APPENDIX B

Application to Deposit a Deleterious Substance under DFO Aquatic Invasive Species Regulations

NOTE: The project plan has been refined since this AIS application was submitted in April 2020, based on input from DFO, DNR, field data collection, and through Indigenous consultations. The EIA registration documents presents the most up to date and comprehensive project proposal and integration of all treatment components (Miramichi Lake, Lake Brook, and the SW Miramichi River).

NORTH SHORE
Micmac District Council

38 Micmac Rd,. Eel Ground, NB
T: 506.627.4611
F: 506.627.4613

8 April 2020

Daniel Bourque
Aquatic Invasive Species National Core Program
Department of Fisheries & Oceans
343 University Avenue
P.O. Box 5030
Moncton, NB
E1C 9B6

RE: 19-IGLF-00001 Eradication of Smallmouth Bass from the Miramichi Watershed

Mr. Bourque,

Enclosed is the amended application to eradicate smallmouth bass (SMB) from the Miramichi watershed, including a response to your 2nd request for additional information from 20 December 2019.

Given that SMB were discovered in the Southwest Miramichi River in August 2019, the scope of the overall eradication now includes a reach of the river.

There are two major components of the application: (1) Miramichi Lake and Lake Brook, and (2) a reach of the Southwest Miramichi River. We have delineated the two components within this application so they can be assessed independently. The plan for the Lake is well-developed and has undergone several rounds of review by DFO, whereas the plan for the river (APPENDICES F and G) requires further information gathering through desktop analysis and fieldwork in spring and summer 2020 to inform the development of a comprehensive plan.

Our intention for including the feasibility assessment for the river component is to demonstrate we have completed a scoping exercise and to commence the regulatory review process. We want to work closely with your team over the coming weeks to gather the data needed to form a comprehensive plan for the river so that smallmouth bass can be eradicated from Miramichi Lake, Lake Brook, and the Southwest Miramichi River in the fall of 2020.

The most effective eradication approach with the highest likelihood of success is to treat the lake and river simultaneously. As such, we are pursuing approval for both components for September 2020.

The following is an outline of the application components:

1. Application – Main Body
2. APPENDIX A – DFO Request for Additional Information (1) and response
3. APPENDIX B – DFO Request for Additional Information (2) and response
4. APPENDIX C – Miramichi Lake Mussel Survey
5. APPENDIX D – Re-establishment Strategy
6. APPENDIX E – Monitoring Plan
7. APPENDIX F – Southwest Miramichi River Eradication Planning
8. APPENDIX G – Fish Control Solutions Ltd. Feasibility Assessment of Rotenone Treatment of the Southwest Miramichi River
9. APPENDIX H – Noxfish Fish Toxicant II PMRA Label
10. APPENDIX I – Noxfish Fish Toxicant II SDS
11. APPENDIX J – Assembly of First Nations Resolution on Invasive Alien Species

The main body of the application and APPENDIX A have previously been reviewed by DFO; however, there have been updates to ensure consistency with the remainder of the amended application. We have highlighted the changes in yellow so it is clear where alterations have been made to sections DFO has previously reviewed.

In the Re-establishment Strategy (APPENDIX D), we have proposed two options; we request DFO's feedback on which option is preferred.

We look forward to hearing from you on the amended application. Given the urgency of the situation and in the interest of moving as quickly as possible, we request direct correspondence by phone or email as questions arise in order to avoid the delays associated with written correspondence. We will answer any questions you may have in a timely fashion.

Sincerely,

Jim Ward
General Manager
North Shore Micmac District Council Inc.

Cc: Serge Doucet,
Alain Hebert,
Paulette Hall,
Guy Robichaud
Chief George H. Ginnish
Chief William (Bill) Ward

Pêches et Océans Canada | Fisheries and Oceans Canada

Eradication of Invasive Smallmouth Bass From Miramichi Lake, NB

Request to authorize the deposit of a deleterious substance pursuant to the Aquatic Invasive Species Regulations

This document constitutes a request from the Proponent (Section 1) to the Minister of Fisheries, Oceans, and the Canadian Coast Guard to authorise the deposit of a deleterious substance to control an aquatic invasive species pursuant to s. 19(3) of the *Aquatic Invasive Species Regulations* SOR / 2015-121 (AISR). The Proponent will include all appropriate details in the project details (Section 2 and 3) as well as details regarding environmental impact (Sections 4-7). Notwithstanding any Authorization received subsequent to this application, the Proponent must ensure compliance with all other relevant provincial and federal legislation and regulations including but not limited to: any relevant Provincial pesticide application and labour laws, the *Canadian Environmental Protection Act, 1999;* the *Canadian Environmental Assessment Act, 2012,* and the *Transportation of Dangerous Goods Act, 1992.* Further this Authorisation may also require a subsequent consultation with affected Indigenous groups.

The applicant must ensure all the relevant information is properly included. An incomplete submission will not be considered. DFO reserves the right to ask the proponent to supply additional information to clarify any elements of the proposal put forth in this application.

Yellow highlights throughout the body of the document indicate updates to the application as of **April 2020.**

APPLICTION COMPONENTS

Application – Main Body
APPENDIX A – DFO Request for Additional Information (1) and response
APPENDIX B – DFO Request for Additional Information (2) and response
APPENDIX C – Miramichi Lake Mussel Survey
APPENDIX D – Re-establishment Strategy
APPENDIX E – Monitoring Plan
APPENDIX F – Southwest Miramichi River Eradication Planning
APPENDIX G – Fish Control Solutions Ltd. Feasibility Assessment of Rotenone Treatment of the Southwest Miramichi River
APPENDIX H – Noxfish Fish Toxicant II PMRA Label
APPENDIX I - Noxfish Fish Toxicant II SDS
APPENDIX J - Assembly of First Nations Resolution on Invasive Alien Species

PLEASE PRINT CLEARLY. PROVIDE ADDITIONAL SHEETS IF REQUIRED.

