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Town of Monterey and Friends of Lake Garfield
Via email to Melissa Noe, Michael Germain, Richard Jaffe and Hy Rosen

From Ken Wagner, Water Resource Services

This constitutes the Water Resource Services (WRS) report for the plant assessment at Lake Garfield. This report was first produced as a draft on August 3, 2017 and has been revised based on comments as of August 22, 2017. It extends the work done previously, as summarized in the Lake Garfield Plant Investigation (2015) and expanded in 2016 by Emily Stockman, working separately from WRS, which did not perform any lake surveys in 2016. Those reports provide important background and should be consulted in addition to this evaluation.

On July 20th Ken Wagner of WRS surveyed the lake with Richard Jaffe and Hy Rosen of the Friends of Lake Garfield (FLG). The group made one complete lap around the lake near the offshore edge of the drawdown zone, evaluating the plant community overall and Eurasian watermilfoil (EWM) distribution more specifically. They then checked on deeper areas, emphasizing locations of past known patches, and looked for evidence of herbivorous insects that attack EWM. On July 26th Ken Wagner returned to the lake, checked more areas for milfoil, and assessed insect herbivore damage on EWM. On August 1st Ken Wagner returned to the lake and extended the survey, working with Maxine Verteramo and Toni Stewart of WRS. Concurrently, a 604b assessment study of water quality in and entering Lake Garfield is underway, providing considerable additional data. At this point conditions in Lake Garfield are fairly well documented.

Water Clarity and Algae:

The water was fairly clear on July 20th; no significant algae blooms were observed and no cyanobacterial particles were encountered. Water quality and habitat structure appeared very favorable on that date. However, on July 26th it was very calm in the morning (and had been calm overnight) and the upper 6 feet or so of water column had visible cyanobacterial particles, with purplish clumps at the surface in the large bowl, mostly over water more than 20 feet deep. This was also a sampling day under the 604b project; water clarity was measured at 11 feet (3.4 m) and oxygen declined sharply to <2 mg/L at 20 feet of water depth and close to 0 mg/L near the bottom.

Microscopic examination of samples from July 26th revealed the surface clumps to be mostly *Planktothrix*, a potentially toxic cyanobacterium, with *Woronichinia, Gomphosphaeria* and *Dolichospermum* (formerly called *Anabaena*) represented in the other cyanobacterial particles observed. When the wind picked up close to noon, the surface scum disappeared and the particles were less obvious in the water. All the observed cyanobacteria were buoyant forms, containing gas pockets that cause them to float; the calm conditions allowed concentration near the surface, while wind redistributed the particles to greater water depth and minimized apparent impact.

On August 1st some peripheral cyanobacteria accumulations were observed, mostly dead or dying aggregations of cells, with generally clear water over most of the pond. There was no observable accumulation of particles over deeper water. Wind was light but present the whole time. Greenish water was observed along the west side of the large bowl, but no distinct algae particles were observed. Algal mats were detected on the bottom, including filamentous green algae in water <10 feet deep in association with rooted plants and cyanobacterial mats in water 15 to 20 feet deep, growing on bare soft sediment. The algae situation will be addressed in greater detail in the 604b project, which includes water quality assessment.

Physical Features:
The shoreline of Lake Garfield is largely rocky, with coarse substrate extending well into the pond in many areas. There is substantial variation, however, with fine sand and silt in some areas. The small bowl (northwestern portion of the lake) has the sandiest shoreline, but there are extensive areas of gravel and some rocks as well. Some of the nearshore area has been altered by human activity to allow safer swimming and boat docking. The large bowl (southeastern portion of the lake) has sandy to silty shallow shelf areas near shore where tributaries enter, but much of the shoreline and nearshore area is very rocky. Within this bowl, the slopes from the northeastern and southwestern shorelines are very steep, while the northwestern shoreline slopes more gradually and the southeastern area has minimal slope, with an emergent wetland grading into a broad expanse of shallow water.

