INTEGRATED PEST MANAGEMENT PLAN (IPM PLAN) FOR COMMON CARP IN BIG EAGLE LAKE, SHERBURNE COUNTY

2022

Abstract

This plan acts as a living document and is updated as progress is made towards lake management goals as they relate to invasive Common Carp. In 2022, this document also serves as a feasibility study to complete internal load reduction projects that will be submitted with a Board of Soil and Water Resources (BWSR) Clean Water Fund Grant Request in 2022 or 2023.

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1. Executive Summary

This document provides additional in-depth information on the Big Eagle Lake Common Carp population identified as a source of total phosphorous loading in the "Big Eagle Lake Water Quality and Load Source Assessment" (2020), summarizes the data collected on carp in 2021 and 2022, and provides next steps in sustainably managing carp to improve water quality in Big Eagle Lake. Management of common carp can help to address internal loading of nutrients that has contributed to Big Eagle Lake being added to the draft listing of impaired waters or the 303(d) list in 2021 with approval by the Environmental Protection Agency in April of 2022.

1.1 Background

Common carp (*Cyprinus carpio*), a non-native fish originating in the Caspian region of Eurasia, are the most widely distributed nuisance fish in the United States (Nico et al., 2012). Carp can have direct and indirect negative effects on water quality by uprooting submergent and emergent aquatic vegetation and by releasing phosphorous sequestered in lake sediments. The phosphorus is then available to free floating algae and can lead to an increase in total phosphorous and Chlorophyll-a concentrations in the lake and to a decrease in water clarity. By removing the carp from the system, both the phosphorus within the carp carcass and the amount that would typically be excreted will be completely removed, while also abating the release of phosphorus created by foraging behavior.

1.2 Carp Management Waterbody

Eagle lake, known locally as Big Eagle Lake, is a 462 acre lake in central Minnesota's Sherburne County and located near the city of Big Lake (Figure1). It is on average 10.7 feet deep with a max depth of 18 feet, classifying this basin as a deep lake in the greater Mississippi River (St. Cloud) Watershed. It is located in the North Central Hardwoods ecoregion and outlets to the Snake River and then to the Elk River before entering the Mississippi river downstream. Big Eagle Lake is on the MN DNR's Infested Waters List for Eurasian Watermilfoil since 2006.

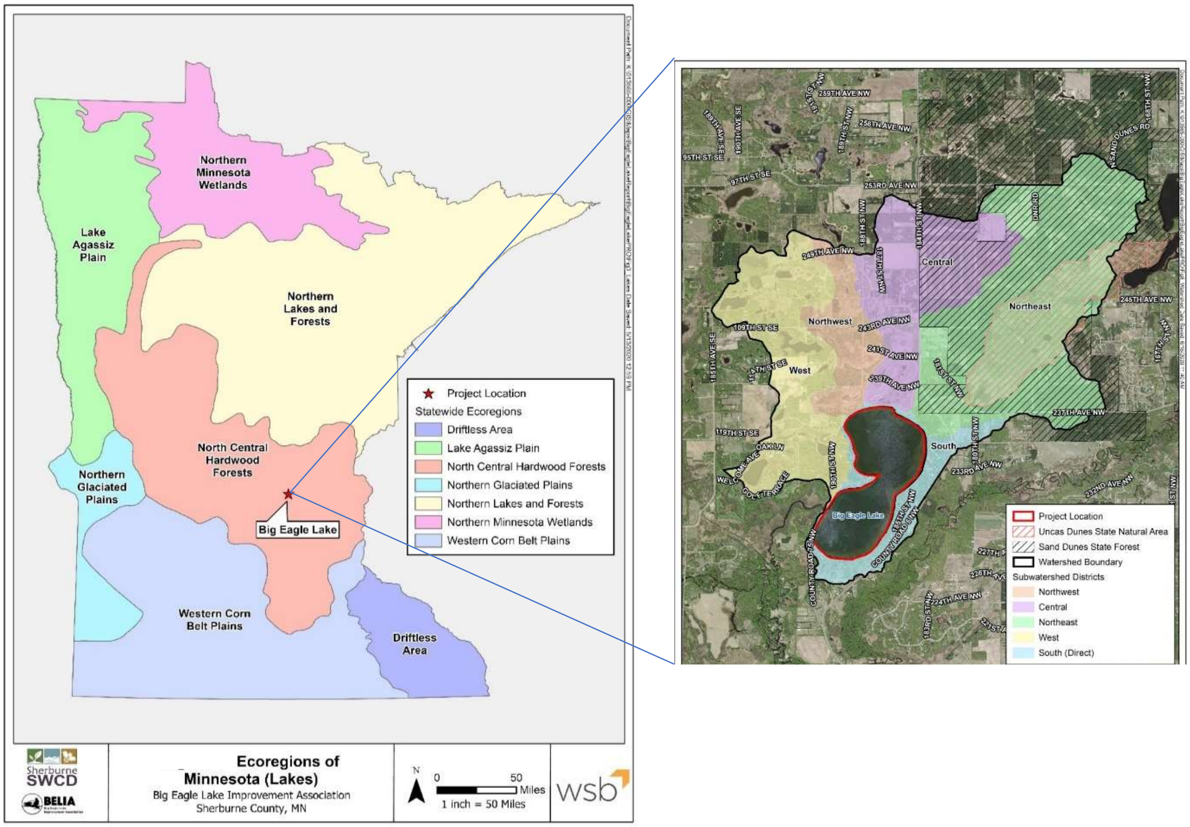


Figure 1. Big Eagle Lake location within the state and sub-watershed in Sherburne County Minnesota.

It is on the MPCA's impaired waters list due to poor water clarity and excess nutrients since 2022. These impairments limit recreational opportunities as well as waterfowl habitat, native aquatic vegetation abundance, and native game fish populations (Table 1). Water quality assessments are described in two documents including the Water Quality Assessments of Select Lakes within the Mississippi River (St. Cloud) Watershed (2012) and Big Eagle Lake Water Quality Assessment and Load Source Assessment (2020). The more recent study is used to summarize water quality trends throughout this document.

Lake	Lake Classification	Big Eagle Lake (Phosphorus summer average)	Water Quality Standard (Phosphorus summer average)
Big Eagle Lake	Deep	51 µg/L	40 µg/L

Table 1. Water quality as it pertains to total phosphorus in Big Eagle Lake (MPCA, 2012). In the 2019 study, a deep lake classification was used to compare WQ data.

The 2020 study was completed in partnership with Sherburne SWCD and the Big Eagle Lake Improvement Association that described water quality including contributions from inflow at the lake inlets and contributions from in-lake loading sources. This study concluded that the overall load to Big Eagle Lake will need to be reduced by 1,172 pounds per year (Table 2). A rough fish (common carp) population estimate indicated that a portion of this loading can likely be attributed to an elevated carp biomass and carp management may be a low cost BMP to implement along with other water quality improvement projects.

Load Source	Existing Load (Pounds/Year)	Sum of Load Reduction From BMPs (Pounds)[1]	Sum of Load Reduction From BMPs (Pounds)[2]
Central Subwatershed	144.4	25.3	25.3
West Subwatershed	68.2	17.2	17.2
South (Direct) Subwatershed	24.8	21.9	21.9
Northwest Subwatershed	25.6	12.5	25
Northeast Subwatershed	1,168.9	62	124
Atmospheric	123.4	0	0
Septic Systems	18.8	0	0
Total External Load Reduction		138.9	229.9
Internal-Anoxic Sediment Release	1,140	912[3]	969[4]
Internal- Carp	362	259	259
Sum of Internal BMPs		1,171	1,228
Total Load Reduction		1,309	1,457

1- calculated using a 25% TP removal efficiency
2- calculated using a 50% removal efficiency
3- calculated by subtracting the internal carp load of 362 pounds TP, from the total internal load identified in Table 15 of 1,502 pounds TP and using an 80% removal efficiency.
4- calculated by subtracting the internal carp load of 362 pounds TP, from the total internal load identified in Table 15 of 1,502 pounds TP and using an 85% removal efficiency.

Table 2: summary of existing loads and reductions needed to meet water quality goals in Big Eagle Lake. Taken from the 2019/2020 water quality report.

1.3 Integrated Pest Management Approach

This IPM plan is intended to be a living document; using adaptive management to control common carp may include developing new management strategies and plan goals through data collection and analysis. As new data is collected and analyzed, current approaches, data collection efforts, and prioritization may change. This IPM aims to mitigate the effect that common carp are having on the load of excess nutrients to Big Eagle Lake.

This document is also meant to serve as a feasibility study to meet the requirements of the Board of Soil and Water Resources (BWSR) Clean Water Fund (CWF) grant application. To meet the requirements, the following information is included:

- Lake and watershed information (at minimum, include lake morphology and depth, summary of water quality information, and the assessment of aquatic invasive species) (Section 1.3; Section 2)

- Description of internal load vs. external load nutrient reductions (Section 2.6; Attachment 2019 WQ report)
- History of projects completed in the watershed, as well as other in-lake activities if applicable
- Cost benefit analysis of options considered (Section 6.1)
- Projected effective life of the proposed activities;
- Expected water quality outcome (Section 6.4)
- Plan for monitoring surface water quality to assure the project's total phosphorous goal will be achieved during the project's effective life (Section 6.5)
- Methods used to estimate adult and juvenile carp populations (Section 4.2.3; Section 5)
- Description of the known interconnectedness of waterbodies (lakes, ponds, streams, wetlands, etc.) (Section 2)
- Identified nursery areas (Section 5.3)
- Methods used to track carp movement (Section 4.2.2; Section 5.3)
- Proposed actions to limit recruitment and movement (Section 6.2; Attachment MEMO)
- Proposed actions to reduce adult carp populations (Section 6.3)2. Watershed and waterbody characterization

2. Watershed overview

2.1 Lakes

Big Eagle Lake is the only lake that falls within the project area. The total surface area of the lake is 462 acres with 71% or 330 acres of littoral area (Figure 2). The shoreline is 4.2 miles in length. The average depth is 10.7 feet and the maximum depth is 18 feet.

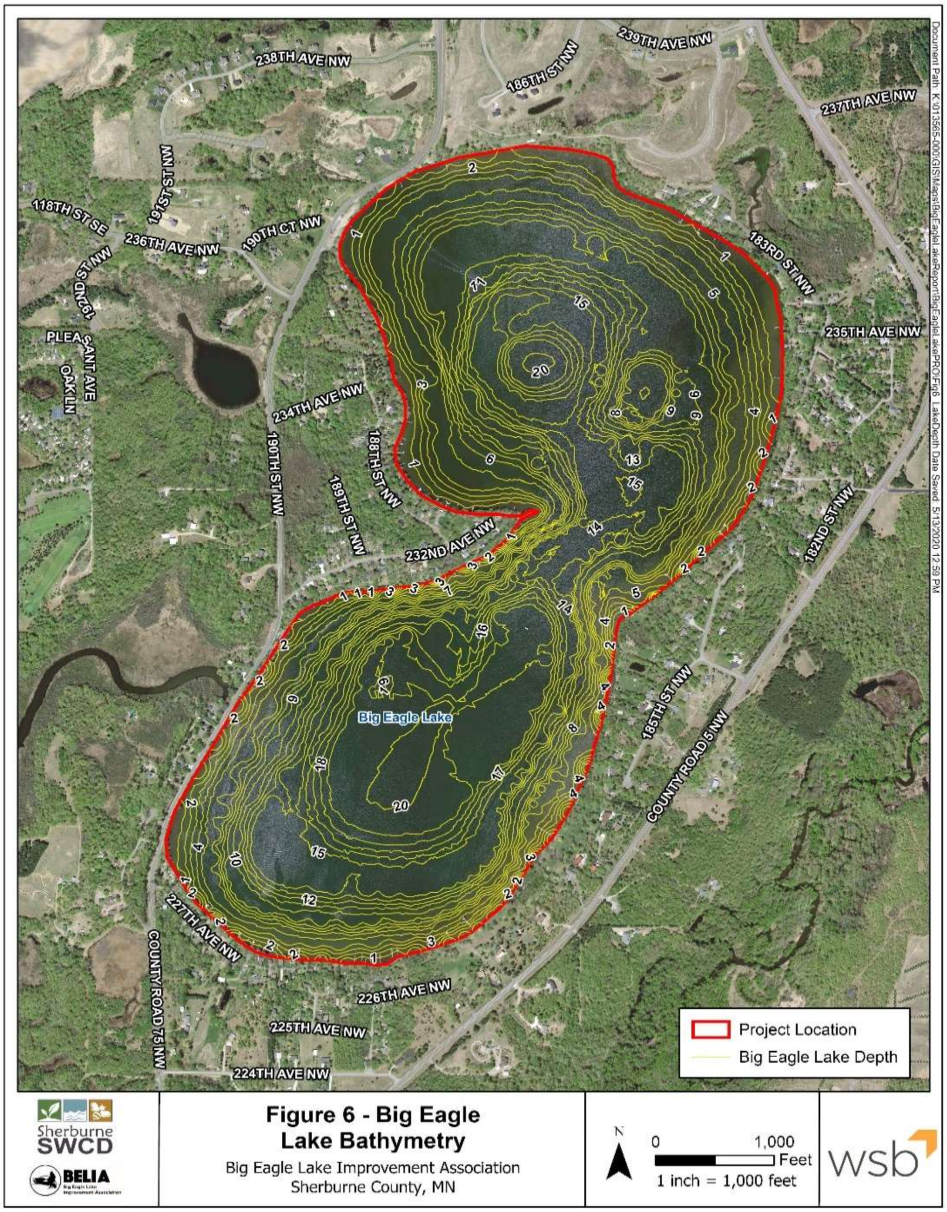


Figure 2. Big Eagle Lake Bathymetry

The ordinary high-water level (OHW) for Big Eagle Lake is 924.5'. Between December 22, 1941, and November 8, 2019 a total of 185 water level readings have been taken. The highest reading recorded is 924.95' on April 8, 1956 and the lowest recorded reading was 922.45' on August 31, 2019; resulting in a recorded water elevation range of 2.5'.

