Prepared by: EOR & Blue Water Science

For the Lake Minnetonka Conservation District

DRAFT

Lake Minnetonka Vegetation & AIS Master Plan: Aquatic Vegetation Harvesting Program Evaluation

DRAFT - 10.09.2019

water ecology community

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1. INTRODUCTION

In the Upper Midwest, mechanical harvesting is primarily used to manage Eurasian watermilfoil (EWM) and to a lesser extent, to control dense stands of native vegetation. Most often, mechanical harvesting is used to enhance or provide recreational access to and from publicly used spaces such as docks, swimming piers, or public boat landings. Literature suggests that harvesting provides temporary, short-term reductions in aquatic plant biomass. Mechanical harvesting is often viewed as a maintenance technique rather than a long-term management strategy. In Lake Minnetonka, Crowell et al. (1994) observed that a mid-growing season harvest reduced average EWM biomass in plots for 6 weeks after the initial harvest, when compared to reference areas. Other studies have shown that the effects of mechanical harvesting may last as little as 3-4 weeks (Rawls, 1975, Cooke et., al, 1989). Still, other studies show that despite the potential for rapid regrowth of biomass, there may be beneficial long-term effects (maintenance of navigable channels) especially when harvesting is conducted later in the growing season and cuts are made closer to the sediment surface (Unmuth et., al, 1998). For example, in Lake Wingra (Madison, WI), EWM averaged only 4% of its original length in harvested, shallower water sites (less than 3 meters deep), three years after a one-time harvesting effort (Unmuth et., al, 1998). While all aquatic plant management techniques have strengths and weaknesses, mechanical harvesting can be a component of an integrated aquatic plant management approach.

2. PURPOSE

The purpose of this evaluation is to:

1) Define the aspects of a successful mechanical harvesting program for the Lake Minnetonka Conservation District (LMCD),

2) Identify the strengths and weaknesses of the existing harvesting program, and

3) Develop a recommendation for aspects of the program that should be sustained, and highlight areas of the harvesting program that are in need of improvement.

This report will also outline short-term and long-term quantifiable goals for the mechanical harvesting program. These goals will specify when and under what conditions mechanical harvesting is most likely to produce optimum results in Lake Minnetonka.

3. EXISTING PROGRAM OVERVIEW

3.1. LMCD Harvesting Program Goals

The LMCD Harvesting Program has been in operation since 1989. The goal of the LMCD Harvesting Program is to ensure safe navigation for lakeshore owners and the general public, reduce the amount of aquatic invasive species (AIS) available to spread by boaters and other means throughout the busy season, reduce biomass in the lake, and provide an alternative to other AIS management methods where they are not feasible or desired.

3.2. Harvesting Priorities

Traditionally, harvesting priorities have targeted locations where vegetation is impeding boat navigation on the lake, with higher priority given to areas of the lake where EWM / curlyleaf pondweed (CLP) had formed a floating mat. The general goal of LMCD harvesting program is to provide public harvest channels cut parallel to shore and out to open water. These high priority areas include locations in which vegetation may have posed a hazard or public nuisance for the safety of boaters and/or property by hindering navigation Figure 1.

These types of locations are well suited for mechanical harvesting because mechanical harvesting provides immediate relief whereas herbicides typically take 7 to 14 days to take full effect, and are dependent on the type and concentration of herbicide used. However, harvesting vegetation as it reaches nuisance conditions represents a reactionary methodology.

Figure 1. LMCD Public Harvesting Illustration.

3.3. Staffing

The LMCD hires a site supervisor and 4-5 other seasonal employees prior to each harvesting season that are specifically dedicated to the weed harvesting program. The LMCD solicits feedback from previously employed staff members prior to recruiting any new employees. Tom Elmer has been retained as the site supervisor from 2013 to 2018. Recruitment for new seasonal employees is initiated in February via League of Minnesota Cities, online venues local newspaper ads, local school districts, and local colleges. The aquatic vegetation harvesting program is managed by Vickie Schleuning, Executive Director of the LMCD. Ms. Schleuning was hired by the LMCD on September 12th, 2016. Ms. Schleuning is a graduate of the University of Minnesota Carlson School of Business (Master of Business Administration) and South Dakota State University (Bachelor of Science Degrees in Health Science and Microbiology, minor in Chemistry). She is a Minnesota Registered Environmental Health Specialist, maintains Certificates in Federal Emergency Management Agency and Project Management, as well as participated in the Baldrige Examiner Training Experience and various Advanced Leadership Groups. Ms. Schleuning also has an AIS Detector Certification as does one other staff member at LMCD.

The LMCD also prepares contracts with Curfman Trucking and Repair, Inc. for trucking and mechanic services. Occasionally, additional specialty mechanics are hired depending on the repair item. In the past, these specialty mechanics have primarily been used for addressing hydraulic issues associated with the harvesters. Table 1. provides a list of all positions and qualifications associated with the mechanical harvesting program.

Table 1. LMCD Harvesting Staff Qualifications.

Position	Lake Service Provider Permit	Watercraft Operators Permit	Advanced education in ecological, environment, or similar	Experience with watercraft	Experience with large equipment, farm, bus, etc.	Class A Driver's License / Heavy Machinery	Flagging Training/ Certification	Better Business Bureau Rating	Familiarity with mechanics (farm, vehicle, watercraft, etc.)	Specialty experience, degree or certification preferred	Emergency response, safety
Harvester Operators	R	R	P	P	P						
Onsite Supervisor	R	R	P	P	P				P		P
General Maintenance & Repair (Contracted)					P			P	P	R	
Specialty Mechanic (Contracted)					P			P	P	R	
Trucking of AIS (Contracted)						P/R*		P			
Hauling harvesters of public streets (Contracted Hennepin County)					R	R	R				
General Outboard/ Boat Repair								P	R	P/R	

R- Required, P- Preferred

*Trucking license depends on machinery being hauled.

3.3.1. Staff Roles and Responsibilities

Site Supervisor

The site supervisor performs a wide variety of tasks, under the discretion of the LMCD Executive Director. Table 2 outlines the daily routines and weekly responsibilities for the site supervisor during the harvesting season. A complete position description, including additional pre and post-harvesting season responsibilities, is provided in the LMCD Eurasian Watermilfoil Harvesting Program Employee Manual.

Table 2. Site Supervisor Routines and Responsibilities: Source: LMCD.

Timeline	Daily Activity Description
6:00 AM	Ensure that the cell phone and all walkie talkies charged. Check the weather conditions.
6:15 AM	Leave LMCD office to meet crew at pre-determined sit. Drop off trailer at the off load site.
6:30 AM	Prepare logs and job assignments for day according to the job assignment schedule. Blue Harvester logs for the Harvesters, green log for the High Speed Transport (HST), AIS log for the Shore.
7:00 AM	Crew arrives. Disperse job assignments for the day. Disperse Keys, Walkie Talkies, & Logs. Re-Check weather conditions. Ensure safety equipment and BMP in place.
7:30 AM	Arrive at boats. Daily maintenance. Send harvesters to start cutting.
8:00 AM	Pick up conveyor. Transport to offload site and set up. Check fuel and grease.
8:30-4:30 PM	Monitor boats (redirect as needed). Deal with complaints at the boat ramp. Scout areas
4:45 PM	Unload final load on each boat. Send boats to overnight storage area and clean up.
5:15 PM	Review day with crew (comments and suggestions). Discuss meeting place for following day. Collect keys, walkie talkies (turned off) and completed logs.
5:30 PM	Crew leaves for day. Return to LMCD offices. Throw away trash. Provide any floatables and lost and founds to Office. Report any solar light issues to office. Charge cell phone and walkie talkies. Advise truck when and where to meet for the following day.
Weekly Responsibilities	
1. Arrange fuel truck at least 24 hours before needed. 2. Keep at least 1 full 5 gallon diesel and gas in trailer at all times. 3. Insure all boats have all safety gear at all times when in operation. 4. Complete daily harvesting logs weekly. 5. Turn in to office prior weeks' logs and receipts every Mon. a.m. 6. Turn in completed time sheets (checked) every other Mon. as per schedule and hand out new time sheets to crew. 7. Check with office at least once/day regarding schedule and concerns. 8. Every Thurs. advise office of plans for following week (to be put on website). 9. Any time truck and trailer are left for an extended period (weekends, 4th. of July etc.) disconnect and park separately in far N.W. corner of office lot. 10. Insure trailer lights are working; especially the wireless rig for the shore conveyor. 11. Keep plenty of water bottles on hand for the crew. 12. On hot days keep an eye on crew for signs of dehydration and/or hypothermia. 13. Leave keys in all equipment as long as personnel are on site. When no one is on site all keys should be removed and everything that can be locked must be. 14. Report any repairs, emergencies, or other complaints to LMCD Executive Director or other staff right away for follow up as needed.	

Harvesters, High Speed Transporters, Shoreline Conveyors

Daily and weekly routines and responsibilities for harvesters and high-speed transporters are provided in Table 3. Daily and weekly routines and responsibilities for the shore conveyer are provided in Table 4. A complete position description, including additional pre and post-harvesting season responsibilities is provided in the LMCD Eurasian Watermilfoil Harvesting Program Employee Manual. These positions are performed under the direction of the site supervisor. The site supervisor is ultimately responsible for ensuring that all activities identified for the harvesters, transporters, and conveyers are completed at the end of each day. The site supervisor reports directly to the LMCD executive director who oversees the harvesting program and provides guidance for future harvesting activities.

