MINNEHAHA CREEK WATERSHED DISTRICT

QUALITY OF WATER QUALITY OF LIFE

MEMORANDUM

DATE: January 26, 2017

TO: MCWD Board of Managers

FROM: Eric Fieldseth, MCWD AIS Program Manager

RE: Lake Minnewashta Zebra Mussel Rapid Response Report

This report details the rapid response to the discovery of Zebra mussels in Lake Minnewashta from August to October, 2016. MCWD staff discovered Zebra mussels at the Lake Minnewashta boat launch during a routine early detection monitoring event. This is the second early infestation in the District that the early detection monitoring program has found. Through lake-wide searching, the population was believed to be contained to the public access area. A multi-agency response was coordinated between MCWD, Carver County and the Lake Minnewashta Preservation Association. 29 acres were treated with the copper-based EarthTec QZ, the largest treatment to-date in Minnesota for zebra mussels. Copper concentrations were held between 0.3 and 0.5 ppm and 100% control of zebra mussels being monitored in the treatment area was found by day 10. These concentrations were much less than what has been used in previous treatments (1 ppm in Christmas Lake). Many lessons from the Christmas Lake rapid response were applied to this situation, and influenced our decision on product, rates and exposure time needed.

This report from the Lake Minnewashta Rapid Response will be a model that can be followed by others in the state and country. While we know we can now control zebra mussels in a defined, somewhat enclosed area, time will ultimately tell if rapid response to an early infestation can really eradicate zebra mussels from a lake. Continued searching in Lake Minnewashta will occur over the next few years before one could say that complete eradication occurred.

MINNEHAHA CREEK WATERSHED DISTRICT

QUALITY OF WATER QUALITY OF LIFE

Rapid Response to Zebra Mussel Infestation

Lake Minnewashta

Carver County, MN

Report Authors:
Eric Fieldseth
Jill Sweet

Minnehaha Creek Watershed District
December 30, 2016

Report on Monitoring of
Zebra Mussel Pilot Project for Lake Minnewashta

By

Minnehaha Creek Watershed District (MCWD)

Submitted to:

Invasive Species Program
Division of Ecological and Water Resources
Minnesota Department of Natural Resources

Lake: Minnewashta County: Carver DOW Number: 10000900

Project Year: Year 1

Primary ISS Contact: Keegan Lund

Partners: MCWD, Carver County, Lake Minnewashta Preservation Association & MN DNR

Survey Methods: Snorkel, SCUBA, wading, sampler plates, dock/lift checks

Last Treatment Date: 09/21/2016

Date(s) of Survey(s): 08/18, 08/19, 08/26, 10/28

Survey Results: **Pre-treatment surveys – ZM's at access only**. **Post-treatment equipment survey 10/28 – no ZM's found.**

Date of Report: 12/30/2016

Author(s) of Report: Prepared by Eric Fieldseth & Jill Sweet

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Summary of Results

In this report we summarize zebra mussel monitoring and post-treatment data from August 18 – October 28, 2016, collected during and after the rapid response to zebra mussels in Lake Minnewashta. Zebra mussels were first discovered in Minnewashta by the MCWD's early detection monitoring program on August 18, 2016. Through further surveys, the population appeared to be localized to the public access area and a rapid response was initiated. Partners in the response included MCWD, Carver County and the Lake Minnewashta Preservation Association. A 29 acre bay was cordoned off with barriers, and treated with EarthTec QZ for 10 days at a target copper concentration of 0.3 to 0.5 ppm. An additional 0.61 acre area, within the 29 acre area and surrounding the boat launch where the infestation occurred, was also cordoned off with barriers and treated with EarthTec QZ. 100% mortality of zebra mussels was observed by day 10. Other parameters monitored included dissolved oxygen, pH, conductivity, water temperature and observations on non-target impacts. A survey of docks and lifts taken out of the water by residents was also conducted on October 28, 2016 with no zebra mussels being found. This report fulfills the post-treatment monitoring requirements outlined in the DNR Zebra Mussel Pilot Project Protocols and Permit 2016-1684.

Background Context:

The Minnehaha Creek Watershed District has an intensive AIS Early Detection Monitoring Program it implements at several lakes across its District (*Appendix F*). Past monitoring events on Lake Minnewashta include the following:

2014

- Zebra mussel sampler plate at public access dock – checked 1 to 2 times per month
- July 23, 2014 – Comprehensive Early Detection Survey – no zebra mussels found, no veligers present in samples. (*Appendix A*).

Results: No new AIS discovered

2015

- Zebra mussel sampler plate at public access dock, Fishing Pier and Fishing Pier on west end of lake – checked weekly
- 7 volunteers with zebra mussel sampler plates around the lake
- July 21, 2015 – Comprehensive Early Detection Survey – no zebra mussels found, no veligers present in samples. (*Appendix B*)

Results: No new AIS discovered

2016

- Zebra mussel sampler plate at public access dock – checked weekly
- August 18, 2016 – Early Detection Survey at public access

Results: Zebra Mussels found on August 18th.

Timeline of Rapid Response Events

August 18, 2016 *(Thursday)*

MCWD staff conducted an early detection survey at the public access to Lake Minnewashta. The survey was to involve wading and snorkeling of an area encompassing 100 feet of shoreline at the access to about 40 feet lakeward. Four juvenile zebra mussels were found right away attached to rocks directly underneath the west dock at the public access, in 1 to 2 feet of water. No zebra mussels were present on the zebra mussel sampler plate, which was located on the east dock. MCWD staff immediately notified MN DNR AIS Specialist Keegan Lund.

August 19, 2016 *(Friday)*

MCWD and DNR performed a survey to determine the extent of the infestation. A total of 12 man hours were spent searching 9 different areas of the lake and found no additional zebra mussels beyond the public access. However, another 10 juvenile zebra mussels were found directly under the same dock at the public access, again in 1 to 2 feet of water. (*Appendix C*)

August 22, 2016 *(Monday)*

MCWD organized a meeting with partners to discuss next steps. Partners included the Lake Minnewashta Preservation Association, Carver County, City of Chanhassen and MN DNR. Details around the discovery of zebra mussels were discussed, as well as potential next steps. The following details in the discovery made this infestation a good candidate for a rapid response:

- Localized population in a contained bay - 14 zebra mussels found within a ~10 foot radius underneath the western dock of the public access, all in depths of one to two feet of water.
- Size distribution of the 14 zebra mussels ranged from 2 mm – 12 mm, leading us to believe they were likely introduced at this size and rather than introduced via a reproducing population in the lake. We would expect more zebra mussels of a similar size range if reproduction was the source of introduction. Additionally, the location of the infestation, with all zebra mussels being found within 10 feet of each other under the same dock at the public access, leads one to assume this infestation was introduced via watercraft.
- Extensive monitoring program in-place by MCWD and volunteers from Lake Minnewashta Preservation Association. No zebra mussels have been found prior.
- No veligers found in samples that were taken on August 19th.

