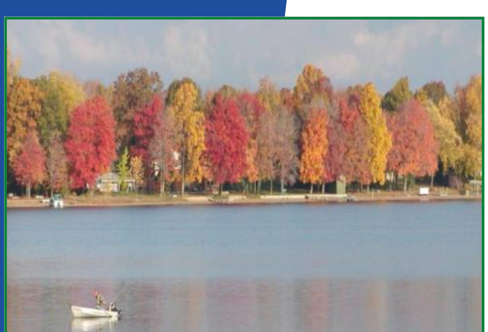
2014 Milfoil Solution® Report at the City of Greater Sudbury, Ontario

Prepared for:

The City of Greater Sudbury



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1.0 Introduction

Since its widespread introduction, the exotic-invasive Eurasian watermilfoil (*Myriophyllum spicatum*, herein referred to as milfoil) has become one of the most problematic plants in North American lakes. Rapid growth and reproduction by seed, stolon and fragment allows this plant to create dense, monotypic stands that displace native species. In turn, these dense beds can reduce biodiversity, cause detrimental changes to water quality and impact the aesthetics and recreational use of the water. In 2011, EnviroScience initiated the **Milfoil Solution®** process at six lakes within the City of Greater Sudbury, Ontario to combat nuisance populations of milfoil using the milfoil weevil (*Euhrychiopsis lecontei)*.

The milfoil weevil is a native insect to North America that began feeding on Eurasian watermilfoil once it was introduced. This milfoil-specialist completes its entire life cycle on the plant (egg-larvae-pupae-adult) and is capable of producing multiple generations in one growing season. Throughout the fall months, weevils move to shore to overwinter in dry, loose soils and returns to the water as the ice recedes in the spring to continue the process. The most significant impacts to milfoil occur during the larval life stage of the insect. During the larval stage, weevils feed on the meristem (growing tip) of the plant and burrow through the stem. This disrupts nutrient flow within the plant and allows air to escape the stem, reducing its natural buoyancy causing it to collapse. This process also leaves the weakened plant susceptible to secondary infection. Over time, milfoil stands become weakened diminishing their ability to compete with native species and prepare for winter months. Although milfoil weevils are present throughout the southern extent of Ontario and the northern U.S. states, they are often in populations unable to cause significant declines. Milfoil Solution® is utilized to increase weevil populations to aid in reducing nuisance stands of milfoil.

Although stocking did not occur in 2014, EnviroScience biologists returned to each stocking site to monitor the progress of the weevil stocking. A milfoil bed that had not been stocked (i.e. untreated) was sampled in 2014 in all lakes that had been stocked during the 2011-2013 Milfoil Solution® program with exception to Simon Lake which was discontinued in 2012 due to excessive algal growth. This untreated site is intended to serve as a rough comparison for samples taken at stocked sites and to establish additional sampling sites for future monitoring efforts. Given the variability in weevil presence and weevil damage noted on the milfoil beds, a much more robust and costly experimental design would have been required to adequately establish statistically meaningful differences between stocked and unstocked sampling sites. Hannah Lake and Middle Lake, which had not been stocked with weevils between 2011 and 2013, were also sampled in 2014 and may serve as reference (untreated) lakes for future monitoring initiatives. This report discusses the results of the 2014 survey at all lakes stocked with exception to Simon Lake.

The table below outlines the Milfoil Solution® program for Sudbury, Ontario including site establishment and the number of weevils stocked:

	2011		2012		2013	
Grant Lake	-	-	S1	5,000	S1	4,000
Long Lake	S1-S4	23,000	S1, S3	11,000	S3, S5	10,000
McFarlane Lake	S1-S3	15,000	S3	5,000	S2	6,000
Richard Lake	S1, S2	18,000	S1, S2	7,000	S2	6,000
Simon Lake	S1	10,000	S1	5,000	*	*
St. Charles Lake	S1	9,700	S1	7,000	S1	4,000
Total		**75,700**		**40,000**		**30,000**

* Simon Lake did not receive weevils in 2013 due to excess issues with algae growth. The 4,000 weevils proposed for Simon Lake were redistributed to Long Lake (2,000 weevils) and Richard Lake (2,000 weevils).

2.0 Survey Methods

An initial survey is performed prior to weevil stocking at each site with a late-season survey conducted six to eight weeks later. These surveys provide the opportunity to compare and monitor changes in the aquatic plant community and the weevil populations between sites and seasons. These surveys are integral in monitoring changes that occur in both the augmented weevil population and the health of milfoil over the course of the program in order to make informed management decisions. It is important to note that while these surveys provide insight in terms of broad level changes to the milfoil community, they are not a perfect monitoring method. While a much more in-depth sampling and surveying design would provide statistical significance, this comes at a much greater financial cost to perform and is beyond the scope needed to make these informed management decisions. Qualitative observations in these surveys include the health of milfoil, identification of native plant species present, and the presence of weevils and weevil-induced damage. Quantitative measurements include milfoil density and weevil population density. Milfoil density is determined by randomly collecting stems throughout the milfoil bed using a 0.09 m^2 quadrat. This sample is then converted to the number of stems per square meter (stems/m^2). Weevil population density (number of weevils per stem) is determined through lab analysis of 30 stems sampled from three transect lines at each site.

3.0 2014 Survey Results and Discussion

The results and discussion for the 2014 survey have been combined and organized by lake. Each "lake" subheading includes the results of the 2014 survey for each site, tables with measured milfoil and weevil density, and a comparison to previous seasons for each lake in the program. Comparisons across lakes as well as the overall success of the program will be discussed in: "Section 5.0 General Discussion". Please note that most comparisons in milfoil density will be made across late season surveys. Although milfoil density recorded during the initial survey is relevant, these results are often not as descriptive as late-season milfoil density since milfoil continues to grow throughout the summer. Comparing late-season surveys provide us a better snapshot of the program since milfoil has reached its peak density for the season and reduces variability based on fluctuations in early season growth.