Table 3. Harvester and High Speed Transporter Routines and Responsibilities.

Timeline	Daily Activity Description
7:00 AM	Arrive to designated parking area to either carpool or begin duties. This area should be addressed the day prior during the closing meeting.
7:05 AM	Discuss areas that need to be harvested for the day, need special attention (via bay maps) and areas that should be left untouched. Go over assignments (specific to position) for the day - there will be a rotating schedule for positions including; Harvester 7 or 8, High Speed Transporter (HST), Shore Conveyor or Office.
7:15 AM	Carpool to Harvester Storage Site - or begin maintenance for the day if already at the site. Maintenance includes; checking gas levels, grease points on all machines, putting up Bimini's, and insuring that you have your PFD, throwable device, backpack with all tools, horn, assigned worksheets, walkie talkie and keys. Diesel trucks should arrive every Monday. You will either be asked to wait for the truck the morning of or asked to harvest and return when they arrive.
7:45 AM	Begin harvesting areas that were addressed at the morning meeting.
11:00-12:00 PM	Lunch break- coordinate with Supervisor to figure out the most efficient schedule. This time should be used to refill water bottles, use restrooms, re-establish where you have cut and what still needs to be done for the rest of the day.
12:00-4:30 PM	Continue your assignments for the day. Communicating with the Supervisor on areas that have been cut, when HST assistance is needed, water refills as well as weather updates.
4:30-5:00 PM	Begin commuting to the overnight parking for the day. Insure that all boats are clear of visible weeds, Bimini is put down and stored for the day, all garbage is removed from the boats, and boats are idle for ten minutes before being shut off. Insure that all paperwork is filled out and up to date before leaving the boat for the day. The paperwork should be made in ¼ increments and each task should be noted on the sheets. Be sure to note each trip to the shore conveyor or connecting to the HST, as well as the ending hours. Include the engine hours before turning the engine off.
5:00-5:30 PM	All walkie talkies (turned off), paperwork, and keys need to be returned to the Supervisor at the end of the day. Paperwork should be completed.

Table 4. Shore Conveyor Routines and Responsibilities.

Timeline	Daily Activity Description
7:00 AM	Arrive to designated parking area to either carpool or begin duties. This area should be addressed the day prior during the closing meeting.
7:05 AM	Discuss areas that need to be harvested for the day, need special attention (via bay maps) and areas that should be left untouched. Go over assignments (specific to position) for the day - there will be a rotating schedule for positions including; Harvester 7 or 8, High Speed Transporter (HST), Shore Conveyor or Office.
7:10 AM	Assist Supervisor in carpooling other interns to the harvesting site. Remain in vehicle as you will be assisting in moving the shore conveyor. The Supervisor will need assistance in backing up the truck to attach the hitch to the shore conveyor for transport from the overnight parking site to the offload site.
7:30 AM	Once you arrive at the overnight parking site to pick up the shore conveyor assist in backing up the truck towards the shore conveyor hitch. Lift the shore conveyor so that the hitch can rest on the truck. Secure the conveyor and insure that both boards are removed from the front of the tires of the shore conveyor. Lights from the back of the truck need to be put on the back of the shore conveyor, INSURE THIS IS TURNED ON. The battery pack will need to be plugged into the outlet near the hitch, and the battery pack will rest on the conveyor. Spare batteries for the lights are in the truck if needed.
8:00 AM	Once you arrive to the site your first responsibility will be to assist the site supervisor in parking the shore conveyor at the offload site. Insure that the conveyor is in a level area with a water depth that is capable of harvesters and the high speed being able to attach. The shore conveyor should allow room for other launching boats, insure this is the case while parking.
8:20 AM	1. Back conveyor into place ensuring centerline is perpendicular to waterline. 2. Centerline of axel of conveyor will be 2 feet above or below edge of water depending on steepness of ramp. 3. The support bars on bottom of counterweight box must be on cement. 4. Disconnect truck hitch. 5. Put cement blocks behind wheels. 6. Two 6" x 8" beams below arms with 2'x2' plywood on top centered and as far towards the water as possible. Beam number and sizes may vary as needed by the depth of the box and the steepness of the ramp. 7. Start motor and slowly raise until disconnected from truck. Care must be taken that the conveyor does not start to "bounce". If this happens; stop and wait for it to stop. 8. Raise until counterweight box hits bottom. Top of box must be 3 to 6 inches above water. 9. If incorrect depth reattach to truck and move forward or back as appropriate. 10. Pull pin and clevis and lower tongue to ground reattaching pin and clevis {ensuring the Conveyor engine is turned off). 11. Raise until tongue swings clear and chain up to the conveyor. 12. Breakdown is reverse except that tong must be held up by one person when lowering. 13. Place ladder and leave keys in per normal procedure. • When you arrive to the site location and detach the conveyor from the truck insure that you first grease all six grease points prior to submerging the conveyor into the water. Also ensure that two persons are always used, any time anyone is underneath any portion of the equipment the motor is turned off, if either person is unsure of what is happening: Stop immediately and clarify, if either person is nervous: Stop immediately and clarify, and if at any time the truck is in line with conveyor be sure to turn off the truck if no one is at controls.
9:00 AM	Take this time to get updates from the harvesters, checking load sizes, location in the bays, and if the HST needs to go to where the harvesters are cutting. • Coordinate with the site supervisor to insure the truck will be coming in ample time. The HST~ allowed to hook up to the shore conveyor while no truck is underneath. Just insure they are not offloading prior too. • It is your job to assist boats that may be using the boat ramp and are next to the shore conveyor. ASK the boaters first, don't just assume they need assistance. Create a buffer between yourself and the conveyor and direct their trailer into the water.
10:00 AM	Your primary responsibility is to direct the harvester's and the HST into the shore conveyor. Insure that all conveyors on these machines are completely down to avoid detachment while unloading. • Paperwork referring to AIS and the types of weeds on loads is also your duty. THIS SHOULD BE DONE AFTER EACH LOAD. Pay attention to the types of weeds in the load being offloaded. • If the Supervisor is not present, he/she should inform you of where the trucks offload site is so you can communicate this to the truck driver. Loads should be completely full before they are leaving to the site. • When the truck is gone this should be communicated to the HST. It is most efficient to unload half-loads to the HST from the harvesters when this occurs so they can continue cutting while waiting on the truck.

Timeline	Daily Activity Description
11:00-12:00 PM	Lunch break - coordinate with the Harvesters and the Supervisor to figure out the most efficient schedule. This time should be used to refill water bottles, use restrooms, reestablish where the Harvesters have cut and what still needs to be done for the rest of the day.
12:00-4:30 PM	Continue the daily assignments. Communicating with the Supervisor on areas that have been cut, when the HST needs to pick up a load from the Harvesters, water refills as well as weather updates.
4:35 PM	Insure that you are communicating when the last truck load will be accepted. All machines should be unloaded before the truck leaves to ensure the boats are empty overnight. This is especially important over weekends.
5:00-5:30 PM	The shore conveyor should be cleaned of all hanging weeds, making it appear clean of all scraps. This is best done with a bucket and water to wash excess mud and weeds from the attachment site. All floating weeds around the conveyor should be put on the conveyor to clear landings of all debris before the truck leaves. The Shore Conveyor must be cleaned of all weeds before transport on the road. • The shore conveyor will be de-assembled the same way as it was assembled. Boards are returned to the back of the truck, the landing should be swept clean, and the bricks should be returned to the conveyor. All equipment (rakes, shovels, brooms) need to be returned to the trailer. Two people will need to be available to reattach the tongue. The conveyor will never be left up overnight. • You will assist the Supervisor in hooking the shore conveyor back up to the truck and returning it to the overnight parking site. You will also assist in locking up the trailer and hitching it to the truck to be returned to office parking lot. • Be sure the leave the offload site CLEANER than it was the morning of.

3.3.2. Staff Training, Protocol, and Program Review

The LMCD has drafted a harvesting program operations and procedures manual that provides details on harvesting season procedures and preparation, program schedules, harvesting maps, vegetation disposal sites, and reports and research for management of AIS. A hardcopy report is available upon request to the LMCD. The LMCD also conducts seasonal training for all equipment operators. Training includes proper operation of weed harvester equipment, maintenance protocol, and safety training including classroom, dry-dock, and on-the-water training for each season. A training manual is reviewed by all harvester staff and emphasizes equipment operation, safety, and customer service. Table 5 provides a general outline of the training protocol used to guide the operation and safety training for harvesting staff. Adjustments to this training schedule are made as deemed necessary by the site supervisor.

Table 5. General Training Protocol. Source – LMCD.

