2021

Aquatic Plant Survey Report

Lake Redstone Bays

Sauk County, Wisconsin

Arapaho, Cardinal, Chickadee, Hummingbird, Mourning Dove, & Oriole

Project initiated by:
Lake Redstone Protection District

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ABSTRACT

Aquatic plant surveys of six bays in Lake Redstone, Sauk County Wisconsin, were completed in 2021 as an ongoing effort to gauge Eurasian watermilfoil (*Myriophyllum spicatum,* EWM) occurrence where control activities may be needed. Arapaho, Cardinal, Chickadee, Hummingbird, Mourning Dove, and Oriole Bays were surveyed August 12th, 2021. Each bay has its own management history with varying stages of pre-and post-treatment monitoring for EWM. Although some bays had been treated with herbicide in past years in an effort to control EWM, no bays were treated with herbicide in spring 2019, 2020, or 2021 and dredging of all the bays surveyed took place July through December 2019. The surveys employed methods from Hauxwell (2010), but with a higher resolution survey grid than would be used on a whole-lake scale. EWM was the most commonly occurring species in all 6 bays in 2021. However, all bays except Arapaho had lower EWM occurrence in 2021 when compared to 2020. The decrease in EWM was statistically significant in 2 of those bays. Littoral frequency of plants overall (combined native and non-native) was lowest compared to previous years all bays except Arapaho. These data suggest the littoral frequency of native aquatic plants is on a downward trend since 2014. When comparing ***native*** plant occurrence in 2021 to 2020, there were no statistically significant (SS) changes in native species. When comparing ***native*** plant occurrence from the ***first*** survey to data collected in 2021, there were 8 SS declines in native species and 1 SS increase in native plant species.

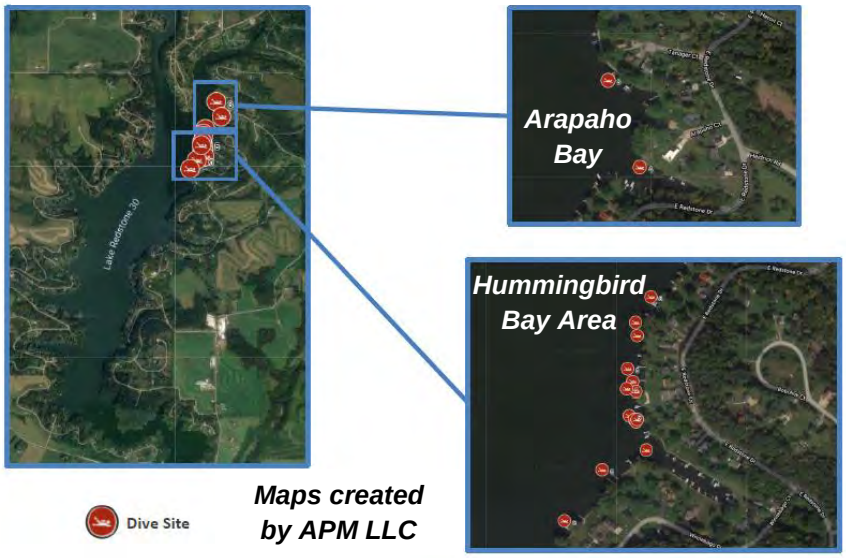
Management Recommendations are as follows; 1) Protect native aquatic plants. 2) Control nuisance native vegetation with hand-pulling or raking, where permitted. 3) Continue water quality & AIS monitoring. 4) Conduct aquatic plant surveys of bays in 2022 as needed for management of EWM and a whole-lake aquatic plant survey of Lake Redstone. 5) Consider DASH as an alternative to manual removal of EWM as recommended by Aquatic Plant Management LLC.

Table of Contents

INTRODUCTION

The Lake Redstone Protection District (LRPD) partnered with Aquatic Plant and Habitat Services to complete aquatic plant surveys of 6 bays in 2021 as a continued effort in gauging EWM occurrence where control activities may be needed. Dredging occurred in Lake Redstone from July through December of 2019 to remove sediment from 27 locations, protect lake property values, maintain and improve the lake, and aim to improve water quality[1]. In June 2021, Aquatic Plan Management LLC (APM) was hired for three days to manually remove EWM from 2 locations in Arapaho Bay and several areas near the mouth of Hummingbird Bay. Diver assisted suction harvesting was not used in 2021 but was recommended by APM for future EWM removal due to the dense nature of some of the EWM colonies. No herbicide treatment occurred in any bays in 2019, 2020, or 2021.

Figure 1 – EWM Manual Removal Locations

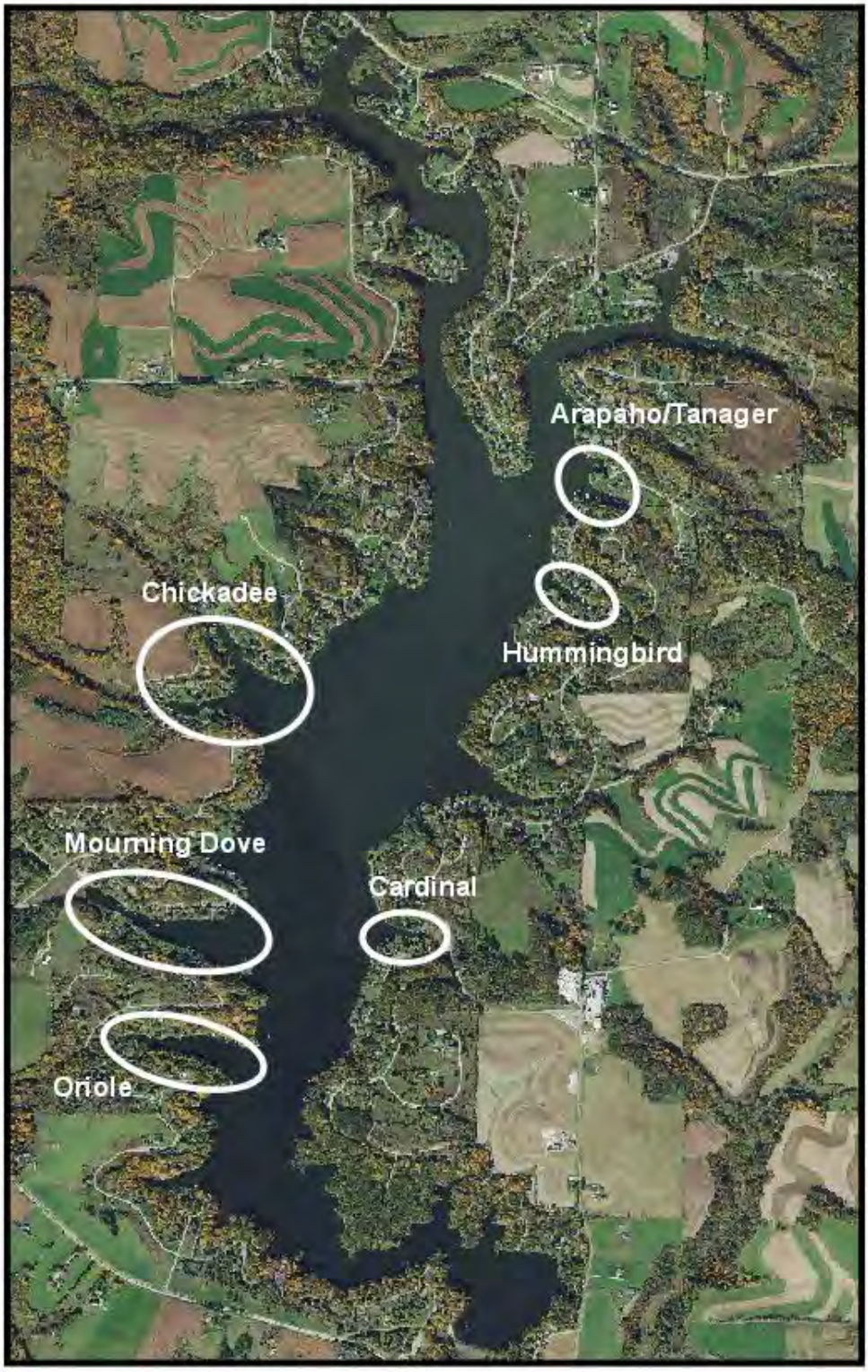


Study Site

Lake Redstone is a drainage lake in Sauk County, Wisconsin with a surface area of 635 acres. The lake is an impoundment of Big Creek, which is a tributary of the Baraboo River, in Sauk County. The lake was created in 1965 with the construction of the dam on Big Creek initiated by a real estate developer with the intention of establishing 1,600 residential lots (Leverance & Panuska, 1997). Recent concerns about sedimentation prompted studies, one of which estimated annual sediment loading at 3,000 cubic yards per year[2]. Flooding in 2018 resulted in an additional 67,340 cubic yards of sediment loading in the bays[2]. The Lake District pursued dredging of 27 locations in 2019. The lake is considered an Area of Special Natural Resource Interest due to the presence of certain plant or animal species or unique ecological communities identified in the WDNR Natural Heritage Inventory. Lake Redstone is classified as a eutrophic system based on data collected since 1979 with low water clarity (Secchi depth of 2-3 feet since 2009). The 6 bays surveyed in 2021 are illustrated in Figure 2.

[1] https://www.lakeredstonepd.org/dredging-meeting-minutes. June 2018 Dredging Informational Meeting PowerPoint Presentation.
[2] https://www.lakeredstonepd.org/dredging-meeting-minutes. A Proposal for Dredging on Lake Redstone. Lake Redstone Protection District. May 18, 2019

Figure 2 – Lake Redstone Map of Bays Surveyed in 2021



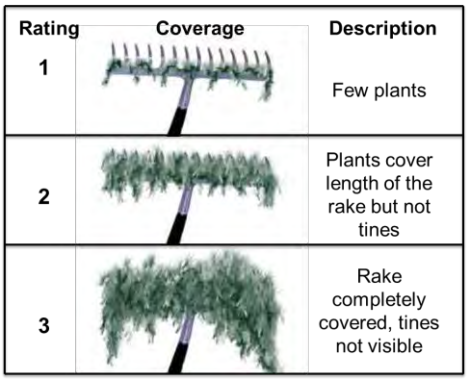
GOALS AND OBJECTIVES

GOAL: The main goal was to survey aquatic plants in select bays at a higher resolution (compared to whole-lake survey) for making management decisions, specifically related to EWM management.

OBJECTIVES:

1. Complete a survey of all aquatic plants in 6 bays at pre-determined survey points.
2. Analyze data and create maps of plant distribution, sediment type, and depth.
3. Compare results of the previous surveys using Chi-squared tests to identify statistically significant changes in native and invasive plant species since 2015.
4. Provide a final report.

Figure 3 – Rake Fullness Illustration



METHODS

Field Methods

Field methods followed the standardized protocol developed by the Wisconsin Department of Natural Resources (WDNR) in Hauxwell et. al (2010) and the surveys were completed August 12th, 2021. All plant survey dates completed by APHS LLC are in List 1. Point-intercept maps were generated for Arapaho (55 pts), Cardinal (71 pts), Chickadee (121 pts), Hummingbird (65 pts), Mourning Dove (123 pts), and Oriole (104 pts) resulting in 539 sample points. The survey coordinates were uploaded to an iPhone using Avenza Maps application, allowing navigation to each survey point in the bays. Points that were deeper than 12 feet were not surveyed based on previous findings that maximum rooting depth of any bay-wide survey since 2015 was 11 feet (Table 4), with the exception of Cardinal Bay in 2021 where EWM was found at a 12-ft deep sample point, but the EWM was growing adventitious roots and was likely free-floating and not rooted on site (see Cardinal EWM for more information). The average maximum rooting depth is 5.4 feet among all years of all bays that were surveyed since 2014. A double-sided rake head on a telescopic pole was used to sample each point for aquatic plants, depth, and dominant sediment type (muck, rock, or sand). The rake fullness rating for total coverage of plants on the rake and a separate rake fullness rating for each species present were recorded (Figure 3). Any survey points that were inaccessible were recorded as such and no sample was taken. Aquatic plants found within 6 feet of the sample point but not found on the rake were counted as visual observations.

List 1 – Aquatic Plant Survey Dates

- Aug. 11, 2014
- July 17-18, 2015
- Aug. 17-18, 2016
- Sept. 8-9, 2017
- Aug. 24-25, 2018
- July 17 & Aug. 3-4, 2019
- Aug. 11-13, 2020
- Aug. 12, 2021

Data Analysis Methods

Survey data were used to calculate statistics including Simpson Diversity Index, species richness, Nichols (1999) Floristic Quality Index, frequencies, rake fullness and number of visual sightings among other summary statistics. Following guidelines in Hauxwell (2010), species that were recorded as visuals (i.e., within 6 feet of a survey point but not sampled with the rake) were not included in Simpson Diversity Index and FQI calculations. Also, filamentous algae occurrence was not used in some statistical calculations but data was collected to gauge its frequency throughout the 6 bays.

Summary Statistics

Summary statistics provide a general overview of the plant community in each bay and can be used to make comparisons among the bays and within the same bay over time. However, ***these statistics should not be used to compare to other lakes where a whole-lake survey has been done***. Explanations of summary statistics are in Table 2. Floristic Quality Index (FQI, Nichols 1999) is listed in Table 1 but is worth providing more explanation. The FQI incorporates aquatic plant species associated with lake communities and native to Wisconsin by using the Coefficient of Conservatism (C) ranging from 0 to 10. The C value estimates the likelihood of a plant species occurring in an environment that is relatively unaltered from pre-settlement conditions. As human disturbance increases, species with a lower C value occur more frequently while more sensitive species with a higher C value occur less frequently. To calculate floristic quality, the mean C value of all species found in the lake is multiplied by the square root of the total number of plant species in the lake. Only plants found on the rake are included in the calculations. In other words, the FQI metric helps us understand how close the aquatic plant community is to one of undisturbed conditions. A higher FQI value assumes a healthier aquatic plant community. Floristic quality values can be compared on a statewide value, but Nichols (1999) recommends comparing values within one of the four ecoregional-lake types. Lake Redstone falls within the "Driftless" ecoregional-lake type. However, the ***FQI values for each bay or even mean values of all bays cannot be compared to other lakes in the driftless region because the bays are not representative of a whole-lake survey***.

Individual Species Statistics

Individual species statistics assess the plant species composition in the 6 bays and allow for comparisons of the plant community within the bays (Table 1).

Chi-squared tests

A chi-squared test of plant occurrence was done for all bays. The statistical test helps determine whether there is a significant difference between two data sets by comparing the number of sites a particular plant species was found in two different years. The alpha, or Type I error rate was set at 0.05, meaning there is a 5% chance of claiming there is a significant change when no real change has occurred. Chi-squared tests compared differences in plant occurrence from 2020 to 2021. The tests also compared differences from the first year of the bay being surveyed to 2021.

Table 2 – Summary Statistics Explanations

Statistic		Explanation
1	Total number of sites visited	The total number of sites sampled, which is not necessarily equal to the number of survey points because some sites may not be accessible.
2	Total number of sites with vegetation	Number of sites where at least one plant was found on the rake (does not include moss, sponges, filamentous algae, or liverworts).
3	Maximum depth of plants	Depth of deepest site where at least one plant was found on the rake (does not include moss, sponges, filamentous algae, or liverworts).
4	Total number of sites shallower than maximum depth of plants	Number of sites where depth was less than or equal to the maximum depth where at least one plant was found on the rake.
5	Frequency of occurrence at sites shallower than maximum depth of plants	Total number of sites with vegetation (2) / Total number of sites shallower than maximum depth of plants (4).
6	Average number of species per site (split into four subcategories)	a) Shallower than maximum depth – the average number of species found per site at sites less than or equal to the maximum depth where at least one plant was found on the rake (4).
		b) Vegetated sites only – the average number of species found per site at sites where at least one plant was found on the rake (2).
		c) Native species shallower than maximum depth – Same explanation as 6(a), non-native species excluded from average.
		d) Native species at vegetated sites only – Same explanation as 6(b), non-native species excluded from average.
7	Species Richness (split into two subcategories)	a) Total number of species found on the rake at all sites (does not include moss, sponges, filamentous algae, or liverworts
		b) Including visuals – Same explanation as 7(a) and including visual observations within 6 feet of the sample sight
8	Simpson Diversity Index	Estimates the heterogeneity of a community by calculating the probability that two individuals randomly selected from the data set will be different species. The index ranges from 0-1, and the closer the value is to one, the more diverse the community. Visual observations (within 6 feet of sample point) are not included in calculation of index.
9	Coefficient of Conservatism (C)	This is not a statistical calculation, but rather a value assigned to each plant species based on how sensitive that species is to disturbance. C values range from 1 to 10 with higher values assigned to species that are more sensitive to disturbance (Nichols, 1999).
10	Floristic Quality Index	How similar the aquatic plant community is to one that is undisturbed (Nichols, 1999). This index only factors species raked at survey points and does not include non-native species. The FQI is calculated using coefficient of conservatism values (9).

