Le Sueur River Watershed

May 2021

Le Sueur River Watershed Stressor Identification Report—Lakes

A study of local stressors limiting the biotic communities in lakes within the Le Sueur River Watershed.

Prepared for the Minnesota Pollution Control Agency.

DEPARTMENT OF NATURAL RESOURCES

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CLEAN WATER LAND & LEGACY AMENDMENT

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Cover photo-Various aquatic plant communities from Lura Lake (top and bottom left), Beaver Lake (bottom right), and Hanska Lake (top right) in southern Minnesota.

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Contents

Contents i
List of Tables ii
List of Figures iii
Key Terms and Abbreviations iv
Executive Summary vi
1. Introduction 1
1.1. Monitoring and Assessment of Lakes 1
1.2. Stressor Identification Process 2
1.3. Summary of Lake Stressors 2
2. Overview of Le Sueur River Watershed Lakes 4
2.1. Background 4
2.2. Monitoring and Summary of Biological Impairments 5
3. Possible Stressors to Lake Fish Communities in the LSRW 10
3.1. Candidate and Inconclusive Causes 10
3.2. Eliminated Causes 13
4. Evaluation of Candidate Causes in Impaired Lakes 15
4.1. Madison Lake (DOW 07-0044-00) 15
4.2. Lura Lake (DOW 07-0079-00) 24
4.3. Bass Lake (DOW 22-0074-00) 31
5. Evaluation of Candidate Causes in Vulnerable Lakes 38
5.1. Reeds Lake (DOW 80-0055-00) 38
6. Conclusions and Recommendations 44
Conclusions 44
Recommendations 45
References 47

List of Tables

Table 1. Summary of lake characteristics and metrics for FIBI tools. 1

Table 2. Summary of potential stressors of biological communities in Minnesota lakes. 2

Table 3. Lake FIBI Tools with respective number of lakes assessed in the LSRW, FIBI thresholds, and lower/upper 90% confidence limits (CL). 5

Table 4. Summary of lakes in the LSRW assessed with FIBI Tools. 7

Table 5. Fish species captured[1] in LSRW lakes assessed as impaired or inconclusive. Sampling method abbreviations colored red represent species that contributed negatively to the FIBI score based on a combination of the species' guilds and the tool used, blue sampling methods contributed positively to the FIBI score, and black sampling methods did not affect the FIBI negatively or positively. Asterisks represent species with historical sampling records in a lake, but the species was not captured during recent FIBI sampling. Dashed lines represent species that do not have historical, or recent, records of their presence in that lake. 8

Table 6. Interpretation of Score the Shore survey data (From Perleberg et al. 2019). 11

Table 7. Summary of the stressors associated with the biologically impaired or vulnerable lakes in the LSRW. 44

List of Figures

Figure 1. FIBI sampled lakes within the Le Sueur River Watershed, and the location of the Le Sueur River Watershed in Minnesota. Black squares represent communities within the watershed and background colors represent Level III ecoregions. 4

Figure 2. LSRW land cover classes, derived and grouped from NLCD 2016 data, with lakes sampled and assessed with FIBI protocols. Lakes that are labeled on the map correspond to lakes assessed as not supporting aquatic life use, were considered inconclusive and vulnerable to future impairment, or were not assessable with FIBI protocols. 6

Figure 3. Map of floating leaf and emergent aquatic vegetation of Madison lake on 08/05/2014. 19

Figure 4. Madison Lake (07-0044-00) fish community and stressors; based on fish index of biological integrity (FIBI) results. 23

Figure 5. Lura Lake (03-0506-00) fish community and stressors; based on fish index of biological integrity (FIBI) results. 30

Figure 6. Bass Lake (22-0074-00) fish community and stressors; based on fish index of biological integrity (FIBI) results. 37

Figure 7. Reeds Lake (81-0055-00) fish community and stressors; based on fish index of biological integrity (FIBI) results. 43

Key Terms and Abbreviations

APM .... Aquatic Plant Management

AMA .... Aquatic Management Area

Contributing watershed .... All upstream areas bounded peripherally by a divide that ultimately drain into a particular watercourse or water body

DOW .... Division of Waters number; in this report, a unique identification number for water basins in Minnesota. Numbering follows the format of XX-YYYY-ZZ where XX is a county code, YYYY is the basin number in that county, and ZZ is the sub-basin identifier

FIBI .... Fish-based lake index of biological integrity; an index developed by the DNR that compares the types and numbers of fish observed in a lake to what is expected for a healthy lake (range from 0–100). More information can be found at the [MNDNR Lake Index of Biological Integrity website]

HUC .... Hydrologic Unit Code

Insectivorous species .... A species that predominantly eats insects

Intolerant species .... A species whose presence or abundance decreases as human disturbance increases

Littoral acres .... In this report, the acres of a lake that are 15 feet deep or less

LSRW .... Le Sueur River Watershed

MDA .... Minnesota Department of Agriculture

MNDNR .... Minnesota Department of Natural Resources

MPARS................................ Minnesota Department of Natural Resources Permitting and Reporting System

MPCA .... Minnesota Pollution Control Agency

Nearshore survey .... In this report, a fisheries survey conducted at evenly spaced, but random sites along the shoreline utilizing 1/8 inch mesh seines and backpack electrofishing to characterize primarily the nongame fish community of a lake

Small benthic-dwelling species .... A species that is small and predominantly lives in close proximity to the bottom

StS .... Score the Shore survey; a survey designed by the MNDNR to be able to rapidly assess the quantity and integrity of lakeshore habitat so as to assess differences between lakes and detect changes over time

TMDL .... Total Maximum Daily Load

Tolerant species ……………… A species whose presence or absence does not decrease, or may even increase, as human disturbance increases

TP …………………………………… Total phosphorus; measurement of all forms of phosphorus combined

USEPA …………………………….. United States Environmental Protection Agency

Vegetative-dwelling species …………………………… A species that has a life cycle dependent upon vegetated habitats

Weight of evidence approach ……………………….. A method of using multiple sources or pieces of information to classify a waterbody as impaired

WMA ……………………………… Wildlife Management Area

WPA ………………………………. Waterfowl Production Area

Executive Summary

Over the past few years, the Minnesota Pollution Control Agency (MPCA) in coordination with the Minnesota Department of Natural Resources (MNDNR) has substantially increased the use of biological monitoring and assessment as a means to determine and report the condition of the state's lakes by examining the current fish communities at multiple sites throughout major watersheds. Fish communities are sampled using a combination of trap nets, gill nets, beach seines, and backpack electrofishing. From these data, a fish-based index of biological integrity (FIBI) score can be calculated, which provides a measure of overall fish community health. More information about the sampling and assessment process can be found at the MNDNR lake index of biological integrity website. If biological impairments are found, stressors to the aquatic community must be identified.

Stressor identification (SID) is a formal and rigorous process that identifies stressors causing biological impairment of aquatic ecosystems and provides a structure for organizing the scientific evidence supporting the conclusions (Cormier et al. 2000). In simpler terms, it is the process of identifying the major factors causing harm to aquatic life. SID is a key component of the major watershed restoration and protection projects being carried out under Minnesota's Clean Water Legacy Act.

This report summarizes SID work related to lakes in the Le Sueur River Watershed (LSRW). The LSRW encompasses over 710,000 acres characterized predominantly as agricultural land, and includes the cities of Eagle Lake, Janesville, New Richland, Wells and Mapleton. The LSRW also contains lakes, rivers, streams, ditches, and wetland complexes.

Of the lakes within the LSRW, six were sampled and assessed using the FIBI to evaluate biological health. Of the lakes that were sampled, three were assessed as not supporting aquatic life use based, in part, on FIBI scores that were below the impairment threshold established for similar lakes. One additional lake was considered vulnerable to future impairment based on FIBI scores near the impairment threshold.

After examining many candidate causes for the biological impairments, the following stressors were identified as probable causes of stress to aquatic life within the LSRW:

- Eutrophication
- Physical Habitat Alteration

This SID report follows a format to first summarize candidate causes of stress to the biological communities at the 8-digit hydrologic unit code (HUC) scale. Within the summary (Section 3), there is information about how each stressor relates broadly to the LSRW, water quality standards, and general effects on biology. Sections 4 and 5 are organized by impaired or vulnerable lake Division of Waters (DOW) number. Each section discusses the available data and relationships to the fish communities in more detail.

1. Introduction

1.1. Monitoring and Assessment of Lakes

The approach used to identify biological impairments in lakes includes the assessment of fish communities present in lakes throughout a major watershed. The fish-based lake index of biological integrity (FIBI) utilizes fish community data collected from a combination of trap nets, gill nets, beach seines, and backpack electrofishing. From this data, an FIBI score can be calculated for each lake that provides a measure of overall fish community health based on species diversity and composition. The MNDNR has developed four FIBI tools to assess different types of lakes throughout the state (Table 1; Table 3). More information on the FIBI tools and assessments based on the FIBI can be found at the MNDNR lake index of biological integrity website. Although an FIBI score may indicate that a lake's fish community is impaired, a weight of evidence approach is still used during the assessment process that factors in considerations such as sampling effort, sampling efficiency, tool applicability, location in the watershed, and any other unique circumstances to validate the FIBI score.

A common misconception regarding assessment decisions based on the FIBI is that if a lake supports a quality gamefish population (e.g., high abundance or desirable size structure of a popular gamefish species), that lake should be considered healthy. This is not necessarily true because both game and nongame fish species must be considered when holistically evaluating fish community health. Oftentimes, the smaller nongame fishes serve ecologically important roles in aquatic ecosystems and are generally the most sensitive to human-induced stress. Likewise, high abundance or quality size structure of gamefish populations will not disproportionately affect the FIBI score because multiple metrics are used to evaluate different components of the fish community and each contributes equal weight to the total FIBI score.

Table 1. Summary of lake characteristics and metrics for FIBI tools.

	Tool			
Lake characteristics	**2**	**4**	**5**	**7**
Generally deep (many areas greater than 15' deep)	X	X		
Generally shallow (most areas less than 15' deep)			X	X
Generally with complex shape (presence of bays, points, islands)	X		X	
Generally with simpler shape (lack of bays, points, and islands)		X		
Species richness metrics				
Number of native species captured in all gear	X			
Number of intolerant species captured in all gear	X	X	X	
Number of tolerant species captured in all gear	X	X	X	X
Number of insectivore species captured in all gear	X			X
Number of omnivore species captured in all gear	X	X	X	
Number of cyprinid species captured in all gear	X			
Number of small benthic dwelling species captured in all gear	X	X		X
Number of vegetative dwelling species captured in all gear	X	X		X

Lake characteristics	Tool			
	2	4	5	7
Community composition metrics				
Relative abundance of intolerant species in nearshore sampling	X		X	
Relative abundance of small benthic dwelling species in nearshore sampling	X	X		
Relative abundance of vegetative dwelling species in nearshore sampling				X
Proportion of biomass in trap nets from insectivore species	X	X	X	X
Proportion of biomass in trap nets from omnivore species	X	X	X	
Proportion of biomass in trap nets from tolerant species	X	X	X	X
Proportion of biomass in gill nets from top carnivore species	X	X	X	X
Presence/absence of Intolerant species captured in gill nets	X	X		
Total number of metrics used to calculate FIBI	**15**	**11**	**8**	**8**

1.2. Stressor Identification Process

Stressor Identification (SID) is a formal and rigorous process that identifies stressors causing biological impairment of aquatic ecosystems. The process provides a structure for organizing scientific evidence to support conclusions (Cormier et al. 2000). In simpler terms, it is the process of identifying the major factors causing harm to aquatic life. Stressor identification is a key component of the major watershed restoration and protection strategy (WRAPS) projects being carried out under Minnesota's Clean Water Legacy Act.

1.3. Summary of Lake Stressors

The MNDNR has developed a separate document that describes the various stressors of biological communities in lakes, including where they are likely to occur, their mechanism of harmful effect, Minnesota's standards for those stressors where applicable, and the types of data available that can be used to evaluate each stressor (MNDNR 2018; Table 2). Many literature references are cited, providing additional sources of information. The document is entitled "Stressors to Biological Communities in Minnesota's Lakes" and can be found on the MNDNR lake index of biological integrity website. Additionally, the United States Environmental Protection Agency (USEPA) has information, conceptual diagrams of sources and causal pathways, and publication references for numerous stressors to aquatic ecosystems on their CADDIS website.

Table 2. Summary of potential stressors of biological communities in Minnesota lakes.

Stressor	Examples of Anthropogenic Sources	Examples of Links to Aquatic Biology
Eutrophication	Inputs of excessive nutrients from agricultural runoff, animal waste, fertilizer, industrial and municipal wastewater facility discharges, non-compliant septic system effluents, and urban stormwater runoff	Detrimental changes to aquatic plant diversity and abundance, restructuring of plankton communities, detrimental effects to vegetative dwelling and sight-feeding predatory fishes
Physical Habitat Alteration	Riparian lakeshore development, aquatic plant removal, non-native species	Detrimental changes to aquatic plant diversity and abundance, reduced

Stressor	Examples of Anthropogenic Sources	Examples of Links to Aquatic Biology
	introductions, water level management, impediments to connectivity, sedimentation	diversity and abundance of habitat specialists, reductions in spawning success
Altered Interspecific Competition	Unauthorized bait bucket introductions or unintentional transport, introductory and supplemental stocking activities by management agencies or private parties, angler harvest	Detrimental changes to energy flow, reductions in native species diversity and abundance through predation or competition for resources
Temperature Regime Changes	Climate change resulting from emission of greenhouse gases	Physiological stress and reduced survival, particularly for intolerant coldwater fishes, increases in aquatic plant biomass and distribution
Decreased Dissolved Oxygen	Inputs of excessive nutrients, climate change resulting from emission of greenhouse gases	Suffocation, detrimental effects to locomotion, growth, and reproduction of intolerant fishes
Increased Ionic Strength	Road salt and de-icing product applications, industrial runoff and discharges, urban stormwater and agricultural drainage, wastewater treatment plant effluent	Detrimental effects to intolerant fishes and other aquatic organisms
Pesticide Application	Herbicide applications to aquatic plant communities, runoff and drift from herbicide and insecticide applications to agricultural, suburban, and urban areas	Reduced aquatic plant biomass, reduced abundance and diversity of vegetative dwelling fishes
Metal Contamination	Runoff and leaching from mining operations, industrial sites, firing ranges, urban areas, landfills, and junkyards	Reduced survival, growth, and reproduction of fishes
Unspecified Toxic Chemical Contamination	Runoff and leaching from industrial sites, agricultural areas, mining, logging, urban and residential activities, and landfills, spills, illegal dumping, and discharges from industries, municipal treatment facilities, and animal husbandry operations	Altered food web dynamics, reduced fitness of fishes from chronic exposure

2. Overview of Le Sueur River Watershed Lakes

2.1. Background

The Le Sueur River Watershed (LSRW) encompasses over 710,000 acres characterized predominantly as agricultural land, and includes the cities of Eagle Lake, Janesville, New Richland, Wells and Mapleton (Figure 1). The LSRW also contains several lakes, rivers, streams, and wetland complexes, and is part of two different Level III ecoregions: North Central Hardwood Forest and Western Cornbelt Plains.

Figure 1. FIBI sampled lakes within the Le Sueur River Watershed, and the location of the Le Sueur River Watershed in Minnesota. Black squares represent communities within the watershed and background colors represent Level III ecoregions.

2.2. Monitoring and Summary of Biological Impairments

The FIBI sampling protocols were used on six lakes within the LSRW, however, two of these lakes were not assessable because of small size or a history of winterkill (Figure 2; Table 4). None of these lakes had FIBI scores at or above the impairment threshold that would be considered as fully supporting for aquatic life use (Table 3; Table 4). Reeds Lake (81-0055-00) was assessed as inconclusive information and was considered vulnerable to future impairment (Table 4). Lakes considered to have inconclusive information to make an assessment decision yielded enough sampling data, but results were conflicting or very near an impairment threshold and prevented the ability to make a clear determination about the health of the lake. Three lakes were assessed as not supporting aquatic life use because they had FIBI scores that were below the impairment threshold (Table 4). These lakes include Madison (07-0044-00), Lura (07-0079-00), and Bass (22-0074-00). The remainder of this document will review stressor information for the four LSRW lakes that were either assessed as not supporting aquatic life use or considered vulnerable to future impairment.

Table 3. Lake FIBI Tools with respective number of lakes assessed in the LSRW, FIBI thresholds, and lower/upper 90% confidence limits (CL).

