Integrated Pest Management Plan (IPM Plan) for Common Carp in Normandale Lake

Prepared for the Nine Mile Creek Watershed District

January 26, 2023

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Table of Contents

Table of Figures

Table of Tables

Executive Summary

Normandale is a shallow lake in Bloomington, MN and is part of the Nine Mile Creek Watershed District (NMCWD). It is a high-value lake to the residents and recreators who engage with it. Several projects have been implemented in recent years to work towards improving water quality conditions like total phosphorous (TP), water clarity, and chlorophyll-a (the amount of algae in water). The carp population that spiked in abundance following the refilling of Normandale Lake following a lake drawdown could negatively impact improving water quality conditions.

Studies of the fisheries in Normandale Lake began in 2018 and in 2019, and young carp were surveyed in very high numbers. Although some carp were eaten by predators, many still remain and the size of the individual carp in that age class continues to increase. In order to understand and ultimately reduce the impact of this group of carp in Normandale Lake, NMCWD contracted WSB to develop more intense studies and population reduction efforts to address this issue. Using existing data, and further field data, WSB constructed an integrated pest management (IPM) plan for this specific population and the conditions that exist in Normandale Lake.

This IPM plan looks holistically at the ecological and hydrological conditions of Normandale Lake and the connected water bodies to best target the vulnerabilities of common carp and develop the most cost-effective ways to reduce adult carp populations in Normandale Lake and to reduce the chances of another spike in new young surviving carp (recruitment) from occurring again.

Overall, the goal is to continue to promote healthy ecological balance as a lake, improve water quality, and the overall experience residents have with the lake. This plan addresses any gaps in data that need to be collected, implementation tasks to meet goals, and how to monitor the status of carp in Normandale Lake to address any changes in their population. It is understood to be a "living document" in which continued data collection is incorporated into the matrix of the document in order to incorporate all that has been done and planned for carp management in Normandale Lake in one place.

Acronyms/Definitions

Baited box net: Relatively large net (30 feet X 60 feet) laying on the bottom of the lake with mesh walls 10 feet tall which can be raised quickly off the bottom of the lake above the water surface to trap all fish inside. Cracked corn is spread in the area of the trap which attracts carp inside the area where they are trapped when the walls are raised.

CLP: Curly lead pondweed.

CMR: Mark and recapture estimate is another way to estimate the number of animals in a population. It is typically more accurate but requires more effort and time to complete. It requires at least one effort to give animals a distinguishable/recognizable mark and then at least one effort at a later date to capture more animals and to check how many of the animals had the mark from the first effort and developing a ratio of how many animals were previously captured and how many have not been captured before. The population estimate is more accurate with more marks given initially and more recaptured animals with those marks in follow up efforts.

CPUE: Catch per unit effort is a general term to describe a rate of how many individuals captured during a standardized unit of effort like time, net, or person. When used with electrofishing for fish, this rate can be used to estimate a number of carp or goldfish in one acre of a lake.

DO: Dissolved oxygen.

Electrofishing: This is a method that employs controlled electricity directed into the water to temporarily immobilize fish. Systems can be used on a small barge, a backpack carried by an individual, or a motorboat. It is a standardized and effective method of sampling fish.

FQI: Floristic quality index

IPM: Integrated Pest Management

MAISRC: Minnesota Aquatic Invasive Species Research Center.

MNDNR: Minnesota Department of Natural Resources.

NMCWD: Nine Mile Creek Watershed District.

MPCA: Minnesota Pollution Control Agency.

MUM technique: Modified Unified Method. This term refers to a technique where using sound to herd carp and block nets to guide their movements, the fish can be relocated to an area where they can be captured more effectively.

Nursery: This refers to multiple connected water bodies where one or more are locations found to be sources of animals that are born/spawned/hatched and then move into another permanent lake at some developmental life stage. For example, carp have been found to move into shallow ponds or lakes to spawn and then return to the main lake. Those eggs in the shallow pond hatch and the young carp grow up and eventually move into the main lake. That shallow pond is functioning as a nursery.

PIT tag: Passive integrated transponders (technology used in pet chips) that are quickly implanted inside fish and released. When in close proximity (10-18 inches) to a wire that is connected to a computer, the identification number associated with the tag is recorded as well as the exact time it was detected.

Recruitment: This refers to the process of adding new surviving individuals to a population. For example, a large number of young goldfish hatch from eggs and survive their first 1-2 years of life would indicate high recruitment. It has been found that there is low or no recruitment of goldfish and carp when there are lots of bluegill sunfish of many different sizes.

RPBCWD: Riley Purgatory Bluff Creek Watershed District.

SAV: Submerged aquatic vegetation.

Seine net: Typically, a long net (in this case 200 feet) that is weighted to lake bottom on one side and floated to the water surface on the other creating a vertical wall in the water. The net is initially laid in the water around a presumed group of fish and then is slowly pulled back into the shore concentrating the fish and eventually used to remove the fish from the lake.

Spawning: Behaviors relating to reproductive processes in fish, amphibians and mollusks. For example, the production of and laying of viable eggs by fish.

TP: Total phosphorus.

Trap/fyke net: Standardized gear type used to catch all types of fish moving around shorelines naturally. Typically used in places where electrofishing surveys are not feasible. Mini fyke nets are specifically designed to be able to catch small fish.

USGS: United States Geological Survey

YOY: Young of year refers to a fish that hatched from an egg within the same year that it was found. For example, a goldfish that was caught in August 2021 and was only 2-3 inches long was likely an egg laid in the spring of 2021.

1.0 Description of Watershed

Located within Hennepin County, the Nine Mile Creek Watershed District (NMCWD) lies in the Minnesota River Basin in the southern portion of the Twin Cities metropolitan area and belongs to the Lower Minnesota River Watershed. The watershed district covers roughly 50 square miles of land area and encompasses the land area that drains to Nine Mile Creek (NMCWD website) shown in Figure 1. The NMCWD serves the cities of Bloomington, Eden Prairie, Edina, Hopkins, Minnetonka, and Richfield within Hennepin County. Normandale Lake is fed by Nine Mile Creek which runs from the north in Hopkins and Minnetonka, through Normandale Lake and outlets on the southeast side of the lake and eventually flows to the Minnesota River. Since 1959, the NMCWD has strived to conserve, protect, and manage the water resources within the NMCWD and has implemented a variety of projects aimed to improve water quality.

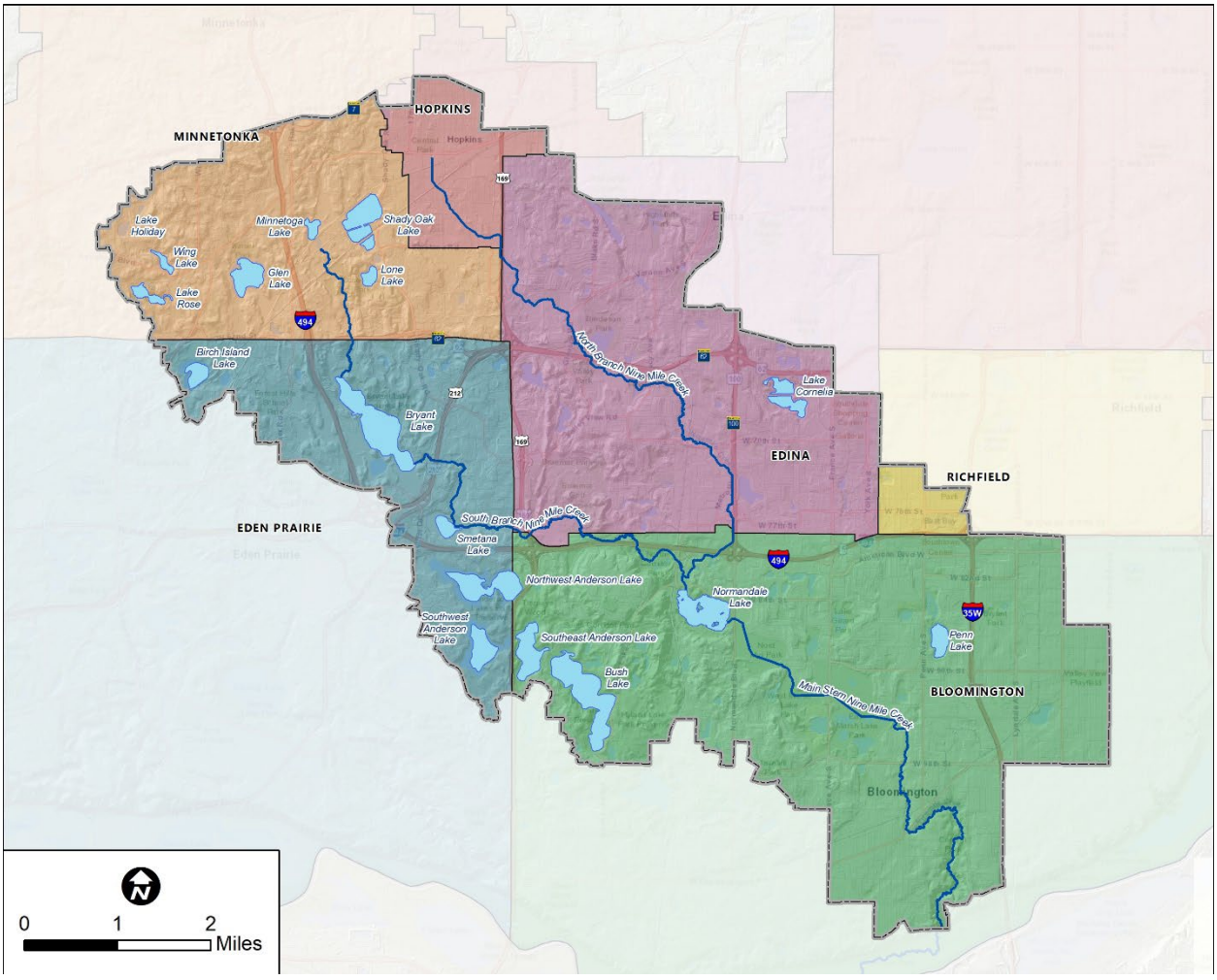

FIGURE 1: MAP OF NINE MILE CREEK WATERSHED DISTRICT AND THE ASSOCIATED MUNICIPALITIES IT ENCOMPASSES. MAP PRODUCED BY BARR ENGINEERING.

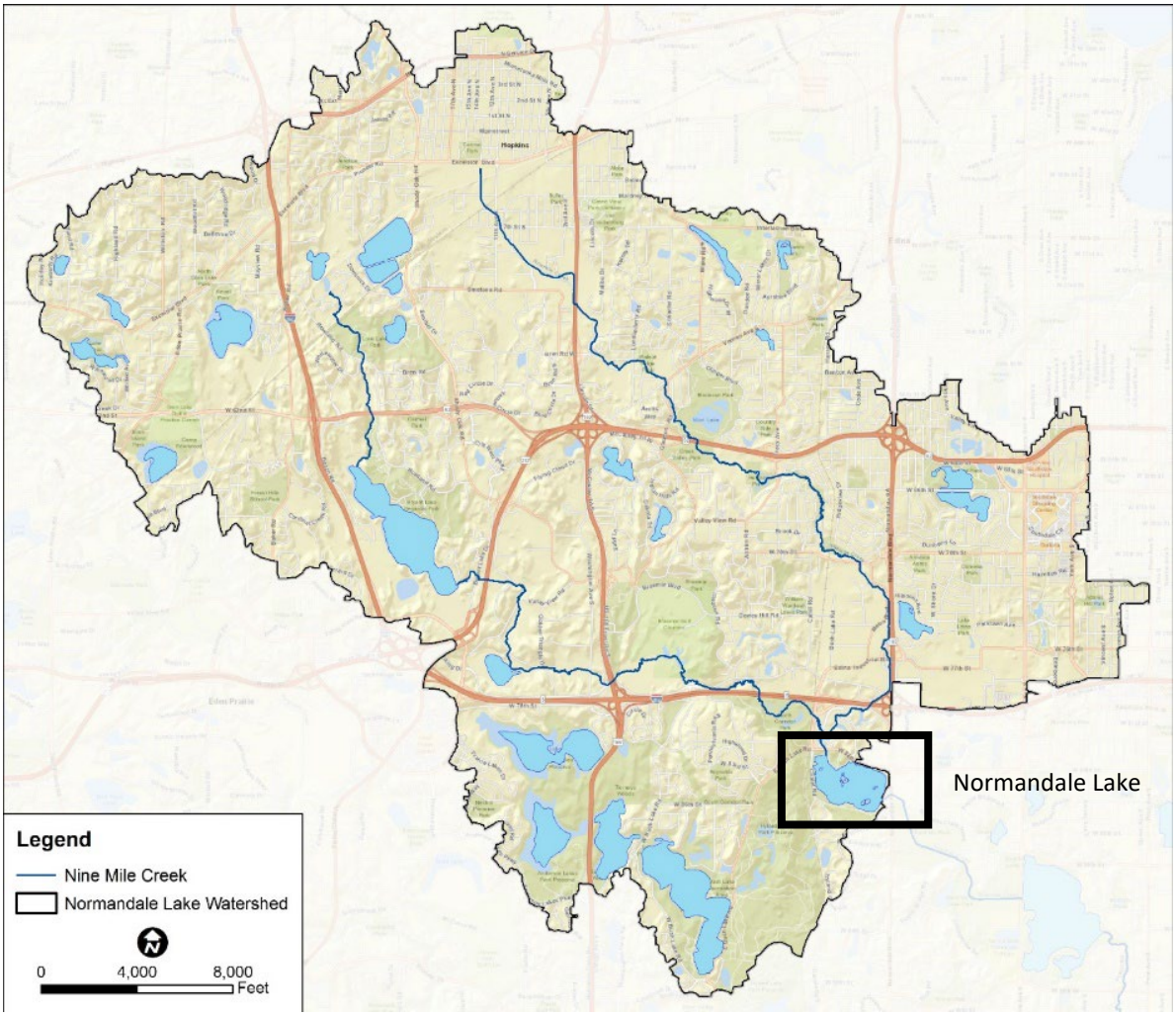

FIGURE 2: MAP SHOW THE AREAS AND WATERBODIES THAT ENCOMPASS THE DRAINAGE TO NORMANDALE LAKE. MAP PRODUCED BY BARR ENGINEERING.

