NEE environmental consulting

Rogers Lake Non-Chemical and Chemical Vegetative Control Assessment and Options

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Prepared for;

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TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY 3
2.0 INTRODUCTION 4
3.0 SUMMARY OF FINDINGS 4
3.1 Plant Survey 4
3.2 Herbicide Impact Assessment on Human Health 5
3.3 Domestic Well Impact Evaluation 6
3.4 Wildlife Impact Evaluation 7
4.0 INVASIVE SPECIES MANAGEMENT OPTIONS 8
4.1 Mechanical Management Options 8
4.1.1 Hand Pulling/DASH 9
4.1.2 Harvesting – Plant Harvester 9
4.1.3 Hydroraking 9
4.1.4 Benthic Barrier/Shading 10
4.1.5 Dredging 11
4.2 Biological Management Options 11
4.2.1 Milfoil Weevil 11
4.2.2 Grass Carp 12
4.3 Chemical Management Options 13
4.3.1 2,4 - D 14
4.3.2 Carfentrazone 14
4.3.3 Diquat 15
4.3.4 Endothall 15
4.3.5 Fluridone 16
4.3.6 Flumioxazone 17
4.3.7 Triclopyr 18
4.4 Management Matrix 19
5.0 BREAKDOWN BY VARIABLE 20
6.0 CONCLUSION 21
7.0 REFERENCES 22
8.0 FIGURES 23

1.0 EXECUTIVE SUMMARY

The Towns of Lyme and Old Lyme, CT have experienced a problematic invasive species infestation in Rogers Lake for many years. An overgrowth of variable-leaf milfoil (*Myriophyllum heterophyllum)* fanwort (*Cabomba caroliniana*) and lily species have decreased accessibility and recreational use in Rogers Lake. New England Environmental, Inc. (NEE) conducted an investigation to assess possible management options along with their respective possible impact on environmental and human health of Rogers Lake and the surrounding community. A qualitative and quantitative plant study revealed that while the extent of invasive infestation is widespread, there has not been a drastic increase in density or population over the past four years. Knowledge that invasive populations are relatively stable allows us to consider a multitude of management strategies: mechanical, biological and chemical. After all possible management options were identified, an assessment of herbicide impact on human health was conducted to evaluate the human health risks associated with chemical management options. It was discovered that with the high level of regulation from State, Federal and local government, including the Connecticut Department of Public Health (CTDPH), human and environmental health are the main priority when applying chemicals. Furthermore, the United States Environmental Protection Agency (EPA) classified each of the three studied chemicals among the least toxic classifications. Even with this information, NEE conducted a domestic well impact evaluation, which revealed that it would be nearly impossible for water from Rogers Lake to be pumped into private and public drinking water wells around the lake. Finally, NEE conducted a wildlife impact evaluation to identify all wildlife habitat currently available in Rogers Lake and discover if any management options could possibility negatively impact any of those habitats. Very little disturbance to habitat by target species management was discovered through this study.

The abovementioned studies all form one conclusion: each management option should be considered based on efficacy and affordability due to the relatively low level of human and environmental health impact. After analyzing each possible management option, it is the opinion of NEE that applications of Flumioxazin (an herbicide) is the optimal management option for reducing the presence of the target invasive species, variable-leaf milfoil and fanwort, and selective (only in specific areas) hydroraking is the best option for all nuisance lily and watershield species.

2.0 INTRODUCTION

The residents of Rogers Lake in Lyme and Old Lyme, Connecticut have been struggling with an over population of various water lily species as well as two invasive species for the past 13 years. In the past four years, these nuisance species have heavily impacted recreational use and access to Rogers Lake. The invasive species in question are variable-leaf milfoil (*Myriophyllum heterophyllum)* and fanwort (*Cabomba caroliniana*), which have not decreased in density regardless of past control attempts. At the request of the Towns, New England Environmental, Inc. (NEE) has conducted an investigation to determine the current condition of Rogers Lake as well as ascertain plausible invasive species control measures. The studies included in NEE's investigation include a plant survey, an herbicide impact on human health assessment, a domestic well impact evaluation and a wildlife impact evaluation. The following report reviews the findings of all completed studies and their respective impact on invasive species control options.

3.0 SUMMARY OF FINDINGS

3.1 Plant Survey

Mark June-Wells of All Habitat Services, LLC (at the time of this study) conducted a comprehensive vegetative survey of Rogers Lake during the week of August 17, 2014. June-Wells discovered 27 aquatic plant species within the lake, ranking Rogers Lake as one of the most highly diverse lakes in The State of Connecticut in terms of plant species. The dominant plant species found in the lake is southern naiad (*Najas guadalupensis*), a common native aquatic plant species throughout the United States.

June-Wells's survey identified two non-native, invasive species in Rogers Lake: variable-leaf milfoil and fanwort. These two non-native plants are present in high density in approximately 31 acres or 32% of the littoral zone, (the specific range of depth where plants thrive). The littoral zone encompasses 36.15% of the total lake body. Fanwort and variable-leaf milfoil account for only 4.14% and 8.29% of the total plant community respectively, but their cover is extensive. Figure 1 outlines the areas where fanwort and variable-leaf milfoil were found in Rogers Lake. The two invasive species are mostly concentrated at the southern tip of the lake, near the town beach, and along the banks in the center of the lake, near the boat launch as well as areas around the islands. If variable-leaf milfoil and fanwort continue to spread, they will dominate the littoral zone and decrease the impressive plant diversity of Rogers Lake.

Plant surveys were also conducted previously in 2002, 2006, 2010 and 2011. It is difficult to compare these sets of data because different individuals conducted different surveys over the years, however using levels of abundance and overall breadth of infestation, a rough comparison can be made. Data from 2010 show variable-leaf milfoil as the vastly dominant species, while in 2011 its dominance decreases and the abundance of southern naiad increases. As stated above, data from 2014 show southern naiad as the dominant species. When comparing percent compositions from 2011 to 2014, there does not appear to be a significant change in fanwort and variable-leaf milfoil abundances. These data show that

native vegetation has continued to thrive, while there has not been a drastic increase in invasive species. It should also be noted that the Towns of Lyme and Old Lyme conducted weed harvesting of variable-leaf milfoil and fanwort in 2012. As mentioned above, this treatment did not diminish the quantities of invasive species within Rogers Lake.

Rogers Lake also contains an abundance of three water lily species (*Nympha odorata, Nuphar variegata* and *Brasenia schreberi*). While these lilies are not invasive species, they comprise 4.66%, 1.55% and 6.22% of the total plant community respectively and negatively impact recreational use in Rogers Lake. Lily density is often coupled with the density of fanwort and variable-leaf milfoil, compounding their impact on lake access and recreational use. Management of the non-native species and selective removal of the lily species will greatly increase access and recreational use of the lake.

