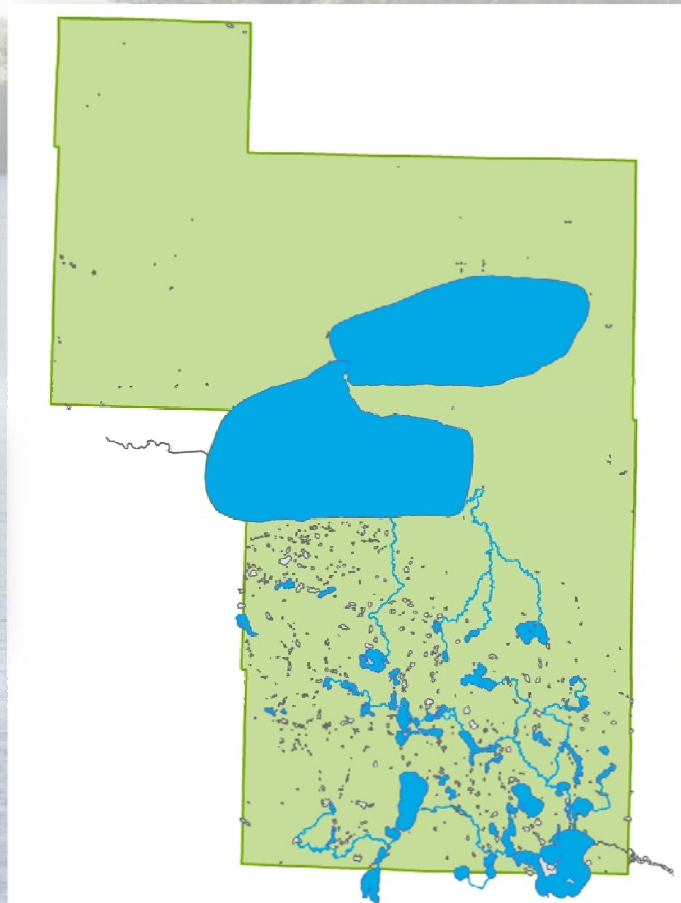
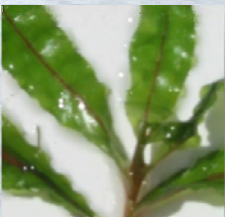
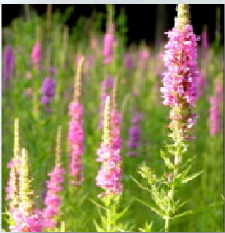


Beltrami County

AIS Prioritization

A planning tool developed for AIS risk management and prevention

2016



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Minnesota Pollution Control Agency

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Introduction

Background

Aquatic Invasive Species (AIS) are aquatic plants and animals that are not native to Minnesota, and cause environmental changes to our waters, have negative economic consequences to our communities, or are harmful to human health. Minnesota's natural resources are threatened by a number of Aquatic Invasive Species such as Zebra mussels, Flowering rush, Eurasian watermilfoil and Asian carp. Invasive species are usually spread by humans.

Zebra mussels are particularly harmful because they spread so rapidly and there are currently no effective treatment options. They attach to hard surfaces such as boats, docks, boat lifts, aquatic plants, and water intake pipes, and can clog pipes, cut feet, and damage boats.

Zebra mussels have a large economic impact to water treatment facilities, lakeshore owners, lake recreators, and the tourism industry.

Zebra mussels also affect the aquatic ecosystem by filtering out microscopic plankton from the water, and therefore removing the food source for other aquatic organisms. This has implications up the food chain, such as affecting fish populations.

As of the end of 2015 Zebra mussels have been found in approximately 94 lakes in Minnesota, and the DNR has included an additional 106 water bodies on their infested waters list because they are connected to a lake infested with Zebra mussels (MNDNR 2015) (Figure 1). The infestations are clustered around areas with high traffic lakes such as Brainerd, Alexandria, Detroit Lakes and Minneapolis. This pattern of spread is consistent with what has been seen in Michigan, another state with Zebra mussel infested lakes (Johnson *et al.* 2006).

In order to slow or stop the spread of Zebra mussels in Minnesota, a concentrated effort is required. Ideally, unlimited resources would be available to protect all lakes, but in reality budgets are always limited. Therefore, prioritizing lakes due to their risk of infestation is helpful in creating and implementing an AIS management plan.

Project Goals

Highest risk time of year
+
Highest risk lakes
=
When/where to focus AIS prevention

The goals of this project were to assess the risk of Zebra mussel infestation in Beltrami County in order to prioritize funding and efforts to prevent the further spread of Zebra mussels. Fifty lakes were selected by Beltrami County for this prioritization document. Lakes were chosen based on size, public accesses and use.

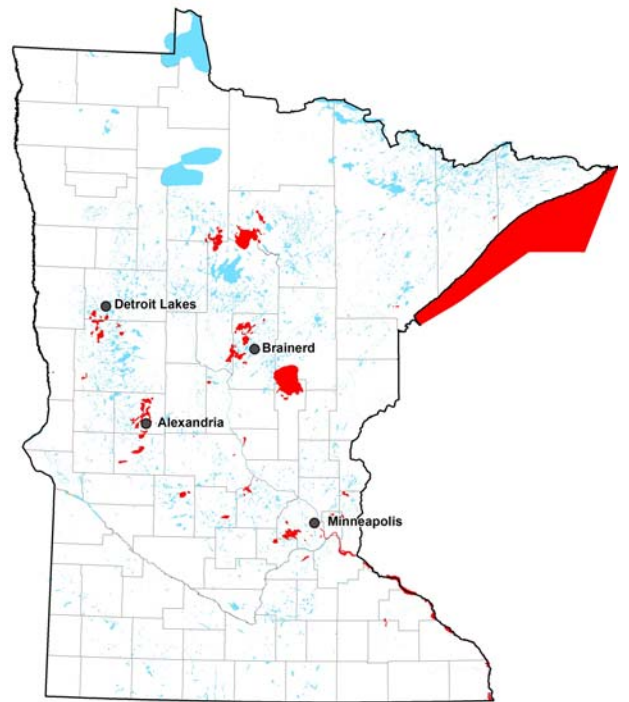


Figure 1. Minnesota Lakes infested by Zebra mussels, 2015.

Vectors of spread were evaluated for each lake such as connectivity to other water bodies and public use. In addition, the suitability of each water body to Zebra mussel establishment was evaluated considering

water chemistry, and substrate. A report card was developed for each water body showing the available data and assigned risk category.

These risk ratings can be used in AIS management plans to prioritize lakes for specific prevention measures. A summary table using the assessments to form management recommendations is provided (Table 14). This table can be used to guide the most efficient use of AIS funds in the most effective way possible.

Setting

Watersheds

A basin is the area of land drained by a river or lake and its tributaries. Minnesota has 4 divides. All water in Minnesota eventually flows into 1 of 4 rivers. The divides are made of 8 major drainage basins (Figure 2). Each drainage basin is made up of smaller units called watersheds, which correspond to the drainage of a tributary or lake system.

Watersheds are categorized as major or minor. A minor watershed is the smallest category of watershed. A group of minor watersheds that eventually flows into a common stream, such as the Otter Tail, forms a major watershed. A group of major watersheds that flow into a common river, such as the Red River, form a basin. A group of basins that flow into a common river form a divide.

Most of the Beltrami County lakes are in the Red River Basin or the Upper Mississippi River Basin (Figure 2).

The Red River of the North Basin stretches from northeastern South Dakota and west-central Minnesota northward through eastern North Dakota and northwestern Minnesota into southern Manitoba. It ends where the Red River empties into the southern end of Lake Winnipeg.

The Minnesota portion of the Red River Basin covers about 37,100 square miles in northwestern Minnesota in all or part of 21 counties. It is home to about 17,842 miles of streams and 668,098 acres of lakes.

The terrain of the Red River Basin in Minnesota is very diverse; from the flat, intensively farmed plain just east of the length of the Red River, to the rolling uplands full of trees and lakes in the east-central portion of the basin, to the extensive wetlands in the northeast.

The Upper Mississippi River Basin covers approximately 20,100 square miles. It starts at the Headwaters in Itasca State Park and runs a general north easterly course to Bemidji, then over to Grand Rapids before turning south and running through Brainerd, Little Falls, St. Cloud and the Twin Cities Metro area before it combines with the St. Croix River at Lock and Dam 2 near Hastings. As the river runs its course it drains a mixture of forests, prairie, agriculture and urban land areas (MPCA 2000).

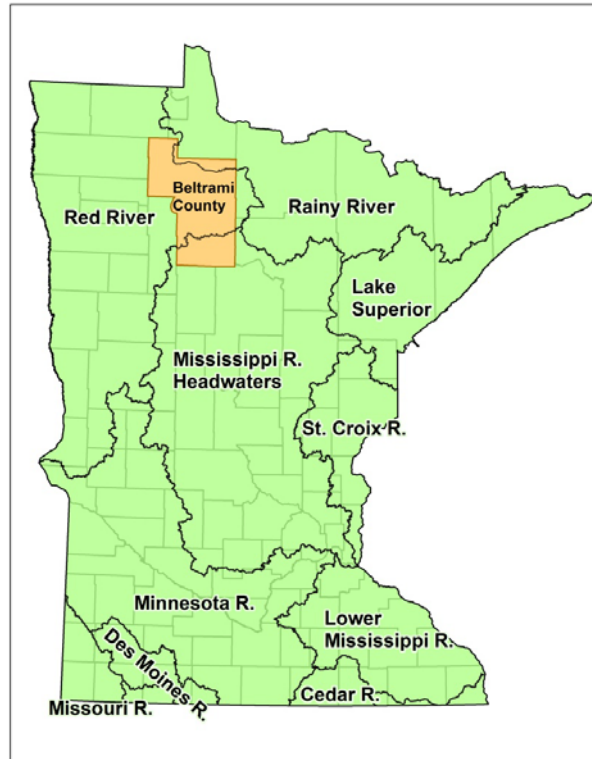


Figure 2. Minnesota showing all major drainage basins and Beltrami County.

Beltrami County

Beltrami County contains three major watersheds: Mississippi River Headwaters Watershed, Upper/Lower Red Lake Watershed and the Clearwater River Watershed (Figure 3). Watersheds are important to consider in aquatic invasive species (AIS) planning because AIS can spread downstream. An infestation in a large chain of lakes, such as the Mississippi Headwaters, can have implications for the Mississippi River Headwaters Watershed as well as downstream watersheds like the rest of the Mississippi River Basin.



Figure 3. Beltrami County with its major watersheds, lakes, and rivers.

History of AIS in Beltrami County

Plants

The only aquatic invasive plant documented in Beltrami County is Purple loosestrife (Figures 4, 7). Purple loosestrife is a wetland plant that can take over large areas. It has a biological control option in beetles. To read more about Purple loosestrife biological control, visit <http://www.dnr.state.mn.us/invasives/aquaticplants/purpleloosestrife/biocontrol.html>.



Figure 4. Purple loosestrife in a wetland (left), and the purple flowers (right).

Curly-leaf pondweed is also a common invasive plant in Minnesota (Figure 5). It is unknown when it was first established; however, it was most likely introduced to the state by accident in the early 1900s when common carp were intentionally brought to Minnesota. Curly-leaf pondweed has been in Minnesota so long that many people do not realize that it is a non-native species (DNR). It is possible that Curly-leaf pondweed exists in some Beltrami County lakes and is just not documented.

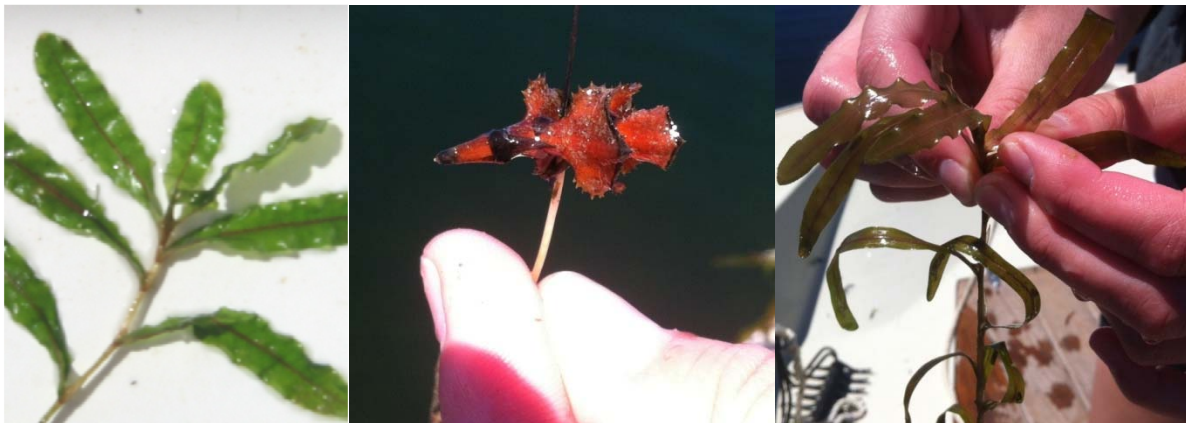


Figure 5. Curly-leaf pondweed (left), turion (wintering bud) (middle), and young Curly-leaf pondweed plant beginning to curl (right).

Zebra mussels

Zebra mussels were first discovered in Beltrami County in 2014, when they were documented in Cass Lake (Figures 6-7). A citizen discovered the zebra mussels while collecting shells on the beach on the southeast corner of Cedar Island. The area is a popular beach and swimming area where people park their watercraft to swim and fish.

Three hollow (dead) zebra mussels of varying sizes (ages) were collected. The samples were given to a DNR creel clerk who submitted them to the DNR area fisheries office in Bemidji where they were verified to be zebra mussels.

Following the identification, DNR staff conducted a search on Cass Lake around the northwest and southeast points of Cedar Island. The crew inspected more than 200 items along 565 feet of shoreline and 2,500 square feet of lake habitat and found zebra mussels in a variety of sizes.

This is the first confirmed adult zebra mussel find in the Bemidji area. Cass Lake was designated as Zebra mussel infested. The reach of the Mississippi River between Cass Lake and Lake Winnibigoshish was also designated as zebra mussel waters with this discovery. Lake Winnibigoshish was designated as infested with zebra mussels in 2013 due to the discovery of zebra mussel veligers.

Buck Lake, Andrusia Lake, Wolf Lake, Pike Bay, Pug Hole Lake, Kitchi Lake, Little Rice Lake and Big Rice Lake and their respective connecting rivers were also designated as zebra mussel infested. While no zebra mussels have been found in these lakes, they are heavily used by boaters traveling from Cass Lake.

The above information was taken from a DNR News Release, 9/12/2014.



Figure 6. Lakes designated as infested with Zebra mussels in 2014 (MN DNR).

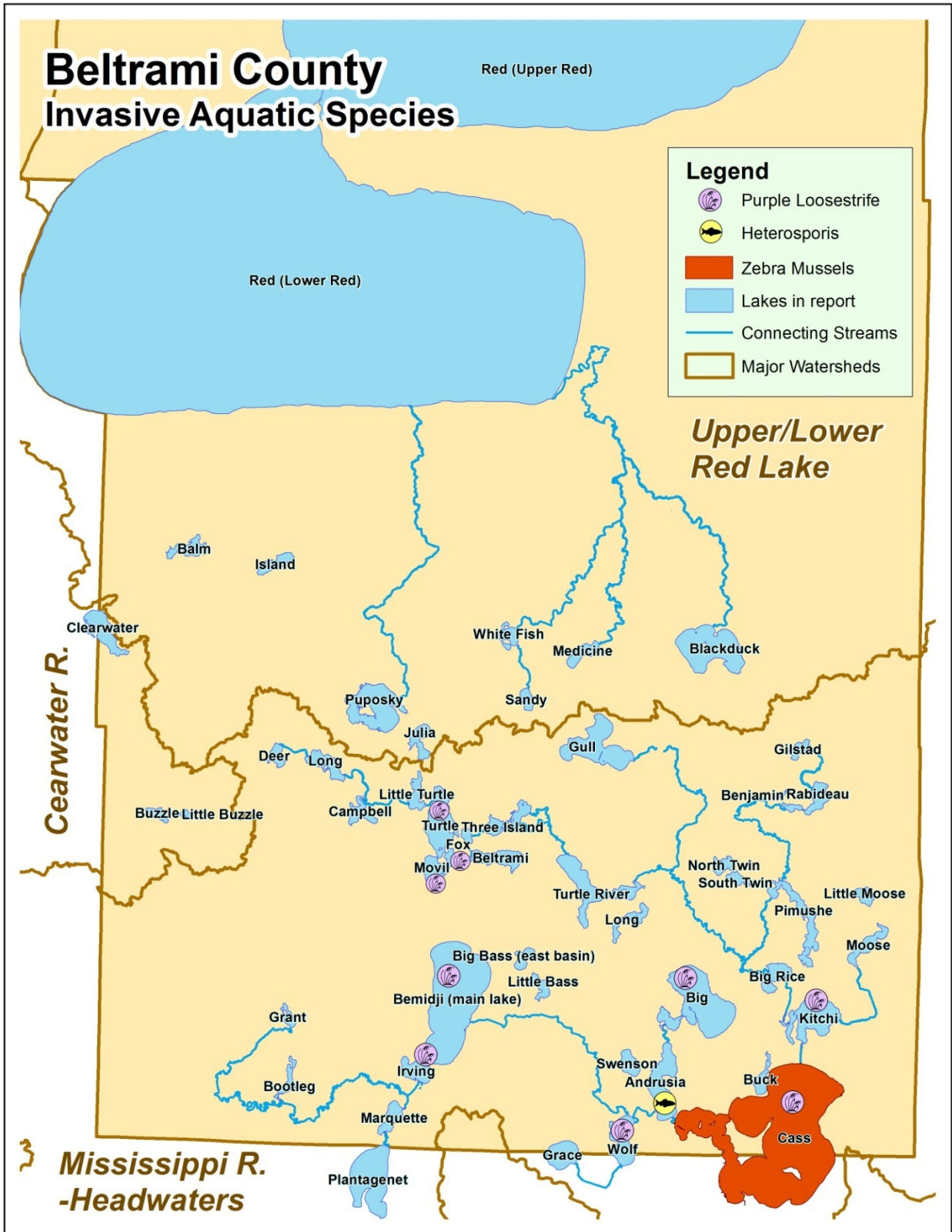


Figure 7. Aquatic invasive species infestations in Beltrami County.