Section 1: Proponent information

1.1. Proponent Name (e.g. business operating name)		
North Shore Micmac District Council Inc.		
1.2. Point of Contact Name		
Jim Ward		
1.3. Proponent Address		
38 MicMac Road Eel Ground, NB		
Province	**Postal Code**	
New Brunswick	E1V 4B1	
1.4. Proponent contact information		
E-mail address	**Telephone**	**Cellphone**
jimward@nb.aibn.com	506 627-4611	
1.5. Date Submitted (DD/MM/YYYY)		
04/04/2019		
1.6. Project partners (if applicable)		
Business operating name	**Contact name**	**Telephone**
Atlantic Salmon Federation	Nathan Wilbur	506 442-2185
Maliseet Nation Conservation Council	Patricia Saulis	506 472-8803
Miramichi Salmon Association	Mark Hambrook	506 622-6445
Miramichi Watershed Management Committee	Debbie Norton	506 627-6492
New Brunswick Salmon Council	Peter Cronin	506 238-4616
New Brunswick Wildlife Federation	Charlie Leblanc	506 866-4345

Section 2: Primary Project Details

2.1. Target Invasive Species		
Smallmouth Bass (SMB) *Micropterus dolomieu*		
2.2. Name and Location of the Body of Water[1]		
The project site is Miramichi Lake and its outflow, Lake Brook, which is located in west-central New Brunswick in the upper reaches of the Southwest Miramichi River watershed, approximately 20 km south-east of the village of Juniper. See the attached maps for the lake location and site features (Figure 1 and Figure 2). UPDATE: Based on the discovery of SMB in the SW Miramichi River in August 2019 after this application process has begun, the project scope has now expanded to include approximately a 15-km reach of the river – see APPENDICES F and G for river treatment planning and scoping. The	**Latitude**	46°27'33.90"N
	Longitude	66°58'17.68"W

program is now delineated into two components: (1) Miramichi Lake and Lake Brook, (2) a reach of the SW Miramichi River (see Figure 2). For the most effective eradication approach, Miramichi Lake, Lake Brook, and the specified reach of the SW Miramichi River would be treated simultaneously in 2020.		

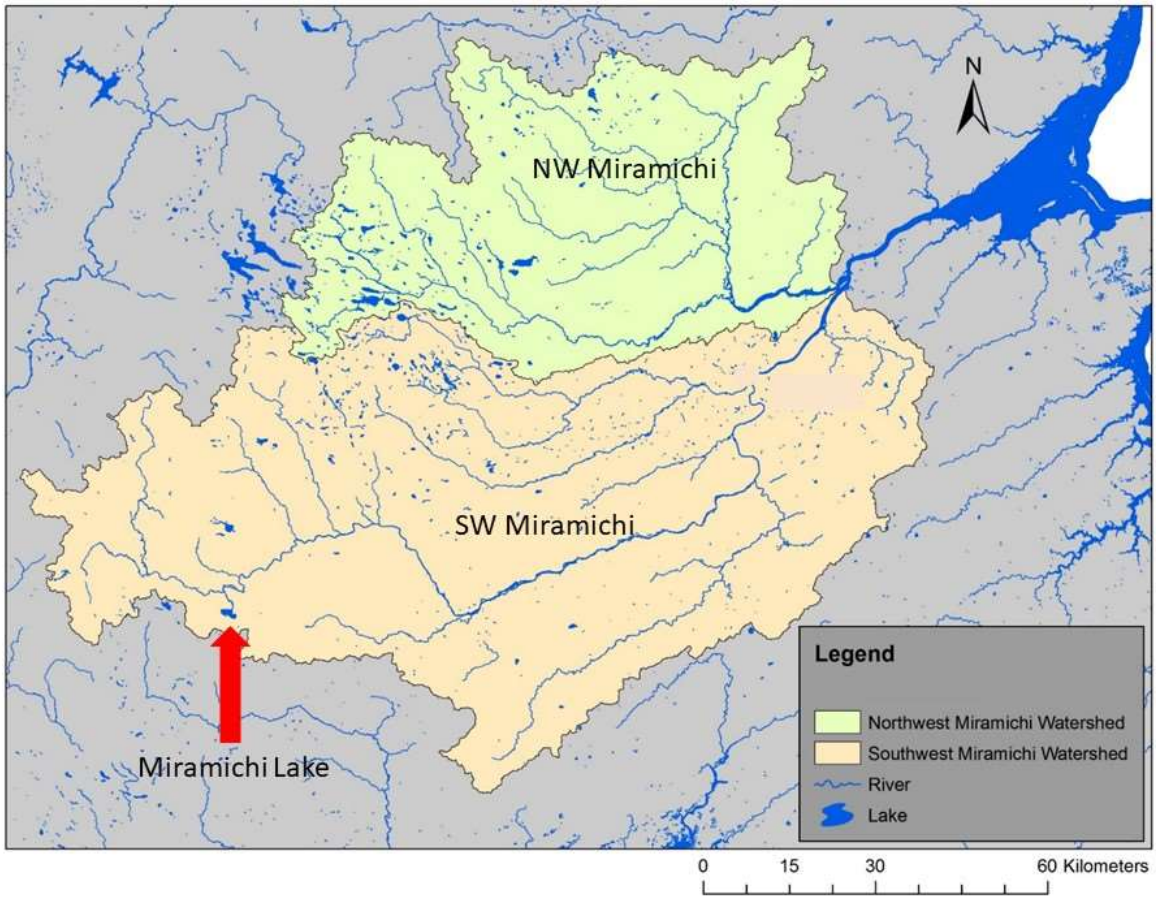
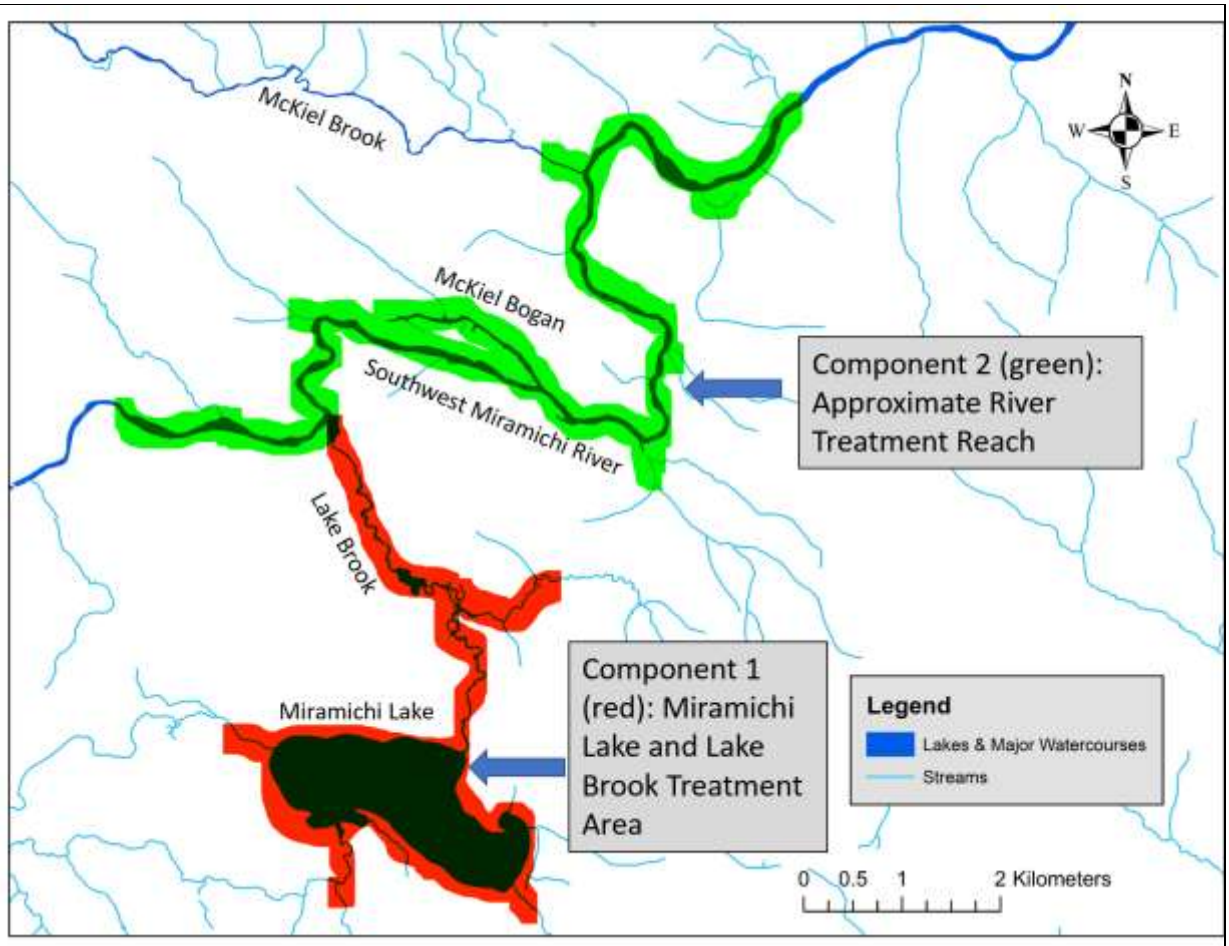


