Eurasian Watermilfoil in Lake Leelanau
Report on Field Activities in 2021

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Table of Contents

Executive Summary

In the summer of 2020, the Lake Leelanau Lake Association and the Grand Traverse Band of Ottawa and Chippewa Indians (GTB) began efforts to bring Eurasian Watermilfoil (EWM) under control in Lake Leelanau using a combination of benthic barriers, Diver Assisted Suction Harvesting (DASH), and hand-pulling. In all, 2.4 acres of dense EWM infestations were treated with benthic barriers, including 1.8 acres using biodegradable burlap barriers.

Burlap barriers deployed in 2020 remained intact and generally prevented return of EWM during the summer of 2021. Divers hand-pulled sparse EWM plants that were re-invading the interior sections of large burlap barriers, while noting that EWM was spreading from untreated stands along the edges of barriers and would have to be controlled through the use of smaller barriers.

In 2021, an additional 1.1 acres of burlap barriers were deployed over infestations that were either untreated in 2020 or where treatment by DASH was not effective.

While the surface area covered by dense infestations of EWM was significantly reduced in the lake, much smaller colonies were discovered in new locations. Virtually all of these newly-discovered colonies were treated by hand-pulling.

Several techniques of native aquatic plantings were utilized to expedite the recovery of plant communities in areas controlled with benthic barriers. Although only limited survival was observed in 2021, coordinated research efforts will continue to evaluate and optimize transplanting techniques. During the course of the 2021 field season the partners continued to refine techniques for large barrier deployment and scouting for very small and scattered EWM infestations. In particular, orthomosaic photography from an aerial drone shows great promise for discovering, precisely locating, and rapidly treating new EWM colonies.

Summary of 2021 Field Season

Assessment of EWM and control efforts began in early May, using visual observations from a boat, underwater video from a drone (Trident ROV), and rake tosses. Early observations showed that burlap barriers installed in June of 2020 were still in place, secure, and slowly degrading. Small amounts of EWM and other plants were observed over these large barriers, primarily near the edges.

DASH and hand-pulling sites were assessed and showed very mixed results. Some sites seemed to respond well to DASH treatment, with the observed size of infestations significantly reduced, although not entirely eliminated. Other sites were not noticeably reduced in size or density, despite being treated several times during the summer of 2020. Young EWM plants near the bottom, or root fragments left behind when EWM plants were pulled, seemed to be the most likely causes of rapid return of EWM to treated sites.

Assessment of all known EWM sites in late May showed that some sites which had been left untreated because they were not large or dense enough in 2020 for treatment by barriers, but were too large for treatment by DASH, exhibited a significant increase in density and surface area. These sites included one shallow water site near the Mebert Creek Natural Area in Bingham Township and several large infestations south of Grant's Point in Bingham Township (Figure 1). Concern about the rapid expansion of these sites, along with two DASH sites that did not respond well to treatment, caused GTB to open talks with officials from Michigan's Department of Environment, Great Lakes, and Energy (EGLE) with the intention of gaining approval for use of burlap barriers on sites untreated in 2020.

A meeting between GTB and EGLE personnel in late June resulted in approval for the use of burlap barriers on carefully documented dense infestations. Burlap from the supplier was ordered immediately, and plans were made to add personnel to resume deploying barriers while continuing with DASH and hand-pulling on sites that seemed to respond well to treatment.

Following submission of documentation on proposed barrier sites to EGLE and the arrival of burlap material on July 28, barrier deployment began on July 29. Over the next week about 1.1 acres of burlap barrier was placed on EWM beds. Sites included three large infestations south of Grant's Point and a site immediately south of the Lake Leelanau Narrows (Figure 1). Two relatively small barriers were also placed about ½ mile south of the DNR west side boat launch in Centerville Township. Because these barriers were deployed late in the season, when EWM plants had in some cases grown nearly to the surface, care was taken to weigh the barriers down with extra re-rod and sandbags, a process that was finished by mid-August.

Site 1. Lake Leelanau Narrows

Site 2. Grant's Point - North

Site 3. South of MDNR Boat Launch

Figure 1. South Lake Leelanau 2021 Benthic Barrier Locations

Despite the late start and short time-frame (only four days for barrier deployment), significant improvements were made in the efficiency and targeting of barriers. In particular, 20ft pieces of ½" re-rod were used to spread each barrier to its full 30ft width, eliminating the need for side anchors. Attached at intervals of approximately 50ft, the re-rod allowed for deployment without stopping to set

side anchors. Not only does this reduce the time involved (less than an hour to set a 540 x 30ft barrier), but it eliminates the need to pause, thus reducing drifting in sidewinds.

DASH diving began in mid-June, but numerous equipment problems delayed the start of work for several weeks. The decision to deploy barriers meant that some sites planned for DASH treatment were skipped in favor of barriers, and DASH work was concentrated on a handful of locations adjacent to barriers deployed in 2020 or treated with success by DASH in 2020 (but requiring follow-up). By late summer, most DASH work was abandoned in favor of using the contracted divers to hand-pull newly discovered sites which were considered a higher priority.

Scouting for new infestations was undertaken throughout the field season, often from our work boat using a modified "crow's nest" mounted to allow the observer to get a better angle looking down into the water. This activity was usually undertaken only on very calm days when visibility allowed accuracy in finding new infestations. Cruising the drop-offs (about 6-12ft) resulted in the discovery of numerous small infestations and scattered EWM plants. Newly discovered EWM infestations included:

* A small site just north of the Lake Leelanau Narrows in North Lake Leelanau

* Several scattered sites along the Narrows boat channel

* A somewhat larger site in the SE corner of South Lake Leelanau in Paradise Cove

* Scattered small infestations north and south of the DNR boat launch in Bingham Township.

In nearly all cases, newly-discovered sites were immediately hand-pulled by either volunteer divers or by contracted divers. For instance, the single known site in North Lake Leelanau was hand-pulled on three separate visits, yielding a total of less than 10lbs of EWM. Other sites along the far SE side of South Lake Leelanau were hand-pulled by divers diverted from DASH or by volunteers. This activity continued until early October, when field operations for the year came to a close.

In mid-September, Zero Gravity Aerial (ZGA) was engaged to photograph areas of the lake where barriers had been deployed, and areas of known dense infestations that would likely require barriers in 2022. This photography accurately showed the exact location of barriers, as well as a birds-eye view the size, shape, exact location, and density of EWM infestations that had yet to be treated.

Native aquatic plants were harvested by divers for transplant onto barrier sites on three different dates in July and August.

Key Findings

Much time and effort was spent in evaluating the effectiveness of the non-chemical techniques for bringing EWM under control in Lake Leelanau. The strategy of treating each infestation as a separate and discrete entity, usually through a first intensive treatment followed by maintenance efforts in successive visits until the infestation is eradicated, remains the overall guiding strategy of control efforts in the lake.

Evaluating the effectiveness of biodegradable barriers to control EWM was of paramount interest. Prior to the 2021 field season the rate of decay of the burlap material, the rate and manner of re-colonization of the barrier sites, and the composition and growth rate of plants over the barriers were all unknown. Key findings and observations include:

1. **Benthic barriers, both biodegradable and synthetic, are effective in eradicating large infestations of EWM.**
2. **Large and dense beds of EWM, responsible for the vast majority of the biomass of this invasive plant in the lake and the source of numerous fragments capable of generating new infestations, have been greatly reduced.**
3. **Hand-pulling by divers, using either the DASH system or collection in bags for delivery to the boat and disposal, varies greatly in its effectiveness in eliminating individual infestations.**
4. **Newly discovered infestations were found in widely scattered locations in South Lake Leelanau, and one in North Lake Leelanau near the Narrows.**
5. **To date, we have not seen flowering EWM plants and therefore believe no sexual reproduction has happened. Therefore, we are hopeful EWM has not established a seed bed in Lake Leelanau, a key for success in our future control efforts.**
6. **Use of ortho-mosaic photographs taken by an aerial drone is the best way to find new infestations and to pinpoint the size and location of known infestations.**
7. **Efforts to transplant native aquatic plants into barrier sites to "jump-start" the recolonization by desirable species show promise, but need more research and practice in the field.**

Discussion

Benthic barriers, both biodegradable and synthetic, are effective in eliminating large infestations of EWM

Approximately 2.4 acres of benthic barriers were deployed in 2020 on sites that were originally selected as candidates for benthic barriers and confirmed by visual observation prior to barrier deployment. At the time, many questions needed to be answered, particularly about the use and efficacy of large biodegradable barriers.

Deployment: Could large (40ft x 400ft) burlap barriers be effectively deployed over preselected target EWM beds, and would these barriers stay in place on the bottom and pose no threat to recreational boaters and fishermen? This question was answered in the affirmative in 2020.

Effectiveness: Would biodegradable barriers initially kill most or all EWM over which they were deployed, and at what rate would EWM or other native plants recolonize the barriers? By the end of 2020, visual observations by divers and ROV photography indicated that barriers had only occasional regrowth of EWM or other plants, and no EWM was observed growing up from below the barrier. Photos taken in May of 2021 showed that barriers remained intact and continued to suppress all but occasional plant re-growth (Figure 2).

As the season progressed, some barriers experienced more rapid regrowth of plant life established on top of the barrier. Importantly, EWM was not observed growing up through the weave of the barrier material, but rather EWM became established apparently by fragments that landed on the barrier, sending out roots that went down through the burlap into sediments below. Native plants, including Naiads and Pondweed species, also established themselves on the barriers, often in folds or troughs where plant fragments collected.

Photo 1. Burlap barrier with little to no aquatic vegetation.

Photo 2. Burlap barrier with abundant re-colonization.

A noticeable edge effect was observed. Barriers that were smaller, or that were not wide or large enough to adequately cover the entire width of an infestation, showed pronounced recolonization along the edges. This “layering” phenomena was not unexpected, but it underscored the need to treat the entire infestation when barriers are applied.

