Results of Fisheries and Oceans Canada's 2017 Asian Carp Early Detection Field Surveillance Program

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RESULTS OF FISHERIES AND OCEANS CANADA'S 2017 ASIAN CARP EARLY DETECTION FIELD SURVEILLANCE PROGRAM

by

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In 2017, Fisheries and Oceans Canada's Asian Carp Program continued early detection field surveillance for Asian carps in Canadian waters of the Great Lakes. Four crews sampled 1 051 sites from spring to fall at 30 locations in tributaries and connecting channels within the basin. Seven gear types were used to target large-bodied and small-bodied fishes in habitats well-suited to different life stages of Asian carps. A total of 50 893 fishes were captured, representing 87 species. Surrogate species that share similar habitats and feeding preferences to Asian carps were used to assess the effectiveness of the gear types and sampling techniques. Captured surrogates included 887 buffalo (*Ictiobus* spp.) and 1 955 Common Carp (*Cyprinus carpio*). No Asian carps were detected during the early detection surveillance work in 2017. The Toronto Region and Conservation Authority sampled a further 160 sites in five waterbodies targeting Asian carps. Additionally, DFO sampled 43 sites with two gear types to search for eggs and larval Asian carps. In 2018, the Asian Carp Program will continue to sample areas that are high risk for the arrival of Asian carps in Canadian waters of the Great Lakes.

RÉSUMÉ

Colm, J., Marson, D. and Cudmore, B. 2019. Results of Fisheries and Oceans Canada's 2017 Asian Carp Early Detection Field Surveillance Program. Can. Manuscr. Rep. Fish. Aquat. Sci. 3168 vi+ 69 p.

En 2017, le Programme sur la carpe asiatique de Pêches et Océans Canada a poursuivi ses activités de détection précoce des carpes asiatiques dans les eaux canadiennes des Grands Lacs. Quatre équipes ont échantillonné 1 051 sites, du printemps à l'automne, dans 30 emplacements situés dans les affluents et voies interlacustres du bassin. Sept types d'engins ont été utilisés pour cibler les espèces de gros et de petits poissons dans des habitats qui conviennent aux différents stades de vie des carpes asiatiques. Au total, 50 893 poissons ont été capturés, représentant 87 espèces. Des espèces de remplacement qui ont des habitats et des préférences alimentaires similaires à ceux de la carpe asiatique ont été utilisées pour évaluer l'efficacité des types d'engins et des techniques d'échantillonnage. Les espèces de remplacement capturées comprenaient 887 buffalos (*Ictiobus* spp.) et 1 955 carpes communes (*Cyprinus carpio*). Aucune carpe asiatique n'a été détectée lors des travaux de détection précoce en 2017. L'Office de la protection de la nature de Toronto et de la région a échantillonné 160 sites supplémentaires dans cinq plans d'eau dans le but de détecter les carpes asiatiques. De plus, le MPO a échantillonné 43 sites en utilisant deux types d'engins afin de trouver des œufs et des larves des carpes asiatiques. En 2018, le Programme de la carpe asiatique continuera d'échantillonner des zones représentant un risque élevé pour l'arrivée de carpes asiatiques dans les eaux canadiennes des Grands Lacs.

PREFACE

Fisheries and Oceans Canada's Asian Carp Program has conducted early detection surveillance for Asian carps around the Great Lakes Basin since 2013. The program has worked to improve sampling protocols and identify early detection sites in areas considered suitable for Asian carps that can be sampled effectively with a suite of gear types. Asian Carp Program surveillance data summary reports like this one have been produced each year since 2013 identifying the changes in methods and locations that have taken place. As 2017 marks the fifth year of sampling, standard protocols have been realized, and methods and sampling locations are not expected to change greatly from year to year. The Asian Carp Program will continue early detection surveillance around the Great Lakes basin for the foreseeable future. As such, shorter data summaries will be produced each year as a sub-series to this report. Any changes to methodology or sampling locations will be noted in the data summary reports; however, readers will be referred back to this report for detailed descriptions of methods. An in-depth report is planned for every five years, which will highlight major changes and updates to the program as well as present cumulative summaries from the previous five years as an appendix.

INTRODUCTION

The focus of Fisheries and Ocean's Canada's (DFO) Asian Carp Program is to prevent the entry and establishment of Asian carps in the Great Lakes through outreach, early detection, response and management. The Asian Carp Program's early detection surveillance field sampling program was developed in the winter of 2012 and sampling was initiated in the spring of 2013 (Marson et al. 2014). This component of the program involves extensive sampling of targeted sites using traditional fisheries sampling gear types. Field sampling has continued since 2013 and expanded annually, with 2017 marking the fifth year of early detection surveillance.

The early detection of aquatic invasive species is essential for preventing their establishment in aquatic environments, as the sooner a species is detected, the more management response options are available to address the issue (Lodge et al. 2006; Vander Zanden et al. 2010). Using a variety of fish sampling equipment and techniques, the early detection field program surveys sites in tributaries of the Canadian side of the Great Lakes that have been identified as the most suitable and at highest risk for the arrival and establishment of Grass Carp (*Ctenopharyngodon idella*), Silver Carp (*Hypophthalmichthys molitrix*), Bighead Carp (*H. nobilis*) and Black Carp (*Mylopharyngodon piceus*) (Cudmore et al. 2012). Members of the genus *Ictiobus*[1] (referred to as buffalo throughout this report) and Common Carp (*Cyprinus carpio*) are used as surrogate species to assess the effectiveness of sampling efforts as they are large-bodied, mobile species that are widely distributed through the Great Lakes, occupy similar habitats and have similar feeding strategies to Asian carp species (Dettmers and Creque 2004, ACRCC 2014).

In addition to early detection of Asian carps, another goal of the field program is to establish baseline fish community data in parts of the Great Lakes likely to be used and impacted by these species. This will allow scientists to quantitatively assess their impacts, should they establish, and to help provide restoration targets. Additionally, all four species of Asian carp feed on different components of the food web and, thus, will not compete with one another. It is vital to collect data on the whole fish community to capture the full range of impacts that are expected from any or all of these species.

From May 23rd to October 26th, 2017, 30 waterbodies that included wetlands, tributary rivers and interconnected waters were sampled by the Asian Carp Program's early detection surveillance field crews in the Canadian waters of the Great Lakes. The fish community present in each sampling area was assessed, with a focus on the detection of Asian carps and surrogate species. An additional five waterbodies around Toronto were sampled by the Toronto and Region Conservation Authority (TRCA) targeting Asian carps following DFO protocols to supplement DFO's sampling (Appendix 1). Following detections of Grass Carp eggs in the Sandusky River, a tributary of Lake Erie (Embke et al. 2016), DFO's Asian Carp Program also conducted targeted sampling for Asian carp eggs and larval fishes (Appendix 2). This report summarizes the Asian Carp Program's 2017 sampling effort.

METHODS

To identify areas in the Great Lakes basin most suited to Asian carps, spatial modelling was conducted using variables important to their reproductive biology (Nicholas Mandrak, University

[1] Note: *Ictiobus* spp. hybridize in the Great Lakes and are often indistinguishable as separate species. For ease of reporting, they are all considered buffalo species in this report.

of Toronto Scarborough, 1265 Military Trail, Toronto, Ontario, M1C 1A4, unpublished data). Modelled variables included hydrograph and water velocity data, water temperature data and unimpounded river length. These variables are important to cue movement up river, for initiating spawning, maintaining the eggs in suspension and achieving development (Kocovsky et al. 2012 and references therein). A total of 57 tributaries on the Canadian side of the Great Lakes were identified as suitable or highly suitable for Asian carps. These sites were ground-truthed for habitat and sampling suitability before being considered early detection surveillance sites. Sites may be deemed unsuitable for sampling due to access, depth, substrate, vegetation density or the size of the waterbody. Additionally, large, shallow, productive wetlands around the basin were also selected for surveillance due to the abundance of food, particularly submerged aquatic vegetation important for Grass Carp.

Since the field program began in 2013, surveillance has expanded to cover 36 early detection sites in all four Canadian Great Lakes across three seasons (Figure 1). Within these 36 early detection surveillance sites, standardized field sites were selected that are sampled every year with the same gear type. There are approximately 900 standardized field sites across the Great Lakes basin. Additionally, targeted field sites are selected that reflect suitable habitat patches that may change year to year (i.e. due to changes in water level, new woody debris objects, etc.). Maps of standardized and targeted sampling locations at each early detection surveillance site are found in Appendix 3.

Seven gear types were used to sample the early detection surveillance sites: boat electrofishing units, fyke nets, hoop nets, seine nets, trammel and tied-down gill nets, and trap nets. This variety of gear types targeted both large and small-bodied fishes in a variety of habitats. Sampling the full breadth of the fish community increases the likelihood of detecting all four species of Asian carps, at both juvenile and adult life-stages. Additionally, it provides valuable baseline fish community data from around the basin. Descriptions of each gear type and the standard effort are found below.

BOAT ELECTROFISHER

Boat electrofishing was conducted using two sizes of vessels. Crews operated with a 21’ extra-heavy duty model Smith-Root Electrofishing boat and a 24’ Henley jon boat. Both were equipped with a 7.5 kilowatt Generator Powered Pulsator (GPP) and dual-anode booms. Boats operated with two netters who would retrieve stunned fishes and transfer them into a live-well in the boat. Sampling effort was recorded as seconds shocked for each site. Electrofishing effort was standardized to approximately 600 seconds per site.

FYKE NET SAMPLING

Box fyke nets with a 0.32 mm ace mesh size, 0.61 m hoop diameter, 0.61 m by 4.6 m lead length and 0.61 m by 1.3 m wing length were deployed. The fyke nets include a 10.16 cm square nylon mesh modification on the net entrance to reduce the catch of large snapping turtles. Fyke nets were set in wadeable habitats (<1.5 m water depth), with low or no flow, and on a variety of vegetation and substrate types. Fyke nets were set with the lead attached to shore and the net pulled taut perpendicular to the shoreline. When the water depth was greater than the net depth, a float was placed within the cod-end of the net to ensure that captured turtles had access to air. Fyke nets were set for approximately 24 hours.

HOOP NET SAMPLING

Three sizes of hoop nets were deployed in 2017 in habitats that could not be sampled by other gear types due to depth restrictions or flowing water. Three foot diameter hoop nets with a length of 4.57 m with two funnels and 2.54 cm bar mesh were set in flowing waters between approximately 1.5 m and 3.5 m depth. Five foot (6.1 m length and 2.54 cm bar mesh) and six foot diameter (6.7 m length and 6.35 cm bar mesh) hoop nets were set in deeper (i.e. >3.5m) flowing water. Hoop nets are frequently used in efforts in the Mississippi watershed for the removal of Asian carps. Hoop nets were set with the open end of the net facing downstream. The cod-end of the net was tied to an anchor that was set upstream, using the flow of the water to keep the net deployed. Hoop nets were typically set for 48 hours.

SEINE NET SAMPLING

A bag seine 9.14 m long, 1.52 m tall, with 3.18 mm ace mesh in the bag and 4.76 mm ace mesh on the wings was used for sampling wadeable, low-flow habitats, with moderate vegetation. In flowing waters, seining was performed in the direction of the flow. Captured fishes were transferred into bins filled with water. Generally, three hauls were conducted to target small-bodied fishes.

TRAMMEL NET AND TIED-DOWN GILL NET SAMPLING

Trammel nets and tied-down gill nets were deployed in a length of 182.9 m with inner gill-net mesh sizes ranging from 8.89 cm to 10.16 bar mesh (17.78 cm to 20.32 cm stretch mesh sizes) and a net depth of 4.2 m. The trammel nets have two additional panels of netting that sandwich the inner gill net panels. The outer netting is 45.72 cm bar mesh nylon netting that works to bag large-bodied fishes in the net (fishes too large to be captured by the inner monofilament gill netting). The tied-down gill nets have nylon netting every 1.52 m to compress the nets. Tying the nets leaves them looser in the water column, making them more effective for bagging larger fish. Tied-down gill nets were used in place of trammel nets when water clarity was high and the more frequent nylon netting of the trammel would be visible to fishes. Both net types were used to target large-bodied fishes in nearshore habitats.

A net is set to the shore and run perpendicular out from shore approximately 20-30 m. The boat is then turned and 120-140 m of net is deployed parallel to shore, and then the final 20-30 m is deployed perpendicular back into shore. This deployment technique blocks fishes into the enclosed area. Heavily vegetated areas can be sampled if the net is deployed on the outer margins of the vegetation so that it would cover the full depth of the water column. Setting the net in very heavy vegetation would limit its effectiveness as the lead-line would not always push through the vegetation and would be held up off bottom, allowing fishes to escape below the lead-line.

Once the net is set, the boat enters the blocked-off area and uses a trimmed-up motor to create disturbance in the water. Additionally, crew members use modified plungers to “pound” the area. Revving the engine, banging the hull of the vessel, or pounding the water’s surface with plungers actively frightens fishes in an attempt to get them to flee in the direction of the net. This method, referred to as “pounding”, was developed by researchers working in the Mississippi watershed on the removal of Asian carps, which are known to be net avoidant species (ACRCC 2014). When possible, boat electrofishing was used in tandem with the trammel nets to disturb the

blocked area and cause fishes to flee into the set net. The electrofishing crew would dip net any fishes that were stunned by the electrofishing boat.

This sampling method provides several advantages over traditional gill netting methods, including reduced set times, which reduces stress on captured fishes; increased catch of sedentary fishes; and, allows for an increased number of sites to be sampled per day. Trammel nets were set for a short amount of time (effort standardized to approximately 20 minutes) in order to minimize the entanglement time of fishes. Sampling effort was recorded as the amount of time from when the net was fully deployed, to the point when crews starting pulling the net back into the boat.

TRAP NET SAMPLING

Trap nets, with a mesh size of 2.54 cm, 1.2 m depth, a 27.43 m long lead and two wings 3 m long by 1.2 m deep were used to sample areas with low to no flow on a variety of substrate types. Trap nets were set in similar habitats as fyke nets, but the coarser mesh and larger net size targeted larger-bodied fishes. Trap nets required deeper water than fyke nets (i.e. a minimum of 1.2 m set depth) in order to deploy properly. Trap nets were set with the lead attached to shore then the net was pulled taut and deployed perpendicular to the shoreline. A float was added to the net to provide access to the surface for any captured turtles. Trap nets were set for a standardized time of approximately 24 hours.

FISH AND HABITAT DATA COLLECTION

Captured fishes were identified, measured (total length) and returned to the water near the site of capture. Voucher specimens were preserved in 10% formalin for species requiring laboratory verification. Digital vouchers were taken of each species based on DFO vouchering protocols (Mandrak and Bouvier 2014). GPS coordinates and habitat data, including water and air temperature (°C), dissolved oxygen (mg/L), conductivity (µS/cm), pH, turbidity (NTU), wind speed (km/h), water depth (m), sampling distance from shore, number of coarse woody debris objects, substrate percent composition (Wentworth Scale (Wentworth 1922)) and aquatic vegetation type and percent cover, were recorded for each site.

RESULTS

In 2017, DFO's Asian Carp early detection field surveillance program sampled 1 051 sites across 30 waterbodies in Canadian waters of the Great Lakes basin. In total, 228 field sites were sampled in Lake Huron, 203 in the Huron-Erie Corridor, 462 sites in Lake Erie, and 59 in Lake Ontario.

A total of 50 893 fishes were captured in 2017, representing 87 species (Table 1). The mean numbers of fishes and species per waterbody were 1 696 and 31, respectively. The mean numbers of fishes and species captured per site were 48 and 6, respectively. The waterbody that yielded the greatest mean number of fishes per site sampled was Big Creek with 82 fishes; while Credit River yielded the fewest, nine fishes per site (Table 2). Bayfield River yielded the greatest mean number of species per site, nine; while the Credit River yielded a mean of two species per site. Of the species captured, the most abundant were Gizzard Shad (*Dorosoma cepedianum*) with 11 773 fishes (~23.1% of all fishes captured), Bluegill (*Lepomis macrochirus*) with 5 197

fishes (~10.2%), Brown Bullhead (*Ameiurus nebulosus*) with 3 632 fishes (~7.1%), Pumpkinseed (*Lepomis gibbosus*) with 2 751 fishes (~5.4%) and Emerald Shiner (*Notropis atherinoides*) with 2 678 fishes (~5.3%) (Table 3).

Boat electrofishing was the most used gear type (343 sites), while the seine net was the least used gear type (18 sites) (Table 4). The gear that yielded the greatest mean number of fishes per site was the seine net, with approximately 167 fishes per site, on average; while tied-down gill nets yielded the fewest, a mean of one fish per site. Boat electrofishing yielded the greatest mean number of species detected per site (10); while tied-down gill nets yielded only one species, on average, per site (Table 4).

BOAT ELECTROFISHER

Boat electrofishing was conducted at 343 sites across 29 waterbodies. A total of 212 157 seconds of shocking were completed, with a mean of 619 seconds per site (Table 4). The greatest amount of shocking effort was conducted in the Grand River (17 370 seconds across 28 sites), while the least amount of shocking was conducted in the Pine River (600 seconds at one site) (Table 5). The Credit River was the only waterbody where boat electrofishing was not conducted.

A total of 26 763 fishes were caught with this gear type, with a mean of 78 fishes per site sampled (Figures 2 and 3). Seventy-nine species were detected by boat electrofishing, with a mean of 10 species detected per site sampled (Figure 4). In total, 257 buffalo and 1 174 Common Carp were captured using boat electrofishing (Figure 5).

FYKE NET

Fyke nets were set at 265 sites in all 30 waterbodies sampled. Fykes were set for a total of 5 702 hours, with a mean of 21.5 hours per site (Table 4). The greatest amount of fyke net effort was conducted in the Welland River (535 hours across 25 sites); while the least amount of fyke net effort was conducted in Big Creek (23 hours at one site) (Table 5).

In total, 15 040 fishes were captured in fyke nets, with a mean of 57 fishes per site (Figures 2 and 3). Seventy-four species were detected in fyke nets, with a mean of six species per site (Figure 4). One buffalo and 48 Common Carp were detected in fyke nets (Figure 5).

HOOP NET

Hoop nets were set at 41 sites in 10 waterbodies. A total of 1 640 hours of hoop net sampling were completed, with an average set time of 40.0 hours per site (Table 4). The greatest amount of hoop net sampling was conducted in the Grand River (479 hours across 13 sites); while the least amount of hoop net sampling was conducted in the Ausable River (41 hours at one site) (Table 5). Hoop nets were only deployed in deep, flowing rivers: Ausable River, Big Creek, Big Otter Creek, Cedar Creek, Credit River, Detroit River, Grand River, Jeannette's Creek, Thames River, and Welland River.

A total of 371 fishes representing 21 species were captured in hoop nets. One site on the Grand River yielded 252 of these fishes; this outlier site has been removed for the summaries below, leaving 119 fishes from 20 species captured at the other 40 sites. A mean of two fishes and two

species were captured per site (Figures 2 and 3). No buffalo were captured in hoop nets, but four Common Carp were caught with this gear (Figure 5).

Generally, there were minimal differences between the three sizes of hoop net deployed in 2017. The 5’ diameter nets were used at 34 sites, compared to 22 and 26 sites for the 3’ and 6’ nets, respectively. The number of hours of set time was, therefore, also greater with the 5’ nets (1 513 hours compared to 884 and 984 for the 3’ and 6’ nets, respectively). The 3’, 5’ and 6’ diameter nets captured a total of 25, 42, and 52 fishes respectively, with means of two, four, and four fishes per site, respectively. The 3’, 5’ and 6’ nets captured 13, 17, and 12 species, respectively, with means of one, three, and two species per site, respectively. In terms of surrogate species, four Common Carp were caught in hoop nets; three of these were captured in a 5’ net at one site in the Grand River, and the other was captured in a 3’ net on the Thames River. To note, the site with 252 fishes was set with a 5’ hoop net.

SEINE NET

Seine nets were used at 18 sites in nine of the waterbodies sampled. A total of 37 hauls were completed, with an average of 2 hauls per site (Table 4). The most seining effort occurred in the Welland River, with eight hauls conducted across three sites; the least seining effort occurred in the Credit and Maitland rivers, with one haul at one site each (Table 5). Seining only occurred in Bayfield River, Coldwater River, Credit River, Long Point Bay, Maitland River, Pine River, Rouge River, Sauble River, and Welland River.

A total of 3 003 fishes were captured in the seine, with a mean of 167 fishes per site (Figures 2 and 3). Seining captured the most fishes per site of any gear type. Forty-one species were detected while seining, with a mean of nine species per site (Figure 4). One Common Carp was captured in a seine net (Figure 5). No buffalo were captured.

TRAMMEL AND TIED-DOWN GILL NETS

Trammel nets were used at 157 sites in 21 waterbodies. A total of 3 908 minutes of trammel net sampling were conducted, with a mean of 24.9 minutes per site (Table 4). The greatest amount of trammel net sampling was conducted on the Grand River (561 minutes across 18 sites); while sampling was conducted for 15 minutes at one site on the Bayfield River (Table 5).

In total, 1 125 fishes were captured in trammel nets, with a mean of 7 fishes per site (Figures 2 and 3). Sixteen species were detected with this gear type, a mean of two species per site (Figure 4). A total of 558 buffalo and 397 Common Carp were captured in trammel nets (Figure 5).

Tied-down gill nets were used at 30 sites across 10 waterbodies. A total of 696 minutes of sampling occurred, with a mean of 23.2 minutes per site. The most gill net effort was employed in Rondeau Bay with a total of 157 minutes across 4 sites. The least gill net effort was employed in the Pine River, with 15 minutes at one site (Table 3).

A total of 24 fishes were captured in tied-down gill nets, with a mean of one fish per site (Figures 2 and 3). Seven species were detected in tied-down gill nets, with a mean of one species per site (Figure 4). A total of two buffalo and 12 Common Carp were caught with this gear (Figure 5).

TRAP NET

Trap nets were set at 197 sites in all 30 waterbodies sampled. A total of 4 210 hours of trap net sampling was completed, with an average of 21.4 hours per site (Table 4). The greatest amount of trap net effort was conducted in the Welland River, with 456 hours of sampling across 21 sites. The least amount of trap net effort was 21 hours at one site on the Shebeshekong River (Table 5).

A total of 4 567 fishes were caught in the trap net, with a mean of 23 fishes per site (Figures 2 and 3). Forty-three species were detected in trap nets, with a mean of five species per site (Figure 4). A total of 69 buffalo and 319 Common Carp were captured in trap nets (Figure 5).

SURROGATE SPECIES

A total of 2 842 surrogate fishes were detected, of which there were 887 buffalo and 1 955 Common Carp. The buffalo ranged in size from 79 to 900 mm total length, with a mean and median total length of 600 mm and 631 mm, respectively. The most buffalo were captured in the Thames River, where 346 were caught. Buffalo was captured in 15 of 30 waterbodies sampled. It was captured in all three Great Lakes sampled; however, in Lake Huron, it was only detected in the Ausable River. Common Carp ranged in size from 30 to 915 mm total length, with a mean and median total length of 591 mm and 621 mm, respectively. The most Common Carp were captured in Cedar Creek, where 332 were captured. Common Carp was captured in all but three waterbodies sampled (Magnetawan, Mississagi, and Shebeshekong rivers).

Trammel nets captured the most buffalo overall, a total of 558 (~63% of all buffalo captured) (Figure 6). Boat electrofishing was also effective at capturing buffalo, with 257 (~29%) captured in this gear type. Boat electrofishing captured the most Common Carp, with a total of 1 174 (~60% of all Common Carp captured). Trammel nets and trap nets were also effective gears for capturing Common Carp, with a total of 397 (20%) and 319 (16%) individuals captured, respectively.

ASIAN CARPS

No Asian carps were captured during the 2017 early detection surveillance work. A dead Grass Carp (unknown sex and ploidy) was found on a Lake Erie beach near Dunnville, ON in July; and a triploid Grass Carp was captured in a commercial trap net in Lake Huron near Sarnia, ON also in July.

OTHER AQUATIC INVASIVE SPECIES

Other aquatic invasive fish species were captured during DFO's early detection surveillance work targeting Asian carps. This includes 559 Goldfish (*Carassius auratus*); 40 Goldfish x Common Carp hybrids (*Carassius auratus X Cyprinus carpio*); 1 215 Round Goby (*Neogobius melanostomus*); 281 Rudd (*Scardinius erythrophthalmus*); and 23 Tubenose Goby (*Proterorhinus semilunaris*) (Table 2).

SUMMARY

In 2017, DFO's Asian Carp Program early detection surveillance crews sampled 30 waterbodies in the Great Lakes basin identified as highly suitable for Asian carps. Although fewer early detection sites were visited in 2017 compared to previous years, each location was sampled more thoroughly. Seven gear types were used to target large and small-bodied fishes in a variety of wetland and riverine habitats where Asian carps would be likely to arrive. A total of 1 051 field sites were sampled and 50 893 fishes representing 87 species were captured. Fewer fish were captured per sampling event in 2017 compared to previous years (Marson et al. 2014, Marson et al. 2016, Marson et al. 2018, Colm et al. 2018), and this may be due to high water levels in 2017 (Canadian Hydrographic Services Historical monthly mean water levels from the Coordinated network for each of the Great Lakes, http://www.tides.gc.ca/C&A/network_means-eng.html [accessed March 19, 2018]) meaning fish were less concentrated.

Surrogate species for Asian carps (i.e. buffalo and Common Carp) were captured in most gear types; however, buffalo were not captured in a hoop net or seine. This is likely because hoop nets are set in faster flows than buffalo typically occupy, and buffalo are generally large enough to avoid a seine net. Trammel nets, boat electrofishing and trap nets were all very effective at capturing the surrogate species. Buffalo and Common Carp were the 13th and seventh most abundant species, respectively, across all sampling in 2017, suggesting our sampling methods are targeting large-bodied, mobile species appropriately.

