The Connecticut Agricultural Experiment Station, New Haven

Control of *Potamogeton crispus* and *Myriophyllum spicatum* in Crystal Lake, Middletown, CT

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INTRODUCTION:

Crystal Lake is a 32-acre state owned water body located in Middletown, CT. It has a mean depth of 3 meters and a maximum dept of 9 meters (Jacobs and O'Donnell, 2002). The southern half of the lake is shallow with a muck bottom, while the northern half is deep with a bottom consisting of considerable ledge and rock. Public access via a state boat launch ramp and a town beach is available at the southern end. At the northern end, a private club operates a second beach. The remainder of the shoreline consists of private residences with the exception of an undeveloped peninsula jutting out from the southwest corner. Recreational use of the lake has become increasingly hindered by the invasive aquatic plant *Potamogeton crispus* (curly leaf pondweed) (Figure 1). Invasive aquatic plant species can threaten native species (Pimentel et al. 2000) and reduce property values of homes nearby (Fishman et al. 1998). *Potamogeton crispus* is now found in all New England states (IPANE, 2009). It is most problematic in the months of May and June then it sets reproductive structures, called turions, and rapidly disappears (Capers et al. 2005). *Myriophyllum spicatum (*Eurasian water milfoil) is another invasive species that inhabits the lake, but to date has reached only moderate nuisance levels. An aquatic plant listed by the State of Connecticut as an endangered species, called *Potamogeton vaseyi* (Vasey's pondweed), has been determined by the Connecticut Department of Environmental Protection (CT DEP) to also inhabit Crystal Lake. In 2006, the CT

Figure 1. *Potamogeton crispus* reaching surface in Crystal Lake.

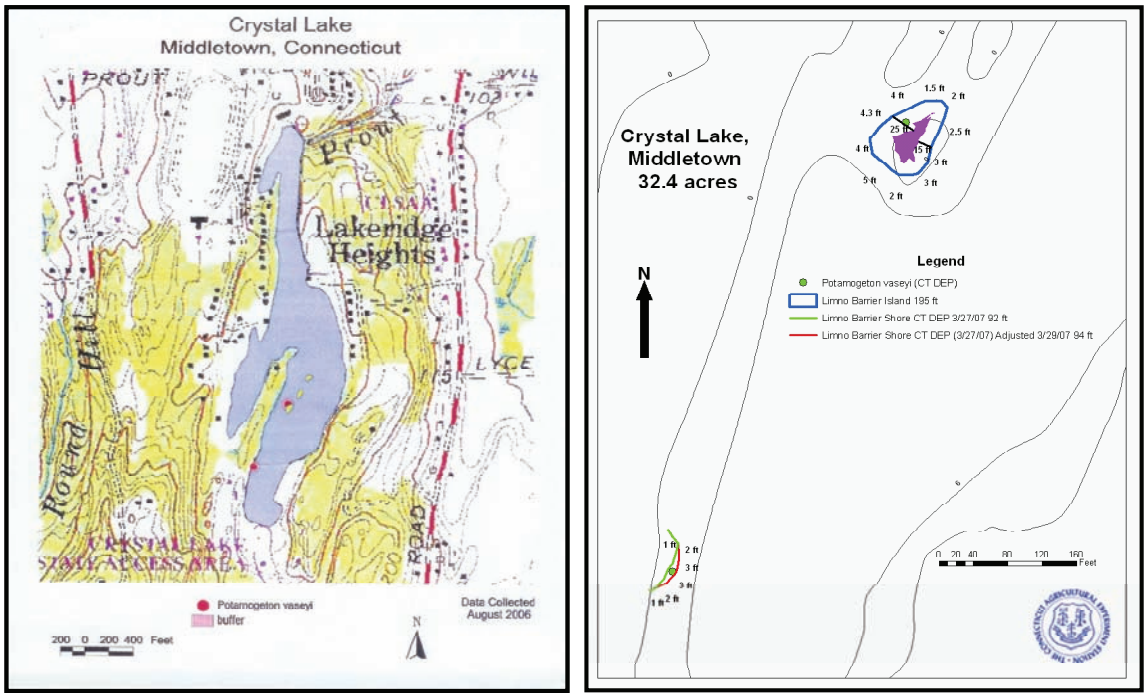

Figure 2. Locations of *Potamogeton vaseyi* (left) and limnobarriers (right) in Crystal Lake.

DEP located two patches of *Potamogeton vaseyi* near the west end of the town beach and the west side of the southern island (Figure 2). Samples of these plants reside in the George Safford Torrey Herbarium (CONN) at the University of Connecticut in Storrs.

In cooperation with the Town of Middletown and residents concerned about the condition of Crystal Lake, The Connecticut Agricultural Experiment Station (CAES) was asked to devise a strategy to control the nuisance vegetation with an herbicide. CAES decided to test an April application of the herbicide Reward (diquat dibromide). Reward is a contact herbicide that has short residual activity in the environment. The April treatment was earlier than typically performed but holds promise to control the *Potamogeton crispus* before it produces the turions needed to produce the following year's plants (Getsinger, 2005). In addition, native plants like *Potamogeton vaseyi*, begin growth later in the season and, therefore, may be offered some protection. Further protection of *P. vaseyi* from herbicides could be offered by installing an impermeable barrier from surface to bottom around the plant patches. Commercial products called, called limnobarriers, are available for this purpose and will be tested as part of this study.

OBJECTIVES:

1. Determine the effectiveness of controlling *Potamogeton crispus* and *Myriophyllum spicatum* with an early season application of Reward.

2. Determine the effectiveness of the early season application on preserving Potamogeton vaseyi *and other native vegetation.*

3. Determine if limnobarriers are necessary to prevent the herbicide from harming Potamogeton vaseyi..

Figure 3. Installation of limnobarrier around island in Crystal Lake.

MATERIALS AND METHODS:

VISUAL SURVEYS

We conducted midsummer visual surveys before the herbicide application in 2004 and after the herbicide application in 2007 and 2008. The 2004 survey was part of a CAES statewide monitoring effort (CAES IAPP, 2009). We used survey and transect protocol as established by the CAES Invasive Aquatic Plant Program (IAPP) (CAES IAPP, 2009) and a more thorough georeferenced grid technique described below. Our visual survey was accomplished by slowly traveling through the littoral zone and recording all aquatic plant species on a bathymetric lake map. To identify plants that were not clearly visible, we obtained samples from water less than three meters deep by hand or with a long-handled rake. In deeper water, we obtained plants with a grapple attached to a rope. When field identification was questionable, we brought samples back to the lab for further review using the taxonomy of Crow and Hellquist (2000a, 2000b). Depth was measured by rake handle, drop line or digital depth finder. Particular attention was paid to areas where the CT DEP had found Potamogeton vaseyi and these locations were protected with limnobarriers. Because Potamogeton vaseyi is rare, it is not easy to identify. Nancy Murray, a CT DEP wildlife biologist who specializes in rare and endangered species, checked the lake for the presence of Potamogeton vaseyi each year to supplement this study.

TRANSCETS

We used the CAES IAPP (2007) transect method to collected quantitative frequency and abundance information on the aquatic plants in 2007 and 2008 and compared the results to data gathered from the same transects in 2004. We selected transect locations using a random-representative method to assure that all variety of habitat types were represented. We established four transects positioned perpendicular to the shoreline. We recorded the frequency and abundance of each plant species found within a 2 m^2 area at 0, 5, 10, 20, 30, 40, 50, 60, 70 and 80 m from the shore. Transects 1, 2 and 3 contain 10 points while transect 4 contains only 6 points because of the narrowness of the lake. We took transect data in the late summer of each year. Species abundance was ranked on a 1 – 5 scale (1 = rare - 5 = very abundant). One specimen of each species was mounted and placed in the CAES herbarium (NHES).