Twice during the course of the summer divers hand-pulled EWM from barriers at the Gordon's Point area. Even within this area, considerable variation in the rate of recolonization was observed. The south end of this large barrier assemblage attempted to cover an EWM bed that was estimated to be 70-80ft wide with a combination of synthetic LBBs along the eastern flank with an adjacent 40ft wide burlap barrier set in deeper water. Both types of barriers killed the target plants below them, but gaps between the barriers and along both the shallow and deep edges produced significant EWM colonies.

Photo 3. EWM growing in gap between Synthetic Lake Bottom Blankets (LBBs).

Two divers spent about 2 hours on the southernmost 16,000ft^2 barrier on June 27, removing an estimated 40lbs of EWM. By contrast, the northernmost barriers remained nearly free of EWM, and plants found on the barrier were removed in less than an hour on two occasions.

Burlap barriers set near Grant's Point (40 x 700ft) showed a much greater "layering" effect along the shallow edge. At this location, EWM was not fully covered by the barrier because a significant part of the EWM plants were growing in less than 8ft water depth. The DASH crew was deployed to this location to try to remove EWM near the north end of the barrier, along the shallow eastern edge, and off the southern end. While the biomass of EWM was greatly reduced by this barrier and to some extent by DASH follow-up, the rate of recolonization here underscores the need to completely treat dense infestations when barriers are first applied, and then to follow up by treating uncovered edges and removing any EWM fragments that are reestablishing on the barriers. Small but dense EWM stands left near the edge of a barrier will become a source of fragments and layering that has the potential to rapidly recolonize on the barrier.

Synthetic LBBs showed a considerable variation in the rate of success. A set of 10 LBBs (200 x 20ft) placed on the north end of the Gordon's Point area in May of 2020 was highly successful in eliminating this infestation. Diver, ROV, underwater photography, and aerial drone observations show virtually no return of EWM to this site. By contrast, a set of 22 LBBs (440 x 20ft) at the southern end of the same ½ mile long infestation experienced considerable recolonization of EWM and native plants within a year of barrier removal. While plants were spaced fairly far apart where the synthetic barriers were removed, the new re-growth was healthy and reached nearly to the surface by late summer.

In summation, barriers eradicated all EWM that they covered. To be completely effective, initial treatment with barriers needs to completely treat the entire infestation, including the edges, and needs to be followed up with removal of any EWM fragments that land on the barrier. Since barriers themselves, unlike DASH and hand-pulling, do not produce fragments when deployed, recolonization should be greatly reduced if 100% of the EWM bed is treated in the initial barrier deployment.

Large and dense beds of EWM have been greatly reduced in the lake.

Efforts to bring EWM under control in Lake Leelanau can be accurately assessed by a combination of two factors:

1) Surface coverage of EWM can be accurately determined by aerial drone imagery that covers the entire littoral zone of the lake. The technique of creating orthomosaic photos of weed beds by overlaying multiple images from slightly different angles to create a very accurate "portrait" of the exact extent and location of EWM in a lake is developing rapidly. Unfortunately, such images from Lake Leelanau do not exist for 2019 or 2020.

   The original surface coverage of EWM was estimated at 5-10 acres in 2019, prior to the onset of treatment with barriers and DASH. This estimate was based on using a boat to encircle visible infestations of EWM using mapping software (OnXHunt) to show the size and shape of the EWM.

   This estimate was generally confirmed as part of a vegetation survey of both North and South Lake Leelanau by Restorative Lake Sciences (RLS) in June of 2020. Unfortunately, the RLS survey was conducted soon after the deployment of approximately 2 acres of barriers over the largest and most dense infestations in South Lake Leelanau. RLS reported 3.52 acres of EWM. By adding the 2 acres of EWM covered by barriers, about 5.5 acres of EWM were documented in early 2020.

   Current estimates, based on orthomosaic photos, show less than 3 acres of remaining EWM in Lake Leelanau, in relatively much less dense patches in the near vicinity to barriers deployed in 2020 and 2021, and in smaller sites left largely untreated (Otto Road, Mebert Creek, Mebert Shoal) but planned for barriers in 2022. Additionally, very small sites, including 45 newly-discovered locations reported in 2021, do not add significantly to the total surface coverage of EWM in the lake.

   Given the difficulty of estimating EWM surface coverage from a boat, none of these estimates can be taken as a fully accurate representation of progress in combating EWM. However, going forward, the systematic use of aerial drone photography with follow-up ground truthing will allow highly accurate estimation of the exact location and coverage of EWM at the end of each field season.

2) Number and location of discrete infestations. This is an important metric of control because, while surface coverage of EWM may be reduced, EWM is spreading into new locations by fragments that are capable of establishing new colonies. Fragments are created by disturbance from boats, well-intentioned efforts to pull the plants, and maybe most importantly by auto-fragmentation where long stems become brittle, break off, and drift to establish new colonies elsewhere. As a means of gauging success, however, this metric is also flawed. Estimates of 11 EWM infestations in 2019 relied entirely on observations from a boat by Brian Price and several volunteers. The RLS survey in 2020, along with continued scouting efforts by LLLA, documented another 10 sites, raising the total to 21 infestations. By 2021, improvements to scouting technique and redoubled scouting efforts turned up 45 new discrete infestations. Most of the newer discoveries were much smaller than previous sites, but nevertheless EWM has the capability of spreading widely to new locations.

   By available measures, the surface area of EWM in Lake Leelanau has been reduced by an estimated 60% primarily through the use of barriers placed on the largest and most dense infestations. Because large and dense infestations were targeted first, it is likely that the biomass of EWM in Lake Leelanau has been reduced by a considerably larger percentage than its surface

coverage. Spread of EWM to new locations is a real concern, but in terms of surface coverage or biomass, it represents a very small fraction of the total amount of EWM in the lake.

Hand-pulling by divers, using either the DASH system or collection in bags for delivery to the boat and disposal, varies greatly in its effectiveness in eliminating individual infestations.

DASH diving was used to treat five infestations along the west side of Lake Leelanau in 2020. All of these sites were considered either too small or contained a relatively high percentage of native plants mixed in with EWM and therefore were not considered candidates for benthic barrier treatment. Of the five sites treated by DASH or hand-pulling (or a combination of both) the following results were apparent by 2021.

Site 1: Lake Leelanau Narrows – this site was treated with 7 LBBs over the densest part of the infestation, followed up by DASH immediately after LBBs were deployed and then again in late summer. Both treatments ended when divers could no longer find EWM plants to pull. By spring of 2021 neither the size of the infestation or vigor of the plants seemed to have responded to DASH or hand-pulling, so a decision was made to cover the entire site with a double-wide burlap barrier, which was deployed on July 30. Follow-up included two 10x20ft burlap barriers placed on the edges of the larger barrier in an attempt to cover everything. A small number of nearby EWM plants were pulled by hand.

Site 2: DNR Launch North (AKA Laskey) – This site was a relatively small (~200ft^2) ¼ mile south of Centerville Township Park. The site was DASHed twice in 2020 and also hand-pulled. Responding to treatment, this site was reduced in size and vigor. In 2021 it was DASHed once and hand-pulled once.

Site 6: Kelenske Point North: This site showed two small but dense clusters of EWM embedded in a well-established native plant community. Control efforts included DASH in late June 2020, followed up by hand pulling in late August. EWM at this site responded to treatment but came back in reduced amounts. Further control included hand-pulling on August 19 and 24 of 2021. DASH and hand-pulling of this site yielded a total of approximately 140lb of EWM.

Site 15: Kelenske Point South: A dense but small site was hand-pulled twice in 2020 and twice in 2021. Responding to treatment, this site produced less EWM and took less dive time in each treatment. In the final August visit to this site, only a handful of plants were found and pulled.

The above descriptions of efforts to bring infestations under control through DASH or hand-pulling illustrates the large variability of response to treatment. The factors that may influence this response include:

- **Maturity of Infestation** - The experience of DASH practitioners on other lakes seems to indicate that long-established EWM infestations have plants with large and intertwined root systems with multiple stems. Tall plants may also conceal an underlayer of smaller plants near the bottom that shoot up into the gap once tall plants are removed. In addition, it is likely that root fragments left behind produce new plants in a matter of weeks.
- **Substrate Conditions** - Substrates in Lake Leelanau with EWM infestations range from very soft, silty sediments where plants are easily pulled, to firm sediments and cobble, where it is very difficult to pull entire plants with the roots.

- **Visibility** - Divers are greatly hindered by poor visibility as plants come up releasing a cloud of sediment into the water. This can obscure the view of even larger plants but may make it impossible to see very small plants near the bottom. In addition, stands with luxurious native vegetation make it hard for the diver to work down to the bottom, following an EWM stem to get it out by the root. Algal blooms later in the summer also hinder diving efforts.

Our team of divers generally believes that hand-pulling will be difficult, time-consuming, and largely ineffective on older, established, and dense infestations. It may be effective to place small barriers over the densest areas of EWM (the "core" area of an infestation) while thoroughly and repeatedly hand-pulling nearby individual EWM stems. Such efforts would achieve the effectiveness of barriers while limiting damage done to native plant communities.

Newly discovered infestations, ideally with all plants in the same year class and shallow-rooted, may respond well to treatment by hand-pulling. This may explain why a newly discovered site (Kelenske Pt.) that was hand-pulled in 2020 seemed to respond well to treatment.

Newly discovered infestations were found in widely scattered locations in South Lake Leelanau, and one in North Lake Leelanau near the Narrows.

During the course of the summer, scouting for new infestations was conducted over virtually the entire littoral zone of both North and South Lake Leelanau. North Lake Leelanau was primarily scouted by volunteer Jim Wysor along with other volunteers, while South Lake Leelanau was scouted on multiple occasions by Brian Price and Ron Reimink. In almost all cases, newly discovered EWM infestations were hand-pulled within weeks in an attempt to stop the spread of EWM to new areas (Figure 1).

Photo 3. SCUBA diver hand-pulling EWM.