Soft sediment is found in shallow areas with limited slope, but significant deposits of fine sediment are found mainly at water depths >6 feet. This is partly a function of drawdown over many years, which allows peripheral fine sediment to move away from shore where there is significant slope. Drawdown also allows cycles of freezing and thawing to move rocks upward to the surface of the exposed sediment, such that some areas have seemingly spongy sediment but with a rock and gravel covered surface. There are rocky areas in up to 20 feet of water, especially along the steep slopes in the large bowl, but most areas >12 feet deep have a substantial organic sediment covering, and the shallow, flat southeastern end of the lake has substantial organic deposits grading out from the wetland. This diversity of physical substrate is to some degree responsible for the many plant species found in Lake Garfield.

Plant Survey Points:
While nearly all of the shoreline and a considerable portion of the lake to a depth of about 20 feet was observed, global positioning system (GPS) points were recorded only when something of interest was detected. Those points, starting with 214 and ending with 257, are shown in Figure 1. The itemized summary of observations is provided in Table 1. Important observations include:

1. In most areas <10 feet deep some combination of pondweeds dominated the plant community. Bigleaf pondweed (*Potamogeton amplifolius*) and Robbins pondweed (*Potamogeton robbinsii*) were the most abundant large leaved species, although a mix of thin leaved species was abundant in many areas as well. Robbins pondweed grows close to the bottom and does not cause recreational impairment in the vast majority of cases. Bigleaf pondweed does reach the surface and can impede swimming, boating and fishing. Thin leaved pondweed species included sago pondweed (*Stuckenia pectinata*), slender

pondweed (*P. pusillus*), and Vasey's pondweed (*P. vaseyii*). Additional pondweeds found in Lake Garfield include flatstem pondweed (*P. zosteriformis*), Richardson's pondweed (*P. richardsonii*) and boat-tipped pondweed (*P. praelongus*). Common naiad (*Najas flexilis*) is in the pondweed family and is also common in Lake Garfield, mostly in shallow water. Other species of Potamogeton have been listed in past studies and are undoubtedly present; the flora of Lake Garfield appears very rich.

2. GPS227 – Water chestnut (*Trapa natans*) found. Unaware of any previous report of this invasive species for Lake Garfield. Only two plants found, both pulled. Birds are the likely means for invasion of this plant species in the shallow southern area. It is known from some area lakes, but is not a dominant species anywhere nearby.
3. GPS235-245 – Former 10 acre dense patch area, now with just remnant smaller patches and scattered growths. Considerable expanses of bare sediment with rooted EWM stems about 6 inches long, some sprouting new plants. Some colonization by pondweeds, especially bigleaf pondweed, but many areas that were dense EWM have limited plant cover now. No evidence of recent activity, likely to have been open area since late winter.
4. GPS224-226, 230-234 – Former smaller patch area that extended around the point with large rock over 3 years, now reduced to one smaller dense patch (GPS 226) and scattered EWM growths, mostly extending south from big rock. Pondweed species colonizing to some degree. Additional EWM found as single plants along west shore south of GPS 234 on 8/1/17, but no dense growths observed.
5. GPS246-257 – Former linear patch along east shore, now reduced to a small patch and scattered growths. Area to south gets steep and deep, limiting plant growth. A variety of pondweed species, mostly Robbins pondweed and bigleaf pondweed, are present.
6. No EWM was found in the southeastern half of the lake beyond GPS 257 on the northeast side. No EWM was found south of GPS 226 on the southwest side on 7/20/17, but a few scattered plants were detected along the southwest shore southeast of GPS 226 on 8/1/17. Steep slopes from shore limit plants along much of the shore areas in this portion of the lake, but then the lake gets shallow at the southeastern end and plant growth is very dense. No EWM was found on 7/20/17 in the southeastern end, while a single EWM plant was detected on 8/1/17.
7. EWM growth in water <6 feet deep (drawdown depth) was minimal, represented by single plants that were widely scattered. EWM growth in water 6-8 feet deep (ice contact zone) was uncommon, but single stems and scattered aggregations of EWM were noted in a few areas. EWM growth in water 8-15 feet deep was highly variable, but much less than in 2014-2016 in areas of past patches. Growth of all vascular plants declines strongly in water >15 feet deep, with no plants by 20 feet of water depth.
8. Considerable rafts of thin leaved pondweed (possibly including Vasey's pondweed, a state-listed rare species) were observed floating on the surface and accumulating along shorelines. Many of these pondweeds die off at this time of year, so this is a natural occurrence, but accumulations were dense enough to interfere with recreation in multiple areas.