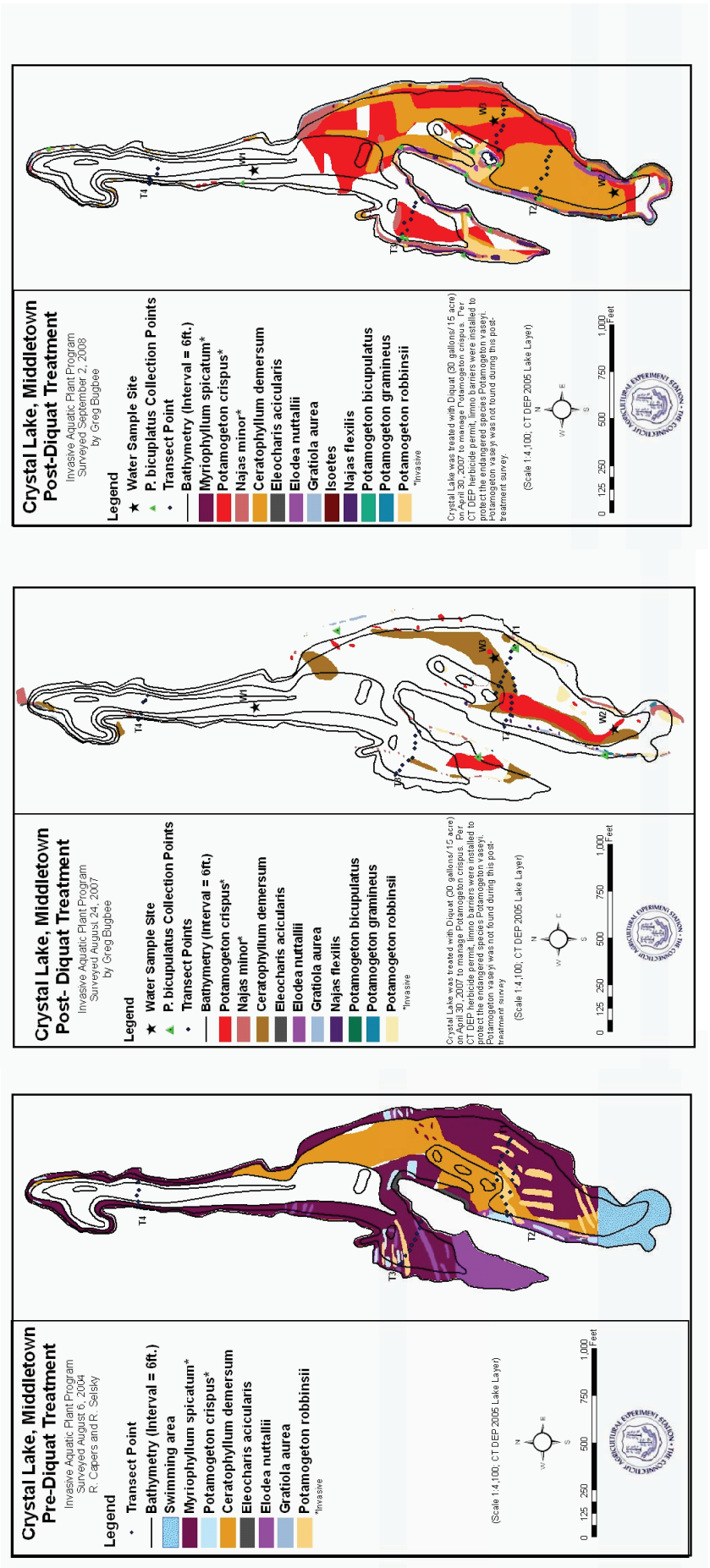

Figure 4. Visual surveys aquatic plant vegetation surveys of Crystal Lake 2004, 2007, 2008.

Table 1. Presence (Y) or absence (N) of turions on *Potamogeton crispus* prior to treatment.

	Site 1				Site 2				Site 3				Site 4			
Rep #	Length* (cm)	Turions old	Turions new	rhizome	Length* (cm)	Turions old	Turions new	rhizome	Length* (cm)	Turions old	Turions new	rhizome	Length* (cm)	Turions old	Turions new	rhizome
1	60	N	N	Y	40	Y	N	Y	35	Y	N	Y	70	Y	N	Y
2	55	N	N	Y	80	N	N	Y	30	Y	N	Y	68	Y	N	Y
3	50	N	N	Y	50	N	N	Y	25	N	N	N	25	Y	N	Y
4	45	N	N	Y	30	N	N	Y	15	N	N	N	70	N	N	Y
5	40	N	N	Y	45	N	N	N	30	N	N	Y	70	N	N	Y
6	40	N	N	Y	30	N	N	Y	28	N	N	Y	50	N	N	Y
7	65	N	N	Y	33	N	N	Y	28	N	N	Y	85	Y	N	Y
8	50	N	N	Y	40	N	N	Y	15	N	N	Y	40	Y	N	Y
9	65	N	N	Y	50	Y	N	Y	16	Y	N	Y	95	Y	N	Y

* Stem length

GEOREFERENCED GRID

A georeferenced grid method for quantifying plant frequency and abundance was utilized in 2006, 2007 and 2008. We took vegetation samples with a grapple at one-second longitudinal and latitudinal intervals throughout the entire lake in both spring and summer (Figure 5, 6, 7). The numbers of georeferenced grid points were 210, 211 and 211 in the spring and 200, 211 and 212 in the summer for 2006, 2007 and 2008, respectively. The differences were due to our inability to get into the town swim area in August 2006 and variations in the accuracy of the global position system causing some shoreline points to not be in the lake. Samples obtained on the georeferenced grid were brought back to the laboratory and dried at 75 C°. We used dry weights as a measure of plant abundance.

To be certain turions had not yet formed on the P. crispus, nine plants were examined from four randomly selected locations on April 27, 2007 (Table 1). No plants contained new turions formed in 2007, but many contained the previous year's turions at the basal part of the plant.

Element occurrence (E0) special plant survey forms were mailed to Nancy Murray, at the CT DEP as required in herbicide permit #07147. The required mid summer 2007 forms were not supplied until January 2009 because of confusion over the need to supply forms when no state listed species were found.

WATER CHEMISTRY

We used a YSI® 58 meter (YSI Inc., Yellow Springs, Ohio), to measure water temperature and dissolved oxygen. Measurements were taken at a depth of 0.5 m and then at 1 m intervals to the bottom of a deep portion of the lake (W1, Figure 4) and at two other widely distributed spots where the water was shallower (W2, W3, Figure 4). We used a Secchi disk to measure transparency. Water samples were obtained at 0.5 m below the surface and 0.5 m off the bottom at each location. We stored samples at 3 C° until they were analyzed. The conductivity and pH was measured with a Fisher-Accumet® AR20 meter (Fisher Scientific International Inc., Hampton, NH), and alkalinity was quantified by titration with 0.16N H_2SO_4 to a pH 4.5 end point (expressed as mg/l $CaCO_3$). Finally, we analyzed total phosphorus by the ascorbic acid method with potassium persulfate digestion (American Public Health Association, 1995). Posttreatment water samples, required by herbicide permit #07147 (see appendix) were taken on May 25, 2007 and delivered to the Center for Environmental Sciences and Engineering, 270 Middle Turnpike, Storrs, CT per chain of custody protocol (see appendix) put forth by Chuck Lee of the CT DEP. The results of these tests were not reported to CAES.