Big Eagle Lake is listed as infested with Eurasian Watermilfoil and has been listed since 2006.

2.2 Streams

The project area includes three (3) stream segments (Figure 3). These connections provide unimpeded travel to nearby wetlands that carp could use in their springtime spawning migration. In 2022 these three stream reaches were monitored with radiotelemetry surveys and remote cameras to document potential carp migration. The results of this activity are described in greater detail in section 5.3.

Figure 3: Stream connections to Big Eagle Lake Note: stream 100, 500, and 700 were monitored for carp movement in the 2021-2022 monitoring period with the use of cameras and radiotelemetry.

Unnamed Creek (Stream) 07010203-692 (#700 on map; Outlet): This stream is considered the outlet of Big Eagle Lake. It starts at the outlet of Big Eagle Lake (crossing of county highway 75) and ends 1.25 miles downstream at the confluence with the Snake River, which drains into the Elk River shortly after. A carp barrier has historically been in place upstream of the outlet structure, but the efficacy of this barrier has not been tested. This barrier was demolished in a high-water event in Spring of 2022. Reports of carp sightings on both sides of the barrier have been reported historically and carp movement was confirmed at this connection during the springtime migration period with the use of camera monitoring and radio-telemetry.

Unnamed Creek (Stream) 07010203-999 (#100 on map; Northeast Inlet): This stream is a tributary to Big Eagle Lake and forms the one (1) major inlet. MPCA maps show the stream segment starting 0.6 miles upstream of Big Eagle Lake near the Sand Dunes State Forest. The segment is also identified to the west of Big Eagle Lake as a tributary to the unnamed outlet to Big Eagle Lake. This is a separate segment. Reports of carp sightings have been reported at the culvert just upstream of the confluence to the lake; however, no carp sightings were recorded with the 2022 camera monitoring.

Unnamed Creek (Stream) (#500 on map; Southwest Inlet): This stream is a tributary to Big Eagle Lake but is not a major large drainage area. However, connectivity does exist in high water years to nearby wetlands and reports of carp sightings here have been made. In 2022, camera monitoring for carp movement confirmed this connection is used by carp in the springtime migration period.

2.3 Wetlands

There are 207 wetland basins identified by the National Wetland Inventory (NWI) within the Big Eagle Watershed totaling 644 acres of wetlands within the watershed (Figure 4). 125 or 60% of these wetlands are freshwater emergent, which may provide some nutrient transformation functions. Another 46 or 22% are freshwater forested/shrub wetlands providing additional stormwater retention and nutrient transformation functions among others.

Wetlands can also serve as carp spawning grounds. Carp are known to migrate to shallow wetland basins in the springtime to recruit young. The adults then return to the more stable main basin to overwinter. In 2022 wetlands have not been sampled for young of the year or bluegill sunfish. This activity is recommended on wetlands that have stream connectivity to Big Eagle Lake as carp management is pursued. The wetlands downstream of the outlet and upstream of the southwest inlet are potential carp spawning areas as carp movement through these connections was detected in the springtime of 2022 camera and radiotelemetry monitoring period.

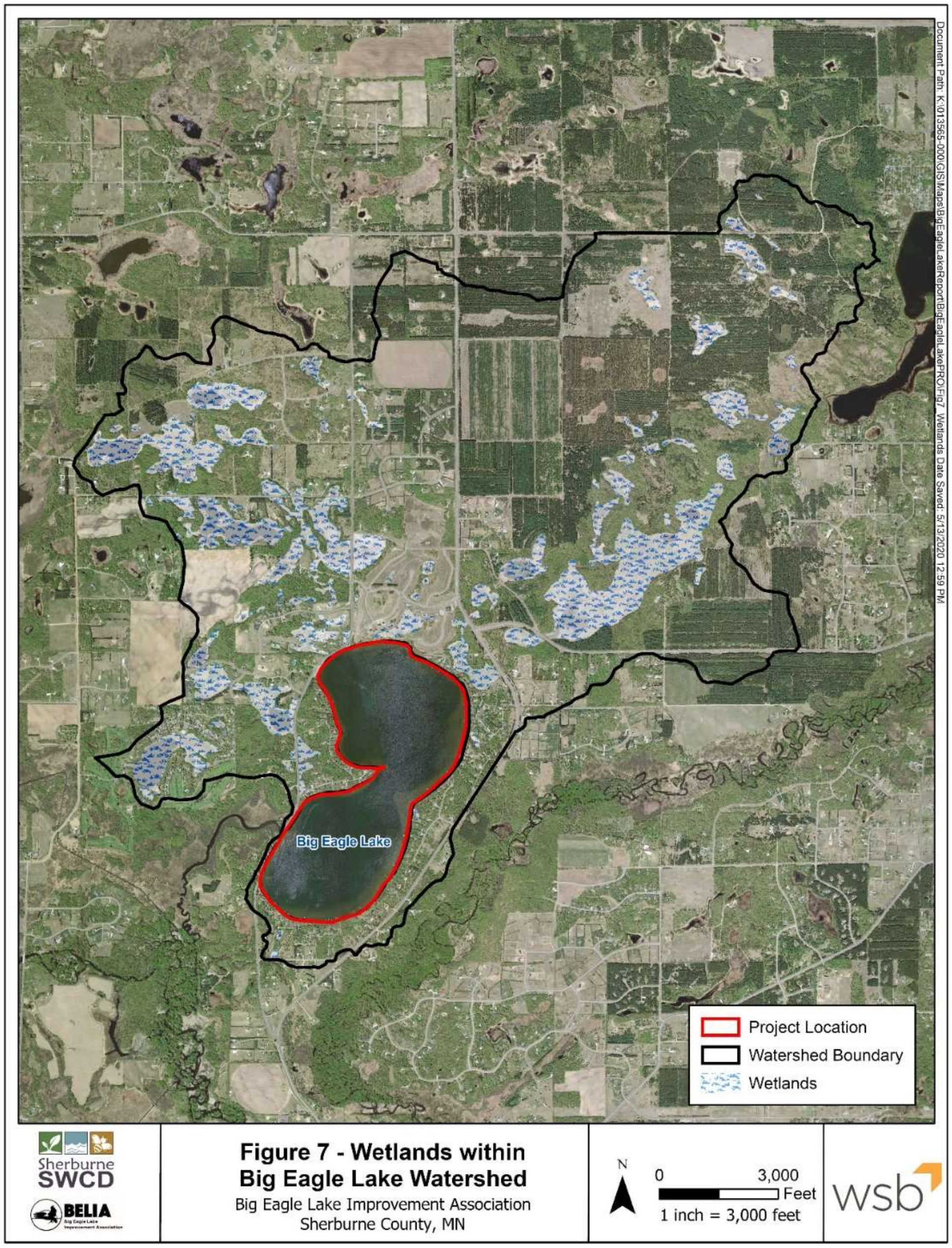


Figure 4. Wetlands within the Big Eagle Lake Watershed

2.4 Subwatersheds

The watershed boundaries were delineated for Big Eagle Lake through use of satellite topographic imagery, LIDAR contours, the National Wetland Inventory, and the Minnesota DNR Public Waters Inventory. The total watershed size analyzed in the 2020 study encompasses 4,330 acres this area excludes the actual area of Big Eagle Lake.

Subwatershed	Acres	% of total watershed
Northwest	364	8
Central	867	20

Northeast	1,814	42
West	952	22
South (Direct)	333	8
Total	4,330	100

Table 3. Subwatersheds and associated Acreages

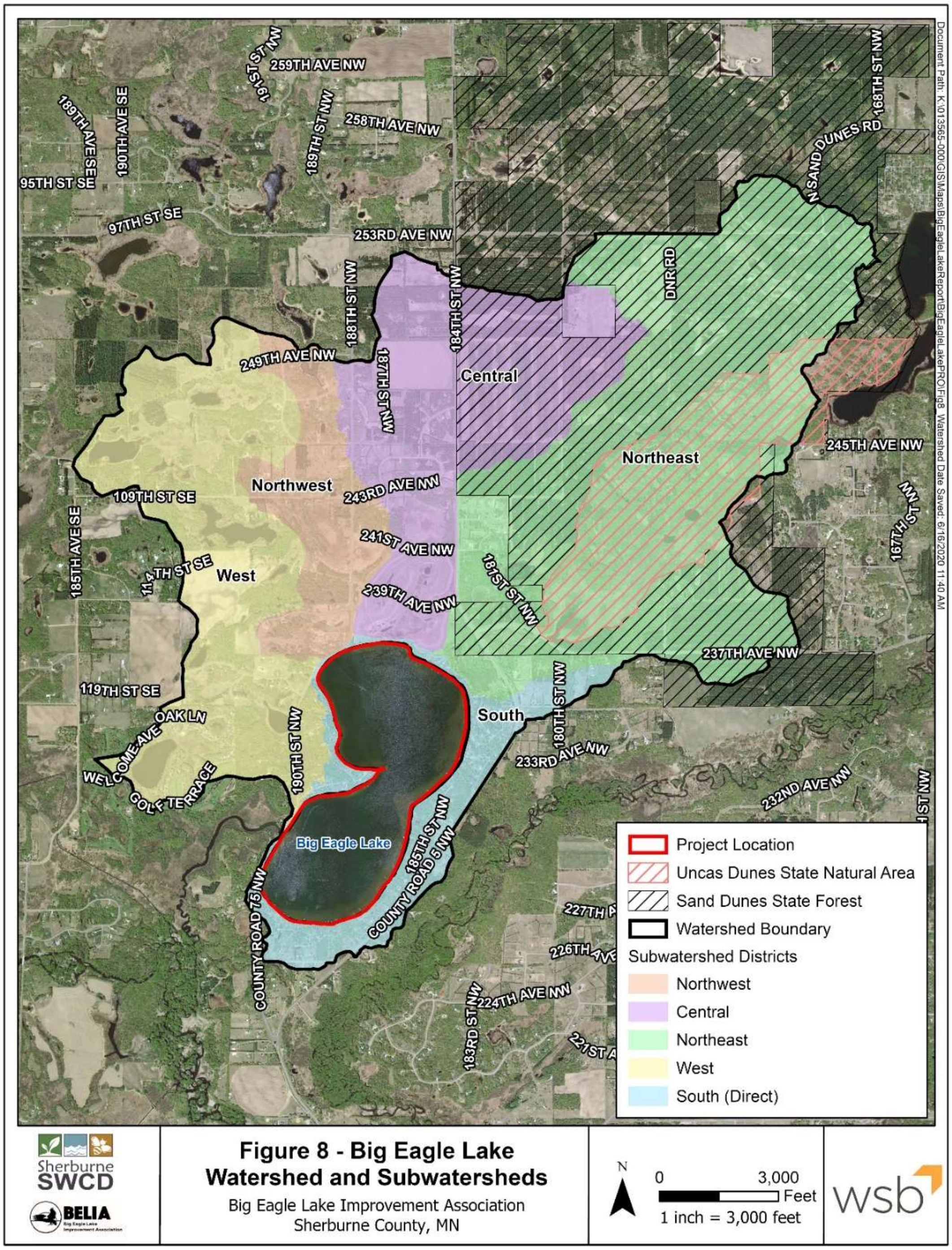


Figure 5. Big Eagle Lake Watershed and Subwatersheds

Northwest Subwatershed: The Northwest Subwatershed is approximately 364 acres (8.4% of the watershed area) and includes two major inlets:

- The first inlet includes two wetlands approximately ½ mile north of Big Eagle Lake. The area on the east side of County Road (CR) 75 drains through a culvert to the west side. The Subwatershed area on the west side then drains to the south via an underground storm drain to "The Woods" development and discharges into a small pond. The water flows out of this pond, through an open ditch running south, and in to a 24" culvert. The culvert crosses CR 75 and discharges into an open lake ditch, where the water is carried to Big Eagle Lake.

