Susceptibility of Alberta's Irrigation Water to Invasive Mussels

Water Quality Analysis

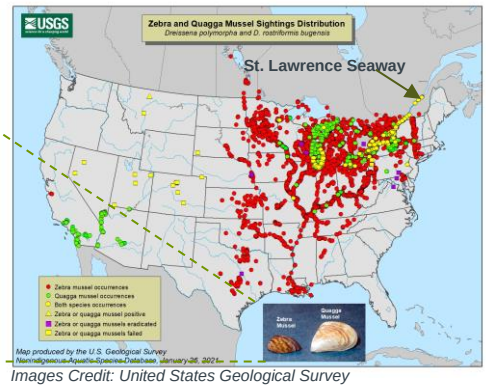
Background

Zebra and quagga mussels are freshwater mussels that are not from Alberta, making them an invasive species. Invasive mussels attach to any hard surface in the water, and can damage ecosystems and water infrastructure. Prevention is critical because control is often difficult. Alberta does not have any established populations of invasive mussels, but intercepts potential introductions of mussels every year. If introduced to Alberta's lakes and reservoirs, invasive mussels would dramatically affect Alberta's irrigation infrastructure by clogging pipelines, water intakes or other equipment.

The survival and growth of invasive mussels depends on suitable water conditions. Water quality has been monitored within irrigation reservoirs and conveyance networks since 2006, and the data suggests that Alberta's irrigation water would provide suitable habitat for invasive mussels.

History of Invasive Mussels in North America

Zebra mussels (*Dreissena polymorpha*) and quagga mussels (*Dreissena bugensis*) are two species of small, freshwater mussels, native to the Black and Caspian Seas of Eurasia. They were unintentionally transported in cargo ship ballast water released in the St. Lawrence Seaway in the early 1980s. From there, they spread throughout much of the eastern United States. Invasive mussels are easily transported by trailered watercraft that travel overland from infested waterbodies. In 2013 they were discovered in Lake Winnipeg, Manitoba, with more detections since. Alberta inspection stations have stopped mussel-infested watercraft destined for several Alberta lakes. In 2020, an inspection station intercepted a mussel-fouled boat destined for Lake Newell, which supplies water in the Eastern Irrigation District.



Images Credit: United States Geological Survey

alberta.ca/irrigation-strategy.aspx

Classification: Public

Risk of Invasive Mussel Introduction and Establishment in Alberta

Each summer, several recreationists transport watercraft into or through Alberta. These travelers sometimes come from mussel-infested waterbodies in Canada and the United States. In fact, some of the destinations could be reached within a day, and mussels survive out of water for up to 30 days. Once in a lake or waterbody, zebra and quagga mussels will attach onto any hard surface in the water, like rocks, docks, and water equipment. Mussels reproduce very quickly and have clogged pipes of hydroelectric and industrial facilities in the United States. In Alberta, invasive mussels would clog irrigation pipelines and associated intake structures, trash racks, fish screens, weirs, and gates in the infested water. This would slow or stop the flow of water. Invasive mussels also consume small particles in the water, taking food from native fish species. Beaches could become covered in zebra and quagga mussel shells, which are very sharp and can cause injury. The effects of invasive mussels have major economic, environmental, and social, consequences.

Photo credit: Marrone Bio Innovations

Influence of Water Quality on Invasive Mussel Establishment

Whether or not invasive mussels could survive in a particular water body depends on the water chemistry and climate. Temperature, dissolved oxygen, pH, chlorophyll *a*, and calcium are the most important water quality parameters for mussel survival. If a water body has those parameters at the right levels, that water body is at risk for establishment and survival of invasive mussels (Table 1). Calcium, pH, and temperature are the most important predictors, because calcium is needed for shell growth, while pH and temperature allow for veliger (mussel larvae) survival.

Parameters for suitable mussel habitat:

- Calcium
- pH
- Temperature
- Chlorophyll *a*
- Dissolved oxygen

Calcium

Calcium is an important element for mussels as it is used to grow their shells. Mussel larvae, called veligers, need more calcium than the adults. Ideal calcium concentrations range from 40- 55 mg/L. In European mussel populations, less than 10 per cent of larvae can survive in water with calcium concentrations of 24 mg/L because they cannot properly grow a shell. However, some North American lakes have invasive mussel populations that appear to require only 10 mg/L to initiate shell growth and 25 mg/L to maintain the shell. While minimum calcium levels for invasive mussel growth vary among locations, it is generally accepted that calcium concentrations must be at least 15 mg/L to sustain populations. Maximum levels for growth also vary, but research indicates that mussels will thrive with up to 60 mg/L of calcium. In general, calcium levels of 15 – 40 mg/L are expected to allow invasive mussels to grow.

pH

Water with a pH greater than 7.5 is generally required for veliger development. Veliger growth cannot happen at a pH of 7.4 or less. Adult mussels can survive in water with a pH ranging from 7.0 – 9.0, but the ideal range is 7.4 – 8.0. Considering these varying ranges, it is generally accepted that waterbodies with a pH of 7.5 – 9.0 would allow invasive mussels to grow.