Training Event	Duration (Days)	Description
Classroom Training	1-1.5	New harvesting staff will complete all required employment paperwork. In addition, staff are required to obtain a Lake Service Providers Permit and Watercraft Operators Permit. The training manual is thoroughly reviewed with special emphasis on program goals and initiatives, types of vegetation, safety issues, safety equipment, maintenance, record keeping, emergency procedures, and supplementary materials such as photos, handouts, etc. Training on basic marlinspike seamanship is also conducted for daily use in securing the vessels. A review of the organization, human resource issues, behavior, public contact, communications, etc. is conducted.
Dry Dock	0.5	The staff are shown the vessels on land with emphases on size, displacement, operation, daily maintenance, safety, and other items. Starting the engines on the harvesters, operation of the hydraulic controls, best practices, as well as the placement of the various equipment are covered. Daily maintenance is reviewed. The HST and shore conveyor are reviewed in the same manner, noting the outboard engine is not started unless water available. A brief tour on land around the lake is given to begin familiarization of the bays, parking/docking, and off-load sites.
On-the-Water	>2	Harvesting vessels are launched in the water early on the second or third day of training and occurs over two days or more depending on proficiencies. Each driver assigned to that vessel will initially board with the site supervisor during the launch. The site supervisor initially starts and operates the boat while launching and clearing the launch ramp. Once clear and in open water, the controls are turned over to the harvesting staff to operate until the next vessel arrives for launch. The vessel is secured while the new vessel is launched. The assigned staff will undergo the same procedure with the site supervisor. This repeats until all vessels have been launched. Once all have been launched all the vessels are driven across Spring Park Bay to old channel (less wind, good parking spot) bay where most of the on-water training takes place. The site supervisor sets up a "slalom" course of 8 to 10 buoys of varying distances apart, first parallel to the wind and later at right angles. Each staff practices traversing these courses in all of the vessels until proficient and comfortable. Two Buoys are set slightly wider than the width of a harvester perpendicular to the wind and the staff practice approaching the "gate' and dropping the hitch at the right time. The harvesters and HST work together to learn to "hook up" in open water with plenty of maneuvering room. The HST is backed into shore and secured to simulate the shore conveyer. With one person ashore to give the standard hand signals, the drivers "land" the boats and engage the hitches. All harvesting staff practice all maneuvers until proficient. Harvesting staff will then join the site supervisor on a harvester and practice harvesting vegetation/biomass in a safe area away from potential hazards. Best practices and safe operations will be reviewed and include the most problematic scenarios and what to do if something goes wrong.
Ongoing Oversight	Continuous	Harvesting staff are monitored throughout the season, closely the first few weeks. Meetings are conducted in the mornings before harvesting and end of the day to review operations, records and safety practices and equipment. Ongoing review of the LMCD staff occurs throughout the season. In office meetings are held periodically to review program operations and experiences. Office staff will randomly visit site meetings, offload sites, parking areas, etc. to monitor conditions.

3.3.3. Safety Program Review

In October 2018, the LMCD voluntarily requested a Limited Service Safety Hazard survey by MNOSHA be conducted on all harvesting equipment. Overall, the inspection indicated good safety practices were being followed; however, the following safety hazards were identified:

- "Description: 29 CFR 1910.22(d)(1): The employer did not ensure that walking-working surfaces were inspected, regularly and as necessary, and maintained in a safe condition: On the weed harvester the ladders needed to have slip resistance treads replaced to prevent falls. Chains were broken or missing on the openings on the operating stations. The midrail was missing on the guard rail of one of the machines. Employer has taken the equipment out of service since September. Recommended Action: Missing parts should be replace before machines are put in service again. Midrails should be halfway between the top rail and the bottom of guardrail and should be able to with stand a force of 200 lb."

- "Description: 29 CFR 1910.145(c)(3): Safety instruction signs were not used where there was a need for general instructions and suggestions relative to safety measures: The motor on the weed harvester would get hot after running for a while. There was no warning sign concerning the risk. Employer has taken machine out of service. Recommended Action: A sign warning that it was hot should be place on or by machine to warn of hazard."

- "Description: 29 CFR 1910.28(b)(1)(i): The employer did not ensure that each employee on a walking-working surface with an unprotected side or edge that was 4 feet (1.2 m) or more above a lower level was protected from falling by one or more of the following: guardrail systems, safety net systems or personal fall protection systems, such as personal fall arrest, travel restraint, or positioning systems: On the weed harvester machine, there was an unprotected narrow runway that had a fall greater than 4 feet. Employer had removed harvester from service. Recommended Action: Before putting back in service, Contact manufacturer and find out if area can be guarded to prevent falls or if it is not feasible to use a guardrail or other fall protection employer must prove three things.
  - When the employer can demonstrate that the use of fall protection systems is not feasible on the working side of a platform used at a loading rack, loading dock, or teeming platform, the work may be done without a fall protection system, provided:[1910.28(b)(1)(iii)]
    - The work operation for which fall protection is infeasible is in process; [1910.28(b)(1)(iii)(A)]
    - Access to the platform is limited to authorized employees; and, [1910.28(b)(1)(iii)(B)]
    - The authorized employees are trained in accordance with §1910.30.[1910.28(b)(1)(iii)(C)]"

The LMCD is currently working on addressing the safety concerns identified by MNOSHA. According to the LMCD, there have been no reported injury claims related to the harvesting program for the last 25 years.

3.4. Equipment

Table 6 summarizes the existing lake vegetation harvesting equipment owned by the LMCD. The LMCD has developed standard operating procedures (SOP) for operating the harvesting equipment in accordance with manufacturer recommendations. The SOPs include conducting daily pre-start, mid-day, and post-work checks. All LMCD staff are trained in how to perform these checks and are expected to operate the equipment in accordance with SOP. More information on the SOPs and daily checks can be found in the LMCD Harvesting Program Manual.

Table 6. Summary of existing lake harvesting equipment owned by the LMCD.

Equipment	Summary	Date Purchased	Scheduled Replacement Year	Purchase Cost	Replacement Cost (2020 estimate)
Harvester #6	Aquarius Systems, Equipment ID XI002, 2003, 14,500 lbs, 85 hp, Model H-820, 47 ft length	5/30/2003	2018	$98,878	$201,931.50
Harvester #7	Aquarius Systems, Equipment ID XV626, 2005, 15,000 lbs, 85 hp, Model H-820, 47 ft length	6/2/2005	2020	$112,021	$201,931.50
Harvester #8	Aquarius Systems HM-1000 s/n UN020 Aquatic Plant Harvester #8, Vessel ID UN020, Year 2012, Model HM-820-11, Engine Cummins B3.3, 85 hp, 45.5 ft length	7/18/2012	2027	$175,891	$211,150.00
Transport Barge	1991 Model T-34 Transport Barge w/ 2004 Mercury Optimax, 150 hp, Steel Hull ID LU067, Aquarius Systems, 9,500 lbs, 32 ft 10 in length	5/7/2003 (Barge) 4/28/2005 (motor)	2008	$26,112	$184,473.00
Harvester Tilt-Deck Trailer	Model UMI Inc. Serial # BT-7-114-89, 800 lbs, Horsepower (SAE) 8 power rack, GVWR 23,800 lbs, cylinders 1, Model T-8T powered tilt-deck trailer. Capacity 8 tons, length 37 ft, width 8 ft, height 4 ft, deck height 2 ft 8 in	11/30/1989	2019	$8,150	$42,024.00
Shore Conveyor	Model c-800, Serial BC-19-116-89 08/04/1989; or model c-800 Serial BC-18-113-89 07/11/1989; or Floating combi-conveyor model C-500 F 08/21/1989; multiple documents so need to verify information on equipment	8/21/1989	2019	$8,000	$50,470.00
Total				**$429,052**	**$891,980.00**

3.5. Cost of Existing Mechanical Harvesting Program

3.5.1. Financial summary

Table 7 summarizes the financial analysis of the harvesting program from 2008 to 2018 and factors in labor, equipment costs, and other program operations with actual annual inflation rates derived from the Federal Reserve Bank of Minneapolis. The dollar amounts shown are based on 2018 dollars. Based on data received by the LMCD, an average of 346 acres per year was harvested from 2008 to 2018 at an average cost of $514 per acre. The average cost to implement the LMCD harvesting program over the same time period was $173,430 per year. For comparison, a cost estimate was developed to contract out the harvesting program to a private entity to perform the same level of effort per year from 2008 to 2018. A private contractor rate of $790 per acre was obtained from a quote received from a private contractor with similar equipment and staff capacity on Lake Minnetonka. The private contractor average cost to implement the same acreage of aquatic vegetation harvested was $273,428 per year.

3.5.2. Cost Comparison

Table 8 summarizes the financial analysis of the harvesting program projected out 5 years, 10 years, and 20 years into the future. The dollar amounts shown in the table include an annual LMCD salary increase of 3% (based on historical trends), a 3% annual inflation rate, and that all equipment is paid in full at the time of purchase. No financial options were included in the analysis. Based on the projections, the cost for the LMCD to continue the existing weed harvesting program will incur substantial expenses in year 2020 due to the need to replace most of the existing harvesting equipment. Weed harvester #8 is the only piece of equipment that does not need to be replaced in year 2020; all other pieces of equipment will be past their scheduled replacement years (see Table 6 for reference). Subsequently, the total projected 5-year harvesting program for the LMCD will cost approximately $93,398 more compared to hiring out the work to a private contractor over the same time span. However, by year 2030, the 10-year projected costs for the LMCD program will be approximately $134,733 less, and by year 2040, the 20-year projected cost for the LMCD program will be $678,640 less than hiring out the work to a private contractor.