Listed below are the survey dates for each lake:

Lake Name	Survey Date
Grant Lake	August 20, 2014
Hannah Lake	August 20, 2014
Middle Lake	August 20, 2014
Long Lake	August 19, 2014
McFarlane Lake	August 18, 2014
Richard Lake	August 19, 2014
St. Charles Lake	August 20, 2014

Grant Lake

- **S1** – This site was originally established in 2012 and stocked over two consecutive years consisting of 5,000 weevils in the first year and 4,000 weevils in the second. In 2014, milfoil at this site was moderate to dense and composed 75% of the plant community. Milfoil density consisted of 81.48 stems/m^2 (See Table 2) but remained 30cm below the surface. At this time, milfoil was heavily damaged and bent over with 80% of the stems showing signs of weevil damage. Weevils were identified in all life stages during the 2014 survey with a weevil density of 0.20 weevils/stem (See Table 1). The native aquatic plant species, small pondweed (*Potemogeton pusillus*), water naiad (*Najas flexilis*) and white water lily (*Nymphaea odorata*) were present at this stocking site.

- **U1 –** A milfoil bed that had not been stocked was sampled in Grant Lake in 2014. Milfoil at U1 was dense comprising 99% of the plant community with a density of 229.63 stems/m^2. At the time of the survey, milfoil was 15cm below the surface and heavily damaged with 90% of the stems showing signs of larval damage. Weevils were observed in all life stages with a density of 0.10 weevils/stem. Fern pondweed (*P. robinsii*), small pondweed, water naiad and yellow lily (*Nuphar variegatum*) were all present at this site in low quantities.

Table 1. Weevil population analysis (weevils/stem) in Grant Lake

Site #	Parameter Measured	July 25, 2012	September 4, 2012	July 27, 2013	August 29, 2013	August 20, 2014
S1	Total weevils Total stems **Avg. weevils/stem**	22.00 30.00 **0.73**	0.00 30.00 **0.00**	7.00 30.00 **0.32**	2.00 30.00 **0.07**	6.00 30.00 **0.20**
U1	Total weevils Total stems **Avg. weevils/stem**	**	**	**	**	3.00 30.00 **0.10**

Table 2. EWM Density (stems/m^2) in Grant Lake

Site #	July 25, 2012	September 4 2012	July 27, 2013	August 29, 2013	August 20, 2014
S1	**135.02**	**359.26**	**155.56**	**96.30**	**81.48**
U2	**	**	**	**	**229.63**

Grant Lake has shown continual progress since the first year of stocking in 2012. Milfoil density at Grant Lake has decreased each year since the initial stocking season from 359.26 stems/m^2 in 2012 to 81.48 stems/m^2 in 2014. Prior to stocking in 2012, milfoil composed 99% of the plant community with less than 5% of the plants showing signs of larval damage. In 2014, damage caused by larval feeding was observed on 80% of the milfoil stems at S1, with many of the stems bent over and dying back. Although milfoil is still the dominant species at S1, native species now make up a higher percentage of the plant community at this site. With such a high amount of larval feeding, further reductions in milfoil density are expected by the 2015 season at this site.

Another positive aspect of the 2014 survey was the presence of a healthy weevil population at the untreated site. Although milfoil density was much higher and weevil density was slightly lower at this site, roughly 90% of the plants showed signs of larval damage. It is likely that we will see a decline in milfoil density at U1 through the 2015 season as the milfoil stand becomes weakened by larval feeding. The high percentage of damage stems at S1 and U1 in Grant Lake speaks to the suitability of the surrounding area to provide suitable overwintering habitat benefiting the weevil population.

Hannah Lake

Hannah Lake was not treated with the Milfoil Solutions process and therefore serves as a long-term reference lake for comparing to lakes stocked with weevils. Two untreated sites were established in 2014: U1 and U2.

- **U1 –** Milfoil at this site comprised 99% of the plant community with several small pondweed shoots making up the difference. Milfoil was 50cm below the surface and healthy with 10% showing signs of larval damage. Milfoil density consisted of 170.37 stems/m^2 (See Table 4). During the survey, weevils were observed in all life stages with a density of 0.07 weevils/stem (See Table 3).

- **U2** – Milfoil at this site composed 99% of the plant community and was well below the surface (2m down). The milfoil bed consisted of healthy, low and bushy stems with less than 10% showing signs of weevil damage. Similar to U1, milfoil density consisted of 170.37 stems/m^2 where as weevil density consisted of 0.07 weevils/stem. Weevils were observed in the larval life stage during visual searches within the site. Richardson’s pondweed (*P. richardsonii*) was also present at this site.

Table 3. Weevil population analysis (weevils/stem) in Hannah Lake

Site #	Parameter Measured	August 20, 2014
U1	Total weevils Total stems **Avg. weevils/stem**	2.00 30.00 **0.07**
U2	Total weevils Total stems **Avg. weevils/stem**	2.00 30.00 **0.07**

Table 4. EWM Density (stems/m^2) in Hannah Lake

Site #	August 20, 2014
U1	**170.37**
U2	**170.37**

Weevil densities and the amount of damage at Hannah Lake are comparable to native weevil populations observed prior to stocking in 2011. The results from this survey will be compared to other lakes in Section 4.0 – General Discussion.

Long Lake

- **S1** – This site received 12,000 weevils throughout the first and second year of the program, with 7,000 weevils stocked in 2011 and 5,000 weevils in 2012. Milfoil at this site has dramatically dropped in density since the late season survey in 2013 to 20.37 stems/m^2 composing only 30% of the plant community (See Table 6). In its place, water naiad has become the dominant species present. Milfoil growth consisted of 60cm tall plants that appeared to be new, healthy growth with no weevil damage observed. ES biologists were not able to locate weevils in any life stage at during visual searches and did not observe weevils when determining weevil density. Large-leaf pondweed (*P. amplifolius*), Richardsons' pondweed and bur-reed (*Sparganium sp.*) was also observed at this site.

