Freshwater mussel surveys in the Sydenham River Nature Reserve, Ontario, 2017

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The Sydenham River Nature Reserve was established by Ontario Nature in 2016 and encompasses a 2.5 km stretch of the Sydenham River, one of the most biodiverse areas in Canada. The Sydenham River watershed supports the richest community of freshwater mussels in all of Canada with 35 native mussel species historically and 32 still considered extant today including 14 species at risk (SAR). In partnership with Ontario Nature, Fisheries and Oceans Canada (DFO) surveyed the entire length of river within the reserve in 2017 using a semi-qualitative timed-search method and a quantitative quadrat method. Across the five sites surveyed in the reserve, a total of 1,691 live individuals representing 23 species including 188 individuals of seven SAR were found. Of these individuals, 86.00% were found during the timed-search surveys. Mean site density (± 1 standard error) was calculated from the quadrat survey data and ranged from 0.10 (± 0.06) mussels/m^2 to 1.04 (± 0.35) mussels/m^2. While all of the species found during the survey of the Sydenham River Nature Reserve in 2017 were known to inhabit the Sydenham River, the data collected provide valuable baseline information on the freshwater mussel community found within the Sydenham River Nature Reserve to Ontario Nature.

RÉSUMÉ

Goguen, M.N., McNichols-O'Rourke, K.A., and Morris, T.J. 2022. Freshwater mussel surveys in the Sydenham River Nature Reserve, Ontario, 2017. Can. Data Rep. Fish. Aquat. Sci. 1351: vi + 17 p.

La réserve naturelle de la rivière Sydenham a été créée par Ontario Nature en 2016. Elle comprend un tronçon de 2,5 km de la rivière Sydenham, l'une des zones les plus riches en biodiversité au Canada. Le bassin versant de la rivière Sydenham abrite la plus riche communauté de moules d'eau douce de tout le Canada. En effet, 35 espèces de moules indigènes ont été recensées dans le passé et 32 sont encore considérées comme existantes, dont 14 espèces en péril. En 2017, en partenariat avec Ontario Nature, Pêches et Océans Canada a effectué un relevé dans la réserve sur toute la longueur de la rivière en utilisant une méthode semi-qualitative de recherche à intervalles réguliers et une méthode quantitative de relevés par quadrats. Sur l'ensemble des 5 sites de la réserve qui ont fait l'objet d'un relevé, un total de 1 691 individus vivants représentant 23 espèces, dont 188 individus de 7 espèces en péril, ont été trouvés. De ce nombre, 86 % ont été recensés lors de relevés effectués à intervalles réguliers. La densité moyenne du site a été calculée à partir des données de relevés par quadrats, et variait de 0,10 (écart-type ± 0,06) moule/m2 à 1,04 (± 0,35) moule/m2. Même si la présence de toutes les espèces trouvées lors du relevé de la réserve naturelle de la rivière Sydenham en 2017 était déjà reconnue, les données recueillies fournissent à Ontario Nature de précieuses données de référence sur la communauté de moules d'eau douce présente dans la réserve naturelle de la rivière Sydenham.

INTRODUCTION

The Sydenham River watershed bears the title of being one of Canada's most biodiverse areas, providing essential habitat for freshwater mussel, freshwater fish, bird, reptile, and amphibian species [St. Clair River Conservation Authority (SCRCA) 2022]. This turbid system is found in the Carolinian Zone in southwestern Ontario and is formed by two distinct river branches (Dextrase et al. 2003). The smaller north branch flows 160 km in length and is termed the North Sydenham River at the confluence of its two main tributaries: Bear Creek and Black Creek (Metcalfe-Smith et al. 2003; McNichols-O'Rourke et al. 2012). The larger east branch flows 200 km and is identified as the East Sydenham River (Metcalfe-Smith et al. 2003; McNichols-O'Rourke et al. 2012). These two branches join in Wallaceburg, ON and continue to flow until draining into Lake St. Clair (Metcalfe-Smith et al. 2003; 2007; McNichols-O'Rourke et al. 2012). Due to its biological importance, the Sydenham River was the first river in Canada to have an aquatic ecosystem recovery strategy developed (Dextrase et al. 2003). The East Sydenham River was also designated as one of 13 freshwater Key Biodiversity Areas (KBA) in Canada by the International Union for Conservation of Nature (IUCN; Tognelli et al. 2017). The critical importance of the Sydenham River for countless species at risk (SAR) has made it the focus of many conservation efforts, including those for freshwater mussels.