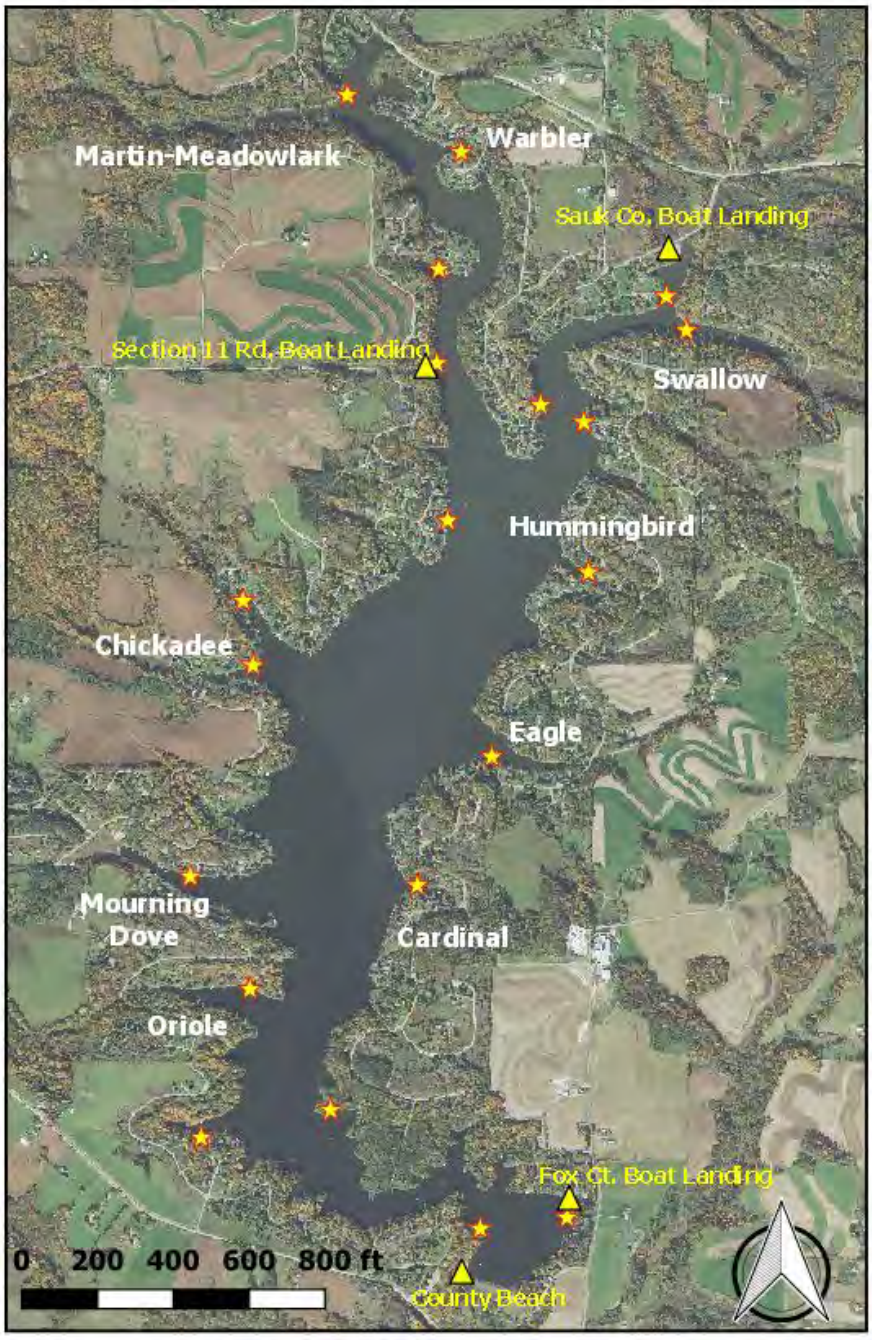
Table 1 – Individual Species Statistics Explanations

Individual Statistic	Explanation
Average Rake Fullness	Mean rake fullness rating ranging from 1 to 3. See Rake Fullness Illustration.
Number of sites where a species was found	The total number of survey points where a particular species was found on the rake.
Number of visual sightings	The total number of times a particular species was visually observed within 6 feet of a sampling point, but not collected on the rake.
Frequency of Occurrence FOO (split into two subcategories)	a) Among vegetated sites only – The number of sites at which a particular species is found on the rake divided by the total number of vegetated sites (Table 2, #2).
	b) Among sites shallower than the maximum depth of plants – The number of sites at which a particular species is found on the rake divided by the total number of sites less than or equal to the maximum depth of plants (Table 2, #4). Also known as **littoral frequency.**
Relative frequency (%)	This value represents the degree to which a particular species contributes to the total of all observations. The sum of all relative frequencies is 100%.

EWM Sampling for Genetic Analysis

Samples were collected for DNA genetic analysis to detect whether hybrid watermilfoil (Eurasian X northern watermilfoil) is present. Existence of hybrid watermilfoils is a recent phenomenon in Wisconsin but evidence suggests that traditional herbicides used for EWM, including 2,4-D, are not as effective in killing hybrid watermilfoils (Glomski & Netherland 2010, Poovey et al. 2007, Nault et al. 2018). Results of the genetic analysis are expected in the first quarter of 2022 and will help guide future management.

Figure 4 – 2021 Locations of EWM Sampling for Genetic Analysis



RESULTS

The results for all 6 bays are summarized in Tables 3, 4, and 5. Table 3 lists individual species found in each bay in 2021 and corresponding statistics for each species. Table 4 lists summary plant statistics for each bay in 2021 and previous years. Table 6 covers floristic quality results for 2021 and previous years. Results are further described later in this section.

Table 3 - Plant Species Results

Bay Name	Common Name	Scientific Name	Frequency of Occurrence at Veg. Sites (%)	Littoral Frequency (%)	Relative Frequency (%)	# Sites	Average Rake Fullness	# Visual
Arapaho*	Eurasian water milfoil	*Myriophyllum spicatum*	71.43	45.45	62.50	5	1.20	6
	Coontail	*Ceratophyllum demersum*	14.29	9.09	12.50	1	1.00	1
	Small pondweed	*Potamogeton pusillus*	14.29	9.09	12.50	1	1.00	0
	Sago pondweed	*Stuckenia pectinata*	14.29	9.09	12.50	1	1.00	0
	White water lily	*Nymphaea odorata*	-	-	-	-	-	1
Cardinal	Eurasian water milfoil	*Myriophyllum spicatum*	63.16	21.43	0.15	12	1.25	4
	Small pondweed	*Potamogeton pusillus*	31.58	10.71	0.04	6	1.00	0
	Coontail	*Ceratophyllum demersum*	26.32	8.93	0.03	5	1.00	3
	Sago pondweed	*Stuckenia pectinata*	26.32	8.93	0.03	5	1.00	0
	Wild celery	*Vallisneria americana*	10.53	3.57	0.00	2	1.00	1
	Curly-leaf pondweed	*Potamogeton crispus*	5.26	1.79	0.00	1	1.00	0
Chickadee	Eurasian water milfoil	*Myriophyllum spicatum*	76.47	16.88	52	13	1.08	9
	Coontail	*Ceratophyllum demersum*	41.18	9.09	28	7	1.29	2
	Small pondweed	*Potamogeton pusillus*	11.76	2.60	8	2	1.00	0
	White water lily	*Nymphaea odorata*	5.88	1.30	4	1	3.00	6
	Sago pondweed	*Stuckenia pectinata*	5.88	1.30	4	1	1.00	0
	Horned pondweed	*Zannichellia palustris*	5.88	1.30	4	1	1.00	0
Hummingbird	Eurasian water milfoil	*Myriophyllum spicatum*	59.09	20.31	34.21	13	1.38	9
	Coontail	*Ceratophyllum demersum*	36.36	12.50	21.05	8	1.25	5
	Small pondweed	*Potamogeton pusillus*	31.82	10.94	18.42	7	1.00	0
	Sago pondweed	*Stuckenia pectinata*	18.18	6.25	10.53	4	1.00	0
	Wild celery	*Vallisneria americana*	13.64	4.69	7.89	3	1.00	0
	Slender waterweed	*Elodea nuttallii*	4.55	1.56	2.63	1	1.00	0
	Small duckweed	*Lemna minor*	4.55	1.56	2.63	1	1.00	3
	White water lily	*Nymphaea odorata*	4.55	1.56	2.63	1	1.00	5
	Filamentous algae		4.55	1.56		1	1.00	5
	Common watermeal	*Wolffia columnbiana*	-	-	-	-	-	2
Mourning Dove	Eurasian water milfoil	*Myriophyllum spicatum*	66.67	20.00	40.91	18	1.22	10
	Coontail	*Ceratophyllum demersum*	44.44	13.33	27.27	12	1.25	2
	Slender naiad	*Najas flexilis*	18.52	5.56	11.36	5	1.00	0
	Sago pondweed	*Stuckenia pectinata*	11.11	3.33	6.82	3	1.00	0
	Small pondweed	*Potamogeton pusillus*	7.41	2.22	4.55	2	1.00	1
	Wild celery	*Vallisneria americana*	7.41	2.22	4.55	2	1.50	0
	Curly-leaf pondweed	*Potamogeton crispus*	3.70	1.11	2.27	1	1.00	0
	Slender waterweed	*Elodea nuttallii*	3.70	1.11	2.27	1	1.00	0
	White water lily	*Nymphaea odorata*	-	-	-	-	-	7
Oriole	Eurasian water milfoil	Myriophyllum spicatum	100.00	21.43	60	6	1.50	2
	Coontail	Ceratophyllum demersum	33.33	7.14	20	2	1.50	0
	Small pondweed	Potamogeton pusillus	16.67	3.57	10	1	1.00	0
	Sago pondweed	Stuckenia pectinata	16.67	3.57	10	1	1.00	0
	White water lily	Nymphaea odorata	-	-	-	-	-	1

Table 4 – Summary Plant Statistics for Surveyed Bays 2015-2021

Bay & Year		1	2	3	4	5	6 Average # of species per site				7 Species Richness		8	
		Total # sites visited	Total # sites w/ vegetation	Max. depth of plants	Total # sites shallower than max. depth of plants	Littoral frequency** (%)	a) Shallower than max. depth	b) Vegetated sites only	c) Native shallower than max. depth	d) Native at veg. sites only	a) Total # species on rake at all sites	b) Including visuals	Simpson's Diversity Index	Littoral frequency of EWM (%)
Cardinal	2015	67	33	7	46	71.7	1.15	1.61	0.85	1.39	7	8	0.74	30
	2016	65	39	6	45	86.7	1.73	2.00	1.42	1.83	9	11	0.83	31
	2017	66	35	7	46	76.1	1.61	2.11	1.11	1.65	8	9	0.76	50
	2018	61	39	11	60	65.0	1.10	1.69	0.90	1.54	10	11	0.75	20
	2019	59	29	9	53	54.72	0.70	1.28	0.55	1.16	5	7	0.71	15
	2020	**62**	**26**	**7**	**45**	**57.8**	**1.09**	**1.88**	**0.78**	**1.52**	**8**	**8**	**0.79**	**31**
	2021	63	18	6*	39	46.2	0.77	1.67	0.46	1.20	6	6	0.76	28
Chickadee (Both Arms)	2015	119	14	4.5	32	43.8	0.78	1.79	0.44	1.56	6	7	0.69	34
	2019	120	13	5	50	26.0	0.32	1.23	0.12	1.00	4	6	0.61	18
	2020	**119**	**46**	**6.5**	**83**	**55.4**	**0.78**	**1.41**	**0.23**	**1.19**	**5**	**5**	**0.45**	**55**
	2021	119	17	6.5	77	22.1	0.27	1.47	0.12	1.50	6	6	0.64	17
Oriole	2015	68	26	9	48	54.17	0.90	1.65	0.63	1.36	5	5	0.70	27
	2016	62	28	7	44	63.6	0.91	1.43	0.77	1.26	6	6	0.69	14
	2017	56	22	9.5	46	47.8	0.76	1.59	0.52	1.09	5	6	0.57	24
	2018	56	13	6	32	40.6	0.56	1.38	0.50	1.23	5	6	0.62	6
	2019	60	8	5	27	29.6	0.37	1.25	0.33	1.13	4	5	0.48	4
	2020	**60**	**16**	**7**	**38**	**43.2**	**0.59**	**1.38**	**0.22**	**1.00**	**3**	**5**	**0.52**	**38**
	2021	55	6	6	28	21.4	0.36	1.67	0.14	1.33	4	5	0.58	21
Mourning Dove	2016	122	59	7.5	89	66.3	1.04	1.58	0.88	1.39	9	10	0.68	17
	2017	122	56	6.5	78	71.8	1.19	1.66	0.88	1.28	8	9	0.62	31
	2018	122	36	6	75	48.0	0.84	1.75	0.81	1.69	8	8	0.72	3
	2020	**122**	**26**	**7.5**	**87**	**29.9**	**0.47**	**1.58**	**0.25**	**1.22**	**5**	**8**	**0.68**	**22**
	2021	120	27	8	90	30.0	0.49	1.63	0.28	1.47	8	9	0.74	20
Hummingbird	2016	59	34	6	59	57.6	0.93	1.62	0.58	1.21	7	9	0.66	36
	2017	63	32	6	63	50.8	0.81	1.59	0.52	1.27	7	8	0.65	29
	2018	60	31	5.5	56	55.4	1.00	1.81	0.75	1.56	8	9	0.78	25
	2019	55	19	5	51	37.3	0.47	1.26	0.24	1.00	4	5	0.60	24
	2020	**55**	**25**	**7**	**55**	**45.5**	**0.64**	**1.40**	**0.24**	**1.08**	**5**	**7**	**0.55**	**40**
	2021	64	22	7	64	34.4	0.59	1.73	0.39	1.39	8	9	0.79	20
Arapaho**	2015	55	17	4	21	81.0	0.95	1.18	0.57	1.20	6	6	0.73	33
	2019	54	13	8	45	28.9	0.49	1.69	0.22	1.43	6	6	0.68	24
	2020	**55**	**10**	**6**	**29**	**34.5**	**0.52**	**1.50**	**0.21**	**2.00**	**5**	**5**	**0.60**	**31**
	2021	55	7	4	11	63.6	0.73	1.14	0.27	1.00	4	5	0.56	45

EWM with adventitious roots was found at 12 feet but was likely not rooted at that depth. Furthermore, the next deepest sample point of plant occurrence was 6 feet deep. **Arapaho Bay was also surveyed in 2015, but was labeled "Tanager Bay". Herbicide treatment occurred during the years listed in red text. The results of these herbicide treatment years is considered post-treatment.* ***Results in BOLD text are considered post-dredging, which occurred after the 2019 surveys.*

Table 5 – Floristic Quality Results for Surveyed Bays 2015-2021

Bay & Year		Coontail, *Ceratophyllum demersum*	Slender waterweed, *Elodea nuttallii*	Water stargrass, *Heteranthera dubia*	Small duckweed, *Lemna minor*	Slender nalad, *Najas flexilis*	White water lily, *Nymphaea odorata*	Long-leaf pondweed, *Potamogeton nodosus*	Small pondweed, *Potamogeton pusillus*	Large duckweed, *Spirodela polyrhiza*	Sago pondweed, *Stuckenia pectinata*	Wild celery, *Vallisneria americana*	Horned Pondweed (*Zannichellia palustri*)	N (native species only)	Mean C	FQI
Cardinal	2015	X	X	-	X	-	-	-	X	-	X	X	-	6	5.0	12.2
	2016	X	X	X	X	-	-	-	X	X	X	X	-	8	5.1	14.5
	2017	X	X	X	-	X	X	-	X	-	-	X	-	7	5.4	14.4
	2018	X	X	X	X	X	-	-	X	X	X	X	-	9	5.2	15.7
	2019	X	-	-	-	-	-	-	X	-	X	X	-	4	4.8	9.5
	2020	X	X	X	-	X	-	-	X	-	X	X	-	7	5.4	14.4
	2021	X	-	-	-	-	-	-	X	-	X	X	-	4	4.8	9.5
Chickadee (Both Arms)	2015	X	X	-	-	-	X	-	X	-	X	-	-	5	5.2	11.6
	2019	X	-	-	-	-	X	-	-	-	-	-	-	2	4.5	6.4
	2020	X	-	-	-	-	X	-	X	-	-	-	-	3	5.3	9.2
	2021	X	-	-	-	-	X	-	X	-	X	-	X	5	5.2	11.6
Oriole	2015	X	X	-	-	-	-	-	X	-	X	-	-	4	5.0	10.0
	2016	X	X	-	-	-	X	-	X	-	X	-	-	5	5.2	11.6
	2017	X	X	-	-	-	X	-	X	-	-	-	-	4	5.8	11.5
	2018	X	X	-	-	-	-	-	X	-	X	-	-	4	5.0	10.1
	2019	X	-	-	-	-	X	-	-	-	X	-	-	3	4	6.9
	2020	X	-	-	-	-	-	-	X	-	-	-	-	2	5	7.1
	2021	X	-	-	-	-	-	-	X	-	X	-	-	3	4.3	7.5
Mourning Dove	2016	X	X	-	X	-	X	-	X	-	X	X	-	7	5.1	13.6
	2017	X	X	-	-	X	X	-	X	-	X	X	-	7	5.4	14.4
	2018	X	X	-	-	X	X	-	X	-	X	X	-	7	5.4	14.4
	2020	X	-	-	-	X	-	-	X	-	X	-	-	4	4.8	9.5
	2021	X	X	-	-	X	-	-	X	-	X	X	-	6	5.3	13.1
Hummingbird	2016	X	X	-	-	-	X	-	X	-	X	X	-	6	5.3	13.1
	2017	X	X	-	-	-	X	-	X	-	X	X	-	6	5.3	13.1
	2018	X	X	-	-	-	X	X	X	-	X	X	-	7	5.6	14.7
	2019	X	-	-	-	-	X	-	-	-	-	X	-	3	5	8.7
	2020	X	X	-	-	-	X	-	X	-	-	-	-	4	5.8	11.5
	2021	X	X	-	X	-	X	-	X	-	X	X	-	7	5.1	13.6
Arapaho*	2015	X	-	-	-	-	X	-	X	-	X	-	-	4	4.8	9.5
	2019	X	-	-	-	-	X	-	X	-	X	-	-	4	4.8	9.5
	2020	X	-	-	-	-	X	-	X	-	X	-	-	4	4.8	9.5
	2021	X	-	-	-	-	-	-	X	-	X	-	-	3	4.3	7.5

*This table includes only those species that were found on the rake at survey points and those that are listed in Nichols (1999). X=present. Herbicide treatment occurred during years listed in red text. * Arapaho Bay was also surveyed in 2015, but was labeled "Tanager Bay"*

Arapaho / Tanager Bay

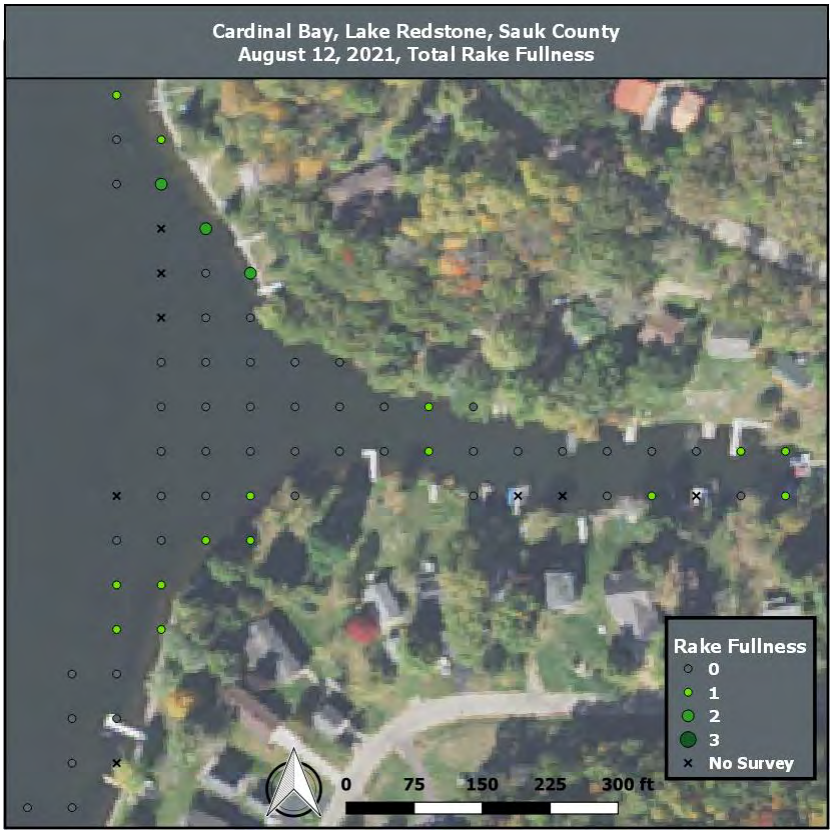
This was the fourth survey of Arapaho Bay, the first being 2015 using the name “Tanager Bay.” A total of 55 points were sampled and the maximum rooting depth was only 4 feet compared to 6 feet in 2020 and 8 feet in 2019. It is worth noting in 2019 that the maximum rooting depth of 8 feet occurred with coontail found at one sample point with the next deepest rooting depth of 5 feet. Eleven sample points were ≤4 feet deep and only 7 of those sites had vegetation. A total of 5 species were found including EWM and one of which was visual only (maps in Appendix A). Similar to all previous surveys of the bay, Eurasian watermilfoil was the most common species found at 45% of littoral points in 2021, 31% in 2020, 24% in 2019, and 33% in 2015. Three native species were found at only 10% of littoral points each. Similar to previous years, the plant community is homogeneous. The Simpson Diversity Index was 0.56 on a scale from 0 to 1. The FQI only factors species raked at survey points and does not include invasive species. Therefore, 3 species were counted yielding a floristic quality of 7.5 and an average C value of 4.3 (Table 5). Chi-squared tests revealed no statistically significant (SS) changes in the aquatic plant community when comparing 2020 to 2021 but there was a significant decrease in one native species (coontail) when comparing 2015 to 2021 (Appendix G).