It should be noted that the results of this financial analysis are based on harvesting an average of 346 acres per year. If the actual acreage is higher or lower than 346 acres per year, the results in Table 8 would be different (e.g. personnel, equipment, maintenance cost, etc. would be higher or lower, depending on the amount of acres harvested). In other words, the results of this analysis can't be extrapolated to other acreage scenarios.

Table 7. Financial summary of LMCD Harvesting Program 2008-2018.

Year	EWM Harvesting Program Equipment & Repair (2018 $)	Office & Supplies (2018 $)	Personnel Services (2018 $) **	Truck Service-EWM (2018 $)	Contingency-EWM (2018 $)	Public Info/ Legal (2018 $)	EWM Reserve Expense (2018 $)	Prevention Prgrm (2018 $)	Sub-Total EWM Harvesting Program (2018 $)	Inflation Rates in MN (source: Federal Reserve Bank of Minneapolis)	Equipment Cost	TOTAL LMCD Harvesting Program Cost (2018 $)	Acres Harvested	Cost per Acre (2018 $)
2008	$55,813	$185	$64,265	$20,998	$1,760	$213	$0	$23,524	$166,757	3.8%	$0	**$166,757**		
2009	$42,258	$211	$69,512	$27,643	$5,944	$202	$0	$31,696	$177,466	-0.4%	$0	**$177,466**		
2010	$51,077	$324	$65,806	$23,177	$1,315	$1,382	$0	$36,670	$179,752	1.6%	$0	**$179,752**	384	$468
2011	$38,775	$239	$50,927	$13,378	$10,545	$181	$0	$39,375	$153,420	3.2%	$0	**$153,420**	268	$572
2012	$20,041	$1,013	$79,329	$21,439	$6,438	$184	$0	$43,342	$171,786	2.1%	$199,010	**$370,796**	412	$900
2013	$17,834	$897	$62,850	$13,809	$3,306	$337	$12,005	$36,523	$147,560	1.5%	$0	**$147,560**	267	$553
2014	$34,850	$1,665	$68,949	$21,930	$4,010	$23	$1,453	$38,231	$171,111	1.6%	$0	**$171,111**	391	$438
2015	$25,613	$1,202	$66,993	$13,831	$2,670	$20	$0	$39,753	$150,082	0.1%	$0	**$150,082**	576	$261
2016	$28,194	$2,472	$53,029	$17,333	$3,405	$0	$0	$26,582	$131,015	1.3%	$0	**$131,015**	278	$471
2017	$28,437	$1,351	$50,695	$15,687	$5,231	$0	$0	$33,039	$134,442	2.1%	$0	**$134,442**	261	$515
2018	$28,959	$887	$62,854	$17,270	$5,022	$0	$0	$10,342	$125,334	2.2%	$0	**$125,334**	278	$451
2019														
TOTAL	**$371,851**	**$10,446**	**$695,208**	**$206,497**	**$49,645**	**$2,541**	**$13,458**	**$359,077**	**$1,708,723**		**$199,010**	**$1,907,733**	**3,115**	
AVERAGE	**$33,805**	**$950**	**$63,201**	**$18,772**	**$4,513**	**$231**	**$1,223**	**$32,643**	**$155,338**		**$18,092**	**$173,430**	**346**	**$514**

Table 8. Financial summary of LMCD Harvesting Program, 2020 to 2040 cost projections. The costs assume an average harvest of 346 acres per year.

Year	EWM Harvesting Program Equipment & Repair	Office & Supplies	Personnel Services*	Truck Service - EWM	Contingency-EWM	Public Info/ Legal	EWM Reserve Expense	Prevention Program	Sub-Total EWM Harvesting Program	Total Equipment Cost less Residual Value at Time of Purchase**	TOTAL LMCD Harvesting Program Cost	Contractor Cost***	Difference in Contractor Cost to LMCD Cost
2020	$35,867	$1,008	$67,056	$19,918	$4,788	$245	$1,298	$34,635	$164,814	$670,578	$835,392	$273,427	-$561,965
2021	$36,943	$1,038	$69,068	$20,515	$4,932	$252	$1,337	$35,674	$169,758	$0	$169,758	$281,630	$111,871
2022	$38,051	$1,069	$71,140	$21,131	$5,080	$260	$1,377	$36,744	$174,851	$0	$174,851	$290,079	$115,227
2023	$39,193	$1,101	$73,274	$21,764	$5,233	$268	$1,418	$37,846	$180,097	$0	$180,097	$298,781	$118,684
2024	$40,368	$1,134	$75,472	$22,417	$5,389	$276	$1,461	$38,982	$185,500	$0	$185,500	$307,744	$122,245
										TOTAL 5-year	**$1,545,598**	**$1,451,661**	**-$93,938**
2025	$41,579	$1,168	$77,736	$23,090	$5,551	$284	$1,505	$40,151	$191,065	$170,607	$361,672	$316,977	-$44,695
2026	$42,827	$1,203	$80,068	$23,783	$5,718	$293	$1,550	$41,355	$196,797	$0	$196,797	$326,486	$129,689
2027	$44,112	$1,239	$82,470	$24,496	$5,889	$301	$1,596	$42,596	$202,701	$269,206	$471,907	$336,281	-$135,626
2028	$45,435	$1,276	$84,945	$25,231	$6,066	$310	$1,644	$43,874	$208,782	$0	$208,782	$346,369	$137,587
2029	$46,798	$1,315	$87,493	$25,988	$6,248	$320	$1,694	$45,190	$215,045	$0	$215,045	$356,760	$141,715
										TOTAL 10-year	**$2,999,800**	**$3,134,533**	**$134,733**
2030	$48,202	$1,354	$90,118	$26,768	$6,435	$329	$1,745	$46,546	$221,496	$197,780	$419,277	$367,463	-$51,814
2031	$49,648	$1,395	$92,821	$27,571	$6,628	$339	$1,797	$47,942	$228,141	$0	$228,141	$378,487	$150,346
2032	$51,137	$1,436	$95,606	$28,398	$6,827	$349	$1,851	$49,381	$234,985	$0	$234,985	$389,841	$154,856
2033	$52,672	$1,480	$98,474	$29,250	$7,032	$360	$1,906	$50,862	$242,035	$0	$242,035	$401,537	$159,502
2034	$54,252	$1,524	$101,428	$30,127	$7,243	$371	$1,963	$52,388	$249,296	$24,114	$273,410	$413,583	$140,172
2035	$55,879	$1,570	$104,471	$31,031	$7,460	$382	$2,022	$53,960	$256,775	$837,907	$1,094,682	$425,990	-$668,692
2036	$57,556	$1,617	$107,605	$31,962	$7,684	$393	$2,083	$55,578	$264,478	$0	$264,478	$438,770	$174,292
2037	$59,282	$1,665	$110,833	$32,921	$7,915	$405	$2,146	$57,246	$272,413	$0	$272,413	$451,933	$179,520
2038	$61,061	$1,715	$114,158	$33,908	$8,152	$417	$2,210	$58,963	$280,585	$0	$280,585	$465,491	$184,906
2039	$62,893	$1,767	$117,583	$34,926	$8,397	$430	$2,276	$60,732	$289,002	$0	$289,002	$479,456	$190,453
2040	$64,779	$1,820	$121,111	$35,973	$8,649	$443	$2,345	$62,554	$297,673	$265,800	$563,473	$493,839	-$69,634
										TOTAL 20-year	**$7,162,283**	**$7,840,923**	**$678,640**

*includes a LMCD salary increase on 3% per year based on historical trends

**assumes all equipment is paid in full at the time of purchase

***includes a contractor cost increase of 3% per year

4. EXISTING PROGRAM EVALUATION

Traditionally, the LMCD harvesting program has been used to provide immediate relief in areas of the lake where herbicides or other management approaches would not be as effective, are not permitted, or where an immediate solution was required such as in areas where vegetation hindered boater safety and/or usability. The LMCD has strived to keep interested stakeholders updated regularly with information regarding the estimated path the harvesters would take throughout the lake. Other information about harvesting activities was also made available through the LMCD website and social media.

The LMCD does not have a clear plan in place that clearly defines where and when harvesting should take place on a bay by bay basis. Operating in a reactionary method has allowed critics of the LMCD harvesting program to raise concerns regarding fragmented vegetation washing ashore.

Previous harvesting efforts by the LMCD have not used GPS technology to map the path of harvesters. This has resulted in a lack of data showing acreage harvested in comparison with expended effort (Figure 2). GPS-guided equipment would greatly improve location accuracy of all harvested areas and would allow for site evaluations post-harvest to determine the success of the harvest.

Because plant growth rates vary from bay to bay, some bays or channels may be better candidates for weed harvesting compared to others. Documentation of the frequency of re-harvesting would help determine where to best focus the harvesting effort, or to determine if herbicide treatments should be used for areas with strong re-growth rates. Areas with dense native aquatic vegetation that impacts navigation should be priority target areas for mechanical harvesting due to prohibited use of herbicide in these areas.

A compilation of issues with the current harvesting identified by stakeholders and through our review include are shown below. These have not been verified by EOR.