The Sydenham River watershed supports the richest community of freshwater mussels in all of Canada (Dextrase et al. 2003; Metcalfe-Smith et al. 2003; Metcalfe-Smith et al. 2007). Historically, 35 native species were found in the Sydenham River with 32 still considered extant today (McNichols-O'Rourke et al. 2012). This includes 14 of the 16 SAR identified as at-risk in Ontario by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and/or listed under the federal *Species at Risk Act* (SARA; Government of Canada 2022; Table 1). The Sydenham River has been surveyed extensively for freshwater mussels due to the abundance of SAR (Clarke 1992; Metcalfe-Smith et al. 1998; 1999; 2003; 2007; McNichols-O'Rourke et al. 2012; Fisheries and Oceans Canada unpublished data). A long-term monitoring program to track the recovery of SAR in the Sydenham River was developed and a network of 15 index stations was established (Metcalfe-Smith et al. 2007). The previous surveys and index stations cover an expansive area of the Sydenham River; however, some areas have yet to be surveyed due to site access issues or water depth limitations.

One such area that had remained unsearched is now part of the Sydenham River Nature Reserve. The reserve was established by Ontario Nature in 2016 and further expanded in 2021 to span 390 acres of land around the Sydenham River (east branch) southeast of Alvinston, ON including 2.5 km of river length (Ontario Nature 2022). In 2017, Fisheries and Oceans Canada (DFO) completed an extensive survey for freshwater mussels within the reserve in partnership with Ontario Nature. The objective of this survey was to complete a full assessment of the freshwater mussel community in the reserve to provide Ontario Nature with baseline data in conjunction with the formation of the Sydenham River Nature Reserve.

METHODS

SAMPLING METHODS

In July 2017, the 2.5 km stretch of the Sydenham River that runs through the Sydenham River Nature Reserve was surveyed for freshwater mussels. The river was separated into five sites of 500 m lengths (Table 2; Figure 1). Each site was surveyed using both a semi-quantitative timed-search method and a quantitative quadrat method. A crew of 7 – 10 people completed a 4.5 person-hour timed-search survey using mussel viewers, mussel scoops, or tactile searching throughout the entire 500 m length of each site (Metcalfe-Smith et al. 2000). The timed-search survey approach used was determined by water clarity and depth. Additionally, ten quadrats of 1 m^2 were excavated within the 500 m length of each site following the modified procedure of Metcalfe-Smith et al. (2007; Figure 2, 3). Each quadrat was searched using three different techniques: 1) visual search with the naked eye, 2) visual search with a viewing box, and 3) excavation to a depth of 10 – 15 cm. The location of each quadrat was determined randomly, using a three-point random number generator sequence: 1) distance along the site (length); 2) distance off the center line (width); and, 3) left (0) or right (1) off the center line. If a randomly selected location was too deep to effectively survey, the next random location on the list was used. The quadrat excavation occurred before the timed-search survey at a site to avoid densities being altered by the movement of animals during the timed-search survey and so that the animals found during the quadrat surveys would not be included in the timed-search survey results (quadrat locations remained marked during the timed-search survey; Figure 4). In total, 22.5 person-hours of timed-search surveys were completed throughout the entire 2.5 km stretch of river and 50 m^2 of area was excavated during the quadrat surveys. In both survey methods, each mussel found alive was identified to species, counted, measured (maximum length in millimeters), and sexed visually (if sexually dimorphic) before being returned to the river. Shells and valves of species not observed live at a site were also identified, classified as fresh (i.e., tissue present, intact ligament, intact periostracum) or weathered, and enumerated. All of the shells and valves detected were weathered unless otherwise stated.

Environmental data were also collected at each site during the quadrat survey. Before excavation began, depth (meter stick) and water clarity (0.60 m turbidity tube) were measured within each quadrat. The following data were collected in each quadrat through visual estimation after excavation was complete: substrate composition (%), degree of siltation (low, medium, high), degree of algal growth (low, medium, high), shading (open, partly open, dense), and presence or absence of aquatic macrophytes. Definitions of substrate sizes were taken from Stanfield (2010): boulder (>250 mm in diameter), cobble (65 – 250 mm), gravel (2 – 65 mm), sand (<2 mm), and “other” material (mud, muck, silt, and detritus). The estimation of siltation was based on the amount of silt disturbed into the water column while excavating the quadrat. The estimation of low, medium, or high siltation was subjective and differed between sites in order to capture variation within a site. The estimation of algal growth was categorized as low if <20% of surface substrate was covered in algae, medium if 20 – 50% coverage, and high if >50% coverage. Shading was estimated as open if no vegetation

cover was directly above the quadrat, partly open if <50% vegetation cover, and dense if >50% vegetation cover. Any amount of aquatic macrophytes observed within a quadrat was recorded as present. The data visually estimated after excavation were collected to provide a general understanding of the site characteristics and were not meant to provide a quantitative measure. Only the environmental data that are relevant to this report will be presented.

DATA ANALYSIS

Mean site density and mean site species richness were calculated for each site using the quadrat survey data. Mean site density was calculated by first using the following equation from Thompson (2012):

$$[1] \qquad D_{quadrat} = \frac{\tau}{A}$$

where τ is the total abundance of unionids in a quadrat and A is the total area sampled in the quadrat (i.e., 1 m^2). The mean site density was then calculated using the following equation:

$$[2] \qquad D_{site} = \frac{\sum D_{quadrat_i}}{n}$$

where $\sum D_{quadrat_i}$ is the summation of the quadrat densities within a site and n is the total number of quadrats surveyed at the site. Standard error for the mean site density was calculated by dividing the standard deviation by the square root of the number of samples (McDonald 2009); the number of samples refers to the number of quadrats surveyed within the site.