- The second major inlet includes an additional wetland on the northwest side of CR 75 that also collects water from the curve to the north. A 24" culvert carries the water to the southeast side of CR 75 and discharges into an open ditch. The ditch carries to the water into Big Eagle Lake.

Central Subwatershed: The Central Subwatershed is approximately 867 acres (20.0% of the watershed area). Various storm sewers, drains, and culverts collect water from the roadways and land of the "Shores of Eagle Lake" addition. The water is collected in small ponds or open ditches, which then discharge into an open wetland. The flowage then directs all water to Big Eagle Lake.

Northeast Subwatershed: The Northeast Subwatershed is approximately 1,814 acres (42% of the watershed area). Water collection begins north of 253rd Ave NW and begins to flow southwest through various wetlands. A larger wetland east of CR 5 collects water, which then crosses under CR 5 through a culvert. The culvert drains into an open ditch on the west side of the road, and the open ditch then carries the water into Big Eagle Lake. This subwatershed drains large portions of the Uncas Dunes State Natural Area and Sand Dunes State Forest.

West Subwatershed: The West Subwatershed is approximately 952 acres (22.0% of the watershed area). Water flows through various ponds as it heads from the north to the south. Water eventually flows to a small lake located south of the DNR Public Access and west of County Road 75. This water heads into a drainage ditch and goes south until it reaches 232 Avenue. The ditch on the west side eventually flows through a culvert pipe under 232 Avenue that empties into an open ditch. This ditch carries the water to the lake.

South Subwatershed (Direct): The south watershed includes the immediate area surrounding the lake and the septic systems installed on Big Eagle Lake. The south watershed is estimated to be 333 acres (8% of the watershed area). The water that flows through this subwatershed is not filtered through any additional ponds or wetlands before discharging into Big Eagle Lake.

2.5 Land Use

Big Eagle Lake is found entirely within the North Central Forest Hardwoods Ecoregion (NCHF). This ecoregion is a transition from the Northern Lakes and Forest Ecoregion to the north and the North Glaciated Plains, Western Corn Belt Plains, and Driftless area to the south. It is a transitional landscape from forested to agriculture.

The major land use in this region is agriculture (49.5%), with grassland (15.2%) and deciduous forests (10.9%) being subdominant land uses. The remaining land uses/land cover types include conifer forests, water, wetlands, shrubland, and urban, but all are less than 6.5% individually.

The 2011 National Land Cover Database was used to identify the major land use types and areas within the Big Eagle Lake Watershed. Figure 8 shows land use data for the Big Eagle Lake Watershed based on the 2011 National Land Cover Database.

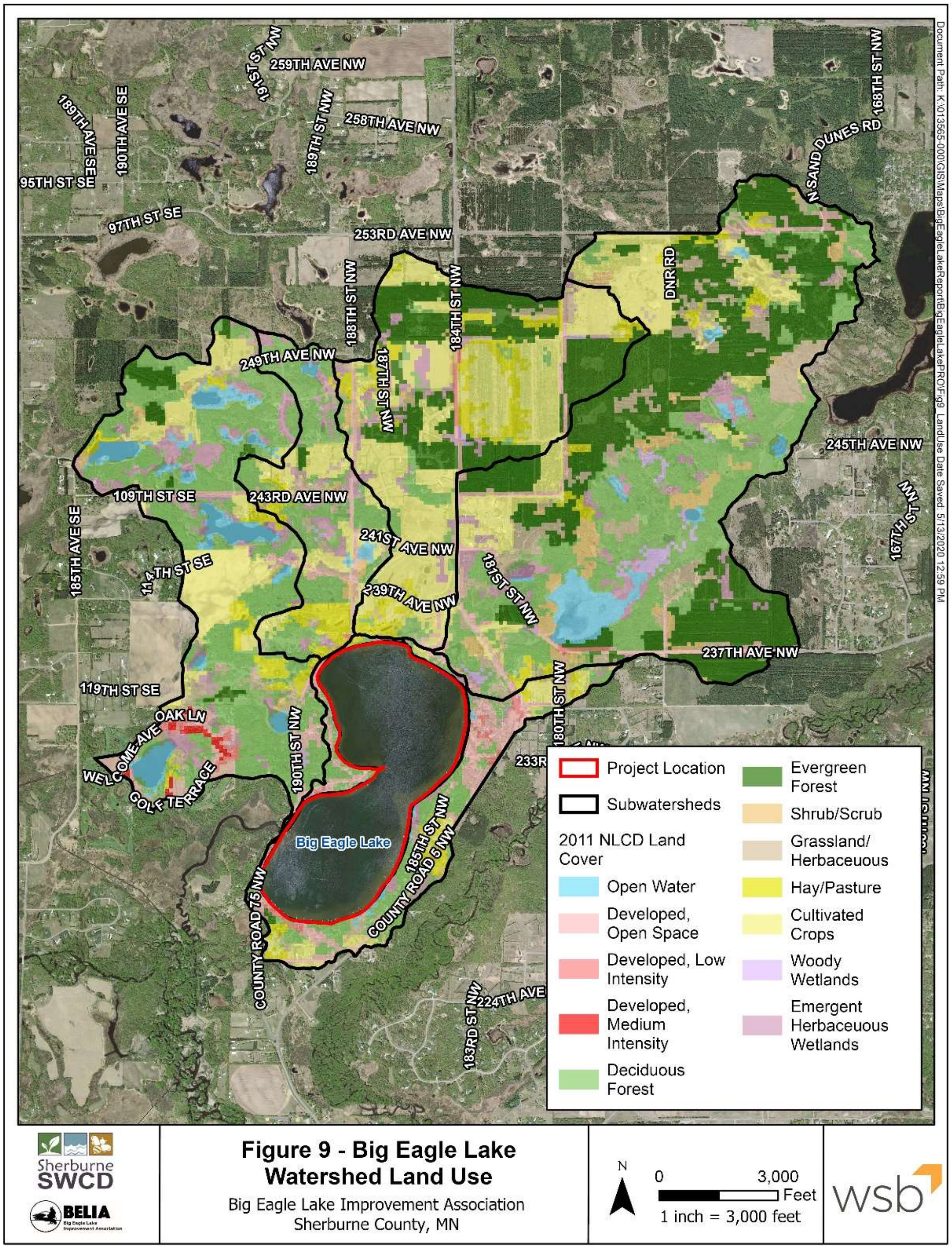


Figure 6. Big Eagle Lake Watershed Land Use. Source: 2011 National Land Cover Database.

	Subwatershed					
Land Use	Northwest (Acres)	Central (Acres)	Northeast (Acres)	West (Acres)	South-Direct (Acres)	Total Acres (%)
Cultivated Crops	66.31	367.97	209.11	149.83	43.11	836.33 (19)
Deciduous Forest	155.55	51.78	463.20	402.05	107.00	1179.58 (27)
Developed, Low Intensity	1.23	6.67	4.63	15.63	17.75	45.91 (1)
Developed, Open Space	23.93	33.28	68.67	9.84	82.97	218.69 (5)
Emergent Herbaceous Wetlands	36.94	45.03	80.91	63.50	17.76	244.14 (6)
Evergreen Forest	2.94	230.24	592.65	86.25	1.89	913.97 (21)
Hay/Pasture	38.55	98.95	37.58	29.18	29.17	233.43 (5)
Herbaceous	21.78	18.09	164.40	42.48	12.74	259.49 (6)
Open Water	8.01	0.05	77.46	35.92	7.84	129.28 (3)
Shrub/Scrub	6.90	10.13	83.83	96.71	1.24	198.81 (5)
Woody Wetlands	1.11	2.67	24.04	10.54	43.11	81.47 (2)

Table 4. Land Uses within the Big Eagle Lake Watershed and associated acreages

2.6 Big Eagle Lake Water Quality

Big Eagle is on the MPCA list of impaired waterbodies for excess nutrients that limit aquatic recreation. It was listed in 2022 with approval from the EPA.

In 2019, the Big Eagle Lake Improvement Association, Sherburne Soil and Water Conservation District, and WSB collaborated to develop a water quality sampling plan and implement that plan to update the Big Eagle Lake Water Quality dataset, assess the current water quality of inlets and the Big Eagle Lake basin against established state water quality standards. Data collected in 2019 was analyzed along with MPCA sampling data in intermittent years from 1978 to 2009 to develop loading estimates for both internal and external sources of nutrients. In addition, two sediment cores were taken to determine the phosphorous release rate from the sediments as part of an internal loading assessment.

Based on data collected in 2019 by BELIA and Sherburne SWCD, Big Eagle Lake in-lake growing season average for total phosphorous was 46 µg/l, 6 µg/l higher than the state standard, secchi depth was measured at 1.3 meters, 0.1 meter shallower than the state standard, and chlorophyll-a concentration was 39.52 µg/l, more than double the state average. To determine the source of these impairments or loading of total phosphorous, WSB first used a P8 model to identify the contribution from five (5) subwatersheds surrounding Big Eagle Lake. This modeling effort shows that the largest amount of total phosphorous comes from the Northeast subwatershed which outlets into the east side of Big Eagle Lake after crossing under 183rd Avenue NW (station 100).

When compared to state standards, both TP and secchi depth average growing season results (June-September) were very close to meeting those standards in 2019, while chlorophyll-a was very elevated (Table 5). Table 5 below summarizes the calculated growing season averages and state standards for Big Eagle Lake.

	2019 Average Result	State Standard
Total Phosphorous (mg/l)	0.046	0.04
Secchi Depth (m)	1.3	1.4
Chlorophyll-a (ug/l)	39.52	14

Table 5. Big Eagle 2019 Average Water Quality Results and Comparative State Standards

According to the 2019-2020 monitoring results, the overall load to Big Eagle Lake will need to be reduced by 1,172 pounds per year or 65.1% to meet water quality standards. While there a number of external load reduction BMPs available, many of them account for only a small percentage of the total load reduction needed, with the exception of the wetland restorations. Internal load reduction, by sequestering anoxic total phosphorous release via an alum treatment, provides the largest load reduction and would be necessary to meet the load reduction required, but is also the single most expensive alternative.

2.7 Big Eagle Lake Aquatic Vegetation

Two (2) documents provided by the BELIA offer some information on the historical vegetative community of the lake and associated issues. Big Eagle has been on the MN DNR infested waters list for Eurasian Watermilfoil since 2006.

A document titled "Big Eagle Lake Improvement Association Lake Management Plan-2008" (no author), indicates that Eurasian water milfoil (EWM) a common aquatic invasive species was present at the time of the report in 2008 and was first detected in 2005. One of the strategies identified in this plan was to conduct a whole lake vegetation survey; which it appears would be the first one completed for Big Eagle Lake. No additional information on vegetation is provided in this document.

The other document is a report drafted by Eric Fieldseth, AIS Consulting, who completed a vegetation survey of Big Eagle Lake in 2015 and 2018. Early season sampling (May) data from the 2018 survey notes indicate that aquatic vegetation was found at only 23.7% of the survey points (108 acres) with curly leaf pondweed (CLP) present at 21.6% of all points or 91% of the vegetated sample points which indicates that CLP is very dominant in the spring. This is compared to the 2015 survey in which CLP was found at only 10.35% of the sampling points in May.

Species diversity was similar between the 2015 survey and the 2018 survey when both the early and late season results for the 2018 survey are combined. Between the 2015 and 2018 surveys coontail, muskgrass, Eurasian water milfoil, decreased in frequency of occurrence, while northern watermilfoil, white stem pondweed, and elodea, were not found. Conversely, curlyleaf pondweed, water stargrass, narrow-leaf pondweed, southern naiad, and sago pondweed increased in frequency of occurrence and wild celery and yellow water lily were documented.

The floristic quality index (FQI) for the aquatic community in 2018, was calculated at 16.7 which is degraded, based on the North Central Hardwood Forest FQI threshold value of 18.6. Lastly, the maximum depth of plant submerged plant growth increased from 7 ft in 2015 to 9 ft in 2018, but the late season survey showed growth out to only 4.5 feet, which is another indication of reduced water clarity.

2.8 Big Eagle Lake Fishery

In 2021, MN DNR conducted a targeted survey of the nearshore fish species in Big Eagle Lake. This data was combined with trap net and gill net data from the 2020 standard survey to provide a Fish-based Index of Biological Integrity (IBI) score. Types of fish present can help identify stressors that may be negatively affecting the lake environment (MN DNR website). Certain species cannot survive without clean water and a healthy habitat including Banded Killifish, Blackchin Shiner, and Iowa Darters while others are tolerant of degraded conditions including Black Bullhead, Green Sunfish, and Common Carp.

All six (6) of these species were sampled in either 2020 or 2021 in Big Eagle Lake. Data from this survey will contribute biological information about the health of the fish community to the Mississippi River-St. Cloud Watershed assessment process in coordination with the MN Pollution Control Agency (MN DNR website). Based on the fish IBI survey, Big Eagle was found to be fully supportive of aquatic life (MPCA, 2022).