Normandale Lake

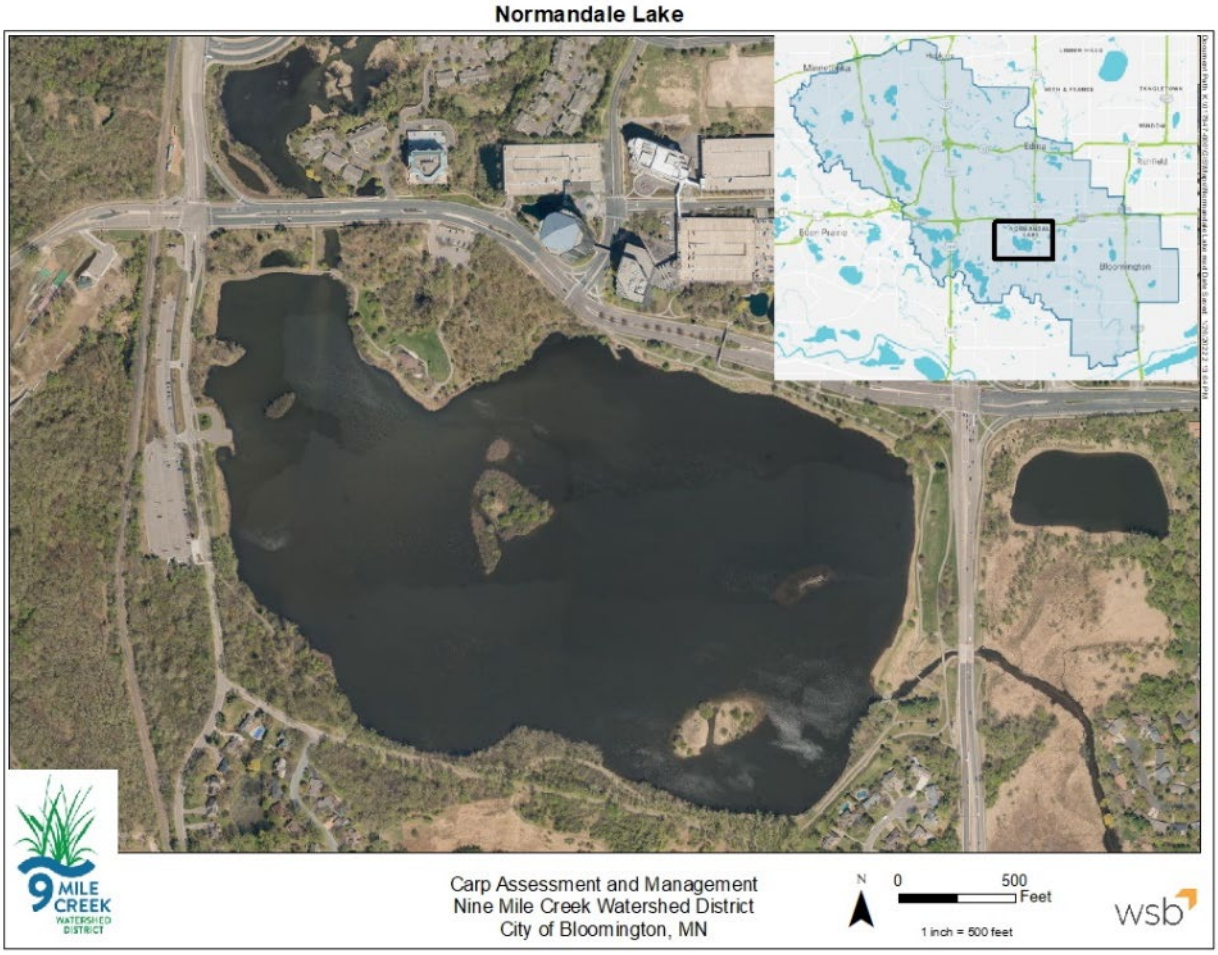

FIGURE 3: MAP SHOWS AN AERIAL OF NORMANDALE LAKE AND WHERE IT IS LOCATED IN THE WATERSHED DISTRICT.

Normandale Lake, an approximately 116 acre lake, is a man-made lake centrally located in the NMCWD, as shown in Figure 3; it was converted to a lake from a wetland by the District in the late 1970s for flood control. It is a shallow lake that receives water from six cities and over 21,000 acres of land, shown in Figure 2. It has an average depth of 4.2 feet and a maximum depth of 10 feet characterizing the entirety of the lake as littoral in nature.

Normandale Lake and the surrounding park are highly recreated by pedestrians, and anglers also use the lake, although to a lesser degree. It is also a valuable water treatment best management practice (BMP) for the Nine Mile Creek. It allows suspended solids to slow down and settle in the shallow entry to the lake and provides high quality habitat to native plants and animals.

The NMCWD began its Normandale Lake Improvement Project in 2018 with the goals of improving water quality and overall ecological health of the lake. To date, the projects that have been implemented have included a lake drawdown (2018-2019), aluminum (alum) treatment (2019), herbicide treatments for curly leaf pondweed (2020, 2021, 2022) and ongoing carp management. Herbicide treatments will continue yearly in Normandale Lake, depending on the results of aquatic plant surveys, through 2024.

Water Quality

Normandale Lake currently meets state standards for the three water quality standards used to judge a lake, and it is not on the state's impaired waters list, illustrated in Figure 4. However, due to its shallow nature and urban watershed, it does have frequent algal blooms. These algal blooms can impede recreation due to odor and appearance. The District's Normandale Lake Water Quality Improvement Project seeks to reduce the amount of phosphorus in the lake that fuels algae growth.

Fisheries

A public water access is located on the west side of the lake. Public watercraft is limited to 6 horsepower engines so most watercraft are canoes and kayaks. Normandale Lake has not been surveyed formally by the MNDNR but is managed by the MNDNR through stocking efforts for bluegill sunfish and black crappies following winterkill years. Largemouth bass are periodically stocked in small numbers (20 adults in 2022). NMCWD contracted Riley Purgatory Bluff Creek Watershed District to complete fishery surveys of the lake using mini trap nets in 2018 and 2019.

Species sampled during the 2018 and 2019 surveys included black bullhead, black crappie, bluegill sunfish, common carp, golden shiner, green sunfish, hybrid sunfish, largemouth bass, northern pike, pumpkinseed sunfish, and yellow bullhead. During the 2019 survey, using both mini trap nets and electrofishing surveys, the most abundant species was common carp. The carp were mostly between 0-5 inches long, indicating a young of year (YOY) age class was spawned. It appears that this age class now represents the most common age class in the lake. The adult carp biomass density in 2018 was estimated at 145.8 pounds/acre and 140.7 pounds per acre in 2019.

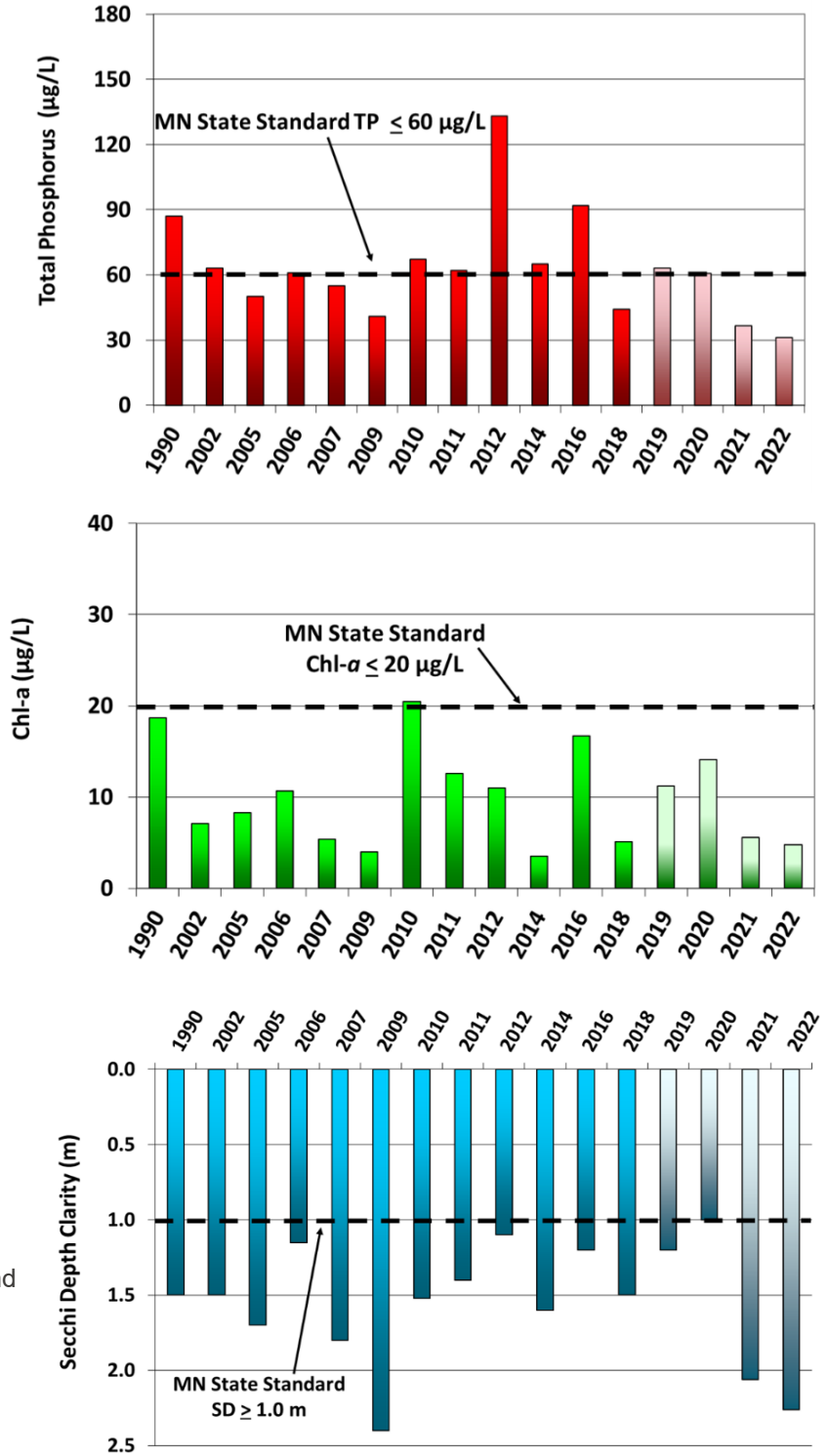

FIGURE 4: DATA SHOWING TP CONCENTRATIONS IN NORMANDALE LAKE (TOP), CHLOROPHYL-A CONCENTRATIONS (MIDDLE), AND SECCHI DEPTH MEASURES (BOTTOM). SOURCE: WQ REPORT: BARR ENGINEERING COMPANY

Aquatic Vegetation

Since monitoring of aquatic plant diversity and abundance began in 2002, Normandale Lake has met the MNDNR's plant index of biotic integrity (IBI) goals every year since 2009. This is indicated by the hashed line in Figure 5. The 2018 Engineer's Report had identified curly-leaf pondweed (CLP), an aquatic invasive species, to be problematic in terms of releasing phosphorous load within the lake.