INSTALLATION AND REMOVAL OF LIMNOBARRIERS

On April 27, 2007 Aquatic Control Technologies, Inc. of Sutton MA, installed limnobarriers (Figure 3) around the two sites determined by CT DEP to contain Potamogeton vaseyi (Figure 2). Water ranged from 0 – 1m deep. On May 10, 2007 the limnobarriers were removed.

APPLICATION OF HERBICIDE

Reward was applied by CAES at a rate of 2 gallons per surface acre to the southern half of the lake (30 gallons total) on April 30 2007. This rate was based on CT DEP permit #07147 (see appendix). To maximize mixing, the herbicide was diluted 1:1 with water in a 25 gallon electric sprayer and applied 0.3 meters below the surface near the propeller of a motorized boat.

RESULTS AND DISCUSSION:

VISUAL SURVEY

CAES IAPP performed the first detailed survey of Crystal Lake in August 2004 (Figure 4). Four native species; Ceratophyllum demersum, Eleocharis acicularis, Elodea canadensis (identification change to E. nuttallii in 2006-2008), and Potamogeton robbinsii were recorded along with the invasive species; Potamogeton crispus and Myriophyllum spicatum. After the herbicide treatment in August 2007, the survey was repeated and four additional native species were found; Gratiola aurea, Najas flexilis, Potamogeton bicupulatus, and Potamogeton gramineus (Figure 4). One invasive species, M. spicatum was not present, while P. crispus remained and a new invasive species, Najas minor, was found. The disappearance of M. spicatum was unexpected as this plant is known to survive applications of contact herbicide by regrowth from a strong root system. Samples of plants resembling Potamogeton vaseyi were obtained but all samples were identified as a similar native plant P. bicupulatus (Figure 4). Our survey in 2008 (Figure 4) found all the plants present in the 2007 survey plus the native species Isoetes sp. M. spicatum returned in low abundance to a few locations in the shallow cove in the southwest portion of the lake. The increase in species richness from 8 species in 2006 to 12 species in 2008 may be the result of the herbicide reducing competition from the invasive species.

TRANSECTS

Trends for transects were similar to those in the general surveys (Table 2). In 2004, four native and two invasive species were found. Ceratophyllum demersum was the most frequently observed native species being found on 20 of the 36 transect points. The other three native species; Eleocharis acicularis, Elodea nuttallii, and Potamogeton robbinsii. occurred on only 12 transect points. The invasive species, Potamogeton crispus and Myriophyllum spicatum were the most frequently observed plants. They occurred on 22 and 21 transect points, respectively. After the herbicide treatment in 2007, the frequency of all native species, with the exception of Elodea nuttallii, was reduced. By 2008, however, Ceratophyllum demersum, Eleocharis acicularis, Gratiola aurea, Isoetes sp., Ludwigia palustris, and Potamogeton pusillus, had rebounded to levels greater than prior to treatment in 2004. The two native species that did not rebound to pretreatment levels were Elodea nuttallii and Potamogeton robbinsii (data contradicts georeferenced grid below). The frequency of two invasive species increased in 2008. Najas minor was not found in 2004 but was found on 8 transect points in 2008. Potamogeton crispus increased from a frequency of 6 in 2004 to 27 in 2008. This dramatic increase is likely due in

part to transect data being taken in September in 2008 compared to August in 2004. P. crispus is known to begin it's growth from turions in late August. The subjective abundance ranking generally followed the trends in frequency.

GEOREFERENCED GRID

Our data from the georeferenced grid provide the most detailed look at effects of the herbicide treatment on the plant community in Crystal Lake (Figures 5, 6, 7, Table 3). Because Potamogeton crispus is most prolific in the spring and declines by summer, the spring data are used here to describe it's frequency and abundance unless otherwise noted. The summer data will be used for all other plants because growth of these plants generally peak at this time. Potamogeton crispus was the most frequently observed plant in 2006 and 2008 with 160 (76% of all points) and 123 (58%) occurrences respectively. No P. crispus occurred after the herbicide treatment in spring 2007, but by summer 2007 it was found at 30 grid points (27%). By spring 2008, P. crispus had recovered to a frequency of 123 grid points (58%). This constitutes a reduction of only 18 percent from pretreatment levels and contradicts evidence of long term control with spring treatments put forth by Poovey et al. (2002). Myriophyllum spicatum was the next most frequently found plant, occurring at 37 grid points (19 %) in 2006. The Diquat application eliminated M. spicatum in 2007 and only three occurrences were observed in 2008. Exceptional control of M. spicatum was not expected as Diquat is not systemic and its effects on its perennial root system should have been minimal (Aquatic Ecosystem Restoration Foundation, 2005). Without good root control plants can quickly grow back. Najas minor showed an increase from four (2%) occurrences in 2006 to 14 (7%) in 2007 and 44 (20%) in 2008. This is an annual plant that reproduces by seed and is capable of rapid expansion particularly if existing vegetation is disturbed. Ceratophyllum demersum was the most frequent native plant being found 46 (23%), 38 (18%) and 102 (48%) points in 2006, 2007, and 2008 respectively. The 2008 increase in C. demersum may be due to its lack of a root system and ability to rapidly populate areas where other plants were controlled. Other native species such as Eleocharis acicularis, Elodea nuttallii, Gratiola aurea, Potamogeton pusillus and Potamogeton robbinsii showed frequency increases from 2006 to 2008. The increase in P. robbinsii was most dramatic, with only 3 occurrences (2%) in 2006, 24 (11%) in 2007 and 43 (20%) in 2008. Decreased competition from invasive species may partially explain this phenomenon. Najas flexilis declined from a frequency of 11 (6%) in 2006, to 6 (3%) in 2007, and 2 (1%) in 2008. A shift from N. flexilis to N. minor is likely. The mean dry weights of the plant taken from the grid points generally followed the same pattern as the frequency.

Table 2. Frequency and abundance of plant species on transects in Crystal Lake.

Scientific Name	Common Name	Frequency (Abundance) 2004	2007	2008
Ceratophyllum demersum	Coontail	20(2.8)	13(1.5)	20(3.0)
Eleocharis acicularis	Spikerush	1(3.0)	1(1.0)	3(2.7)
Elodea nuttallii	Waterweed	5(3.0)	0	1(1.0)
Gratiola aurea	Golden hedge-hyssop	0	0	2(2.0)
Isoetes sp.	Quillwort	0	0	1(1.0)
Ludwigia palustrus	Marsh primrose-willow	0	0	3(2.5)
*Myriophyllum spicatum**	Eurasian watermilfoil	21(1.3)	0	0
*Najas minor**	Brittle waternymph	0	2(2.0)	8(2.4)
*Nymphaea odorata***	White water lily	0	0	0
*Potamogeton bicupulatus***	Snailseed pondweed	0	0	0
*Potamogeton crispus**	Curly leaf pondweed	6(1.7)	9 (1.1)	27(2.3)
*Potamogeton gramineus***	Variable leaf pondweed	0	0	0
Potamogeton pusillus	Small Pondweed	0	0	2(1.0)
Potamogeton robbinsii	Robins Pondweed	22(2.9)	2 (2.0)	7(2.3)
*Potamogeton vaseyi****	Vasey's pondweed	0	0	0
*Stuckinia pectinatus***	Sago pondweed	0	0	0

*Invasive plant
**Not found on transects but observed in lake by CAES
***Not found on transects but observed in lake by CTDEP.

Table 3. Frequency and abundance of plant species on georeferenced grid in Crystal Lake.