Where broad, relatively shallow areas (~6-12ft) provide suitable habitat for EWM to establish across a wide area, transects were run back and forth with a spotter on the boat. A GPS was used to maintain a distance of about 50ft between transects. This was done twice in St Mary's Bay (just south of the Narrows), once in North Lake Leelanau (just north of the Narrows), and in Paradise Cove in the far SE end of the lake. Two new but very small infestations were found in St. Mary's Bay and hand-pulled within days. A somewhat larger and scattered infestation was discovered in Paradise Cove and hand-pulled by divers the following week.

The majority of lake shoreline is characterized by a relatively broad shelf that extends out from the shoreline, followed by a relatively narrow and steep drop-off which bottoms out at depths that are not capable of supporting EWM or other rooted aquatic vegetation (deeper than about 15ft). In these locations, a boat would run along the drop-off with a spotter. If EWM was spotted, the boat would go back to confirm visually or collect plants with a rake. In all cases, confirmed EWM sites were marked with a GPS waypoint, and divers were dispatched to pull any visible EWM. While on site, divers scouted nearby underwater areas to locate and pull any stray plants not visible from the surface.

When using this method, the number of locations reported is somewhat subjective. If a gap of more than 100ft or so exists between EWM plants, then a new waypoint would be assigned to a location and considered a separate site. In all, about 45 new locations were discovered in this manner.

Most newly discovered EWM infestations were along the east shoreline in Bingham Township. This area has sparse populations of native plants, with large stretches having no rooted vegetation at all, so new EWM plants were relatively easy to locate and pull.

New infestations were found about ½ mile south of Fountain Point, on the western shore opposite and southward from Fountain Point, in the Narrows channel, and a couple of very small infestations near Skeba Point on the western shoreline. With the exception of one larger infestation (1/2 mile south of Fountain Point), all of the known new locations were hand-pulled in 2021 within a week or two of discovery (Figure 1).

It is believed that the primary way that new infestations are established is by fragments released in late summer as EWM stems "auto-fragment." Plant tips, complete with new rootlets, breakoff as stems reach near the surface. In addition, boat traffic and other disturbances likely create a smaller number of fragments. Fragments are generally buoyant and beginning in late July, large numbers of EWM fragments are found floating in the lake. After one particularly large wind event in August, large numbers of fragments of EWM were found washed up on shorelines 5 miles south of known EWM infestations. While the vast majority of fragments end up in water too shallow to allow establishment of a new colony, even a small percentage of fragments capable of establishing new colonies in this way pose a serious problem.

Attempts to stop the spread of EWM to new areas in Lake Leelanau will depend on our ability to:

1. Greatly reduce the biomass (as measured by surface area) of EWM in the lake to reduce the generation of new fragments
2. Discover and immediately treat new infestations, especially those that are found outside the main area of EWM infestations (roughly the middle 1/3 of South Lake Leelanau).
3. Treat with a combination of small barriers and effective hand-pulling as soon as discovered.

To Date, EWM plants have not been observed flowering in Lake Leelanau.

Eurasian Watermilfoil spreads both sexually and asexually. Sexual reproduction takes place in late summer when plants reach the surface forming dense mats. Flowers are finger-size reddish stalks that rise above the surface several inches. Seeds are produced and disbursed from these stalks. Seeds are viable for an estimated 7 years. If a seed bed is established, then even if an EWM infestation is eradicated by use of a barrier, for instance, seeds will presumably remain viable under the barrier and will sprout and re-grow after the barrier disintegrates.

Perhaps because the invasion of EWM into Lake Leelanau is relatively new, no matting at the surface has been seen. And while observers have been looking for flower spikes late in the year, none have yet been observed.

If in fact sexual reproduction has not yet taken place in Lake Leelanau, and no seed bed exists, the importance of eradicating large dense infestations is underscored. There may be a narrow window of opportunity to not only get EWM under control but to move beyond "control" (prevention of EWM becoming a major nuisance) to something close to eradication.

Use of ortho-mosaic photographs taken by an aerial drone is the best way to find new infestations and to pinpoint the size and location of known infestations.

In September 2021, Zero Gravity Aerial (ZGA) was contracted to provide images from an aerial drone. The purpose was to pinpoint the exact location and configuration of large benthic barriers placed in the lake through the first two years of field operations, and to locate and spatially display the EWM infestations.

Photo 4. Aerially documented EWM colony near Mebert Creek

The ortho-mosaic image is produced using image recognition software that assembles multiple digital photos captured in a predetermined autonomous flight path. The image produced is geo-rectified and allows for precise placement when uploaded to mapping programs. ZGA has been awarded a patent by the U. S. Patent and Trademark Office for the adaptation of this process to aquatic venues.

A limited area of the lake, generally within about ¼ mile of existing barriers, was flown and photographed by ZGA on September 28, 2021. The ortho-mosaic images were reviewed by the partners and Dennis Wiand, owner of ZGA, on three occasions. The consensus is that this technique shows great promise in mapping known infestations, planning treatment, and for locating new infestations.

- Barriers can be documented precisely as they are placed in the lake, including locating what EWM plants have been missed along the edges of the barrier requiring follow-up treatment.
- Ortho-mosaic imagery flown prior to barrier deployment can determine the surface extent of infestations to be covered, as well as the shape, size and location of the barrier that would best "fit" the infestation.
- Aerial drone imagery is capable of comprehensively covering large areas of potential EWM spread, pinpointing EWM down to individual stems for follow-up by ground-truthing and treatment. While the images can't necessarily differentiate between EWM and some types of plants whose visual profile resembles EWM, the images and geo-referencing will allow rapid follow-up by observers and divers, eliminating the need to scout large areas of the lake by observers on boats. It will help to ensure that new infestations are rapidly found and treated, and that new infestations do not remain undiscovered.

Efforts to transplant native aquatic plants into barrier sites to "jump-start" the recolonization by desirable species show promise but need more research and practice in the field.

Barriers placed on the bottom of the lake kill all of the plants under them, both desirable and undesirable. While the amount of area covered by the barriers to date represents only 3.5 acres, or about 0.04% of the area of Lake Leelanau, some damage is done to native plants.

Use of biodegradable burlap barriers at the same time presents an opportunity to re-introduce a desirable mix of native plants. As the barriers break down, generally in the second season after deployment, a substrate is presented for the transplant of native plants.

In 2021, field crews transplanted native aquatic plants from higher density beds in close proximity to restoration areas. Native plantings were prioritized in 2020 barrier control areas where monitoring efforts documented less than 25% native plant presence. Where surveys documented the re-establishment of plants in 25% or greater of the photos taken, then natural re-colonization was assumed to be already occurring from surrounding founder colonies. Species transplanted included various Potamogeton species, Vallisneria and Elodea, all of which are abundant in Lake Leelanau and were noted in areas surrounding treatment sites. Plantings were done using two primary methods, from stem fragments (or root-less Chara) deployed from the boat and by using bare roots and/or tubers planted by a scuba diver.

Photo 5. Planting of rooted plants with SCUBA divers.

Photo 6. Weighted stems prepared for deployment.

Stem fragments or cutting from stem tips have been successfully propagated and planted with pond-weeds and Elodea. Stem tips were cut in lengths of 4 to 8 inches, wrapped in burlap or cheesecloth with soil, weighted with small rocks, tied off with twine and deployed from the boat over restoration areas. Bare roots and tubers were harvested, stored in water and planted via scuba diver in at least 3 inches of substrate.

Densities of planting varied based on control area bed size, but a target planting spacing was established at 10 to 15 ft. Transplanting's were randomized with species and techniques to improve biodiversity and overall success.

In Gordons Point and Grants Point control areas, weighted stem fragments deployed from the boat were planted at a density of 75+ per site, weighted stem fragments planted via SCUBA into the barrier at approximately 25 per site, and rooted plants - 100-120 plants per barrier.

Initial SCUBA inspections following plantings showed little survival, and the need for refining our planting techniques. Plantings took place late July and early August, which likely may not be the ideal time for transplanting. GTB has been coordinating with Grand Valley State University to further

evaluate these techniques and to evaluate the timeframe for re-establishing native vegetation on EWM treatment sites. A carefully developed study design evaluating natural re-colonization as well as supplemental transplanting's among various sizes of barriers will provide managers with techniques and strategies for future EWM control and the restoration of native communities.

Summary

In 2021, the LLLA and the GTB learned that benthic barriers deployed in 2020 were effective in killing dense infestations of EWM and preventing return of EWM to these sites, provided that all of the EWM in a discrete infestation is covered by the barrier or otherwise removed in the first initial treatment. We believe follow-up maintenance treatments prevent recolonization by EWM. As such, use of biodegradable barriers shows great promise as a means to bring EWM under control in lakes that have similar characteristics to Lake Leelanau, particularly where the invasive plant is not widely established and where relatively steep bottom topography limits the extent and width of available habitat for EWM. The partners believe that a combination of employing new technology (especially aerial drone images) to find and treat infestations soon after establishment, along with targeting barriers on large, dense infestations and then progressing to smaller infestations, allows for the possibility of bringing EWM under control and possibly eradicating the invasive plant from large areas of the lake.

In the third year of EWM control on Lake Leelanau (2022) we hope to refine the techniques of scouting, barrier targeting and deployment, repeated hand-pulling of very small and newly established infestations, and reestablishment of native plant communities. We believe this will drastically reduce the surface coverage and biomass of EWM in Lake Leelanau. If successful, this effort can point to an integrated non-chemical means to bring EWM under control in a way that can be transferred to other lakes dealing with EWM.

Lake Leelanau LAKE ASSOCIATION lakeleelanau.org

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Acknowledgements

This work would not have been possible without the steadfast support of the board of directors of the **Lake Leelanau Lake Association**, and especially Tom Hiatt (Board President) and Kathy Birney (Treasurer).

Similarly, the **Grand Traverse Band of Ottawa and Chippewa Indians,** and its Tribal Council, played an essential role in all phases of planning, fundraising and execution of this project. GTB Natural Resources Department staff members **Josh Jackiewicz and Nate Campbell** were part of the field crew and greatly assisted with data collection, boat operations and benthic barrier deployments.