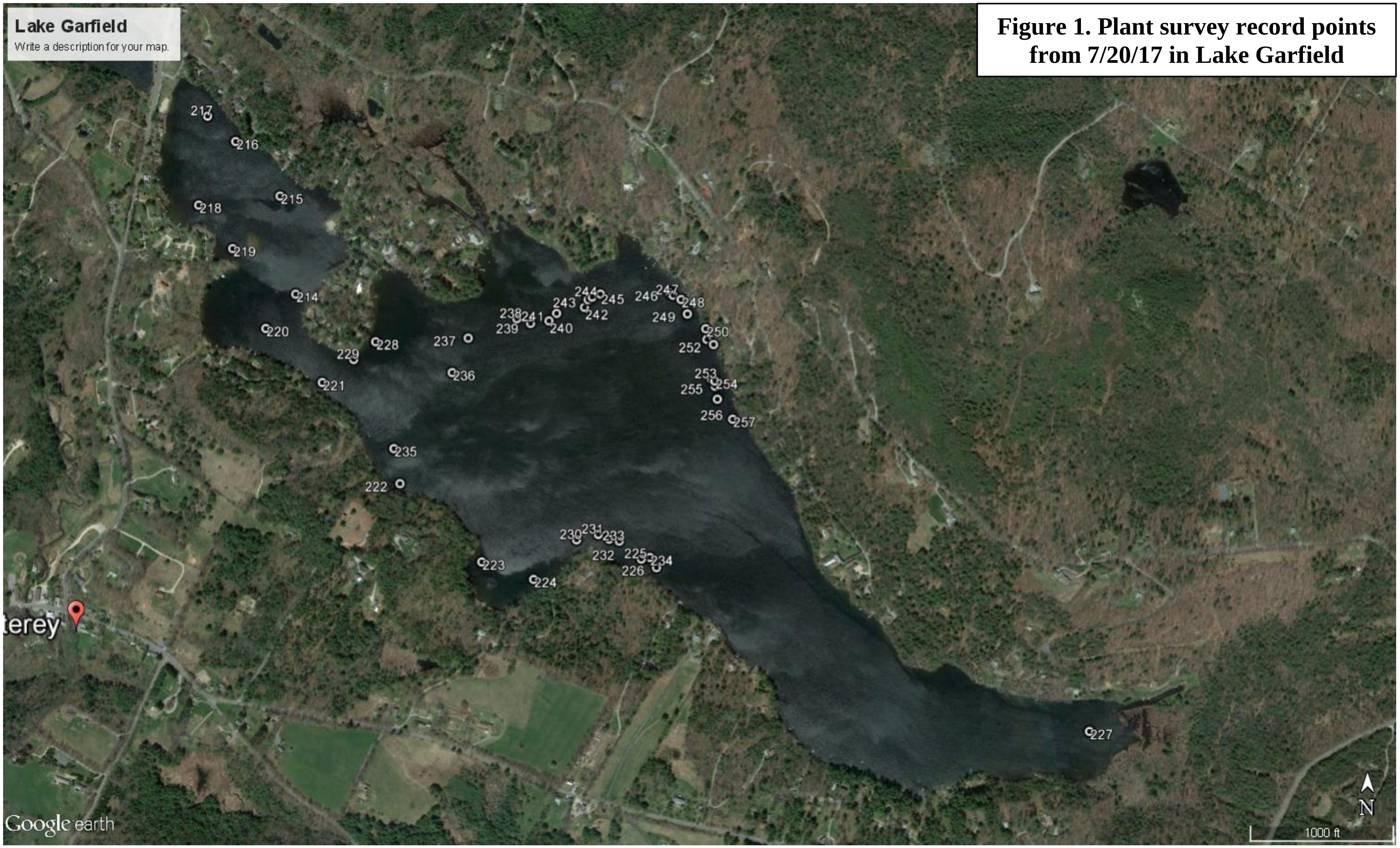

Figure 1. Plant survey record points from 7/20/17 in Lake Garfield

Table 1. Record of Plant Survey Points in Lake Garfield on July 20, 2017

GPS Point	Water Depth (ft)	EWM	Other Plants or Notes
214	4	0	Multiple pondweed species (Pr, Pa, Pp, Pz, Pp, Sp, Nf, thinleaf forms)
215	4	0	Multiple pondweed species
216	3.5	Scattered	Multiple pondweed species
217	3	0	Pa patch near beach
218	4.5	0	Multiple pondweed species
219	4	0	Sp
220	6	1	Multiple pondweed species
221	5	1	Multiple pondweed species
222	5	1	Multiple pondweed species
223	6	0	Pa with protruding seedheads (other areas of Pa not yet fruiting)
224	6	Scattered	Pa
225	4	Scattered	Pa, Pp
226	6	Patch	Extends from GPS 225, gets denser
227	3	0	Trapa natans (water chestnut) found; 2 plants pulled
228	5	0	Pa patch
229	1	0	Polygonum amphibian patch along shore
230	7-10	Scattered	Remnants of past patch, multiple pondweed species present
231	8	Scattered	Remnants of past patch, multiple pondweed species present
232	8	Scattered	Remnants of past patch, multiple pondweed species present
233	8	0	Pr very dense
234	12	1	Multiple pondweed species
235	8-10	Scattered	Remnants of past patch, stubby EWM stems at bottom, some sprouting
236	10-14	Scattered	Remnants of past patch, stubby EWM stems at bottom, some sprouting
237	8-10	Scattered	Remnants of past patch, stubby EWM stems at bottom, some sprouting
238	6	0	Pr dense
239	8-10	Patch	Moderate density, part of former larger dense patch
240	15	4	Subtantial bare sediment, short EWM stems observed
241	8	0	Pr, Pa
242	12-14	Scattered	
243	8-12	Scattered	
244	8	Patch	Not dense, but almost exclusively EWM
245	7-8	0	Pr very dense
246	8	Scattered	Pa
247	10	Scattered	Pa
248	13	0	Pr
249	17	0	No plants
250	10	0	Multiple pondweed species
251	12	Scattered	Multiple pondweed species
