Otter Tail River Watershed

AIS Prioritization

A planning tool developed for AIS risk management and prevention



Report Date:	February 25, 2015				
Funded by:	Environment and Natural Resources Trust Fund (ENRTI	7)			
·	Red River Basin Commission				
	Becker County				
	Clay County				
	Otter Tail County				
	Wilkin County				
	Pelican River Watershed District				
	Buffalo Red River Watershed District				
	Wild Rice River Watershed District				
Project Partners:	Red River Basin Commission				
	Becker County				
	Clay County				
	Otter Tail County				
	Wilkin County				
	Pelican River Watershed District				
	Buffalo Red River Watershed District				
	Wild Rice River Watershed District				
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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.



Figure 1. Minnesota Lakes infested by Zebra mussels, 2014.

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 2015, approximately 60 lakes in Minnesota are infested with Zebra mussels (MNDNR 2014) (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

The goals of this project were to assess the risk of Zebra mussel infestation in the Otter Tail River Watershed in order to prioritize funding and efforts to prevent the further spread of Zebra mussels. 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, substrate, dissolved oxygen and temperature. 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 16). This table can 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.

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.



Figure 2. Minnesota showing all major drainage basins, the Red River Basin, and the Otter Tail River Watershed.

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.

Otter Tail River Watershed

The Otter Tail River Major Watershed represents an area of about 1,920 square miles, including areas of substantial portions of Otter Tail, Becker and Wilkin counties, and very small portions of Clay and Clearwater counties (Figure 3).

The Otter Tail River Watershed is a drainage basin of the Red River and the major tributaries of the watershed are the Ottertail and Pelican Rivers. Where the Otter Tail River joins the Bois de Sioux River is considered to be the headwaters of the Red River. The majority of the lakes in the Red River Basin are found in the Otter Tail River Watershed.

There are no watershed districts in the Otter Tail River Watershed; however, the Tamarac National Wildlife Refuge encompasses the headwaters of the watershed and there are numerous Lake Improvement Districts. Lake Improvement Districts have taxing authority on the lakeshore properties, and therefore have an income source to use to combat invasive species. The Lake



Figure 3. Otter Tail River Watershed with lakes and streams assessed in this report shown in blue.

Improvement Districts in the Otter Tail River Watershed include the Pelican Group of Lakes Improvement District, the Pine Lakes Improvement District, the Little McDonald, Kerbs & Paul Lakes Improvement District, the Big McDonald Lake Improvement District, the Devils Lake Improvement District, and the South Turtle Lake Improvement District.

Pelican River Watershed

The Pelican River Watershed is a subwatershed of the Otter Tail River Major Watershed (Figure 4). Its headwaters start north of Floyd Lake in Campbell Creek. From there it flows south through Floyd Lake, through the City of Detroit Lakes to Detroit, Sallie, Melissa, Pelican, Lizzie and Prairie Lakes. From Prairie Lake it flows south and joins the Otter Tail River near Fergus Falls.

There are two taxing entities in the Pelican River Watershed that have jurisdiction over the area. The Pelican **River Watershed** District encompasses the northern portion of the watershed through Lake Melissa. Pelican Lake has a Lake Improvement District, which encompasses Pelican, Bass, Fish and Little Pelican Lakes and includes all lakeshore properties.



Figure 4. Otter Tail River Watershed and Pelican River Subwatershed with its lakes and rivers.

History of AIS in the Otter Tail River Watershed

Plants

Curly-leaf pondweed

Curly-leaf pondweed is a common invasive plant in the Otter Tail River Watershed (Figures 7-8). 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).

As of 2013, Curly-leaf has been found in Detroit, Sallie, Melissa, Upper Cormorant, Middle Cormorant Pelican, Toad and Big Pine Lakes (Figure 8). It is possible that it exists in other lakes as well and is just not documented.

Flowering Rush

Flowering Rush, an invasive emergent plant, was first identified in Deadshot Bay in the mid-1970's and spread into the Big Detroit Lake by the end of that decade (Figures 5-6). It is thought that it was purchased from a nursery and planted in Deadshot Bay intentionally due to its showy pink flowers. By the early 1980's it was found in many places around Big and Little Detroit; and moved down the Pelican River to Muskrat, Sallie and Melissa.

Flowering rush was mechanically harvested from 1967 to the mid 2000s in an effort to keep it under control. In the 2000s the Pelican River Watershed District (PRWD) began chemical herbicide treatment. Initial herbicide treatments were not deemed successful, so in 2010 PRWD adopted a ten-year plan to research effective ways to control Flowering rush. This research has



Figure 5. Map of Detroit Lake showing the spread of Flowering rush (prwd.org).

proved successful, and the herbicide *Diquot* has significantly reduced Flowering rush in Detroit, Sallie and Melissa Lakes in the past couple years.



Figure 6. A Flowering rush plant showing its pink flower and emergent reed-like vegetation.



Figure 7. Curly-leaf pondweed turion (wintering bud) (left), and young Curly-leaf pondweed plant beginning to curl (right).



Figure 8. Aquatic plant infestations in the Otter Tail River Watershed.

Zebra mussels

Pelican River Watershed

Zebra mussels were first discovered in the Pelican River Watershed in Pelican Lake. A property owner found them in September of 2009 and the MNDNR confirmed their establishment after a survey that same day. In that survey, larger Zebra mussels were found (1/2-3/4 inches long), which could mean that the mussels had already been there for a year.

After confirmation in Pelican Lake, the MNDNR looked for Zebra mussels in Lake Lizzie, the next lake downstream. They found a few Zebra mussels attached to boat lifts at this time. From this information, it is probable that the Zebra mussels in Lake Lizzie came down the Pelican River from Pelican Lake; however, it also could have been an independent infestation.

In 2011, Zebra mussels were found in Prairie Lake. Again, it is probable that these mussels came downstream from Lake Lizzie. Therefore, it took approximately two years for the zebra mussels to



Figure 9. Zebra mussel infestation history in the Pelican River Watershed.

become fully established in Lake Lizzie and move down the river to Prairie Lake (Figure 9).

In 2012, Zebra mussels were found in the Otter Tail River after it's confluence with the Pelican River. From Orwell Reservoir, they have spread into Wilkin County (Figures 11-12). In 2013, they were found in Lake Lida (Figure 9).

As of 2013, Zebra mussels had only been found downstream from Pelican Lake. This means that for five years after the Pelican Lake infestation, they had only likely spread downstream in the Pelican River by flow. As of 2014, this changed and zebra mussels were found in Lake Melissa, which is upstream of Pelican Lake. This upstream spread could be due to lake users such as boaters or property owners purchasing infested equipment such as docks and boat lifts (Figure 9).

Rose Lake

Zebra mussels were found in Rose Lake in September of 2011, and were traced to a single infested boat lift as a source (Figure 11). In October 2011 the infested area was treated with copper sulfate to attempt eradication since they were only found in a small area. Zebra mussel adults (3) were found in the treated area during a survey in 2012. No survey was conducted in 2013. A snorkel survey in 2014 found no adult zebra mussels. Additional monitoring is planned for summer of 2015 to determine if Zebra mussels are established in Rose Lake. For planning purposes, it is imperative to determine if Rose Lake is infested with Zebra mussels because it has major implications for the rest of the Otter Tail River Watershed. Zebra mussels could potentially spread from Rose Lake downstream to Otter Tail Lake.

Little McDonald, Kerbs, Paul and Rusche Lakes

In 2012, Little McDonald, Kerbs, Paul and Rusche Lakes tested positive for Zebra mussel veligers and was listed as infested (Figure 11). Tests in 2013 and 2014 were negative for Zebra mussel veligers. Future monitoring will be beneficial in determining if these lakes are truly infested or not. As of 2015, there is no natural outlet to this group of lakes, so there is likely no downstream spread risk.

Pickerel Lake

In 2014, one adult Zebra mussel was found in Pickerel Lake and the lake was listed as infested (Figure 11). No other Zebra mussels were found in 2014, so future monitoring should determine if there is a thriving adult population in the lake.



Figure 10. Adult Zebra mussels on a sampling plate on Pelican Lake, 2013.



Figure 11. The spread of Zebra mussels in the Pelican River Watershed from 2009-2013.



Figure 12. The spread of zebra mussel adults in the Otter Tail River.

Zebra Mussel Risk Assessment

Lake Methods

All the major lakes in the Otter Tail River Watershed have water chemistry, temperature, and dissolved oxygen data available (Table 1). These data were collected by the Pelican River Watershed District, Lake Associations, Otter Tail COLA, Tamarac National Wildlife Refuge, the Minnesota Pollution Control Agency, the Department of Natural Resources and the Pelican Group of Lakes Improvement District, and were used in the Zebra mussel risk assessment for lakes.

Lake Name	Lake ID
Upper Cormorant	03-0588-00
Middle Cormorant	03-0602-00
Big Cormorant	03-0576-00
Big Floyd	03-0387-02
Little Floyd	03-0386-00
Detroit	03-0381-00
Sallie	03-0359-00
Melissa	03-0475-00
Little Pelican	56-0761-00
Pelican	56-0786-00
Lizzie	56-0760-00
Prairie	56-0915-00
Elbow	03-0159-00
Many Point	03-0158-00
Round	03-0155-00
Flat	03-0242-00
Height of Land	03-0195-00
Toad	03-0107-00
Six	56-0369-00
Scalp	56-0358-00
Rose	56-0360-00
Long	56-0388-02
Little Pine	56-0142-00
Big Pine	56-0130-00
Rush	56-0141-00
Star	56-0385-00
Dead	56-0383-00
Otter Tail	56-0242-00
West Battle	56-0239-00
East Battle	56-0138-00
Clitherall	56-0238-00

Table 1. Major lakes in the Pelican River Watershed.

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 Detroit Lakes and Fergus Falls Area Chambers of Commerce. The hotels and resorts on the lake attract local and regional visitors, increasing the risk of 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 these 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.

Lake	Parcels*	Access	Resort	Fishing	Total*	Risk
		Parking*	Units*	Tournaments*		
Pelican	999	600	4,065	70	5,734	High
Big Cormorant	643	360	3,930	70	5,003	High
Otter Tail	1,258	1,320	2,040	380	4,998	High
Big Pine	495	750	3,555	50	4,850	High
Detroit	608	240	3,330	40	4,218	High
Rush	430	435	2,445	70	3,380	High
West Battle	707	645	1,500	50	2,902	High
Dead	443	540	1,095	0	2,078	High
Star	443	570	435	0	1,448	Moderate
Melissa	397	300	720	0	1,417	Moderate
Clitherall	384	30	885	0	1,299	Moderate
Toad	183	225	795	0	1,203	Moderate
East Battle	423	120	630	0	1,173	Moderate
Many Point	88	15	990	0	1,093	Moderate
Round	149	75	795	0	1,019	Moderate
Middle Corm	198	270	495	0	963	Moderate
Sallie	236	495	75	0	806	Moderate
Elbow	293	30	285	36	644	Low
Rose	163	300	180	0	643	Low
Height of Land	141	480	0	0	621	Low
Floyd	380	225	0	0	605	Low
Little Pine	309	225	60	0	594	Low
Upper Corm	233	150	150	0	533	Low
Lizzie	337	165	0	0	502	Low
Little Floyd	111	120	180	0	411	Low
Long	236	15	120	0	371	Low
Scalp	117	60	0	0	177	Low
Prairie	138	36	0	0	174	Low
Six	76	75	0	0	151	Low
Little Pelican	120	0	0	0	120	Low
Flat	20	0	0	0	20	Low

Table 3. Public use rating calculations.