- **S2** – This site has not been stocked since the first year of the program in 2011 when it received 6,000 weevils. In 2014, milfoil composed 50% of the plant community with a density of 92.59 stems/m^2. Milfoil was most dense closer to shore and became less dominant towards open water at the site. Overall, milfoil appeared to be healthy and consist of relatively new growth, however remained 0.5 to 1.5m below the surface. Less than 10% of the plants showed signs of larval damage and weevils were not observed at the site during visual surveys or within samples collected to determine weevil density. Small pondweed was the other dominant species at the site with fern pondweed, large-leaf pondweed, northern waterweed (*Elodea nutalli*), Richardson's pondweed, watershield (*Brasenia schreberi*) and yellow water lily also present. Please note that hand harvesting took place throughout the bay adjacent to the site, however damage to milfoil indicative of harvesting was not observed within the specific location of S2.

- **S3** – Weevils were stocked across two years at S3 including 2011 (5,000 weevils) and 2013 (5,000 weevils) totaling 10,000 weevils. During the 2014 survey, milfoil composed 30% of the plant community and was 1 – 1.5m below the surface with a density of 48.15 stems/m^2. Less than 10% of the plants showed signs of weevil damage and consisted of relatively new growth, roughly 30cm in length. Weevils were not observed during visual searches, however one was collected in samples with a weevil density of 0.03 weevils/stem (See Table 5). The remainder of the plant community consisted of fern pondweed, large-leaf pondweed, northern waterweed, Richardson's pondweed and water naiad.

- **S4** – This site has not been stocked since the initial year of the program when 5,000 weevils were stocked, however surveys have been performed throughout the duration of the program. In 2014, milfoil composed 70% of the plant community with a density of 75.93

stems/m^2. Milfoil remained well below the surface of the water with roughly half of the plants 50cm below the surface with the remaining 1.0m below the surface. Less than 10% of the milfoil showed signs of larval damage with older shoots beginning to senesce while new growth (1.0m down) appeared to be healthy. Although weevils were not collected in samples to determine density, weevils were observed in the larval stage during visual searches. Eelgrass (*Vallisneria americana*) and large-leaf pondweed were also identified at this site.

- **S5 –** S5 was first established in 2013 and stocked with 4,000 weevils. Milfoil at this site composed 85% of the plant community with a density of 90.74 stems/m^2. At the time of the survey milfoil was 50cm below the surface of the water with 50% of the plants showing signs of larval damage. These damaged plants were brown, bent over in the water column and dying back. Weevils were observed in the larval and adult life stages during visual surveys but were not collected in samples to determine weevil density. Eelgrass, fern pondweed, northern waterweed, water naiad and white water lily (*Nymphaea odorata*) were also identified at this site.

- **U1 –** A milfoil bed that had not been stocked was sampled in Long Lake in 2014. The location of this site was determined by visually searching for milfoil beds similar to, but with considerable distance from, established stocking sites. This site was established within proximity to the public launch at the end of Kantola Road. Milfoil at this site composed 80% of the plant community with a density of 101.85 stems/m^2. At the time of the survey, milfoil was 1.5m below the surface of the water with 40% of the plants showing signs of larval damage and beginning to senesce. Weevils were observed in the egg, larval and adult life stages during visual surveys but were not observed in samples collected to determine weevil density. Flat-stemmed pondweed (*P. zosteriformis*) was also identified at this site.

Throughout the duration of the program, Long Lake received the most weevils in comparison to any other lake in the Sudbury program. However, due to the size and length of Long Lake, ES biologists made the decision to focus stocking on the eastern end of the lake. Focusing on one section of the lake allowed ES biologists to locally increase weevil presence to lead to declines in milfoil. In addition, this reduces the risk of spreading out stocking too thin and mimicking a natural low population. In total, 44,000 weevils were stocked in Long Lake over the three seasons of the program.

Table 5. Weevil population analysis (weevils/stem) in Long Lake

Site #	Parameter Measured	July 23, 2011	September 15, 2011	July 6, 2012	September 4, 2012	July 27, 2013	August 28, 2013	August 19 2014
S1	Total weevils Total stems **Avg. weevils/stem**	4.00 30.00 **0.13**	19.00 30.00 **0.63**	1.00 30.00 **0.03**	3.00 30.00 **0.10**	**	15.00 30.00 **0.50**	0.00 30.00 **0.00**
S2	Total weevils Total stems **Avg. weevils/stem**	3.00 30.00 **0.10**	21.00 30.00 **0.70**	**	3.00 30.00 **0.10**	**	13.00 30.00 **0.43**	0.00 30.00 **0.00**
S3	Total weevils Total stems **Avg. weevils/stem**	0.00 30.00 **0.00**	20.00 30.00 **0.67**	1.00 30.00 **0.03**	0.00 30.00 **0.00**	0.00 30.00 **0.00**	9.00 20.00 **0.45**	1.00 30.00 **0.03**
S4	Total weevils Total stems **Avg. weevils/stem**	0.00 30.00 **0.00**	22.00 30.00 **0.73**	**	0.00 30.00 **0.00**	**	9.00 30.00 **0.30**	0.00 30.00 **0.00**
S5	Total weevils Total stems **Avg. weevils/stem**	**	**	**	**	0.00 30.00 **0.00**	13.00 29.00 **0.45**	0.00 30.00 **0.00**
U1	Total weevils Total stems **Avg. weevils/stem**	**	**	**	**	**	**	0.00 30.00 **0.00**

***Site not surveyed*

Table 6. EWM density (stems/m^2) in Long Lake

Site #	July 23, 2011	September 15, 2011	July 6, 2012	September 4, 2012	July 27, 2013	August 28, 2013	August 19, 2014
S1	403.70	74.07	328.70	272.84	**	200.00	20.37
S2	74.07	177.78	**	308.87	**	77.78	92.59
S3	140.70	148.15	184.36	362.14	129.63	133.33	48.15
S4	88.89	111.11	**	289.63	**	96.30	75.93
S5	**	**	**	**	118.52	133.33	90.74
U1	**	**	**	**	**	**	101.85

***Site not surveyed*

Following a dry, hot summer in 2012 which led to explosive milfoil growth at lakes province wide, milfoil density declined at all sites below late-season densities of 2011. The most notable changes in 2014 were at S1 and S3 where milfoil substantially decreased in density and composed only 30% of the plant community. Decreases in overall percentage of the plant community were also observed at S2 (from 95% to 50%) and S4 (from 80% to 70%). This continual decrease in milfoil density over the duration of the program at all Long Lake stocking sites is very promising for future declines at Long Lake.