252	10	3	No other plants
253	8-10	Patch	One end of patch
254	8-10	Patch	Other end of patch
255	8	0	Pr, Pa
256	11	Scattered	No other plants
257	8-12	0	Multiple pondweed species

Former EWM Patch Observations:

As multiple people have noticed, the formerly large and dense patches of EWM in the northwestern part of the large bowl that existed and expanded in 2014-2016 are now much reduced in area and density. There are still several patches of more than scattered growths, however (Figure 2), all within areas that had dense growth in 2016. In former patch areas where no EWM is visible from the surface, the root crowns and short stems remain at the bottom, some now sprouting new stems but none looking healthy. EWM has not reached the surface anywhere in the lake yet, but is within 2 feet of the surface in at least 2 locations (A and B on Figure 2). The total area of dense EWM is estimated now at <2 acres, with up to 3 more acres of growth characterized as more than scattered but less than dense.

Inspection of collected EWM stems revealed a wide range of invertebrates, but only one species known to damage EWM, the milfoil weevil, *Euhrychiopsis lecontei*, and then only one adult specimen was found. Other invertebrates included two common snails (*Amnicola* and a lymneid species), several species of midge fly larvae (Chironomidae, but not *Cricotopus myriophylii*, a species known to harm EWM), a mayfly, a caddisfly, an aquatic sowbug (Asellidae), a damselfly, and a leech species. Samples from existing patches with healthy EWM showed little sign of damage. Samples from sparse growths in areas where EWM had been abundant previously and was now represented mostly by short blackened stems were not appreciably different from the healthy patches in terms of invertebrate fauna.