- Slow speed of harvesters limits the amount of vegetation that can be harvested and excludes harvest abilities of remote areas
- Management decisions on when and where to harvest have been decided by Site Supervisor (LMCD Employees) and Bay Captains (not LMCD employees), not the LMCD. Harvest areas were determined from historical areas, scouting by supervisor, customer complaints, bay captains.
- Incomplete collection of plant fragments during harvest and potential for floating vegetation
- Only 5 or 6 sites exist for vegetation disposal, thereby limiting the efficiency of harvesting due to delays in offloading weeds. Private parties have suggested additional offloading sites would provide additional lake access
- Need to identify a time, place, and threshold for when harvesting is appropriate versus alternative options such as herbicide treatments
- Stakeholders have identified a lack of a clear chain of command for addressing repairs and equipment problems
- Stakeholder identified lack of detailed service/ maintenance records

- ➢ Hydraulic motor issues and hose leaks (including leaks during storage)
- ➢ Stakeholder identified improper winterizing techniques leading to equipment damage (i.e. animal damage to center counsel and seats). Also exposed cutter teeth when equipment is in storage (safety concern)

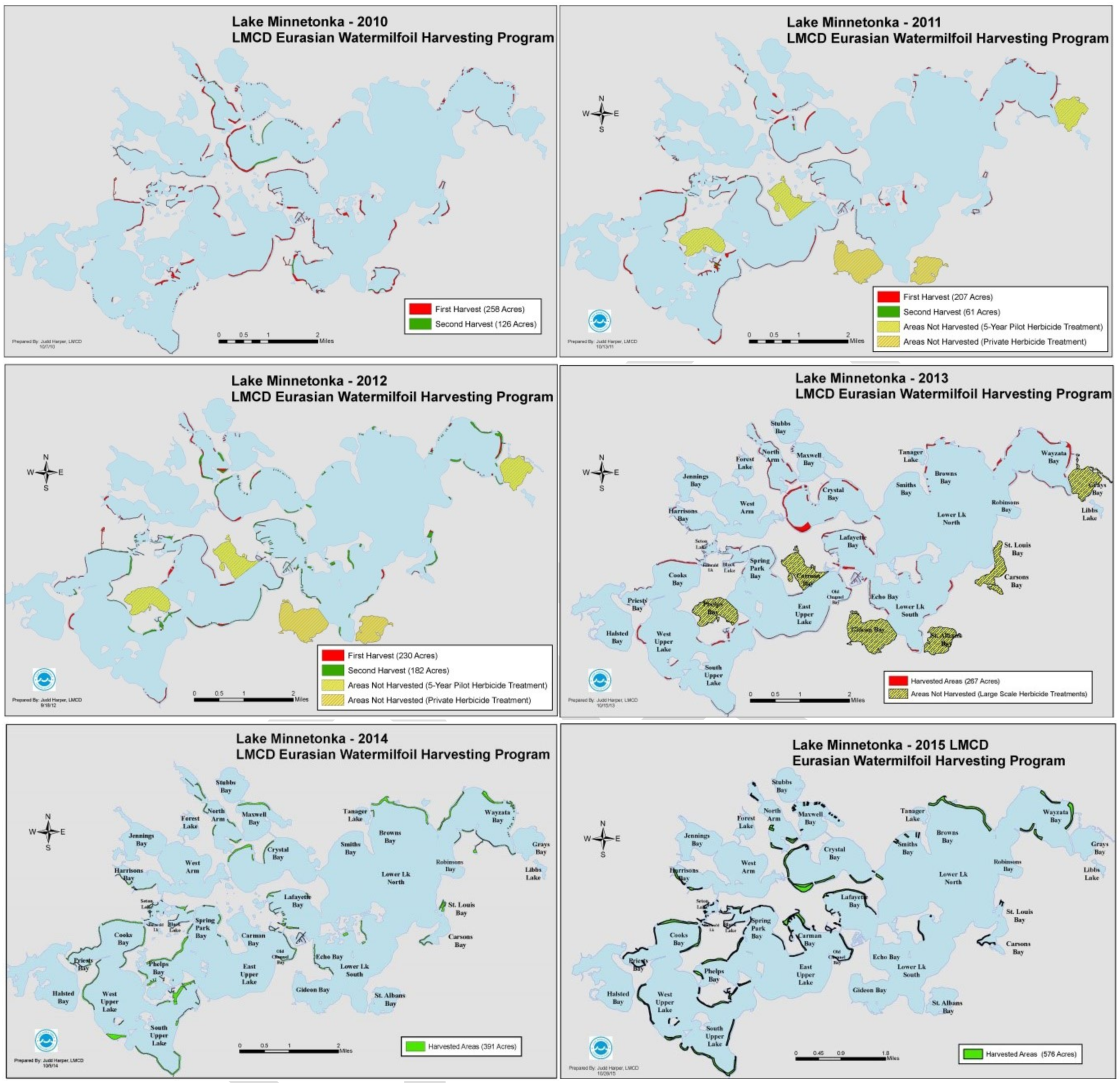

Figure 2. Examples of Lake Minnetonka Harvest Maps, 2010 to 2015.

5. FUNDAMENTALS OF MECHANICAL HARVESTING

5.1. Aspects of a Successful Mechanical Harvesting Program

The variability in the effectiveness of any mechanical harvesting program is directly correlated with the following key variables:

- Defining realistic goals for a harvesting program and conveying these goals to stakeholders
- Specifications, dimensions, operator experience, and efficiency of harvesting equipment
- Seasonality, frequency, and duration of harvest(s) across spatiotemporal scales
- Spatial distribution/abundance of the aquatic plant species being harvested
- Funding and support from community
- Public relations and direct lines of communication between harvesting staff and stakeholders
- Access and availability to accurate data in regards to the location and timing of harvest activities

5.2. Positive and Negative Aspects of Mechanical Harvesting

Mechanical Harvesting Advantages and Disadvantages

All aquatic plant management techniques have positive and negative attributes. The potential advantages and disadvantages of mechanical harvesting are shown in Table 9 and Table 10.

Table 9. Advantages and disadvantages of mechanical harvesting (McComas 2011).

Advantages
Water can be used immediately following harvest treatment. Some aquatic herbicides have restrictions on use of treated water for drinking, swimming, and irrigation.
Harvesting takes the plant material out of the water so the plants do not decompose slowly in the water column as they do with herbicide treatment. Additionally, oxygen content of the water is generally not affected by mechanical harvesting, although turbidity and water quality may be affected in the short term.
Nutrient removal can occur but is usually minimal because only small areas of lakes (1 to 2%) are typically harvested. It has been estimated that aquatic plants contain less than 30% of the annual nutrient loading that occurs in lakes.
The plant community is altered but remains largely intact because most harvesters do not remove submersed plants all the way to the lake bottom. Like mowing a lawn, clipped plants remain rooted in the sediment and regrowth begins soon after the harvest.
Mechanical harvesting is site specific because plants are only removed where the harvester operates.
Mechanical harvesting is perceived to be environmentally neutral by the public whereas concerns over the safety and long-term toxicology of herbicide applications remain despite widespread research and registration requirements that are enforced by regulatory agencies.

Disadvantages
Mechanical harvesting equipment has limited production, therefore repair and replacement costs can be expensive.
The area that can be harvested in a day depends on the size of the harvester, transport time, distance to disposal site, and density of the plants being harvested. These factors result in a wide range of costs. The cost of harvesting is site-specific, but mechanical harvesting is generally more expensive that other plant control methods.
Mechanical harvesters are not selective and remove native plants along with target weeds. However, most native plants will likely return by the next growing season or before.
By-catch, or the harvesting of non-target organisms such as fish, crayfish, snails, macro invertebrates, along with weeds can be a concern. If the total area of the lake is less than 10% of the lake's area, this will likely be of little consequence.
Regrowth of cut vegetation can occur quickly. For example if Eurasian milfoil can grow 1 to 2 inches per day as reported, a harvest that cuts 5 feet deep could result in plants reaching the water surface again only one to two months after harvesting. Speed of regrowth depends of the target weed, time of year harvested, water clarity, water temperature and other factors.
Floating plant fragments produced during mechanical harvesting can be a concern because aquatic weeds can regrow vegetatively from even small pieces of vegetation. Homeowners downwind of the harvesting site may not appreciate have to regularly rake weeds and floating fragments off their beaches.
Disposal of harvested vegetation can be an expensive and difficult. It takes time and additional money to transport the plants to shore, load the material and dispose of the cut material off site.
Costs of moving the cut vegetation from the harvester to shore will add significantly to the cost of operation. Harvesters move relatively slow, so the extra time traveling to and from the off load site must be factored into the operation.

Mechanical Harvesting Comparison with Herbicides

Table 10. Comparison of mechanical harvesting vs. herbicides (prepared by DNR). Source: LMCD Comprehensive Eurasian Watermilfoil and Curly-leaf Pondweed Management Plan, 2013).

