than 12 feet deep. These passes were generally made within 50 feet of the shoreline. The boats were outfitted with GPS systems, with the treatment zones preloaded on them, to ensure accuracy and record the amount of acreage that the boats covered.

The following paragraphs summarize the 2019 treatment activities, including both endothall (Aquathol® K and Aquathol® Super K) and chelated copper (Komeen Crystal™).

July 23, 2019: Day 1

SLM staff arrived at the City of North Tonawanda boat launch at 700 Sweeney Street at the foot of Service Road at 0800 hours, launched the work skiff and airboat, and began assembling the treatment systems. Following on-site meetings with staff from the USACE and NYSDEC, and confirmation with the Canal Corp. that the creek/canal flow had slowed to the desired rate (50 cfs), SLM personnel began to transfer the herbicide at approximately 1100 hours. Two treatment crews were sent out, consisting of either a lead applicator or a lead applicator and an assistant/technician. Treatment began at approximately 1200 hours. One team was sent to the upper treatment sites (i.e., predominantly east of West Canal Park) while the other treated the endothall (Aquathol® K) treatment areas west of West Canal Park. Aside from brief breaks when the boats stopped to reload herbicide, the treatments continued uninterrupted until the operation was completed at approximately 2000 hours.

A total of 14 areas, comprising approximately 102.5 acres were treated with endothall (Aquathol® K) on Day 1 (see Table 2-2 and Figures 2-2a through 2-2e). Before treatment began, one limnocorral was installed near the Route 265 bridge, between the bridge and the boat dock on the canal, and on the eastern side of the dock on the canal, immediately downstream from the first limnocorral. Both limnocorral areas were treated using a hand-held spray gun. The floating limnocorrals, both 100 feet in length, were secured to the creek/canal bottom with cinder blocks and to the shoreline on each end. Both limnocorrals extended from above the surface of the water to the creek/canal bed in order to isolate the Hydrilla bed from the surrounding flowing water. The limnocorrals remained in place until August 14, 2019, when they were removed by SLM.

The base of operations was moved upstream to the Amherst Veterans Canal Park launch towards the end of Day 1 of the treatment. At the City of North Tonawanda boat launch, 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 2000 hours, resulting in a total treatment time of approximately 8 hours.

July 24, 2019: Day 2

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 0900 hours and was completed by 1500 hours for a total treatment time of approximately 6 hours. On Day 2, three areas treated on Day 1 were retreated with endothall (Aquathol® K): Nine Mile Island (10), Amherst Marine/Ransom Creek (11), and Tonawanda Creek/Ship N Shore (12)

(see Table 2-2 and Figure 2-1a through 2-1e). Due to the water flow of the canal, the bottom curtain portions of the limnocorrals were pushed into a location where they were no longer encompassing all of the Hydrilla plants as needed. SLM staff accompanied by USACE staff repositioned the limnocorrals to appropriately encompass the Hydrilla plants while being less susceptible to impact from the flow of the canal.

Additionally, SLM staff initiated the chelated copper (Komeen Crystal™) spot treatment that was proposed for approximately 8.8 acres, but had to cease the application due to a defective batch of herbicide that floated on the water's surface instead of sinking. The herbicide was left to dissolve and was not present in sufficient amounts to impact vegetation. Therefore, these areas are not included on any of the figures in this report.

August 13 and 14, 2019: Spot Treatment

Due to insufficient control at the approximately 15-acre treatment plot near West Canal Park, an additional application of 250 gallons of endothall (Aquathol® K) was made over two days, August 13 and August 14, 2019 (see Figure 2-2). The area was treated at a concentration of 1.5 parts per million (ppm) on August 13 and 1.0 ppm on August 14 (see Table 2-2).

Additionally, spot treatment with endothall (Aquathol® Super K) and chelated copper (Harpoon®) also occurred. Eleven sites, totaling approximately 4.8 acres, were treated with endothall (Aquathol® Super K) on August 13, 2019 (see Figure 2-4a through 2-4b). Four treatment areas totaling approximately 7 acres were also treated with chelated copper on August 13, 2019 (see Table 2-2 and Figure 2-4a through 2-4b).

On August 14, 2019, in addition to the 15-acre area treated with endothall (Aquathol® K) near West Canal Park discussed above, one area (Site 1 – animal dock), approximately 0.33 acres in size, was treated with endothall (Aquathol® Super K).

2.4 Quantity of Herbicide Used and Total Area Treated

A summary of the herbicide quantities applied during the July and August 2019 treatment activities is provided in Table 2-2. The planned treatment areas were divided into distinct areas or plots using a geographic information system (GIS), the total amount of endothall or chelated copper to be applied to each area/plot was calculated, and the products were then applied as described in Section 2.3.

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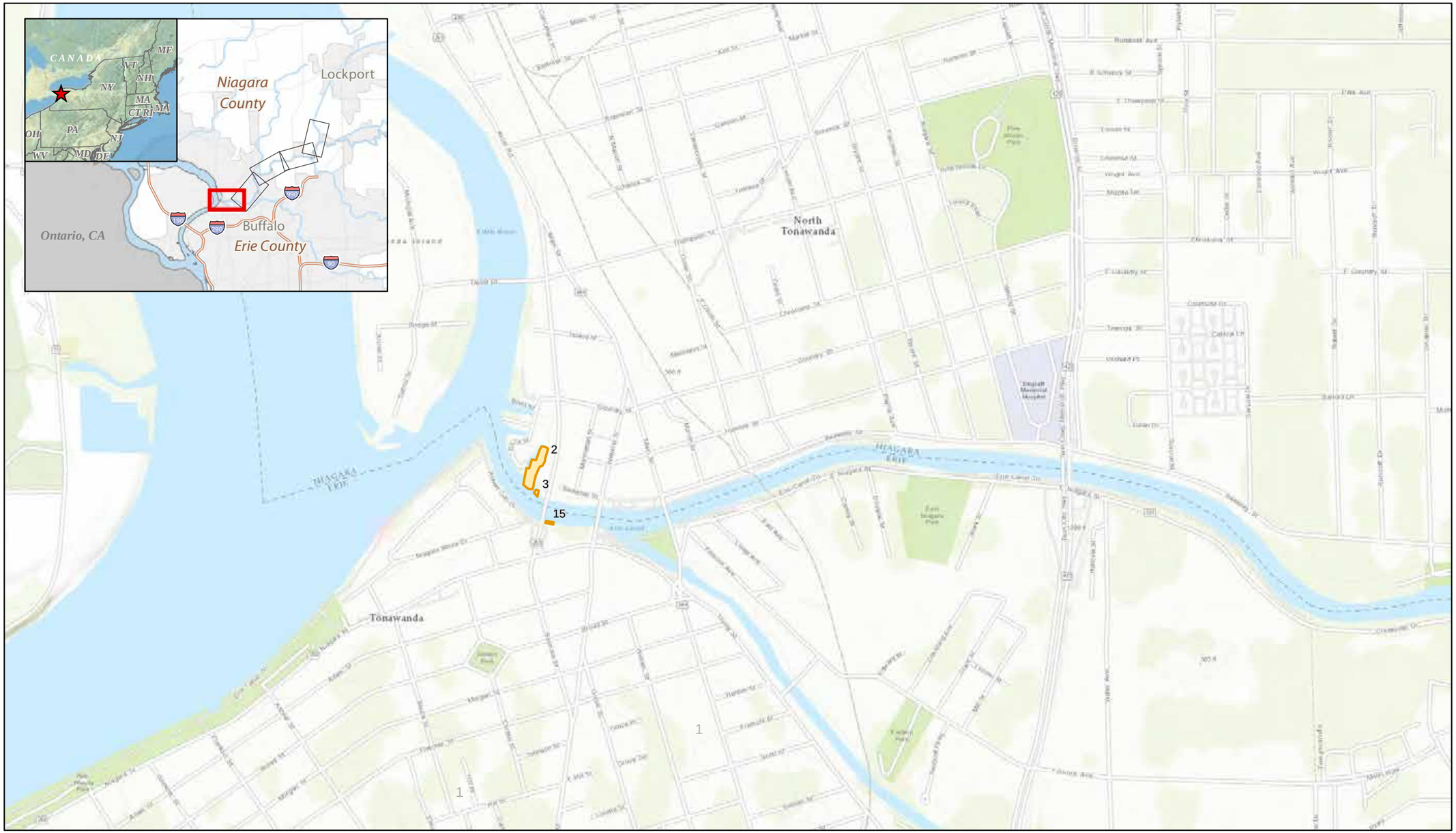

Date: 2/25/2020

SOURCE: ESRI 2018; USACE ERDC 2018.

Figure 2-1a Endothall (Aquathol®K) Treatment Areas - Treated on July 23 and July 24, 2019

Tonawanda Creek/Erie Canal, Erie and Niagara Counties, New York

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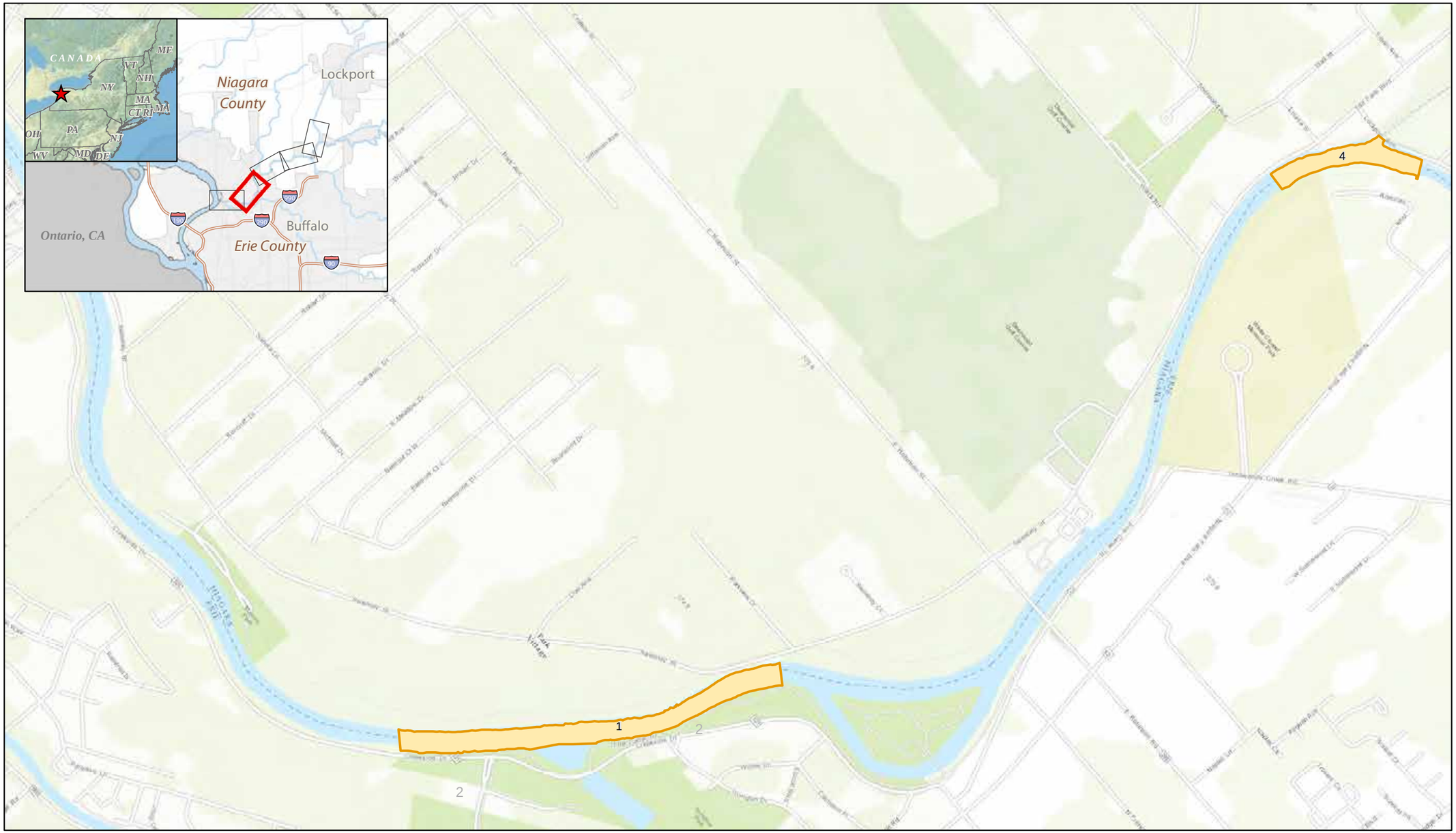

Date: 2/25/2020

SOURCE: ESRI 2018; USACE ERDC 2018.

Figure 2-1b Endothall (Aquathol®K) Treatment Areas - Treated on July 23 and July 24, 2019

Tonawanda Creek/Erie Canal, Erie and Niagara Counties, New York

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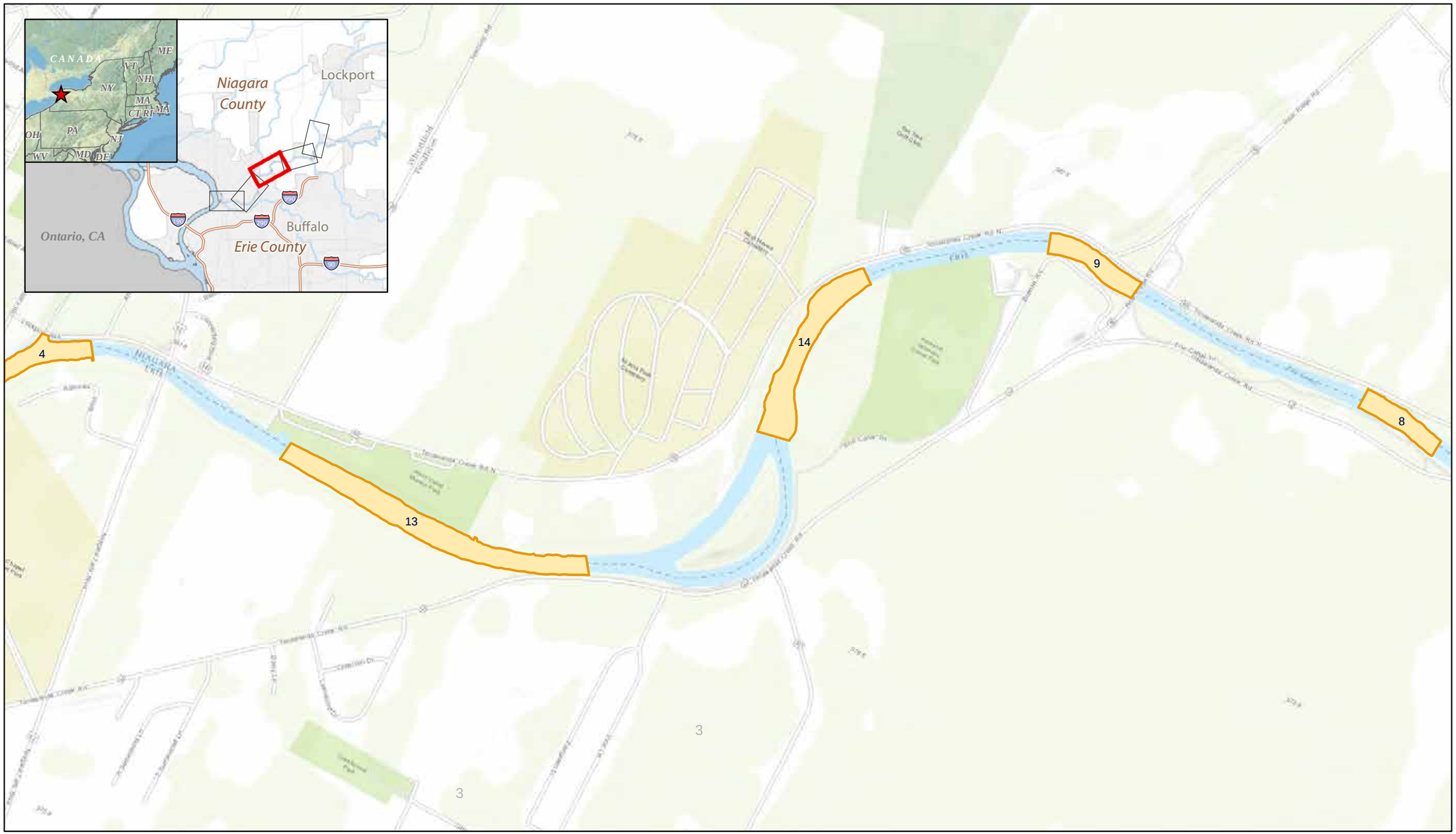
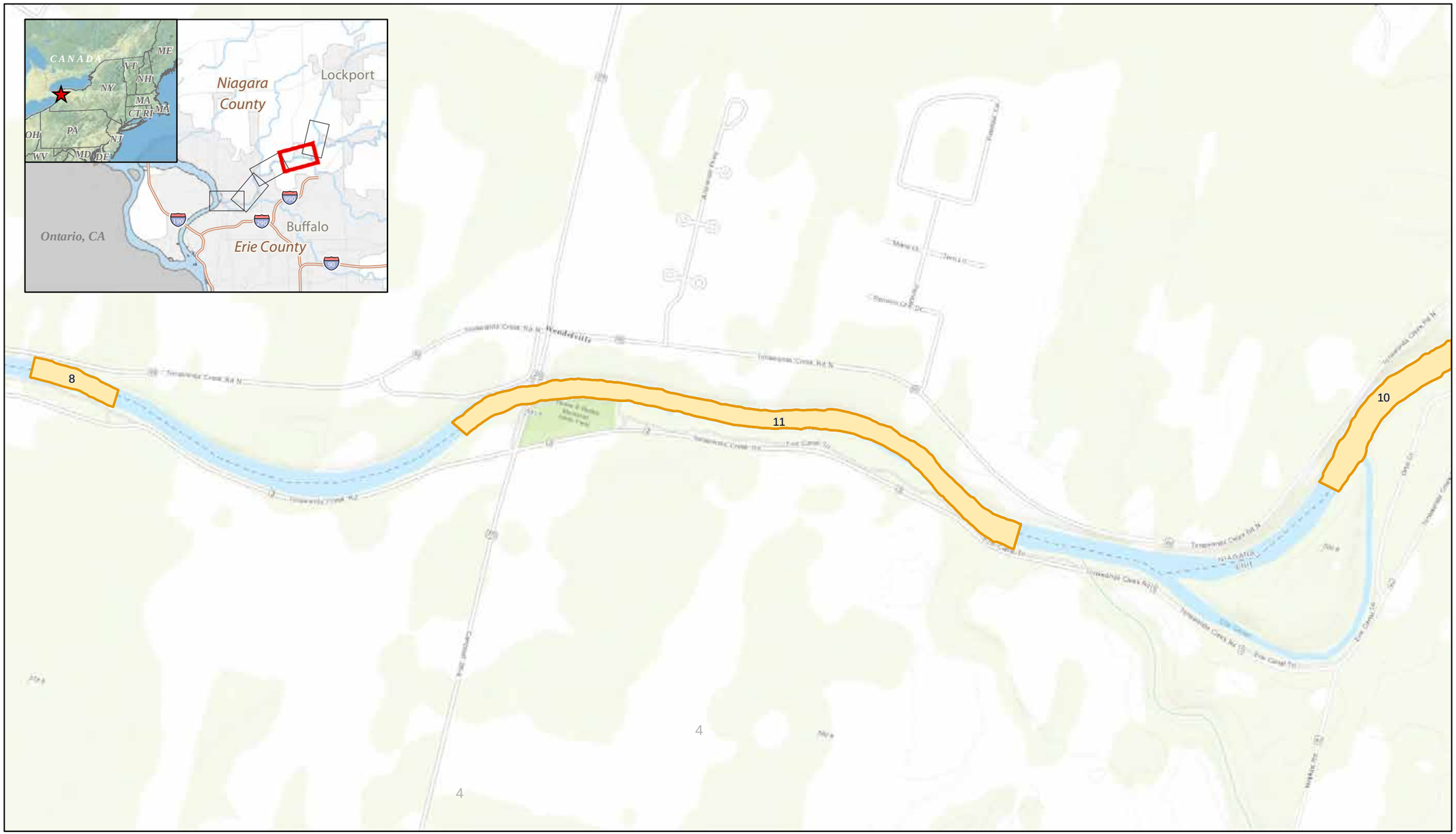


SOURCE: ESRI 2018; USACE ERDC 2018.

Figure 2-1c Endothall (Aquathol®K) Treatment Areas - Treated on July 23 and July 24, 2019

Tonawanda Creek/Erie Canal, Erie and Niagara Counties, New York

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\2-1 Endothall (Aquathol®K) Treatment Areas - July 23 and July 24, 2019.mxd



SOURCE: ESRI 2018; USACE ERDC 2018.

Figure 2-1d Endothall (Aquathol®K) Treatment Areas - Treated on July 23 and July 24, 2019

Tonawanda Creek/Erie Canal, Erie and Niagara Counties, New York

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Date: 2/25/2020

SOURCE: ESRI 2018; USACE ERDC 2018.