After only one season of stocking in 2013, S5 also showed decreases in milfoil density with a small increase in the overall percentage of the plant community (80% to 85%). In addition, weevil damage was observed on 50% of the plants by the 2014 survey which is suggestive of an established weevil population. Similarly, weevil damage was observed on 40% of the milfoil present at the sampled untreated site on Long Lake. The presence of weevils and larval damage at this site also provides a positive outlook with respect to the ability for weevils to become established in greater densities across Long Lake. It is expected that this larval feeding will negatively impact the plant's ability to overwinter leading subsequent declines in 2015

McFarlane Lake

- **S1 –** S1 was only stocked during the 2011 season with 5,000 weevils, however a late-season survey was performed each year of the program. Milfoil at this site was dense comprising 95% of the plant community with a density of 200.00 stems/m^2 (See Table 8).

Milfoil at S1 consisted of a mixture of new and older growth, the majority of which consisted of healthy new growth 30cm in length with minimal signs of larval damage. Older growth at this site consisted of stems roughly 0.5m below the surface with 80% showing signs of larval damage. Weevils were not collected in samples to determine density, however weevils were observed in the egg larval and pupal life stages during the survey. Richardson's pondweed and water crowfoot (*Ranunculus sp.*) were also observed at this site.

- **S2** – This site was stocked over two seasons consisting of 5,000 weevils in 2011 and 6,000 weevils in 2013. During the 2014 survey, milfoil at this site was dense and composed 75% of the plant community with a density of 114.81 stems/m^2. The plants remained 30cm to 1m below the surface of the water with older growth showing damage and dying back. Weevil damage was observed on 40% of the stems with weevils observed in the larval and pupal life stages. Weevils were not present in the samples collected to determine weevil density. Flat-stemmed pondweed, northern waterweed, small pondweed and white water lily were also present.

- **S3** – Ten thousand weevils were stocked at this site across the first two seasons of the program (5,000 each year). At the time of the 2014 survey, milfoil composed 99% of the plant population with 20% of the milfoil flowering. Milfoil density at this site consisted of 172.22 stems/m^2. Although the milfoil was topped out and flowering, roughly 70% were showing signs of weevil damage. Weevils were observed in all life stages while actively searching throughout the survey, however only one weevil was collected in samples. Weevil density consisted of 0.03 weevils/stem (See Table 7). Large-leaf pondweed was also observed at this site.

- **U1** – A milfoil bed that had not been stocked was sampled in McFarlane Lake in 2014. Milfoil density at the time of the survey consisted of 125.93 stems/m^2 and composed 90% of the plant population. Milfoil remained 50cm below the surface of the water with less than 5% showing signs of larval damage. Weevils were not observed at this site during active visual searches or in samples collected to determine weevil density. Some aquatic moth (*Acentria ephemerella*) damage was observed at this site but was very minimal. Eelgrass, large-leaf pondweed, Richardson's pondweed, small pondweed and water naiad were also present at this site.

Table 7. Weevil population analysis (weevils/stem) in McFarlane Lake

Site #	Parameter Measured	July 11, 2011	September 15, 2011	August 4, 2012	September 4, 2012	July 27, 2013	August 27, 2013	August 18, 2014
S1	Total weevils Total stems **Avg. weevils/stem**	15.00 30.00 **0.50**	27.00 30.00 **0.90**	**	3.00 30.00 **0.10**	**	20.00 30.00 0.67	0.00 30.00 **0.00**
S2	Total weevils Total stems **Avg. weevils/stem**	5.00 30.00 **0.17**	39.00 30.00 **1.30**	**	2.00 30.00 **0.07**	0.00 30.00 **0.00**	10.00 30.00 0.34	0.00 30.00 **0.00**
S3	Total weevils Total stems **Avg. weevils/stem**	5.00 30.00 **0.17**	17.00 30.00 **0.57**	0.00 30.00 **0.00**	9.00 30.00 **0.30**	**	17.00 30.00 0.57	1.00 30.00 **0.03**
U1	Total weevils Total stems **Avg. weevils/stem**	**	**	**	**	**	**	0.00 30.00 **0.00**

***Site not surveyed*

Table 8. EWM density (stems/m^2) in McFarlane Lake

Site #	July 11, 2011	September 15, 2011	August 4, 2012	September 4, 2012	July 27, 2013	August 27, 2013	August 18, 2014
S1	**233.33**	**255.56**	**	**278.46**	**	**85.19**	**200.00**
S2	**177.78**	**325.92**	**	**265.18**	**225.93**	**162.96**	**114.81**
S3	**107.40**	**166.67**	**223.60**	**201.26**	**	**137.04**	**172.22**
U1	**	**	**	**	**	**	**125.93**

***Site not surveyed*

Over the duration of the program, milfoil decreased in density at all sites from the late season survey in 2011 to the late season survey in 2013. Most notably, were the declines in density at S1 (255.56 stems/m^2 to 85.19 stems/m^2) and S2 (325.92 stems/m^2 to 162.96 stems/m^2) between 2011 and 2013. Although this decline in milfoil density continued into the 2014 season at S2, milfoil density increased at S1 and S3. While it is difficult to speculate why milfoil density increased at S1 and S3 in 2014, it is important to note that these sites have not been stocked since 2011 and 2012 respectively. In addition, larval feeding was observed on 80% of the older growth at S1 and 70% of the stems at S3. This occurrence of damaged stems was higher in 2014 than any other season at these sites and is expected to lead to further declines in the 2015 season.

In comparison to the stocking sites on McFarlane Lake, milfoil density at U1 was lower in comparison to S1 and S3. With such a low occurrence of larval feeding (less than 5%) and weevil presence, it is likely that this site will increase in density in 2015.