Lake FIBI Tool	Number of LSRW Lakes Assessed	FIBI Threshold	Lower CL	Upper CL
Tool 2	2	45	36	54
Tool 4	0	38	30	46
Tool 5	1	24	9	39
Tool 7	1	36	27	45

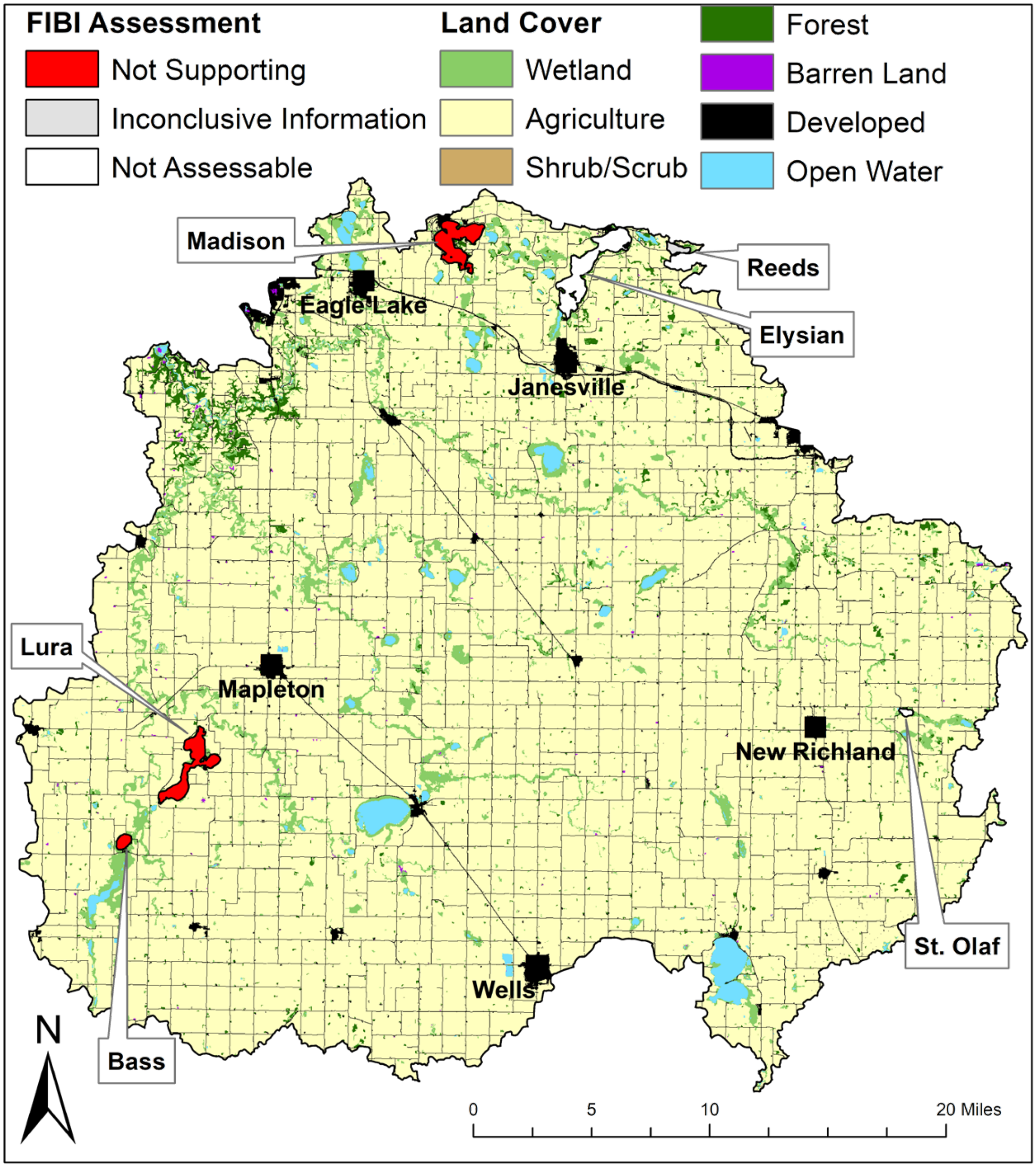


Figure 2. LSRW land cover classes, derived and grouped from NLCD 2016 data, with lakes sampled and assessed with FIBI protocols. Lakes that are labeled on the map correspond to lakes assessed as not supporting aquatic life use, were considered inconclusive and vulnerable to future impairment, or were not assessable with FIBI protocols.

Table 4. Summary of lakes in the LSRW assessed with FIBI Tools.

DOW	Lake Name	County	Nearshore Survey Year(s)	Notes	DNR GIS Acres	FIBI Tool	% Littoral[1]	FIBI Score(s)	Below Impairment Threshold	Assessment Status[2]
07-0044-00	Madison	Blue-Earth	2014, 2015	Sentinel Lake	1,446	2	71	12, 12	Yes, Yes	NS
07-0079-00	Lura	Blue-Earth	2017	1994 reclamation; little connectivity	1,359	5	100	14, 14	Yes, Yes	NS
22-0074-00	Bass	Faribault	2017	N/A	199	7	86	21	Yes	NS
81-0055-00	Reeds	Waseca	2016, 2016, 2018	difficult sampling, tool uncertainty, Vulnerable	195	2	57	44, 43, 35	Yes, Yes, Yes	IC, Vuln

≤ lower CL	> lower CL & ≤ threshold	> threshold & ≤ upper CL	> upper CL	Inconclusive Information

[1] % littoral is the percentage of the lake that is less than 15 feet deep calculated using MNDNR GIS data.
[2] "FS" indicates fully supporting aquatic life use, "IC" indicates inconclusive information, "NS" indicates not supporting aquatic life use, and "Vuln" indicates vulnerable to future impairment.

Table 5. Fish species captured[1] in LSRW lakes assessed as impaired or inconclusive. Sampling method abbreviations colored red represent species that contributed negatively to the FIBI score based on a combination of the species' guilds and the tool used, blue sampling methods contributed positively to the FIBI score, and black sampling methods did not affect the FIBI negatively or positively. Asterisks represent species with historical sampling records in a lake, but the species was not captured during recent FIBI sampling. Dashed lines represent species that do not have historical, or recent, records of their presence in that lake.

Species	Tolerance, Feeding, and/or Habitat Guild[2]	Madison (07-0044-00) (Tool 2)	Lura (07-0079-00) (Tool 5)	Bass (22-0074-00) (Tool 7)	Reeds (81-0055-00) (Tool 2)
Banded Killifish	Nat, Int, Ins, Veg	-	-	-	NS
Bigmouth Buffalo	Nat, Tol, Ins	NS, GN, TN	*	*	-
Black Bullhead	Nat, Tol, Omn	NS, GN, TN	NS, GN, TN	GN, TN	TN
Black Crappie	Nat, TC	NS, GN, TN	NS, GN, TN	NS, GN, TN	NS, GN, TN
Bluegill	Nat, Ins	NS, GN, TN	NS, TN	NS, GN, TN	NS, GN, TN
Bluntnose Minnow	Nat, Omn, Cyp	NS	-	*	NS
Bowfin	Nat, TC, Veg	GN, TN	-	-	-
Brook Stickleback	Nat, Ins	NS	-	-	-
Brown Bullhead	Nat, Omn	TN	-	-	-
Central Mudminnow	Nat, Ins, Veg	-	-	-	NS
Channel Catfish	Nat, TC	GN, TN	GN, TN	GN	*
Common Carp	Tol, Omn	NS, GN, TN	NS, GN, TN	GN, TN	TN
Emerald Shiner	Nat, Ins	NS	-	-	-
Fathead Minnow	Nat, Tol, Omn, Cyp	-	NS	NS	-
Freshwater Drum	Nat, Ins	NS, GN, TN	-	-	-
Golden Shiner	Nat, Ins, Cyp	NS, GN	NS, GN, TN	*	NS
Green Sunfish	Nat, Tol, Ins	*	NS, TN	NS	NS
Iowa Darter	Nat, Int, Ins, Smb, Veg	NS	-	-	NS
Johnny Darter	Nat, Ins, Smb	NS	-	*	NS
Largemouth Bass	Nat, TC	NS, GN, TN	NS, GN, TN	NS, GN	NS, GN, TN
Least Darter	Nat, Int, Ins, Smb, Veg	-	-	-	NS
Logperch	Nat, Int, Ins, Smb	NS	-	-	-

Species	Tolerance, Feeding, and/or Habitat Guild[2]	Madison (07-0044-00) (Tool 2)	Lura (07-0079-00) (Tool 5)	Bass (22-0074-00) (Tool 7)	Reeds (81-0055-00) (Tool 2)
Northern Pike	Nat, TC, Veg	NS, GN, TN	NS, GN, TN	NS, GN	NS, GN, TN
Orangespotted Sunfish	Nat, Tol, Ins	-	-	NS	-
Pugnose Shiner	Nat, Int, Ins, Veg, Cyp	-	-	-	NS
Pumpkinseed	Nat, Ins	NS	*	*	NS, TN
River Carpsucker	Nat, Omn	GN	-	-	-
Shortnose Gar	Nat, TC	GN, TN	-	-	-
Smallmouth Buffalo	Nat, Ins	GN	-	-	-
Spotfin Shiner	Nat, Ins, Cyp	NS	-	-	-
Spottail Shiner	Nat, Ins, Cyp	NS	-	-	NS
Tadpole Madtom	Nat, Ins, Smb, Veg	-	NS	*	NS
Walleye	Nat, TC	NS, GN, TN	GN, TN	NS, GN, TN	TN
White Crappie	Nat, TC	NS, GN, TN	*	-	GN, TN
White Sucker	Nat, Omn	NS, GN	*	-	TN
Yellow Bullhead	Nat, Omn	NS, GN, TN	*	NS, GN, TN	NS, GN, TN
Yellow Perch	Nat, Ins	NS, GN, TN	NS, GN, TN	NS, GN, TN	NS, GN
Species Richness		*29*	*13*	*13*	*23*

[1] Sampling methods that the species were captured with are abbreviated as follows: NS=Backpack Electrofishing and Seining, GN=Gillnetting, and TN=Trap Netting.
[2] Tolerance, feeding, and habitat guilds are abbreviated as follows: Nat=Native, Int=Intolerant, Tol=Tolerant, Ins=Insectivore, Omn=Omnivore, TC=Top Carnivore, Smb=Small Benthic-Dwelling, Veg=Vegetative-Dwelling, and Cyp=Cyprinid.

3. Possible Stressors to Lake Fish Communities in the LSRW

3.1. Candidate and Inconclusive Causes

Eutrophication

Land use disturbance and excess nutrients such as TP have been identified as causes of eutrophication in lakes. Water quality measurements taken in the four LSRW lakes assessed for aquatic life use indicate that TP averages 75.5 µg/L and varies from 31 µg/L to 151 µg/L. Similarly, land use disturbance in the upstream watersheds averages 44.8% and varies from 34% to 68%. Two of the four lakes are located in watersheds that exceed 40% land use disturbance (i.e., agricultural, developed, and/or mining). Cross and Jacobson (2013) found that TP levels are typically significantly elevated when land use in the contributing watershed approaches 40%, with higher rates of TP elevation in shallow lakes and in watersheds with agricultural land use disturbance. Five of the 11 lakes assessed by MPCA for aquatic recreation within the LSRW are impaired based on MPCA's nutrient water quality standards (MPCA 2015). The standards require that TP and either chlorophyll-a or transparency need to exceed an established threshold to be listed as impaired. MPCA's nutrient water quality standards have been established for aquatic recreation use; however, fish communities may exhibit responses at lower threshold levels. Given the above information, eutrophication will be evaluated further as a potential stressor within the LSRW.

Physical Habitat Alteration

MNDNR Score the Shore (StS) data (Perleberg et al. 2019) indicates that lakes within the LSRW have similar riparian shoreline disturbance on average to lakes statewide, although lakes were not selected at random for calculating the statewide average. The average StS score for lakes within the LSRW was 75, which is just higher than the statewide average of 73. Likewise, the average scores for developed and undeveloped sites in the LSRW were 65 and 92, respectively. The score for developed sites was slightly higher than the statewide average of 63. "Low" StS scores are indicative of disturbed riparian lakeshore habitat whereas "high" StS scores are indicative of relatively undisturbed riparian lakeshore habitat (Perleberg et al. 2019; Table 6). Results, including the large discrepancy in score between developed and undeveloped sites, indicate that habitat loss from riparian lakeshore development may be higher on lakes within the LSRW than lakes statewide. An alternative measure, dock density, can also be used to evaluate the level of disturbance occurring along the shoreline of a lake. Dock densities exceeding 16 docks per mile can significantly affect fish communities and habitat (Jacobson et al. 2016; Dustin and Vondracek 2017). Of the four lakes in the LSRW that were assessed for aquatic life use, three lakes had dock densities exceeding 16 docks per mile. Dock density averaged 15.6 docks per mile and varied from 1.4 to 21.9 docks per mile. Therefore, riparian lakeshore development will be evaluated further as a potential stressor within the LSRW.

Table 6. Interpretation of Score the Shore survey data (From Perleberg et al. 2019).

Mean Lakewide Score	Mean Shoreland Score	Mean Shoreline Score	Mean Aquatic Score	Rating
85-100	28-33.3	28-33.3	28-33.3	High
66-84	22-27	22-27	22-27	Moderate
50-65	17-21.5	17-21.5	17-21.5	Low
<50	<17	<17	<17	Very Low

A review of MNDNR Permitting and Reporting System (MPARS) information indicates that permits have been and are currently issued to mechanically and chemically remove emergent, floating-leaf, and submerged plants on at least 3 lakes within the LSRW. Additional removal of submerged plants outside of the date range of available permit data, removal that does not require a permit, and illegal removal of plants has also occurred within the LSRW.

A review of non-native species that would have the potential to alter physical habitat, including aquatic plant community structure, indicates that several species—Common Carp, Curly-leaf Pondweed, and Eurasian Watermilfoil—are present in a subset of lakes within the LSRW.

A review of the Minnesota inventory of dams indicates that there are 19 dams located within the LSRW; however, not all water control structures may be identified or included in this inventory. Minimal quantitative data is available describing fish habitat conditions prior to engaging in long-term water level management on lakes within the watershed and the effects of water level management on the FIBI score are unknown. Therefore, water level management is an inconclusive stressor due to a lack of data from which to draw conclusions.

A review of the MNDNR Watershed Health Assessment Framework (WHAF) tool indicates that the potential for aquatic disruption from culverts, bridges, and dams is higher than the statewide average (MNDNR 2020c). A lower score indicates higher potential for aquatic disruption, and the LSRW scores 45 out of a possible 100, whereas the statewide average is 53. Preliminary data from a MNDNR culvert inventory is also available for culverts that have been assessed to date. Of the 72 culverts that have been evaluated in the LSRW, 38% create a possible barrier to fish passage at some flows due to their size, function, or design (A. Hillman, MNDNR, unpublished data).

A review of sedimentation data indicates that measures such as total suspended solids or substrate embeddedness are lacking for most lakes within the LSRW. Although sedimentation may influence FIBI scores for certain lakes, the lack of high quality quantitative data and scientific research on the topic makes it challenging to draw conclusions for lakes within the LSRW.

Altered Interspecific Competition

A review of MNDNR survey data indicates that the LSRW is affected by non-native species that can directly compete with native fish species for resources. All four of the assessed lakes within the watershed contain Eurasian Watermilfoil and/or Common Carp. Eurasian Watermilfoil has the potential directly compete with native and non-invasive plant species, while Common Carp can compete directly with directly compete with native fishes for habitat and nutrition.

A review of gamefish management activities indicates that stocking and harvest regulations occur in many lakes within the LSRW. While some gamefish management activities can result in significant changes to the fish community of a lake, in general, there is an overall lack of conclusive evidence linking these changes to FIBI scores. Therefore, gamefish management activities are considered inconclusive as potential stressors to the fish community because the effects of gamefish management on the FIBI score are unknown.

Pesticide application

Pesticide application may contribute to the impaired fish communities in the LSRW; however, since the most prominent agricultural pesticide types used in the watershed are often not monitored, conclusive evidence that these toxins are a source of impairment is lacking.