Figure 2-1e Endothall (Aquathol®K) Treatment Areas - Treated on July 23 and July 24, 2019

Tonawanda Creek/Erie Canal, Erie and Niagara Counties, New York

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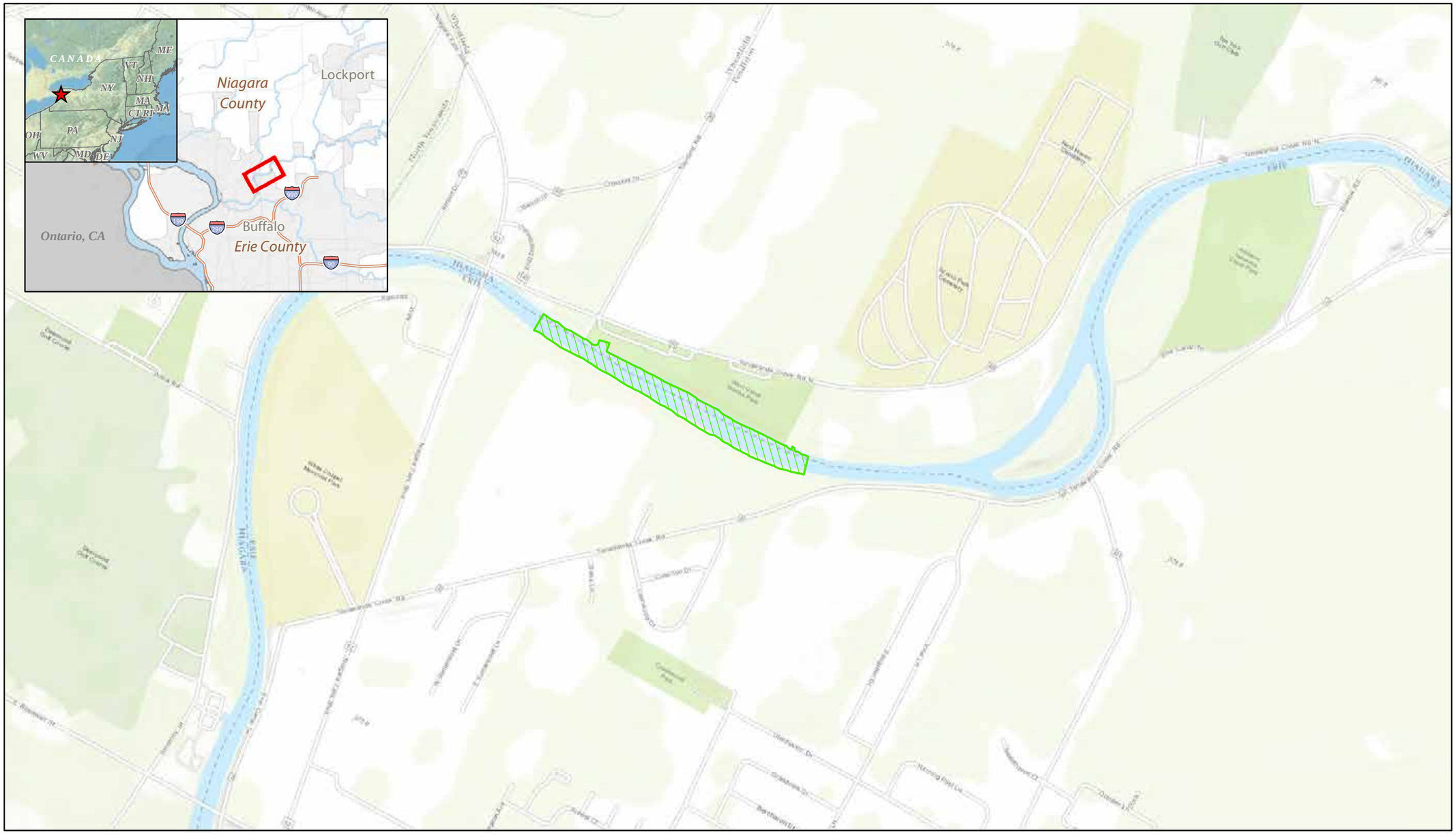


August Endothall (Aquathol®K) Spot Treatment

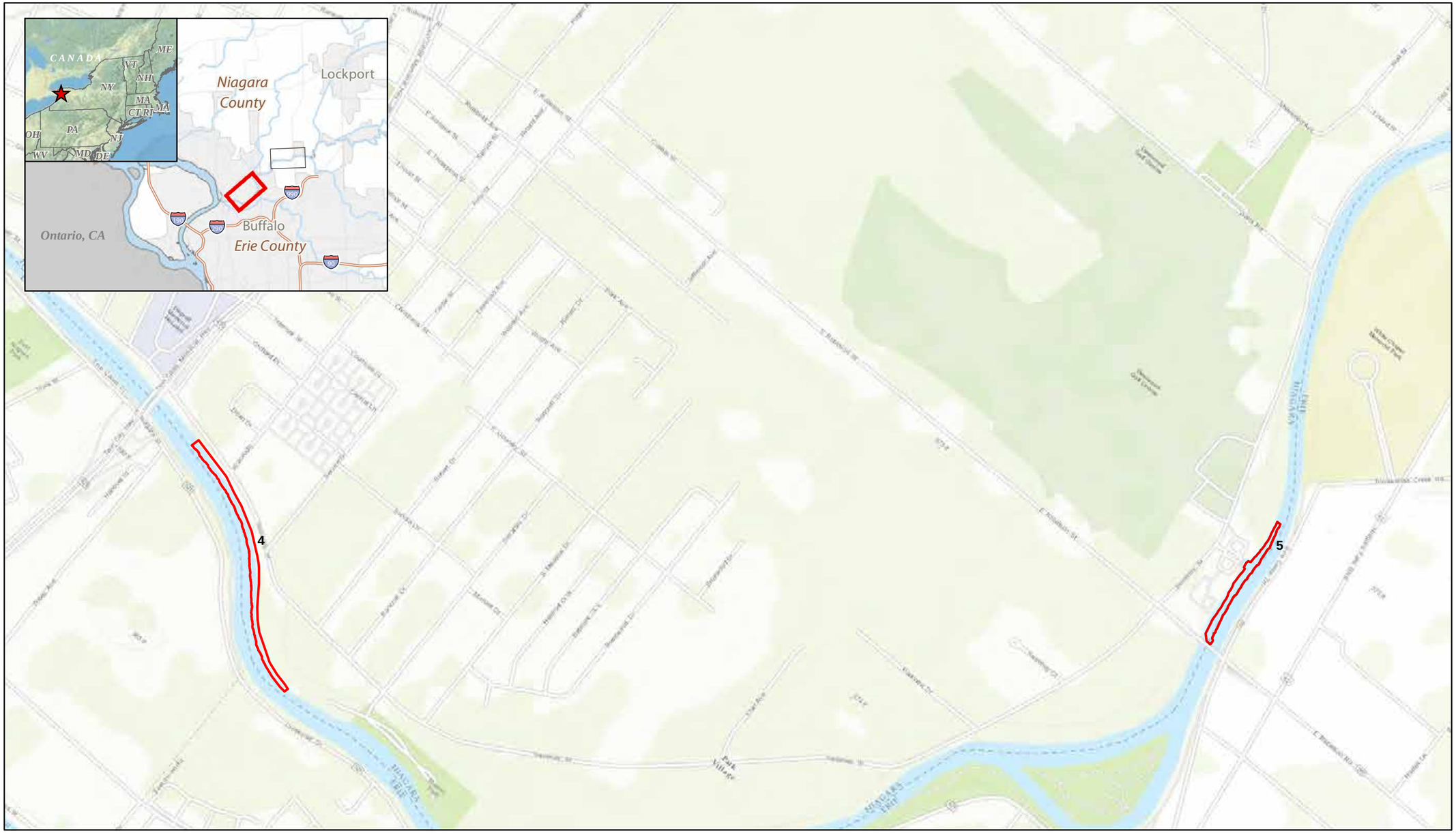
0 500 1,000 Feet

Date: 2/25/2020

SOURCE: ESRI 2018; USACE ERDC 2018.

Figure 2-2 August Endothall (Aquathol®K) Spot Treatment - August 13 and 14, 2019

Tonawanda Creek/Erie Canal, Erie and Niagara Counties, New York



SOURCE: ESRI 2018; USACE ERDC 2018.

Figure 2-3a Copper (Harpoon®) Spot Treatment Areas - August 13, 2019

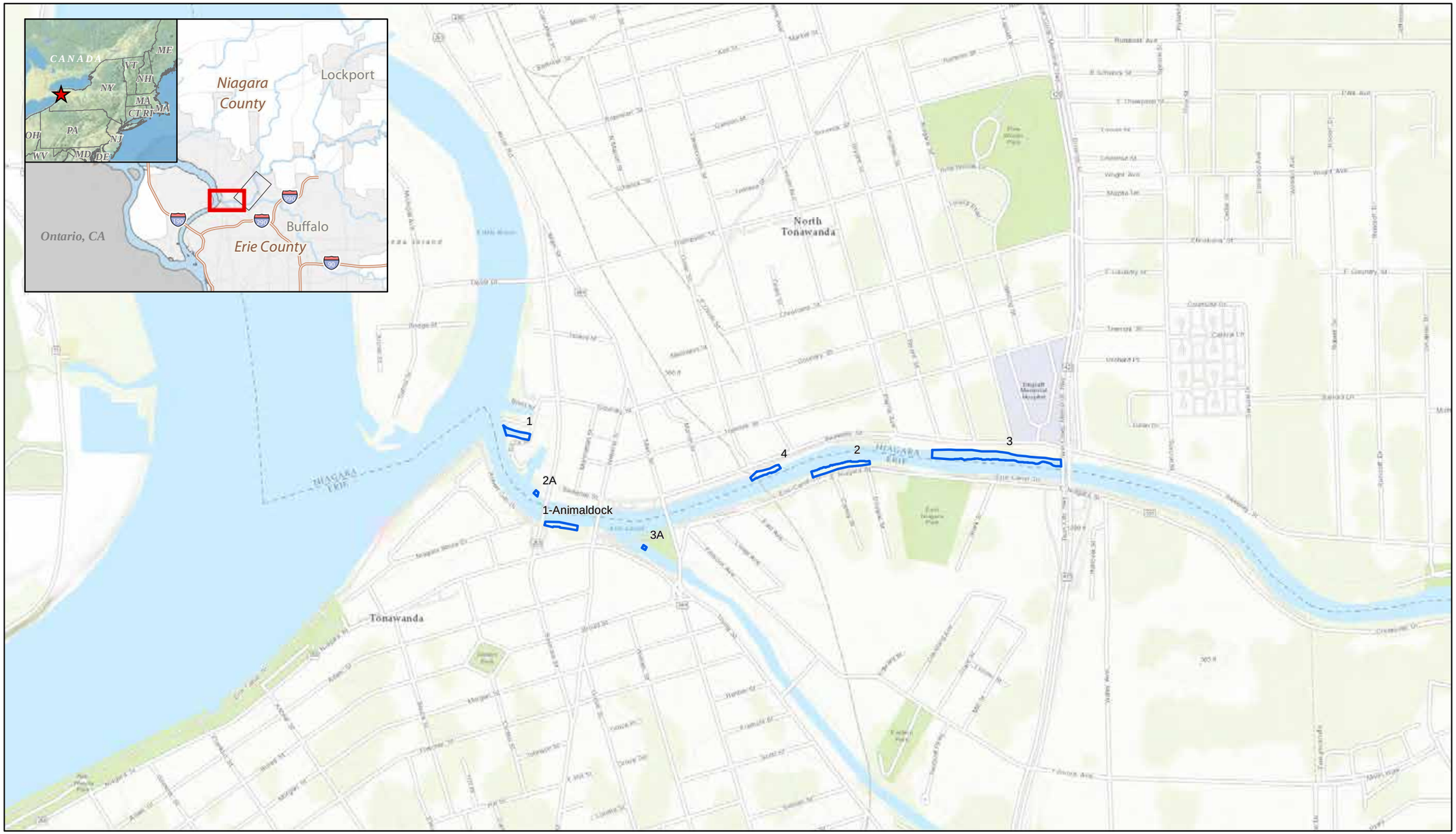
Tonawanda Creek/Erie Canal, Erie and Niagara Counties, New York

SOURCE: ESRI 2018; USACE ERDC 2018.

Figure 2-3b Copper (Harpoon®) Spot Treatment Areas - August 13, 2019

Tonawanda Creek/Erie Canal, Erie and Niagara Counties, New York

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\2-4 Endothall (Aqyathol® Super K) Spot Treatment - August 13 and 14, 2019.mxd



August Endothall (Aquathol® Supker K) Spot Treatment Areas

0 500 1,000 Feet

N

Date: 2/25/2020

SOURCE: ESRI 2018; USACE ERDC 2018.

Figure 2-4a Endothall (Aquathol® Super K) Spot Treatment Areas - August 13 and 14, 2019

Tonawanda Creek/Erie Canal, Erie and Niagara Counties, New York

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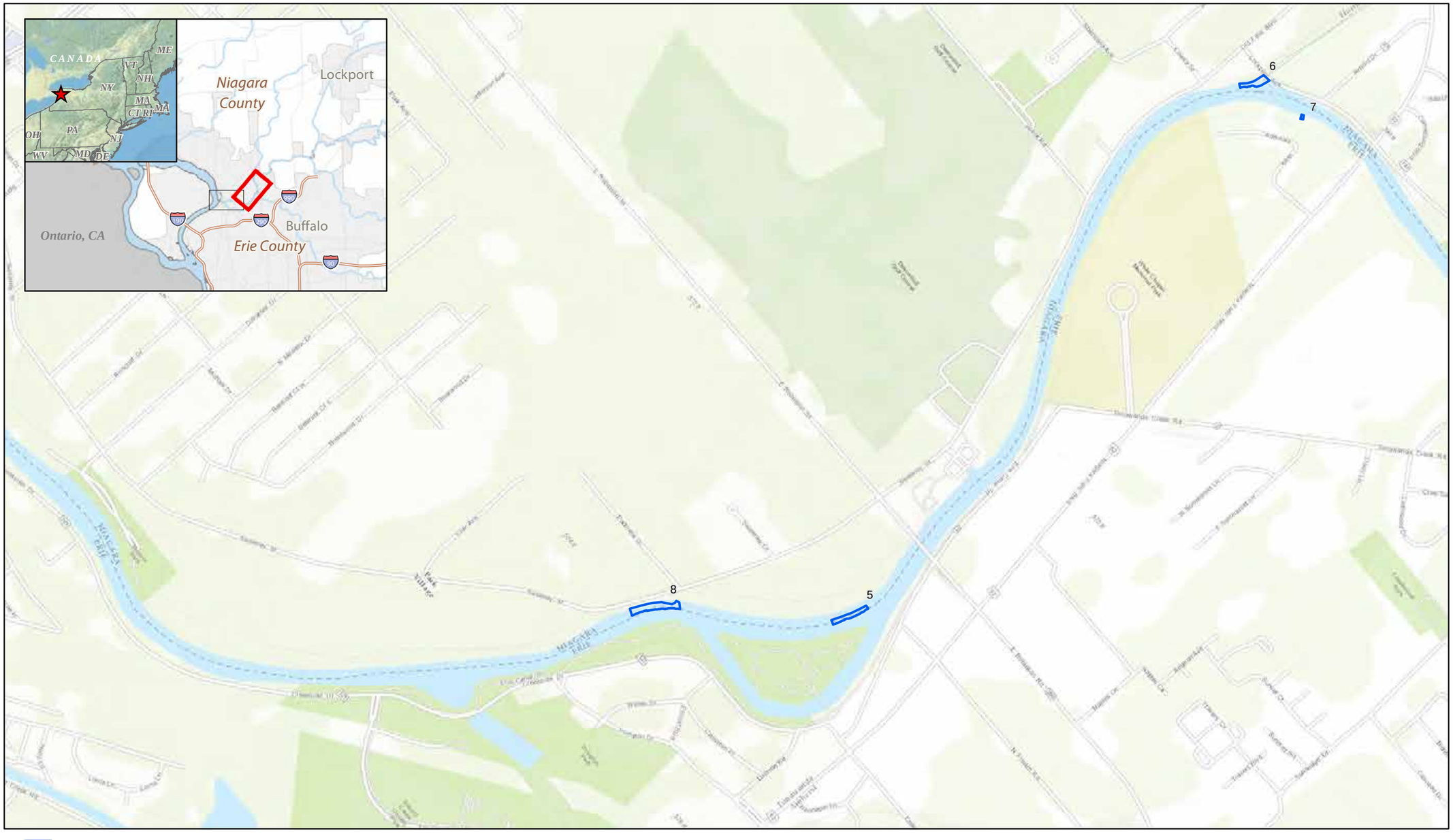


SOURCE: ESRI 2018; USACE ERDC 2018.

Figure 2-4b Endothall (Aquathol® Super K) Spot Treatment Areas - August 13 and 14, 2019

Tonawanda Creek/Erie Canal, Erie and Niagara Counties, New York

Table 2-2 Herbicide Application Summary, by Canal Treatment Area

Date	Treatment Area	Acres	Endothall (Aquathol® K) Applied (gallons)	Targeted Concentration (ppm)	Copper (Harpoon ®) Applied (pounds)	Targeted Concentration (ppm)	Endothall (Aquathol® Super K) Applied (gallons)	Targeted Concentration (ppm)
7/23/19	1 - Mayor's Park/Dog Park	17	201	1.5	N/A	N/A	N/A	N/A
	2 - Wardell's Marina	0.9	5	1.5	N/A	N/A	N/A	N/A
	3 - Wardell's Marina	0.04	0.5	1.5	N/A	N/A	N/A	N/A
	4 - Sawyer Creek	6.1	74	1.5	N/A	N/A	N/A	N/A
	5 - East Canal Road	3.1	27	1.5	N/A	N/A	N/A	N/A
	6 - West Canal Road	3.8	28	1.5	N/A	N/A	N/A	N/A
	8 - Tonawanda Creek Road	3.7	36	1.5	N/A	N/A	N/A	N/A
	9 - Veteran's Park	4.8	44	1.5	N/A	N/A	N/A	N/A
	10 - Nine Mile Island	12.6	99	1.5	N/A	N/A	N/A	N/A
	11 - Amherst Marine/Ransom Creek	24.5	239	1.5	N/A	N/A	N/A	N/A
	12 - Tonawanda Creek/Ship N Shore	0.6	3	1.5	N/A	N/A	N/A	N/A
	13 - West Canal Park – Revised Section A	15.1	175	1.5	N/A	N/A	N/A	N/A
	14 - West Canal Park – Revised Section B	10.2	108	1.5	N/A	N/A	N/A	N/A
	15	0.04	0.5	1.5	N/A	N/A	N/A	N/A
	Total	**120.5**	**1,040**	--	--	--	--	--
7/24/19	10 - Nine Mile Island	12.6	70	1.0	N/A	N/A	N/A	N/A
	11 - Amherst Marine/Ransom Creek	24.5	175	1.0	N/A	N/A	N/A	N/A
	12 - Tonawanda Creek/Ship N Shore	0.6	2.5	1.0	N/A	N/A	N/A	N/A
	Total	**37.7**	**247.5**	--	--	--	--	--

Table 2-2 Herbicide Application Summary, by Canal Treatment Area

Date	Treatment Area	Acres	Endothall (Aquathol® K) Applied (gallons)	Targeted Concentration (ppm)	Copper (Harpoon ®) Applied (pounds)	Targeted Concentration (ppm)	Endothall (Aquathol® Super K) Applied (gallons)	Targeted Concentration (ppm)
8/13/19	1	0.33	N/A	N/A	N/A	N/A	33.5	5.0
	2	0.64	N/A	N/A	N/A	N/A	69.3	5.0
	3	2.05	N/A	N/A	N/A	N/A	91	5.0
	4	4	N/A	N/A	704	1.0	N/A	N/A
	5 - Botanical Gardens	1.95	N/A	N/A	596	1.0	N/A	N/A
	8	0.68	N/A	N/A	220	1.0	N/A	N/A
	10	0.34	N/A	N/A	160	1.0	N/A	N/A
	1A[1]	0.33	N/A	N/A	N/A	N/A	33.5	5.0
	2A[1]	0.03	N/A	N/A	N/A	N/A	2	5.0
	3A[1]	0.03	N/A	N/A	N/A	N/A	2	5.0
	4	0.32	N/A	N/A	N/A	N/A	43	5.0
	5	0.34	N/A	N/A	N/A	N/A	40	5.0
	6	0.33	N/A	N/A	N/A	N/A	41	5.0
	7	0.02	N/A	N/A	N/A	N/A	2	5.0
	9	0.68	N/A	N/A	N/A	N/A	58	5.0
	West Canal Park	14	150	1.5	N/A	N/A	N/A	N/A
	Total	**25.7**	**150**	--	**1,680**	--	**381.8**	--
8/14/19	1 (animal dock)	0.33	N/A	N/A	N/A	N/A	45	5.0
	West Canal Park	14	100	1.0	N/A	N/A	N/A	N/A
	Treatment Area 1 from 8/13	0.33	N/A	N/A	N/A	N/A	20	5.0
	Total	**14.7**	**100**	--	--	--	**65**	--
Total Quantity Applied:			**1,537 gallons**		**1,680 pounds**		**480.3 pounds**	

Notes:
[1]To differentiate these three sites from those treated with Harpoon on August 13, 2019, they have been denoted as 2A and 3A.

Key:
N/A = not applicable
ppm = parts per million

The dosing was predetermined and calculated by the USACE based on the treatment area acreages and volumes. The target concentration of endothall (Aquathol® K) for all of the treated areas in the main creek/canal channel was 1.5 milligrams per liter or ppm on Day 1 and 1.0 ppm on Day 2 of the July treatment. This dose was calculated on the entire water volume of the creek/canal treated areas, but the herbicide was applied in the infested areas along the shoreline, resulting in higher concentrations at the time of application. For the August spot treatment, the target concentration of endothall (Aquathol® K) was 1.0 ppm and endothall (Aquathol® Super K) was 5.0 ppm, and copper (Harpoon®) was 1.0 ppm.

2.5 Herbicide Contact Time and Dispersion for July Treatment

Herbicide was applied to pre-determined areas of the creek/canal on July 23 and 24, 2019. The USACE and E & E performed water sampling after the July 23 and 24, 2019, applications to determine the endothall (Aquathol® K) concentrations and dispersion of herbicide from the first day of application through July 29, 2019. The USACE performed water sampling on July 23, 24, and 25, 2019, and E & E performed sampling on July 26 and 29, 2019.

2.5.1 Initial Sampling Results for July – First 48 Hours

The USACE performed endothall (Aquathol® K) concentration sampling between river mile (RM) 1.0 and RM 16 of the creek/canal area at varying spatial and temporal intervals on Days 1 and 2 (July 23 and 24, 2019) of treatment and dispersion, as well as on Day 3 (July 25, 2019) (see Table 2-3).

The samples were analyzed using an enzyme-linked immunoassay procedure specific for endothall (Aquathol® K). 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 (or 0.007 ppm). Samples were analyzed at dilutions of 10:1 or 20:1 with detection limits of 0.07 ppm or 0.14 ppm, respectively, or as non-diluted samples with a detection limit of 0.007 ppm. The sampling results analyzed and reported by the USACE 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 relative percent difference of endothall between samples and evaluate analytical precision. 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.

Endothall (Aquathol® K) concentrations were generally the lowest during the 48-hour treatment window at the downstream-most end of the treatment area (RM 0-2) where no direct treatment was applied within the main channel/canal, as well as at RM 3.0 which was directly treated. The remaining areas within the directly treated areas (RM approximately 4.8, 6.0, 9.0) evidenced fluctuations in endothall

(Aquathol® K) concentration, from non-detect up to nearly 4.0 ppm. The upstream-most extent of the project area at RM 16 had the highest concentrations during the 48-hour treatment window, ranging from 0.24 up to 5.76 ppm for an indirectly treated area. Areas 10 (Nine Mile Island), 11 (Amherst Marine/Ransom Creek), and 12 (Tonawanda Creek/Ship N Shore) were retreated on July 24, 2019. This is evident in the increased endothall (Aquathol® K) concentrations seen on July 24, 2019, at the 22 hours after treatment (HAT) and 24 HAT sampling around RM 10.

2.5.2 Water Sampling Results Following Flow Resumption in July

As discussed in detail in Section 2.6.2, flows were managed by the Canal Corp. approximately 24 hours prior to, during the 48-hour application period, and immediately after. On July 22, 2019, at approximately 0830 hours, flow gates were closed within the canal system, and flow was minimized prior to herbicide application to 50 cfs Canal Corp. resumed flows on July 25, 2019, at 1425 hours.

As stated above, following the initial sampling effort by USACE, E & E collected grab samples of water at 1.0-mile intervals along Tonawanda Creek/Erie Canal on July 26 and 29, 2019 (see Table 2-3 for sampling results). These sample locations and denotations are provided in Appendix A. E & E 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 (RM 0) and ending at Lockport Road/Robinson Road in Lockport, New York, approximately 15 miles to the northeast. Sampling locations were spaced approximately 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 (RM 2.8);
- East side of Ellicott Island Park (dog park) 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 A1 through A24 in Appendix A.

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 using a hand-operated peristaltic pump. 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.