2.8.1 Big Eagle MN DNR standard survey summary

Big Eagle Lake is one of the most popular angling lakes in Sherburne County (Cibulka, Personal Communication). The MN DNR has completed a standard survey on the Big Eagle Lake fishery six (6) times beginning in 1982 and again in 1988, 1993, 2002, 2012 with the latest survey completed in 2020. These surveys have typically been conducted in July or August and utilized multiple gear types including, electrofishing, standard trap nets, specialized trap nets, gill nets, and seine nets. While survey data does not provide an estimate of the population size, the surveys do provide data on relative abundance, size distribution, and growth rates.

For this report we have focused on catch per unit of effort (CPUE), or how many fish per unit of time or net set, to provide an idea of relative abundance for each survey year and also identify trends across years. We also are using just standard trap net and gill net data to report on CPUE as data was available for almost all survey years for these gear types.

Big Eagle Trap Net Data

Trap net data was available for five (5) of the six (6) survey years (1982, 1993, 2002, 2012, and 2020). Based on this data, Big Eagle supports a relatively diverse assemblage of fish species. Sixteen represented species include black bullhead, black crappie, bluegill, brown bullhead, common carp, common shiner, green sunfish, hybrid sunfish, largemouth bass, northern pike, pumpkinseed, walleye, white crappie, white sucker, yellow bullhead, and yellow perch. Species diversity varies by year with a peak in 2020 with 15 species captured, each year adult common carp were sampled while young of the year carp ((0-5 inches) were only sampled in 2020 (table 6).

Year	# species sampled	Presence/absence Adult carp (>7 inches)	Presence/absence young of year common carp (0-5 inches)
1982	13	Yes	N/A
1993	13	Yes	No
2002	8	Yes	No
2012	7	Yes	No

2020	15	Yes	Yes

Table 6: Historical survey data from MN DNR standard surveys that shows presence absence of adult carp and young of the year carp in Big Eagle Lake.

Three (3) of the species not captured in the 2002 and 2012 surveys were bullhead species (black, brown, and yellow). Yellow perch, white crappie, pumpkinseed, green sunfish, and common shiner trap net catch rates declined during this same time period. Northern pike were not captured in the 2012 trap net survey after showing consistent catch rates during the previous three (3) surveys (average value was 0.55 CPUE or 3.6 individual fish/survey year). Walleye were captured for the first time during the 2012 survey.

Bluegill had the highest relative abundance in 3 out of the 4 survey years (1993, 2002, and 2012), and were the second most abundant portion of the catch in the 1982 survey. When looking at all survey data, white crappie and black crappie were also abundant, but catch rates have declined with white crappie not found in the 2002 and 2012 surveys. Black crappie is typically the second most abundant fish species found in the trap nets surveys.

It is important to note that gear can be biased (better at catching certain species than others), but it can still be informative to see assemblage data and look at trends in catch rates across multiple years.

Big Eagle Gill Net Data

Gill net data was available for all six (6) years; 1982, 1988, 1993, 2002, 2012, and 2020. Similar to gill net data, the Big Eagle fish assemblage is relatively diverse with 15 different species represented in the catch data. Diversity of species captured remained consistent unlike trap net data. The number of different species captured ranged from 11 (2012) to 14 (2020). Hybrid sunfish and green sunfish were not captured in gill nets, but bowfin (dogfish) were; all other species captured in trap nets were also captured in gill nets.

Three (3) gamefish species are present in Big Eagle Lake; Northern Pike, Walleye, and Largemouth Bass. Northern Pike have a higher relative abundance than walleye or largemouth from the perspective of the CPUE data (electrofishing data may represent largemouth bass more accurately). Figure 7 below shows the gill net CPUE values for these three (3) species.

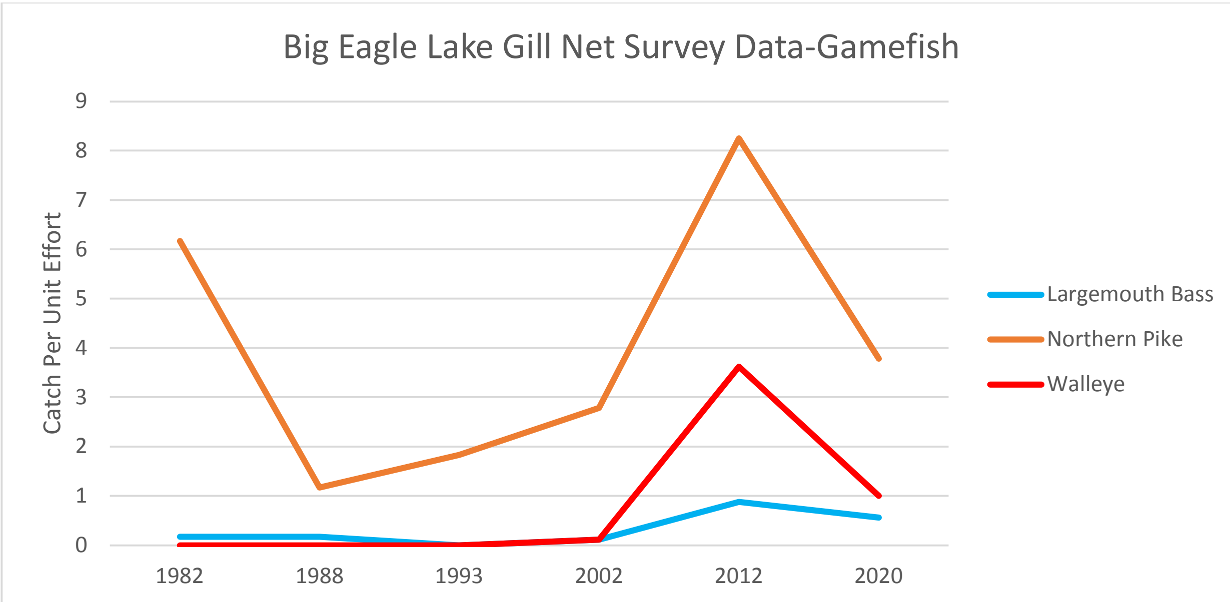


Figure 7. Big Eagle Gill Net Data (Gamefish)

Panfish data shows varying trends regarding CPUE data (Figure 8). Black crappie CPUE more than doubled from 1993 to 2002 and has slightly declined in 2020. White crappie have decreased to 0 and yellow perch relative abundance has been low since the 2002 survey. Pumpkinseed relative abundance remains consistently low, and bluegill appear to remain low for gill net relative abundance (inverse of trap net data) with the exception of a dramatic spike in 1993 and again in 2020.

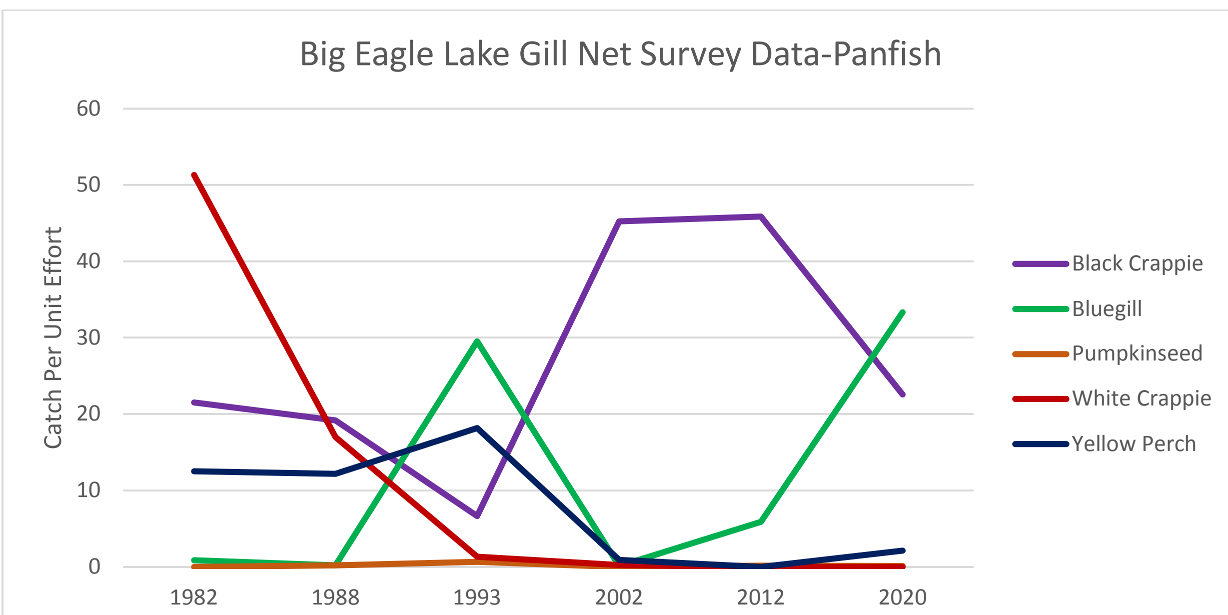


Figure 8. Big Eagle Gill Net Data (Panfish)

The common carp population was assessed in 2019 and again in 2021. The methods and results are described in section 5. Section 3 and 4 give an overview of carp life history and impact on water quality followed by a general approach to carp management. Section 6 gives recommendations for IPM plan specific to Big Eagle Lake

3. Common Carp Life History and Impact on Lake Ecology

3.1 Life Cycle

Shallow lake basins in the Upper Midwest are prone to low oxygen levels that lead to winterkill events. These basins can support reproductive success in a variety of fish species because of low predator abundance resulting from such events. Carp commonly use migration routes in the springtime to access shallow lake basins to exploit the absence of predator species to hatch young. The process of young fish growing into adulthood is known as recruitment. Carp are able to withstand low oxygen conditions and live to exploit basins they overwinter in that experience winterkill of more sensitive fish species.

Carp are highly fecund and long lived. An adult female can have between 300,000 to 500,000 eggs per year and live upwards of 60 years. Combined with their ability to withstand low oxygen levels, this makes carp highly invasive under the right conditions. Carp are quick to grow in warm water and within 2-3 months of hatching can grow to nearly 0.5 pounds. In Minnesota, carp can grow to be greater than ten inches in length after their first year and quickly grow to a size that is too large for predator species to pray on them.

Carp have a homing instinct and will return to the basin they were hatched to complete their reproductive cycle. They typically leave these basins when they are one (1) to two (2) years in age and return the year after as adult with reproductive capabilities. It should be mentioned that some recruitment may happen in a deeper main basin if conditions allow. This occurrence is limited with an abundance of predator species such as bluegill sunfish, who are known to predate on carp eggs and larvae.

3.2 Diet

Carp are benthivores meaning they feed on material on the bottom of the lake. Food sources include plants, insects and crustaceans, while they are also known to feed on fish eggs and larvae as well as smaller fish. Carp feed when water temperatures are above 64°F and feeding is greatly reduced or even stops when water temperatures dip below 45°F.

3.3 Habitat & Behavior

Carp can inhabit a variety of lake basins and use stream connections to migrate between waterbodies. In the springtime, carp are often found to be migrating en masse through stream connections to shallow lake or wetland basins to reproduce and return to deeper more stable basins for summer through winter. In these “main basins” Carp typically use the shoreline and shallow water habitat to feed in the summer through fall and overwinter in a variety of habitat types within these basins. In the winter, carp tend to school together, sometimes forming dense aggregations.

3.4 Effects on Environment

A large population of carp is known to degrade the environment due to the nature of their feeding habits. Accordion like mouthparts are designed to dig into the mud and their diet of plant material often uproots native and non-native vegetation. This results in less diversity of plants in the lake and reduces overall plant biomass. This reduced plant diversity and biomass results in higher chlorophyl and algae in the lake and the disturbance of bottom sediment releases excess phosphorus to further feed algal growth.