Darlene Doorlag offered us the exclusive use of her landing on Lake Leelanau, allowing us to keep boats and equipment in a secure location that greatly improved the efficiency of our operations. "Dar" provided that one essential thing: the perfect location from which to conduct our work.

Centerville Township and Supervisor Jim Schwantes allowed our team to use the road end adjacent to the Township Park on Lake Leelanau to prep barriers for deployment and then load them onto our workboat.

Great Lakes Restoration Initiative through the Bureau of Indian Affairs funded three years of project implementation. GLRI and BIA were an essential component to our work and our long-term goals of invasive species eradication and Great Lakes ecosystem restoration.

Don Les, who after a long academic career as an expert in aquatic plants, willingly provided insight into the particular biology of EWM and in techniques of transplanting native plants.

Lindsay Chadderton and Andrew Tucker, of the Nature Conservancy's Aquatic Invasive Species program made many observations and suggestions that set us off on productive lines of inquiry.

The Edmund and Virginia Ball Foundation, its Executive Director Chuck Ball and advisor Dr. Tim Keilty, made valuable contributions both financial and practical.

Volunteers made important contributions to our work throughout the summer. Some of the volunteers include:

- **Jim Wysor**: Principal operator of our Trident ROV underwater drone, and Jim and volunteers took on the responsibility of monitoring all of North Lake Leelanau for any sign of EWM presence.
- **Dan Harkness**: for help in scouting EWM infestations and working with our divers, installing dock at our base on Lake Leelanau and anything else we asked him to do.
- **Austin O'Connor**: who helped remove the dock and tidy up our work base at season's end.
- **Volunteer Divers** who spent, collectively, over 100 hours of dive time hand pulling EWM, documenting the recolonization of plants over barriers, and adjusting newly set benthic barriers. The divers include:
    - Tim Page: a "regular"
    - Dave Dumoulin and Jay Logerman: divers who took on Billman's Beach EWM
    - Nancy Lyons
    - Caitlin Watkins

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We could not have accomplished this work without three essential **contractors**:

- **Restorative Lake Sciences**: Dr. Jennifer Jones and crew documented in the size and extent of EWM beds and conducted a full vegetation survey in 2020, and a Feasibility Study in 2021 that helped confirm the progress made in controlling EWM in the lake.
- **MTT DASH Divers**: Mike Smith and his crew not only used their equipment and expertise in DASH, but switched over to primarily hand-pulling newly discovered sites late in the summer, allowing us to put extra effort into controlling the spread of EWM into new areas of the lake.
- **Annalise Povolo**: Annalise continued to provide her effort, insight, and expertise in working with volunteer divers.

The Board and volunteers of the newly formed Friends of Lake Leelanau Foundation, which has committed itself to funding our next three years of work to control EWM in Lake Leelanau, and also to establishing an endowment fund that will protect the lake far into the future.

Appendix A – Descriptions of EWM Sites in Lake Leelanau

Sites Discovered in 2019

Site 1 – Narrows South
First observed: 7-8-19
Location: 44 58.40 N, 85 42.36W
Waypoints: 16, 54 and 55
Robust stand EWM, 5-10 ft depth, about 50yd SW of channel entry. Original estimated extent: 30ft x 70 ft. Highest priority site because of boat traffic on the edge of the Narrows channel.
2019 Treatment: DASH divers on site for 3 days October 8-10. About 500 lbs removed. Diver estimate 50% of total site treated. Visibility good, sand hard-packed so removal slowed.
2020 Treatment: 5 Lake Bottom Blankets were installed on May 20, and 2 more were added on June 9 on the densest areas. Inspected by MTT divers on 5/21 to check LBB configuration and make sure barriers stayed in location. (See Appendix B.)
The DASH crew returned to the site to pull EWM from near the edges of the blankets in mid-June, finishing when all observed EWM had been harvested. About 300# removed.
In September EWM was observed, probably from low plants that had been missed in the early summer treatment and grew rapidly by late summer. This was addressed by hand pulling and then again with follow-up in September 2020 by the DASH crew until all visible EWM was again eliminated.
2021 Treatment: Two 30' x 66' long burlap barriers were placed side by side over the site on July 30. Divers followed up to make sure the overlap covered all EWM, and also installed two smaller (10x20) barriers at the NW and SW edges to cover EWM otherwise missed. Twice divers came back to the site to pull any remaining visible EWM, less than 10 lbs.
2022 Prescription: Follow-up maintenance by hand-pulling. Potential site for native transplants.

Site 2 – DNR Launch North (AKA Laskey)
First Observed: 8-12-19
Location: 44 55.079N, 85 43.431 W about ¼ mile south Hohnke Road
Waypoint: 53
Notes: Small stand EWM, est 100sq ft., 11 ft depth
2020 Treatment: Visited 5/5 by MTT and BP. On 6/9 visited again and decision to DASH only. DASH June 25. No fall follow-up.
2021 Treatment: Hand-pulled on 6/15, 6/28, and 7/20. About 100 lbs removed in total. MTT DASHed and removed 11 bags in July.
2022 Prescription: Follow-up maintenance via hand-pulling

Site 3 – DNR Launch South
First Observed: 8-12-19
Location: 44 5.28N, 85 43.04W About ¼ south of DNR boat launch
Waypoint: LLLA 49
Notes: 9ft water, about 150sq ft.
2020 Treatment: Visited 5/21 but little EWM visible, even with diver in the water. DASH diving as part of treatment for Site 4 in June 2020 (see below)
2021 Treatment: MTT observed "heavy reproduction" of EWM with EWM overtaking native plants which had previously been dominant between the two dense stands at the north and south end of the

area. By mid-summer the dense stands were too large and dense for DASH to be effective, and two burlap barriers were placed on the largest infestations. At summer end, EWM remains in sporadic clumps outside the two barriers, and very likely young plants observed by MTT remain and will be a problem in 2022.
2022 Prescription: Hand-pull sporadic clumps, clean EWM off barriers and be prepared to deploy "mini-barriers" along the edges of barriers set in 2021 and if necessary in dense infestations elsewhere.

Site 4 – Willow Point South
First Observed: 8-9-19
Location: 44 54.28N, 85 43.04W Just south of point with large willow, about ½ mile south boat launch
Waypoints: 36,38,52, LLLA 17-19
2019 Notes: Robust stand EWM, about 200sq ft. (In fact stand extends into deeper water, and expands north and south)
2020 Treatment: This site first visited on 5/21 when EWM had not progressed far in spring growth. By June growth was more visible, but mixed with natives, and decision to DASH only.
RLS veg survey indicated additional EWM in rake tosses between Sites 3 and 4. DASH diving started in late June at Site 4, then continued northward for about ¼ mile to Site 3 until visible EWM was removed. Also, from Site 4 eastward into water to 15 ft deep, EWM was discovered and pulled by the DASH crew.
2021 Treatment: DASH followed by barrier. See discussion above as Site 3 and Site 4 should be treated as one location.

Site 5 – Kozelko
First Observed: 8-12-19
Location: 44 53.56N, 85 42.50W. Off Rice Creek
Waypoints: 49,50
Notes: Limited number of individual plants observed mixed with natives, in shallow water (less than 5ft.)
2020 Treatment: Hand-pulled by AP on 8/10. Very limited amount found in original location and scouting revealed a few more strands about 100 ft south. All pulled.
2021 Treatment: No visible EWM.
2022 Prescription: Revisit until no EWM observed for at least 3 years

Site 6 – Kelenske Pt (North)
First Observed: 8-12-19
Location: 44 53.25N, 85 42.36 W 100 yd north of Kelenske Pt
Waypoints: 47,48, 56, 91
Notes: Robust stand EWM, 8.5 ft water, 150 sq ft. Sporadic to SW for 50 yds.
2020 Treatment: Marked for MTT and DASHed late June 2020. Many natives in and around infestation, including northern milfoil. Followed up by hand pulling on 8/25 and 8/26 until no more visible EWM.
2021 Treatment: Hand-pulled on 6/8, 6/28, 8/19 (about 100lbs) and one bag hand-pulled by MTT.
2022 Prescription: Hand pull in 2022 at least twice in season.

Site 7 – Cedar River mouth
First Observed: 8-10-19
Location: around 44 50.49N, 85 45.01W off river mouth

Waypoints: 15, 42
Notes: Individual plants scattered widely between natives and also northern milfoil. Extent not well known. About 7 ft depth
2020 Treatment: BP visited site July 27 but found no EWM plants. Did not spend much time there but assume similar to 2019.
2021 Treatment: BP and RR visited the area twice, checking previous waypoints but not finding EWM. In late August while running transects two new small locations were found, near river mouth and about 50yds NE.
2022 Prescription: Survey by drone hand pulling among extensive "aquatic garden" if time permits. Observation only if necessary.

Site 8 – Sanborn
First Observed: 7-3-19
By: Jeff Sanborn and Brian Price
Location: 44 50 03N, 85 43.12W just north of former Sanborn house N of Birch Pt.
Waypoints: 39,40,43,44
Notes: Individual plants, perhaps 20-40, in about 5-7 ft depth, mixed native veg present
2020 treatment: Visited in June by BP and determined to be about same as observed in 2019. Hand pulled by AP on 7/27. About 5 #
2021 Treatment: Ron R removed about 5 plants on a single site visit.
2022 Prescription: Hand pull if necessary

Site 9 – Gordon Point and Site 10 – Reed Bed
First Observed: 7-8-19
Location: From 44 54.07N northward for about 2000 feet. About 85 42.34W
Waypoints: 27,28,75,59. LLLA 9-14 and 27, 28 (locations of sampling sites)
Notes: Extensive EWM from 500 ft south of Gordon Pt extending northward for about 2000 feet. 7-12 ft depth. No EWM south of blue-topped boat lift, about 5 houses south of point. Site 9 and Site 10 appeared to be separate in observations from the boat and rake tosses in 2019, but by 2020 they had either filled in to form a continuous stand of EWM or the growth between the two sites was just not easily visible in 2019.
2020 Treatment: EWM was clearly visible mid-May only at northern end of the area, the Reed Bed Site. In May, decision to begin treatment only on this part of site. When visited on June 8 EWM extended from 5th house south of the Gordon Point (same as previous year) to Site 10 (Reed Bed). From Gordon Point southward EWM was mixed with natives, but dominant from Gordon Pt north extending for an estimated 1,200 feet. Estimated 40-70 ft wide at Gordon Point, narrowing to the north. Thickest density in 7-12 feet. Decision to place burlap barriers to south of Reed Bed.