Figure 5 – Arapaho Bay Total Rake Fullness Map

Cardinal Bay

This was the seventh consecutive aquatic plant survey of Cardinal Bay (2015-2021). A total of 70 survey waypoints were attempted in Cardinal Bay, 63 of which were surveyed because 4 points were deeper than the maximum sampling depth of 12 feet and 3 were obstructed by docks. The maximum depth of aquatic plant occurrence was 6 feet, however EWM was found at a 12-ft sample point most likely floating below the lake surface and happened to be captured during sampling. This seems likely because the EWM was sprouting adventitious roots and the next deepest sample point with plant occurrence was 6 feet. There were 39 survey points ≤6 feet and 18 of those sites had vegetation (Table 4). A total of 6 species were found including EWM (maps in Appendix B). EWM was the most common species in 2021 and 2020, while it was the second-most common species in 2017, 2018, and 2019. The Simpson Diversity Index for Cardinal Bay was 0.76 on a scale from 0 to 1. The FQI only factors species raked at survey points and does not include invasive species. Therefore, 4 species were counted with a floristic quality of 9.5 and average C value of 4.8. Chi-squared tests revealed no statistically significant (SS) changes in the aquatic plant community when comparing 2020 to 2021, and SS decrease in filamentous algae and coontail when comparing 2015 to 2021 (Appendix G).

Figure 6 – Cardinal Bay Total Rake Fullness Map



Chickadee Bay

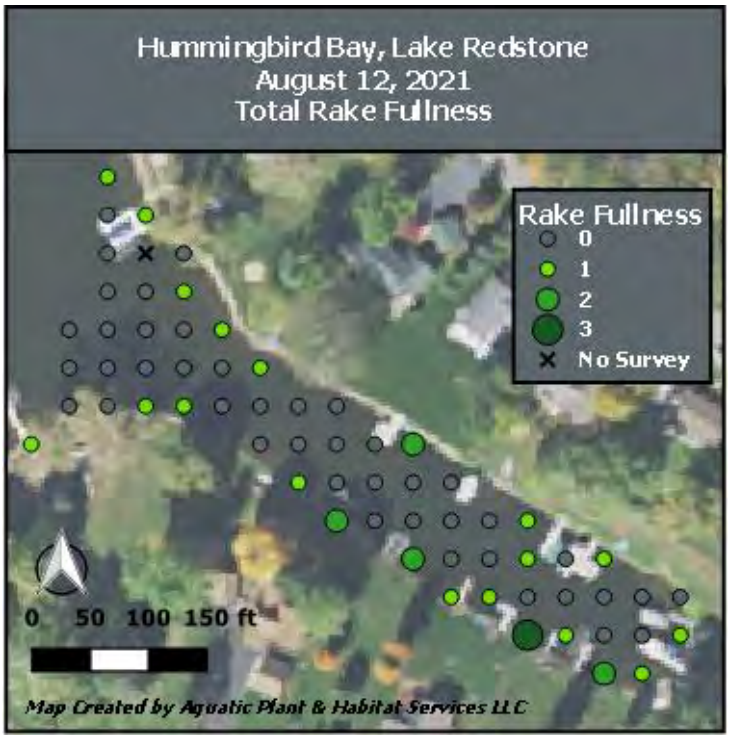
This was the fourth survey of Chickadee, the first of which occurred in 2015. The south arm of Chickadee Bay was also surveyed 2016 through 2018. Only results from the 2015, 2019, 2020, and 2021 surveys are listed in this report. There were 119 points surveyed in Chickadee Bay, 77 of which were the same depth or shallower than the maximum rooting depth of 6.5 feet. There were 17 sites with vegetation (Table 4). A total of 6 species were found on the rake samples including EWM (maps in Appendix C). Similar to 2019 and 2020, EWM and coontail were the most common species found at 76% and 41% of littoral survey points respectively. Together they accounted for 80% of the total relative frequency, indicating a highly homogeneous plant community in the bay (Table 3). The Simpson Diversity Index was 0.64 on a scale of 0 to 1. The FQI only factors species raked at survey points and does not include visuals or aquatic invasive species. Therefore, 5 species were included in the calculation, resulting in a floristic quality of 11.6 and average C value of 5.2 (Table 5). Chi-squared tests revealed a statistically significant (SS) decrease in EWM in 2021 when compared to 2020, and no SS changes in 2021 when compared to 2015 (Appendix G).

Figure 7 – Chickadee Bay Total Rake Fullness Map

Hummingbird Bay

This was the sixth consecutive survey of Hummingbird Bay (2016-2021). Sixty-four points were surveyed out of a possible 65 because 1 point was obstructed by piers. All 64 points were the same depth or shallower than the maximum rooting depth of 7 feet and 22 of those sites surveyed had vegetation (Table 4). A total of 9 species of aquatic plants were found, one of which was "visual only" (maps in Appendix D). Filamentous algae is not counted as one of the 9 species. Eurasian watermilfoil and coontail were the most common species found at 20% and 13% of littoral survey points respectively. Together they accounted for 55% of the total relative frequency indicating a less homogeneous plant community compared to previous years. The Simpson Diversity Index was 0.79 on a scale from 0 to 1. The FQI only factors species raked at survey points and does not include visuals or aquatic invasive species. Therefore, 7 species were included in the calculation, yielding a floristic quality of 13.6 with an average C value of 5.1 (Table 5). Chi-squared tests revealed a statistically significant decrease in coontail in 2021 when compared to data from 2016 and a significant decrease in EWM in 2021 when compared to 2020. (Appendix G).

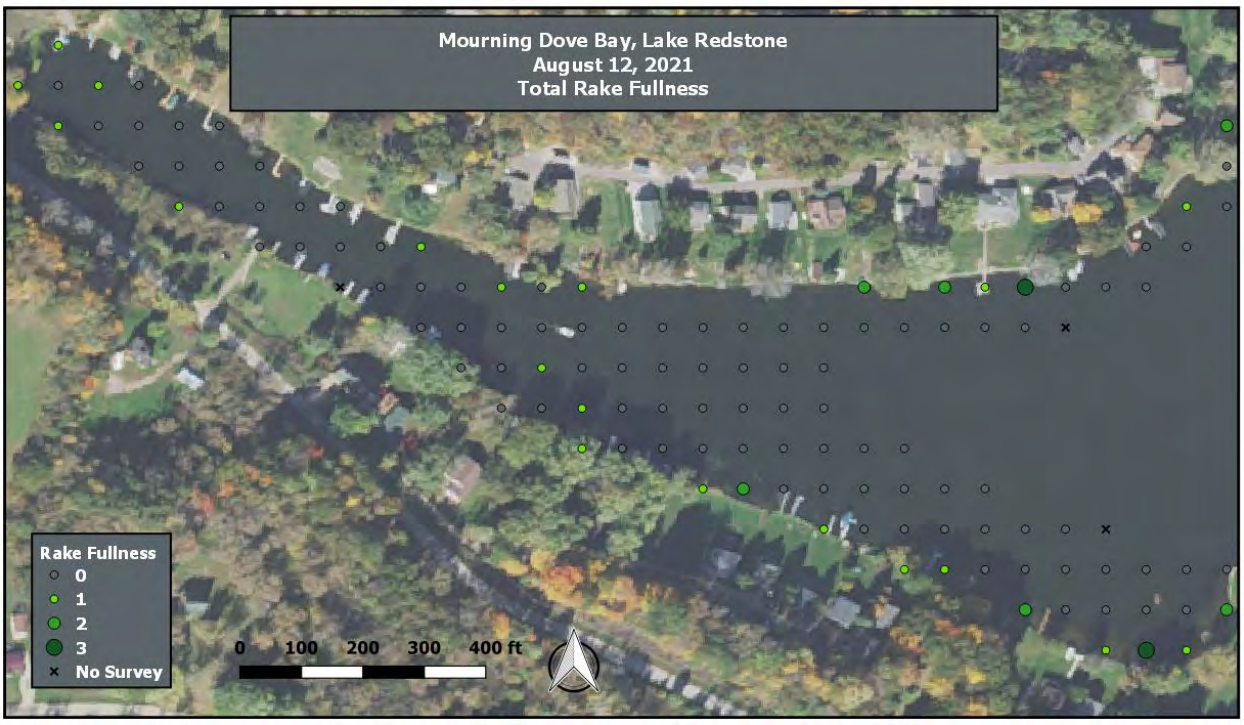
Figure 8 – Hummingbird Bay Total Rake Fullness Map



Mourning Dove Bay

This was the fifth survey of Mourning Dove Bay (2016-18 and 2020-21). A total of 123 predetermined survey waypoints exist in Mourning Dove Bay and 120 were surveyed because two points were deeper than 12 feet and one point was obstructed by docks. The maximum rooting depth was 8 feet. There were 90 survey points ≤8 feet deep and 27 sites had vegetation. A total of 9 species of aquatic plants were found, one of which was "visual only". Maps of plant species can be found in Appendix E. EWM and coontail were the most common species found at 20% and 13% of littoral survey points respectively and accounted for 68% of the total relative frequency, indicating the plant community in Mourning Dove Bay is homogeneous. Chi-squared tests of all plant species revealed a statistically significant (SS) decrease in coontail, white water lily, and filamentous algae in 2021 when compared to 2016. There was a SS increase in slender naiad between the 2016 and 2021 data sets (Appendix G). There was no SS change in any species between 2020 and 2021. The Simpson Diversity Index was 0.74 on a scale from 0 to 1. The FQI does not include aquatic invasive species. Therefore, 6 species were included in the calculation, yielding a floristic quality of 13.1 with an average C value of 5.3 (Table 5).

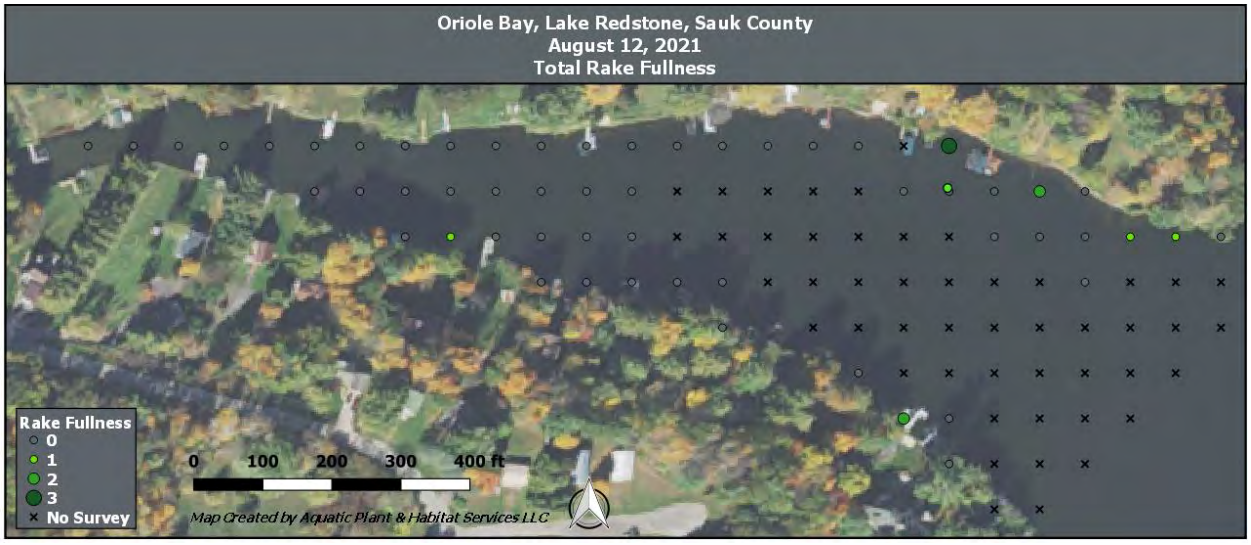
Figure 9 – Mourning Dove Bay Total Rake Fullness Map



Oriole Bay

This was the seventh consecutive survey of Oriole Bay (2015-2021). A total of 104 predetermined survey waypoints exist in Oriole Bay but about half are consistently deeper than 12 feet. This year there were 55 points actually surveyed with a maximum rooting depth of 6 feet. There were 28 survey points ≤7 feet deep and only 6 sites had vegetation. A total of 5 species of aquatic plants were found, one of which was "visual only". Maps of plant species can be found in Appendix F. EWM was the most common species found at 21% of littoral survey points and alone accounted for 60% of the total relative frequency, indicating the plant community in Oriole Bay is homogeneous (Table 3). Chi-squared tests of all plant species revealed a statistically significant (SS) decrease in 2021 slender waterweed and coontail when compared to 2015 data. There were no SS differences between the 2020 and 2021 data sets (Appendix G). The Simpson Diversity Index for Oriole Bay was 0.58 on a scale from 0 to 1. The FQI does not include aquatic invasive species. Therefore, 3 species were included in the calculation, yielding a floristic quality of 7.5 with an average C value of 4.3 (Table 5).

Figure 10 – Oriole Bay Total Rake Fullness Map



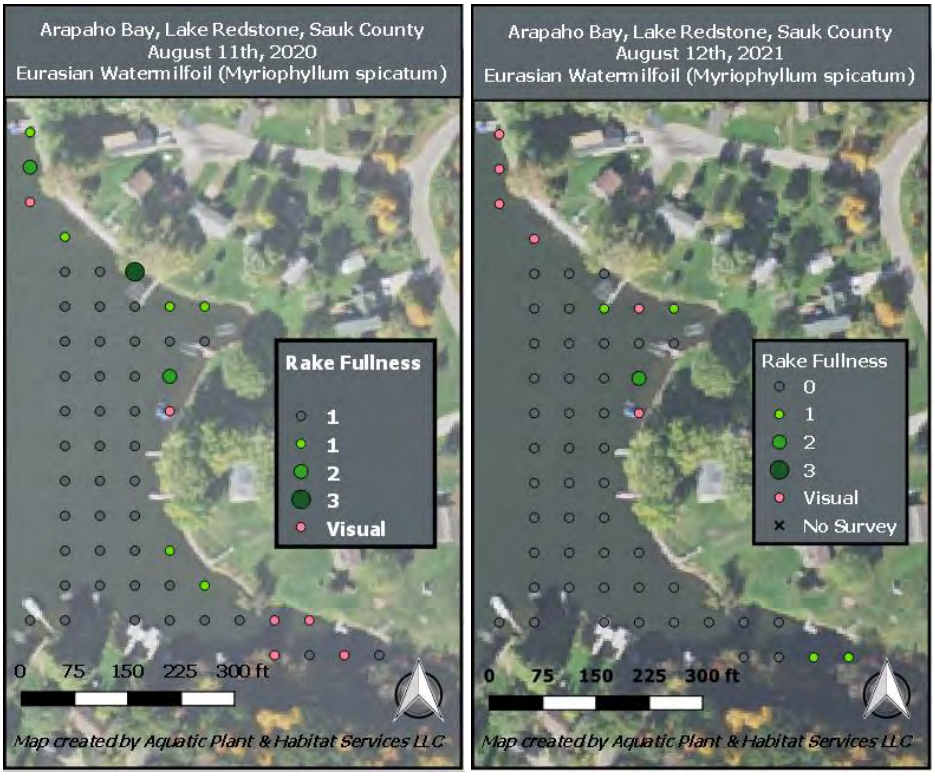
Eurasian Watermilfoil & Management History

Eurasian watermilfoil (EWM) was found in all bays and was actually the most commonly occurring plant species in all 6 bays as well. In 2021, littoral frequency of EWM was lower than 2020 levels in all bays except Arapaho. Decreases of EWM between 2020 and 2021 were statistically significant in Chickadee and Hummingbird Bays. When comparing EWM in 2021 to the first survey year for each bay, there were no statistically significant differences. There was no herbicide treatment of any bays in 2019, 2020, nor 2021. Each bay has its own management history and an assessment of EWM in each bay is included in this section.