Table 2-3 Summary of Post-treatment Canal/Creek Water Sample Results for July 2019

River Mile	Location ID[2]	Endothall (Aquathol® K) Concentrations in ppm[3] Sampling Dates[1] 7/23/19 (1 HAT)[4]	7/23/19 (3 HAT)	7/24/19 (18 HAT)	7/24/2019 (22 HAT)	7/24/2019 (23 HAT)	7/25/2019 (42 HAT)	7/25/2019 (48 HAT)	7/25/2019 (51 HAT)	7/26/2019	7/29/2019
0.0	H0C									ND	ND
1.0	H1A	ND		ND	0.00		ND	0.01		ND	ND
	H1B	ND		0.00	0.00		ND	0.01			
	H1C			ND	0.00		ND	0.01			
2.0	H2A	1.60		1.35	0.12		ND	0.13			
	H2B	1.71		1.18	ND		ND	0.05		ND	ND
	H2C			1.18	0.02		ND	ND			
2.8[5]	H2.8									ND	ND
3.0	**H3A**	**1.79**		**0.90**	**1.36**		**0.43**	**0.07**			
	H3B	**1.93**		**1.75**	**1.36**		**0.27**	**0.03**			
	H3C			**1.75**	**1.47**		**0.11**	**0.17**		**ND**	**ND**
3.5[5]	H3.5									ND	ND
4.0	H4A	ND		ND	0.08		5.43	0.79	1.00	ND	ND
	H4B	ND		ND	0.02		5.88	0.98	1.05	ND	ND
	H4C				0.14		5.81	0.76	1.03		
5.0	H5A	2.04		1.37	0.14		0.26	0.55			
	H5B	2.58		0.17	ND		0.38	0.70		ND	ND
	H5C			0.72	0.03		0.41	0.83			
6.0	**H6A**	**2.34**		**1.09**	**0.71**		**0.40**	**0.05**			
	H6B	**2.09**		**0.95**	**0.63**		**0.04**	**0.11**			
	H6C			**2.04**	**0.56**		**0.01**	**0.09**		**ND**	**ND**
6.3[5]	H6.3									ND	ND
7.0	H7A	2.64		1.39	1.77			0.57		0.11	ND
	H7B	2.33		1.46	2.23			0.65			
	H7C			1.32	2.00	2.66		0.59			

Table 2-3 Summary of Post-treatment Canal/Creek Water Sample Results for July 2019

River Mile	Location ID[2]	Endothall (Aquathol® K) Concentrations in ppm[3] Sampling Dates[1] 7/23/19 (1 HAT)[4]	7/23/19 (3 HAT)	7/24/19 (18 HAT)	7/24/2019 (22 HAT)	7/24/2019 (23 HAT)	7/25/2019 (42 HAT)	7/25/2019 (48 HAT)	7/25/2019 (51 HAT)	7/26/2019	7/29/2019
8.0	H8A	3.06		0.16	ND			1.13			
	H8B	1.01		0.17	0.36			1.11		0.27	ND
	H8C			0.17	0.93			0.81			
9	**H9A**		**3.96**	**0.05**	**1.22**	**0.32**		**0.30**	**1.05**	**0.44**	**ND**
	H9B		**2.75**	**0.06**	**1.66**	**0.12**		**0.56**	**0.99**		
	H9C				**0.34**	**0.08**		**0.57**	**1.20**	**0.31**	**ND**
10	H10A		2.75	1.70	2.90	3.04		0.15	0.12	0.53	ND
	H10B		0.76	1.89	3.99	2.95		0.08	0.34		
	H10C			2.00	2.26	2.26		0.15	0.33		
10.1[5]	H10.1									0.69	ND
11	H11A	2.09	1.94	1.12	1.11	1.21		2.06	1.64		
	H11B	3.03	2.30	0.98	0.63	0.58		1.48	1.13	0.40	ND
	H11C			1.04	1.29	0.81		1.11	0.92		
12	H12A	2.90	1.48	0.11	0.17			0.70			
	H12B	3.53	1.35	0.04	0.16			0.94			
	H12C			0.18	0.45			0.92		0.43	ND
13	H13A	1.81	1.44	0.58	0.09			0.70		0.34	ND
	H13B	2.20	1.03	0.45	ND			0.67			
	H13C			0.46	0.16			0.53			
14	H14A	0.01	0.01	0.31	0.36			0.54			
	H14B	0.01	0.01	0.26	0.45			0.59		0.26	ND
	H14C			0.29	0.34			0.67			
15	H15A	1.97		1.69	2.84		0.34	0.46			
	H15B	2.11		0.10	ND		0.06	0.11			
	H15C									0.40	ND

Table 2-3 Summary of Post-treatment Canal/Creek Water Sample Results for July 2019

River Mile	Location ID[2]	Endothall (Aquathol® K) Concentrations in ppm[3] Sampling Dates[1] 7/23/19 (1 HAT)[4]	7/23/19 (3 HAT)	7/24/19 (18 HAT)	7/24/2019 (22 HAT)	7/24/2019 (23 HAT)	7/25/2019 (42 HAT)	7/25/2019 (48 HAT)	7/25/2019 (51 HAT)	7/26/2019	7/29/2019
16	H16A	5.65		3.69	2.66		0.56	0.62			
	H16B	5.76		3.31	0.24		0.58	0.57			
	H16C			3.35	1.15		0.63	0.50			

[1] Application occurred on July 23 and 24, 2019. Samples collected by USACE on July 23, 24, and 25; E & E collected all samples on July 26 and 29, 2019.

[2] Location IDs were assigned by USACE or E & E. Numbers indicate river mile of location and letters indicate location within creek/canal.

[3] Endothall results were provided by USACE for all samples.

[4] HAT was measured from the initial treatment on July 23, 2019.

[5] Side channel samples.

Key:

HAT = hours after treatment
A = north/west side of creek/canal
B = south/east side of creek/canal
C = center of canal/creek
ND = non-detect (detection limit of 0.07 ppm unless otherwise noted by footnote)
Blank cell = no sample collected
Bold text = samples taken within the main treatment areas

Google Earth was used to navigate to the predetermined sampling locations. At the time of collection, a Bad Elf GPS 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. All samples collected by E & E on July 26 and 29, 2019, were shipped on ice to University of Florida (Marci Netherland) for analysis. Samples arrived on the morning of July 30, 2019. All samples were analyzed using an enzyme-linked immunoassay procedure specific for endothall (RaPID Assay® Endothall Test Kit).

The purpose of E & E's sampling effort was to determine the movement and degradation of endothall (Aquathol® K) 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 flow management). Sample results from July 26, 2019, indicated the presence of endothall (Aquathol® K) from RM 7.0 through RM 15.0. Concentrations in this area ranged from 0.11 to 0.69 ppm (see Table 2-3 and Figures A1-1 through A1-19 in Appendix A). On July 29, 2019, sample results indicated that endothall (Aquathol® K) concentrations were all non-detect.

The Canal is generally an east-west feature, but in some locations, it is actually oriented in other directions. Therefore, for the purposes of this report, flows are described as east or west. In the summer, flow conditions in the canal are primarily from west to east (away from the Niagara River). This flow pattern is opposite of the natural flows that occur in the system during the winter when the Canal is closed. During treatment in July 2019, the western end of the treatment area (RM 0 – RM 1) evidenced very low or non-detect concentrations throughout the monitoring window (Day 1 through Day 7), indicating that there was no westward movement of the herbicide toward the Niagara River.

Lateral Dispersion

Samples were collected at various locations on both banks of the creek/canal and in the center. Based on the data in Table 2-3, there is disparity in when and where herbicide laterally dispersed across the creek/canal. Immediately following treatment (1 HAT on Day 1; July 23, 2019), lateral dispersion was evident across the creek/canal upstream to approximately RM 8 where concentrations began to show some differences between the north and south sides of the creek/canal; this was evident up to RM 13. Sampling at 3 HAT on Day 1 showed some mixing occurring between RM 9 and RM 10.

Lateral dispersion was generally evident on Day 2 (July 24, 2019), with the exception of several areas where mixing of the herbicide across the canal appeared to occur; for example RM 3.0, RM 5.0, and RM 6.0 at 18 HAT, and RM 9.0, RM 10, RM 15, and RM 16 at 22 HAT. On Day 3 (July 25, 2019), lateral dispersion was evident throughout the treatment area. Therefore, based on the data presented in Table 2-3, management of flows (see Section 2.7.2) generally helped to enable the lateral dispersion of herbicide across the creek.

2.6 Herbicide Contact Time and Dispersion for August Treatment

The USACE conducted water sampling following the endothall (Aquathol® K) spot treatments on August 13 and 14, 2019, which occurred over an approximately 14-acre area, between RM 5 and RM 6. The USACE conducted water sampling between RM 1 and RM 16 of the creek/canal area at varying spatial and temporal intervals.

Concentrations of endothall (Aquathol® K) immediately following treatment (1 HAT) ranged between 0.07 ppm and 1.14 ppm between RM 5 and RM 13 (see Table 2-4). Over the next three sampling events (3 HAT, 18 HAT, and 22 HAT), concentrations were highest at RM 15, indicating an eastward movement of herbicide. By August 15, 2019 (49 HAT and 57 HAT), herbicide concentrations were less than 0.75 ppm.

Similar to the July treatment, the downstream-most end of the treatment area (RM 0 – RM 1) evidenced non-detect concentrations throughout the monitoring window, indicating that there was no westward movement of the herbicide toward the Niagara River. Therefore, the August sampling data again illustrates the effects of flow management.

2.7 Flow Monitoring and Flow Management

Flow monitoring and flow 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.

2.7.1 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 10 and 11, 2019, 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 Figure 2-5).

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, on July 2 and 3, 2019, 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, except where the creek/canal depth was too shallow to allow for four measurements. These data were used to create a depth profile and velocity profile at each location (see Appendix B). 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 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 creek/canal where single, continuous velocity measurements could be obtained that would represent the approximate mean cross-sectional velocity (see Appendix B).

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:

- South to north (away from the Niagara River) in Tonawanda Creek/Erie Canal at North Tonawanda Botanical Gardens;
- East to west (towards the canal) in Tonawanda Creek at New Road in Pendleton; and
- Northeast to southwest (towards the Niagara River) 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 creek/canal 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

Table 2-4 Summary of Post-treatment Canal/Creek Water Sample Results for August 2019

		Endothall (Aquathol® K) Concentrations in ppm[3] Sampling Dates[1]										
River Mile	Location ID[2]	8/13/2019 (1 HAT)[4]	8/13/2019 (3 HAT)	8/14/2019 (18 HAT)	8/14/2019 (22 HAT)	8/14/2019 (24 HAT)	8/14/2019 (27 HAT)	8/14/2019 (29 HAT)	8/14/2019 (30 HAT)	8/14/2019 (31 HAT)	8/15/2019 (49 HAT)	8/15/2019 (57 HAT)
1.0	HS1											
2.0	HS2	ND	ND	ND	ND		ND			ND	ND	ND
3.0	**HS3**					**0.15**		**0.15**	**0.04**	**ND**	**ND**	**ND**
4.0	HS4				0.67	0.27	0.67	0.27	0.01	0.20	ND	ND
5.0	HS5	0.12	ND	0.06	0.09		0.09			ND	0.08	ND
6.0	**HS6**	**0.26**	**0.52**	**0.22**	**0.15**		**0.15**			**0.11**	**0.08**	**0.09**
7.0	HS7	0.07	ND	0.11	0.12		0.12			0.08	0.07	ND
8.0	HS8	1.14	0.69	0.12	0.10		0.10			0.13	0.07	0.09
9	**HS9**	**0.36**	**0.37**	**0.08**	**ND**		**ND**			**ND**	**ND**	**ND**
10	HS10	0.25	0.47	0.12	0.12		0.12			ND		
11	HS11	0.07	ND	ND	ND		ND			ND		
12	HS12	0.19	0.30	ND	ND		ND		ND			
13	HS13	0.99	0.12	ND	0.08		0.08		0.09			
14	H14A		0.56	0.08	0.41		0.41		0.44		0.33	
	H14B		1.5	ND	1.20		1.20		1.49		0.32	
	H14C		0.37	0.11	0.27		0.27		0.69		0.31	
15	H15A		1.5	1.34	2.41		2.41		1.86			0.72
	H15B		2.12	1.48	2.41		2.41		2.70			0.62
	H15C		3.00	1.65	2.17		2.17		1.90			0.69
16	H16A		ND		1.01		1.01		1.29		0.75	
	H16B		ND		0.11		0.11		0.14		0.46	
	H16C		ND		1.33		1.33		0.54			

Notes:

[1] Application occurred on August 13 and 14, 2019. Samples were collected by USACE.

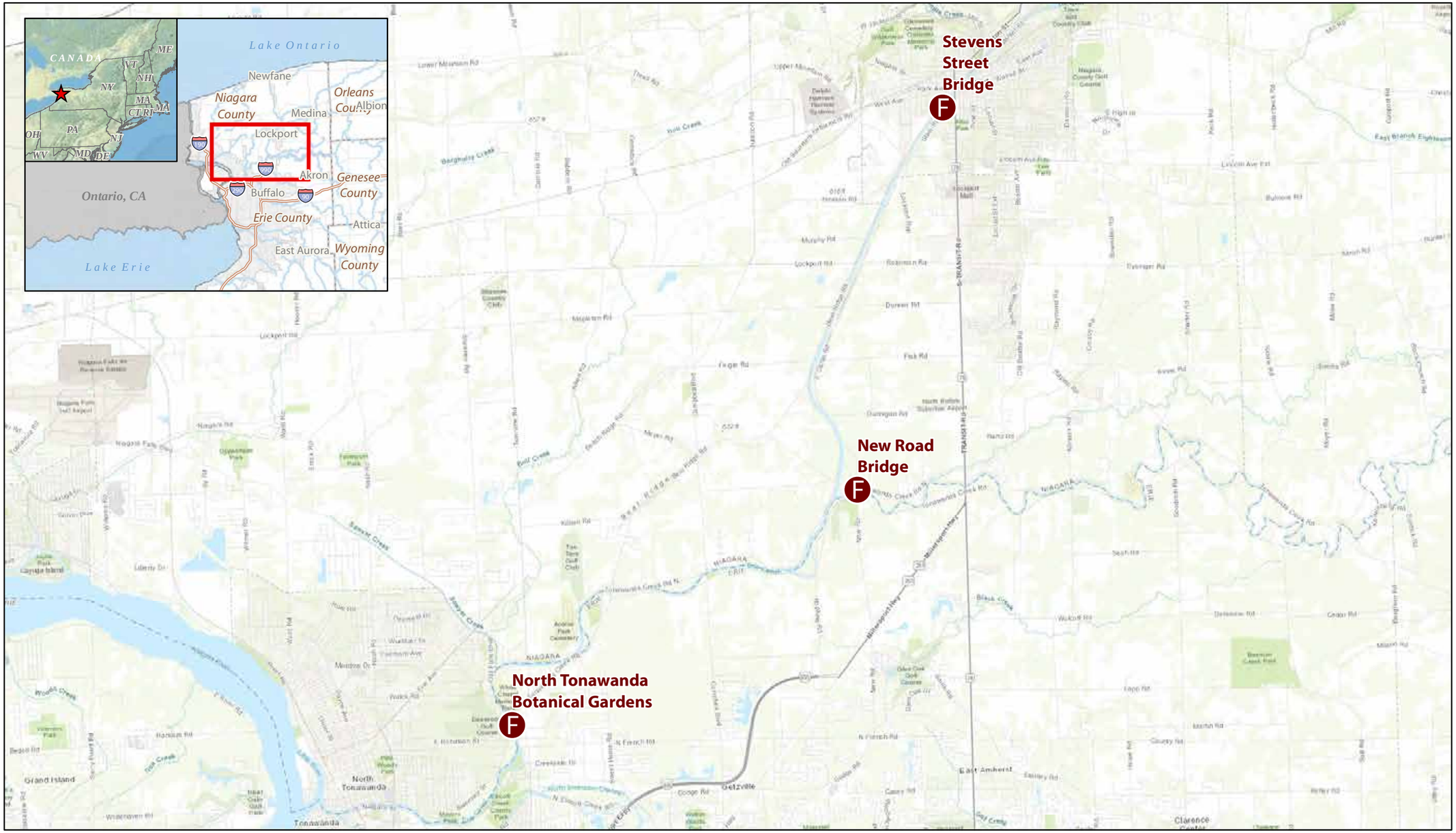
[2] Location IDs were assigned by the USACE. Number indicates river mile of location and letter indicates location within creek/canal.

[3] Endothall results were provided by USACE for all samples.

[4] HAT was measured from the initial treatment on August 13, 2019.

Key:

HAT = hours after treatment
A = north/west side of creek/canal
B = south/east side of creek/canal
C = center of canal/creek
ND = non-detect (detection limit of 0.07 ppm unless otherwise noted by footnote)
Blank cell = no sample collected
Bold text = samples taken within the main treatment areas



SOURCE: ESRI 2018; USACE ERDC 2018.

Figure 2-5 Flow Monitoring Locations

Tonawanda Creek/Erie Canal, Erie and Niagara Counties, New York

the total cross-sectional area based on the measured level. The relationships used for these calculations are depicted on the graphs in Appendix B.

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.

All monitoring stations successfully recorded flow before, during, and after treatment. During treatment, flow at the all stations fluctuated as a function of water level, which was influenced by the Niagara River levels and New York Power Authority (NYPA) operations. This is reflected in the flow, velocity, and level graphs in Appendix C.

Hourly updates were provided to the USACE regarding flow conditions observed over the previous hour at each monitoring location between the hours of 8 a.m. and 6 p.m. For the overnight hours, hourly flow data were compiled and provided to the USACE the following morning.

Additionally, several spot velocity readings were taken on July 23 and 24, 2019, to corroborate the flow readings taken by the in-stream meters (see Table 2-5). Spot readings were measured using the SonTek FlowTracker 2. The readings were taken 5 feet from the shoreline at a depth of 1 foot. Limitations to the spot-readings included the length of the pole and not having access to a boat during the treatment window. As a result, the spot velocity readings differed greatly from the in-stream meter data. The average difference between velocity readings at the Botanical Gardens monitoring station was 91%, the natural channel of Tonawanda Creek (near East Canal/New Road) had an average difference of 121%, and the Steven's Street monitoring station had an average difference of 127%. This comparison indicates that the spot velocity readings were not an accurate way to corroborate the flow readings recorded by the in-stream meters. This is likely due to the limitations mentioned above, which prevented spot readings at the same location as the in-stream meters.

Table 2-5 Spot Velocity Readings

	Locations														
	Botanical Gardens					New Road					Steven's Street				
Date	Time	X (ft)	Y (ft)	Velocity (ft/s)	Flow Direction	Time	X (ft)	Y (ft)	Velocity (ft/s)	Flow Direction	Time	X (ft)	Y (ft)	Velocity (ft/s)	Flow Direction
7/23/2019	1210	5	1	-0.0072	South	1300	5	1	-0.011	East	1350	5	1	0.2433	Northeast
	1220	5	1	-0.0095		1310	5	1	-0.0204		1400	5	1	0.0307	
	1230	5	1	-0.0167		1320	5	1	-0.1907		1410	5	1	0.1256	
	1440	5	1	-0.0651	South	--	--	--	--	--	--	--	--	--	--
	1450	5	1	-0.0255		--	--	--	--		--	--	--	--	
	1500	5	1	0.0223		--	--	--	--		--	--	--	--	
7/24/2019	1115	5	1	0.0101	South	1040	5	1	0.063	East	1005	5	1	0.0437	Southwest
	1120	5	1	-0.0034		1045	5	1	0.0364		1010	5	1	0.0754	
	1125	5	1	0.0014		1050	5	1	0.0379		1015	5	1	0.0817	

2.7.2 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, 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 July 23 and 24, 2019, Canal Corp. ceased flows out of Lockport by closing the bypass gate opening at approximately 0800 hours on July 22, 2019. As stated above, Canal Corp. reported that they were operating at 50 cfs. 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. Several lock fills were observed in the level data obtained near the Stevens Street Bridge showing sudden decreases in level and flow direction towards the locks (away from the Niagara River) (see Appendix C). The bypass gate was reopened at approximately 1430 hours on July 25, 2019.

Canal Corp. stopped flow again at 0800 hours on August 12, 2019, for the spot treatment on August 13, 2019, and resumed flow at 1200 hours on August 15, 2019. No flow monitoring was conducted for the August spot treatment.

2.7.3 Flow Observations

As part of its relicensing studies, the 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 Chippewa-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 0700 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 evident in the water level data obtained during this project (see Appendix C). The water level at North Tonawanda Botanical Gardens exhibited a cyclic behavior on an approximately daily cycle. Similar cyclic fluctuations in water levels were also observed at the Pendleton and Lockport monitoring locations; although the magnitude of the fluctuations was less than that observed in North Tonawanda and had other changes in level superimposed on the daily cycle. During 2018, the maximum water level generally occurred in the late morning/early afternoon (1100 to 1400 hours) with a few exceptions, likely due to rain events. Minimum water levels were generally observed overnight (2200 to 0600 hours), with a magnitude change of 0.5 to 0.7 feet. Measurements in 2019 showed the maximum water level generally occurring in the late morning/early afternoon (1000 to 1400 hours). Minimum water levels were generally observed overnight (2200 to 0600 hours), with a magnitude change between 0.3 and 0.7 feet. Anomalies in this pattern were likely due to heavy rains at the end of the monitoring period (July 28, 2019). 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 north (away from the river) with lower magnitude flow fluctuations to the south (toward the river) (see Appendix C).

At the Stevens Street monitoring station, flow rates were generally below 1,000 cfs, averaging 250 cfs to the northwest (toward the locks) prior to the treatment period. During treatment, flows averaged between 0 to 250 cfs to the northwest and the southeast. Before and during treatment, there were a few instances of high flows towards the northwest and the southeast (up to 1,992 cfs) likely due to boat traffic. Following resumption of flow at the locks and bypass gates on July 25, 2019, flow rates increased again to an average of 200 to 250 cfs to the east (see Appendix C).

Flows out of the natural channel of Tonawanda Creek (near East Canal/New Road) were generally measured between 0 and 100 cfs before and during treatment. Some fluctuations in flow direction were likely due to the backwater influence of the canal (resulting from changes in Niagara River level and changes in lock status in Lockport), creating westward flow. The typical flow is corroborated by the U.S. Geological Survey (USGS) gauging station data on Tonawanda Creek in Rapids, New York (USGS Station Number 04218000; USGS 2019).

2.8 2019 Vegetative Monitoring and Treatment Summary

The USACE conducted point intercept surveys on four dates throughout the growing season to determine Hydrilla distribution, as illustrated in Figure 2-6.

Based on that monitoring, Hydrilla was effectively treated from just east of the West Canal Park boat ramp all the way to the end of the treatment area (the rock cut), even though the monitoring for herbicide residues does not indicate the concentration exposure time (CET) needed for effective control was achieved for the July 2019 treatment. The only location where Hydrilla was found post-treatment was near the West Canal Park boat ramp. That area was re-treated with endothall (Aquathol® K) on August 13 and 14, 2019 (see Figure 2-2).

During the August treatment, smaller plots of endothall – Aquathol® Super K (granular) – were used to the west of West Canal Park. Additionally, a larger plot of copper (Harpoon®) was also treated. In the western portion, no residual monitoring sites achieved the CET needed to effectively treat Hydrilla. The only area where monitoring demonstrated effective CET was the larger site treated with Aquathol® K near the West Canal Park boat ramp. All areas treated with Aquathol® Super K and copper (Harpoon®) showed either new growth or regrowth during post-treatment surveys. The reason for the less effective treatment closer to the Niagara River was likely due to the changing hydrologic regimes, small plot sizes, and in-flows from Ellicott Creek.