- 10 LBB's in a double wide gang were set on Reed Bed site on 5/22. Growth of EWM in this area was clearly visible by mid-May. The LBB's were removed on 7/14.
- 22 LBB's were place in a double wide gang on 6/8/20 in a nearly straight line with S end off end of Basye Dock. Inner edge in about 7ft, with nearby shoal easily visible. All 22 LBB's were removed on 8/11.

As June progressed, EWM was clearly visible extending well north of the 22 LBB set almost to the location of the 100 LBB set at the Reed bed.

- On 6/15 two large burlap barriers (40' by 400') were set from the north end of the 22 LBB northward to about 100 ft south of the previous 10LBB Reed Bed set.

By late June EWM was easily observed west and adjacent to the 22 LBB set in deeper water.

- On June 30 another burlap barrier was set alongside and immediately west of the LBB's, with a gap of about 0 to 4 feet between the barriers. Care was taken to not set over the LBB's since they would need to be removed, but not the burlap.

Over the course of the summer these barriers were repeatedly checked and sampled. Time did not allow for extensive DASH follow-up. MTT did DASH around the 10LBB (Reed Bed) site in early July, and along the shoal (east) side of the 400' northern burlap barrier, and between the ends of the two large burlap barriers. (See Appendix B.)

2021 Treatment: No significant DASH work or hand-pulling was done here except over the barriers, where less than 50# of EWM was collected over 3 different occasions.
2022 Prescription: Aerial drone imagery shows the effectiveness of the burlap barriers through 2021, but EWM remains along the edges, between barriers, and in a few rips or holes in the interior of one barrier. A combination of smaller barriers and hand-pulling with the intention of clearing the entire site or EWM should be a major objective.

Site 11 – Grant's Point
First Observed: 7-8-19
Location: From 44 55.40N to 44 55.87N, at approximately 85 42W (from 1st house N Mebert NA to Grants Pt.
Waypoints: 60-64, 57, 101. LLLA 05,06,30,33
Notes: Large and robust bed of EWM, in summer of 2019 appeared nearly continuous with some breaks, stretching about 4000 ft south of Grants point in water ranging from 6-12 ft. Width varied, but up to 50 ft. In 2020, only the northernmost extent of this area was solid EWM, becoming much more sporadic in smaller but intense infestations to the south.
2020 Treatment: Unlike Gordon's Point, where EWM seemingly expanded greatly between 2019 and 2020 (or at least became more visible), the Grant's Point area presented a less continuous EWM infestation in 2020 than seemed to be evident in 2019. Accordingly, decisions were made to only place barriers on the most obvious and continuous EWM that was observed.
Two burlap barriers were set from about 100 feet N of the large white mooring buoy northward on June 19 (Between waypoints LLLA 05 and 06). EWM was thick and contiguous, with a fairly steep bank becoming steeper to the north. With about 700' of barrier set and only 100' still on the boat, native plants became predominant, so a decision was made to cut the barrier off at about 700'. About 50 feet north of the burlap barrier, a fairly narrow but intense EWM infestation was located. The densest part of this was covered with a single LBB on 6/28 and a single additional LBB on 7/14 (Waypoints LLLA 30,33).

The area was DASHed in late September over a 4 day period. MTT cleared EWM from the area extending about 200 yards north from the burlap, which included fairly dense areas interspersed with native plants and sparse EWM. They also worked along most of the shoal edge of the burlap, and around the deeper edge at the north end. MTT also DASHed to about 100 yards south of the burlap barrier, where EWM became more mixed with natives and sporadic.
2021 Treatment: DASH treatment removed 155 bags of EWM (about 500lbs) primarily off the north end of the Grant's Point barrier and along the eastern (shallow) edge of the barrier. This effort did not result in EWM being eliminated from the site, and also the barrier is degrading here quickly allowing return of EWM.

2022 Treatment: Plans should be made to spot narrow barriers along the shoal edge of the 2020 barrier, ideally of synthetic material to be removed by early July. EWM is found to extend for up to 800 ft to the north of Grants Point, and small dense infestations would be appropriate for barriers carefully placed by divers, with hand-pulling in the sporadic sites that remain.
A much larger area of EWM located about 3,000-4,000 feet south of Grant's Point returned as 3 very distinct and dense infestations in 2021. (This site is sometimes referred to in notes as "Farber Site" as it is in front of and to the north of the home of LLLA board member). On July 28 and 29 three burlap barriers were placed on the infestations, and drone imagery shows that the barriers were highly effective in covering the bulk of the biomass.
2022 Prescription: Follow-up mini-barriers and hand-pulling for the southern sites. The northern sites will require use of smaller barriers adjacent to the 2020 barrier. Small EWM infestations extend for 500 ft to the north of Grants Point but are sporadic and narrow and the bank gets steeper. Diver placed mini-barriers would be appropriate with hand-pulling to remove scattered EWM.

2020 New Sites

Site 12 - Mebert Shoal
First observed: 6/14/20 Also observed by RLS survey
Location: 44 54.58N 85 42.54W
Waypoints 58, 70-73. LLLA 08
Notes: Intense EWM stand appears nearly pure, about 50 wide and 100 ft long on a line between Hohnke Rd and Gauthier Camp site, off edge of shoal.
2020 Treatment: Set Burlap fragment, about 40 x 80 ft, on core of area on 6/29. Only anchored on corners, sandbagged. DASHed in September until no visible EWM remaining.
2021 Treatment: none. The barrier set in 2020 was too small to cover the site and DASH did not have much impact on observed EWM in 2021.
2022 Prescription: Burlap barrier set to cover entire site with follow-up to remove outlying EWM plants.

Site 13 - Otto Road
First Observed: RLS crew mapped as single larger site during fieldwork in late June 2020. Confirmed by BP and DH as medium size, dense, about 50 x 100 feet solid EWM. 6ft of water. Source of many floating fragments
Location: 44 56.18N 85 42.40W
Waypoints: LLLA 24-26
2020 Treatment: Since a new site, and major source of spread, decision was made to relocate LBB's from Site 1 (7 on 7/10) and Site 10 (Reed Bed on 7/14). 16 total LBB's did not cover the site, as there were many gaps in coverage and EWM around the edges. No DASH in 2020.
2021 Treatment: None. Aerial drone photos show the location of Lake Bottom Blankets set in 2020, but the site is much larger (now estimated to be at least 80 x 170 ft) than could be covered with available barriers.
2022 Prescription: A combination of burlap barriers with the intention of covering all dense EWM at the site, and spot barriers or hand-pulling to remove outlying EWM.

Site 14 – Otto Road North Sites
First Observed by RLS. Follow up by BP and Dan Harkness on July 6, 2020.

Location: 44 56.25N to 44 56.44N at approximately 85 42.38W.
Waypoints: 82-89 and 94, 95. LLLA 21-23 and 51
Notes: a number of small sites clustered about 100 yards to 500 yards north of the larger Site 13 above. Waypoints were marked on visible infestations, and buoys marked larger sites. Most infestations were nearly pure EWM over cobbles crusted with marl.
2020 Treatment: Hard substate made for decent visibility but harder pulling. Largest site at Waypoint LLLA 21 was DASHed in September 2020 over two days. Other smaller sites were hand pulled.
2021 Treatment: Waypoint 21 was hand-pulled on 7/9 and 7/12 by Ron R. A total of 80 lbs was removed.
2022 Prescription: Use of aerial drone imagery to guide diver-placed mini-barriers over the 10-15 dense infestations that persist. Hand-pulling of sporadic clumps and outliers.

Site 15 – Kelenske Point South
Observed: RLS survey June 2020, confirmed by BP on July 6.
Location: 44 53.15N 85 42.36W
Waypoint: LLLA 16
Notes: From surface appeared small and dense, but turned out to be bigger.
2020 Treatment: hand-pulled by diver over a 3 day period in August 2020
2021 Treatment: Visited on 6/28 (few plants pulled) and on 8/19 (about 10lbs)
2022 Prescription: Hand-pull as necessary

Site 16 - Billman's Beach
Observed: RLS survey, confirmed by BP and DH on July 6.
Location: 44 52.18N 85 43.23W
Waypoint: 78, LLLA 15
Notes: Appeared as fairly dense EWM site among "aquatic garden" of pondweeds, valisneria, and native plants. Visited on 8/10/20 by AP. BP and Ron Reimink also to assess and determine best treatment. Divers found EWM very difficult to pull among very heavy native vegetation of many species. Decision to defer treatment until 2021, developing a strategy least disruptive to natives.
2020 Treatment: none
2021 Treatment: volunteer divers Dave Dumoulin and Jay Logerman hand-pulled on 7/3 and again in August. About 100 lbs removed.
2022 Prescription: Observe and develop a plan that may include small barrier in "core" area of EWM along with continued hand-pulling.