3.2 Herbicide Impact Assessment on Human Health

Debbie Listernick, Senior Risk Assessor from O'Reilly, Talbot & Okun Associates, Inc., conducted a literature review of potential human toxicity related to the application of Fluridone, Flumioxazin and Carfentrazone. These three chemicals were chosen because they initially appeared to be the best chemical treatment options for variable-leaf milfoil and fanwort. The two main factors considered when assessing human health risks are (1) the levels of chemical where no effects occur and (2) the levels to which people may be exposed.

All pesticides distributed or sold in the United States must be registered by the United States Environmental Protection Agency (EPA). This registration requires scientific data displaying proof that the chemical will not cause unreasonable risks to human health or the environment when used as directed on product labeling. The EPA reviews each registered pesticide every 15 years and has issued a review for Fluridone, Flumioxazin and Carfentrazone within the last five years.

The State of Connecticut has issued a Memoranda of Agreement (MOA) between the CT Department of Public Health (CTDPH) and the Connecticut Department of Energy & Environmental Protection (CTDEEP) requiring that CTDPH approve all issued permits involving introduction of chemicals into waters of the State in areas tributary to reservoirs, lakes, ponds or streams used for public water supply. All permit applications subject to this MOA shall be reviewed by the commissioner of DEEP. The chemical review process is closely monitored by not only the EPA and CTDEEP but also the CTDPH, keeping environmental and human health a top priority.

Past proposals for chemical use in Rogers Lake have not been received well by residents because of concerns regarding incidental exposure to chemicals after herbicide application. However, it is important to note that EPA Swimmer Exposure Assessment Models (SWIMODEL) conducted for each of the three herbicides examined as part of the registration review program did not show risk for concern at their required application concentrations when assessing exposure pathways including oral ingestion, dermal absorption or inhalation. These studies suggest that there is likely to be little or no risk to residents of Rogers Lake

regarding human health risks associated with swimming, eating fish or drinking water from wells (see also Section 3.3) surrounding Rogers Lake after chemical application.

Specific chemical details from Listernick's findings are outlined in more detail under the corresponding herbicide information section of "Chemical Management Options."

3.3 Domestic Well Impact Evaluation

The aforementioned research has shown that the three most effective chemicals under consideration for treatment in Rogers Lake would be heavily monitored and regulated to insure the absence of harmful human health effects associated with drinking water from private wells around Rogers Lake. However, since chemical application is the management option of most concern to residents, NEE requested a study be completed to evaluate the extent of hydraulic connections between Rogers Lake and surrounding domestic wells. John Hankins of Fuss & O'Neill conducted this investigation to determine the level of risk or impact to these wells if herbicides are applied to the lake. The scope of this investigation is as follows: Fuss & O'Neill conducted a windshield survey of the communities surrounding Rogers Lake, reviewed published resources related to the geology and hydrology of the region, interviewed the Health Directors and Sanitarians of the towns of Lyme and Old Lyme, reviewed available well logs for the surrounding communities and reviewed proposed chemical treatment methods.

After factoring in multiple variables such as physical characteristics of the geological unit, (i.e. particle size), the local topography, the presence of surface water bodies, the depth to bedrock, and the type of aquifer feeding the wells, Fuss & O'Neill determined that the direction of groundwater flow is towards Rogers Lake from all directions, making it a regional groundwater discharge point. The only exception to this is the south and southwest portions near the spillway, where groundwater flow is toward the Mill River outlet stream.

Historical well data and observations by Fuss & O'Neill indicate that most wells surrounding Rogers Lake are relatively shallow, depths of 10 to 20 feet, and generally have a diameter of 30 to 36 inches. These "overburden wells" draw water from the saturated coarse-grained stratified drift aquifer that surrounds the lake, or overburden material. The volume of domestic water use is minimal compared to the production capabilities of this aquifer. Therefore, it would be very unlikely that any overburden wells would be able to draw a sufficient amount of water to reverse the natural direction of groundwater flow toward the lake. The remainder of wells surrounding Rogers Lake are drilled bedrock wells, which are considerably deeper and draw water from water-bearing fractures in the bedrock. These wells are so deep (drawing water directly from the aquifer, below bedrock) that it would be impossible for groundwater from the lake to migrate to these wells. This information, coupled with the knowledge of topography around the lake indicates that it is very unlikely that residential wells would uptake any water from Rogers Lake.

3.4 Wildlife Impact Evaluation

Michelle Ford, Certified Wildlife Biologist (CWB), of New England Environmental, Inc. conducted a wildlife habitat assessment in October of 2014 in order to document existing wildlife habitat within Rogers Lake and discover any possible restrictions or impacts to wildlife habitat across all potential invasive species management options. The habitats observed during this assessment are open water habitat, submerged and floating aquatic vegetation, shoreline habitat, and islands.

Open water areas provide foraging and overwintering habitat for a variety of fish species such as largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), brown bullhead (*Ameiurus nebulosus*), black crappie (*Promosix nigromaculatus*), chain pickerel (E*sox niger*), walleye (*Sander vitreus*), yellow perch (*Perca flavescens*), pumpkinseed (*Lepomis gibbosus*) and bluegill (*Lepomis macroshirus*). Rogers Lake is also stocked each fall with more than 10,000 brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*). Open water habitat is particularly desirable to species that inhabit deeper, cooler waters such as walleye, chain pickerel, trout and bullhead.

Floating aquatic vegetation also supplies habitat for a vast variety of wildlife. NEE identified 25 species of submerged and floating-leaved aquatic vegetation, which produce habitat for a variety of species. The predominant species of floating-leaved vegetation within the lake are variegated pond-lily (*Nuphar variegata*), fragrant water lily (*Nymphaea odorata*) and watershield (*Brasenia schreberi*). These plant species provide valuable above-water perching locations for amphibians such as green frogs (*Lithobates clamitans*) and American bullfrogs (*Lithobates catesbeianus*). High densities of these plants are more conducive to shelter, breeding and foraging for minnows, juvenile fish and juvenile turtles, while lower densities attract larger fish such as largemouth and smallmouth bass because they prefer warmer waters in spring and summer. Snapping turtles (*Chelydra* serpentine) favor the greater depth of organic material along the bottom of the lake for shelter and often hibernate in the mucky shallows in the wintertime. Furthermore, these favorable habitats attract aquatic predators such as the great blue heron (*Ardea herodias*). Lilies provide excellent habitat for numerous species, including those listed above. Although lilies are among the species listed to be managed in Rogers Lake, some lily presence in the lake is invaluable to wildlife prosperity and lilies should only be selectively removed.