Figure 1. The Miramichi River watershed located in central New Brunswick, showing the location of Miramichi Lake.



UPDATE: Figure 2. Smallmouth Bass eradication components: (1) Miramichi Lake and Lake Brook (red); (2) reach of the Southwest Miramichi River (green).

2.3. Proposed pesticide, drug, or active agent[2]

Please describe here or in an annex any details related to the:

- Formulation: **Noxfish Fish Toxicant II (PMRA label in APPENDIX H)**
- Active ingredient: **Rotenone**
- The supplier (if applicable): **Wellmark International (d.b.a. Central Life Sciences), 1501 East Woodfield Road, Suite 200W, Schaumburg, Illinois 60173**
- Number of applications or deposits: **1**
- The required amount of pesticide per application or deposit and total: **4590 gallons**
- Date(s) of applications or deposits: **Two day application between 1 – 30 September 2020**
- The method of dispersal (injection, drip, backpack spray, boat, airplane): **Boat with pumps (primary), drip (on 4 small lake inflows and 1 outflow), and backpack spray (on lake periphery amongst stagnant water and vegetation)**

2.4. Pesticide registration number[3]	**2.5. Drug Identification number[4]**
PMRA # 33247	NA

2.6. Emergency Registration[5]

NA

2.7. Project Start date (DD/MM/YYYY)	25/08/2020 (site preparation begins)
2.8. Anticipated pesticide use date(s) (DD/MM/YYYY)	2-day application between 01/09/2020 – 30/09/2020
2.9. Project End date (DD/MM/YYYY)	15/10/2020 (+ post application monitoring)

[1]Please attach a map of the site and surrounding areas, and include a description of the treatment location.
[2]DFO may only authorise the use of a drug or pest control product that is registered pursuant to the *Food and Drugs Act* or the *Pest Control Products Act.* Please consult Health Canada's Pest Management Regulatory Agency for more details.
[3] Please consult PMRA's registry at this website: http://pr-rp.hc-sc.gc.ca/ls-re/index-eng.php
[4] Please consult Health Canada's Drug Registry at this website https://health-products.canada.ca/dpd-bdpp/index-eng.jsp
[5] if an emergency registration is granted, please include the appropriate documentation in an annex

Section 3: Rationale

3.1. Invasion History

Please describe here or in an annex outlining any details related to the introduction, spread, and current abundance of the target species.