On July 26 a more detailed assessment of possible insect herbivore damage to EWM was conducted, following the protocols for examination outlined by Paul Lord of SUNY Oneonta. The upper 3 feet of stem was collected and examined for stem damage, leaf damage, meristem (upper growth tip) damage, and actual live weevils (larvae, pupae or adult). The results (Table 2) indicate relatively little damage from insect herbivores, with almost 80% of examined plants showing no signs of damage. Of the other 20% that did exhibit some possible damage from insect herbivores, about three quarters of those showed signs of meristem damage. This will prevent further upward growth of milfoil plants, but will not cause stem collapse.

It may be that sufficient damage to collapse much of the EWM population was done last year, later in summer of 2016 when the population of weevils or other EWM herbivores peaked, and what can be seen now is just aftermath. The plant survey of mid-summer 2016 found extensive EWM patches, but was not performed by WRS and there is no interpretation of the results in terms of possible insect herbivore damage. No one expected such a collapse, and while this has been documented in other lakes in the northeast, it is not a commonly known phenomenon in Berkshire regional lakes infested with EWM. We can theorize what occurred, but have no definitive proof of insect herbivore impact.

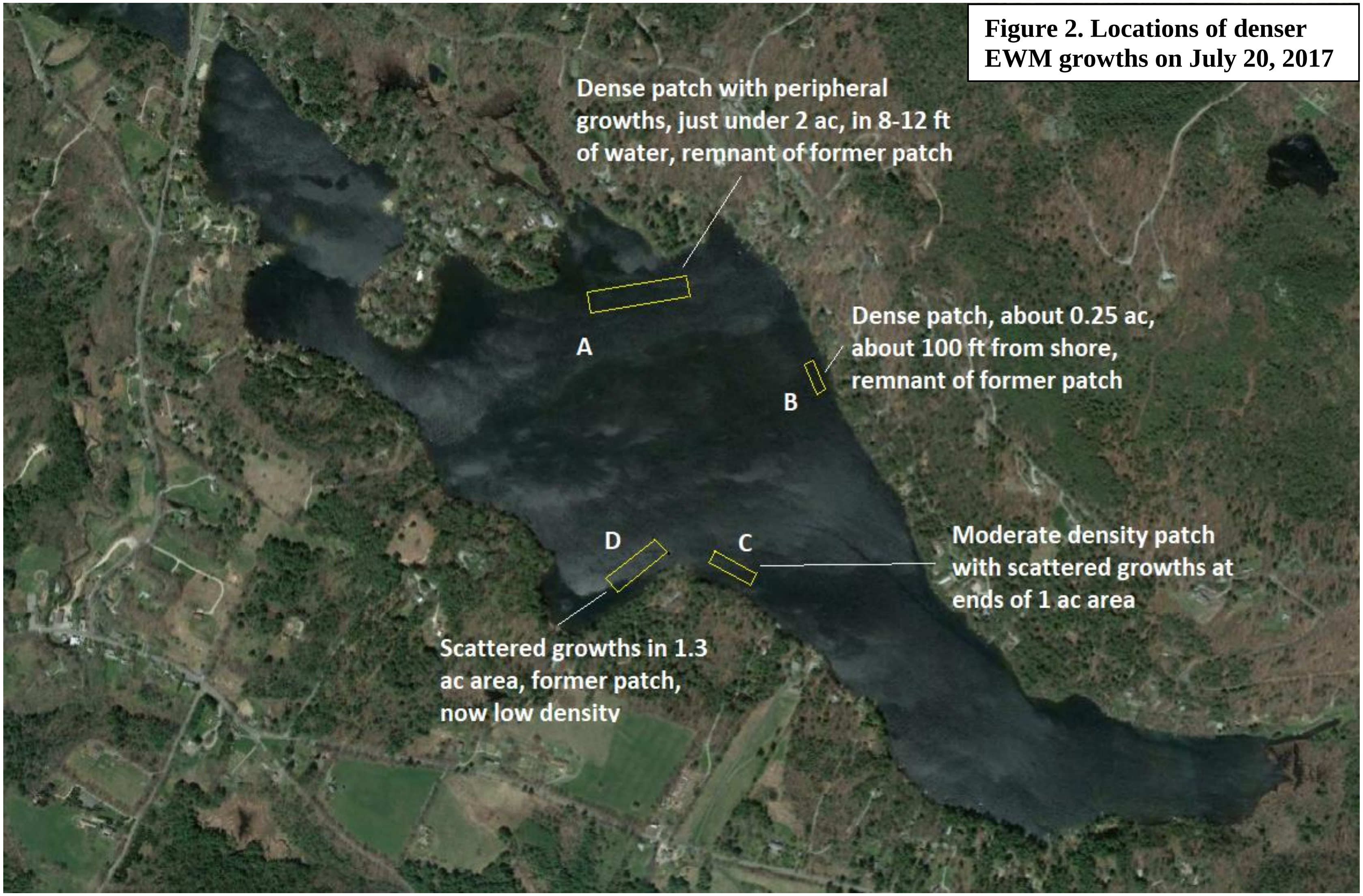

Figure 2. Locations of denser EWM growths on July 20, 2017

Table 2. Insect herbivore damage assessment for milfoil plants in Lake Garfield

		Damage to:			
Metric	No visible damage	Stem	Meristem	Leaves	Total
Plants	47	2	9	1	59
%	79.7%	3.4%	15.3%	1.7%	100%

Overall Evaluation and Management Implications:

The drawdown continues to limit EWM growth in <6 feet of water and may have an effect to about 8 feet water depth through ice damage. Other plants, mainly annuals, grow well in shallow water and are dense in many areas. However, some perennial plants (e.g., Robbins pondweed and some bigleaf pondweed stocks) are surviving drawdown in exposed areas of finer sediment and thriving. Areas with rocky nearshore zones or very steep slopes have few plants, but overall there is a diverse, well-structured aquatic plant community in Lake Garfield. There is some recreational interference by native species in areas <6 feet deep that is not controlled by drawdown. EWM threatens plant community structure in water 8-15 feet deep, and the rise and expansion of patches since 2013 has spurred activity at the town level to consider control options beyond drawdown.