*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	0-700	701-1,999	2,000+
(the sum of public access parking spaces, resort units,			
lake parcels and special events)			

Water Chemistry

Available water quality data was compiled and analyzed for each major lake and stretch of river in the Otter Tail River Watershed. 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.

	Risk		
Parameter	Low Little Potential for	Moderate (survivable,	High
	Larval Development	but will not flourish)	(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

Table 5	Water column	Zehra musse	l suitability	criteria (Mackie and	Claudi 2010)
rable 5.	water column	Leona musse	a sunaonny	criteria (what the and	Claudi 2010).

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
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 2014).

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).

	Public Use Total Boat		
	Units	Connectivity	Combined Risk Rating
Low Risk	0-700	0 = Headwaters Lake	0-1,000
Moderate Risk	701-2,000	2,500 = Chain of Lakes	1,000-6,000
High Risk	2,000+	5,000 = Infested or Infested lake upstream	6,000+

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

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).

	Water Quality	Substrate	Combined Risk Rating
Low Risk	0 = The majority of	0 = Sand, Silt, Muck	0 - Low
	averages in green category.		
Moderate Risk	500 = The majority of averages in yellow category.	500=Submerged macrophytes	1,000 - Moderate
High Risk	1,000 = The majority of averages in red category.	1,000 = Rocks, Gravel, Rubble	2,000 - High

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

River Methods

Water chemistry data have been collected throughout the Pelican River by the Pelican River Watershed District, the International Water Institute and the Minnesota Pollution Control Agency (Figures 14-17). For this assessment, the watershed was split into nine sections (Table 10, Figure 13).

Table 10. Stream Sections in the Otter Tail River Watershed (Figure 13).

Section	Name
1	Pelican River, Becker County
2	Pelican River, Otter Tail County
3	Otter Tail River Headwaters
4	Otter Tail River, HOL to Pine Lakes
5	Otter Tail River, North Otter Tail Lake
6	Otter Tail River to Fergus Falls
7	Dead River
8	Battle Creek
9	Toad River

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 Pelican River and the headwaters of the Otter Tail 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.



Figure 13. Pelican River stream segments used in this report.

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 Pelican and Otter Tail Rivers have some submerged vegetation, are usually lined with emergent vegetation, have 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 (Table 11). 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). For the purposes of this study, the Mackie and Claudi (2010) numbers are used as guides, but further research is needed to be more decisive conclusions can be made.

Infestation Risk Rating

In the Pelican River Watershed, the lakes are fairly close in proximity to each other, and therefore the distance between lakes is likely short enough to transport veligers to downstream lakes. It is thought that the Zebra mussel infestation in Pelican Lake moved downstream to Lizzie and Prairie Lakes. Because a continual source of Zebra mussel veligers from a lake is needed to sustain a stream population of Zebra mussels, distance from the nearest lake is the limiting factor for an infested stream. In streams, public use is secondary, and a larger threat to downstream lakes than the stream itself (Table 11).

	Risk Rating				
	Low	Moderate	High		
Connectivity	No lakes connected	No upstream infested lakes	Upstream infested lakes		
Distance from nearest upstream lake*	>32 km (20 mi)	10-32 km (6.2-20 mi)	0-10 km (0-6.2 mi)		
Presence of aquatic vegetation/wetland conditions*	Yes	Moderate	No		
Public use	Fishing, paddle sports	Fishing, ricing, bait harvest, waterfowl hunting, paddle sports	Motorboating, camping, fishing, bait harvest, waterfowl hunting, paddle sports		
Overall rating	>32 km (20 mi) from nearest upstream lake and the presence of aquatic vegetation and wetland conditions	10-32 km (6.2-20 mi) from nearest upstream lake, and some aquatic vegetation and wetland conditions	0-10 km (0-6.2 mi) from nearest upstream lake		

Table 11. Infestation Risk Rating for streams and rivers.

*possible limiting parameter for streams

Suitability Rating

Total suspended solids data were available from the Pelican and Otter Tail Rivers. Results show that it is well below the threshold of 96 mg/L (Figures 14-16). Therefore, the total suspended solids are likely not limiting to Zebra mussels. It appears that flow is the main potential limiting factor to Zebra mussel establishment, so it was given the most weight when considering suitability (Table 12).

Table 12. Suitability Rating for streams and rivers.

	Risk Rating Low	Moderate	High
Habitat suitability/substrate	Muddy water, silty mucky substrate	Clear to cloudy water, gravel and rocks	Clear water, rocky, very low flow
Flow rate*	High flow	Moderate flow	Low flow, dams and stagnant backwaters
Water chemistry*	Average turbidity and/or total suspended solids over the thresholds	Maximum turbidity and/or total suspended solids over the thresholds	Average and maximum turbidity and/or total suspended solids under the thresholds
Maximum temperature	>30 C		<30 C
Average dissolved oxygen	<7 mg/L		> 7 mg/L
Overall rating	High flow and high turbidity and/or total suspended solids	Moderate flow and low turbidity and/or total suspended solids; rocky substrate	Low flow, dams and backwaters and low turbidity and/or total suspended solids; rocky substrate

*possible limiting parameter for streams



Figure 14. Total suspended solids results in the Pelican River of Becker County. Refer to site locations in Figure 12.



Figure 15. Total suspended solids results in the Pelican River of Otter Tail County. Refer to site locations in Figure 13.



Figure 16. Total suspended solids results in the Otter Tail River. Refer to stream sections in Table 10, Figure 13.



Figure 17. Stream monitoring sites in the Otter Tail River Watershed of Becker County.



Figure 18. Stream monitoring sites in Otter Tail County.

Lake Risk Assessment Summary: Floyd Lake

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: Otter Tail Location: North of Detroit Lakes Surface Area: 1,177 acres Percent Littoral: 73% Max Depth: 34 ft Inlet: Campbell Creek

Summary

The only probable vector of spread for Floyd Lake is by humans and their boats/equipment since it is a headwaters lake. If Zebra mussels were introduced into Floyd Lake they would likely infest the lake, but may not thrive in large numbers due to the lack of hard substrate.

Attr	ibute	Description	Number	Infestation Risk
Wate	er Connectivity	Headwaters	0 upstream lakes	Low
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (380)		
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (225)	605	Low
Subs (mear	trate Suitability a abundance, DNR)	Sand, Silt	56.3%, 33.3%	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		8.6	63	8.2-8.8
Alkalinity*	mg/L	197	8	100-280
Specific Conductance*	uS/cm	380	53	>110
Secchi Depth	ft	9.6	82	6.56-13.12
Chlorophyll a	ug/L	3.8	19	2.5-8
Total Phosphorus	ug/L	17.6	35	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	28 C (218 observations)	>32 C	High
Dissolved oxygen	Polymictic	<7 mg/L	High

Lake Risk Assessment Summary: Little Floyd Lake

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: Otter Tail Location: North of Detroit Lakes Surface Area: 214 acres Percent Littoral: 44% Max Depth: 34 ft Inlet: Pelican River

Summary

The only probable vector of spread for Little Floyd Lake is by humans and their boats/equipment since its only upstream lake is Floyd Lake (a headwaters lake.) If Zebra mussels were introduced into Little Floyd Lake they would likely infest the lake, but may not thrive in large numbers due to the lack of hard substrate.

Att	ribute	Description	Number	Infestation Risk
Wat	ter Connectivity	Chain of lakes	One upstream headwaters lake	Low
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (111)		
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (300)		Low
Sub (mea	strate Suitability n abundance, DNR)	Sand, silt, muck	45%, 32 %, 27%	Low

Water Chemistry Risk Summary

Parameter	Unit	Average	Count	Suitable Range
Calcium*	mg/L	NA	0	>30
pH*		8.3	471	8.2-8.8
Alkalinity*	mg/L	NA	0	100-280
Specific Conductance*	umhos	407.1	394	>110
Secchi Depth	ft	8.6	306	6.56-13.12
Chlorophyll a	ug/L	8.8	94	2.5-8
Total Phosphorus	ug/L	29.2	255	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	28.9 °C (316 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Detroit Lake

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. Substrate: High Risk

Characteristics Major Basin: Otter Tail Location: Detroit Lakes Surface Area: 3,067 acres Percent Littoral: 62% Max Depth: 89 ft Inlet: Pelican River

Summary

Detroit Lake has a moderate probability of infestation from upstream since there is only one main lake upstream, and no current Zebra mussel infestations upstream of the lake. Due to its location within the City of Detroit Lakes, the lake has very high public use, which is high risk. If Zebra mussels were introduced into Detroit Lake they would likely thrive due to suitable water chemistry and substrate.

Attr	ibute	Description	Number Infestation R	
Wate	er Connectivity	Chain of lakes One upstream lake		Moderate
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (608)		
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (3610)	eort units, public 4,218 H s and special (3610)	
Subs (mear	trate Suitability n abundance, DNR)	Sand, gravel	47%, 13%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.1	737	8.2 - 8.8
Alkalinity*	mg/L	186.4	14	100 - 280
Specific Conductance*	uS/cm	410.4	587	>110
Secchi	ft	10.2	355	6.56-13.12
Chlorophyll a	ug/L	8.3	41	2.5 - 8
Total Phosphorus	ug/L	25.4	43	25 - 35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	28 C (309 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Lake Sallie

Infestation Risk Rating: Moderate

- 1. <u>Connectivity</u>: Moderate Risk
- 2. <u>Public Use</u>: Moderate Risk

Suitability Risk Rating: High

- 1. <u>Water Chemistry</u>: High Risk
- 2. <u>Substrate</u>: High Risk

Characteristics

Major Basin: Ottertail Location: South of Detroit Lakes Surface Area: 1272.88 acres Percent Littoral: 45% Max Depth: 50 ft Inlet: Pelican River

Summary

Lake Sallie is in the middle of a chain of lakes, which is a moderate infestation risk. If any upstream lakes become infested, it will spread to Lake Sallie. Lake Melissa, which is immediately downstream from Lake Sallie is infested. If Zebra mussels were introduced into Lake Sallie they would likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	1 immediate downstream infested lake	Moderate
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (236)		
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (570)	806	Moderate
Substrate Suitability (mean abundance, DNR)		Sand, Gravel	80%, 14%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.4	486	8.2-8.8
Alakalinity*	mg/L	190.0	5	100-280
Specific Conductance*	uS/cm	413.5	437	>110
Secchi Depth	ft	7.5	411	6.56-13.12
Chlorophyll a	ug/L	18.3	88	2.5-8
Total Phosphorus	ug/L	37.0	346	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	27.7 °C (287 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Lake Melissa INFESTED

Overall Risk Rating: INFESTED

- 1. <u>Connectivity</u>: Moderate Risk
- 2. <u>Public Use</u>: Moderate Risk

Suitability Risk Rating: High

- 1. <u>Water Chemistry</u>: High Risk
- 2. Substrate: High Risk

Characteristics Major Basin: Ottertail Location: South of Detroit Lakes Surface Area: 1,850 acres Percent Littoral: 51% Max Depth: 37 ft Inlet: Pelican River

Summary

Lake Melissa is currently infested with Zebra mussels, which is why the overall risk rating is high. Due to suitable water chemistry and substrate, Zebra mussels are likely to thrive in Lake Melissa.