- Illegally introduced, non-native SMB were discovered in Miramichi Lake in 2008 and it is the first and only known occurrence in the Miramichi watershed
- SMB are currently contained in the lake but will eventually escape and colonize the river system
- SMB pose a significant risk to the entire Miramichi ecosystem and its Atlantic salmon, which supports First Nations Food, Social, and Ceremonial fisheries. Atlantic salmon also supports a culturally and economically important recreational fishery in the Miramichi watershed.
- SMB spread from the lake to the river system (inevitable if not eradicated) will be a disaster for wild Atlantic salmon of the Miramichi and the socio-economic benefits associated with the fisheries.
- SMB disrupt the native food web structure in Miramichi Lake.
- DFO's plan to "contain and reduce" SMB in the lake will not eradicate them
- This program is costing DFO ~$80-120K/year, indefinitely. The department has already spent ~$1 M since 2008.
- In 2010, DFO initiated a 3-year containment, control program using physical removal methods (Biron et al. 2014). Two barrier fences were installed in 2009 near the outlet of Miramichi Lake to contain SMB and prevent their dispersal into the Miramichi River system (O'Donnell and Reid 2009). Barriers have been operated seasonally each year after ice-out (i.e., May through October) from 2009 to date although complete containment is unlikely given that the barrier may become permeable to young-of-the-year SMB for short periods due to maintenance for debris removal and fluctuating water levels. Juvenile SMB were captured in Lake Brook in 2009 and 2010 (DFO 2013); however, no SMB have been observed in Lake Brook since that time. Between 2010 and 2012, SMB in Miramichi Lake were removed using boat electrofishing, gillnetting, and fyke-netting: 2,584 SMB removed in 2010; 523 SMB removed in 2011; and 46 SMB removed in 2012 (Biron et al. 2014). The fishing effort more than doubled in 2011 and 2012 from 2010, and the catch-per-unit-effort declined by 99%. As expected, based on the extensive history of such control measures, eradication was not achieved since all life-history stages of SMB were still present caught annually up until present day. A monitoring and containment program using a variety of physical methods was implemented after 2012 resulting in ~500 young-of-year, <10 juveniles, and <10 adults removed in both 2013 and 2014. Three sexually mature bass were captured in 2017 (Brian Richard, personal

communication) and young-of-the-year bass were observed in late July 2017. There were 1144 YOY and 19 adult smallmouth bass collected in 2018.

- All age classes of SMB (young-of-year, juveniles, adults) continue to be captured every year since DFO began the contain and reduce program; the program has failed to achieve its DFO-set goal of no young-of-year for three consecutive years.
- This effort has served to illustrate that eradication of SMB using physical methods from Miramichi Lake is difficult or impossible considering its moderate size (220 ha), seasonally warm water temperatures (≤ 28.7 °C) and ample spawning substrate favorable to SMB. Several inlets and Lake Brook outlet to the Southwest Miramichi River make effective SMB containment difficult.
- Until 2015, DFO would not consider eradication using a deleterious substance for two main reasons:
  1) there was no legislation allowing it although it was occurring in other Canadian provinces
  2) DFO considered it to be technically not possible
  Both of these limitations have been addressed:
  - In 2015, federal Aquatic Invasive Species (AIS) legislation under DFO came into effect which now legally allows the use of a deleterious substance registered for use in Canada under the Pest Management Regulatory Agency (PMRA) to control unwanted invasive species. The purpose of the federal legislation is to create a tool for DFO to use that allows timely action in cases like Miramichi Lake.
  - Eradication using rotenone is technically feasible. An assessment and eradication plan was prepared for Miramichi Lake by experts in the field and found that the size and complexity of the lake are not limiting factors in the success of a rotenone eradication. Eradicating SMB in the lake is of medium complexity.

UPDATE: SMB were discovered in a remote stretch of the SW Miramichi River a short distance below the confluence with Lake Brook, which connects Miramichi Lake to the river. Details are provided in APPENDIX F on SMB occurrences, distribution, and removals in the river in fall 2019, and a scoping exercise for an eradication plan for the river to complement the lake treatment (APPENDICES F and G).

3.2. Harm to fish, fish habitat, use of fish

Please describe, here or in an annex, the potential effects of the targeted aquatic invasive species on the following topics if applicable:

- **Harm to fish**
- **Harm to fish habitat**
- **Harm to the use of fish**

Harm to fish

A SMB escape from Miramichi Lake and colonization in the Southwest Miramichi River risks devastating effects on native fish species in the Miramichi system, such as the Atlantic salmon. Native species would suffer effects of predation and competition for habitat and resources, and overall food web disruption.

DFO (2009) put forth a risk assessment concluding that the risk of negative consequences from SMB was high in the lake and moderate in the river. Chaput and Caissie (2010) considered the impacts to Atlantic salmon were different between lake and river environments: the overall risk to the aquatic biota in lakes is considered to be high with low uncertainty; and the overall risk for riverine environments is considered to be moderate but with high uncertainty. For lakes, the SMB will likely become a dominant component of the food web while causing significant widespread reductions in native biota. For riverine environments, a measurable decrease in abundance of native populations may occur in some locations where SMB have become a dominant component of the food web. These

fish are known to alter community structures by decreasing abundances and diversity of native fish species (i.e. cyprinids, perch) (Kerr and Grant 1999, MacRae and Jackson 2001), trigger resource competition and restrict habitat usage (MacRae and Jackson 2001, Morbey et al. 2007).

The major concern within the Miramichi River system, however, is the high likelihood of downstream dispersal and colonization resulting in habitat overlap and predation on Atlantic salmon. Juveniles of both species prefer similar riverine habitat features, resulting in direct competition (DFO 2009). SMB bass are also predators of juvenile Atlantic salmon (Carr and Whoriskey 2009).

There is concern that SMB will also negatively impact alewife by disrupting the food web in Miramichi Lake, the primary spawning/rearing area for commercially and ecologically important alewife in the Southwest Miramichi River system.

Harm to fish habitat
The presence of SMB does not in itself harm fish habitat, although it increases competition for valuable habitat with native species and disrupts the food web structure. Eradication will benefit native species by eliminating competition for habitat with a non-native species.

Harm to the use of fish
Atlantic salmon in the Miramichi system supports First Nation FSC fisheries for multiple Mi'kmaq First Nation communities. The threat of SMB colonizing the river and competing with salmon introduces a direct and significant harm to the use of salmon by Indigenous communities. The establishment of invasive species has been deemed by the Assembly of First Nations to infringe on Aboriginal and Treaty rights (APPENDIX J).

Atlantic salmon also supports a culturally and economically important recreational fishery in the Miramichi system. Miramichi Atlantic salmon angling is renowned, attracting anglers from across Canada and the world. This sector supports 637 full time equivalent jobs in rural communities and has an annual value of $16 million to the GDP (Gardner Pinfold 2011). Effects of SMB colonization in the river introduces a direct harm to the recreational angling use of salmon by Canadians and international visitors.