According to a USEPA report by Atwood and Paisley-Jones (2017), farmers in the United States account for 20% of global pesticide use. In 2017, the most commonly sold pesticides to Minnesota agricultural producers, ranked by weight, were glyphosate (herbicide), acetochlor (herbicide), metam sodium (fungicide), metolachlor (herbicide), atrazine (herbicide), and chlorpyrifos (insecticide; MDA 2020); however, these estimates do not include pesticide seed treatments. Seed treatments have recently become widely adopted, with a majority of row crop seeds treated with pesticides such as neonicotinoids prior to planting. Neonicotinoids, broad-spectrum systemic insecticides, are the fastest growing class of insecticides worldwide and are now registered for use on hundreds of field crops in over 120 different countries (Morrissey et al. 2015; Douglas and Tooker 2015). Coating seeds with insecticide as a method of pest management poses a particular risk to aquatic environments as most seed-applied neonicotinoids (80–98%) fail to enter treated plants and instead dissolve into soil water (Goulson 2014).

Pesticides can affect fish communities through several pathways. Direct effects to fish include nervous, metabolic, and endocrine system disruptions, as well as negative effects to ontogenetic development (Köhler and Triebskorn 2013). Chlorpyrifos, a commonly used insecticide, has been found to be highly toxic to fish (e.g., Bluegill Sunfish LC_{50} = 1.8 ppb) and aquatic invertebrates (e.g., Daphnia LC_{50} = 0.1 ppb) on an acute basis (Corbin and Flaherty 2009). Aquatic invertebrates, often more sensitive to agricultural pesticides than their terrestrial relatives (Krupke and Tooker 2020), mediate indirect negative effects on fish abundances and community structure (Yamamuro et al. 2019). For example, Yamamuro et al. (2019) observed a 91% reduction in average annual yields of Rainbow Smelt in a freshwater lake within a primarily agricultural watershed and attributed the reduction to neonicotinoid pesticide contamination resulting in a lack of invertebrate prey. As many waterbodies in Minnesota share similar agricultural watershed characteristics, it is plausible that pesticides are negatively affecting FIBI scores either through direct or indirect means. Indirect impacts are common with pesticide application, and often unrelated to the toxicity on the species ultimately affected. The indirect pathway by which pesticides can reduce the abundance of prey available for insectivorous fishes is a critical consideration for maintaining healthy aquatic ecosystems composed of appropriately balanced native fish communities, and is likely of greater concern than the direct effects to the fishes themselves.

In the Upper Mississippi-Minnesota River Watershed (HUC4: 0702), insecticides were applied to 40% of agricultural acres in 2017, and herbicides applied to 88% (USDA 2017); however, Douglas and Tooker (2015) suggest that 79–100% of corn acres and 34–44% of soybean acres are also planted using neonicotinoid-coated seeds in the United States. In the Upper Mississippi-Minnesota River Watershed, corn and soybean production accounted for 53% and 46% of agricultural acres, respectively (USDA 2017). Approximately 84% of the land use in the LSRW is categorized as cultivated agricultural land (NLCD 2016). Extrapolations suggest that 48–62% percent of all land within the LSRW is planted using treated seeds and that other insecticides and herbicides may also be applied to 34% and 74% of all land, respectively. Furthermore, results from National Lake Assessment monitoring in Minnesota indicate that the number of detected pesticides and total pesticide concentration in lakes is positively related to percent of watershed in cropland (MDA 2019).

Despite relatively limited information, pesticide monitoring has resulted in the designation of one LSRW stream, Little Beauford Ditch (AUID: 07020011-642), as impaired for chlorpyrifos on MPCA's 2020 impaired waters list (MDA 2020b; MPCA 2020a). In 2008, the MPCA identified two waterbodies within the Le Sueur River Watershed as being impaired for the acetochlor water quality standard: the Le Sueur River and Little Beauford Creek (MDA 2020b). As of 2013, these were the only two waterbodies nationally reported for acetochlor impairments, and therefore, there are no opportunities to compare the nature of similar assessments, listings, probable causes, or approaches to delisting. In 2014, both reaches were removed from the USEPA 303(d) Impaired Waters List after a series of successful BMP's. MDA pesticide sampling in 2018 revealed an additional proposed impairment for chlorpyrifos in Beauford Ditch. This 2018 MDA pesticide water quality data will be assessed for the 2020 USEPA 303(d) Impaired Waters List.

3.2. Eliminated Causes

Temperature Regime Changes

A review of data on the Minnesota Climate Trends (MNDNR 2020a) indicates that mean July air temperatures within the LSRW may have increased by an average of 0.04 °F per decade over the last century as a result of climate change. Increases in lake-specific air temperature have been shown to be correlated with increases in water temperature (Robertson and Ragotzkie 1990); however, the amount of change within the LSRW does not warrant concerns of fish habitat loss. Although modeling evidence suggests that water temperature has slightly increased in lakes within the LSRW, limited research is available to demonstrate the magnitude of change needed to result in changes to the fish community as indicated by the FIBI.

Decreased dissolved oxygen

Data regarding dissolved oxygen concentrations in lakes is generally limited to discrete profiles collected during periodic MPCA and MNDNR surveys or is provided as anecdotal information when related to summer or winterkill events. As such, limited information exists to indicate whether dissolved oxygen concentrations are changing in a manner that might result in changes to fish communities, and specifically cool- and warmwater species, in the LSRW.

Increased Ionic Strength

A review of MPCA's Impaired Waters List indicates that no lakes within the LSRW were assessed as impaired for aquatic life use based on the chronic standard for chloride (MPCA 2018a). Chloride concentrations that are toxic to fish and other aquatic organisms would need to exceed the aquatic life use standards. Therefore, standards and actions intended to address chloride impairments should provide adequate protection to eliminate chloride as a likely candidate cause for impaired fish communities in the LSRW.

Metal Contamination

A review of MPCA's Impaired Waters List indicates that all four LSRW lakes assessed in this report (i.e. Madison, Lura, Bass, and Reeds) have been identified as impaired for aquatic consumption based on mercury levels; however, MPCA and local partners have developed a statewide mercury reduction plan approved by the USEPA to address these impairments (MPCA 2007). Mercury concentrations that are toxic to fish and other aquatic organisms would need to far exceed the aquatic consumption standards. Therefore, standards and actions intended to address aquatic consumption impairment should provide adequate protection to eliminate mercury as a likely candidate cause for impaired fish communities in the LSRW.

Unspecified Toxic Chemical Contamination

A review of publicly accessible MPCA data indicated that most properties that generate hazardous waste were located around the major population centers within the LSRW (e.g., Eagle Lake, Janesville, New Richland, Wells and Mapleton), and that they were not likely a significant stressor to fish communities (MPCA 2018b).

4. Evaluation of Candidate Causes in Impaired Lakes

Three lakes were assessed as not supporting aquatic life use because they had FIBI scores that were below the impairment threshold (Table 4). These lakes include Madison (07-0044-00), Lura (07-0079-00), and Bass (22-0074-00). Causes of stress to the fish communities in these impaired lakes are evaluated.

4.1. Madison Lake (DOW 07-0044-00)

Madison Lake is 1,446 acres in size and has a maximum depth of 59 feet. The littoral zone of the lake covers 71% of the lake area. Madison Lake is scored with FIBI Tool 2. Lakes scored with this tool are characterized as generally deep with complex shaped shorelines (i.e., presence of bays, points, and sometimes islands) and high species richness relative to lakes that are shallower and/or have less complex shorelines (Table 1).

Eutrophication has been identified as a candidate stressor to aquatic life use in Madison Lake. Physical habitat alteration, pesticide application and altered interspecific competition are inconclusive stressors (Figure 3). A description of available data and current understanding of levels believed to affect fish communities is discussed below.

Biological Community

The fish community in Madison Lake was sampled in two distinct FIBI surveys. The 2014 survey utilized seining and backpack electrofishing data from August 2014 and gill netting and Trap netting data collected in July 2014. The 2015 survey utilized backpack electrofishing and seining data collected in July 2015 and gill netting and trap netting data collected in July 2016. The health of the fish community was evaluated using these data and FIBI tool 2. The FIBI uses fish community data to measure a lake's health, and the types of fish species present can help identify any stressors that may be negatively affecting the lake environment. The FIBI score, composed of 15 fish community diversity and composition metrics for tool 2 lakes (Table 1), indicates the overall health of a lake by comparing it to what is expected for a healthy lake. The FIBI score of 12 for both surveys was below the impairment threshold (45) developed for lakes that are similar to Madison Lake (Table 3). Seven additional nearshore surveys were completed in 2008, 2009, 2010, 2011, and 2013, and resulted FIBI scores which ranged from 6-16. These surveys will not be discussed any further, because they occurred prior to the sampling window for assessment.

During the FIBI surveys, 29 fish species were captured (Table 5). The proportion of biomass in trap nets from tolerant species (16%-40% of biomass from Common Carp, Bigmouth Buffalo, and Black Bullheads) was above levels expected for similar lakes as indicated by the respective FIBI metrics. The proportion of biomass in trap nets from insectivores (14%-27% of biomass from Bigmouth Buffalo, Bluegill, and Freshwater Drum), and proportion of individuals captured in the nearshore sampling that are classified as intolerant species (<1% of count from Logperch) were below levels expected for similar lakes as indicated by the respective FIBI metrics. Two intolerant species, two tolerant species, three small benthic-dwelling species, and three vegetative-dwelling species were sampled.

Because this is the first time utilizing the FIBI protocols in the lake assessment process, historical surveys of similar rigor are unavailable to facilitate comparison of fish species assemblages through time. However, historic data indicates that several additional species have been sampled in Madison Lake in MNDNR Fisheries surveys. Several Fathead Minnows were captured in 1997 and 2010, Gizzard Shad were regularly sampled in Madison Lake between 1974 and 2010, several Longnose Gar were sampled between 1974 and 1997, many white bass were captured between 1982 and 2010, and one Highfin Carpsucker was identified by MNDNR Fisheries staff in 1988 (MNDNR 2020b). These historically sampled species may be represented by only one or two occurrences and identification confirmation cannot occur due to the lack of vouchered specimens.

Data Analysis/Evaluation for Each Candidate Cause

Eutrophication

Eutrophication has the potential to occur at a level that would contribute to the impaired fish community in Madison Lake based on review of watershed disturbance information. Eutrophication is considered a candidate stressor, based on review of relevant water quality information.

Recent water quality data collected and summarized by MPCA indicates that the 10-year mean total phosphorus (TP) is 63 parts per billion (ppb) (N=45), chlorophyll-a is 65.5 ppb (N=29), and Secchi transparency is 4.6 feet (N=79) in Madison Lake. These parameters indicate that excess nutrients are a candidate cause of stress to the fish community. According to the Le Sueur River Watershed Total Maximum Daily Load report, the modeled annual phosphorus load is 5,916 pounds; however, the modeled annual phosphorus load capacity is 2,259 pounds (MPCA 2015). This requires a 61.8 percent load reduction to achieve the total phosphorus standard set for North Central Hardwood Forests Lakes.

Of the 11,180 acres within the contributing watershed, 68.1% is classified as unnatural land cover (i.e., 60.9% agricultural and 7.2% developed), and 31.9% is classified as natural (i.e. 28.4% water or wetland, and 3.4% forested or herbaceous; MNDNR 2020c). The percentage of unnatural land cover exceeds a threshold identified by MNDNR Fisheries Research that could result in significantly elevated TP levels (Cross and Jacobson 2013). Approximately 92% of the agricultural land within Madison Lake's contributing watershed is cultivated, whereas 8% is hay and pasture land. Noteworthy to this discussion is the potential for artificial drainage tiling and ditching in agricultural areas to expand the lake's contributing watershed to a larger size than its topographical watershed; however, the content of this report will stay within the frame of the lake's natural watershed, since tiling and ditching information are not readily available.

Additionally, 10 actively registered animal feedlots maintain a combined 520 beef cattle - slaughter/stock, 196 "beef cattle - feeder/heifers", and 7,950 "swine between 55-300 pounds" within the contributing watershed of Madison Lake (MPCA 2016). Combined, there are 2,780 animal units within Madison's contributing watershed. Two of the feedlots are considered to be within the "shoreland" of Madison Lake's contributing watershed. Surface runoff from agricultural land could be contributing excess nutrients (e.g., TP) into the lake.

Residentially developed land within the contributing watershed is predominantly located along the shoreline of Madison Lake, as well as the community of "Madison Lake". In 1961, Minnesota Department of Health investigated complaints of untreated sewage into the lake. In 1975, the city of Madison Lake constructed a municipal sewer system that when into service, which began discharging downstream of the lake into the Le Sueur River. In 2010, a sewer extension project that connected the city of Lake Madison's wastewater to the Mankato Waste Water Treatment Facility allowed additional lake residents to be sewered. About 90 percent of Madison's contributing watershed falls within the boundaries of Blue Earth County. From 2000 to 2014, the city of Madison Lake had the second highest growth in new residents within the county (39.8 percent; Blue Earth County 2016). From 2010 to 2015, 975 compliance inspections were completed on septic systems within the Blue Earth County and found 67 percent were found to be compliant, 14 percent were considered a failure to protecting ground water, and 19 percent were considered as imminent threats to public health classifications. According to the Le Sueur River Watershed TMDL report, an estimated 86.9 pounds per year of phosphorus (2.3% of total load) enters Madison Lake from septic systems (MPCA 2015). With 57% of the shoreline of Madison Lake recorded as "Developed" during a 2014 MNDNR StS survey, direct runoff from lawn fertilizers and discharge from failing individual sewage treatment systems could contribute excess nutrients into the lake if not properly managed.

Madison Lake's contributing watershed is relatively small as indicated by a watershed-to-lake ratio of 7.7:1. As such, management actions intended to minimize nutrient inputs would be relatively targeted and reasonably attainable.

No AMAs occur within Madison Lake's contributing watershed; however, one Wildlife Management Area does exist within the contributing watershed of Madison Lake, which provides land use protections to valuable contributing wetlands. Almost 40 acres of private land in Madison Lake's contributing watershed are protected through conservation easements established through the Minnesota Board of Water and Soil Resources (BWSR) Reinvest in Minnesota (RIM) Reserve program, and 46 acres are enrolled in the CREP program (BWSR 2021). Additionally, nearly 1,015 acres (i.e., 9% of Madison Lake's contributing watershed) have been identified as drained or partially drained wetlands that could be restored (Ducks Unlimited 2014). Undeveloped lands, particularly parcels in public ownership that are protected from future development, can play a critical role in collecting and filtering rainfall, recharging the groundwater supply, and reducing surface runoff that could otherwise be contributing sediment and nutrients into lakes and rivers.

Common Carp are known to modify the structure and function of aquatic ecosystems (Huser et al. 2017). Carp dig in the bottom sediment with their mouths while searching for food, re-suspending sediment, increasing water turbidity, and uprooting aquatic plants. At great enough densities, Common Carp play a significant role in nitrogen and phosphorus transport from sediment to the water column as a result of both physical sediment disturbance and excretion. With the littoral zone of the Madison Lake covering 71% of the lake area, large Common Carp populations could intensify the effects of eutrophication. However, carp populations are not large originators of excess nutrients, but rather function as agents for nutrient re-suspension.

Information about Select Inconclusive and Eliminated Causes

Physical Habitat Alteration

Physical habitat alteration may be occurring at a level that may be negatively affecting the fish community in Madison Lake based on review of information reflecting riparian lakeshore development, aquatic plant removal, non-native species introduction, water level management, connectivity loss, and sedimentation. Therefore, physical habitat alterations will be considered as an inconclusive cause of stress to the fish community of Madison Lake.

Increased housing development, shoreline alterations, and prolonged high water have negatively affected cattail and bulrush beds on the lake, as described in the 2018 lake management plan (MNDNR, unpublished data). Riparian lakeshore habitat quality, as indicated by a MNDNR StS score of 76.6, is moderate within Madison Lake and above the statewide average score of 73. A moderate score indicates that, on average, surveyed sites have a high percentage of unaltered habitat but that at least one zone (i.e., shoreland, shoreline, or aquatic) has lower habitat quality than a high scoring site. Developed sites that generally retain a high percentage of natural habitat areas may score in this range. In this case, development has had a relatively uniform effect on all habitat components, and indicates that some replacement of trees, shrubs, and natural ground cover with open yards, in addition to removal of some in-lake habitat, has likely occurred. Replacement of riparian vegetation with open lawns oftentimes results in increased nutrient inputs from fertilizer and lawn clippings, reduced buffering capacity, destabilized shoreline, and elimination of future contributions of coarse woody habitat into the lake. Riparian buffering along the major inlet from Indian and Alice lakes should be a priority to reduce siltation and surface runoff. Every opportunity should be taken to enhance and protect the wetland complexes between Madison Lake, Indian and Alice lakes and the wetland complex on the east bay of the lake. Protection should include acquisition, flowage or conservation easement, fish passage and reduction of channelization and drainage. These wetland areas are essential spawning and rearing habitat for northern pike and walleye populations. One effective way to protect shoreline is through acquisition of Aquatic Management Areas (AMAs); however, no AMAs exist on Madison Lake to protect vulnerable shoreline from development. One Wildlife Management Area does exist within the contributing watershed of Madison Lake, which provides land use protections to valuable contributing wetlands.