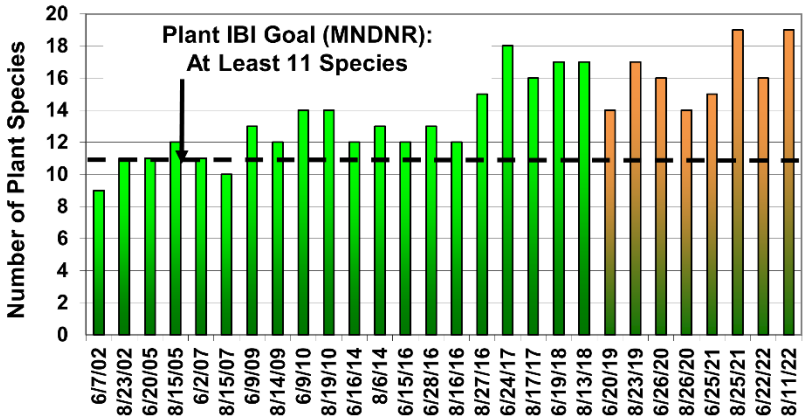

FIGURE 5: NUMBER OF PLANT SPECIES SURVEYED FROM 2002 THROUGH 2022.

In 2018, the District began implementation of a water quality improvement project for Normandale Lake. A drawdown of the lake was completed in fall of 2018 to expose the lakebed to a winter freeze and reduce the abundance of curly-leaf pondweed. A comparison of pre- and post-project aquatic plant data to assess changes after completion of the drawdown and alum treatment to improve water quality in Normandale Lake documented an overall improvement in the plant community in 2019. CLP frequency and biomass declined in 2019, frequency of three native species increased, and quality of the plant community, measured by floristic quality index (FQI), improved.

In 2019, four aquatic invasive plant species (CLP, Eurasian watermilfoil, reed canary grass, and hybrid cattail) were present in the lake. As noted in the previous paragraph, the District's water quality improvement project reduced CLP frequency and biomass. Eurasian watermilfoil (EWM) was not observed in the lake during 2019, but a small cluster of EWM occurred just upstream of the lake in August, and EWM has been observed in small clusters in the lake since. Reed canary grass and hybrid cattail extent have not changed since first observed in the lake in 2016 – reed canary grass was common along the shoreline and hybrid cattail was observed at one location.

The District will also assess the need to improve dissolved oxygen conditions in the lake, after evaluating monitoring data and following the completion of herbicide treatments on the lake. 2022 results indicate that Normandale Lake met MPCA water quality standards for secchi disc (measure of clarity), chlorophyll *a* concentration, and total phosphorus for shallow lakes. According to the MNDNR proposed plant IBI, the lake's plant community is not impaired.

An alum treatment was completed in spring of 2019. Partial lake herbicide treatments of the remaining CLP occurred in 2020, 2021, and 2022, with additional herbicide treatments planned through 2024, as needed, to manage CLP.

Continuation of water quality and biological monitoring is recommended in upcoming years to assess the impacts of the improvement project(s) on the condition of the lake's water quality and biological community.

(source: NMCWD website, Engineer's Report 2018, Barr Engineering Company)

2.0 Planning Documents and Management Plans

2018 Engineer's Report: Barr Engineering Company

2019 Normandale Fishery report: Riley Purgatory Bluff Creek Watershed District (RPBCWD)

2019 May through June radiotelemetry report: Carp Solutions

2019 WQ Report: Barr Engineering Company

2021 Carp survey and management report: WSB

3.0 Ecological Impacts of Carp

A high density (number of individuals per acre of lake) of adult carp is known to degrade the environment due to the nature of their feeding habits and excretion rates. Accordion like mouthparts are designed to dig into the mud and their diet of plant material often uproots native and non-native vegetation and disturbs bottom sediment, releasing excess phosphorus to further feed algal growth. This results in less diversity of plants in the lake and reduces overall plant biomass, potentially resulting in higher chlorophyll and algae in the lake. The disturbance of bottom sediment releases excess phosphorus to further feed algal growth. The **Minnesota Department of Natural Resources lists common carp as a regulated invasive species**. The United States Geological Survey lists common carp as a non-indigenous aquatic species. Both agencies and collective research have shown that carp impacts water quality, aquatic vegetation, and native fisheries.

By managing common carp abundance, lake ecology can be improved. A reduction in internal phosphorus loading may reduce algal growth and a reduction in uprooting of vegetation can improve habitat for other fish species as well as waterfowl.

An internal load calculation for phosphorus can be done using the carp population estimate and methodology described in LaMarra (1975) from experiments completed in Minnesota. LaMarra calculated total phosphorus (TP) loading rates (1.07-2.18 mg $P/m^2/day$) from carp using carp biomass density (200 kg/ha). For calculating internal loading due to carp, we use the more conservative factor of 1.07 mg $P/m^2/day$ and carp biomass estimate developed for the lake in question.

4.0 Carp Life History

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 that recruit to the adult population. The process of young fish growing into adulthood is known as recruitment.

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 two-three 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 prey 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 during the spawning migration the following year as adults with reproductive capabilities.

Recruitment may happen in a deeper main basin if conditions allow, i.e. high vegetative abundance and low predator abundance. This occurrence is limited when there is an abundance of predator species, such as bluegill sunfish, who are known to predate on carp eggs and larvae. Bass and pike predate upon young carp fingerlings.

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.

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.

5.0 Introduction to Carp Integrated Pest Management (IPM)

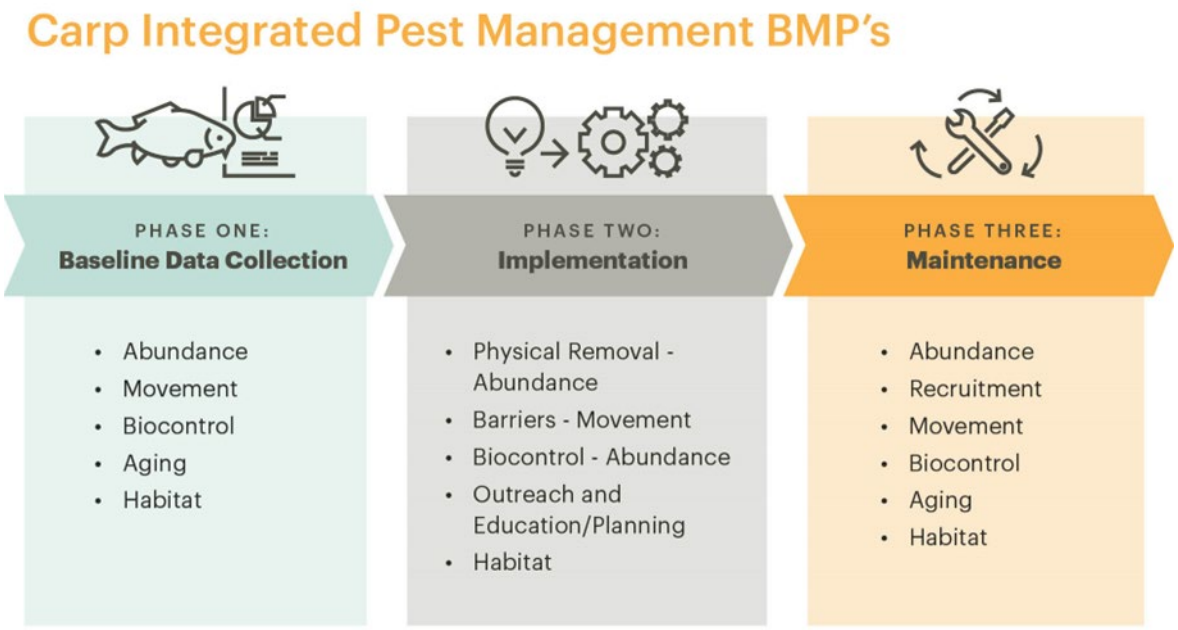

FIGURE 6: PHASES OF TYPICAL CARP IPM PROGRAMS.

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 populations sustainably. An Integrated Pest Management (IPM) Plan is meant to guide carp mitigation techniques through gathering baseline 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 maintenance that includes monitoring and adapting these actions to the most up to date conditions (Figure 6).

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 Normandale 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.

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 a 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 MNDNR 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 from 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 MNDNR and allowed only on a case-by-case basis.

Fyke-nets

This type of net is standard sampling gear for the MNDNR. They consist of a vertical net section that extends to and is anchored to shore that 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.

Carp Spatial Usage

Understanding movement patterns helps 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

Radiotelemetry is widely used to track animal movements and some tags are specifically designed for use in water. These can be used to implant into Carp so that movement in lake and through the watershed can be tracked. Tracking using this method can be done with a stationary antenna but is mostly collected using manual survey data where tags are located by boat or land. This information can be used to describe aggregation areas or movement that can be associated with springtime spawning migration. Both 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 on a 24/7 basis. Other species could be tagged with PIT tags and tracked with the use of stationary antennae's as well. This would help to understand movement patterns and how blocking or removal techniques can be altered to avoid impact to native species.

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. These cameras can be accessed at any time or triggered to record at intervals to catch potential carp movement. In the springtime, recordings or viewing would be most important after rain events as these are known to spur carp movement.

Acoustics

Acoustic telemetry provides another option for monitoring absence/presence or fine scale fish movements using low frequency signals to monitor fish populations. Acoustics use an active signal the same as radio, while PIT is passive. The signal is received by a hydrophone which can be connected to a data logger to capture movement past a "gate" along a waterway. Acoustics may be used in place of a PIT system in locations where water depth and channel width limit the use of PIT as the detection range for acoustics is much larger.

Population Estimate Techniques

A variety of methods are available for estimating fish abundance. Any singular method used may accurately, over, or underestimate the actual population based on sampling error and bias, the size of the population (large), level of effort in sampling, or other factors. The reader should approach the estimates presented with caution and within the context of sampling design, project area, and confidence interval generated with the estimate, and understand that estimates may be adjusted, validated, or simply changed with additional data or improved methodologies. Estimates generated may be thought of in a qualitative fashion i.e., is the population high, moderate, or low. Common carp management uses a biomass density (lbs./acre) unit to quantify and assess the level of potential degradation to the aquatic environs which are/is the subject of the planning document(s). This concept is presented graphically in Figure 7.

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).

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 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 them. For example, a self-cleaning barrier could be placed in a stream that has high level of debris, this type of barrier may be expensive and require a power source.

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. Seine nets are often 1,000 – 3,000 feet in length and strung around an aggregation of carp. 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.

Limitations to seine netting are often times obstructions on the lake bottom. Rocks, logs, or even dense vegetation can limit the effectiveness of a seine netting attempt. These can be alleviated with reconnaissance of known aggregation sites with the use of side scan sonar, dragging chain, and divers that can target and remove obstructions. The MUM technique (described below) can be used in combination with seine netting to move aggregations of carp away from obstructions that have been identified but cannot be moved.

Targeted Electrofishing

Boat electrofishing is used to sample carp. Most times, it is not considered a removal tool. However, in certain conditions, it can be effectively used as a removal activity. Conditions that might trigger electrofishing to capture and remove fish are when aggregations exist in open water, often in the springtime or late fall, and/or carp are trapped near a barrier in a stream setting. Radiotags are a useful tool in identifying aggregations in open water. These aggregations can then be targeted with boat electrofishing to remove carp biomass. This is especially helpful when the biomass is nearing the critical threshold and seine netting is not as effective.

In Stream Trapping Techniques

A variety of methods can be used to trap and remove fish during spawning migration through streams. Examples of these methods could include the push trap (shown in Figure 7), or other trap designs that are specific to the stream reach. This type of operation would require a significant effort April through June to check traps daily and remove carp that are trapped in or around them.

FIGURE 7: NOVEL CONCEPT KNOWN AS A PUSH TRAP INSTALLED IN A STREAM.

The push trap, 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.

Vertical grates or other barriers to stream movement can be used to stop or slow movement of carp, causing them to aggregate out front. Carp can then be trapped in a section of the stream by erecting a barrier behind the aggregation and individuals can be removed using nets and electrofishing (backpack and/or boat).

Baited Traps

Baited traps can include a variety of sizes and shapes including hoop style nets and box nets. A box net trap refers to a mesh net that lays on the lake bottom with net walls around the outside seen in Figure 8. These walls are attached with ropes to vertical metal pipes that extend above the water surface. These ropes are then run to shore so they can be pulled to raise the net walls, trapping the fish inside. The fish are then corralled to a corner and rolled into a holding tank, usually a large flat bottom boat, to be removed from the lake.

FIGURE 8: PHOTO SHOWING A BAITED BOX NET TRAP WITH WALLS RAISED.