The alewife stock supports a commercial fishery in the estuary of the Miramichi river system. Miramichi Lake is the primary spawning and rearing area on the Southwest Miramichi River system. The stock, and associated commercial fishery, is at risk of being impacted by SMB.

3.3. Benefit of eradication

Please describe here or in an annex the anticipated benefit of permanently removing the targeted species.

Eradicating SMB is a remediation measure that will have a temporary impact on the lake, but will eliminate the risk of the invasive fish establishing in the Miramichi River system to the detriment of the native ecosystem and its fisheries. It is ultimately a conservation action to maintain the integrity of the entire river system.

There are direct and substantial benefits of eradicating SMB. Benefits include preserving the integrity of the native ecosystem by removing a disruption to the natural food web, eliminating a non-native

predator and competition for valuable habitat and resources with native species. Permanent removal of invasive SMB eliminates the imminent risk to the greater Miramichi watershed, not just to Miramichi Lake.

Benefits of eradication also include avoiding a permanent disaster to the cultural and socio-economic value of fisheries that the native Miramichi ecosystem supports. These include, but are not limited to, the Indigenous FSC Atlantic salmon fishery and the recreational salmon fishery. Eradication will eliminate the threat to these fisheries.

3.4. Considered alternative measure of control

Describe measures considered in the following categories: 1) No action, 2) Physical Control, 3) Biological Control, and 4) Chemical Control. Please provide the rationale for each scenario.

No Action

The "do nothing" option presents a high risk of SMB invasion into the Southwest Miramichi River. Without control and containment measures over the past 10 years, the SMB population would likely have expanded to thousands or tens of thousands of individuals in the lake. As invasive success is strongly based on propagule pressure, this would have increased the risk of expansion into the Southwest Miramichi River by as much as two orders of magnitude (van den Heuvel et al. 2017). Given the significant threat to the native ecosystem and fisheries it supports, the risk of doing nothing is too high. This is why the eradication effort has garnered broad, and strong, support from Indigenous organizations and diverse stakeholder groups.

Alternatives

A number of alternatives (Table 1) have been evaluated by experts in eradication of invasive species in order to identify the best option (van den Heuvel et al. 2017).

Table 1. Assessment of SMB control and eradication options for Miramichi Lake.

Options	Comments
Physical Removal – nets & electrofishing	Extremely limited success in achieving eradication worldwide; most promising in very simple environments. May lead to decreased intraspecific competition and accelerated maturation of SMB and thus, greater recruitment. SMB control in Miramichi Lake between 2010-2012 decreased SMB biomass, but all age classes continue to be caught annually to 2018, including YOY.
Biological Control – predator & pathogen	Rarely used for eradication due to lack of potential, selective control agents. Predators will likely attack Atlantic Salmon too. Pathogens carry risks to non-target species and other environmental concerns. Two SMB parasites (tapeworm and protozoan) are known but would need to be tested.
Genetic Manipulation – sterile or triploid individuals	Generally not 100% sterile. More sophisticated methods such as genetic control would take years and much study.

Dewatering	Likely impractical due to groundwater recharge, ability of SMB to burrow in mud, and risk of SMB being discharged to nearby areas or downstream.
Explosives – detonating cord	Not effective in water depths >3 m.
Piscicide	Rotenone is the only piscicide registered in Canada for eradication of SMB. Exposure times and concentrations of rotenone necessary to kill fish are well known and technologies for treatment are well developed. Application can be timed to avoid or mitigate impacts to alewives.
Permanent Dam	Installing a permanent dam structure at the outlet of Miramichi Lake into Lake Brook would not isolate the lake from the Southwest Miramichi River. Such a structure would continuously spill water year-round and only serve to regulate the lake level; the risk of SMB escaping the lake would remain. Furthermore, a dam would create the added complexity of upstream and downstream fish passage requirements for several migratory species like alewife, sea lamprey, American eel, brook trout, and Atlantic salmon. This creates a risk to alewives and the associated commercial fishery, particularly given that Miramichi Lake is the primary spawning area for the stock. The dam option would be of no advantage over the current barrier fence system: water would still flow from the lake into Lake Brook and the risk of SMB escape would remain. This approach would cause unnecessary further disruption and harm to the native ecosystem.

Of the methods evaluated for eradicating SMB from Miramichi Lake, only the use of rotenone is feasible and practical for Miramichi Lake. The option of treating with rotenone is the most highly developed method with the greatest likelihood of success compared to all other options. Rotenone toxicity to fish species is well established, standard operating procedures (SOPs) govern its use (Finlayson et al. 2018), and it is the most widely used tool in North America, including in Canada, for eradicating unwanted aquatic invasive species. The use of rotenone is also most prevalent because it can be safely used by humans and breaks down naturally very quickly (days) once applied to a temperate body of water. The analysis of options concludes treatment of Miramichi Lake with rotenone is the best eradication option with a high likelihood of success, preventing future invasion of SMB into the Miramichi River system.

3.5. Community impact

Please describe the impact of the targeted species on the local community. Include any opinions from local Indigenous groups, or other local stakeholders. Also include any potential impacts on Indigenous or community activities.

The impact of a SMB colonization in the Miramichi River system will have significant, and permanent, impacts on local Indigenous and non-Indigenous communities, culturally and economically. Without eradication in Miramichi Lake, it is inevitable SMB will escape from Miramichi Lake and colonize the river system with broad implications for local communities.

The greatest concern is impacts to Atlantic salmon throughout the Miramichi watershed. This species supports Indigenous FSC fisheries for various First Nations along the Miramichi. SMB impacts to salmon and thus FSC fisheries will have a profound impact on a traditional food source and cultural heritage within First Nation communities.

Atlantic salmon also supports a recreational salmon fishery that is highly valued by local communities, New Brunswick residents, and non-resident visitors. The fishery is valued at $16 Million annually and supports 637 full time equivalent jobs in local rural communities (Gardner Pinfold 2011). The Miramichi is known worldwide as destination for Atlantic salmon angling, and therefore is important as a tourist destination for the province of New Brunswick. Approximately 1 in every 40 jobs in the region is dependent on salmon angling and related tourism, and 1 in 3 jobs in the food services and accommodations sector relies on salmon angling (Gardner Pinfold 2011).