Attr	Attribute Description Number Infestation		Infestation Risk	
Water Connectivity		Chain of lakes	4 upstream lakes	Moderate
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (397)		Moderate
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (1,020)	1,417	
Subs (mean	trate Suitability a abundance, DNR)	Sand, Gravel	82%, 10%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.5	304	8.2-8.8
Alkalinity*	mg/L	200	1	100-280
Specific Conductance*	uS/cm	392.8	271	>110
Secchi Depth	ft	8.8	246	6.56-13.12
Chlorophyll a	ug/L	11.3	11	2.5-8
Total Phosphorus	ug/L	23.0	18	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	29.3 °C (357 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Upper Cormorant

Overall 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: Ottertail Location: West of Detroit Lakes Surface Area: 926.83 acres Percent Littoral: 51% Max Depth: 29 ft Inlet: From Bijou Lake



Summary

The most probable vector of spread for Upper Cormorant Lake is by humans and their boats/equipment since it is a headwaters lake. If Zebra mussels were introduced into Upper Cormorant Lake they would likely infest the lake, but may not thrive in large numbers due to the lack of hard substrate.

Att	Attribute Description Number Infe		Infestation Risk	
Water Connectivity		Headwaters	0 upstream lakes	Low
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (233)	533	Low
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (300)		
Sub abu	strate Suitability (mean ndance)	Sand, silt, muck	25%, 39%, 35% Low	

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	NA	0	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi	ft	7.4	91	6.56-13.12
Chlorophyll a	ug/L	13.4	44	2.5-8
Total Phosphorus	ug/L	31.1	44	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	28.4 °C (19 observations)	>32 C	High
Dissolved oxygen	Polymictic	<7 mg/L	High

Lake Risk Assessment Summary: Middle Cormorant

Infestation Risk Rating: Moderate

- 1. <u>Connectivity</u>: Moderate Risk
- 2. <u>Public Use</u>: Moderate Risk

Suitability Risk Rating: High

- 1. <u>Water Chemistry</u>: High Risk
- 2. Substrate: High Risk

Characteristics Major Basin: Ottertail Location: West of Detroit Lakes Surface Area: 408.72 acres Percent Littoral: 35% Max Depth: 40 ft Inlet: Upper Cormorant Lake

Summary

Middle Cormorant Lake is in the middle of a chain of lakes, which is a moderate infestation risk. If any upstream lakes become infested, it could spread to Middle Cormorant Lake. If Zebra mussels were introduced into Middle Cormorant Lake they would most likely thrive due to suitable water chemistry and substrate.

Attr	ibute	Description Number Infestation Ris		Infestation Risk
Water Connectivity		Uninfested Chain of Lakes 3 upstream lakes		Moderate
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (198)		
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (765)	963	Moderate
Substrate Suitability (mean abundance, DNR)Sand, gravel73%, 42%		High		

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.9	4	8.2-8.8
Alkalinity*	mg/L	194	5	100-280
Specific Conductance*	uS/cm	342	5	>110
Secchi Depth	ft	11.4	416	6.56-13.12
Chlorophyll a	ug/L	5	17	2.5-8
Total Phosphorus	ug/L	16.2	17	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	28 °C (15 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Big Cormorant

Overall 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: Ottertail Location: West of Detroit Lakes Surface Area: 3657.06 acres Percent Littoral: 22% Max Depth: 75 ft Inlet: Middle Cormorant Lake



Summary

Big Cormorant Lake has a moderate probability of infestation from upstream since it is in a chain of lakes. Due to its location and size, the lake has very high public use, which is high risk. If Zebra mussels were introduced into Big Cormorant Lake they would most likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Uninfested Chain of Lakes	4 upstream lakes	Moderate
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (643)	.3)	
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (4,360)	5,003	High
Substrate Suitability (mean abundance, DNR)		Sand, Rubble, Gravel	55%, 30%, 33%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Range for Zebra Mussels
Calcium*	mg/L	NA	0	>30
pH*		8.7	10	8.2-8.8
Alkalinity*	mg/L	250	11	100-280
Specific Conductance*	uS/cm	460	8	>110
Secchi	ft	18.9	178	6.56-13.12
Chlorophyll a	ug/L	4.0	78	2.5-8
Total Phosphorus	ug/L	25.2	89	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	25.9 °C (23 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Pelican Lake INFESTED

Overall Risk Rating: INFESTED

- 1. <u>Connectivity</u>: High 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



Summary

Pelican Lake is currently an infested lake (listed in 2009), and has a high infestation risk rating. In fact, it had the highest public use score in the Otter Tail River Watershed. Its substrate and water chemistry is suitable for Zebra mussel establishment and growth.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of infested lakes	2 infested lakes upstream	High
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (999)Total number of resort units, public access parking spots and special events for summer (4,735)		TP-1
	Non-resident Watercraft Impact			High
Substrate Suitability (mean abundance, DNR)		Sand, Gravel	78.8%, 18.3%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	35	55	>30
pH*		8.4	75	8.2-8.8
Alkalinity*	mg/L	192.5	12	100-280
Specific Conductance *	uS/cm	394.8	75	>110
Secchi	ft	12.8	192	6.56-13.12
Chlorophyll a	ug/L	4.8	116	2.5-8
Total Phosphorus	ug/L	14.6	116	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.5 °C (37 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Little Pelican Lake INFESTED

Overall Risk Rating: INFESTED

- 1. <u>Connectivity</u>: High Risk
- 2. <u>Public Use</u>: Low Risk

Suitability Risk Rating: Moderate

- 1. <u>Water Chemistry</u>: High Risk
- 2. <u>Substrate</u>: Low

Characteristics Major Basin: Ottertail Location: South of Detroit Lakes Surface Area: 345 acres Percent Littoral: 74% Max Depth: 25 ft Inlet: Pelican River

Summary

Little Pelican is currently an infested lake due to its connection with Pelican Lake; however, very few Zebra mussels have been found. It has a moderate suitability rating due to its substrate and eutrophic status.

Attribute		Description Number		Infestation Risk
Water Connectivity		Chain of lakes Connected to infested lake		High
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (120)	120	Low
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (0)		
Subs abun	trate Suitability (mean idance)	Silt, Muck	NA	Low

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	34	55	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	180	10	100-280
Specific Conductance *	uS/cm	412	12	>110
Secchi Depth	ft	8.5	87	6.56-13.12
Chlorophyll a	ug/L	9.8	87	2.5-8
Total Phosphorus	ug/L	23.9	87	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.5 °C (38 observations)	>32 C	High
Dissolved oxygen	Polymictic	<7 mg/L	High
Lake Risk Assessment Summary: Lake Lizzie INFESTED

Overall Risk Rating: INFESTED

- 1. <u>Connectivity</u>: High Risk
- 2. <u>Public Use</u>: Low Risk

Suitability Risk Rating: Moderate

- 1. <u>Water Chemistry</u>: High Risk
- 2. Substrate: High Risk

Characteristics

Major Basin: Ottertail Location: North of Pelican Rapids Surface Area: 1,900acres Percent Littoral: 43% Max Depth: 66 ft Inlet: Pelican River

Summary

Lake Lizzie is infested with Zebra mussels (listed in 2009). Its substrate and water chemistry is suitable for Zebra mussel establishment and growth.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	1 upstream infested lake	High
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (337)		
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (165)502		Low
Substrate Suitability (mean abundance)Sand, Rubble, Gravel42%, 33%, 25%		High		

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.4	3	8.2-8.8
Alkalinity*	mg/L	193.3	3	100-280
Specific Conductance *	uS/cm	NA	0	>110
Secchi Depth	ft	12.7	61	6.56-13.12
Chlorophyll a	ug/L	5.3	62	2.5-8
Total Phosphorus	ug/L	16.1	62	25-35
Turbidity	mg/L	1.2	3	<96

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	25.6 °C (27 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Prairie Lake INFESTED

Overall Risk Rating: INFESTED

- 1. <u>Connectivity</u>: High 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: Ottertail Location: Pelican Rapids Surface Area: 1,002 acres Percent Littoral: 80% Max Depth: 22 ft Inlet: Pelican River



Summary

Prairie Lake is infested with Zebra mussels (listed in 2011). Its water chemistry is suitable for Zebra mussel establishment and growth, but spread may be limited by the substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	3 upstream infested lakes	High
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (138)		
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (36)174		Low
Subs abun	trate Suitability (mean idance)	Sand, Silt	72.1%, 15.4%	Low

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.5	1	8.2-8.8
Alkalinity*	mg/L	180	1	100-280
Specific Conductance*	uS/cm	380	1	>110
Secchi Depth	ft	9.8	44	6.56-13.12
Chlorophyll a	ug/L	5.8	43	2.5-8
Total Phosphorus	ug/L	20.6	44	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	27.8 °C (27 observations)	>32 C	High
Dissolved oxygen	Polymictic	<7 mg/L	High

Lake Risk Assessment Summary: Elbow Lake

Overall 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: Ottertail Location: North of Detroit Lakes Surface Area: 985 acres Percent Littoral: 24% Max Depth: 70 feet Inlet: Bottom Creek, Bear Creek, Moore Lake

Summary

Elbow Lake is at the very top of the Otter Tail River Watershed, and there are no upstream lakes. It has a moderate suitability rating due to sand and soft substrates and suitable water chemistry.