The shoreline structure of Rogers Lake is inconsistent and results in fragmented habitat areas. The underdeveloped shoreline areas on the northern portion of the lake provide the most consistent habitat for avian species. Overhanging branches in these areas may also provide shade for fish such as largemouth and smallmouth bass as well as perching locations for piscivorous species such as the belted kingfisher (*Megaceryle alcyon*). Downed trees also provide suitable habitat for fish, reptiles and birds. Birds such as the northern cardinal (*Cardinalis cardinalis*) and blue jay (*Cyanocitta cristata*), which are more adapted to

urban environments, flourish in the developed areas of the lake. These habitat areas should not be affected by any management options.

Islands both increase bank/shoreline habitat and provide foraging and shelter to a wide variety of species, being vegetated with mature deciduous trees and shrub groundcover. Species that may benefit from these islands are not limited to, but include: foxes (*Vulpes vulpes*), white-tailed deer (*Odocoileus virginianus*), common raccoon (*Procyon lotor*), red-eared sliders (*Trachemys scripta elegans*) and eastern painted turtles (*Chrysemys picta*), the northern watersnake (*Nerodia s. sipedon*) and waterfowl such as kingfishers, mallard ducks (*Anas platyrhynchos*) and Canada geese (*Branta canadensis*). These animals may use the islands for foraging, reproduction, nesting, perching and shelter. While there are invasive species surrounding the islands, it is very unlikely that any invasive management will affect island habitat.

4.0 INVASIVE SPECIES MANAGEMENT OPTIONS

4.1 Mechanical Management Options

The following options involve physical removal by hand or by man-operated machines. Mechanical options are very labor intensive, and tend to be more expensive because much more time is needed to control invasive species mechanically than by other measures. There is also higher risk of further spreading invasive species such as variable-leaf milfoil and fanwort through mechanical control means because it is nearly impossible to collect all fragments of uprooted plants. Mechanical management options are also not selective, therefore native species could be unintentionally uprooted or damaged while collecting target species. Conversely, mechanical management options do not require any chemical introduction into the water body, which is often very appealing to residents. Mechanical options can be very effective in managing lily species because they do not fragment or grow back as quickly.

Most mechanical options do not require Connecticut State permits; this is assumed for all below-listed options unless otherwise stipulated. Mechanical options will likely require a local inland wetland permit.

4.1.1 Hand Pulling/DASH

Diver assisted suction harvesting (DASH) is a method in which a diver hand pulls target plants and feeds the plant material into a tube, which pumps the plants onto the boat for storage and removal. This eliminates some spread of fragments. Hand pulling consists of pulling plants by hand and storing them in bags. These bags are then disposed of off-site.

Hand pulling can be conducted on the surface or by a diver. This method is best used for small lakes and ponds because of the energy intensive nature of removal. Therefore these methods can be very costly for large scale invasive species removal. Hand

pulling is not a best management practice for large invasions of stem plants like variable-leaf milfoil *or* fanwort because of inevitable fragmentation during the hand pulling operation and further spread during collection. DASH and hand pulling could be effective on lily species, but not very time efficient.

DASH costs about $15,000.00 per acre of treated area because of the required pumping equipment, while hand pulling costs closer to $12,000.00 per acre. The best time to perform hand pulling and DASH services is during the growing season because this is when plant density is greatest.

4.1.2 Harvesting – Plant Harvester

In the United States, harvesting is the most widely used method of mechanical invasive species management. A plant harvester is a specialized boat that cuts and collects plant material below the water surface. Plants are cut near their base by the harvester, which then loads them onto a conveyor system and delivers the plant to the boat. This plant material is then collected and disposed of off-site. Harvesting presents similar problems to those encountered with hand pulling: fragmentation is likely to occur, causing further spread of the invasive species. Harvesters were initially designed for Eurasian milfoil (*M. spicatum*) control, therefore there is some rationale behind harvesting variable-leaf milfoil. However, this technique only provides temporary clearing of the infested areas, as subsurface rhizomes remain following the harvesting, which will result in the re-growth of vegetation.

Harvesting should take place in the growing season, to optimize populations collected. It is vastly less expensive to harvest plants than it is to hand-pull them; it costs anywhere from $500.00 to $2,500.00 per acre depending on density and species. This is the least expensive mechanical option.

The Towns of Lyme and Old Lyme harvested variable-leaf milfoil and fanwort in 2012 with little to no success.

4.1.3 Hydroraking

While harvesting cuts plants above the sediment, hydroraking attempts to remove the plant roots. Hydroraking involves the use of a specially designed aquatic vehicle called a hydrorake, which is similar to a floating backhoe with a York rake instead of a bucket. Another equipment option used is suspending a large backhoe off of a low-draft boat to remove plant material from the soil. The collected plant material is then stored on shore and disposed of off-site or composted. This method is most often used to clean swimming areas and boat launches. Hydroraking, like the other mechanical options, causes a great deal of fragmentation. This is not an optimal control for stem plants like variable-leaf milfoil or fanwort because of further spread the fragmentation would cause.

Lily species can be very effectively managed by Hydroraking. NEE has performed numerous successful lily management projects through hydroraking. Lily species do not grow back as quickly as the two invasive species found in Rogers Lake. Hydroraking the lily species from specific recreational areas would decrease their numbers enough to greatly improve recreational use while maintaining enough native aquatic vegetation habitat for native reptiles, amphibians and fish in the Rogers Lake.

If hydroraking were to be conducted in Rogers Lake, hydrorakers would need to take care when working, as the majority of areas where lilies are found also contain one or both of the invasive species in question. One option would be to conduct chemical applications to the target invasive species before hydroraking occurs (if a chemical option is chosen). Another option would be to install a fragment barrier (floating silt fence) around the area where the hydroraking would occur in an effort to restrict the displacement or fragmentation of variable-leaf milfoil and fanwort.

Hydroraking usually costs approximately $6,000.00 to $8,000.00 per acre or $175 per hour depending on density and contractor, which is relatively inexpensive compared to other mechanical options. This should take place during the growing season to maximize control effects.

4.1.4 Benthic Barrier/Shading

Benthic barriers are portable panels of porous synthetic fabric. These panels can be placed on the bottom of ponds and lakes to control invasive aquatic plant growth, such as milfoil species. Benthic barriers are usually used to control small infestations. The panels remain out of sight throughout the control time period. They are useful in water too deep for harvesting or where chemical application is not acceptable. Once benthic barriers are installed, an immediate open area of water is created. This could be desirable for areas around boat docks, swimming areas and along shorelines. In situations where invasive species are widespread in larger lakes, benthic barriers can be valuable as part of an integrated weed management strategy.