Given the potential impact of SMB to Miramichi communities, particularly in relation to Atlantic salmon, eradication of SMB has garnered broad support from local Indigenous organizations and conservation NGO stakeholders. These include, but are not limited to, the proponent and project partners listed in Section 1 of this application.

Section 4: Environmental Impacts

4.1. Habitat types affected by proposed project

Identify all types of aquatic habitat that will directly be affected by the proposed deposit. Please provide details of how each type will be affected.

Habitat types:

- **Lake (Lacustrine)**
- **River or stream (Riverine)**
- **Wetlands (Palustrine)**
- **Estuary (Estuarine)**
- **Salt water (Marine)**

The primary habitat affected is Miramichi Lake (lacustrine). Habitat in several intermittent inlet tributaries (< 500 m) and Lake Brook (riverine), and adjacent peripheral wetlands around the lake (palustrine) will be affected by the proposed project. In summary, unavoidable temporary water quality impacts will occur within the treatment area. There will be no impacts to estuarine or marine habitats. See detailed explanations of impacts in Sections 4.2-4.5.

4.2. Description of project site

Please provide a detailed description of biological and physical characteristics within the proposed project site.

Lake Physical Characteristics

Located approximately 160 km upriver from the head of tide in the headwaters of the Southwest Miramichi River watershed, Miramichi Lake is a reasonably small temperate lake with several input tributaries and a single output that drains into Lake Brook (a 5.3 km tributary to the Southwest Miramichi River). Miramichi Lake is approximately 2.8 km long with an average width of 0.8 km (Figure 3). The surface area is estimated to be 2.21 km^2. Most areas of the lake are moderately shallow (< 4 m) with two deeper areas (> 6 m). Biron et al. (2014) described shoreline substrate characteristics

throughout the lake to vary from muddy with aquatic vegetation, to sandy and exposed, to organic-rich mud, to sand-gravel mix, to mud-flats, with each characterization having some presence of naturally occurring logs and boulders. The water has a natural tea-coloured pigmentation, mostly due to the presence of humic matter from upstream and surrounding bogs. Cold, clear streams and shoreline water seepage was also observed at the lake indicating significant groundwater input. The pH of the lake water as measured June 22, 2017 was 7.3 and the conductivity 25 µS/cm. No other records of water chemistry for Miramichi Lake could be found though some may exist as unpublished data within either DFO or the New Brunswick government. The geology in the lake watershed is reported as igneous and conductivity shows very soft water characteristic of Canadian Shield geology. The presence of eroded gravel and large igneous boulders indicates the basin of the lake is predominantly glacial till. The lake sits in a deep bowl just below a plateau of land that demarcates the divide between the Miramichi and St. John River watersheds and as such can be considered a headwater lake. The sub-watershed for the lake is dominated by forests and some wetland.