Arapaho Bay EWM

EWM was the most common plant with scattered distribution at 5 sample points (9 in 2020) and visual observation at another 6 points (same as 2020). EWM littoral frequency was 45% in 2021, 31% in 2020, 24% in 2019, and 33% in 2015. Even though EWM was at fewer sample points in 2021 (5) compared to 2020 (9), EWM littoral frequency was higher in 2021 because of the difference in maximum rooting depth between those two years[3]. No herbicide treatment has occurred in Arapaho Bay but Aquatic Plant Management LLC was hired to manually remove EWM at 2 locations (Figure 1). EWM at the areas of manual removal was reduced or absent in comparison to 2020. A chi-squared test of EWM revealed no significant change in EWM between 2015 and 2020 nor between 2019 and 2020.

Figure 11 – Arapaho Bay Eurasian Watermilfoil Maps 2020-2021

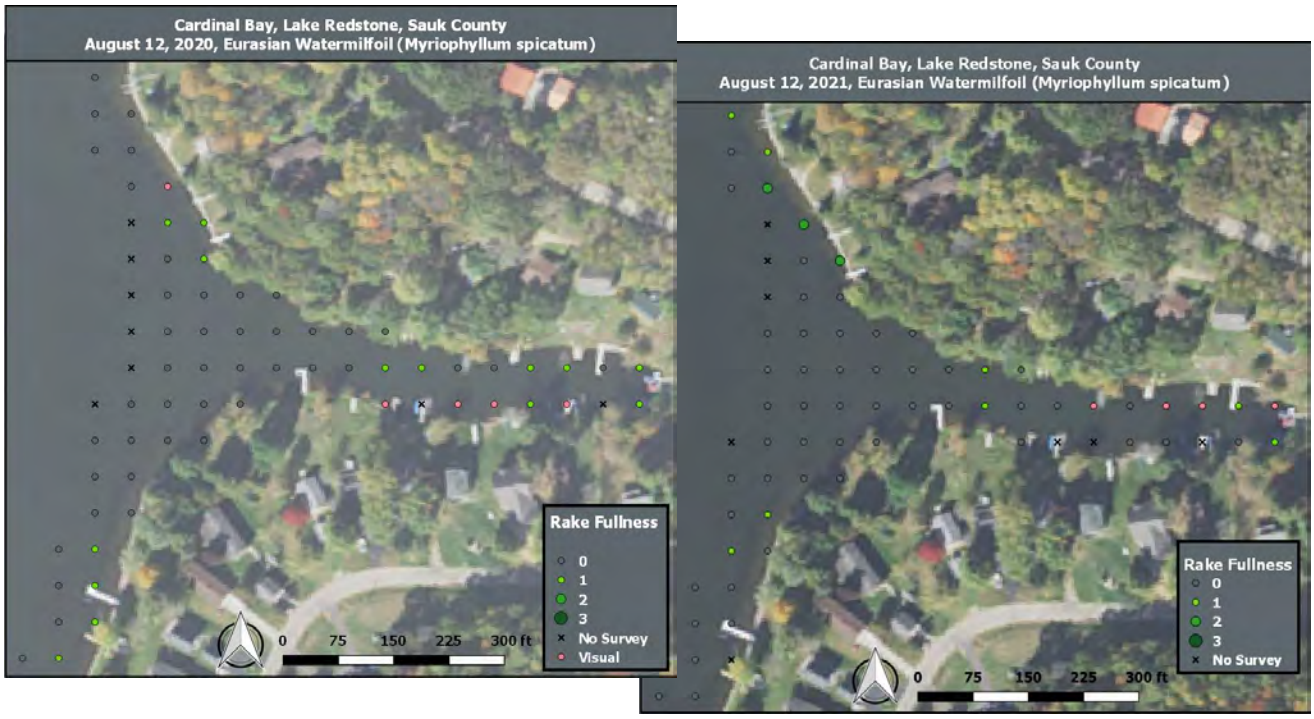


[3] EWM littoral frequency = #points with EWM / #points shallower than max depth of plants.
2020 EWM littoral frequency = 9/29 = 31%
2021 EWM littoral frequency = 5/11 = 45%

Cardinal Bay EWM

EWM was the most common plant with occurrence at 12 points (14 in 2020) and visual observation at another 4 points (5 in 2020). EWM was found at a 12-ft sample point most likely floating below the lake surface and happened to be captured during sampling. This seems likely because the EWM was sprouting adventitious roots and the next deepest sample point with plant occurrence was 6 feet. EWM littoral frequency was 21% in 2021, 31% in 2020, 15% in 2019, 20% in 2018, 50% in 2017, 31% in 2016, and 30% in 2015. Herbicide was applied in Cardinal Bay in spring of 2016 and 2018. A chi-squared test of EWM revealed no significant change in EWM between 2015 and 2021 nor between 2021 and 2021.

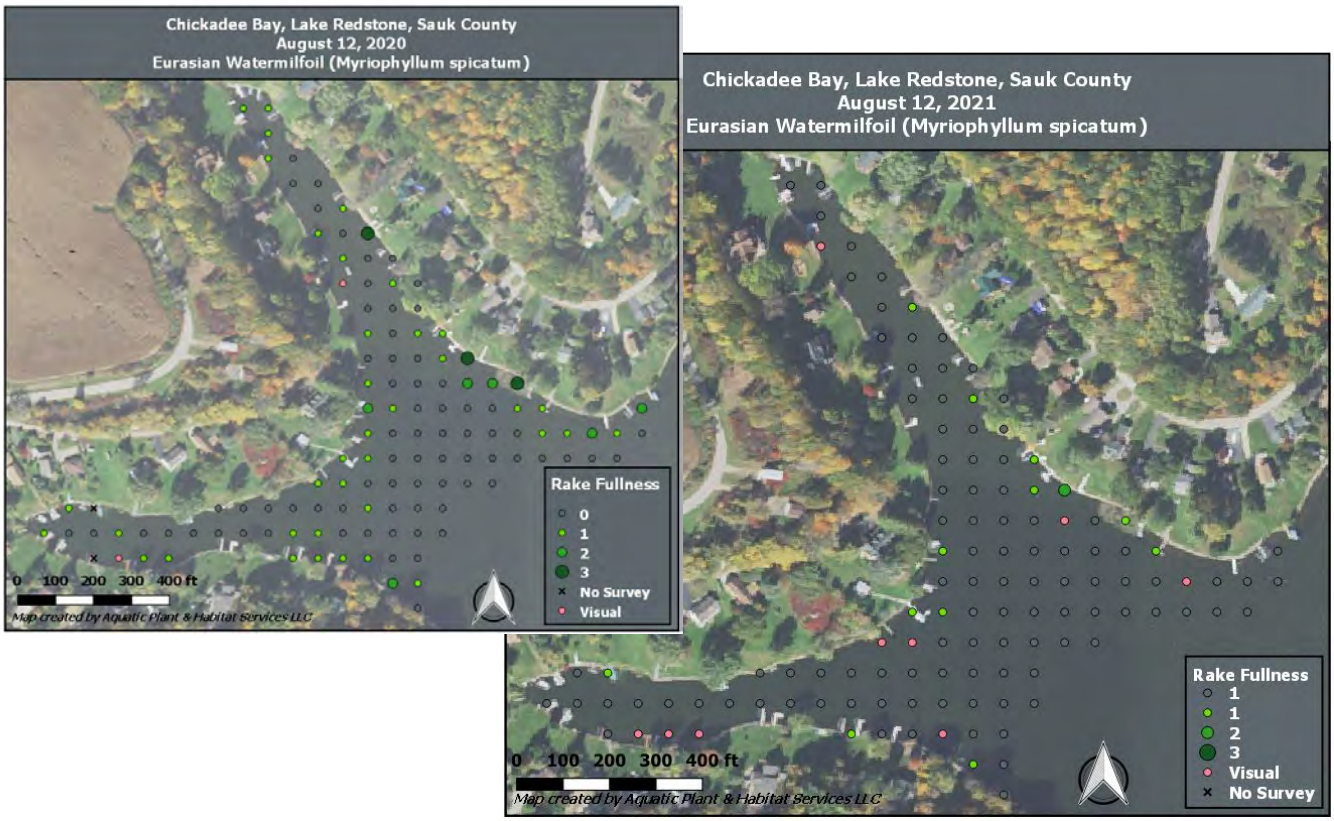
Figure 12 - Cardinal Bay Eurasian Watermilfoil Maps 2020-2021



Chickadee Bay EWM

EWM was the most common aquatic plant in 2021 and was found at 13 sites (46 in 2020) and 9 visual observations (2 in 2020). EWM littoral frequency was 17% in 2021, 55% in 2020, 18% in 2019, and 34% in 2015. Herbicides were applied to the southern arm of Chickadee Bay in spring of 2016 to combat EWM. A chi-squared test of EWM data revealed a statistically significant decrease between the whole-bay survey in between 2020 and 2021 but no significant difference between 2015 and 2021.

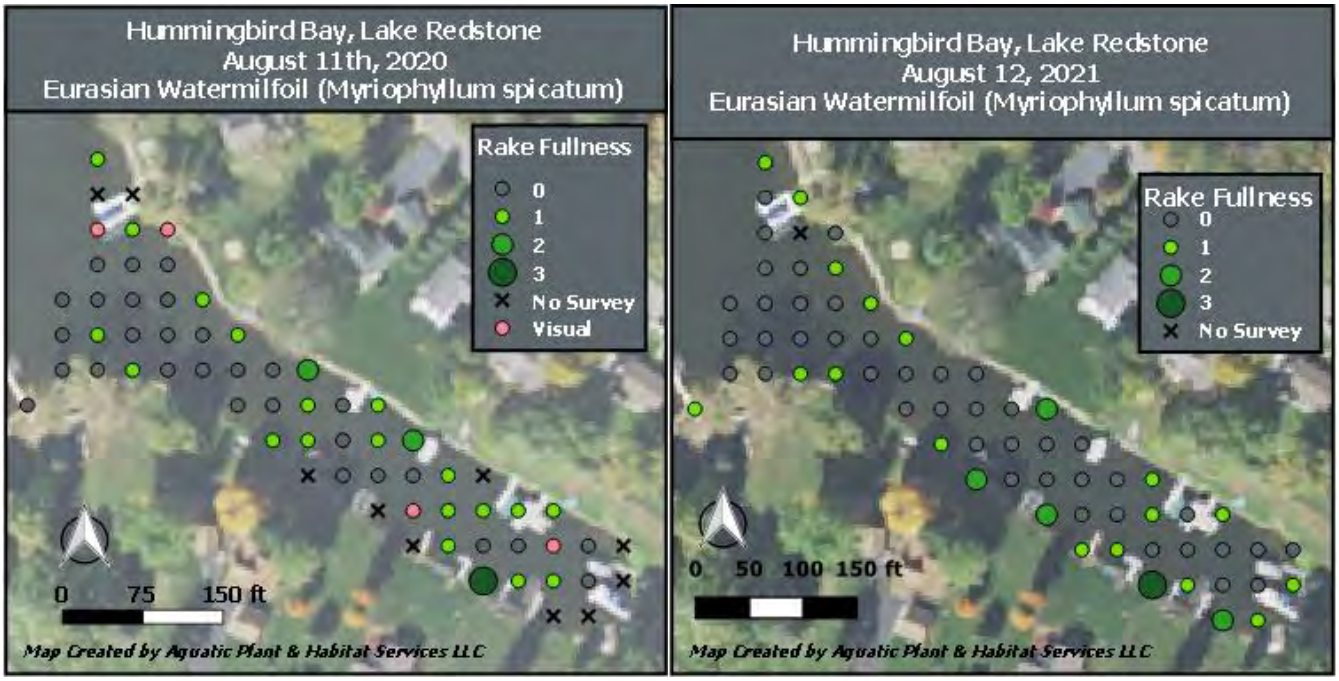
Figure 13 – Chickadee Bay Eurasian Watermilfoil Maps 2020-2021



Hummingbird Bay EWM

EWM was the most common species found in Hummingbird Bay and was found at 13 survey points (22 in 2020) and another 9 visual observations (4 in 2020). EWM littoral frequency was 20% in 2021, 40% in 2020, 24% in 2019, 25% in 2018, 29% in 2017 and 36% in 2016. Herbicide treatment was conducted in Hummingbird Bay in spring 2017. There was a statistically significant decrease in EWM between 2020 and 2021.

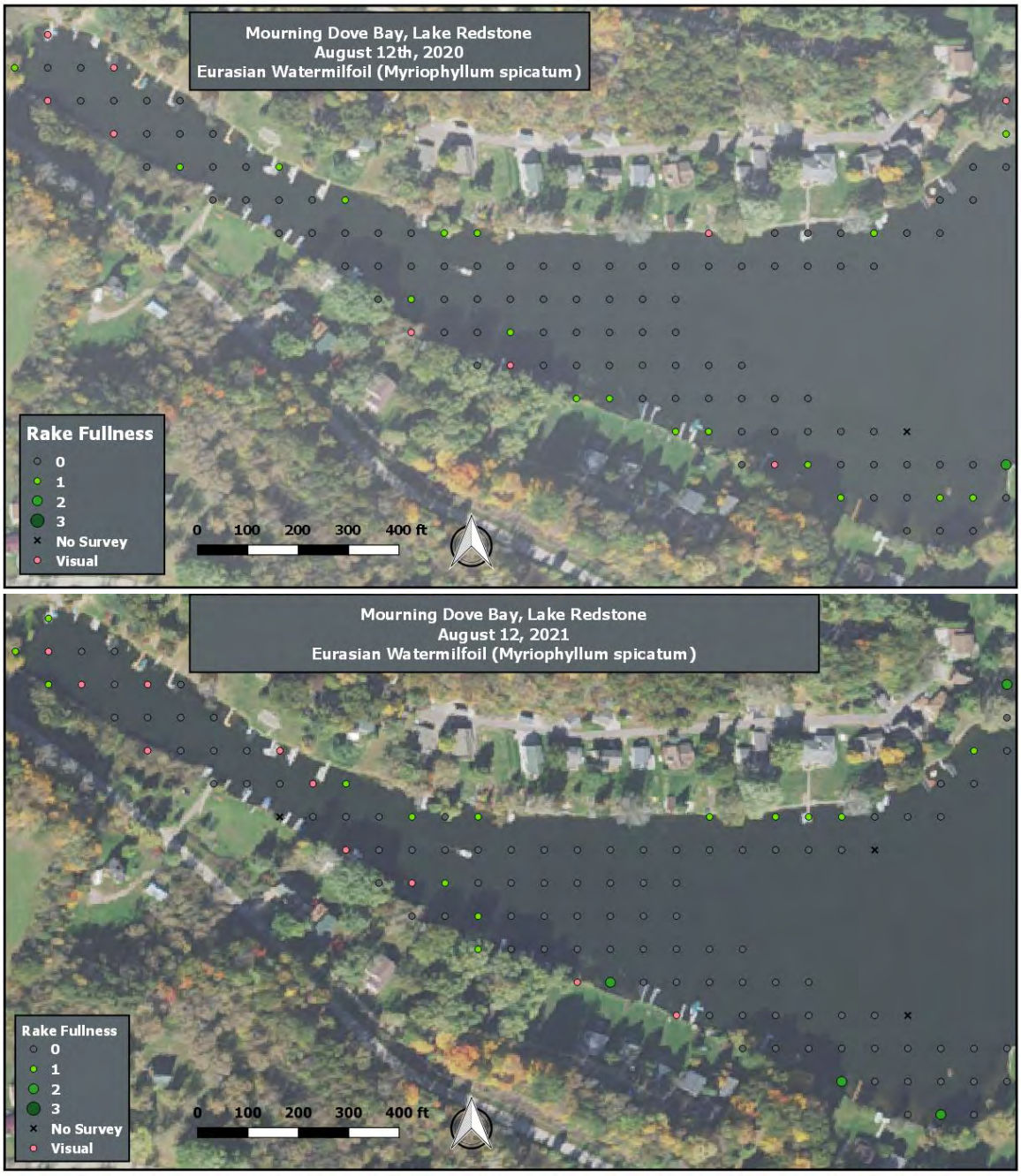
Figure 14 – Hummingbird Bay Eurasian Watermilfoil Maps 2020-2021



Mourning Dove Bay EWM

EWM was found at 18 sites (19 in 2020) and visual observation at another 10 points (9 in 2020) making it the most common species in 2020 and 2021. Littoral frequency was 20% in 2021, 22% in 2020, 3% in 2018, 31% in 2017, and 17% in 2016. Herbicide treatment was done in 2018 to control EWM. A chi-squared test of 2021 EWM data found no statistically significant difference when compared to 2020 nor when compared to 2016.