A hoop net is a passive capture device that can be checked daily for the presence of carp once the baiting has begun. Carp can swim into an open hoop in the net and get caught after traveling through a throat or restricted portion of the net towards the back as they seek out the bait inside.

Carp are trained to aggregate in these trap areas 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.

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 Normandale 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

As techniques are explored to remove carp biomass, adjustments or new techniques may be necessary to improve efficiencies. WSB has incorporated U.S. Geological Survey (USGS) vetted methods including the Modified Unified Methodology (MUM) of herding and removing carp biomass. This method had been used by the USGS to move and target Asian carp species in riverine systems and includes the use of speaker systems to exploit carps' sensitivity to noise. Aggregations of carp can be moved using speaker systems and strategic net sets help to guide them in direction that is advantageous for capturing carp. This has been especially useful in seine netting attempts that try to avoid known obstructions in the lake.

Innovative techniques are continually being developed as carp management evolves. System specific methods may be developed as a waterbody is explored or more broadly used devices may become important tools.

6.0 Nine Mile Creek Watershed District Normandale Lake IPM Planning and Development

Through this IPM Plan, the NMCWD has developed a holistic approach to carp management, treating the main lake and connected upstream wetlands as a whole. In order to continue to meet water quality goals and protect the ecological balance of the lake as well as reducing phosphorous resuspension, the District has set a goal of reduction to 89 pounds/acre or less of carp biomass sustained for the long-term. As carp management information on the lakes and new techniques are always changing, this IPM Plan will address meeting goals of Normandale Lake and assuring the improvements achieved through state and federal grants continue to support overarching nutrient management goals.

Normandale Lake

This IPM Plan prioritizes Normandale Lake and its lakeshed. Normandale Lake is a popular lake for recreation, including walking and shoreline fishing. Total phosphorus levels have exceeded state standards in years past, although the lake is not on the state's impaired waters list. NMCWD is working to improve water quality and the ecological health of Normandale Lake, which includes working to manage the carp population below the ecologically damaging threshold.

As NMCWD staff have evaluated previous management efforts on the lake, namely the 2018/2019 lake drawdown, 2019 alum treatment, and follow-up aquatic herbicide applications, consideration was taken for the potential impact of carp on degrading the effectiveness of the 2019 alum treatment. Projections suggest an inevitable increase in biomass of carp as the 2019 age class grows unless the population is reduced and further recruitment is diminished or blocked.

The NMCWD concluded that carp management was a cost-effective tool to protect the effective of the alum treatment, while also reducing phosphorus loading to due high levels of carp biomass. However, all the different carp removal tools do not always produce the same result. To that effect, the NMCWD will also consider cost-benefit when choosing carp management goals and tools. At some point, the NMCWD may decide that reducing carp populations to 89 lbs./acre would not be worth the cost, as it may be more expensive to reduce carp populations when the existing biomass is already low, similar to the law of diminishing returns. This will be assessed during each annual update of the IPM Plan.

CARP MANAGEMENT STRATEGIES & Goals

The NMCWD has distinct overarching strategies for carp management. Through this IPM and the previous carp management work and studies conducted on Normandale Lake, carp management goals for Normandale Lake have been set to reduce and maintain overall carp populations to below the water quality threshold. To help achieve successful long-term management without carp population rebound, it is important to also take steps to block recruitment and to understand how the connected system works as a whole to better management the carp population.

Previous studies demonstrate that carp biomass densities of 100 kg/ha (89 lbs/acre) are ecologically damaging. To effectively manage and maintain carp below this threshold, a reduction to a density of 60 lbs/acre has been recommended by WSB. By managing at a lower level, early detection of potential recruitment events may provide managers an opportunity to address the increase in carp population and biomass before it returns to a damaging level.

7.0 IPM Phase 1- Baseline Data Collection

The initial phase of this IPM plan is to gather any relevant scientific information pertaining to the current, past and future carp population in the lake. These data stand as benchmarks for evaluating the effects of

the following implementation phase. It is important to obtain this data to approach and execute implementation in the most cost-effective way that is driven by empirical measurements.

7.1 Carp Abundance Estimates

Carp biomass estimates give managers a way to track progress towards the biomass reduction goal. As with all methods of estimating population abundance, CPUE estimates have error associated with them. To compensate for this error but also to accurately describe carp removal efforts, two estimates are presented. The first is a CPUE carp biomass estimate and the second is mark/recapture methodology. These methodologies are described above in section 5.0. The data collected in the field to obtain the overall estimate via electrofishing CPUE are tabulated in Table 1 below.

TABLE 1 – ELECTROFISHING TRANSECT DATA FOR 2021 AND 2022

	Date	Transect	Time (hours)	Catch	CPUE	Population estimate (individuals)
2021	21-Jun	1	0.3	6	18	3385
		2	0.3	7	21	3930
		3	0.3	8	24	4475
		4	0.3	3	9	1751
	29-Jun	1	0.3	28	84	15369
		2	0.3	23	69	12646
		3	0.4	27	67.5	12373
	15-Jul	1	0.3	8	24	4475
		2	0.3	17	51	9377
		3	0.3	15	45	8288
		4	0.5	10	19.4	3631
2022	6-Jun	1	0.4	28	80	14643
		2	0.3	19	57	10467
		3	0.3	31	93	17003
	7-Jul	1	0.3	5	15	2841
		2	0.3	8	24	4475
		3	0.3	9	27	5020
	18-Jul	1	0.3	6	18	3385
		2	0.3	4	12	2296
		3	0.3	11	33	6109

Each removal event using baited box net traps in 2021 and 2022 was tabulated and organized to follow the population reduction trends. The first three columns represent the three independent variables used to calculate that event's population estimate. These estimates are displayed in Table 2 below.

TABLE 2 - DATA FROM EACH RECAPTURE EVENT AND EACH EVENT'S INDIVIDUAL POPULATION ESTIMATE.

Date	Total captured (n)	Total marks (K)	Total recaptured (k)	Population estimate (N)
7/29/2021	201	151	0	30703
8/5/2021	124	151	1	9499
8/12/2021	105	200	2	7101
8/18/2021	365	200	4	14712
8/19/2021	205	200	1	20702
9/1/2021	498	200	9	10029
8/2/2022	167	322	2	18087
8/4/2022	82	389	5	5394
8/12/2022	124	389	6	6963
8/17/2022	323	387	12	9669
8/29/2022	114	385	4	8877
9/1/2022	36	385	1	7140
9/8/2022	327	385	5	21100

Each year's abundance estimate and associated biomass estimate using both methods are displayed in Table 3 for comparison and tracking purposes.

TABLE 3 - POPULATION AND BIOMASS DENSITY ESTIMATES USING BOTH ELECTROFISHING CPUE AND MARK/RECAPTURE METHODS

	CPUE		CMR	
	Population estimate	Biomass estimate (pounds/acre)	Population estimate	Biomass estimate (pounds/acre)
2021 pre-removal	8833 ± 5346	140 ± 29	15458 ± 8116	277 ± 159
Remaining post-removal	7333	111	13958	251
2022 pre-removal	8973 ± 6202	166.5 ± 50	13,178	199.7 ± 102
Remaining post-removal	7898	145	12,103	182.9

Understanding the tables and understanding those results in terms of effect on the lake can be complex. For educational purposes, we have aligned those results diagrammatically in Figure 9.

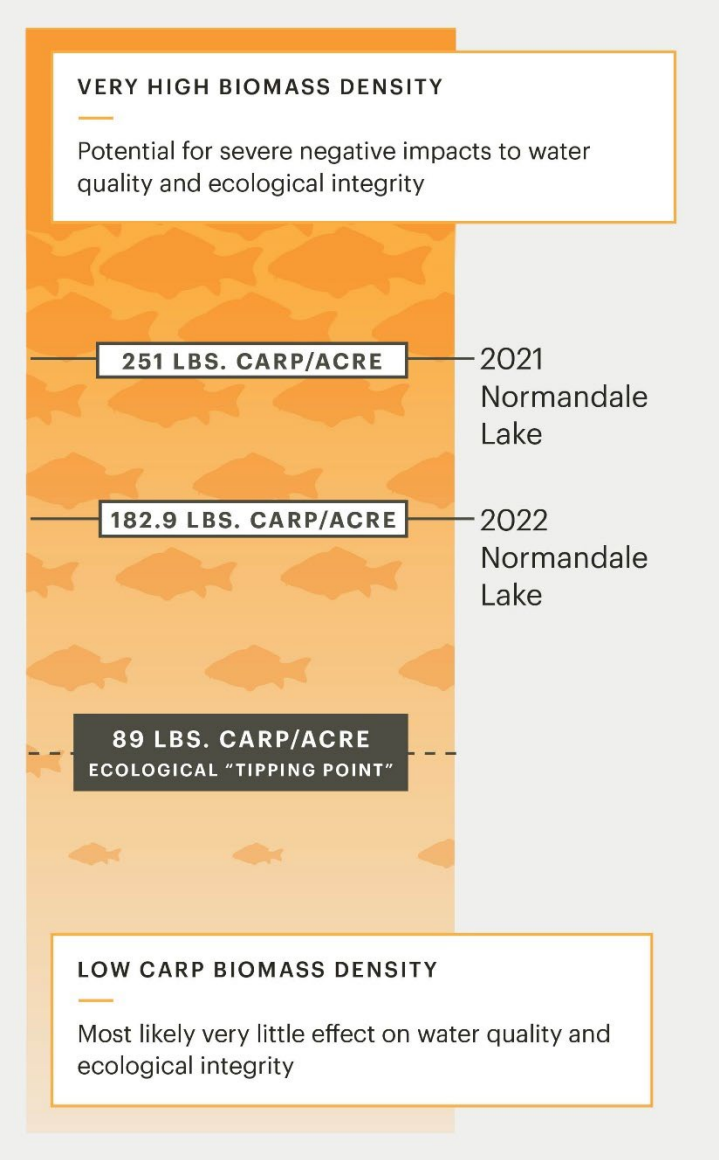

FIGURE 9: AN ILLUSTRATION OF CARP BIOMASS ESTIMATES AND HOW IT CAN MOVE TO ACHIEVE GOALS FOR REDUCING THE ECOLOGICAL IMPACT. WE PRESENTED THE RESULTS OF THE MARK AND RECAPTURE BIOMASS ESTIMATES FOLLOWING REMOVAL EFFORTS FOR THAT YEAR.

- *BDC1 Complete a boat electrofishing CPUE estimate for Normandale Lake*
- *BDC2 Generate a mark and recapture estimate for Normandale Lake*

7.2 Internal TP Load Calculations

Using the abundance estimates from the previous sections, we have developed an internal TP load estimate for Normandale Lake at approximately 405 lbs. of TP per year. Other likely sources of internal TP load would be anoxic sediment release as well as the small patches of CLP remaining after the 2018/2019 drawdown.

- *BDC3 Calculate internal P load from carp based on data collected in BDC1 and BDC2*

7.3 Movement

Determining how carp use the system is critical to the development of the carp IPM plan. Understanding movement patterns will allow NMCWD staff to identify potential nursery sites, migration routes, and wintering areas where carp may be vulnerable to large scale biomass removal or blockage to movement to limit recruitment.

7.3.1 Radio Telemetry

To track movement, the NMCWD commissioned 12 low frequency radio tags to be implanted in carp in spring 2019. Carp Solutions staff actively tracked the 2019 radio-tags using a loop antenna every two weeks from May through June of 2019. During those surveys a minimum of 5 tagged individuals never left the main lake. Several tags were not located after the initial survey on May 14th, 2019. Two tags were located in upstream backwater areas of Nine Mile Creek on May 28th, 2019, seen in Figure 10 below. Since this effort, no further surveys or radiotags have been implanted to track the movement of carp.