The most recent aquatic plant surveys on Madison Lake, 2014 and 2019 transect surveys, indicate that the lake does support a diverse plant community relative to similar lakes in the region (N=27 and N=17, respectively), resulting in a relatively high floristic quality index (FQI; 28 and 21, respectively). These attributes indicate that fish habitat provided by aquatic plants may not be lacking. The diversity of aquatic plants present in Madison Lake is surprising considering the poor water clarity from eutrophication and associated algal blooms. In 2014, around 6.7 acres of emergent vegetation was found during a floating-leaf and emergent plant mapping survey (Figure 3). This is less than 0.5 percent of the total lake acreage, and about 0.7 percent of the littoral area of Lake Madison. Vegetation removal can adversely affect the fish community and can occur via several pathways. Landowners can destroy some submersed and floating-leaf vegetation without needing an Aquatic Plant Management (APM) permit, whereas emergent plant removal always requires an APM permit and riparian vegetation removal is governed by county zoning standards. Despite this, compliance checks and enforcement are oftentimes limited. As such, it is difficult to quantify the total amount of habitat loss that has and is presently occurring (whether legal or illegal) around and within Madison Lake. According to MPARS, between 2010 and 2019 (10 years), an average of 6.6 permits were granted per year to remove submersed plants via automated aquatic plant control devices or herbicides to enhance recreational use or provide riparian access. These permits are often 50 feet by 100 feet sections, or they are 15 feet wide and their length is from the shoreline out to reasonable recreational boat accessibility. Anecdotal information about potential plant removal activities (and other habitat alterations such as addition of sand blankets or rip-rap) within a lake can also be inferred from dock counts, and a review from 2019

Google imagery indicates that approximately 215 docks (17.3 docks per mile of shoreline) were present on the lake at that time. Densities exceeding 16–24 docks per mile have been linked to changes in fish community composition (Dustin and Vondracek 2017). Based on the dock density estimate, aquatic plant removal has likely contributed to some physical habitat loss within the lake, which could result in changes to the fish community as evaluated by the FIBI.

Figure 3. Map of floating leaf and emergent aquatic vegetation of Madison lake on 08/05/2014.

Curly-leaf Pondweed and Eurasian Water-milfoil, two non-native aquatic plant species, are present in Madison Lake. No significant changes to the physical habitat resulting from their presence have been documented.

Common Carp are known to modify the structure and function of aquatic ecosystems (Huser et al. 2017). They can reduce aquatic plant densities both directly and indirectly. Carp dig in the bottom sediment with their mouths while searching for food, re-suspending sediment, increasing water turbidity, and uprooting aquatic plants. In shallow lakes of homogeneous depth, light penetration can decrease when a threshold turbidity is exceeded, and submergent plants can disappear (Scheffer 1990). With the littoral zone of the Madison Lake covering 71% of the lake area, large Common Carp populations could intensify the effects of eutrophication. This could alter the trophic state of Madison Lake from a clear vegetated state to a turbid algal state. Consequently, carp are likely contributing to physical habitat alterations that are inconclusive stressors to the fish community in Madison Lake.

The hydrology and area of Madison Lake has changed dramatically over time. In the 1880's, the east bay of Madison Lake was dry and was farmed for corn and potatoes, but was flooded in 1929. In 1939, the Civilian Conservation Corps constructed a ditch between Madison Lake and Mud Lake intended to be an additional inlet to Madison. After a wet spring and improvements to the drainage at the outlet in 1941, the lake level increased 5.5 feet. In 1966, Ditch # C-2 at 108N 25W was repaired, draining Indian and Alice Lakes to Madison bringing the lake level to its more stable current state. In 1993, 48-inch culverts were replaced by 72x59-inch perched culverts between Madison and Mud Lakes (Soupir 2013). The water level is currently unregulated (i.e., no water control structure), and Madison Lake has naturally varied by 8 feet over the past 75 years, from 1,011 feet above sea level in 1943 to 1,019 feet above sea level in 1993 and 2016. However, no significant change in water level has been caused by the culvert's construction. This perched culvert structure reduces connectivity and fish passage with the downstream watershed, which includes Mud Lake. Further isolating Madison Lake, an electric fish barrier was constructed in 2018 downstream of Madison Lake (near 610th Avenue near the town of Eagle Lake) to be used as an additional barrier for invasive fishes. Although this electric fish barrier may prevent mass migrations of invasive carp into Madison Lake, the barrier may also prevent native fish species from migrating to and from Madison Lake and the Le Sueur River. The trophic ecology and population dynamics in Madison Lake are continuously monitored by MN DNR staff to explain any unexpected consequences of these fish barriers (e.g., effects on gizzard shad, possible walleye and northern pike movements, etc).

Within the contributing watershed, no dams, one bridge on the southeast side, and one culvert on the southwest side of Madison Lake have been documented in the National Inventory of Dams, MDOT Bridge and Culvert Inventory, and the MNDNR Culvert Inventory, respectively. Other culverts and crossings also occur within the large contributing watershed, but they have not been evaluated. Such a barrier may reduce migrations of both detrimental and beneficial species; however, this has yet to be documented.

Pesticide Application

Pesticide application may be occurring at a level that would contribute to the impaired fish community in Madison Lake; however, a lack of adequate data makes it difficult to provide evidence that pesticides are a source of impairment. A review of Minnesota Department of Agriculture (MDA) incident reports indicated no occurrence of spills within the upstream watershed of Madison Lake (MDA 2020a); however, the quantity and proximity of pesticide usage that could affect fish communities may be present. Forty-four percent of total agricultural acres in the LSRW in 2010 incorporated the use of acetochlor, a common corn herbicide (MDA 2013). In 2008, the MPCA identified two waterbodies within the Le Sueur River Watershed as being impaired for the acetochlor water quality standard: the Le Sueur

River and Little Beauford Creek. As of 2013, these were the only two waterbodies nationally reported for acetochlor impairments, and therefore, there are no opportunities to compare the nature of similar assessments, listings, probable causes, or approaches to delisting. In 2014, both reaches were removed from the USEPA 303(d) Impaired Waters List after a series of successful BMP's. MDA pesticide sampling in 2018 revealed an additional proposed impairment for chlorpyrifos in Beauford Ditch. This 2018 MDA pesticide water quality data will be assessed for the 2020 USEPA 303(d) Impaired Waters List. MDA also conducts sampling to monitor surface waters for pesticides. A summary of monitoring data from the 2017 National Lakes Assessment concluded that pesticide levels detected in nearby Eagle Lake were below chronic standards for class 2B lakes (Ribikawskis et al. 2019). While found at considerably high concentrations, Metolachlor did not exceed the Chronic Class 2B threshold for pesticide impairment at Eagle Lake in 2007, 2012, or 2017 (Ribikawskis et al. 2019).

Altered Interspecific Competition

Altered interspecific competition is not likely occurring at a level that would contribute to the impaired fish community in Madison Lake based on review of non-native species occurrence, stocking activities, angling, and other harvest-related activities.

To date, Common Carp, Eurasian Watermilfoil and Curly-leaf Pondweed have been documented as non-native species in Madison Lake. While the influence of these aquatic plant species are noticeable on native plant species distributions in Madison Lake, direct negative influences to the native fish community are unlikely. First discovered in Madison Lake in 2010, Eurasian water-milfoil limits recreational activities by forming dense mats on the water surface and disrupts aquatic ecosystems by competing with and displacing native plants (MNDNR, unpublished data). Common Carp have the potential to displace other native fish species if they occur at high densities; however, within Madison Lake, catch rates from recent surveys indicate that they are occurring at relatively normal densities when compared to other lakes in the same lake class (MNDNR, unpublished data), and direct competition with the native fish community is unlikely.

Madison Lake is managed primarily for Walleye, Black Crappie, and Bluegill and secondarily for Northern Pike and Largemouth Bass (MNDNR, unpublished data). Although Madison Lake experiences some Walleye natural reproduction, Walleye fry are stocked every other year (even years) to supplement the population. Northern Pike fry are stocked on odd years. All other fish species are the result of natural reproduction.

Historically, Madison Lake had been stocked with Northern Pike and Walleye. Northern Pike fry were recently stocked in Madison Lake in 2011, 2013, and 2015, and will continue to be stocked during odd years. The management plan goal for Northern Pike in Madison Lake calls for 3-6 fish per gill net, with at least 20% measuring over 30 inches. Prior to 1990, Walleye fingerlings were stocked annually at an average rate of 1,226 per littoral acre. Walleye stocking was reduced from 1.0 lb/surface acre to 0.5 lb/surface acre between 1992 and 2002. Since 2002, Walleye fry have been stocked at a rate of 1,000 per surface acre in two out of three years. In 2012, fry stocking was lessened to every other year at the same rate (MNDNR, unpublished data). Most Minnesota lakes that are stocked with Walleyes receive an average of 1,000 fry annually or 2.0 pounds of fingerlings biennially per littoral acre. No significant relationships between FIBI scores or metrics and the number of species stocked, relative abundance of stocked species, or Walleye stocking density have been observed in Minnesota lakes (Drake and Pereira 2002; J. Bacigalupi, MNDNR, unpublished data). However, effects in individual lakes are possible as results of management activities can vary considerably based on individual lake characteristics and communities.

Relative abundance of adult Walleye in Madison Lake has been relatively consistent partially due to stocking efforts, and is currently slightly higher than the lake class inner quartile range; however, the fish community has not shifted towards being dominated by Walleye (MNDNR, unpublished data). Northern Pike abundance has also been relatively high, having its third highest catch rate on record in 2016. The management plan goal for Northern Pike in Madison Lake is 3.0 to 6.0 fish/gill net, with at least 20% measuring over 30.0 inches; however, density dependent factors may be influencing the Northern Pike population as 8.1 fish/trap net were caught and two percent were greater than 30 inches. Yellow Perch (a primary forage species for Walleye and Northern Pike) in Lake Madison are abundant (22.1 fish/gill net in 2016), which ranked between the second and third quartiles for the same lake class. While Yellow Perch are relatively abundant, the size structure is small (90% less than 8.0 inches), creating an excellent prey resource for predator species.

Angling and other harvest-related activities also have potential to alter interspecific competition but are unlikely stressors. Madison Lake is a popular lake for local anglers and provides opportunities for several sportfish species. From 1988 to 1990, angling pressure was estimated to exceed 100 hours/acre/year, largely directed toward crappies (MNDNR, unpublished data). More recently, angling effort on Madison Lake has been estimated at 53 angler-hours/acre/year with the highest effort directed towards Walleye and Crappie (30% and 15%, respectively; MNDNR 2017). Following this 2016 angler survey, a 24-inch minimum length regulation on Northern Pike has been applied in an attempt to increase the average length of Northern Pike captured by anglers. Madison Lake also maintains a commercial fishery for Common Carp and Bigmouth Buffalo, with significant amounts of fish migrating from the Le Sueur River.

Common Carp can induce bottom-up effects within aquatic ecosystems that increase total phosphorus and turbidity while decreasing chlorophyll-a biomass and macrophyte cover. This is known to decrease macroinvertebrate biomass and growth in juvenile Largemouth Bass and juvenile Bluegill (Wahl et al. 2011). These bottom-up effects can influence multiple trophic levels, thus modifying aquatic community structure and function. In 2014 and 2016 trap net surveys on Madison Lake, Common Carp made up 36% and 13% of fish biomass, respectively. Common Carp can shift how nutrients are cycled throughout the trophic system of Madison Lake, which may result in an alteration in interspecific competition.

Madison Lake (07-0044-00) Fish Community and Stressors; Based on Fish Index of Biological Integrity (FIBI) Results

Fish Community:

- FIBI scores: 12, 12 (33 points below impairment threshold for similar lakes)
- Species sampled that negatively affect the FIBI score: Common Carp, Bigmouth Buffalo, Yellow Bullhead, Black Bullhead, Bluntnose Minnow, River Carpsucker, White Sucker
- Species sampled that positively affect the FIBI score: Black Crappie, Bluegill, Emerald Shiner, Golden Shiner, Iowa Darter, Johnny Darter, Largemouth Bass, Logperch, Northern Pike, Pumpkinseed, Spotfin Shiner, Spottail Shiner, Walleye, Yellow Perch
- Other species that have previously been sampled: Paddlefish, Fathead Minnow, Green Sunfish

Candidate Causes:

- Eutrophication (excess nutrients): 63 ppb mean total phosphorus, 68% of contributing watershed classified as unnatural land cover.

Inconclusive Causes:

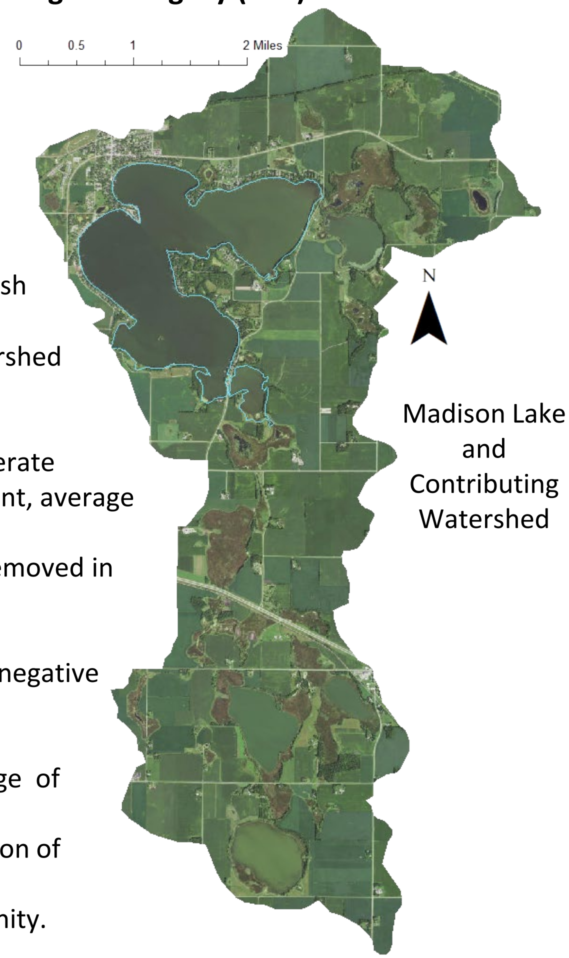
- Physical habitat alteration: Moderate dock density of 17.3 docks per mile of shoreline, moderate lakewide Score-the-Shore (StS) of 77, Curly-leaf Pondweed and Eurasian Water-milfoil present, average 6.6 annual aquatic plant removal permits, electric fish barrier downstream
- Pesticide application: 2008 Acetochlor impairment on Le Sueur River and Beauford ditch (Removed in 2014). 2018 Chlorpyrifos impairment on Beauford Ditch.

Eliminated Causes:

- Altered interspecific competition: Curly-leaf Pondweed and Eurasian Water-milfoil present, negative effects of stocking activities or harvest unlikely.

Recommendations:

- Use best management practices to minimize inputs of excess nutrients given large percentage of watershed classified as unnatural land cover.
- Promote restoration of natural shoreline buffers that contain native vegetation and protection of floating-leaf and emergent aquatic vegetation.
- The lack of connectivity, whether natural or unnatural, could be influencing the fish community.



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DEPARTMENT OF NATURAL RESOURCES

Figure 4. Madison Lake (07-0044-00) fish community and stressors; based on fish index of biological integrity (FIBI) results.

4.2. Lura Lake (DOW 07-0079-00)

Lura Lake is 1,359 acres in size and has a maximum depth of 9 feet. The littoral zone of the lake covers 100% of the lake area. Lura Lake is scored with FIBI Tool 5. Lakes scored with this tool are characterized as generally shallow (most areas less than 15' deep) with a complex shape (presence of bays, points, islands; Table 1).

Eutrophication and physical habitat alteration have been identified as likely stressors to aquatic life use in Lura Lake and will be evaluated further. Conversely, altered interspecific competition and pesticide application have been identified as inconclusive stressors (Figure 4). A description of available data and current understanding of levels believed to affect fish communities is discussed below.