Unfortunately, benthic barriers are non-selective. All plant species beneath the barriers are affected when covered, however studies have been conducted with eurasian milfoil (*M. spicatum* L.) to pinpoint a timeline that will effectively eliminate milfoil, while removing the barrier early enough to allow regrowth of native plants (Laitala et. Al., 2012). This duration was determined to be eight weeks. There is always the possibility of re-infestation after removal of benthic barriers, which could be eliminated when used as part of an integrated management plan. Benthic barriers also pose a maintenance issue as they often require re-positioning, additional weight placement and can sometimes trap air bubbles underneath them which allows sunlight to reach the plants and subsequently allows growth to continue. This approach is not commonly used to control large infestations.

Benthic barriers do not commonly require extensive permitting but may require a local inland wetland permit. If chosen as a management option, the local commissions would need to be contacted for more information on permitting.

4.1.5 Dredging

Dredging is the physical removal of sediment and rooted plants by excavation. This method can completely remove unwanted species when done correctly but would be difficult to remain selective. Therefore in the process of eliminating the two invasive species, many native species would be eliminated as well. Dredging is not usually used for aquatic weed control due to the extremely high cost associated with the operation of the machinery needed. Dredging can be useful in a setting such as a small pond to eradicate a species such as cattail. If the pond is dredged down deep enough that the water level is above the height of the cattail, it is unlikely that the cattail will grow back. However dredging Rogers Lake may not effectively eradicate submersed species such as variable-leaf milfoil or fanwort. Submersed weeds will most likely still infest the lake following dredging, as appropriate water depths and high water clarity will likely still exist. Dredging would cause significant fragmentation which would lead to re-development of non-native species (milfoil and fanwort) throughout Rogers Lake. In addition the dredging activities would eliminate much of the native vegetation found in the littoral zone of Rogers Lake.

Dredging is extremely difficult and tedious to permit. Permits would be necessary from the local Inland Wetlands Agency, ACOE, CTDEEP 401 Water Quality Certification, and potentially several other permit review submittals to state agencies.

4.2 Biological Management Options

The biological management options of focus are herbivorous insects and fish, namely the milfoil weevil (*Eubrychiopsis lecontei*) and grass carp (*Ctenopharyngodon idella*). These are natural predators of milfoil and fanwort species.

In order to permit the use of these two species as invasive species control, the Towns of Lyme and Old Lyme would need to submit Special Importation and Liberation Permits and the site must be visited and inspected by CTDEEP as well as the Inland Fisheries Division and Habitat Conservation and Enhancement Program.

4.2.1 Milfoil Weevil

The life cycle of the milfoil weevil (*Eurychiopsis lecontei*) is completed in about 30 days. While adults feed on leaves and stems, larvae are stem borers that consume apical meristems. This allows the weevil to moderately decrease plant densities. While ponds and lakes with native weevil populations have displayed lower overall prevalence of milfoil, research studying the value of introducing weevil populations with purchased

insects, as would be the case in Rogers Lake, has been inconclusive (Gettys et. al., 2014). The research conducted by Gettys et. al. suggests that introducing the milfoil weevil into Rogers Lake would likely not be very successful.

Aforementioned use of native populations of milfoil weevil to control specific plant species under optimal conditions has been moderately successful, however the insects have never been used with any degree of success on variable-leaf milfoil. Furthermore, while milfoil weevil specifically targets Eurasian milfoil, the weevil hasn't had much success even in managing this species. Variable-leaf milfoil is not the weevil's preferred food source, therefore there is a high chance that the weevil would affect non-target species.

There are no human health effects associated with the milfoil weevil, and the weevil does not usually carry any disease that would negatively impact native wildlife. Due to restocking, it costs approximately $1,000.00 to $200,000.00 per year to effectively treat with milfoil weevil populations. These prices are extremely variable because they are dependent on how well the weevil adjusts to its new habitat and other extraneous deaths, facilitating the possibility of an unknown number of multiple restocking events. The potential high cost, coupled with the low efficacy of the milfoil weevil, makes it an unfavorable method of invasive control.

4.2.2 Grass Carp

Sterile grass carp are large herbaceous fish that are used for invasive plant management to eliminate the possibility of overgrowth and spread of invasive species. However, the two invasive species in Rogers Lake are not the fish's preferred food source and grass carp may negatively impact water quality. Introduction of grass carp could increase fish waste within Rogers Lake and possibly cause removal of nutrient cycling plant material. The use of grass carp would likely be detrimental to the diverse plant species in Rogers Lake for all of these reasons. There is also always the risk of a new fish population causing or spreading fish disease among native fish, which would decrease the impressive diversity and quantity of fish in Rogers Lake.

A permanent barrier would need to be set up at the spillway to keep the fish from escaping the lake. Additional barriers may also be needed to prevent the Carp from possibly eating native vegetation in other healthy/non-infested bodies of water. The Towns would inevitably need to restock at least every five years due to death or migration, which could be very costly.

Rogers Lake also has historical records of two State-listed species; clasping leaf water horehound (*Lycopus amplectens*) and creeping St. John's wart (*Hypericum adpressum*). Grass carp would inevitably impact these two plants if introduced into the lake. While these two State-listed species were not found during the 2014 plant survey and would mostly be found upland in marshes, (beyond the reach of fish), previous

correspondence between Rogers Lake Authority and CTDEEP regarding the release of grass carp was deemed an impermissible management method. CTDEEP informed the Rogers Lake Authority that due to historical records of these two State-listed shoreline plant species, the CTDEEP will not support the release of grass carp into Rogers Lake. Their approval is necessary to permit the use of grass carp, therefore it is very unlikely this method will be a viable option for management.

While introduction of grass carp may be a more effective biological control method than the milfoil weevil, it is still not an optimal method and would likely not provide the desired results.

4.3 Chemical Management Options

When considering chemical applications there are more factors and concerns than other treatment options, namely human safety. Rogers Lake houses a densely populated residential community with private water wells (both dug and drilled). The aforementioned *Domestic Well Impact Evaluation* study details possible impacts on residents' water supply when applying chemical herbicides.

The primary state permit required is referred to as "Permit Application for Use of Pesticides in State Waters" (DEEP-PEST-APP-200). This is reviewed by and ultimately approved the CTDEEP. A copy of this permit application and additional supporting information must be sent to Town's Inland Wetlands Agencies at the time that the application is submitted to CTDEEP. Local Commissions do not have the authority to unilaterally deny a permit, but CTDEEP does seek their input. A Coastal Consistency Review may be necessary to obtain permits. Lyme and Old Lyme are listed as having land or water defined as "coastal area" according the CGS Section 22a-94 (a). In addition, permitting standards and requirements in Connecticut protect wildlife and human safety. Chemical applications where public and private water supplies exist trigger reviews by both CTDEEP and CTDPH. Any chemical application over 80 acres or 20 miles, (measured linearly), in one year also requires a NPDES permit. A Notice of Intent must be submitted pursuant to the General Permit for Point Source Discharges to Waters of the State. An approval must be granted from the DEEP Water Permitting and Enforcement Division. Currently the infestation of invasive species within Rogers Lake is not over 80 acres. At this time this permit would not be needed, however it could be if the entire littoral zone was treated in one year.