Middle Lake

Like Hannah Lake, Middle Lake was not treated with the Milfoil Solutions process and therefore serves as a long-term reference lake for comparing to lakes stocked with weevils. Two untreated monitoring sites were established in 2014: U1 and U2.

- **U1** – Milfoil at U1 was dense comprising 99% of the plant community. Milfoil density consisted of 155.56 stems/m^2 with healthy plants roughly 1.5m below the surface (See Table 10). Weevils were observed in all life stages while actively searching at the site, however only one weevil was observed in samples collected with a density of 0.03 weevils/stem (See Table 9). Although in low quantities, bur-reed and water naiad were also present at this site.

- **U2** – Milfoil density consisted of 138.89 stems/m^2 and composed 99% of the plant community. Stems appeared to be healthy, bushy and remained 1m below the surface of the water. Less than 10% of the stems showed signs of larval damage. Weevils were not observed during visual surveys, however were collected in samples with a weevil density of 0.03 weevils/stem. Small pondweed and bur-reed were also present at this site.

Similar to the results from Hannah Lake, this survey provides a snapshot of the conditions at a lake that did not receive stocking throughout the duration of the program. Weevil densities and the amount of damage at Hannah Lake are comparable to native weevil populations observed prior to stocking in 2011. The results from this survey will be compared to other lakes in Section 4.0 – General Discussion.

Table 9. Weevil population analysis (weevils/stem) in Middle Lake

Site #	Parameter Measured	August 20, 2014
U1	Total weevils Total stems **Avg. weevils/stem**	1.00 30.00 **0.03**
U2	Total weevils Total stems **Avg. weevils/stem**	1.00 30.00 **0.03**

Table 10. EWM Density (stems/m^2) in Middle Lake

Site #	August 20, 2014
U1	**155.56**
U2	**138.89**

Richard Lake

- **S1** – S1 was stocked over the first two seasons of the program receiving 9,000 weevils the first season and 3,500 weevils during the second season. In 2014, milfoil at this site was dense comprising 85% of the plant community with a density of 207.41 stems/m^2 (See Table 12). Milfoil remained 1m below the surface of the water and appeared to be healthy and bunchy. Less than 5% of the milfoil showed signs of weevil damage. Weevil density consisted of 0.10 weevils/stem with weevils observed in the egg and larval life stages (See Table 11). Small pondweed and water starweed (*Zosterella dubia*) were observed at this site.

- **S2** – This site was stocked similar to S1 during the first two seasons of the program, but received an additional 6,000 weevils in 2013. Milfoil at this site was dense and located 1m below the surface. Milfoil density during the 2014 survey consisted of 159.26 stems/m^2 and composed 99% of the plant community. At the time of the survey, milfoil consisted of healthy new growth with less than 10% showing signs of larval damage. Weevils were observed in the egg, larval and adult life stages with a density of 0.07 weevils/stem. Flat-stem pondweed, Richardson's pondweed and water naiad were also observed at S2.

- **U1** – A milfoil bed that had not been stocked was sampled in Richard Lake in 2014. Milfoil was dense composing 99% of the plant community with a density of 146.30 stems/m^2. Milfoil remained 50cm below the surface and consisted of low lying bushy plants. Larval damage on the plants was observed to be higher in shallower water (30% showing damage) and lower in deeper water (10% showing damage). Weevils were observed at U1 in the larval and adult life stages with a density of 0.03 weevils/stem. Eelgrass, water naiad, water starweed, white-stemmed pondweed (*P. praelongus*) and whorled milfoil (*Myriophyllum verticillata*) were also present at this site.

Richard Lake received the second highest number of weevils over the duration of the program with 31,000 stocked over three seasons. In addition, Richard Lake boasts a healthy native weevil population, which was observed prior to stocking in the 2011 season. The results of the stocking efforts at Richard Lake have been mixed throughout the duration of the program. While we observed a decrease in milfoil density following the 2012 season at both sites, milfoil density increased at both sites by 2014. Milfoil density at S2 remained lower than the late season survey in 2011, while milfoil density doubled at S1 by 2014.

Overall, stocking efforts at Richard Lake have been met with mixed results. Although these fluctuations in milfoil density have been observed throughout the program, it is also important to note that milfoil remained well below the surface of the water throughout the past three seasons at Richard Lake. This includes the 2012 growing season, while milfoil was topped out at the surface of the water at most lakes throughout the program, milfoil remained 45cm below the surface throughout the stocking sites. This reduction in milfoil reaching the surface can greatly benefit the aesthetic and recreational quality of a waterway.

Table 11. Weevil population analysis (weevils/stem) in Richard Lake

Site #	Parameter Measured	August 16, 2011	September 17, 2011	July 24, 2012	September 4, 2012	August 2, 2013	August 27, 2013	August 20, 2014
S1	Total weevils Total stems **Avg. weevils/stem**	13.00 30.00 **0.43**	14.00 30.00 **0.47**	5.00 30.00 **0.17**	26.00 30.00 **0.87**	**	13.00 30.00 **0.43**	3.00 30.00 **0.10**
S2	Total weevils Total stems **Avg. weevils/stem**	3.00 30.00 **0.10**	16.00 30.00 **0.53**	6.00 30.00 **0.20**	29.00 30.00 **0.97**	5.00 30.00 **0.17**	30.00 30.00 **1.00**	2.00 30.00 **0.07**
U1	Total weevils Total stems **Avg. weevils/stem**	**	**	**	**	**	**	1.00 30.00 **0.03**

Table 12. EWM density (stems/m^2) in Richard Lake

Site #	August 16, 2011	September 17, 2011	July 24, 2012	September 4, 2012	August 2, 2013	August 27, 2013	August 19, 2014
S1	**103.70**	**111.11**	**95.47**	**171.30**	**	**114.82**	**207.41**
S2	**118.52**	**200.00**	**81.67**	**149.91**	**214.82**	**118.52**	**159.26**
U1	**	**	**	**	**	**	**146.30**

Simon Lake

Simon Lake received 15,000 weevils over the initial two stocking seasons of the program. Weevils were not stocked in 2013 due to excessive algae growth of a thick-filamentous algae that covered the surrounding bays including the stocking sites. Since the program had been cancelled at this lake, EnviroScience did not perform a survey in 2014.