Biological Community

The fish community in Lura Lake was sampled using two separate seining and backpack electrofishing events during August 2017, and gill netting and trap netting during August 2017. The health of the fish community was evaluated using these data and FIBI tool 5. The FIBI scores from this tool 5 are composed of eight fish community diversity and composition metrics (Table 1) that indicates the overall health of a lake by comparing it to what is expected for a healthy lake. The FIBI scores of 14 and 14 were below the impairment threshold (24) developed for lakes that are similar to Lura Lake (Table 3).

During the 2017 FIBI surveys, 13 fish species were captured (Table 5). The abundance of tolerant species (i.e., Black Bullheads, Common Carp, and Green Sunfish) was above the levels expected for similar lakes as indicated by the respective FIBI metrics, while the lack of any species captured that are intolerant to stressors and the low number of omnivorous species were both below the levels expected for similar lakes. No intolerant species, three tolerant species, one small benthic dwelling species, and two vegetative dwelling species were sampled.

Because this is the first time utilizing the FIBI protocols in the lake assessment process, historical surveys of similar rigor are unavailable to facilitate comparison of fish species assemblages through time. Previous MNDNR Fisheries surveys captured a similar suite of game fish species, however, neither backpack electrofishing nor seining using the FIBI protocols occurred prior to 2017 to document the nongame fish species present in Lura Lake (MNDNR 2020b). Several Bigmouth Buffalo were captured between 1991 and 2003, Pumpkinseed Sunfish were regularly sampled in Lura Lake between 1972 and 1991, White Crappie were commonly sampled between 1982 and 1993, White Suckers were captured in 1987 and 1993, and Yellow Bullheads were captured by MNDNR Fisheries staff in 1992, 1993, and 2013 (MNDNR 2020b). These historically sampled species may be represented by only one or two occurrences and identification confirmation cannot occur due to the lack of vouchered specimens.

The fish community was altered significantly after a 1994 whole lake chemical reclamation of Lura Lake was conducted by MNDNR in order to kill the Common Carp and Black Bullheads that had become overabundant, driving much of the lake’s water quality deterioration. An assessment was conducted nearly 15 years after the 1994 reclamation and showed that carp and bullhead levels were near pre-reclamation numbers. At that time, reclamation options were again being considered. However, the 2013 assessment showed numbers of Black Bullheads and Common Carp that were back down to near post-reclamation levels and illustrated a fishery with good opportunities for largemouth bass, northern pike, black crappie, yellow perch, and walleye angling. A standard survey of the fish community was conducted in 2020 and indicated moderate numbers of Walleye, Yellow Perch, and Largemouth Bass. Northern Pike and Black Crappies were abundant in the survey. This indicates a relatively healthy top predator community in the lake.

Data Analysis/Evaluation for Each Candidate Cause

Eutrophication

Eutrophication is likely occurring at a level that would contribute to an impaired fish community in Lura Lake based on review of relevant water quality and watershed disturbance information.

Recent water quality data collected and summarized by MPCA indicates that the 10-year (2010-2019) mean total phosphorus (TP) is 151 parts per billion (ppb) (N=34), chlorophyll-a is 52.9 ppb (N=32), and Secchi transparency is 1.3 feet (N=40) in Lura Lake. These parameters indicate that excess nutrients are a candidate cause of stress to the fish community. According to the Lura Lake Final Total Maximum Daily Load Study Excess Nutrients (2013) report, the modeled annual phosphorus load was estimated to be 6,756 pounds; however, the modeled annual phosphorus load capacity is 2,128 pounds. This requires a 68.5 percent load reduction to achieve the total phosphorus standard set for Western Cornbelt Plains. Of the 2,658 acres within the contributing watershed (which includes the lake proper), 51.9% is classified as open water, and 39.8% is classified as unnatural land cover (i.e., 33.8% agricultural and 6.0% developed; MNDNR 2020c). The percentage of unnatural land cover is near a threshold identified by MNDNR Fisheries Research that could result in significantly elevated TP levels (Cross and Jacobson 2013). If the surface area of Lura Lake is removed from this watershed calculations, 82.2% of the remaining 1,291 acres within the contributing watershed are classified as unnatural land cover. Noteworthy to this discussion is the potential for artificial drainage tiling and ditching in agricultural areas to expand the lake's contributing watershed to a larger size than its topographical watershed; however, the content of this report will stay within the frame of the lake's natural watershed, since tiling and ditching information are not readily available.

Approximately 100% of the agricultural land within Lura Lake's contributing watershed is cultivated, therefore 0% is hay or pasture land. Within the contributing watershed of Lura Lake, two actively registered animal feedlots maintain 970 swine under 55 pounds, and 2,400 swine between 55-300 pounds (MPCA 2016). Combined, there are 768.5 animal units within Lura's contributing watershed. Both feedlots are considered to be within Lura Lake's "shoreland". Surface runoff from agricultural land could be contributing excess nutrients (e.g., TP) into the lake. According to the Lura Lake Final Total Maximum Daily Load Study Excess Nutrients (MPCA 2020d) report, phosphorus produced by these animal units is estimated to be 2,711.7 pounds per year, in which an estimated 134.5 pounds of this phosphorus likely enters Lura Lake every year.

Residentially developed land within the contributing watershed is predominantly located along the shoreline of Lura Lake. Current data regarding individual sewage treatment system compliance indicates that there are only 11 septic systems within Lura Lake's contributing watershed (T. Grant, Blue Earth County, Personal Communication). One older septic system may be considered a non-imminent public health threat for failing to protect groundwater. Runoff from lawns and discharge from failing individual sewage treatment systems could contribute excess nutrients into the lake if not properly managed; however, the small number of septic systems within this watershed are not likely to contribute as a stressor to aquatic life.

Lura Lake's contributing watershed is relatively small as indicated by a watershed-to-lake ratio of 2.4:1. As such, management actions intended to reduce excess nutrient inputs should be relatively targeted and reasonably attainable.

Although a high percentage of land is classified as unnatural, one Waterfowl Production Area (WPA) and one 92 acre wooded campground exist within the contributing watershed. There are no private lands in Lura Lake's contributing watershed that are protected through the RIM or CREP programs (BWSR 2021). However, approximately 143 acres (i.e., 5% of Lura Lake's contributing watershed) have been identified as drained or partially drained wetlands that could be restored (Ducks Unlimited 2014). The Undeveloped lands, particularly parcels in public ownership that are protected from future development, play a critical role in collecting and filtering rainfall, recharging the groundwater supply, and reducing surface runoff that could otherwise be contributing sediment and nutrients into lakes and rivers.

Common Carp are known to modify the structure and function of aquatic ecosystems (Huser et al. 2017). Carp dig in the bottom sediment with their mouths while searching for food, re-suspending sediment, increasing water turbidity, and uprooting aquatic plants. Carp play a significant role in nitrogen and phosphorus transport from sediment to the water column as a result of both physical sediment disturbance and excretion. With the littoral zone of the Lura Lake covering 100% of the lake area, large Common Carp populations could intensify the effects of eutrophication. However, carp populations are not large originators of excess nutrients, but rather function as agents for nutrient re-suspension.

Information about Select Inconclusive and Eliminated Causes

Physical Habitat Alteration

Physical habitat alteration has the potential to be occurring at a level that would contribute to an impaired fish community in Lura Lake based on review of information reflecting riparian lakeshore development, aquatic plant removal, non-native species introduction, water level management, connectivity loss, and sedimentation. Physical Habitat Alteration is considered an Inconclusive Cause to impairment in Lura Lake.

Riparian lakeshore habitat quality, as indicated by a MNDNR StS score of 75, is moderate within Lura Lake and slightly higher than the statewide average (73). A moderate score indicates that, on average, surveyed sites have a high percentage of unaltered habitat but that at least one zone (i.e., shoreland, shoreline, or aquatic) has lower habitat quality than a high scoring site. Developed sites that generally retain a high percentage of natural habitat areas may score in this range. Development has had the largest effect on the shoreland and shoreline habitat components, which indicates that replacement of trees, shrubs, and natural ground cover with open yards has most likely occurred. Replacement of riparian vegetation with open lawns oftentimes results in increased nutrient inputs from fertilizer and lawn clippings, reduced buffering capacity, destabilized shoreline, and elimination of future contributions of coarse woody habitat into the lake.

The most recent aquatic plant transect surveys on Lura Lake (2011 and 2013) indicate that the lake has moderate aquatic plant diversity, relative to similar lakes in the region (N=11 and N=8, respectively), resulting in moderate FQI values (17 and 12, respectively). These attributes indicate that fish habitat provided by aquatic plants may not be a major contributing impairment to the Lura Lake fish community. The relatively low to moderate diversity of aquatic plants present in Lura Lake is likely the result of a combination of large expanses of littoral areas with poor water clarity from eutrophication and associated algal blooms, rather than the result of physical plant removal by lakeshore owners, which is generally more of a concern in lakes with much higher residential development. According to MPARS, no properties are permitted to remove submersed, emergent, and floating-leaf plants via pesticide application, mechanical removal, or automated aquatic plant control devices to enhance recreational use or provide riparian access, but data for other sources of removal are lacking. As of April of 2020, no floating-leaf and emergent vegetation survey has been conducted on Lura Lake. Eurasian Watermilfoil and Curly-leaf Pondweed, both non-native species, are present in Lura Lake. No significant changes to the physical habitat resulting from their presence has been documented. Anecdotal information about potential plant removal activities (and other habitat alterations such as addition of sand blankets or rip-rap) within a lake can also be inferred from dock counts, and a review from 2011 Google imagery indicates that approximately 20 docks (0.4 docks per mile of shoreline) were present on the lake at that time. Densities exceeding 16–24 docks per mile have been linked to changes in fish community composition (Dustin and Vondracek 2017). Significant changes to the fish community are unlikely based on the dock density estimate and lack of recent permits for plant removal.

Common Carp are known to modify the structure and function of aquatic ecosystems (Huser et al. 2017). They can reduce aquatic plant densities both directly and indirectly. Carp dig in the bottom sediment with their mouths while searching for food, re-suspending sediment, increasing water turbidity, and uprooting aquatic plants. In shallow lakes of homogeneous depth, light penetration can decrease when a threshold turbidity is exceeded, and submergent plants can disappear (Scheffer 1990). With the littoral zone of the Lura Lake covering 100% of the lake area, large Common Carp populations could intensify the effects of eutrophication. This could alter the trophic state of Lura lake from a vegetated clear state to a turbid algal state. Consequently, carp are likely contributing to physical habitat alterations that are inconclusive stressors to the fish community in Lura Lake.

An aeration system was installed in 1976 and a second system was added in the south basin in 1996. No winterkills have been reported since the lakewide reclamation in 1994. The MNDNR will continue to monitor winter oxygen and advise aeration permittees when to operate systems, as needed.

The water level in Lura Lake is unregulated (i.e., no water control structure) and therefore varies seasonally. No significant inlets to Lura Lake exist within the contributing watershed. There are two outlets on the south side of the Lura lake. One outlet is a natural outlet that flows through Two small metal culverts underneath gravel roads, and two wetlands before flowing into Rice Creek. Another outlet is completely sub-surface within drain tile and flows from Lura Lake into Rice Creek. These culverts and outlets have been identified as potential barriers to fish passage, which could have a negative effect on species richness in Lura Lake and therefore the FIBI score.

Approximately eight miles of eroding shoreline were restored in the late 1990s. A 3:1 slope was established, rock was placed at the toe of the slope and a riparian buffer of native vegetation approximately 20 meters wide was created using continuous signup CRP. The primary goal of this project was to reduce erosion from both the shoreline and the shoreland of Lura Lake. Erosion can lead to increased sedimentation, decreased water clarity, loss of nearshore aquatic habitat, and increased eutrophication of the lake.

Altered Interspecific Competition

Altered interspecific competition is not likely occurring at a level that would contribute to the impaired fish community in Lura Lake based on review of non-native species occurrence, stocking activities, angling, and other harvest-related activities.

To date, Common Carp, Eurasian Watermilfoil and Curly-leaf Pondweed have been documented as non-native species in Lura lake. Common Carp have the potential to displace other native fish species if they occur at high densities; however, within Lura Lake, catch rates from recent surveys would indicate that they are occurring at relatively normal densities when compared to other lakes in the same lake class (MNDNR, unpublished data), and direct competition with the native fish community is unlikely.

Historically, Lura Lake had been stocked with Bluegill, Largemouth Bass, Walleye, Black Crappies, Northern Pike and Yellow Perch. MNDNR Fisheries currently stocks Walleye fry at a rate of 500 per littoral acre annually, as described in the 2019 lake management plan (MNDNR, unpublished data). No significant relationships between FIBI scores or metrics and the number of species stocked, relative abundance of stocked species, or Walleye stocking density have been observed in Minnesota lakes (Drake and Pereira 2002; J. Bacigalupi, MNDNR, unpublished data). However, effects in individual lakes are possible as management activities can vary considerably based on individual lake characteristics and communities.

Relative abundance of adult Walleye in Lura Lake has been somewhat variable and is currently slightly higher than the lake class median. For almost ten years after the 1994 reclamation, Walleye catch rates have ranged from 12.0/net to 49.0/net with a mean of 27.3/net. Since 2004, catch rates have dropped to a mean of 5.5/net. Current catch rates are within the lake class interquartile range, indicating that the fish community has not shifted towards being dominated by Walleye as a result of stocking (MNDNR, unpublished data). Likewise, Yellow Perch (a primary forage species for Walleye) have exhibited a declining trend in recent surveys, but the observed decline is consistent with the statewide trend (Bethke et al. 2015) and may not be a direct result of current Walleye densities that have been influenced by stocking.

Angling and other harvest-related activities also have potential to alter interspecific competition but are unlikely stressors. Angler effort and harvest have not been quantified for Lura Lake, therefore no data exists with which to evaluate the effects of angling on fish community composition. Regardless, no special regulations have been implemented that might reflect concerns about angler harvest or result in changes to fish community composition through altered interspecific competition. Some commercial harvest of Common Carp and bullheads has also occurred, but this has likely had little effect on current fish community structure.

Common Carp can induce bottom-up effects within aquatic ecosystems that increase total phosphorus and turbidity while decreasing chlorophyll-a biomass and macrophyte cover. This is known to decrease macroinvertebrate biomass and growth in juvenile Largemouth Bass and juvenile Bluegill (Wahl et al. 2011). These bottom-up effects can influence multiple trophic levels, thus modifying aquatic community structure and function. Common Carp made up 11% of fish biomass in a 2017 trap net survey on Lura Lake, but less than 1% of the total fish count, relative to other species in the trap nets. Common Carp can shift the how nutrients are cycled throughout the trophic system of Lura Lake, which may result in an alteration in interspecific competition. Consequently, altered interspecific competition is considered an inconclusive stressor to the fish community in Lura Lake.

Pesticide Application

Pesticide application may be occurring at a level that would contribute to the impaired fish community in Lura Lake; however, a lack of adequate data makes it difficult to provide evidence that pesticides are a source of impairment. A review of Minnesota Department of Agriculture (MDA) incident reports indicated no occurrence of spills within the upstream watershed of Lura Lake (MDA 2020a); however, the quantity and proximity of pesticide usage that could affect fish communities may be present. Forty-four percent of total agricultural acres in the LSRW in 2010 incorporated the use of Acetochlor, a common corn herbicide (MDA 2013). In 2008, the MPCA identified two waterbodies within the Le Sueur River Watershed as being impaired for the Acetochlor water quality standard: the Le Sueur River and Little Beauford Creek. As of 2013, these were the only two waterbodies nationally reported for Acetochlor impairments, and therefore, there are no opportunities to compare the nature of similar assessments, listings, probable causes, or approaches to delisting. In 2014, both reaches were removed from the USEPA 303(d) Impaired Waters List after a series of successful BMP's. MDA pesticide sampling in 2018 revealed an additional proposed impairment for chlorpyrifos in Beauford Ditch. This 2018 MDA pesticide water quality data will be assessed for the 2020 USEPA 303(d) Impaired Waters List.