Outcomes of the August 22nd partner meeting:

- Carver County would coordinate internally and externally to close the main access and open the previously closed secondary access at Lake Minnewashta Regional Park.
- MCWD reviewed different treatment scenarios with estimated costs. Consensus was reached to develop quotes for product and treatment costs for Potash (Potassium Chloride) and EarthTec QZ (copper-based) to treat a 29 acre bay where the infestation occurred.
- Carver County would purchase the containment curtain.
- More lakewide searching would continue.

August 23, 2016
MCWD submitted a permit application to DNR for treatment of 29 acres with Potash or EarthTec QZ.

August 24, 2016
Main access at the Lake Minnewashta Regional Park was closed and secondary access was opened. A containment curtained was installed at the channel leading from the 29 acre bay to the main lake, as well as an area surrounding the boat launch where the infestation occurred (0.61 acres).

August 26, 2016
Second lakewide search occurred with staff from MCWD, DNR, and Carver County. No additional zebra mussels were found outside the public access area. (*Appendix D*)

September 1, 2016
MCWD organized a meeting with partners (Carver County & Lake Minnewashta Preservation Association) to discuss final costs and options. EarthTec QZ was chosen as the product of choice due to costs; the cost of Potash was quoted as 3 times as expensive. Timeliness was also a consideration, Potash would have required an amended or new emergency authorization from the US EPA, whereas EarthTec QZ already had an EPA approved label for zebra mussels. A lower Copper concentration range of 0.3 to 0.5 ppm was proposed for the EarthTec QZ treatment based previous data from the manufacturer and previous lab trials by MCWD that showed 100% mortality of zebra mussels with EarthTec QZ at 0.5 and 1.0 ppm at 8 days exposure. Additionally, MCWD was also involved in ongoing research led by the USGS examining concentrations and exposures of different products, including EarthTec QZ, for zebra mussel control with water temperature as a variable. Early results from this research were also supporting the thought that lower concentrations of EarthTec QZ would effective. It was hoped that this lower rate would allow for fewer non-target impacts. Financial and technical roles for each partner group were also established at this meeting.

September 8, 2016
MN DNR issued the permit for zebra mussel control of 29 acres in Lake Minnewashta.

September 13 – September 23, 2016
Treatment and daily monitoring occurred.

September 27, 2016
Containment barriers removed & public access shifted back to main access.

October 28, 2016
MCWD & Carver County performed an equipment survey of docks and lifts removed from Lake Minnewashta. No zebra mussels found. (*Appendix E*)

Treatment Site Description

Lake Minnewashta is located in NE Carver County, near the City of Chanhassen. It falls within the Minnehaha Creek Watershed District, a local government agency responsible for managing and protecting the water resources of the Minnehaha Creek Watershed. The zebra mussel infestation occurred at the public access to the lake, which is located in the Lake Minnewashta Regional Park, operated by Carver County. The public access is located in a 29 acre bay referred to as "Little Minnie", which has a channel that leads to the main lake. Little Minnie is surrounded by undeveloped parkland, consisting of both woodlands and wetlands. Aquatic plants are abundant along the fringe of Little Minnie (*figure 1*), consisting of water lilies, Coontail, Eurasian Watermilfoil and Sago Pondweed. The substrate immediately around the public access is small rock that was brought in to stabilize the access. Outside of this immediate area the sediment is mostly muck. Little Minnie drops off to 29 feet out in front of the access, and has a deep channel across the middle of the lake and a similarly deep hole on the opposite end (*figure 2*).

Lake Minnewashta Treatment Map

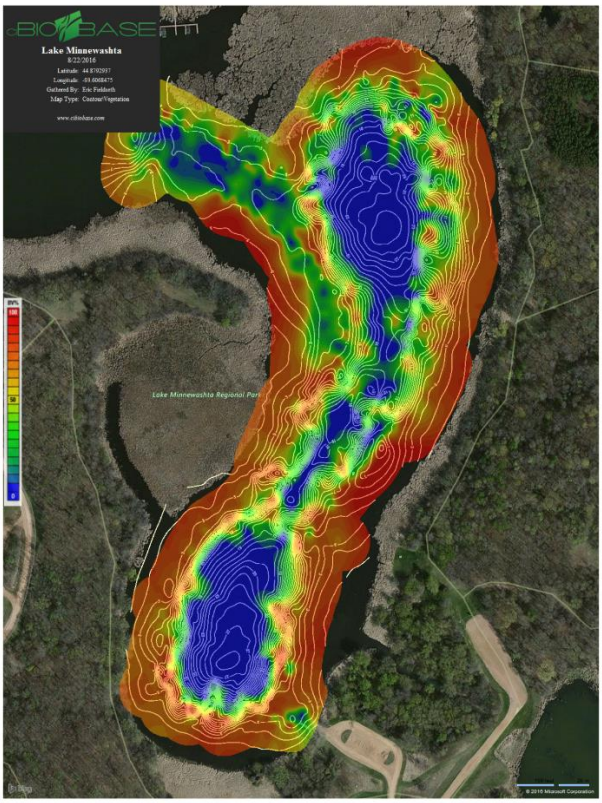


Figure 1. Aquatic vegetation biovolume

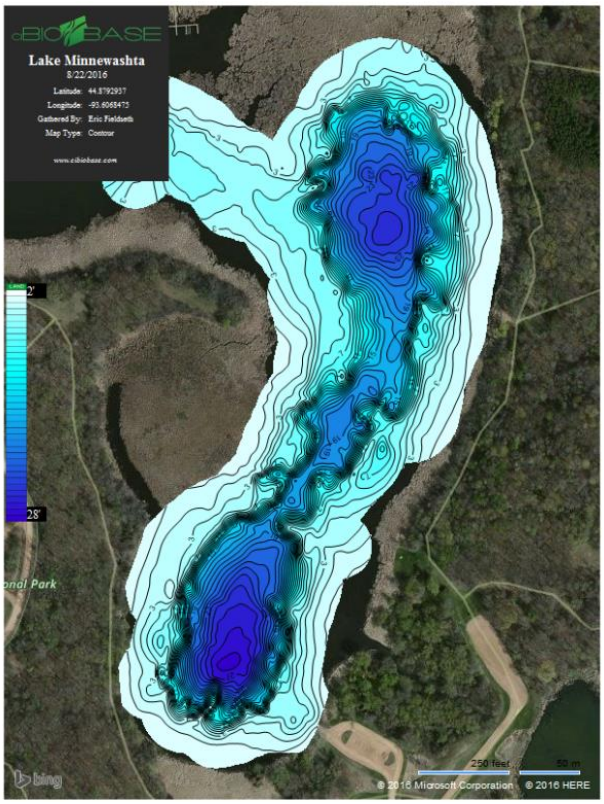


Figure 2. Bathymetric map

Treatment Design

The approach for this rapid response treatment was to treat as large of an area that was possible and reasonable, which was one of the many lessons learned from the rapid response on Christmas Lake. Given the depth of the middle of the bay, it was not practical to place a containment barrier across the middle of the bay and expect it to reach the lake bottom. The most practical area to place the barrier was the section of the channel from the bay to the main lake that was less than 5 feet of water. Beyond this point in the channel, it drops off to 10 to 11 feet which is too deep for a barrier. 10 foot deep barriers were used for areas greater than 4 feet to ensure a good seal, while the 5 foot barriers were used along the shorelines where depths were 4 feet or less. It's important to note that while they are called 10 and 5 foot barriers, approximately one foot of that length includes the float which is above the surface of the water and a few inches are needed along the lake bottom in order to place sand bags to create a seal. Barriers were installed in two locations, one stretching across the channel where the bay enters the main lake, and the other around the public access area where the infestation occurred. This was done to allow for a more aggressive treatment approach in the small area where we knew zebra mussels were present while the larger area was a buffer to hopefully catch any stray mussels that may have spread from the launch.