Table 13. Weevil population analysis (weevils/stem) in Simon Lake

Site #	Parameter Measured	Aug. 23, 2011	Sept. 17, 2011	July 6, 2012	Sept. 17, 2012	July 26, 2013	Aug. 28, 2013
S1	Total weevils Total stems **Avg. weevils/stem**	10.00 30.00 **0.33**	23.00 30.00 **0.77**	7.00 30.00 **0.23**	4.00 30.00 **0.13**	1.00 30.00 0.03	5.00 29.00 0.17

Table 14. EWM density (stems/m^2) in Simon Lake

Site #	August 23, 2011	September 17, 2011	July 6, 2012	September 17, 2012	July 26, 2013	August 28, 2013
S1	**133.33**	**29.63**	**80.48**	**371.00**	**296.30**	**159.26**

St. Charles Lake

- **S1 –** This site was stocked every year throughout the duration of the program receiving a total of 20,000 weevils (2011: 9,700 weevils; 2012: 7,000 weevils; 2013: 4,000 weevils). At the time of the 2014 survey, milfoil composed 90% of the plant community with a density of 83.33 stems/m^2 (See Table 16). Milfoil remained 50cm below the surface of the water with 30% showing signs of larval damage. Weevils were present in the egg, larval and adult life stages with a density of 0.17 weevils/stem (See Table 15). In addition to milfoil, *Nitella sp.,* bur-reed and slender leaf pondweed were present.

- **U1 –** A milfoil bed that had not been stocked was sampled in St. Charles Lake in 2014. Milfoil density at U1 consisted of 166.67 stems/m^2 and composed 99% of the plant community. Milfoil remained 50cm below the surface and consisted of low lying bushy plants, similar to S1. Overall, the milfoil appeared to be healthy with larval damage observed on 10% of the stand. Weevils were observed at U1 in the egg, larval and adult life stages with a density of 0.03 weevils/stem. Large-leaf pondweed, bur-reed and slender leaf pondweed were also present at this site.

St. Charles Lake was stocked every season throughout the duration of the program with a total of 20,700 weevils. During the first season, milfoil density was observed to decline greatly from 529.63 stems/m^2 to 133.33 stems/m^2. Following the initial decrease in density in 2011, milfoil density consistently declined each year by the late season survey to a consistent ~80 to 90 stems/m^2. Interestingly, milfoil density was highest all seasons during the initial survey, with a reduction in milfoil by the end of the season. Throughout the duration of the program it was apparent that this site was capable of sustaining a healthy weevil population keeping milfoil from reaching the surface of the water. This stunted milfoil growth at S1 was observed during the 2014 follow-up survey where milfoil remained well below the surface of the water.

During the 2014 survey, milfoil density at the untreated site was roughly double what was observed at S1. In addition, weevils were present at a lower density with less larval damage to the standing milfoil in comparison to S1. It is difficult to say if the weevil presence at U1 is due to stocking efforts at S1 or indicative of a native weevil population. Regardless, it appears that this site is capable of supporting a healthy weevil population.

Table 15. Weevil population analysis (weevils/stem) in St Charles Lake

Site #	Parameter Measured	July 30, 2011	September 14, 2011	June 15, 2012	September 4, 2012	July 26, 2013	August 29, 2013	August 20, 2014
S1	Total weevils Total stems **Avg. weevils/stem**	5.00 30.00 **0.17**	21.00 30.00 **0.70**	8.00 28.00 **0.29**	40.00 30.00 **1.33**	18.00 27.00 **0.67**	1.00 27.00 **0.04**	5.00 30.00 **0.17**
U1	Total weevils Total stems **Avg. weevils/stem**	**	**	**	**	**	**	1.00 30.00 **0.03**

Table 16. EWM density (stems/m^2) in St Charles Lake

Site #	July 30, 2011	September 14, 2011	June 15, 2012	September 4, 2012	July 26, 2013	August 28, 2013	August 20, 2014
S1	**529.63**	**133.33**	**92.59**	**86.08**	**211.11**	**96.30**	**83.33**
U1	**	**	**	**	**	**	**166.67**

4.0 General Discussion

This season marked the fourth consecutive year of surveying and monitoring the Milfoil Solution® Program at the Greater City of Sudbury. Listed below are some of the positive highlights observed following the 2014 Follow-up survey:

- Milfoil density in 2014 was lower than the late-season survey in 2011 at Grant Lake, Long Lake, McFarlane Lake (S1, S2), Richard Lake (S1) and St. Charles Lake.
- Larval damage was observed on 40% of the stems or greater at Grant Lake S1 (80%) and U1 (90%), Long Lake S5 (50%) and U1 (40%), McFarlane Lake S1 (80% of old growth), S2 (40%) and S3 (70%).
- Milfoil composed 50% or less of the plant community at Long Lake stocking sites: S1, S2 and S3.
- Milfoil remained well below the surface of the water and did not flower at all sites except McFarlane Lake S3.

As discussed above, milfoil density was observed to decline over the duration of the program at sites within all stocked lakes (with exception to Simon Lake which was not surveyed in 2014). This consists of declines at 10 of the 12 stocking sites established throughout the program. Sites that did not show an overall decrease in density from the 2011 late-season survey consist of McFarlane Lake S3 and Richard Lake S1 which have not been stocked since the 2012 season.

In addition to these declines in milfoil density, we have observed some of the highest occurrences of larval feeding across the program. Most damage cause to the plants is during the larval feeding stage. As weevil larvae burrow the stem, they limit the potential for stem elongation, flower and disrupt the storage and transportation of energy throughout the plant. Burrowing also creates small holes throughout the stem causing the plant to sink to the bottom of the lake leaving it open to secondary infection. As milfoil becomes weakened over the duration of the summer, the ability of the plant to overwinter is reduces often causing greater declines in the subsequent year. It appears that this process has been occurring at a majority of sites throughout the Greater City of Sudbury Milfoil Solution® program.