Site 17 - Dunklow Farm SE (Dar's Landing)
Observed: RLS Survey June 2020, confirmed by BP and DH on July 6, 2020.
Location: 44 56.17N 85 43.16W
Waypoint: LLLA 20
Notes: Similar to Site 16 as EWM among native plants. Fairly dense near shore, running eastward into deeper water and becoming more mixed with natives.
2020 Treatment: None
2021 Treatment: Hand-pulled by Ron R on 7/26 (40lbs). MTT hand-pulled in September, removing about 90 lbs.
2022 Prescription: Continue hand-pulling

Site 18– Mebert Creek Natural Area
Observed: October 6, 2020 (BP), following up on suspicious weed bed in 2017 shoreline drone survey. A check of 2017 drone survey shows that infestation was well established in 2017.
Location: 44 54.45N 85 42.30W about 200 yds south of Gauthier camp
Waypoints: 103 (s end) and 104 (n end)
Notes: This stand is near shore at Mebert Creek Natural Area, in very shallow water among old stumps, set apart from the larger lake by extensive shoal area north of Reed Bed. Quite dense at southern edge and becoming more sparse to the north over about 100 yards.
2021 Treatment: None, but careful observation shows expansion and filling in.
2022 Prescription: Burlap barrier over entire site, along with careful marking and signing because site is very shallow and full of stumps. Extreme hazards to boater prevent all but a few boats from going near this spot, but still needs careful marking.

Site 19 – DNR Boat Launch
Observed: August of 2020
Location: 44 54.50N 85 43.26W
Notes: Not observed until late summer when a few strands of EWM were evident just south of launch ramp in about 3-4 ft of water.
2020 and 2021 Treatment: None. Site remains unchanged.
2022 Prescription: Hand pull

Newly Discovered Sites in 2022

Repeated and careful scouting, particularly in August and September, discovered a number of new sites of EWM. All sites were confirmed and marked by waypoints, and almost all were hand-pulled within days. Since most of these locations were very sparse EWM, often spread out over a significant area, each new site is described as an area.

North Lake Leelanau - This site is about 50 meters north of the Narrows channel markers. Discovered in late May, only a few separate plants or clumps of plants were found. About 10lb of plants were harvested by Annalise Povolo and volunteer Caitlyn Watkins on June 9. A visit in July failed to turn up more plants. On August 9 Ron Reimink harvested about 10 plants.
2022 Prescription: As the only known infestation in North Lake Leelanau, this site should be visited and hand-pulled at least monthly through the season

Lake Leelanau Narrows Sites - Sporadic clumps of plants were found in several locations in the Lake Leelanau Narrows. On August 23 Ron Reimink and Brian Price pulled EWM at the following locations:

- NE edge of M-204 bridge – 5 plants (L167)
- Below power transmission line, east side of channel – 1 plant (L163)
- About 20lb from Narrows Yacht Club, in and around docks at north end. (L164-65) This site was revisited by RR and Bp on 8/30 and by BP on November 15, with a few plants removed each time.
- About 5 lb in and around Garvin's dock (L154), about 50 ft south of M-204 bridge on the east side

2022 Prescription: Carefully scout the entire channel at least monthly through the season, removing any observed EWM. As the entrance to NLL, this is a very high priority.

Saint Mary's Bay and South Channel - Two small infestations were hand-pulled on 8/23 by RR with careful scouting of transect lines

- Waypoint 162, about ½ mile south of Narrows on east side. About 20lbs harvested
- Waypoint 161, about 25 feet NE of SE channel marker. About 10 lbs harvested

2022 Prescription: Hand-pull at least monthly through the season. High priority

Haring's Point: 1.1 miles south of Fountain Point on the west side. Two small infestations were found, one on each side of the point (Waypoints 131 and 132). Pulled by RR on 7/22 and again in August, the sites yielded a total of about 20lb.
2022 Prescription: Hand pull at least twice

Channel South: About 1800 ft. SW of Fountain Point along the west side. Pulled by RR on 8/16, about 20lbs.
2022 Prescription: Hand-pull at least twice, scout along entire shoreline.

Fountain Point South: About 1.1 miles south of Fountain Point on the east side (opposite Haring's Point) a series of 4 small infestations were marked. The smallest (Waypoints 161, 162) were pulled by RR on 8/16, yielding less than 10lb total. The southernmost of the infestations are both larger and may require a combination of mini-barriers and hand-pulling.
2022 Prescription: Careful scouting, combination of mini-barriers and hand-pulling. Aerial drone to identify locations.

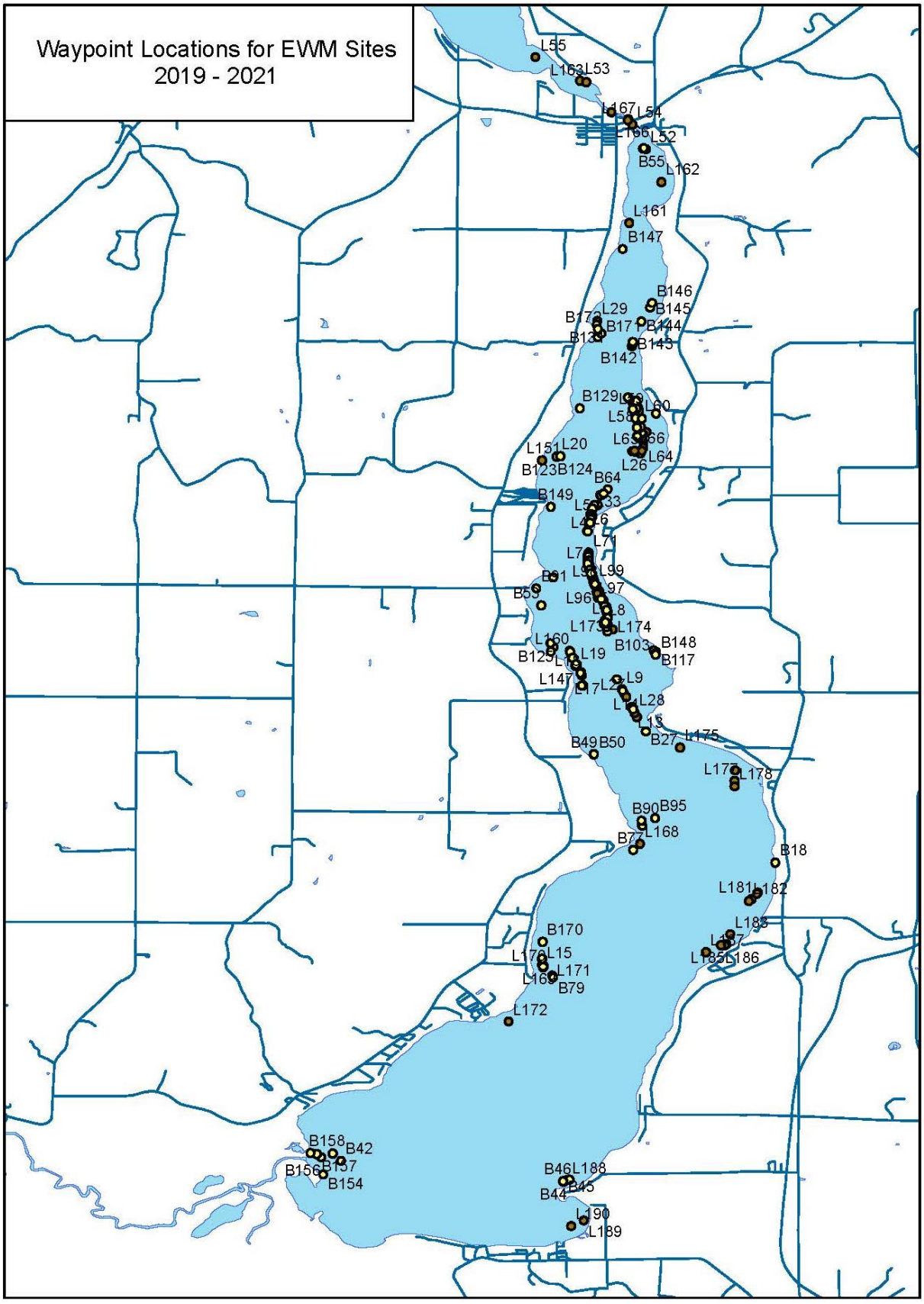
Bingham Boat Launch North and South: Within about ½ mile of the boat launch in either direction a series of small clumps of EWM were discovered on September 1. Waypoints 175-182 were small and widely separated EWM infestations from about ½ mile south of Gordon's Point to about 200 meters north of the Boat Launch. Waypoints 183-186 were about ¼ mile south of the Boat Launch.
2022 Prescription: Careful scouting and swim this entire shoreline, with hand-pulling of known and new locations at least twice in the season.

Paradise Cove – located in the extreme SE end of SLL off Belknap Creek (Waypoints 189, 190). MTT hand-pulled over a two day period, yielding about 30lb EWM
2022 Prescription: Hand-pulling as the EWM is mixed in with natives

SE SLL between Lakefront and Birch Point Road. MTT divers hand-pulled about 90 lbs of EWM over a 4 day period in September. Described as "very sporadic" the site appears to be scattered plants and clumps over a ½ mile of shoreline.
2022 Prescription: Hand pull at least twice

Skeba Point: Several very small clumps were observed by Ron R and BP while scouting in late August from Skeba Point south to Leelanau Pines Campground. The southernmost of the waypoints did not yield any EWM on a return trip, but one area off Skeba Point did yield about 10lbs. About 1/4 mile SE of the Billman's Beach site.
2022 Prescription: Hand-pulling and scouting.