4. Common Carp IPM General Approach

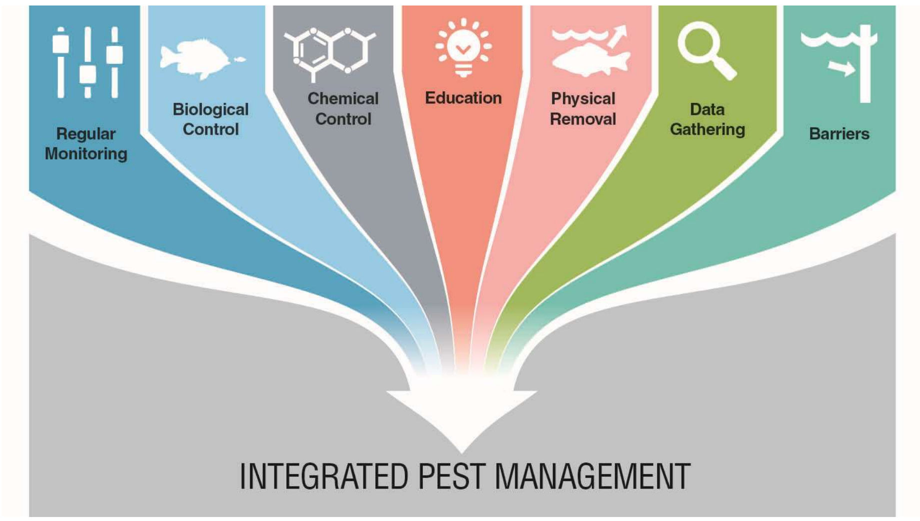


Figure 9: Schematic of Carp Integrated Pest Management Plan

Research shows that by addressing different life stages and developing an understanding of the spatial usage of the system or watershed, it is possible to control the carp population sustainably. An integrated Pest Management (IPM) Plan is meant to guide carp mitigation techniques through gathering data and implementing a variety of control and reduction techniques after the extent of the problem is better understood. These management actions are meant to be followed by regular monitoring and adapting these actions to the most up to date conditions (Figure 9).

4.1 Data Collection Tools & Techniques

Before management tools are put into practice, it is important to understand the extent of the problem. Capturing carp for the purpose of estimating the population size, employing marks or tracking devices, developing a size or age structure, and finally to reduce the population, is done with a variety of tools and techniques.

The following sections describe the data collection tools and techniques that are commonly used in carp management. These are followed by results of data collection and analysis in Big Eagle Lake to date. These results are being used to recommend further management action to reduce the carp population and biomass and sustain progress towards carp management goals.

4.1.1 Sampling Carp

Electrofishing

Boats and backpack electrofishing units can be employed to sample fish for tagging purposes, estimating population, and in some cases, removing fish from the system. These tools apply an pulsed DC electric field between an anode and cathode that are placed in the water. The electric current temporarily paralyzes fish and attracts them to the field where they can be captured by a net. The effective range of these units is between 0 and 6 feet from the anode, making this tool most effective in shallow water. Stunned fish recover quickly and can be released back to the basin, often with no harm done.

Gill Netting

Gill nets are part of the MN DNR standard sampling gear and can be effectively used to capture carp for sampling purposes or for large scale removal. They consist of a net panel made out of monofilament and can be sized according to the target species. This type of net captures fish by entangling them behind the gill plate when they attempt to move through the material. Care must be taken with this type of sampling gear because a fish left too long or in warm water temperatures can experience damage to the gills, killing the fish in some cases. Coordination for the use of these nets for removal is required through the DNR and allowed only on a case by case basis.

Fyke-nets

This type of net is standard sampling gear for the Minnesota DNR. The consist of a leader net section that extends to and is anchored to shore, this guides fish into the trap. The trap has a rectangular frame with hoops containing narrowing throats to effectively trap fish inside. These nets are typically set for one to two overnight periods and checked daily and are helpful to assess the assemblage of fish species in a waterbody. They are not very effective at capturing large carp but are particularly useful in sampling small carp within their first year of life. Using fyke nets to sample main basins and shallow connected basins can help to inform managers if these basins are supporting carp recruitment.

Large Scale Removal events

Large scale removal events are designed to remove carp biomass but can also be used to collect fish for sampling purposes. As fish are being sorted and moved off the lake, managers can scan fish for tags or marks and get an exact or estimated number of total fish removed from the lake. The ratio of marked to unmarked fish are used to refine population estimates while the number and biomass of carp removed tracks progress towards meeting management goals. It is sometimes useful to use these events to employ additional marks to complete population estimates in the future.

4.1.2 Carp Spatial Usage

Understanding movement patterns will help to identify potential migration routes and basins used for spawning, and winter aggregation areas. These can be targeted for removal operations or to block movement that is associated with spawning migration.

Radiotags

Carp can be implanted with radio-tags that can be manually tracked to signify movement in lake and through the watershed. This information can be used to describe aggregation areas or movement that can be associated with springtime spawning migration. Both of these behaviors may be targeted for removal operations.

Passive Integrated Transponder (PIT) tags

Passive Integrated Transponder (PIT) tags can be implanted into a subset of carp to aid in a mark-recapture estimate and/or to be used in conjunction with stationary antennae that are designed to capture movement of tags. Stationary antenna can be installed in strategic locations in connecting streams to capture movement data.

In 2021 a subset of only six (6) carp were implanted with PIT tags in Big Eagle Lake. This low number of carp implanted was due to relatively low catch rates in the CPUE survey that was completed at this time. In response, it was decided that an alternative to PIT tag antennaes would have to be used to augment radio-tag movement data.

Remote cameras

In some cases, it is advantageous to begin monitoring for carp movement through stream connections before or during carp tagging efforts. Remote cameras that are connected through wi-fi or cellular connections can provide an opportunity to support tag movement data with ocular recordings.

4.1.3 Population Estimate Techniques:

Catch Per Unit Effort (CPUE) Estimate of Population

Population estimates have been developed by using a boat electrofishing catch per unit effort (CPUE) model of estimation, a model that was developed at the University of Minnesota in 2009 (Bajer, 2009). This model uses the number of carp captured standardized by time spent electrofishing to estimate density of carp per hectare in a waterbody (Equation 1).

$$\text{Density/hectare} = 4.71 * \text{carp captured per hour} + 3.04$$

Equation 1: Electrofishing catch per unit effort (CPUE) equation of estimating density of carp within a basin.

Using this model gives researchers a chance to get a snapshot of carp relative abundance in a basin at the time of the survey. Multiple surveys are completed in one season between August and October when water temperatures are between 59-77 °F. Multiple surveys are completed to reduce the bias due to environmental conditions and the density is averaged and multiplied by average weight of fish to report a biomass estimate in kilograms per hectare in that year. The standard deviation from the mean value represents the variation in catch rates per survey in a given year.

Mark-Recapture Estimate of Population

This method uses a ratio of marked to un-marked fish to estimate the number of individuals in a waterbody. Accuracy of this method rests on the following assumptions being met: 1) no individuals immigrate or emigrate during the sampling period, 2) each individual has an equal chance of being captured, 3) sufficient time between initial marking period and recapture is allowed for individuals to disperse throughout the population, and 4) marks remain distinguishable throughout the sampling period (Chapman, 1951).

4.1.4 Block

Biological Controls

A robust panfish and gamefish population can act as a biological control, especially when the carp biomass has been suppressed or movement into spawning grounds has been mostly eliminated. Bluegill sunfish are known to be the main predator of carp eggs and larvae and it can be beneficial to support their population in areas where carp spawning occurs. This can be done by routine stocking and/or aeration in basins that experience low oxygen conditions in the winter or summer.

Carp Barriers

Carp barriers can be employed to protect sensitive areas from the destructive foraging behavior of carp or to prevent carp from exploiting migration routes. Barrier placement should be balanced with the potential need for native fish passage who employ these same migratory behaviors, like the northern pike. To address the concern for native fish species, barriers can be designed as temporary or movable to block carp movement but allow for native fish movement if these occur at different times. Data would need to be collected on native fish movement to determine the correct time and placement of barriers if this is a concern.

Another consideration to have when placing a barrier in a connecting waterway is the maintenance associated with the structure. In some cases, traditional grate style barriers to movement are not feasible due to the flow conditions, inaccessibility, and/or time constraints for managers to complete this maintenance. In some cases, a design can take into account these constraints and mitigate for them. For example, a self cleaning barrier could be place in a stream that has high level of debris, this type of barrier may be expensive and require a power source.

4.1.5 Carp Biomass Removal Methods

Seine Netting

Large groups of carp known as aggregations, can be targeted with large seine nets, under ice or in open water. To identify aggregations, radio-telemetry can be used to improve effectiveness of netting the most carp possible, this is known as the “judas technique”. This technique uses radio telemetry to identify aggregations of carp and guides an accurate area to net when communicated to the commercial fishing crew. Big Eagle Lake’s relatively shallow grade, sandy bottom and lack of significant debris could show haul areas with large groups of carp able to be commercially netting without significant issue.

In stream trapping techniques

A variety of methods can be used to trap and remove fish during spawning migration through streams. These methods could include the push trap (described below), or other trap designs that are specific to the stream reach. In the Spring of 2022, a reconnaissance was completed in Big Eagle to determine the feasibility of commercial seine netting and in-stream trapping at the outlet site (Attachment X). The outlet site at Big Eagle has historically been used as a carp trap and run by the MN DNR. It does seem feasible to run a trap here in some years but would likely require a significant effort April through June.

Baited Box Traps

A baiting and trapping method known as baited box trapping could be implemented as another tool for carp removal. A box net trap refers to a mesh net that lays on the lake bottom with attached walls around the outside. These walls are attached to vertical metal pipes that extend above the water surface. The walls are attached to ropes that run to shore and when the ropes are pulled in, the walls quickly rise above the surface trapping the fish within the trap area inside. The fish are corralled to a corner and rolled into a holding tank, usually a large flat bottom boat.

Carp are trained to aggregate in the trap area over a number of days by providing bait on a daily basis. The bait can be broadcast by a resident or deposited in a mesh bag that allows for carp to pull the bait through the bag. This method based on carp research and has been found to be over 98% selective for carp when comparing percentage of non-carp species also captured. All fish captured could be counted and a sample measured. All carp would be removed from the lake and all non-target species would be returned to the lake.

Push trap

Using this method, a modified pen is installed in the channel with a one-way set of tines that allow a migrating carp to push the tine up and enter the pen but is unable to lift the tine to escape the pen. During periods of high carp movement, this pen can accumulate and hold large number of carp which can be immobilized with a backpack electrofisher and removed from the trap easily.

Chemical

A chemical treatment known as a Rotenone treatment can be applied to a lake in certain situations. This method is meant to kill all of the fish in the system before re-stocking and other restoration efforts are pursued. This method is not recommended for Big Eagle Lake as the native fish community is heathy and is expected to strengthen as carp management and reduction using other methods is pursued.

Innovative Techniques

Each waterbody presents an opportunity to develop new and innovative techniques to capture carp to reduce biomass. This might include a combination of the techniques listed above or incorporating new ideas. WSB has experimented with sound to "herd" carp into traps or seines and are exploring ways to quantify and automate capture remotely. As techniques are implemented and a carp IPM is updated, new ways to capture carp can be included as options to move forward with.

5. Big Eagle Lake Carp Assessment Summary

The Sherburne SWCD and BELIA commissioned WSB to complete an assessment of the common carp population in 2019 and 2021 with the objective to assess the potential impact common carp may be having on the water quality and ecological integrity of Big Eagle Lake.

Although carp management is not the only action to improve water quality, it may be a necessary component of an overall lake management plan. Carp can cause loading of nutrients internally within a basin due to their feeding habits and excretion rates when biomass becomes elevated. An elevated carp biomass threshold value currently used and established by the scientific community is 89.9 lbs/acre (Bajer, 2012).

To assess the extent of the carp problem in Big Eagle Lake, a carp movement study was initiated that included a reconnaissance of the lake to determine the feasibility of seine netting and stream trapping to remove carp biomass (appendix x). A summary of the carp abundance estimate and recon is provided below.

5.2 Big Eagle Carp Abundance Estimates

By estimating the population size, resource managers may be able to assess existing carp density against the established threshold value of 89.9 lbs/acre to determine if additional carp management is necessary (Bajer, 2012). If future management is required and/or desired, additional components of an integrated pest management (IPM) approach, which may include collection of movement data (radio-telemetry, PIT tag monitoring), physical or chemical removal, and suppression of carp recruitment with use of barriers to movement, predator species enhancement, habitat restoration, and a component of outreach and education, may be pursued.

5.2.1 Big Eagle Lake CPUE Results

In 2019 carp biomass estimate a carp population and biomass estimate was completed using boat electrofishing catch per unit effort (CPUE) methodology with a follow-up survey completed in Fall of 2021 (table 7). The population estimate resulting from an average of the two CPUE survey indicates that 141 +/- 115 lbs/acre of carp biomass may be present Big Eagle Lake. This number can be compared to the ecological tipping point of 89.9 lbs/acre (100 kg/ha) identified in the literature to determine an overabundance of carp biomass. The CPUE methodology is described in greater detail in section 4.

Lake	Year	CPUE Estimate (lbs/acre)	Threshold Value (lbs/acre)
Big Eagle Lake	2019	172 +/- 168	89.9
	2021	109 +/- 61	
	Average	140 +/- 32	

Table 7: Big Eagle Lake CPUE results 2019 and 2021.

CPUE estimates give managers a high level look at the population estimated to be in lake. The two years of data suggest that the population of carp is moderately high in Big Eagle Lake and that a reduction in the population could benefit water quality and support other water quality projects pursued in the watershed. For the purpose of estimating the amount of internal loading contributed from common carp, the 2019 estimate is used as this data was available for analysis at the time of the water quality assessment and load source assessment conducted in that year.