There were a few changes to the suite of gears used in 2017 compared to previous years sampling. Trawl nets were deployed in 2013 to 2016 in northern Ontario tributaries (Georgian Bay and Lake Superior) as the rockier, deeper habitats made other gears difficult to deploy. Field crews have done more scouting in these northern areas and have since found locations where the other gears are suitable. As a result, use of the trawl net was discontinued in 2017. Three sizes of hoop net were used in 2017. A small (3' diameter) and a large (5' or 6' diameter) hoop net are both required to target medium to fast flowing habitats at various depth ranges; however, the large, 6' nets used in previous years were cumbersome and difficult to deploy. After testing both large hoop net sizes in 2017, it was determined that the 5' nets yielded similar, if not slightly larger, numbers of fish per set and are much more manageable to set and fish than the 6' hoop nets. The 6' nets will not be used in future early detection surveillance. Although no buffalo and few Common Carp were captured in the hoop net and the seine net, hoop nets target areas that are difficult to sample with other gears and are successful for capturing Asian carps in other parts of North America, while seines are excellent at targeting small-bodied and juvenile fishes unlikely to be captured in passive gears and at targeting habitats that are too shallow or turbid for boat electrofishing to be effective (Poos et al. 2007). Both of these gears remain an important component of the program and more scouting for suitable locations for hoop and seine nets will occur in 2018.

Due to time limitations, sampling in three of the 36 early detection sites was not possible in 2017. The Kaministiqua and Goulais rivers, both in Lake Superior, were not visited. Although Lake Superior is suitable for Asian carps, it is lower risk than sites in lakes Erie, Huron and Ontario (Cudmore et al. 2011, DFO 2017). Sampling these higher risk sites more thoroughly was prioritized in 2017. To date, no Asian carps have been detected in Lake Superior. Unless the

level of threat increases, sampling the Kaministiqua and Goulais rivers is likely to occur every three years. The Toronto Islands were not sampled in 2017 as part of specific early detection surveillance for Asian carps; however, this area was sampled by TRCA as part of their ongoing fisheries monitoring projects. Targeted sampling for Asian carps will occur in this area going forward.

The spawning habitat suitability modeling for Asian carps was recently re-assessed for Canadian tributaries in the Great Lakes to better reflect spawning conditions observed in their invaded range (Nicholas Mandrak, University of Toronto Scarborough, 1265 Military Trail, Toronto, Ontario, M1C 1A4, unpublished data). Early detection sites will be re-evaluated based on this new research and new sites may be scouted or added in 2018.

No Asian carps were detected during the 2017 early detection surveillance program. Two Grass Carp were found in Ontario in July, one in Lake Erie and the other in Lake Huron. Both of these fish were found near existing early detection surveillance sites, suggesting our efforts are directed in the right areas.

In 2018, the Asian Carp Program will continue to conduct early detection surveillance across wetland and riverine habitats in the Great Lakes basin to protect Canadian waters from the threats posed by these invasive fishes.

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TABLES

Table 1 Summary of the 2017 catch data for the Asian Carp Program's early detection surveillance.

Catch Data	
Total number of sites	1 051
Total number of waterbodies	30
Total number of fishes caught	50 893
Total number of species detected	87
Total number of surrogates caught	2 842
Total number of Asian carps caught	0
Mean number of fishes caught per waterbody	1 696
Mean number of fishes caught per site	48
Mean number of species per waterbody	31
Mean number of species per site	6

Table 2 Catch data by waterbody for the 2017 Asian Carp Program's early detection surveillance.

Waterbody Name	Number of Sites	Number of Fishes	Mean Number of fishes per Site	Number of Species	Mean Number of Species per Site	Number of Buffalo	Number of Common Carp
Ausable River	80	5 561	70	59	7	24	110
Bayfield River	10	353	35	28	9	0	15
Big Creek	9	742	82	20	7	8	64
Big Otter Creek	45	3 127	69	39	6	0	108
Canard River	47	2 042	43	38	7	129	122
Cedar Creek	63	2 976	47	36	8	53	332
Coldwater River	31	586	19	22	5	0	39
Credit River	12	112	9	13	2	0	4
Detroit River	45	767	17	43	5	8	36
Grand River	97	3 414	35	43	7	25	112
Jeannette's Creek	26	1 318	51	26	6	49	37
Jordan Harbour	30	1 613	54	24	5	49	96
Kettle Creek	13	1 052	81	26	5	7	60
Long Point Bay	66	2 944	45	36	6	2	65
Magnetawan River	9	444	49	23	6	0	0
Maitland River	13	637	49	25	5	0	16
Mississagi River	11	123	11	14	3	0	0
Nanticoke Creek	23	544	24	31	5	0	59
Nottawasaga River	12	486	41	20	7	0	9
Pine River	10	768	77	27	6	0	6
Rondeau Bay	62	2 325	38	34	6	1	44
Rouge River	17	659	39	25	6	0	6
Ruscom River	43	1 401	33	32	6	21	210
Sauble River	22	1 573	72	34	7	0	13
Shebeshekong River	8	401	50	16	5	0	0
Spanish River	14	939	67	22	8	0	7
Sturgeon River	8	139	17	20	5	0	2
Sydenham River	74	4 795	65	41	6	52	121
Thames River	58	3 219	56	36	5	346	129
Welland River	93	5 833	63	44	7	113	133

Table 3 Summary of the species captured during the 2017 Asian Carp Program's early detection surveillance. Common and scientific names according to Page et al. (2013). Status in capital letters refers to *Species at Risk Act* listing; lower case status refers to COSEWIC assessment.

Common Name	Species	Status[2]	Number Captured	Rank Abundance
Alewife	*Alosa pseudoharengus*		33	49
Banded Killifish	*Fundulus diaphanus*		106	42
Black Bullhead	*Ameiurus melas*		33	49
Black Crappie	*Pomoxis nigromaculatus*		432	22
Black Redhorse	*Moxostoma duquesnei*	sc	15	56
Blackchin Shiner	*Notropis heterodon*		246	31
Blacknose Dace	*Rhinichthys atratulus*		29	50
Blacknose Shiner	*Notropis heterolepis*		40	47
Blackside Darter	*Percina maculata*		2	64
Blackstripe Topminnow	*Fundulus notatus*	SC	2	64
Bluegill	*Lepomis macrochirus*		5 197	2
Bluntnose Minnow	*Pimephales notatus*		2 374	6
Bowfin	*Amia calva*		421	23
Brassy Minnow	*Hybognathus hankinsoni*		1	65
Brook Silverside	*Labidesthes sicculus*		573	18
Brook Stickleback	*Culaea inconstans*		6	60
Brown Bullhead	*Ameiurus nebulosus*		3 632	3
Brown Trout	*Salmo trutta*		2	64
buffalo	*Ictiobus* sp		887	13
Central Mudminnow	*Umbra limi*		43	46
Channel Catfish	*Ictalurus punctatus*		958	12
Channel Darter	*Percina copelandi*	THR	1	65
Chinook Salmon	*Oncorhynchus tshawytscha*		1	65
Common Carp	*Cyprinus carpio*		1 955	7
Common Shiner	*Luxilus cornutus*		629	16
Creek Chub	*Semotilus atromaculatus*		10	58
Emerald Shiner	*Notropis atherinoides*		2 678	5
Fathead Minnow	*Pimephales promelas*		137	39
Flathead Catfish	*Pylodictis olivaris*		3	63
Freshwater Drum	*Aplodinotus grunniens*		418	24
Ghost Shiner	*Notropis buchanani*		861	14
Gizzard Shad	*Dorosoma cepedianum*		11 773	1
Golden Redhorse	*Moxostoma erythrurum*		151	38
Golden Shiner	*Notemigonus crysoleucas*		837	15
Goldfish	*Carassius auratus*		559	19
Goldfish X Common Carp hybrid	*Carassius auratus X Cyprinus carpio*		40	47

Grass Pickerel	*Esox americanus vermiculatus*	SC	16	55
Greater Redhorse	*Moxostoma valenciennesi*		48	45
Green Sunfish	*Lepomis cyanellus*		68	44
Greenside Darter	*Etheostoma blennioides*		1	65
Hornyhead Chub	*Nocomis biguttatus*		86	43
Iowa Darter	*Etheostoma exile*		2	64
Johnny Darter	*Etheostoma nigrum*		22	53
Lake Chubsucker	*Erimyzon sucetta*	THR	4	62
Largemouth Bass	*Micropterus salmoides*		1 421	10
Least Darter	*Etheostoma microperca*		1	65
Logperch	*Percina caprodes*		364	27
Longnose Gar	*Lepisosteus osseus*		598	17
Mimic Shiner	*Notropis volucellus*		1 712	8
Mooneye	*Hiodon tergisus*		1	65
Muskellunge	*Esox masquinongy*		1	65
Northern Hog Sucker	*Hypentelium nigricans*		7	59
Northern Pike	*Esox lucius*		194	35
Northern Sunfish	*Lepomis peltastes*		35	48
Orangespotted Sunfish	*Lepomis humilis*		12	57
Pugnose Minnow	*Opsopoeodus emiliae*	SC	1	65
Pugnose Shiner	*Notropis anogenus*	END	23	52
Pumpkinseed	*Lepomis gibbosus*		2 751	4
Quillback	*Carpiodes cyprinus*		247	30
Rainbow Smelt	*Osmerus mordax*		3	63
Rainbow Trout	*Oncorhynchus mykiss*		3	63
River Redhorse	*Moxostoma carinatum*	SC	2	64
Rock Bass	*Ambloplites rupestris*		573	18
Rosyface Shiner	*Notropis rubellus*		24	51
Round Goby	*Neogobius melanostomus*		1 215	11
Rudd	*Scardinius erythrophthalmus*		281	28
Shorthead Redhorse	*Moxostoma macrolepidotum*		203	34
Silver Lamprey	*Ichthyomyzon unicuspis*		4	62
Silver Redhorse	*Moxostoma anisurum*		131	40
Smallmouth Bass	*Micropterus dolomieu*		481	20
Spotfin Shiner	*Cyprinella spiloptera*		455	21
Spottail Shiner	*Notropis hudsonius*		398	25
Spotted Gar	*Lepisosteus oculatus*	THR	29	50
Spotted Sucker	*Minytrema melanops*	SC	162	36
Stonecat	*Noturus flavus*		2	64
Striped Shiner	*Luxilus chrysocephalus*		18	54
Tadpole Madtom	*Noturus gyrinus*		23	52
Trout-perch	*Percopsis omiscomaycus*		16	55
Tubenose Goby	*Proterorhinus semilunaris*		23	52

Walleye	*Sander vitreus*		127	41
Warmouth	*Lepomis gulosus*	SC	5	61
White Bass	*Morone chrysops*		208	33
White Crappie	*Pomoxis annularis*		209	32
White Perch	*Morone americana*		254	29
White Sucker	*Catostomus commersonii*		372	26
Yellow Bullhead	*Ameiurus natalis*		161	37
Yellow Perch	*Perca flavescens*		1 668	9
Catfish family	Ictaluridae		505	
Herring Family	Clupeidae		1	
Lamprey family	Petromyzontidae		1	
Minnow family	Cyprinidae		25	
Sucker family	Catostomidae		77	
Sunfishes and basses family	Centrarchidae		533	
Unknown	Unknown		27	

[2]END=Endangered; SC=Special Concern; THR=Threatened

Table 4 Summary of the catch data by gear type used in the 2017 Asian Carp Program's early detection surveillance.

Gear Type	Acronym	Total Effort	Mean Effort per Site	Unit	Number of Sites	Number of Water bodies	Number of Fishes	Mean Number of Fishes per Site	Number of Species	Mean Number of Species per Site	Number of Buffalo sp.	Number of Common Carp	Mean Number of Surrogates per site
Boat Electrofishing	BEF	212 157	618.5	sec	343	29	26 763	78	79	10	257	1 174	6
Fyke Net	MFN	5 702.0	21.5	hrs	265	30	15 040	57	74	6	1	48	2
Hoop Net	HN	1 639.6	40	hrs	41	10	371	9	21	2	0	4	2
Seine Net	SN	37	2.1	hauls	18	9	3 003	167	41	9	0	1	1
Trammel Net	TRM	3 908.3	24.9	mins	157	21	1 125	7	16	2	558	397	11
Tied-down Gill Net	TDG	696	23.2	mins	30	10	24	1	7	1	2	12	1
Trap Net	TN	4 210.4	21.4	hrs	197	30	4 567	23	43	5	69	319	4

Table 5 Summary of sampling effort by waterbody for boat electrofishing (BEF), fyke nets (MFN), hoop nets (HN), seine nets (SN), trammel nets (TRM), tied-down gill nets (TDG), and trap nets (TN) during the 2017 Asian Carp Program's early detection surveillance.

Waterbody Name	BEF # of Sites	BEF Effort (sec)	MFN # of Sites	MFN Effort (hrs)	HN # of Sites	HN Effort (hrs)	SN # of Sites	SN Effort (hauls)	TRM # of Sites	TRM Effort (min)	TDG # of Sites	TDG Effort (min)	TN # of Sites	TN Effort (hrs)
Ausable River	25	14 608	22	458	1	41	0	0	19	369	0	0	13	283
Bayfield River	3	1 830	2	47	0	0	2	4	1	15	0	0	2	39
Big Creek	6	3 610	1	23	1	44	0	0	0	0	0	0	1	24
Big Otter Creek	15	9 160	12	251	2	83	0	0	8	245	0	0	8	164
Canard River	18	11 123	11	234	0	0	0	0	8	308	0	0	10	207
Cedar Creek	22	13 255	18	382	2	85	0	0	11	230	0	0	10	235
Coldwater River	8	5 700	9	199	0	0	2	6	3	78	4	94	5	114
Credit River	0	0	4	80	2	69	1	1	2	30	1	18	2	39
Detroit River	15	9 150	12	252	4	168	0	0	4	80	5	75	5	102
Grand River	28	17 370	20	415	13	479	0	0	18	561	0	0	18	372
Jeannette's Creek	10	5 900	6	125	3	128	0	0	3	243	0	0	4	75
Jordan Harbour	5	3 020	7	140	0	0	0	0	8	146	0	0	10	205
Kettle Creek	4	2 400	2	35	0	0	0	0	5	97	0	0	2	36
Long Point Bay	21	13 215	19	432	0	0	1	3	4	63	8	122	13	285
Magnetawan River	4	2 560	3	68	0	0	0	0	0	0	0	0	2	44
Maitland River	6	3 700	2	48	0	0	1	1	2	48	0	0	2	48
Mississagi River	4	3 200	4	91	0	0	0	0	0	0	0	0	3	68
Nanticoke Creek	7	4 020	7	163	0	0	0	0	5	323	0	0	4	85
Nottawasaga River	6	5 434	3	66	0	0	0	0	0	0	2	101	1	22
Pine River	1	600	4	77	0	0	2	6	0	0	1	15	2	36
Rondeau Bay	24	13 755	13	292	0	0	0	0	10	254	4	157	11	242
Rouge River	3	2 369	6	129	0	0	3	3	1	16	0	0	4	81
Ruscom River	14	8 400	9	193	0	0	0	0	8	158	0	0	12	259
Sauble River	5	2 900	8	170	0	0	3	5	0	0	3	45	3	60
Shebeshekong River	3	1 830	3	60	0	0	0	0	0	0	1	48	1	21

Spanish River	6	4 235	5	123	0	0	0	0	0	0	0	0	3	72
Sturgeon River	3	1 825	2	43	0	0	0	0	0	0	1	21	2	47
Sydenham River	28	17 112	19	418	0	0	0	0	14	236	0	0	13	274
Thames River	22	13 676	7	156	10	461	0	0	9	173	0	0	10	214
Welland River	27	16 200	25	535	3	81	3	8	14	235	0	0	21	456

FIGURES

Figure 1 DFO Asian Carp Program's early detection surveillance sites in Canadian waters of the Great Lakes.

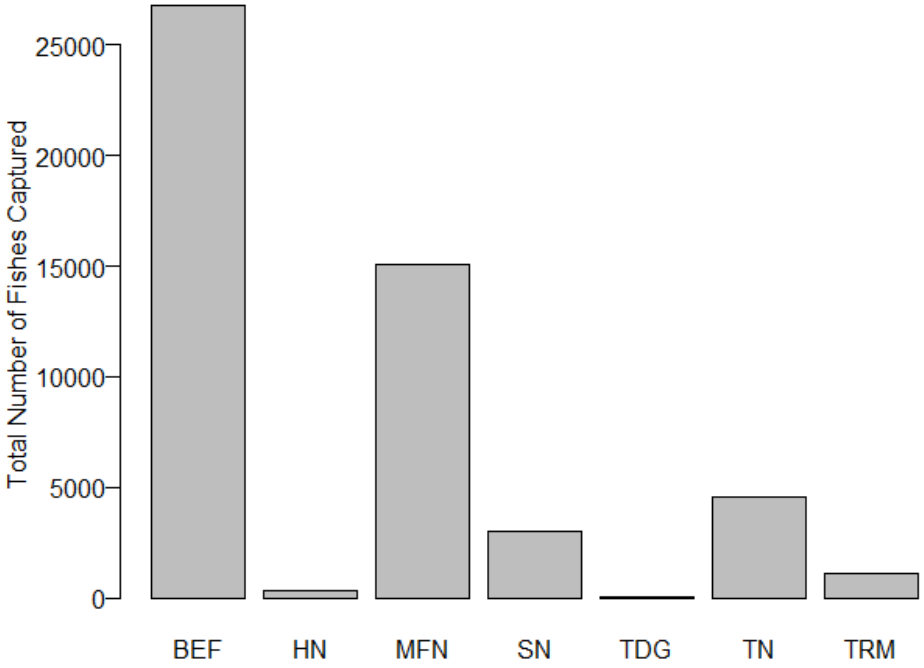

Figure 2 Total number of fishes captured by gear type during the 2017 Asian Carp Program's early detection surveillance. Gears included boat electrofishing (BEF), fyke nets (MFN), hoop nets (HN), seine nets (SN), trammel nets (TRM), tied-down gill nets (TDG), and trap nets (TN).

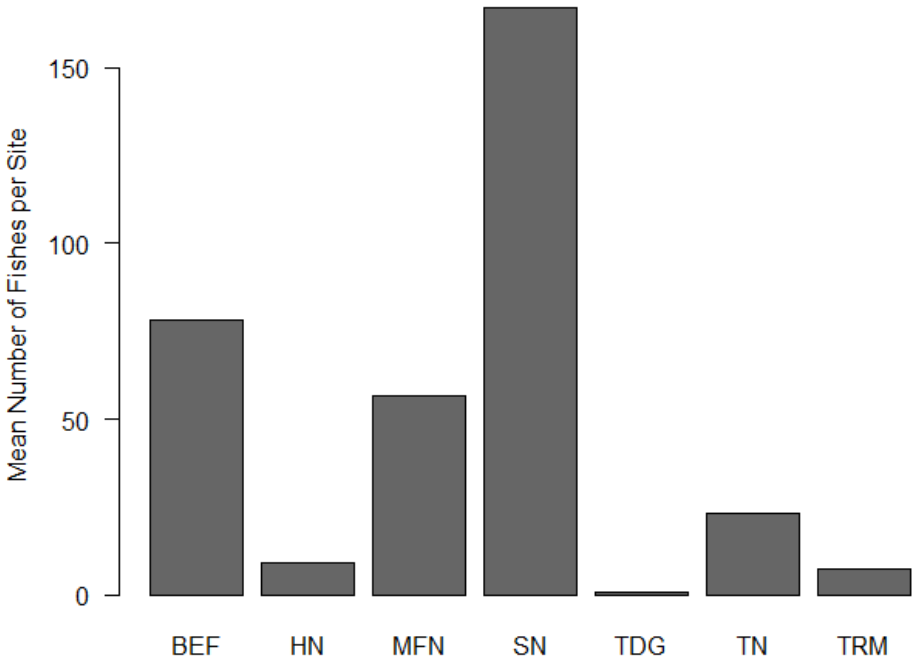

Figure 3 Mean number of fishes captured per site by gear type during the 2017 Asian Carp Program's early detection surveillance. Gears included boat electrofishing (BEF), fyke nets (MFN), hoop nets (HN), seine nets (SN), trammel nets (TRM), tied-down gill nets (TDG), and trap nets (TN).

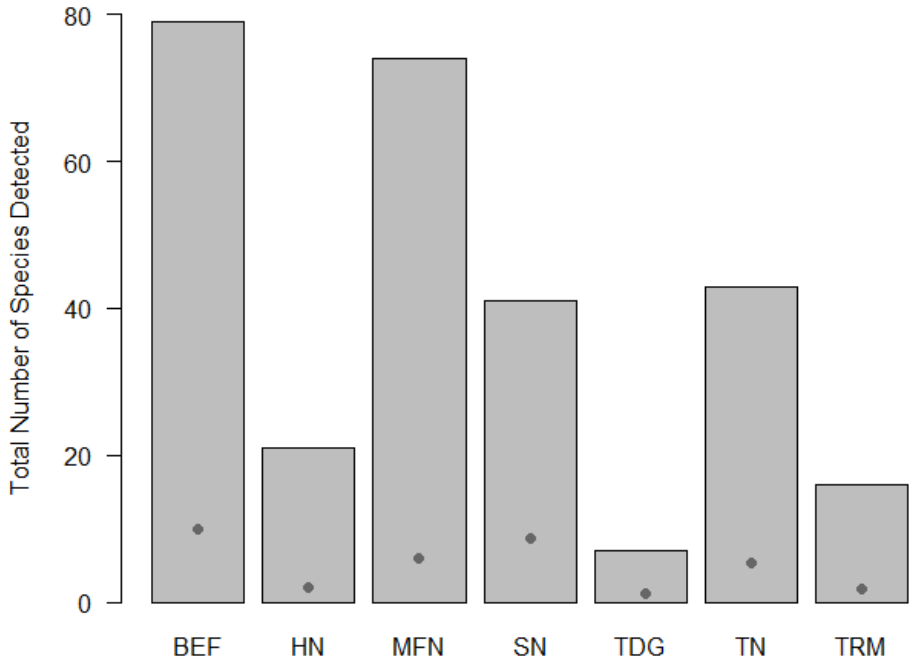

Figure 4 Total number of species detected by gear type during the 2017 Asian Carp Program's early detection surveillance. Dark grey dot indicates the mean number of species detected per site. Gears included boat electrofishing (BEF), fyke nets (MFN), hoop nets (HN), seine nets (SN), trammel nets (TRM), tied-down gill nets (TDG), and trap nets (TN).

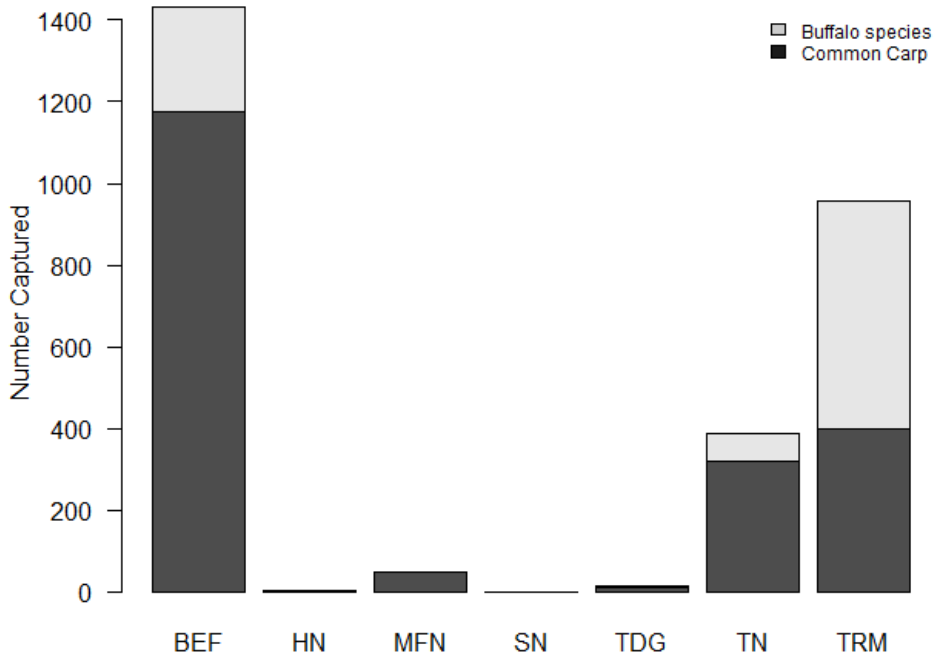

Figure 5 Number of surrogate species, Buffalo (*Ictiobus* sp.) and Common Carp (*Cyprinus carpio*), captured by gear type during the 2017 Asian Carp Program's early detection surveillance. Gears included boat electrofishing (BEF), fyke nets (MFN), hoop nets (HN), seine nets (SN), trammel nets (TRM), tied-down gill nets (TDG), and trap nets (TN).

APPENDIX 1: TORONTO AND REGION CONSERVATION AUTHORITY SAMPLING FOR ASIAN CARPS

In 2017, the Toronto and Region Conservation Authority (TRCA) continued early detection surveillance targeting Asian carps on behalf of DFO's Asian Carp Program. This sampling was conducted in Toronto area tributaries of Lake Ontario in conjunction with their on-going monitoring projects in order to reduce overlap of efforts. Sampling by TRCA was conducted from June 1st to October 23rd, 2017. The TRCA followed Asian Carp Program protocols using four of the same gear types, including: boat electrofishing (operating with an 18' dual boom Smith-Root electrofishing boat with a 7.5 GPP; 16' single boom Smith-Root electrofishing boat with a 2.5 GPP; or a 12' single boom Smith-Root electrofishing boat with a 5.0 GPP), fyke nets, trammel nets, and trap nets.

The TRCA sampled 160 sites across five waterbodies (Figures A1.1-A1.5). Four of these (Duffins Creek, Frenchman's Bay, Humber River, Rouge River) are considered suitable for Asian carps; Carruthers Creek was scouted due to its proximity to the other, higher risk sites. All four gear types were used to sample in Duffins Creek, Frenchman's Bay and the Humber River (Table A1.5). Only boat electrofishing was used to sample Carruthers Creek, and boat electrofishing and trammel nets were used in the Rouge River.