Zebra Mussel Risk Assessment

Lake Methods

All the selected lakes in Beltrami County have water chemistry, temperature, and dissolved oxygen data available (Table 1). These data were collected by the Lake Associations, Red Lake Nation Department of Natural Resources, Beltrami SWCD, Minnesota Pollution Control Agency, and the Minnesota Department of Natural Resources, and were used in the Zebra mussel risk assessment for lakes.

Table 1. Selected lakes in Beltrami County.

Lake Name	Lake ID
Andrusia	04003800
Balm	04032900
Beltrami	04013500
Bemidji	04013002
Benjamin	04003300
Big	04004900
Big Bass (East Basin)	04013202
Big Rice	04003100
Blackduck	04006900
Bootleg	04021100
Buck	04004200
Buzzle	04029700
Campbell	04019600
Cass	04003000
Clearwater	04034300
Deer	04023000
Fox	04016200
Gilstad	04002400
Grace	29007100
Grant	04021700
Gull	04012000
Irving	04014000
Island	04026500
Julia	04016600
Kitchi	04000700
Little Bass	04011000
Little Buzzle	04029800
Little Moose	04000800
Little Turtle	04015500
Long	04022700
Long	04007600
Marquette	04014200
Medicine	04012200
Moose	04001100
Movil	04015200
North Twin	04006300
Pimushe	04003200
Plantagenet	29015600
Puposky	04019800

Table 1 continued on next page...

Table 1 continued. Selected lakes in Beltrami County.

Lake Name	Lake ID
Rabideau	04003400
Red (Lower Red)	04003502
Red (Upper Red)	04003501
Sandy	04012400
South Twin	04005300
Swenson	04008500
Three Island	04013400
Turtle	04015900
Turtle River	04011100
White Fish	04013700
Wolf	04007900

Water Connectivity

One of the highest risks to a water body becoming infested with Zebra mussels is if a nearby upstream lake is infested (Horvath 1996). Infested lakes can serve as a source of Zebra mussel veligers for downstream water bodies and adjacent lakes; however the inter-lake distance must be fairly close for the spread to be possible. Various studies have suggested a downstream veliger dispersal of 1-18 km (0.6-11 miles) in small streams (Lucy *et al.* 2005; Horvath *et al.* 1996). In this assessment, lakes that have an infested lake already identified less than 20 km (12 mi) upstream are at a high risk of infestation since the Zebra mussels could spread downstream (Table 2). Lakes that are in a chain have a moderate risk because if any upstream lakes get infested with Zebra mussels (<20 km), they could spread downstream. Headwaters lakes have a very low risk of infestation through water connectivity.

In addition to stream connections, adjacent water bodies have the potential to infest each other via boats going from one lake to another, regardless if the lakes are connected or not.

Table 2. Water connectivity and the related risk of Zebra mussel infestation.

Water Connectivity Category	Risk of infestation
Headwaters lake	Low risk
Chain of lakes (<20 km apart)	Moderate risk
Upstream infested lake (<20 km apart)	High risk

Public Use

Boats and water related equipment have been shown to be one of the largest vectors in the spread of Zebra mussels (Johnson *et al.* 2001). Public use can be measured by some surrogate statistics. First, the number of public accesses and related parking spots are known on each lake. The more public accesses on the lake, the more potential boats can use the lake. Secondly, the number of resorts and hotels on the lake are documented through the Bemidji Area Chamber of Commerce. A lot of resorts and hotels on the lake show that there are many visitors to the lake outside the immediate area, which poses more risk for infestation. Thirdly, the number of fishing tournaments and special events on lakes is documented through a permitting process. Fishing tournaments and special events draw visitors to the lakes. And finally, the homeowners on the lake own an average of one dock/boat lift/boat per property. The purchase of an infested boat lift or other water related equipment has been the source of several documented new infestations in Minnesota. This use relationship coupled with transport of boats and water equipment from lake to lake, increases the probability of infestation. "Destination lakes" for popular fish species like walleyes and muskies along with popular recreation waters for boating and swimming are at increased risk for infestation.

Public access inspections data was reviewed for each lake, but difficulty in standardizing data across lakes challenges the reliability of the data to be used as part of public use data for the final risk assessment.

The numbers used represent boating units per summer. For parcels, an average of one boat per parcel was used in the calculation. For fishing tournaments, the total boats participating in the tournament was used.

For access parking and resort units, the numbers were multiplied by 15 weeks of summer between Memorial Day and Labor Day for an estimated total summer use. This number is likely underestimated, but the ratings still come out the same either way, showing that the calculations are very robust (Tables 3-4). In weighting the resorts and accesses by the 15 weeks of summer, they are weighted appropriately compared to the resident parcels.

Table 3. Public use rating calculations.

Lake	Parcels*	Access Parking*	Resort Units*	Fishing Tournaments*	Total*	Risk
Bemidji	362	1185	5,655		7,202	High
Gull	199	165	3,480		3,844	High
Red (Upper Red)	374	405	2,070		2,849	High
Andrusia	136	75	1,665	375	2,251	High
Blackduck	191	330	1,485	35	2,041	Moderate
Kitchi	94	0	1,815		1,909	Moderate
Moose	89	225	960		1,274	Moderate
Turtle	181	105	525		811	Moderate
Pimushe	78	225	495		798	Moderate
Cass	315	240	135	80	770	Moderate
Plantagenet	218	225	45	60	548	Moderate
Grace	169	180	0	189†	538	Moderate
Campbell	56	195	150		401	Low
Irving	109	180	0	100	389	Low
Balm	63	225	90		378	Low
Beltrami	190	180	0		370	Low
Medicine	14	150	195		359	Low
Turtle River	141	135	30	24	330	Low
Wolf	95	150	75		320	Low
Big	154	75	90		319	Low
Big Rice	27	0	225		252	Low
Julia	107	120	0		227	Low
Movil	215	0	0		215	Low
Deer	40	150	0		190	Low
Big Bass (east basin)	87	75	0		162	Low
Long	162	0	0		162	Low
Three Island	56	45	60		161	Low
Rabideau	38	120	0		158	Low

† This number is not a fishing tournament, but a count of non-resident boats from access inspections in 2014.

Table 3 is continued on the next page...

Table 3 continued. Public use rating calculations.

Lake	Parcels*	Access Parking*	Resort Units*	Fishing Tournaments*	Total*	Risk
Sandy	34	90	0		124	Low
North Twin	38	75	0		113	Low
Grant	34	75	0		109	Low
Island	31	75	0		106	Low
Fox	29	0	70		99	Low
Little Bass	83	0	0		83	Low
Gilstad	22	60	0		82	Low
South Twin	37	45	0		82	Low
Benjamin	11	60	0		71	Low
Marquette	67	0	0		67	Low
Buzzle	18	45	0		63	Low
Buck	61	0	0		61	Low
Little Turtle	60	0	0		60	Low
Clearwater	56	0	0		56	Low
Little Buzzle	6	45	0		51	Low
Long	43	0	0		43	Low
Swenson	42	0	0		42	Low
Puposky	35	0	0		35	Low
White Fish	33	0	0		33	Low
Bootleg	18	0	0		18	Low
Little Moose	6	0	0		6	Low
Red (Lower Red)	0	0	0		0	Low

*All numbers are the total number of boats for the 15 weeks of summer.

Table 4. Use ratings and assigned risk for Zebra mussel infestation.

	Low Risk	Moderate Risk	High Risk
Total Boat Units (the sum of public access parking spaces, resort units, lake parcels and special events)	0-500	501-2,200	2,201+

Water Chemistry

Available water quality data was compiled and analyzed for each major lake and stretch of river in Beltrami County. The average was calculated for each available parameter. The values were then compared to the ranges in Table 5 to determine the potential for Zebra mussels to establish and reproduce in the water body. Calcium was considered first, based on its importance in shell formation (Mackie & Schloesser 1996); however calcium data were not available for all water bodies. Next, alkalinity, hardness and pH were considered (Mackie & Claudi 2010; Hincks & Mackie 1997). Lastly, Secchi depth, chlorophyll a and total phosphorus were considered, although they are not sufficient parameters alone to assess risk (Mackie & Claudi 2010).

Total phosphorus and chlorophyll a are useful for determining the lake's trophic state, which does affect suitability for Zebra mussels. Zebra mussels thrive best in mesotrophic lakes (Karatayev et al. 1998, Nelepa 1992). Eutrophic lakes have a lower suitability due to too much phosphorus and chlorophyll a, and usually softer substrates.

Table 5. Water column Zebra mussel suitability criteria (Mackie and Claudi 2010).

Parameter	Risk		
	Low Little Potential for Larval Development	Moderate (survivable, but will not flourish)	High (favorable for optimal growth)
Calcium (mg/l)	8-15	15-30	>30
pH	7.0-7.8 or 9.0-9.5	7.8-8.2 or 8.8-9.0	8.2-8.8
Hardness (mg/L)	30-35	55-100	100-280
Alkalinity (mg/L)	30-55	55-100	100-280
Specific Conductance (umhos)	30-60	60-110	>110
Secchi depth (m)	1-2 or 6-8	4-6	2-4
Chlorophyll a (ug/L)	2.0-2.5 or 20-25	8-20	2.5-8
Total Phosphorus	5-10 or 35-50	10-25	25-35

Substrate Suitability

One of the reasons Zebra mussels are such a nuisance is that they attach to hard substrates via their byssal threads. Zebra mussels prefer a hard substrate for attachment although they will attach to plants as well (Karatayev et al. 1998). In lakes, they have been documented to colonize on rocks, docks, boatlifts and water intake pipes. Lakes with mainly soft substrate and not many man-made structures may not be as supportive to Zebra mussel colonization. Plants have just moderate suitability because in Minnesota they die off at the end of each summer, meaning the Zebra mussels that are attached to them must crawl to other substrates or die off during winter (Karatayev et al. 1998). Comments are made for each water body, its dominant substrate, and its likelihood to support Zebra mussels. The substrate types were determined by the MNDNR (Table 6).

Table 6. Substrate descriptions and their suitability to Zebra mussel survival.

Substrate (MNDNR)	Description	Suitability to Zebra mussels
Muck	Decomposed organic material	Low
Marl	Calcareous material	Low
Silt	Fine material with little grittiness	Low
Sand	Diameter less than 1/8 inch	Low
Submerged macrophytes	Underwater rooted plants	Moderate
Woody debris	Downed trees	Moderate
Gravel	Diameter 1/8 to 3 inches	High
Rubble	Diameter 3 to 10 inches	High
Boulder	Diameter over 10 inches	High

Temperature

Zebra mussels begin reproduction when water temperature is above 12 C, but ideal reproduction temperature occurs above 17-18 C (McMahon 1996). The upper thermal limit for North American Zebra mussels occurs somewhere around 30 C (McMahon 1996) The optimal temperature range for zebra mussel spawning in North America is estimated to between 18-26 C.

In Minnesota, lakes are usually ice-covered on average from November to March. During the ice-covered season, it is assumed that the water temperature is too cold for Zebra mussel spawning. However, the Zebra mussels do over-winter at the bottom of the lake (Mackie *et al.* 1989).

In summer, Minnesota lakes rarely exceed 30 C (86 F); therefore, it is likely that the Zebra mussels reproduce all summer once the water temperature reaches 17-18 C. This occurrence has been documented in Pelican Lake, where Zebra mussel veligers were first found at 18 C in 2012 and 19 C in 2013 (Rufer 2015).

The maximum temperature was reported for each lake and the risk was assigned based on if the lake exceeded 32 C in mid-summer or not (Table 7). The lake’s mixing regime and period of hypolimnetic anoxia were also noted as research has found that few Zebra mussel veligers occur below the thermocline in temperate lakes (Mackie *et al.* 1989).

Table 7. Temperature values and their impact on Zebra mussel survival.

Survival Potential	Temperature Range	Risk Rating
Prevent zebra mussel establishment	> 32 C	Low
Little impact on mussel survival	8 – 31 C	High

Infestation Risk Rating

The two main vectors of spread for Zebra mussels are lake connectivity and public use. The risks from these two categories were combined for an overall risk of infestation rating for each lake. A scoring system was used to weight each of these two categories, which resulted in three overall risk categories (Table 8).

Table 8. Combined infestation risk rating using public use and connectivity.

	Public Use Total Boat Units	Connectivity	Combined Risk Rating
Low Risk	0-700	0 = Headwaters Lake	0-1,000
Moderate Risk	701-2,000	100-800 = 1-8 upstream lakes 1000 = more than 9 upstream lakes	1,000-2,500
High Risk	2,000+	2,000 = Infested or Infested lake upstream	2,500+

Zebra mussel Suitability Rating

The two main factors for zebra mussels thriving in a lake are suitable water chemistry and suitable substrate. The risks from these two categories were combined for an overall suitability rating for each lake. This suitability rating can be interpreted as the probability that Zebra mussels will thrive in the lake. A scoring system was used to weight each of these two categories, which resulted in three overall risk categories (Table 9).

Table 9. Combined Zebra mussel suitability rating using water chemistry and substrate.

	Water Quality	Substrate	Combined Risk Rating
Low Risk	0 = The majority of averages in green category.	0 = Sand, Silt, Muck	0 - Low
Moderate Risk	500 = The majority of averages in yellow category.	500=Submerged macrophytes	1000 - Moderate
High Risk	1,000 = The majority of averages in red category.	1,000 = Rocks, Gravel, Rubble	2000 - High

River Science

Unlike lakes, rivers are not usually ideal habitat for Zebra mussels. Studies have shown that the turbulence in streams and rivers causes high Zebra mussel veliger mortality and assists in preventing the veligers from settling on hard substrates (Horvath & Lamberti 1999). Without an infested lake upstream continually supplying the stream with Zebra mussel veligers, the stream is unlikely to sustain a large population on its own. Although streams can be pathways for downstream infestations, the probability of Zebra mussel veliger survival decreases with distance downstream (Horvath & Lamberti 1999; Horvath *et al.* 1996).

For small streams (like the Turtle River), even the presence of an infested lake upstream supplying veligers will probably not allow the stream to support populations of Zebra mussel adults. Strayer (1991) found that in streams <10 meters wide (33 feet) there were no stable adult Zebra mussel populations. Zebra mussel adults seem to only survive in the largest rivers (>100 m wide) or large pools and stagnant backwaters.

Turbulence & Flow

Studies show that turbulence or shear may be the limiting factor for Zebra mussel survival in streams and rivers (Horvath & Lamberti 1999). Although specific flow rates are not determined, it appears that in streams and rivers, zebra mussels are only self-sustaining behind dams and stagnant backwaters. Therefore, for the purposes of this risk assessment, any stream sites are considered to have low risk due to the flow in the river, even if there is no flow data available.

Downstream Dispersal

Zebra mussel veliger abundance has been shown to decrease with distance in streams. Veligers have been found 10-18 km (6-11 miles) downstream of an infested lake in stream systems (Horvath *et al.*,1996). In heavily vegetated wetland stream systems, the dispersal distance has been found to be about 1 km (0.6 mile), which is much lower. There are a few possible factors affecting Zebra mussel veliger survival in wetlands streams, including aquatic vegetation, low water velocity, unsuitable water characteristics, limited substrate availability, and/or increased predation pressure (Bodamer & Brossenbroek 2008). These results show that protecting aquatic vegetation from removal, limiting stream dredging, and installing wetlands could help as a barrier for spreading Zebra mussels downstream.


The Turtle River and the headwaters of the Mississippi have some submerged vegetation, usually lined with emergent vegetation, has sandy/rocky substrate and mostly clear water. Taking into account the literature and the condition and habitat of the river, for the purposes of this risk assessment, 32 km (20 mi) is considered the longest a veliger could theoretically travel. This distance of 32 km is very conservative, but until further research is conducted a better estimate is not available.