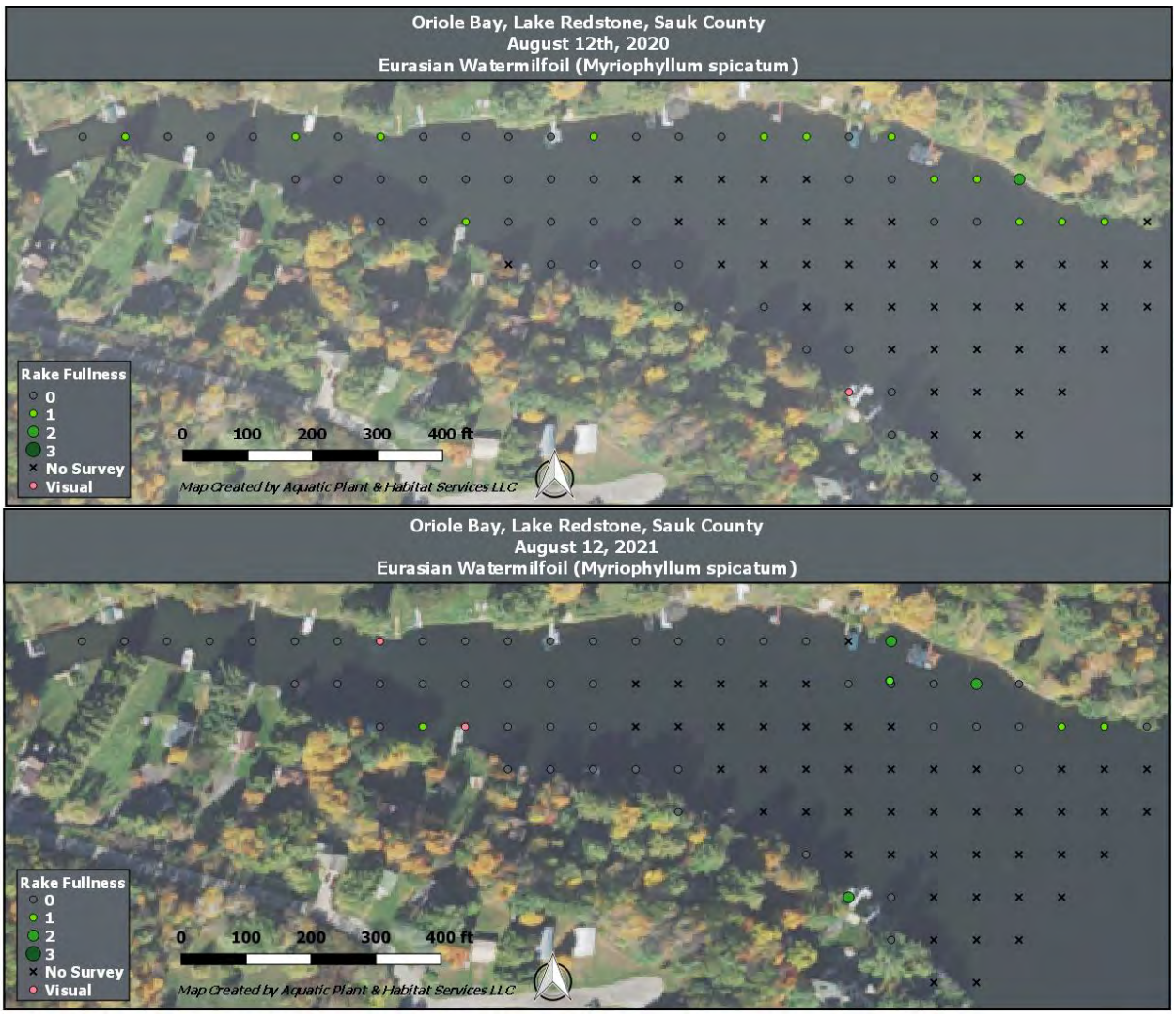
Figure 15 – Mourning Dove Bay Eurasian Watermilfoil Map



Oriole Bay EWM

EWM was found at 6 sites (14 sites in 2020) and visual observation at another 2 points (1 in 2020) making it the most common aquatic plant species in 2021. Littoral frequency was 21% in 2021, 38% in 2020, 4% in 2019, 6% in 2018, 24% in 2017, 14% in 2016, and 27% in 2015. Herbicide treatment was done in 2016 to control EWM. A chi-squared test of EWM data revealed no statistically significant difference when comparing data from 2015 to 2021 nor 2020 to 2021.

Figure 16 – Oriole Bay Eurasian Watermilfoil Maps 2020-2021



DISCUSSION

Aquatic Plants are Necessary for Healthy Lakes

Aquatic plants serve important functions in lake systems. They provide structural habitat for small invertebrates that are an important food source for juvenile game fish and adult panfish. Plants also provide structural habitat for juvenile and small fish to hide from predators and vice versa as larger predators may lurk in the shadows of plants in wait of forage. Aquatic plants also provide foraging and/or hiding structure for reptiles, amphibians, and waterfowl. The shorelines of lakes are buffered from wave action when aquatic plants absorb some of the wave energy. Aquatic plants are important consumers of nutrients that would otherwise be available for nuisance algal growth. For these reasons, native aquatic plants should be protected in lakes and a healthy aquatic plant community should be promoted.

There are times when native aquatic plants grow to nuisance levels that hinder the aforementioned functions and also negatively impact recreation. An overabundance of vegetation can cause oxygen depletion in the water as plants decompose, thereby reducing the oxygen available to fish and other aquatic organisms.

Changes in Native Plant Occurrence

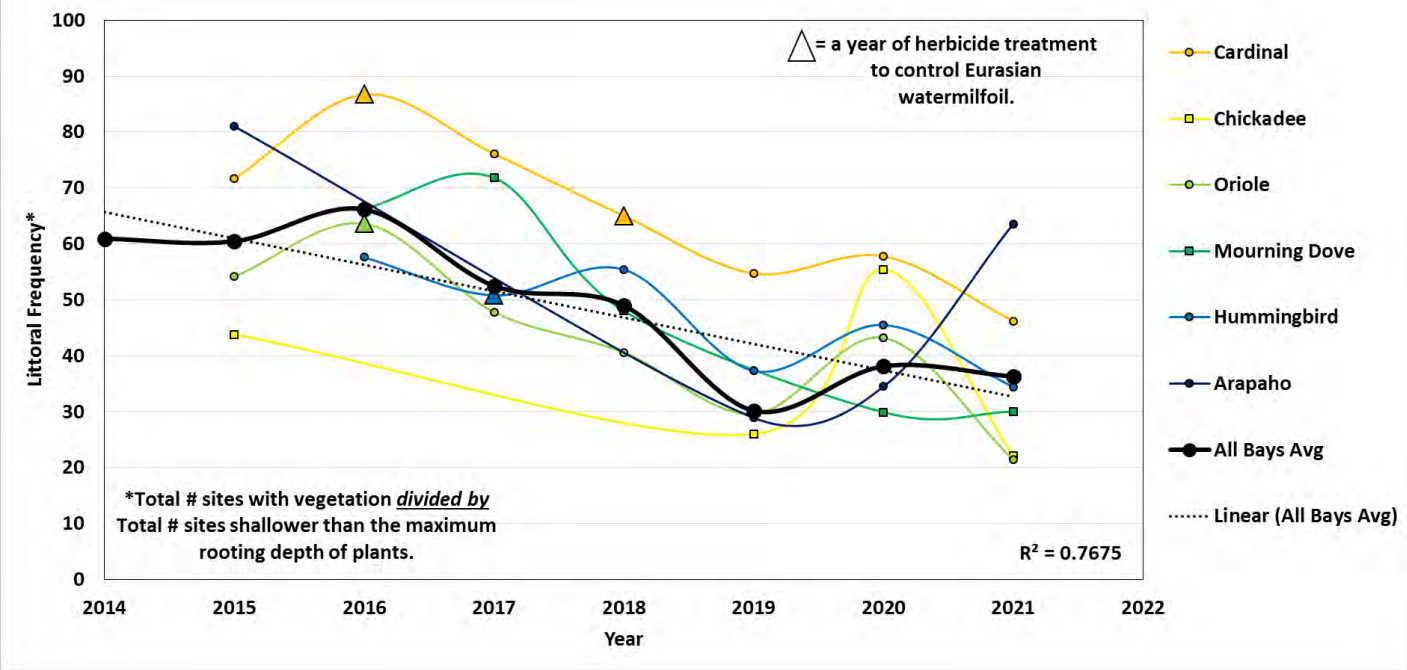
When comparing 2021 native species occurrence with that of 2020, there were no statistically significant declines in native plant species. In contrast, when comparing 2021 native species occurrence with the first year surveyed for each of the bays there were 8 statistically significant (SS) declines in native plant species and 3 SS declines in filamentous algae.[4] There was 1 SS increase in native species when compared to the first year surveyed. Based on these results, it seems as though there continues to be an overall decline in native plant occurrence and filamentous algae in the bays that are being studied. Although there was also a decrease in EWM in 2021 in all bays except Arapaho, there does not appear to be a strong trend of declining EWM since 2014. EWM occurrence is discussed further in the following page(s).

[4]Coontail SS decrease in 5 bays, white water lily SS decrease in 1 bay, and slender waterweed SS decrease in 2 bays. Slender naiad SS increase in 1 bay.

Reduced Plant Occurrence (Native & Non-native Species)

The graph in Figure 17 charts a function of the total number of sites where plants (native & non-native) *do* occur vs. the total number of sites where plants *could* occur, AKA littoral frequency (Table 4), thereby factoring in water clarity because it only includes points that are equal to or shallower than the maximum depth of aquatic plants. In theory, if water clarity declines so do the number of points shallower than the maximum depth of plants. This graph shows that average littoral frequency was lowest in 2021 for all bays[5] except Arapaho Bay. A linear trendline[6] of the average littoral frequency among all bays[7] surveyed each year suggests the littoral frequency of aquatic plants (combined native and non-native) has been on a downward trend from 2014 through 2021 with an R^2 value of 0.77.[8] This trend could be due to environmental factors such as the historic flooding in the area in 2018 that also likely impacted aquatic plant growth the following year (2019). The trend does not appear to be consistent among only bays treated with herbicide. In other words, herbicide treatment in a given year does not appear to be a main factor in driving down littoral frequency of all species, although it can't be ruled out as a contributing factor.

Figure 17 – Littoral Plant Frequency Graph

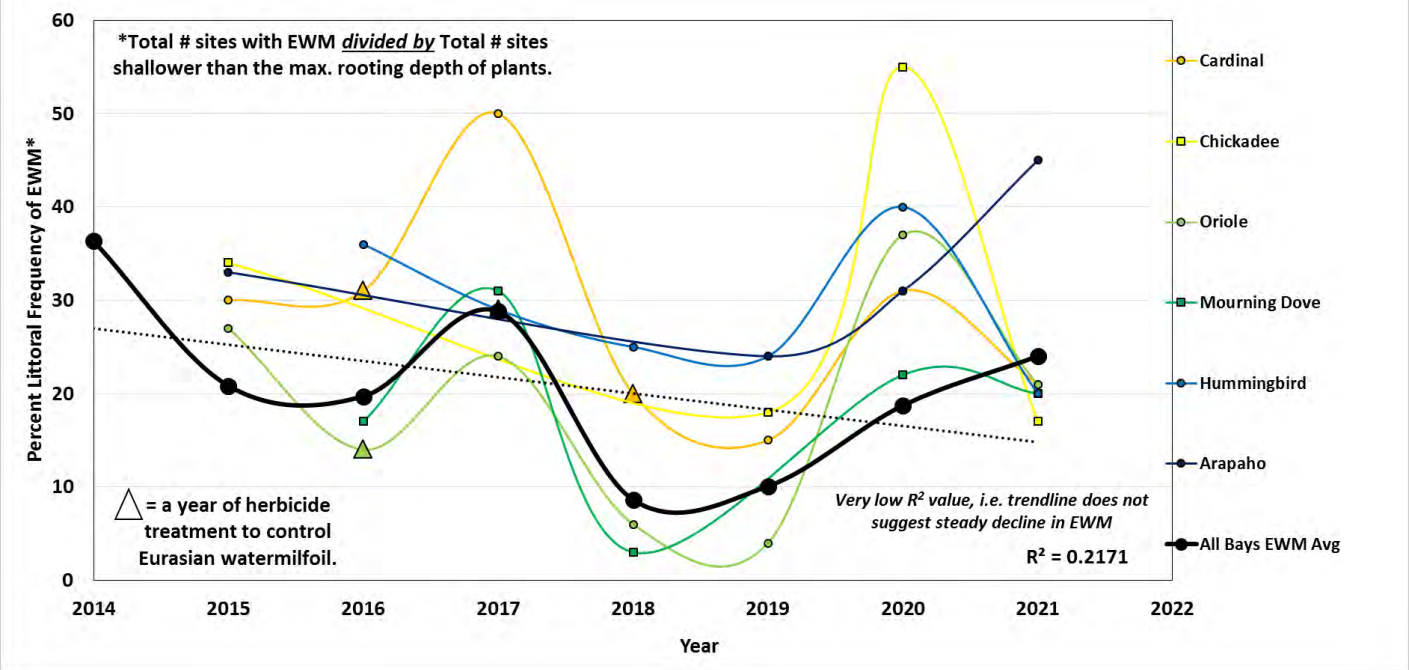


[5] Mourning Dove Bay was lowest in 2020 at 29.9% littoral frequency and nearly identical in 2021 at 30%.
[6] A **linear trendline** is a best-fit straight line that is used with simple **linear** data sets. Data is **linear** if the pattern in its data points resembles a line. A **linear trendline** usually shows that something is increasing or decreasing at a steady rate.
[7] All bays surveyed includes all those surveyed in a given year except for County F Bay in 2019 & 2020 (see 2020 report for more information).
[8] **R-squared** value measures the **trendline** reliability - the nearer **R**^{2} is to 1, the better the **trendline** fits the data.

EWM Littoral Frequency

Figure 18 illustrates EWM littoral frequency in the six bays surveyed from 2015 through 2021. ***In summary, all bays except Arapaho Bay had lower EWM occurrence in 2021 compared to 2020. The decrease in EWM was statistically significant in Chickadee and Hummingbird Bays.*** This is in contrast to 2020 results when 13 bays had increased EWM occurrence after dredging occurred in 2019, which was unexpected because the act of dredging removes sediment and along with it come roots and seeds. However, EWM and non-native/invasive species in general thrive in disturbed environments and the dredging may have opened a niche for EWM to recolonize more quickly than native species. Furthermore, EWM samples from Lake Redstone were collected in 2021 for genetic testing to rule out the presence of hybrid watermilfoil, which is the genetic cross between Eurasian watermilfoil and native northern watermilfoil (*Myriophyllum sibiricum*). Although Lake Redstone does not have northern watermilfoil present, the introduction of the hybrid strain could occur through boat traffic. The most recent genetic testing of Lake Redstone EWM was done in 2013 with results concluding the milfoil was Eurasian and not hybrid. Results of the 2021 samples are expected in early 2022.

Figure 18 – Eurasian Watermilfoil Littoral Frequency Graph



Identifying Trigger Frequencies for Herbicide Treatment

The following idea was presented in the 2017 report for Lake Redstone to help decide where herbicide treatment should occur, if at all. One possible management strategy is to identify a littoral frequency of EWM that triggers consideration for herbicide treatment the following spring. Table 6 lists the littoral frequencies of EWM the year before they were treated with herbicide. Woodpecker Bay had low EWM littoral frequency of only 9% in 2016 but only the northern section of the bay was treated in 2017 and is not included in the table. If we take an average pre-treatment littoral frequency of EWM for all bays that had herbicide treatment (not including Woodpecker), the result is approximately 36%. Of the bays surveyed in 2021, only Arapaho Bay had a frequency higher than this trigger value at 45%. Herbicide treatment is not recommended in Arapaho Bay in 2022 because the bay is wide overall and herbicide would be subject to rapid dispersal unless herbicide enclosures were deployed.

Table 6 – Past EWM Frequencies before Herbicide Treatment

Bay & Year		Littoral frequency of EWM	Average littoral frequency of EWM
Martin-Meadowlark	2014	42	36
Swallow	2014	52	
	2017	29	
Cardinal	2015	30	
	2017	50	
Chickadee*	2015	34	
Oriole	2015	27	
Eagle	2017	30	
Hummingbird	2016	36	
Mourning Dove	2017	31	

**The entire bay was surveyed in 2015 but only the southern arm of the bay was treated with herbicide in 2016.*

General Management Recommendations

Similar to previous years' recommendations, all native aquatic plants should be protected, especially due to the declining trend in plant occurrence. Hand removal of nuisance aquatic plants, even native plants, is permitted by Chapter NR 109 but the removal cannot occur in a designated sensitive area (identified in Sefton & Graham 2009) without a permit, is limited to a single area no more than 30 feet wide measured along shore, and must not harm the overall aquatic plant community.

Volunteer water monitoring and early detection of aquatic invasive species is an important component of lake management. Continued water monitoring and AIS surveying is recommended.

The Lake Redstone Protection District has done commendably in funding pre-post plant surveys, yielding valuable data since 2014. Although there was an increase in plant occurrence in 2020 and 2021 compared to the sharp drop in 2019, the overall trend suggests aquatic plant growth is declining in surveyed bays since 2014. Continued plant surveys in bays are recommended where needed. Although herbicide treatment of EWM in Arapaho Bay is not advised, it is still wort discussing with other partners involved in management of Lake Redstone.

Table 8 - Management Recommendations Summary

1. Protect native aquatic plants as they provide important structural habitat and contribute to a healthy lake system.
2. If necessary, shore land owners can hand pull or rake nuisance native vegetation in a <30-foot-wide area that is contiguous and parallel to shore. Designated sensitive areas require a permit. This should be done on very limited basis as native aquatic plants appear to be declining in surveyed bays since 2014.
3. Continue volunteer water quality and AIS monitoring.
4. Conduct aquatic plant surveys of bays in 2022 as needed and plant for a whole-lake aquatic plant survey of Lake Redstone in 2022.
5. If hand removal is used in 2022, pursue DASH instead of manual removal as recommended by Aquatic Plant Management LLC.