TRCA captured 6 479 fishes representing 36 species (Table A1.1). The mean number of fishes and species caught per site was 40 and four, respectively. The greatest number of fishes was captured in Duffins Creek (3 058 fishes at 46 sites, or a mean of 66 fishes per site) (Table A1.2). The most species were detected in the Humber River (26 species across 35 sites). The most abundant species detected were Brown Bullhead with 2 251 individuals (35% of all fishes captured by TRCA), Pumpkinseed with 1 023 individuals (16%), and Largemouth Bass with 549 individuals captured (8%) (Table A1.3). A total of 69 Common Carp were detected by TRCA.

Boat electrofishing was the most frequently used gear type (66 sites in all five waterbodies sampled) (Table A1.4). The total boat electrofishing effort was 25 868 seconds, with a mean of 392 seconds per site. Trammel nets were the least used gear type (28 sites in four waterbodies). The total amount of trammel effort was 830 minutes, with a mean of 30 minutes per site. Fyke nets caught the most fishes (a total of 3 869 and a mean of 111 fishes per site). Trammel nets caught the fewest (a total of seven fishes). Fyke nets also detected the most species (26), while trammel nets detected the fewest (4). Trap nets captured the most Common Carp per site (a total of 29 across 31 sites).

In 2018, TRCA will continue to target Asian carps in Duffins Creek, Frenchman's Bay, and the Humber and Rouge rivers, and around the Toronto Islands following DFO's Asian Carp Program protocols.

TABLES

Table A1.1 Summary of catch data for the 2017 TRCA early detection surveillance for Asian carps.

Catch Data	
Total number of sites	160
Total number of waterbodies	5
Total number of fishes caught	6 479
Total number of species detected	36
Total number of surrogates caught	69
Total number of Asian carps caught	0
Mean number of fishes caught per waterbody	1 080
Mean number of fishes caught per site	40
Mean number of species per waterbody	16
Mean number of species per site	4

Table A1.2 Summary of catch data by waterbody for the 2017 TRCA early detection surveillance for Asian carps.

Waterbody Name	Number of Sites	Number of Fishes	Mean Number of Fishes per Site	Number of Species	Mean Number of Species per Site	Number of Buffalo	Number of Common Carp
Carruthers Creek	8	57	7	0	1	0	0
Duffins Creek	46	3 058	66	22	3	0	7
Frenchman's Bay	59	1 641	28	21	5	0	42
Humber River	35	1 661	47	26	3	0	20
Rouge River	12	62	5	8	2	0	0

Table A1.3 Summary of species captured during the 2017 TRCA early detection surveillance for Asian carps. Common and scientific names according to Page et al. (2013). No species assessed or listed as At Risk were captured by TRCA.

Common Name	Species	Number Captured	Rank Abundance
Alewife	*Alosa pseudoharengus*	288	4
Banded Killifish	*Fundulus diaphanus*	1	23
Black Crappie	*Pomoxis nigromaculatus*	42	13
Bluegill	*Lepomis macrochirus*	284	5
Bluntnose Minnow	*Pimephales notatus*	34	14
Bowfin	*Amia calva*	63	11
Brook Stickleback	*Culaea inconstans*	4	20
Brown Bullhead	*Ameiurus nebulosus*	2 251	1
Brown Trout	*Salmo trutta*	1	23
Channel Catfish	*Ictalurus punctatus*	1	23
Chinook Salmon	*Oncorhynchus tshawytscha*	5	19
Common Carp	*Cyprinus carpio*	69	10
Common Shiner	*Luxilus cornutus*	16	16
Creek Chub	*Semotilus atromaculatus*	4	20
Emerald Shiner	*Notropis atherinoides*	3	21
Fathead Minnow	*Pimephales promelas*	266	6
Gizzard Shad	*Dorosoma cepedianum*	16	16
Golden Shiner	*Notemigonus crysoleucas*	120	9
Goldfish	*Carassius auratus*	1	23
Goldfish X Common Carp	*Carassius auratus X Cyprinus carpio*	1	23
Green Sunfish	*Lepomis cyanellus*	2	22
Largemouth Bass	*Micropterus salmoides*	549	3
Northern Pike	*Esox lucius*	62	12
Pumpkinseed	*Lepomis gibbosus*	1 023	2
Rock Bass	*Ambloplites rupestris*	19	15
Round Goby	*Neogobius melanostomus*	189	7
Rudd	*Scardinius erythrophthalmus*	2	22
Sea Lamprey	*Petromyzon marinus*	1	23
Smallmouth Bass	*Micropterus dolomieu*	1	23
Spottail Shiner	*Notropis hudsonius*	1	23
Threespine Stickleback	*Gasterosteus aculeatus*	10	17
White Bass	*Morone chrysops*	1	23
White Perch	*Morone americana*	7	18
White Sucker	*Catostomus commersonii*	16	16
Yellow Bullhead	*Ameiurus natalis*	2	22
Yellow Perch	*Perca flavescens*	135	8
bullhead	*Ameiurus* sp	162	
crappie	*Pomoxis* sp	2	
minnow	*Pimephales* sp	45	
sunfish	*Lepomis* sp	35	

Unknown	Unknown	745

Table A1.4 Summary of the catch data by gear type used in the 2017 TRCA early detection surveillance for Asian carps.

Gear Type	Acronym	Total Effort	Mean Effort per Site	Unit	Number of Sites	Number of Water-bodies	Number of Fishes	Mean Number of Fishes per site	Number of Species	Mean Number of Species per Site	Number of Common Carp
Boat Electrofishing	BEF	25 868	391.9	sec	66	5	1 549	25	25	3	28
Fyke Net	MFN	798.5	22.8	hrs	35	3	3 869	111	26	6	7
Trap Net	TN	681.5	22	hrs	31	3	1 054	34	19	5	29
Trammel Net	TRM	830	29.6	min	28	4	7	0	4	1	5

Table A1.5 Summary of sampling effort by waterbody for boat electrofishing (BEF), fyke nets (MFN), trap nets (TN) and trammel nets (TRM) during the 2017 TRCA early detection surveillance for Asian carps.

Waterbody Name	BEF Number of Sites	BEF Effort (sec)	MFN Number of Sites	MFN Effort (hrs)	TN Number of Sites	TN Effort (hrs)	TRM Number of Sites	TRM Effort (min)
Carruthers Creek	8	960	0	0	0	0	0	0
Duffins Creek	12	4 080	13	287.63	13	261.64	8	149
Frenchman's Bay	29	11 459	13	287.16	10	230.57	7	215
Humber River	8	8 289	9	223.75	8	189.33	10	360
Rouge River	9	1 080	0	0	0	0	3	106

FIGURES

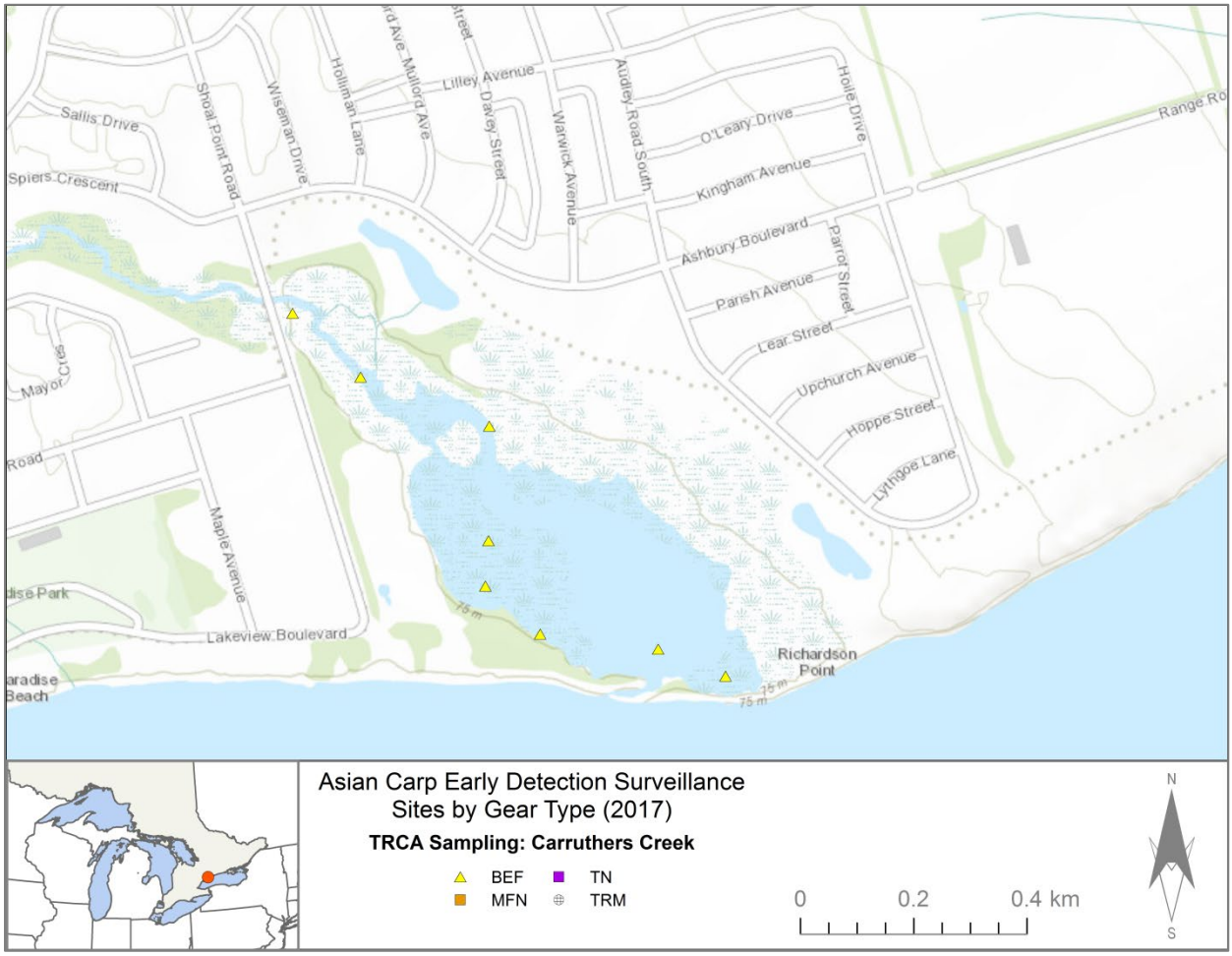

Figure A1.1 2017 Toronto and Region Conservation Authority (TRCA) early detection surveillance for Asian carps field sampling sites in Carruthers Creek.

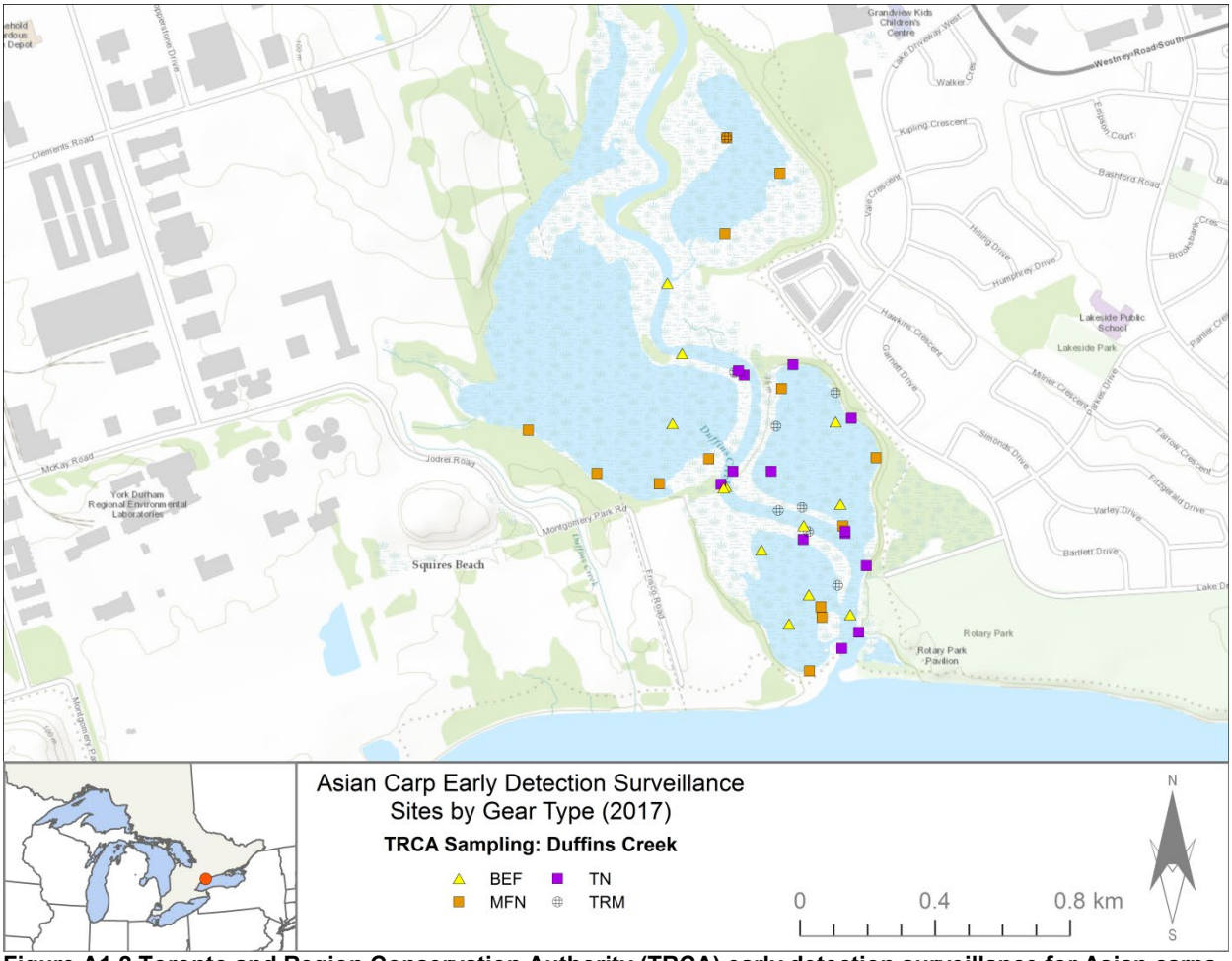

Figure A1.2 Toronto and Region Conservation Authority (TRCA) early detection surveillance for Asian carps field sampling sites in Duffins Creek.

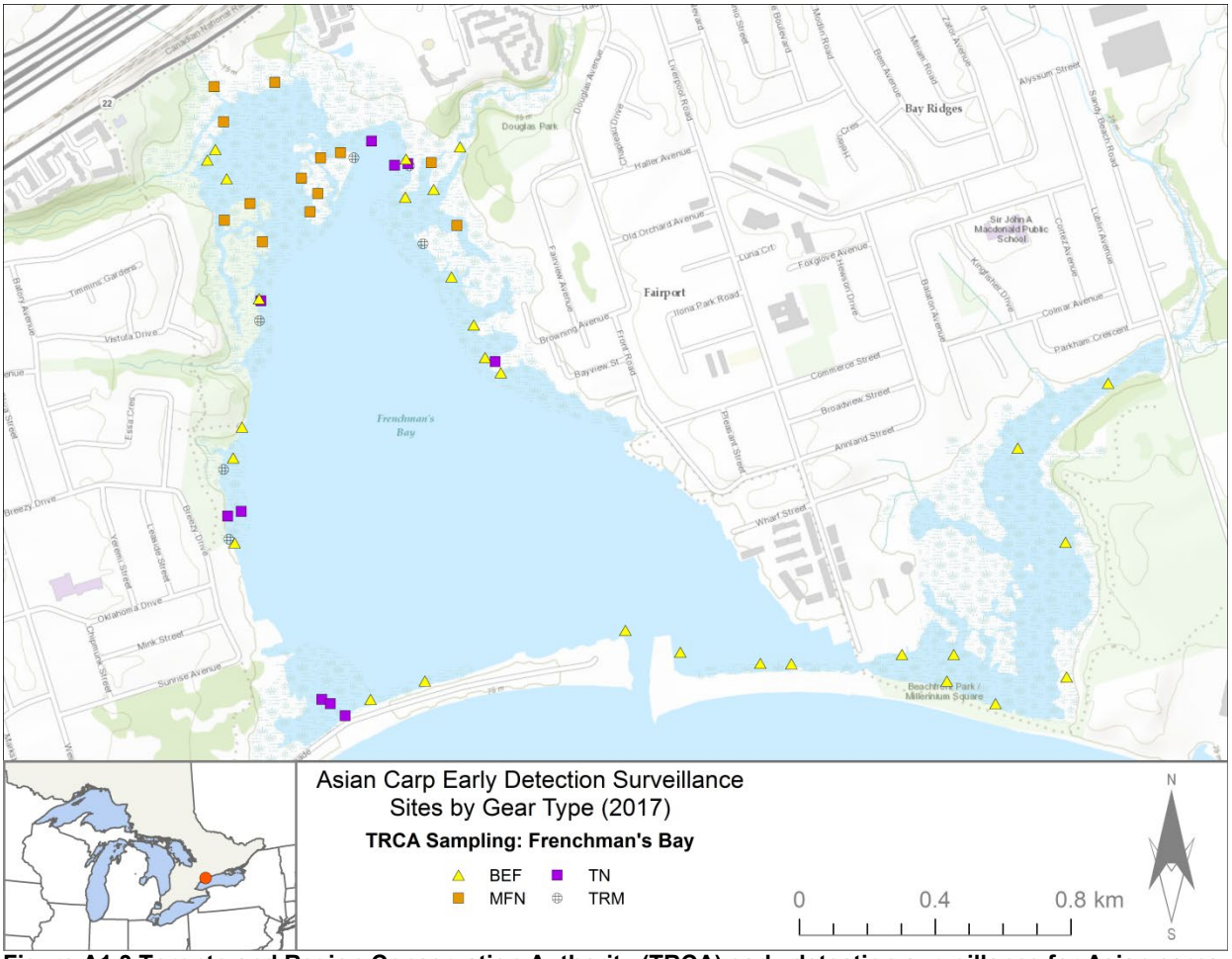

Figure A1.3 Toronto and Region Conservation Authority (TRCA) early detection surveillance for Asian carps field sampling sites in Frenchman's Bay

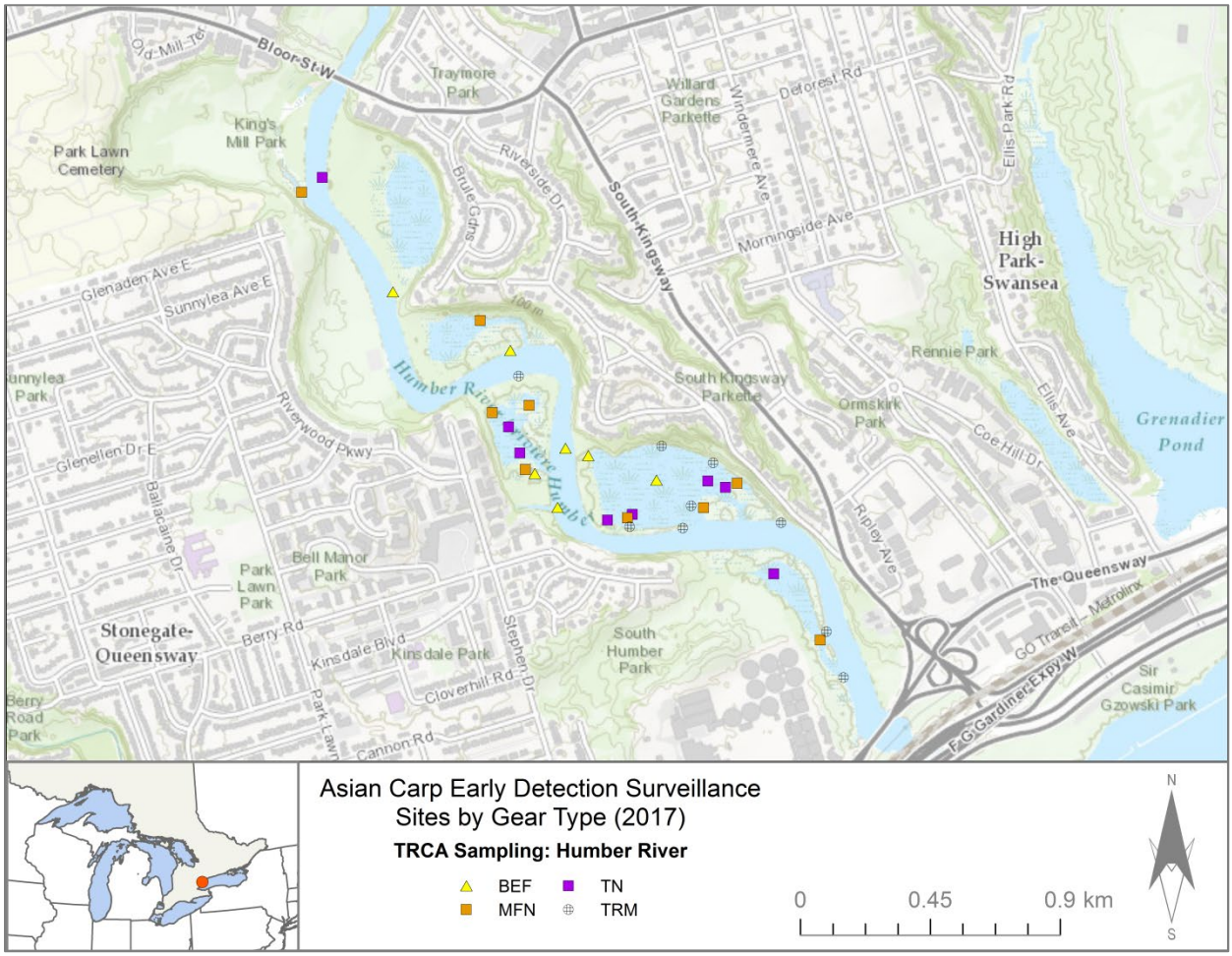

Figure A1.4 Toronto and Region Conservation Authority (TRCA) early detection surveillance for Asian carps field sampling sites in Humber River

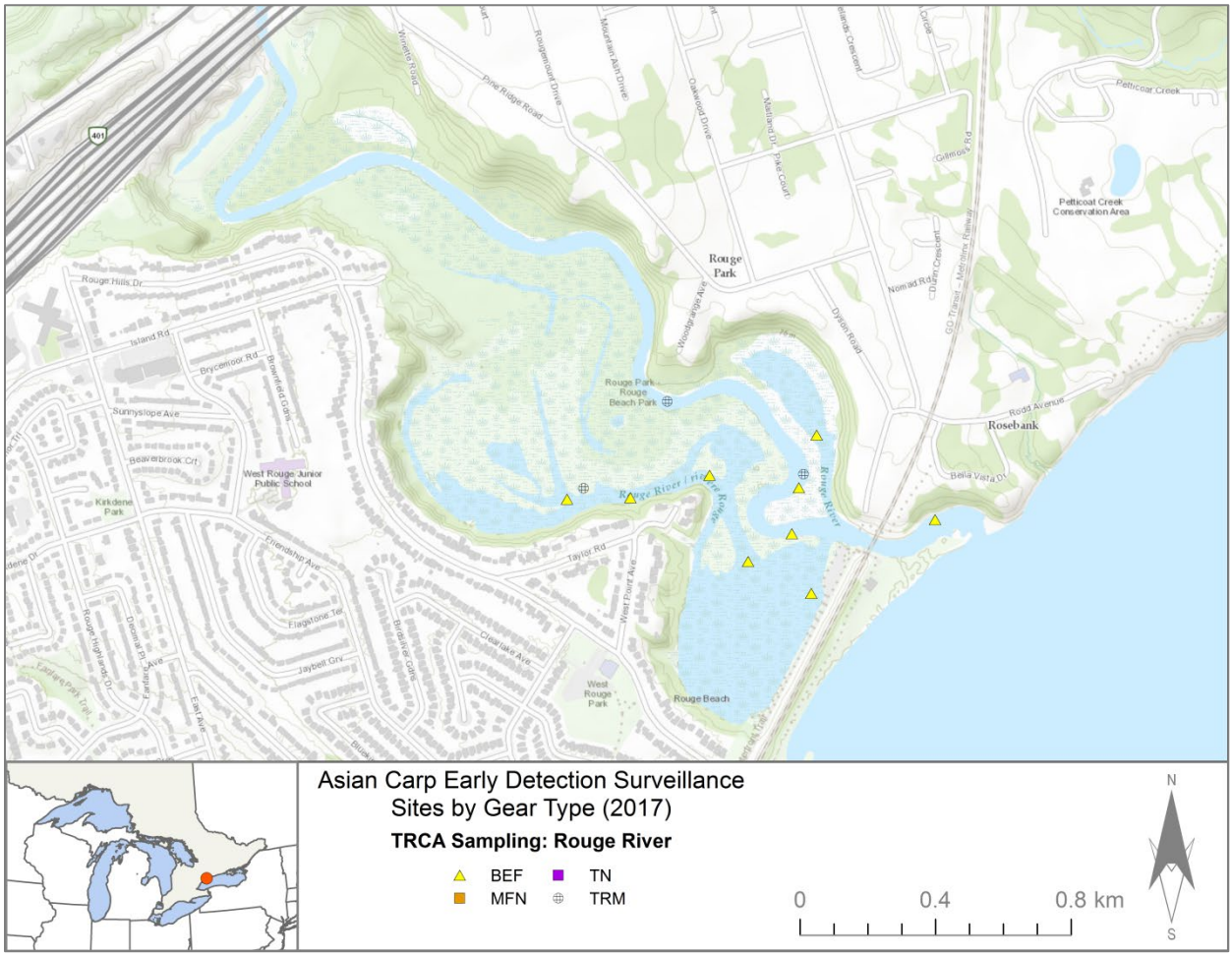

Figure A1.5 Toronto and Region Conservation Authority (TRCA) early detection surveillance for Asian carps field sampling sites in Rouge River.