There are many different types of herbicides that effectively control fanwort and variable leaf milfoil, including contact herbicides and systemic herbicides, which are described below. A contact herbicide is an herbicide that only affects those portions of the plant that come in direct contact with the chemical. A systemic herbicide is mobile in plant tissue via the plant's water-conducting system (xylem) or food-transporting vessels (phloem)is absorbed by the leaves and/or roots and then spread throughout the rest of the plant (Small & Broude, 2012).

All chemical information is sourced either from specific herbicide labels or the CTDEEP Pesticides Management Program's Nuisance Aquatic Vegetation Management guidebook unless otherwise sited.

4.3.1 2,4-D (2,4-Dichlorophenoxyacetic Acid)

2,4-D is a systemic herbicide with a half-life ranging from 13 to 40 days and plant death can take up to four to six weeks. It is available in both liquid and granular formulations. While, variable-leaf milfoil and fanwort grow most aggressively by fragmentation and rhizome activity, they do also grow from seed. 2,4-D does not affect seeds that potentially exist in the substrate, therefore applications must be repeated every season for two to three years to ensure sufficient death in the seed bank in Rogers Lake of the target species.

The granular form of the chemical, which most commonly used aquatically, is impregnated on clay granules that resist decomposition in water and sink to the lake bottom. The granules slowly release minute amounts of 2,4-D for up to two years when sitting at the bottom of the lake. 2,4-D is the oldest organic aquatic herbicide approved for use in the United States and made up about 50% of Agent Orange.

2,4-D is commonly used to effectively control milfoil and lily species. However, water bodies treated with 2,4-D may not be used for irrigation purposes for at least seven days or until treated water contains 100 ppb or less of the chemical, due to its toxicity to a wide variety of plants. 2,4-D has been linked to numerous human diseases and disorders including cancer, endocrine disruption, reproductive toxicity, neurotoxicity and kidney/liver damage. For these reasons 2,4-D is regulated under the Safe Drinking Water Act and cannot be permitted for use in a public water supply watershed. 2,4-D is not recommended for application in Rogers Lake because of the aforementioned health effects.

4.3.2 Carfentrazone

Carfentrazone is a post-emergent contact herbicide that effectively controls against a variety of plants including variable-leaf milfoil. Its half-life ranges from three to nine days, meaning the chemical would not persist in the water for very long.

The CTDEEP categorizes Carfentrazone as a "Group 2" chemical for introduction into a public water supply watershed. This means that no applications will be approved if they take place closer than ¼ mile upstream of a distribution reservoir. A distribution reservoir is a reservoir constructed to equalize the supply and demand of the community or is used for treated water and provides supplies in emergency. No such water supplies are found within a ¼ mile downstream of the outlet of Rogers Lake.

The EPA lists Carfentrazone as Category III or IV for human health toxicity, the second least and least toxic classifications respectfully. There is no indication that

Carfentrazone is carcinogenic or mutagenic and all EPA risk assessment model parameters (SWIMODEL) including oral and inhalation exposure through swimming or food consumption were below EPA's level of concern at an application rate of 0.2 lb/acre. Carfentrazone is moderately toxic to rainbow trout (at 16ppm) and to bluegill sunfish (at 2.0ppm).

The efficacy of this herbicide on fanwort has not been well documented or studied in the past, however there are studies that indicate fairly high efficacy with variable-leaf milfoil (Neterland & Glomski, 2007). Carfentrazone does not appear to have any large effect on fanwort, therefore it does not seem to be an ideal herbicide to control invasive species in Rogers Lake.

4.3.3 Diquat

Diquat is a fast-acting non-selective contact herbicide that effectively controls many free-floating and submerged weeds including variable-leaf milfoil. Wide coverage is necessary when applying this chemical. Diquat is considered "broad-spectrum" and therefore kills a wide range of plant species, although susceptibility of different submersed species varies significantly. It is likely that some of the native vegetation in Rogers Lake would be affected by an application of Diquat. Furthermore, Diquat's ability to rapidly kill plant life may lead to oxygen depletion, which can harm or kill fish within the water body and potentially increase algae production if overused in the lake.

Diquat has relatively low toxicity to fish species and is relatively non-toxic to mammals at label application rates. The pesticide label requires that treatments be split so that no more than one half of the water body is treated at one time with at least 14 days between each application.

There are application limitations due to the pH range that Diquat requires: 4.0-8.0. Diquat has a half-life of two to 210 days, depending on seasonal sunlight and depth of water. Diquat is also strongly attracted to, and binds with soil particles and tends to accumulate in soil, which may cause significant issues if Rogers Lake is ever to be permitted for dredging in the future. It only kills plant matter when it makes direct contact with the plant, therefore Diquat is not effective in lakes with muddy water or if plants are covered in silt. Diquat is also not as effective once plant matter has become dense. As both invasive species in Rogers Lake have become very dense, Diquat is not the best option for control.

4.3.4 Endothall

Endothall is a broad spectrum contact herbicide that prevents certain plants from making essential proteins. The half-life of Endothall is five to 10 days and disappears from soil in seven to 21 days. There are many factors, such as density/size of plants, water movement and water temperature, that determine how quickly Endothall works.

In favorable conditions, plants begin to die back within three to five days (Klee, 2014). Endothall is commonly used to treat Eurasian milfoil, but not variable-leaf milfoil or fanwort.

There are multiple formulations of Endothall including granular and liquid. Liquid Endothall is more suitable for large scale applications. It can be sprayed on the water or be injected below the water surface. In general, liquid formulations of Endothall will readily kill fish present in a treatment site. Most product labels recommend no treatment with Hydrothol 191 Endothall where fish are an important resource (as they are in Rogers Lake) or if there is a significant invertebrate and wildlife presence within the lake. The rapid killing nature of this chemical causes the buildup of decaying plant matter, which decreases dissolved oxygen and could harm fish and other lake wildlife.

Endothall may not be permitted for use in a public water supply watershed.

4.3.5 Fluridone

Fluridone is a systemic herbicide that interferes with protein production, leading to damage to chlorophyll and thus compromising photosynthesis. Most formulations of Fluridone, including the formulation best suited for treatment of Rogers Lake (SonarONE), must remain in contact with the plant for 45 to 60 days for effective management. Many Fluridone products require treatment of the entire water column, however there is a new Fluridone product, SonarONE, that does allow treatments of partial areas of lakes. A minimum of 5 acres should be treated for optimal results using SonarONE. Testing would need to be conducted during the treatment period to ensure that the proper amount of herbicide was found within the treatment area.