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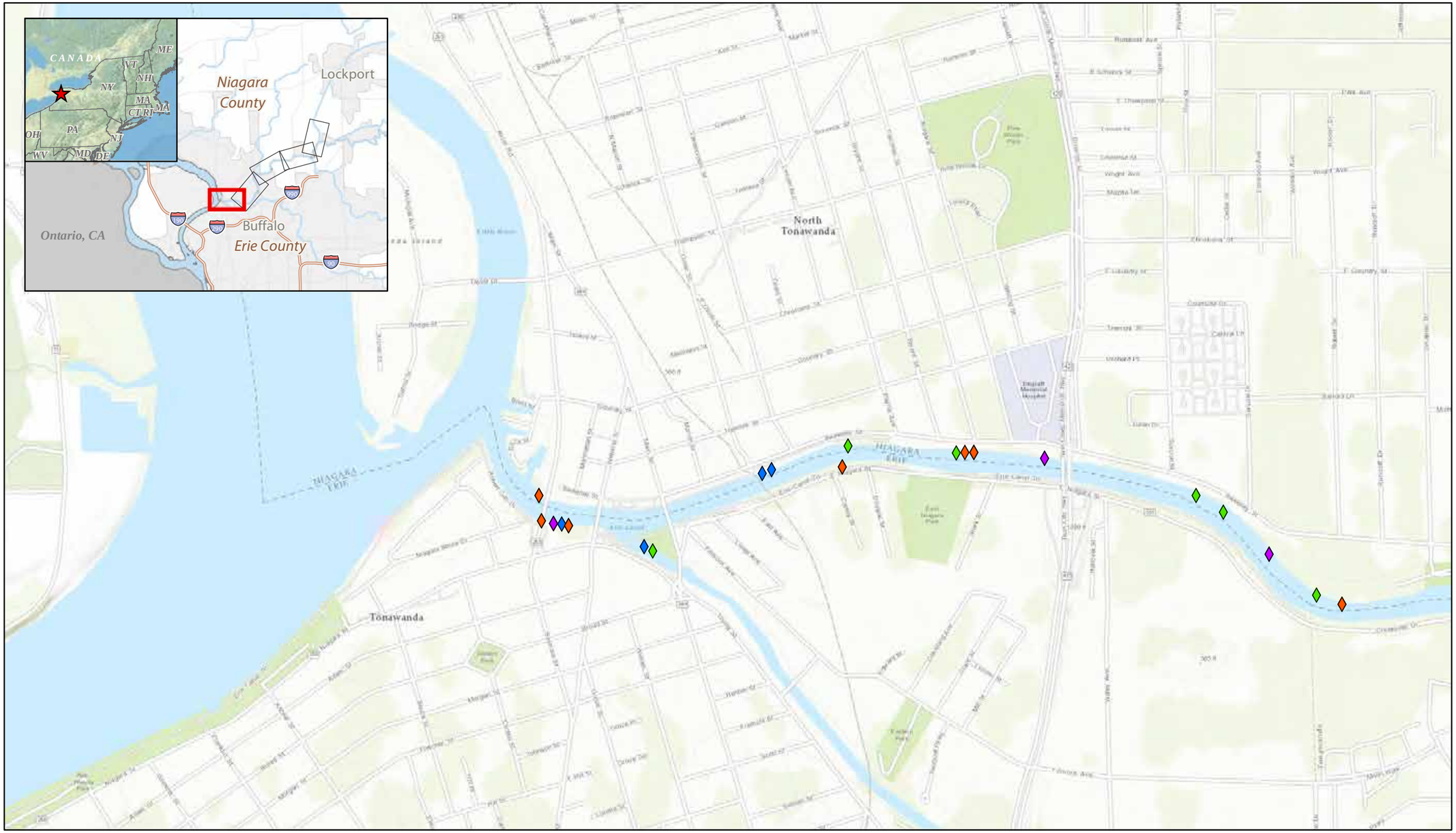
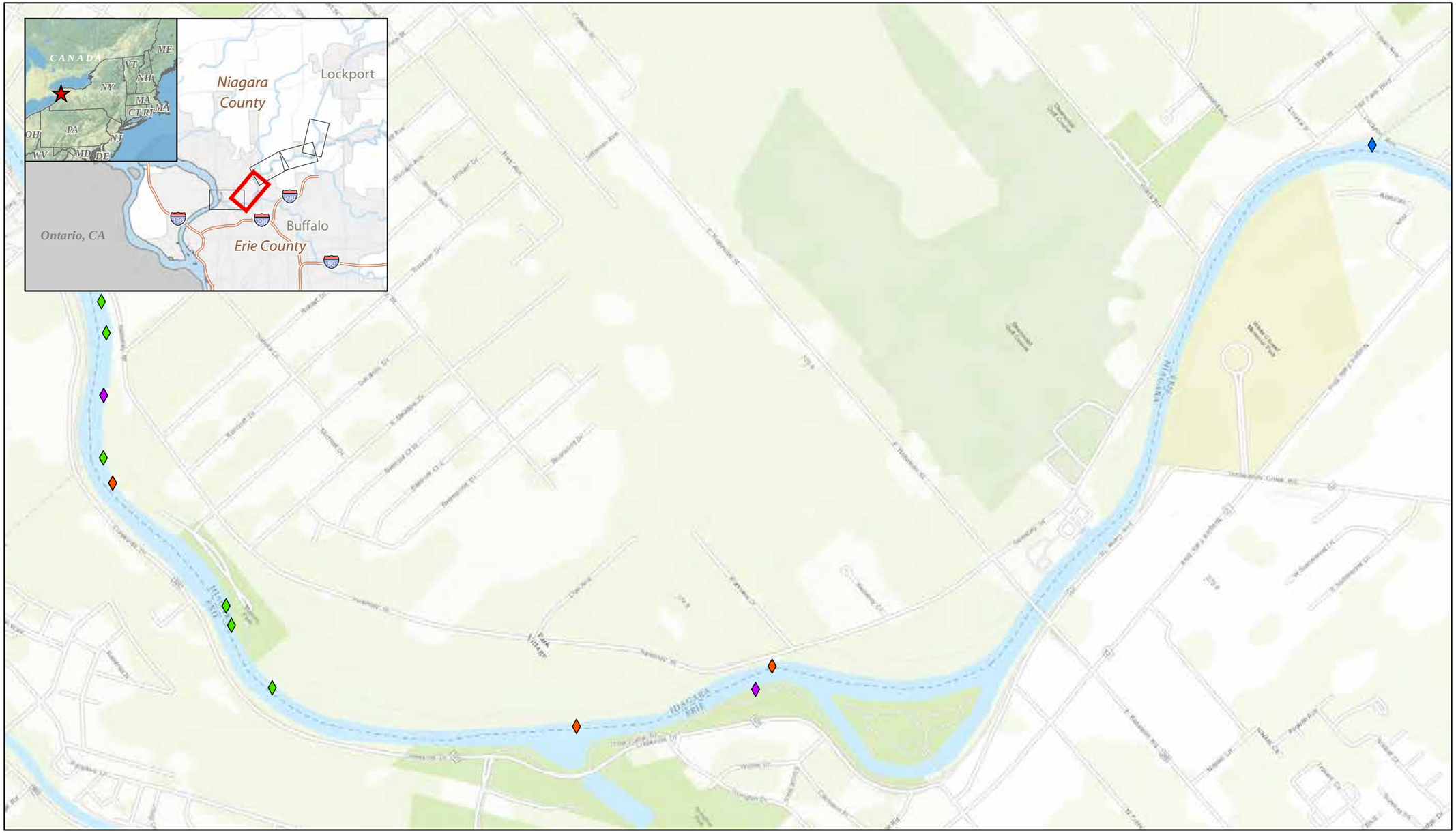


SOURCE: ESRI 2018; USACE ERDC 2018.

Figure 2-6a Hydrilla Distribution 2019

Tonawanda Creek/Erie Canal, Erie and Niagara Counties, New York

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\2-6 Hydrilla Distribution.mxd



SOURCE: ESRI 2018; USACE ERDC 2018.

Figure 2-6b Hydrilla Distribution 2019

Tonawanda Creek/Erie Canal, Erie and Niagara Counties, New York

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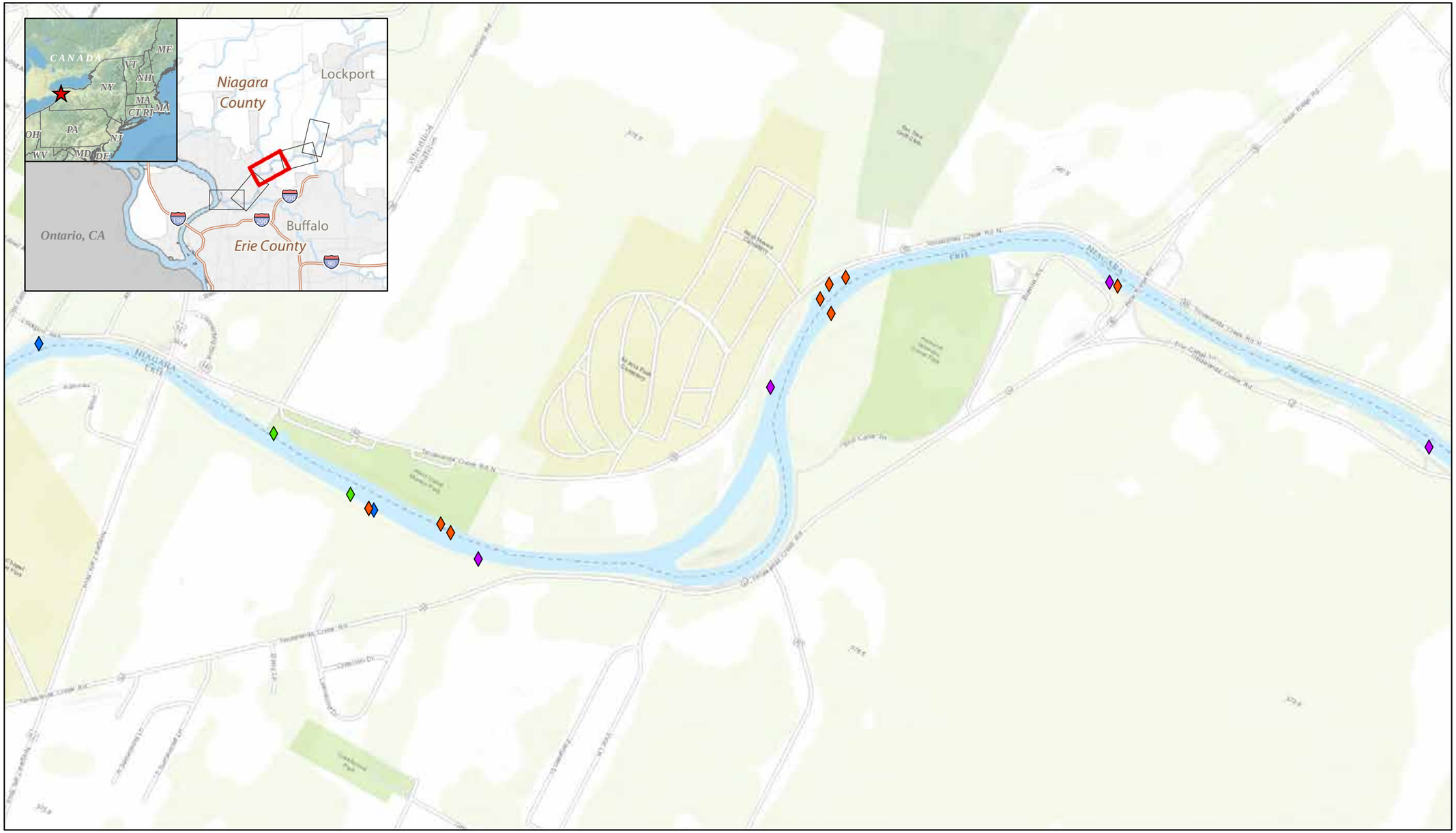


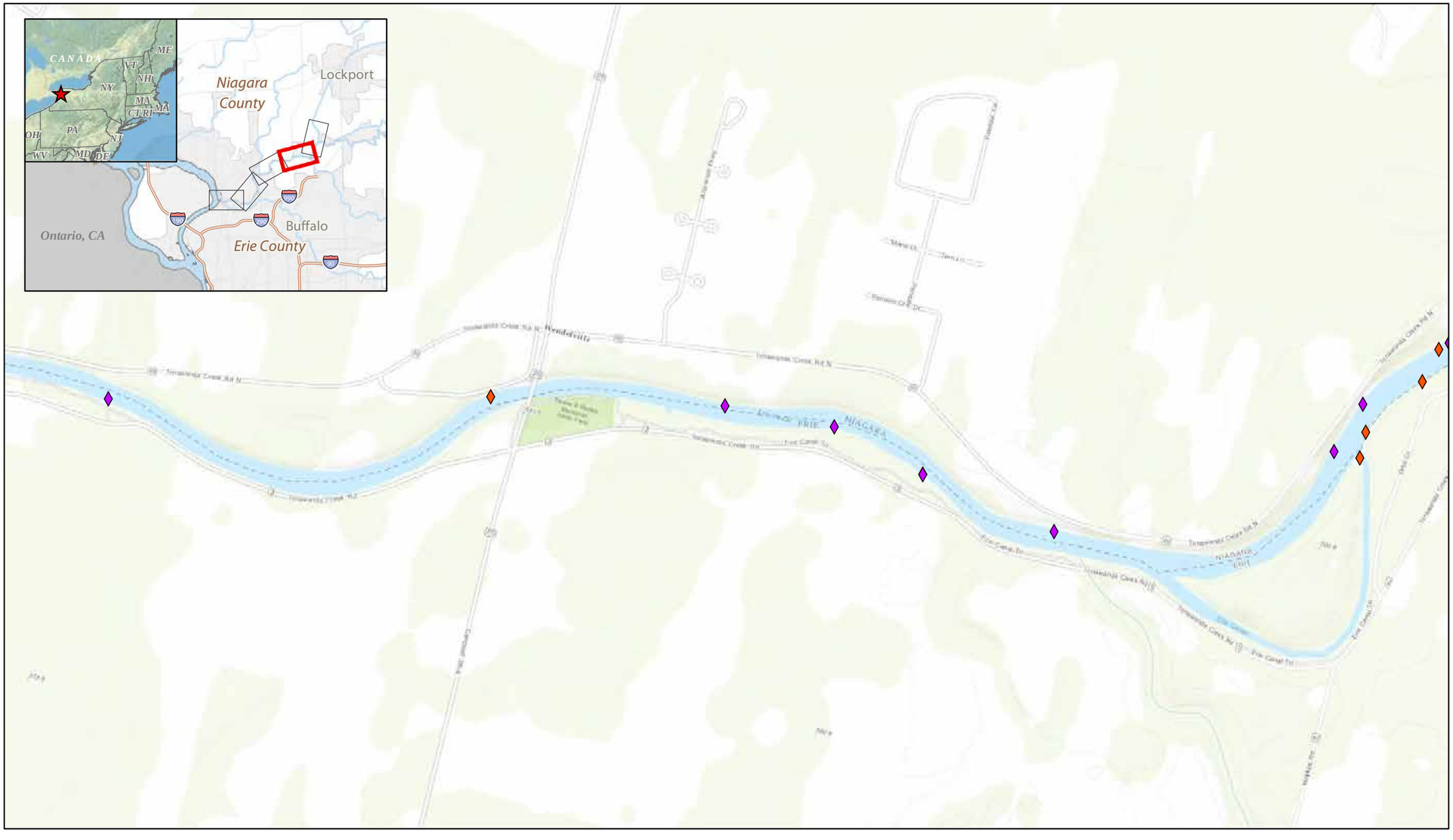
Date: 2/25/2020

SOURCE: ESRI 2018; USACE ERDC 2018.

Figure 2-6c Hydrilla Distribution 2019

Tonawanda Creek/Erie Canal, Erie and Niagara Counties, New York

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\2-6 Hydrilla Distribution.mxd



SOURCE: ESRI 2018; USACE ERDC 2018.

Figure 2-6d Hydrilla Distribution 2019

Tonawanda Creek/Erie Canal, Erie and Niagara Counties, New York

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\2-6 Hydrilla Distribution.mxd

SOURCE: ESRI 2018; USACE ERDC 2018.

Figure 2-6e Hydrilla Distribution 2019

Tonawanda Creek/Erie Canal, Erie and Niagara Counties, New York

3 Study Improvements

The study improvements, summarized below, were based on lessons learned from previous years' endothall application efforts, coordination with the study partners during the 2019 treatment season, and activities conducted during the 2019 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 2019 application were effective at detecting the herbicide and for tracking its movement and degradation.

3.2 Flow Monitoring and Management

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 again in 2019, as they have been since 2015. 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 sensors tipping due to boat traffic observed in 2017 did not occur in 2018 or 2019. Therefore, no adjustments to the sensors or deployment will be required in 2020.

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 significant input remaining is that from the natural channel of Tonawanda Creek entering the canal in Pendleton, New York. The flow rate of Tonawanda Creek averaged 65 cfs during the 2019 application period (USGS 2019). This inflow rate can be matched at Lockport by operating the bypass gate at a comparable flow rate.

Flow Monitoring Locations

No issues with meter tipping were noted at the three monitoring locations and all three monitors were easily accessed. It is anticipated that the three locations used in 2019 will be used again in 2020. However, the deployment location within each stream section should be evaluated for stability prior to subsequent deployments. The height of the sensor above the streambed must be known, so the structure used to secure the sensor must itself be stable and vertical within the water. Areas outside navigation channels and away from docks should continue be used to the extent practicable in order to minimize the effects of turbulence caused by boat traffic. Even if the same monitoring locations are used in the future, it is recommended to obtain new velocity and depth cross-sectional measurements at each monitoring location prior to application events. Both the cross-sectional area and locations representative of the average velocity may vary from year to year as a result of erosion, deposition, dredging, construction, etc.

3.3 2019 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 USACE 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 GPS units that are used for navigation to ensure accurate herbicide placement.

Going forward, it is suggested that a minimum size be identified for the treatment plots to ensure efficacy. Some of the plots treated in 2019 were too small to anticipate good control. A minimum plot size of 0.25 acre should be considered for copper products, and 0.5 acre for endothall (Aquathol® K). Additionally, treatment plots should be finalized 72 hours prior to treatment to ensure that appropriate planning and coordination can be completed to ensure accuracy and that adequate product is on-hand.

Herbicide Type and Volumes

If feasible, utilize bubble curtains in lieu of limnocorrals for future treatments. Bubble curtains have advantages over limnocorrals with respect to ease of use as well as the ability to treat a deeper area below the water's surface. Additionally, with the use of a limnocorral, there is a risk that someone might cut the lines that secure it to the shore; that risk would be eliminated with the use of a bubble curtain.

Flow Monitoring

During the 2018 field season, the USACE Buffalo noted that there were instances in which flow rates reported through the monitoring efforts did not match what they saw from their boats on the canal or what the herbicide monitoring showed. In the 2018 report, E & E recommended that to help to address these potential discrepancies in the future, written notes regarding flow observations should be

taken during such instances. Notes should include date/time/location of visual observations of potential flow discrepancies. This will allow field observations to be reviewed along with flow monitoring data and precipitation and wind data. Additionally, the USACE could perform spot velocity measurements using an instantaneous velocity meter provided by E & E.

Spot velocity measurements were taken in 2019 but due to the limitations discussed in Section 2.6.1 (i.e., readings had to be taken from the shore), E & E recommends using a boat to obtain spot velocity readings during the treatment window. This would allow spot readings to be taken at a location significantly closer to the location of the in-stream meters, resulting in more similar readings. This would aid in corroborating the flow readings obtained from the in-stream meters.

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.

4 References

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

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

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A Water Quality Sampling Location Maps

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A1 Sampling Locations 2019.mxd

Date: 3/2/2020

July Endothall (Aquathol®K) Treatment
Figure A1-1
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- July Sample Locations 2019
- July Endothall (Aquathol®K) Treatment
- Mile Post
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

N

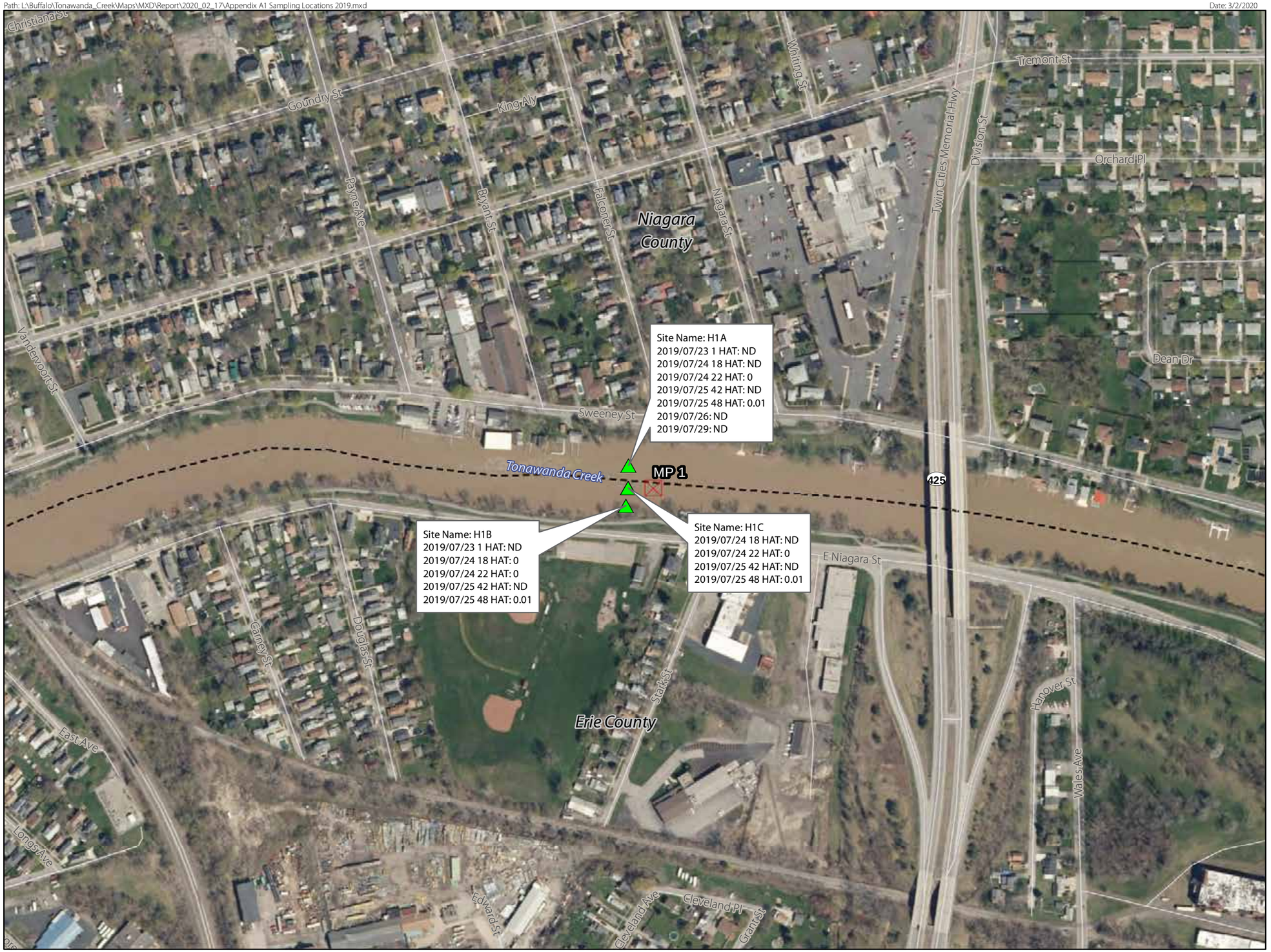
SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018; Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A1 Sampling Locations 2019.mxd

Date: 3/2/2020



July Endothall (Aquathol®K) Treatment
Figure A1-2
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- July Sample Locations 2019
- Mile Post
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018; Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A1 Sampling Locations 2019.mxd

Date: 3/2/2020

July Endothall (Aquathol®K) Treatment
Figure A1-3
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- July Sample Locations 2019
- Mile Post
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018; Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A1 Sampling Locations 2019.mxd

Date: 3/2/2020

July Endothall (Aquathol®K) Treatment
Figure A1-4
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- July Sample Locations 2019
- July Endothall (Aquathol®K) Treatment
- Mile Post
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018; Ecology and Environment, Inc. 2020; USACE ERDC 2018.