APPENDIX 2: LARVAL FISH AND EGG SAMPLING

Individual Grass Carp have been detected in the Great Lakes since the 1980's (USGS Nonindigenous Aquatic Species (NAS) Database (https://nas.er.usgs.gov/default.aspx)); however, it has been assumed that these were mostly triploid individuals incapable of reproducing. In more recent years, diploid individuals have been detected in the basin, and in 2013 young individuals of approximately two years of age were captured in the Sandusky River in Ohio, a tributary of Lake Erie. These fish were presumed to have hatched there (Chapman et al. 2013). The U.S. Geological Survey (USGS) and the University of Toledo conducted targeted sampling for larval Grass Carp and eggs (icthyoplankton) in the Sandusky River in 2014 and 2015, and Grass Carp eggs were detected in the 2015 samples (Embke et al. 2016). In 2016, DFO's Asian Carp Program began pilot testing gears for sampling eggs and larval life stages of Asian carps (specifically Grass Carp) in select, high risk locations in Canadian waters of the Great Lakes basin. Two gear types, bongo nets and larval light traps, similar to those deployed in the Sandusky River, were used.

BONGO NET AND LARVAL LIGHT TRAP SAMPLING

Four waterbodies were selected for larval and egg sampling in 2017 (Figure A2.1) that are highly suitable for Asian carp spawning and are close in proximity to the Sandusky River (i.e. western basin of Lake Erie). These include the Grand, Sydenham and Thames rivers in Lake Erie and the Huron-Erie Corridor. The Credit River in Lake Ontario was also selected as three adult diploid Grass Carp were captured nearby in Lake Ontario in 2015. A total of 43 sites were sampled with 16 bongo net tows and 27 light trap sets (Table A2.1). Sites were sampled following rain events as best as possible, as high flows are conducive to spawning (Kolar et al. 2007).

Bongo nets targeting fish eggs consisted of a stainless steel frame with two 50 cm diameter openings. Attached to the frame is a pair of 2 m long cylindrical plankton nets, with 50 cm openings, 500 micron mesh size and 11 cm cod ends. The net design was consistent with designs used by partner agencies collecting Asian carp larval fish and eggs in rivers in the United States. The Bongo net was deployed off of the bow of the boat, on either the port or starboard side of the vessel. Horizontal tows were completed to sample stretches of river. The net was deployed to sample approximately 0.5 m below the surface of the water. The tow speeds were adjusted to ensure that the nets remained fully deployed, and filtration efficiency remained high. During sampling, a flow meter was deployed adjacent to the nets to calculate the flow rate and corresponding volume of water sampled. The bongo nets were towed for 180 seconds per site with a target measured flow rate of approximately 0.4-0.6 m/s.

A quadrafoil type larval fish light trap with a cloverleaf-shaped design was used to capture larval fishes. The trap is made of clear polycarbonate, is 30 cm in diameter and 25 cm tall, with four entry points that are 5 mm wide. A mesh strainer of 250 microns is installed in the collection basin of the trap. The light trap was lit by a white waterproof flashlight placed in the central light tube of the trap. The light tube size is 28 mm in diameter, and 25 cm in depth. The traps were placed in sets of three, tethered together and spaced one metre apart. Three sets of three traps were deployed simultaneously: one set in heavy submerged vegetation, one in open water and one set in, or adjacent to, woody debris. The traps were deployed for one hour, starting 30 minutes after sunset. The standardized set times were one hour in order to minimize the risk of predation of captured larval fishes.

Samples obtained from the bongo nets and larval light traps were coarsely picked in the field to remove any large debris, vegetation, or small-bodied adult fishes that could be easily identified. Samples were then preserved in 95% ethanol. Samples were picked through more thoroughly in the lab to remove additional vegetation and invertebrates and were flushed with new 95% ethanol. A subsample of larval fish was taken from each site and the larval fish were counted and weighed to estimate the total number of fish present and the weight of the sample. Samples were sent to the University of Toronto Scarborough population genomics lab[2] to determine presence of Asian carps based on genetic material. Further sample preparation included mechanical maceration/homogenization followed by enzymatic digestion. DNA was then extracted from a small subsample of the homogenate and amplified for metabarcoding analysis using mitochondrial COI.

RESULTS AND DISCUSSION

A few trends can be observed in the larval data (Table A2.1). The Credit River samples yielded very few larval fishes in either gear type. This may be because sampling occurred later in the season than the other samples, and perhaps larval fishes were too large to recruit into the gear or had shifted habitats. The Sydenham and Thames rivers were sampled at the same time and there were nearly twice as many fish captured in the Thames River than the Sydenham River, but the weight was estimated to be much less, as the larval fish from the Thames River were much smaller than those from the Sydenham River. Additionally, the bongo nets captured more larval fish in Sydenham River, while the light traps captured more in the Thames River.

Genetic testing will confirm the species of larval fish present in the samples; however, there were a few adult cyprinids and juveniles from other families that could be identified. Emerald Shiner appeared in multiple samples from each waterbody except the Grand River; this included seven samples from bongo nets and four light trap samples. Gizzard Shad appeared in several samples (two bongo nets and two light trap samples) from the Sydenham and Grand rivers. Other species detected in one or two samples with fewer than 10 individuals include Alewife, Brook Silverside, Channel Catfish, Largemouth Bass, Pumpkinseed, temperate bass species, Yellow Perch and Yellow Bullhead. Results from the 2016 pilot test in the Credit River yielded negatives for Grass Carp.

Some eggs were detected in the samples, but were not well documented during picking. All eggs observed were less than one millimeter in diameter. Grass Carp eggs observed in North America are typically 4-5 mm in diameter (George and Chapman 2015, Jones et al. 2017), indicating our eggs were most likely from small-bodied, native species.

In 2018, the Asian Carp Program will continue to search for Asian carp icthyoplankton using bongo nets and larval light traps following major rain events. Sampling will expand to include additional waterbodies identified as priorities in our early detection surveillance work.

[2] UTSC population genomics lab: Dr. Nathan R. Lovejoy, Dr. Nathan K. Lujan and Dr. Nicholas E. Mandrak.

TABLES

Table A2.1 Summary of larval fish sampling by waterbody and gear type.

Waterbody Name	Date of sampling	Gear Type	Number of Sites	Effort	Units	Count (#)	Weight (g)
Credit River	14/08/2017	Bongo net	4	720	sec	2	0.25
Credit River	14/08/2017	Light trap	9	553	min	8	2.79
Grand River	25/07/2017	Bongo net	4	720	sec	1238	24.06
Sydenham River	28/06/2017	Bongo net	5	900	min	19 473	646.04
Sydenham River	28/06/2017	Light trap	9	535	sec	155	8.11
Thames River	27/06/2017	Bongo net	3	540	min	1 880	25.09
Thames River	28/06/2017	Light trap	9	667	sec	43 022	408.38

FIGURES

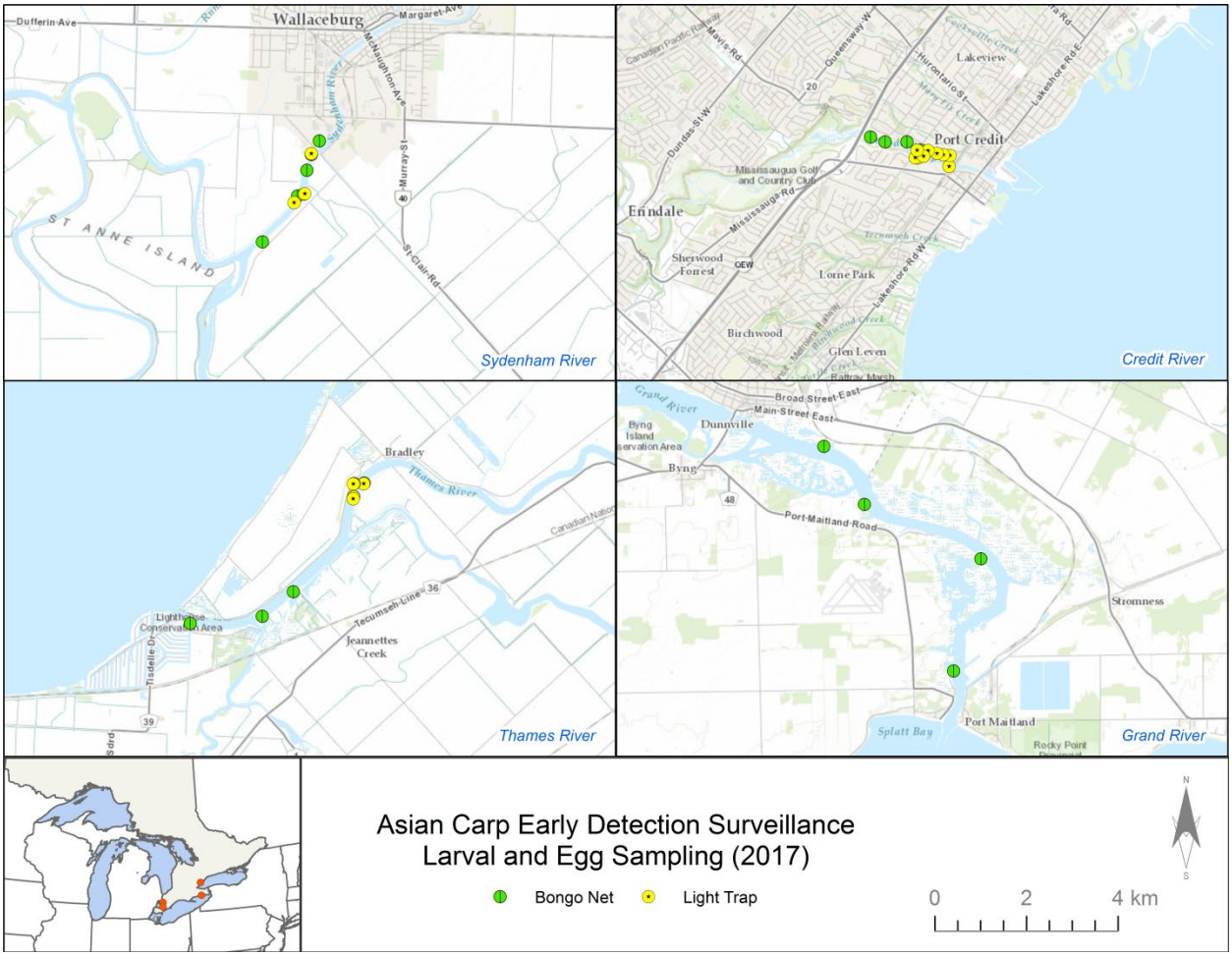

Figure A2.1 Sampling locations for larval Asian carps and eggs using bongo nets and larval light traps. Sampling occurred in four tributaries where early detection surveillance for adults also occurs.

APPENDIX 3: FIELD SAMPLING SITE MAPS

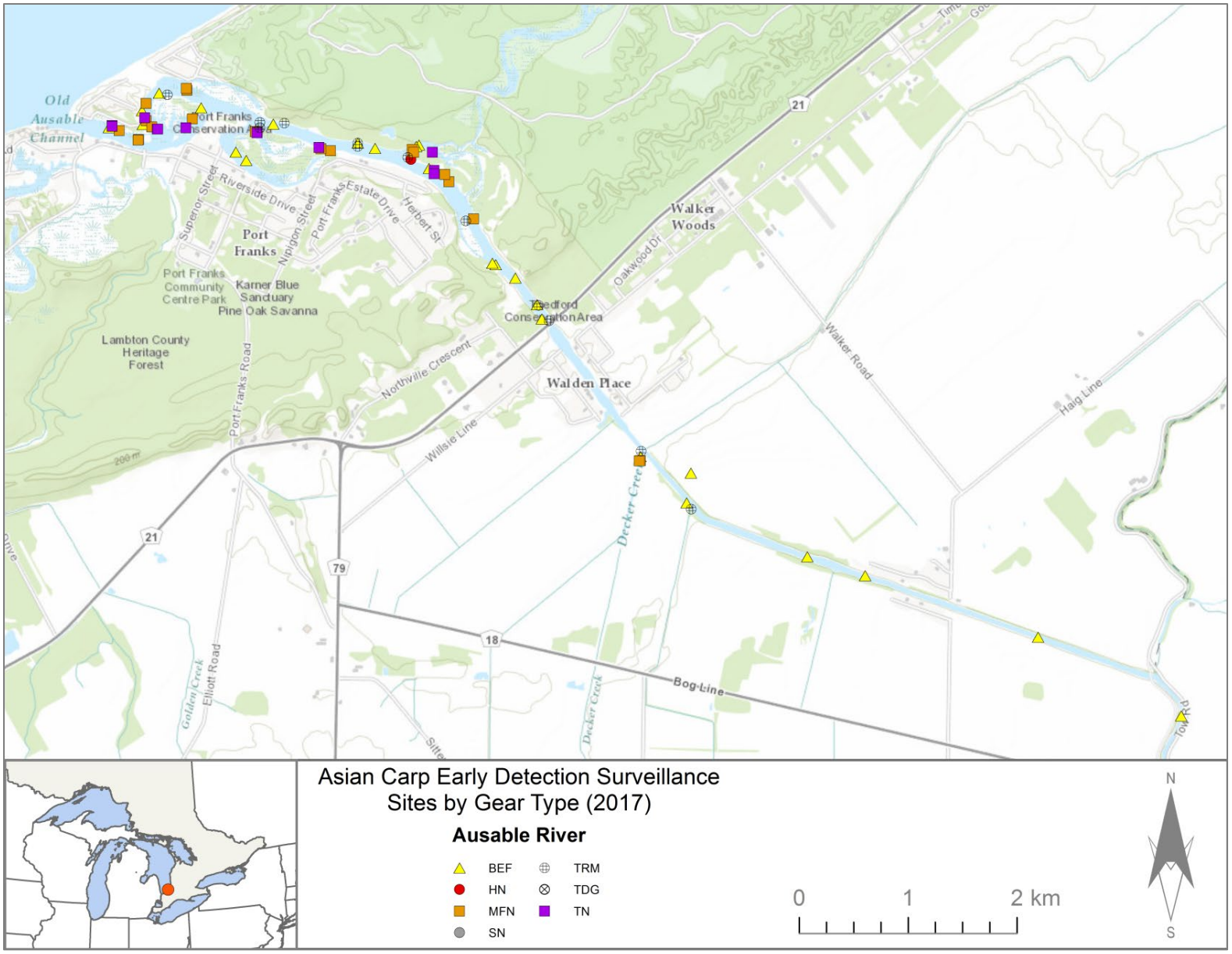

Figure A3.1 2017 Asian Carp Program early detection surveillance field sampling sites in the Ausable River.

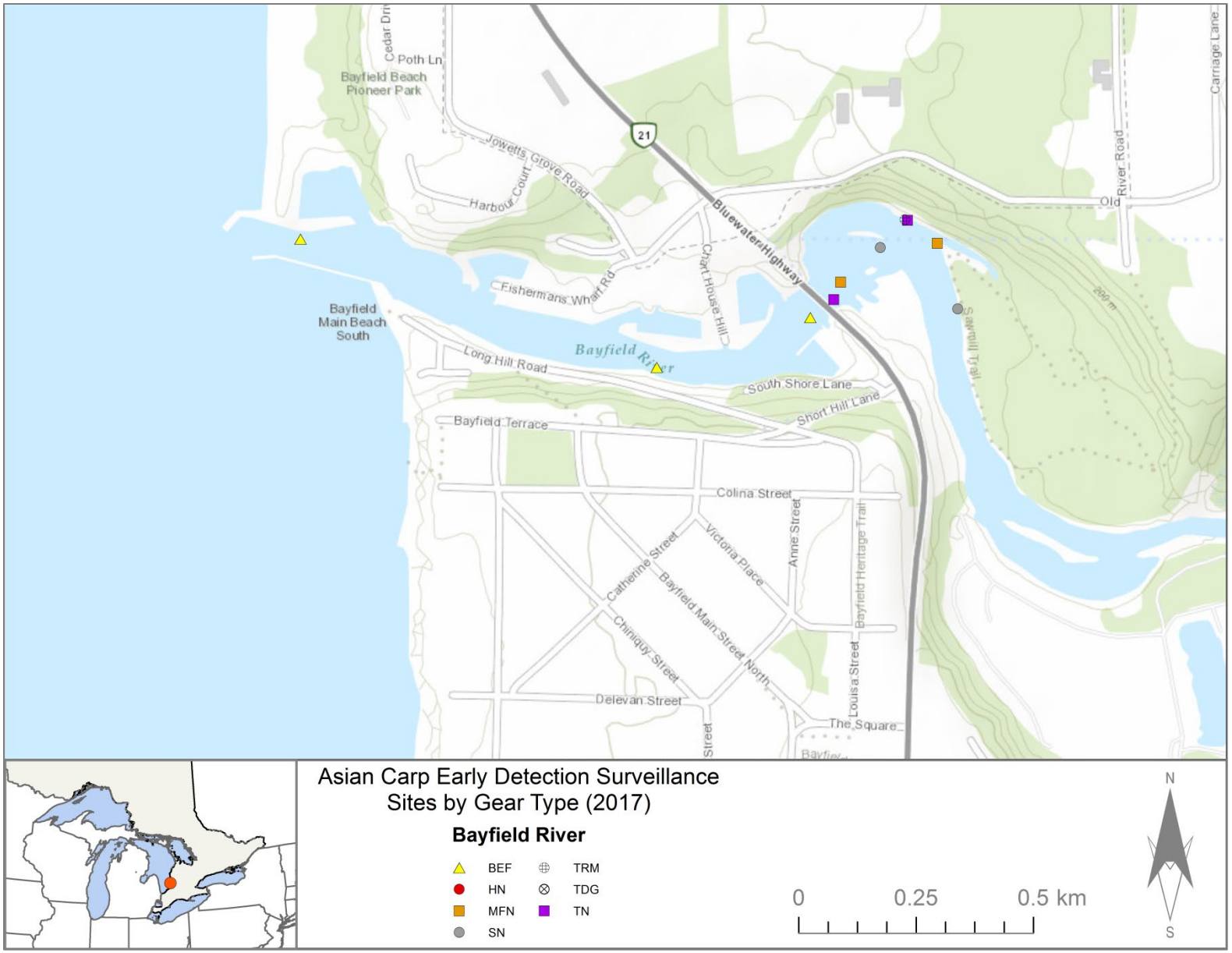

Figure A3.2 2017 Asian Carp Program early detection surveillance field sampling sites in the Bayfield River.

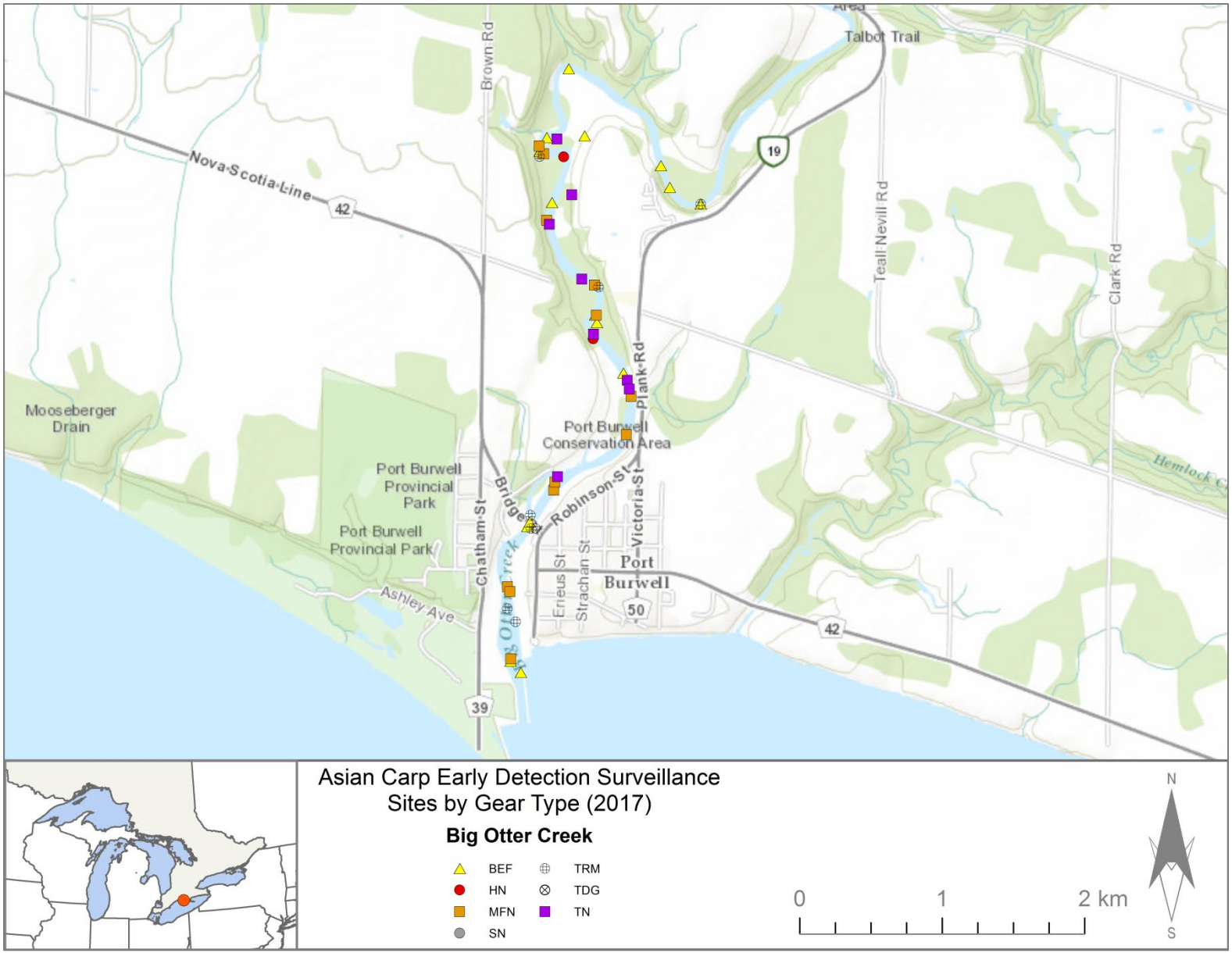

Figure A3.3 2017 Asian Carp Program early detection surveillance field sampling sites in Big Otter Creek.

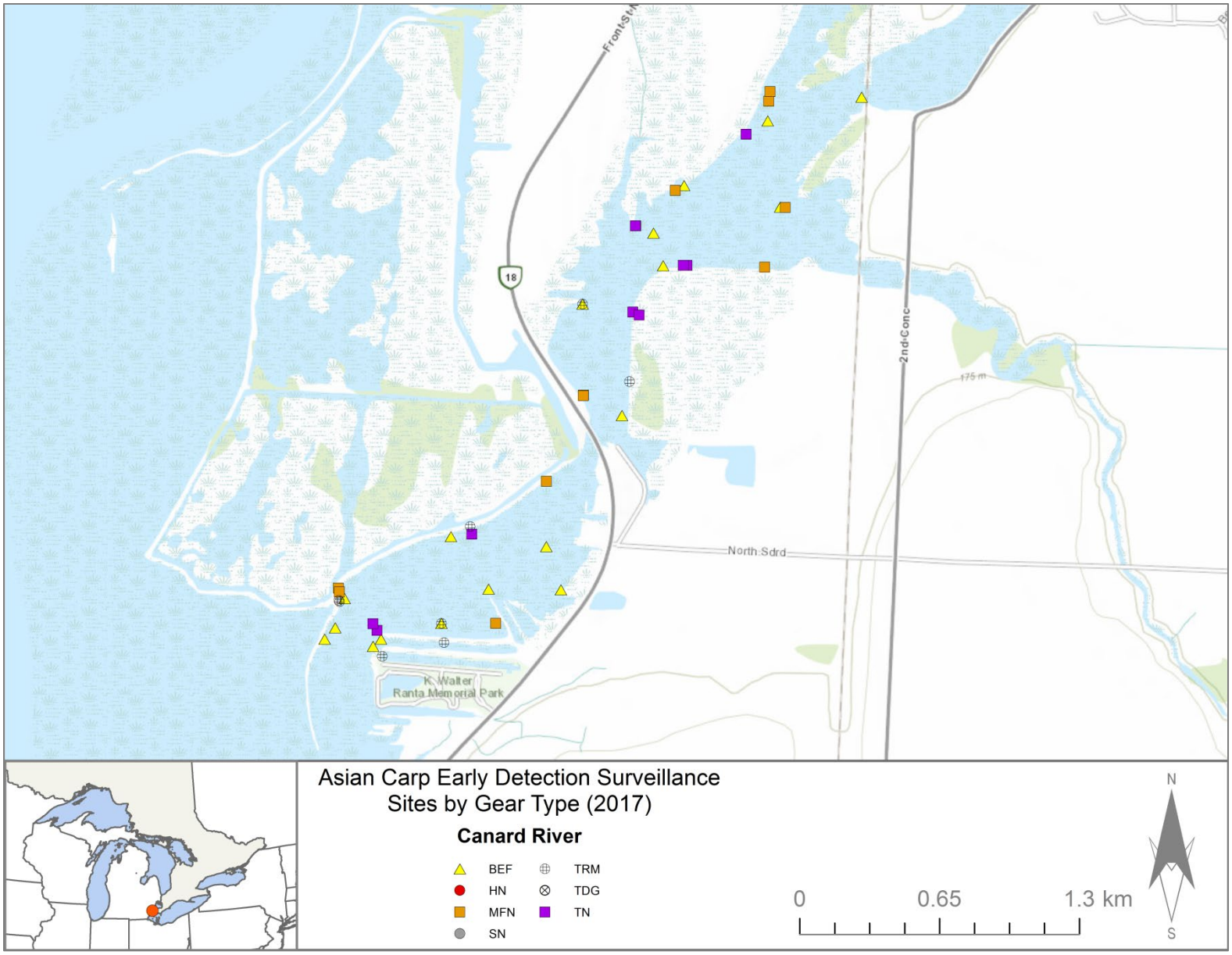

Figure A3.4 2017 Asian Carp Program early detection surveillance field sampling sites in the Canard River.