Scientific Name	Common Name	Frequency (mean dry wt) Spring 2006	Spring 2007	Spring 2008	Summer 2006	Summer 2007	Summer 2008
Ceratophyllum demersum	Coontail	10(0.9)	16(3.6)	19(0.7)	46(4.8)	38(3.3)	102(11.8)
Eleocharis acicularis	Spikerush	0	0	0	0	0	5(2.1)
Elodea nuttallii	Waterweed	5(2.4)	1(0.3)	0	5(0.8)	1(2.0)	11(5.3)
Gratiola aurea	Golden hedge-hyssop	3(0.5)	1(2.0)	0	2(0.5)	3(0.3)	3(0.4)
*Isoetes sp.***	Quillwort	0	0	0	0	0	0
*Ludwigia palustrus***	Marsh primrose-willow	0	0	0	0	0	0
*Myriophyllum spicatum**	Eurasian watermilfoil	24(1.3)	0	0	37(3.6)	0	3(7.8)
Najas flexilis	Nodding waternymph	0	0	1(0.6)	11(6.9)	6(1.4)	2(0.9)
*Najas minor**	Brittle waternymph	0	0	0	4(1.0)	14(2.9)	43(2.6)
*Nymphaea odorata***	White water lily	0	0	0	0	0	0
Potamogeton bicupulatus	Snailseed pondweed	0	0	2	0	2(3)	0
*Potamogeton crispus**	Curly leaf pondweed	160(7.6)	0	123(19.3)	9(1.2)	27(0.6)	106(7.1)
*Potamogeton gramineus***	Variable leaf pondweed	0	0	0	0	0	0
Potamogeton pusillus	Small Pondweed	0	0	0	0	0	6(1.4)
Potamogeton robbinsii	Robins Pondweed	3(0.2)	6 (5.7)	4 (0.4)	3(4.1)	24(2.0)	43(7.8)
*Potamogeton vaseyi****	Vasey's pondweed	0	0	0	0	0	0
Stuckinia pectinatus	Sago pondweed	0	0	2(4.4)	0	0	0

*Invasive plant
**Not found on georeferenced grid but observed in lake by CAES
***Not found on georeferenced grid but observed in lake by CTDEP.

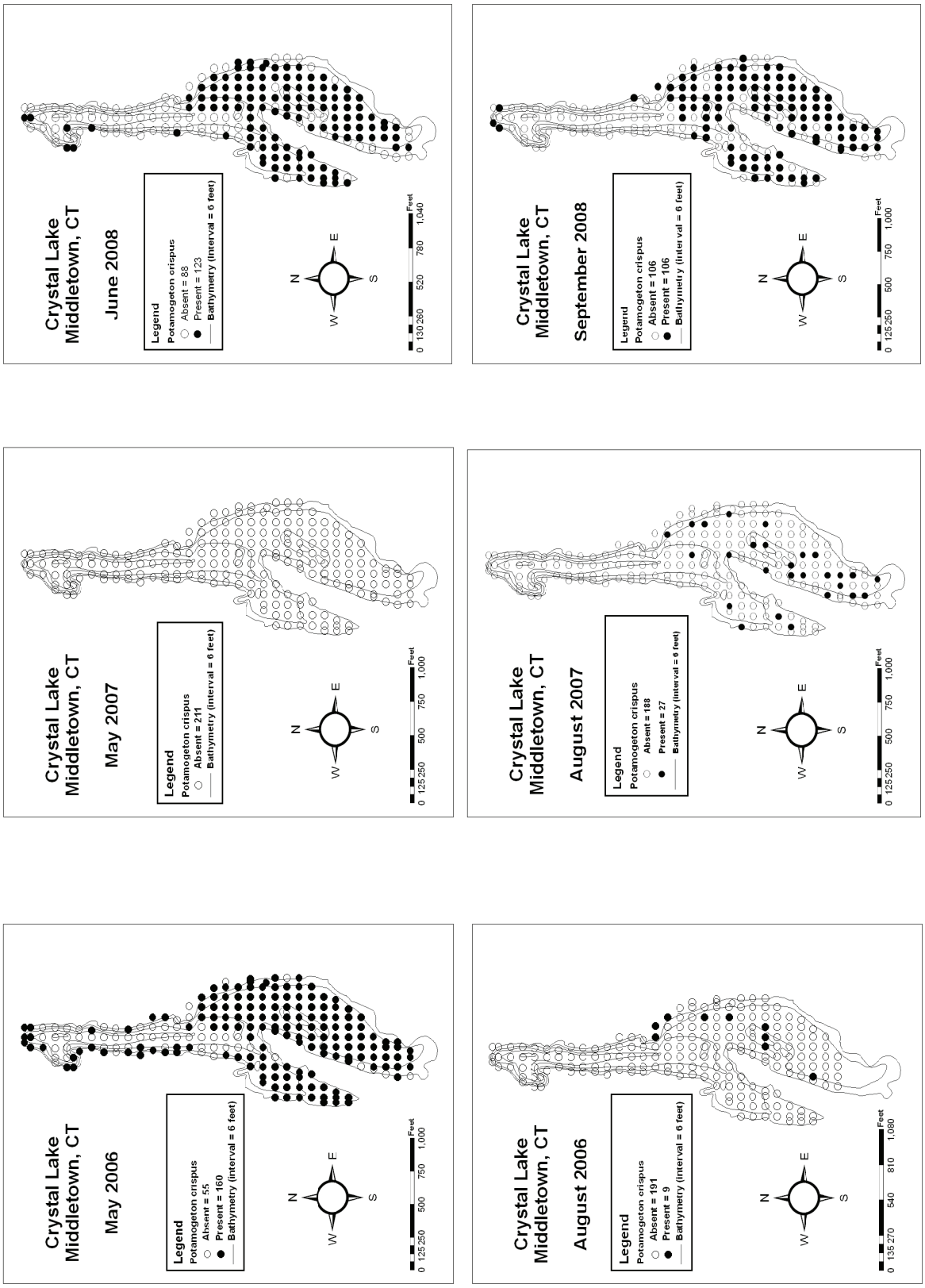

Figure 5. Presences or absence of *Potamogeton crispus* on georeferenced grid points in Crystal Lake.