The half-life for Fluridone is about four to 97 days, therefore additional treatments would likely be necessary to keep up concentrations during the exposure period. Fluridone targets both variable-leaf milfoil and fanwort among other plants and plant death occurs slowly, which decreases the chance of oxygen depletion, but requires a very long contact time of 45 to 90 days.

Fluridone generally has a very low order of toxicity to humans, fish and wildlife. It is registered for use in ponds and other surface waters, including human drinking systems. It can have adverse effects on all submerged plants so extremely low rates of application (8 ppb) must be used for selectivity to remain possible.

The CTDEEP categorizes Fluridone as "Group 2" for introduction into a public water supply watershed. This means that no applications will be approved if they take place closer than ¼ mile upstream of a distribution reservoir. Application is also restricted by CTDEEP within ¼ mile from <u>any</u> drinking water supplies, both surface and well. When these parameters apply, as they do in Rogers Lake, concentrations of the active ingredient Fluridone may only be as high as 150 ppb. If the lake or reservoir being treated is a direct source of potable water within ¼ mile, rates of 8 to 20 ppb may be

applied. As stated above in the *Domestic Well Impact Evaluation*, water from Rogers Lake is not a likely source of water for surrounding wells, therefore rates of 150 ppb may be applied.

4.3.6 Flumioxazin

Flumioxazin is a broad spectrum contact herbicide that effectively controls a wide variety of species including variable-leaf milfoil and fanwort. The half-life of Flumioxazin is between one to five days, which means the chemical would not persist in the lake for very long. It is slightly to moderately toxic to fish, moderately to highly toxic to aquatic invertebrates and practically non-toxic to birds, small mammals and bees. After degradation, Flumioxazin breaks down into APH and THPA, which do not pose a significant risk to groundwater resources.

Flumioxazin is highly regulated for human and environmental safety. It categorized as "Group 3-limited use chemicals." This means that the following 5 conditions must be met in order to apply the chemical: (1) The applicant demonstrates that there is a specific need for this chemical such as specific target plant in a specific location, (2) The Commissioner of DEEP and the Commissioner of CTDPH, or the Commissioner's designee shall conduct specific reviews of the permit application. Factors in the review may include, but are not limited to: proximity to water supply intakes and public water supply wells, volume of chemical applied, area of application, or water body level and history of pesticide use, (3) The maximum permissible application rate of Flumioxazin is not exceeded, (4) The permit may require the applicant to comply with conditions including, but are not limited to: monitoring downstream of the application area for the presence of Flumioxazin and/or other byproducts, onsite inspections, water level manipulation, etc., (5) The Commissioner of CTDPH, or the Commissioner of CTDPH's designee shall complete a review and provide the Commissioner or Designee's decision, including any required permit conditions to DEEP. The Commissioner of DEEP shall include the Commissioner of CTDPH's or the Designee's permit conditions in any permit issued by the Commissioner of DEEP. These processes do not hinder the towns' ability to permit for Flumioxazin, but rather provide strict guidelines to ensure human and environmental health safety.

Flumioxazin is listed as mild to low toxicity for human health; EPA Category III or IV, which are the second least and least toxic categories. Flumioxazin has tested negative for the possibility to act as a mutagen (reproductively and developmentally), neurotoxin, and tested unlikely to act as a carcinogen. EPA SWIMODEL for aquatic use post-application exposure to children and adults at 400ug/L showed no scenarios of concern for oral and dermal exposure. 400 ug/L is the maximum application rate, thus will never be exceeded and should not cause any human health impact.

Flumioxazin is most effective when applied to young or actively growing vegetation with limited density and in waters lower than a pH of 8.5. The maximum pH found in

Rogers Lake is 8.5, therefore Flumioxazin would be a viable option for treatment. The rapid death of plant matter can cause a decrease in oxygen and may be fatal to fish species in the lake. When the target species are densely populated, as in Rogers Lake, Flumioxazin is most effective when used in spot treating specific locations. This will avoid a rapid decrease in dissolved oxygen from decaying plant material.

4.3.7 Triclopyr

Triclopyr is a systemic herbicide that effectively treats a broad range of plants including Eurasian milfoil, but is typically not used for treatment of variable-leaf milfoil and fanwort. It can have moderate success in controlling lily species as well. Triclopyr has a half-life of one to 10 days and is not likely to be mobile enough to contaminate groundwater. The aquatic formulation of Triclopyr is practically non-toxic to fish, invertebrates, birds and bees, but the decomposing byproducts of Triclopyr are slightly toxic to aquatic invertebrates.

While Triclopyr is selective, it has the potential to effect non-target emergent plants. Rapid decomposition of plant matter when using Triclopyr may cause significant oxygen depletion, therefore no more than one half of the water body should be treated at one time and subsequent treatments must be at least 10 to 14 days apart. Overall, although Triclopyr is non-toxic and safe for use in Rogers Lake, it has extremely low efficacy for the target nuisance plants.

Plant Management Strategy	Type	Efficacy of Control	Cost**	Timing	Permitting	Notes
DASH	Mechanical	Invasive sp.----- Low Lilies---------- High	$15,000/acre	Growing Season	No state permit, may require a local inland wetlands permit	• High efficacy for non-fragmenting species (lilies) but not efficient • Very low efficacy for the two invasive species • Fairly expensive for all controlled species • No human health effects
Hand Pulling	Mechanical	Invasive sp.----- Low Lilies---------- High	$12,000/acre	Growing Season	No state permit, may require a local inland wetlands permit	• High efficacy for non-fragmenting species (lilies) but not efficient • Very low efficacy for the two invasive species • Fairly expensive for all controlled species • No human health effects
Harvester	Mechanical	Invasive sp.----- Low Lilies---------- Fair	$500 - $2,500/acre	Growing Season	No state permit, may require a local inland wetlands permit	• Fair efficacy for lily species but not commonly done • Low efficacy for the two invasive species • Fairly inexpensive • No human health effects
Hydroraking	Mechanical	Invasive sp.----- Low Lilies---------- High	$6,000 - $8,000/acre or $175/hour	Growing Season	No state permit, may require a local inland wetlands permit	• Low efficacy for the two invasive species • High efficacy for lily and watershield species • Fairly inexpensive mechanical management option • No human health effects
Benthic Barrier/Shading	Mechanical	Low (Integrative - Fair)	$24,000 - $54,000/acre	Growing Season	No state permit, may require a local inland wetlands permit	• Low efficacy for all species when used independently • Fairly effective when used as part of an integrated management strategy • More permitting requirements • No human health effects
Dredging	Mechanical	Invasive sp.----- Low Lilies---------- High	$50,000 - $75,000/acre	Autumn or During Low Water	Yes – Inland Wetlands Agency, ACOE, 401 Water Quality Certification, and potential several other permit review submittals to state agencies	• Usually low efficacy in controlling these two invasive species o Unless extreme depths are reached when dredging (not recommended) • High efficacy when eradicating lilies (not current goal) • Extremely expensive o Extra fees for planning and engineering • Decrease lake diversity • No human health effects
Grass Carp	Biological	Invasive sp.------ Fair Lilies---------- Low	$50-$300/acre	Stock in Late Winter or Early Spring	Yes – Special Importation & Liberation Permits. Site must visited & inspected by DEEP, Inland Fisheries Division and Habitat Conservation & Enhancement Program	• May reasonably decrease invasive species • May negatively affect native vegetation • Possibly spread fish disease amongst native fish • Extensive permitting • May negatively affect water quality • No human health effects
Milfoil Weevil	Biological	Unknown/Poor	$1,00-$200,000/year	Growing Season	Yes – Special Importation & Liberation Permits. Site must visited & inspected by DEEP, Inland Fisheries Division and Habitat Conservation & Enhancement Program	• Unpredictable diet – possibility of decreasing native vegetation • Poor efficacy on all target species • Can be expensive depending on how many restocking events • Requires multiple levels of permitting • No human health effects • Likely low environmental health effects