Along with the increased larval feeding observed in 2014, it is important to consider the impact weather has had on the program. While the dry-hot summer of 2012 provided ideal growing conditions for milfoil and proved difficult for management efforts, 2013 and 2014 provided a cooler start to the summer. Similar to 2013, a cold-wet start to the spring and summer in 2014 likely attributed to slowed growth of milfoil. In addition to providing a late start to the season for milfoil growth, this provided the opportunity for overwintering weevils to become established in the lake prior to the plants reaching the surface and branching profusely. Although the weather conditions likely contributed to slower milfoil growth they are supplemental to this form of biological control. This slowed growth allows the ability for weevils to begin feeding on milfoil prior to milfoil reaching the surface. By the 2014 survey, milfoil remained low in the water column at all sites with exception to McFarlane S3 where “matting’ and flowering were observed. This lack of “matting” and flowering can also limit the amount of sexual reproduction and fragmentation caused by boats that can occur within the site.

Sampling was conducted at two reference lakes, Hannah and Middle, as well as one untreated milfoil bed in other lakes, except Simon. Sampling at these untreated locations offers some degree of comparison to sites stocked with weevils. Comparison, however, is tempered by the use of only one untreated sampling location per lake as well as sampling in only one year. The two reference lakes offer the best opportunities for comparison to stocked lakes over the long-term.

Within lakes, milfoil density at untreated sites within Grant Lake, Long Lake and St. Charles were higher than stocked sites while densities were lower in comparison to stocked sites at Richard Lake and McFarlane (with exception to S2). While some sites boasted healthy weevil presence and larval feeding (Grant Lake and Long Lake), others (McFarlane Lake, St. Charles) showed limited presence of weevils larval feeding.

Interestingly, milfoil density at Hannah Lake and Middle Lake was well within the mid-range of all other sites. Unlike some of the untreated sites within stocked lakes, Hannah and Middle Lakes consisted of relatively low weevil density and weevil induced damage which is typically indicative of a native weevil population.

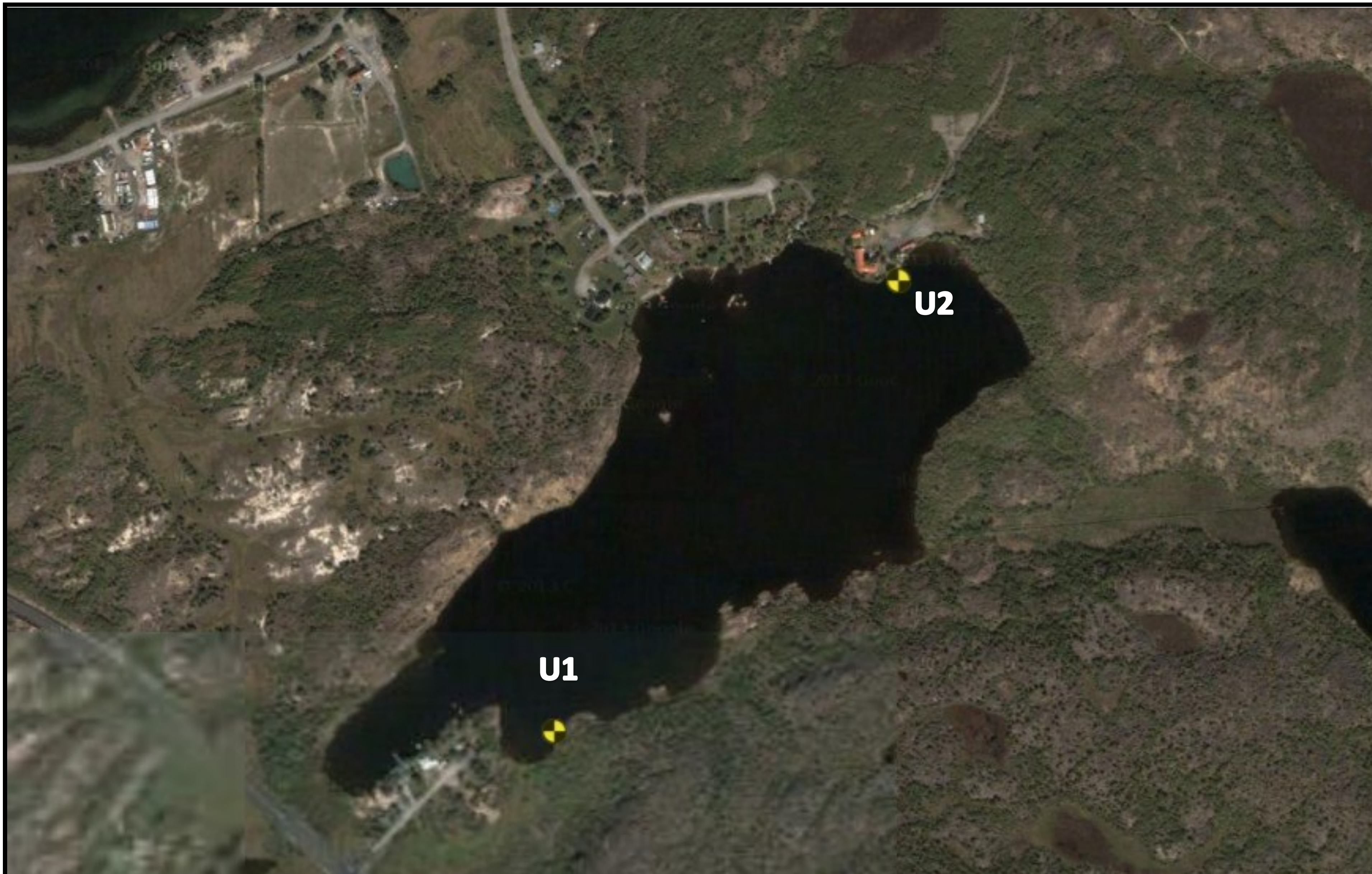
Year to year fluctuations between weevil populations and milfoil density are natural and reflect the predator-prey nature of biological control. Considering the excessive growth observed in 2012, the continual progress throughout the 2013 and 2014 seasons provide some insight into the potential for stocking to provide significant declines in milfoil. These results build on previous successes towards management of Eurasian watermilfoil in Sudbury as well as understanding of the relationship of milfoil and the milfoil weevil throughout the northern extent of the infestation in Ontario.