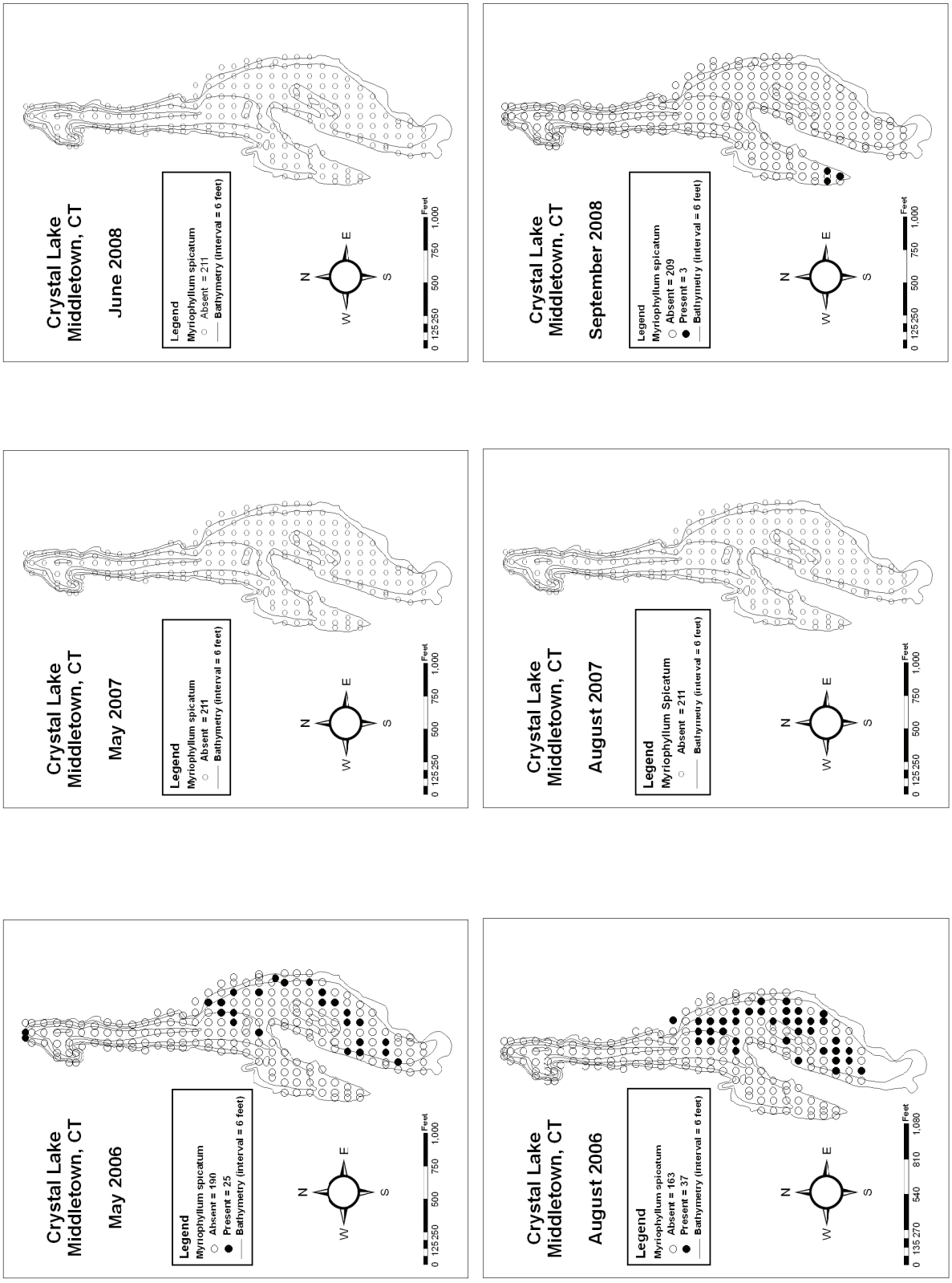

Figure 6. Presences or absence of *Myriophyllum spicatum* on georeferenced grid points in Crystal Lake.

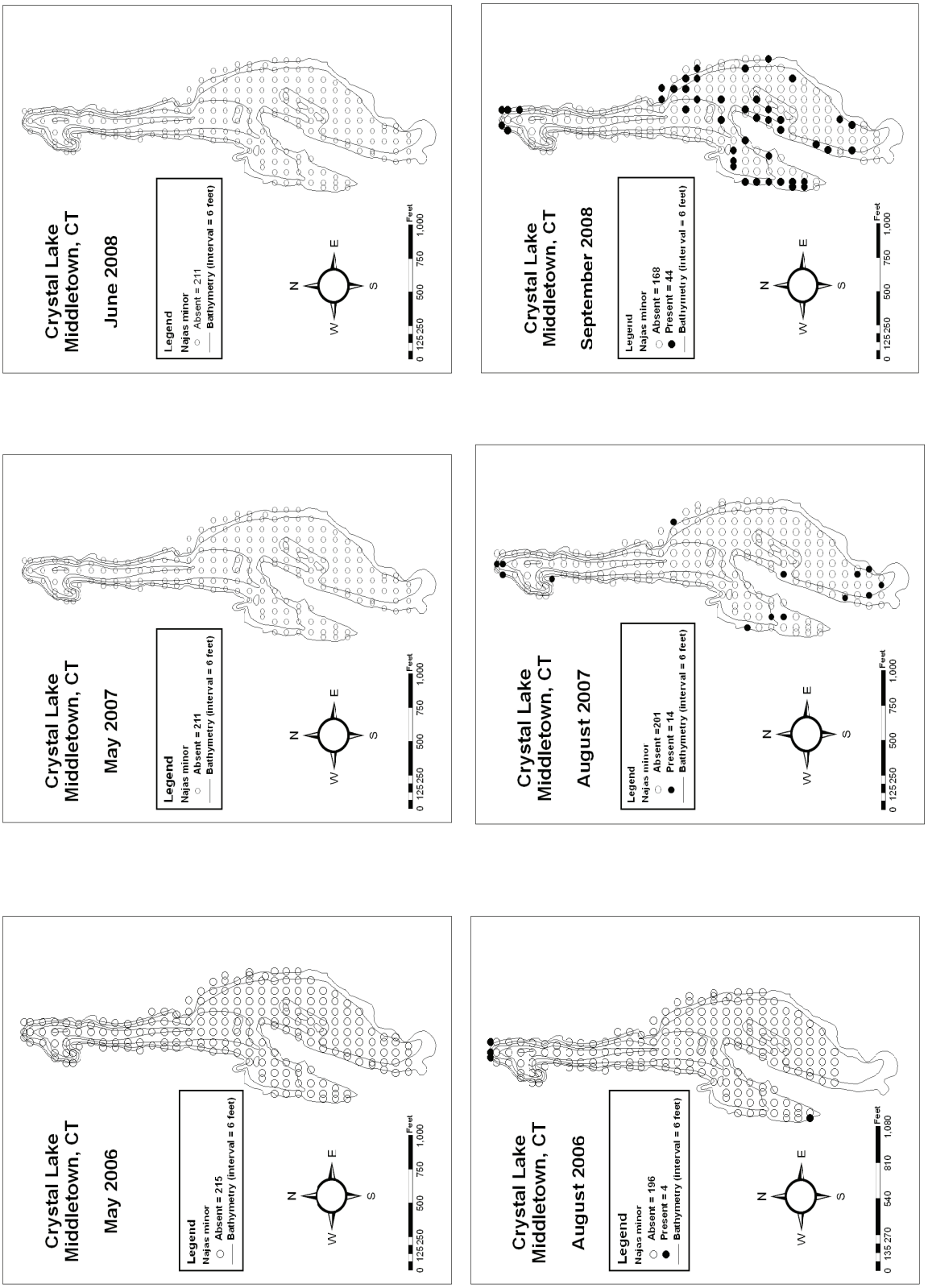

Figure 7. Presences or absence of *Najas minor* on georeferenced grid points in Crystal Lake.