Effectiveness of Control	Mechanical Harvesting	Herbicides
Reliability	Never fails [to remove plants]	Can fail
Time to relief	Immediate	7 to 14 days
Vegetation is collected and removed from the lake	Yes (Nutrients in plants are removed from lake)	No (Nutrients in plants are NOT removed from lake)
Duration of control (and need for multiple treatments)	Shorter?	Longer?
Creation of channels	Good	Not so good
Control of plants over a large area	Not so good	Good
Additional Considerations	**Mechanical Harvesting**	**Herbicides**
Cost	Often higher	Often lower
Percentage of cost attributable to labor	high	low
Capital investment	high	None [for customer]
Duration of work	Continues over the season	One or a few days
Variability in cost	higher	lower
Disposal of harvested plants	Can be difficult to find a place where plants can be delivered	Not applicable (plants decompose in lake)
Potential spread within a lake	Should not be employed on lakes where the distribution of milfoil is limited	Can be employed on lakes where the distribution of milfoil is limited
Effects on non-target organisms or lake ecosystem	**Mechanical Harvesting**	**Herbicides**
Removes invertebrates, fish, frogs, snakes, turtles, etc	Yes	No
When target plant is an exotic, removal or destruction of native vegetation	Yes	Yes or no, depending on particular herbicide used
Increased fragmentation	More	Less
Disturbs sediment and causes suspension of sediment in the water column, which in turn may reduce water clarity	Often does, likely to a greater extent	May do so, likely to a lesser extent
Potential negative effects of introducing chemicals into the aquatic environment	No (except hydraulic fluid and oil from breaks in lines)	Yes
Restrictions on use of water after treatment	No	In some cases
Selectivity	Limited or none	Some are, some are not
Minnesota Regulations (M.R. 6280)	**Mechanical Harvesting**	**Herbicides**
Small area can be treated without a permit to control milfoil or other submersed aquatic plants	Yes	No (Alway*s* requires a permit from the DNR)
Limit on the amount of area that may be treated	50% of the littoral zone	15% of the littoral zone

Mechanical Harvesting Case Studies

An overview of case studies which highlight the positive and negative impacts of mechanical harvesting on native plants and animals is shown in Table 11.

Table 11. Positive and negative impacts of mechanical harvesting and associated case studies.

Positive Impacts on Native Plants and Animals
✓ Olson et al. (1998) studied the impact of mechanical harvesting of aquatic macrophytes on fish in four Minnesota lakes. Based on the results they concluded that changing the strategy of harvesting from clear-cutting the top meter of vegetation to selectively cutting deep channels throughout the lake may simultaneously improve the fishery and recreational value of a lake **Case Study:** **Managing Macrophytes to Improve Fish Growth: A Multi-lake Experiment**
✓ Macrophyte harvesting can be a cost-effective means to remove phosphorus from an urban shallow lake system, and this management tool has the potential to factor into dynamic and creative lake and watershed management plans. A 2004 study conducted by Three Rivers Park District on Lake Minnetonka found that the mechanical harvesting program removes approximately 510 pounds of phosphorus per year at an estimated cost of $204 per pound, significantly lower than the estimated phosphorus removal costs for most watershed BMPs. **Case Study 1:** **Phosphorus Removal by Plant Harvesting on Lake Minnetonka** **Case Study 2:** **Aquatic plant harvesting: An economical phosphorus removal tool in an urban shallow lake**
✓ Mechanical harvesting conducted over an extended time period has the potential to result in a positive change in the aquatic plant community from watermilfoil to low growing native species that typically stay below the maximum, harvested depth. Repeated harvesting of EWM prevents it from forming a canopy and shading out other vegetation **Case Study:** **Lake Noquebay Rehabilitation District Aquatic Plant Management Goals & Objectives**
✓ Selective cutting of channels, paths, or openings is an effective means of creating valuable edge habitat (Engel 1995). Larger fish often associate with plant bed edges (Engel 1987) where macroinvertebrate prey resources are mostly concentrated (Sloey et al. 1997). Thus a reduction in dense vegetation, rather than eradication, should increase predator-prey interactions, improve fish growth (Bettoli et al. 1992, Bettoli et al. 1993) and augment fish production (Smith 1993) **Case Study:** **Eurasian Watermilfoil as a Fishery Management Tool**
Negative Impacts on Native Plants and Animals
✓ Mechanical harvesting can potentially have a significant negative impact on the abundance of the milfoil weevil (*Euhrychiopsis lecontei*) depending on the scale of harvesting efforts relative to the size of the lake **Case Study:** **The Effects of Harvesting Eurasian Watermilfoil on the Aquatic Weevil *Euhrychiopsis lecontei***
✓ Research on fish catch during mechanical harvesting of submersed vegetation has noted that the impact is likely to vary tremendously between lakes, due to the differences in aquatic macrophytes, their densities, and different fish stocks. Haller et al. (1980), Mikol (1985), and Wile (1978) found that harvesting removed predominantly small sunfish or yellow perch **Case Study:** **The interaction between biology and the management of aquatic macrophytes**
✓ Mechanical harvesting can also incidentally remove vertebrates inhabiting the vegetation and lead to shifts in aquatic plant community composition **Case Study:** **Vertebrates removed by mechanical weed harvesting in Lake Keesus, Wisconsin. Journal of Aquatic Plant Management**

5.3. Implications for Lake Minnetonka

From 2010-2018, the LMCD harvested an average area of 346 acres per year. The littoral zone in Lake Minnetonka equates to an area of approximately 5,850 acres. Mechanical harvesting an average area of 346 acres/year equates to less than 1% of the entire littoral zone, significantly less than the 50% littoral limit that could be potentially harvested in accordance with DNR regulations. The small scale of the LMCD harvesting program relative to the total surface area of Lake Minnetonka suggests any positive or negative impacts to native plants and animals resulting from the LMCD harvesting program are likely minimal on a lake-wide basis. Nevertheless, mechanical harvesting may have localized impacts in the portions of the lake in which harvesting activities take place. Therefore, the LMCD should work with DNR fisheries biologists and wildlife professionals to screen areas of the lake that may provide critical fish or wildlife habitat. These critical areas include important fish spawning areas, sensitive wildlife areas, undeveloped shorelines, or sanctuaries for reptiles, especially turtles. Critical (no-cut) areas should clearly be identified on maps depicting harvesting priorities, see Lake Monona example in (Figure 3).

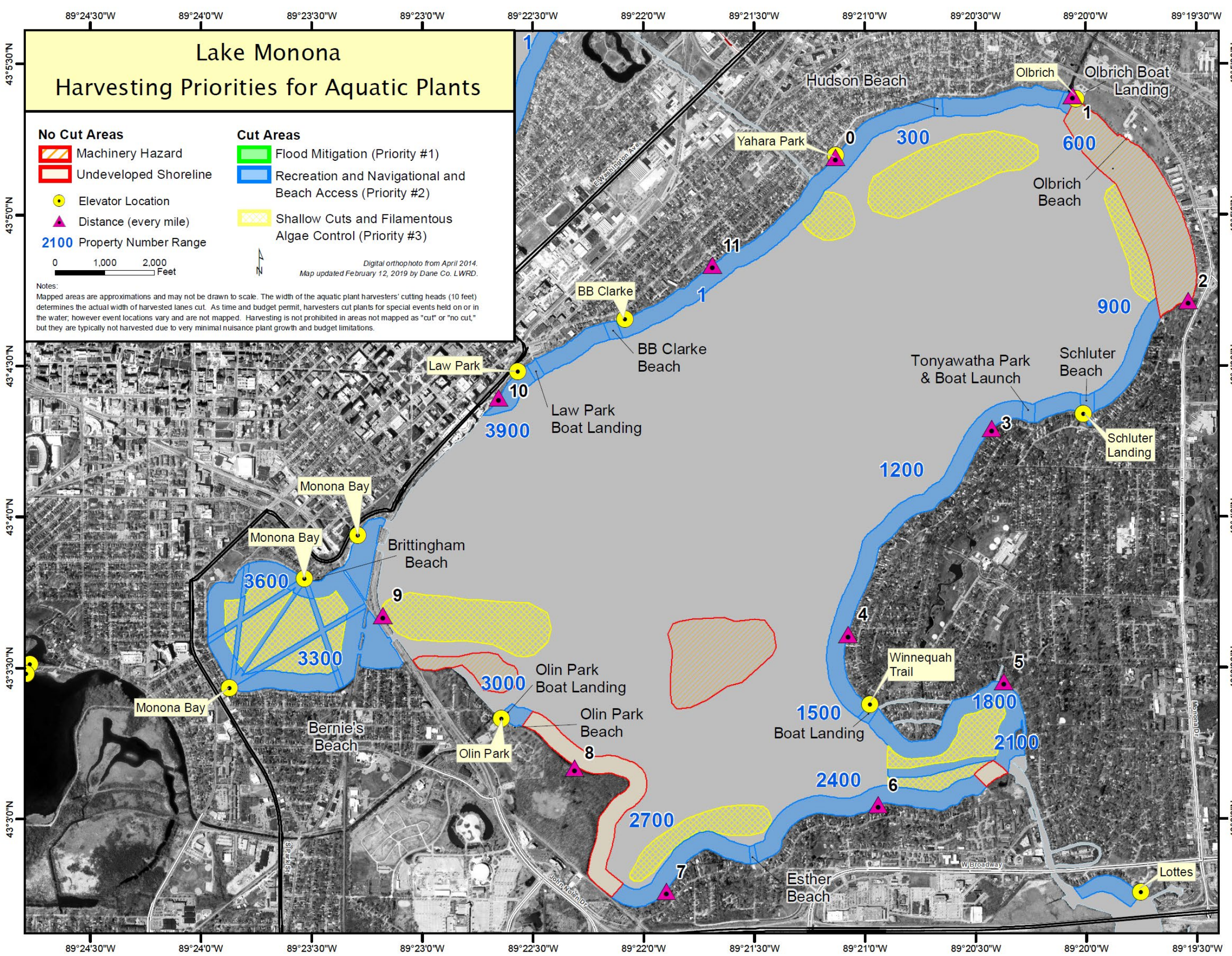

Figure 3. Lake Monona (Madison, Wisconsin) harvesting priorities for aquatic plants.