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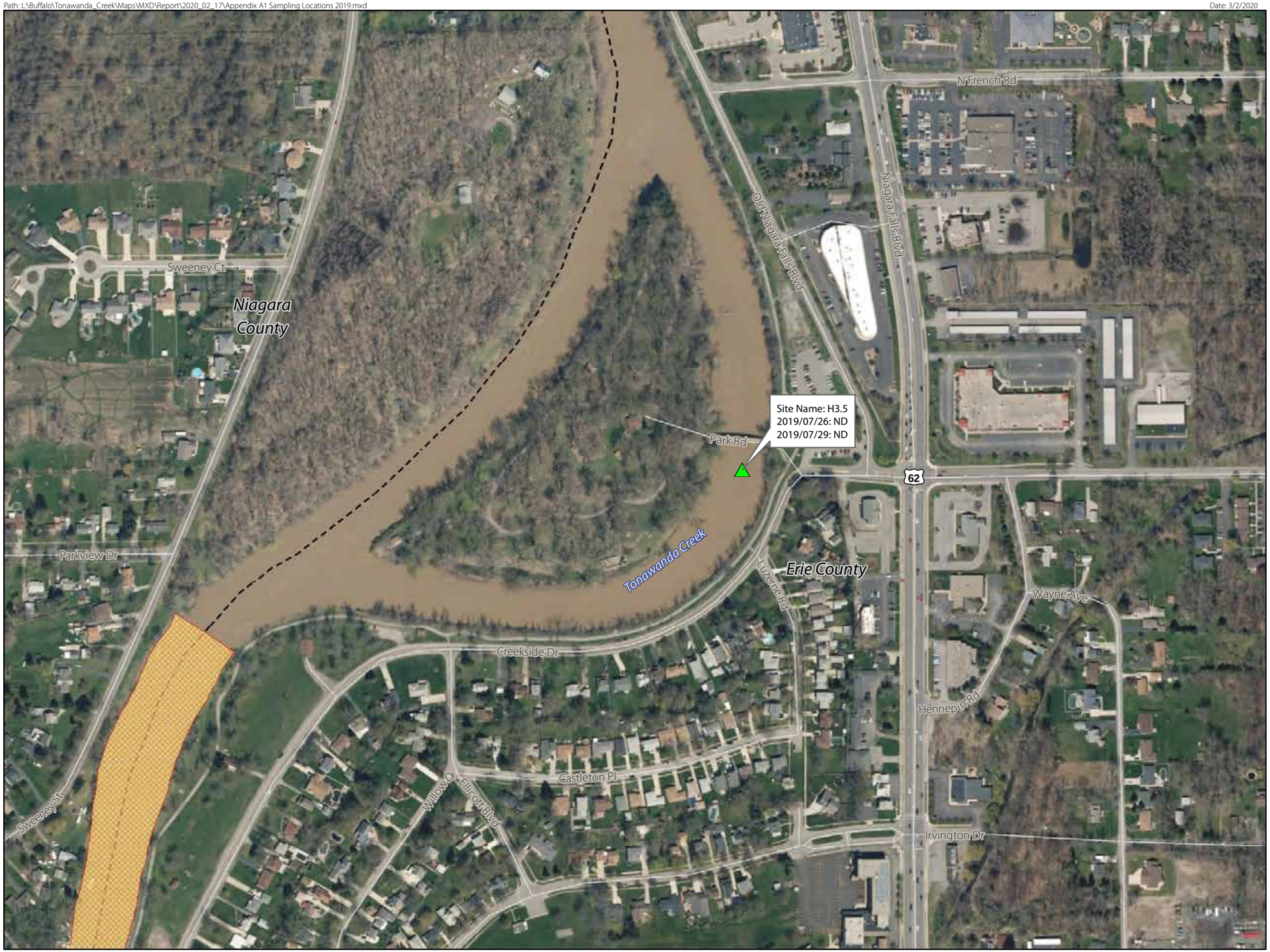
Date: 3/2/2020



July Endothall (Aquathol®K) Treatment
Figure A1-5
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- July Sample Locations 2019
- July Endothall (Aquathol®K) Treatment
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018; Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A1 Sampling Locations 2019.mxd

Date: 3/2/2020

July Endothall (Aquathol®K) Treatment
Figure A1-6
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- July Sample Locations 2019
- Mile Post
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018; Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A1 Sampling Locations 2019.mxd

Date: 3/2/2020

July Endothall (Aquathol®K) Treatment
Figure A1-7
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- July Sample Locations 2019
- July Endothall (Aquathol®K) Treatment
- Mile Post
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

N

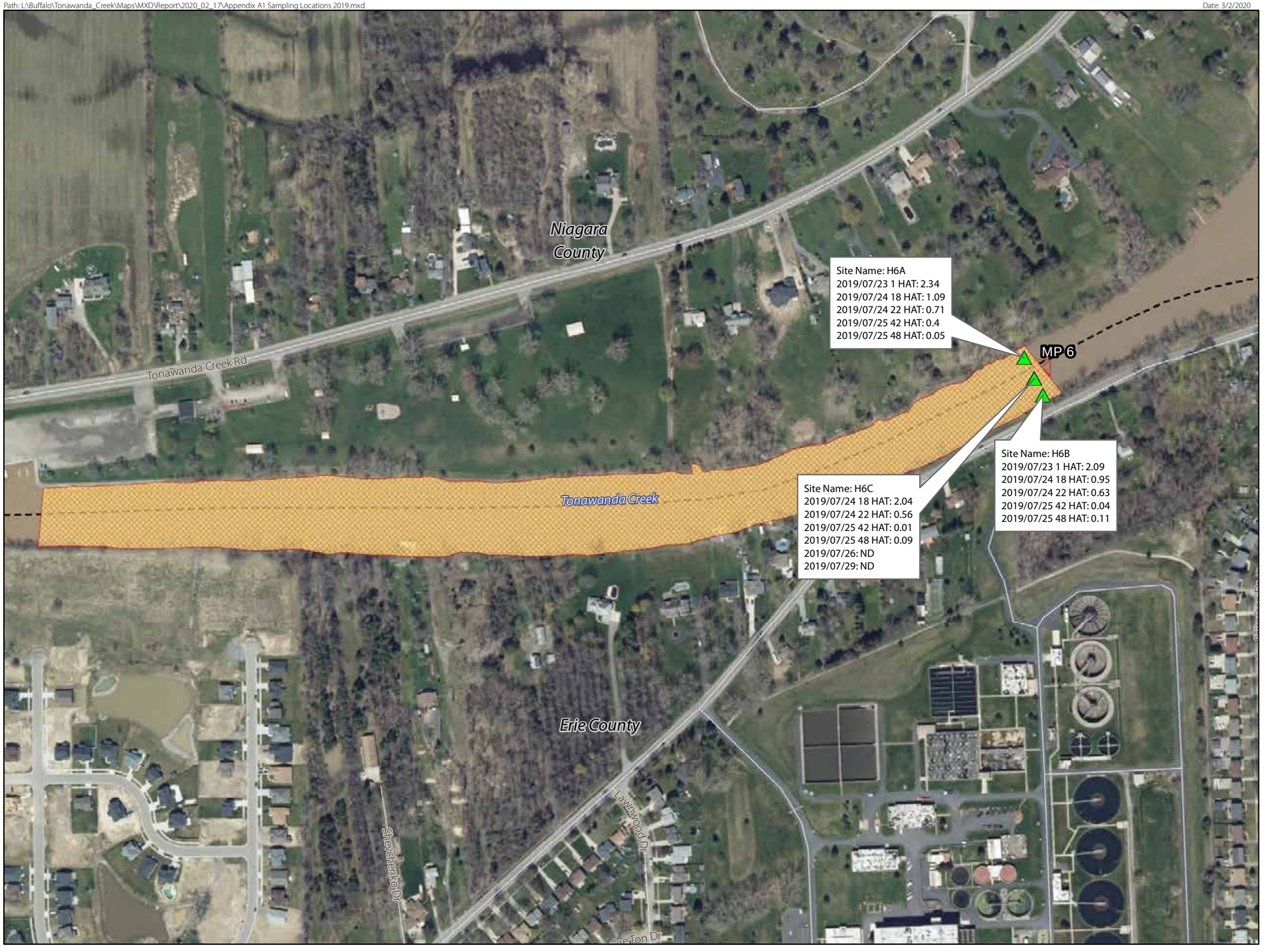
SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018;
Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A1 Sampling Locations 2019.mxd

Date: 3/2/2020



July Endothall (Aquathol®K) Treatment
Figure A1-8
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- July Sample Locations 2019
- July Endothall (Aquathol®K) Treatment
- Mile Post
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018; Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A1 Sampling Locations 2019.mxd

Date: 3/2/2020

July Endothall (Aquathol®K) Treatment
Figure A1-9
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- July Sample Locations 2019
- July Endothall (Aquathol®K) Treatment
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

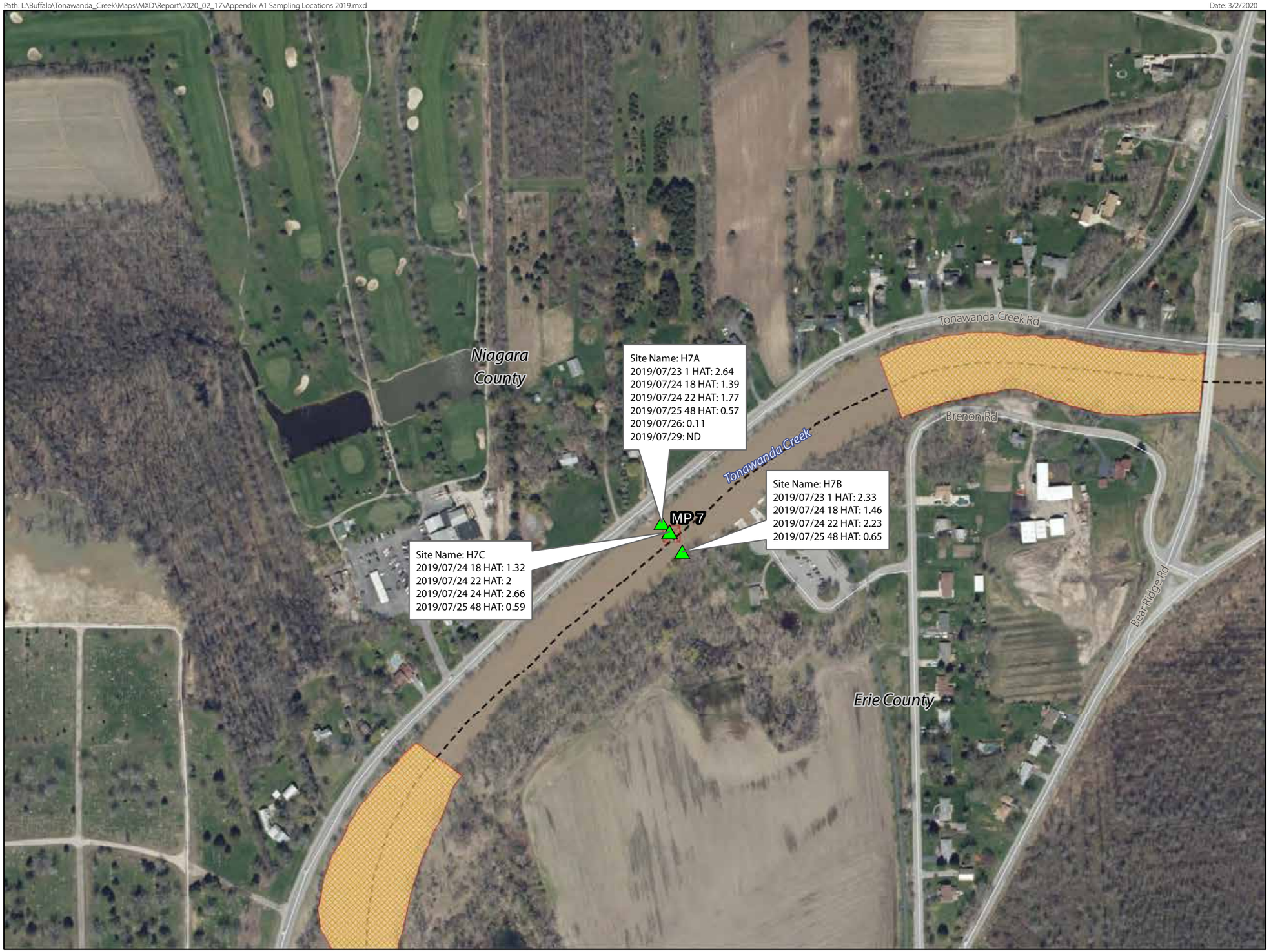
SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018;
Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A1 Sampling Locations 2019.mxd

Date: 3/2/2020



July Endothall (Aquathol®K) Treatment
Figure A1-10
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- July Sample Locations 2019
- July Endothall (Aquathol®K) Treatment
- Mile Post
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

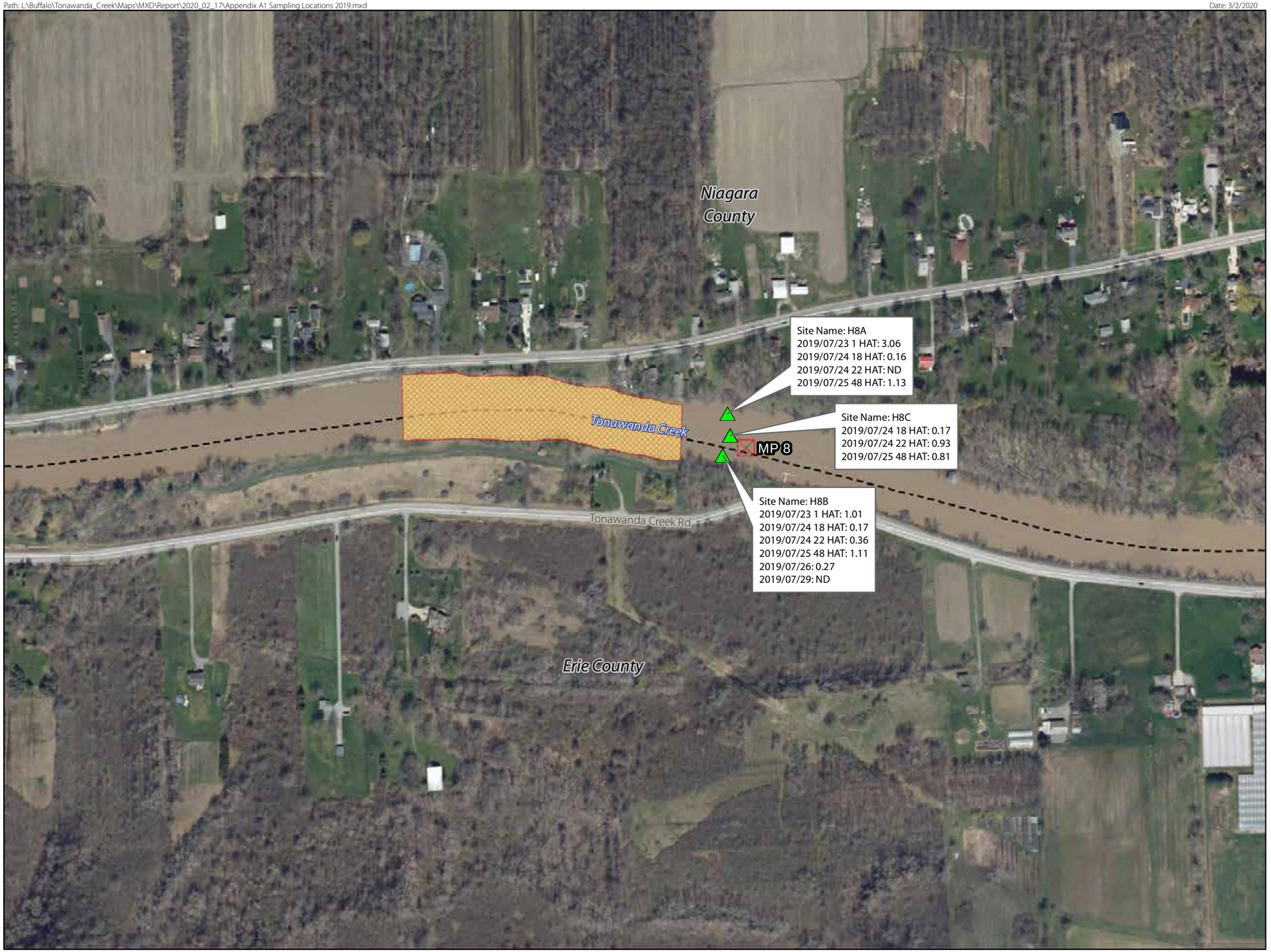
SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018;
Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A1 Sampling Locations 2019.mxd

Date: 3/2/2020



July Endothall (Aquathol®K) Treatment
Figure A1-11
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- July Sample Locations 2019
- July Endothall (Aquathol®K) Treatment
- Mile Post
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

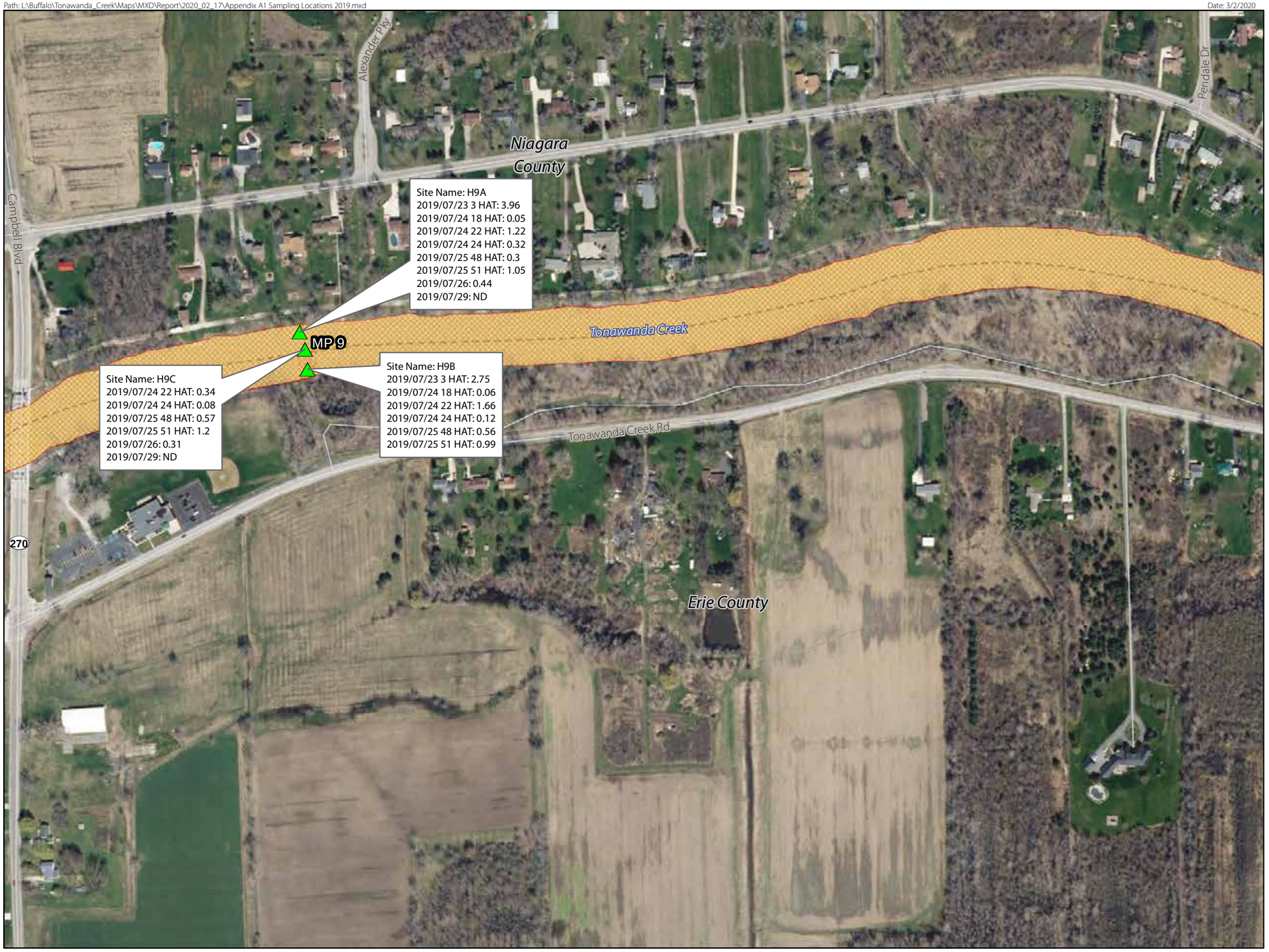
SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018; Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A1 Sampling Locations 2019.mxd

Date: 3/2/2020



July Endothall (Aquathol®K) Treatment
Figure A1-12
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- July Sample Locations 2019
- July Endothall (Aquathol®K) Treatment
- Mile Post
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

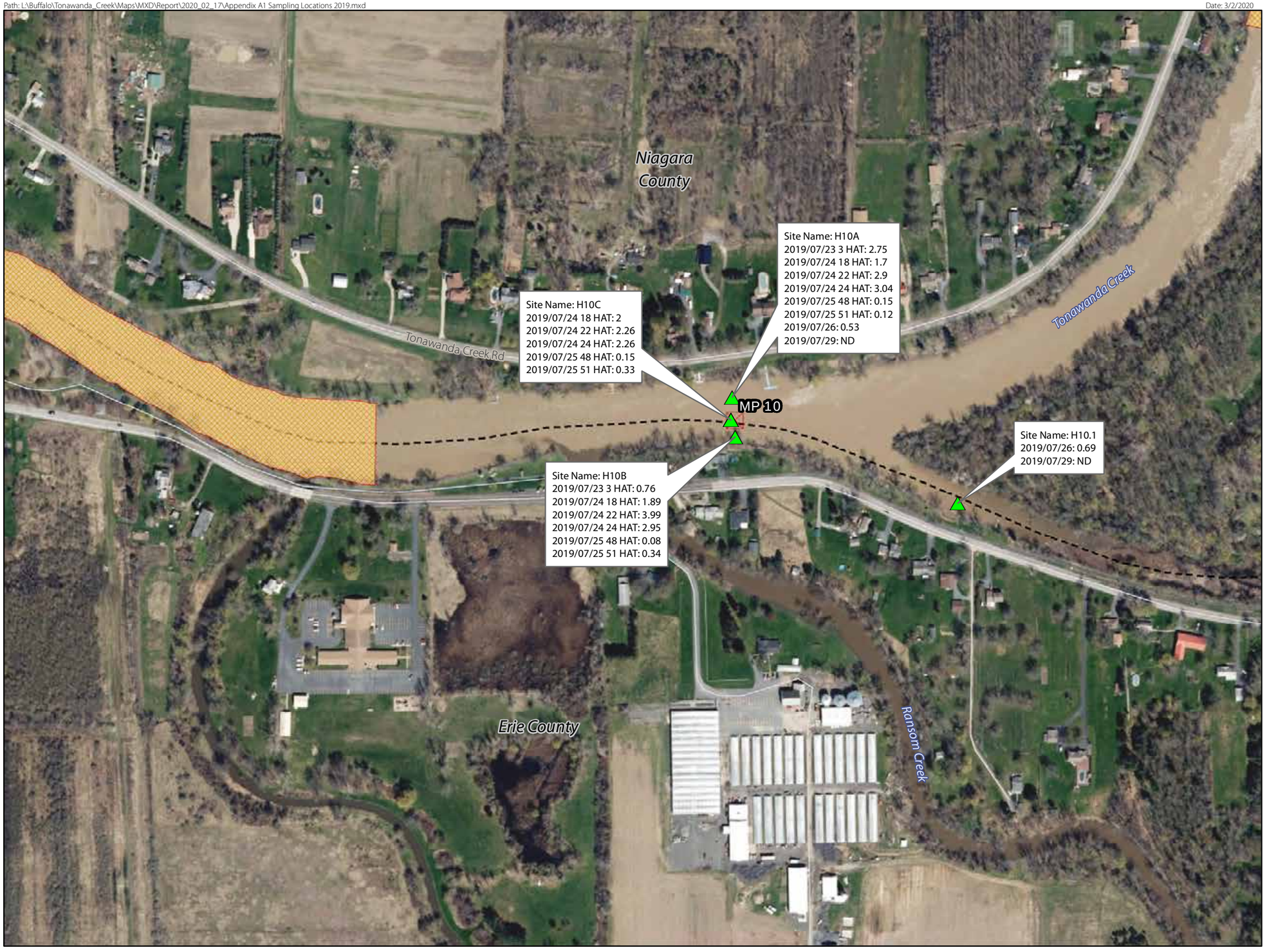
SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018;
Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A1 Sampling Locations 2019.mxd

Date: 3/2/2020



July Endothall (Aquathol®K) Treatment
Figure A1-13
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- July Sample Locations 2019
- July Endothall (Aquathol®K) Treatment
- Mile Post
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