Temperature

Water temperature determines the window of time that mussels can reproduce, and the growth rate of adult invasive mussels. When the water temperature reaches 12°C, adult mussels release eggs and sperm into the water column, which is where fertilization occurs. Ideal temperatures are 20 – 22°C for larval development and 20 – 25°C for adults; however, it is believed adult invasive mussels can survive in water up to 30°C. Water temperatures of 17– 24°C are required for viable populations.

Chlorophyll *a*

Chlorophyll *a* indicates if phytoplankton, plant-like organisms including algae– the primary food source for invasive mussels– is present in a water body. Levels of chlorophyll *a* from 2.5 – 8 µg/L are considered ideal, however concentrations up to 25 µg/L will support moderate mussel growth. Water bodies with concentrations of chlorophyll *a* below these values do not have enough food supply for mussels. Concentrations greater than 25 µg/L could indicate algal blooms, which would make the water cloudy, or turbid, and interfere with veliger survival.

Dissolved Oxygen

Estimates on dissolved oxygen needs tend to vary, but research suggests that dissolved oxygen levels below 4 mg/L will not allow invasive mussels to survive.

Interesting reads:

- More information on the risk and cost that invasive mussels pose to the irrigation industry can be found in the report titled;

  Dreissenid Mussels and Alberta's Irrigation Infrastructure: Strategic Pest Management Plan and Cost Estimate" (Paterson Earth & Water Consulting 2018).

- Alberta Environment and Parks (AEP) estimated the total annual cost of invasive mussels to Alberta, not including irrigation or rural water supply pipelines, would be about $75.5 million (Neupane 2013).

Table 1. Survival and development criteria for invasive dreissenid mussels in the temperate zone of North America and Europe (Mackie and Claudi 2010; Claudi and Prescott 2011).

Parameter	Adults: No Long-term Survival	Veligers: Uncertainty of Survival	Moderate Infestation Level	High Infestation Level
Calcium (mg/L)	<8	<15	16 - 24	≥24
Alkalinity (mg CaCO3/L)	< 30	30 - 55	45 - 100	>90
Total hardness (mg CaCO3/L)	<30	30 - 55	45-100	≥90
pH	<7.0 or >9.5	7.1 - 7.5 or 9.0 - 9.5	7.5 - 8.0 or 8.8 - 9.0	8.2 - 8.8
Mean summer temperature (°C)	<17	17 - 20 or >29	20 - 22 or 25 - 28	22 - 24
Dissolved oxygen mg/L (% saturation)	<3 (25)	5 - 7 (25-50)	7 - 8 (50-75)	≥8 (>75)
Conductivity (µS/cm)	<30	<30 - 60	60 - 110	≥110
Salinity (mg/L)	>10	8 - 10	5 - 10	<5
Secchi depth (m)	<0.1 >8	0.1 - 0.2 or >2.5	0.2 - 0.4	0.4 - 2.5
Chlorophyll *a* (µg/L)	<2.5 or >25	2.0 - 2.5 or 20-25	8 - 20	2.5 - 8
Total phosphorous (µg/L)	<5 or >50	5 - 10 or 30 - 50	15 - 25	25 - 35

Alberta's Irrigation District Water Quality – Risk for Invasive Mussels

The Government of Alberta, in partnership with Alberta's irrigation districts, has been monitoring water quality in the irrigation districts from June to September most years since 2006. The water chemistry of most irrigation reservoirs and water supply systems in southern Alberta would allow invasive mussels to survive and reproduce here. These waterbodies contain adequate calcium levels (>20mg/L), ideal ranges for pH (7.6 – 9.3), and enough dissolved oxygen (>4 mg/L). The observed levels of chlorophyll *a* also indicate suitable conditions for mussel survival. Water temperatures in the summer months in most irrigation reservoirs and water supply systems rarely exceed 25°C, which would allow for mussel reproduction and development, but the reproductive season would be short. This also suggests that the rate of mussel growth would be slow, around 1 – 1.5 mm/month (Paterson Earth & Water Consulting, 2018). Further, according to Paterson (2018), Cavan Lake Reservoir in Ross Creek Irrigation District would not allow for invasive mussel development because of high levels of naturally occurring potassium, which kills invasive mussels. All other irrigation reservoirs are considered at risk.

Conclusions and Recommendations

Alberta's irrigation water is at high risk for the introduction and establishment of invasive mussels because of:

- Their spread throughout North American waterbodies,
- The number of boats with mussels detected at Alberta's inspection stations each summer, and
- Ideal habitat conditions.

Trends from 10 years of water quality data for the parameters discussed in this document are fairly consistent and stable. Important parameters of temperature, pH, and calcium are easy to collect as part of regular monitoring activities, and should continue to be monitored. Monitoring of other parameters such as dissolved oxygen and chlorophyll *a* could be re-introduced if invasive mussels are detected in Alberta waterbodies, to provide the most relevant data to re-calculate mussel growth rate and reproduction for a rapid response plan if needed.

The introduction of invasive mussels to Alberta's irrigation water supply would be damaging to the irrigation sector and broader agriculture industry of southern Alberta. It is important to continue efforts to prevent the introduction of invasive zebra and quagga mussels to the province, such as monitoring, education and outreach, and watercraft inspections.

References

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For more information

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