Attr	ibute	Description	Number	Infestation Risk
Wate	er Connectivity	Headwaters Lake	0 upstream lakes	Low
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (293)		
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (351)	644	Low
Subs abun	trate Suitability (mean idance)	Sand, Silt, Marl 60.8%, 40.4%, Lo		Low

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.5	18	8.2-8.8
Alkalinity*	mg/L	182.5	8	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi Depth	ft	18.2	54	6.56-13.12
Chlorophyll a	ug/L	3.6	24	2.5-8
Total Phosphorus	ug/L	12.4	35	25-35

*primary parameters for zebra mussel suitability

	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: Many Point Lake

Overall Risk Rating: Moderate

- 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: Ottertail Location: North of Detroit Lakes Surface Area: 1,700 acres Percent Littoral: 44.3% Max Depth: 91.9 feet Inlet: Otter Tail River

Summary

Many Point Lake is at the top of the Otter Tail River Watershed, with only Elbow Lake upstream. It is close enough to Elbow Lake so that if Elbow Lake became infested, the Zebra mussel veligers could move downstream. It has low use except for the Many Point Scout Camp.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	1 upstream headwaters lake	Moderate
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (88)		
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (1,005)	1,093	Low
Subs abun	trate Suitability (mean idance)	Sand, Marl, Silt	58.8%, 57.9%, 42.5%	Low

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	NA	0	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi Depth	ft	10.8	11	6.56-13.12
Chlorophyll a	ug/L	5.3	12	2.5-8
Total Phosphorus	ug/L	14.7	12	25-35

*primary parameters for zebra mussel suitability

	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: Round Lake

Overall Risk Rating: Moderate

- 1. <u>Connectivity</u>: Moderate Risk
- 2. <u>Public Use</u>: Low Risk

Suitability Risk Rating:

- 1. <u>Water Chemistry</u>: High Risk
- 2. Substrate: High Risk

Characteristics

Major Basin: Ottertail Location: North of Detroit Lakes Surface Area: 1094.18 acres Percent Littoral: 51.35% Max Depth: 68.2 feet Inlet: Otter Tail River

Summary

Round Lake has a moderate infestation risk rating due to the presence of upstream lakes and its public use. The public use on Round Lake mainly comes from a Tamarac National Wildlife Refuge campground on the west side. This use is considered lower risk than a resort. If Zebra mussels were introduced to Round Lake they likely establish due to suitable substrate and water chemistry.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	2 upstream lakes	Moderate
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (149)		
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (870)	1,019	Low
Subs abun	trate Suitability (mean idance)	Marl, Sand, Silt, Gravel	48.3%, 36.7%, 28.3%, 16.7%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	NA	0	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi Depth	ft	13.1	127	6.56-13.12
Chlorophyll a	ug/L	7.6	12	2.5-8
Total Phosphorus	ug/L	19.3	12	25-35

*primary parameters for zebra mussel suitability

	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: Flat Lake

Overall 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

Characteristics Major Basin: Ottertail Location: North of Rochert Surface Area: 1,837acres Percent Littoral: 100% Max Depth: 19 feet Inlet: Egg River

Summary

Flat Lake is located within the Tamarack National Wildlife Refuge and outlets to the Otter Tail River. It is a shallow lake with wild rice on the north and west sides of the lake. It has a low infestation risk rating and a moderate suitability rating.

Attr	ibute	Description	Number	Infestation Risk
Water Connectivity		Headwaters Lake	0 upstream lakes	Low
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (20)		
Public	Non-resident Watercraft Impact	-resident Watercraft act Total number of resort units, public access parking spots and special events for summer (0)		Low
Subs	trate Suitability	Muck, sand, wild rice	NA	Low

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	27.0	1	>30
pH*		8.69	21	8.2-8.8
Alkalinity*	mg/L	117.5	4	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi Depth	ft	10.2	73	6.56-13.12
Chlorophyll a	ug/L	7.3	13	2.5-8
Total Phosphorus	ug/L	33.2	13	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	25.6°C (71 observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely High

Lake Risk Assessment Summary: Height of Land Lake

Overall Risk Rating: Moderate

- 1. <u>Connectivity</u>: Moderate Risk
- 2. Public Use: Low Risk

Suitability Risk Rating: High

- <u>Water Chemistry</u>: High Risk
 <u>Substrate</u>: High Risk

Characteristics Major Basin: Ottertail Location: East of Rochert Surface Area: 3,788.2 acres Percent Littoral: 91.1% Max Depth: 20.9 feet Inlet: Otter Tail River, North Twin Lake

Summary

Height of Land Lake has a relatively low public use rating, but there are three upstream lakes. The water chemistry and substrates are suitable for Zebra mussels.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	3 upstream lakes	Moderate
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (141)		
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (480)	621	Low
Subs abun	trate Suitability (mean idance)	Sand, Silt, Detritus, Gravel	66.3%, 45%, 12.5%, 10.4%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.4	11	8.2-8.8
Alkalinity*	mg/L	154	5	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi Depth	ft	5.9	25	6.56-13.12
Chlorophyll a	ug/L	11.9	20	2.5-8
Total Phosphorus	ug/L	35.0	20	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	22°C (2 observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely High

Lake Risk Assessment Summary: Toad Lake

Overall Risk Rating: Moderate

- 1. <u>Connectivity</u>: Low Risk
- 2. <u>Public Use</u>: Moderate Risk

Suitability Risk Rating: High

- <u>Water Chemistry</u>: High Risk
 <u>Substrate</u>: High Risk

Characteristics

Major Basin: Ottertail Location: East of Rochert Surface Area: 1,700 acres Percent Littoral: 43% Max Depth: 29 feet Inlet: 4 minor inlets

Summary

Toad Lake does not have any upstream lakes draining to it, but it has a moderate public use rating. If Zebra mussels were introduced to Toad Lake they would likely establish due to suitable substrate and water chemistry.

Attribute		Description	Number	Infestation Risk
Wate	er Connectivity	Headwaters Lake	0 upstream lakes	Low
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (183)		
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (1,020)	1,203	Moderate
Subs abun	trate Suitability (mean idance)	Sand, Silt, Rubble, Gravel	63.8%, 32.1%, 28%, 15%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.6	8	8.2-8.8
Alkalinity*	mg/L	165	4	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi Depth	ft	10.9	397	6.56-13.12
Chlorophyll a	ug/L	12.1	43	2.5-8
Total Phosphorus	ug/L	24.5	43	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26°C (24 observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely High

Lake Risk Assessment Summary: Lake Six

Overall Risk Rating: Low

- 1. <u>Connectivity</u>: Low Risk
- 2. Public Use: Low Risk

Suitability Risk Rating: High

- <u>Water Chemistry</u>: Moderate Risk
 <u>Substrate</u>: High Risk

Characteristics Major Basin: Ottertail Location: SW of Frazee Surface Area: 193 acres Percent Littoral: 34% Max Depth: 130 feet Inlet: None

Summary

Lake Six has no upstream lakes and a low public use rating, so the risk of infestation is low. If Zebra mussels were introduced to Lake Six they would likely establish due to suitable substrate and water chemistry.

Attr	tribute Description Number Infestation		Infestation Risk	
Wate	er Connectivity	Headwaters Lake	0 upstream lakes	Low
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (76)		
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (75)151		Low
Subs abun	trate Suitability (mean dance)	Gravel, Sand, Rubble	48%, 28%, 15% High	

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.5	1	8.2-8.8
Alkalinity*	mg/L	148	5	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi Depth	ft	22.1	75	6.56-13.12
Chlorophyll a	ug/L	2.3	25	2.5-8
Total Phosphorus	ug/L	9.2	25	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	27.8°C (18 observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely High

Lake Risk Assessment Summary: Scalp/Seven Lake

Overall Risk Rating: Moderate

- 1. <u>Connectivity</u>: Moderate Risk
- 2. <u>Public Use</u>: Low Risk

Suitability Risk Rating:

- 1. <u>Water Chemistry</u>: High Risk
- 2. <u>Substrate</u>: High Risk

Characteristics Major Basin: Ottertail Location: SW of Frazee Surface Area: 251.3 acres Percent Littoral: 45.4% Max Depth: 89.8 feet Inlet: Six Lake

Summary

Lake Seven has just one upstream lake and a low public use rating, so the risk of infestation is moderate. If Zebra mussels were introduced to Lake Seven they would likely establish due to suitable substrate and water chemistry.

Attr	ibute	Description Number Infestation		Infestation Risk
Water Connectivity		Chain of lakes	1 upstream headwaters lake	Moderate
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (117)		
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (60)	177	Low
Subs abun	trate Suitability (mean idance)	Sand, Gravel, Rubble	73.3%, 20.8%, 4.2%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.8	4	8.2-8.8
Alkalinity*	mg/L	166.7	3	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi Depth	ft	23.7	128	6.56-13.12
Chlorophyll a	ug/L	2.6	46	2.5-8
Total Phosphorus	ug/L	10	46	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	14.1°C (84 observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely High

Lake Risk Assessment Summary: Rose Lake INFESTED

Overall 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. Substrate: High Risk

Characteristics Major Basin: Ottertail Location: SW of Frazee Surface Area: 1,200.5 acres Percent Littoral: 54.3% Max Depth: 136.8 feet Inlet: From Lake Seven



Zebra mussels were found in Rose Lake in September of 2011, and were traced to a single infested boat lift as a source. In October 2011 the infested area was treated with copper sulfate to attempt eradication. Zebra mussel adults (3) were found in the treated area in 2012. No survey was conducted in 2013. A snorkel survey in 2014 found no zebra mussels. Additional monitoring is planned for summer of 2015 to determine if Zebra mussels are established in Rose Lake.

Attr	oute Description Number Infestatio		Infestation Risk	
Water Connectivity		Chain of lakes	2 upstream lakes	Moderate
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (163)		
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (480)	643	Low
Subs abun	trate Suitability (mean idance)	Suitability (mean Sand, Rubble, Gravel 62.5%, 18.8%, 16.7%		High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	NA	0	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi Depth	ft	10.9	73	6.56-13.12
Chlorophyll a	ug/L	5.8	12	2.5-8
Total Phosphorus	ug/L	14.8	12	25-35

*primary parameters for zebra mussel suitability

	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: Long Lake

Overall 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. Substrate: High Risk

Characteristics Major Basin: Ottertail Location: East of Vergas Surface Area: 1,288. 8 acres Percent Littoral: 42.8% Max Depth: 127.9 feet Inlet: Rose Lake

Summary

Rose Lake, which is designated as infested with Zebra mussels, is located directly upstream and adjacent to Long Lake. If 2015 monitoring in Rose Lake confirms Zebra mussels (See page 44), Long Lake would change to a high infestation risk due to connectivity.

Attribute		Description	Number	Infestation Risk
Wate	er Connectivity	Chain of lakes	3 upstream lakes	Moderate
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (236)		
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (135)371		Low
Subs abun	trate Suitability (mean idance)	Sand, Muck, Gravel	60%, 30%, 10%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	156.7	3	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi Depth	ft	9.0	209	6.56-13.12
Chlorophyll a	ug/L	8.9	52	2.5-8
Total Phosphorus	ug/L	23.3	52	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	27.8°C (32observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely High

Lake Risk Assessment Summary: Little Pine Lake

Overall Risk Rating: Moderate

- 1. <u>Connectivity</u>: Moderate Risk
- 2. Public Use: Low Risk

Suitability Risk Rating: High

- <u>Water Chemistry</u>: High Risk
 <u>Substrate</u>: High Risk

Characteristics Major Basin: Ottertail Location: North of Perham Surface Area: 2080.3 acres Percent Littoral: 36.7% Max Depth: 71.9 feet Inlet: Otter Tail River

Summary

Little Pine Lake has a moderate infestation risk. Rose Lake is upstream, and is infested with Zebra mussels. If Zebra mussels are confirmed in 2015, Little Pine Lake's infestation rating would change to high (red).