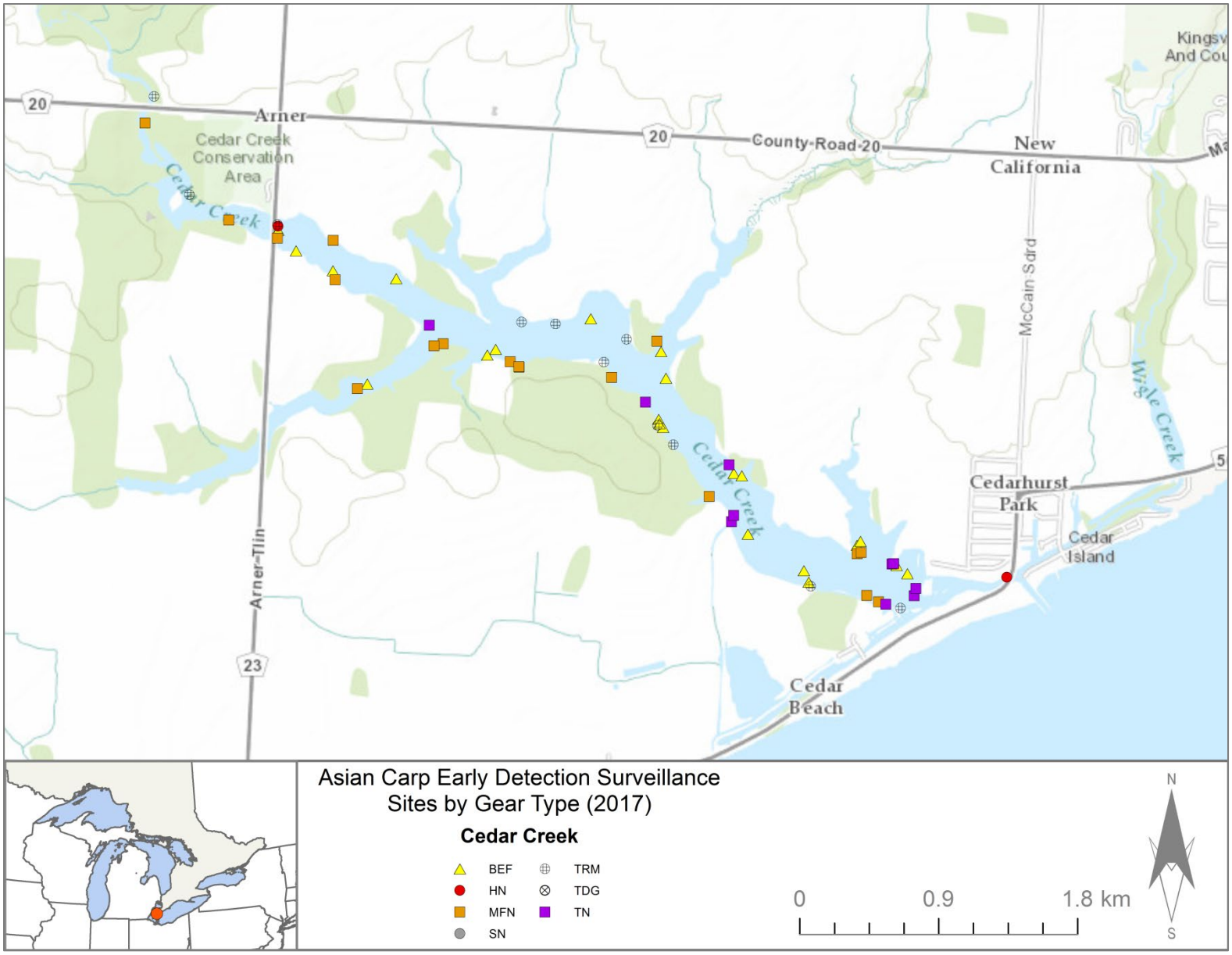

Figure A3.5 2017 Asian Carp Program early detection surveillance field sampling sites in Cedar Creek

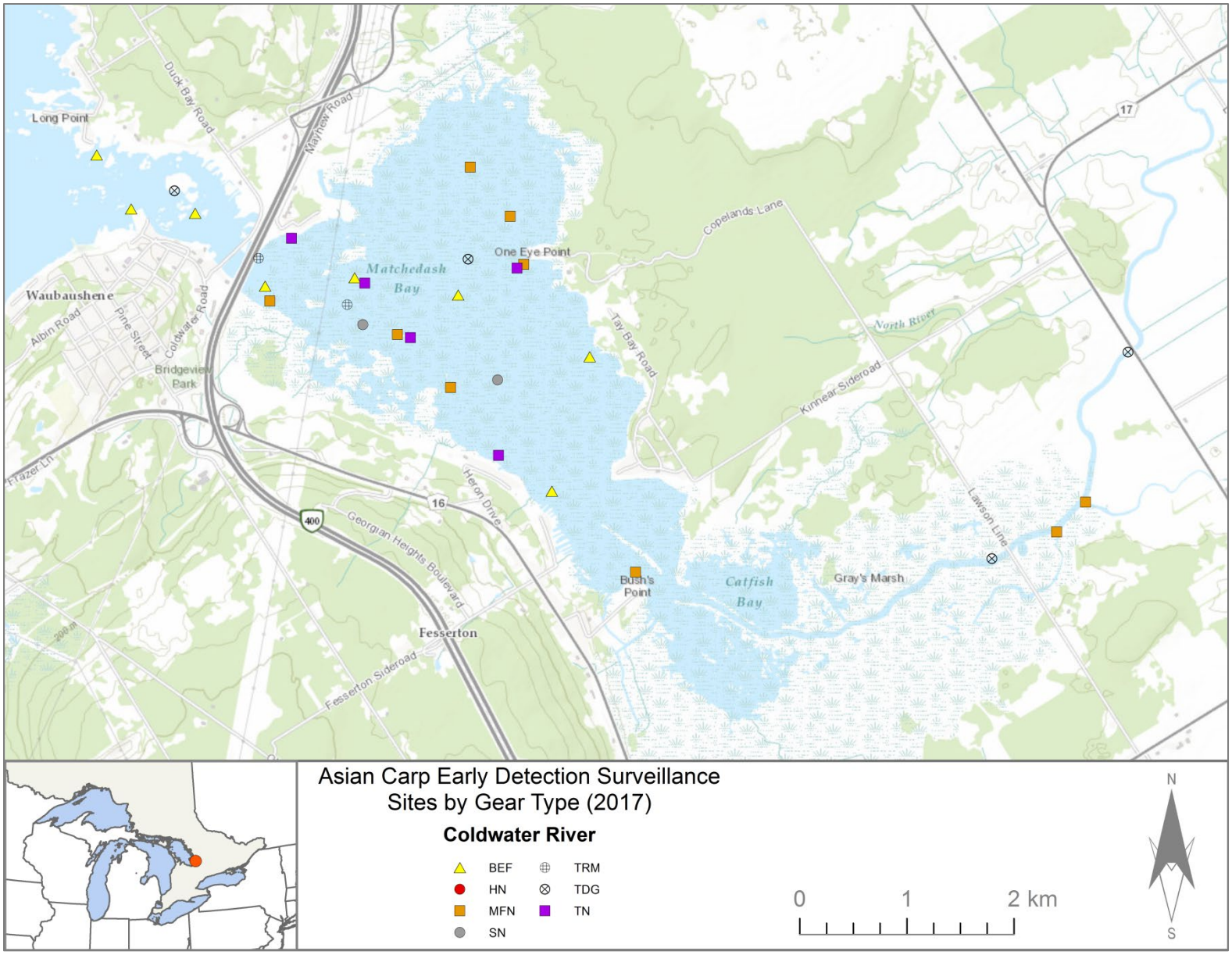

Figure A3.6 2017 Asian Carp Program early detection surveillance field sampling sites in the Coldwater River.

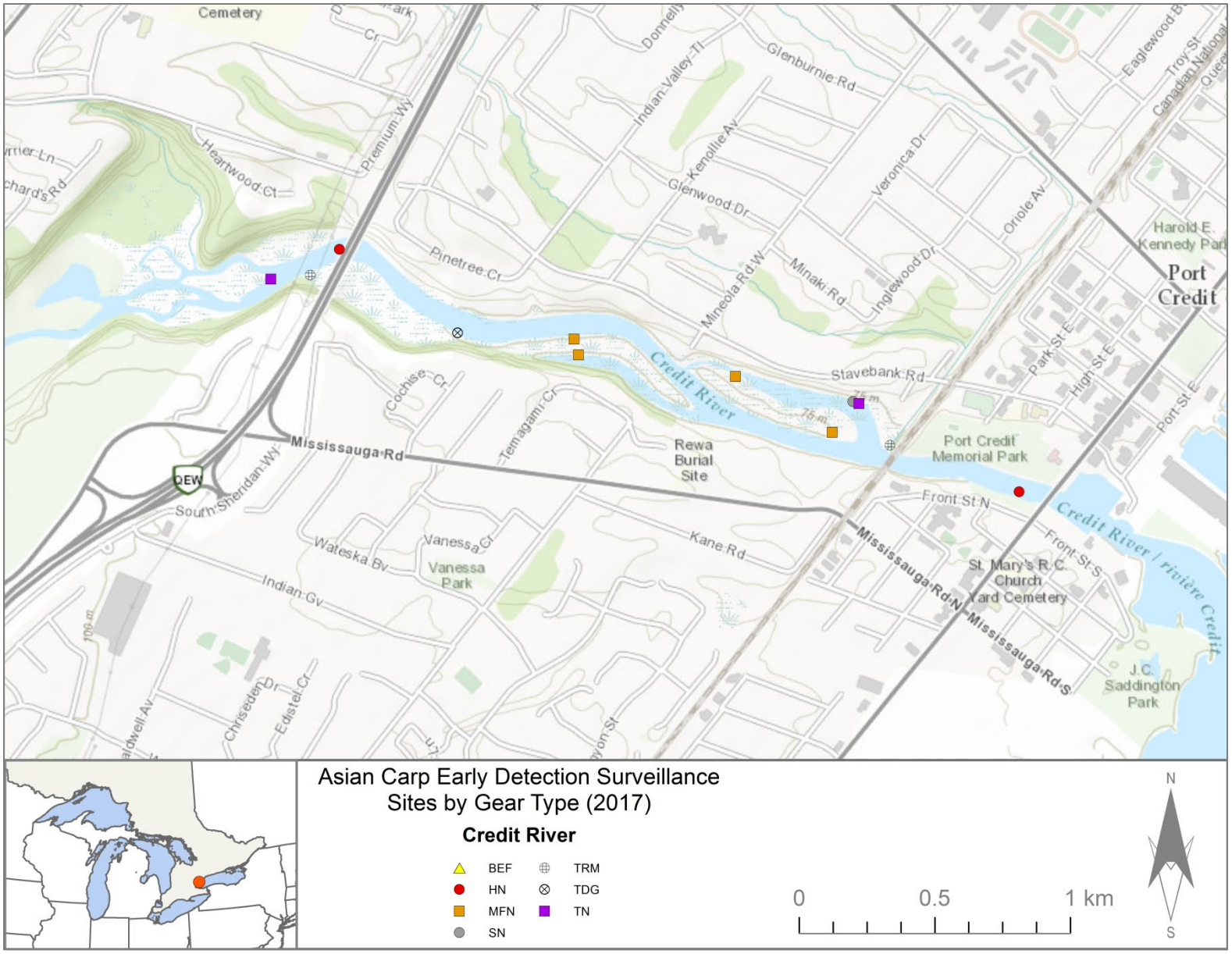

Figure A3.7 2017 Asian Carp Program early detection surveillance field sampling sites in the Credit River.

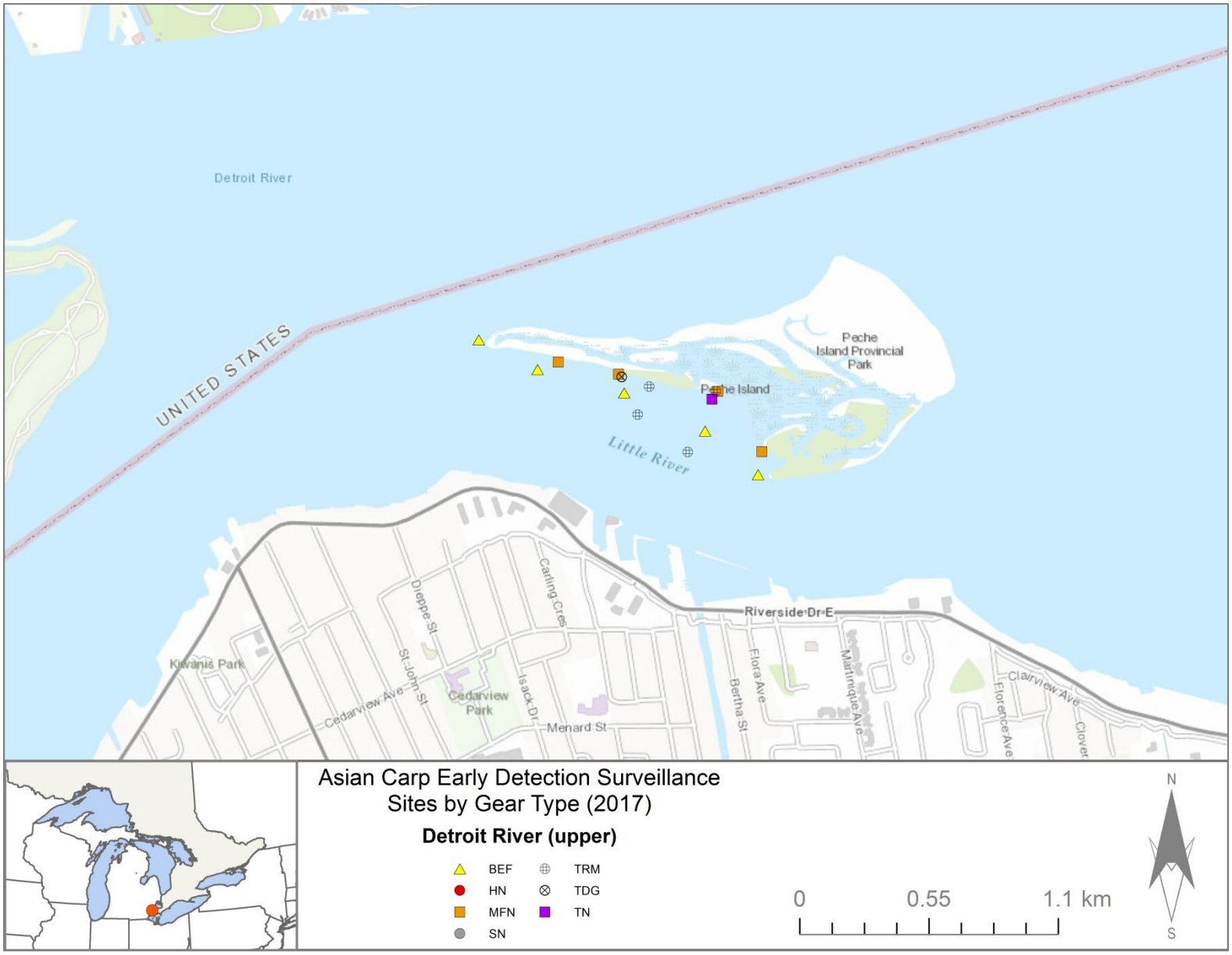

Figure A3.8 2017 Asian Carp Program early detection surveillance field sampling sites in the upper Detroit River.

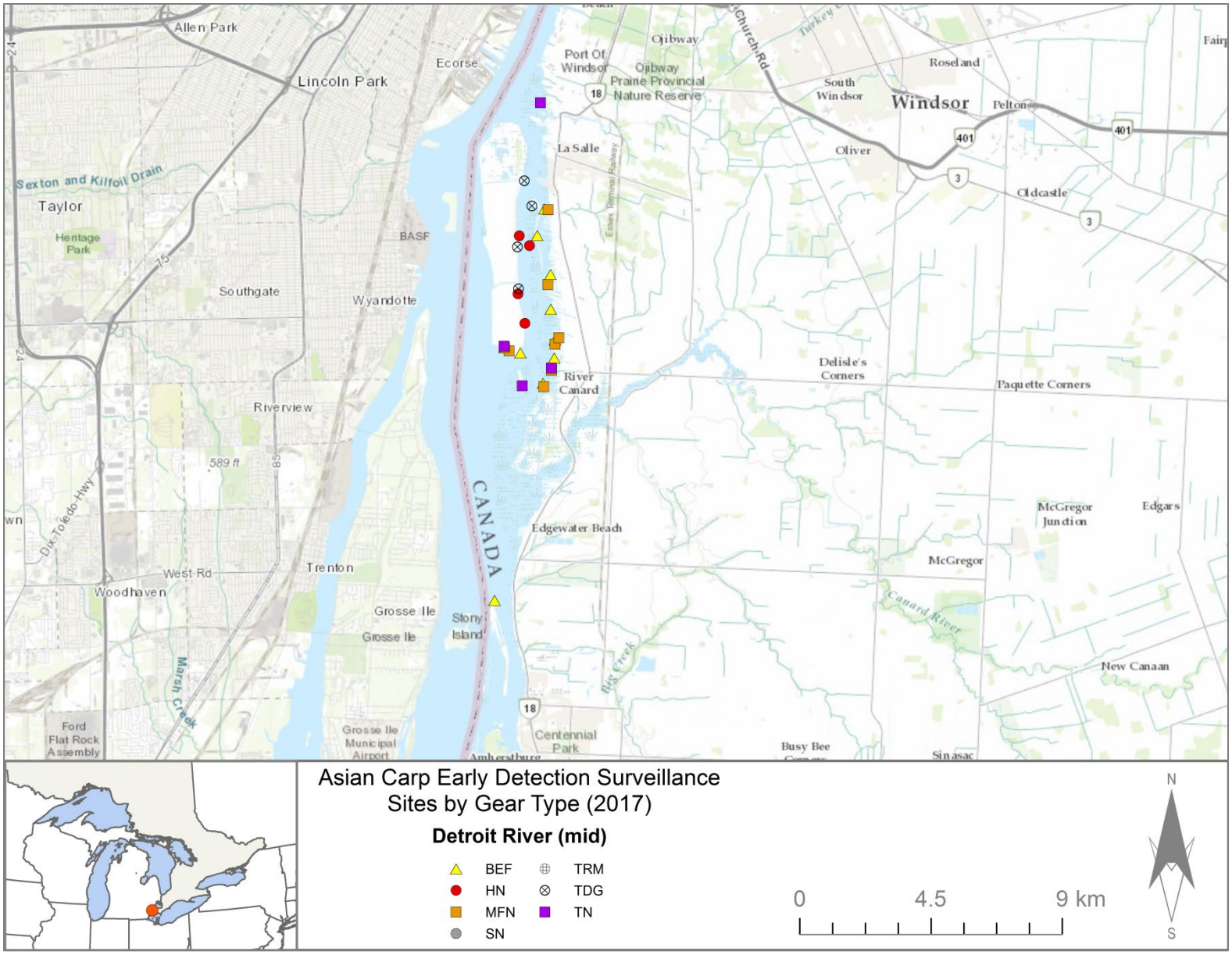

Figure A3.9 2017 Asian Carp Program early detection surveillance field sampling sites in the mid Detroit River.

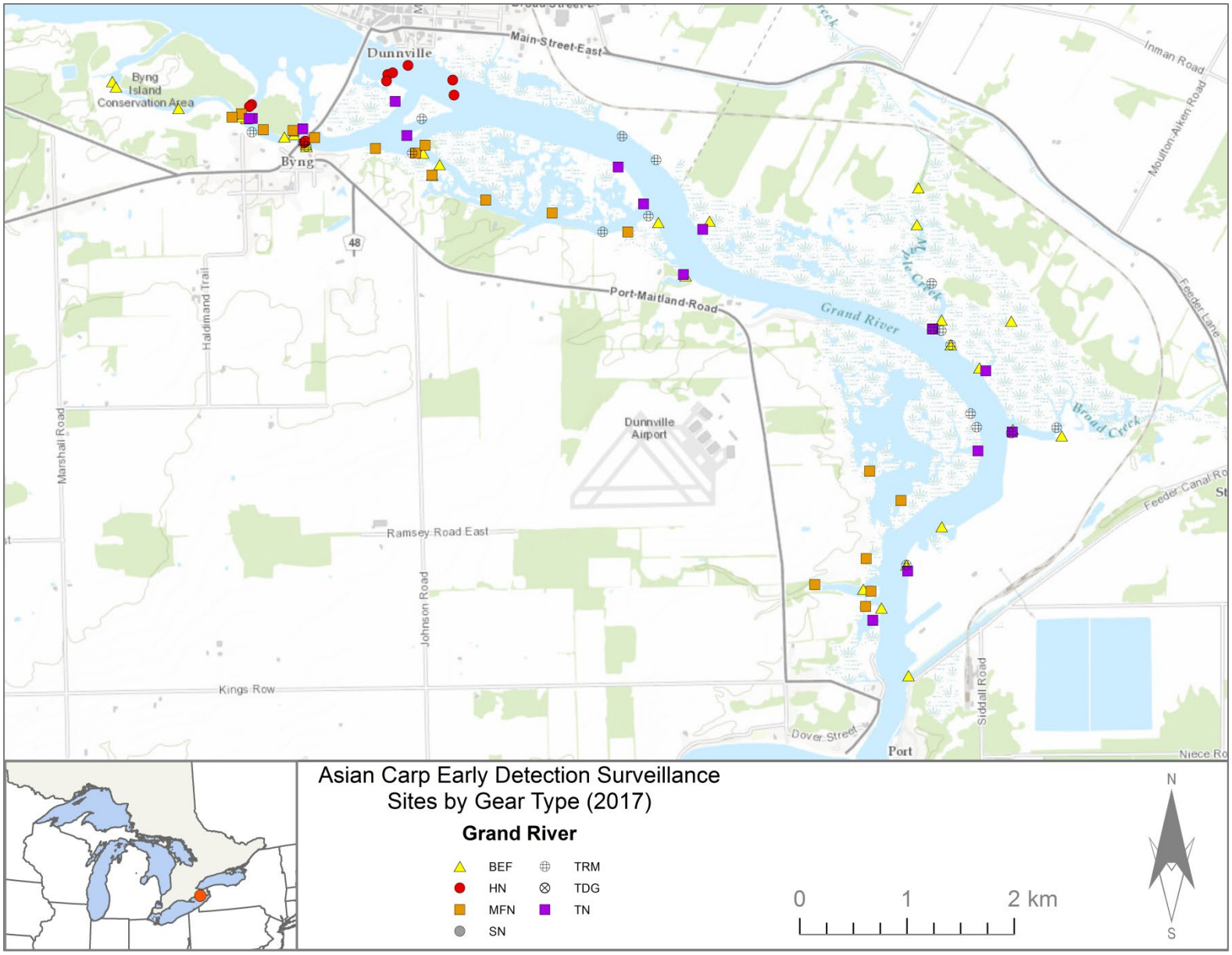

Figure A3.10 2017 Asian Carp Program early detection surveillance field sampling sites in the Grand River.

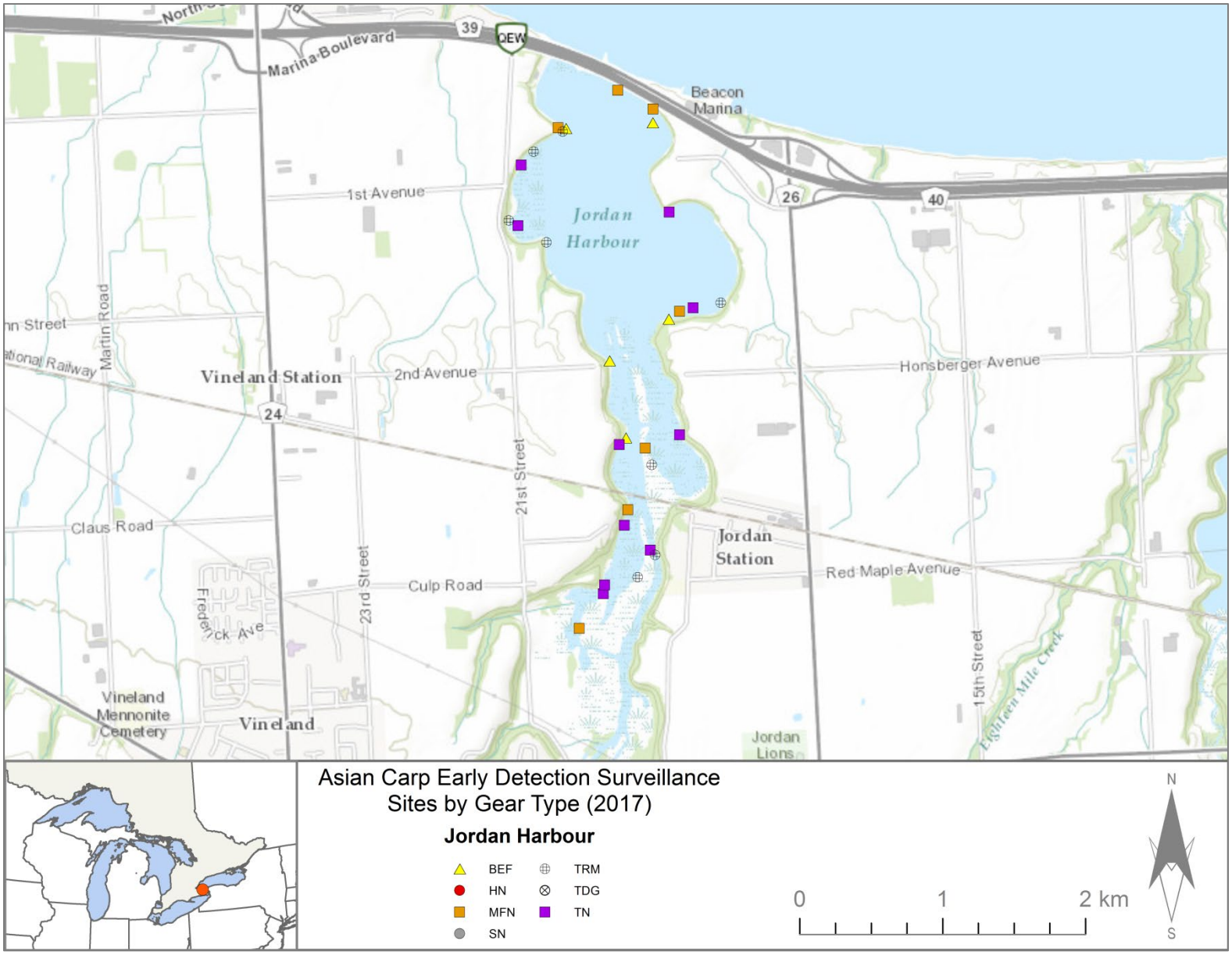

Figure A3.11 2017 Asian Carp Program early detection surveillance field sampling sites in Jordan Harbour.