The average of the 2019 and 2021 survey overlaps both of the individual survey dates and is being used to report the estimated biomass that resides in Big Eagle Lake. At 140 +/- 32 lbs/acre, the total number of individual carp estimated in Big Eagle = 4,330 +/- 974. To meet threshold value (89.9 lbs/acre) roughly 1,300 to 2,000 individual carp need to be removed from the system. A higher amount of biomass removed will help to ensure the threshold value is not easily surpassed as carp may recruit and/or grow larger.

5.2.2 Big Eagle Lake Mark-recapture Results

In 2021, a total of 16 carp were marked with PIT tag (6) or radiotag (10). Initially the mark-recapture estimate was planned to be completed as a way to validate the CPUE estimate and provide a more accurate estimate of carp abundance. The number of marked fish is not currently sufficient to make a reliable estimate of the population and no large scale capture event has been completed. Marks will be employed during future phases of the project if possible and PIT tag numbers will be used in aggregate to attempt a mark-recapture estimate of the population in the case a large scale capture event is completed and a sufficient recapture rate has been achieved.

5.2.3 Big Eagle Carp size structure

The MN DNR completed a standard survey of the fishery in Big Eagle Lake in 2020. This survey found 15 species including bluegill, northern pike, and common carp. The size structure of common carp sampled in this survey suggest that some recruitment is happening in-lake as the sizes ranged from 0-24 inches with the majority of carp in the 0-7 inch range (Figure 12).

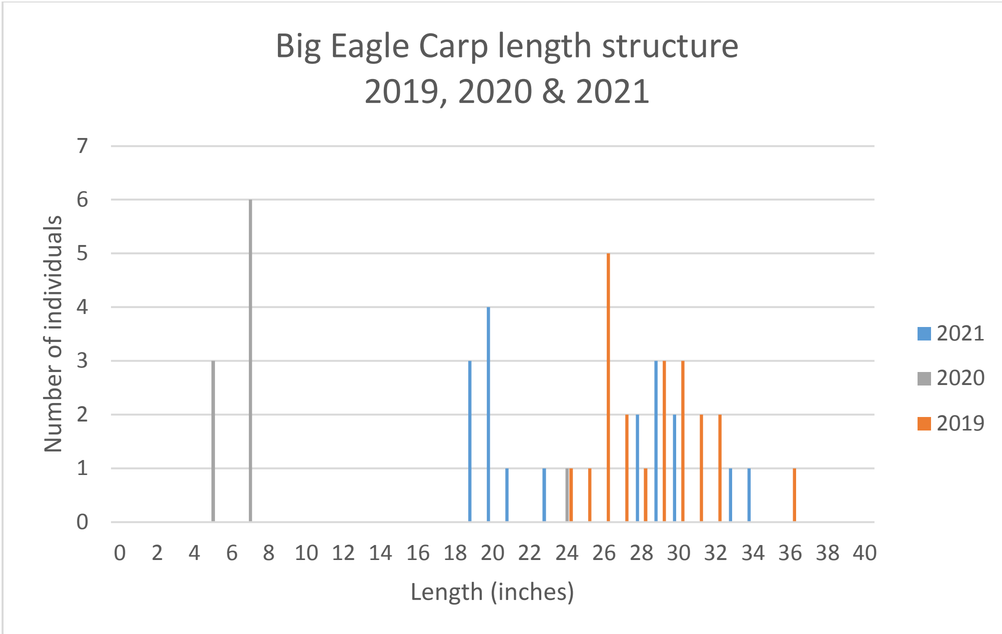


Figure 12: Carp size structure graphs (2019, 2020, 2021). Carp were captured using a boat electrofisher in 2019 and 2021, small carp were sampled in MN DNR standard survey using gill nets in 2020.

5.3 Big Eagle Carp Spatial Usage and seine netting feasibility study

5.3.1 Radiotags

In Big Eagle Lake, a total of ten (10) high-frequency radiotags were implanted in to carp ranging in size from 19-34 inches on 9/30/2021 and 10/7/2021. Carp locations have been tracked by WSB and BELIA volunteers from November 2021 through June 2022. Data collected in this time period have identified over-wintering aggregation sites and movement out of the basin through the outlet channel (Figure 13, 14). Radiotelemetry movement data was supplemented with the use of remote cameras in the springtime of 2022.

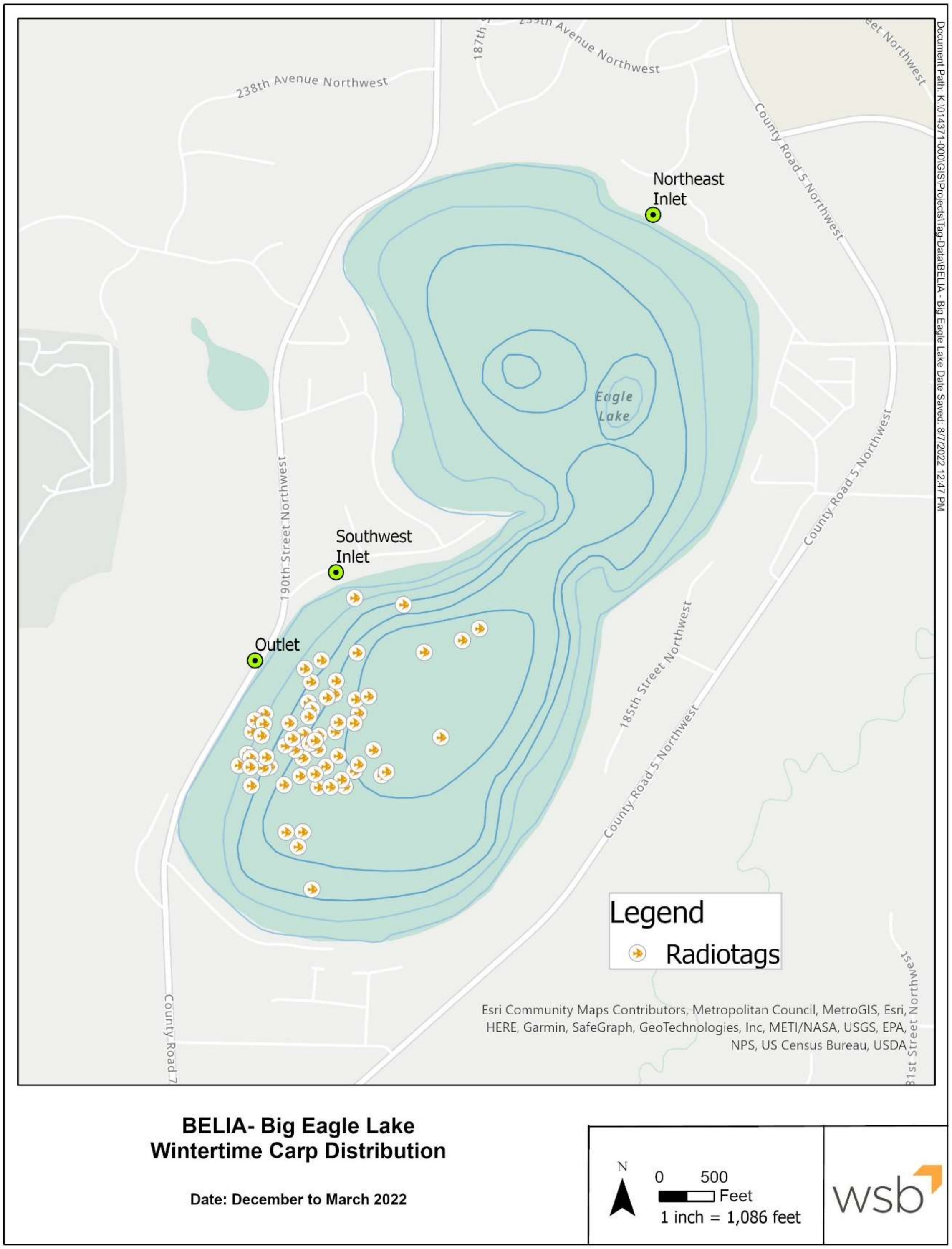


Figure 13: Telemetry data from December 2021 to March 2022 indicate winter aggregation areas in Big Eagle Lake.

Aggregation sites can be targeted with removal operations using various techniques including seine netting. To begin defining the feasibility of seine netting in Big Eagle Lake, a lake reconnaissance was completed on May 16, 2022. The details of this recon event were delivered to project partners in a memorandum titled Big Eagle Lake Commercial Netting Reconnaissance. The results of this event indicate that the bottom substrate is favorable to seine netting and no insurmountable debris was detected that may inhibit a seine attempt. However, the possibility of getting snagged, torn, and/or carp outmaneuvering the net exists in any system and capture is not a guarantee. To alleviate some risk, it would be preferable to pursue an seine netting attempt in open water conditions.

Movement outside of the main basin in April through June likely indicates a spawning migration route. In the spring of 2022, one tag was confirmed outside of the main basin in the outlet channel towards the Snake and Elk River. A large wetland complex exists downstream that carp may be utilizing for spawning ground but the location these carp spawned is not confirmed. A high water event in June may have allowed carp to pass downstream and the return to normal water levels may prevent movement back into the basin. This is because of the presence of the overflow and tine structure at the outlet.

One tag (149.613) was confirmed downstream of the outlet structure while two additional tags (149.534, 149.573) have been undetected in surveys since late May 2022. It is unconfirmed the direction these two tags might have gone but it is assumed they may have left through the outlet structure or the southwest inlet as these locations are where carp observations were made via camera monitoring. At the end of the project period in 2022, it had not been confirmed if these fish returned to the main baisin of Big Eagle Lake. This data will help to guide a carp barrier re-design and operation that is needed after high flows damaged the barrier in the springtime of 2022.

Two radio-tagged carp expired in the Springtime of 2022. One tag (149.504) was confirmed a bowfishermen shot the carp as Sherburne SWCD staff, Dan Cibulka, was present at the time and able to retrieve the radiotag on 5/12/2022. This event occurred at the outlet site and the carp was shot downstream of the carp barrier but upstream of the bridge. One tag (149.555) was tracked near a wetland north of Big Eagle on 5/16/2022 and confirmed a dropped tag on 5/23/2022 when the carcass was found with the sutures visible. It is unknown how this carp got to this location but it is assumed a bowfishermen may have dumped the carcass here. Five (5) active radiotags remain in Big Eagle as of July 2022.

Although radio-tag data suggests that a portion of the population migrates out of the lake during spawning season, it is still unknown where the spawn takes place downstream or the frequency of migration back to the main basin of Big Eagle Lake.

High water events that allow movement out of and back into Big Eagle, or the occasional hatch and survival of young in-lake may contribute to the recruitment of carp to Big Eagle Lake. More frequent trap-net sampling in Big Eagle combined with aging data on the carp population may help to determine the frequency of recruitment events in-lake while trap-net sampling in basins connected to the lake will help to determine the contribution from these basins to the carp population in Big Eagle. This data can help managers to track the progress of carp management activities by showing trends over time or to focus efforts to lessen in-lake recruitment as migration routes are blocked.