Lura Lake (07-0079-00) Fish Community and Stressors; Based on Fish Index of Biological Integrity (FIBI) Results

Fish Community:

- FIBI scores: 14, 14 (10 points below impairment threshold for similar lakes)
- Species sampled that negatively affect the FIBI score: Common Carp, Green Sunfish, Black Bullhead
- Species sampled that positively affect the FIBI score: Black Crappie, Bluegill, Golden Shiner, Largemouth Bass, Northern Pike, Tadpole Madtom, Walleye, Yellow Perch
- Other species that have previously been sampled: Bigmouth Buffalo, Pumpkinseed, White Crappie, White Sucker, Yellow Bullhead

Candidate Causes:

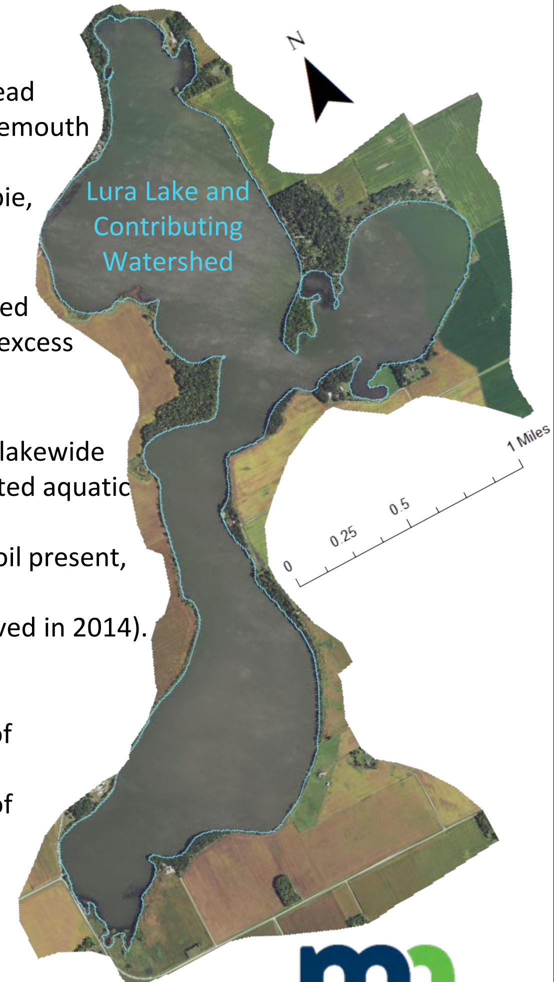
- Eutrophication (excess nutrients): 151 ppb mean total phosphorus, 34% of contributing watershed classified as unnatural land cover, non-supporting for aquatic recreational use and impaired for excess nutrients

Inconclusive Causes:

- Physical habitat alteration: Moderate dock density of 0.4 docks per mile of shoreline, moderate lakewide Score-the-Shore (StS) of 75, Eurasian Water-milfoil and Curly-leaf Pondweed present, no permitted aquatic plant removal activity, reclamation in 1994, fish barrier at outlets
- Altered interspecific competition: Common Carp, Curly-leaf Pondweed and Eurasian Water-milfoil present, negative effects of stocking activities or harvest unlikely
- Pesticide application: 2008 Acetochlor impairment on Le Sueur River and Beauford ditch (Removed in 2014). 2018 Chlorpyrifos impairment on Beauford Ditch.

Recommendations:

- Use best management practices to minimize inputs of excess nutrients given large percentage of watershed classified as unnatural land cover.
- Promote restoration of natural shoreline buffers that contain native vegetation and protection of floating-leaf and emergent aquatic vegetation.
- The lack of connectivity, whether natural or unnatural, could be influencing the fish community.
- Monitor fish community for potential Common Carp management or a need to repeat reclamation



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DEPARTMENT OF NATURAL RESOURCES

Figure 5. Lura Lake (03-0506-00) fish community and stressors; based on fish index of biological integrity (FIBI) results.

4.3. Bass Lake (DOW 22-0074-00)

Bass Lake is 199 acres in size and has a maximum depth of 20 feet. The littoral zone of the lake covers 86% of the lake area. Bass Lake is scored with FIBI Tool 7. Lakes scored with this tool are characterized as generally shallow with greater than 80% littoral area and moderate species richness (Table 1).

Eutrophication and physical habitat alteration have been identified as a likely stressor to aquatic life use in Bass Lake and will be evaluated further. Conversely, altered interspecific competition and pesticide application have been identified as inconclusive stressors (Figure 5). A description of available data and current understanding of levels believed to affect fish communities is discussed below.

Biological Community

The fish community in Bass Lake was sampled using seining and backpack electrofishing during July 2018, and gill netting and trap netting during June 2018. The health of the fish community was evaluated using these data and FIBI tool 7. The FIBI score of 21 was below the impairment threshold (36) developed for lakes that are similar to Bass Lake (Table 3).

During the FIBI survey, 13 fish species were captured (Table 5). The high number tolerant species captured across sampling methods (i.e. Black Bullheads, Common Carp, Fathead Minnows, Orangespotted Sunfish, and Green Sunfish) exceeded levels expected for similar lakes, and the biomass of insectivore species caught in trap nets (34% of trap net biomass was from Bluegills and Yellow Perch) was lower than expected for similar lakes as indicated by the respective FIBI metrics. The lack of any small benthic dwelling species captured across all sampling methods also was a large contributor to the low FIBI score. No intolerant species, five tolerant species, one vegetative dwelling species, and zero small benthic dwelling species were sampled.

Because this is the first time utilizing the FIBI protocols in the lake assessment process, historical surveys of similar rigor are unavailable to facilitate comparison of fish species assemblages through time. Previous MNDNR Fisheries surveys captured a similar suite of game fish species, however, neither backpack electrofishing nor seining using the FIBI protocols occurred prior to 2018 to document the nongame fish species present in Bass Lake (MNDNR 2020b). Three Johnny Darters and seven Bluntnose minnows were captured and identified in the field in 1954, three Pumpkinseed Sunfish were sampled in 1981 and 1984, four Bigmouth Buffalo were sampled in 1986, and one Tadpole Madtom was sampled in 1996 (MNDNR 2020b). These historically sampled species may be represented by only one or two occurrences and identification confirmation cannot occur due to the lack of vouchered specimens. Note that Johnny Darters and Tadpole Madtoms are classified as small benthic dwellers, and the lack of small benthic dwellers in the recent survey was a negative influence on the FIBI score.

A reclamation of the Bass Lake fish community took place in 1988 with the goal of reducing the biomass of Black Bullheads. Following the reclamation Bass Lake was stocked with Northern Pike, Largemouth Bass, Black Crappie, Bluegill, Yellow Perch, Channel Catfish, and Flathead Catfish. This reclamation event successfully reduced Black Bullhead biomass, and improved sportfish populations for several years. However, by 1996, Black Bullhead catches had increased to pre-reclamation levels, driving a reduction in Bluegill, Black Crappie and Yellow Perch catches by 2013. Walleye and Northern Pike populations have been maintained successfully through regular stocking regimes. This regular stocking and management of top predators may also be partially driving the low panfish catches in more recent years.

Data Analysis/Evaluation for Each Candidate Cause

Eutrophication

Eutrophication is likely occurring at a level that would contribute to an impaired fish community in Bass Lake based on review of relevant water quality and watershed disturbance information.

Recent water quality data collected and summarized by MPCA indicates that the 10-year (2010-2019) mean total phosphorus (TP) is 51.7 parts per billion (ppb) (N=10), chlorophyll-a is 29.0 ppb (N=10), and Secchi transparency is 3.3 feet (N=10) in Bass Lake. These parameters indicate that the lake is likely receiving inputs of excess nutrients that could negatively affect the fish community. Chlorophyll-a levels exceed eutrophication standards for lakes and reservoirs in western corn belt plains; however, TP and Secchi transparency do not exceed these water quality standards, therefore the lake is not listed as nutrient impaired. In lakes assessed with the FIBI, we have observed that the fish community is often impacted at lower levels of phosphorus than would trigger a water quality impairment.

Of the 487 acres within the contributing watershed, 43.6% is classified as open water, and 33.9% is classified as unnatural land cover (i.e., 26.2% agricultural and 7.7% developed; MNDNR 2020c). The percentage of unnatural land cover is just lower than the threshold identified by MNDNR Fisheries Research that could result in significantly elevated TP levels (Cross and Jacobson 2013). If the surface area of Bass Lake is removed from this acreage, 62.3% of the remaining 288 acres within the contributing watershed are classified as unnatural land cover. Cross and Jacobson (2013) also found shallow lakes, in agricultural landscapes to be more sensitive to elevated TP. Noteworthy to this discussion is the potential for artificial drainage tiling and ditching in agricultural areas to expand the lake's contributing watershed to a larger size than its topographical watershed; however, the content of this report will stay within the frame of the lake's natural watershed, since tiling and ditching information are not readily available.

Approximately 93.5% of the agricultural land within Bass Lake's contributing watershed is cultivated, and 6.5% is hay or pasture land. There are no actively registered feedlots within the contributing watershed (MPCA 2016).

Residentially developed land within the contributing watershed is predominantly located along the shoreline of Bass Lake. Faribault County Soil and Water Conservation District has actively enforced the 1994 DNR shore land septic ordinance for all property owners in the Bass Lake watershed. Sixty septic systems were upgraded between 1994 and 2000. All of these systems were failing and contributing directly to the lake. This marks a substantial decline in direct nutrient loading to Bass Lake. In addition to the septic contributions, runoff from lawns could contribute excess nutrients into the lake if not properly managed.

Bass Lake's contributing watershed is relatively small as indicated by a watershed-to-lake ratio of 2.5:1. As such, management actions intended to reduce excess nutrient inputs should be relatively targeted and reasonably attainable.

Although a high percentage of land is classified as unnatural, one 87-acre Conservation Reserve Enhancement Project (CREP) was completed in 2003 and exists on the lake's west side. The major benefit of this CREP project was restoration of a 19-acre wetland area in the watershed. However, besides this 19-acre wetland complex, over 38 acres (i.e., 8% of Bass Lake's contributing watershed) have been identified as drained or partially drained wetlands that could be restored (Ducks Unlimited

2014). Undeveloped lands, particularly parcels in public ownership that are protected from future development, can play a critical role in collecting and filtering rainfall, recharging the groundwater supply, and reducing surface runoff that could otherwise be contributing sediment and nutrients into lakes and rivers.

Common Carp are known to modify the structure and function of aquatic ecosystems (Huser et al. 2017). Carp dig in the bottom sediment with their mouths while searching for food, re-suspending sediment, increasing water turbidity, and uprooting aquatic plants. Carp play a significant role in nitrogen and phosphorus transport from sediment to the water column as a result of both physical sediment disturbance and excretion. With the littoral zone of the Bass Lake covering 85.9% of the lake area, large Common Carp populations could intensify the effects of eutrophication. However, carp populations are not large originators of excess nutrients, but rather function as agents for nutrient re-suspension.

Physical Habitat Alteration

Physical habitat alteration is likely occurring at a level that would contribute to an impaired fish community in Bass Lake based on review of information reflecting riparian lakeshore development, aquatic plant removal, non-native species introduction, water level management, connectivity loss, and sedimentation.

Riparian lakeshore habitat quality, as indicated by a MNDNR StS score of 72.3, is moderate within Bass Lake and slightly lower than the statewide average (73). A moderate score indicates that, on average, surveyed sites have a high percentage of unaltered habitat but that at least one zone (i.e., shoreland, shoreline, or aquatic) has lower habitat quality than a high scoring site. Developed sites that generally retain a high percentage of natural habitat areas may score in this range. Development has had the largest effect on the shoreland and shoreline habitat components, which indicates that replacement of trees, shrubs, and natural ground cover with open yards has most likely occurred. Replacement of riparian vegetation with open lawns oftentimes results in increased nutrient inputs from fertilizer and lawn clippings, reduced buffering capacity, destabilized shoreline, and elimination of future contributions of coarse woody habitat into the lake.

The most recent aquatic plant transect survey on Bass Lake (June 30, 2008) indicates that the lake has moderate to high aquatic plant diversity, relative to similar lakes in the region (N=24), resulting in a relatively high FQI (28). These attributes indicate that fish habitat provided by aquatic plants may not be lacking. The relatively high diversity of aquatic plants present in Bass Lake is surprising considering the poor water clarity from eutrophication and associated algal blooms during summer months. Vegetation removal can adversely affect the fish community and can occur via several pathways. Eurasian Watermilfoil and Curly-leaf Pondweed, both non-native species, are present in Bass Lake. No significant changes to the physical habitat resulting from their presence has been documented. Curly-leaf Pondweed had been abundant in plant surveys since 1986, but have appeared to be less dominating in recent years since the 1988 reclamation. Recently, species such as Muskgrass, Coontail, and Canada Waterweed have become more dominant in Bass Lake.

Landowners can destroy some submersed and floating-leaf vegetation without needing an APM permit, whereas emergent plant removal always requires an APM permit and riparian vegetation removal is governed by county zoning standards. Despite this, compliance checks and enforcement are oftentimes limited. As such, it is difficult to quantify the total amount of habitat loss that has and is presently occurring (whether legal or illegal) around and within Bass Lake. Bass Lake receives an annual herbicide treatment, which removes up to 15 percent of the vegetation in the littoral area. According to MPARS, there have been an average of 1.8 permits per year (2010-2019) to remove submersed, emergent, and floating-leaf plants via pesticide application, mechanical removal, or automated aquatic plant control devices to enhance recreational use or provide riparian access, but data for other sources of removal are lacking. There is a clear need to instill an understanding of the importance of maintaining higher densities of native aquatic vegetation and the vital role plants play in the stability and success of the Bass Lake fish community. As of April of 2021, no floating-leaf and emergent vegetation survey has been conducted on Bass Lake.

Anecdotal information about potential plant removal activities (and other habitat alterations such as addition of sand blankets or rip-rap) within a lake can also be inferred from dock counts, and a review from 2015 Google imagery indicates that approximately 47 docks (21.9 docks per mile of shoreline) were present on the lake at that time. Densities exceeding 16–24 docks per mile have been linked to changes in fish community composition (Dustin and Vondracek 2017). Based on the dock density estimate, aquatic plant removal has likely contributed to some physical habitat loss within the lake, which could result in changes to the fish community as evaluated by the FIBI.

Common Carp are known to modify the structure and function of aquatic ecosystems (Huser et al. 2017). They can reduce aquatic plant densities both directly and indirectly. Carp dig in the bottom sediment with their mouths while searching for food, re-suspending sediment, increasing water turbidity, an uprooting aquatic plants. In shallow lakes of homogeneous depth, light penetration can decrease when a threshold turbidity is exceeded, and submergent plants can disappear (Scheffer 1990). With the littoral zone of the Bass Lake covering 85.9% of the lake area, large Common Carp populations could intensify the effects of eutrophication. This could alter the trophic state of Bass lake from a vegetated clear state to a turbid algal state. Consequently, carp are likely contributing to physical habitat alterations that are inconclusive stressors to the fish community in Bass Lake.

The water level in Bass Lake is unregulated (i.e., no water control structure) and therefore varies seasonally. One inlet to the lake exists on the southwest shoreline, which comes from a 50-acre wetland within an 85-acre Conservation Reserve Enhancement Project. Another source of water into Bass Lake is through a drain tile network that enters on the north shoreline. There is one outlet on the northeast side of the Bass lake. This is a natural outlet that flows through a 24-inch metal culvert underneath a gravel road, and through a wetland before flowing into Rice Creek. This culvert and outlet have been identified as a potential barrier to fish passage, which could have a negative effect on species richness in Bass Lake and therefore the FIBI score.

Information about Select Inconclusive and Eliminated Causes

Altered Interspecific Competition

Altered interspecific competition is not likely occurring at a level that would contribute to the impaired fish community in Bass Lake based on review of non-native species occurrence, stocking activities, angling, and other harvest-related activities.

To date, Common Carp, Eurasian Watermilfoil and Curly-leaf Pondweed have been documented as non-native species in Lura lake. Common Carp have the potential to displace other native fish species if they occur at high densities; however, within Bass Lake, catch rates from recent surveys would indicate that they are occurring at relatively normal densities when compared to other lakes in the same lake class (MNDNR, unpublished data), and direct competition with the native fish community is unlikely.