Appendix B - Mapped EWM Sites in Lake Leelanau



Waypoints and Corresponding Coordinates

Site	Date	Latitude	Longitude	Site	Date	Latitude	Longitude
B1	6/24/20	44.8739231	-85.7156311	B42	7/31/20	44.9194812	-85.7159185
B2	6/24/20	44.8739264	-85.7155878	B43	7/31/20	44.9196619	-85.7156018
B3	7/1/20	44.9302096	-85.7166731	B44	8/3/20	44.9203293	-85.7157184
B4	7/1/20	44.9301057	-85.7167318	B45	8/3/20	44.9203302	-85.7157831
B5	7/1/20	44.9299392	-85.7167176	B46	8/3/20	44.9200643	-85.7160079
B6	7/1/20	44.9280958	-85.7172956	B47	8/3/20	44.9200584	-85.7159326
B7	7/1/20	44.9165010	-85.7150537	B48	8/3/20	44.9200677	-85.7159859
B8	7/1/20	44.9163412	-85.7150175	B49	8/3/20	44.9200506	-85.7159752
B9	7/1/20	44.9075689	-85.7127998	B50	8/3/20	44.9190103	-85.7152486
B10	7/1/20	44.9071859	-85.7125621	B51	8/5/20	44.9437220	-85.7111964
B11	7/1/20	44.9070289	-85.7124818	B52	5/17/21	44.9777300	-85.7097074
B12	7/1/20	44.9052556	-85.7114813	B53	6/1/21	44.9866052	-85.7181918
B13	7/1/20	44.9049608	-85.7113066	B54	6/1/21	44.9809196	-85.7114344
B14	7/1/20	44.9040137	-85.7108595	B55	6/1/21	44.9896420	-85.7239689
B15	7/6/20	44.8718142	-85.7231515	B56	6/3/21	44.9441182	-85.7106557
B16	7/6/20	44.8876731	-85.7103309	B57	6/3/21	44.9439913	-85.7107921
B17	7/6/20	44.9093311	-85.7179364	B58	6/3/21	44.9433826	-85.7107583
B18	7/6/20	44.9096984	-85.7181509	B59	6/3/21	44.9437057	-85.7105048
B19	7/6/20	44.9106337	-85.7187378	B60	6/3/21	44.9427640	-85.7104257
B20	7/6/20	44.9378422	-85.7212041	B61	6/3/21	44.9406971	-85.7099607
B21	7/6/20	44.9439082	-85.7105778	B62	6/3/21	44.9400662	-85.7102787
B22	7/6/20	44.9433389	-85.7106662	B63	6/3/21	44.9397182	-85.7099942
B23	7/6/20	44.9409746	-85.7096349	B64	6/3/21	44.9389917	-85.7099906
B24	7/6/20	44.9382017	-85.7103614	B65	6/3/21	44.9385161	-85.7101947
B25	7/6/20	44.9384441	-85.7110967	B66	6/3/21	44.9385529	-85.7111401
B26	7/6/20	44.9384622	-85.7114479	B67	6/3/21	44.9303020	-85.7168568
B27	7/8/20	44.9066217	-85.7121625	B68	6/4/21	44.9212493	-85.7162254
B28	7/8/20	44.9045704	-85.7111406	B69	6/4/21	44.9217042	-85.7164482
B29	7/8/20	44.9554308	-85.7159608	B70	6/4/21	44.9237095	-85.7170521
B30	7/8/20	44.9315192	-85.7162720	B71	6/4/21	44.9252770	-85.7171229
B31	7/24/20	44.9176596	-85.7147849	B72	6/4/21	44.9222738	-85.7165938
B32	7/24/20	44.9183733	-85.7149364	B73	6/4/21	44.9211091	-85.7162530
B33	7/24/20	44.9304244	-85.7167700	B74	6/16/21	44.9210058	-85.7162124
B34	7/31/20	44.9210510	-85.7162113	B75	6/16/21	44.9211077	-85.7162136
B35	7/31/20	44.9209916	-85.7161159	B76	6/16/21	44.9211919	-85.7162553
B36	7/31/20	44.9209894	-85.7161348	B77	6/16/21	44.9212499	-85.7162726
B37	7/31/20	44.9200805	-85.7160066	B78	6/16/21	44.9213139	-85.7162838
B38	7/31/20	44.9200643	-85.7160016	B79	6/16/21	44.9213872	-85.7162872
B39	7/31/20	44.9203366	-85.7159235	B80	6/16/21	44.9214691	-85.7162942
B40	7/31/20	44.9202821	-85.7160571	B81	6/16/21	44.9215455	-85.7163185
B41	7/31/20	44.9202418	-85.7160726	B82	6/16/21	44.9216166	-85.7163531

Waypoints and Corresponding Coordinates cont.

Site	Date	Latitude	Longitude	Site	Date	Latitude	Longitude
B85	6/16/21	44.9218024	-85.7164290	B128	6/16/21	44.9237922	-85.7170769
B86	6/16/21	44.9218682	-85.7164427	B129	6/16/21	44.9237177	-85.7170621
B87	6/16/21	44.9219886	-85.7164798	B130	6/16/21	44.9235933	-85.7170481
B88	6/16/21	44.9221080	-85.7164927	B131	6/16/21	44.9233915	-85.7170114
B89	6/16/21	44.9222819	-85.7165408	B132	6/16/21	44.9231970	-85.7169107
B90	6/16/21	44.9223586	-85.7165847	B133	6/16/21	44.9243728	-85.7172606
B91	6/16/21	44.9224696	-85.7166422	B134	6/16/21	44.9244429	-85.7172462
B92	6/16/21	44.9226012	-85.7167104	B135	6/16/21	44.9245628	-85.7172411
B93	6/16/21	44.9227277	-85.7167704	B136	6/16/21	44.9246930	-85.7172365
B94	6/16/21	44.9211587	-85.7162674	B137	6/16/21	44.9247188	-85.7172348
B95	6/16/21	44.9211066	-85.7163304	B138	6/16/21	44.9248018	-85.7172269
B96	6/16/21	44.9211778	-85.7163486	B139	6/16/21	44.9249761	-85.7172182
B97	6/16/21	44.9212364	-85.7163555	B140	6/16/21	44.9249719	-85.7171412
B98	6/16/21	44.9213165	-85.7163742	B141	6/16/21	44.9248422	-85.7171234
B99	6/16/21	44.9213946	-85.7163913	B142	6/16/21	44.9247527	-85.7171037
B100	6/16/21	44.9214530	-85.7164060	B143	6/16/21	44.9246512	-85.7171289
B101	6/16/21	44.9215880	-85.7164559	B144	6/16/21	44.9245479	-85.7171394
B102	6/16/21	44.9216573	-85.7164783	B145	6/16/21	44.9244181	-85.7171250
B103	6/16/21	44.9217003	-85.7164977	B146	6/16/21	44.9243651	-85.7171597
B104	6/16/21	44.9217443	-85.7165172	B147	6/17/21	44.9106390	-85.7187329
B105	6/16/21	44.9218134	-85.7164980	B148	6/17/21	44.9107950	-85.7186534
B106	6/16/21	44.9218686	-85.7165132	B149	6/22/21	44.9222563	-85.7166276
B107	6/16/21	44.9219507	-85.7165343	B150	6/22/21	44.9210657	-85.7162474
B108	6/16/21	44.9219965	-85.7165458	B151	6/29/21	44.9373130	-85.7231639
B109	6/16/21	44.9220583	-85.7165746	B152	7/6/21	44.9401941	-85.7101835
B110	6/16/21	44.9220975	-85.7166015	B153	7/6/21	44.9402535	-85.7105751
B111	6/16/21	44.9221448	-85.7166272	B154	7/6/21	44.9445958	-85.7108852
B112	6/16/21	44.9222024	-85.7166463	B155	7/6/21	44.9447269	-85.7109112
B113	6/16/21	44.9222726	-85.7166669	B156	7/6/21	44.9449519	-85.7109581
B114	6/16/21	44.9223351	-85.7166797	B157	7/6/21	44.9450378	-85.7109689
B115	6/16/21	44.9231530	-85.7169904	B158	8/13/21	44.9293458	-85.7168367
B116	6/16/21	44.9233091	-85.7170626	B159	8/14/21	44.9097868	-85.7180266
B117	6/16/21	44.9234162	-85.7170133	B160	8/17/21	44.9125855	-85.7195694
B118	6/16/21	44.9234151	-85.7170694	B161	8/20/21	44.9681530	-85.7118193
B119	6/16/21	44.9235377	-85.7171086	B162	8/20/21	44.9734605	-85.7076649
B120	6/16/21	44.9236596	-85.7171381	B163	8/20/21	44.9864062	-85.7174394
B121	6/16/21	44.9237277	-85.7171713	B164	8/20/21	44.9824836	-85.7141416
B122	6/16/21	44.9238060	-85.7172063	B165	8/20/21	44.9824949	-85.7141312
B123	6/16/21	44.9238987	-85.7172207	B166	8/20/21	44.9816293	-85.7119544
B124	6/16/21	44.9239939	-85.7172394	B167	8/23/21	44.9814576	-85.7119752
B125	6/16/21	44.9240105	-85.7171481	B168	8/24/21	44.8875610	-85.7104017
B126	6/16/21	44.9239626	-85.7171265	B169	8/24/21	44.8716970	-85.7230108
B127	6/16/21	44.9238642	-85.7171108	B170	8/24/21	44.8714579	-85.7229912

Waypoints and Corresponding Coordinates cont.