Each site was going to follow the same treatment protocol of maintaining between 0.3 and 0.5 ppm Copper for 8 to 14 days. These concentrations were chosen based off previous lab trials by MCWD, ongoing research being led by the USGS and advice from the manufacturer. Water volume for each site was determined by creating a bathymetric map using sonar data we

collected and uploaded into CiBiobase. The larger site had deeper depths so additional temperature/dissolved oxygen profiles were taken to determine if the bay was stratified. The bay was stratified, with a thermocline around the 4 to 5 meter depth. After consulting with the PLM Lake and Land Management, the applicator for this project, it was determined to dose the top 5 meters of water volume in the larger area, and then follow up with copper concentration monitoring at 1 meter depth increments to confirm the product was staying above the thermocline and not mixing below it.

Treatment Monitoring

Mortality Bioassay within the Treatment- Caged Mussels

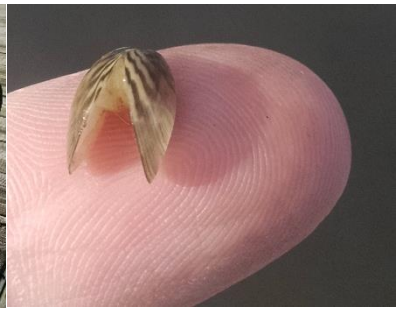
Zebra mussel mortality was assessed in each treatment area by using bioassays with zebra mussels collected from nearby Christmas Lake. Collection was conducted with the DNR, and all appropriate permits were in place. Since only 14 zebra mussels were found in Lake Minnewashta, and subsequently removed, live zebra mussels were needed to properly evaluate the treatment. Bioassays were placed in each treatment site.

Methods

25 zebra mussels ranging in size from 7 to 10 mm were selected and placed into acrylic tubes with a fine mesh on each end. The tubes were then placed in plastic mesh cages and sealed with zip ties. The size range was chosen to reduce the chances of the zebra mussels being reproductive, but large enough not to escape the mesh cages. The cages were then placed in each treatment site where they would be assessed daily for mortality. Cages were placed in each treatment site 2 days prior to treatment to allow for acclimation. On the day of treatment prior to application, each cage was pulled out of the water and zebra mussels were examined to determine if they were still viable and healthy animals. This was done by tapping on each animal with a forceps and seeing if they appeared closed, and not gaping. Each day post-treatment, the cages were pulled and zebra mussel mortality was assessed. A zebra mussel was ruled dead if it was completely gaping, with no or little tissue intact. Zebra mussels that were gaping, but still had some tissue intact were left in the cages until they met our rule for determining dead zebra mussels.

Acrylic tubes with fine mesh on each end.

Zebra Mussel cages.



Dead gaping zebra mussel.

Results

Prior to treatment, all zebra mussels in the cages appeared healthy and viable. Mortality of zebra mussels was not observed until after day 4 of treatment. 100% mortality of zebra mussels was observed by day 7 in the 0.61 acre site, and day 10 in the 29 acre site (*Figure 3 and 4*).

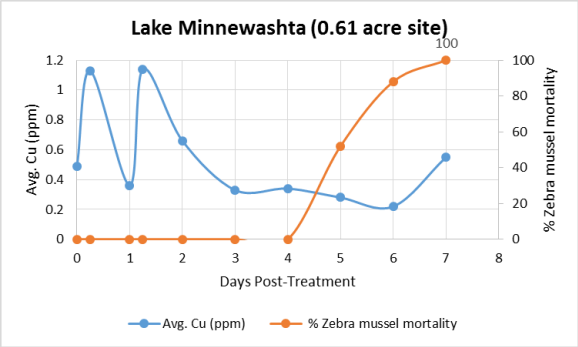


Figure 3. Zebra mussel mortality in 0.61 acre site

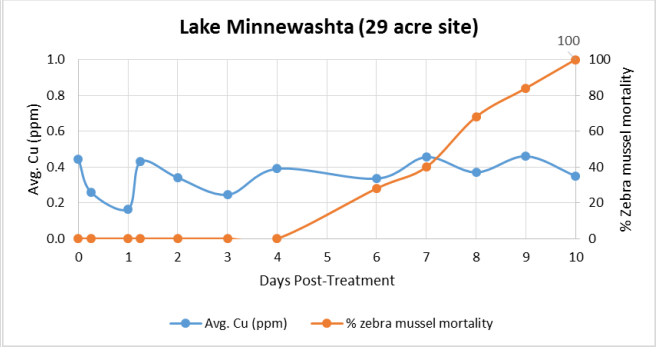


Figure 4. Zebra mussel mortality in 29 acre site

Pesticide Concentrations

Target copper concentrations in each site was 0.3 to 0.5 ppm. Bump treatments were necessary to maintain target concentration, and occurred on days 1, 3, 6 & 8. Treatment in the 0.61 acre site was completed by day 7 (*Figure 3*), and by 10 in the 29 acre site (*Figure 4*).

Methods

Copper concentration was measured just prior to treatment, and then daily during the treatment process. More frequent samples were taken during the first day of treatment, when most of the background uptake of copper occurs and dissipation is more rapid. Concentrations were measured in the field using a LaMotte 1200 Colorimeter.

LaMotte 1200 Colorimeter

Van Dorn sampler

In the 0.61 acre site, three locations were selected as sample sites (*Figure 5*). At each sample site, a grab sample was taken from the surface and copper concentrations were measured. An average of the three sites was then recorded on the data sheet.

In the 29 acre site, 5 sample sites were chosen. They represented different areas of the bay, including deep and shallow areas (*Figure 5*). At the shallow sites, grab samples were taken from the surface and analyzed. At the deeper sites, grab samples were taken from the surface, and a Van Dorn Water Sampler was used to take a discrete sample from 2 meters depth. Surface samples were averaged across the 5 sample sites and recorded on the data sheet. The 2 meter samples were taken at three of the locations and averaged across those sites and recorded. Copper concentrations were also taken along a depth profile in the deepest spot of the lake every 1 meter to assess concentration by depth. Temperature and dissolved oxygen profiles were also taken in this location, and a thermocline existed around 4 to 5 meter depth.