Mean site species richness was calculated by first using the following equation:

$$[3] \qquad SR_{quadrat} = \frac{number\ of\ species}{A}$$

where the numerator is the total number of species in a quadrat and A is the total area sampled in the quadrat (i.e., 1 m^2). The mean site species richness was calculated using the following equation:

$$[4] \qquad SR_{site} = \frac{\sum SR_{quadrat_i}}{n}$$

where $\sum SR_{quadrat_i}$ is the summation of the quadrat species richness values within a site and n is the total number of quadrats surveyed at the site. Standard error for the mean site species richness was calculated by dividing the standard deviation by the square root of the number of samples (McDonald 2009); the number of samples refers to the number of quadrats surveyed within the site.

RESULTS

Across the five sites surveyed in the Sydenham River Nature Reserve, a total of 1,691 live individuals representing 23 species were found, including 188 individuals of seven SAR (Figure 5 – 7). When separating the results by method, 86.00% of the live individuals were found during the timed-search surveys (Table 3). These 1,456 individuals represented 22 species with live species richness ranging from 17 species to 20 species across the five sites. Two additional species were found only as shells for a total species richness of 24: the Endangered *Paetulunio fabalis* (Rayed Bean) and the common *Strophitus undulatus* (Creeper). *Amblema plicata* (Threeridge) was the most abundant species detected during the timed-search surveys representing 36.00% (524 individuals) of all animals found. Of the live individuals detected during the timed-search surveys, 8.79% (128 individuals) were SAR representing six species: *Cambarunio iris* (Rainbow), *Epioblasma rangiana* (Northern Riffleshell), *Epioblasma triquetra* (Snuffbox), *Pleurobema sintoxia* (Round Pigtoe), *Ptychobranchus fasciolaris* (Kidneyshell), and *Quadrula quadrula* (Mapleleaf). *Quadrula quadrula* was the most abundant SAR with an overall relative abundance of 2.82% (41 individuals) and a SAR relative abundance of 32.00%. Four of the six live SAR observed were found at all five sites with *C. iris* found at one site and *P. sintoxia* found at four sites.

The remaining 14.00% of live individuals were found during the quadrat surveys with 235 individuals representing 17 species (Table 4). Live species richness ranged from six species to 13 species across the five sites. As in the timed-search surveys, *A. plicata* was the most abundant common species found during the quadrat surveys representing 20.85% (49 individuals) of all animals found. The proportion of observed SAR found during the quadrat surveys was higher than in the timed-search surveys with 25.53% (60 individuals) of all animals represented by six SAR: *E. rangiana*, *E. triquetra*, *P. fabalis*, *P. sintoxia*, *P. fasciolaris*, and *Q. quadrula*. Two additional SAR were observed as valves only bringing the total species richness to 19: *Obovaria subrotunda* (Round Hickorynut) and *Simpsonaias ambigua* (Salamander Mussel). *Epioblasma rangiana* was the most abundant SAR with an overall relative abundance of 14.04% (33 individuals) and a SAR relative abundance of 55.00%; *E. rangiana* was also the only SAR to be found at all five sites. Mean site density (± 1 standard error) ranged widely from 0.10 (± 0.06) mussels/m^2 to 1.04 (± 0.35) mussels/m^2 (Table 5). Mean site species richness ranged from 0.06 (± 0.03) mussels/m^2 to 0.39 (± 0.08) mussels/m^2 (Table 5). Relevant environmental data is presented in Table 6.

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Table 1. Species at risk in Ontario and their current COSEWIC assessment (Government of Canada 2022), federal *Species at Risk Act* listing (Government of Canada 2022), and provincial *Endangered Species Act* listing (OMNRF 2022) as of January 2022. UC indicates species that are under consideration for SARA listing. The historical (H) and current (C) occurrence of each SAR in the Sydenham River watershed is indicated as summarized in McNichols-O'Rourke et al. (2012). Species found live in the watershed are indicated by Y and species known only as shells/valves in the watershed are indicated by SH. Nomenclature here and throughout follows MolluscaBase eds. (2022).