Attribute Description Number		Infestation Risk		
Water Connectivity		Chain of lakes	8 upstream lakes	Moderate
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (309)		
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (285)594		Low
Subs abun	trate Suitability (mean dance)	Sand, Rubble, Gravel	80%, 15%, 5%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.28	6	8.2-8.8
Alkalinity*	mg/L	187.9	6	100-280
Specific Conductance*	uS/cm	355	2	>110
Secchi Depth	ft	7.66	129	6.56-13.12
Chlorophyll a	ug/L	16.13	38	2.5-8
Total Phosphorus	ug/L	28.5	38	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	27.2°C (18 observations)	>32 C	High
Dissolved oxygen	8.5 (15 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Big Pine Lake

Overall 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. Substrate: High Risk

Characteristics

Major Basin: Ottertail Location: East of Perham Surface Area: 4,730 acres Percent Littoral: 50.2% Max Depth: 70.6 feet Inlet: Otter Tail River, Toad River, Nitche lake, Alvis Creek

Summary

Big Pine Lake has a high infestation risk due to very high public use. In addition, Rose Lake is upstream, and is infested with Zebra mussels. If Zebra mussels are confirmed in 2015, Big Pine Lake's connectivity rating would change from moderate (yellow) to high (red), and the overall infestation risk rating would remain high (red).

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	9 upstream lakes	Moderate
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (495)		
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (4,355)	4,850	High
Subs abur	trate Suitability (mean idance)	Sand, Rubble, Muck	75%, 16%, 8%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.4	22	8.2-8.8
Alkalinity*	mg/L	184.4	18	100-280
Specific Conductance*	uS/cm	360	12	>110
Secchi Depth	ft	6.9	568	6.56-13.12
Chlorophyll a	ug/L	21.1	45	2.5-8
Total Phosphorus	ug/L	36.2	45	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	25.6°C (18 observations)	>32 C	High
Dissolved oxygen	7.9 (25 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Rush Lake

Overall Risk Rating: High

- 1. <u>Connectivity</u>: High 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: Ottertail Location: North of Ottertail Surface Area: 5,233.8 acres Percent Littoral: 67.1% Max Depth: 65 feet Inlet: Otter Tail River, Boedigheimer Lake

Summary

Rush Lake has a high infestation risk due to very high public use. In addition, Rose Lake is upstream, and is infested with Zebra mussels. If Zebra mussels are confirmed in 2015, Rush Lake's connectivity rating would change from moderate (yellow) to high (red).

Attr	Attribute Description		Number	Infestation Risk
Water Connectivity		Chain of lakes	10 upstream lakes	Moderate
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (430)		
Non-resident Watercraft Impact		Total number of resort units, public access parking spots and special events for summer (2,950)	3,380	High
Subs abun	trate Suitability (mean idance)	Sand, Silt, Muck, Gravel	68%, 20.3%, 15%, 7%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.4	30	8.2-8.8
Alkalinity*	mg/L	148.6	19	100-280
Specific Conductance*	uS/cm	320	9	>110
Secchi Depth	ft	6.4	67	6.56-13.12
Chlorophyll a	ug/L	12.9	50	2.5-8
Total Phosphorus	ug/L	29.7	52	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.1°C (33 observations)	>32 C	High
Dissolved oxygen	8.6 (15 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Star Lake

Overall Risk Rating: Moderate

- 1. <u>Connectivity</u>: Moderate Risk
- 2. <u>Public Use</u>: Moderate Risk

Suitability Risk Rating: High

- <u>Water Chemistry</u>: High Risk
 <u>Substrate</u>: High Risk
- 2.

Characteristics

Major Basin: Ottertail Location: SW of Dent Surface Area: 4,454 acres Percent Littoral:58.6% Max Depth: 90 feet Inlet: Round Lake, Elbow Lake



Summary

Star Lake has a moderate infestation risk rating and a high public use rating. If Zebra mussels were introduced into Star Lake, they would likely establish due to suitable hard substrate and water chemistry.

Attr	ibute	Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	2 upstream lakes	Moderate
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (443)		
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (1,005)	1,448	Moderate
Subs abun	trate Suitability (mean idance)	Muck, Rubble, Sand, Gravel	40%, 25%, 25%, 10%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	183.3	3	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi Depth	ft	14.2	294	6.56-13.12
Chlorophyll a	ug/L	6.23	43	2.5-8
Total Phosphorus	ug/L	17.12	43	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.7°C (6 observations)	>32 C	High
Dissolved oxygen	8.1 (6 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Dead Lake

Overall Risk Rating: Moderate

- 1. <u>Connectivity</u>: Moderate Risk
- 2. <u>Public Use</u>: High Risk

Suitability Risk Rating:

- 1. <u>Water Chemistry</u>: High Risk
- 2. <u>Substrate</u>: High Risk

Characteristics

Major Basin: Ottertail Location: West of Richville Surface Area: 7,567.1 acres Percent Littoral: 90.9% Max Depth: 60.6 feet Inlet: Dead River, Star Lake, Peterson Lake

Summary

Dead Lake has a moderate infestation risk rating and a high public use rating. If Zebra mussels were introduced into Dead Lake, they would likely establish due to suitable hard substrate and water chemistry.

Attr	Attribute Description Number Infeste		Infestation Risk	
Water Connectivity		Chain of lakes	2 upstream lakes	Moderate
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (443)		
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (1,635)	2,078	High
Subs abun	trate Suitability (mean idance)	Sand, Silt, Gravel, Muck	61%, 20%, 16%, 13%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.6	18	8.2-8.8
Alkalinity*	mg/L	196.7	12	100-280
Specific Conductance*	uS/cm	340	18	>110
Secchi Depth	ft	10.0	276	6.56-13.12
Chlorophyll a	ug/L	7.6	189	2.5-8
Total Phosphorus	ug/L	23.5	190	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	28.4°C (108 observations)	>32 C	High
Dissolved oxygen	9.5 (25 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Otter Tail Lake

Overall Risk Rating: High

- 1. <u>Connectivity</u>: High Risk
- 2. <u>Public Use</u>: High Risk

Suitability Risk Rating:

- 1. <u>Water Chemistry</u>: High Risk
- 2. Substrate: High Risk

Characteristics Major Basin: Ottertail Location: West of Ottertail Surface Area: 14,074.2 acres Percent Littoral: 47.7% Max Depth: 111.5 feet Inlet: Otter Tail River, Dead River, Lake Blanche

Summary

Otter Tail Lake has a high infestation risk due to very high public use. In addition, Rose Lake is upstream, and is infested with Zebra mussels. If Zebra mussels are confirmed in Rose Lake in 2015, Otter Tail Lake's connectivity rating would change from moderate (yellow) to high (red).

Attr	ibute	Description	Number	Infestation Risk
Wate	er Connectivity	Chain of lakes	11 upstream lakes	High
Jse	Resident Watercraft/Boat Lift Impact	Number of parcels (1258)		
Public U	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (3,740)	4,998	High
Subs abun	trate Suitability (mean dance)	Sand, Gravel, Rubble	85%, 10%, 5%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.1	19	8.2-8.8
Alkalinity*	mg/L	171	19	100-280
Specific Conductance*	uS/cm	326	13	>110
Secchi Depth	ft	11.7	226	6.56-13.12
Chlorophyll a	ug/L	6.7	149	2.5-8
Total Phosphorus	ug/L	18.0	149	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	27°C (48 observations)	>32 C	High
Dissolved oxygen	8.0 (15 observations)	<7 mg/L	High

Lake Risk Assessment Summary: West Battle Lake

Overall Risk Rating: Moderate

- 1. <u>Connectivity</u>: Moderate Risk
- 2. <u>Public Use</u>: High Risk

Suitability Risk Rating:

- 1. <u>Water Chemistry</u>: High Risk
- 2. <u>Substrate</u>: High Risk

Characteristics Major Basin: Ottertail Location: East of Battle Lake Surface Area: 5,565.4 acres Percent Littoral: 60.3% Max Depth: 108 feet Inlet: Clitherall Lake, East Battle Lake

Summary

West Battle Lake has a moderate infestation risk rating due to high public use and just two upstream lakes. If Zebra mussels were introduced into West Battle Lake, they would likely establish due to suitable water chemistry and hard substrate.

Attr	Attribute Description Number I		Infestation Risk		
Wate	er Connectivity	Chain of lakes	2 upstream lakes	Moderate	
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (707)			
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (2,195)	2,902	High	
Subs abun	trate Suitability (mean idance)	Sand, Gravel, Rubble	80%, 14%, 9%	High	

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.61	70	8.2-8.8
Alkalinity*	mg/L	182	10	100-280
Specific Conductance*	uS/cm	352	14	>110
Secchi Depth	ft	13.1	369	6.56-13.12
Chlorophyll a	ug/L	3.4	63	2.5-8
Total Phosphorus	ug/L	13.0	63	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.7°C (44 observations)	>32 C	High
Dissolved oxygen	8.4 (20 observations)	<7 mg/L	High

Lake Risk Assessment Summary: East Battle Lake

Overall Risk Rating: Moderate

- 1. <u>Connectivity</u>: Moderate Risk
- 2. <u>Public Use</u>: Moderate Risk

Suitability Risk Rating:

- <u>Water Chemistry</u>: High Risk
 <u>Substrate</u>: High Risk

Characteristics Major Basin: Ottertail Location: North of Vining Surface Area: 1,985.1 acres Percent Littoral: 41.9% Max Depth: 86.9%

Inlet: Brandborg Creek, Stuart Lake

Summary

East Battle Lake has a moderate infestation risk rating due to moderate public use and just two upstream lakes. If Zebra mussels were introduced into East Battle Lake, they would likely establish due to suitable water chemistry and hard substrate.

Attr	Attribute Description Number I		Infestation Risk	
Water Connectivity		Chain of lakes	2 upstream lakes	Moderate
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (423)		
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (750)1,173		Moderate
Subs abun	trate Suitability (mean idance)	Sand, Gravel, Muck	55%, 20%, 20%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.4	12	8.2-8.8
Alkalinity*	mg/L	207.1	7	100-280
Specific Conductance*	uS/cm	347	10	>110
Secchi Depth	ft	12.54	87	6.56-13.12
Chlorophyll a	ug/L	5.36	88	2.5-8
Total Phosphorus	ug/L	15.43	88	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	23.4°C (48 observations)	>32 C	High
Dissolved oxygen	9.3 (10 observations	<7 mg/L	High

Lake Risk Assessment Summary: Clitherall Lake

Overall Risk Rating: Moderate

- 1. <u>Connectivity</u>: Low Risk
- 2. <u>Public Use</u>: Moderate Risk

Suitability Risk Rating: High

- 1. Water Chemistry: High Risk
- 2. <u>Substrate</u>: High Risk

Characteristics Major Basin: Ottertail Location: South of Citherall Surface Area: 2539.8 acres Percent Littoral: 56.48% Max Depth: 68.6 feet Inlet:

Summary

Clitherall has a moderate infestation risk rating. There are no upstream lakes to supply Zebra mussels to Clitherall Lake, and it has a moderate public use rating. If Zebra mussels were introduced into Clitherall Lake, they would likely establish due to suitable water chemistry and hard substrate.