Grant Lake
City of Greater
Sudbury, Ontario

Weevil Stocking Sites
Untreated Sites

200 ft
100 m
N

MILFOIL SOLUTION



Hannah Lake
City of Greater
Sudbury, Ontario

Weevil Stocking Sites
Untreated Sites

1000 ft
200 m
N

MILFOIL SOLUTION

Long Lake
Northeast End
City of Greater
Sudbury, Ontario

Weevil Stocking Sites

Untreated Sites

1000 ft
200 m

N

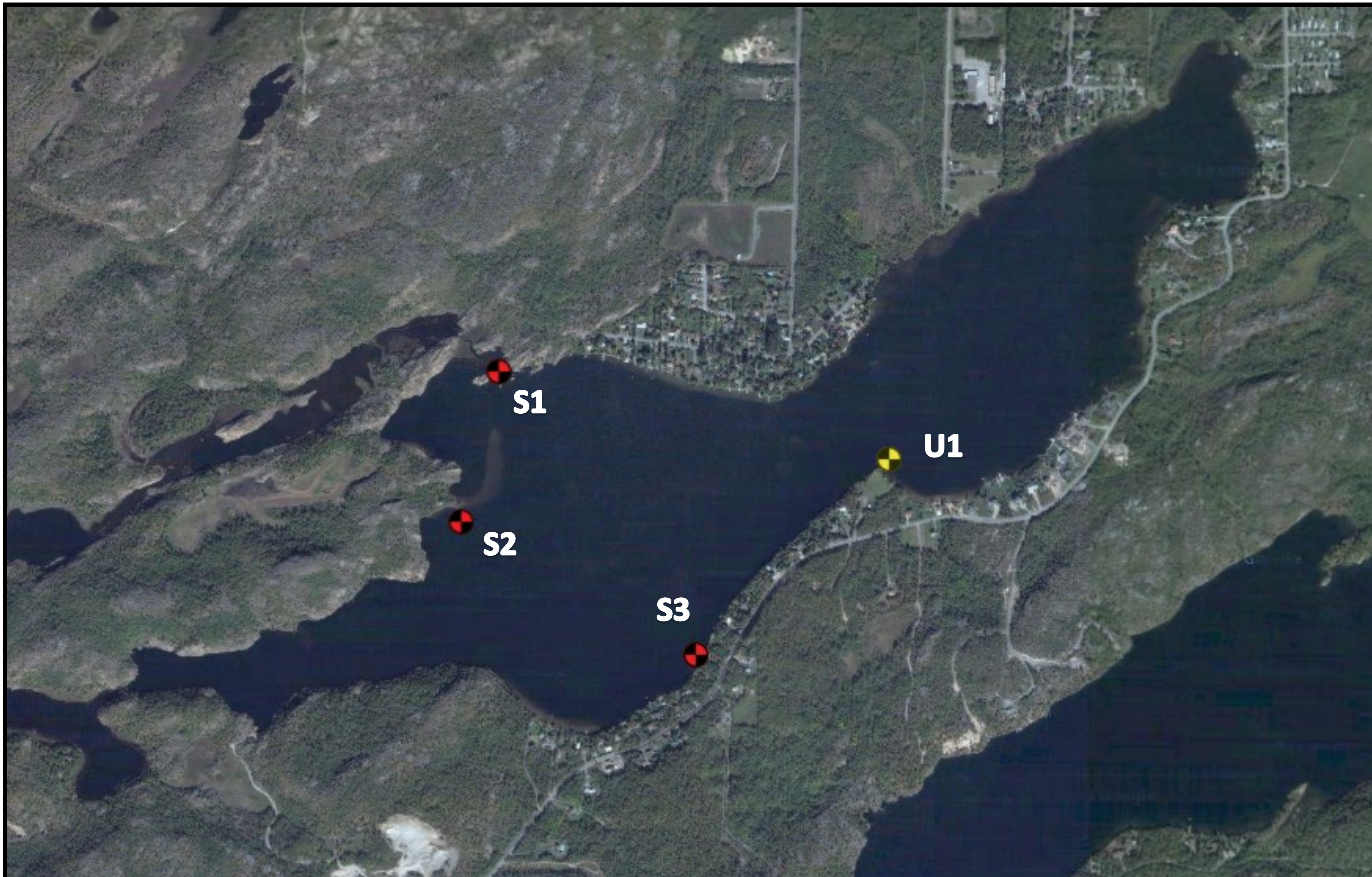
MILFOIL SOLUTION

Long Lake
Southwest End
City of Greater
Sudbury, Ontario

Weevil Stocking Sites
Untreated Sites

1000 ft
200 m
N

MILFOIL SOLUTION



McFarlane Lake
City of Greater
Sudbury, Ontario

Weevil Stocking Sites
Untreated Sites

1000 ft
200 m

N

MILFOIL SOLUTION

Middle Lake
City of Greater
Sudbury, Ontario

Weevil Stocking Sites
Untreated Sites

200 ft
100 m
N

MILFOIL SOLUTION

Richard Lake
City of Greater
Sudbury, Ontario

Weevil Stocking Sites
Untreated Sites

1000 ft
200 m

N

MILFOIL SOLUTION

Simon Lake
City of Greater
Sudbury, Ontario

Weevil Stocking Sites

1000 ft
200 m

N

MILFOIL SOLUTION

St. Charles Lake
City of Greater
Sudbury, Ontario

Weevil Stocking Sites
Untreated Sites

200 ft
100 m

N

MILFOIL SOLUTION