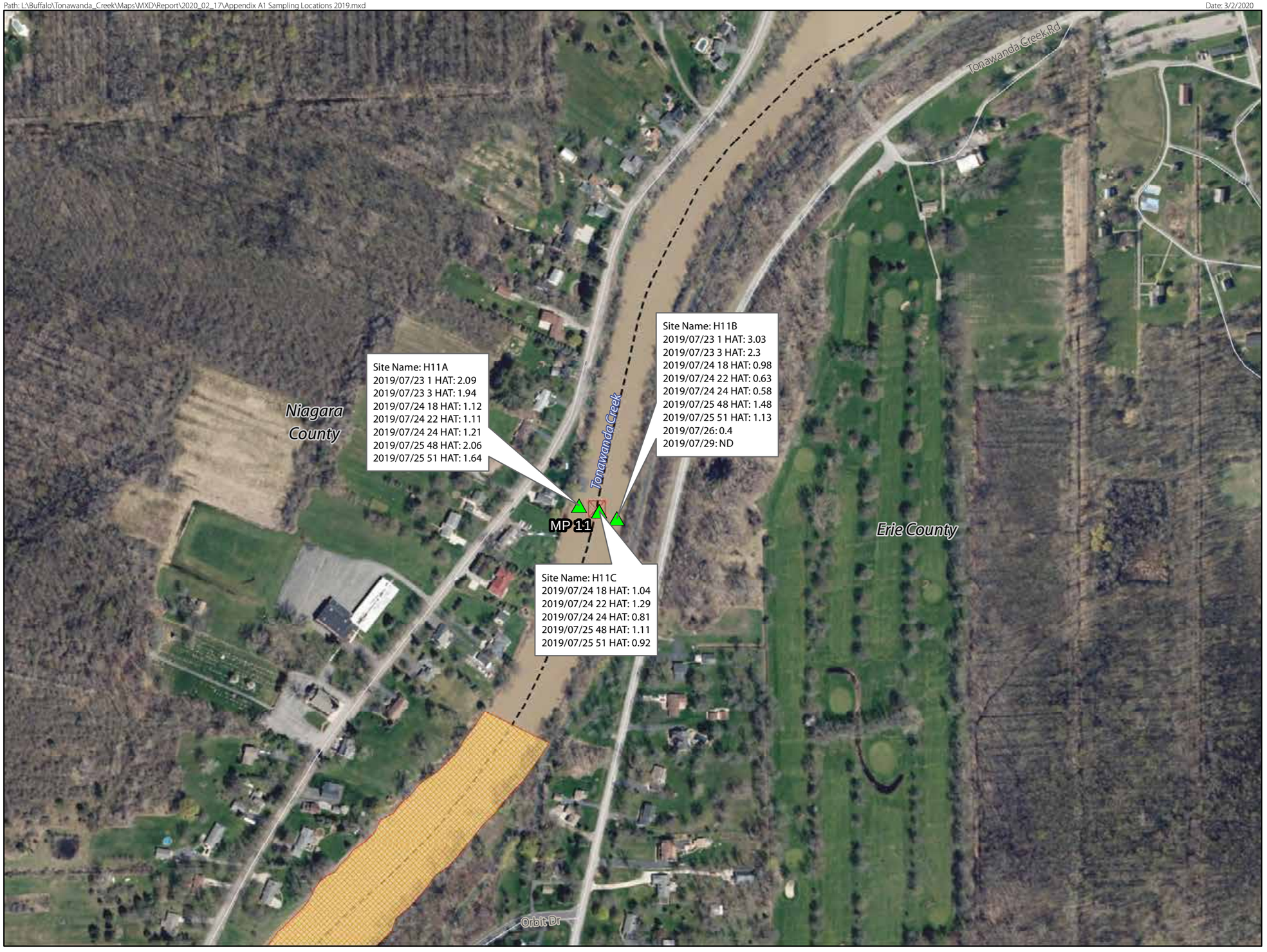
SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018;
Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A1 Sampling Locations 2019.mxd

Date: 3/2/2020



July Endothall (Aquathol®K) Treatment
Figure A1-14
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- July Sample Locations 2019
- July Endothall (Aquathol®K) Treatment
- Mile Post
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018;
Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A1 Sampling Locations 2019.mxd

Date: 3/2/2020

July Endothall (Aquathol®K) Treatment
Figure A1-15
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- July Sample Locations 2019
- July Endothall (Aquathol®K) Treatment
- Mile Post
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

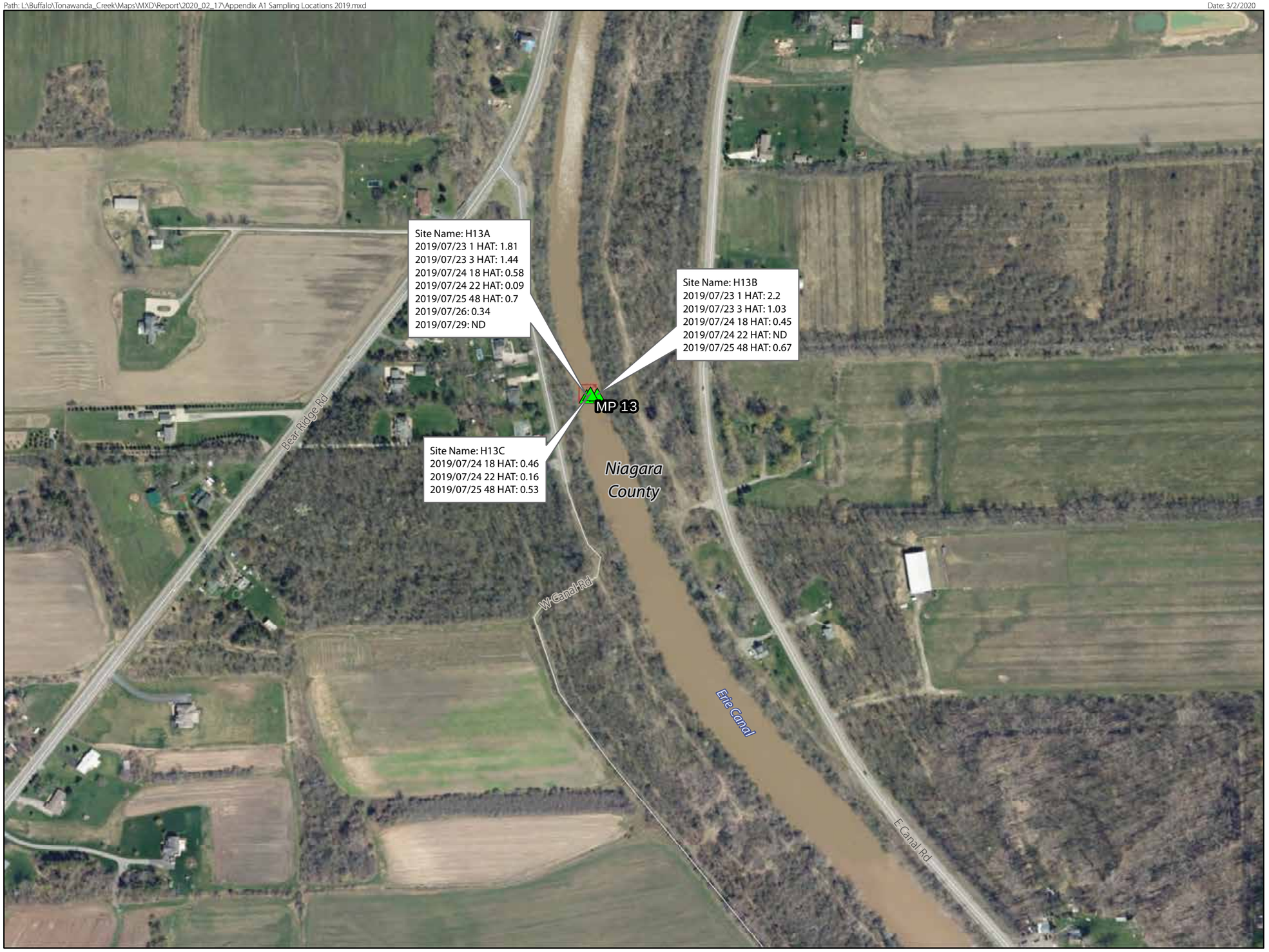
SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018;
Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A1 Sampling Locations 2019.mxd

Date: 3/2/2020



July Endothall (Aquathol®K) Treatment
Figure A1-16
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- July Sample Locations 2019
- Mile Post
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

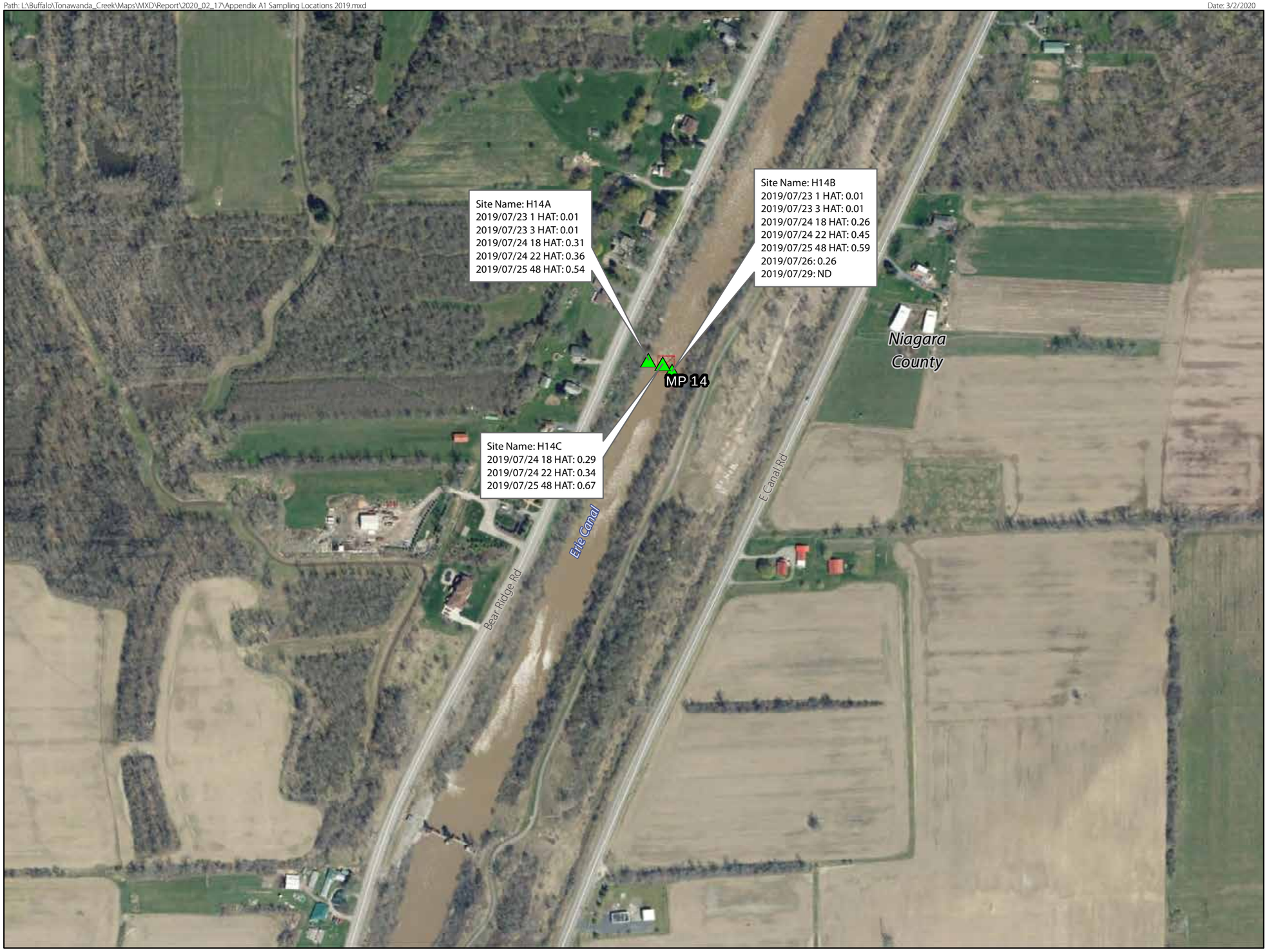
SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018;
Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A1 Sampling Locations 2019.mxd

Date: 3/2/2020



July Endothall (Aquathol®K) Treatment
Figure A1-17
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- July Sample Locations 2019
- Mile Post
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018;
Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A1 Sampling Locations 2019.mxd

Date: 3/2/2020

July Endothall (Aquathol®K) Treatment
Figure A1-18
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- July Sample Locations 2019
- Mile Post
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

N

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018; Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A1 Sampling Locations 2019.mxd

Date: 3/2/2020

July Endothall (Aquathol®K) Treatment
Figure A1-19
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- July Sample Locations 2019
- Mile Post
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

N

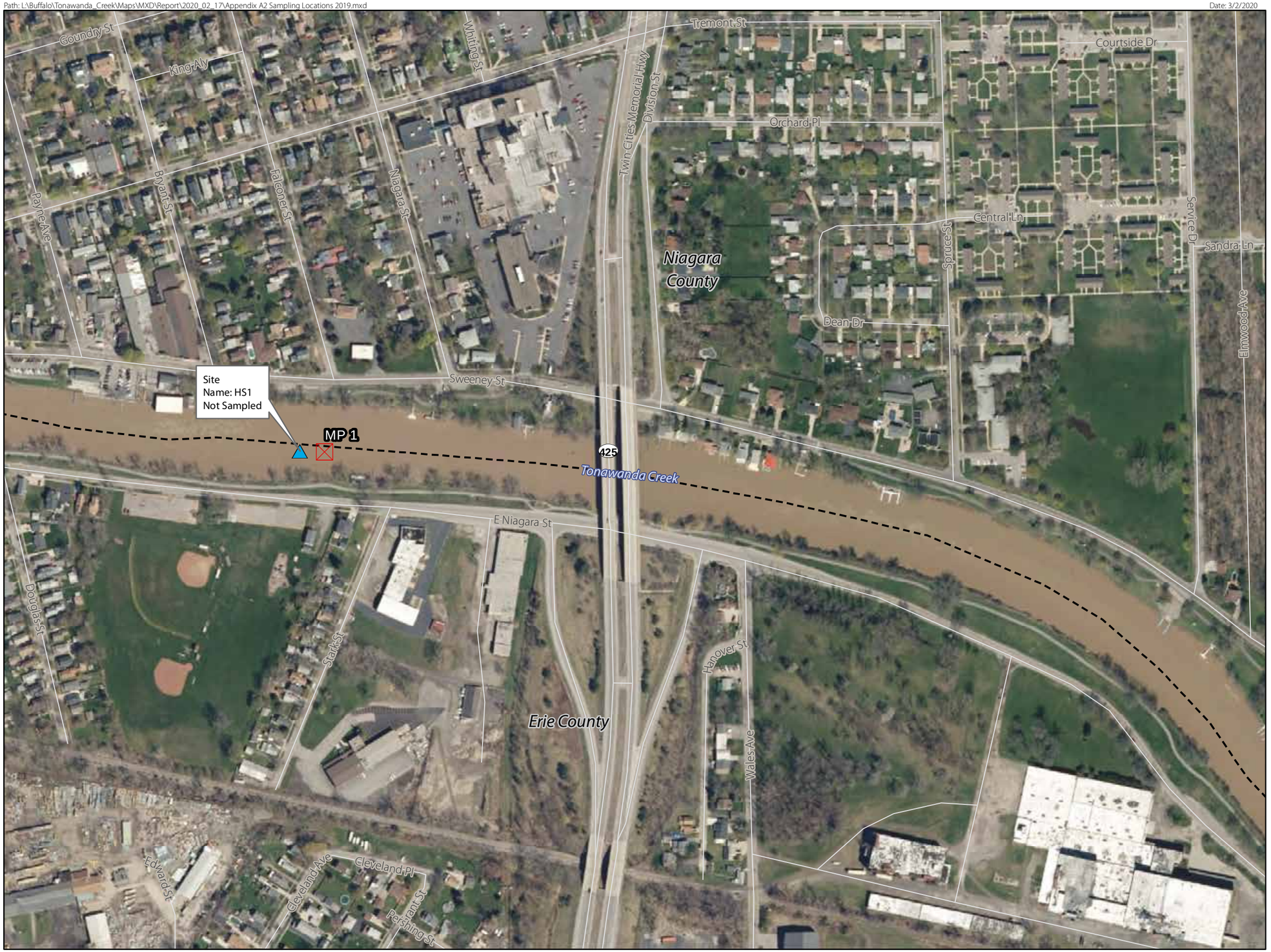
SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018; Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A2 Sampling Locations 2019.mxd

Date: 3/2/2020



August Endothall (Aquathol®K) Spot Treatment
Figure A2- 1
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- August Sample Locations 2019
- Mile Post
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

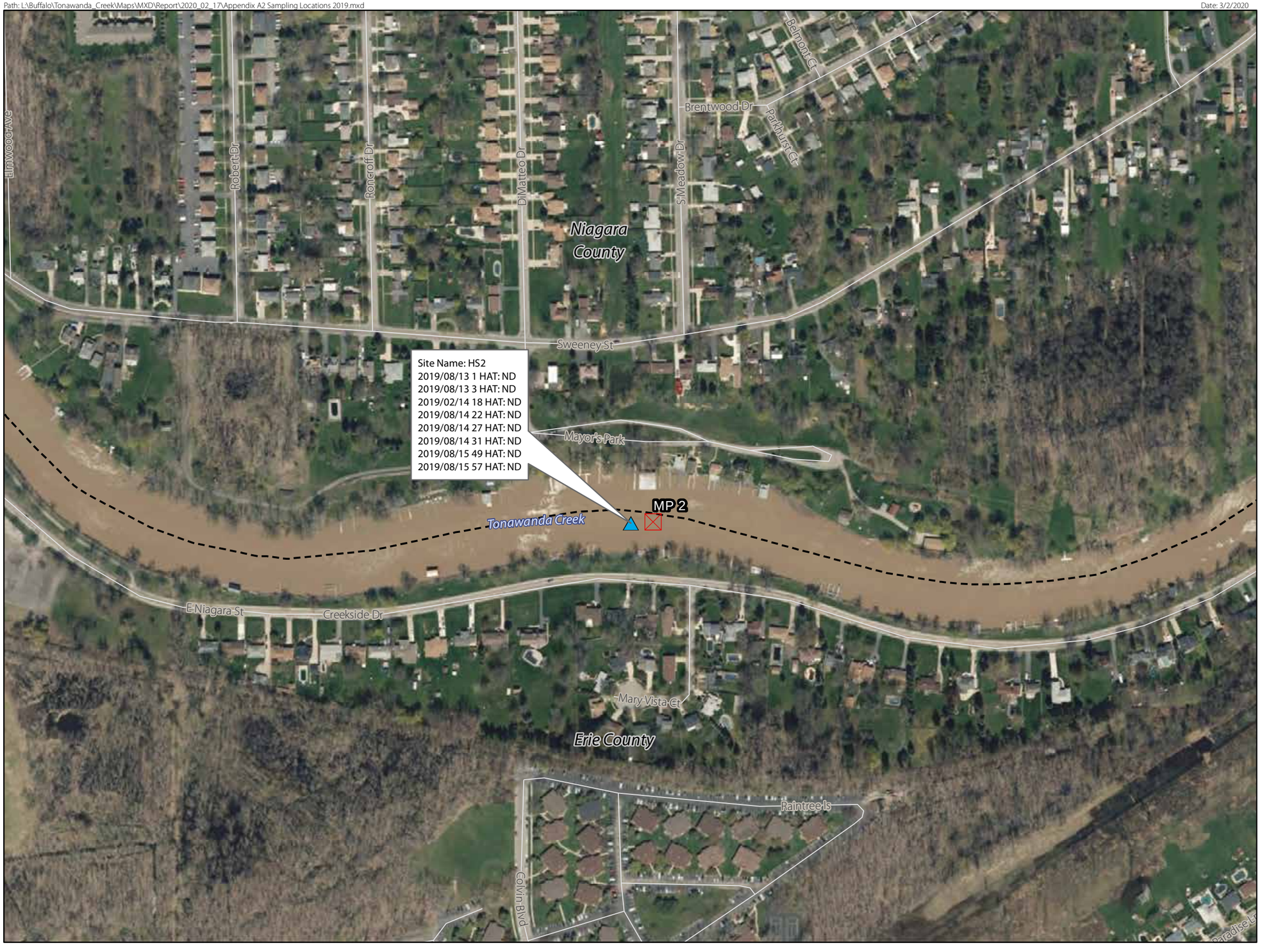
SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018; Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A2 Sampling Locations 2019.mxd

Date: 3/2/2020



August Endothall (Aquathol®K) Spot Treatment
Figure A2- 2
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- August Sample Locations 2019
- Mile Post
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

N

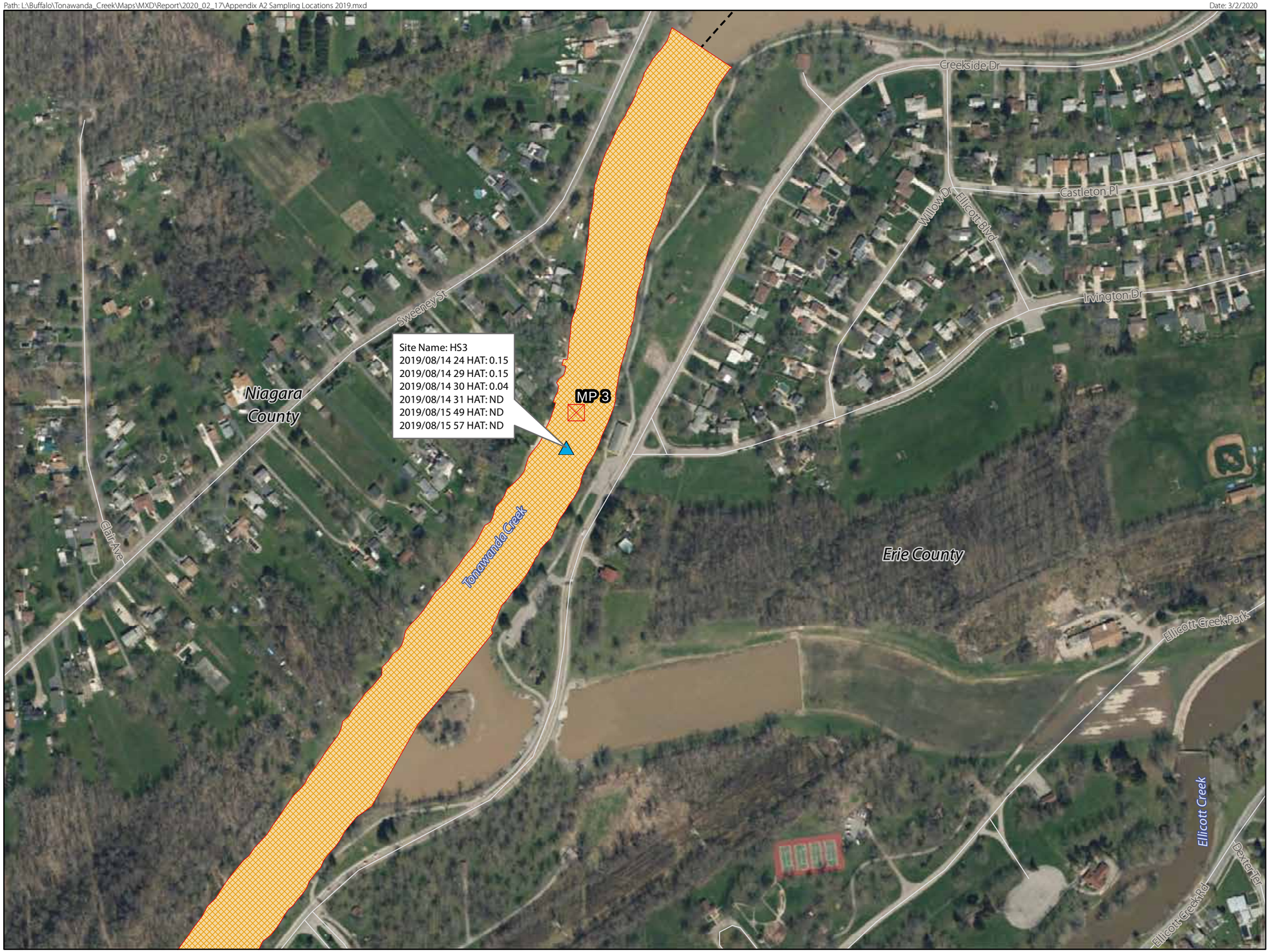
SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018; Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A2 Sampling Locations 2019.mxd

Date: 3/2/2020



August Endothall (Aquathol®K) Spot Treatment
Figure A2- 3
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- August Sample Locations 2019
- August Endothall (Aquathol®K) Spot Treatment
- Mile Post
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