**All costs include costs associated with one treatment and do not include permitting costs unless otherwise stipulated

Plant Management Strategy	Type	Efficacy of Control	Cost**	Timing	Permitting	Notes
2-4D	Chemical	Invasive sp.---- Good Lilies---------- Fair	$300-$800/acre	Early June	Yes – DEEP Permit with Potential Coastal Consistency Review and Public Health Department Review. *DEEP Wildlife Division if endangered or threatened species*	• Half-Life: 13-40 days • Multiple treatments needed • Effective treatment of *M. heterophyllum* • Moderately effective treatment of lily species • Extensive negative human health effects • *Must send a copy of your permit application to your town Inland Wetlands Agency at the time you submit your application to DEEP. Local Commissions do not have the authority to unilaterally deny a permit, but DEEP does seek their input. *
Carfentrazone	Chemical	Milfoil ---------- Good Lily/Fanwort--- Poor	$690/acre	Spring/Early Summer	Yes – DEEP Permit with Potential Coastal Consistency Review and Public Health Department Review. *DEEP Wildlife Division if endangered or threatened species*	• Half-Life: 3-9 days • Meets regulation-required distance from reservoir • In least/second least EPA toxicity category o Concentrations below EPA's level of concern - at application rate • Not well documented/tested
Diquat	Chemical	Invasive sp.---- Good Lilies---------- Poor *(Short Term)*	$320/acre	Growing Season	Yes – DEEP Permit with Potential Coastal Consistency Review and Public Health Department Review. *DEEP Wildlife Division if endangered or threatened species*	• Half-Life: 2-210 days • Immediately binds to organic matter o Not biologically available in water very long • Non-toxic to aquatic organisms • Very toxic when in contact with skin • pH restrictions • Not effective in dense or turbid water environments
Endothall	Chemical	Poor	$400-$700/acre	Spring/Early Summer	Yes – DEEP Permit with Potential Coastal Consistency Review and Public Health Department Review. *DEEP Wildlife Division if endangered or threatened species*	• Half-Life:5-10 days o Disappears from soil in 7-21 days • Liquid formulations are toxic to fish and aquatic invertebrates/wildlife • Decrease in dissolved oxygen (also toxic to fish) • Not permitted for use in public water supply watershed • Not particularly effective on any of 3 target plants
Fluridone	Chemical	Invasive sp.---- Good Lilies---------- Poor	$500-$1000/acre per treatment	Spring/Early Summer	Yes – DEEP Permit with Potential Coastal Consistency Review and Public Health Department Review. *DEEP Wildlife Division if endangered or threatened species*	• Half-Life: 4-97 days • High efficacy for both invasive species • Requires 3-5 applications in one season • Low toxicity to humans and fish • Low risk of oxygen depletion • Allowed with permitted constrictions near public water wells
Flumioxazin	Chemical	Invasive sp.---- Good Lilies---------- Poor	$1,190/acre	Growing Season	Yes – DEEP Permit with Potential Coastal Consistency Review and Public Health Department Review. *DEEP Wildlife Division if endangered or threatened species*	• Half-Life: 1-5 days • High efficacy for both target invasive species • Slightly to moderately toxic to fish • Moderately to highly toxic to aquatic invertebrates • Highly regulated for human health safety • No signs of human toxicity under regulated parameters
Triclopyr	Chemical	Invasive sp.----- Poor Lilies---------- Fair	$500/acre	Spring/Early Summer	Yes – DEEP Permit with Potential Coastal Consistency Review and Public Health Department Review. *DEEP Wildlife Division if endangered or threatened species*	• Half-Life: 1-10 days • Poor efficacy for both invasive species • Moderate efficacy on lily species • Not selective • No groundwater contamination • Threat of oxygen depletion

**All costs include costs associated with one treatment and do not include permitting costs unless otherwise stipulated

5.0 BREAKDOWN BY FACTORS

The table below reviews the potential management options by three parameters, which are likely considered the most important evaluation factors when assessing management options at Rogers Lake. The management options evaluated were restricted to options that are legitimate control options and would have an effect on the target species. This distinction is important because it would be useless for example, to evaluate a chemical and assign it as least costly for lilies if the chemical will have no chance of managing lily species. In looking at one parameter at a time, it is easier to make an informed decision on the best management option for each target species. The management options are listed under each parameter from highest (1) to lowest (3) ranking.

Parameter	Invasive Species	Lily Species
Highest Efficacy	1. 2,4-D 2. Flumioxazin 3. Carfentrazone (milfoil) Fluridone (fanwort)	1. Hydroraking 2. Hand Pulling/DASH 3. Dredging
Lowest Environmental and Human Health Impact	1. Fluridone 2. Flumioxazin 3. Diquat	1. Hand Pulling/DASH 2. Hydroraking 3. Harvesting
Least Costly	1. Grass Carp 2. 2,4-D 3. Diquat	1. Triclopyr 2. Harvesting 3. Hydroraking

6.0 CONCLUSION

Each study detailed in this report outlines the possible human and environmental health issues associated with the implementation of nuisance plant management at Rogers Lake. While any action has the possibility of impacting the lake ecosystem to some extent, the studies conducted by NEE display how minimal and unlikely those impacts may be.