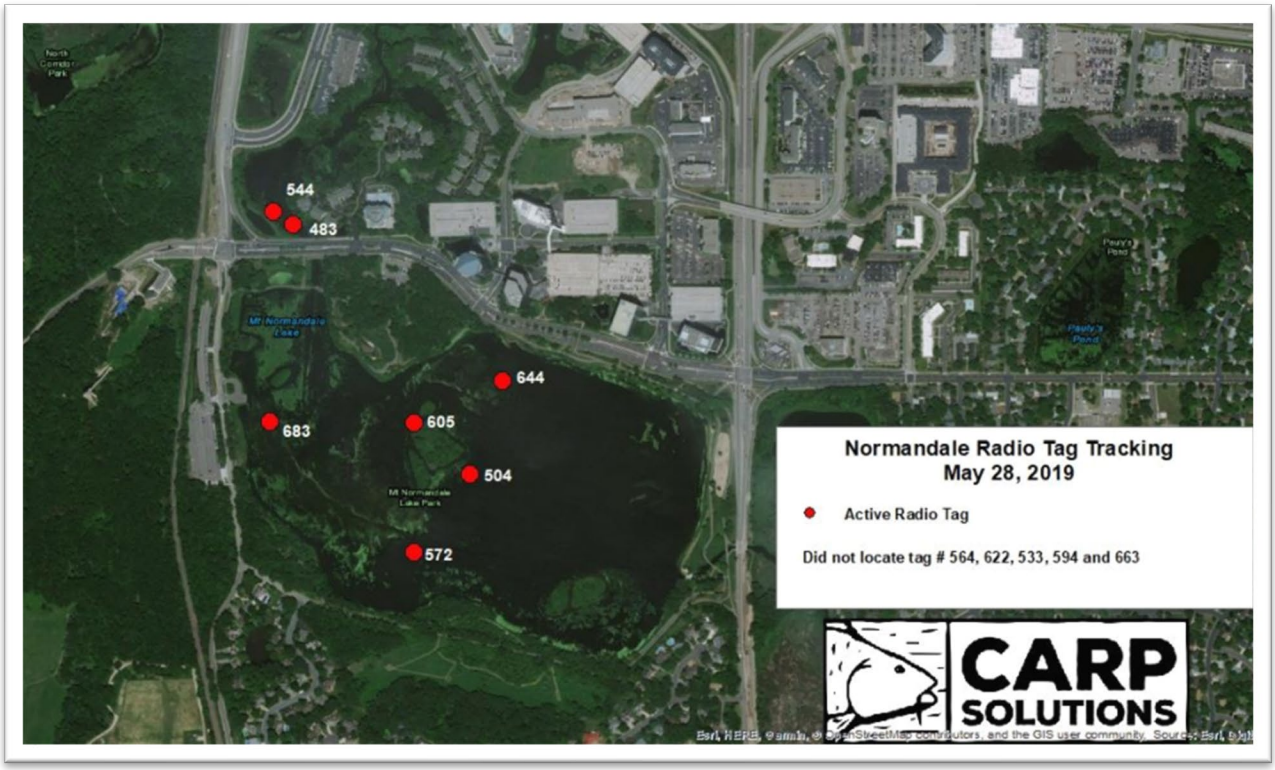

FIGURE 10: MAP OF RADIOTAGGED CARP LOCATIONS ON MAY 28, 2019.

- *BDC6 Implant 12 adult carp with low frequency radio transmitters*
- *BDC7 Complete weekly surveys during carp spawning period to identify migration routes and nursery sites*

7.3.2 PIT Tags, Stations and Data Summary

Passive integrated transponder (PIT) tags were implanted and released in 200 carp in 2021 and 199 more in 2022. The progression of PIT tag implants over time is explained in Table 4 below. These PIT tagged carp were monitored via an automated station from July 2021 through

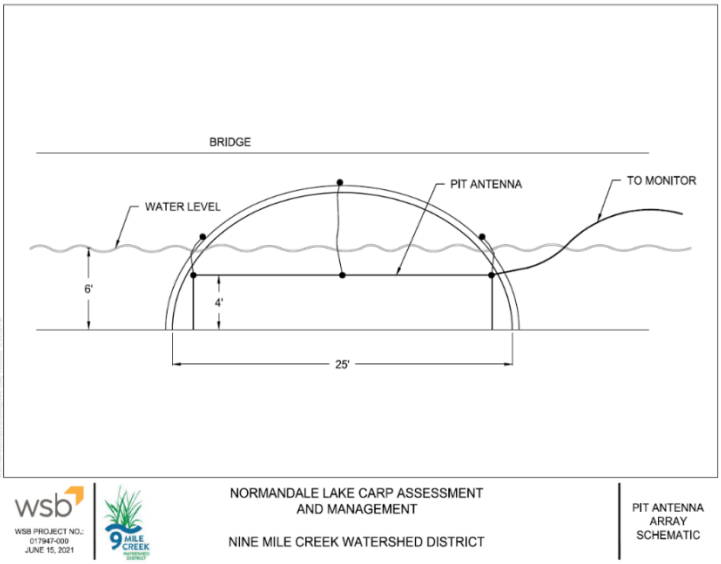

FIGURE 11: SCHEMATIC DESIGN FOR SUBMERGED PIT ANTENNA AT THE NORMANDALE INLET.

November 2022 displayed in Figure 11. Migration routes that allow access to shallow basins that carp exploit for use as nursery sites are the support mechanism for carp recruitment in those systems where carp spawn outside the main basins. Carp have evolved to seek out these sites since hard winters in Minnesota periodically freeze shallow basins resulting in winterkill of most or all fish species. Absence of predator species, such as bluegill sunfish, greatly increase the chance for survival of carp eggs and larvae. PIT tags and stationary receivers are currently being used to track the movement of carp each season.

Carp movement out of Normandale Lake is being studied using PIT tags and an automated antenna at the 84th Street bridge. The timing and environmental conditions in which carp tend to migrate through the short stretch of Nine Mile Creek from the walking bridge and the 84th Street bridge is important to not only prevent passage to potential spawning grounds, but also important to adult removal efforts. Angler reports of catching carp in the Nine Mile inlet to Normandale just downstream of 84th Street, as well as the documentation of radiotagged carp being detected in upstream areas, suggested movement out of the lake was occurring. In response to this, the antenna was installed to attempt to quantify and understand the timing of this movement of carp.

Carp tend to be drawn to faster moving water through creeks and channels. This regularly occurs in the spring when snow melt and spring rains trigger higher flow rates in Nine Mile Creek. Therefore, it was important to plot PIT antenna detections together with nearby rainfall events in order to explain some of the activity at the antenna.

In Figure 12 below, the number of unique PIT tags detected each day was plotted throughout the open water period.

TABLE 4 – TABULATION OF PIT TAGS IMPLANTED IN CARP IN 2021 AND 2022. 10 PIT TAGGED CARP WERE REMOVED ON SEPTEMBER 1ST 2021. TWO MORE WERE REMOVED ON AUGUST 12TH, 2022 AND TWO MORE ON AUGUST 17TH, 2022

Date	PIT tags implanted by date	Total assumed PIT tags in Normandale
6/21/2021	26	26
6/29/2021	78	104
7/15/2021	47	151
8/5/2021	49	200
6/6/2022	83	273
7/7/2022	28	301
7/18/2021	21	322
8/2/2022	67	389

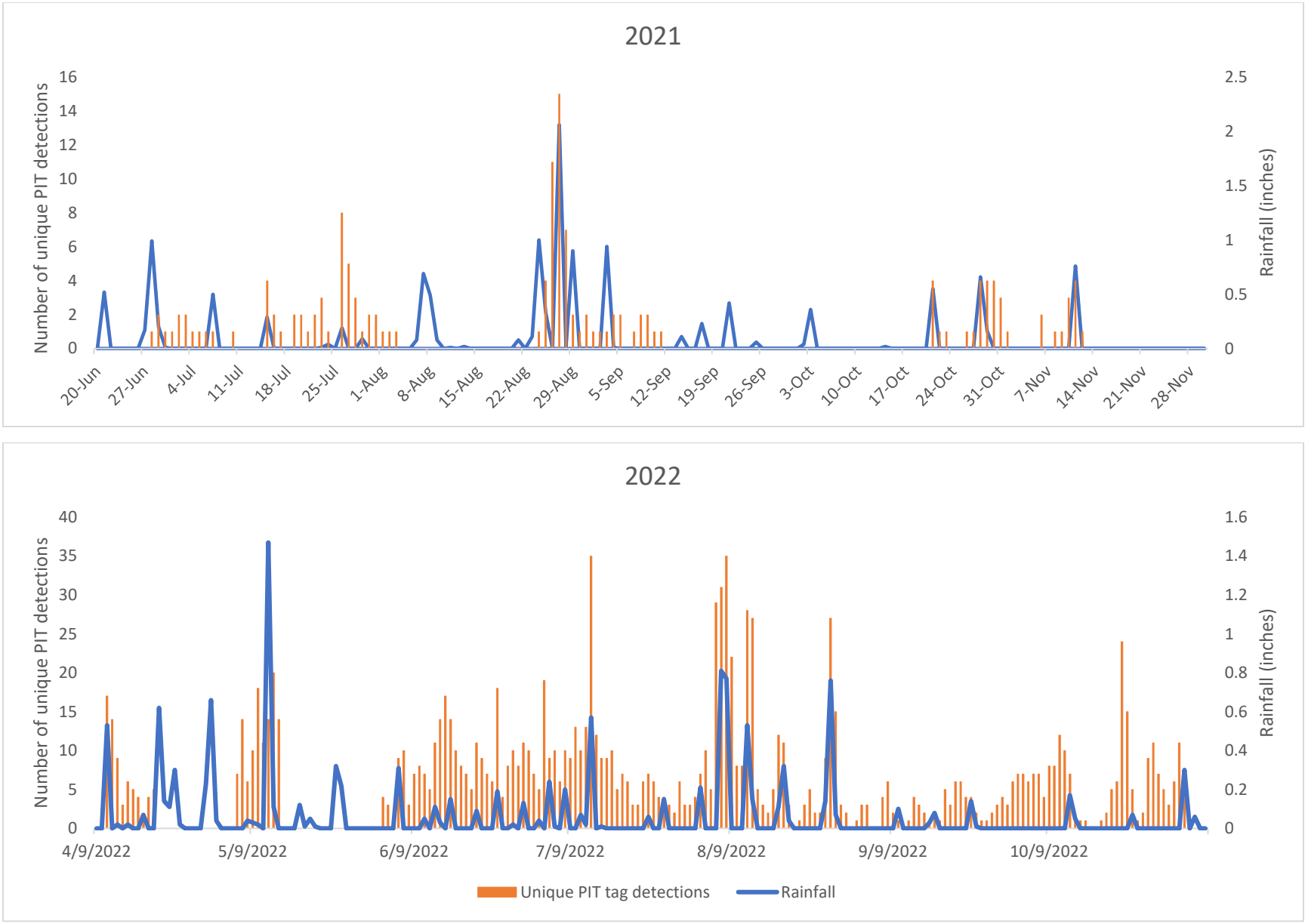

FIGURE 12: MOVEMENT ANALYSIS AT NORMANDALE INLET USING A PIT ANTENNA ARRAY. PRECIPITATION DATA USED FROM COCORAHS MN-HN-110 AT EDINA LAKE PARK.

The PIT antenna was first installed on June 15th, 2021. This is assumed to be after the typical spawning migration season and PIT implants did not begin until the first electrofishing survey on June 21st. Therefore, 2022 is the only year that this movement via PIT tagged carp has been monitored during the typical carp spawning migration season (generally between March and May depending on water temperature). Although there are some exceptions (early August 2021, April 20th through May 1st, 2022), periods of rainfall are closely correlated with carp detections increase with or soon after rainfall events as predicted. In particular, between April 12th and April 17th, approximately 15% of the PIT tagged carp passed antenna and 27% passed between May 5th through May 14th. Combined, 32% of the total tags in Normandale Lake had passed the antenna at least once by May 14th in 2022.

- *BDC8 Implant 200 PIT tags each year until 400 total have been implanted*
- *BDC9 Install PIT station on Nine Mile Creek at 84th street bridge to assess specificity on carp migration through Normandale outlet*
- *BDC11 Assess and report on PIT data*

7.3.3 Remote Camera Monitoring

Stationary cameras could be placed at strategic locations to confirm carp migration routes and/or aggregations of carp during spawning season. These cameras are set up wirelessly and transmit real-time information so that staff can move quickly to coordinate carp removals at optimal times.

7.3.4 Carp Espionage

A volunteer carp sighting program was developed in the Prior Lake Spring Lake Watershed District to gather information from residents who could identify carp sightings and who had the ability to view the waterbodies at all hours of the day. Volunteers were recruited through an outreach campaign on social media. A short form would be filled out with basic information regarding the sighting, along with placing a pin of the location on a map. Carp sightings were broken down into spawning, migration, and groups/clusters. The Carp Espionage program can be found here: https://carp-espionage-plslwd.hub.arcgis.com/. Sightings from this program proved valuable when much of the early spawning activity occurred after work hours and into the night. Having the knowledge carp are showing signs of spawning, WSB could take action to perform removal activities.

7.4 Carp Young of Year and General Fisheries Surveys

Although spawning observations can suggest areas for recruitment, the strength of these recruitment events is not known without sampling using nets or electrofishing in these basins. It is recommended that steps be taken to sample basins suspected of recruitment. Radio-tags and PIT tags can be used to help document springtime movement by adults. Trap netting can be used for small sampling efforts. Another tool for determining potential spawning sites is observing spawning behavior of carp.

Generally, carp spawning behavior is regularly observed from shore around Normandale Lake. At this point, the extent of observable spawning behavior in upstream ponds/wetlands is not well documented. Knowing that adult carp have been documented to leave Normandale Lake upstream in springtime makes the possibility of spawning occurring in these wetlands plausible.