Scientific Name	Common Name	COSEWIC	SARA (Federal)	ESA (Provincial)	H	C
[1]*Cambarunio iris*	Rainbow	Special Concern	Special Concern	Special Concern	Y	Y
Cyclonaias tuberculata	Purple Wartyback	Threatened	UC	UC	Y	Y
Epioblasma rangiana	Northern Riffleshell	Endangered	Endangered	Endangered	Y	Y
Epioblasma triquetra	Snuffbox	Endangered	Endangered	Endangered	Y	Y
Lampsilis fasciola	Wavyrayed Lampmussel	Special Concern	Special Concern	Threatened	Y	Y
Obliquaria reflexa	Threehorn Wartyback	Threatened	Threatened	Threatened	-	Y
Obovaria olivaria	Hickorynut	Endangered	Endangered	Endangered	-	-
Obovaria subrotunda	Round Hickorynut	Endangered	Endangered	Endangered	Y	Y
[2]*Paetulunio fabalis*	Rayed Bean	Endangered	Endangered	Endangered	Y	Y
Pleurobema sintoxia	Round Pigtoe	Endangered	Endangered	Endangered	Y	Y
Ptychobranchus fasciolaris	Kidneyshell	Endangered	Endangered	Endangered	Y	Y
Quadrula quadrula	Mapleleaf	[4]Special Concern	[4]Special Concern	Special Concern	Y	Y
[3]*Sagittunio nasutus*	Eastern Pondmussel	Special Concern	Special Concern	Special Concern	Y	-
Simpsonaias ambigua	Salamander Mussel	Endangered	Endangered	Endangered	Y	Y
Toxolasma parvum	Lilliput	Endangered	Endangered	Threatened	Y	Y
Truncilla donaciformis	Fawnsfoot	Endangered	Endangered	Endangered	SH	Y

Species currently listed under SARA and formerly known as:
[1]*Villosa iris*
[2]*Villosa fabalis*
[3]*Ligumia nasuta*

[4]Great Lakes - Upper St. Lawrence population

Table 2. Site location and sampling date details for the five sites surveyed in the Sydenham River Nature Reserve in 2017. Sites are presented in upstream to downstream order.

Site Code	Drainage	Waterbody	Latitude	Longitude	Date
LSC-SYR-24	Lake St. Clair	Sydenham River	42.79048	-81.83921	20170724
LSC-SYR-25	Lake St. Clair	Sydenham River	42.78840	-81.83423	20170725
LSC-SYR-26	Lake St. Clair	Sydenham River	42.78827	-81.82955	20170725
LSC-SYR-27	Lake St. Clair	Sydenham River	42.78514	-81.82955	20170726
LSC-SYR-28	Lake St. Clair	Sydenham River	42.78385	-81.83539	20170726

Table 3. Total abundance, relative abundance, and frequency of occurrence of mussels observed during the timed-search surveys at five sites in the Sydenham River Nature Reserve in 2017. Species at risk are highlighted. S(#) indicates a species observed as complete shells and the number of shells found. No valves were found. Unknown individuals are included in abundance totals but not in the species richness totals. Sites are presented in upstream to downstream order.

Scientific Name	LSC-SYR-24	LSC-SYR-25	LSC-SYR-26	LSC-SYR-27	LSC-SYR-28	Totals	Relative Abundance (%)	Frequency of Occurrence (%)
Alasmidonta marginata	6	1	4	-	-	**11**	**0.76**	**60.00**
Amblema plicata	106	64	127	58	169	**524**	**35.99**	**100.00**
Cambarunio iris	S(1)	-	-	-	1	**1**	**0.07**	**20.00**
Cyclonaias pustulosa	3	1	5	2	26	**37**	**2.54**	**100.00**
Cyclonaias tuberculata	125	30	11	3	23	**192**	**13.19**	**100.00**
Eurynia dilatata	15	-	10	2	2	**29**	**1.99**	**80.00**
Epioblasma rangiana	8	4	1	9	14	**36**	**2.47**	**100.00**
Epioblasma triquetra	1	2	1	1	1	**6**	**0.41**	**100.00**
Fusconaia flava	9	-	4	4	1	**18**	**1.24**	**80.00**
Lampsilis cardium	-	1	1	-	4	**6**	**0.41**	**60.00**
Lampsilis siliquoidea	1	-	-	2	3	**6**	**0.41**	**60.00**
Lasmigona complanata	2	5	10	8	3	**28**	**1.92**	**100.00**
Lasmigona costata	120	13	25	7	34	**199**	**13.67**	**100.00**
Ligumia recta	3	4	22	5	13	**47**	**3.23**	**100.00**
Ortmanniana ligamentina	16	9	21	3	55	**104**	**7.14**	**100.00**
Paetulunio fabalis	S(2)	-	-	-	-	**-**	**-**	**-**
Pleurobema sintoxia	7	3	8	-	2	**20**	**1.37**	**80.00**
Potamilus alatus	-	6	16	26	20	**68**	**4.67**	**80.00**
Potamilus fragilis	5	6	17	9	9	**46**	**3.16**	**100.00**
Ptychobranchus fasciolaris	6	1	3	1	13	**24**	**1.65**	**100.00**
Pyganodon grandis	S(1)	1	2	3	5	**11**	**0.76**	**80.00**
Quadrula quadrula	3	4	8	9	17	**41**	**2.82**	**100.00**
Strophitus undulatus	S(1)	-	-	-	-	**-**	**-**	**-**
Truncilla truncata	-	-	-	1	-	**1**	**0.07**	**20.00**
Unknown	-	-	-	-	1	**1**	**0.07**	**20.00**
Live abundance	**436**	**155**	**296**	**153**	**416**	**1,456**		
Live species richness	**17**	**17**	**19**	**18**	**20**	**22**		
Total species richness	**21**	**17**	**19**	**18**	**20**	**24**		
Search effort (p-h)	**4.5**	**4.5**	**4.5**	**4.5**	**4.5**	**22.5**		