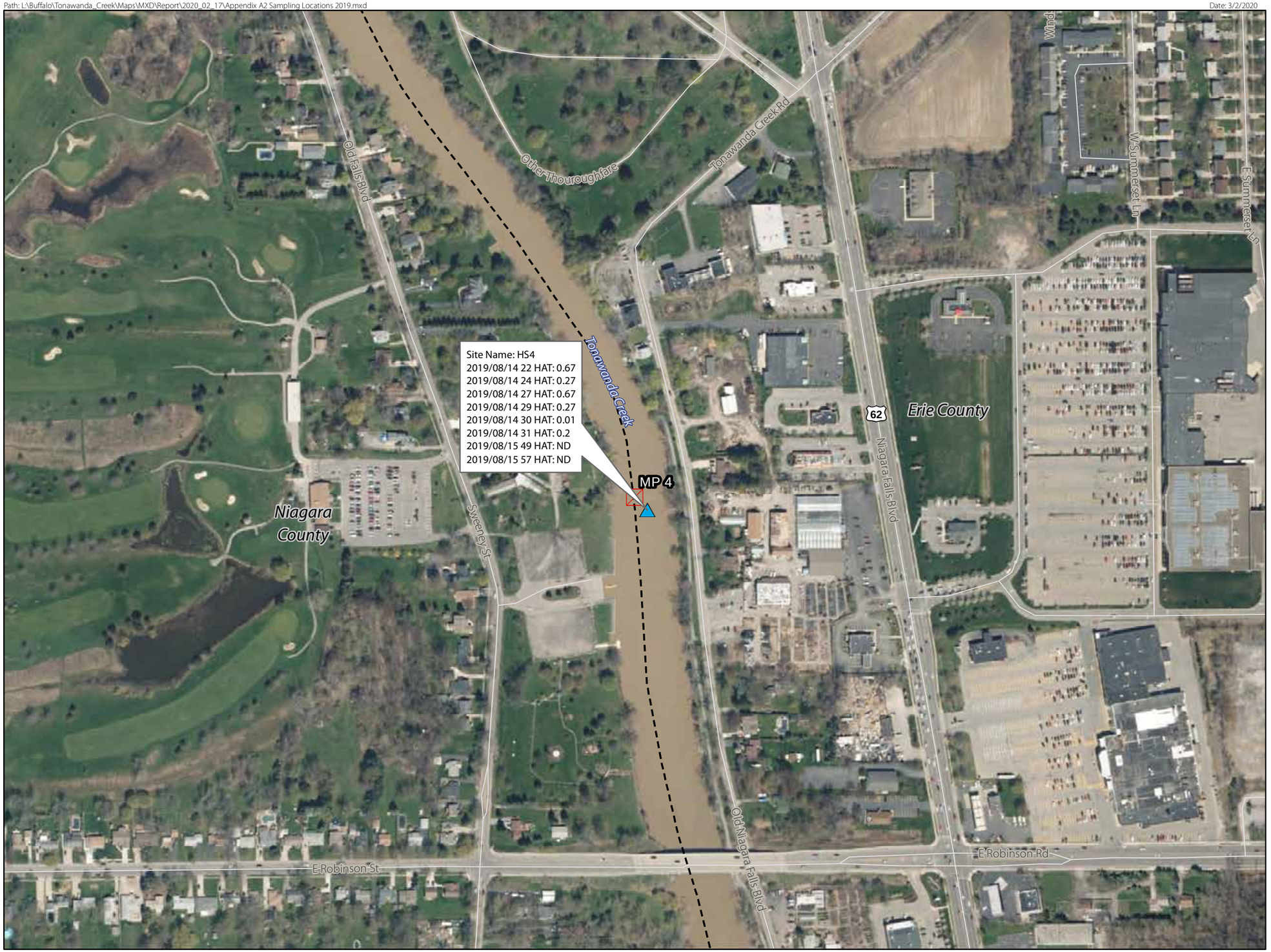
SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018;
Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A2 Sampling Locations 2019.mxd

Date: 3/2/2020



August Endothall (Aquathol®K) Spot Treatment
Figure A2- 4
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- August Sample Locations 2019
- Mile Post
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018; Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A2 Sampling Locations 2019.mxd

Date: 3/2/2020

August Endothall (Aquathol®K) Spot Treatment
Figure A2- 5
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- August Sample Locations 2019
- August Endothall (Aquathol®K) Spot Treatment
- Mile Post
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

N

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018;
Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A2 Sampling Locations 2019.mxd

Date: 3/2/2020

August Endothall (Aquathol®K) Spot Treatment
Figure A2- 6
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- August Sample Locations 2019
- August Endothall (Aquathol®K) Spot Treatment
- Mile Post
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

N

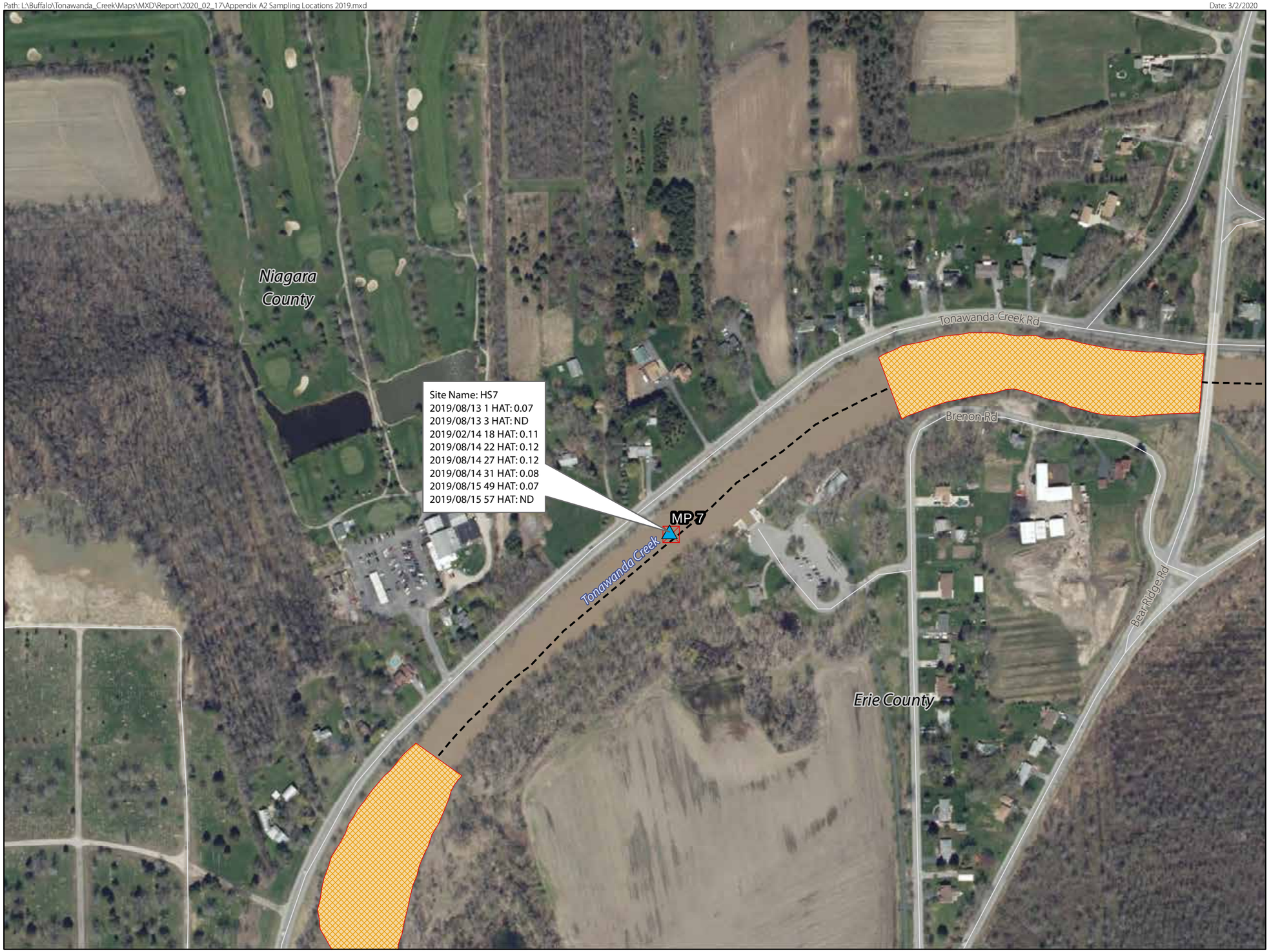
SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018;
Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A2 Sampling Locations 2019.mxd

Date: 3/2/2020



August Endothall (Aquathol®K) Spot Treatment
Figure A2- 7
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- August Sample Locations 2019
- August Endothall (Aquathol®K) Spot Treatment
- Mile Post
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

N

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018;
Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A2 Sampling Locations 2019.mxd

Date: 3/2/2020

August Endothall (Aquathol®K) Spot Treatment
Figure A2- 8
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- August Sample Locations 2019
- August Endothall (Aquathol®K) Spot Treatment
- Mile Post
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

N

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018; Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A2 Sampling Locations 2019.mxd

Date: 3/2/2020

August Endothall (Aquathol®K) Spot Treatment
Figure A2- 9
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- August Sample Locations 2019
- August Endothall (Aquathol®K) Spot Treatment
- Mile Post
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

N

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018;
Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A2 Sampling Locations 2019.mxd

Date: 3/2/2020

August Endothall (Aquathol®K) Spot Treatment
Figure A2- 10
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- August Sample Locations 2019
- August Endothall (Aquathol®K) Spot Treatment
- Mile Post
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018;
Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A2 Sampling Locations 2019.mxd

Date: 3/2/2020

August Endothall (Aquathol®K) Spot Treatment
Figure A2- 11
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- August Sample Locations 2019
- August Endothall (Aquathol®K) Spot Treatment
- Mile Post
- County Boundary
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

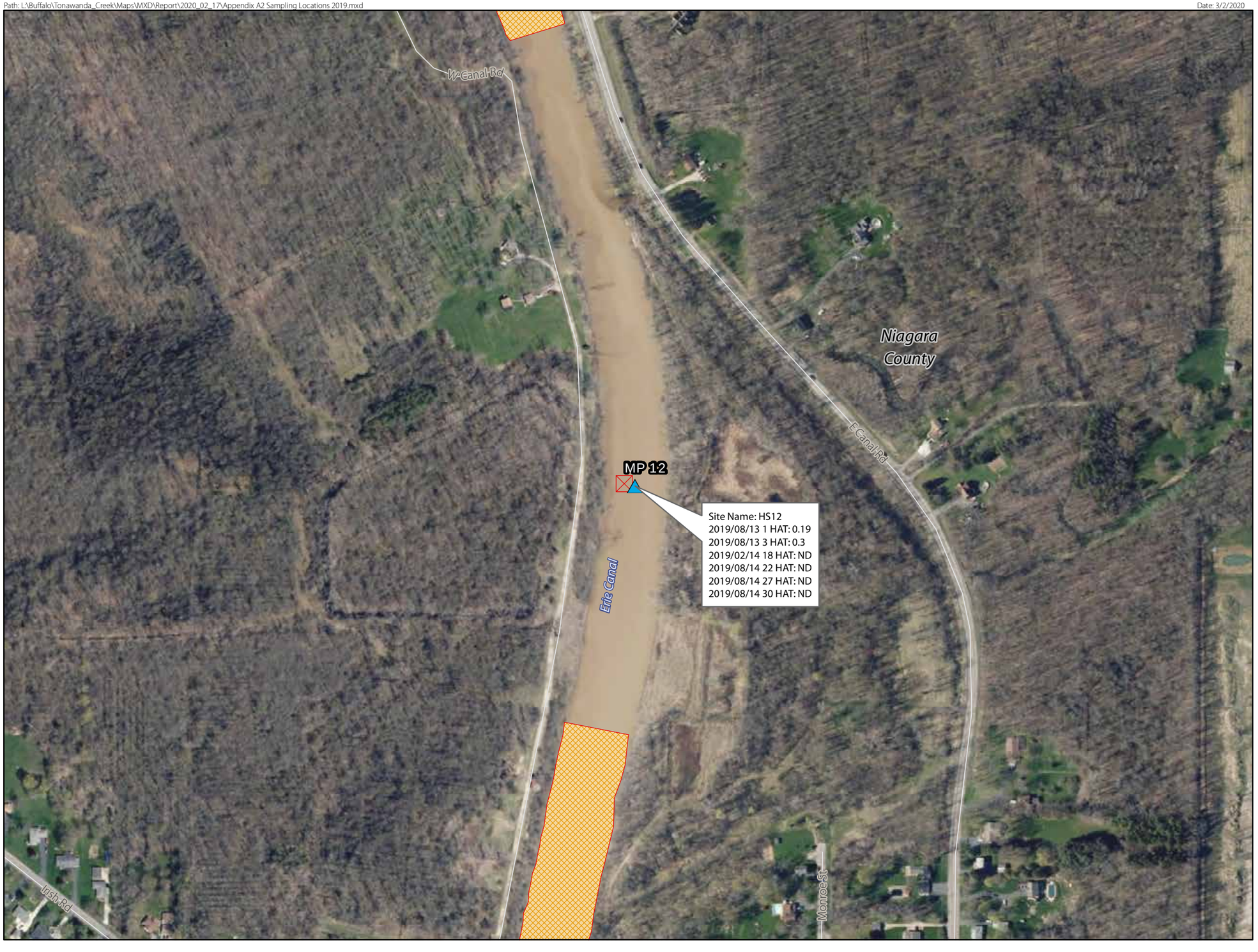
SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018;
Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A2 Sampling Locations 2019.mxd

Date: 3/2/2020



August Endothall (Aquathol®K) Spot Treatment
Figure A2- 12
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- August Sample Locations 2019
- August Endothall (Aquathol®K) Spot Treatment
- Mile Post
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

N

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018;
Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A2 Sampling Locations 2019.mxd

Date: 3/2/2020

August Endothall (Aquathol®K) Spot Treatment
Figure A2- 13
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- August Sample Locations 2019
- Mile Post
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

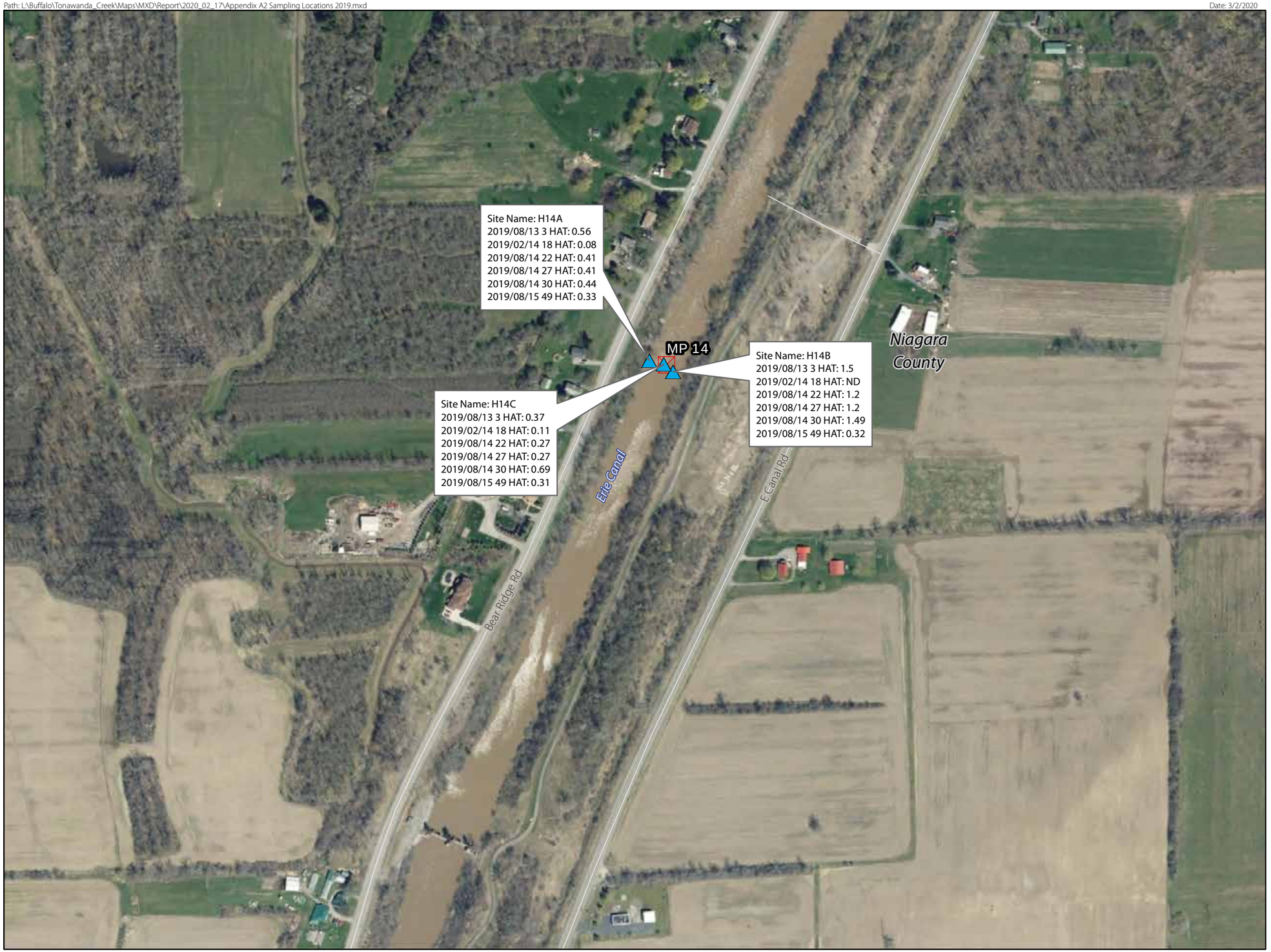
SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018;
Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A2 Sampling Locations 2019.mxd

Date: 3/2/2020



August Endothall (Aquathol®K) Spot Treatment
Figure A2- 14
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- August Sample Locations 2019
- Mile Post
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

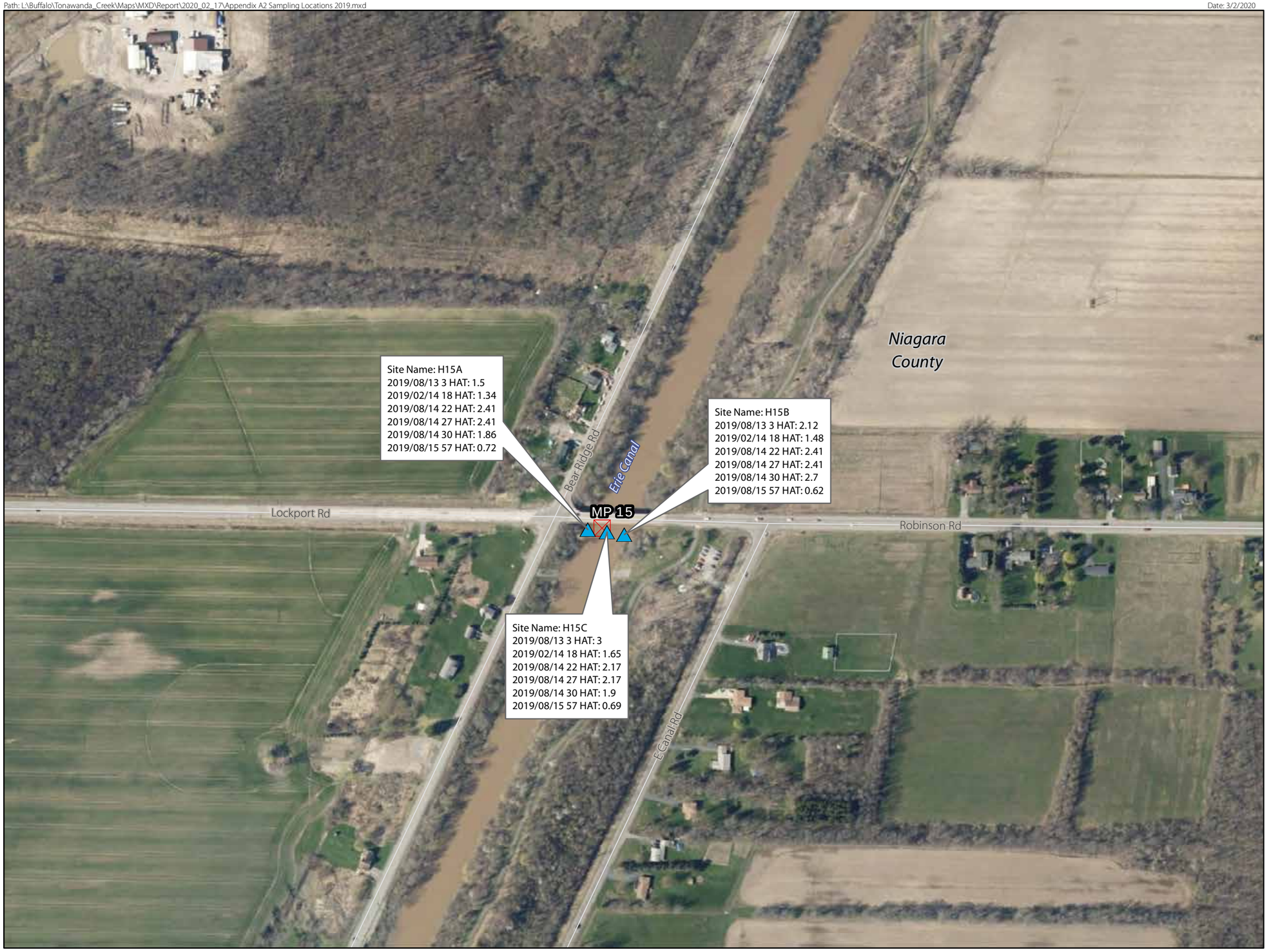
SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018; Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A2 Sampling Locations 2019.mxd

Date: 3/2/2020



August Endothall (Aquathol®K) Spot Treatment
Figure A2- 15
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- August Sample Locations 2019
- Mile Post
- Roadway

*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

SCALE

0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018;
Ecology and Environment, Inc. 2020; USACE ERDC 2018.