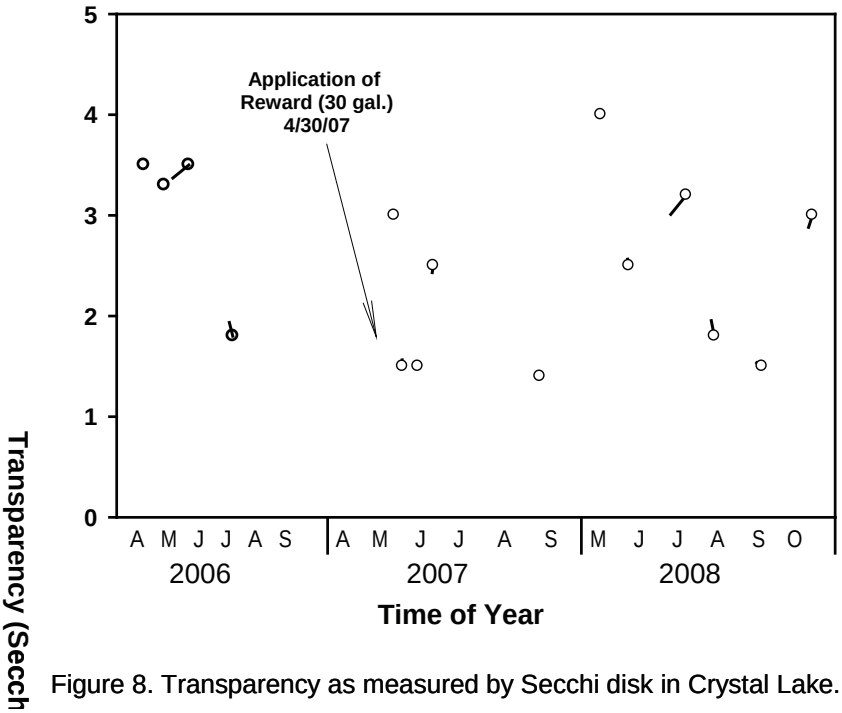

Figure 8. Transparency as measured by Secchi disk in Crystal Lake.

PRESENCE OF PROTECTED PLANT SPECIES

Potamogeton vaseyi is listed as an endangered species by the CT DEP (CTDEP, 2004). It's presence was confirmed by Nancy Murray, a biologist from the CT DEP, with samples taken on August 10, 2006. Two of the samples were mounted and placed in the George Safford Torrey Herbarium at the University of Connecticut in Storrs. Areas where these plants were found are off the southwest side of the southern island and northwest edge of the town beach (Figure 2). The limnobarriers apparently protected the plants, as a revisit by Nancy Murray during the summer of 2007 found P. vaseyi growing within one or both limnobarriered areas (Nancy Murray, personal communication 1/8/09). CAES did not find P. vaseyi during it's surveys but did find two similar plants; Potamogeton bicupulatus and Potamogeton pussillius. Sites where we found P. bicupulatus are shown in Figure 4. A plant from each site is mounted in the CAES herbarium. CAES obtained the 2007 CT DEP Potamogeton vaseyi samples from the UCONN herbarium via inter-herbarium loan and compared them with the P bicupulatus and P. pusillus specimens found by CAES. The CT DEP plants appeared to be slightly different, having slightly narrower foliage and no floating leaves. We could not determine, however, if the CAES and CT DEP plants were different with certainty. We must, therefore, defer issues regarding the presence of Potamogeton vaseyi to the CT DEP.

WATER CHEMISTRY

Water transparency ranged between 1.5 and 4 meters from 2006 to 2008 (Figure 8). Mean transparency was 3.0 m in 2006, 2.4 m in 2007 and 2.8 m in 2008. Given the large fluctuations in transparency in each year (standard deviation of 0.8, 1.1 m and 1.1 respectively), changes in water clarity caused by the herbicide treatment are not substantiated. Other water chemistry measurements (Figure 9) show the Diquat treatment was made to relatively non-thermally stratified water of near 15 C° and thus little stratification of the chemical would be expected. Dissolved oxygen followed expected trends of highest in the early spring and fall and lowest in the bottom water in midsummer. Any reductions in dissolved oxygen caused by the herbicide treatment were minimal. Water pH ranged between 6.2 and 9.4 with highest levels in the spring. Alkalinity was slightly lower in the treatment year (15-21 mg/L $CaCO_3$) compared to the non-treatment years (18-43 mg/L $CaCO_3$). Total P, was highest in the bottom water, where it ranged from 4 to 42 ug/L. The herbicide treatment appeared to have little effect on total P. Conductivity ranged from 65 to 102 us/cm in the surface water and 63 to 155 us/cm in the bottom water. As with the other chemical properties discussed here, little differences in conductivity could be shown before and after treatment

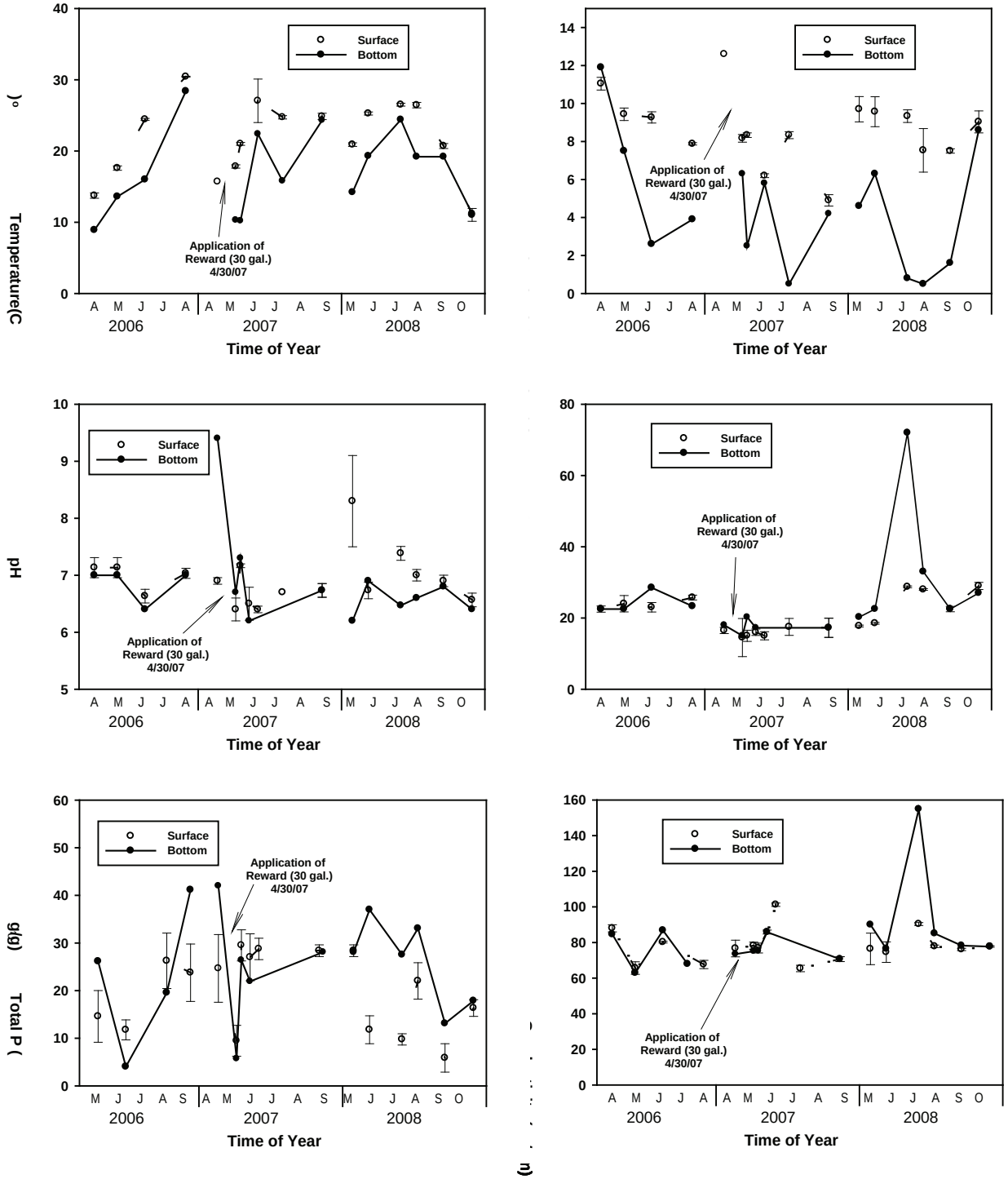

Figure 9. Water chemistry in Crystal Lake 2006 -2008. Error bars equal one standard error of the mean for surface water only.