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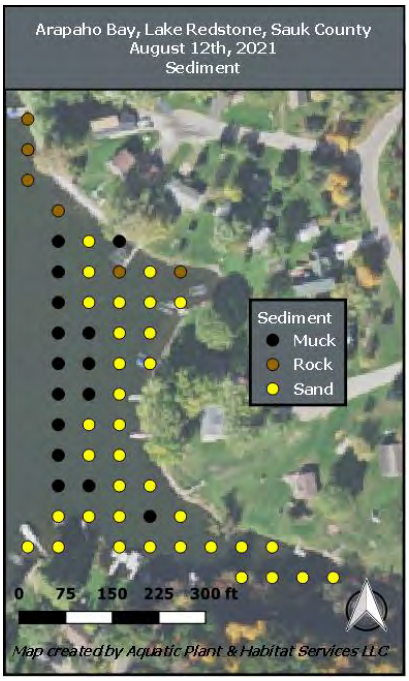
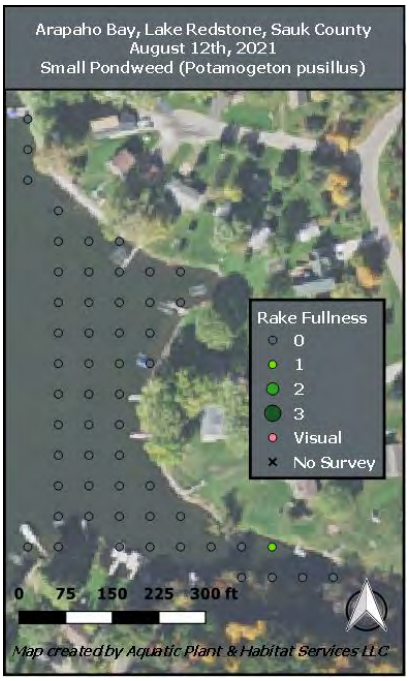
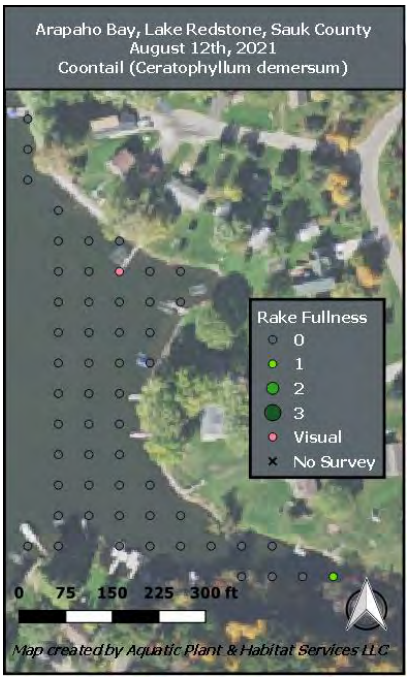
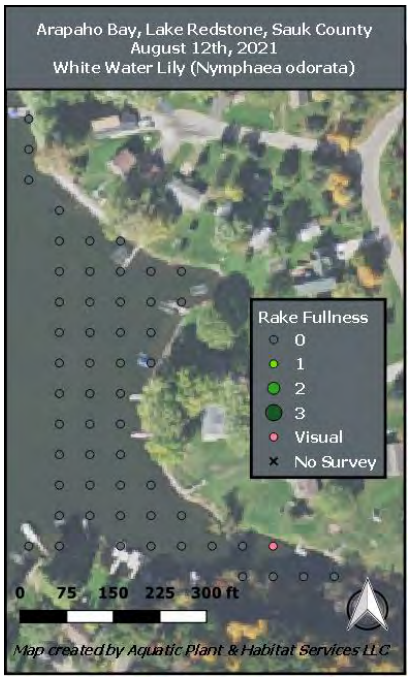
APPENDIX A – ARAPAHO BAY MAPS

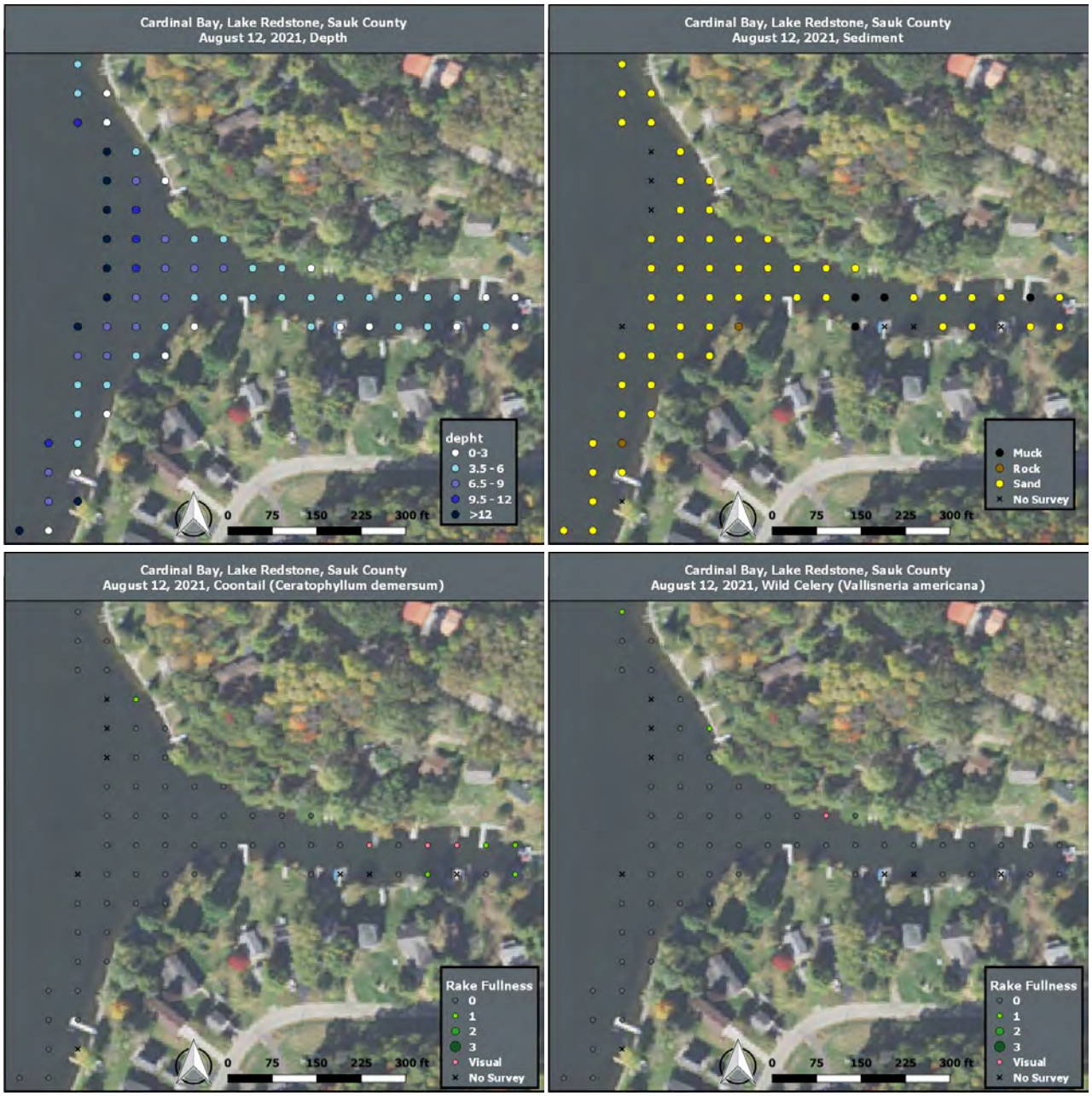


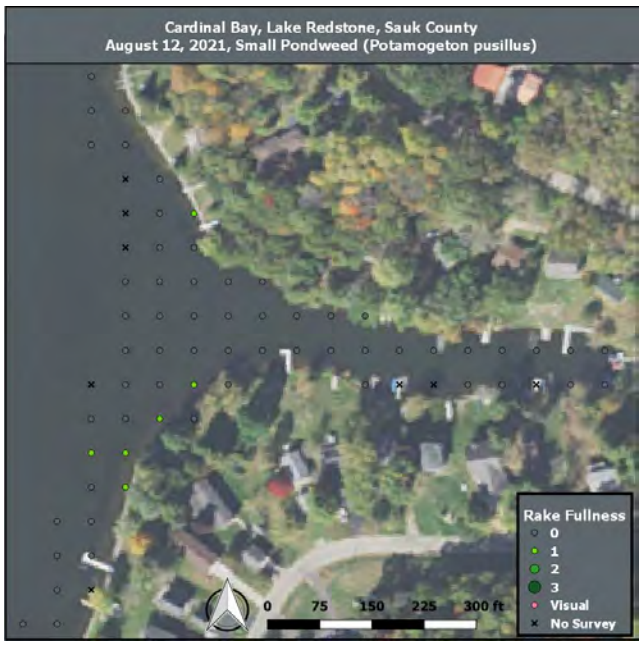


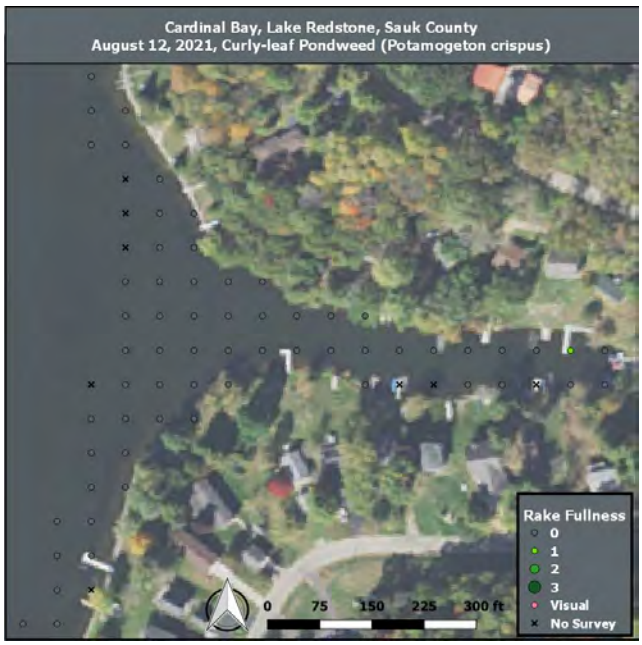


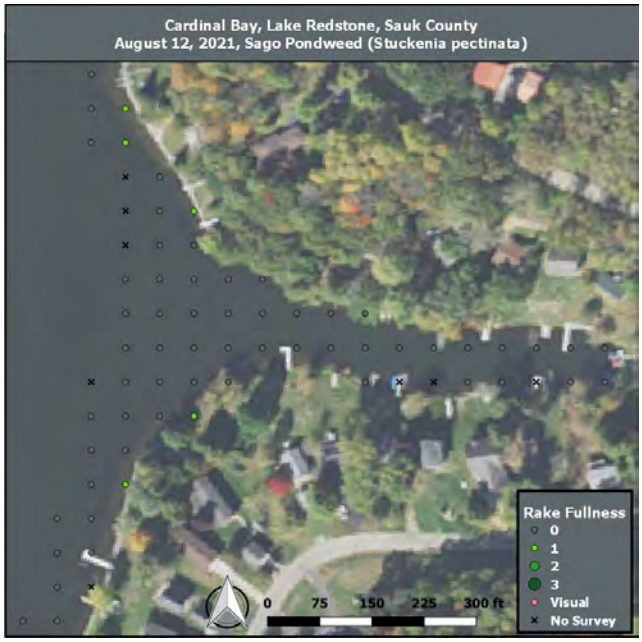


APPENDIX B – CARDINAL BAY MAPS

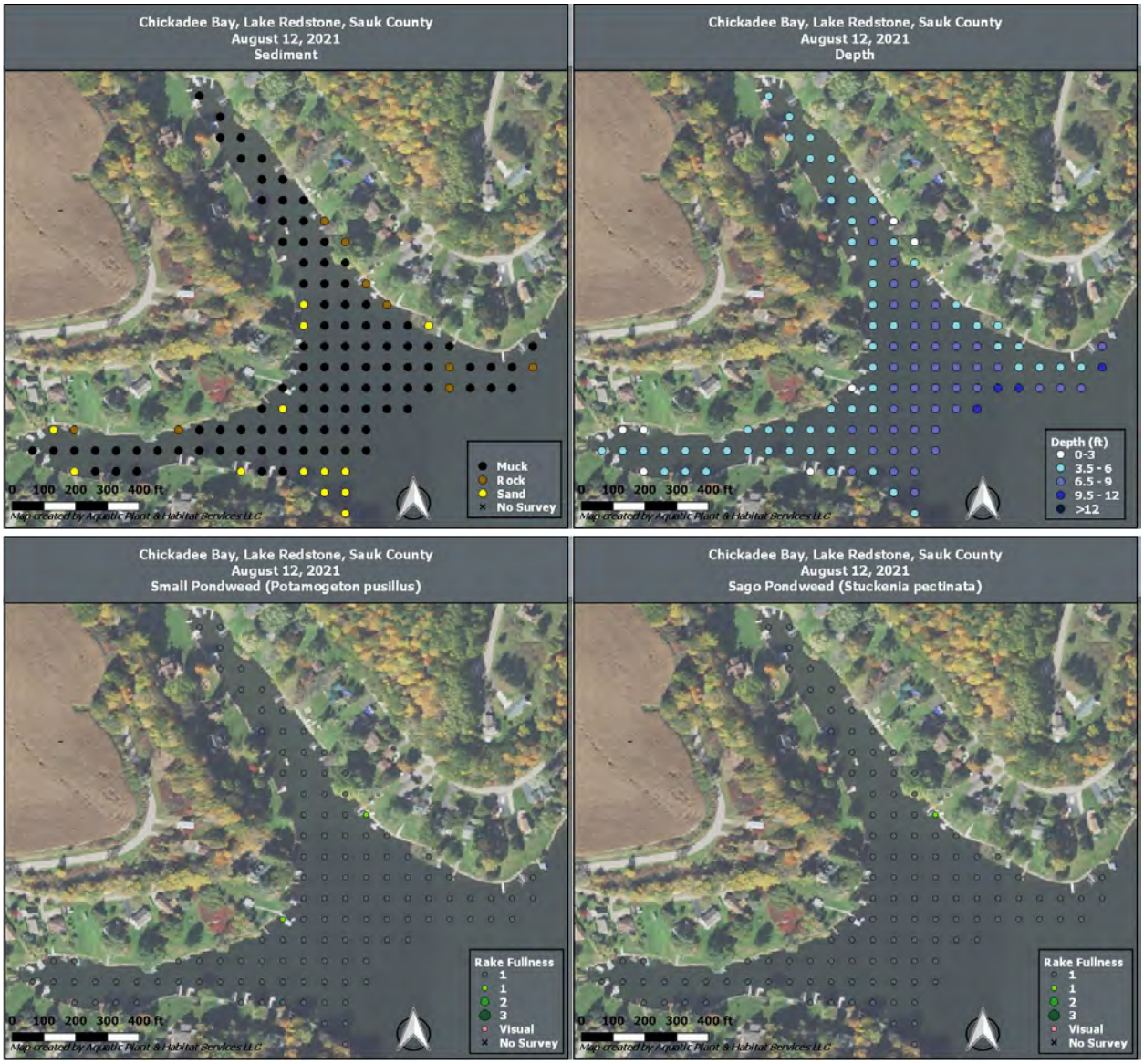



Cardinal Bay, Lake Redstone, Sauk County
August 12, 2021, Small Pondweed (Potamogeton pusillus)
Rake Fullness
0
1
2
3
Visual
No Survey
0 75 150 225 300 ft


Cardinal Bay, Lake Redstone, Sauk County
August 12, 2021, Curly-leaf Pondweed (Potamogeton crispus)
Rake Fullness
0
1
2
3
Visual
No Survey
0 75 150 225 300 ft


Cardinal Bay, Lake Redstone, Sauk County
August 12, 2021, Sago Pondweed (Stuckenia pectinata)
Rake Fullness
0
1
2
3
Visual
No Survey
0 75 150 225 300 ft

APPENDIX C - CHICKADEE BAY MAPS

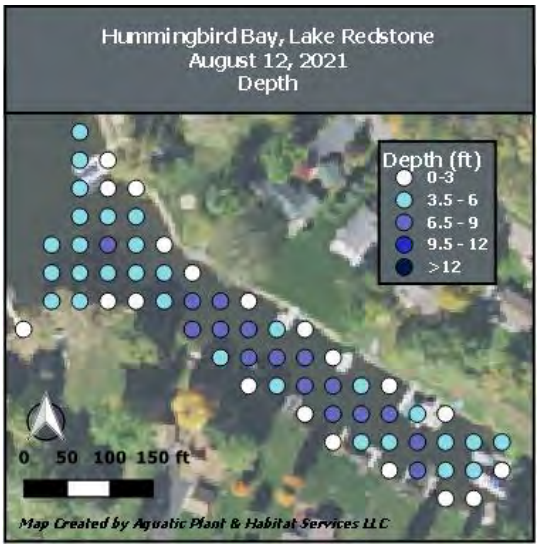


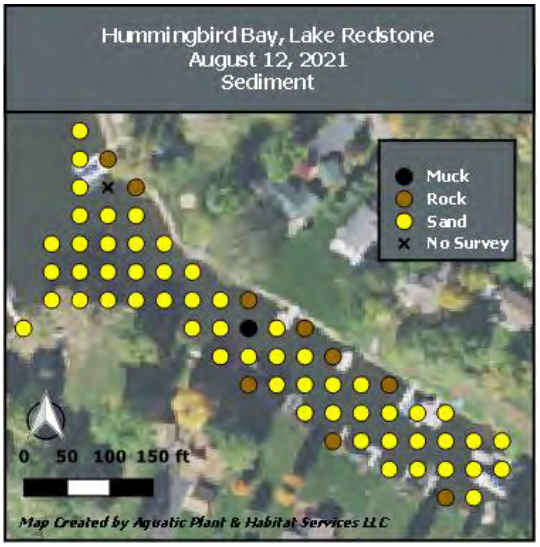

Chickadee Bay, Lake Redstone, Sauk County
August 12, 2021
White Water Lily (Nymphaea odorata)
Rake Fullness
1
1
2
3
Visual
No Survey
0 100 200 300 400 ft
Map created by Aquatic Plant & Habitat Services LLC

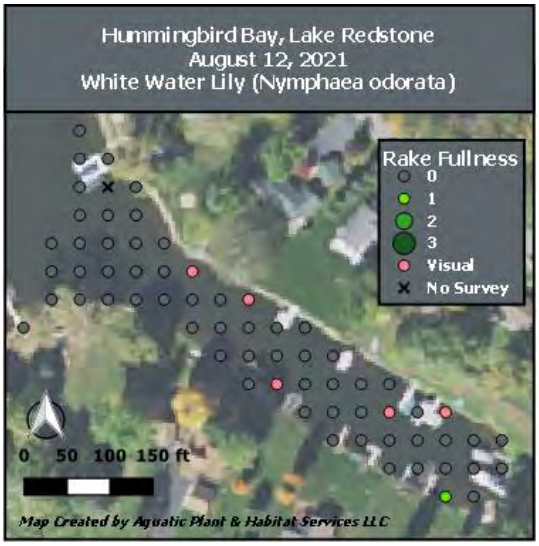

Chickadee Bay, Lake Redstone, Sauk County
August 12, 2021
Coontail (Ceratophyllum demersum)
Rake Fullness
1
1
2
3
Visual
No Survey
0 100 200 300 400 ft
Map created by Aquatic Plant & Habitat Services LLC