During trap net surveys in 2019 (RPBCWD) and electrofishing surveys in spring of 2020 (Carp Solutions), young of year (YOY) carp, spawned in spring of 2019 following the lake refill period, were found to be very abundant. Since it is believed that carp young do not migrate into the main basins until one or two years old, these fish are suspected to have been spawned in the main basin of Normandale Lake. This shows that, given the right conditions, carp can recruit in Normandale. Given the extreme environmental change from before the drawdown to the lake refill point, and the relatively few YOY that have been captured since then, it is likely that significant recruitment occurs infrequently.

TABLE 5 - SYNOPSIS OF GENERAL FISHERIES SURVEYS IN 2022 DIVIDED BY GEAR TYPE. THE TRAP NET UNIT FOR CALCULATIONS OF CPUE WAS NET NIGHT AND FOR ELECTROFISHING, THE UNIT WAS FISH CAPTURED PER HOUR OF SHOCK TIME.

Species	Gear	CPUE	Count	Average Length (inches)
Black bullhead	Electrofishing boat	37.0	37	6.3
	Standard Trap Nets	1.2	12	7.3
	Mini Trap Nets	0.0	0	
Black crappie	Electrofishing boat	3.0	3	4.6
	Standard Trap Nets	0.2	7	6
	Mini Trap Nets	0.8	2	4.4
Bluegill	Electrofishing boat	82.0	82	4.4
	Standard Trap Nets	13.3	133	4.7
	Mini Trap Nets	31.8	382	4.8
Carp	Electrofishing boat	8.0	8	16.3
	Standard Trap Nets	0.4	4	20.2
	Mini Trap Nets	0.0	0	
Golden shiner	Electrofishing boat	5.0	4	4.8
	Standard Trap Nets	0.0	0	
	Mini Trap Nets	0.0	0	
Green sunfish	Electrofishing boat	5.0	5	3.6
	Standard Trap Nets	3.2	32	3.9
	Mini Trap Nets	15.7	188	3.5
Hybrid sunfish	Electrofishing boat	0.0	0	
	Standard Trap Nets	0.0	0	
	Mini Trap Nets	1.5	18	3.5
Largemouth bass	Electrofishing boat	11.0	11	7.8
	Standard Trap Nets	0.0	0	
	Mini Trap Nets	0.0	0	
Northern pike	Electrofishing boat	3.0	3	21.2
	Standard Trap Nets	0.5	5	25.1
	Mini Trap Nets	0.1	1	20.8
Pumpkinseed	Electrofishing boat	41.0	41	3.6
	Standard Trap Nets	5.8	58	3.9
	Mini Trap Nets	21.6	259	3.6
White sucker	Electrofishing boat	2.0	2	9.1
	Standard Trap Nets	0.0	0	
	Mini Trap Nets	0.0	0	
Yellow bullhead	Electrofishing boat	9.0	9	6.9
	Standard Trap Nets	0.7	7	6.1
	Mini Trap Nets	0.3	4	6.1
Yellow perch	Electrofishing boat	1.0	1	4.8
	Standard Trap Nets	0.0	0	
	Mini Trap Nets	0.0	0	

General fisheries data collected by RPBCWD and WSB in 2022 (shown in Table 5) was part of the fishery assessment protocol and is introduced in section 1.0. A baseline assessment of the fishery is important to identify and understand any impacts to the species assemblage and size/age structure as management is carried out, determine if biological control may be an option, and to set goals in regard to fisheries.

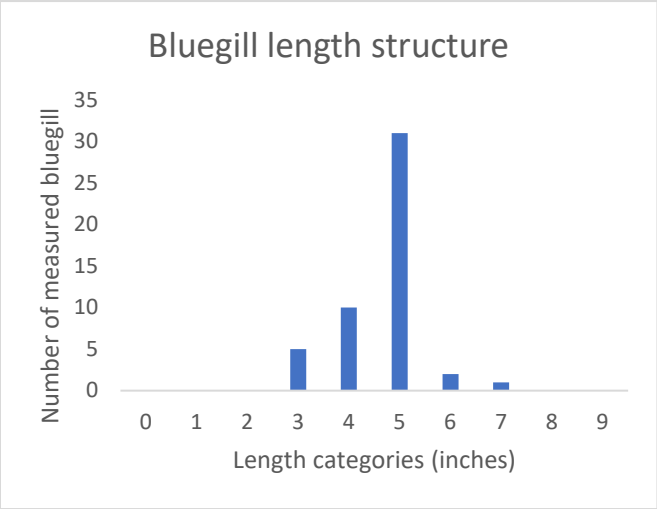

FIGURE 13: BLUEGILL SIZE STRUCTURE FROM 2022 ELECTROFISHING AND TRAP NET SURVEYS.

Species that were sampled in all surveys (2018 through 2022) included black bullhead, black crappie, bluegill sunfish, common carp, golden shiner, green sunfish, hybrid sunfish, largemouth bass, northern pike, pumpkinseed sunfish, and yellow bullhead. During electrofishing surveys in 2022, yellow perch and white suckers were also sampled. Black bullhead and sunfish sp. were generally most abundant. In 2022, most bluegill sampled were between 4-5 inches in length shown in Figure 13. This trend is similar to results of other trap netting efforts in 2018-2020. The results suggest consistent recruitment but a lack of large bluegill sunfish (>6 inches).

According to the MNDNR, Normandale is generally not an actively managed lake for fisheries. Following documented winterkills, they will stock pairs of bluegill and black crappies in order to begin the natural repopulation process. On certain occasions, largemouth bass have been stocked in small numbers.

- *BDC13 Complete targeted YOY and juvenile carp and bluegill surveys in Normandale Lake*

7.5 Habitat Evaluation

Habitat is the critical component to support a resilient and robust fishery. In this document, habitat is defined as the water quality, aquatic vegetation, substrates, bathymetry, and in-lake structure within Normandale Lake.

Water quality and vegetation is described generally for Normandale Lake in Section 1, but additional information on submergent aquatic vegetation is included as it ties overall lake health and can be a direct benefit from carp management.

Submergent aquatic vegetation (SAV) abundance and plant area coverage (PAC) can also be utilized to gauge the change and subsequent improvements in lake ecology. The district collects data on SAV using point-intercept sampling and biomass aquatic plant surveys (data found in 2019 WQ Monitoring report). Number of species surveyed in Normandale shows steady increases from 2002 through 2022 (Figure 5).

In general, historical assessments of aquatic vegetation suggest ample habitat to be used for refugia and foraging is present and healthy in Normandale Lake. Sandy substrate for nesting bluegill is available in more than half of the shoreline. Coarse woody debris is present in many places around the shoreline but not be evenly distributed.

- *BDC15 Complete an ecological assessment to evaluate riparian and/or in lake habitat*

7.6 Carp Size Structure

Documenting size structure (length and weight) allows managers to observe trends in reproduction and recruitment when using size as a surrogate for age as well as determine how the size structure changes in response to management activities. The trend of age class growth is clear in Figure 14. Carp length and weight data has been collected almost every year on Normandale Lake. Weight data is a required metric for determining total and per acre biomass.

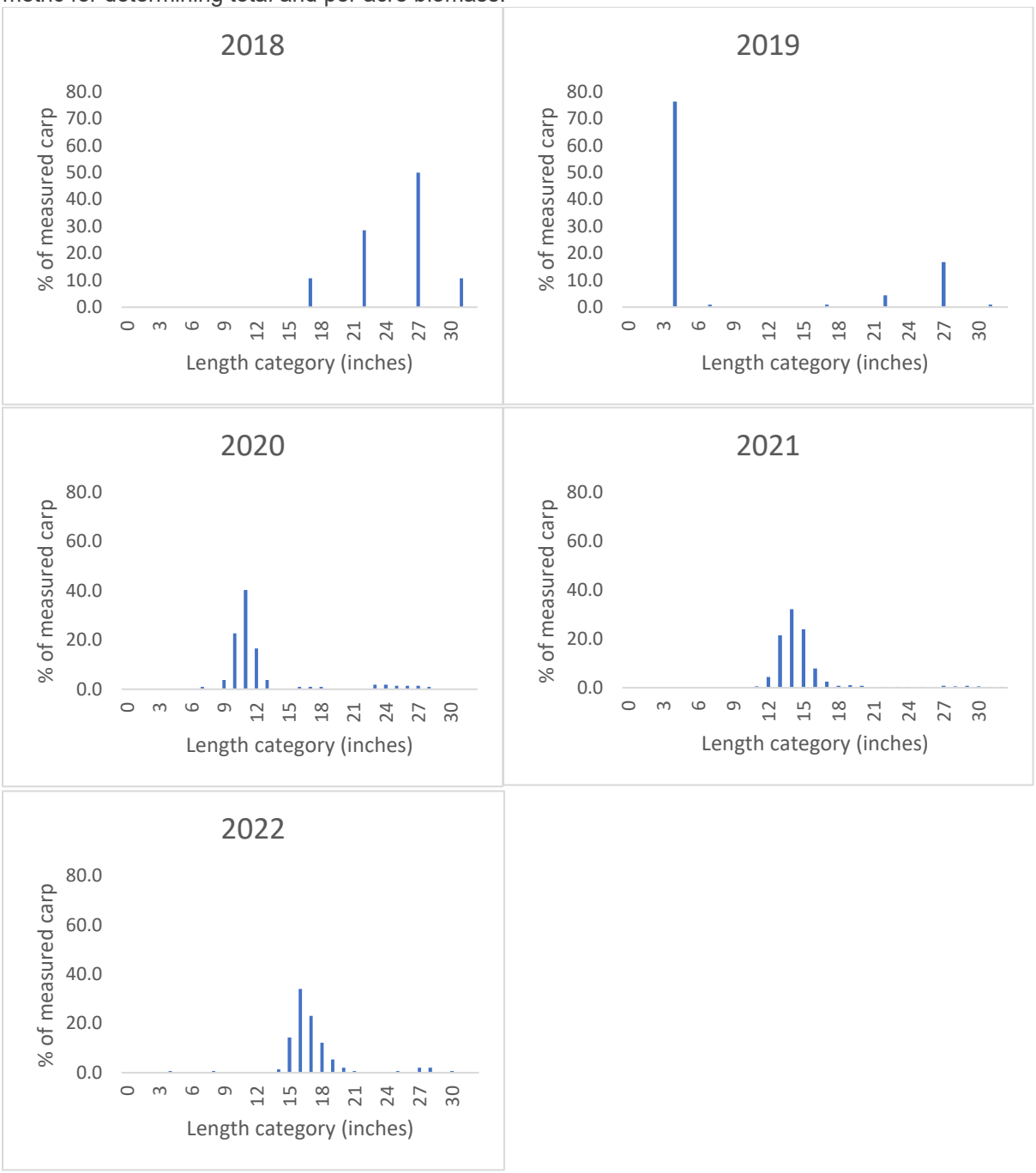

FIGURE 14 HISTORICAL CARP LENGTH STRUCTURES BY YEAR. DATA FROM 2018 AND 2019 EXTRAPOLATED FROM RPBCWD DATA. DATA FROM 2020 EXTRAPOLATED FROM CARP SOLUTIONS REPORT.

Figure 15 helps to explain the small increases in biomass estimates for Normandale Lake even when the population decreases. This is due to the average carp weight, which is increasing each year.