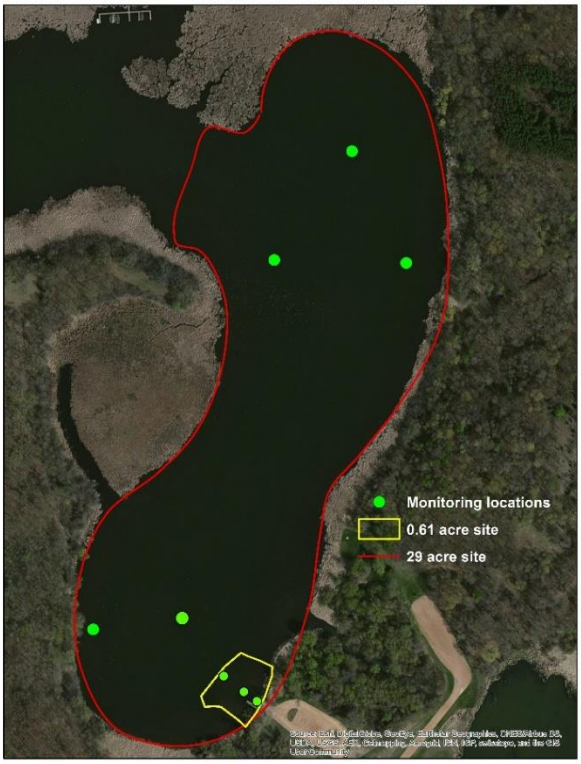


Figure 5. Post-Treatment monitoring locations.

Results

There was greater fluctuation of copper concentration in the 0.61 acre treatment area, especially during the first 2 days with concentrations exceeding our target range. Concentrations were more stable in the 29 acre site during the entire treatment. There also seemed to be more background use of copper in the initial couple days, shown by a quicker dissipation and need for a higher bump treatment. In both treatment sites, concentrations leveled off and fell within our target range of 0.3 to 0.5 ppm after this initial background use (*Figures 3 and 4*). Copper concentrations were very low deeper than 5 meters (< 0.05 ppm), meaning the product did not mix much below the thermocline (*Figure 6*). This confirmed our treatment design to only treat the water volume above the thermocline. The volume below the thermocline had very low dissolved oxygen (< 2 mg/L), and zebra mussels were not expected to survive at these depths if they were present. Copper concentrations continued to dissipate following treatment and removal of barriers on day 14 (*Figure 7*).

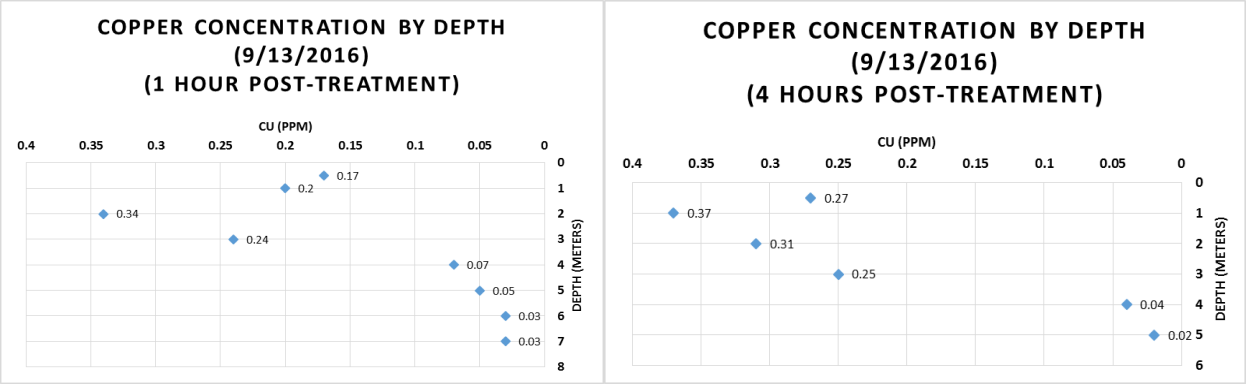


Figure 6. Copper concentration by depth one hour and four hours post-treament on day one of treatment on September 13, 2016. Limited mixing of Copper below the thermocline.

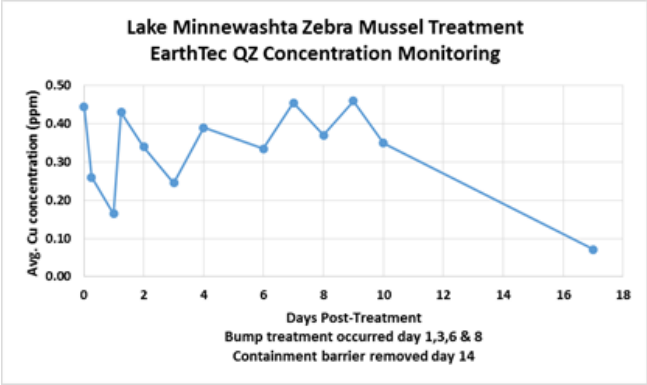


Figure 7. Copper concentration during treatment and dissipation over time.

Other Parameters Monitored

In addition to zebra mussel mortality and copper concentration monitoring, the following parameters were also monitored:

- Dissolved oxygen, water temperature, pH & conductivity
- Native mussel impacts
- Observations on aquatic plant impacts
- Observations on fish impacts

In each treatment site, dissolved oxygen, water temperature, pH & conductivity were measured using a YSI 600 XL multiparameter water quality sonde. Readings were taken from one designated location in the 0.61 acre site, and taken 2 feet below the water's surface. In the 29 acre site, readings were taken at the three deeper locations with dissolved oxygen being read at both the surface and 2 meter depth. Dissolved oxygen started to crash around 24 hours after treatment, and remained very low during the duration of the project. Upon removal of the barrier, dissolved oxygen started slowly climbing back up (*Figure 8 and 9*).

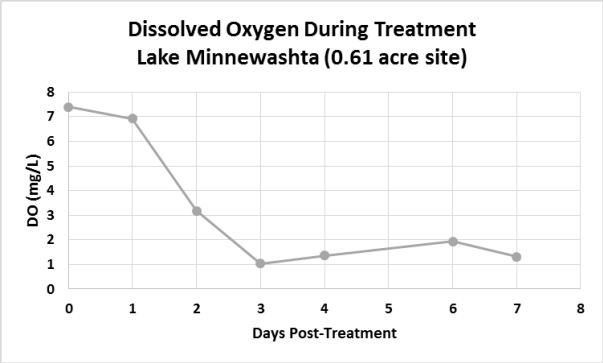


Figure 8. DO in 0.61 acre site during treatment.

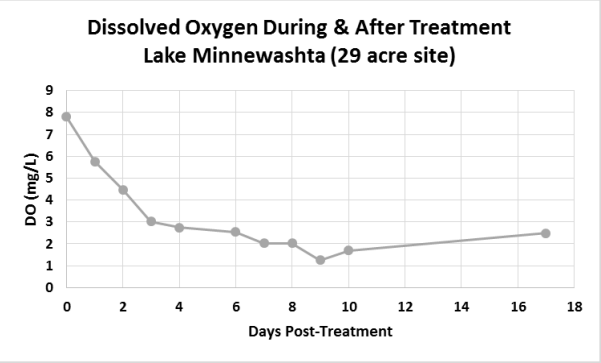


Figure 9. DO during treatment and after barrier removal on day 14.