CONCLUSIONS:

Early season application of Reward (Diquat dibromide) to Potamogeton crispus in Crystal Lake will give control in the application year but little thereafter. Applying the herbicides in several consecutive years may give long-term control if the turion bank is depleted. The possible necessity to utilize limnobarriers each time may make this option impractical. If herbicides are not used, mechanical removal may be an option (McComas and Stuckert, 2000). Control of Myriophyllum spicatum appears more promising, as little regrowth occurred in the follow-up year. Increases in Najas minor could be related to the herbicide application. Native species will be slightly reduced in the treatment year but will rebound to at least pretreatment levels in the follow-up year. Potamogeton vaseyi was protected by the limnobarriers and may be protected, as was most other native species, by applying the herbicide in early spring. The herbicide treatment will not cause significant changes in water transparency or chemistry.

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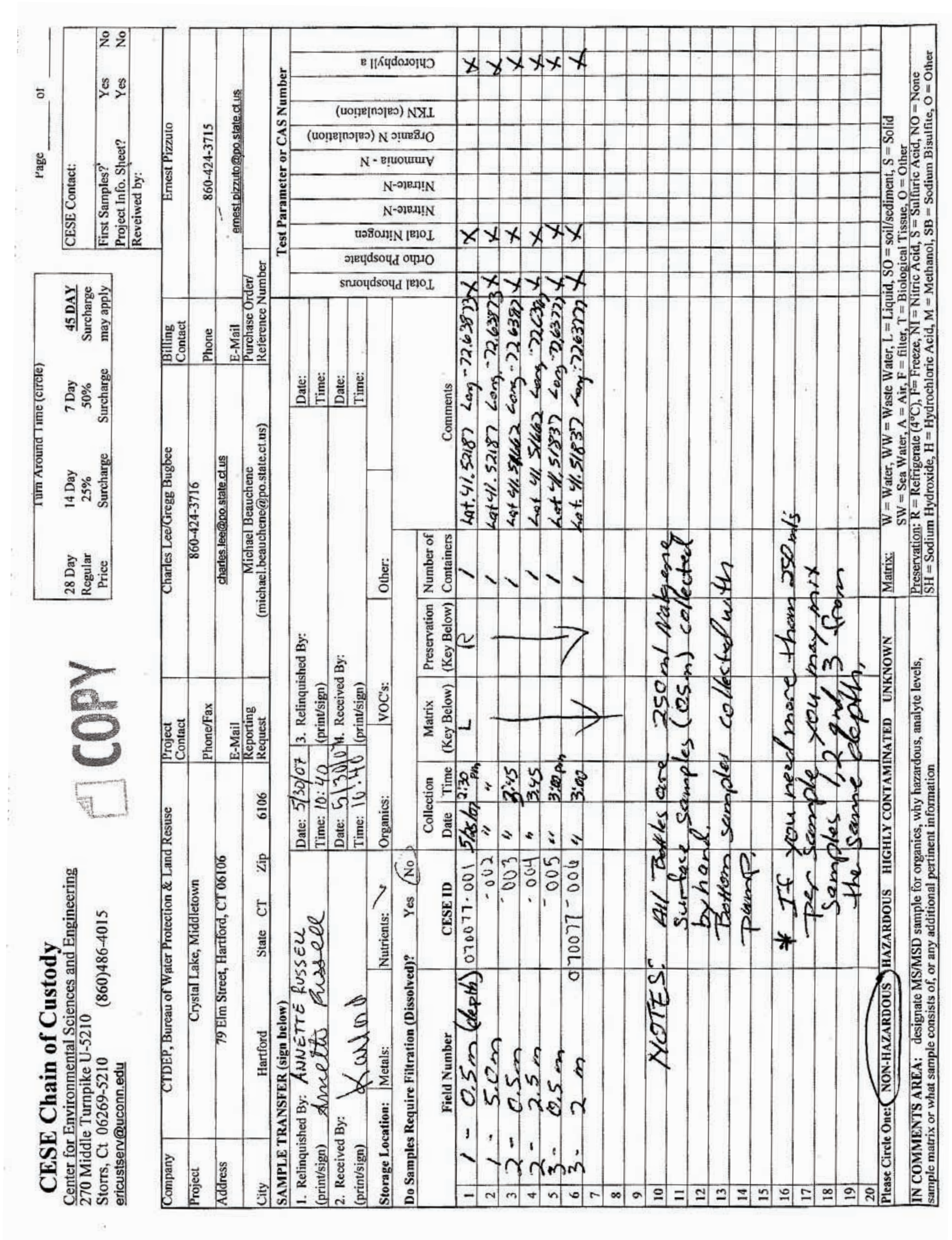
Poovey, A.G., J.G. Skogerboe, and C.S. Owens. 2002. Spring Treatments of Diquat and Endothall for Curlyleaf pondweed control. J. Aquat. Plant Manage. 40:63-67.

APPENDIX:
WATER SAMPLE CHAIN OF CUSTODY FORM



CESE Chain of Custody
Center for Environmental Sciences and Engineering
270 Middle Turnpike U-5210
Storrs, Ct 06269-5210 (860)486-4015
ericustserv@uconn.edu

COPY

Turn Around Time (circle): 28 Day Regular Price | 14 Day 25% Surcharge | 7 Day 50% Surcharge | **45 DAY** Surcharge may apply

Page ___ of ___

CESE Contact:
First Samples? Yes No
Project Info. Sheet? Yes No
Reveiwed by:

Company	CTDEP, Bureau of Water Protection & Land Resuse	Project Contact	Charles Lee/Gregg Bugbee	Billing Contact	Ernest Pizzuto
Project	Crystal Lake, Middletown	Phone/Fax	860-424-3716	Phone	860-424-3715
Address	79 Elm Street, Hartford, CT 06106	E-Mail	charles.lee@po.state.ct.us	E-Mail	ernest.pizzuto@po.state.ct.us
City	Hartford State CT Zip 6106	Reporting Request	Michael Beauchene (michael.beauchene@po.state.ct.us)	Purchase Order/ Reference Number	

SAMPLE TRANSFER (sign below)
1. Relinquished By: (print/sign) ANNETTE RUSSELL / Annette Russell — Date: 5/30/07 Time: 10:40
3. Relinquished By: (print/sign) — Date: Time:
2. Received By: (print/sign) Kurland — Date: 5/30/07 Time: 10:40
4. Received By: (print/sign) — Date: Time:

Storage Location: Metals: Nutrients: ✓ Organics: VOC's: Other:

Do Samples Require Filtration (Dissolved)? Yes (No)

Test Parameter or CAS Number

	Field Number	CESE ID	Collection Date	Collection Time	Matrix (Key Below)	Preservation (Key Below)	Number of Containers	Comments	Total Phosphorus	Ortho Phosphate	Total Nitrogen	Nitrate-N	Nitrate-N	Ammonia - N	Organic N (calculation)	TKN (calculation)		Chlorophyll a	
1	1 - 0.5m (depth)	070077-001	5/25/07	2:30 pm	L	R	1	Lat. 41.52187 Long -72.63873	X		X							X	
2	1 - 5.0m	-002	"	"	↓	↓	1	Lat 41.52187 Long -72.63873	X		X							X	
3	2 - 0.5m	-003	"	3:45			1	Lat 41.5[illegible]1662 Long -72.63[illegible]	X		X							X	
4	2 - 2.5m	-004	"	3:45			1	Lat 41.51662 Long -72.63[illegible]	X		X							X	
5	3 - 0.5m	-005	"	3:00 pm			1	Lat 41.51837 Long -72.637[illegible]	X		X							X	
6	3 - 2 m	070077-006	"	3:00			1	Lat. 41.51837 Long -72.637[illegible]	X		X							X	
7																			
8																			
9																			
10	NOTES: All Bottles are 250 ml Nalgene																		
11	Surface samples (0.5 m) collected																		
12	by hand.																		
13	Bottom samples collected with																		
14	pump.																		
15																			
16	* If you need more than 250 ml's																		
17	per sample you may mix																		
18	samples 1, 2 and 3 from																		
19	the same depth.																		
20																			