The decline in EWM density and coverage in 2017 is a surprise, one that is not easily explained. Drawdown does not impact plants beyond about 8 feet of water depth. There is no indication that anyone has illegally applied herbicides. Suction harvesting was permitted but only about an acre of area on the west side of the large bowl, near the connector to the small bowl, has been addressed by this technique. The most logical explanation is that insect herbivore populations have expanded in response to available EWM and caused a partial population crash, but this is unproven.

Understanding insect herbivory on EWM is fairly complicated. What has been observed can be explained in terms of insect herbivory, but data to clearly demonstrate what occurred are lacking. To be succinct, it appears that the prolonged presence of dense EWM stands over a long, contiguous stretch of lake allowed one or more populations of insect herbivores, most likely the milfoil weevil, to expand to the point where EWM was reduced in abundance. There is minimal evidence of ongoing activity at that level, however. This is all consistent with classic predator-prey ecology, which sets up cycles of boom and bust but never results in the elimination of either predator or prey.

There may have been a boom condition for weevils or other EWM herbivores last summer, resulting in collapse of many EWM plants. Insect herbivores would have been sheltered from fish predation in the very dense stands of EWM found in 2014-2016, allowing population expansion to the point where enough herbivores were present to depress EWM. Survival over winter by EWM was poor with many plants in damaged condition, and what remains in many areas are root crowns and short stems that are trying to rejuvenate. Other areas were less impacted and remain at least moderately dense, but do not appear to be under substantial current pressure by insect herbivores. If insect herbivores were the cause of the EWM density reduction, fish have likely eaten the insect herbivores in the now open areas where EWM was formerly dense.

Fish predation on possible insect herbivores for EWM has been the problem in active attempts to stock weevils to control EWM; fish predation will reduce herbivore populations before they can exert sufficient control over EWM in many cases. Stocking weevils without a very dense EWM community just feeds fish; control of lower density EWM is not achieved. Even with dense EWM stands, the small fish often navigate among the stems and consume insect herbivores, so control has not always been achieved even when EWM is dense.