Impacts to native mussels were also assessed during this treatment. Native mussels are not commonly found in this part of Lake Minnewashta, so to assess the impact we collected 10 native mussels from nearby Christmas Lake, and placed 5 in each of the zebra mussel cages. Collection was conducted with the DNR and all appropriate permits were in place. Mortality was assessed daily, and native mussels were deemed dead if their shells were gaping and they "looked dead". All native mussels were deemed dead by 8 days post-treatment by our assessment. This is likely not the best method to determine mortality in native mussels, and in the future we recommend placing the native mussels in separate cages, and leave them in the lake after treatment is completed to allow freshwater to mix back in. Mortality should be reassessed several days later.

Ruled as dead native mussel.

Observations were also taken on impacts to the aquatic plant community and fish. Prior to treatment, vegetation was abundant along the shoreline of the entire bay (*Figure 1*) and consisted of water lilies, Coontail, Eurasian Watermilfoil and Sago Pondweed. 24 hours after the first treatment, Coontail leaflets were floating on the surface of the water in both treatment sites. The leaflets appeared to be completely stripped off the plants, leaving behind mostly stems. These stems eventually died and formed into a large mass floating in the lake. This likely contributed to the dissolved oxygen crash in the lake. Eurasian watermilfoil remained present, but looked unhealthy. Water lilies appeared slightly damaged and had a "burnt" look, and Sago Pondweed appeared unharmed.

Floating leaflets from Coontail.

Bare stems of remaining Coontail.

Floating mass of dead Coontail

A minor fish kill occurred in the treatment area, likely due to low dissolved oxygen. Below is a chart showing impacts by species (*Figure 10*). Not every fish was counted and measured, but the chart shows the proportion of impact to different species and sizes. Small bullhead and small perch seemed to be the most affected species. Small bluegill were seen swimming throughout the duration of the project, although they tended to be along the treatment curtain and closer to the surface, likely looking for areas of higher dissolved oxygen.

Fish Species	# Dead Fish Observed	Size Range	Additional Notes
Bluegill Sunfish	1	2 inches	Noticed many live Bluegills throughout project.
Bluntnose Minnow	2		
Bullhead	14 +	3 – 12 inches	Counted and measured 14, but there were additional at a similar size range.
Channel Catfish	1	11 inches	
Common Carp	1	24 inches	
Northern Pike	2	22 – 34 inches	
Yellow Perch	9	2 – 8 inches	

Figure 10. Inventory of dead fish observed during treatment on 9/17 & 9/19, 2016.

Post-Treatment, Long-Term Monitoring

Surveys in Treatment Areas:

No post-treatment surveys have occurred in the treatment areas. The 14 zebra mussels found during the initial discovery were all hand removed prior to treatment. Treatment occurred due to the likelihood of additional zebra mussels being present in the treatment area that were difficult to detect. Bioassays were used to monitor zebra mussel mortality, and 100% mortality of caged zebra mussels was observed by day 10 of treatment. Surveys in the treatment areas will resume in spring of 2017.

Surveys outside Treatment Areas:

A post-treatment survey of docks and lifts was performed on October 28, 2016 by staff from the MCWD and Carver County (*Appendix E*). 3 people assessed multiple docks at 4 different locations around the lake, and no zebra mussels were found. Additional in-lake searching will resume in the spring of 2017 when water clarity is better.

Zebra Mussel Settlement Samplers

Settlement samplers are distributed across the lake and checked by volunteers. There have been no reports of zebra mussels. It's expected to have the same number of volunteers again in 2017. The MCWD will continue checking the sampler plate at the boat launch weekly during the boating season.

Veliger Counts

Veliger samples were taken on August 19, 2016. No veligers were present in the samples.

2016 Monitoring Activity Log:

Date of Survey	Time (start-end)	Activity	# Surveyors	Surveyors Affiliation(s)	# Survey Hours	Results
Weekly from 4/18/16 through 8/18/16	15 minutes	**Early Detection**: Check of sampler plates/shorelines at boat launch, and E & W fishing piers	1	MCWD	6.5	No mussels found
2016 Open water season	N/A	**Early Detection:** Volunteer zebra mussel samplers	7	Lake residents	N/A	No mussels found
8/18/16	10:00 AM-10:30 AM	**Early Detection**: Snorkel survey of boat launch.	2	MCWD	1	Zebra Mussels found
8/19/16	9:00 AM-2:00 PM	**Lakewide search**: Snorkel survey	5	MCWD & MN DNR	9.25	No mussels found outside of boat launch area
9/13 – 9/23/16	Daily ~ 1 hour	**Treatment Monitoring**	2	MCWD	20	
8/26/16	10:00 AM - 2:00 PM	**Lakewide search**: Scuba & snorkel survey	9	MCWD, MN DNR, Carver County	10	No mussels found outside of boat launch area
10/28/16		**Dock/Lift checks**	3	MCWD, Carver County, LMPA	2	No mussels found