Water Quality

The water chemistry ranges from Mackie and Claudi 2010 (Table 5) can be applied to streams; however, more applicable water quality parameters to streams are turbidity and total suspended solids. Turbidity has been shown to limit Zebra mussel survival. Although acute exposures to high turbidity can negatively affect a Zebra mussel population, they are able to compensate for some high exposure (McMahon 1996). Chronic high turbidity has a greater negative effect on Zebra mussel survival, as it inhibits their filtering ability (McMahon 1996, Karatayev *et al.* 1998). Mackie and Claudi (2010) suggest upper limits for Zebra mussel survival for total suspended solids at 96 mg/L and turbidity at 80 NTU, if the turbidity is caused mainly from sediment suspension. The combination of high temperature and high turbidity seem to be most stressful to Zebra mussels (Alexander 1994).

Lake Risk Assessment Summary: Andrusia

Infestation Risk Rating: High 1. <u>Connectivity</u> : Moderate Risk 2. <u>Public Use</u> : High Risk
Suitability Risk Rating: High 1. <u>Water Chemistry</u> : High Risk 2. <u>Substrate</u> : High Risk

Characteristics Major Basin: Mississippi R. -Headwaters Location: Northwest of Cass Lake, MN Surface Area: 1,590 acres Percent Littoral: 34.7% Max Depth: 55ft Inlet: Mississippi River, stream from Big Lake	
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Summary

Lake Andrusia has 35 upstream lakes and high public use, which results in a high infestation risk rating. If Zebra mussels were introduced into Lake Andrusia they would likely thrive due to suitable substrate and water chemistry.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of Lakes	35 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (136)	2,251	High
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (2,115)		
Substrate Suitability (mean abundance, DNR)		Gravel, Boulder, Sand	NA	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	39.5	4	>30
pH*		8.2	71	8.2-8.8
Alkalinity*	mg/L	153.7	30	100-280
Specific Conductance*	umhos	308	29	>110
Secchi Depth	ft	10.4	148	6.56-13.12
Chlorophyll a	ug/L	10.0	49	2.5-8
Total Phosphorus	ug/L	19.0	49	25-35


*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.7 C (125 observations)	>32 C	High
Dissolved oxygen	9.0 (105 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Balm

Infestation Risk Rating: Low 1. <u>Connectivity</u> : Low Risk 2. <u>Public Use</u> : Low Risk
Suitability Risk Rating: Moderate 1. <u>Water Chemistry</u> : High Risk 2. <u>Substrate</u> : Low Risk

Characteristics Major Basin: Upper/Lower Red Lake Location: Northwest of Bemidji, MN Surface Area: 537.4 acres Percent Littoral: 55.08% Max Depth: 33 ft Inlet: None	
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Summary

Balm Lake has no upstream lakes and low public use, which results in a low infestation risk rating. If Zebra mussels were introduced into Balm Lake they would do moderately well due to suitable water chemistry.

Attribute	Description	Number	Infestation Risk
Water Connectivity	Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	378	Low
	Non-resident Watercraft Impact		
Substrate Suitability (mean abundance, DNR)	Muck, Marl, Sand	NA	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	24.2	4	>30
pH*		8.2	4	8.2-8.8
Alkalinity*	mg/L	150	4	100-280
Specific Conductance*	umhos	287	4	>110
Secchi Depth	ft	12.8	104	6.56-13.12
Chlorophyll a	ug/L	4.1	11	2.5-8
Total Phosphorus	ug/L	14.2	11	25-35


*primary parameters for zebra mussel Suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	NA	>32 C	Likely high
Dissolved oxygen	NA	<7 mg/L	Likely high

Lake Risk Assessment Summary: Beltrami

Infestation Risk Rating: Low 1. <u>Connectivity</u> : Low Risk 2. <u>Public Use</u> : Low Risk
Suitability Risk Rating: High 1. <u>Water Chemistry</u> : High Risk 2. <u>Substrate</u> : High Risk

Characteristics Major Basin: Mississippi R. -Headwaters Location: North of Bemidji, MN Surface Area: 722 acres Percent Littoral: 55.87% Max Depth: 50 ft Inlet: Stream from Little Gnat Lake	
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Summary

Beltrami Lake has no upstream lakes and low public use, which results in a low infestation risk rating. If Zebra mussels were introduced into Beltrami Lake they would likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of Lakes	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (190)	370	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (180)		
Substrate Suitability (mean abundance, DNR)		Clay, Sand, Silt, Gravel	NA	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	25.4	3	>30
pH*		8.3	56	8.2-8.8
Alkalinity*	mg/L	148	5	100-280
Specific Conductance*	umhos	294	139	>110
Secchi Depth	ft	12.5	260	6.56-13.12
Chlorophyll a	ug/L	4.1	17	2.5-8
Total Phosphorus	ug/L	14.6	12	25-35

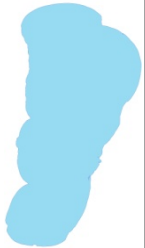
*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.4 C (28 observations)	>32 C	High
Dissolved oxygen	10.5 (21 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Bemidji

Infestation Risk Rating: High 1. <u>Connectivity</u> : Moderate Risk 2. <u>Public Use</u> : High Risk
Suitability Risk Rating: High 1. <u>Water Chemistry</u> : High Risk 2. <u>Substrate</u> : High Risk

Characteristics Major Basin: Mississippi R. -Headwaters Location: North of Bemidji, MN Surface Area: 6,580.5 acres Percent Littoral: 27.64% Max Depth: 76 ft Inlet: Mississippi River	
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Summary

Lake Bemidji has 26 upstream lakes and very high public use, which results in a high infestation risk rating. It has the highest public use rating of all the lakes in Beltrami County. If Zebra mussels were introduced into Lake Bemidji they would likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of Lakes	26 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (362)	7,202	High
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (6,840)		
Substrate Suitability (mean abundance, DNR)		Sand, Clay, Rubble	NA	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	43.2	4	>30
pH*		8.4	578	8.2-8.8
Alkalinity*	mg/L	178.1	77	100-280
Specific Conductance*	umhos	335	10	>110
Secchi Depth	ft	9.5	207	6.56-13.12
Chlorophyll a	ug/L	12.3	40	2.5-8
Total Phosphorus	ug/L	28.0	48	25-35


*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	25.4 C (12 observations)	>32 C	High
Dissolved oxygen	10.1 (12 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Benjamin

Infestation Risk Rating: Low 1. <u>Connectivity</u> : Low Risk 2. <u>Public Use</u> : Low Risk
Suitability Risk Rating: Moderate 1. <u>Water Chemistry</u> : Moderate Risk 2. <u>Substrate</u> : High Risk

Characteristics Major Basin: Mississippi R. -Headwaters Location: South of Blackduck, MN Surface Area: 33.1 acres Percent Littoral: 49.7% Max Depth: 128 ft Inlet: None	
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Summary

Benjamin Lake has no upstream lakes and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into Benjamin Lake, they would likely do moderately well due to limitations in suitable water chemistry.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (11)	71	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (60)		
Substrate Suitability (mean abundance, DNR)		Marl, Gravel	NA	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		7.9	63	8.2-8.8
Alkalinity*	mg/L	49.9	10	100-280
Specific Conductance*	umhos	104	27	>110
Secchi Depth	ft	17.7	8	6.56-13.12
Chlorophyll a	ug/L	3.4	11	2.5-8
Total Phosphorus	ug/L	7.0	5	25-35

*primary parameters for zebra mussel Suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	27.3 C (63 observations)	>32 C	High
Dissolved oxygen	12.9 (56 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Big

Infestation Risk Rating: Low


1. Connectivity: Low Risk
2. Public Use: Low Risk

Suitability Risk Rating: High

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics

Major Basin: Mississippi R. -Headwaters
 Location: East of Bemidji, MN
 Surface Area: 3,592 acres
 Percent Littoral: 57.3%
 Max Depth: 35 ft
 Inlet: Headwater Creek



Summary

Big Lake has no upstream lakes and low public use, resulting in a low infestation rating. If Zebra mussels were introduced to Big Lake they would likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (154)	319	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (165)		
Substrate Suitability (mean abundance, DNR)		Sand, Muck, Marl, Gravel	NA	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	27.5	4	>30
pH*		8.2	4	8.2-8.8
Alkalinity*	mg/L	145	4	100-280
Specific Conductance*	umhos	275	4	>110
Secchi Depth	ft	12.0	110	6.56-13.12
Chlorophyll a	ug/L	5.3	6	2.5-8
Total Phosphorus	ug/L	16.0	6	25-35

*primary parameters for zebra mussel Suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	NA	>32 C	likely high
Dissolved oxygen	NA	<7 mg/L	likely high

Lake Risk Assessment Summary: Big Bass (east basin)

Infestation Risk Rating: Low

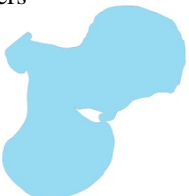
1. Connectivity: Low Risk
2. Public Use: Low Risk

Suitability Risk Rating: High

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics

Major Basin: Mississippi R. -Headwaters
 Location: Northeast of Bemidji, MN
 Surface Area: 337 acres
 Percent Littoral: 80.02%
 Max Depth: 17 ft
 Inlet: None



Summary

Big Bass Lake has no upstream lakes and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into Big Bass Lake they would likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (87)	162	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (75)		
Substrate Suitability (mean abundance, DNR)		Mud, Gravel, Silt, Clay	NA	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	23.8	4	>30
pH*		8.6	10	8.2-8.8
Alkalinity*	mg/L	108.4	5	100-280
Specific Conductance*	umhos	191	10	>110
Secchi Depth	ft	12.8	46	6.56-13.12
Chlorophyll a	ug/L	4.0	32	2.5-8
Total Phosphorus	ug/L	16.3	32	25-35

*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	24.2 C (28 observations)	>32 C	High
Dissolved oxygen	9.4 (28)	<7 mg/L	High

Lake Risk Assessment Summary: Big Rice

Infestation Risk Rating: Moderate


1. Connectivity: Moderate Risk
2. Public Use: Low Risk

Suitability Risk Rating: High

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics

Major Basin: Mississippi R. -Headwaters
 Location: South of Blackduck, MN
 Surface Area: 632.6 acres
 Percent Littoral: 100%
 Max Depth: 13 ft
 Inlet: Turtle River



Summary

Big Rice Lake has 40 upstream lakes and low public use, resulting in a moderate infestation risk rating. If Zebra mussels were introduced into Big Rice Lake they would likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of Lakes	40 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (27)	252	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (225)		
Substrate Suitability (mean abundance, DNR)		Muck, Gravel, Sand	NA	High

Water Chemistry Risk


Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	NA	0	100-280
Specific Conductance*	umhos	322	1	>110
Secchi Depth	ft	8.0	1	6.56-13.12
Chlorophyll a	ug/L	4.5	2	2.5-8
Total Phosphorus	ug/L	38.5	4	25-35

*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	18.39 C (1 observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely high

Lake Risk Assessment Summary: Blackduck

Infestation Risk Rating: Moderate 1. <u>Connectivity</u> : Moderate Risk 2. <u>Public Use</u> : Moderate Risk	Characteristics Major Basin: Upper/Lower Red Lake Location: West of Blackduck, MN Surface Area: 2,686.2 acres Percent Littoral: 46.29% Max Depth: 28 ft Inlet: Coburn Creek, Streams from Crandall and Funk Lakes	
Suitability Risk Rating: High 1. <u>Water Chemistry</u> : High Risk 2. <u>Substrate</u> : High Risk		

Summary

Blackduck Lake has no major upstream lakes and moderate public use, resulting in a moderate infestation risk rating. If Zebra mussels were introduced into Blackduck Lake they would likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of Lakes	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (191)	2,041	Moderate
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (1,850)		
Substrate Suitability (mean abundance, DNR)		Sand, gravel, boulders	NA	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	93	1	>30
pH*		8.2	63	8.2-8.8
Alkalinity*	mg/L	132.6	42	100-280
Specific Conductance*	umhos	280	31	>110
Secchi Depth	ft	9.4	182	6.56-13.12
Chlorophyll a	ug/L	23.3	25	2.5-8
Total Phosphorus	ug/L	34.0	30	25-35


*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.8 C (170 observations)	>32 C	High
Dissolved oxygen	8.6 (157)	<7 mg/L	High

Lake Risk Assessment Summary: Bootleg

Infestation Risk Rating: Low 1. <u>Connectivity</u> : Low Risk 2. <u>Public Use</u> : Low Risk
Suitability Risk Rating: Moderate 1. <u>Water Chemistry</u> : Moderate Risk 2. <u>Substrate</u> : Moderate Risk

Characteristics Major Basin: Mississippi R. -Headwaters Location: West of Bemidji Surface Area: 332.4 acres Percent Littoral: 76% Max Depth: 30 ft Inlet: None	
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Summary

Bootleg Lake has no upstream lakes and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into Bootleg Lake they would likely do moderately well, although more water chemistry data would be helpful in determining suitability.

Attribute	Description	Number	Infestation Risk
Water Connectivity	Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	18	Low
	Non-resident Watercraft Impact		
Substrate Suitability (mean abundance, DNR)	Muck, Gravel, Sand	NA	Moderate

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	NA	0	100-280
Specific Conductance*	umhos	NA	0	>110
Secchi Depth	ft	6.6	5	6.56-13.12
Chlorophyll a	ug/L	20.6	5	2.5-8
Total Phosphorus	ug/L	38.8	5	25-35


*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	NA	>32 C	Likely high
Dissolved oxygen	NA	<7 mg/L	Likely high

Lake Risk Assessment Summary: Buck

Infestation Risk Rating: Low 1. <u>Connectivity</u> : Low Risk 2. <u>Public Use</u> : Low Risk
Suitability Risk Rating: High 1. <u>Water Chemistry</u> : High Risk 2. <u>Substrate</u> : High Risk

Characteristics Major Basin: Mississippi R. -Headwaters Location: East of Bemidji, MN Surface Area: 360 acres Percent Littoral: 33% Max Depth: 53 ft Inlet: None	
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Summary

Buck Lake has no upstream lakes and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into Buck Lake they would likely thrive do to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (61)	61	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (0)		
Substrate Suitability (mean abundance, DNR)		Sand, Muck, Boulders	NA	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	NA	0	100-280
Specific Conductance*	umhos	NA	0	>110
Secchi Depth	ft	11.8	10	6.56-13.12
Chlorophyll a	ug/L	4.2	16	2.5-8
Total Phosphorus	ug/L	16.9	18	25-35

*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	NA	>32 C	Likely high
Dissolved oxygen	NA	<7 mg/L	Likely high

Lake Risk Assessment Summary: Buzzle

Infestation Risk Rating: Low


1. Connectivity: Moderate Risk
2. Public Use: Low Risk

Suitability Risk Rating: Moderate

1. Water Chemistry: High Risk
2. Substrate: Low Risk

Characteristics

Major Basin: Clearwater R.
 Location: Northwest of Bemidji
 Surface Area: 195.5 acres
 Percent Littoral: 28.3%
 Max Depth: 82.8 ft
 Inlet: Stream from Little Buzzle Lake



Summary

Buzzle Lake is a very small deep lake with not much littoral area (28%). It does not have a public access, and has very little public use, which results in a low infestation risk rating. If Zebra mussels were introduced into Buzzle Lake, they would likely survive due to suitable water chemistry, but the substrate may be limiting.

Attribute	Description	Number	Infestation Risk
Water Connectivity	Chain of Lakes	4 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	63	Low
	Non-resident Watercraft Impact		
Substrate Suitability (mean abundance, DNR)	Sand	NA	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		8.4	4	8.2-8.8
Alkalinity*	mg/L	NA	0	100-280
Specific Conductance*	umhos	284	4	>110
Secchi Depth	ft	13.0	22	6.56-13.12
Chlorophyll a	ug/L	2.6	10	2.5-8
Total Phosphorus	ug/L	9.2	10	25-35


*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	25.4 C (7 observations)	>32 C	High
Dissolved oxygen	9.2 (4 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Campbell

Infestation Risk Rating: Low 1. <u>Connectivity</u> : Moderate Risk 2. <u>Public Use</u> : Low Risk
Suitability Risk Rating: Moderate 1. <u>Water Chemistry</u> : High Risk 2. <u>Substrate</u> : Low Risk

Characteristics Major Basin: Mississippi R. -Headwaters Location: North of Bemidji, MN Surface Area: 461.9 acres Percent Littoral: 47.31% Max Depth: 25 ft Inlet: Stream from Peterson Lake, and the Turtle River	
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Summary

Campbell Lake has three upstream lakes and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into Campbell Lake they would likely survive due to suitable water chemistry.