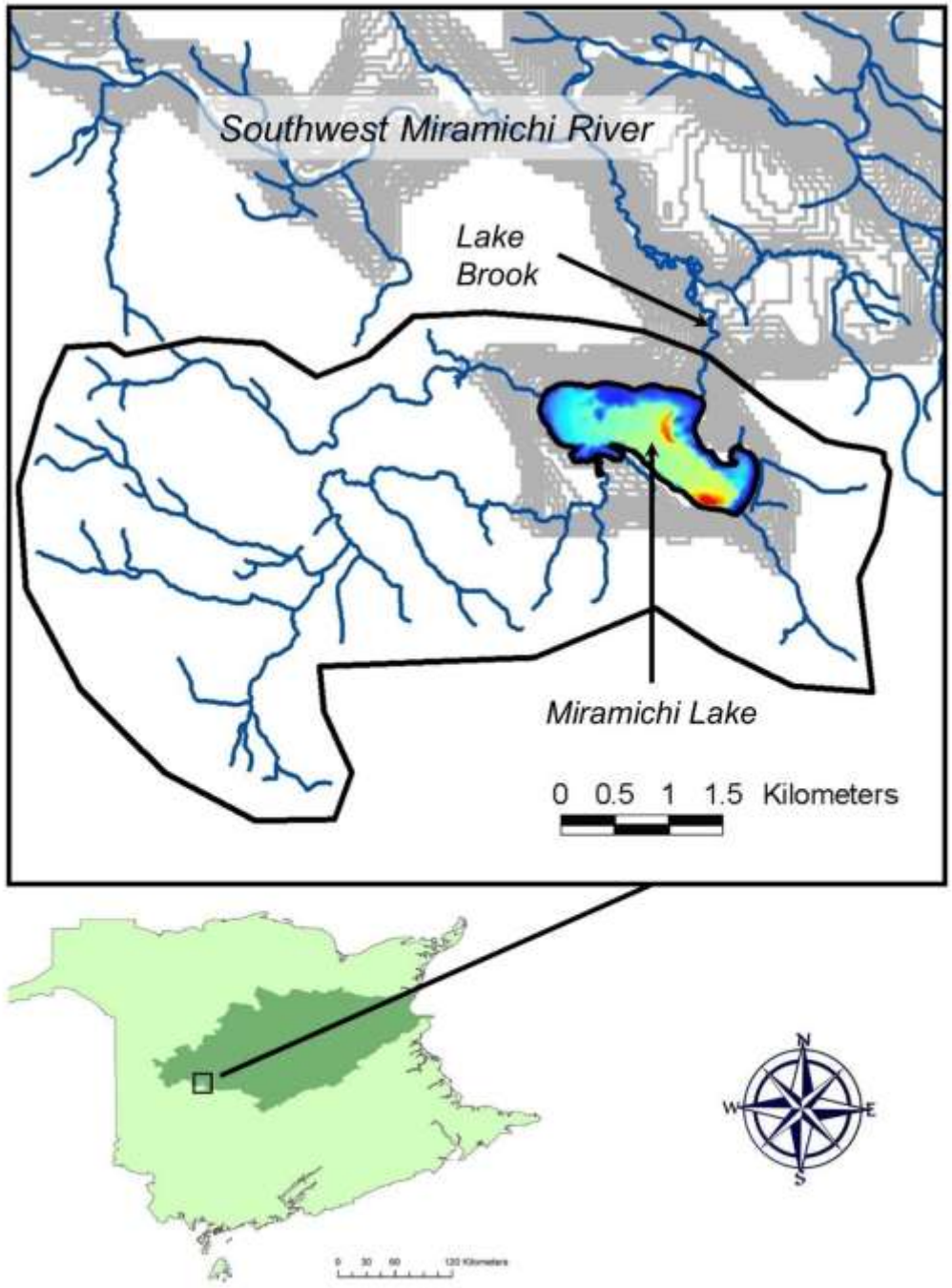


Figure 3. Location of Miramichi Lake within the Miramichi River watershed. The Miramichi Lake sub-watershed is shown by a black boundary and the lake bathymetry with a colour map (red being deeper areas). Grey lines show 1m contours.

Miramichi Lake has an estimated water volume of 11,491,750 m^3 (see APPENDIX B for explanation on updated Lake volume of 5.36 million m^3 verified by NB NRED). The watershed area as estimated just below the outlet of the lake is 43.1 km^2. Based on a regional flow model using 13 gauged stations in the region with similar precipitation, the mean annual flow rate of Lake Brook was estimated to be 0.45

m^3/s (see APPENDIX B regarding Lake Brook flow). Manual flow measurement at the outlet of Lake Brook on June 22, 2017 showed a flow rate of 0.69 m^3/s.

Water temperature data was collected by DFO in 2010, 2011 and 2012 from May through October. From 2010-2012 mean daily water temperature varied seasonally generally ranging from 5-10°C in early May to peak around 25°C in mid-July and settle to 5°C by the end of October. Data collected by the Miramichi River Environmental Assessment Committee (MREAC), on average, followed the same temperature trends observed in 2010-2012. These temperature profiles are more detailed having been collected at 1 m intervals from surface to bottom (Figure 4, van den Heuvel et al. (2017). The lake appeared to be very well mixed with little stratification when monitoring began in mid-June. Thereafter, temperature increased faster in the top 4 m of water, showing a distinct thermocline around that depth. There were three distinct events occurring around July 2nd, July 20th and August 8th (likely wind driven) that caused loss of the thermocline and full mixing of the lake. These summer mixing events are likely common suggesting the lake is of polymictic (mixing more than two times a year). By October the thermocline disappears and the lake returns to an isothermal nature with depth preceding ice-up. Although lake temperature will show slight variation each season, it is expected to follow similar trends each year. The temperature regime is important for planning an eradication using rotenone because its toxicity persistence, natural break down, and deactivation are temperature-sensitive.

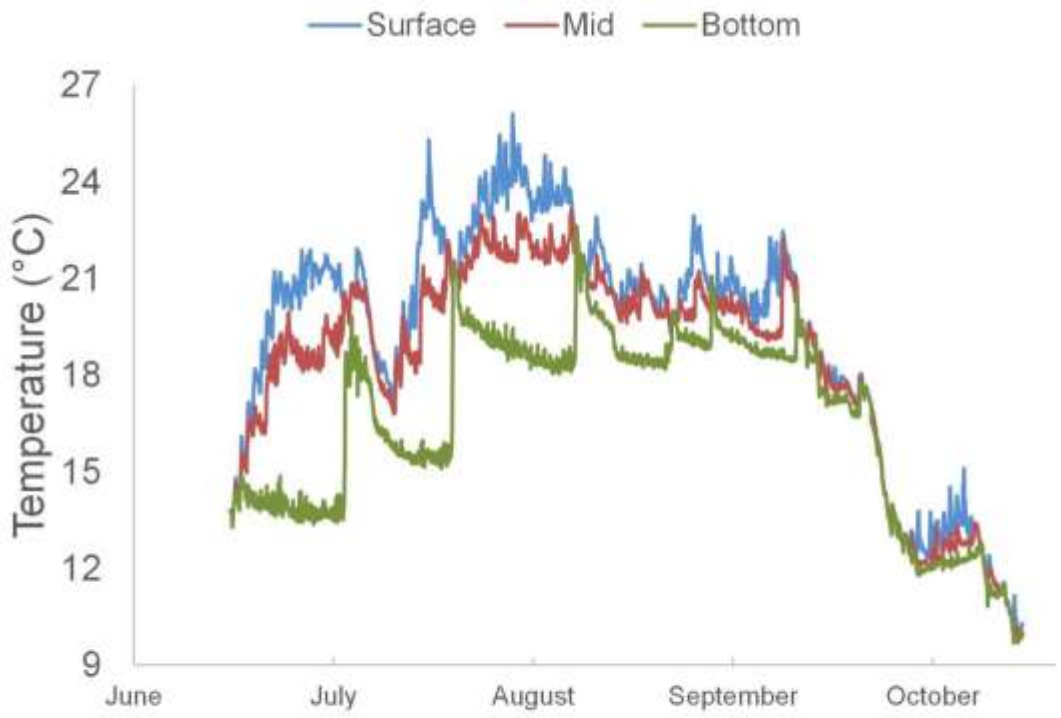


Figure 4. Mean (n = 2 loggers) temperature at surface, mid-depth, and bottom of Miramichi Lake in 2016. Figure created from raw data with permission from MREAC (van den Heuvel et al. 2017).