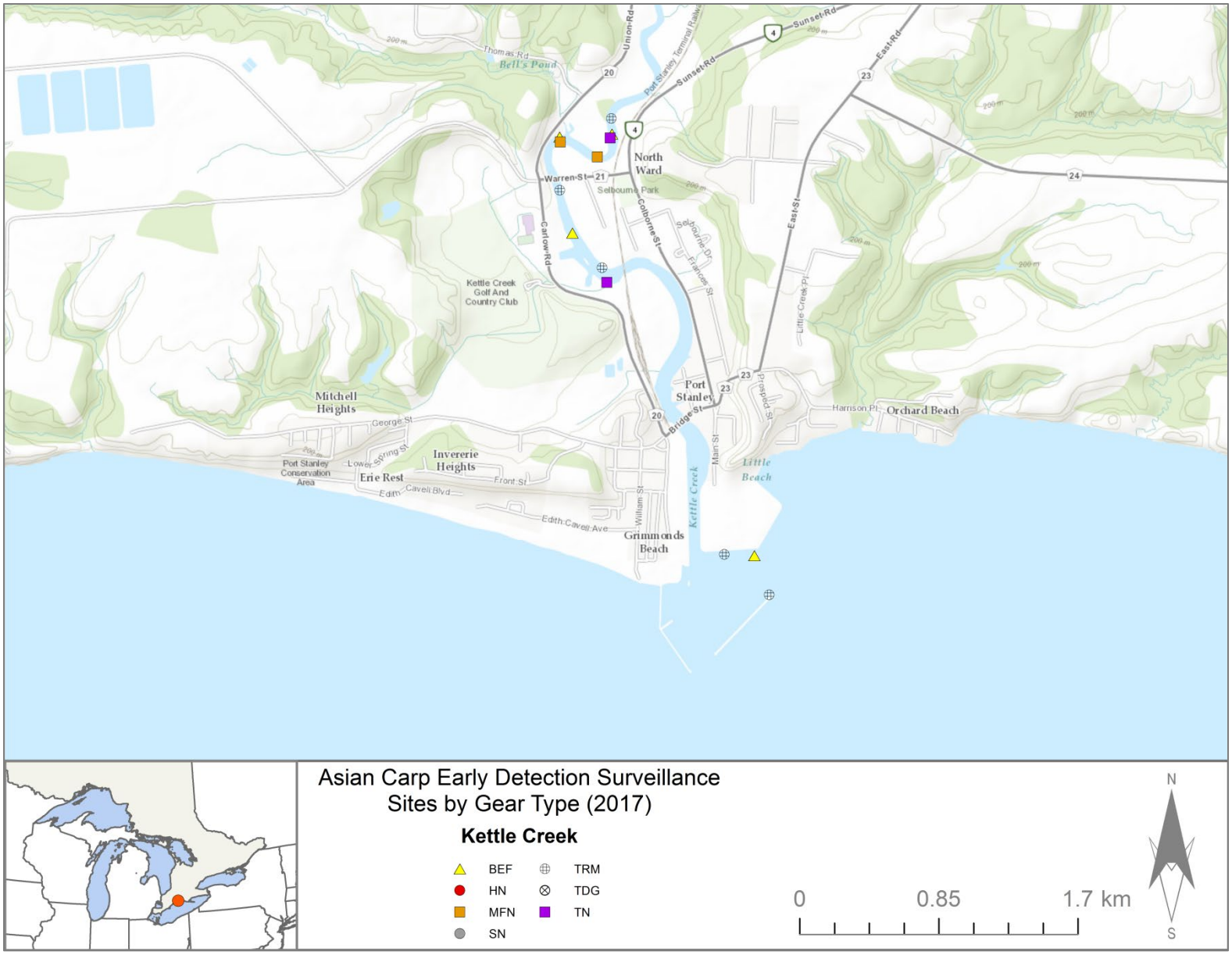

Figure A3.12 2017 Asian Carp Program early detection surveillance field sampling sites in Kettle Creek.

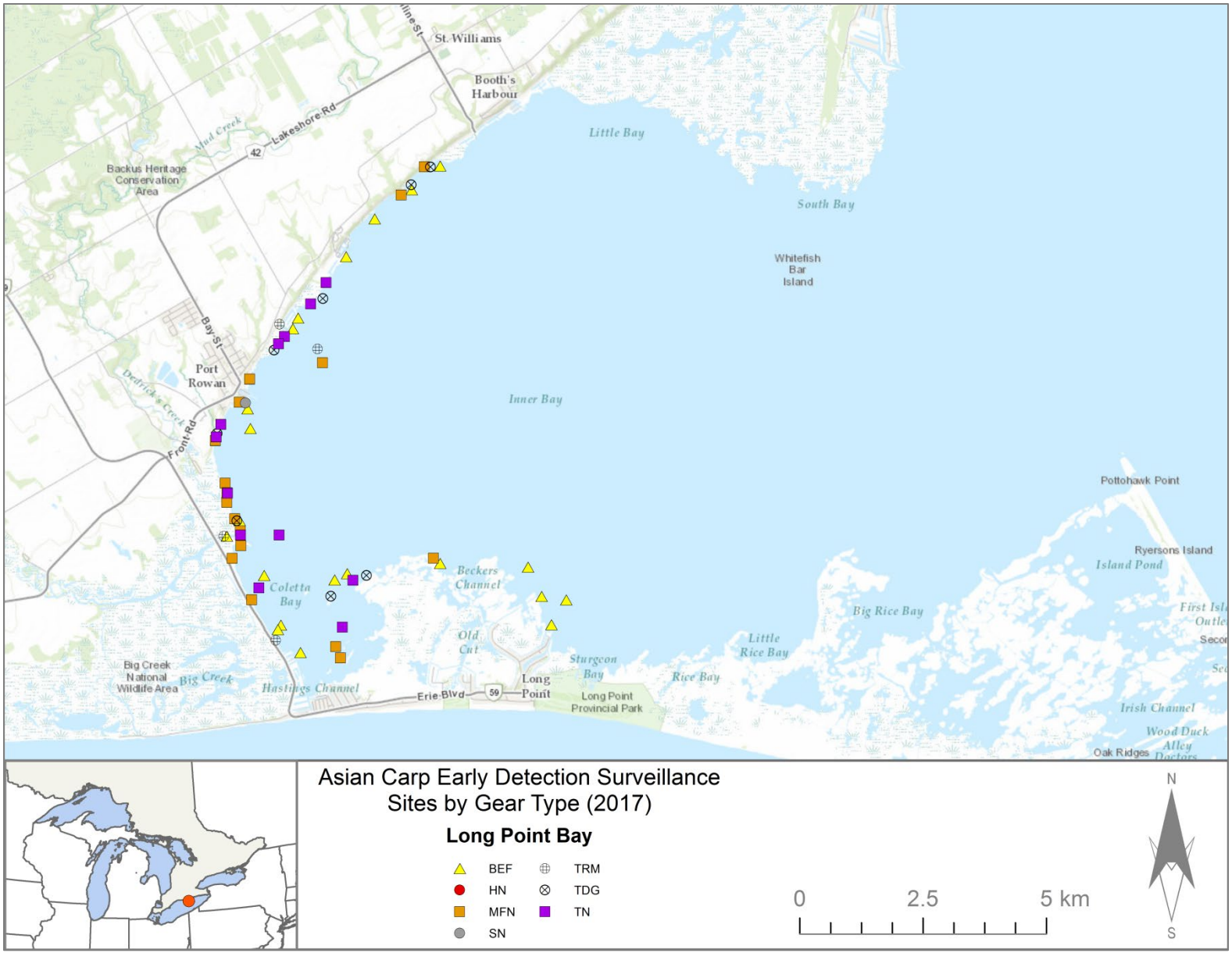

Figure A3.13 2017 Asian Carp Program early detection surveillance field sampling sites in Long Point Bay.

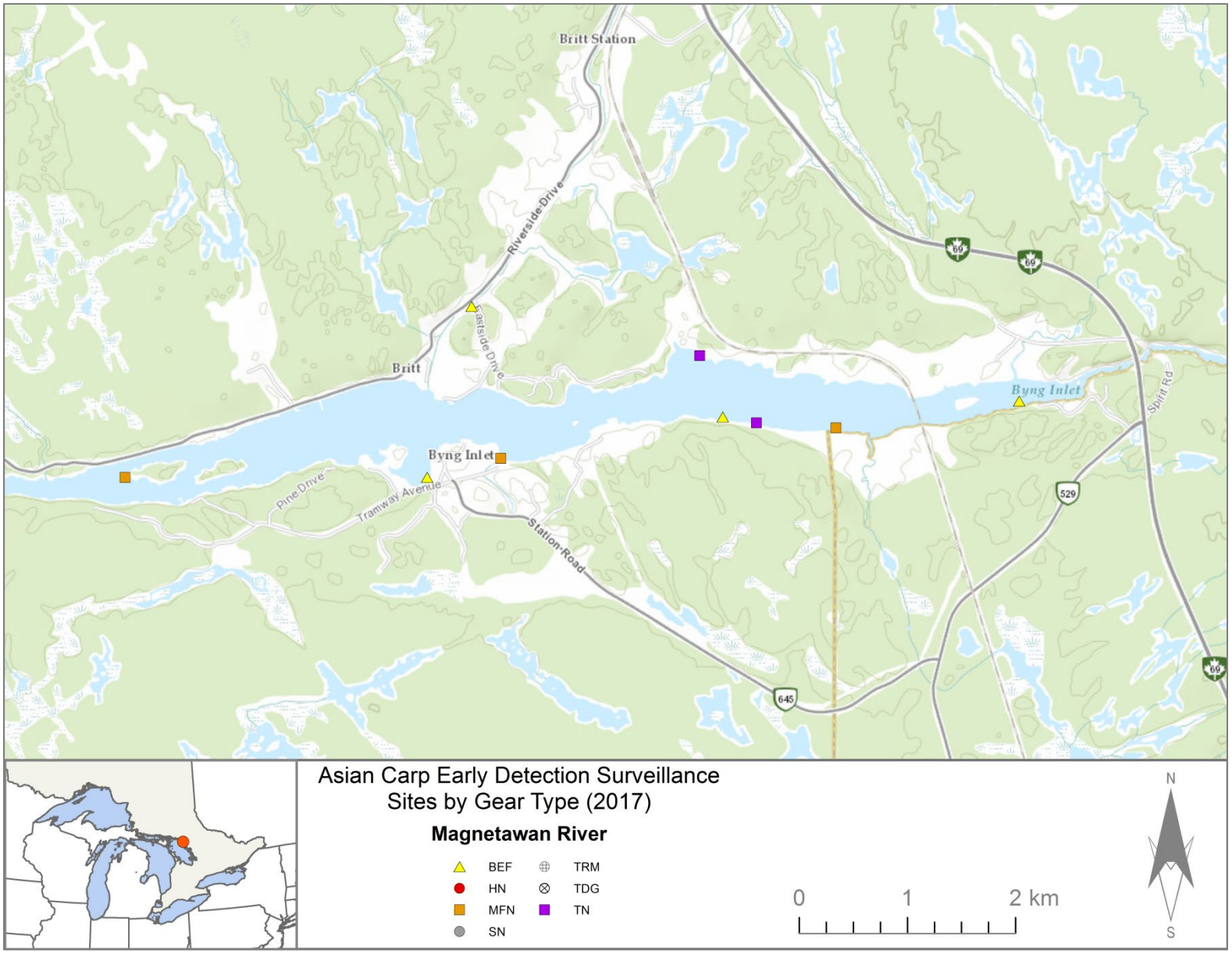

Figure A3.14 2017 Asian Carp Program early detection surveillance field sampling sites in the Magnetawan River.

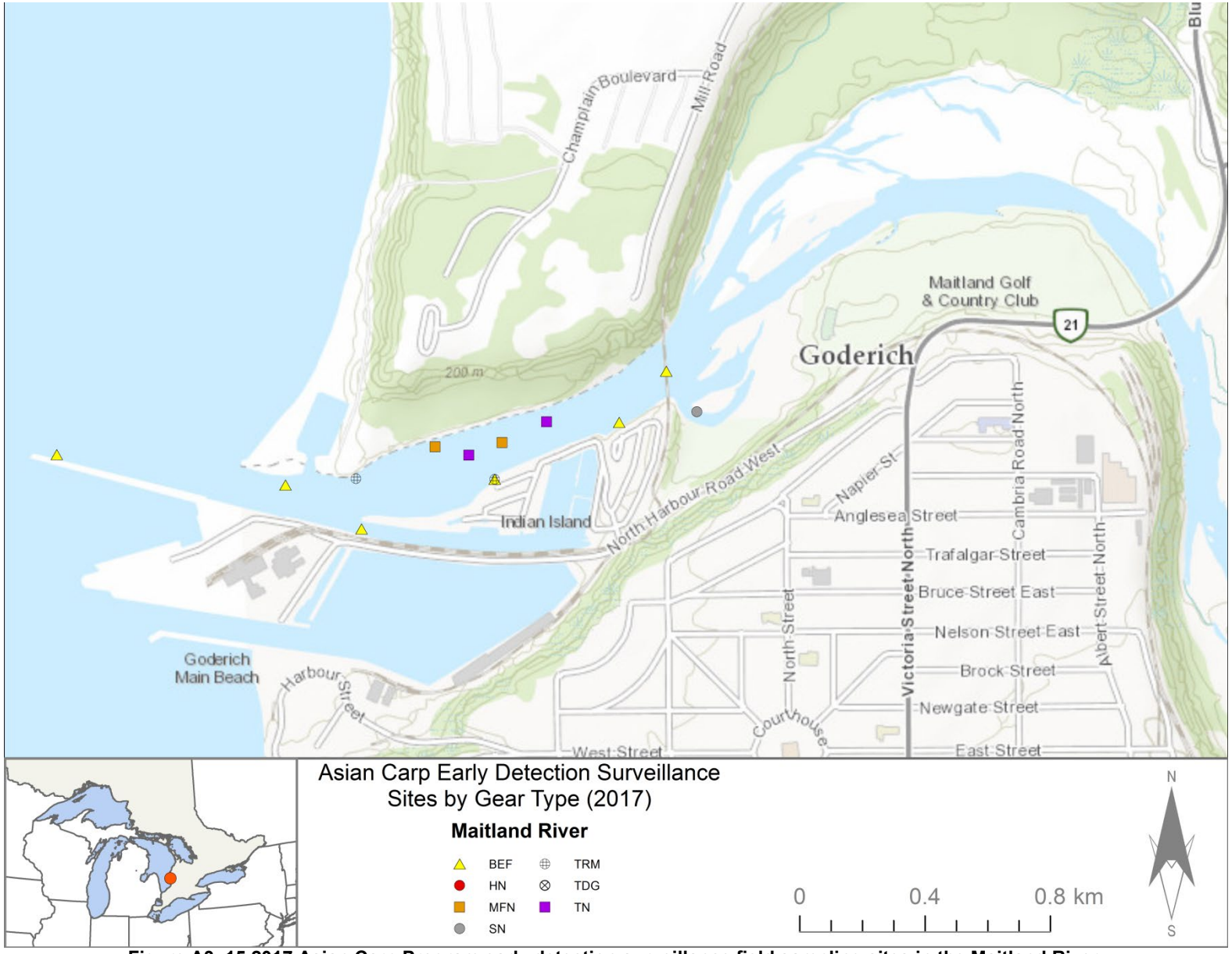

Figure A3. 15 2017 Asian Carp Program early detection surveillance field sampling sites in the Maitland River.

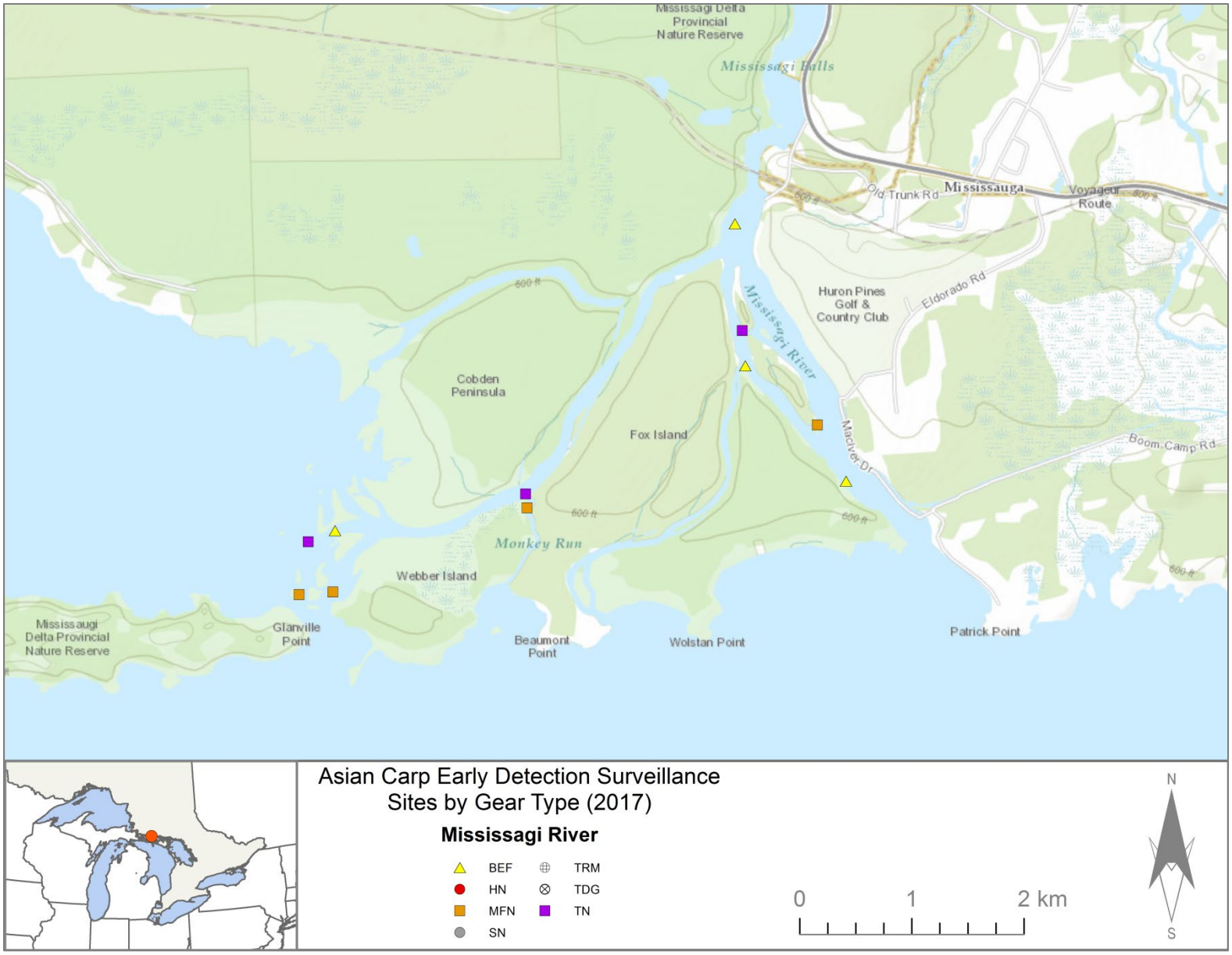

Figure A3.16 2017 Asian Carp Program early detection surveillance field sampling sites in the Mississagi River.

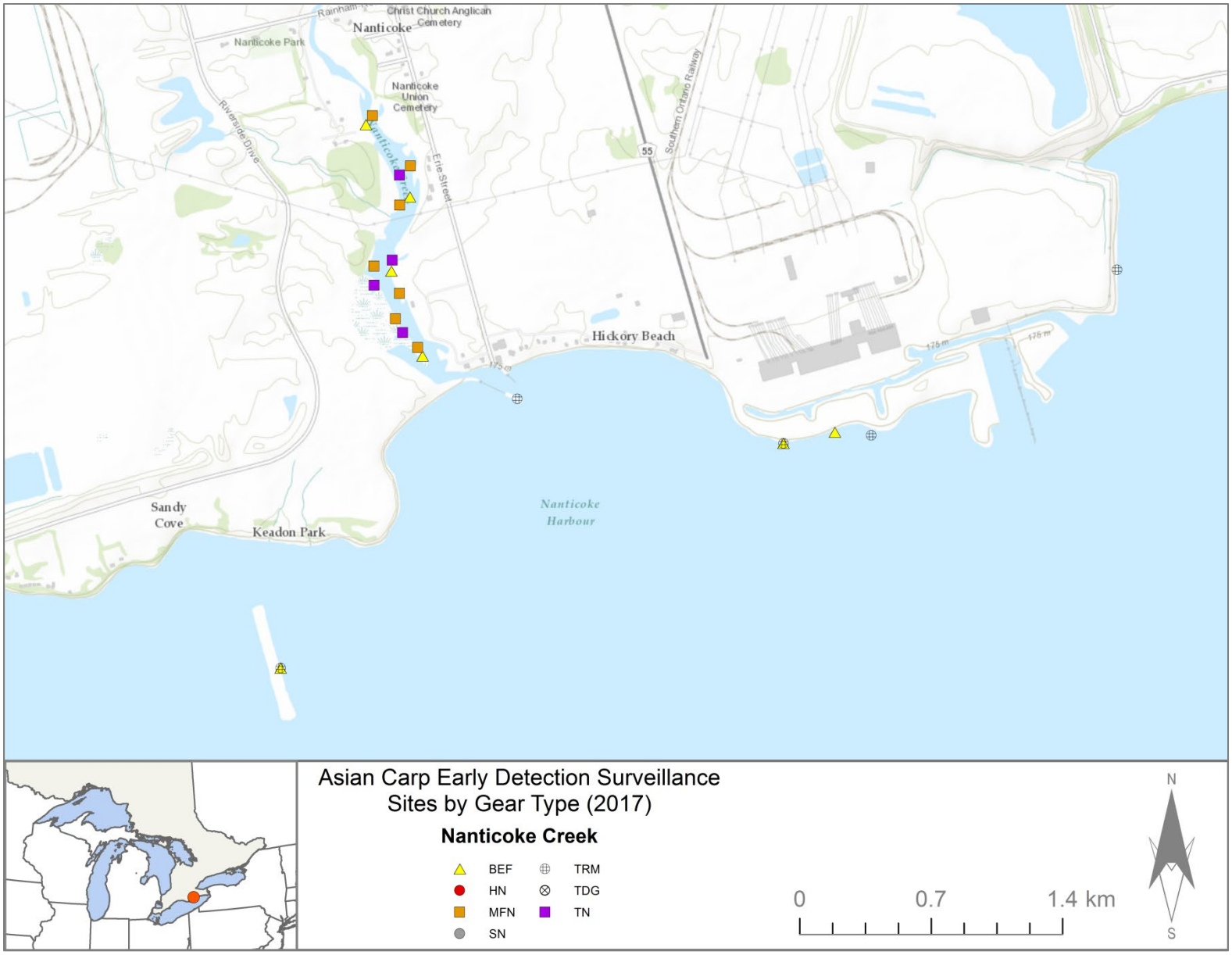

Figure A3.17 2017 Asian Carp Program early detection surveillance field sampling sites in Nanticoke Creek.

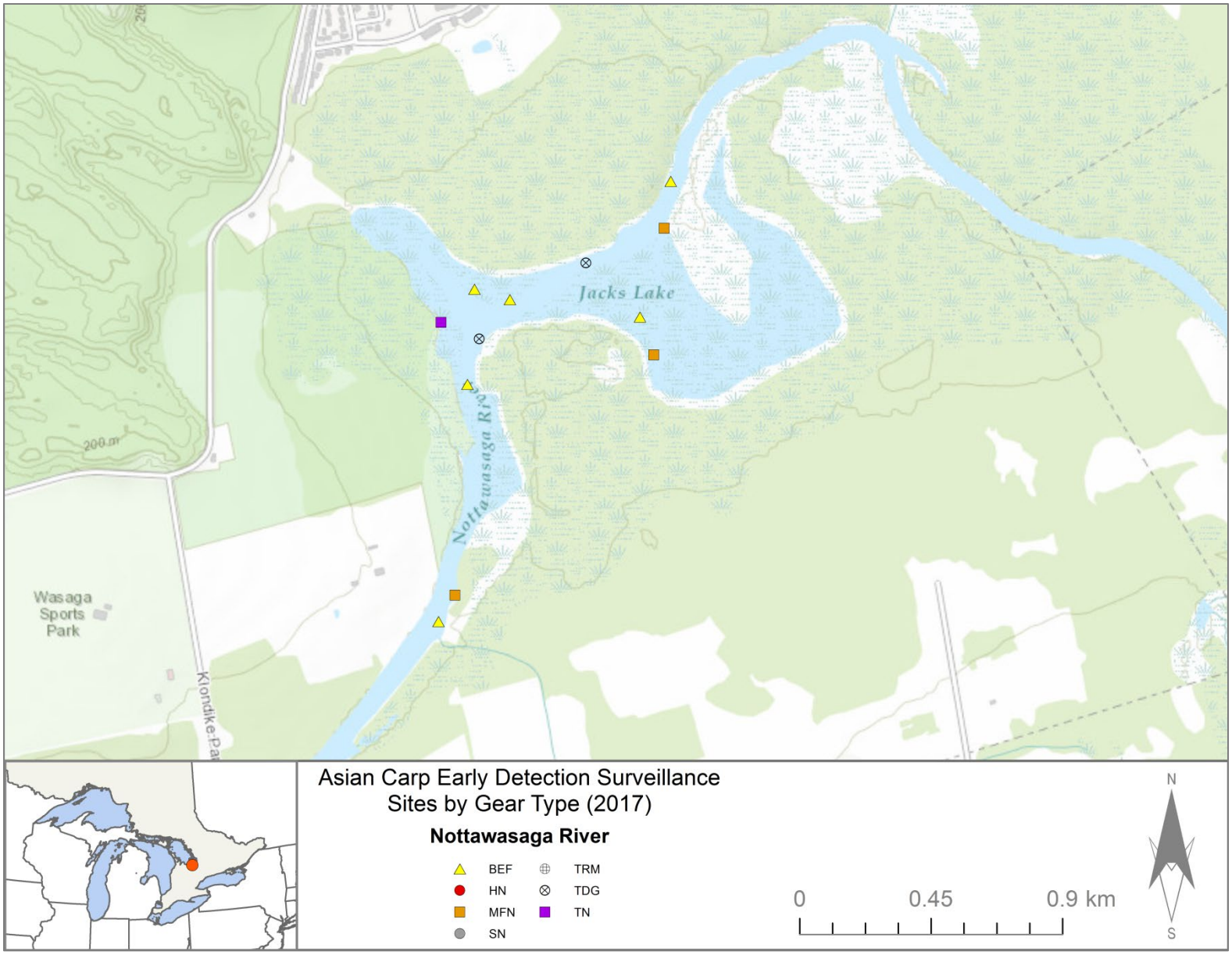

Figure A3.18 2017 Asian Carp Program early detection surveillance field sampling sites in the Nottawasaga River.