Attribute	Description	Number	Infestation Risk
Water Connectivity	Chain of Lakes	3 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	401	Low
	Non-resident Watercraft Impact		
Substrate Suitability (mean abundance, DNR)	Clay, Sand, Muck	NA	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	36.2	4	>30
pH*		8.0	4	8.2-8.8
Alkalinity*	mg/L	159.5	4	100-280
Specific Conductance*	umhos	323.3	4	>110
Secchi Depth	ft	7.1	37	6.56-13.12
Chlorophyll a	ug/L	8.8	19	2.5-8
Total Phosphorus	ug/L	27.6	20	25-35

*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	23.9 C (4 observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely high

Lake Risk Assessment Summary: Cass [INFESTED]

Infestation Risk Rating: Moderate


1. Connectivity: Moderate Risk
2. Public Use: Moderate Risk

Suitability Risk Rating: High

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics

Major Basin: Mississippi R. -Headwaters
 Location: East of Bemidji, MN
 Surface Area: 15,958 acres
 Percent Littoral: 47.6%
 Max Depth: 120 ft
 Inlet: Turtle River, Mississippi River, Fox Creek



Summary

Zebra mussel adults were confirmed in Cass Lake in the summer of 2014. Luckily, not many other Cass County Lakes are located downstream from Cass Lake except for Lake Winnibigoshish, which is already designated as infested. Zebra mussels will likely thrive in Cass Lake due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of Lakes	87 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (315)	770	Moderate
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (455)		
Substrate Suitability (mean abundance, DNR)		Sand, Clay, Muck, Gravel	NA	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		8.2	62	8.2-8.8
Alkalinity*	mg/L	147.9	14	100-280
Specific Conductance*	umhos	325	NA	>110
Secchi Depth	ft	9.1	133	6.56-13.12
Chlorophyll a	ug/L	4.2	6	2.5-8
Total Phosphorus	ug/L	14.8	6	25-35

*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	23 C (74 observations)	>32 C	High
Dissolved oxygen	8.4 (74 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Clearwater

Infestation Risk Rating: Low


1. Connectivity: Moderate Risk
2. Public Use: Low Risk

Suitability Risk Rating: High

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics

Major Basin: Clearwater R.
 Location: Northwest of Bemidji, MN
 Surface Area: 998.8 acres
 Percent Littoral: 34.1 %
 Max Depth: 60 ft
 Inlet: Clearwater River



Summary

Clearwater Lake has five upstream lakes and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into Clearwater Lake they would likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of Lakes	5 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (56)	56	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (0)		
Substrate Suitability (mean abundance, DNR)		Sand, Clay, Muck, Gravel	NA	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		8.5	4	8.2-8.8
Alkalinity*	mg/L	218	5	100-280
Specific Conductance*	umhos	415	8	>110
Secchi Depth	ft	8.0	9	6.56-13.12
Chlorophyll a	ug/L	7.1	65	2.5-8
Total Phosphorus	ug/L	21.6	65	25-35

*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	25.6 C (39 observations)	>32 C	High
Dissolved oxygen	8.7 (28 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Deer

Infestation Risk Rating: Low


1. Connectivity: Moderate Risk
2. Public Use: Low Risk

Suitability Risk Rating: High

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics

Major Basin: Mississippi R. -Headwaters
 Location: North of Bemidji, MN
 Surface Area: 297.8 acres
 Percent Littoral: 45.1%
 Max Depth: 42 ft
 Inlet: Stream from Lake Erick



Summary

Deer Lake has three upstream lakes and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into Deer Lake they would likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of Lakes	3 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (40)	190	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (150)		
Substrate Suitability (mean abundance, DNR)		Sand, Clay, Muck, Gravel	NA	High

Water Chemistry Risk


Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	33.4	6	>30
pH*		8.4	2	8.2-8.8
Alkalinity*	mg/L	152.5	4	100-280
Specific Conductance*	umhos	277	4	>110
Secchi Depth	ft	11.2	91	6.56-13.12
Chlorophyll a	ug/L	5.2	25	2.5-8
Total Phosphorus	ug/L	16.2	25	25-35

*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.4 C (38 observations)	>32 C	High
Dissolved oxygen	8.5 (28 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Fox

Infestation Risk Rating: Moderate 1. <u>Connectivity</u> : Moderate Risk 2. <u>Public Use</u> : Low Risk	Characteristics Major Basin: Mississippi R. -Headwaters Location: North of Bemidji, MN Surface Area: 164.8 acres Percent Littoral: 89.86% Max Depth: 19 ft Inlet: Turtle River	
Suitability Risk Rating: High 1. <u>Water Chemistry</u> : High Risk 2. <u>Substrate</u> : High Risk		

Summary

Fox Lake has 14 upstream lakes and low public use, resulting in a moderate infestation risk rating. If Zebra mussels were introduced into Fox Lake they would likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of Lakes	14 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (29)	99	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (70)		
Substrate Suitability (mean abundance, DNR)		Muck, Sand, Gravel	NA	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	25.9	4	>30
pH*		8.3	26	8.2-8.8
Alkalinity*	mg/L	150	5	100-280
Specific Conductance*	umhos	294	12	>110
Secchi Depth	ft	13.9	90	6.56-13.12
Chlorophyll a	ug/L	4.5	15	2.5-8
Total Phosphorus	ug/L	16.8	10	25-35

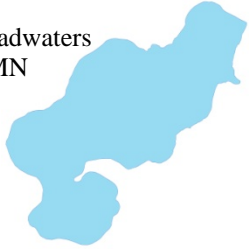
*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.3 C (26 observations)	>32 C	High
Dissolved oxygen	9.2 (19 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Gilstad

Infestation Risk Rating: Low 1. <u>Connectivity</u> : Moderate Risk 2. <u>Public Use</u> : Low Risk
Suitability Risk Rating: Moderate 1. <u>Water Chemistry</u> : High Risk 2. <u>Substrate</u> : Low Risk

Characteristics Major Basin: Mississippi R. -Headwaters Location: South of Blackduck, MN Surface Area: 256.8 acres Percent Littoral: 43.62% Max Depth: 55 ft Inlet: Everton Creek	
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Summary

Gilstad Lake has one upstream lake and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into Gilstad Lake they would likely survive due to suitable water chemistry. The substrate could be limiting to widespread establishment.

Attribute	Description	Number	Infestation Risk
Water Connectivity	Chain of Lakes	1 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	82	Low
	Non-resident Watercraft Impact		
Substrate Suitability (mean abundance, DNR)	Sand, Marl	NA	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	NA	0	100-280
Specific Conductance*	umhos	NA	0	>110
Secchi Depth	ft	8.6	14	6.56-13.12
Chlorophyll a	ug/L	6.0	10	2.5-8
Total Phosphorus	ug/L	21.5	10	25-35

*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	NA	>32 C	Likely high
Dissolved oxygen	NA	<7 mg/L	Likely high

Lake Risk Assessment Summary: Grace

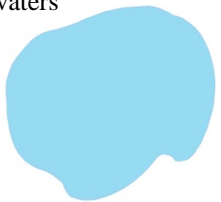
Infestation Risk Rating: Moderate

1. Connectivity: Low Risk
2. Public Use: Moderate Risk

Suitability Risk Rating: High

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
 Major Basin: Mississippi R. -Headwaters
 Location: East of Bemidji, MN
 Surface Area: 859.8 acres
 Percent Littoral: 40.94%
 Max Depth: 42 ft
 Inlet: Headwater Creeks



Summary

Grace Lake has no upstream lakes and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into Grace Lake they would likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (169)	538	Moderate
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (369)		
Substrate Suitability (mean abundance, DNR)		Sand, Gravel, Muck	NA	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	25.3	4	>30
pH*		8.3	4	8.2-8.8
Alkalinity*	mg/L	127.8	4	100-280
Specific Conductance*	umhos	263.5	4	>110
Secchi Depth	ft	14.8	180	6.56-13.12
Chlorophyll a	ug/L	10.8	50	2.5-8
Total Phosphorus	ug/L	27.6	50	25-35


*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	27.2 C (21 observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely high

Lake Risk Assessment Summary: Grant

Infestation Risk Rating: Low 1. <u>Connectivity</u> : Low Risk 2. <u>Public Use</u> : Low Risk
Suitability Risk Rating: Moderate 1. <u>Water Chemistry</u> : High Risk 2. <u>Substrate</u> : Low Risk

Characteristics Major Basin: Mississippi R. -Headwaters Location: West of Bemidji Surface Area: 205.9 acres Percent Littoral: 38.12% Max Depth: 92 ft Inlet: None	
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Summary

Grant Lake has no upstream lakes and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into Grant Lake they would likely survive due to suitable water chemistry. They could be somewhat limited by substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (34)	109	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (75)		
Substrate Suitability (mean abundance, DNR)		Clay, Muck, Sand, Silt	NA	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	32.9	4	>30
pH*		7.9	4	8.2-8.8
Alkalinity*	mg/L	156.3	4	100-280
Specific Conductance*	umhos	305.3	4	>110
Secchi Depth	ft	12.1	27	6.56-13.12
Chlorophyll a	ug/L	2.9	13	2.5-8
Total Phosphorus	ug/L	15.4	13	25-35

*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	NA	>32 C	Likely high
Dissolved oxygen	NA	<7 mg/L	Likely high

Lake Risk Assessment Summary: Gull

Infestation Risk Rating: High


1. Connectivity: Low Risk
2. Public Use: High Risk

Suitability Risk Rating: Moderate

1. Water Chemistry: High Risk
2. Substrate: Low Risk

Characteristics

Major Basin: Mississippi R. -Headwaters
 Location: West of Tenstrike, MN
 Surface Area: 2,255.6 acres
 Percent Littoral: 68.3%
 Max Depth: 28.9 ft
 Inlet: None



Summary

Gull Lake has no upstream lakes, but very high public use, resulting in a high infestation risk rating. If Zebra mussels were introduced into Gull Lake they would likely survive due to suitable water chemistry.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (199)	3,844	High
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (3,645)		
Substrate Suitability (mean abundance, DNR)		Muck, Clay, Sand, Silt	NA	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	27.5	2	>30
pH*		8.2	32	8.2-8.8
Alkalinity*	mg/L	110	5	100-280
Specific Conductance*	umhos	215	12	>110
Secchi Depth	ft	9.8	42	6.56-13.12
Chlorophyll a	ug/L	9.3	11	2.5-8
Total Phosphorus	ug/L	26.8	6	25-35


*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	25.1 C (28 observations)	>32 C	High
Dissolved oxygen	8.1 (21 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Irving

<p>Infestation Risk Rating: Moderate</p> <ol style="list-style-type: none"> <u>Connectivity</u>: Moderate Risk <u>Public Use</u>: Low Risk
<p>Suitability Risk Rating: Moderate</p> <ol style="list-style-type: none"> <u>Water Chemistry</u>: Moderate <u>Substrate</u>: Low Risk

<p>Characteristics</p> <p>Major Basin: Mississippi R. -Headwaters Location: South of Bemidji, MN Surface Area: 661.3 acres Percent Littoral: 89.4% Max Depth: 16 ft Inlet: Mississippi River</p>	
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Summary

Irving Lake has 23 upstream lakes and low public use, resulting in a moderate infestation risk rating. If Zebra mussels were introduced into Irving Lake they would likely do moderately well, and could be limited by water chemistry and/or substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of Lakes	23 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (109)	389	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (280)		
Substrate Suitability (mean abundance, DNR)		Muck, Sand, Clay	NA	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	47.1	3	>30
pH*		8.0	79	8.2-8.8
Alkalinity*	mg/L	195	14	100-280
Specific Conductance*	umhos	396	48	>110
Secchi Depth	ft	5.0	138	6.56-13.12
Chlorophyll a	ug/L	40.4	29	2.5-8
Total Phosphorus	ug/L	69.2	29	25-35

*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.2 C (87 observations)	>32 C	High
Dissolved oxygen	8.0 (79 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Island

Infestation Risk Rating: Low


1. Connectivity: Low Risk
2. Public Use: Low Risk

Suitability Risk Rating: High

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics

Major Basin: Upper/Lower Red Lake
 Location: Northwest of Bemidji, MN
 Surface Area: 424.2 acres
 Percent Littoral: 100%
 Max Depth: 14 ft
 Inlet: None



Summary

Island Lake has no upstream lakes and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into Island Lake they would likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (31)	106	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (75)		
Substrate Suitability (mean abundance, DNR)		Sand, gravel, boulders	NA	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	NA	0	100-280
Specific Conductance*	umhos	NA	0	>110
Secchi Depth	ft	8.0	11	6.56-13.12
Chlorophyll a	ug/L	4.2	12	2.5-8
Total Phosphorus	ug/L	21.6	12	25-35


*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	NA	>32 C	Likely high
Dissolved oxygen	NA	<7 mg/L	Likely high

Lake Risk Assessment Summary: Julia

Infestation Risk Rating: Low 1. <u>Connectivity</u> : Moderate Risk 2. <u>Public Use</u> : Low Risk
Suitability Risk Rating: High 1. <u>Water Chemistry</u> : High Risk 2. <u>Substrate</u> : High Risk

Characteristics Major Basin: Upper/Lower Red Lake Location: North of Bemidji, MN Surface Area: 511.3 acres Percent Littoral: 31.6% Max Depth: 40 ft Inlet: stream from Crane Lake	
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Summary

Julia Lake has two upstream lakes and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into Julia Lake, they would likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of Lakes	2 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (107)	227	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (120)		
Substrate Suitability (mean abundance, DNR)		Clay, Muck, Silt, Sand, Gravel	NA	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	33.5	2	>30
pH*		8.3	14	8.2-8.8
Alkalinity*	mg/L	135	10	100-280
Specific Conductance*	umhos	269	16	>110
Secchi Depth	ft	12.8	55	6.56-13.12
Chlorophyll a	ug/L	8.0	24	2.5-8
Total Phosphorus	ug/L	29.0	27	25-35

*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26 C (67 observations)	>32 C	High
Dissolved oxygen	8.5 (56 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Kitchi


Infestation Risk Rating: High

1. Connectivity: Moderate Risk
2. Public Use: Moderate Risk

Suitability Risk Rating: Moderate

1. Water Chemistry: High Risk
2. Substrate: Low Risk

Characteristics
 Major Basin: Mississippi R. -Headwaters
 Location: East of Bemidji, MN
 Surface Area: 1,858.1 acres
 Percent Littoral: 52.2%
 Max Depth: 56.6 ft
 Inlet: Turtle River, Kitchi Creek



Summary

Kitchi Lake has 46 upstream lakes and moderate public use, resulting in a high infestation risk rating. If Zebra mussels were introduced into Kitchi Lake they would likely survive due to suitable water chemistry. They could be limited somewhat by substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of Lakes	46 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (94)	1,909	Moderate
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (1,815)		
Substrate Suitability (mean abundance, DNR)		Sand	NA	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	41.1	4	>30
pH*		8.01	4	8.2-8.8
Alkalinity*	mg/L	165	4	100-280
Specific Conductance*	umhos	315.3	4	>110
Secchi Depth	ft	10.2	6	6.56-13.12
Chlorophyll a	ug/L	8.5	2	2.5-8
Total Phosphorus	ug/L	27.8	5	25-35


*primary parameters for zebra mussel Suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	25.6 C (20 observations)	>32 C	High
Dissolved oxygen	8.9 (7 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Little Bass

Infestation Risk Rating: Low 1. <u>Connectivity</u> : Low Risk 2. <u>Public Use</u> : Low Risk
Suitability Risk Rating: Low 1. <u>Water Chemistry</u> : Low Risk 2. <u>Substrate</u> : Low Risk

Characteristics Major Basin: Mississippi R. -Headwaters Location: Northeast of Bemidji, MN Surface Area: 362.6 acres Percent Littoral: 84.0% Max Depth: 22 ft Inlet: None	
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Summary

Little Bass Lake has no upstream lakes and low public use, resulting in a low infestation risk rating. Water quality monitoring shows that Little Bass is a soft water lake. Zebra mussels could be limited by water chemistry and substrate.

Attribute	Description	Number	Infestation Risk
Water Connectivity	Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	83	Low
	Non-resident Watercraft Impact		
Substrate Suitability (mean abundance, DNR)	Muck	NA	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	9.1	4	>30
pH*		7.9	4	8.2-8.8
Alkalinity*	mg/L	33.9	4	100-280
Specific Conductance*	umhos	80.4	4	>110
Secchi Depth	ft	17.6	151	6.56-13.12
Chlorophyll a	ug/L	3.6	13	2.5-8
Total Phosphorus	ug/L	13.7	13	25-35


*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	27.2 C (10 observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely high

Lake Risk Assessment Summary: Little Buzzle

Infestation Risk Rating: Low 1. <u>Connectivity</u> : Moderate Risk 2. <u>Public Use</u> : Low Risk
Suitability Risk Rating: Moderate 1. <u>Water Chemistry</u> : Moderate Risk 2. <u>Substrate</u> : Low Risk

Characteristics Major Basin: Clearwater R. Location: Northwest of Bemidji, MN Surface Area: 78 acres Percent Littoral: 58.6% Max Depth: 26.8 ft Inlet: Stream from Whitefish Lake	
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Summary

Little Buzzle Lake has three upstream lakes and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into Little Buzzle Lake they would likely survive, but could be limited somewhat by substrate and available food (chlorophyll a).