Please Circle One: (NON-HAZARDOUS) HAZARDOUS HIGHLY CONTAMINATED UNKNOWN

Matrix: W = Water, WW = Waste Water, L = Liquid, SO = soil/sediment, S = Solid, SW = Sea Water, A = Air, F = filter, T = Biological Tissue, O = Other

Preservation: R = Refrigerate (4°C), F= Freeze, NI = Nitric Acid, S = Sulfuric Acid, NO = None, SH = Sodium Hydroxide, H = Hydrochloric Acid, M = Methanol, SB = Sodium Bisulfite, O = Other

IN COMMENTS AREA: designate MS/MSD sample for organics, why hazardous, analyte levels, sample matrix or what sample consists of, or any additional pertinent information

HERBICIDE APPLICATION PERMIT

Crow, G.E., and Hellquist, C.B. 2000b. Aquatic and Wetland Plants of Northeastern North America. Vol. 2. Angiosperms: Monocotyledons. University of Wisconsin Press, Madison.

04/18/07 15:48 FAX 860 424 4060 DEP WASTE BUREAU CHIEF 002/005

PAGE: 1 OF 3
RUN DATE: 18-APR-2007

STATE OF CONNECTICUT
DEPARTMENT OF ENVIRONMENTAL PROTECTION

CITY OF MIDDLETOWN
319 BUTTERNUT ST
MIDDLETOWN CT 06457-

1. This permit is hereby issued pursuant to Section 22a-66z of the General Statutes, and regulations adopted thereunder.
2. This permit 07147 is issued to: CITY OF MIDDLETOWN
of 319 BUTTERNUT ST
MIDDLETOWN CT 06457-
3. This permit authorizes the application of chemicals at the property owned by:
STATE OF CONNECTICUT, DEPT. OF ENVIRONMENTAL PROTECTION
located at: LIVINGSTON ROAD MIDDLETOWN
4. This permit authorizes the application of chemicals by CITY OF MIDDLETOWN .
5. This permit is issued on 18-APR-2007 and will expire on 31-DEC-2007 .
6. This permit is subject to the following conditions:
a. Permittee may apply the following chemicals to CYRSTAL LAKE GIS No.- 13946

Chemical	Amount of chemical	Times Applied
Reward	60 gallons	1
Copper Sulfate	150 pounds	2

b. Permittee may conduct the application described in paragraph 6a at least 30 DAYS apart, no more than the number of times specified above, and prior to 31-DEC-07 .
c. The permittee shall follow all restrictions and directions as instructed on the chemical label.

d. The permittee shall also adhere to the following specific conditions:

CYRSTAL LAKE
SEE ATTACHED:

e. For any permit to apply chemicals on a lake or pond with any public access owned by the state or a municipality: The permittee shall, prior to any chemical application authorized by this permit, publish notice of such application and post signs in accordance with Section 22a-66a(h) of the Connecticut General Statutes and regulations adopted thereunder.

For any permit to apply chemicals to a private lake or pond having more than one owner of shoreline property: The permittee shall, prior to any chemical application authorized by this permit, publish notice of such application in accordance with Section 22a-66a(h) of the Connecticut General Statutes and regulations adopted thereunder.

f. In evaluating the application for this permit and any other document submitted pursuant to this permit, DEP relies on information and data provided by the applicant and on the applicant's representations. If such information proves to be false, deceptive, incomplete or inaccurate, this permit may be modified, suspended or revoked in accordance with Section 22a-3a-5(d) of the Regulations of Connecticut State Agencies, and any unauthorized activities may be subject to enforcement action.

g. Any document which is required to be submitted by the permittee to DEP under this permit shall be signed by the permittee and by the individual or individuals responsible for actually preparing such document, each of whom shall certify in writing as follows:

"I have personally examined and am familiar with the information submitted in this document and all attachments thereto, and I certify that based on reasonable investigation, including my inquiry of those individuals responsible for obtaining the information, the submitted information is true, accurate and complete to the best of my knowledge and belief. I understand that any false statement made in the submitted information may be punishable as a criminal offense, in accordance with Section 22a-6 of the General Statutes, pursuant to Section 53a-157b of the General Statutes, and in accordance with any other applicable statute."

h. Issuance of this permit does not relieve the permittee of the obligation to obtain any other authorizations required by applicable federal, state and local law.

04/18/07 15:49 FAX 860 424 4060 DEP WASTE BUREAU CHIEF ☑005/005

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i. This permit is subject to and does not derogate any present or future rights or powers of the State of Connecticut and conveys no rights in real or personal property nor any exclusive privileges, and is subject to any and all public and private rights and to any federal, state or local laws pertinent to the property or activity affected by such permit.

j. This permit shall be signed below by the registered pesticide dealer at the time of chemical purchase. Once signed, this permit is invalid for further purchase of chemicals.

18-APR-2007
Date of Permit Issuance

Robert C. Isner, Director
Waste Engineering & Enforcement Division

07147
Permit Number

Date of Chemical Purchase

Signature of Registered Pesticide Dealer

Please cut along dotted line:

CYRSTAL LAKE:

To protect state-listed rare plants, Limno-barriers will be installed based on map showing locations and dated April 2, 2007. Any modifications to the locations of the limno-barrier will need to be approved by DEP. No herbicide will be applied within a 10-foot buffer zone around the limno-barrier to ensure protection of state listed plants.

The limno-barrier will need to be installed according to manufacturer's specifications, by someone who has had experience doing such installations and shall remain in place for 10 days after the application of herbicide.

A detailed survey will be done 1 to 2 weeks after herbicide application to determine the condition of *Potamogeton vaseyi*, and another survey done in early to mid July so we can evaluate the status of *Potamogeton vaseyi*. Special Plant Reporting Forms will need to filled out and submitted to DEP-Nancy Murray within one week from the monitoring date.

A pre-treatment vegetation survey shall be conducted in 2007 and a post treatment survey shall be conducted during the period of peak curlyleaf coverage (first two weeks of June). A second post treatment survey should try to replicate the date of the 2004 CAES survey to the greatest extent practicable.

The following limnological information shall be provided: dissolved oxygen and temperature profiles, and secchi disk readings. Water Samples shall be taken and delivered to the DEP for water chemistry analyses including total phosphorus, nitrogen series and chlorophyll-a. Such readings and samples shall be taken twice after the treatment. One sampling event should be about three weeks to one month after treatment and the other during August.

If the lake is treated within 2 weeks of the use of the McCutcheon Park well, a sample of the well water shall be taken between 1 and 2 weeks after application, and analyzed for diquat by a state-certified laboratory. The applicant shall report the results to the DEP within 1 week after receipt. The applicant is responsible for any remedial activities should the well be contaminated by the herbicide.

The label for diquat products, including Reward, requires treating no more than half the lake at a time, with a 2 week waiting time required before treating the second half. The label also limits the use rate to 1 gallon per acre in areas where the depth is lees than 2 feet.

NOTES