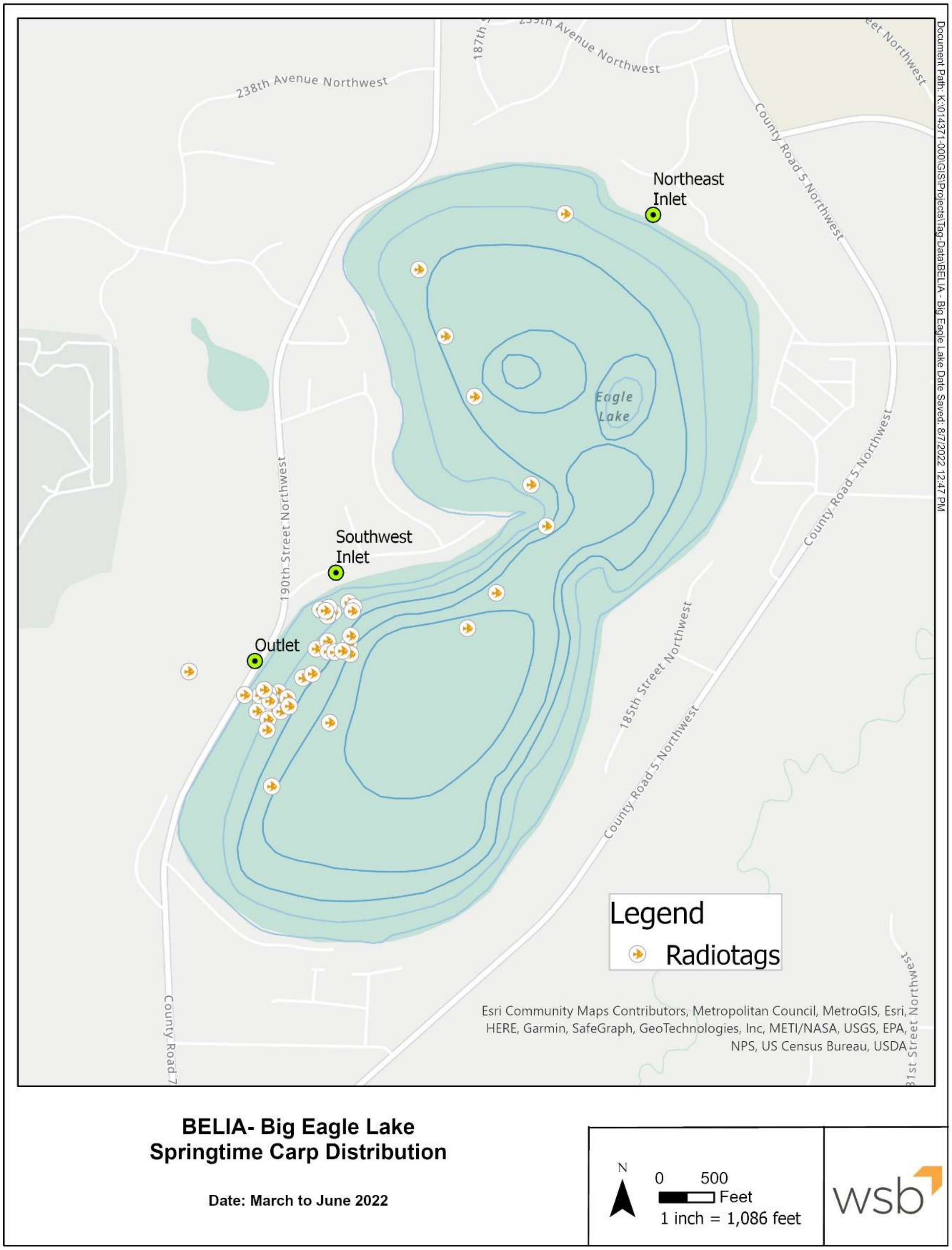


Figure 14: Telemetry data from March 2022 to June 2022 indicate movement that is associated with springtime migration through the outlet channel in the south-west quadrant of the lake. Early springtime data suggests an aggregation of carp persists into open water season.

Early springtime telemetry data suggests that carp remain aggregated. This aggregation of carp could be targeted for removal via a seine net in open water. The commercial fishermen for the area that includes Big Eagle Lake has indicated he may be interested in conducting this work if the opportunity arises and the cost of the operation is covered.

5.3.2 Remote cameras

Remote cameras were chosen to supplement radio-tag movement data as an alternative to PIT tag monitoring as very few PIT tags were able to be implanted into carp in the fall of 2021. Under this task, SWCD staff viewed live camera footage daily between the date of install on April 26, 2022 through the end of May 2022 for the presence absence of carp at the sites. Special attention was given on days after a rain event as carp are known to move in response to these events. Figure 15 shows the camera view at the three sites.

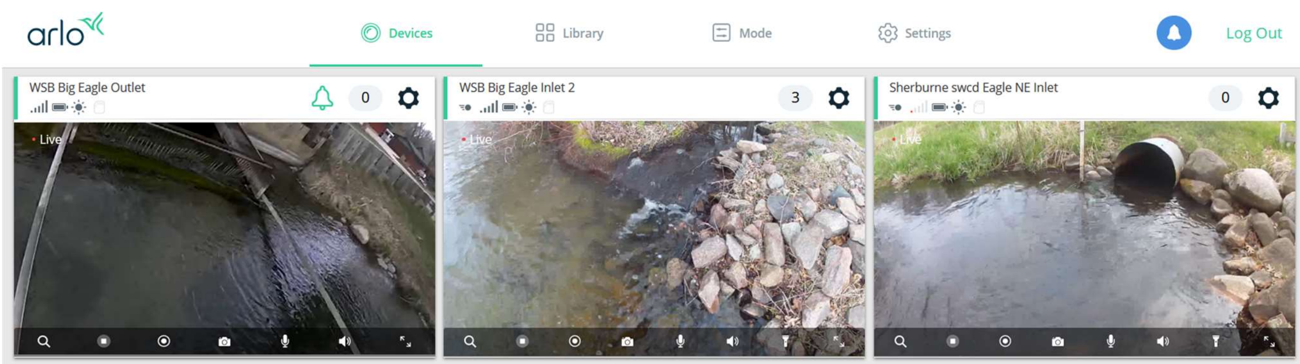


Figure 15: View from cameras at three (3) sites on connecting streams to Big Eagle Lake. WSB Big Eagle Outlet (Outlet), WSB Big Eagle Inlet 2 (Southwest Inlet), and Sherburne swcd Eagle NE Inlet (Northeast Inlet).

Three (3) cameras were installed in connecting streams including the outlet and two inlet sites (Figure 16). These sites were chosen based on historical information gathered and shared by BELIA that carp have been observed migrating through these connections. Arlo Security Camera's were used that could be viewed remotely via a cellular connection and access could be shared with multiple people.

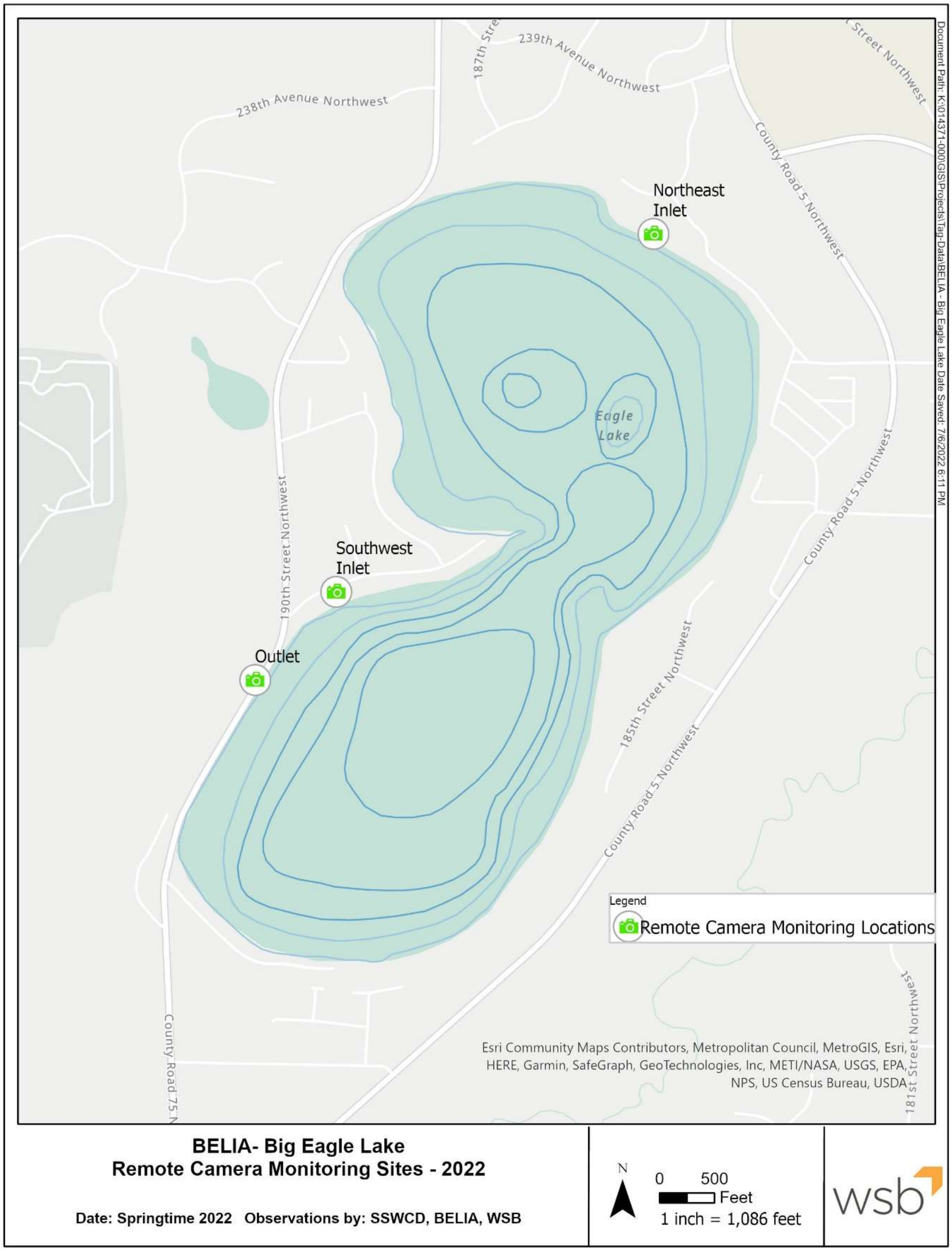


Figure 16: Springtime monitoring sites using remote cameras in the spring of 2022.

Carp movement was observed at the Outlet Site, and the Southwest Inlet Site on May 12-16, 2022. No movement was detected via remote camera or radiotag movement at the Northeast inlet site (table 8). on May 12, SWCD staff reported carp sighting at the Southwest inlet site and BELIA volunteer did a site visit to confirm movement into the stream reach and through a culvert at the road crossing. The observations of carp movement at these two sites in the springtime suggest that carp nursery areas are accessed through these connecting channels.

Date	Camera Site	Carp Observed (Y/N)	Radiotag movement outside Big Eagle Lake main basin (Y/N)	Radiotag number detected outside main basin
5/12/2022	Outlet	Y	Y	149.613, 149.504*
	Southwest Inlet	N	N	
	Northeast Inlet	N	N	
5/14/2022	Outlet	Y	Y	149.613
	Southwest Inlet	Y	N	
	Northeast Inlet	N	N	
5/15/2022	Outlet	Y	Y	149.613
	Southwest Inlet	Y	N	
	Northeast Inlet	N	N	
5/16/2022	Outlet	Y	Y	149.613
	Southwest Inlet	Y	N	
	Northeast Inlet	N	N	

Table 8: Carp observed on cameras and radiotag confirmation of movement outside the main basin. *Fish with tag # 149.504 was harvested by bowfishermen at outlet site between carp barrier and downstream culvert, tag was removed by Sherburne SWCD.

6.0 Big Eagle Carp IPM Implementation Activities

Implementation of a carp integrated pest management plan (IPM) may provide additional phosphorus load reduction benefits as well as other ecological improvements. Integrated pest management provides a more sustainable approach to managing invasive populations, specifically carp, by providing additional control tools rather than just adult removal and ensuring that biomass that is removed will not simply be replaced through recruitment.

Blocking springtime movement and reducing the adult population will be key elements of this plan.

6.1 Carp Barriers

Blocking movement will be accomplished through the use of physical barriers. When designing barriers to block carp movement a variety of factors should be considered to understand how a carp may move under, over, or through the barrier and designing the barrier to ensure that carp cannot move past.

Project data and anecdotal information identifies two locations that carp appear to be accessing as migration routes to potential spawning locations (which have not been confirmed). These two sites are the southwest inlet and the Big Eagle Lake Outlet. To reduce the potential of flooding and maintenance requirements, the barrriers may be "opened" in late summer well after the carp spawning period is over and installed in spring, prior to carp beginning to migrate; most likely in Mid March of any given year.

6.1.1 Southwest Inlet

The southwest inlet or inlet 500 drains into Big Eagle Lake from a small wetland complex. The stream crosses 190th street as it exits a larger wetland area and continues along the east side of this road, crossing two roadways via culvert on it's way. A small wetland exists just north of 232nd Ave NW before the stream crosses under and enters into Big Eagle a short segment later. The culvert under 232nd Ave NW has been identified as a potential barrier site. This culvert is a cement structure that is estimated to be 36 inches in diameter.