Attribute	Description	Number	Infestation Risk
Water Connectivity	Chain of Lakes	3 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	51	Low
	Non-resident Watercraft Impact		
Substrate Suitability (mean abundance, DNR)	Muck	NA	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		8.0	35	8.2-8.8
Alkalinity*	mg/L	NA	0	100-280
Specific Conductance*	umhos	340	15	>110
Secchi Depth	ft	14.4	12	6.56-13.12
Chlorophyll a	ug/L	2.3	6	2.5-8
Total Phosphorus	ug/L	10.3	6	25-35


*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	24.9 C (55 observations)	>32 C	High
Dissolved oxygen	8.0 (55 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Little Moose

Infestation Risk Rating: Low 1. <u>Connectivity</u> : Low Risk 2. <u>Public Use</u> : Low Risk
Suitability Risk Rating: Moderate 1. <u>Water Chemistry</u> : Moderate Risk 2. <u>Substrate</u> : Low Risk

Characteristics Major Basin: Mississippi R. -Headwaters Location: Southeast of Blackduck, MN Surface Area: 303.6 acres Percent Littoral: 100% Max Depth: 4 ft Inlet: None	
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Summary

Little Moose Lake has no upstream lakes and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into Little Moose Lake, they may survive, but could be limited by substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (6)	6	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (0)		
Substrate Suitability (mean abundance, DNR)		Muck	NA	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	NA	0	100-280
Specific Conductance*	umhos	NA	0	>110
Secchi Depth	ft	3.8†	10	6.56-13.12
Chlorophyll a	ug/L	4.6	10	2.5-8
Total Phosphorus	ug/L	12.4	10	25-35

*primary parameters for zebra mussel Suitability


†The reason the Secchi depth is so low is that the maximum depth of the lake is only 4 feet, so the Secchi Disk hits the bottom of the lake.

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	NA	>32 C	NA
Dissolved oxygen	NA	<7 mg/L	NA

Lake Risk Assessment Summary: Little Turtle

Infestation Risk Rating: Low 1. <u>Connectivity</u> : Moderate Risk 2. <u>Public Use</u> : Low Risk
Suitability Risk Rating: High 1. <u>Water Chemistry</u> : High Risk 2. <u>Substrate</u> : Low Risk

Characteristics Major Basin: Mississippi R. -Headwaters Location: North of Bemidji, MN Surface Area: 465 acres Percent Littoral: 61.82% Max Depth: 26 ft Inlet: Turtle River	
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Summary

Little Turtle Lake has 8 upstream lakes and low public use, resulting in a low infestation rating. If Zebra mussels were introduced into the lake they would likely thrive due to suitable water chemistry and substrate.

Attribute	Description	Number	Infestation Risk
Water Connectivity	Chain of Lakes	8 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	60	Low
	Non-resident Watercraft Impact		
Substrate Suitability (mean abundance, DNR)	Muck, Silt	NA	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	44.1	4	>30
pH*		8.2	37	8.2-8.8
Alkalinity*	mg/L	176	5	100-280
Specific Conductance*	umhos	336	11	>110
Secchi Depth	ft	6.7	241	6.56-13.12
Chlorophyll a	ug/L	13.3	31	2.5-8
Total Phosphorus	ug/L	37.4	25	25-35

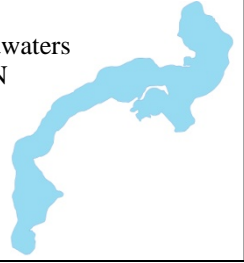
*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.7 C (31 observations)	>32 C	High
Dissolved oxygen	10.1 (15 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Long (0076)

Infestation Risk Rating: Low 1. <u>Connectivity</u> : Low Risk 2. <u>Public Use</u> : Low Risk
Suitability Risk Rating: Moderate 1. <u>Water Chemistry</u> : Moderate Risk 2. <u>Substrate</u> : Low Risk

Characteristics Major Basin: Mississippi R. -Headwaters Location: East of Turtle River, MN Surface Area: 411.9 acres Percent Littoral: 47% Max Depth: 83 ft Inlet: None	
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Summary

Long Lake has no upstream lakes and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into Long Lake they would likely survive due to suitable water chemistry. They may be limited somewhat by food source (chlorophyll a) and substrate.

Attribute	Description	Number	Infestation Risk
Water Connectivity	Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	162	Low
	Non-resident Watercraft Impact		
Substrate Suitability (mean abundance, DNR)	Sand, Muck	NA	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	22.6	3	>30
pH*		8.2	3	8.2-8.8
Alkalinity*	mg/L	98.1	3	100-280
Specific Conductance*	umhos	214.3	3	>110
Secchi Depth	ft	19.1	232	6.56-13.12
Chlorophyll a	ug/L	2.3	30	2.5-8
Total Phosphorus	ug/L	10.2	30	25-35


*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.2 C (5 observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely high

Lake Risk Assessment Summary: Long (0227)

Infestation Risk Rating: Low 1. <u>Connectivity</u> : Moderate Risk 2. <u>Public Use</u> : Low Risk
Suitability Risk Rating: Moderate 1. <u>Water Chemistry</u> : High Risk 2. <u>Substrate</u> : Low Risk

Characteristics Major Basin: Mississippi R. -Headwaters Location: North of Bemidji, MN Surface Area: 657.8 acres Percent Littoral: 100% Max Depth: 15 ft Inlet: streams from Round, Fawn, and Deer Lakes	
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Summary

Long Lake has five upstream lakes and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into Long Lake they would likely survive due to suitable water chemistry. They may be limited somewhat by substrate.

Attribute	Description	Number	Infestation Risk
Water Connectivity	Chain of Lakes	5 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	43	Low
	Non-resident Watercraft Impact		
Substrate Suitability (mean abundance, DNR)	Muck	NA	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	30.5	4	>30
pH*		8.1	4	8.2-8.8
Alkalinity*	mg/L	144.3	4	100-280
Specific Conductance*	umhos	280.8	4	>110
Secchi Depth	ft	10.2	56	6.56-13.12
Chlorophyll a	ug/L	6.3	19	2.5-8
Total Phosphorus	ug/L	27.8	19	25-35

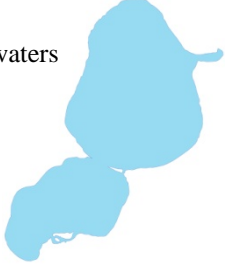
*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	25.6 C (10 observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely high

Lake Risk Assessment Summary: Marquette

Infestation Risk Rating: Low 1. <u>Connectivity</u> : Moderate Risk 2. <u>Public Use</u> : Low Risk
Suitability Risk Rating: Moderate 1. <u>Water Chemistry</u> : High Risk 2. <u>Substrate</u> : Low Risk

Characteristics Major Basin: Mississippi R. -Headwaters Location: South of Bemidji, MN Surface Area: 527.6 acres Percent Littoral: 56.1% Max Depth: 51 ft Inlet: Schoolcraft River	
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Summary

Marquette Lake has nine upstream lakes and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into Marquette Lake they would likely survive due to suitable water chemistry. They may be limited somewhat by substrate.

Attribute	Description	Number	Infestation Risk
Water Connectivity	Chain of Lakes	9 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	67	Low
	Non-resident Watercraft Impact		
Substrate Suitability (mean abundance, DNR)	Muck, Sand	NA	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	42.0	4	>30
pH*		8.1	4	8.2-8.8
Alkalinity*	mg/L	172.8	4	100-280
Specific Conductance*	umhos	326.8	4	>110
Secchi Depth	ft	8.1	37	6.56-13.12
Chlorophyll a	ug/L	9.7	19	2.5-8
Total Phosphorus	ug/L	27.2	19	25-35

*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.1 C (8 observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely high

Lake Risk Assessment Summary: Medicine

Infestation Risk Rating: Low

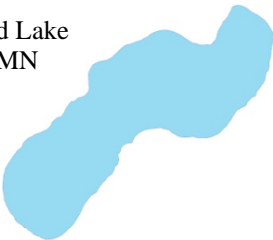
1. Connectivity: Moderate Risk
2. Public Use: Low Risk

Suitability Risk Rating: High

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics

Major Basin: Upper/Lower Red Lake
 Location: West of Blackduck, MN
 Surface Area: 461.3 acres
 Percent Littoral: 68.63%
 Max Depth: 43.9 ft
 Inlet: O'Brien Creek



Summary

Medicine Lake has one small upstream lake and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into Medicine Lake, they would likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of Lakes	1 small upstream lake	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (14)	359	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (345)		
Substrate Suitability (mean abundance, DNR)		Sand, silt, rocks	NA	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	32.8	4	>30
pH*		8.5	49	8.2-8.8
Alkalinity*	mg/L	128.3	6	100-280
Specific Conductance*	umhos	234	15	>110
Secchi Depth	ft	10.2	41	6.56-13.12
Chlorophyll a	ug/L	8.2	16	2.5-8
Total Phosphorus	ug/L	25.0	16	25-35

*primary parameters for zebra mussel Suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	24.6 C (40 observations)	>32 C	High
Dissolved oxygen	8.7 (40 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Moose

Infestation Risk Rating: Moderate

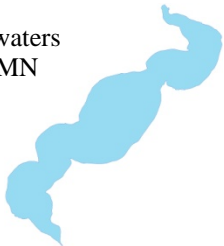
1. Connectivity: Low Risk
2. Public Use: Moderate Risk

Suitability Risk Rating: High

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics

Major Basin: Mississippi R. -Headwaters
 Location: Southeast of Blackduck, MN
 Surface Area: 600.7 acres
 Percent Littoral: 100%
 Max Depth: 13 ft
 Inlet: None



Summary

Moose Lake has no upstream lakes and moderate public use, resulting in a moderate infestation risk rating. If Zebra mussels were introduced into Moose Lake they would likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (89)	1,274	Moderate
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (1185)		
Substrate Suitability (mean abundance, DNR)		Muck, Gravel	NA	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	30.4	3	>30
pH*		8.2	3	8.2-8.8
Alkalinity*	mg/L	120	3	100-280
Specific Conductance*	umhos	227	4	>110
Secchi Depth	ft	13.8	10	6.56-13.12
Chlorophyll a	ug/L	4.6	10	2.5-8
Total Phosphorus	ug/L	12.4	10	25-35

*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	23.2 C (21 observations)	>32 C	High
Dissolved oxygen	8.9 (21 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Movil

Infestation Risk Rating: Moderate

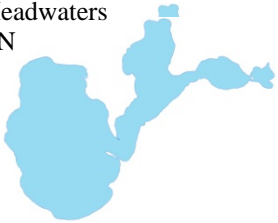
1. Connectivity: Moderate Risk
2. Public Use: Low Risk

Suitability Risk Rating: High

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics

Major Basin: Mississippi R. -Headwaters
 Location: North of Bemidji, MN
 Surface Area: 853.4 acres
 Percent Littoral: 51.09%
 Max Depth: 50.9 ft
 Inlet: Turtle River, and stream from Horseman Lake



Summary

Movil Lake has 11 upstream lakes and low public use, resulting in a moderate infestation risk rating. If Zebra mussels were introduced into Movil Lake they would likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of Lakes	11 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (215)	215	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (0)		
Substrate Suitability (mean abundance, DNR)		Gravel, Muck, Clay, Sand	NA	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	29.5	4	>30
pH*		8.2	4	8.2-8.8
Alkalinity*	mg/L	152.8	4	100-280
Specific Conductance*	umhos	306	4	>110
Secchi Depth	ft	13.2	115	6.56-13.12
Chlorophyll a	ug/L	4.4	37	2.5-8
Total Phosphorus	ug/L	14.2	37	25-35

*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	19.5 C (1 observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely high

Lake Risk Assessment Summary: North Twin

Infestation Risk Rating: Low


1. Connectivity: Low Risk
2. Public Use: Low Risk

Suitability Risk Rating: High

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics

Major Basin: Mississippi R. -Headwaters
 Location: South of Blackduck, MN
 Surface Area: 325.6 acres
 Percent Littoral: 42.64 %
 Max Depth: 65ft
 Inlet: None



Summary

North Twin Lake has no upstream lakes and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into North Twin Lake they would likely survive due to suitable substrate and chemistry. They may be somewhat limited by food source (chlorophyll a).

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (38)	113	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (75)		
Substrate Suitability (mean abundance, DNR)		Sand, gravel, boulders	NA	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	25.2	4	>30
pH*		8.1	4	8.2-8.8
Alkalinity*	mg/L	105.5	4	100-280
Specific Conductance*	umhos	209	4	>110
Secchi Depth	ft	19.2	84	6.56-13.12
Chlorophyll a	ug/L	2.0	29	2.5-8
Total Phosphorus	ug/L	10.5	25	25-35


*primary parameters for zebra mussel Suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.1 C (9 observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely high

Lake Risk Assessment Summary: Pimushe

<p>Infestation Risk Rating: Moderate</p> <ol style="list-style-type: none"> <u>Connectivity</u>: Moderate Risk <u>Public Use</u>: Moderate Risk
<p>Suitability Risk Rating: Moderate</p> <ol style="list-style-type: none"> <u>Water Chemistry</u>: High Risk <u>Substrate</u>: Low Risk

<p>Characteristics</p> <p>Major Basin: Mississippi R. -Headwaters Location: South of Blackduck, MN Surface Area: 1,203.2 acres Percent Littoral: 50.98% Max Depth: 40ft Inlet: North Turtle River</p> 

Summary

Pimushe Lake has 8 upstream lakes and moderate public use, resulting in a moderate infestation risk rating. If Zebra mussels were introduced into Pimushe Lake they would likely survive due to suitable water chemistry. They may be somewhat limited by substrate.

Attribute	Description	Number	Infestation Risk
Water Connectivity	Chain of Lakes	8 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	798	Moderate
	Non-resident Watercraft Impact		
Substrate Suitability (mean abundance, DNR)	Sand, Muck	NA	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	43.2	4	>30
pH*		8.2	38	8.2-8.8
Alkalinity*	mg/L	157.5	4	100-280
Specific Conductance*	umhos	288	10	>110
Secchi Depth	ft	10.2	28	6.56-13.12
Chlorophyll a	ug/L	13.6	14	2.5-8
Total Phosphorus	ug/L	26.2	10	25-35


*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.8 C (26 observations)	>32 C	High
Dissolved oxygen	8.5 (14 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Plantagenet

<p>Infestation Risk Rating: Moderate</p> <ol style="list-style-type: none"> <u>Connectivity</u>: Moderate Risk <u>Public Use</u>: Moderate Risk
<p>Suitability Risk Rating: Moderate</p> <ol style="list-style-type: none"> <u>Water Chemistry</u>: High Risk <u>Substrate</u>: Low Risk

<p>Characteristics</p> <p>Major Basin: Mississippi R. -Headwaters Location: South of Bemidji, MN Surface Area: 2,530.8 acres Percent Littoral: 38.4% Max Depth: 65 ft Inlet: Reservoir Creek, Schoolcraft River, and Cold Creek</p>	
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Summary

Lake Plantagenet has 8 upstream lakes and moderate public use, resulting in a moderate infestation risk rating. If Zebra mussels were introduced into Lake Plantagenet they would likely survive due to suitable water chemistry. They may be somewhat limited by substrate.