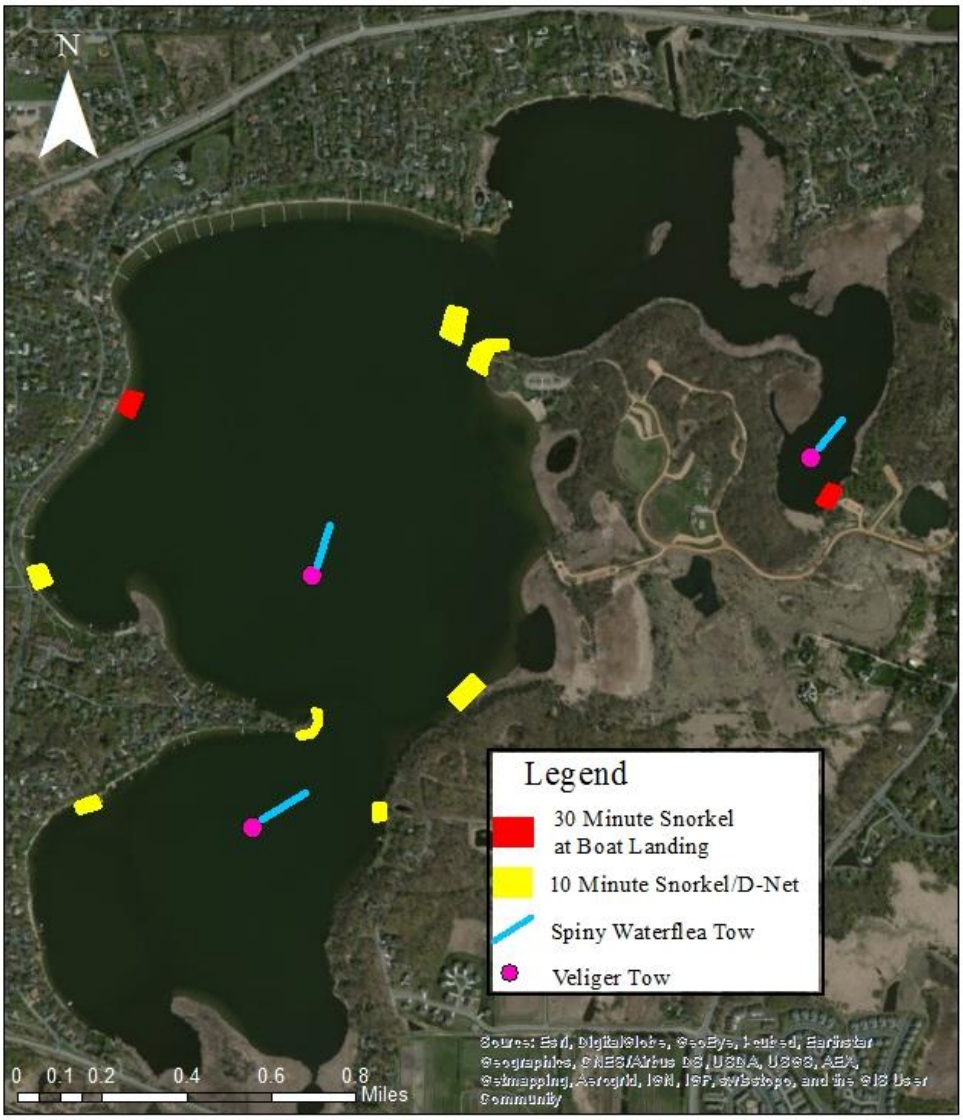
Total Hours: 48+

Summary of Costs:

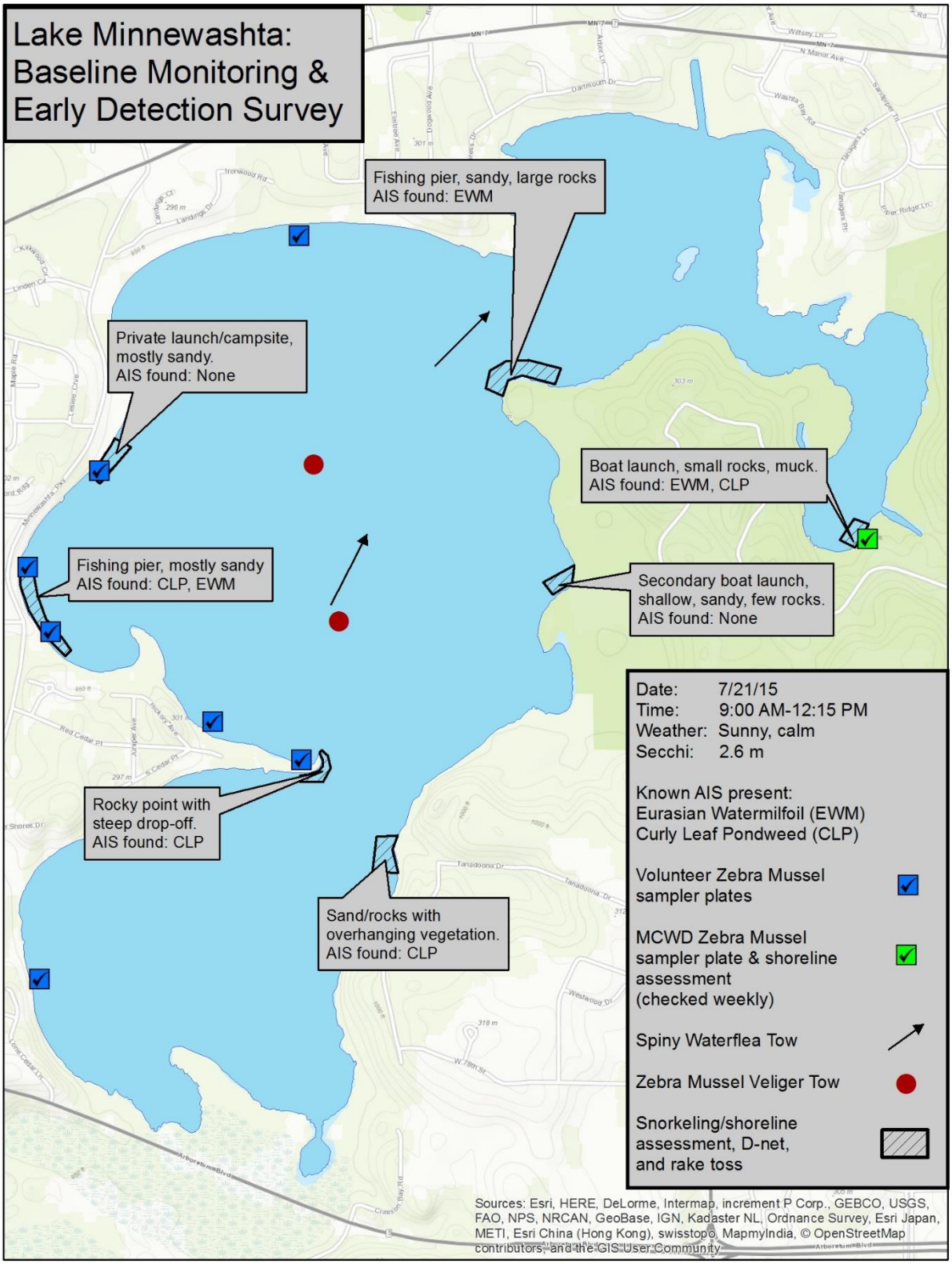
Organization	Cost
Carver County	$14,000 & In-kind services
MCWD	$10,000 & In-kind services
Lake Minnewashta Preservation Association	$7,936.16
MN DNR	In-kind services
Total non-staff time costs	**$31,936.16**

Item	Organization	Cost	Totals
Enclosure Curtain	Carver County	$9,000	
		Sub-total	**$9,000**
EarthTecQZ	MCWD	$10,000	
	Carver County	$5,000	
	Lake Minnewashta Presevation Association	$2,861.16	
		Sub-total	**$17,861.16**
Applicator - PLM Lake Management	Lake Minnewashta Preservation Assocation	$5,075	
		Sub-total	**$5,075**
		Total Non-Staff Time Cost:	**$31,936.16**