Bass Lake fish stocking records begin in 1908, and the species stocked between then and 1987 included walleye, northern pike, largemouth bass, crappie, sunfish, bluegill, white sucker, yellow perch, channel catfish and unidentified minnows. After the 1988 reclamation, Northern Pike, Largemouth Bass, Black Crappie, Bluegill, Yellow Perch, Channel Catfish and Flathead Catfish were stocked. According to the 2014 Bass Lake management plan (MNDNR, unpublished data), MNDNR Fisheries currently stocks Walleye fry at a rate of 1,000 per littoral acre on even years, 25,000 Northern Pike fry annually into the connecting 50-acre CREP wetland, and Bluegills and Black Crappies, as needed. No significant relationships between FIBI scores or metrics and the number of species stocked, relative abundance of stocked species, or Walleye stocking density have been observed in Minnesota lakes (Drake and Pereira 2002; J. Bacigalupi, MNDNR, unpublished data). However, effects in individual lakes are possible as management activities can vary considerably based on individual lake characteristics and communities.

Relative abundance of adult Walleye in Bass Lake has been somewhat variable and is currently well above the 3rd quartile compared with lakes of the same lake class; however, the fish community has not shifted towards being dominated by Walleye as a result of stocking. Conversely, Yellow Perch (a primary forage species for Walleye) have exhibited a declining trend in recent surveys, but the observed decline is consistent with the statewide trend (Bethke et al. 2015) and may not be a direct result of current Walleye densities that have been influenced by stocking.

Angling and other harvest-related activities also have potential to alter interspecific competition but are unlikely stressors. Angler effort and harvest have not been quantified for Bass Lake, therefore no data exists with which to evaluate the effects of angling on fish community composition. Regardless, no special regulations have been implemented that might reflect concerns about angler harvest or result in changes to fish community composition through altered interspecific competition. Some commercial harvest of Common Carp and bullheads has also occurred, but this has likely had little effect on current fish community structure.

Common Carp can induce bottom-up effects within aquatic ecosystems that increase total phosphorus and turbidity while decreasing chlorophyll-a biomass and macrophyte cover. This is known to decrease macroinvertebrate biomass and growth in juvenile Largemouth Bass and juvenile Bluegill (Wahl et al. 2011). These bottom-up effects can influence multiple trophic levels, thus modifying aquatic community structure and function. Common Carp made up 18% of fish biomass in a 2018 trap net survey on Bass Lake, but less than 1% of the total fish count, relative to other species in the trap nets. Common Carp can shift the how nutrients are cycled throughout the trophic system of Bass Lake, which may result in an alteration in interspecific competition. Consequently, altered interspecific competition is considered an inconclusive stressor to the fish community in Bass Lake.

Pesticide Application

Pesticide application may be occurring at a level that would contribute to the impaired fish community in Bass Lake; however, a lack of adequate data makes it difficult to provide evidence that pesticides are a source of impairment. A review of Minnesota Department of Agriculture (MDA) incident reports indicated no occurrence of spills within the upstream watershed of Bass Lake (MDA 2020a); however, the quantity and proximity of pesticide usage that could affect fish communities may be present. Forty-four percent of total agricultural acres in the LSRW in 2010 incorporated the use of Acetochlor, a common corn herbicide (MDA 2013). In 2008, the MPCA identified two waterbodies within the Le Sueur River Watershed as being impaired for the Acetochlor water quality standard: the Le Sueur River and Little Beauford Creek. As of 2013, these were the only two waterbodies nationally reported for Acetochlor impairments, and therefore, there are no opportunities to compare the nature of similar assessments, listings, probable causes, or approaches to delisting. In 2014, both reaches were removed from the USEPA 303(d) Impaired Waters List after a series of successful BMP's. MDA pesticide sampling in 2018 revealed an additional proposed impairment for chlorpyrifos in Beauford Ditch. This 2018 MDA pesticide water quality data will be assessed for the 2020 USEPA 303(d) Impaired Waters List. While the Bass Lake contributing watershed is relatively small, additional surface water runoff from outside of the geographic contributing watershed is known to access Bass Lake through subsurface drainage tile networks on the north shore of the lake.

Bass Lake (22-0074-00) Fish Community and Stressors; Based on Fish Index of Biological Integrity (FIBI) Results

Fish Community:

- FIBI score: 21 (15 points below impairment threshold for similar lakes)
- Species sampled that negatively affect FIBI score: Black Bullheads, Common Carp, Fathead Minnows, Green Sunfish, Orangespotted Sunfish
- Species sampled that positively affect the FIBI score: Black Crappie, Bluegill, Channel Catfish, Hybrid Sunfish, Largemouth Bass, Northern Pike, Walleye, Yellow Perch
- Other species that have previously been sampled: Bigmouth Buffalo, Bluntnose Minnow, Golden Shiner, Johnny Darter, Pumpkinseed, Tadpole Madtom
- Reclamation event in 1988 with goal of reducing Black Bullhead biomass. Biomass was back to pre-reclamation levels by 1996.

Candidate Causes:

- Eutrophication (excess nutrients): 57 ppb mean total phosphorus, 34% of contributing watershed classified as unnatural land cover
- Physical habitat alteration: Moderate dock density of 13.6 docks per mile of shoreline, moderate lakewide Score-the-Shore (StS) of 72, Eurasian Water-milfoil and Curly-leaf Pondweed present, WMA upstream of lake is often subject to drawdowns, weak mechanical barrier (considering upgrade), permitted aquatic plant removal activity

Inconclusive Causes:

- Altered interspecific competition: Common Carp, Eurasian Watermilfoil and Curly-leaf present, negative effects of stocking activities or harvest unlikely
- Pesticide application: 2008 Acetochlor impairment on Le Sueur River and Beauford ditch (Removed in 2014). 2018 Chlorpyrifos impairment on Beauford Ditch. Subsurface drainage via tile from north

Recommendations:

- Use best management practices to minimize inputs of excess nutrients given large percentage of watershed classified as unnatural land cover.
- Promote restoration of natural shoreline buffers that contain native vegetation and protection of floating-leaf and emergent aquatic vegetation.
- The lack of connectivity, whether natural or unnatural, could be influencing the fish community.
- Monitor fish community for potential Common Carp management or a need to repeat reclamation

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DEPARTMENT OF NATURAL RESOURCES

Figure 6. Bass Lake (22-0074-00) fish community and stressors; based on fish index of biological integrity (FIBI) results.

5. Evaluation of Candidate Causes in Vulnerable Lakes

Reeds Lake (80-0055-00) was assessed as having inconclusive information to determine an assessment decision based on the FIBI, and is considered vulnerable to future impairment. Causes of stress to the fish communities in this vulnerable lake are evaluated.

5.1. Reeds Lake (DOW 80-0055-00)

Reeds Lake is 195 acres in size and has a maximum depth of 58 feet. The littoral zone of the lake covers 57% of the lake area. Reeds Lake is scored with FIBI Tool 2. Lakes scored with this tool are generally characterized as deep lakes with high species richness (Table 1).

Eutrophication, physical habitat alteration, altered interspecific competition, and pesticide application have been identified as inconclusive stressors to aquatic life use in Reeds Lake and will be evaluated further (Figure 6). A description of available data and current understanding of levels believed to affect fish communities is discussed below.

Biological Community

The fish community in Reeds Lake was sampled twice using seining and backpack electrofishing during July 2016, and once in August 2018, while gill netting and trap netting occurred during June 2016. The health of the fish community was evaluated using these data and FIBI tool 2. The FIBI scores of 44, 43, and 35, respectively, were just below the impairment threshold (45) developed for lakes that are similar to Reeds Lake (Table 3). The 2016 FIBI scores were only just below the impairment threshold; therefore, Reeds Lake may be a good candidate to prioritize for restoration activities within the LSRW.

During the FIBI surveys, 23 fish species were sampled (Table 5). The number of and proportion of biomass from tolerant species (i.e. Common Carp and Green Sunfish) and omnivore species (i.e. Black Bullhead, Bluntnose Minnow, Common Carp, White Sucker, and Yellow Bullhead) was relatively high, and contributed negatively to the FIBI scores. The proportion of top carnivores in the gill nets (i.e. Northern Pike, Largemouth Bass, Black Crappie, or White Crappie), and insectivore species in the trap nets (i.e. Bluegill, Hybrid Sunfish, Pumpkinseed Sunfish, or Yellow Perch) were relatively low, and also contributed negatively to the FIBI scores. Similarly, the proportion of small benthic dwelling species that were caught in the nearshore sampling methods (i.e. 0%-5% were Iowa Darters, Johnny Darters, or Tadpole Madtoms) was below the level expected for similar lakes. Three intolerant species, three tolerant species, three small benthic dwelling species, and five vegetative dwelling species were sampled.

Because this is the first time utilizing the FIBI protocols in the lake assessment process, historical surveys of similar rigor are unavailable to facilitate comparison of fish species assemblages through time. However, historic data indicates that at least one additional game fish species has been sampled in Reeds Lake. One Channel Catfish specimen was sampled in a MNDNR Fisheries survey in 2011, but they have not been observed in MNDNR surveys since that time (MNDNR 2020b).

Information about Select Inconclusive and Eliminated Causes

Eutrophication

Eutrophication has the potential to be occurring at a level that would contribute to a vulnerable fish community in Reeds Lake; however, it is considered an inconclusive stressor based on review of relevant water quality and watershed disturbance information.

Recent water quality data collected and summarized by MPCA indicates that mean TP is 24.8 ppb (N=4), chlorophyll-a is 14.6 ppb (N=4), and Secchi transparency is 6.2 feet (N=96) in Reeds Lake. These parameters indicate that excess nutrients may not be a primary cause of stress to the fish community.

Of the 544.6 acres within the contributing watershed, 42.9% is classified as unnatural land cover (i.e., 39.1% agricultural and 3.8% developed; MNDNR 2020c). The percentage of unnatural land cover exceeds a threshold identified by MNDNR Fisheries Research that could result in significantly elevated TP levels (Cross and Jacobson 2013). If the surface area of Reeds Lake is removed from this acreage, 65.6% of the remaining 350 acres within the contributing watershed are classified as unnatural land cover. Approximately 25.8% of the agricultural land within Reeds Lake's contributing watershed is hay and pasture land whereas 74.2% is cultivated. Reeds Lake and its contributing watershed are within a "Feedlot Prohibited Area" (Waseca County 2017), and therefore there are no active feedlots (MPCA 2016). Surface runoff from agricultural land could contribute excess nutrients into the lake in the future if not properly managed. Noteworthy to this discussion is the potential for artificial drainage tiling and ditching in agricultural areas to expand the lake's contributing watershed to a larger size than its topographical watershed; however, the content of this report will stay within the frame of the lake's natural watershed, since tiling and ditching information are not readily available.

Residentially developed land within the contributing watershed is predominantly located along the shoreline of Reeds Lake. Current data regarding individual sewage treatment system compliance indicates that there are only 21 septic systems within 500 feet of the shoreline of Reeds Lake (K. Shermo, Waseca County, Personal Communication). One older septic system is classified as a non-imminent public health threat system for failing to protect the groundwater. Runoff from lawns and discharge from failing individual sewage treatment systems could contribute excess nutrients into the lake if not properly managed; however, the small number of septic systems within this watershed make this a less likely stressor to the fish community.

There are no private lands in Reeds Lake's contributing watershed that are protected through the RIM or CREP programs (BWSR 2021). However, approximately 30 acres (i.e., 6% of Reeds Lake's contributing watershed) have been identified as drained or partially drained wetlands that could be restored (Ducks Unlimited 2014). The Undeveloped lands, particularly parcels in public ownership that are protected from future development, play a critical role in collecting and filtering rainfall, recharging the groundwater supply, and reducing surface runoff that could otherwise be contributing sediment and nutrients into lakes and rivers.

Common Carp are known to modify the structure and function of aquatic ecosystems (Huser et al. 2017). Carp dig in the bottom sediment with their mouths while searching for food, re-suspending sediment, increasing water turbidity, and uprooting aquatic plants. Carp play a significant role in nitrogen and phosphorus transport from sediment to the water column as a result of both physical sediment disturbance and excretion. With the littoral zone of the Reeds Lake covering 56.5% of the lake area, large Common Carp populations could intensify the effects of eutrophication. However, carp populations are not large originators of excess nutrients, but rather function as agents for nutrient re-suspension.

Although eutrophication has been identified as an inconclusive cause, Reeds Lake's contributing watershed is relatively small as indicated by a watershed-to-lake ratio of 2.8:1. As such, management actions intended to reduce excess nutrient inputs into the lake would be relatively targeted and reasonably attainable.

Physical Habitat Alteration

Physical habitat alteration has the potential to be occurring at a level that would contribute to a vulnerable fish community in Reeds Lake based on review of information reflecting riparian lakeshore development, aquatic plant removal, non-native species introduction, water level management, connectivity loss, and sedimentation. However, physical habitat alteration has been identified as an inconclusive stressor.

Riparian lakeshore habitat quality, as indicated by a MNDNR StS score of 66, is relatively low within Reeds Lake and slightly lower than the statewide average (73). A low-moderate score indicates that, on average, surveyed sites have a high percentage of altered habitat in at least one zone (i.e., shoreland, shoreline, or aquatic), and has lower habitat quality than a high scoring site. Developed sites that generally retain a high percentage of natural habitat areas may score in this range. Development has had the largest effect on the shoreland and shoreline habitat components, which indicates that replacement of trees, shrubs, and natural ground cover with open yards has most likely occurred. Replacement of riparian vegetation with open lawns oftentimes results in increased nutrient inputs from fertilizer and lawn clippings, reduced buffering capacity, destabilized shoreline, and elimination of future contributions of coarse woody habitat into the lake. Information about shoreline development and impacts including potential plant removal activities, and habitat alterations such as addition of sand blankets or rip-rap within a lake can also be inferred from dock counts. A review from 2015 Google imagery indicates that approximately 60 docks (21.8 docks per mile of shoreline) were present on the lake at that time. Densities exceeding 16–24 docks per mile have been linked to changes in fish community composition (Dustin and Vondracek 2017). One effective way to protect vulnerable shoreline on the lake from development is through acquisition of AMAs; however, there are no AMA's within Reeds Lake's contributing watershed.

The most recent aquatic plant transect survey on Reeds Lake (August 2013) indicates that the lake has moderate aquatic plant diversity, relative to similar lakes in the region (N=18), resulting in a moderate to high FQI value (25). These attributes indicate that fish habitat provided by aquatic plants may not be lacking. The moderate diversity of aquatic plants present in Reeds Lake is likely a result of acceptable water clarity and levels of eutrophication, resulting in less severe algal blooms during summer months. Vegetation removal can adversely affect the fish community and can occur via several pathways. Landowners can destroy some submersed and floating-leaf vegetation without needing an APM permit, whereas emergent plant removal always requires an APM permit and riparian vegetation removal is governed by county zoning standards. Despite this, compliance checks and enforcement are oftentimes limited. As such, it is difficult to quantify the total amount of habitat loss that has and is presently occurring (whether legal or illegal) around and within Reeds Lake. According to MPARS, there have been an average of 3.6 permits per year (2013-2019) to remove submersed, emergent, and floating-leaf plants via pesticide application, mechanical removal, or automated aquatic plant control devices to enhance recreational use or provide riparian access, but data for other sources of removal are lacking. Eurasian Water-milfoil has been present since at least 1994, and continues to spread. The lake's diverse and abundant native aquatic plants in Reeds Lake should help to slow the spread, as well as large herbicide treatments. To date, there have been no FLEM surveys conducted to document the current stands of floating and emergent vegetation present in Reeds Lake.

Recent surveys indicate that Common Carp are sampled at a lower rate than other lakes in the same lake class (MNDNR, unpublished data). Any potential effects on the physical habitat within the lake have not been evaluated or documented. Common Carp are known to modify the structure and function of aquatic ecosystems (Huser et al. 2017). They can reduce aquatic plant densities both directly and indirectly. Carp dig in the bottom sediment with their mouths while searching for food, re-suspending sediment, increasing water turbidity, an uprooting aquatic plants. In shallow lakes of homogeneous depth, light penetration can decrease when a threshold turbidity is exceeded, and submergent plants can disappear (Scheffer 1990). With the littoral zone of the Reeds Lake covering 56.5% of the lake area, large Common Carp populations could intensify the effects of eutrophication. This could alter the trophic state of Reeds lake from a vegetated clear state to a turbid algal state. Consequently, carp are likely contributing to physical habitat alterations that are inconclusive stressors to the fish community in Reeds Lake .

There are no major inlets, and one outlet on the west side of Reeds Lake. The water level in the lake has historically been regulated by a stop-log dam; however, this dam structure has not been utilized in several years. The outlet at Reeds Lake flows through a 4-foot tall by 11-foot wide abutment that contains a steel grate fish barrier. There are five culverts within the waterway between Reeds Lake and the downstream Elysian Lake. These culverts have not been assessed for fish passage issues, at this time. Potential effects to aquatic life within the lake are uncertain; however future investigations may be warranted to restore and/or maintain connectivity to the downstream watershed. If the fish barrier and other crossings are determined to act as barriers to beneficial fish species, actions should be considered to restore connectivity.