Attribute	Description	Number	Infestation Risk
Water Connectivity	Chain of Lakes	8 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	548	Moderate
	Non-resident Watercraft Impact		
Substrate Suitability (mean abundance, DNR)	Sand, Muck	NA	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	42.8	4	>30
pH*		8.2	4	8.2-8.8
Alkalinity*	mg/L	173.5	4	100-280
Specific Conductance*	umhos	323.5	4	>110
Secchi Depth	ft	8.5	202	6.56-13.12
Chlorophyll a	ug/L	12.2	50	2.5-8
Total Phosphorus	ug/L	26.7	50	25-35


*primary parameters for zebra mussel Suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.8 C (20 observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely high

Lake Risk Assessment Summary: Puposky

Infestation Risk Rating: Low 1. <u>Connectivity</u> : Moderate Risk 2. <u>Public Use</u> : Low Risk
Suitability Risk Rating: Moderate 1. <u>Water Chemistry</u> : High Risk 2. <u>Substrate</u> : Low Risk

Characteristics Major Basin: Upper/Lower Red Lake Location: North of Bemidji, MN Surface Area: 2177.2 acres Percent Littoral: 95% Max Depth: 20 ft Inlet: Mud River, stream from Lake Julia	
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Summary

Puposky Lake has 4 upstream lakes and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into Puposky Lake they would likely survive due to suitable water chemistry. They may be limited somewhat by substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of Lakes	4 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (35)	35	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (0)		
Substrate Suitability (mean abundance, DNR)		Silt, Mud, Sand	NA	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		8.7	7	8.2-8.8
Alkalinity*	mg/L	130.6	7	100-280
Specific Conductance*	umhos	257	7	>110
Secchi Depth	ft	4.7	12	6.56-13.12
Chlorophyll a	ug/L	10.0	12	2.5-8
Total Phosphorus	ug/L	30.4	13	25-35


*primary parameters for zebra mussel Suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	27.9 C (8 observations)	>32 C	High
Dissolved oxygen	8.6 (4 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Rabideau

Infestation Risk Rating: Low 1. <u>Connectivity</u> : Moderate Risk 2. <u>Public Use</u> : Low Risk
Suitability Risk Rating: Moderate 1. <u>Water Chemistry</u> : High Risk 2. <u>Substrate</u> : Low Risk

Characteristics Major Basin: Mississippi R. -Headwaters Location: South of Blackduck, MN Surface Area: 680.3 acres Percent Littoral: 75.8% Max Depth: 112ft Inlet: North Turtle River	
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Summary

Rabideau Lake has 3 upstream lakes and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into Rabideau Lake they would likely thrive due to suitable water chemistry. They may be limited somewhat by substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of Lakes	3 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (38)	158	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (120)		
Substrate Suitability (mean abundance, DNR)		Muck, Marl	NA	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		8.0	82	8.2-8.8
Alkalinity*	mg/L	150	5	100-280
Specific Conductance*	umhos	280	13	>110
Secchi Depth	ft	9.8	10	6.56-13.12
Chlorophyll a	ug/L	5.6	12	2.5-8
Total Phosphorus	ug/L	15.3	7	25-35


*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	27.4 C (28 observations)	>32 C	High
Dissolved oxygen	9.1 (9 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Red (Upper Red)

<p>Infestation Risk Rating: High</p> <ol style="list-style-type: none"> 1. <u>Connectivity</u>: Low Risk 2. <u>Public Use</u>: High Risk
<p>Suitability Risk Rating: High</p> <ol style="list-style-type: none"> 1. <u>Water Chemistry</u>: High Risk 2. <u>Substrate</u>: High Risk

<p>Characteristics</p> <p>Major Basin: Upper/Lower Red Lake Location: North of Bemidji, MN Surface Area: 119,271.6 acres Percent Littoral: 99.33% Max Depth: 15 ft Inlets: Manomin Creek, Deer River, Moose Creek, Tamarac River, Domaas Creek, Shotley Brook</p> 

Summary

Upper Red Lake is a headwaters lake, but it has very high public use, resulting in a high infestation risk rating. If Zebra mussels were introduced into Upper Red Lake they would likely thrive due to suitable substrate and water chemistry.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters	No major upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (374)	2,849	High
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (2,475)		
Substrate Suitability (mean abundance, DNR)		Sand, clay, gravel, rocks	NA	High

Water Chemistry Risk


Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		8.4	NA	8.2-8.8
Alkalinity*	mg/L	152.4	24	100-280
Specific Conductance*	umhos	259	NA	>110
Secchi Depth	ft	3.21	12	6.56-13.12
Chlorophyll a	ug/L	13.8	35	2.5-8
Total Phosphorus	ug/L	44.0	57	25-35

*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	25 C	>32 C	High
Dissolved oxygen	8-10 mg/L	<7 mg/L	High

Lake Risk Assessment Summary: Red (Lower Red)

Infestation Risk Rating: Moderate 1. <u>Connectivity</u> : Moderate 2. <u>Public Use</u> : Low	Characteristics Major Basin: Upper/Lower Red Lake Location: North of Bemidji, MN Surface Area: 164,540 acres Percent Littoral: 13.5% Max Depth: 31 ft Inlets: Mosquito Creek, Sandy River, Big Rock Creek, Little Rock Creek, Point Creek, Pike Creek, Mud River, Hay Creek, Blackduck River, Battle River, Sucker Creek	
Suitability Risk Rating: High 1. <u>Water Chemistry</u> : High Risk 2. <u>Substrate</u> : High Risk		

Summary

Lower Red Lake has numerous lakes flowing into it, including Upper Red Lake, and low public use. The overall infestation risk rating is moderate. If Zebra mussels were introduced into Lower Red Lake they would likely thrive due to suitable substrate and water chemistry.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of Lakes	numerous connected lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (NA)	No resorts or privately owned parcels	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (NA)		
Substrate Suitability (mean abundance, DNR)		Sand, clay, gravel, rocks	NA	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		8.3	NA	8.2-8.8
Alkalinity*	mg/L	161.2	29	100-280
Specific Conductance*	umhos	286	NA	>110
Secchi Depth	ft	4.2	5	6.56-13.12
Chlorophyll a	ug/L	9.7	35	2.5-8
Total Phosphorus	ug/L	35.0	71	25-35


*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	24 C	>32 C	High
Dissolved oxygen	10-12 mg/L	<7 mg/L	High

Lake Risk Assessment Summary: Sandy

Infestation Risk Rating: Low 1. <u>Connectivity</u> : Low Risk 2. <u>Public Use</u> : Low Risk
Suitability Risk Rating: Moderate 1. <u>Water Chemistry</u> : High Risk 2. <u>Substrate</u> : Low Risk

Characteristics Major Basin: Upper/Lower Red Lake Location: North of Bemidji, MN Surface Area: 261.3 acres Percent Littoral: 76.3 % Max Depth: 32 ft Inlet: Headwater Creeks	
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Summary

Sandy Lake has no upstream lakes and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into Sandy Lake they would likely survive due to suitable water chemistry. The substrate may be somewhat limiting.

Attribute	Description	Number	Infestation Risk
Water Connectivity	Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	124	Low
	Non-resident Watercraft Impact		
Substrate Suitability (mean abundance, DNR)	Silt, Mud, Sand	NA	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		8.2	36	8.2-8.8
Alkalinity*	mg/L	75.7	6	100-280
Specific Conductance*	umhos	146	16	>110
Secchi Depth	ft	9.0	19	6.56-13.12
Chlorophyll a	ug/L	6.2	21	2.5-8
Total Phosphorus	ug/L	32.8	26	25-35

*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	24.3 C (40 observations)	>32 C	High
Dissolved oxygen	8.5 (40 observations)	<7 mg/L	High

Lake Risk Assessment Summary: South Twin

Infestation Risk Rating: Low

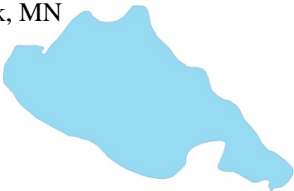
1. Connectivity: Low Risk
2. Public Use: Low Risk

Suitability Risk Rating: High

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics

Major Basin: Mississippi R. -Headwaters
 Location: South of Blackduck, MN
 Surface Area: 221.5 acres
 Percent Littoral: 36.6 %
 Max Depth: 45 ft
 Inlet: None



Summary

South Twin Lake has no upstream lakes and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into South Twin Lake, they would likely survive due to suitable substrate and water chemistry, but may be limited somewhat by food (chlorophyll a).

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (37)	82	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (45)		
Substrate Suitability (mean abundance, DNR)		Sand, gravel, boulders, woody debris	NA	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	23.7	4	>30
pH*		8.1	4	8.2-8.8
Alkalinity*	mg/L	93	4	100-280
Specific Conductance*	umhos	191	4	>110
Secchi Depth	ft	19.4	62	6.56-13.12
Chlorophyll a	ug/L	1.9	20	2.5-8
Total Phosphorus	ug/L	12.4	20	25-35

*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	NA	>32 C	Likely high
Dissolved oxygen	NA	<7 mg/L	Likely high

Lake Risk Assessment Summary: Swenson

Infestation Risk Rating: Low


1. Connectivity: Low Risk
2. Public Use: Low Risk

Suitability Risk Rating: High

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics

Major Basin: Mississippi R. -Headwaters
 Location: East of Bemidji, MN
 Surface Area: 411.8 acres
 Percent Littoral: 35.05 %
 Max Depth: 76 ft
 Inlet: None



Summary

Swenson Lake has no upstream lakes and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into the lake they would likely survive due to suitable substrate and water chemistry, but may be limited somewhat by food (chlorophyll a).

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (42)	42	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (0)		
Substrate Suitability (mean abundance, DNR)		Sand, gravel, rubble	NA	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	21.5	2	>30
pH*		8.2	2	8.2-8.8
Alkalinity*	mg/L	111	2	100-280
Specific Conductance*	umhos	228	2	>110
Secchi Depth	ft	24.2	45	6.56-13.12
Chlorophyll a	ug/L	2.4	43	2.5-8
Total Phosphorus	ug/L	8.7	43	25-35


*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	25.6 C (20 observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely high

Lake Risk Assessment Summary: Three Island

Infestation Risk Rating: Moderate 1. <u>Connectivity</u> : Moderate Risk 2. <u>Public Use</u> : Low Risk
Suitability Risk Rating: High 1. <u>Water Chemistry</u> : High Risk 2. <u>Substrate</u> : Moderate Risk

Characteristics Major Basin: Mississippi R. -Headwaters Location: North of Bemidji, MN Surface Area: 722.1 acres Percent Littoral: 94.02% Max Depth: 25ft Inlet: Turtle River, Streams from Larson and Black Lakes	
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Summary

Three Island Lake has 19 upstream lakes and low public use, resulting in a moderate infestation risk rating. If Zebra mussels were introduced into Three Island Lake, they would likely survive due to suitable substrate and water chemistry.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of Lakes	19 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (56)	161	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (105)		
Substrate Suitability (mean abundance, DNR)		Woody debris, aquatic plants	NA	Moderate

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	27.4	3	>30
pH*		8.1	3	8.2-8.8
Alkalinity*	mg/L	143	3	100-280
Specific Conductance*	umhos	293	3	>110
Secchi Depth	ft	11.9	56	6.56-13.12
Chlorophyll a	ug/L	5.3	23	2.5-8
Total Phosphorus	ug/L	20.9	23	25-35


*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	24.5 C (5 observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely high

Lake Risk Assessment Summary: Turtle

Infestation Risk Rating: Moderate 1. <u>Connectivity</u> : Moderate Risk 2. <u>Public Use</u> : Moderate Risk
Suitability Risk Rating: Moderate 1. <u>Water Chemistry</u> : High Risk 2. <u>Substrate</u> : Low Risk

Characteristics Major Basin: Mississippi R. -Headwaters Location: North of Bemidji, MN Surface Area: 1606.3 acres Percent Littoral: 58.23 % Max Depth: 45 ft Inlet: Turtle River	
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Summary

Turtle Lake has nine upstream lakes and moderate public use, resulting in a moderate infestation risk rating. If Zebra mussels were introduced into Turtle Lake they would likely survive due to suitable water chemistry. They may be limited somewhat by substrate.

Attribute	Description	Number	Infestation Risk
Water Connectivity	Chain of Lakes	9 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	811	Low
	Non-resident Watercraft Impact		
Substrate Suitability (mean abundance, DNR)	Sand, Silt, Clay, Muck	NA	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	30.9	4	>30
pH*		8.2	49	8.2-8.8
Alkalinity*	mg/L	156	5	100-280
Specific Conductance*	umhos	304	12	>110
Secchi Depth	ft	11.4	199	6.56-13.12
Chlorophyll a	ug/L	5.9	20	2.5-8
Total Phosphorus	ug/L	20.9	15	25-35


*primary parameters for zebra mussel Suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.7 C (31 observations)	>32 C	High
Dissolved oxygen	9.3 (21 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Turtle River

<p>Infestation Risk Rating: Moderate</p> <ol style="list-style-type: none"> 1. <u>Connectivity</u>: Moderate Risk 2. <u>Public Use</u>: Low Risk
<p>Suitability Risk Rating: Moderate</p> <ol style="list-style-type: none"> 1. <u>Water Chemistry</u>: High Risk 2. <u>Substrate</u>: Low Risk

<p>Characteristics</p> <p>Major Basin: Mississippi R. -Headwaters Location: East of Turtle River, MN Surface Area: 1740.3 acres Percent Littoral: 39.88% Max Depth: 63 ft Inlet: Turtle River, Stream from Peterson Lake</p> 

Summary

Turtle River Lake has 21 upstream lakes and low public use, resulting in a moderate infestation risk rating. If Zebra mussels were introduced into Turtle River Lake they would likely survive due to suitable water chemistry. They may be limited somewhat by substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of Lakes	21 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (141)	330	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (189)		
Substrate Suitability (mean abundance, DNR)		Sand, Clay, Silt, Muck	NA	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	35.6	3	>30
pH*		8.1	3	8.2-8.8
Alkalinity*	mg/L	157.3	3	100-280
Specific Conductance*	umhos	323.7	3	>110
Secchi Depth	ft	9.4	180	6.56-13.12
Chlorophyll a	ug/L	10.3	44	2.5-8
Total Phosphorus	ug/L	23.6	44	25-35


*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	21 C (20 observations)	>32 C	High
Dissolved oxygen	11.5 (20 observations)	<7 mg/L	High

Lake Risk Assessment Summary: White Fish

Infestation Risk Rating: Low 1. <u>Connectivity</u> : Moderate Risk 2. <u>Public Use</u> : Low Risk
Suitability Risk Rating: High 1. <u>Water Chemistry</u> : Moderate Risk 2. <u>Substrate</u> : Moderate Risk

Characteristics Major Basin: Upper/Lower Red Lake Location: West of Blackduck, MN Surface Area: 384.9 acres Percent Littoral: 41.52 % Max Depth: 98 ft Inlet: Darrigans Creek	
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Summary

White Fish Lake has three upstream lakes and low public use, resulting in a low infestation risk rating. If Zebra mussels were introduced into White Fish Lake they would likely thrive due to suitable substrate and water chemistry.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of Lakes	3 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (33)	33	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (0)		
Substrate Suitability (mean abundance, DNR)		Sand, gravel, woody debris	NA	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	NA	0	100-280
Specific Conductance*	umhos	NA	0	>110
Secchi Depth	ft	14.5	16	6.56-13.12
Chlorophyll a	ug/L	3.6	9	2.5-8
Total Phosphorus	ug/L	11.9	10	25-35

*primary parameters for zebra mussel suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	NA	>32 C	Likely high
Dissolved oxygen	NA	<7 mg/L	Likely high

Lake Risk Assessment Summary: Wolf

Infestation Risk Rating: Moderate


- Connectivity: Moderate Risk
- Public Use: Low Risk

Suitability Risk Rating: High

- Water Chemistry: High Risk
- Substrate: High Risk

Characteristics

Major Basin: Mississippi R. -Headwaters
 Location: West of Cass Lake, MN
 Surface Area: 1073.4 acres
 Percent Littoral: 31.4 %
 Max Depth: 56.9 ft
 Inlet: Mississippi River, Streams from Little Wolf, Mud, and Midge Lakes



Summary

Wolf Lake has 33 upstream lakes and low public use, resulting in a moderate infestation risk rating. If Zebra mussels were introduced into Wolf Lake they would likely thrive due to suitable substrate and chemistry.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of Lakes	33 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (95)	320	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (225)		
Substrate Suitability (mean abundance, DNR)		Muck, Silt, Sand, Gravel	NA	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	42.5	3	>30
pH*		8.0	82	8.2-8.8
Alkalinity*	mg/L	153	40	100-280
Specific Conductance*	umhos	303	53	>110
Secchi Depth	ft	8.4	4	6.56-13.12
Chlorophyll a	ug/L	12.3	4	2.5-8
Total Phosphorus	ug/L	24.3	4	25-35

*primary parameters for zebra mussel Suitability

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	24 C (64 observations)	>32 C	High
Dissolved oxygen	9.6 (64 observations)	<7 mg/L	High

Results and Discussion

Results

The lakes in Beltrami County resulted in differing infestation and suitability risk ratings (Table 10). In general terms, the headwaters lakes came out with the lowest infestation risk ratings because they have no water bodies upstream. Of the selected lakes assessed in this report, the headwaters lakes that also had low public use include Balm, Beltrami, Big, Big Bass, Long (0076), Sandy, North Twin, Grant, Island, Little Bass, South Twin, Benjamin, Buck, Swenson, Bootleg, and Little Moose. Lakes that had moderate infestation risk ratings had the combination of moderate public use and being in the middle of a chain of lakes (Table 10, Figure 7).

Lakes with high infestation risk ratings include Bemidji, Upper Red, Gull, Andrusia, and Kitchi (Figure 7). These lakes each have over 25 upstream lakes, so have high risk from connectivity. These lakes also have a very high public use, especially Bemidji and Upper Red (Figure 6). Lake Bemidji has the highest total of resort units, public accesses, and property owners of any lakes in the county (Table 3). Public use risks come from both lake visitors via boats and lake property owners via boats, boat lifts, docks and other water-related equipment.

About half of the lakes in Beltrami County resulted in a high Zebra mussel suitability rating (Figure 8). The lakes in northwest and north central Minnesota are considered hardwater lakes from glacial deposits of calcium carbonate (limestone) (Wetzel 2001). Most of the lakes in this study had suitable water chemistry for some Zebra mussel growth and development. In some of the more oligotrophic lakes, such as Swenson, North Twin, South Twin, Long (0076), Little Buzzle, and Benjamin, Zebra mussels could be limited by food (chlorophyll a). In addition, some lakes, like Benjamin and Little Bass, had pH, alkalinity and conductivity, which could be limiting to Zebra mussel growth.

The limiting factor that resulted in some lakes receiving a moderate suitability rating was substrate. Zebra mussels are not able to attach silt, muck, and sand directly. In areas with these substrates, the Zebra mussels will attach to plants, native mussels, and pieces of wood or stones (Karatayev et al. 1998). They will also attach to each other in clumps. Therefore, lakes that have predominantly silt, muck and sand have a low substrate suitability rating. In addition, in lakes that tend to be more eutrophic, such as Irving, Zebra mussels have a moderate suitability. Zebra mussels do not thrive in eutrophic lakes like they do in mesotrophic lakes (Karatayev et al. 1998, Nelepa 1992).