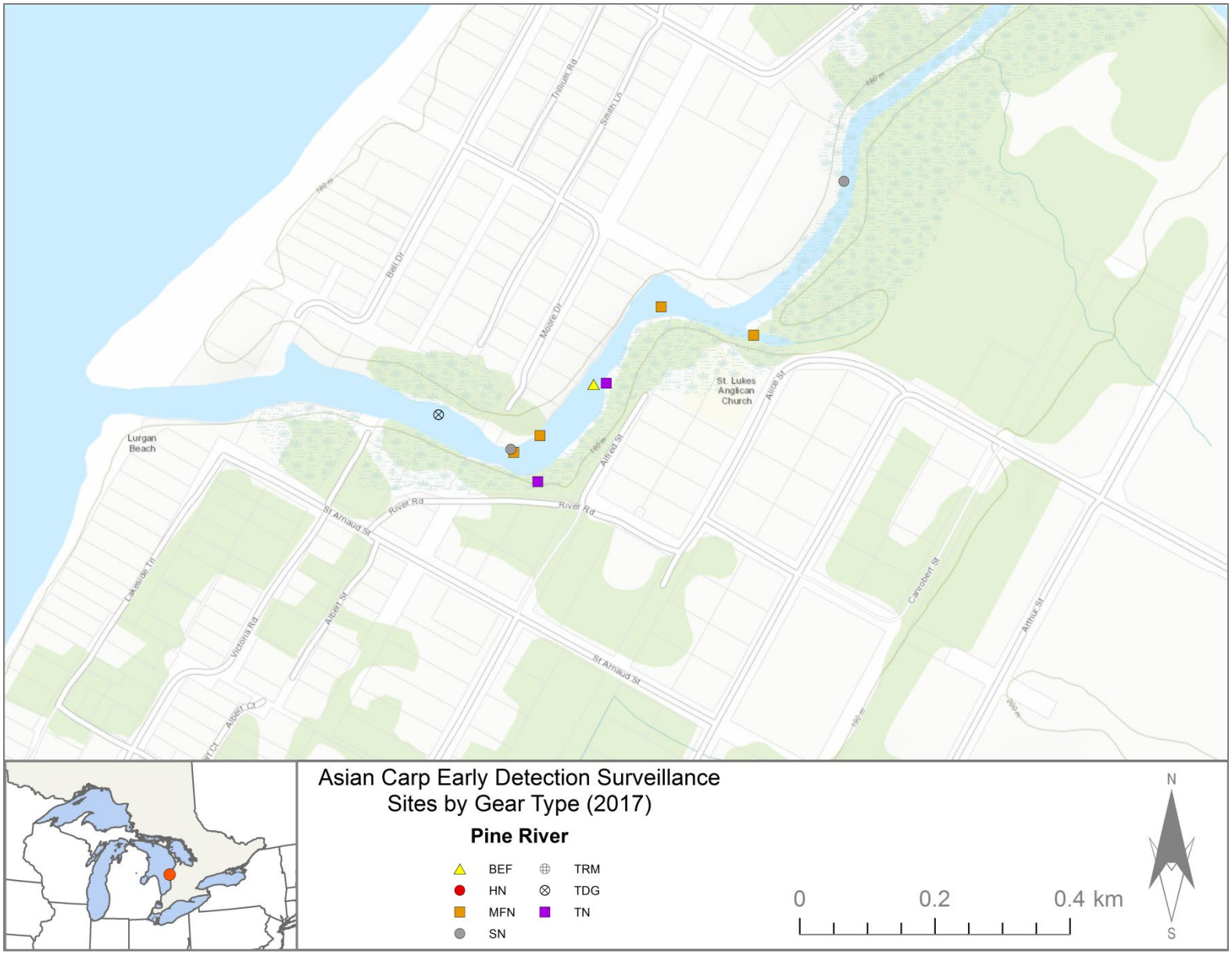

Figure A3.19 2017 Asian Carp Program early detection surveillance field sampling sites in the Pine River.

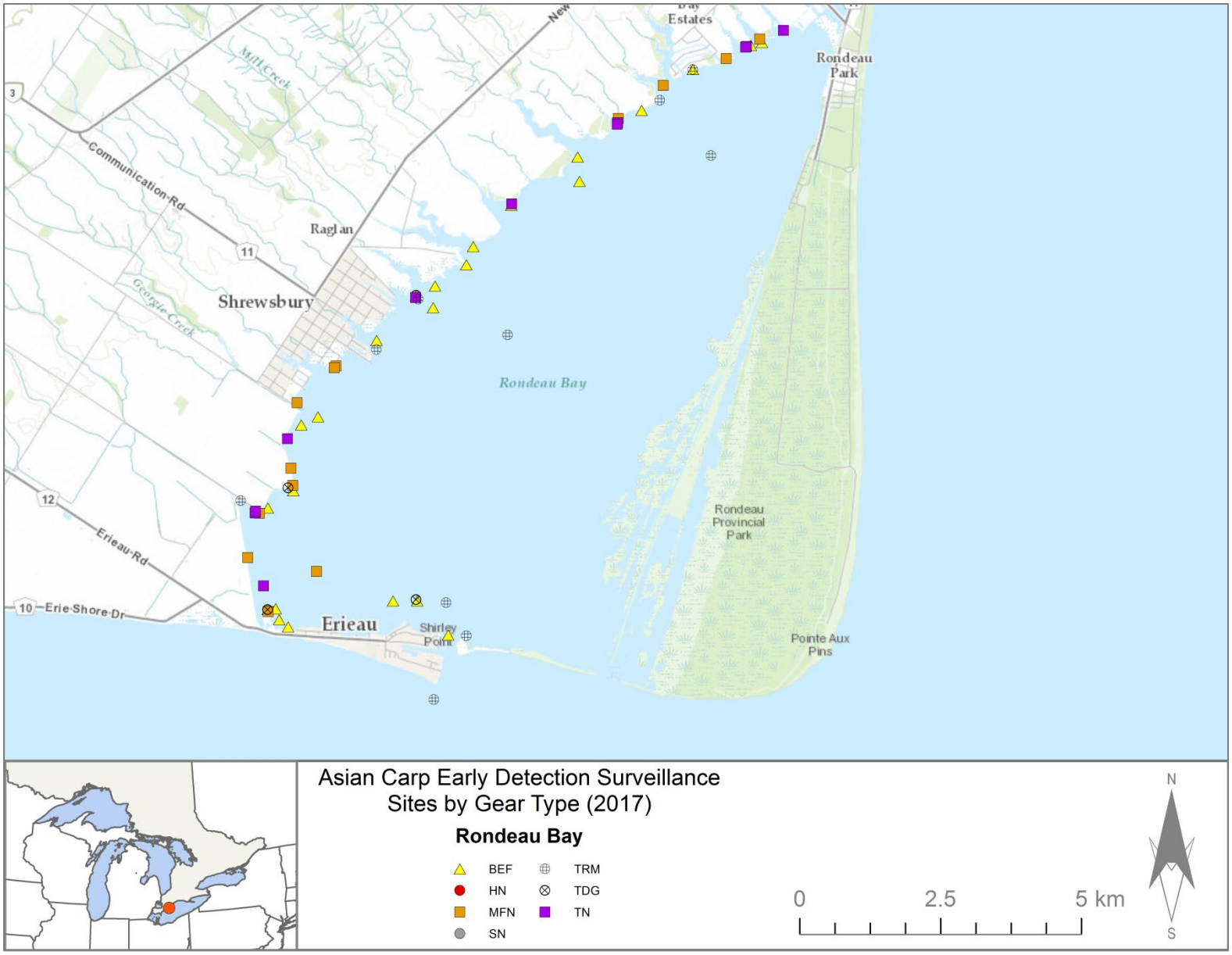

Figure A3.20 2017 Asian Carp Program early detection surveillance field sampling sites in Rondeau Bay.

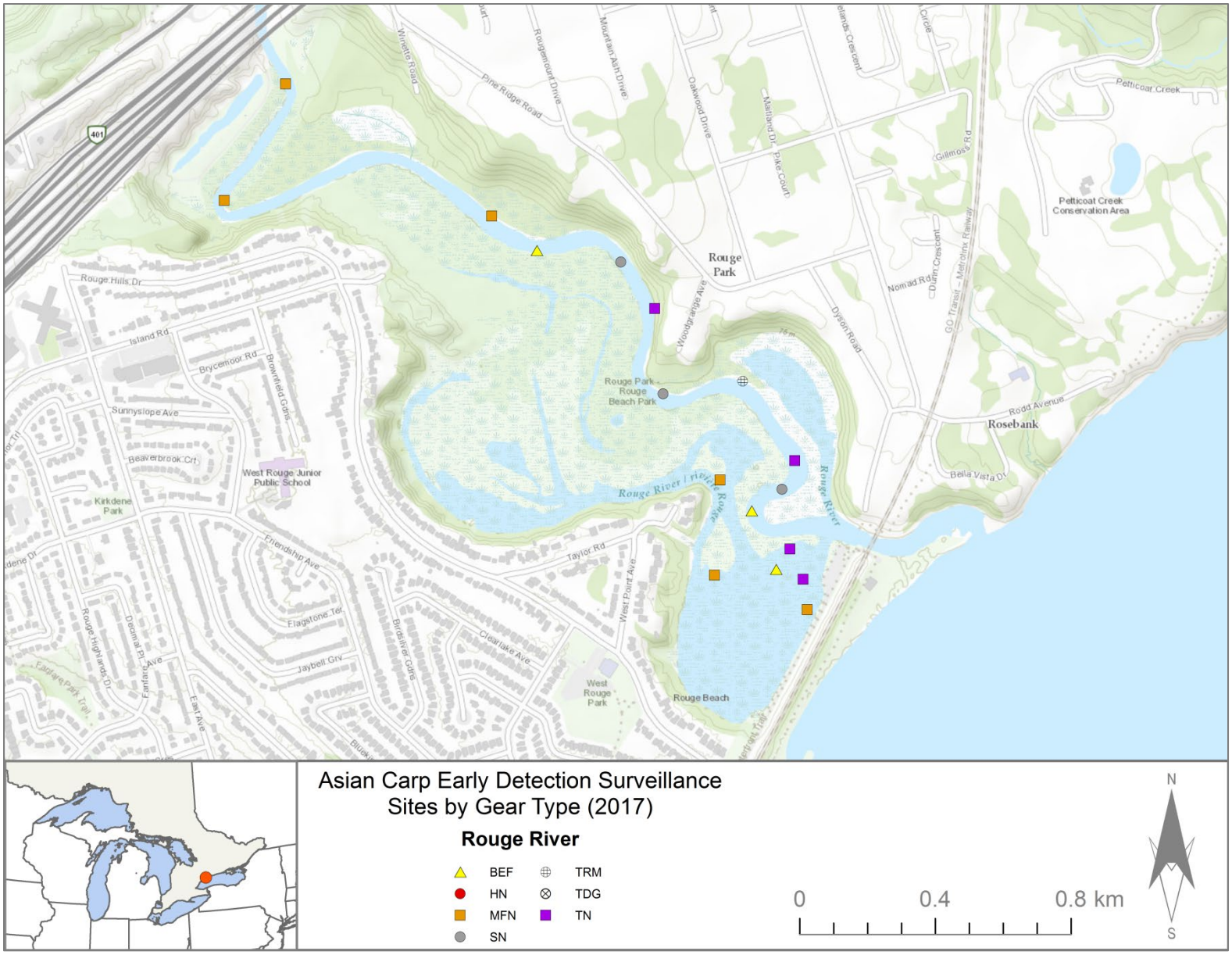

Figure A3.21 2017 Asian Carp Program early detection surveillance field sampling sites in the Rouge River.

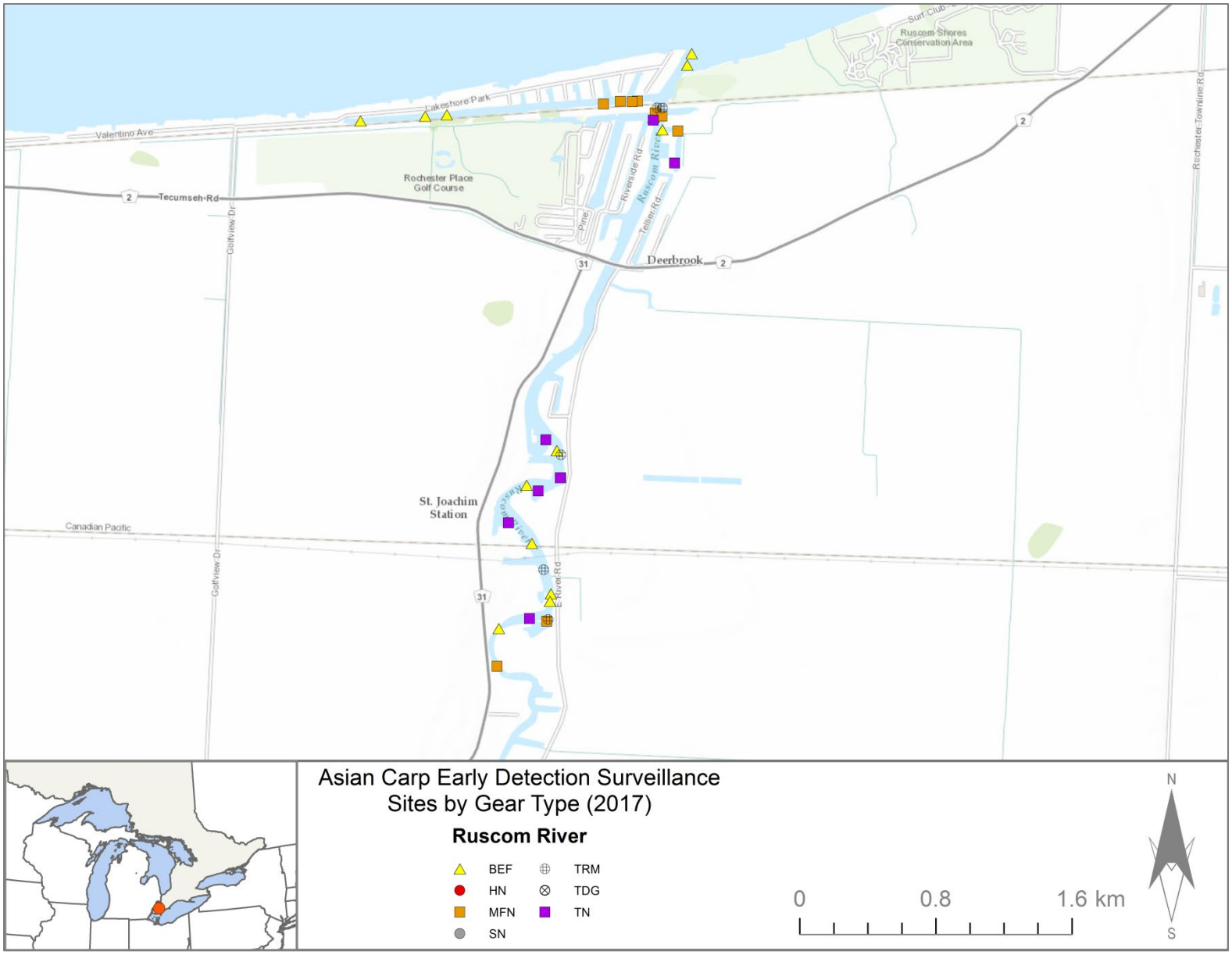

Figure A3.22 2017 Asian Carp Program early detection surveillance field sampling sites in the Ruscom River.

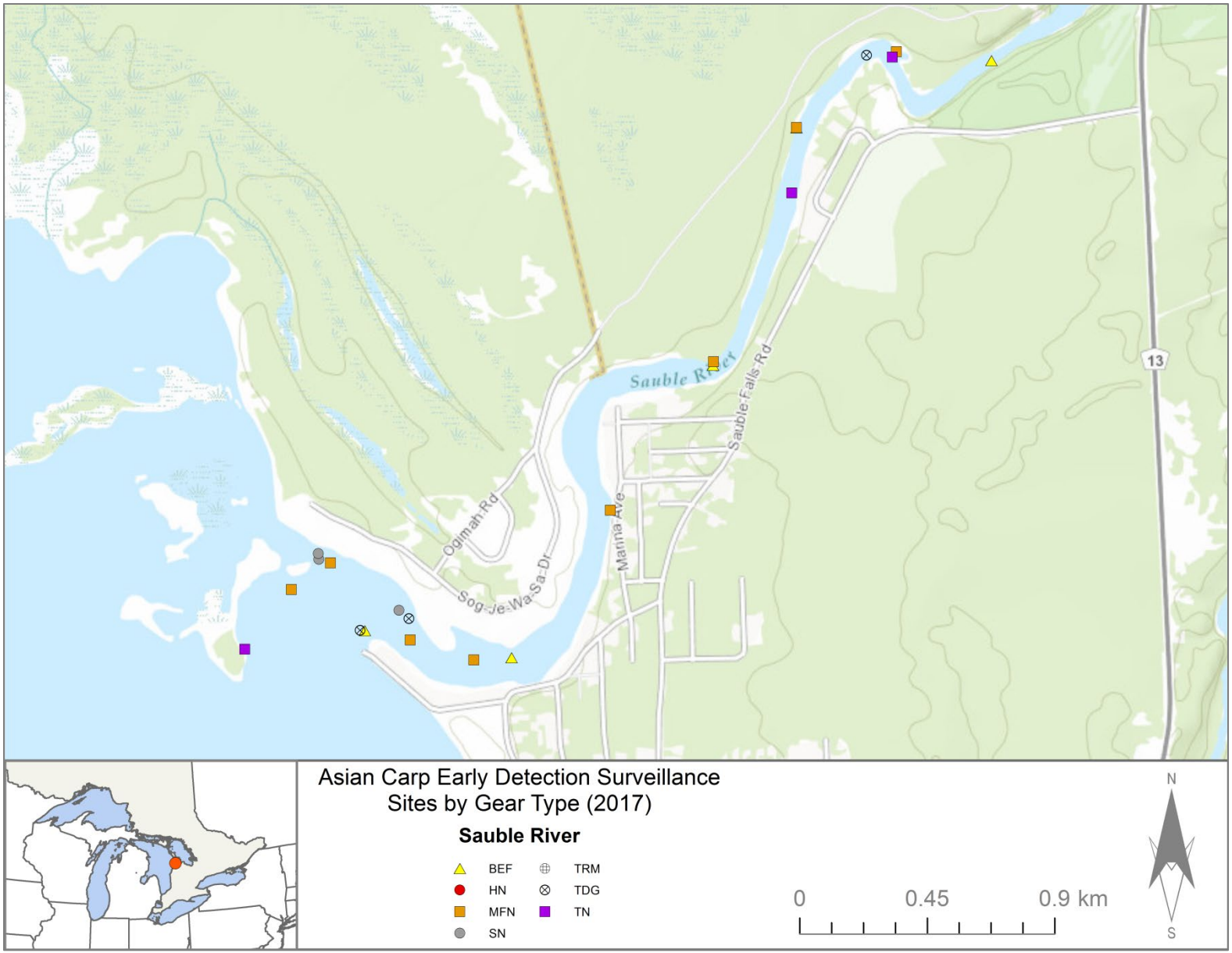

Figure A3.23 2017 Asian Carp Program early detection surveillance field sampling sites in the Sauble River.

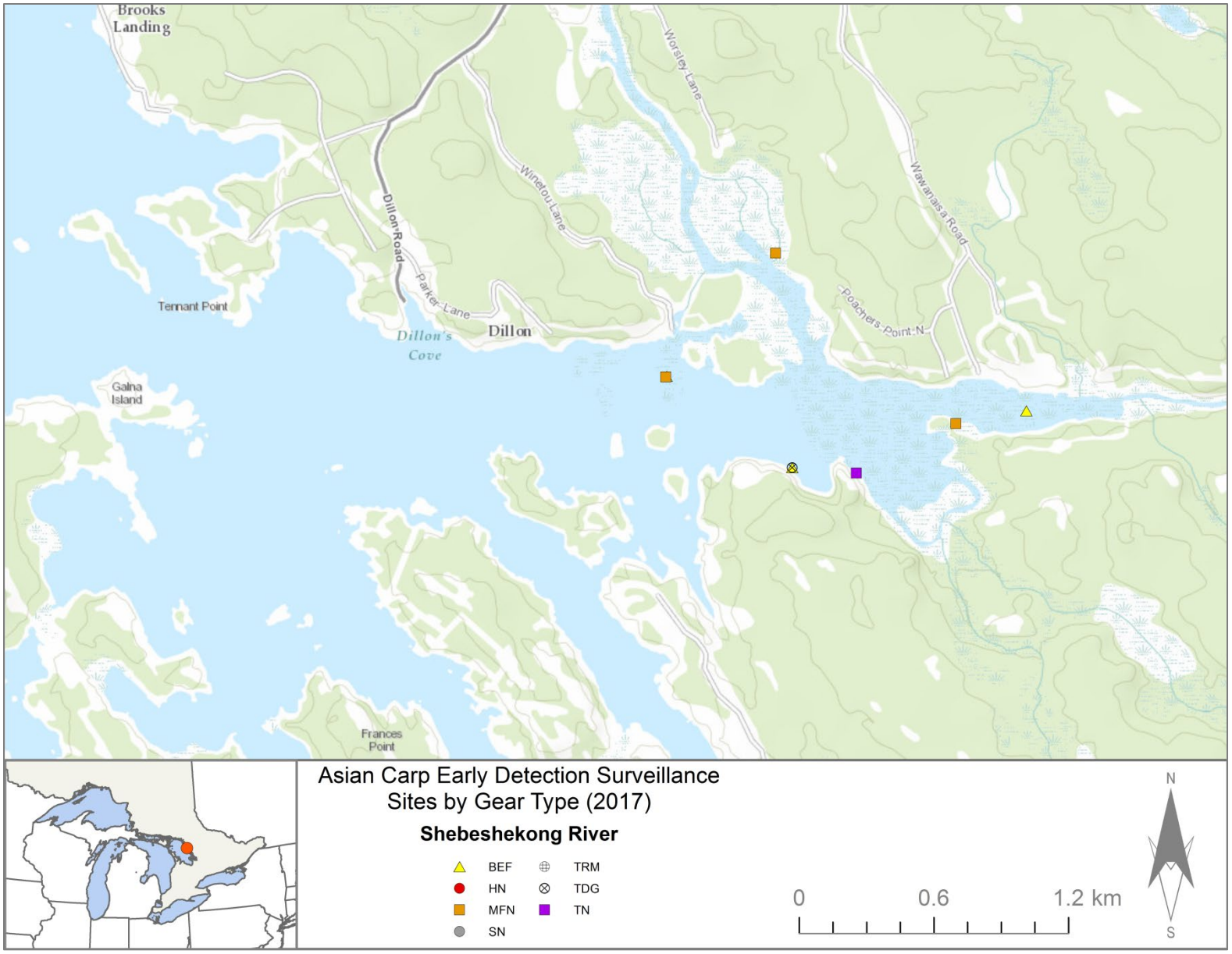

Figure A3.24 2017 Asian Carp Program early detection surveillance field sampling sites in the Shebeshekong River.