6. LMCD HARVESTING PROGRAM RECOMMENDATIONS

Based on available LMCD harvesting data, literature review, and financial analysis and comparison of the existing harvesting program, it is recommended harvesting continue on Lake Minnetonka. There are several key areas that need improvement for the harvesting program to continue, including but not limited to streamlined and efficient data collection of areas harvested, equipment upgrades, and refined SOP's. There will be a need for harvesting on Lake Minnetonka for the foreseeable future, especially considering the financial and permit limitations of herbicide application.

Mechanical harvesting should be evaluated as one component of a comprehensive, integrated aquatic plant management approach. Mechanical harvesting can be beneficial when applied appropriately in a clearly defined space and time. It is not a lake-wide solution that can be applied without specific plans or one that can be used in a reactionary nature. The following paragraphs outline recommended short-term and long-term goals for improving a harvesting program.

6.1. Short Term Goals

6.1.1. Goal 1: Increase Program Transparency through Social Media

In an effort to prevent misinformation from being transmitted, pre-emptive messaging should occur (prior to harvest) to inform cities, residents, and all vested stakeholders regarding all harvesting activities. This could be conducted through a website, via Social Pinpoint, and/or other social media platforms to ensure transparency and avoid misunderstandings about the timing of harvesting events in relationship to plant fragments at downwind locations. Such communications may include the use of the following communication tools: press releases to local newspapers, updates to existing ArcGIS Online map, and updates to Social Pinpoint.

6.1.2. Goal 2: Cleary Define, Prioritize and Map Harvesting Priorities.

The areas for harvest should be clearly delineated, prioritized, and mapped for areas best suited to mechanical harvesting. Figure 4 provides an example of a prioritized harvesting map for Lake Mendota.

Recommended Steps for Achieving Goal #2

A harvesting program should include cooperation with bay captains to determine where mechanical harvesting is proposed, determine site priorities, and streamline the harvesting schedule both prior to and during the harvesting season. This exercise should begin with a review of the most recently harvested areas (Figure 5). All areas within the lake should be categorized and mapped as to use, restrictions, and priority.

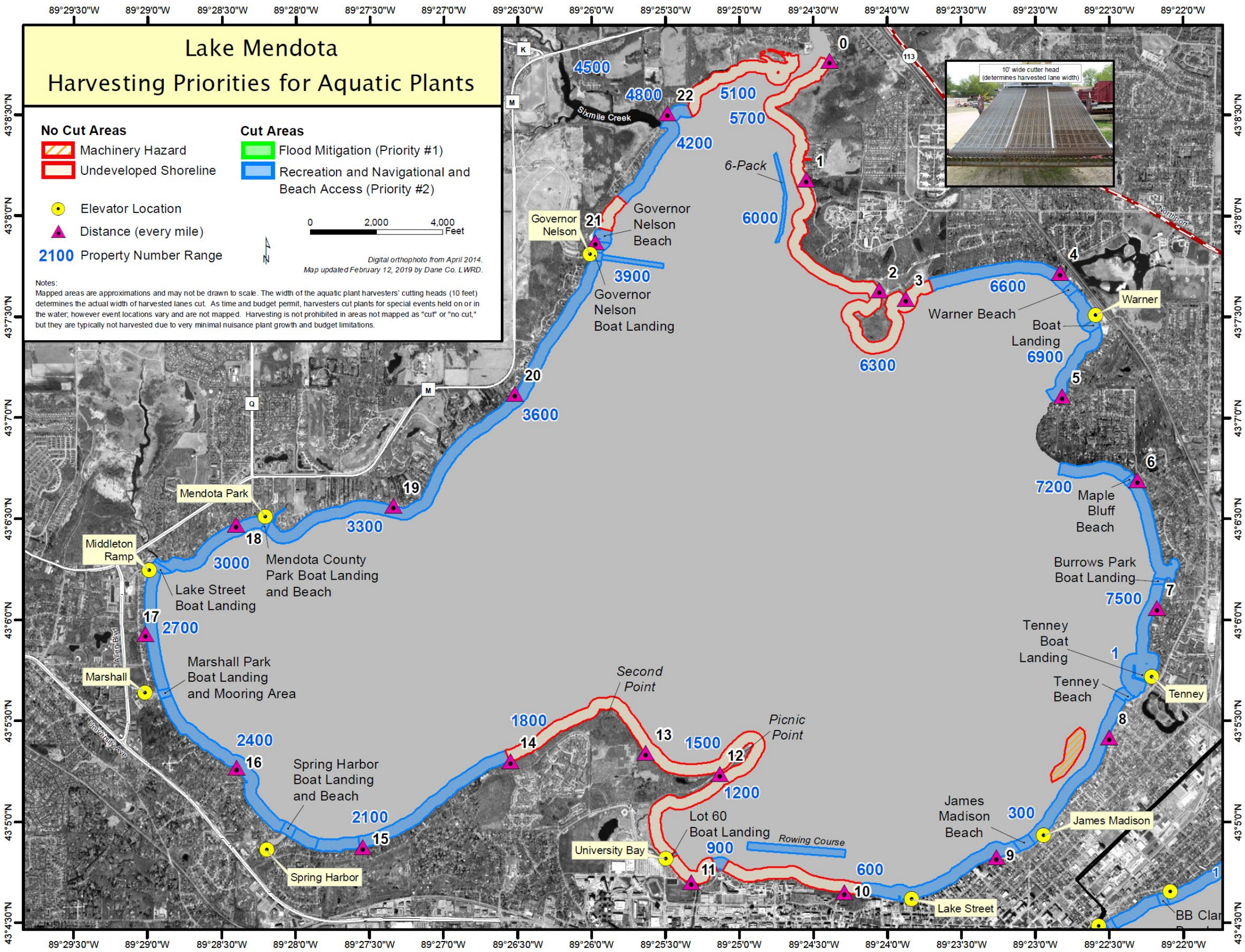

Figure 4. Lake Mendota (Dane County) Harvesting Priorities for Aquatic Plants (source: Dane County Aquatic Plant Management Harvesting Program).

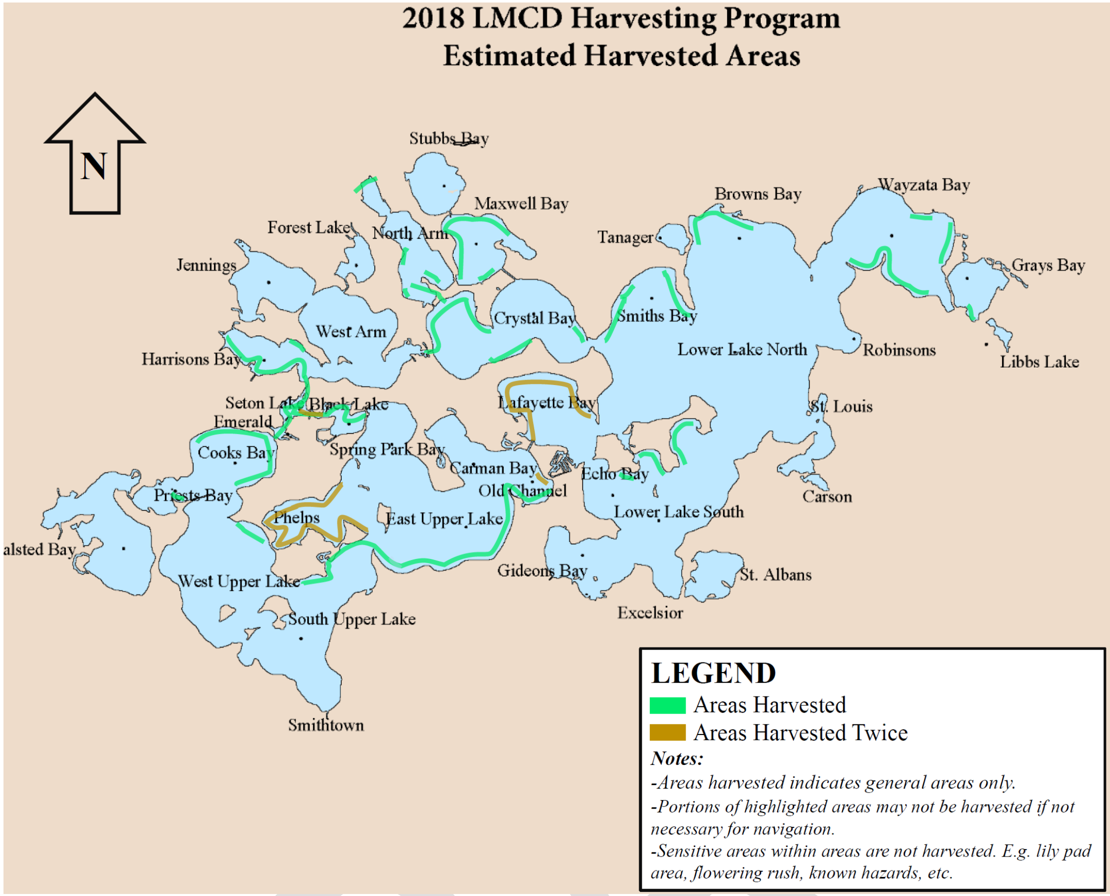

Figure 5. 2018 LMCD Harvesting Locations.