Table 4. Total abundance, relative abundance, and frequency of occurrence of mussels observed during the quadrat surveys at five sites in the Sydenham River Nature Reserve in 2017. Species at risk are highlighted. V(#) indicates a species observed as a valve (one half of a full shell) and the number of valves found. No complete shells were found. Unknown individuals are included in abundance totals but not in the species richness totals. Sites are presented in upstream to downstream order.

Scientific Name	LSC-SYR-24	LSC-SYR-25	LSC-SYR-26	LSC-SYR-27	LSC-SYR-28	Totals	Relative Abundance (%)	Frequency of Occurrence (%)
Alasmidonta marginata	1	-	-	-	-	**1**	**0.43**	**20.00**
Amblema plicata	21	8	2	5	13	**49**	**20.85**	**100.00**
Cyclonaias tuberculata	20	5	-	-	-	**25**	**10.64**	**40.00**
Eurynia dilatata	10	7	1	1	3	**22**	**9.36**	**100.00**
Epioblasma rangiana	11	8	2	1	11	**33**	**14.04**	**100.00**
Epioblasma triquetra	1	-	-	-	2	**3**	**1.28**	**40.00**
Fusconaia flava	7	2	3	-	1	**13**	**5.53**	**80.00**
Lasmigona complanata	-	1	-	-	-	**1**	**0.43**	**20.00**
Lasmigona costata	22	2	-	1	6	**31**	**13.19**	**80.00**
Obovaria subrotunda	-	-	-	-	V(1)	**-**	**-**	**-**
Ortmanniana ligamentina	3	-	1	-	4	**8**	**3.40**	**60.00**
Paetulunio fabalis	2	-	-	-	-	**2**	**0.85**	**20.00**
Pleurobema sintoxia	1	1	1	-	2	**5**	**2.13**	**80.00**
Potamilus alatus	1	-	3	1	1	**6**	**2.55**	**80.00**
Potamilus fragilis	3	4	4	1	3	**15**	**6.38**	**100.00**
Ptychobranchus fasciolaris	-	3	-	-	10	**13**	**5.53**	**40.00**
Pyganodon grandis	-	-	1	-	-	**1**	**0.43**	**20.00**
Quadrula quadrula	-	2	-	-	2	**4**	**1.70**	**40.00**
Simpsonaias ambigua	V(1)	V(1)	-	-	-	**-**	**-**	**-**
Unknown	1	-	-	-	2	**3**	**1.28**	**40.00**
Live species abundance	**104**	**43**	**18**	**10**	**60**	**235**		
Live species richness	**13**	**11**	**9**	**6**	**12**	**17**		
Total species richness	**14**	**12**	**9**	**6**	**13**	**19**		
Search effort (m^2)	**10**	**10**	**10**	**10**	**10**	**50**		

Table 5. Mean site density and mean site species richness of mussels observed during the quadrat surveys at five sites in the Sydenham River Nature Reserve in 2017. SE represents standard error. Sites are presented in upstream to downstream order.

Quadrat	Density					Species Richness				
	LSC-SYR-24	LSC-SYR-25	LSC-SYR-26	LSC-SYR-27	LSC-SYR-28	LSC-SYR-24	LSC-SYR-25	LSC-SYR-26	LSC-SYR-27	LSC-SYR-28
1	0.70	0.10	0.10	0.10	1.50	0.50	0.10	0.10	0.10	0.70
2	0.00	0.10	0.00	0.00	2.20	0.00	0.10	0.00	0.00	0.80
3	0.50	0.00	0.30	0.20	0.00	0.30	0.00	0.30	0.20	0.00
4	3.20	0.00	0.00	0.00	1.10	0.60	0.00	0.00	0.00	0.60
5	2.60	0.00	0.30	0.00	0.20	0.70	0.00	0.30	0.00	0.20
6	1.40	1.10	0.10	0.00	0.00	0.60	0.60	0.10	0.00	0.00
7	0.10	0.30	0.00	0.00	1.00	0.10	0.30	0.00	0.00	0.50
8	0.10	0.20	0.30	0.00	0.00	0.10	0.10	0.30	0.00	0.00
9	0.50	1.50	0.60	0.10	0.00	0.40	0.80	0.40	0.10	0.00
10	1.30	1.00	0.10	0.60	0.00	0.60	0.40	0.10	0.20	0.00
Mean	**1.04**	**0.43**	**0.18**	**0.10**	**0.60**	**0.39**	**0.24**	**0.16**	**0.06**	**0.28**
SE	**0.35**	**0.18**	**0.06**	**0.06**	**0.25**	**0.08**	**0.09**	**0.05**	**0.03**	**0.11**

Table 6. Relevant environmental data collected at each site during the quadrat surveys in the Sydenham River Nature Reserve. The mean measurement and standard error were calculated across the ten quadrats within a site. Sites are presented in upstream to downstream order.