Attribute		Description Number		Infestation Risk
Water Connectivity		Headwaters Lake	0 upstream lakes	Low
Use	Resident Watercraft/Boat Lift Impact	Number of parcels (384)		
Public	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (915)	1,299	Moderate
Substrate Suitability (mean abundance)		Sand, Gravel, Rubble	73%, 23.3%, 18%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.8	10	8.2-8.8
Alkalinity*	mg/L	175	6	100-280
Specific Conductance*	uS/cm	337	7	>110
Secchi Depth	ft	13.8	170	6.56-13.12
Chlorophyll a	ug/L	4.3	70	2.5-8
Total Phosphorus	ug/L	11.2	70	25-35

*primary parameters for zebra mussel suitability

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.3°C (22 observations)	>32 C	High
Dissolved oxygen	8.8 (24 observations)	<7 mg/L	High

Stream Risk Assessment Summary: Pelican River, Becker County

Infestation Risk Rating: Moderate

- 1. <u>Connectivity</u>: Moderate Risk
- 2. <u>Distance from lakes</u>: High Risk
- 3. <u>Public Use</u>: Moderate Risk
- 4. <u>Vegetation</u>: Low Risk

Suitability Risk Rating: Low

- 1. <u>Flow Ra</u>te: Low Risk
- 2. <u>Water Chemistry</u>: Moderate Risk
- 3. <u>Substrate</u>: High Risk
- 4. <u>Dissolved Oxygen</u>: High Risk



Summary

The Pelican River in Becker County is uninfested with Zebra mussels upstream from Lake Melissa. Due to its connectivity to lakes, it is at a high risk for infestation. The stream flow would likely be the limiting factor for Zebra mussel survival within the stream itself. In order for Zebra mussels to be present in the stream, a source would be needed to continually introduce veligers to the stream.

Attribute	Description	Infestation Risk
Water Connectivity	Uninfested chain of lakes	Moderate
Distance from nearest upstream lake	<6 miles between lakes	High
Presence of aquatic vegetation/wetland conditions	Yes	Low
Public Use	Fishing, bait harvest, paddle sports	Moderate
Habitat Suitability	Sand, Gravel, Rocks	High

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	42 (2,016)	Unknown	Low
Maximum Flow (cfs)	153 (2,016)	Unknown	Low
Summer maximum temperature (C)	27.5 (108)	>32 C	High
Dissolved oxygen average (mg/L)	7.7 (114)	<7 mg/L	High

*possible limiting parameter for streams

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	NA	NA	0	>30
Hardness	Mg/L	NA	NA	0	100-280
Specific Conductance	uS/cm	NA	NA	0	>110
Total Suspended Solids	mg/L	5.7	2,054	2,068	<96
Turbidity	NTU	NA	NA	0	<80

Stream Risk Assessment Summary: Pelican River, Otter Tail County

Infestation Risk Rating: INFESTED

- 1. <u>Connectivity</u>: High Risk
- 2. <u>Distance from lakes</u>: Low Risk
- 3. <u>Vegetation</u>: Moderate Risk
- 4. Public Use: Moderate Risk

Suitability Risk Rating: Moderate

- 1. Flow Rate: Low Risk
- 2. <u>Water Chemistry</u>: High Risk
- 3. <u>Substrate</u>: High Risk
- 4. Dissolved Oxygen: High Risk



Summary

The Pelican River is infested with Zebra mussels downstream from Pelican Lake to its pour point at the Otter Tail River near Fergus Falls, MN. The stream flow is likely the limiting factor for Zebra mussel survival within the stream itself, although there are many Zebra mussel source lakes along the stream that continually introduce veligers to the stream.

Attribute	Description	Infestation Risk
Water Connectivity	Infested	High
Distance from nearest upstream lake	64 miles	Low
Presence of aquatic vegetation/wetland conditions	Moderate	Moderate
Public Use	Fishing, bait harvest	Moderate
Habitat Suitability & Substrate	Clear, Sand, Gravel, Rocks	High

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	33 (6)	Unknown	Low
Maximum Flow (cfs)	83 (6)	Unknown	Low
Summer maximum temperature (C)	27.5 (108)	>32 C	High
Dissolved oxygen average (mg/L)	7.7 (114)	<7 mg/L	High

*possible limiting parameter for streams

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	102	139	10	>30
Hardness	Mg/L	244	284	10	100-280
Specific Conductance	uS/cm	410	470	83	>110
Total Suspended Solids	mg/L	10	52	80	<96
Turbidity	NTU	6	22	128	<80

Stream Risk Assessment Summary: Otter Tail River Headwaters

Infestation Risk Rating: Moderate

- 1. <u>Connectivity</u>: Moderate
- 2. <u>Distance from lakes</u>: High
- 3. <u>Vegetation</u>: Low
- 4. Public Use: Moderate

Suitability Risk Rating:

- 1. <u>Flow Ra</u>te: Low
- 2. <u>Water Chemistry</u>: High
- 3. <u>Substrate</u>: High
- 4. Dissolved Oxygen: High



Summary

The Otter Tail River Headwaters starts in Elbow Lake and flows through a few lakes to Height of Land Lake. The distance between lakes in this area are short enough that veligers could possibly spread downstream. The presence of aquatic vegetation and wetland conditions along the stream; however, could affect the ability of veligers to travel downstream and for adults to establish.

Attribute	Description	Infestation Risk
Water Connectivity	Uninfested chain of lakes	Moderate
Distance from nearest upstream lake	<12 miles	High
Presence of aquatic vegetation/wetland conditions	Yes	Low
Public Use	Fishing, paddle sports	Moderate
Habitat Suitability & Substrate	Clear water, sand & boulders	High

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	NA	Unknown	Low
Maximum Flow (cfs)	NA	Unknown	Low
Summer maximum temperature (C)	24.14 (72)	>32 C	High
Dissolved oxygen average (mg/L)	7.02 (60)	<7 mg/L	High

*possible limiting parameter for streams

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	NA	NA	0	>30
Hardness	Mg/L	NA	NA	0	100-280
Specific Conductance	uS/cm	300	352	60	>110
Total Suspended Solids	mg/L	2.6	8	63	<96
Turbidity	NTU	0.9	3.8	63	<80

Stream Risk Assessment Summary: Otter Tail River from HOL to Pine

Infestation Risk Rating: Low

- 1. <u>Connectivity</u>: Moderate
- 2. <u>Distance from lakes</u>: Low
- <u>Vegetation</u>: Low
 <u>Public Use</u>: Moderate

Suitability Risk Rating: Low

- 1. Flow Rate: Low
- 2. <u>Water Chemistry</u>: High
- <u>Substrate</u>: High
 <u>Dissolved Oxygen</u>: High



Summary

The section of the Otter Tail River between Height of Land Lake and the Pine Lakes is 43 miles, which could be too far for Zebra mussel veligers to travel. In addition, aquatic vegetation and wetland conditions can aid in preventing spread downstream.

Attribute	Description	Infestation Risk
Water Connectivity	Uninfested chain of lakes	Moderate
Distance from nearest upstream lake	43 miles	Low
Presence of aquatic vegetation/wetland conditions	Yes	Low
Public Use	Fishing, paddle sports	Moderate
Habitat Suitability & Substrate	Clear water, sand & boulders	High

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	NA	Unknown	Low
Maximum Flow (cfs)	NA	Unknown	Low
Summer maximum temperature (C)	26.5 (51)	>32 C	High
Dissolved oxygen average (mg/L)	8.55 (51)	<7 mg/L	High

*possible limiting parameter for streams

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	NA	NA	0	>30
Hardness	Mg/L	NA	NA	0	100-280
Specific Conductance	uS/cm	309.4	370	51	>110
Total Suspended Solids	mg/L	2.4	7	45	<96
Turbidity	NTU	1.7	7.3	68	<80

Stream Risk Assessment Summary: Otter Tail River, North Otter Tail Lake

Infestation Risk Rating: Moderate

- 1. <u>Connectivity</u>: Moderate
- 2. <u>Distance from lakes</u>: High
- 3. <u>Vegetation</u>: Low
- 4. <u>Public Use</u>: Moderate

Suitability Risk Rating: Low

- 1. <u>Flow Ra</u>te: Low
- 2. <u>Water Chemistry</u>: High
- 3. <u>Substrate</u>: High
- 4. Dissolved Oxygen: High



Summary

This section of the Otter Tail River flows from Big Pine Lake to Otter Tail Lake. Because the lakes are close together on this stretch, it has a moderate infestation risk rating as veligers could travel to downstream lakes. The suitability to adult Zebra mussel establishment is low due to the presence of wetlands and sufficient flow.

Attribute	Description	Infestation Risk
Water Connectivity	Uninfested chain of lakes	Moderate
Distance from nearest upstream lake	<11 miles	High
Presence of aquatic vegetation/wetland conditions	Yes	Low
Public Use	Fishing, paddle sports	Moderate
Habitat Suitability & Substrate	Clear water, sand & boulders	High

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	64.2 (1)	Unknown	Low
Maximum Flow (cfs)	64.2 (1)	Unknown	Low
Summer maximum temperature (C)	26 (41)	>32 C	High
Dissolved oxygen average (mg/L)	9.25 (41)	<7 mg/L	High

*possible limiting parameter for streams

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	76.4	83	7	>30
Hardness	Mg/L	165	180	7	100-280
Specific Conductance	uS/cm	353	375	33	>110
Total Suspended Solids	mg/L	3.4	8	30	<96
Turbidity	NTU	2.8	9.5	48	<80

Stream Risk Assessment Summary: Otter Tail River to Fergus Falls

Infestation Risk Rating: Low

- 1. <u>Connectivity</u>: Moderate
- 2. <u>Distance from lakes</u>: Low
- 3. <u>Vegetation</u>: Low
- 4. <u>Public Use</u>: Moderate

Suitability Risk Rating: Moderate

- 1. Flow Rate: Low
- 2. <u>Water Chemistry</u>: Moderate
- 3. <u>Substrate</u>: Moderate
- 4. Dissolved Oxygen: High



Summary

This stretch of the Otter Tail River flows from Otter Tail Lake to Fergus Falls, where it joins with the Pelican River. Because the lakes are not close together on this stretch, it has a low infestation risk rating. The substrate and water chemistry are suitable for Zebra mussels, but the high water flow rate keeps the suitability at moderate instead of high. Zebra mussel adults were found downstream of Fergus Falls, so this stretch of river is suitable for adult establishment.