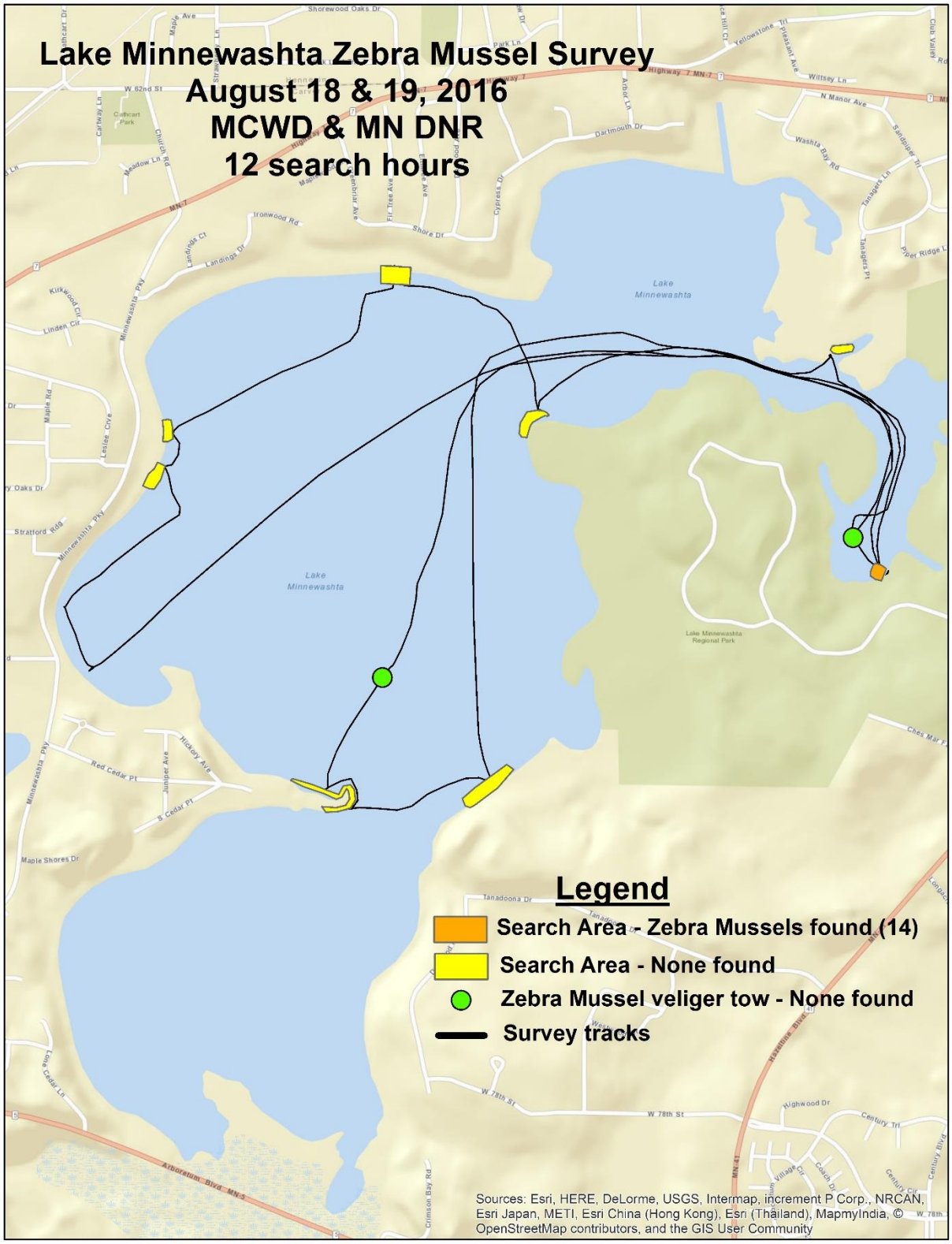
Appendix A: 2014 Early Detection Survey



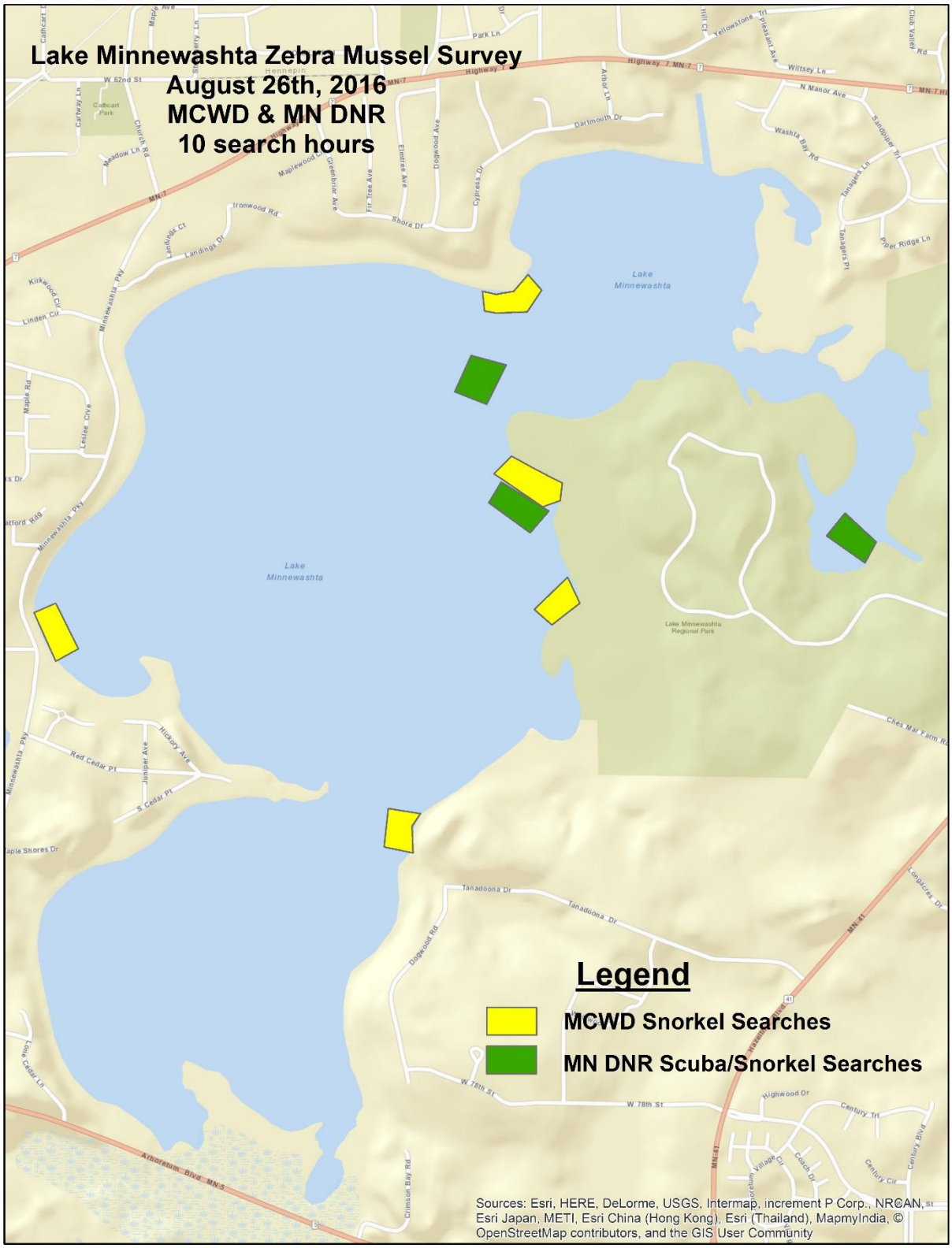
Appendix B: 2015 Early Detection Survey.



Appendix C: Lakewide Zebra Mussel Survey.



Appendix D: Lakewide Zebra Mussel Survey



Appendix E: Dock/Lift Survey.