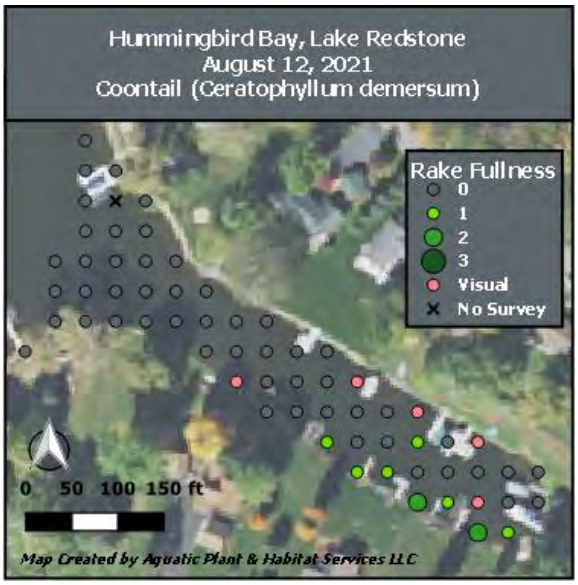

Chickadee Bay, Lake Redstone, Sauk County
August 12, 2021
Horned Pondweed (Zannichellia palustris)
Rake Fullness
1
1
2
3
Visual
No Survey
0 100 200 300 400 ft
Map created by Aquatic Plant & Habitat Services LLC

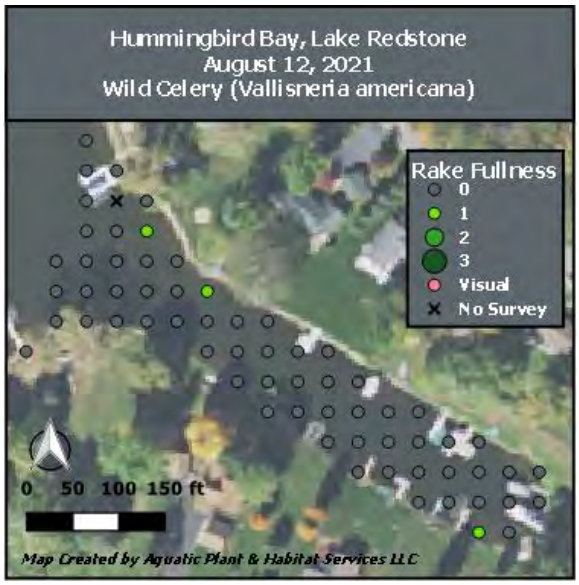
APPENDIX D – HUMMINGBIRD BAY MAPS

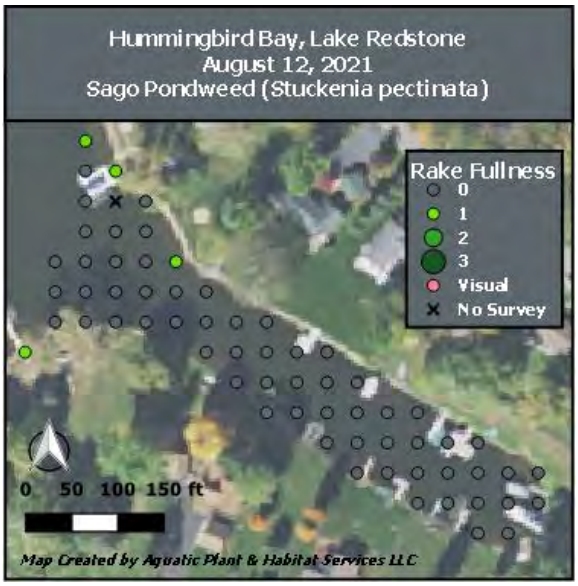






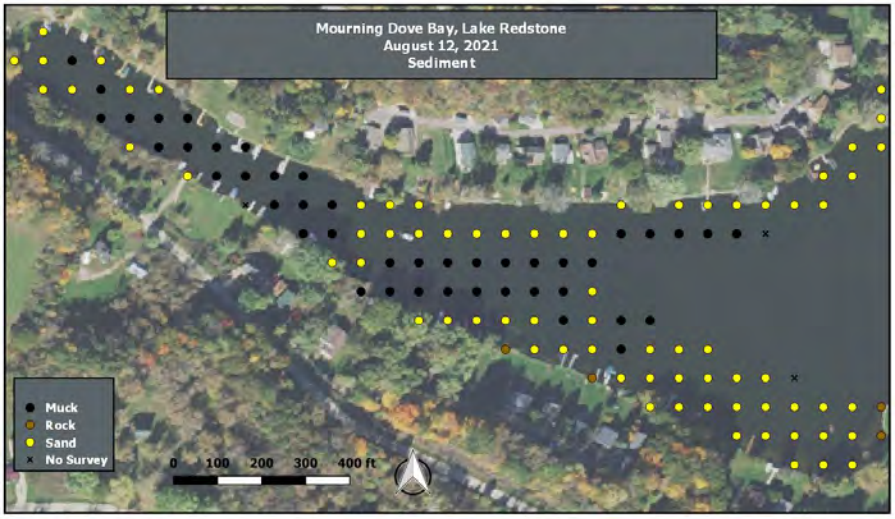

Hummingbird Bay, Lake Redstone
August 12, 2021
Coontail (Ceratophyllum demersum)
Rake Fullness
0
1
2
3
Visual
No Survey
0 50 100 150 ft
Map Created by Aquatic Plant & Habitat Services LLC

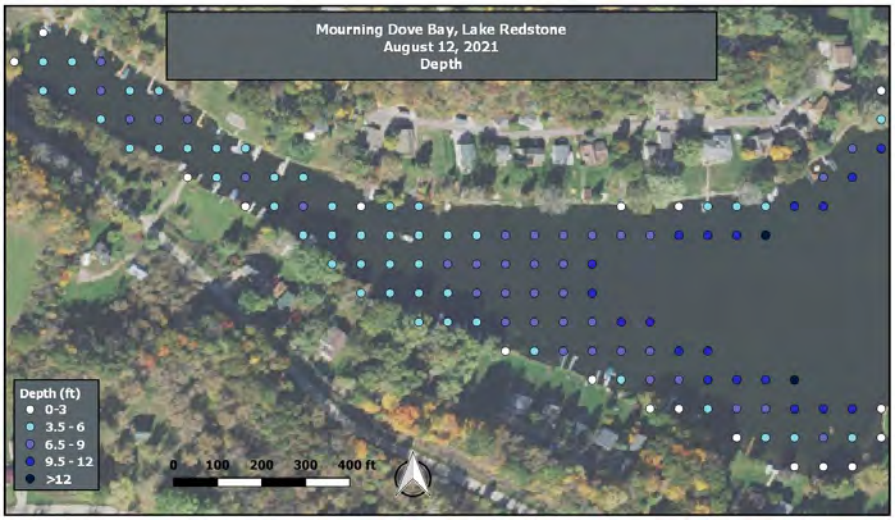

Hummingbird Bay, Lake Redstone
August 12, 2021
Wild Celery (Vallisneria americana)
Rake Fullness
0
1
2
3
Visual
No Survey
0 50 100 150 ft
Map Created by Aquatic Plant & Habitat Services LLC

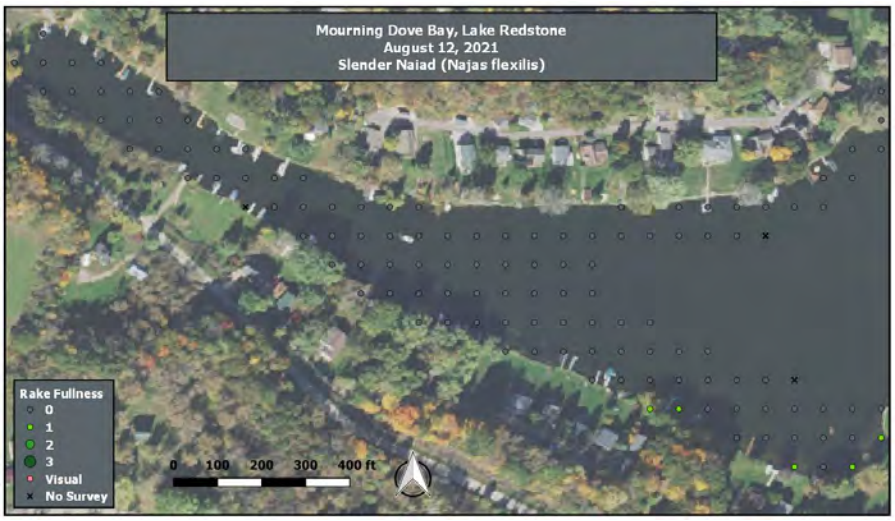

Hummingbird Bay, Lake Redstone
August 12, 2021
Sago Pondweed (Stuckenia pectinata)
Rake Fullness
0
1
2
3
Visual
No Survey
0 50 100 150 ft
Map Created by Aquatic Plant & Habitat Services LLC

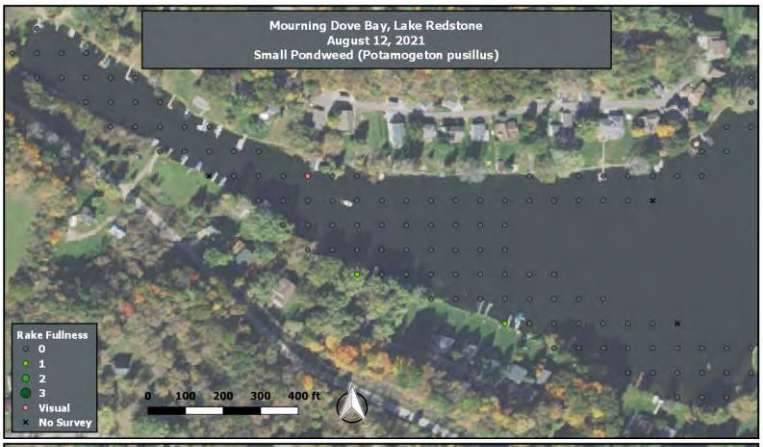

Hummingbird Bay, Lake Redstone
August 12, 2021
Small Duckweed (Lemna minor)
Rake Fullness
0
1
2
3
Visual
No Survey
0 50 100 150 ft
Map Created by Aquatic Plant & Habitat Services LLC

APPENDIX E – MOURNING DOVE BAY MAPS





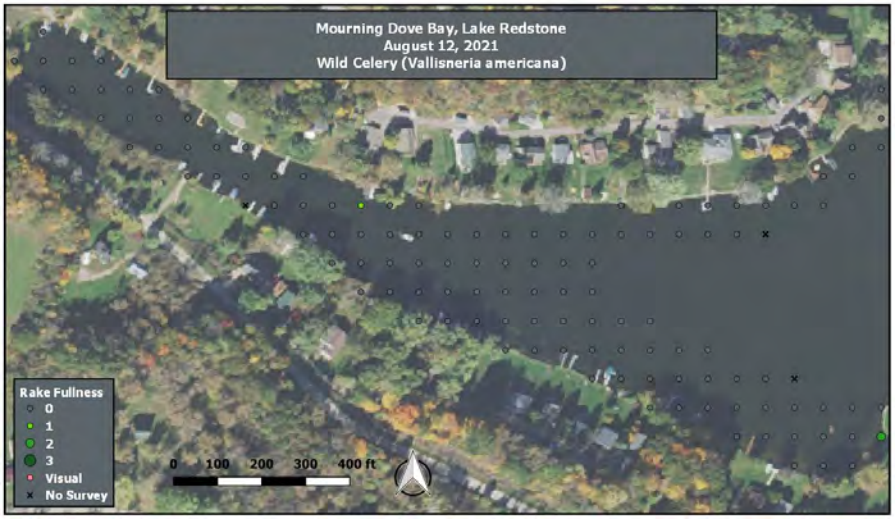


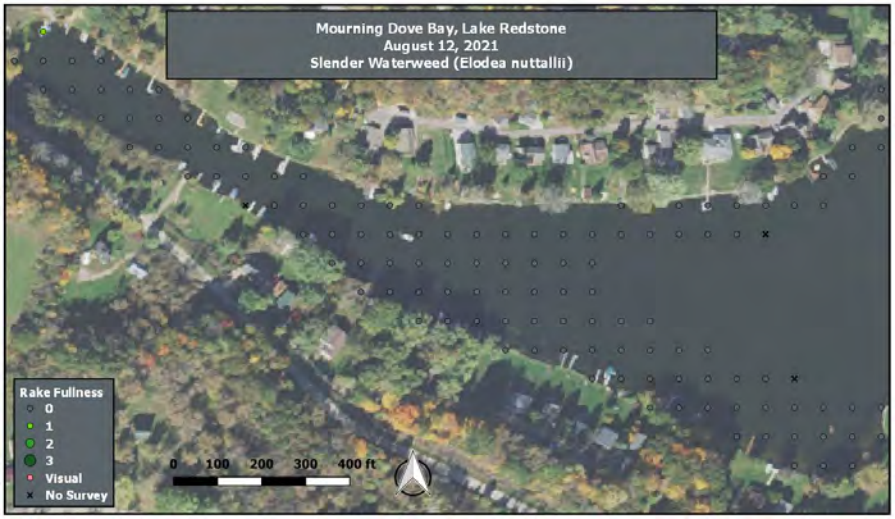

Mourning Dove Bay, Lake Redstone
August 12, 2021
Small Pondweed (Potamogeton pusillus)
Rake Fullness
0
1
2
3
Visual
No Survey
0 100 200 300 400 ft

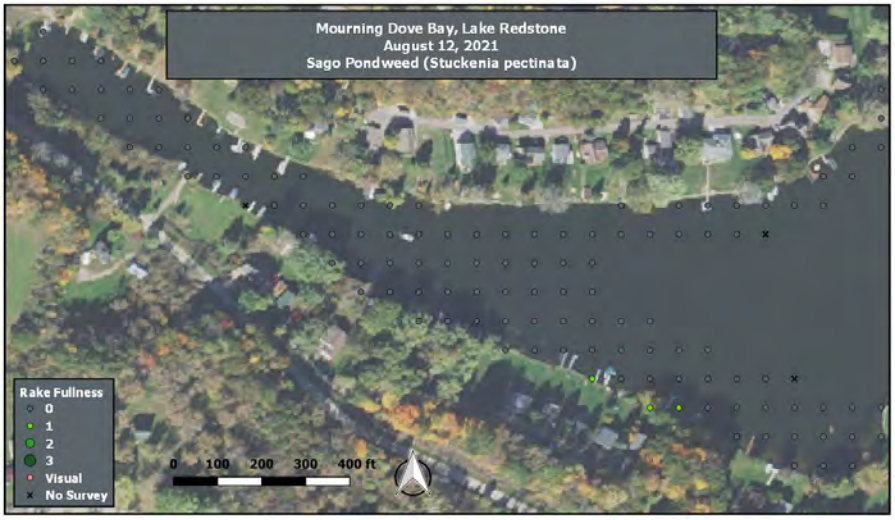

Mourning Dove Bay, Lake Redstone
August 12, 2021
Coontail (Ceratophyllum demersum)
Rake Fullness
0
1
2
3
Visual
No Survey
0 100 200 300 400 ft


Mourning Dove Bay, Lake Redstone
August 12, 2021
White Water Lily (Nymphaea odorata)
Rake Fullness
0
1
2
3
Visual
No Survey
0 100 200 300 400 ft

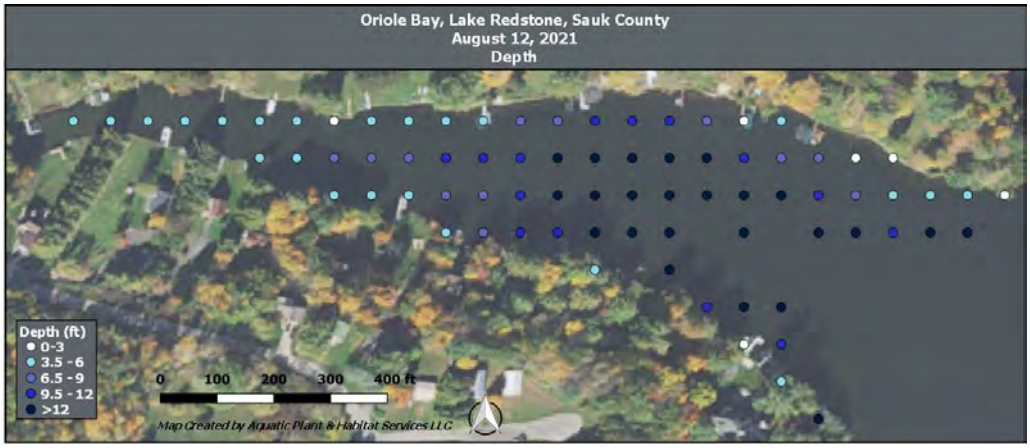

Mourning Dove Bay, Lake Redstone
August 12, 2021
Curly-leaf Pondweed (Potamogeton crispus)
Rake Fullness
0
1
2
3
Visual
No Survey
0 100 200 300 400 ft

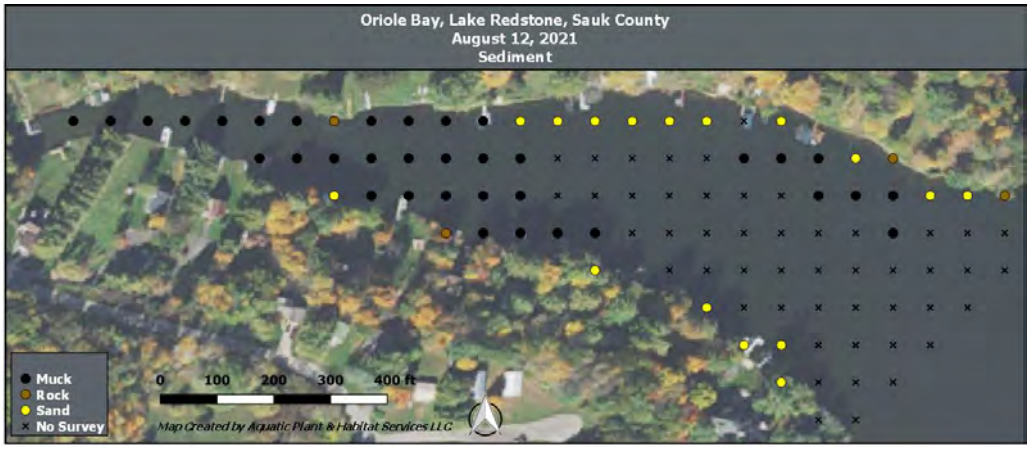

Mourning Dove Bay, Lake Redstone
August 12, 2021
Wild Celery (Vallisneria americana)
Rake Fullness
0
1
2
3
Visual
No Survey
0 100 200 300 400 ft