Attribute	Description	Infestation Risk
Water Connectivity	Uninfested Chain of lakes	Moderate
Distance from nearest upstream lake	48 miles	Low
Presence of aquatic vegetation/wetland conditions	Yes	Low
Public Use	Fishing, paddle sports	Moderate
Habitat Suitability & Substrate	Cloudy water, sandy, boulders	Moderate

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	521.73 (22)	Unknown	Low
Maximum Flow (cfs)	874 (22)	Unknown	Low
Summer maximum temperature (C)	30 (223)	>32 C	High
Dissolved oxygen average (mg/L)	10 (225)	<7 mg/L	High

*possible limiting parameter for streams

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	97	97	1	>30
Hardness	Mg/L	199.6	240	27	100-280
Specific Conductance	uS/cm	387.8	970	234	>110
Total Suspended Solids	mg/L	14.8	760	173	<96
Turbidity	NTU	6.89	46.8	227	<80

Stream Risk Assessment Summary: Dead River

Infestation Risk Rating: Moderate

- 1. <u>Connectivity</u>: Moderate
- 2. <u>Distance from lakes</u>: High
- 3. <u>Vegetation</u>: Low
- 4. Public Use: Low

Suitability Risk Rating: Low

- 1. <u>Flow Ra</u>te: Low
- 2. <u>Water Chemistry</u>: NA
- 3. <u>Substrate</u>: Low
- 4. <u>Dissolved Oxygen:</u> NA



Summary

The Dead River flows from Star Lake through Dead Lake to Otter Tail Lake. This stretch of the river is heavily vegetated and flows through numerous wetlands, which can limit Zebra mussel establishment. The distance between lakes is short; however, which means that if Star Lake became infested, Zebra mussel veligers could move downstream from Star Lake into Dead Lake. The suitability for Zebra mussel adults to establish in this stream stretch is low.

Attribute	Description	Infestation Risk
Water Connectivity	Uninfested chain of lakes	Moderate
Distance from nearest upstream lake	<8.6 miles	High
Presence of aquatic vegetation/wetland conditions	Yes	Low
Public Use	Minimal	Low
Habitat Suitability & Substrate	Wetlands	Low

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	NA	Unknown	Some flow = low
Maximum Flow (cfs)	NA	Unknown	Some flow = low
Summer maximum temperature (C)	NA	>32 C	NA
Dissolved oxygen average (mg/L)	NA	<7 mg/L	NA

*possible limiting parameter for streams

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	NA	NA	0	>30
Hardness	Mg/L	NA	NA	0	100-280
Specific Conductance	uS/cm	NA	NA	0	>110
Total Suspended Solids	mg/L	NA	NA	0	<96
Turbidity	NTU	NA	NA	0	<80

Stream Risk Assessment Summary: Battle Creek

Infestation Risk Rating: Moderate

- 1. <u>Connectivity</u>: Moderate
- 2. <u>Distance from lakes</u>: High
- 3. <u>Vegetation</u>: Low
- 4. <u>Public Use</u>: Moderate

Suitability Risk Rating: Low

- 1. <u>Flow Rate</u>: Low
- 2. <u>Water Chemistry</u>: NA
- 3. <u>Substrate</u>: Low
- 4. Dissolved Oxygen: NA



Summary

Battle Creek flows from West Battle Lake to Otter Tail Lake. This stretch of the river is heavily vegetated and flows through numerous wetlands, which can limit Zebra mussel establishment. The distance between lakes is short; however, which means that if West Battle Lake became infested, Zebra mussel veligers could move downstream from West Battle into Annie Battle and Blanche Lakes to get to Otter Tail Lake. The suitability for Zebra mussel adults to establish in this stream stretch is low.

Attribute	Description	Infestation Risk
Water Connectivity	Uninfested chain of lakes	Moderate
Distance from nearest upstream lake	<7.2 miles	High
Presence of aquatic vegetation/wetland conditions	Yes	Low
Public Use	Fishing, paddle sports	Moderate
Habitat Suitability & Substrate	Wetlands	Low

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	NA	Unknown	Some flow = low
Maximum Flow (cfs)	NA	Unknown	Some flow = low
Summer maximum temperature (C)	NA	>32 C	NA
Dissolved oxygen average (mg/L)	NA	<7 mg/L	NA

*possible limiting parameter for streams

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	NA	NA	0	>30
Hardness	Mg/L	NA	NA	0	100-280
Specific Conductance	uS/cm	NA	NA	0	>110
Total Suspended Solids	mg/L	NA	NA	0	<96
Turbidity	NTU	NA	NA	0	<80

Stream Risk Assessment Summary: Toad River

Infestation Risk Rating: Low

- 1. <u>Connectivity</u>: Moderate
- 2. <u>Distance from lakes</u>: Low
- <u>Vegetation</u>: Low
 <u>Public Use</u>: Moderate

Suitability Risk Rating: Low

- 1. Flow Rate:
- 2. <u>Water Chemistry</u>:
- <u>Temperature</u>:
 <u>Dissolved Oxygen</u>:



Summary

The Toad River flows from Big and Little Toad Lakes into Big Pine Lake. There are no other lakes along this stretch of river, so the distance could be too great for Zebra mussel veligers to travel. This river is also heavily vegetated, which would limit Zebra mussel adult establishment.

Attribute	Description	Infestation Risk
Water Connectivity	Uninfested chain of lakes	Moderate
Distance from nearest upstream lake	26 miles	Low
Presence of aquatic vegetation/wetland conditions	Yes	Low
Public Use	Fishing, paddle sports	Moderate
Habitat Suitability	Cloudy, tea-stained water, wetlands	Low

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	94.9 (9)	Unknown	Low
Maximum Flow (cfs)	230 (9)	Unknown	Low
Summer maximum temperature (C)	27.7 (61)	>32 C	High
Dissolved oxygen average (mg/L)	9.65 (61)	<7 mg/L	High

*possible limiting parameter for streams

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	NA	NA	0	>30
Hardness	Mg/L	NA	NA	0	100-280
Specific Conductance	uS/cm	407	503	65	>110
Total Suspended Solids	mg/L	8.5	44.0	49	<96
Turbidity	NTU	5.6	29.7	80	<80

Results and Discussion

Results

The lakes in the Otter Tail River Watershed resulted in differing infestation and suitability risk ratings (Table 13). In general terms, the headwaters lakes came out with the lowest infestation risk ratings because they have no water bodies upstream. The headwaters lakes in the Otter Tail River Watershed include Floyd, Little Floyd, Upper Cormorant, Elbow, Six, and Flat Lakes.

Lakes with high infestation risk ratings, high public use, and high suitability include Pelican, Big Cormorant, Detroit, Big Pine, Rush and Otter Tail (Table 13). These lakes are all part of chains of lakes, so have risk from connectivity. The highest risk to these lakes; however, is their public use (Figure 19). They have the most resort units, public accesses, and property owners of any lakes in the watershed. Public use risks come from both lake visitors via boats and lake property owners via boats, boat lifts, docks and other water-related equipment. Pelican Lake was the first lake in the watershed to become infested with Zebra mussels, and it also had the highest public use rating of all the lakes in the watershed (Table 3).

West Battle and Dead Lake have high public use risks, but moderate infestation risk (Table 13). This resulted from a low risk in connectivity to other lakes. These lakes would be the second priority as far as risk in the watershed.

Most of the lakes in the Otter Tail River Watershed resulted in a high Zebra mussel suitability rating (Figure 22). The lakes in northwest Minnesota are considered hardwater lakes from glacial deposits of calcium carbonate (limestone) (Wetzel 2001). All of the lakes in this study had suitable water chemistry, including calcium, for some Zebra mussel growth and development.

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, pieces of wood or stones, or clump together on themselves (Karatayev et al. 1998). Therefore, lakes that have predominantly silt, muck and sand have a low substrate suitability rating. These lakes also tend to be more eutrophic, and Zebra mussels do not thrive in eutrophic lakes like they do in mesotrophic lakes (Karatayev et al. 1998, Nelepa 1992). The lakes with moderate suitability ratings included Prairie, Little Pelican, Floyd, Little Floyd, Upper Cormorant, Many Point, Elbow and Flat (Table 13, Figure 22).

The Otter Tail River and Pelican 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, but if the downstream lake is close enough, veligers can be transferred from one lake to another.

Lake Name	 Lake ID	Public Use Risk	Infestation Risk	Suitability Risk	Infestation Status as of March 2015	AIS Program Prioritized Recommendations
Upper Cormorant	03-0588-00	Low	Low	Moderate		1. Education
Middle Cormorant	03-0602-00	Moderate	Moderate	High		1. Education
Big Cormorant	03-0576-00	High	High	High		 Public Access Inspections Education Early Detection Monitoring
Big Floyd	03-0387-02	Low	Low	Moderate		1. Education
Little Floyd	03-0386-00	Low	Low	Moderate		1. Education
Detroit	03-0381-00	High	High	High		 Public Access Inspections Education Early Detection Monitoring
Sallie	03-0359-00	Moderate	Moderate	High		 Education Early Detection Monitoring
Melissa	03-0475-00	Moderate	High	High	Infested with Zebra mussels	 Decontamination station Education
Little Pelican	56-0761-00	Low	High	Moderate	Infested with Zebra mussels	 Decontamination station Education
Pelican	56-0786-00	High	High	High	Infested with Zebra mussels	 Decontamination station Education
Lizzie	56-0760-00	Low	High	High	Infested with Zebra mussels	 Decontamination station Education
Prairie	56-0915-00	Low	High	Moderate	Infested with Zebra mussels	 Decontamination station Education
Elbow	03-0159-00	Low	Low	Moderate		1. Education
Many Point	03-0158-00	Low	Moderate	Moderate		1. Education
Round	03-0155-00	Low	Moderate	High		1. Education
Flat	03-0242-00	Low	Low	Moderate		1. Education
Height of Land	03-0195-00	Low	Moderate	High		1. Education
Toad	03-0107-00	Moderate	Moderate	High		1. Education
Six	56-0369-00	Low	Low	High		1. Education
Scalp	56-0358-00	Low	Moderate	High		1. Education

Table 13. Summary of risk ratings and prioritized recommendations taking into account the risk.