The rivers, such as the Turtle River and Mississippi River, are pathways for the spread of Zebra mussels downstream. Zebra mussel establishment in streams is limited by turbulence and flow, therefore the river itself is likely not a major source of zebra mussels. If lakes in a chain are less than a mile apart, Zebra mussels from an infested lake are likely to move downstream and infest downstream lakes.

Cass Lake was determined to be infested in September of 2014. It is an inconvenient infestation for the region, as the Mississippi River runs through Cass Lake, and there are multiple lakes, including Buck Lake, Andrusia Lake, Wolf Lake, Pike Bay, Pug Hole Lake, Kitchi Lake, Little Rice Lake and Big Rice Lake and their respective connecting rivers that can be boated to from Cass Lake. Inspections of boats leaving Cass Lake for plants, water, and Zebra mussels is very important to limit the spread, along with offering decontamination opportunities from the DNR, County or private business.

Lakes like Grace, where boaters go if Cass is too windy, should have access inspectors also to make sure no plants, water, or Zebra mussels are coming in from Cass Lake.

Table 10. Summary of risk ratings and prioritized recommendations taking into account the risk.

Lake Name	Lake ID	Public Use Risk	Infestation Risk	Suitability Risk	Infestation Status as of March 2015	AIS Program Prioritized Recommendations
Andrusia	04003800	high	high	high		1. Public Access Inspections 2. Education 3. Early Detection Monitoring
Balm	04032900	low	low	moderate		1. Education
Beltrami	04013500	low	low	high		1. Education
Bemidji	04013002	high	high	high		1. Public Access Inspections 2. Education 3. Early Detection Monitoring
Benjamin	04003300	low	low	moderate		1. Education
Big	04004900	low	low	high		1. Education
Big Bass (East Basin)	04013202	low	low	high		1. Education
Big Rice	04003100	low	moderate	high		1. Education
Blackduck	04006900	moderate	moderate	high		1. Public Access Inspections 2. Education
Bootleg	04021100	low	low	moderate		1. Education
Buck	04004200	low	low	high		1. Education
Buzzle	04029700	low	low	moderate		1. Education
Campbell	04019600	low	low	moderate		1. Education
Cass	04003000	moderate	moderate	high	Zebra mussels, 2014	1. Public Access Inspections 2. Decontamination 3. Education

Table continued on next page...

Table 10 continued. Summary of risk ratings and prioritized recommendations taking into account the risk

Lake Name	Lake ID	Public Use Risk	Infestation Risk	Suitability Risk	Infestation Status as of March 2015	AIS Program Prioritized Recommendations
Clearwater	04034300	low	low	high		1. Education
Deer	04023000	low	low	high		1. Education
Fox	04016200	low	moderate	high		1. Education
Gilstad	04002400	low	low	moderate		1. Education
Grace	29007100	moderate	moderate	high		1. Education 2. Public Access Inspections
Grant	04021700	low	low	moderate		1. Education
Gull	04012000	high	high	moderate		1. Public Access Inspections 2. Education 3. Early Detection Monitoring
Irving	04014000	low	moderate	moderate		1. Education
Island	04026500	low	low	high		1. Education
Julia	04016600	low	low	high		1. Education
Kitchi	04000700	moderate	high	moderate		1. Public Access Inspections 2. Education 3. Early Detection Monitoring
Little Bass	04011000	low	low	low		1. Education
Little Buzzle	04029800	low	low	moderate		1. Education
Little Moose	04000800	low	low	moderate		1. Education

Table continued on next page...

Table 10 continued. Summary of risk ratings and prioritized recommendations taking into account the risk

Lake Name	Lake ID	Public Use Risk	Infestation Risk	Suitability Risk	Infestation Status as of March 2015	AIS Program Prioritized Recommendations
Little Turtle	04015500	low	low	moderate		1. Education
Long	04022700	low	low	moderate		1. Education
Long	04007600	low	low	moderate		1. Education
Marquette	04014200	low	low	moderate		1. Education
Medicine	04012200	low	low	high		1. Education
Moose	04001100	moderate	moderate	high		1. Education 2. Public Access Inspections
Movil	04015200	low	moderate	high		1. Education
North Twin	04006300	low	low	high		1. Education
Pimushe	04003200	moderate	moderate	moderate		1. Education 2. Public Access Inspections
Plantagenet	29015600	moderate	moderate	moderate		1. Education 2. Public Access Inspections
Puposky	04019800	low	low	moderate		1. Education
Rabideau	04003400	low	low	moderate		1. Education
Red (Lower Red)	04003502	low	moderate	moderate		1. Education
Red (Upper Red)	04003501	high	high	high		1. Public Access Inspections 2. Education 3. Early Detection Monitoring
Sandy	04012400	low	low	moderate		1. Education

Table continued on next page...

Table 10 continued. Summary of risk ratings and prioritized recommendations taking into account the risk

Lake Name	Lake ID	Public Use Risk	Infestation Risk	Suitability Risk	Infestation Status as of March 2015	AIS Program Prioritized Recommendations
South Twin	04005300	low	low	high		1. Education
Swenson	04008500	low	low	high		1. Education
Three Island	04013400	low	moderate	high		1. Education
Turtle	04015900	moderate	moderate	moderate		1. Education 2. Public Access Inspections
Turtle River	04011100	low	moderate	moderate		1. Education
White Fish	04013700	low	low	high		1. Education
Wolf	04007900	low	moderate	high		1. Education

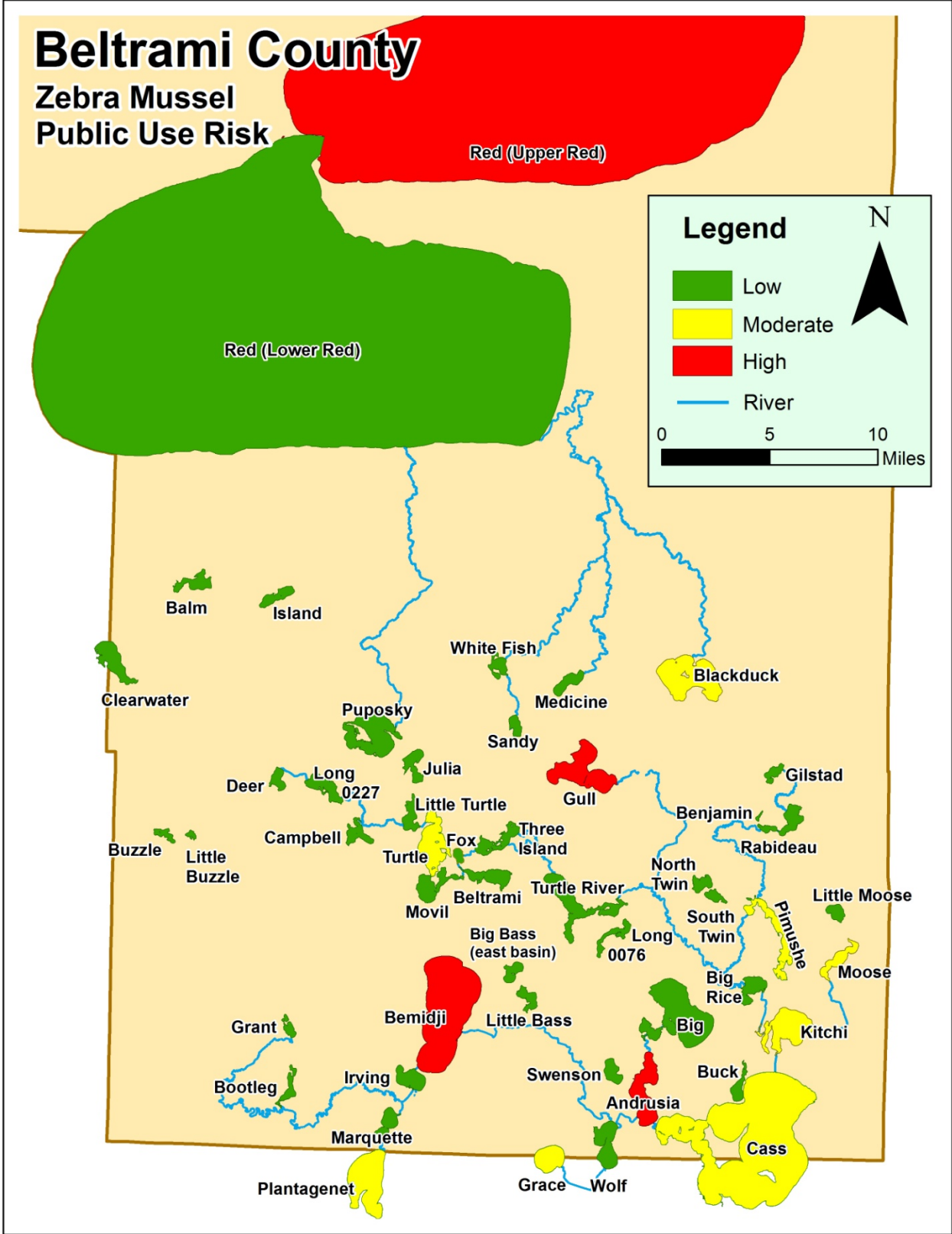


Figure 8. Public use risk rating for lakes in Beltrami County.

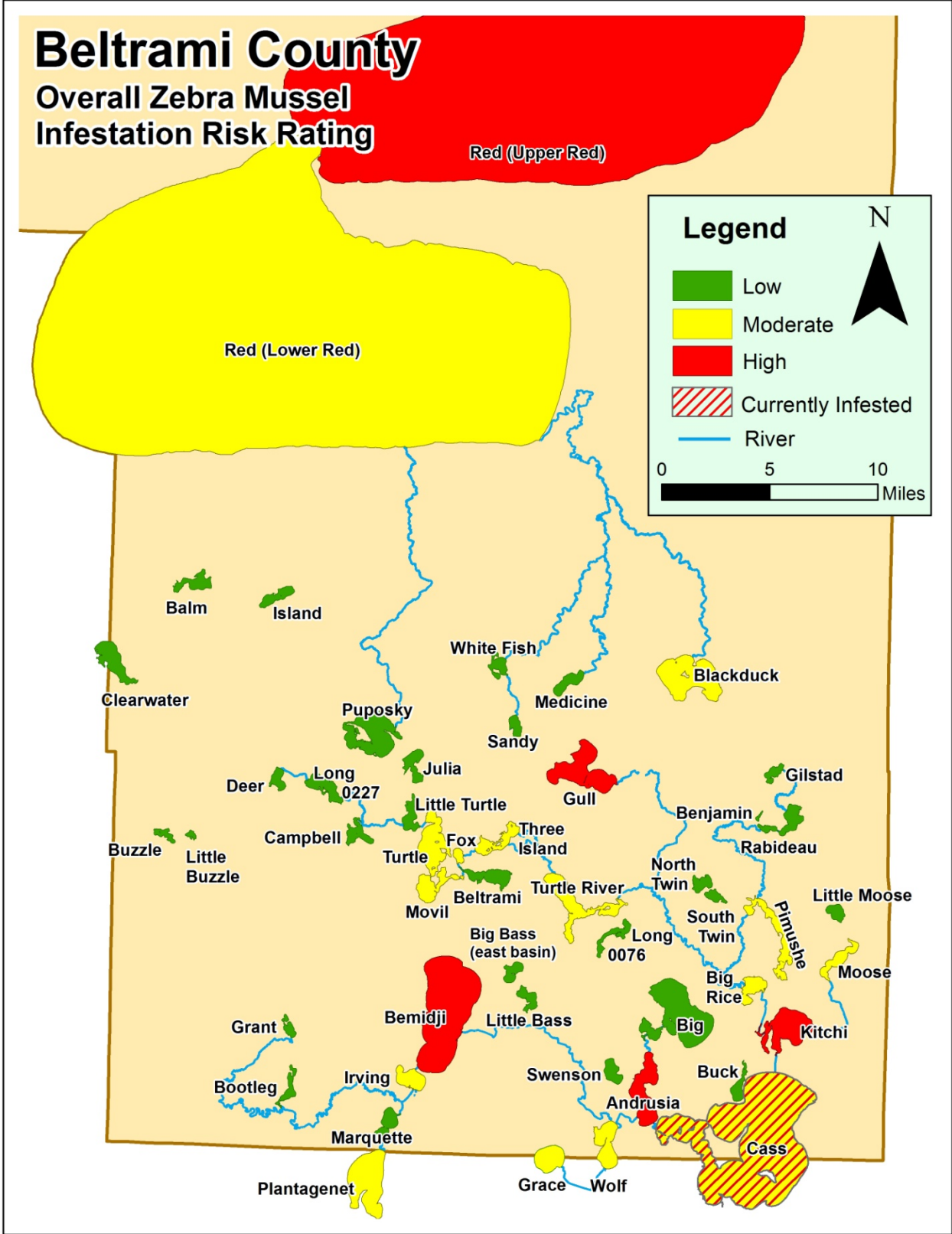


Figure 9. Overall Zebra mussel infestation risk rating in Beltrami County.

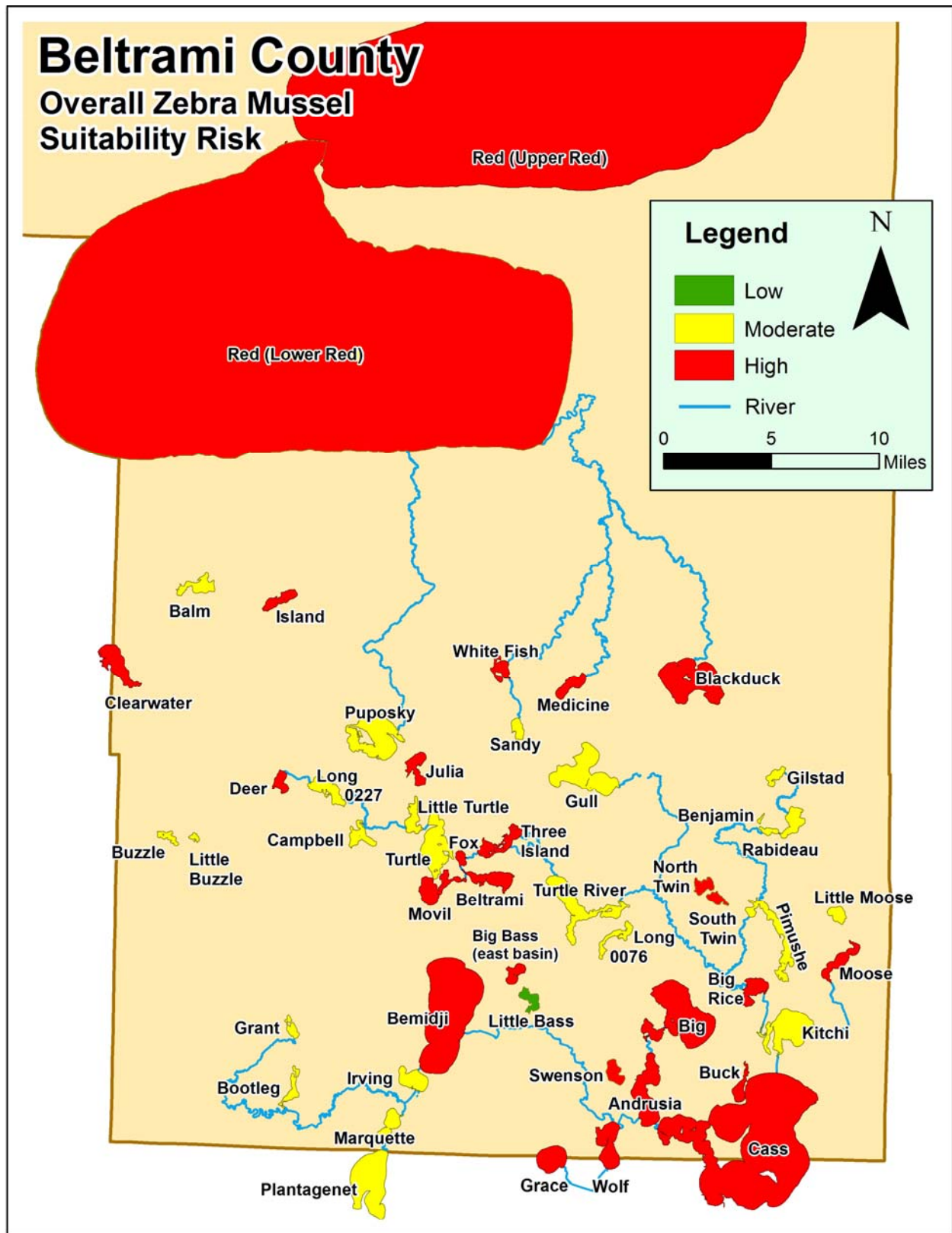


Figure 10. Overall Zebra mussel suitability risk rating in Beltrami County.