Altered Interspecific Competition

Altered interspecific competition has the potential to be occurring at a level that would contribute to a vulnerable fish community in Reeds Lake; however, it is considered an inconclusive stressor based on review of non-native species occurrence, stocking activities, angling, and other harvest-related activities.

Eurasian Water-milfoil and Common Carp, two non-native species, are present in Reeds Lake. Eurasian Water-milfoil has been present since at least 1994, and continues to spread. The lake's diverse and abundant native aquatic plants in Reeds Lake should help to slow the spread, as well as targeted herbicide treatments. Recent surveys indicate that Common Carp are sampled at a lower rate than other lakes in the same lake class (MNDNR, unpublished data). Catch rates from recent surveys would indicate that Common Carp are occurring at relatively low densities when compared to other lakes in the same lake class (MNDNR, unpublished data).

Historically, Reeds Lake had been stocked with Bluegill, Black Crappie, Largemouth Bass, Northern Pike, and Walleye. MNDNR Fisheries currently does not stock Walleye into the lake as it maintains a high diversity of aquatic plants and a robust Centrarchid and northern pike fishery. MNDNR managers believe that the focus of fisheries management on Reeds should be to manage for species best suited for these habitat conditions, which precludes Walleye (MNDNR, unpublished data). Reeds Lake is currently stocked with 25,000 Northern Pike fry annually. Relative abundance of adult Northern Pike in Reeds Lake has been relatively high. The gill net catch rate from a 2016 survey was 25.5 fish/net, which was above the long-term average for Reeds Lake (12.5 fish/net) and far above the catch rate of a previous survey in 2011 (4.6 fish/net). This catch rate ranks far above the third quartile (7.3 fish/net) for lakes in the same lake class. As a result, there may be a potential imbalance in the historic fish community, but the effects of high density Northern Pike populations on non-game species is not fully understood.

Angling and other harvest-related activities also have potential to alter interspecific competition but are unlikely stressors. Angler effort and harvest have not been quantified for Reeds Lake, therefore no data exists with which to evaluate the effects of angling on fish community composition. Regardless, no special regulations have been implemented that might reflect concerns about angler harvest or result in changes to fish community composition through altered interspecific competition.

Common Carp can induce bottom-up effects within aquatic ecosystems that increase total phosphorus and turbidity while decreasing chlorophyll-a biomass and macrophyte cover. This is known to decrease macroinvertebrate biomass and growth in juvenile Largemouth Bass and juvenile Bluegill (Wahl et al. 2011). These bottom-up effects can influence multiple trophic levels, thus modifying aquatic community structure and function. Common Carp made up 6% of fish biomass in a 2016 trap net survey on Reeds Lake, but less than 1% of the total fish count, relative to other species in the trap nets. Common Carp can shift the how nutrients are cycled throughout the trophic system of Reeds Lake, which may result in an alteration in interspecific competition. Consequently, altered interspecific competition is considered an inconclusive stressor to the fish community in Reeds Lake.

Pesticide Application

Pesticide application may be occurring at a level that would contribute to the impaired fish community in Reeds Lake; however, a lack of adequate data makes it difficult to provide evidence that pesticides are a source of impairment. A review of Minnesota Department of Agriculture (MDA) incident reports indicated no occurrence of spills within the upstream watershed of Reeds Lake (MDA 2020a); however, the quantity and proximity of pesticide usage that could affect fish communities may be present. Forty-four percent of total agricultural acres in the LSRW in 2010 incorporated the use of Acetochlor, a common corn herbicide (MDA 2013). In 2008, the MPCA identified two waterbodies within the Le Sueur River Watershed as being impaired for the Acetochlor water quality standard: the Le Sueur River and Little Beauford Creek. As of 2013, these were the only two waterbodies nationally reported for Acetochlor impairments, and therefore, there are no opportunities to compare the nature of similar assessments, listings, probable causes, or approaches to delisting. In 2014, both reaches were removed from the USEPA 303(d) Impaired Waters List after a series of successful BMP's. MDA pesticide sampling in 2018 revealed an additional proposed impairment for chlorpyrifos in Beauford Ditch. This 2018 MDA pesticide water quality data will be assessed for the 2020 USEPA 303(d) Impaired Waters List.

Reeds Lake (81-0055-00) Fish Community and Stressors; Based on Fish Index of Biological Integrity (FIBI) Results

Fish Community:

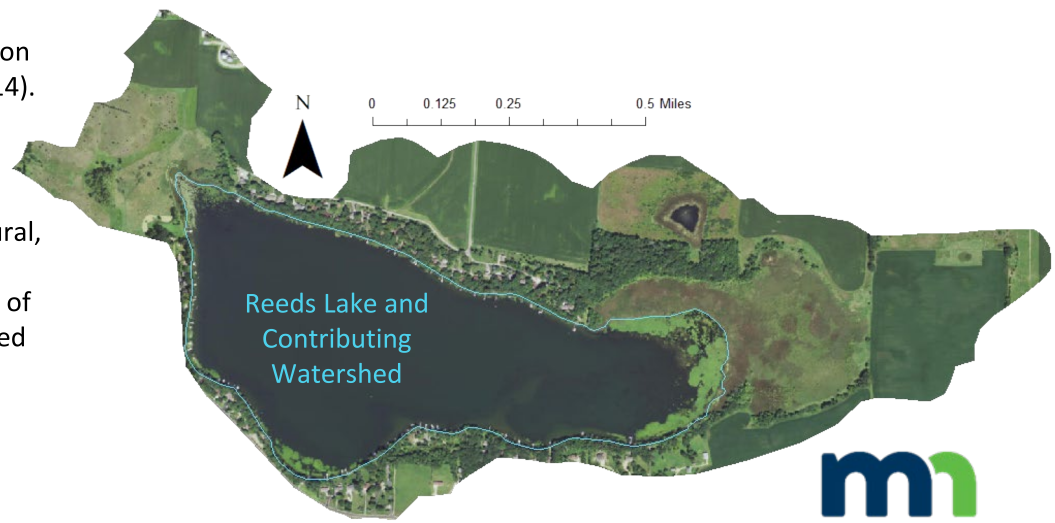
- FIBI scores: 44, 43, 35 (1, 2, and 10 points below impairment threshold for similar lakes)
- Species sampled that negatively affect the FIBI score: Black Bullhead, Bluntnose Minnow, Common Carp, Green Sunfish, White Sucker, Yellow Bullhead
- Species sampled that positively affect the FIBI score: Banded Killifish, Black Crappie, Bluegill, Central Mudminnow, Golden Shiner, Hybrid Sunfish, Iowa Darter, Johnny Darter, Largemouth Bass, Least Darter, Logperch, Northern Pike, Pugnose Shiner, Pumpkinseed, Spottail Shiner, Tadpole Madtom, Walleye, White Crappie, Yellow Perch
- Other species that have previously been sampled: Black Bullhead, Bluntnose Minnow, Channel Catfish, Common Carp, Green Sunfish, White Sucker, Yellow Bullhead

Inconclusive Causes:

- Physical habitat alteration: Moderate dock density of 15.6 docks per mile of shoreline, Eurasian water-milfoil present, Common Carp are present in low numbers, high shoreline development, lack of downstream connectivity because of culverts and fish barrier
- Eutrophication (excess nutrients): 31 ppb mean total phosphorus, 43% of contributing watershed classified as unnatural land cover
- Altered interspecific competition: Eurasian Water-milfoil and Common Carp present at relatively low levels, negative effects of stocking activities or harvest unlikely
- Pesticide application: 2008 Acetochlor impairment on Le Sueur River and Beauford ditch (Removed in 2014). 2018 Chlorpyrifos impairment on Beauford Ditch.

Recommendations:

- Manage the spread of Eurasian Water-milfoil
- The lack of connectivity, whether natural or unnatural, could be influencing the fish community
- Use best management practices to minimize inputs of excess nutrients given large percentage of watershed classified as unnatural land cover



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DEPARTMENT OF NATURAL RESOURCES

Figure 7. Reeds Lake (81-0055-00) fish community and stressors; based on fish index of biological integrity (FIBI) results.

6. Conclusions and Recommendations

Conclusions

Table 7 presents a summary of the stressors associated with the biologically impaired and vulnerable lakes in the LSRW. Eutrophication (excess nutrients) is adversely affecting the fish communities in Madison, Lura, and Bass lakes. These lakes contain relatively high levels of nutrients such as total phosphorus (i.e., greater than approximately 30 ppb) and are located in watersheds with high land use disturbance (i.e., greater than 40%). Reeds lake is considered vulnerable to impairment and contains relatively high land use disturbance, but eutrophication has been listed an inconclusive cause because nutrient levels are relatively low.

Physical habitat alterations are adversely affecting the fish communities in Madison and Bass lakes. Shoreline development on these lakes is relatively high and has resulted in the loss of both riparian vegetation and native floating-leaf and emergent plant stands that serve as important habitat for fish and other organisms. Additionally, both of these lakes are located in watersheds with connectivity concerns, such as culverts or crossings that potentially restrict fish passage. Other biologically impaired LSRW lakes are located in watersheds with connectivity concerns, but physical habitat alteration has been listed an inconclusive cause because shoreline development remains relatively low. Several lakes (i.e., Lura, Bass, and Reeds) are located in relatively isolated watersheds that lack significant inlets and outlets. This lack of connectivity could naturally be limiting species richness and ultimately have a negative influence on the lake's FIBI scores.

Altered interspecific competition was determined to be an inconclusive cause for all lakes that contained non-native species that have the potential to affect fish communities at high densities (e.g., Common Carp and Eurasian Watermilfoil). Many of these lakes contained relatively low densities of the non-native species in recent surveys or lacked data regarding densities.

No conclusive causes were identified for Reeds Lake. Despite this, several inconclusive causes could simultaneously and cumulatively be affecting the fish communities in Reeds Lake. Other uncommon stressors that were not evaluated in this report, in addition to stressors that may have occurred in the past but are not presently occurring, could also be affecting the fish communities in Reeds Lake. Finally, Reeds Lake is relatively isolated (i.e., lack of a significant connectivity) and this could naturally affect fish species richness or limit recolonization of sensitive species if stressors have occurred in the past but have been adequately addressed since that time.

Table 7. Summary of the stressors associated with the biologically impaired or vulnerable lakes in the LSRW.

			Candidate Causes[1]			
Lake Name	**DOW**	**Assessment Decision**	**Eutrophication (Excess Nutrients)**	**Physical Habitat Alteration**	**Altered Interspecific Competition**	**Pesticide Application**
Madison	**07-0044-00**	Impaired	+	+	0	0
Lura	**07-0079-00**	Impaired	+	0	0	0
Bass	**22-0074-00**	Impaired	+	+	0	0
Reeds	**81-0055-00**	Vulnerable	0	0	0	0

[1] "+" supports the case for the candidate cause as a stressor, "0" indicates that evidence is inconclusive as to whether the candidate cause is a stressor

Recommendations

The recommended actions listed below will help to reduce the influence or better understand the stressors that are limiting the fish communities of the LSRW. Collaboration among agencies, watershed districts, and local government units will be imperative for successful planning and implementation of these recommendations within the LSRW. Several of the many examples of past collaborative successes include multiple Lura Lake improvement projects led by the Lura Lake Association, Blue Earth County, and the MNDNR, and several stream restoration and fish passage projects on Iosco Creek led by the Waseca SWCD and the MNDNR. Both examples involved numerous project, organizational, and funding partners that were critical to their success.

Eutrophication (excess nutrients)

Best management practices should be employed to reduce inputs of nutrients into biologically impaired or vulnerable lakes. In agricultural areas, such practices may include applying correct fertilizer types at appropriate rates and times depending on soil type and other factors (e.g., weather), using no till or minimum tillage practices, planting cover crops, maintaining riparian buffer zones around lakes, rivers, and ditches, and using grass waterways and constructed wetlands to filter nutrients from surface waters. In residential areas located around biologically impaired or vulnerable lakes, practices may include minimizing application of lawn fertilizer, reestablishing or maintaining shoreline buffer zones, and ensuring individual sewage treatment systems are compliant with state regulations (Minnesota Rules Chapter 7080) and local government ordinances.

Where applicable, recommendations outlined in lake eutrophication TMDLs should also be followed to minimize potential nutrient inputs from surrounding water bodies. For example, the installation of field and riparian vegetated buffers could reduce nutrients in several of the lakes assessed in this report with relatively small contributing watersheds.

Land acquisition may also be a viable option to protect lakes from eutrophication and other negative effects of development. Undeveloped grassland or wetland areas can provide numerous benefits to the surrounding ecosystem including filtering surface runoff and thereby reducing eutrophication and sedimentation, recharging the groundwater supply, and removing carbon dioxide from the atmosphere.

Physical habitat alteration

Restoration of developed shorelines with natural shoreline buffers should be prioritized when physical habitat alteration has been identified as a candidate cause of stress to a biologically impaired or vulnerable lake. Shoreland owners can significantly improve shoreline habitat by choosing to reestablish or maintain native plants along their property. Natural shorelines provide overhead cover to fish and wildlife species, contribute important coarse woody habitat into the lake, and provide a buffer for nutrient runoff from lawns and impervious surfaces. While shoreline restoration projects vary in scope and size, all can be completed in ways that are visually appealing and that maintain a view of the lake. Once completed, these projects have potential to provide many ecosystem benefits that a more traditional developed shoreline (e.g., mowed lawn and sand beach) could not offer. The MNDNR maintains an interactive Restore Your Shore webpage that provides guidance for shoreland owners and professionals to use in implementing shoreland restoration projects. Protection and restoration of floating-leaf and emergent aquatic vegetation should also be prioritized, especially where aquatic habitat is limited. Shoreland owners should be aware of and adhere to current laws that regulate shoreline and aquatic plant control, riprap, sand blanket, and retaining wall installation, and other shoreline alterations.

Oftentimes lakeshore parcels are privately owned and developed; however, in some situations land acquisition can be a viable option to protect existing natural shoreline and aquatic habitat. Future acquisitions aimed at increasing the percentages of protected shoreline and protected watershed area should be a priority where appropriate. For example, if physical habitat alteration resulting from shoreline development has been identified as a candidate cause of stress to the fish community, emphasis could be placed on land acquisition opportunities to protect remaining undeveloped shoreline.

Recommendations related to other physical habitat alteration concerns should be considered where appropriate. Floating-leaf and emergent vegetation mapping surveys should be completed to document existing plant stands in lakes where these data are lacking (i.e., Lura, Bass, and Reeds). Upstream and downstream connections should be restored when crossings (i.e., dams, culverts, and bridges) have been identified as barriers to fish passage and unevaluated crossings should be inspected for potential concerns. Non-native species (e.g., Common Carp, Eurasian Watermilfoil) should continue to be monitored in lakes where they are present to ensure they do not reach densities that could substantially alter physical habitat in the future. Additionally, efforts to reduce the spread of non-native species, including those that are absent from the LSRW (e.g., Zebra Mussels), should continue to be encouraged.

Altered interspecific competition

Altered interspecific competition was not identified as a conclusive candidate cause of stress in any biologically impaired or vulnerable lakes. Nonetheless, monitoring efforts to better understand densities and potential effects of species such as Common Carp and Eurasian Watermilfoil should be considered. Monitoring of stocking and harvest-related activities should also continue as these data can help inform future changes within biologically impaired or vulnerable lakes.

Historic efforts to reduce densities of Common Carp via trapping and barriers have been controversial and generally unsuccessful within the LSRW (e.g., Madison Lake). The addition of electric fish barriers between the Le Sueur River and Madison Lake have been constructed with the main goal of blocking Silver and Bighead Carp migrations, they can also affect the migrations of Common Carp and other native species. These barriers should be monitored for their efficacy in blocking Carp migrations, and also for the passibility by native fish species.

Pesticide application

Agricultural land use is prevalent within the LSRW, which results in a high potential for varying types and concentrations of pesticides to enter surface waters. Monitoring is needed to evaluate the extent of pesticide use within each lake’s contributing watershed, the number of pesticides and total concentration present in each lake, and any potential negative effects to the fish community that may be occurring as a result. Neonicotinoid monitoring, in particular, should become a standard practice on more lakes due to its water solubility, prevalence, and potential impacts to aquatic organisms.

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