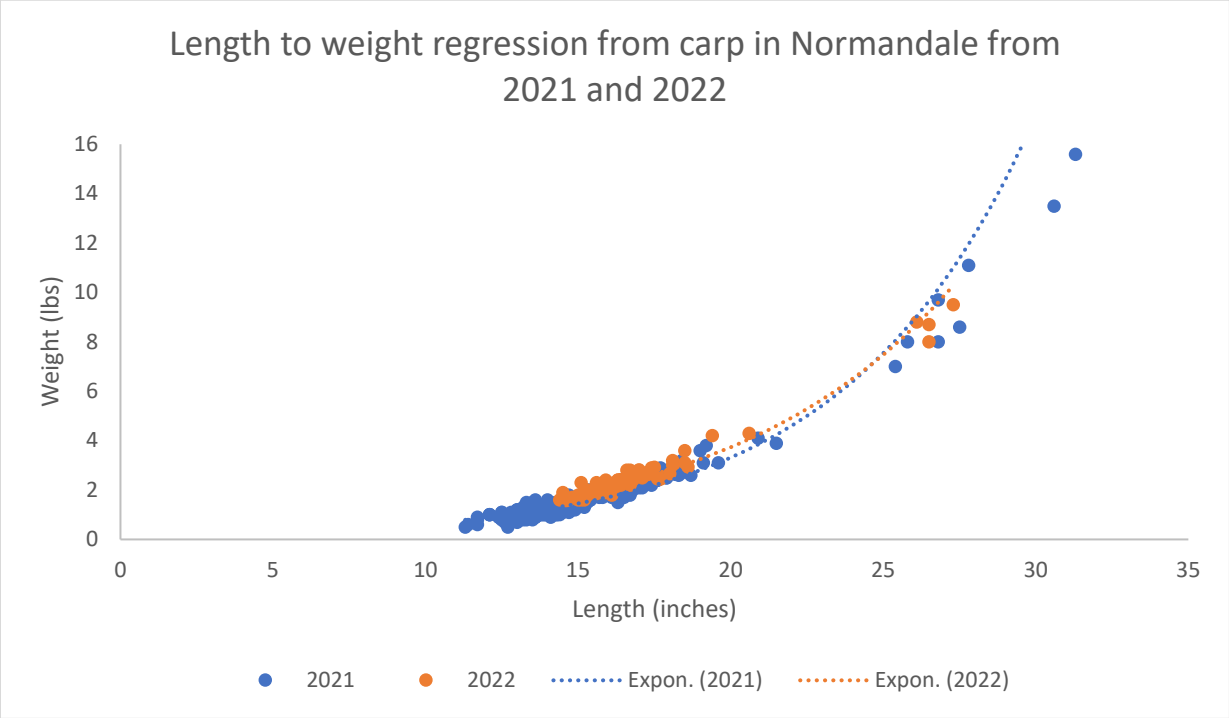

FIGURE 15: A SAMPLE OF CARP IN 2021 AND 2022 WERE MEASURED FOR LENGTH AND WEIGHT TO TRACK CHANGES IN THE OVERALL BIOMASS DENSITY OF CARP IN NORMANDALE LAKE.

7.7 Age structure analysis

An understanding of the historical recruitment of Normandale Lake allows NMCWD to assess the environmental conditions in which carp spawning is most successful in producing surviving young of year. Figure 16 displays the number of carp out of a sample of 48 and their associated ages. The main takeaways from the analysis are that Normandale Lake appears to have supported small but consistent recruitment on most years from 2018 back to the late 1980s. The single carp aged at 50 years old may have been one of the first carp to invade Normandale Lake as it was being built.

For management purposes, this indicates that carp continue to recruit in the lake and the population will slowly rebound if the recruitment is not reduced further and/or the adult population isn't knocked back to a low enough abundance that bluegill and other native predators will be able to completely consume all eggs, larvae, and juvenile carp. Most importantly, this data shows that highly disturbing environmental situations (like a lake drawdown event) can result in a high recruitment event.

- *BDC14 Collect a subsample of 50 individual carp for otolith removal and analysis*

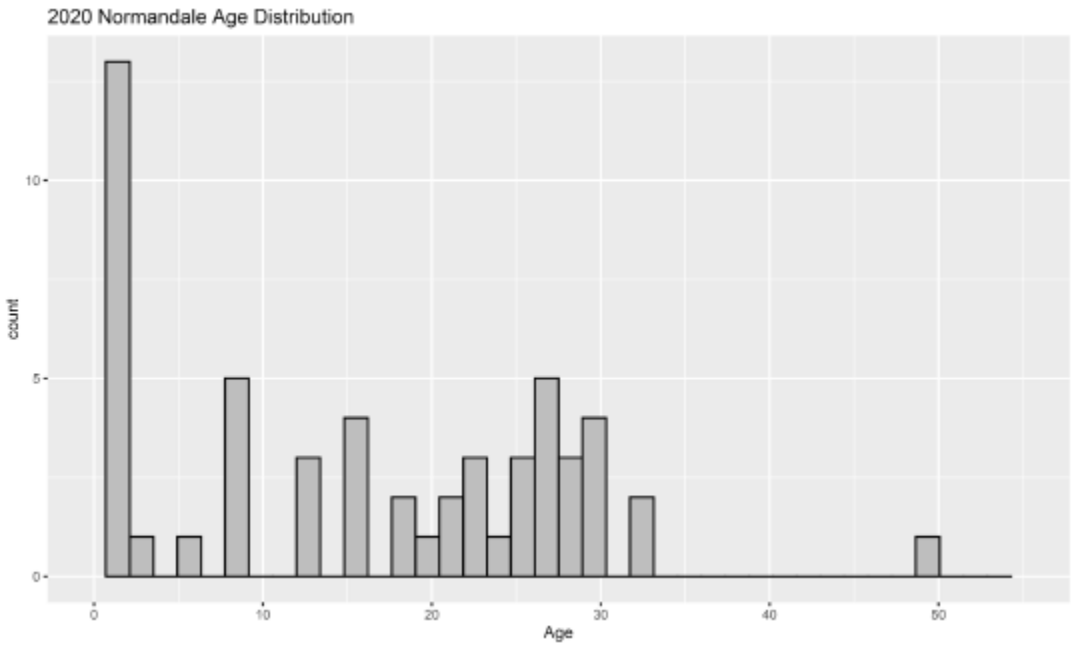

FIGURE 16: HISTOGRAM DISPLAYING AGE OF A SAMPLE OF 48 CARP COLLECTED IN 2020. THE SPIKE AT AGE 1 CONFIRMS THE VERY SMALL CARP WERE SPAWNED IN 2019. DATA PROVIDED BY CARP SOLUTIONS REPORT.

7.8 Baseline Data Collection Data Gaps

7.8.1 Survey of upstream stormwater ponds

To date, there has not been a formal survey via trap netting or electrofishing for the presence of carp in upstream waterbodies. This would include Josten's Pond as well as the wetland just west of East Bush Lake Road. It has been documented through radiotelemetry and PIT antenna data that carp leave the lake through these wetlands, but it is unknown if they function as important nurseries to Normandale Lake.

- *BDC4 Surveys of upstream ponds and wetlands to determine presence of adult and YOY carp.*

7.8.2 Upstream Movement Patterns

Other than the spring radio telemetry surveys conducted in 2019 and PIT data at the 84th Street Bridge in 2021 and 2022, there is little understanding on the extent and timing of movements of adult carp to upstream waters. This data could be collected via PIT antenna stations monitoring 24/7 at periodic points along Nine Mile Creek documenting the extent of the travel of carp from Normandale Lake to upstream water bodies.

7.8.3 Immigration of carp outside of Normandale Lake

Although population estimates have inherent variability, which can take continuous moderate removal efforts to notice a trend of decreasing population estimates, it is possible that carp could be entering Normandale Lake from upstream water bodies. In addition, it is possible that a portion of the population was not within the lake during certain days of the surveys and removal events used to estimate a relatively static population. PIT antenna data show that carp are detected leaving the lake during most times of the summer suggesting that the number of individuals actually present in the lake could be fluctuating up and down over the summer. Our methods of estimating the population

works best with a population that has no ways of leaving and returning to the lake while being estimated. Further information could be gathered to determine to what degree this is occurring.

- *BDC5 PIT tag carp captured during electrofishing survey upstream wetlands*
- *BDC10 Install PIT station(s) on North and/or South Fork of Nine Mile Creek upstream of Normandale Lake*

8.0 IPM Phase 2- Implementation

Plan implementation activities are determined through a data driven approach using the data collected and assessed in previous sections (**primarily Section 7**) of this planning document. To meet the primary goal of this plan, a sustained reduction in carp biomass will be required. The results of abundance estimates indicate that removal should be a primary task; the radio telemetry and PIT station data, along with fisheries survey data, indicate that blocking carp migration may also be a critical component of this IPM.

Remote monitoring of water levels, dissolved oxygen, and fish movements can lead to sudden pivots (rapid response) to different implementation tasks for a specific year. Water level fluctuations during the year can alter migration/movement and precipitate changes to implementation plans and opportunities; extremely high-water levels can result in major issues that negatively affect carp management implementation.

8.1 Removal

Carp can be removed from waterbodies using a variety of methods as documented below. NMCWD will consider the following when deciding which removal methods to employ:

1) **Feasibility:** How likely will this method result in success? What are the obstacles?
2) **Time-Oriented:** Is immediate removal necessary to meet goal deadlines? Will the timeliness affect success of other projects (e.g. alum treatment, herbicide application)?
3) **Cost-Effective:** Is this method worth the cost based on anticipated results?
4) **Effort for Results:** Is this the best method for the amount of effort required? Given limitations of staff, what methods produce the greatest results for the least amount of effort?

Given the wide range of possible removal techniques, it is important for the District to choose the most optimal technique for any given scenario. Factors including season, size of aggregation, location, and general carp behaviors all influence the selection of removal techniques. However, carp populations will continue to diminish and adapt as they approach the 89 lbs./acre threshold. In this scenario, the results of a different approach may have more success i.e. barrier and in-stream removals.

The key is to keep the four primary considerations in mind (feasibility, time-oriented, cost-effective, and effort for results) when making removal technique decisions. A diversified and flexible strategy will help the District continue to make good progress, even in changing conditions.

8.1.1 Baited Box netting

Baited box netting has been the main method of carp biomass reduction. This is mostly due to the bathymetric characteristics and the presence of abundant vegetation make commercial netting success improbable. WSB has leveraged the NMCWD volunteer system to reduce costs of daily bait changing.

WSB also incorporated automated bait monitoring stations using PIT antenna technologies. A stationary antenna was placed around the bait bag so, as tagged carp approached the bait area, they would be detected by the recording reader box on shore. This allowed evaluation of exact timing of aggregations at the bait station to best plan the moment of trapping for better results. The box netting method has been effective at capturing carp in Normandale Lake, but it also has limitations. It works most effectively in 2-4 feet of water with semi-firm lake bottom and little aquatic vegetation, and accessible to volunteers to maintain bait changes. Although locations in 2021 and 2022 have worked, there are not many other places that exhibit the characteristics that maximize the box netting technique. Table 6 below tracks individual removal events.

Box netting now is a confirmed useful technique, but the decision will come to the District of cost-effectiveness as the population approaches the goal and catch rates may decrease over time. WSB continues to develop methods and operations to improve catch rates with less effort.

Now that locations have been identified and the logistics of running a box netting removal program have been streamlined for Normandale Lake, it can be a technique that can be employed quickly if population spikes are identified as part of the maintenance phase in this IPM plan (Phase 3).

I1 Survey Basin for Box net locations

I2 Test Baiting

I3 Install, operate, and remove 3 box nets

TABLE 6: NORMANDALE LAKE REMOVAL EVENTS AND AMOUNT OF BIOMASS REMOVED.

	Date	Number of carp removed	Average Weight (Lbs.)	Lbs. removed	Lbs./Acre removed
2021	29-Jul	201	1.95	392.0	3.4
	5-Aug	75	1.1	82.5	0.7
	12-Aug	105	1.4	147.0	1.3
	18-Aug	363	1.3	471.9	4.1
	19-Aug	204	2.5	510.0	4.4
	1-Sep	498	2.6	1294.8	11.2
	Total	**1446**		**2898.2**	**25.0**
2022	2-Aug	98	2.1	205.8	1.8
	4-Aug	77	3	231.0	2.0
	12-Aug	120	2.7	324.0	2.8
	17-Aug	313	2.9	907.7	7.8
	29-Aug	110	2.5	275.0	2.4
	1-Sep	35	2.5	87.5	0.8
	8-Sep	322	2.7	869.4	7.5
	Total	**1075**		**1943.5**	**16.8**

8.2 Barriers

Barriers may be a critical component of any carp IPM plan. Based on radio and PIT tag data, carp could be exploiting connected waterbodies/wetlands for spawning and recruitment purposes through a network of migration routes connected to Normandale Lake.

Based on this, a barrier designed for the inlet to Normandale between the 84th Street bridge and the park walking bridge is recommended. A wide variety of barrier types exist using velocity, electricity, etc. A fixed physical barrier could be installed with removable panels to allow large migratory fish like northern pike to pass when carp migration is unlikely to occur. A PIT antenna and remote cameras can assist decision making on the timing of the placement of barrier panels to have a minimal effect on native fish movements.
These barriers consist of a series of evenly spaced vertical bars to prevent the movement of adult carp through the barrier while allowing for water flow and the movement of panfish, forage fish, and smaller gamefish. Spacing is typically 1 7/8" between bars based on head measurements of ~2-year old carp that were found to be sexually mature.

The need for this structural barrier could be tested using readily available materials (nets, 2X4 boards, PVC etc.). If it is found to block carp attempting to migrate out of the lake to spawn, a permanent solution could be designed and installed to work toward reducing carp recruitment from winterkill-prone wetlands connected to Normandale.