Path: L:\Buffalo\Tonawanda_Creek\Maps\MXD\Report\2020_02_17\Appendix A2 Sampling Locations 2019.mxd

Date: 3/2/2020

August Endothall (Aquathol®K) Spot Treatment
Figure A2- 16
Tonawanda Creek/Erie Canal
Erie and Niagara Counties, New York

Legend

- August Sample Locations 2019
- Mile Post
- Roadway

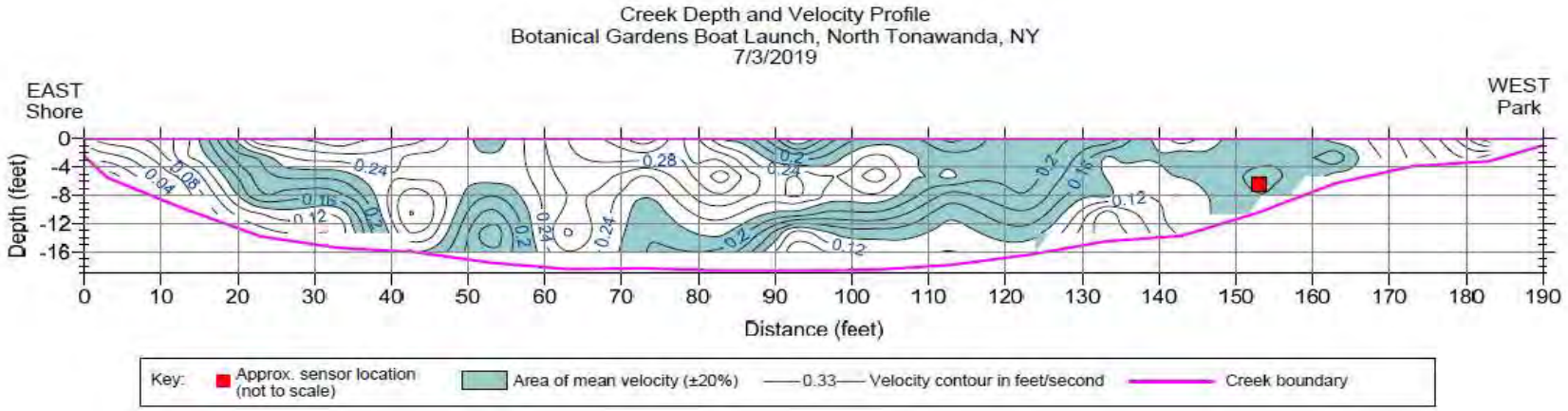
*Note: All sample locations are approximate
HAT- Hours After Treatment
ND- Non-Detect

SCALE

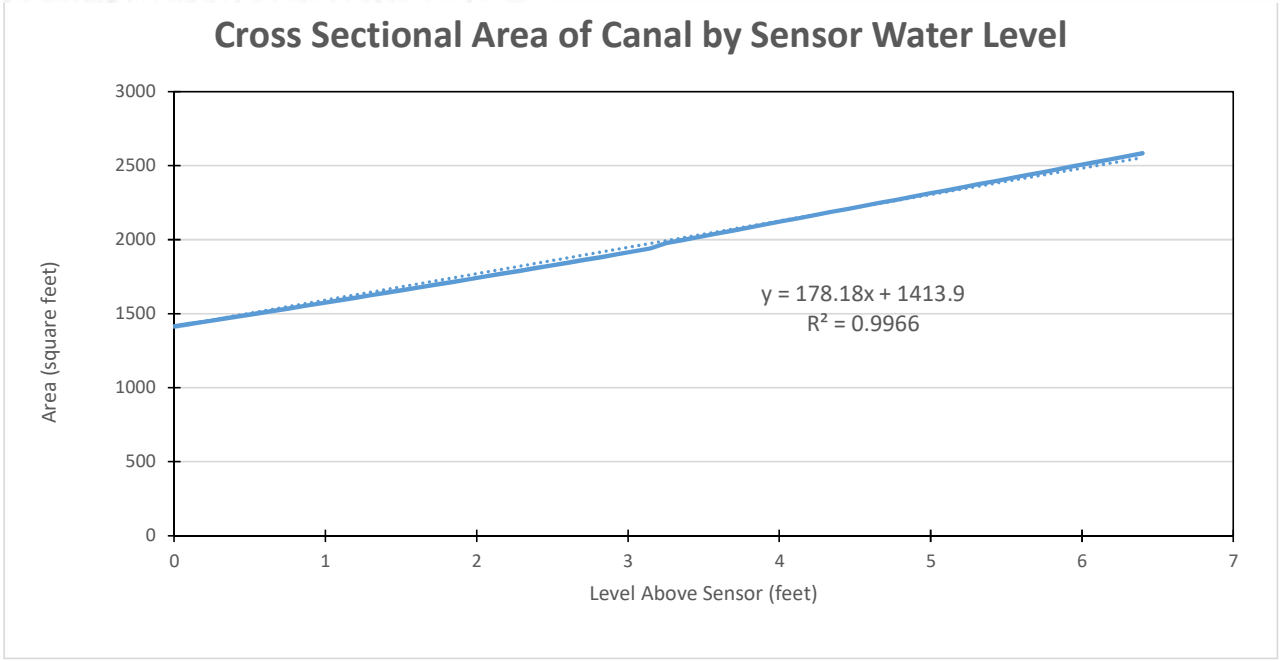
0 0.05 0.1 Miles

SOURCE: ESRI 2012; ESRI 2018;
Ecology and Environment, Inc. 2020; USACE ERDC 2018.

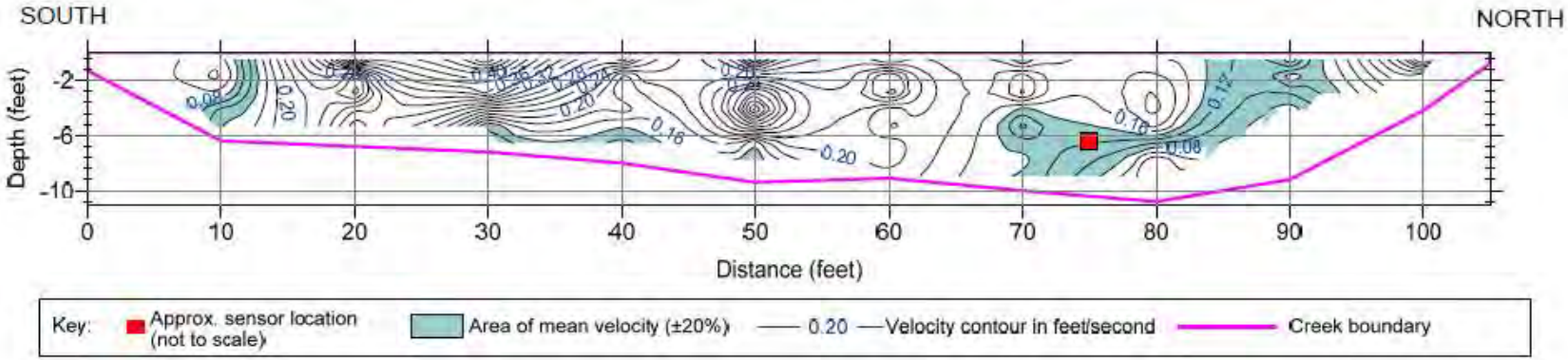
B Creek Cross Sections at Monitoring Locations



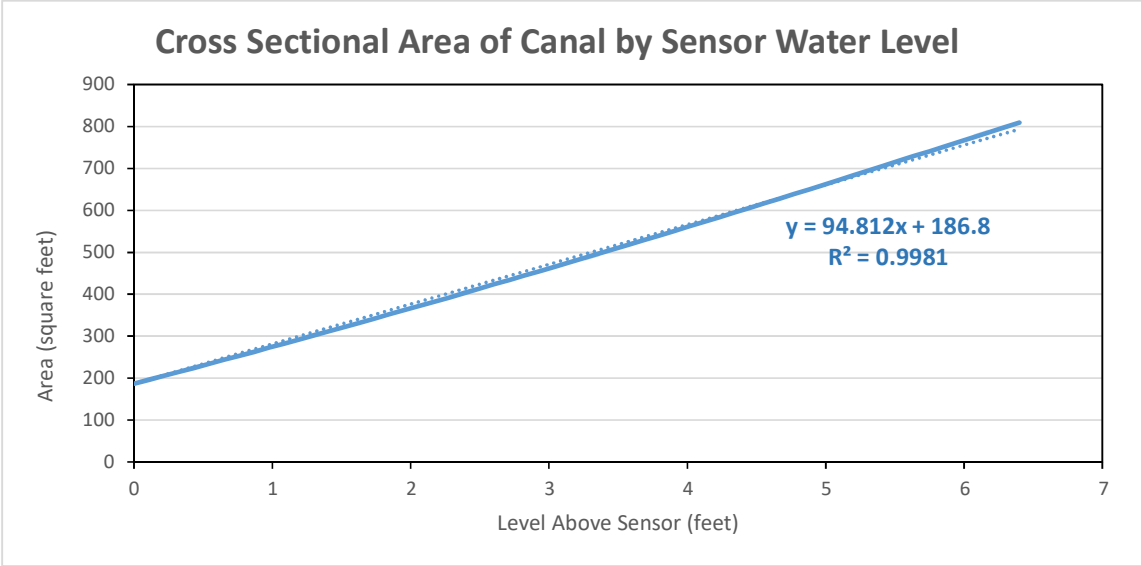
Predicted sensor location: 40' off west bank, 4' off bottom

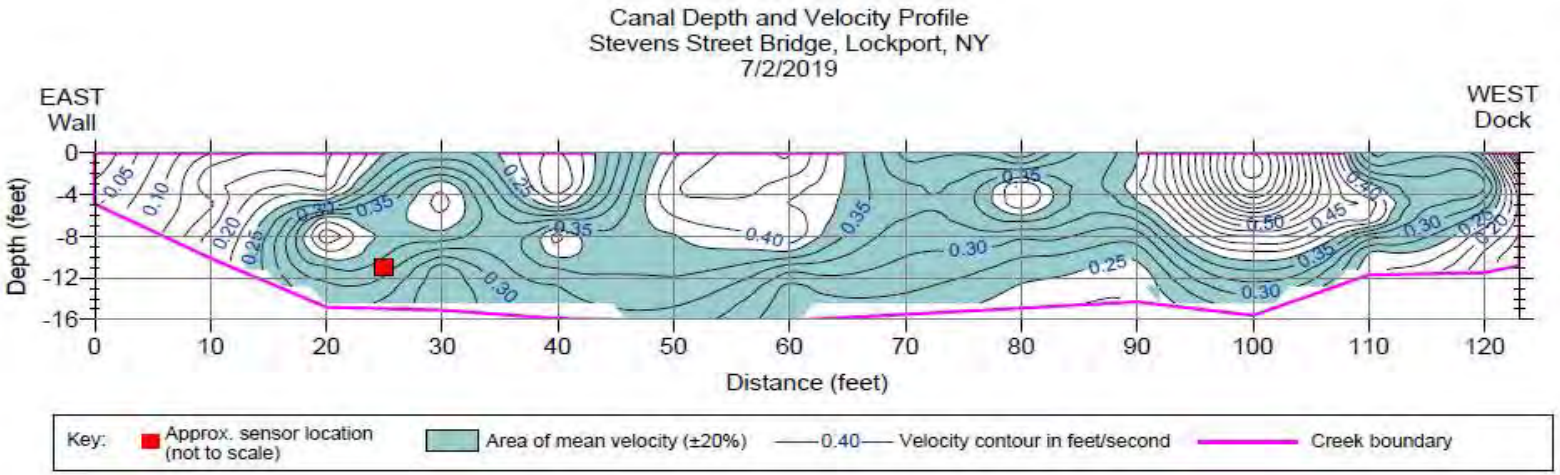


Creek Depth and Velocity Profile
New Road Bridge, Pendleton, NY
7/2/2019

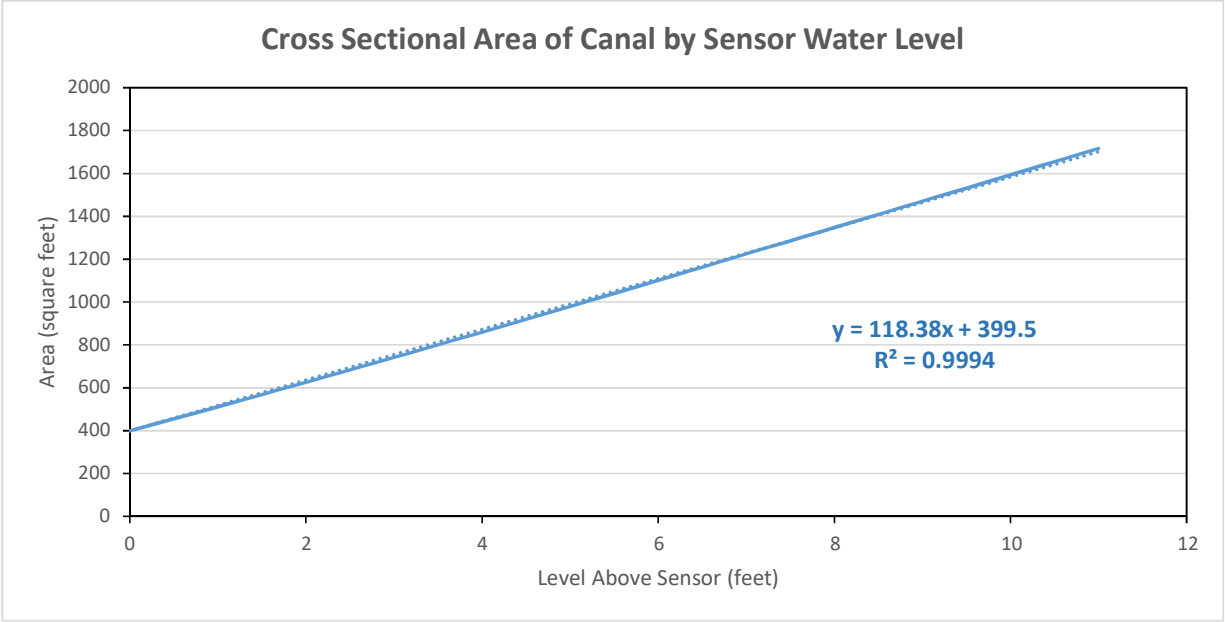


Predicted sensor location: 30' off north bank, 4' off bottom

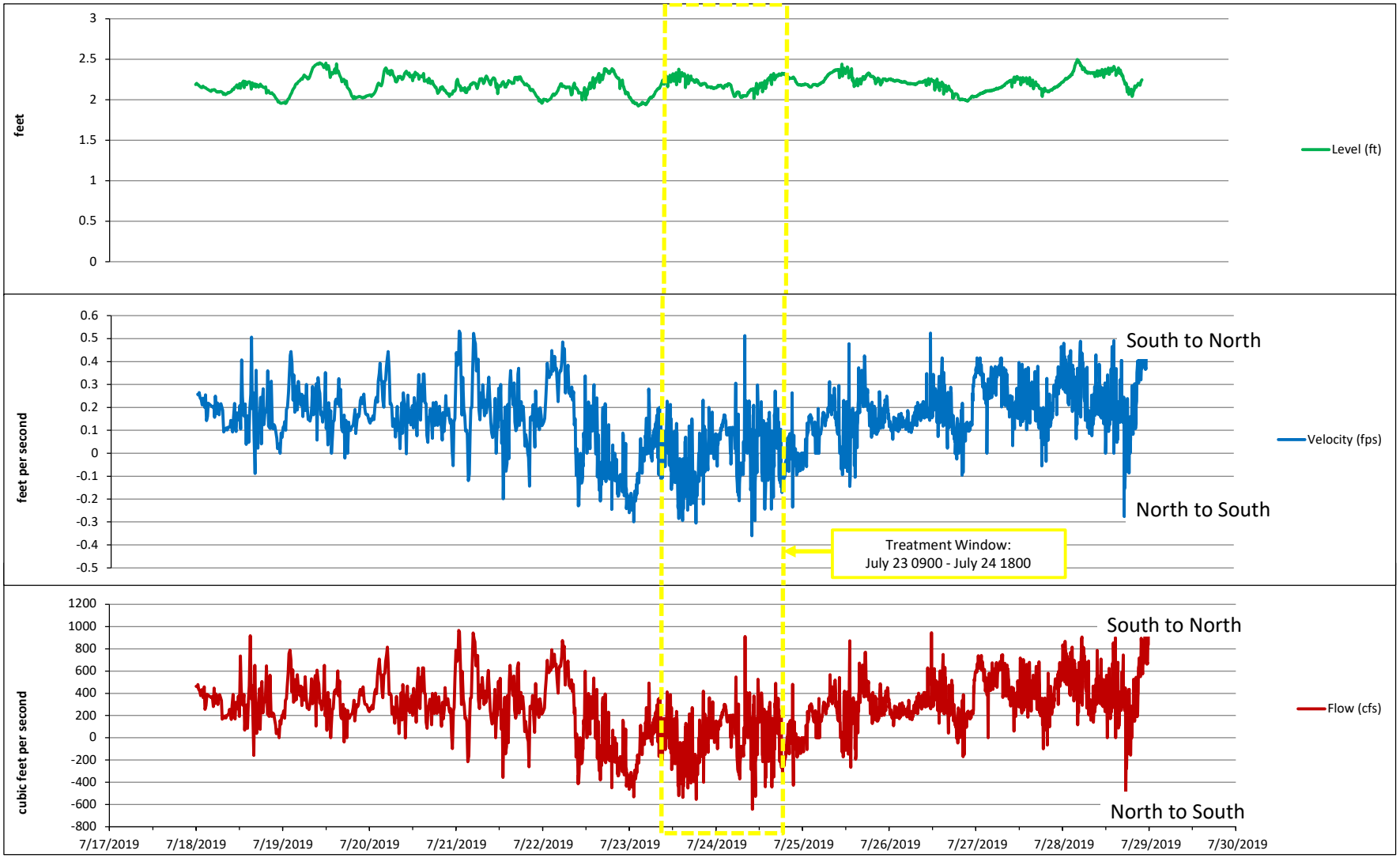




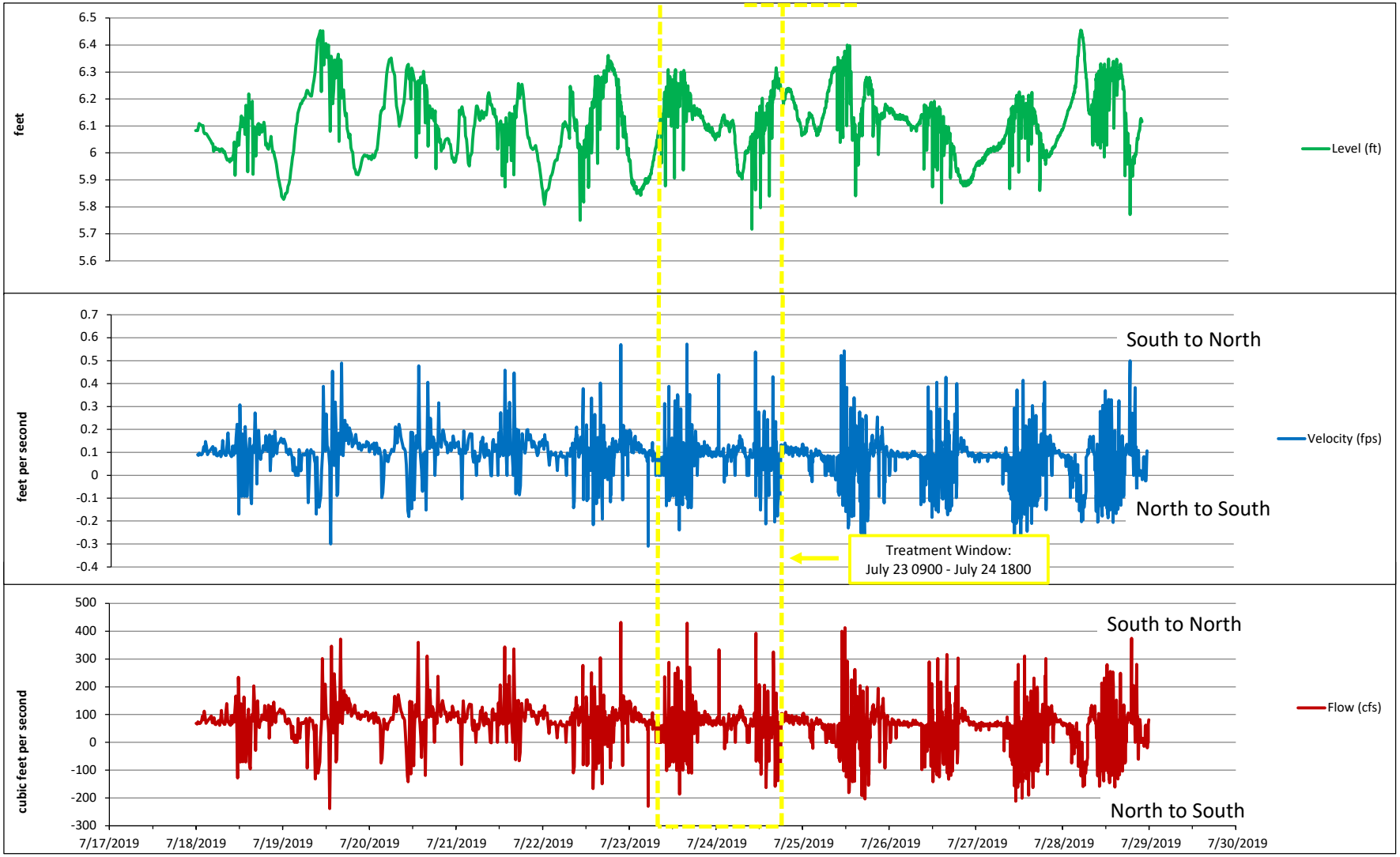
Predicted sensor location: 25' off east wall, 4' off bottom



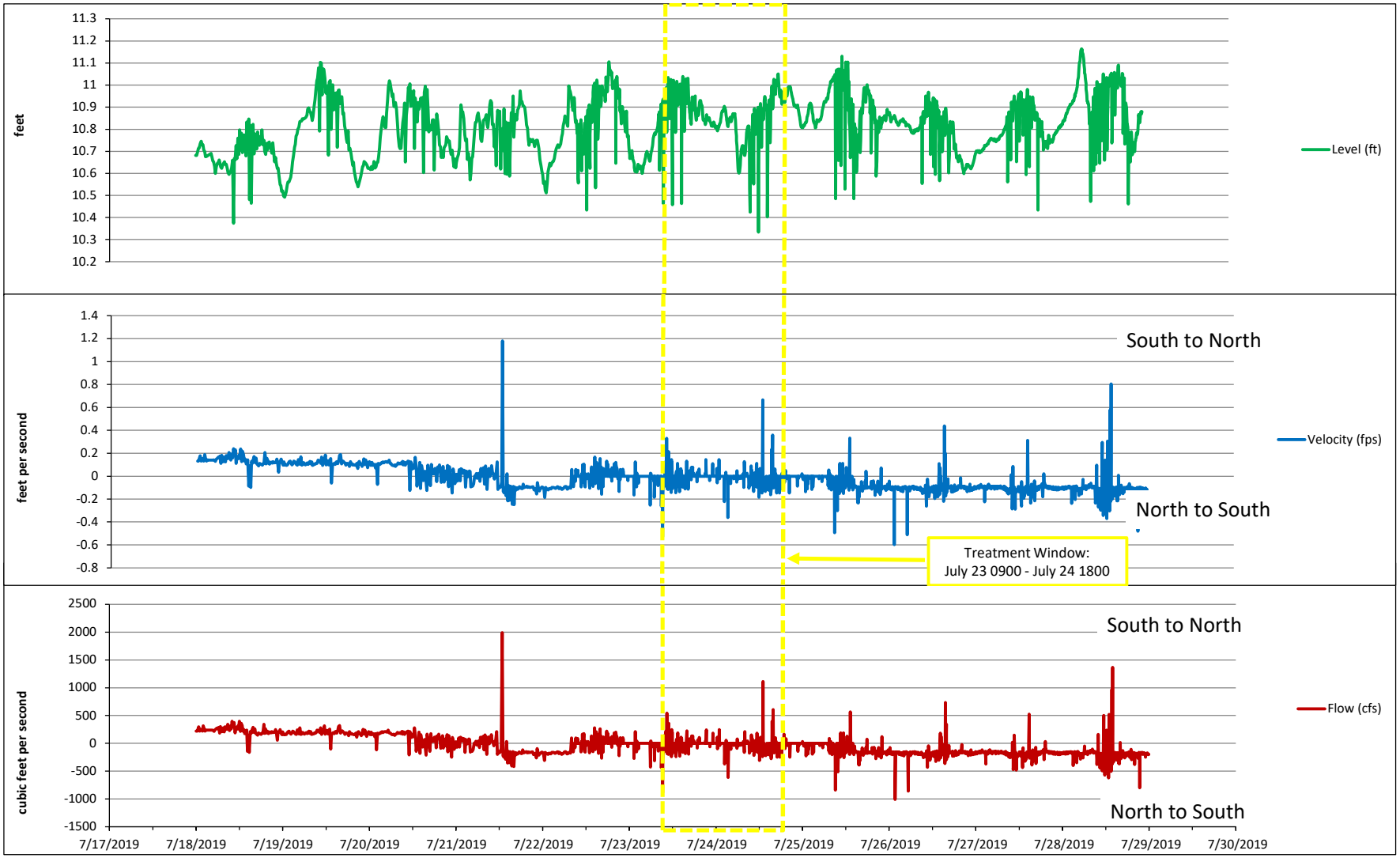
C Flow Meter Data and Water Level Graphs



Summary of Flow Data and Water Levels for Tonawanda Creek at North Tonawanda Botanical Gardens (July 18th - July 28th, 2019)



Summary of Flow Data and Water Levels for Tonawanda Creek at East Canal Road/New Road Bridge in Pendleton (July 18th - July 28th, 2019)



Summary of Flow Data and Water Levels for Tonawanda Creek at Stevens Street bridge in Lockport (July 18th - July 28th, 2019)