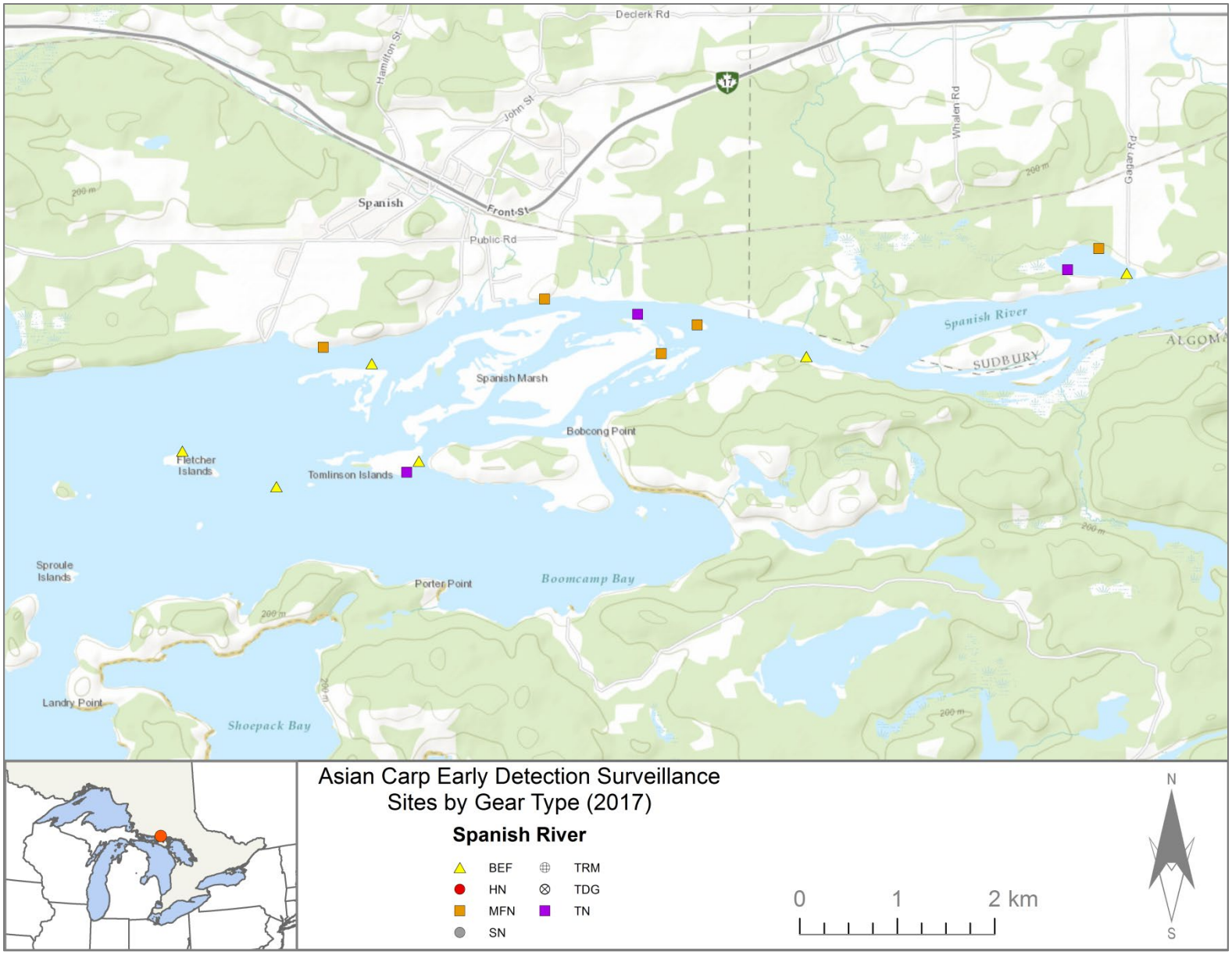

Figure A3.25 2017 Asian Carp Program early detection surveillance field sampling sites in the Spanish River.

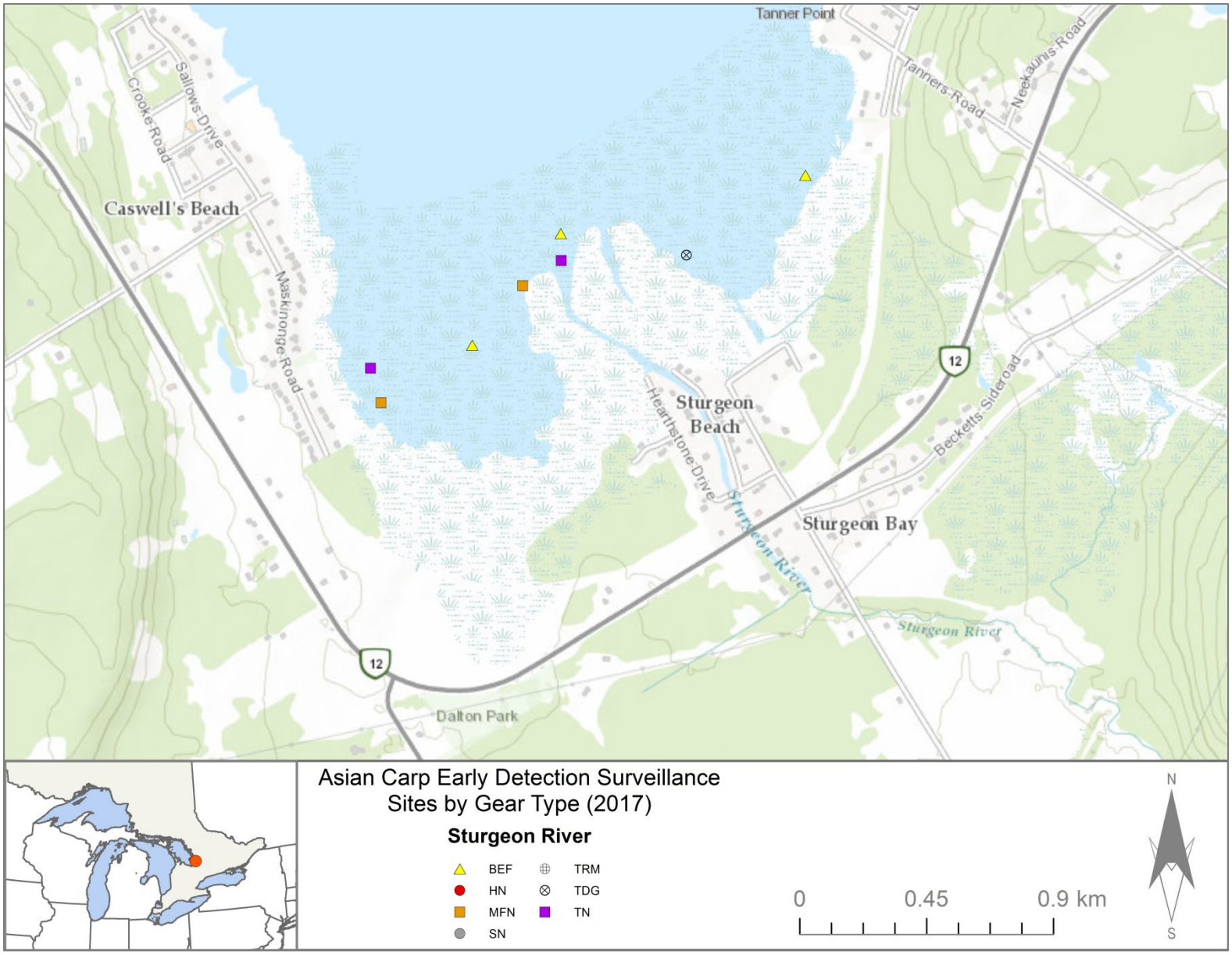

Figure A3.26 2017 Asian Carp Program early detection surveillance field sampling sites in the Sturgeon River.

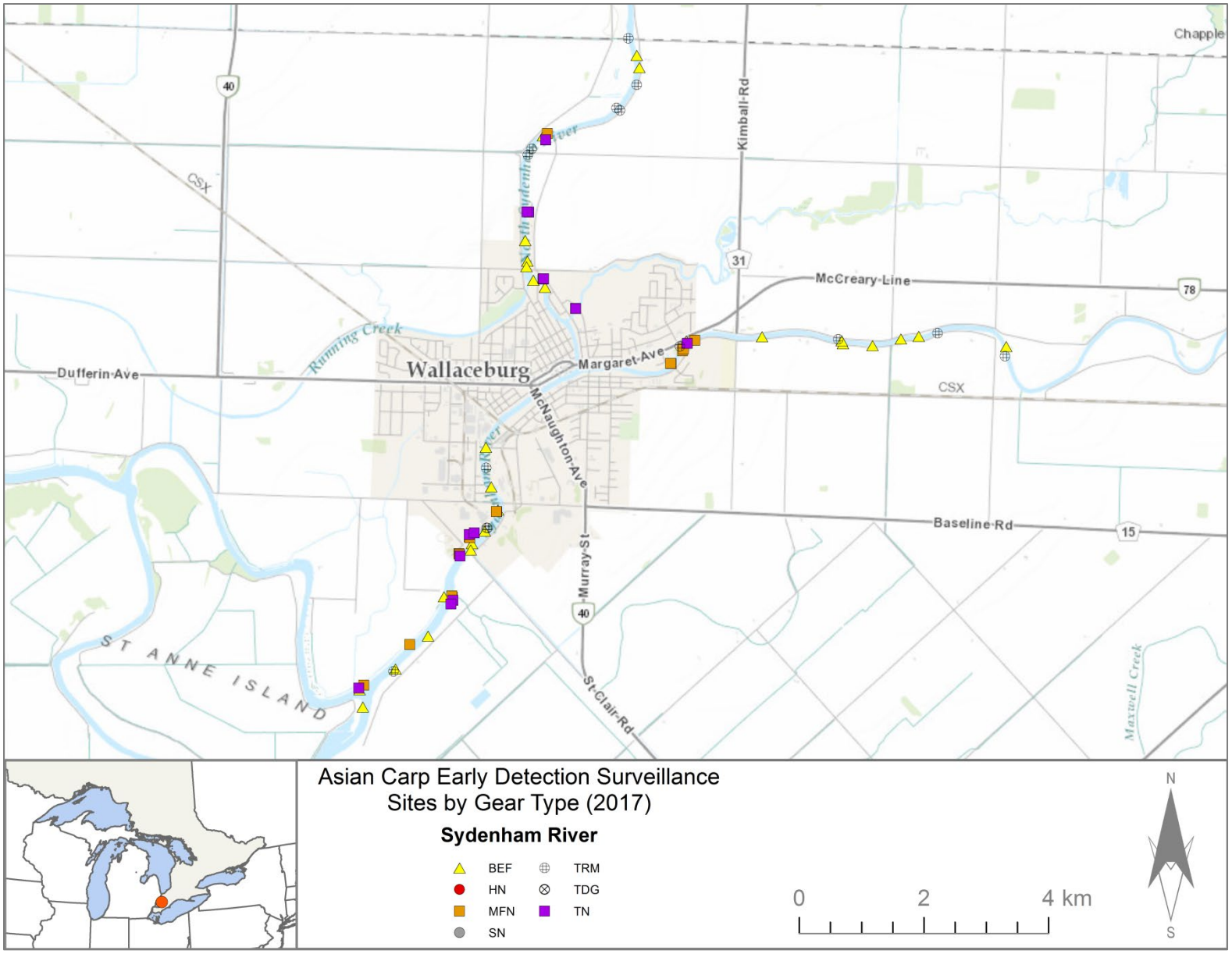

Figure A3.27 2017 Asian Carp Program early detection surveillance field sampling sites in the Sydenham River.

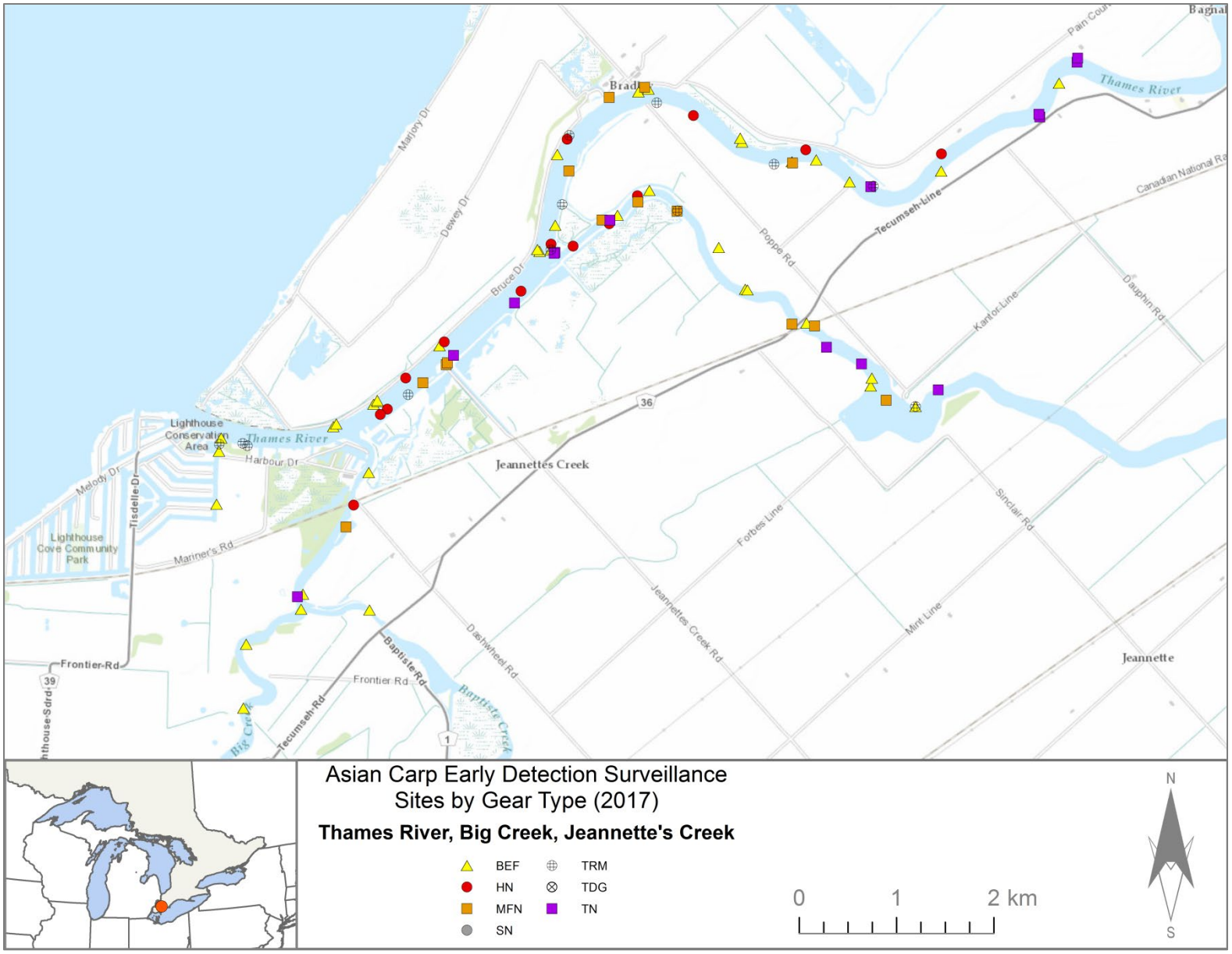

Figure A3.28 2017 Asian Carp Program early detection surveillance field sampling sites in the Thames River, Big Creek and Jeannette's Creek.

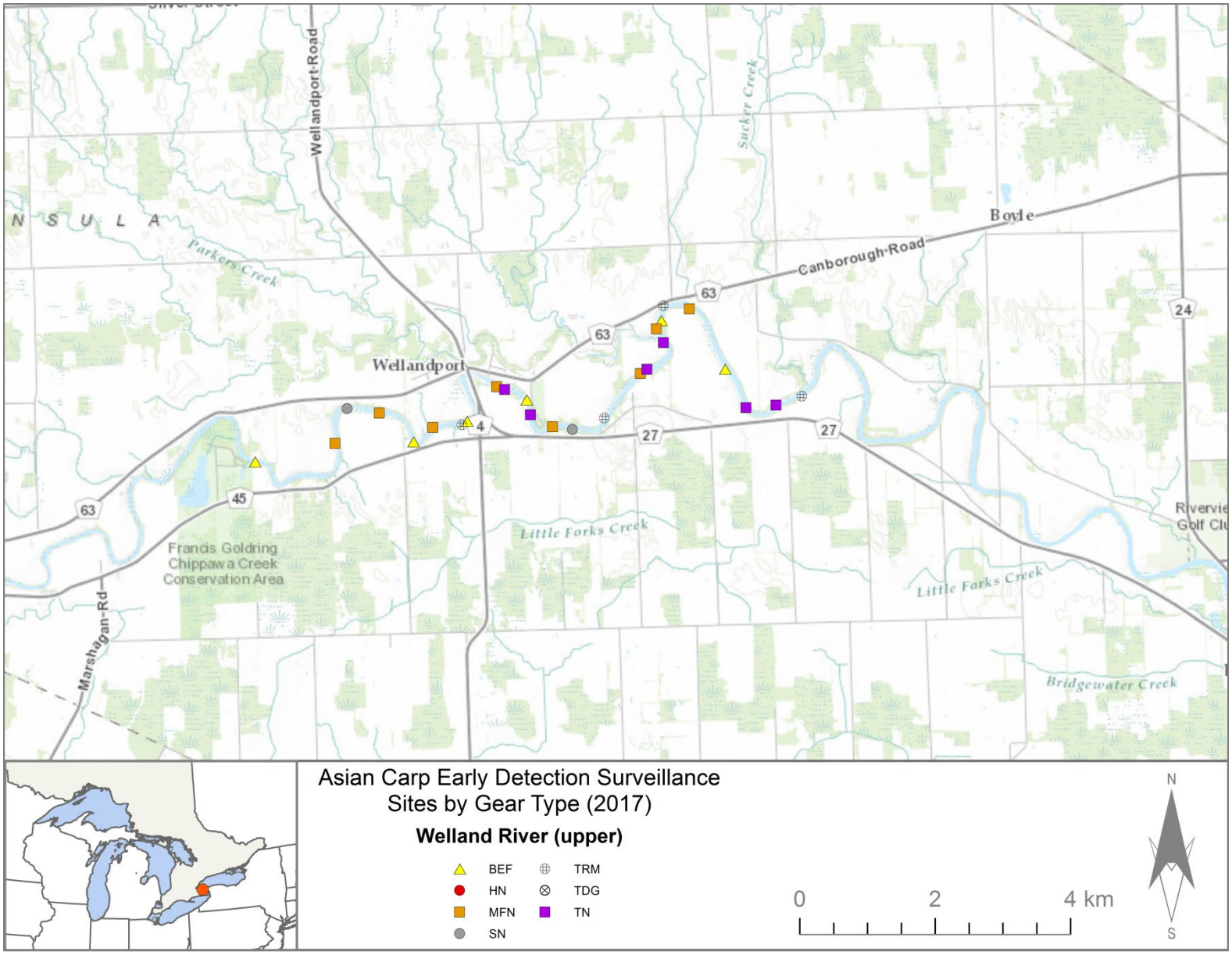

Figure A3.29 2017 Asian Carp Program early detection surveillance field sampling sites in the upper Welland River.

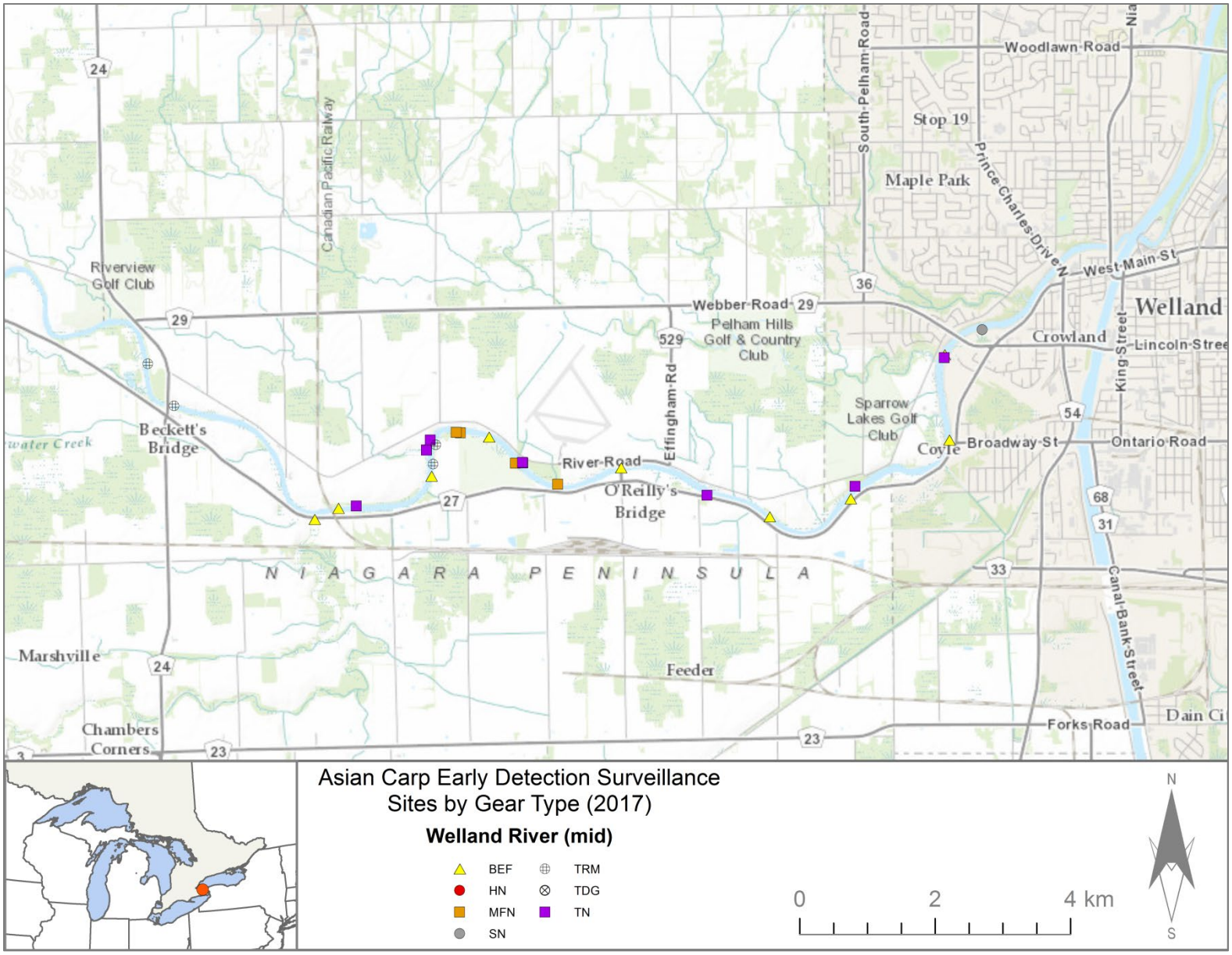

Figure A3.30 2017 Asian Carp Program early detection surveillance field sampling sites in the mid Welland River.

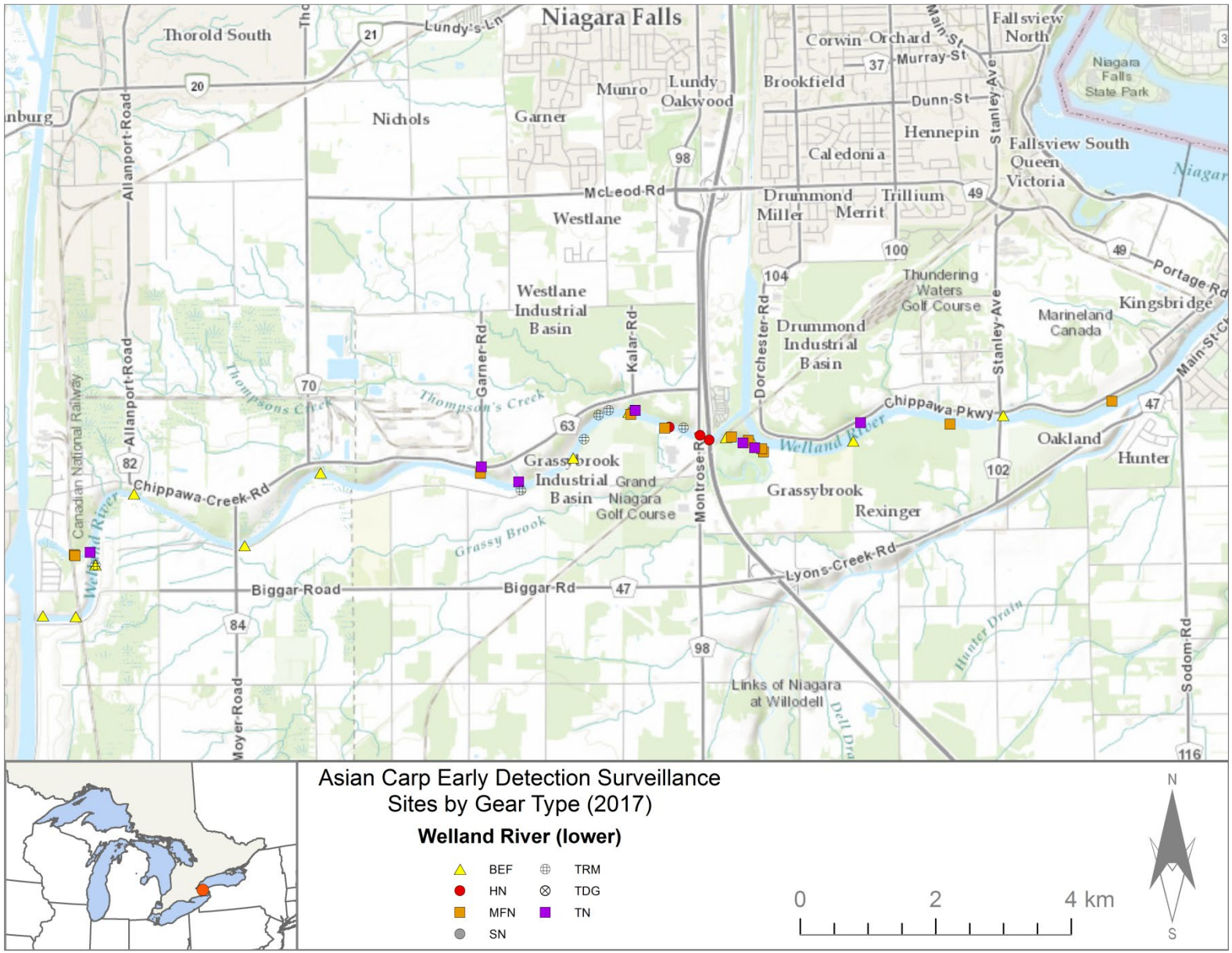

Figure A3.31 2017 Asian Carp Program early detection surveillance field sampling sites in the lower Welland River.