		LSC-SYR-24	LSC-SYR-25	LSC-SYR-26	LSC-SYR-27	LSC-SYR-28
	Depth (m)	0.27 ± 0.04	0.45 ± 0.06	0.41 ± 0.02	0.43 ± 0.03	0.42 ± 0.03
	Water Clarity (m)	0.14 ± 0.02	0.09 ± 0.01	0.11 ± 0.01	0.10 ± 0.004	0.11 ± 0.005
Substrate Composition	**Bedrock (%)**	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	1.50 ± 1.07
	Boulder (%)	19.50 ± 9.38	1.00 ± 1.00	2.00 ± 1.33	4.50 ± 3.20	17.00 ± 8.31
	Cobble (%)	23.00 ± 6.11	2.00 ± 2.00	13.00 ± 6.84	7.50 ± 6.47	13.00 ± 6.51
	Gravel (%)	41.30 ± 7.30	25.50 ± 9.53	45.00 ± 8.16	10.00 ± 6.79	23.50 ± 9.10
	Sand (%)	14.70 ± 4.68	36.50 ± 7.78	18.00 ± 4.36	15.75 ± 2.98	12.50 ± 2.27
	Silt (%)	0.00 ± 0.00	10.00 ± 3.33	5.50 ± 4.11	12.75 ± 4.72	4.50 ± 2.52
	Clay (%)	0.00 ± 0.00	1.00 ± 1.00	12.00 ± 5.59	15.50 ± 7.01	8.50 ± 3.73
	Muck (%)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	1.00 ± 1.00	1.00 ± 1.00
	Marl (%)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
	Detritus (%)	1.50 ± 0.76	24.00 ± 8.69	4.50 ± 2.17	33.00 ± 9.23	18.50 ± 8.57