Appendix F: MCWD Early Detection Protocol

Comprehensive Early Detection Survey

These surveys were completed on most major lakes throughout the MCWD between 2014 and 2015. The surveys were performed to give us an inventory of which AIS exist in our lakes, and also serve as early detection monitoring.

Snorkel Surveys:

Boat Launch Survey (30 minutes per launch)

- Thirty minute snorkel search (2 swimmers at 15 minutes each or 1 at 30 minutes) at each boat landing for aquatic plants, snails and mussels. Snorkeling will occur at non-busy times of the boat launch for safety. The survey should cover 200 feet of shoreline out to the maximum rooting depth or 50 feet from shore, or what is reasonably safe. The diver should make every effort to visually inspect the area for AIS, and collect voucher specimens when appropriate. Each sampling site location should be documented by GPS. Extra attention should be given to areas directly under docks, and in between concrete slabs if available as these are likely areas zebra mussels inhabit.

Lake Sites (Ten minute surveys)

- Ten minute snorkel search at a minimum of two to five scattered lake sites representing different within lake-habitat, substrate and shoreline aspect for aquatic plants, snails and mussels. For larger lakes with a variety of habitat, a minimum of five sites is desired.
    - Sites should maximize places where AIS are most likely to be found within a lake including inlets, highly developed shorelines, plant filled bays, rocky areas, etc.
- Survey should cover about 100 feet of shoreline out to the maximum rooting depth or 50 feet from shore, or what is reasonably safe. The diver should make every effort to visually inspect the area for AIS, and collect voucher specimens when appropriate. Each sampling location should be documented by GPS.

Rake samples for vegetation & D-Net sweeps for snails & mussels:

- Rake samples for aquatic plants and d-net sweeps for snails and mussels will be collected for 5 minutes at each boat landing and scattered sites, checking 5 to 10 random sites within these locations. One staff member will conduct rake samples from one side of the boat while the others collect D-net samples from the other side. If a point-intercept survey was recently done during the season, the rake sample portion can be skipped if you feel the survey was comprehensive.
- Each rake pull will be observed for invasive plants.
- Each D-net haul will be rinsed, placed in a tray and examined for invasive snails and mussels.

Zebra Mussel Veliger Tows:

- Zebra Mussel veliger tows at 3 deep locations around the lake using plankton nets.

Spiny Water Flea Tows:

- Spiny water flea tows at three mid-lake sites using the following protocol adapted from the Wisconsin DNR.
    - Three samples should be collected from three different areas of the lake. The three sampling sites should be deep enough to sample; 15 to 20 feet of water is a good rule of thumb. Ideal locations to sample are the deepest point of the lake,

areas near boat landings (sites of boat traffic), separate basins of the lake, or near lake's inlet. Shallower lakes can be sampled as well by making a more horizontal tow so as not to disturb the bottom of the lake. Take a GPS point where the sampling began.

- Collection:
  - Collect sample with a large diameter (0.5-1 meter opening) zooplankton net with a mesh size of 250 microns. Smaller nets can easily clog with small forms of phytoplankton and zooplankton.
  - A 100 meter horizontal tow is best suited for capturing water fleas. A GPS unit (to measure distance and/or rate of travel) can be used or tow the net for 120 seconds at a low boat speed that prevents the net from surfacing. Ideally, horizontal tows should be oblique, sampling from the top of the thermocline to just below the water's surface. Care must be given that the net does not hit the lake bottom. When this happens, the sample is of muddy water, which is very difficult or impossible to analyze. If you hit the lake bottom, rinse out the sampling equipment and go to a different area of the lake that will provide enough depth for a good tow.
  - Be sure to rinse the net from the outside of the net so that all of the material washes into the plankton collection cup. If water fleas are present, they will likely be visible immediately within the collection cup (but not always). These samples will only be analyzed in the field at this time. Samples could be sent to a lab if available.
  - Record sampling information on the data sheet.

Aquatic Vegetation Meander Survey:

- Determine the maximum rooting depth of aquatic vegetation in the lake. Conduct the meander survey by cruising in a meandering pattern throughout the littoral zone. The boat speed should be slow enough to enable the observers to scan the submerged rooted vegetation and confidently spot AIS. Polarized glasses should be worn and one team member should concentrate their search on either side of the boat. Observers should stop and collect rake samples of aquatic plants at 50 haphazard locations during the meander survey. Contents of the retrieved sample should be quickly scanned for AIS. If weather conditions (e.g., wind/waves) significantly impair visibility note this on the data form. Rake samples will still be collected. Document the shorelines surveyed on the field map and estimate the percent shoreline surveyed.
  - If a point-intercept survey for aquatic plants was recently performed (same season), then the meander survey can be skipped if you feel the point-intercept survey was comprehensive enough.
- If snorkeling is not possible (due to blue green algae, stained water, etc), stop at 50 haphazard locations while boating around the lake and take rake pulls and D-net sweeps. Check rake and net contents for AIS.
- Presence/absence data will be recorded for any AIS found.
- GPS points will be taken at locations that are surveyed for AIS and at points where AIS are found. If the same AIS species is found at three or more of the five lake sites or at three discrete locations during the boat surveys it should be listed as "established" in the

waterbody and no more GPS points are needed. The species should still be listed on the datasheet at each search site it is found.

Weekly Monitoring For Zebra/Quagga Mussels & Aquatic Plants

Zebra/Quagga Mussel Sampling Plates

For waterbodies with a public access dock, sampler plates will be deployed and checked weekly. If no public access dock exists, acquire a volunteer homeowner who could put one on their dock. A combination of both is preferable. The sampler should be tied underneath the dock and hang in the water column about 1 foot off the bottom of the lake. Plates should be examined weekly for the presence or absence of zebra and quagga mussels and recorded. The plate should be scraped clean and re-deployed back under the dock. The rope can often fray, so it should be examined each time and replaced as needed.

Photos of Zebra/Quagga Mussel Samplers – MCWD

Zebra Mussel Sampler from Infested Lake - MCWD

Boat Launch Checks

10 minutes should be spent at each boat launch checking rocks and other substrate for zebra mussels. Search areas directly underneath docks, the underside of rocks, and between the concrete slabs of the launch as zebra mussels prefer shaded areas.

Rake tosses at boat launch

5 -10 minutes twice a month should be spent performing rake tosses to sample for invasive aquatic plants near the boat launch.

Volunteer Monitoring Program

Volunteers are recruited to supplement current early detection efforts on high use lakes and gain access to low use lakes without a public access. They are provided with equipment such as zebra mussel sampler plates, underwater viewing scopes, hand strainers, and a field guide with methods for searching and AIS identification. Volunteers are encouraged to report their search efforts by email or an online reporting form and provide an immediate report if they suspect they have found a new AIS.

Periodic Snorkel searches for zebra mussels and aquatic plants

On high use lakes, additional snorkeling searches will be performed throughout the summer following the comprehensive survey protocol listed above. These surveys will occur at the public access, and at a limited number of other sites around the lake as time and schedule allow.