Table 13 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
Rose	56-0360-00	Low	Moderate	High	Infested with Zebra mussels	 Intensive Monitoring (adults and veligers) Education
Long	56-0388-02	Low	Moderate	High		1. Education
Little Pine	56-0142-00	Low	Moderate	High		1. Education
Big Pine	56-0130-00	High	High	High		 Public Access Inspections Education Early Detection Monitoring
Rush	56-0141-00	High	High	High		 Public Access Inspections Education Early Detection Monitoring
Star	56-0385-00	Moderate	Moderate	High		1. Education
Dead	56-0383-00	High	Moderate	High		 Public Access Inspections Education Early Detection Monitoring
Otter Tail	56-0242-00	High	High	High		 Public Access Inspections Education Early Detection Monitoring
West Battle	56-0239-00	High	Moderate	High		 Public Access Inspections Education Early Detection Monitoring
East Battle	56-0138-00	Moderate	Moderate	High		1. Education
Clitherall	56-0238-00	Moderate	Moderate	High		1. Education



Figure 19. Public Use Risk Rating for lakes in the Otter Tail River Watershed.



Figure 20. Overall Zebra mussel Infestation Risk Rating for lakes in the Otter Tail River Watershed.



Figure 21. Overall Zebra mussel Infestation Risk Rating for lakes and streams in the Otter Tail River Watershed.


Figure 22. Overall Zebra mussel suitability risk rating in the Otter Tail River Watershed.

Data Gaps

This study identified some data gaps in the Otter Tail River Watershed. Calcium is the most important water chemistry parameter when evaluating Zebra mussel habitat suitability. Many lakes did not have any historical calcium data. 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. These data gaps are indicated on the lake report cards. See the table below for a summary of parameters needed for each lake (Table 14).

Water Body Name	Lake ID	Parameters Needed
Upper Cormorant	03-0588-00	Calcium, pH, Alkalinity, Specific Conductance
Middle Cormorant	03-0602-00	Calcium
Big Cormorant	03-0576-00	Calcium
Big Floyd	03-0387-02	Calcium
Little Floyd	03-0386-00	Calcium, Alkalinity
Detroit	03-0381-00	Calcium
Sallie	03-0359-00	Calcium
Melissa	03-0475-00	Calcium
Pelican	56-0786-00	None
Little Pelican	56-0761-00	pH
Lizzie	56-0760-00	Calcium, Specific Conductance
Prairie	56-0915-00	Calcium
Elbow	03-0159-00	Calcium, Specific Conductance, Dissolved Oxygen
Many Point	03-0158-00	Calcium, pH, alkalinity, Specific Conductance, Temperature, Dissolved Oxygen.
Round	03-0155-00	Calcium, pH, alkalinity, Specific Conductance, Temperature, Dissolved Oxygen
Flat	03-0242-00	Specific Conductance, Dissolved Oxygen
Height of Land	03-0195-00	Calcium, Specific Conductance, Dissolved Oxygen
Toad	03-0107-00	Calcium, Specific Conductance, Dissolved Oxygen
Six	56-0369-00	Calcium, Specific Conductance, Dissolved Oxygen
Scalp	56-0358-00	Calcium, Specific Conductance, Dissolved Oxygen
Rose	56-0360-00	Calcium, pH, alkalinity, Specific Conductance, Temperature, Dissolved Oxygen
Long	56-0388-02	Calcium, pH, Specific Conductance, Dissolved Oxygen
Little Pine	56-0142-00	Calcium
Big Pine	56-0130-00	Calcium
Rush	56-0141-00	Calcium
Star	56-0385-00	Calcium, pH, Specific Conductance
Dead	56-0383-00	Calcium
Otter Tail	56-0242-00	Calcium
West Battle	56-0239-00	Calcium
East Battle	56-0138-00	Calcium
Clitherall	56-0238-00	Calcium

Table 14. Summary of data gaps for water bodies in the Otter Tail River Watershed.

Water Body Name	Parameters Needed					
Pelican River, Becker County	Calcium, Hardness, Specific Conductance, Turbidity					
Pelican River, Otter Tail County	None					
Otter Tail River Headwaters	Flow, calcium, hardness					
Otter Tail River, HOL to Pine Lakes	Flow, calcium, hardness					
Otter Tail River, North Otter Tail Lake	None					
Otter Tail River to Fergus Falls	None					
Dead River	Flow, temperature, D.O., calcium, hardness, specific conductance, TSS, turbidity					
Battle Creek	Flow, temperature, D.O., calcium, hardness, specific conductance, TSS, turbidity					
Toad River	Flow, calcium, hardness					

Table 14 continued. Summary of data gaps for water bodies in the Otter Tail River Watershed

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 15.

- 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 2014). 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 nonexistent during the ice-covered season, so there is essentially no risk of veliger transfer in the winter (Rufer 2014).
- 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 (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 Busierre'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 14, 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 15, Rufer 2015).



Figure 23. 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 24. 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

	Typical Minnesota Open Water Season					Typical Minnesota Ice-covered season						
Risk Pathway	April	May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	March
1. Connectivity via a river or stream.	insignificant	insignificant	Low Veligers	High <i>Veligers</i>	Moderate Veligers	Low Veligers	insignificant	insignificant	insignificant	insignificant	insignificant	insignificant
2. Transfer of equipment from lake to lake.	insignificant	insignificant	Moderate Adults & juveniles	High Adults & juveniles	High Adults & juveniles	Low Adults & juveniles	insignificant	insignificant	insignificant	insignificant	insignificant	insignificant
3. Transfer of mussels hitchhiking on vegetation or mud on boats, trailers and gear.	Low Adults & juveniles	Low Adults & juveniles	Moderate Adults & juveniles	High Adults & juveniles	High Adults & juveniles	Moderate Adults & juveniles	Low Adults & juveniles	insignificant	insignificant	insignificant	insignificant	insignificant
4. Transfer of veligers via water in boats (live wells, bilges, etc) and float planes.	insignificant	insignificant	Low Veligers	High Veligers	Moderate Veligers	Low Veligers	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 Adults & juveniles	High Adults & juveniles	High Adults & juveniles	Moderate Adults & juveniles	Low Adults & juveniles	insignificant	insignificant	insignificant	insignificant	insignificant
 Transfer of veligers and juvenile mussels on swimwear, SCUBA equipment, waders or other gear used in water. 	insignificant	insignificant	Low Veligers	High Veligers	Moderate Veligers	Low Veligers	insignificant	insignificant	insignificant	insignificant	insignificant	insignificant

Table 15. Summary of risk pathways depending on the time of year. The Zebra mussel life stage for the pathway is indicated in italics.

Sources: Zebra mussel veliger time-of-year risk was taken from Rufer 2014.

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.

The assessments in this report result combine the report cards with the risk of time of year (Figure 15) in the following specific Aquatic Invasive Species Program Management Recommendations (Table 16). 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.

Activity	Target Lakes	Target Time of Year	Who	Cost	Narrative
Watercraft Inspections	 <u>Priority 1</u>: Detroit Big Cormorant Big Pine Rush Otter Tail <u>Priority 2</u>: West Battle Dead <u>Priority 3</u>: Middle Cormorant Sallie Toad Star 	<u>Priority 1</u> : July <u>Priority 2</u> : August	County	TBD	This activity depends on available funding. If limited funding is available, focus inspections on Priority 1 lakes in July as the best use of funds. If more funds are available, add in Priority 2 and 3 lakes in July. Next, add in August.
Water Quality Monitoring	See Table 14 for data gaps.	May – September	Lake Associations, COLA	TBD	Monitor lakes for missing parameters shown in Table 14. Priority parameters for each lake would be Calcium, Alkalinity, pH and Specific Conductance as they have the most effect on Zebra mussel suitability.

Table. 16. Framework for the watershed's AIS plan.

Table 16 continued on the next page.

Activity	Target Lakes	Target Time of Year	Who	Cost	Narrative
Early Detection Monitoring: Adult Zebra mussels	 <u>Priority 1</u>: Detroit Big Cormorant Big Pine Rush Otter Tail West Battle Dead <u>Priority 2</u>: All 	<u>Priority 1</u> : September <u>Priority 2</u> : Every other week from late June to mid-September	Volunteers	\$0	 In September, conduct a lake-wide inspection of docks and boat lifts as they are removed from the lake. 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/re port.html.
Early Detection Monitoring: Zebra mussel veligers	 Detroit Big Cormorant Big Pine Rush Otter Tail West Battle Dead 	July	County, Watershed District, or Lake Associations	\$450 (\$90/sample)	Collect plankton tow samples in early and late July for veliger analysis. Early detection allows for possible treatment.
Monitoring Zebra mussels in questionably infested lakes	 Rose Little McDonald Kerbs Paul Rusche Pickerel 	July and September	Volunteers, DNR, County	TBD	 All the target lakes have had some evidence of Zebra mussels found in the past, but the Zebra mussel population has not taken over the lake. 1. Monitor these lakes for Zebra mussel veligers in July. 2. Monitor these lakes for adults in June-September a. In September, conduct a lake-wide inspection of docks and boat lifts as they are removed from the lake. 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_monit_oring/report.html

Table. 16 continued. Framework for the watershed's AIS plan.

Table 16 continued on the next page.

Activity	Target Lakes	Target Time of Year	Who	Cost	Narrative
Monitoring: Invasive Plants	 <u>Priority 1</u>: Detroit Big Cormorant Big Pine Rush Otter Tail <u>Priority 2:</u> All 	Mid to late June	County, Watershed District, or Lake Associations	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	<u>Priority 1</u> : 4 th of July week <u>Priority 2</u> : Memorial day to labor day <u>Priority 3</u> : Year round	County and watershed	TBD	Conduct a consistent watershed-wide education program to schools and the general public. In high tourism areas such as Detroit Lakes, Perham, and Ottertail, focus <i>additional</i> education around 4 th of July since that is the highest risk time of the year for spread.
Decontamination	Melissa Pelican Lizzie Prairie	Priority 1: July Priority 2: August	County, DNR, or private business	TBD	Provide decontamination opportunities for boats leaving infested lakes. Inform boaters on where the decontamination station is located.
Rapid Response Plan	All	Year round	County or watershed	TBD	Put together a plan of the chain of contacts if a new infestation is found and the steps to determine if treatment is possible. Having a plan in place allows for quick action if there is a new infestation.

Table. 16 continued. Framework for the watershed's AIS plan.

Table 16 can be used as a framework for the best way to use available funding, as it shows when the priority time of year is and what the priority lakes are for each activity. For example, if funding is limited for watercraft inspections at public accesses, the funding should first be used to cover Detroit, Big Cormorant, Big Pine, Rush and Otter Tail lakes in July. After that, if more funding is available, add in West Battle and Dead Lakes in July, and so forth.

For monitoring, ideally all lakes would be monitored for adults because if trained volunteers are used there is no monetary cost, but there is a large benefit. There are, however, some unique Zebra mussel infestations in Otter Tail County, namely Rose, Little McDonald, Kerbs, Paul, Rusche, and Pickerel Lakes (described on pages 10-11). These lakes should be intensively monitored in 2015 to determine whether Zebra mussels are indeed established. This intensive monitoring consists of testing for Zebra mussel veligers in July, and looking for adults all year. A comprehensive search of all docks and boat lifts removed from the lake in September should be completed as well.

For education, 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 near high risk lakes.

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