The fish community of Lake Garfield was assessed in 2015 and 2016 as part of a UMASS study on drawdown effects. The survey included minnow traps and electrofishing for a limited amount of time, and data have not be released in any processed form. Collected species included largemouth bass, chain pickerel, yellow perch, bluegill and pumpkinseed sunfish, golden shiner and rock bass, with yellow perch most abundant. The size distribution of fish within species seemed favorable, not suggesting any imbalance or any overabundance of small fish. Field observations by WRS in July 2016 include many large fish and not the schools of small fish, especially sunfish, that consume insect herbivores. It may be that the combination of a favorable fish community structure and a large area of dense EWM was enough to allow expansion of populations of insect herbivores to the degree necessary to cause an EWM crash in Lake Garfield.

Yet with EWM much reduced in abundance, the insect herbivores can be expected to decline by either food limitation or predation. The level of EWM damage observed in healthy EWM stands in July 2017 was insufficient to exert much control over EWM. We can expect some resurgence of EWM before insect herbivores can exert any appreciable additional control, setting up another cycle of population growth and decline. This is consistent with anecdotal observations of EWM patches in the past that have come and gone in Lake Garfield, but documentation is lacking.

With the current density of EWM in Lake Garfield, efforts to further depress EWM need to be carefully evaluated in terms of efficiency and cost. Spending money to attack the remaining patches with suction harvesting may be worthwhile, but the cost per unit area harvested will be high due to greater EWM biomass per stem at this time of year in remaining patches. There seem to be 4 distinguishable patches at this point (Figure 2), totaling as much as 5 acres, but no more than 2 acres of dense growth. Use of suction harvesting in the dense parts of patches A and B appears potentially worthwhile, and would involve about 1.5 acres. It might best be accomplished in spring, however, when biomass is lower and harvest efficiency will be higher.

Having a diver hand harvest EWM in areas where it is now only scattered growths may be desirable, particularly in areas where what remains are root crowns and short stems. Substantial areas could be efficiently cleared of EWM that way, facilitating growth by other, more desirable plant species. Much of patch A in Figure 2 and some area beyond the delineated boundary of that patch could be handled this way. Patches C and D from Figure 2 are also good candidates for hand harvesting based on current plant data. For areas where EWM is just remnant root crowns and short, old stems, hand harvesting as soon as possible would be preferred, as these plants are not necessarily dead and some regeneration has already been observed. The former large (10 ac) patch area should have the highest priority in this regard.

Having divers swim the lake area demarcated by 8 and 15 foot water depth contours may be worthwhile, to harvest EWM before density can increase, but there is a trade-off between search time and harvesting that affects cost; this is a potentially effective but not very efficient strategy. There seems to be little value in attempting hand harvesting in water <6 feet deep, as the drawdown limits EWM to single plants and rare scattered growths in shallow water. If and when the deeper EWM population is greatly reduced, some effort might be devoted to shallow water growths, but those shallow water plants are likely started annually from fragments from deeper water plants, and will be replaced annually until the deeper water population is greatly depressed.

Curtaining off existing patches does not seem necessary at this time, as those patches are fragmented and not yet at the surface, although this might become more desirable by late August. Only patches A and B would seem worth addressing in this manner, and then only patch A is in an area with substantial boat traffic. The concept of sequestering EWM patches to limit fragment escape is sound and should remain a consideration for Lake Garfield, but is only warranted if larger patches form.

Certainly there is no need for any herbicide treatment at this point, a welcome relief to many. Over the last 20 years of Lake Garfield management, EWM density and coverage has not increased to a level where herbicides were considered until 2015. The decline in EWM between 2016 and 2017 again puts the population at a level where herbicides appear unnecessary.

Management Prognosis and Recommendations:
Bear in mind that EWM cannot be expected to remain in a “remission” state indefinitely. When there is a resurgence of EWM, the same options discussed for the last two years will be on the table for consideration. Use of herbicides represents the fastest and most effective way to reduce EWM populations to a low level, but elimination is not likely and the potential side effects, real or perceived, are enough to cause concern in the community. If suction harvesting and hand harvesting are applied as a combination, this should be done before patches become too large and early enough in the growing season (usually May and into June) that the biomass of individual plants is still low, increasing efficiency, reducing fragment escape, and lowering cost. This requires planning and decisions will have to be based on data from the previous summer in most cases to allow timely response. Hand harvesting small plants, notably the remnant EWM root crowns and limited stems in the former large, dense patch area, could be done at any time and should occur before those plants recover. Drawdown appears to be doing an excellent job of controlling EWM in water <6 feet deep, and the current program is appropriate as is.