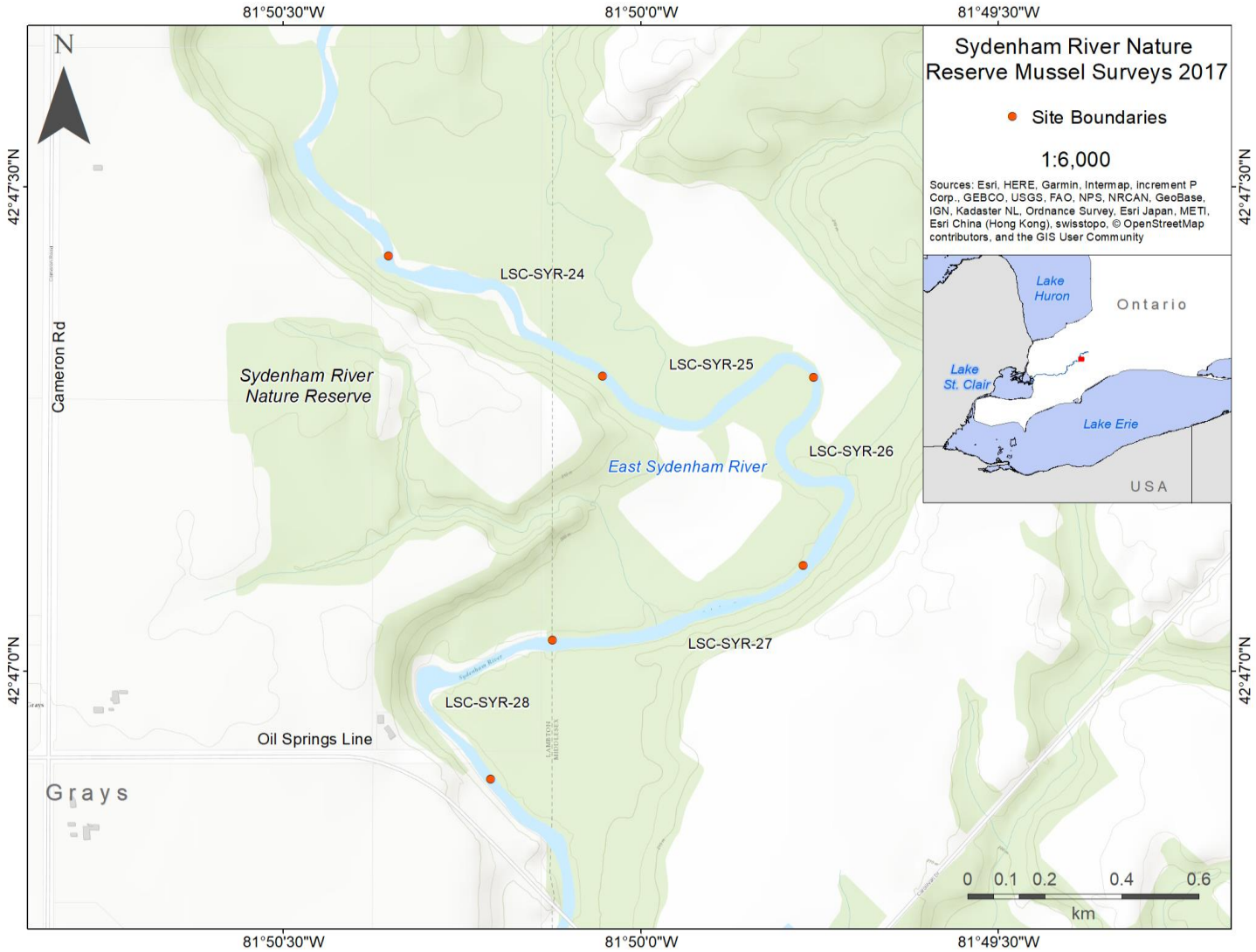

Figure 1. The five sites surveyed using the timed-search method and quadrat method in the Sydenham River Nature Reserve in 2017. The red markers indicate the upstream and downstream boundaries of the five continuous 500 m long sites.

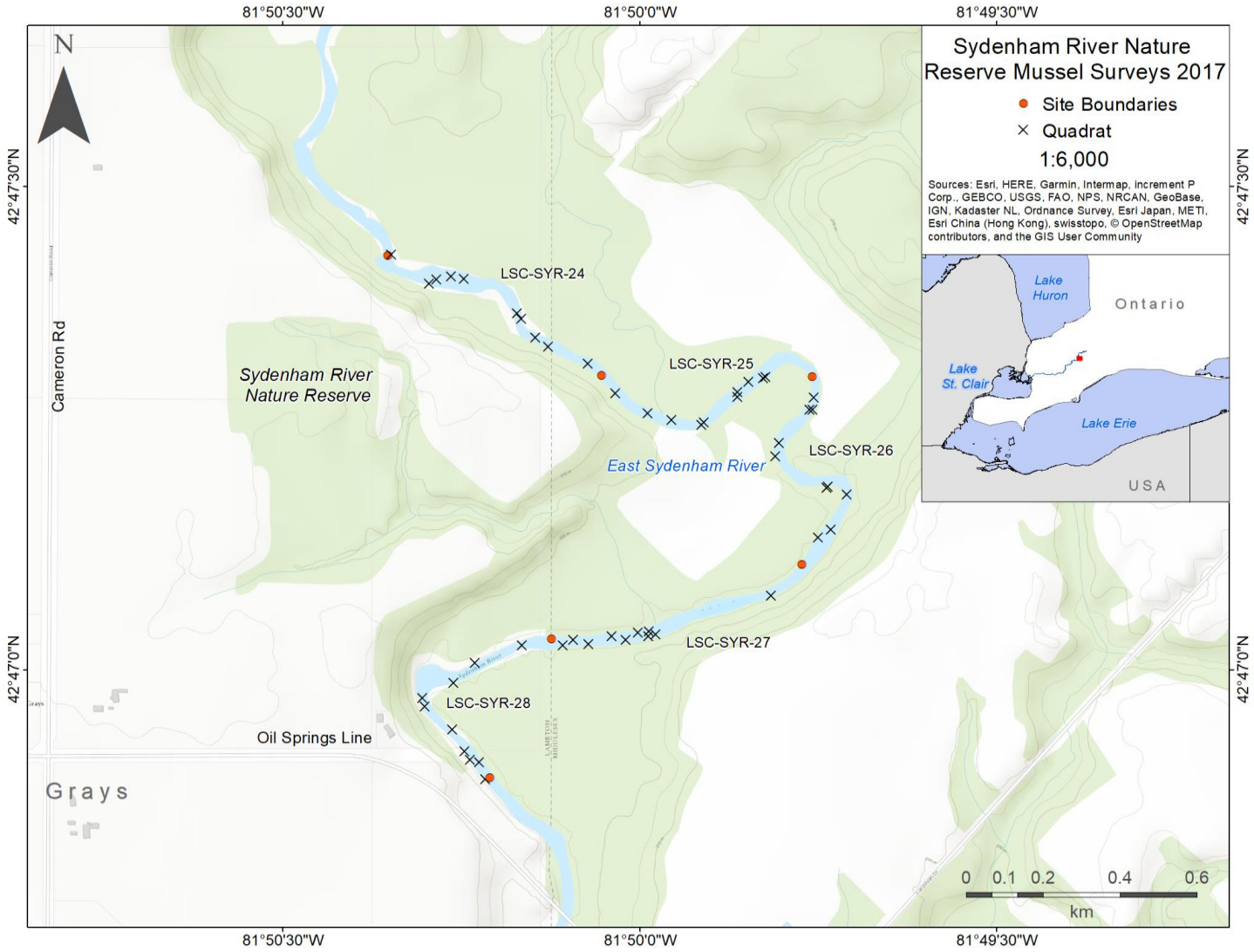

Figure 2. Location of the 50 quadrats (1 m^2 each) that were excavated across the five sites in the Sydenham River Nature Reserve in 2017. The red markers indicate the upstream and downstream boundaries of the five continuous 500 m long sites.