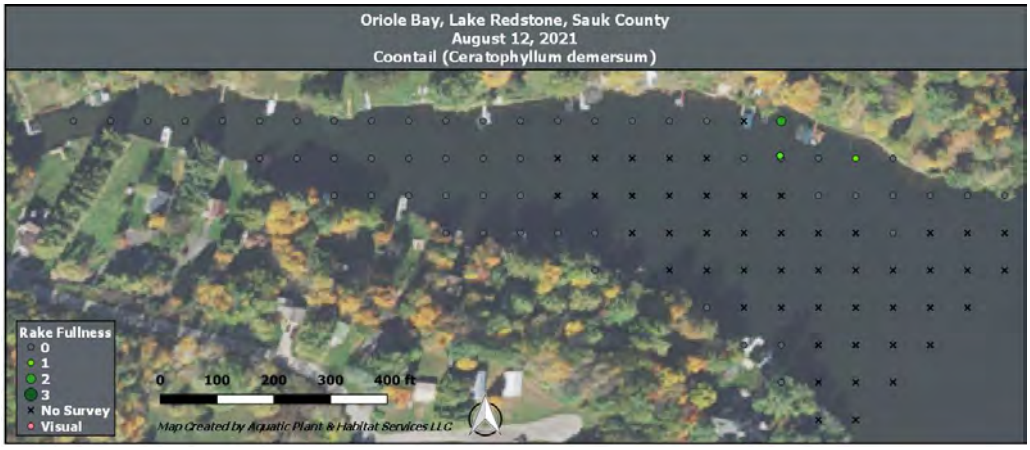

Mourning Dove Bay, Lake Redstone
August 12, 2021
Slender Waterweed (Elodea nuttallii)
Rake Fullness
0
1
2
3
Visual
No Survey
0 100 200 300 400 ft

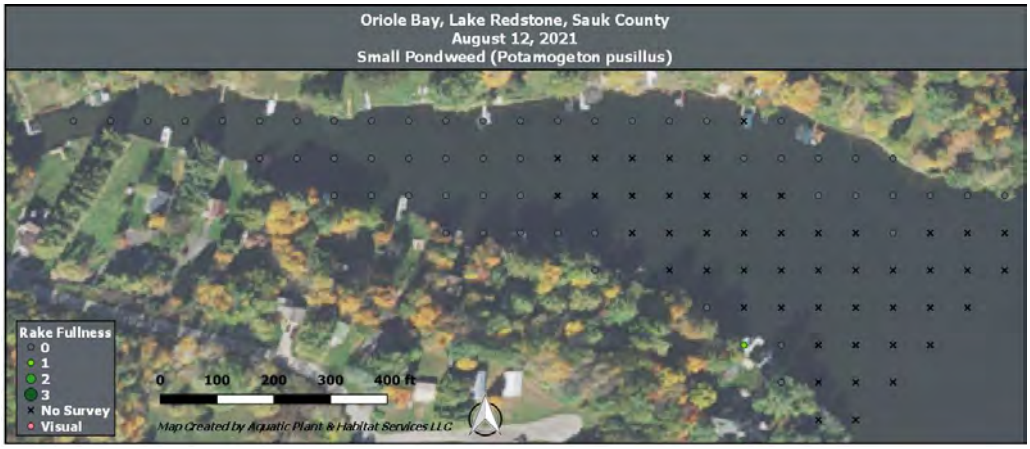

Mourning Dove Bay, Lake Redstone
August 12, 2021
Sago Pondweed (Stuckenia pectinata)
Rake Fullness
0
1
2
3
Visual
No Survey
0 100 200 300 400 ft

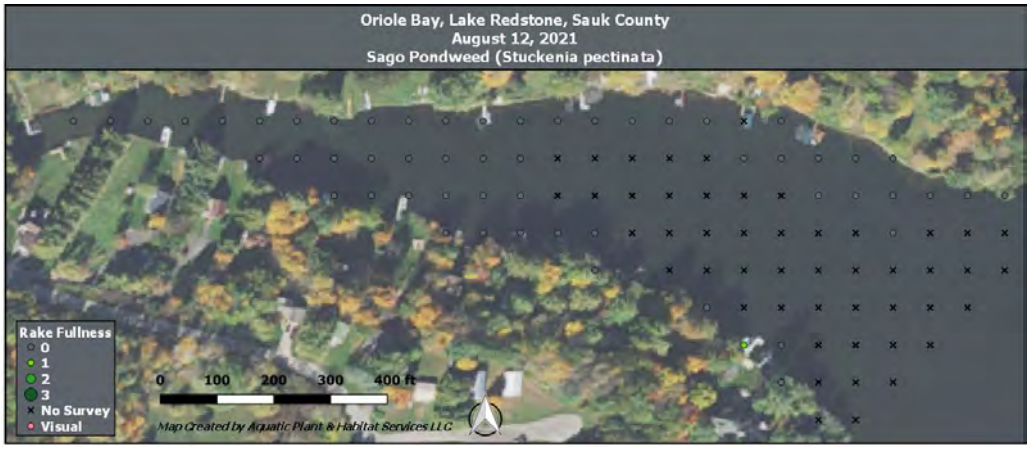
APPENDIX F – ORIOLE BAY MAPS

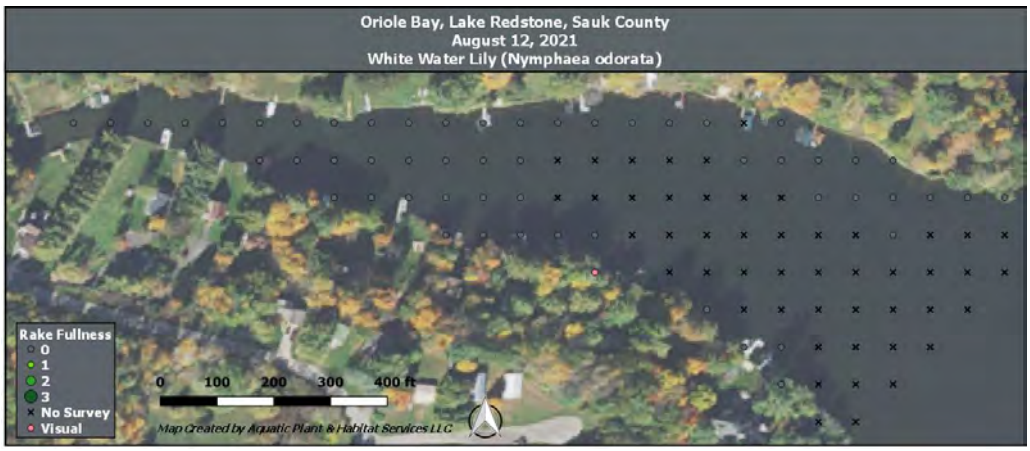







Oriole Bay, Lake Redstone, Sauk County
August 12, 2021
Small Pondweed (Potamogeton pusillus)
Rake Fullness
0
1
2
3
No Survey
Visual
0 100 200 300 400 ft
Map Created by Aquatic Plant & Habitat Services LLC

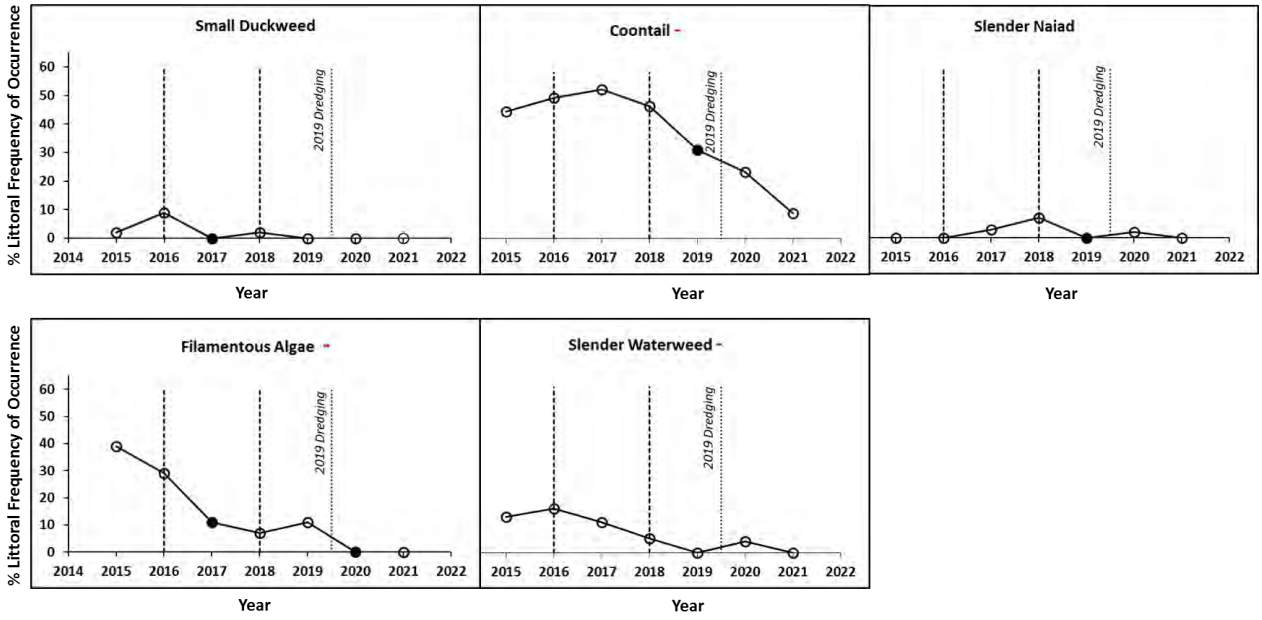

Oriole Bay, Lake Redstone, Sauk County
August 12, 2021
Sago Pondweed (Stuckenia pectinata)
Rake Fullness
0
1
2
3
No Survey
Visual
0 100 200 300 400 ft
Map Created by Aquatic Plant & Habitat Services LLC


Oriole Bay, Lake Redstone, Sauk County
August 12, 2021
White Water Lily (Nymphaea odorata)
Rake Fullness
0
1
2
3
No Survey
Visual
0 100 200 300 400 ft
Map Created by Aquatic Plant & Habitat Services LLC

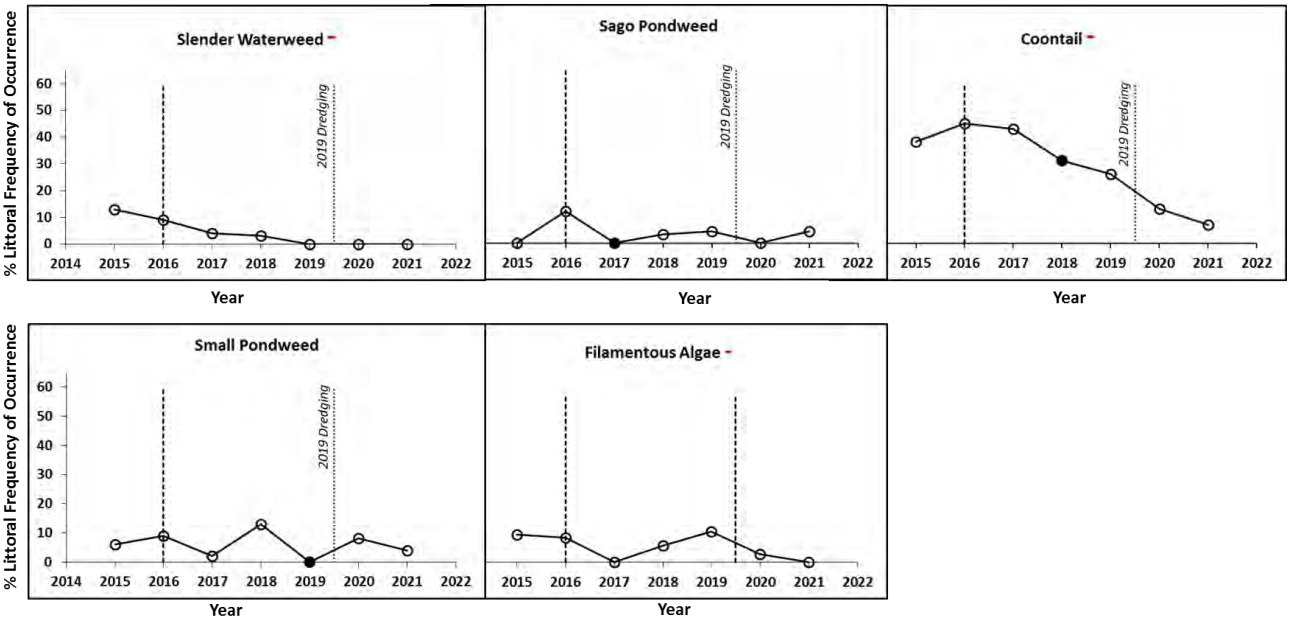
APPENDIX G – CHI-SQUARED TEST GRAPHS

Percent littoral frequency (# sites plants found at points shallower than maximum rooting depth) is on the y-axis and each year a plant survey was completed is on the x-axis. Only species with a statically significant change (using Chi-squared tests) for at least one of the years are displayed. The dashed vertical lines represent years when herbicide treatments were done. Open circles represent ***no*** statistically significant change, solid circles represent a statistically significant change. Statistically significant changes between the first year of surveying and 2021 data are represented by **+** or **–** adjacent to plant names.

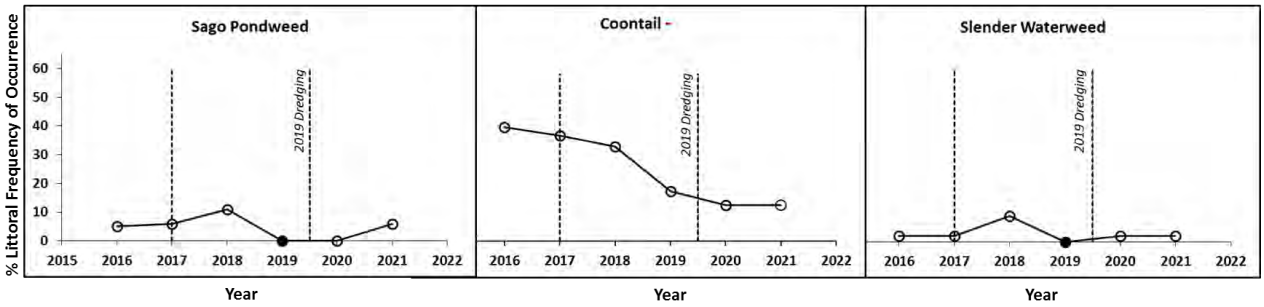
Cardinal Bay 2015-2021

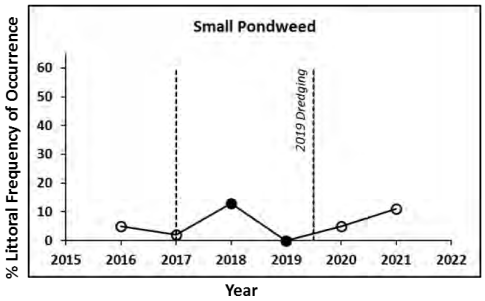


Oriole Bay 2015-2021

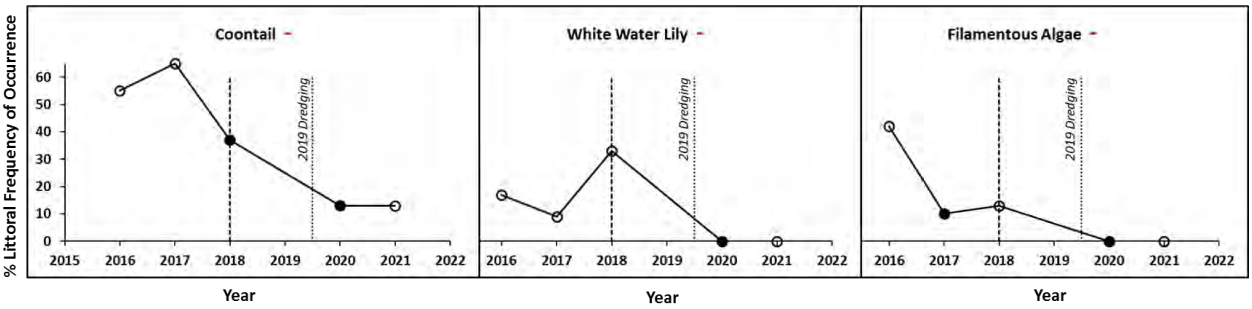


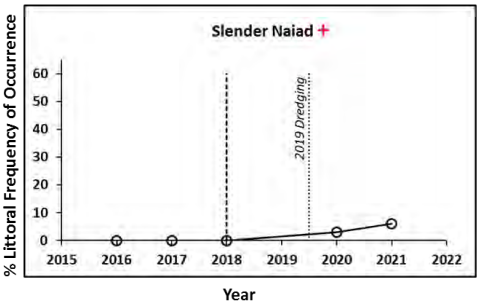
Hummingbird Bay 2016-2021



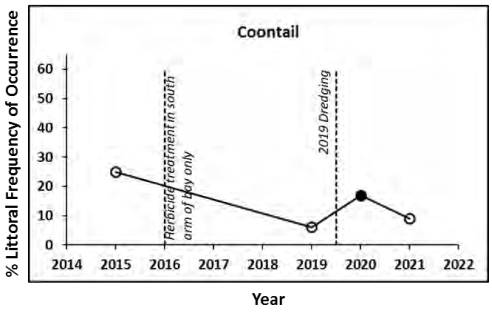


Mourning Dove Bay 2016-2021

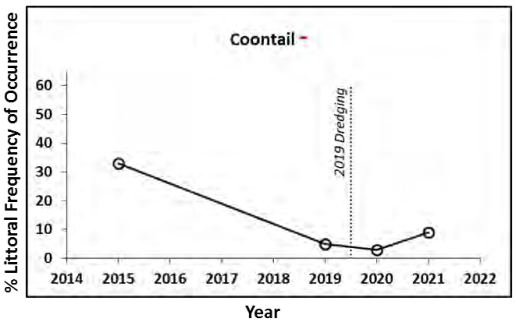




Chickadee Bay 2014-2021



Arapaho Bay 2015-2021



Chi-squared Test Results for Eurasian Watermilfoil