Site	Date	Latitude	Longitude	Site	Date	Latitude	Longitude
B171	8/24/21	44.8704647	-85.7218319	L24	7/16/19	44.9985897	-85.7521540
B172	8/24/21	44.8644484	-85.7274685	L25	7/17/19	44.8755031	-85.7174682
B173	8/30/21	44.9158507	-85.7145584	L26	7/17/19	44.8754964	-85.7174791
B174	8/30/21	44.9153420	-85.7139669	L27	7/17/19	44.9020891	-85.7096559
B175	9/1/21	44.9000592	-85.7052229	L28	7/17/19	44.9073878	-85.7126704
B176	9/1/21	44.8970719	-85.6981171	L29	7/17/19	44.9180172	-85.7147504
B177	9/1/21	44.8957012	-85.6981422	L30	7/17/19	44.9213866	-85.7164194
B178	9/1/21	44.8950067	-85.6981914	L31	7/17/19	44.9250926	-85.7170874
B179	9/1/21	44.8811968	-85.6951294	L32	8/7/19	44.9969207	-85.7389215
B180	9/1/21	44.8810967	-85.6952572	L33	8/7/19	45.0200300	-85.7328291
B181	9/1/21	44.8803734	-85.6959853	L34	8/7/19	45.0414151	-85.7376365
B182	9/1/21	44.8801433	-85.6962772	L35	8/8/19	44.9434012	-85.7083461
B183	9/1/21	44.8757990	-85.6987208	L36	8/9/19	44.9080389	-85.7178802
B184	9/1/21	44.8745270	-85.6992446	L37	8/9/19	44.9080905	-85.7178676
B185	9/1/21	44.8744218	-85.6994498	L38	8/9/19	44.9081124	-85.7178398
B186	9/1/21	44.8744118	-85.6999482	L39	8/10/19	44.8439375	-85.7196050
B187	9/1/21	44.8734806	-85.7019051	L40	8/10/19	44.8439424	-85.7195715
B188	9/1/21	44.8438703	-85.7198464	L41	8/10/19	44.8439439	-85.7195689
B189	9/1/21	44.8386256	-85.7177471	L42	8/10/19	44.8464030	-85.7492233
B190	9/1/21	44.8379099	-85.7193504	L43	8/20/19	44.8437218	-85.7203660
L1	6/17/19	44.8811888	-85.9728114	L44	8/20/19	44.8437304	-85.7203873
L2	6/17/19	44.8812054	-85.9728233	L45	8/20/19	44.8437372	-85.7203979
L3	6/17/19	44.8812158	-85.9728199	L46	8/20/19	44.8437425	-85.7203939
L4	6/17/19	44.8812221	-85.9728236	L47	8/20/19	44.8899249	-85.7101404
L5	6/17/19	44.8626048	-86.0034464	L48	8/20/19	44.8898843	-85.7101158
L6	6/17/19	45.0405159	-85.7293019	L49	8/20/19	44.8991909	-85.7164265
L7	6/17/19	44.8754313	-85.7157035	L50	8/20/19	44.8991622	-85.7164019
L8	6/17/19	44.7964910	-85.6415712	L51	8/20/19	44.9080617	-85.7178498
L9	6/25/19	44.9142427	-85.7245222	L52	8/20/19	44.9080473	-85.7178360
L10	6/25/19	44.9063021	-85.7180664	L53	8/20/19	44.9185023	-85.7232912
L11	6/25/19	44.8759877	-85.7227727	L54	8/20/19	44.9778225	-85.7099089
L12	6/25/19	44.8701775	-85.7217766	L55	8/20/19	44.9778108	-85.7099047
L13	6/25/19	44.8583981	-85.7406116	L56	9/5/19	44.8904522	-85.7101855
L14	6/25/19	44.8516080	-85.7502989	L57	9/5/19	44.9328097	-85.7155650
L15	6/25/19	44.8475563	-85.7512155	L58	6/9/20	44.9161881	-85.7150842
L16	7/8/19	44.9777875	-85.7100191	L59	6/14/20	44.9050537	-85.7113269
L17	7/10/19	44.9984761	-85.7520948	L60	6/19/20	44.9299233	-85.7167329
L18	7/16/19	44.8851389	-85.6928966	L61	6/19/20	44.9280895	-85.7172270
L19	7/16/19	44.8644645	-85.7321357	L62	6/19/20	44.9165165	-85.7150152
L20	7/16/19	44.8644648	-85.7321283	L63	6/28/20	44.9327335	-85.7155153
L21	7/16/19	44.8644714	-85.7321291	L64	6/28/20	44.9335435	-85.7146269
L22	7/16/19	44.8644655	-85.7321393	L65	6/28/20	44.9191813	-85.7151979
L23	7/16/19	44.9985977	-85.7521637	L66	6/28/20	44.9184588	-85.7149453

Waypoints and Corresponding Coordinates cont.

Site	Date	Latitude	Longitude	Site	Date	Latitude	Longitude
L67	6/28/20	44.9179331	-85.7148405	L111	6/10/21	44.9246768	-85.7171611
L68	6/28/20	44.9176994	-85.7146720	L112	6/10/21	44.9239972	-85.7171435
L69	6/28/20	44.9171862	-85.7146860	L113	6/14/21	44.9248129	-85.7171611
L70	6/28/20	44.9158233	-85.7146683	L114	6/14/21	44.9244159	-85.7171750
L71	6/28/20	44.9150993	-85.7146899	L115	6/14/21	44.9239963	-85.7171642
L72	6/28/20	44.9156601	-85.7147715	L116	6/14/21	44.9223475	-85.7166443
L73	6/28/20	44.9160759	-85.7148673	L117	6/14/21	44.9212313	-85.7162587
L74	6/28/20	44.9161360	-85.7151307	L118	6/29/21	44.9123650	-85.7083142
L75	6/28/20	44.9088524	-85.7134777	L119	7/2/21	44.9108798	-85.7188107
L76	7/1/20	45.0282656	-85.7480644	L120	7/2/21	44.9220756	-85.7217037
L77	7/16/20	44.8867695	-85.7113016	L121	7/2/21	44.9125222	-85.7219602
L78	7/16/20	44.8716537	-85.7229639	L122	7/2/21	44.9107679	-85.7187145
L79	7/30/20	44.8701668	-85.7216538	L123	7/6/21	44.9125735	-85.7195301
L80	8/12/20	44.9440614	-85.7109253	L124	7/11/21	44.9378057	-85.7212280
L81	8/12/20	44.9428242	-85.7107661	L125	7/11/21	44.9378775	-85.7207633
L82	8/14/20	44.9439839	-85.7113804	L126	7/16/21	44.9135818	-85.7220349
L83	8/14/20	44.9448598	-85.7114543	L127	7/16/21	44.9106151	-85.7188208
L84	8/14/20	44.9453071	-85.7118051	L128	7/16/21	44.9178994	-85.7147713
L85	8/17/20	44.9454545	-85.7119677	L129	7/16/21	44.9193182	-85.7154939
L86	8/17/20	44.9427767	-85.7110094	L130	7/21/21	44.9440724	-85.7182181
L88	8/24/20	44.9408617	-85.7101396	L131	7/21/21	44.9532544	-85.7158926
L89	8/24/20	44.9427685	-85.7101600	L132	7/21/21	44.9549549	-85.7159900
L90	8/24/20	44.9450031	-85.7109336	L133	7/21/21	44.9524146	-85.7113919
L91	8/27/20	44.8905229	-85.7102567	L134	7/21/21	44.9526939	-85.7113977
L92	8/28/20	44.9207054	-85.7238913	L135	7/21/21	44.9315208	-85.7163025
L93	9/1/20	44.9416342	-85.7102603	L136	7/21/21	44.9309724	-85.7167054
L94	9/1/20	44.9415847	-85.7108580	L137	7/30/21	44.9248603	-85.7171643
L95	9/1/20	44.9404562	-85.7107558	L138	7/30/21	44.9243758	-85.7171273
L96	9/4/20	44.8908604	-85.7084690	L139	7/30/21	44.9239081	-85.7172122
L97	9/8/20	44.9225186	-85.7166462	L140	7/30/21	44.9231300	-85.7169466
L98	9/21/20	44.9183603	-85.7150397	L141	7/30/21	44.9226261	-85.7167906
L99	9/22/20	44.9215429	-85.7164113	L142	8/9/21	44.9521214	-85.7114777
L100	9/22/20	44.9239305	-85.7170990	L143	8/9/21	44.9523704	-85.7113945
L101	9/22/20	44.9315582	-85.7158872	L144	8/9/21	44.9526677	-85.7114126
L102	9/23/20	44.9168772	-85.7145961	L145	8/9/21	44.9553579	-85.7102586
L103	10/6/20	44.9124653	-85.7083307	L146	8/9/21	44.9570982	-85.7091166
L104	10/6/20	44.9126571	-85.7086499	L147	8/9/21	44.9577109	-85.7089011
L105	10/6/20	44.9162992	-85.7149469	L148	8/9/21	44.9647471	-85.7126465
L106	6/7/21	44.9130685	-85.7216193	L149	8/30/21	44.9121182	-85.7083790
L107	6/8/21	44.9096629	-85.7181468	L150	9/2/21	44.9313146	-85.7219772
L108	6/8/21	44.8716093	-85.7229957	L151	9/2/21	44.9124955	-85.7195042
L109	6/10/21	44.9252970	-85.7171221	L152	9/2/21	44.9116776	-85.7191984
L110	6/10/21	44.9251105	-85.7171442	L153	9/2/21	44.9107973	-85.7187426

Waypoints and Corresponding Coordinates cont.

Site	Date	Latitude	Longitude
L153	9/2/21	44.9107973	-85.7187426
L154	9/2/21	44.9080792	-85.7179542
L155	9/2/21	44.8446295	-85.7515172
L156	9/2/21	44.8473616	-85.7503037
L157	9/2/21	44.8468701	-85.7518049
L158	9/2/21	44.8472736	-85.7524008
L159	9/2/21	44.8473903	-85.7531559
L160	9/12/21	44.9329859	-85.7151445
L161	9/12/21	44.9310921	-85.7165748
L162	9/12/21	44.9310468	-85.7166275
L163	9/12/21	44.9303073	-85.7167863
L164	9/12/21	44.9302946	-85.7167823
L165	9/12/21	44.9302585	-85.7167741
L166	9/12/21	44.9301120	-85.7167383
L167	9/12/21	44.9299452	-85.7167065
L168	9/12/21	44.9296913	-85.7167773
L169	9/12/21	44.9292092	-85.7169561
L170	9/28/21	44.8726158	-85.7231178
L171	9/28/21	44.8748051	-85.7230917
L172	10/6/21	44.9537597	-85.7154687
L173	10/6/21	44.9543478	-85.7159142
L153	9/2/21	44.9107973	-85.7187426
L154	9/2/21	44.9080792	-85.7179542
L155	9/2/21	44.8446295	-85.7515172
L156	9/2/21	44.8473616	-85.7503037
L157	9/2/21	44.8468701	-85.7518049
L158	9/2/21	44.8472736	-85.7524008
L159	9/2/21	44.8473903	-85.7531559
L160	9/12/21	44.9329859	-85.7151445
L161	9/12/21	44.9310921	-85.7165748
L162	9/12/21	44.9310468	-85.7166275
L163	9/12/21	44.9303073	-85.7167863
L164	9/12/21	44.9302946	-85.7167823