After reviewing all variables above, NEE suggests the use of Flumioxazin to control variable-leaf milfoil and fanwort because it is cost efficient, low in human health toxicity, effective and highly regulated by the CTDEEP and CTDPH. As outlined in the well impact study, it is very unlikely that any chemicals applied to Rogers Lake will be drawn into local drinking water wells. In order to monitor this, it is likely that the CTDEEP will require regular well water testing. Furthermore, Flumioxazin has the potential to eliminate both invasive species more effectively than most other chemicals. Any biological or mechanical options would likely have little to no effect on these two species, as was seen when the Towns of Lyme and Old Lyme attempted to harvest invasive species two years ago.

NEE has identified hydroraking as the best method to selectively remove lily and watershield species in Rogers Lake. Based off past experience by NEE, mechanical options are more effective than chemical application in controlling lily and watershield species. While many mechanical options would work well in eliminating lily and watershield species, NEE has had much success with hydroraking as a method of lily removal because of its efficiency, ability to remain selective and the hydrorake removes a great deal of root mass as well. As mentioned in the plant survey, many invasive species inhabit areas with lilies in high densities. When removing lilies, care must be taken to not fragment the two invasive species, as this will facilitate further growth and spread throughout the lake. The best options to reduce potential spread through fragmentation include well timed chemical treatments of invasive species followed by hydroraking or the installation of a fragment barrier, placed between the invasive species and lily/watershield species prior to hydroraking.

These suggested management options have a very high chance of successfully restoring the recreational use and access to Rogers Lake. It should be understood that eradication is unlikely, meaning fanwort and variable leaf milfoil will likely always be present at some level within the lake and will require long-term management. The densities of the two aggressive invasive species do not appear to be growing significantly, however it is very unlikely that the invasive species will ever decrease in density or number if no action is taken. No action is an option if the cost or suggestions supplied in this report are not desirable to the Towns of Lyme and Old Lyme or if the Towns do not believe that the current levels of invasive species and lilies within the lake are detrimental to the enjoyment and use of the lake recreationally.

7.0 REFERENCES

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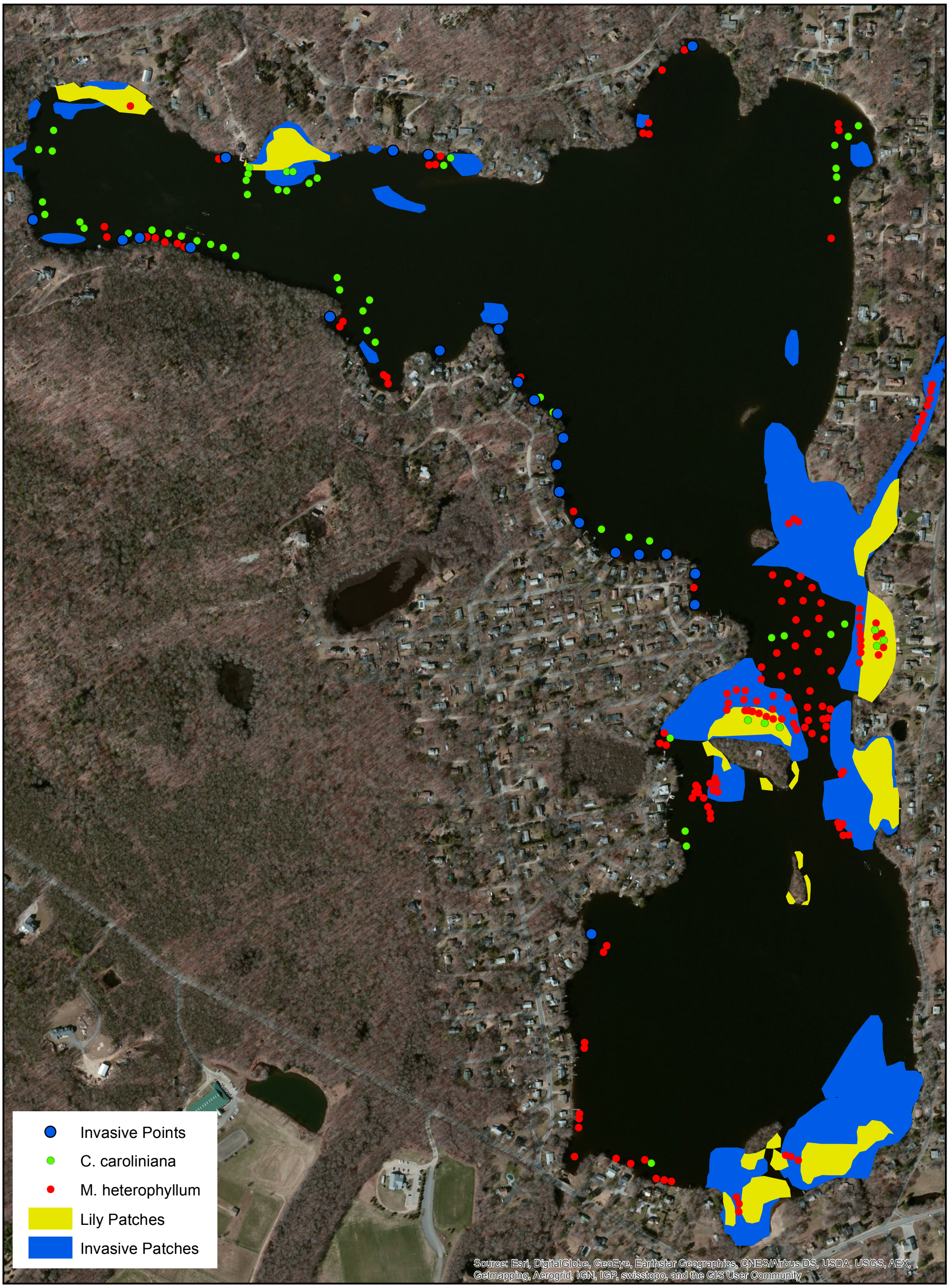

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Figure 1
Extent of Invasive and Lily/Watershield Species

Rogers Lake
Lyme & Old Lyme, CT

20 Feb 2015

NEE Job # 14-4467

Data Source: Office of Geographic Information (MassGIS)

30 cm Color Digital Ortho Image 2008/2009
Digital Parcel Standard, Level 3

87,000 0 174,000 Miles

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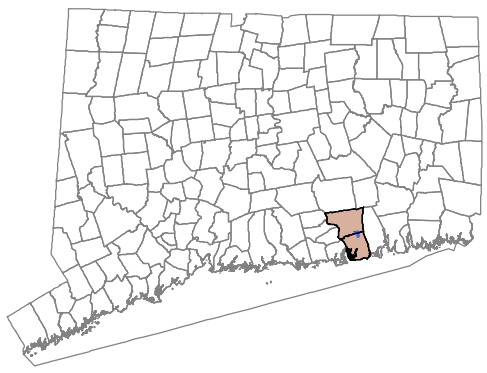
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Longitude 72° 18' 4" W