An alternative idea would be to design a barrier that could function as a removal system as well. This would involve the installation of a rigid "holding pen" that could let carp attempt to move upstream but be blocked when directed into it. They would be guided by a net material that could be raised into place quickly when PIT antennas, water temperatures, and flow rates of the creek indicate a likely time carp would be passing through. This net wall could be removed quickly to allow debris and native fish attempting to migrate in order to have minimal maintenance needed.

If the barrier design is successful at holding an aggregation of carp in the pen, a combination of backpack and boat electrofishing could easily immobilize the adults, where they could be lifted out either by hand into a truck on the walking path next to the creek, or with machinery that could lift many carp from the water to a truck/trailer quickly and efficiently. This method could be a dual-purpose option of recruitment reduction as well as adult biomass removal.

I4 Field survey potential in-stream trapping locations.
I5 Install Normandale Lake inlet barrier/trap and cameras
I6 Monitor and operate trap for ~4 weeks in the second quarter of a given year.

8.3 Bluegill Stocking

Research completed by the Minnesota Aquatic Invasive Species Research Center (MAISRC) showed that bluegill sunfish are the main predator of carp, preying on the eggs and larvae of carp young of year. Carp actively seek out nursery sites that are devoid of these predator fish and proliferate in lakes where bluegill abundance is low. A robust panfish and gamefish population may act as biological control and complements the other IPM strategies (Weber et al., 2012). These predator fish are necessary to prevent carp recruitment after a significant portion of the carp biomass has been removed or to keep carp from establishing in lakes.

In 2017, the Prior Lake Spring Lake Watershed District partnered with the University of Minnesota as part of a graduate research project to assess the effectiveness of using bluegill sunfish as biocontrol for common carp (Poole, 2018). The eastern basin at the 12/17 wetland restoration site was one of four study basins in the Twin Cities metro area used; it was stocked with both spawning carp and adult bluegill to measure the effective rate of bluegill predation on carp eggs. The results from the study indicate that bluegill predation had a major effect on the abundance of post-larval carp. In the 12/17 wetland study basin, there 0% recruitment of carp during the study period.

Historical data on bluegill populations in Normandale Lake suggest bluegill populations are healthy and should be abundant enough to prevent significant recruitment events within Normandale Lake. If surveys of upstream wetlands show evidence of YOY carp survival coupled with low bluegill populations, WSB will work with NMCWD and the MNDNR to plan for appropriateness and feasibility of bluegill stocking in these wetlands.

8.4 Aeration

NMCWD and Barr Engineering are studying oxygen conditions in Normandale Lake to consider if improving oxygen conditions in the lake would increase chances of sensitive native fish like bluegill from encountering winterkill and also reduce anoxic sediment release of phosphorus. An aeration system may be one way that oxygen conditions could be improved in the lake, if necessary. This may help ensure biocontrol agents are sustainably managed to keep carp recruitment to a minimum.

8.5 Carp Disposition Options

To date, WSB has been transporting carp carcasses to offsite burial locations. This option is one of few that are permitted through the MNDNR Fisheries Research permit given for carp removal operations. It is unlikely that enough pounds are captured in one event to make it cost-effective to send a FisH2o truck for live transport to market. With future research, WSB hopes to be permitted to offer carp carcasses for more useful purposes.

Options for the disposition of removed carp could include, but are not limited to:

- Rendering/Fertilizer
- Organic Recycling
- Animal Feeding Operations
- Burial
- Incineration

9.0 IPM Phase 3- Maintenance

9.1 Update Population estimates

As the implementation phase progresses, we expect the overall population to be steadily decreasing. Tracking this progress is, as previously mentioned, important to understanding what and how those tasks are working. Although annual estimates of abundance is not likely necessary, periodic surveys every 2-3 years is valuable in confirming progress toward the goal. It also allows opportunities to detect significant changes that can be addressed before the changes become too difficult to reverse. For example, if another recruitment event produces another large class of young carp, techniques specifically designed to mitigate the impact of those small carp before growing to adults can be implemented.

M1 Complete CPUE abundance estimate once every 2-3 years on Normandale Lake after the biomass density goal is met

9.2 Sampling for YoY and Juvenile

Using standard sampling methods in addition to electrofishing surveys can detect large recruitment events that can be compared to index results of trap netting efforts of previous years. Leveraging understood and potential outcomes based on those periodic surveys can allow the NMCWD to act quickly to mitigate the impacts of large changes in the population.

9.3 PIT Monitoring

Continued understanding of number of individuals moving, distance traveled, direction of travel, and implications to the evaluation of the carp population in Normandale Lake can be better understood with continuous PIT antenna monitoring in strategic places in the lakeshed. Antennas at the Normandale inlet at 84th Street teamed with antennas in each fork of the Nine Mile Creek upstream would gather information that could dictate any needed management upstream of the lake. In addition, PIT antennas can optimize timing of trapping operations, whether those operations are around a barrier or using baited box net removal methods.

9.4 Barriers

Conceptual designs and practices are in the process of development and evaluation for efficacy of blocking carp spawning migration as well as minimizing the impact to native species and safety to park visitors. Using automated systems to monitor passage by carp can reduce the effort required to run the barrier and can be optimized for the situation. For example, water temperature monitoring, PIT tag alarms, and remote cameras to observe fish passage could be employed to reduce the maintenance required to keep the barrier operational.

9.5 Removals

As previously mentioned, a spike in population is detected after implementation goals are met could trigger rapid response actions. It would be anticipated that the earlier action is taken, the less overall effort would be required to continue to meet goals.

9.6 Bluegill Stocking

The MNDNR has noted that the management plan for Normandale to this point only included stocking of panfish like bluegill and black crappie following documented winterkill events in efforts to jumpstart natural reproduction. Observations around the lake each spring could trigger the need for accelerated restocking efforts in cooperation with the MNDNR. In addition, periodic general fisheries and targeted bluegill surveys could also trigger accelerated discussions if a significant drop in panfish populations is determined.

9.7 Ageing

Collecting a follow up sample of carp for ageing purposes allows the NMCWD to determine if any age classes were spawned and survived since the previous ageing analysis was completed. The strength of those age classes (proportion of the population represented by each age class) can be compared to original baseline data collection results to forecast effort required to mitigate the impacts of those age classes. The NMCWD can then more accurately plan for the future.

9.8 Standard Fish Surveys

To evaluate the ecological health of the fishery in Normandale, periodic standard fish survey with MNDNR standard traps can be used to compare to previous years of surveys. These trends can help determine the impacts of carp management on the health of the lake's fish populations. These surveys can be doubled with 9.2 and 9.1 to be most cost-effective.

9.9 Innovation Process

New technologies and methods are being continuously developed. Applying a wide range of tactics is necessary to continue to remove biomass that has been sensitized to previous techniques and has learned to avoid capture. WSB will apply any emerging and appropriate methods to meet goals in a sustainable manner.

10.0 Plan Schedule

Baseline Data Collection Phase

Task ID	Sub-Phase	Phase- Baseline Data Collection	Status	2018	2019	2020	2021	2022	2023 Q1	2023 Q2	2023 Q3	2023 Q4	2023 Q1	2023 Q2	2023 Q3	2023 Q4
BDC 1	Abundance	Complete a boat electrofishing CPUE Estimate for Normandale	Complete													
BDC 2		Generate a mark and recapture estimate for Normandale Lake	Complete													
BDC 3		Calculate internal P load from carp based on data collected in BDC1 and BDC2	Complete													
BDC 4		Surveys of upstream ponds and wetlands to determine presence of adult and YOY carp.	2023													
BDC 5	Movement	PIT tag carp captured during electrofishing survey upstream wetlands	2023													
BDC 6		Implant 12 adult carp with high frequency radio transmitters	Complete													
BDC 7		Complete weekly surveys during carp spawning period to identify migration routes and nursery sites	Complete													
BDC 8		Implant 200 PIT tags each year until 400 total have been implanted.	Complete													
BDC 9		Install PIT station on Nine Mile Creek at 84th street bridge to assess specificity on carp migration through Normandale outlet	Complete													
BDC 10		Install PIT station(s) on North and/or South Fork of Nine Mile Creek upstream of Normandale Lake	2023													
BDC 11		Assess and Report on PIT data	Complete													
BDC 12	Biocontrol	Complete baseline fisheries (MN DNR Standard) survey to document assemblage and relative abundance (MN DNR)	Complete													
BDC 13		Complete targeted YoY and juvenile carp and bluegill surveys in Normandale	Complete													
BDC 14	Ageing	Collect a subsample of 50 individual carp for otolith removal and analysis	Complete													
BDC 15	Habitat	Complete an ecological assessment to evaluate riparian and/or in lake habitat	Complete													

Implementation Phase

Task ID	Sub-Phase	Phase-Implementation	Status	2021				2022				2023				2024				2025			
				Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
I1	Physical Removal	Survey Basin for Box net locations	Complete																				
I2		Test Baiting	Complete																				
I3		Install, operate, and remove 3 box nets	In-progress																				
I4		Field survey potential in-stream trapping locations.	Complete																				
I5		Install Normandale Lake inlet barrier/trap and cameras	2024																				
I6		Monitor and operate trap for ~4 weeks in the second quarter of a given year.	2024																				
I7		Complete 4 individual nightly or daily targeted electrofishing removal operations during elevated carp spawning activity or when aggregated in shallow water areas in open water in a given year	2024																				
I8		Complete upstream lake removals as dictated by abundance estimate values starting in 2024	2024																				
I9		Maintain carp biomass removal records	In-progress																				
I10	Administrative and Planning or Outreach and Education	Finalize Normandale Carp IPM in January 2023	In-progress																				
I11		Distribute Plan to NMCWD and City of Bloomington and others identified in this section in February 2023	2023																				
I12		Schedule initial meeting to discuss and identify opportunities to collaborate on completing tasks identified in the plan	2023																				
I13		Schedule meetings as needed and update IPM plan	2023																				
I14		Apply for funding to support Implementation	2023/2024																				

I15	Barriers	Field survey candidate barrier locations (primary) and identify additional locations	2023/2024																				
I16		Design barriers at selected locations	2023/2024																				
I17		Permits for barriers (Local, state, federal based on design)	2023/2024																				
I18		Barrier and camera installation	2023/2024																				
I19	Habitat	Install additional coarse wood structure	??																				
I20		Investigate if aeration systems are needed to prevent winterkill of native predators	2023/2024																				

Task ID	Sub-Phase	Phase-Maintenance	Status	2026	2027	2028	2029	2030
M1	Abundance	Complete CPUE abundance estimate once every 2-3 years on Normandale Lake after the biomass density goal is met	Recommended					
M2		Based on findings on Upstream waterbodies, Update PEs for these ponds on a similar schedule (can alternate and batch CPUEs to save funds)	Recommended					
M3		If a spike in PE is detected, implement removal as a rapid response action	Recommended					
M4	Recruitment	Complete sampling for young of year/juvenile carp and bluegill on Normandale once every 2 to 3 years	Recommended					
M5		Sample documented nursery sites to ensure no spawning or recruitment success once every 2 to 3 years	Recommended					
M6		Stratified random sampling for YoY in hydrologically connected waterbodies every 2 to 3 years.	Recommended					
M7	Biocontrol	Update baseline (MN DNR Standard) survey using the same methodology for comparative analysis every 4 years	Recommended					
M8		Complete Targeted bluegill survey to augment or fill data gaps from standard survey concurrently with standard survey (every 4 years)	Recommended					
M9	Ageing	Collect and assess carp otoliths from a subsample of 50-100 individuals once every 5 years to monitor changes and identify recruitment events or increases in abundance	Recommended					
M10	Movement	Maintain Nine Mile Creek branch antennas to monitor PIT tag migration	Recommended					
M11		Maintain 84th Street bridge antenna to detect movement out of Normandale	Recommended					
M12		Seasonal installation and uninstallation of PIT Stations	Recommended					
M13		Analyze and report on PIT data	Recommended					
M14		Implant additional PIT Tags to increase the number of at-large PIT tags to 500 at any one time	Recommended					

11.0 Partners and Funding

Currently the NMCWD is supplying funding for the carp IPM plan for Normandale Lake.

12.0 2023 Recommendations

The IPM plan has identified the tasks that are yet to be completed as well as tasks that should continue in order to further approach carp management goals. These tasks include:

BDC8	Install PIT station on Nine Mile Creek at 84th street bridge to provide additional specificity on carp migration (date and time) and determine if other tributaries are being utilized.
BDC9	Install PIT station(s) on North Fork of Nine Mile Creek upstream of Normandale Lake
BDC9	Install PIT station(s) on South Fork of Nine Mile Creek upstream of Normandale Lake
I3	Installation of box nets and traps
I3	Deployment of box netting, removing carp from lake, disposal
I3	Uninstall of equipment, decontamination, and patching
I9	Data analysis and IPM updates

WSB will provide a budget and timeline to complete these tasks as dictated by the IPM plan for contracting consideration in 2023.

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