If insect herbivores are indeed the cause of the observed decline in EWM in Lake Garfield, this would suggest a built-in, albeit delayed, mechanism to keep EWM from dominating the plant community as it has in many other Berkshire lakes. Part of this mechanism is a balanced fish community that prevents small fish, especially sunfish, from becoming dominant. Part of this mechanism is a healthy native plant community that covers the bottom and limits rooting by

EWM fragments. As long as the drawdown can be used to keep the nearshore area relatively free of EWM, having to endure a few years of EWM patches in deeper water before insect herbivores reduce its density at no cost may be tolerable. Sequestering patches when detected still represents a valid mechanism to slow the spread of EWM in that case, but active removal by herbicides or harvesting may be unnecessary. It would be inappropriate to jump to conclusions with regard to insect herbivores as a control mechanism for deeper water EWM in Lake Garfield based on existing information, but it is the only explanation that fits the existing data.

It appears fair to state that insect herbivores are not currently exerting any discernible control over EWM in Lake Garfield; EWM remains, a few denser patches exist, and no significant damage was detected during this survey. The choice is therefore whether to apply follow up methods, such as suction and hand harvesting to continue to force a decline in the EWM population, or to let nature takes its course and see what happens next year. Either is a defensible strategy, as long as it is recognized that some management is needed, including ongoing drawdown and some support for deeper EWM control in coming years, even if it is just installation of a fragment barrier.

Given some understanding of current finances and interests, the following program is suggested, but should be subject to discussion by all interested parties:

1. Continue the 6 foot drawdown. Note that this does not have to occur at that level every year, but it needs to happen at least every other to every third year with appropriate weather conditions. Since weather conditions are not reliably predictable, planning for drawdown every year is necessary, but the drawdown can be reduced in depth or terminated early if conditions are not conducive to success (which includes both EWM control and timely refill), and can be skipped if previous summer plant conditions suggest little need for additional control that year. One of the main state agency concerns over drawdown relates to possible impacts on the fish community. To that end, it would be appropriate to collect fish community data. Inquiry about existing data made to the Division of Fisheries and Wildlife revealed that surveys were conducted in 2015 and 2016 as part of a UMASS project relating to drawdowns, but we know of no plans for further surveys.
2. Monitor EWM distribution in early June and early August to assess annual change in EWM. If patches of more than an acre form, consider installing a fragment barrier to limit fragment distribution and discourage boat traffic that could increase fragmentation.
3. Apply suction harvesting or hand harvesting in remaining patch areas A-D, with priority order of A, B, C, then D to lower the EWM population further, as funding allows. This may not be economically viable in 2017, as the denser patches have near maximum biomass now and harvesting will be less efficient and more costly. Getting a vendor under contract to work in May 2018 may be preferable.
4. Hand harvest EWM in areas deeper than 6 feet where patch formation is a potential threat. The former large patch in the large bowl has many remnant EWM plants that are just root crowns and short stems now. These could be efficiently hand harvested before they can recover. Hand harvesting in areas where growth is not or has not been dense may be inefficient, but will provide protection from patch formation where funds allow.
5. Consider control of native vegetation in the small bowl and selected areas of the large bowl (coves on the northwest side, southeastern channel to homes in the area). Use of a

mechanical harvester has been approved pending restrictions from NHESP, which include not harvesting until the start of August, after the protected Vasey's pondweed has set seed and died off. Hand harvesting in front of individual homes has been approved and can be applied at a small scale; use of a vendor to handle larger areas may be practical.

Permits are in place for all of the above options, but note that application in any area not covered expressly in the permit will require additional approval. A careful reading of the Orders of Conditions is warranted.