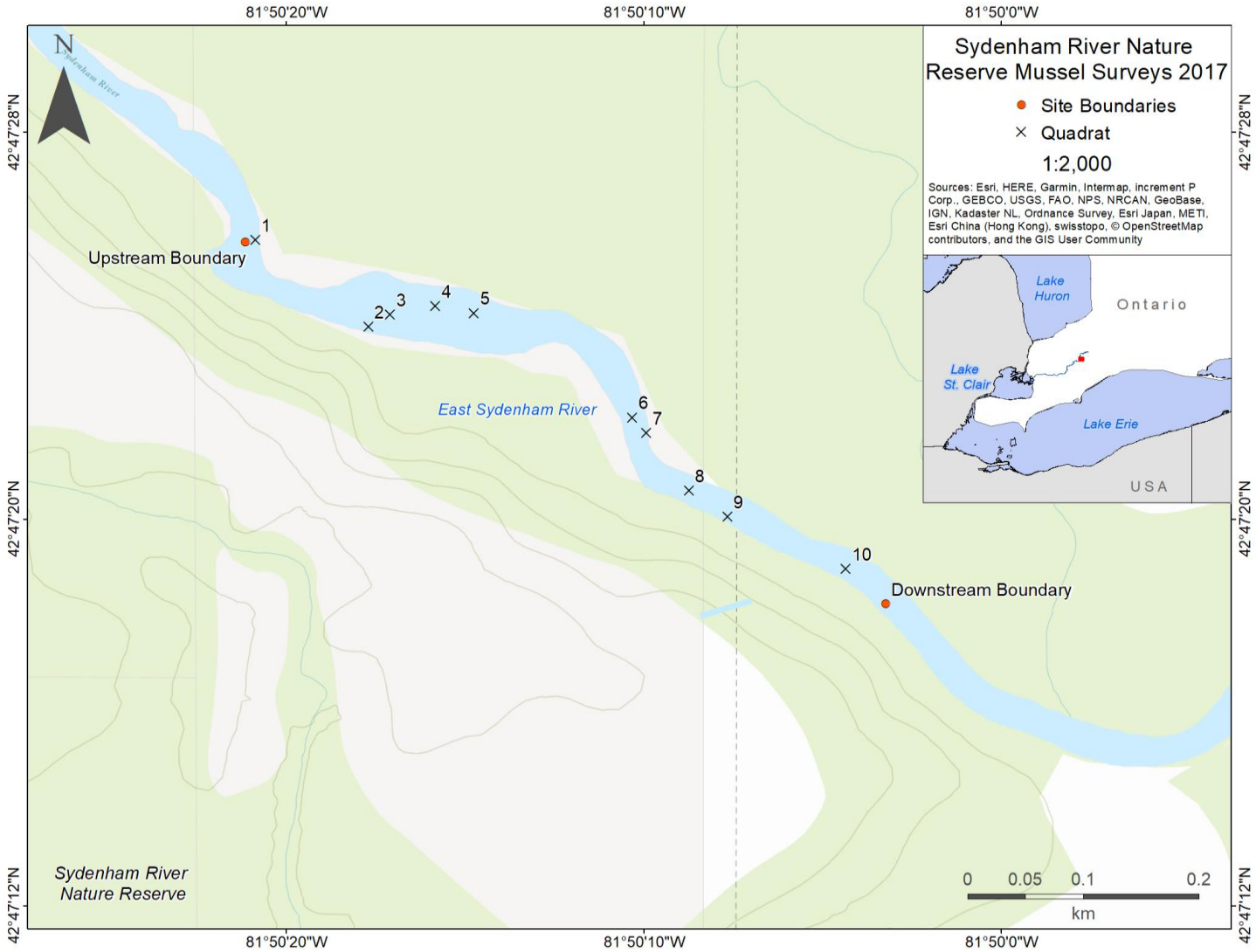

Figure 3. Single site example of the ten randomly selected quadrats that were excavated within LSC-SYR-24 in the Sydenham River Nature Reserve. A three point random number generator was used to determine the position of each quadrat within a site.

Figure 4. Two crew members excavating a quadrat in one of the five sites of the Sydenham River Nature Reserve. The rebar was left in place during the timed-search survey to mark the location of the completed quadrat.

Figure 5. Almost 1,700 live animals were found during the timed-search and quadrat surveys at the Sydenham River Nature Reserve.

Figure 6. Mussels being processed after the timed-search survey at one site in the Sydenham River Nature Reserve.

Figure 7. Male and female Endangered Northern Riffleshell (*Epioblasma rangiana*) found during surveys of the Sydenham River Nature Reserve.