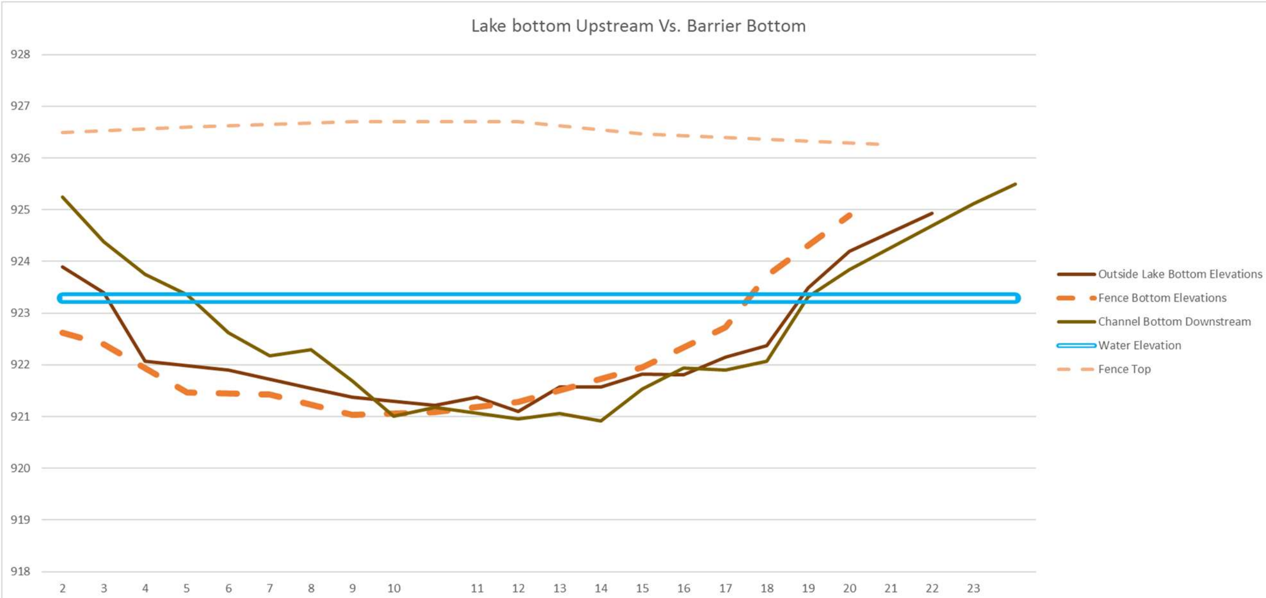
BELIA volunteers have proposed a design for the southwest inlet which consists of a series of 3/8" diameter vertical bars/rods placed at 2" on center to cover the culvert and impede carp movement. This barrier design should be effective in eliminating any movement of carp through the culvert as long as the grating covers the entire culvert opening and that water levels do not rise above the height of the culvert and provide an alternative swim path for carp.

An operation and maintenance plan to ensure that the grating does not get overwhelmed with debris and restrict water flow will need to be developed. Perhaps the installation of a remote camera to view the barrier in real time can be part of this plan. A water level meter with the ability to transmit real time water level data can also be added to provide additional assurance that the barriers will not contribute to flooding or other undesirable impacts.

6.1.2 Big Eagle Lake Outlet

The outlet structure was constructed by BELIA members to prevent movement of carp into and out of Big Eagle Lake. The operation and maintenance has been performed by this group. The barrier extends from shore to shore on the lakeside of the outlet structure and is made of welded steel and the grating welded vertically and is spaced at 2 inches. A section of the existing barrier is removable, allowing for the option to allow fish passage at certain times.

A survey was completed in the fall of 2022 on the re-installed outlet barrier and a rough sketch was completed to assess the current conditions. The substrate near the barrier mostly consists of boulders, this made assessing the closeness of the bottom of the fence to the channel bottom. However, the data suggests that gaps could exist. The top of the fence extends approximately 3.5 feet above the water elevation in November 2022. A look at historic water elevations suggests that this extension above the water surface is limited to approximately 1.5 feet.



To strengthen the barrier design, the height of the barrier should be extended by ~1' and angled upstream (lakeward, rather than being completely vertical). This will make it harder for the fish to estimate where to jump from and prevent movement over top the barrier.

If the fencing material is at or slightly below the sediment interface for the entire portion of the barrier that is underwater, and there is rock or other material there to prevent burrowing, that should be sufficient to prevent movement under. However, it is suspected that in high flow events, these rocks may shift out of place, allowing occasional movement under the fence. It is recommended that welded tines or fencing be buried in the substrate 4-8 inches and 4-8 inch rock be placed on both sides of the barrier.

Gaps have been observed between the bank and the barrier. This connection must be strengthened to ensure that carp can not breach at this location and additional erosion does not occur.

This work maybe completed in-kind by BELIA volunteers or with a contracted service. It is our understanding that the barrier materials can be fabricated by a BELIA volunteer and it is unknown at this time the cost of materials.

6.2 Carp Biomass Removal

A number of options are available to reduce the population of adult carp in Big Eagle Lake and are described in Section 4; however; it is recommended to pursue seine netting as the primary removal technique with baited box netting and/or trapping at the outlet site as secondary options. The reconnaissance that was completed in the springtime of 2022 determined that seining in the area of carp aggregation is feasible.

6.2.1 Seine Netting

Open water seine netting can be done when carp are found to be aggregating and open water exists in the fall or in springtime after ice out and before the fishing opener. Radiotag data indicate that carp remain aggregated in the southwest quadrant of the lake after ice out through early Spring while no data is available to indicate or not indicate a fall aggregation.

Under-ice seining is also feasible on Big Eagle Lake as a strong aggregation persists from early to late winter. If this method of carp removal is pursued, it is recommended that an open water seine be included with the work-plan. Although the reconnaissance using sonar and underwater drone footage suggests that a net would pull through the area, a net pulled through in open water can confirm this. This would help to ensure that a seine net is successfully pulled under water. The number of fish that are captured can be variable.

Maintaining 5-8 active radio tags in Big Eagle will be necessary to track the formation of aggregations and schedule a removal operation. Without the aid of radio tags, the timing of the aggregation would be unknow and the commercial crew may not be successful or may not be interested in pursuing an unknown aggregation.

BELIA volunteers and/or Sherburne SWCD staff can use the radio receiver to monitor the location of tags and communicate to WSB staff to coordinate the commercia crew for removal operations. WSB staff would be available to confirm the location and compactness of the aggregation to ensure the effort will target the maximum number of individual carp.

6.2.2 Baited Box Netting

The tendency of carp to be attracted to bait in Big Eagle is currently not known but could be determined relatively inexpensively by BELIA volunteers installing and monitoring bait stations that consist of a mesh bag filled with 10-50 pounds of cracked corn (bait). These stations could be installed after the spawning period concludes in early to mid June and monitoring for 2-4 weeks to determine if carp are consuming the bait consistently and quickly (1-2 nights).

If so, then a baited box net could be installed to capture carp at the most heavily visited station. WSB staff would be available to install and "lift" the net to capture carp. The number of "lifts" or site visits would be determined by the available budget and the efficacy of the trapping.

6.2.3 Outlet Fish Trap

Trapping at the outlet site is feasible and has been done in the past, however; this operation will require a barrier and trap to be designed to fit in the outlet channel, the trap could be a temporary trap similar to the push-trap style described in section 4.2.5. If trapping in the outlet stream is pursued, it would require a substantial amount of effort. This effort could be contracted or managed by the lake association volunteers as the site would have to be checked daily, by remote cameras or site visits, and carp would need to be removed and native fish returned to the lake or stream promptly.

6.2.4 Bowfishing

As a coordinated effort, bowfishing may be encouraged to further reduce carp populations within Big Eagle Lake. Tracking carp removed and proper disposal of carp carcasses would need to be a part of this activity and the potential targeting of native gamefish need to be considered for this technique. The BELIA may want to consider an organized bowfishing event. Disposal could be offered as part of the event and data on total number and weight of fish removed should be collected to update the existing population estimate and determine if the removal goal has been met.

6.3 Maintenance Activities

After carp biomass has been reduced and measures are put into place to limit recruitment it will be important to monitor the effectiveness of management activities. The operation and maintenance of the carp management plan in Big Eagle includes updates to the population and biomass estimates by conducting a CPUE survey, maintaining active radiotags in the system to track distribution and efficacy of the barriers, and monitoring the bluegill population and the recruitment of young carp by conducting surveys and doing an aging study on the carp in Big Eagle.

6.3.1 PE update- 2-3 years post removal and before an alum app.

Observations and young of year surveys can help to estimate if the population has rebounded. It is recommended that these tasks be supplemented with a electrofishing carp CPUE survey that would replicate the surveys completed in 2019 and 2021. This will be especially important to complete before an alum treatment is completed to ensure that the carp biomass is being suppressed and that their activities will not disrupt the anticipated improvements of this treatment.

6.3.2 Radio tags if there is evidence to suggest barriers have been compromised or if follow up removal using seine netting is to be pursued

Radiotags can not only help to test the efficacy of the barriers but inform managers of the spatial distribution in Big Eagle. This will be important if carp removal efforts are pursued by seine netting, or baited traps. Placement of traps or seine nets would be based partly on the distribution of carp in the system.

6.3.4 BLG and carp YoY surveys

Monitoring for the recruitment of young carp could be done with trap-net or gill net surveys each fall. This data could be used with MN DNR sampling data that is expected to be completed every four years in Big Eagle Lake. If young carp are captured and bluegill abundance drops, it may be warranted to enhance habitat for bluegill in a number of ways including winter aeration, or fish sticks along shorelines or other.

6.3.5 Ageing

To monitor the frequency and strength of recruitment events, aging a subset of carp can be completed. This requires the harvest of carp and the extraction of a bone inside their head called an otolith. These can then be processed to be read under a microscope. Rings that form on the otolith as a carp grows can be counted, much like rings on a tree.

This data can be valuable to monitor the effectiveness of carp management activities. This task can be pursued at the beginning of the project period and in three or more years as carp biomass removal and management strategies are put into place. Ages collected at the beginning of the project period can provide a baseline for the recruitment strength and frequency and changes can be monitored with future sampling of this type.

6.3.6 PIT monitoring

Testing the efficacy of the barriers could happen as they are implemented. This can be done with the use of radiotags and/or PIT stations and/or camera monitoring. PIT tag monitoring would provide the greatest confidence in data collected but would require a greater number of carp to be captured and then released. Radiotag battery life is expected to be up to three years but may be less. If radiotag maintenance is pursued, it is recommended that new tags be implanted every two years. Tags implanted in 2021 may need to be refreshed in the fall of 2023.

6.3.7 Barrier Maintenance/Inspections

Regular monitoring of the barriers is recommended, especially in the spring-time when an increase in water flow may impact the conditions. Monitoring cameras can continue to be used for this purpose but likely will need to be supplemented with site visits that might include underwater surveillance. The BELIA members have taken on this task in past years. It would be important to develop an operation and maintenance plan to ensure that this work continues.

6.4 Carp Management Cost Estimate

The tasks described above are given in the table below with an estimated cost. These costs are given as a range that can be refined as tasks are pursued and the amount of effort has been determined. Many of these tasks assume some level of volunteer participation and is captured in the given cost range. The timeline for these activities is described in the task description in section 6.1 through 6.3. Carp removal may be pursued as soon as the springtime of 2023 or perhaps the winter of 2024. The timeline for maintenance activities is dependent on this start date and other activities, such as alum treatments, that are to be pursued.

Task	**Cost (min-max)**
Implementation activities	
Carp Barriers	
Southwest Inlet and Outlet	$5,000 - 7,000
Carp Biomass Removal	
Seine Netting	$4,000 - 10,000
Baited Box Netting	$12,000 - 24,000
Outlet Fish Trap	$10,000 - 18,000
Bowfishing	Unk
Maintenance Activities	
CPUE Updates	$3,500 - 4,100
Radiotag Maintenance	$2,700 - 5,000
BLG and YOY Surveys	$3,000 - 3,700
Aging	$3,000 - 6,000
PIT monitoring	$5,500 - 7,900
Barrier Maintenance/inspections	Unk
TOTAL	$48,700 - 85,700

The bowfishing and barrier maintenance and inspections cost are not estimated. The pursuance of these activities and level of effort to complete them will be decided by Sherburne SWCD and BELIA as carp management is pursued.

7. Expected water quality outcome

By reducing the carp biomass density from 171 lbs/acre to 50 lbs/acre, loading from carp can be reduced from ~363 pounds to 104 pounds per growing season.

8. Surface water monitoring plan

Continued monitoring of in-lake and in-stream water quality (secchi depth, TP, Chl-a) can provide critical data to evaluate the effectiveness of implemented BMPs over time. BELIA will continue to conduct water quality monitoring on a reoccurring basis per the MPCA's citizen volunteer monitoring program. This data can then be used to update the 2019 WQ monitoring analysis to continue tracking trends.

9.Summary

In summary, historical data and data collected in 2019 indicate that Big Eagle Lake is impaired as it is not meeting numerical water quality standards for total phosphorous, chlorophyll-a, or secchi depth, and is not providing designated or beneficial uses i.e supporting healthy cool or warm water biota and suitable for aquatic recreation. The impairment for Big Eagle Lake is due to excess nutrients (Total Phosphorous), which in turn has elevated the chlorophyll-a (algae) concentration in Big Eagle Lake and reduced water clarity (secchi depth).

The primary sources of this impairment are the northeast subwatershed and internal loading from carp and anoxic sediment release. Combined these three (3) sources contribute 87% of the TP load to Big Eagle Lake. To meet water quality standards for Big Eagle Lake, nearly 65% of the existing TP load needs to be eliminated. Carp management can be a critical component to reducing this loading and could compliment an alum treatment.

The bottom disturbance caused by carp may reduce the longevity of traditional in-lake management techniques such as alum treatments. In deep lake basins, portions of the lake are protected from active foraging behavior but in littoral areas, sediments can be disturbed by carp foraging behavior that settle into the deeper areas of the lake. This disruption can decrease the longevity of an alum treatment that is costly to implement. It could be advantageous to pursue an alum treatment after carp biomass has been reduced in Big Eagle.