In Lake Minnetonka, areas that should be targeted for mechanical harvesting include (but are not limited to):

- Areas where vegetation is impeding navigation and an immediate solution is required (public accesses, licensed multiple dock sites)
- Areas where herbicides are not effective due to water movement such as connecting channels and/or bays with flows (e.g., Black and Seton)
- Primary contact recreation (swimming) areas where herbicide use may be undesirable
- Areas with dense natives (herbicides not allowed)
- Areas where genetic composition of EWM/Hybrid EWM suggests resiliency to herbicides
- Public access areas where aquatic plants accumulate and can be picked up

Once categorized, informed decisions must be made on the use of mechanical harvesting on a site-specific basis. Next, feedback and approval from affected cities, bay captains, residents, and the LMA on the specific areas of the lake that are most likely to benefit from mechanical harvesting should be solicited. Because aquatic plant growth varies from bay to bay and year to year, it will be necessary to evaluate plant growth conditions in bays and recommend appropriate harvesting on a year by year basis, within the limits of the planned harvesting priority areas and DNR permit.

While bay captains will be involved in the decision making process the administrator of the harvesting program should be responsible for making the final decision on the use of mechanical harvesting on a site-specific basis. Someone with aquatic plant experience is necessary to proactively balance staff and harvesting equipment resources and priorities with the needs and ecological conditions of the entire lake. AIS detector training is also preferred. Local groups or individuals would retain the option of contracting for additional harvesting or special event harvesting needs.

6.2. Long Term Goals

6.2.1. Native Aquatic Plant Community Restoration

Active restoration of native aquatic vegetation may be necessary following removal of invasive aquatic vegetation if natives do not naturally re-establish. Restoring a healthy native aquatic plant community represents a vitally important strategy for increasing the natural resiliency of the lake to future AIS invasions. Increasing the resiliency of the native plant community represents a measurable return on investment. As the percentage of the lake occupied by native aquatic plants increases, there is less opportunity for invasive species to take hold.

Natural re-establishment of native vegetation is primarily governed by competition with invasives, water clarity, and native propagule supply (Verhoeven, 2019). If native vegetation fails to re-establish under limited competition with invasives and suitable water clarity conditions, the native propagule supply is likely limiting re-establishment and active restoration of native aquatic plants via transplants or seeding may be necessary. Fortunately, Lake Minnetonka has an ample supply of native aquatic plants within the lake that should theoretically provide adequate supply if invasives can be reduced.

Case Studies

Ongoing research at the University of Minnesota is examining the effectiveness of seeding native aquatic plants into plots where CLP and EWM have been controlled (Verhoeven, 2019). The DNR has established preliminary methods for restoring native aquatic vegetation using transplants following herbicide treatments of invasive aquatic plants such as EWM. In 2018, the DNR worked with Coon Creek Watershed District and Freshwater Scientific Services, LLC to attempt native, submergent plant restoration efforts in Crooked Lake, Anoka County. Results from this effort can be evaluated by clicking on the Case Study, hyperlinked below.

Case Study: Submersed Aquatic Plant Restoration: A Case Study from Below the Surface

Aquatic plant restoration has also been attempted by Three Rivers Park District at Hyland Lake and Lake Rebecca. The projects were implemented following several years of CLP treatments and alum treatments to provide suitable conditions for native plant establishment. Plants selected for transplant included native pondweeds (*Potamageton* spp.) and water stargrass (*Heteranthera dubia*) which were hand-harvested from an un-infested donor lake. Data collection on native plant response is ongoing, but preliminary results indicate successful establishment of transplanted species in several plots.

The following list summarizes observations on preliminary outcomes and costs of native aquatic plant restorations.

1) A significant amount of permitting is involved in moving plants from one lake to another.
    a. Note: Lake Minnetonka has an ample, native aquatic plant community and native seedbank that may allow for in-lake transfers. This would significantly reduce the amount of time spent permitting and reduce travel time between sites.
2) Harvesting and transporting plants is very time and labor intensive, requiring manual labor to carefully harvest plants by hand, place in coolers, and transport.
3) Native plant transplants respond differently depending on the lake, despite apparently similar suitable conditions. Furthermore, certain areas within the same lake have been more successful than others as demonstrated in Crooked Lake where some plots were completely unsuccessful while other areas had multiple species take hold. There is not enough evidence to determine what makes any particular site more or less successful.
4) Initial start-up costs for experimental sized plots (10-20 square feet) typically involve staff time (team of 4-5 individuals working for two consecutive 8-hour days), gardening supplies, landscape stakes, burlap fabric, and sufficient fencing material to create an enclosure around the transported aquatic plants (optional).
5) To date, the scale of implementation has been quite small. Experimental plots have been between 9 square feet on Hyland Lake and Lake Rebecca to a maximum of 16 square feet on Crooked Lake. The small plot size is a reflection of the time and labor involved in harvesting, transporting, and re-planting the aquatic plants.
6) The most successful species in transplanting efforts was large-leaf pondweed (*Potamogeton amplifolius*); however, several other species have been attempted with mixed results including flat stem pondweed (*Potamogeton zosteriformis*), clasping-leaf pondweed (*Potamogeton richardsonii*), water celery (*Valisnera americana*) and water stargrass.

7. REFERENCES

Bartodziej, W.M., S.L. Blood, and K. Pilgrim. 2017. Aquatic plant harvesting: an economical phosphorus removal tool in an urban shallow lake. Journal of Aquati Plant Management 55: 26-34.

Bettoli, P. W., M.J. Maceina, R.L. Noble, and R.K. Betsill, R. K. 1992. Piscivory in largemouth bass as a function of aquatic vegetation abundance. North American Journal of Fisheries Management 12(3)509-516.

Bettoli, P. W., M.J. Maceina, R.L. Noble, and R.K. Betsill. 1993. Response of a reservoir fish community to aquatic vegetation removal. North American Journal of Fisheries Management 13(1):110-124.

Cooke, G. D., A.B. Martin, and R.E. Carlson. 1990. The effect of harvesting on macrophyte regrowth and water quality in LaDue Reservoir, Ohio. Journal of the Iowa Academy of Science 97(4): 127-132.

Crowell, W., N. Troelstrup Jr., L. Queen, and J. Perry. Effects of harvesting on plant communities dominated by Eurasian watermilfoil in Lake Minnetonka, MN. Journal of Aquatic Plant Management 32:56-60.

Engel, S. 1987. Impact of submerged macrophytes on largemouth bass and bluegills. Lake and Reservoir Management 3:227-234.

Engel, S. 1995. Eurasian watermilfoil as a fishery management tool. Fisheries 20(3):20-27.

Haller, W. T., J.V. Shireman, and D.F. Durant. 1980. Fish harvest resulting from mechanical control of hydrilla. Transactions of the American Fisheries Society 109(5):517-520.

Lake Noquebay Rehabilitation District. 2009. Aquatic plant management goals and objectives.

Lund K., Dauphinais J., and Johnson J. 2018 “Submersed aquatic plant restoration: A case study from below the surface.” Upper Midwest Invasive Species Conference, 17 October 2018, Mayo Civic Center, Rochester, MN. Oral Presentation.

Mikol, G.F. 1985. Effects of harvesting on aquatic vegetation and juvenile fish populations at Saratoga Lake, New York. Journal of Aquatic Plant Management 23:59-63.

Nichols, S.A. The interaction between biology and the management of aquatic macrophytes. Aquatic Botany 41(1-3):225-252.

Olson, M. H., S.R. Carpenter, P. Cunningham, S. Gafny, B.R. Herwig, N.P. Nibbelink, and K.A. Wilson. 1998. Managing macrophytes to improve fish growth: a multi-lake experiment. Fisheries 23(2):6-12.

Three Rivers Park District. 2004. Phosphorus removal by plant harvesting on Lake Minnetonka.

Rawls, C. K. 1975. Mechanical control of Eurasian watermilfoil in Maryland with and without 2, 4-D application. Chesapeake Science 16(4):266-281.

Sheldon, S.P. and L.M. O’Bryan. 1996. The effects of harvesting Eurasian watermilfoil on the aquatic weevil *Euhrychiopsis lecontei*. Journal of Aquatic Plant Management 34:76-77.

Sloey, D., T. Schenck, and R. Narf. 1997. Distribution of aquatic invertebrates within a dense bed of Eurasian milfoil (*Myriophyllum spicatum* L.). Journal of Freshwater Ecology 12(2):303-313.

Unmuth, J. M., D.J. Sloey, and R.A. Lillie. 1998. An evaluation of close-cut mechanical harvesting of Eurasian watermilfoil. Journal of Aquatic Plant Management 36:93-100.

Verhoeven, M. 2019. "Restoring native plants after curlyleaf and milfoil control: What's holding them back?" Minnesota Aquatic Invasive Species Research Center AIS Research and Management Showcase, 17 September 2019, University of Minnesota, St. Paul, MN. Oral Presentation.

Wile, I. 1978. Environmental effects of mechanical harvesting. Journal of Aquatic Plant Management 16:14-20