Data Gaps

This study identified some data gaps in Beltrami County. Calcium is the most important water chemistry parameter when evaluating Zebra mussel habitat suitability. Many lakes did not have any historical calcium data, but in 2015 this data was collected by volunteers. There are now just a few lakes that are missing calcium data (Table 11). Since they are hardwater lakes, it can be presumed that their calcium is high enough for Zebra mussel survival, but it is better to have the actual data numbers for evaluation. It is recommended that this data be collected to assist with overall verification of water chemistry. Lakes and streams with populations of freshwater mussels offer an additional level of habitat suitability to also support non-native mussel species. The data gaps are indicated on the lake report cards. See the table below for a summary of parameters needed for each lake (Table 11).

Table 11. Summary of data gaps for water bodies in Beltrami County.

Lake Name	Lake ID	Parameters Needed
Balm	04-0329-00	Temperature, Dissolved Oxygen
Benjamin	04-0033-00	Calcium
Big	04-0049-00	Temperature, Dissolved Oxygen
Big Rice	04-0031-00	Calcium, pH, Alkalinity, Dissolved Oxygen
Bootleg	04-0211-00	Calcium, pH, Alkalinity, Specific Conductance, Temperature, Dissolved Oxygen
Buck	04-0042-00	Calcium, pH, Alkalinity, Specific Conductance, Temperature, Dissolved Oxygen
Buzzle	04-0297-00	Calcium, Alkalinity
Campbell	04-0196-00	Dissolved Oxygen
Cass	04-0030-00	Calcium
Clearwater	04-0343-00	Calcium
Gilstad	04-0024-00	Calcium, pH, Alkalinity, Specific Conductance, Temperature, Dissolved Oxygen
Grace	29-0071-00	Dissolved Oxygen
Grant	04-0217-00	Temperature, Dissolved Oxygen
Island	04-0265-00	Calcium, pH, Alkalinity, Specific Conductance, Temperature, Dissolved Oxygen
Little Bass	04-0110-00	Dissolved Oxygen
Little Buzzle	04-0298-00	Calcium, Alkalinity
Little Moose	04-0008-00	Calcium, pH, Alkalinity, Specific Conductance, Temperature, Dissolved Oxygen
Long	04-0227-00	Dissolved Oxygen
Long	04-0076-00	Dissolved Oxygen
Marquette	04-0142-00	Dissolved Oxygen
Movil	04-0152-00	Dissolved Oxygen
North Twin	04-0063-00	Dissolved Oxygen
Plantagenet	29-0156-00	Dissolved Oxygen
Puposky	04-0198-00	Calcium
Rabideau	04-0034-00	Calcium
Red (Lower Red)	04-0035-02	Calcium
Red (Upper Red)	04-0035-01	Calcium
Sandy	04-0124-00	Calcium
South Twin	04-0053-00	Temperature, Dissolved Oxygen
Swenson	04-0085-00	Dissolved Oxygen
Three Island	04-0134-00	Dissolved Oxygen
White Fish	04-0137-00	Calcium, pH, Alkalinity, Specific Conductance, Temperature, Dissolved Oxygen

Vectors of Spread – Infestation Routes

In order to have a watershed strategy for AIS program management, the vectors of spread for each lake needs to be determined. This risk assessment process also identifies the vectors of spread for the lakes in the watershed. For headwaters lakes there is no risk of infestation from upstream, so any new infestation would come from lake users (boats, boat lifts, docks, etc). For lakes in a river chain, both lake users and upstream lakes need to be considered as potential vectors of spread.

Zebra mussels can be transferred from infested waters through several different pathways. These pathways are highly dependent upon the time of year and the stage in the Zebra mussel life cycle. The risk pathway ratings for time of year are shown in Table 12.

1. Connectivity via a river or stream.
An upstream infested lake is almost certain to infest downstream lakes if the stream distance between lakes is short enough.
2. Transfer of equipment from lake to lake.
The transfer of a large breeding adult Zebra mussel population from one lake to another on an infested boat lift, dock, swim raft or other water-related equipment has a very high probability of infesting a lake.
3. Transfer of mussels hitchhiking on vegetation or mud on boat and trailers.
The risk of hitchhiking mussels depends somewhat on the time of year. When vegetation dies off in the fall, the Zebra mussels fall off into the sediments. Therefore, Zebra mussels are only attached to plants from approximately June to September. Zebra mussels can't be transferred alone in mud because they do not thrive in soft substrates; they need to be attached to a hard surface.
4. Transfer of veligers or mussels from live wells, bilges, and any area of the boat that holds water.
The risk of veliger transfer depends greatly on the time of year. In infested lakes in northwest Minnesota, it has been documented that Zebra mussel veligers are at peak concentrations in early July (Rufer 2015). Therefore, July is the month of the year where veliger transfer from lake to lake has the highest risk for infestation. Research has shown that veligers are non-existent during the ice-covered season, so there is essentially no risk of veliger transfer in the winter (Rufer 2015).
5. Transfer of juvenile mussels on boats not thoroughly cleaned after being tied up on infested waters for an extended period of time.
The risk of mussel transfer on boats is highest in July through September, because that is when the mussels are reproducing and settling on new hard surfaces.
6. Transfer of veligers and juvenile mussels on swimwear, SCUBA equipment, waders or other gear used in water.
The risk of veliger transfer on gear depends somewhat on the time of year. July and August would be the times of highest risk throughout the year. Overall, this pathway is considered to be very low risk potential because the amount of water transferred is so small.

Risk – Time of Year

The risk of Zebra mussel infestation varies by the time of year. Data sources show that in Minnesota, the time of year that has the highest concentration of Zebra mussel veligers matches up with the highest use time for the public (Figures 23-24, Pesch & Bussiere 2014, Rufer 2015). The implications of these data indicate that additional prevention measures should be implemented during July to prevent Zebra mussel spread.

In Pesch and Bussiere’s (2014) survey of 2nd Homeowners in Central and West Central Minnesota, the highest use time of year was July, at an average of 16 days during that month (Figure 23, Pesch & Bussiere 2014). Rufer’s monitoring of Zebra mussel veligers in Pelican Lake, a Zebra mussel infested lake in Otter Tail County, shows the peak density for Zebra mussels is in July (Figure 24, Rufer 2015).

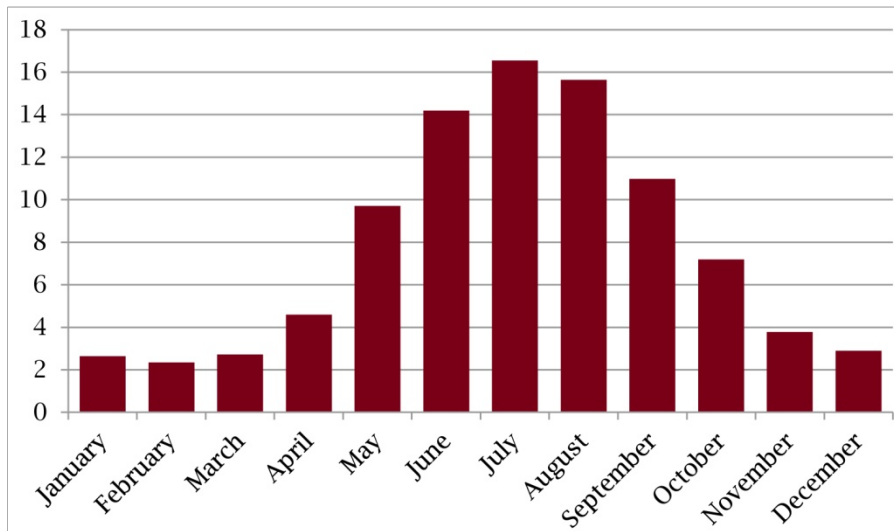


Figure 11. Average number of days occupied per month (n=552) from Pesch & Bussiere 2014.

The full report can be downloaded from this link:

<http://www.extension.umn.edu/community/research/reports/docs/2014-2nd-Homeowners.pdf>

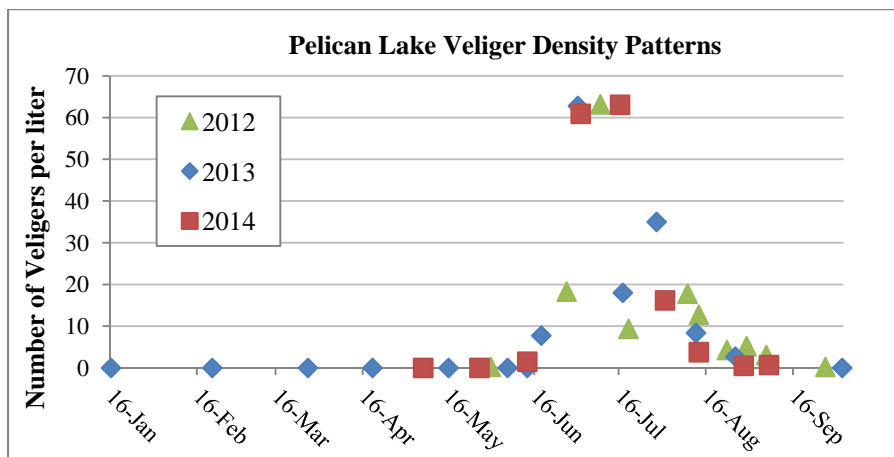


Figure 12. Veliger densities in Pelican Lake, 2012-2014 from Rufer 2015.

The full report can be downloaded from this link:

<http://pgolid.org/wp-content/uploads/2014/01/PGOLID-Veliger-Report-2012-2014.pdf>

Table 12. Summary of risk pathways depending on the time of year. The Zebra mussel life stage for the pathway is indicated in italics.

Risk Pathway	Typical Minnesota Open Water Season							Typical Minnesota Ice-covered season				
	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	March
1. Connectivity via a river or stream.	insignificant	insignificant	Low <i>Veligers</i>	High <i>Veligers</i>	Moderate <i>Veligers</i>	Low <i>Veligers</i>	insignificant	insignificant	insignificant	insignificant	insignificant	insignificant
2. Transfer of equipment from lake to lake.	insignificant	insignificant	Moderate <i>Adults & juveniles</i>	High <i>Adults & juveniles</i>	High <i>Adults & juveniles</i>	Low <i>Adults & juveniles</i>	insignificant	insignificant	insignificant	insignificant	insignificant	insignificant
3. Transfer of mussels hitchhiking on vegetation or mud on boats, trailers and gear.	Low <i>Adults & juveniles</i>	Low <i>Adults & juveniles</i>	Moderate <i>Adults & juveniles</i>	High <i>Adults & juveniles</i>	High <i>Adults & juveniles</i>	Moderate <i>Adults & juveniles</i>	Low <i>Adults & juveniles</i>	insignificant	insignificant	insignificant	insignificant	insignificant
4. Transfer of veligers via water in boats (live wells, bilges, etc) and float planes.	insignificant	insignificant	Low <i>Veligers</i>	High <i>Veligers</i>	Moderate <i>Veligers</i>	Low <i>Veligers</i>	insignificant	insignificant	insignificant	insignificant	insignificant	insignificant
5. Transfer of juvenile mussels on boats not thoroughly cleaned after being tied up on infested waters for an extended period of time.	insignificant	insignificant	Moderate <i>Adults & juveniles</i>	High <i>Adults & juveniles</i>	High <i>Adults & juveniles</i>	Moderate <i>Adults & juveniles</i>	Low <i>Adults & juveniles</i>	insignificant	insignificant	insignificant	insignificant	insignificant
6. Transfer of veligers and juvenile mussels on swimwear, SCUBA equipment, waders or other gear used in water.	insignificant	insignificant	Low <i>Veligers</i>	High <i>Veligers</i>	Moderate <i>Veligers</i>	Low <i>Veligers</i>	insignificant	insignificant	insignificant	insignificant	insignificant	insignificant

Sources: Zebra mussel veliger time-of-year risk was taken from Rufer 2015.

Zebra mussel adult and juvenile time-of-year risk was taken from Mackie & Claudi 201, Mackie 1996, McMahon 1996.

AIS Program Management Recommendations

In an ideal world, all Aquatic Invasive Species (AIS) prevention programs would be applied to all lakes. In reality, budgets are always limited, so prioritization of programs due to risk ratings is necessary. Due to the differing risk ratings, programs can be individualized to fit each lake's risk category (Table 13). Lakes with high public use ratings should be at the highest priority for boat inspections at public accesses. Lakes that are already infested should have boat-washing stations nearby for decontamination. All lakes should be targeted with a watershed-wide education program. Because the highest risk time of the summer and one of the highest tourism times of the summer intersect on 4th of July week, focus *additional* targeted education and outreach during this time of year. For monitoring, ideally all lakes would be monitored for adult Zebra mussels because if trained volunteers are used there is no monetary cost, but there is a large benefit.

The assessments in this report result combine the report cards with the risk of time of year (Figure 12) in the following specific Aquatic Invasive Species Program Management Recommendations (Table 13). This portion of the report can be inserted directly into the county's AIS Plan, and guide the use of the county's AIS funds in the most efficient and effective way possible.

Table 13. Framework for the watershed's AIS plan.

Activity	Target Lakes	Target Time of Year	Who	Cost	Narrative
<i>Watercraft Inspections</i>	<p><u>Priority 1:</u></p> <ul style="list-style-type: none"> • Andrusia • Bemidji • Gull • Upper Red • Cass <p><u>Priority 2:</u></p> <ul style="list-style-type: none"> • Blackduck • Grace • Kitchi • Moose • Turtle • Pimushe • Plantagenet <p><u>Priority 3:</u></p> <ul style="list-style-type: none"> • Campbell • Irving • Beltrami • Medicine • Balm 	<p><u>Priority 1:</u> July</p> <p><u>Priority 2:</u> August</p>	County	TBD	This activity depends on available funding. If limited funding is available, focus inspections on the high risk public use lakes (Andrusia, Bemidji, Gull and Upper Red) and the infested lakes (Cass) in July. If more funding is available, add in moderate public use risk lakes (Blackduck, Grace, Kitchi, Moose, Turtle, Pimushe, and Plantagenet) in July. Next, add in August inspections, and next priority 3 lakes (highest scores of the low public use risk lakes).

Table 13 continued on the next page...

Table. 13 continued. Framework for the watershed’s AIS plan.

Activity	Target Lakes	Target Time of Year	Who	Cost	Narrative
<i>Water Quality Monitoring</i>	See Table 11 for data gaps.	May – September	Lake Associations	TBD	Monitor lakes for missing parameters shown in Table 11. Priority parameters for each lake would be Calcium, Alkalinity, pH and Specific Conductance as they have the most effect on Zebra mussel suitability.
<i>Early Detection Monitoring: Zebra mussel veligers</i>	<ul style="list-style-type: none"> • Andrusia • Bemidji • Gull • Kitchi • Upper Red 	July	County or Lake Associations	\$450	Collect plankton tow samples in high infestation risk lakes in early and late July for veliger analysis. Early detection allows for possible treatment.
<i>Early Detection Monitoring: Adult Zebra mussels</i>	<p><u>Priority 1:</u></p> <ul style="list-style-type: none"> • Andrusia • Bemidji • Gull • Kitchi • Upper Red <p><u>Priority 2:</u></p> <ul style="list-style-type: none"> • Big Rice • Blackduck • Fox • Grace • Irving • Moose • Movil • Pimushe • Plantagenet • Lower Red • Three Island • Turtle • Turtle River • Wolf <p><u>Priority 3:</u> All lakes</p>	<p><u>Priority 1:</u> September</p> <p><u>Priority 2:</u> Every other week from late June to mid-September</p>	Volunteers, Lake Associations	\$0	<p>a. In September, conduct a lake-wide inspection of docks and boat lifts as they are removed from the lake.</p> <p>b. Place a cinder block in 5-8 feet of water near the public access and any other heavily used areas of the lake, and have the volunteers check the block (pull it up or snorkel) every other week from late June to mid-September. Record results on the MN DNR’s website: http://www.dnr.state.mn.us/volunteering/zebramussel_monitoring/report.html</p>

Table 13 continued on the next page...

Table. 13 continued. Framework for the watershed’s AIS plan.

Activity	Target Lakes	Target Time of Year	Who	Cost	Narrative
Monitoring: Invasive Plants	<p><u>Priority 1:</u></p> <ul style="list-style-type: none"> • Andrusia • Bemidji • Gull • Kitchi • Upper Red <p><u>Priority 2:</u></p> <ul style="list-style-type: none"> • Big Rice • Blackduck • Fox • Grace • Irving • Moose • Movil • Pimushe • Plantagenet • Lower Red • Three Island • Turtle • Turtle River • Wolf <p><u>Priority 3:</u> All lakes</p>	Mid to late June	County, Lake Associations, or private contractor	TBD	Conduct plant surveys to look for aquatic invasive plants. Mid to late June will catch Curly-leaf pondweed, Flowering rush, and Eurasian watermilfoil.
Education and Outreach	All	<p><u>Priority 1:</u> 4th of July week</p> <p><u>Priority 2:</u> Memorial day to labor day</p> <p><u>Priority 3:</u> Year round</p>	County and watershed	TBD	Conduct a consistent watershed-wide education program to schools and the general public. In high tourism areas such as Bemidji, focus additional education around 4 th of July since that is the highest risk time of the year for spread.
Decontamination	Cass	<p>Priority 1: July</p> <p>Priority 2: August</p>	County, DNR, or private business	TBD	Provide decontamination opportunities for boats leaving infested lakes. Inform boaters on where the decontamination station is located.

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