Biological Characteristics
SMB Distribution in Space and Time

In the spring, invasive SMB move from deeper overwintering locations to shallow near-shore spawning grounds as water temperatures increase. Feeding activity is estimated to begin at a water temperature of around 8°C (early to mid-May), while spawning typically begins in late May or early June when temperatures reach 15-18 °C (Curry et al. 2005, DFO 2009). Curry et al. (2005) found in other New Brunswick lakes (Oromocto and Mactaquac) embryos hatched and young-of-the-year (YOY) are present by the end of May. Shallow (< 1.5m) waters with sand/gravel substrate, little to no aquatic vegetation or algae and close proximity to logs and large rock are preferred spawning habitats (Pflug and Pauley 1984, DFO 2009). Biron et al. (2014) classified that area of Miramichi Lake as the shallow grounds between the shore and the deep hole adjacent to the outlet (sectors 1 and 16, see Biron et al., 2014). DFO (2013) exemplifies this idea by showing the in-season habitat distribution (July and August 2010-2012) of captured YOY SMB to be concentrated in this region. Three mature female bass were reported caught in this area by local fishermen contracted for control measures in 2017 (Brian Richard, personal communication), and YOY bass were found in July 2017. YOY/juveniles tend to frequent shallow waters under brush or rocks preying on midge larva, mayfly nymphs and small fish. Adults inhabit moderately shallow waters where rocks/large woody debris are available (DFO 2009) preying on cyprinids, *Alosa sp.* YOY and perch *sp*. (Kerr and Grant 1999). Feeding cessation is reported to occur when water temperatures decline to 7-10°C (October) (DFO 2009), and SMB are also reported to burrow in the mud at temperatures below 7 °C (Kerr and Grant 1999). However, SMB, because of its expanding range and better understanding of its winter habitats has become an increasingly popular ice fishing species in thousands of lakes west of the rocky mountains, including the great lakes. Thus any dormancy or feeding cessation in lake environments would not appear to be long in duration. However, should burrowing occur for any duration it is significant in that this behavior will likely protect SMB from rotenone toxicity at temperatures below 7°C since sediment can sequester rotenone (Dawson et al. 1991). Thus, an eradication treatment should be avoided at temperatures below 10 °C; such temperatures do not occur in Miramichi Lake until late October.

UPDATE: SMB distribution has expanded to include a reach of the SW Miramichi River – see APPENDIX F.

Non-Target Species Distribution in Space and Time

Based on a DFO survey from 2010, there are a total of 18 known fish species, including SMB, present in Miramichi Lake (DFO 2013). Table 2 identifies 17 native, and 1 non-native (SMB) species found in Miramichi Lake and Lake Brook. DFO (2013) used a combination of sampling techniques during their efforts to capture SMB and recorded a diverse ichthyofauna with most numerous species being yellow perch, white sucker and white perch. Capture efforts took place between April and October and included methods such as boat electrofishing, setting gillnets and fyke nets. Most of the species captured were year-round residents of the lake. Nonetheless, several diadromous species were recorded and included American eel, sea lamprey, Atlantic salmon, and alewife. Most notable of these records would be the alewife; large spawning runs (tens of thousands) are known to enter Miramichi Lake each spring with significant numbers of YOY leaving in July and August (DFO 2009, DFO 2013).

Table 2. Fish species[1] found in Miramichi Lake and Lake Brook in 2009-2012 using gillnet, seine, electrofisher, and fyke net (O'Donnell and Reid 2009; DFO 2013).

Species	Miramichi Lake	Lake Brook
alewife *Alosa sp.*	X	X
American eel *Anguilla rostrara*	X	X
Atlantic salmon *Salmo salar*	X	X
banded killifish *Fundulus diaphanous*	X	

blacknose dace *Rhinichthys atratulus*		X
brook trout *Salvelinus namaycush*	X	X
brown bullhead *Ameiurus nebulosus*	X	X
common shiner *Luxilus cornutus*	X	X
creek chub *Scardinius atromaculuatus*	X	X
fallfish *Semotilus corporalis*	X	X
golden shiner *Notemigonus crysoleucas*	X	X
lake chub *Couesius plumbeus*	X	X
pearl dace *Margariscus margarita*	X	
sea lamprey *Petromyzon marinus*	X	X
smallmouth bass *Micropterus dolomieu*	X	X
white perch *Morone Americana*	X	
white sucker *Catostomus commersoni*	X	X
yellow perch *Perca flavescens*	X	X

[1] "Mummichug", presumably mummichog (*Fundulus heteroclitus*) were recorded in the O'Donnell and Reid (2009) report, however killifish are often misidentified as mummichog and it is improbable that mummichog are present here, so that identification is not considered valid (van den Heuvel et al. 2017).

4.3. Anticipated environmental effects of proposed project

Please provide a detailed description of anticipated aquatic environmental effects associated with the deposit within the proposed project site. Please ensure the following elements are included as well as any other

- **List of species affected**
- **Harm to fish, to fish habitat and to the use of fish**
- **Impacts to species at risk (listed under the *Species at Risk Act).***

List of Species Affected

Table 2 provides a list of fish species affected by a rotenone treatment. Effects to fish and other aquatic species are described below.

Harm to fish, to fish habitat and to the use of fish

Eradication Effects on Salmonids and Other Fish Species

Atlantic salmon and brook trout, *Salvelinus fontinalis,* in Miramichi Lake and Lake Brook will be killed during the eradication treatment as these salmonids (24 h LC50 values = 0.0018 and 0.0024 mg/L rotenone) are twice as sensitive to rotenone as SMB (24 h LC50 value = 0.0047 mg/L rotenone) according to Marking and Bills (1976). The habitat is likely to be recolonized because these species are migratory. (UPDATE: see Re-establishment Plan in APPENDIX D)

Miramichi Lake is the spawning area for an alewife stock. A rotenone treatment in the fall would avoid impacting alewife, since adults spawn in the spring and then leave the lake. DFO (2009; 2013) reported that YOY alewife leave the lake in significant numbers in July and August, thus the fall treatment would avoid impacting both post-spawned adults and most or all juveniles. Therefore, the treatment is not expected to impact the use of alewife by the commercial fishery, located in the estuary of the Miramichi (~170 km downriver).

Other native fishes inhabiting Miramichi Lake and Lake Brook include a variety of cyprinids, percids, killifish, and other species (Table 2; O'Donnell and Reid 2009; DFO 2013). If present during treatment

most these organisms will be killed, although some individuals of tolerant species including brown bullhead (*Ameiurus nebulosus*) and golden shiners (*Notemigonus crysoleucas*) are likely to survive a treatment of 0.075 mg/L rotenone based on published LC50 values (Marking and Bills 1976). Other migratory species like American Eel and Sea Lamprey will recolonize naturally (UPDATE: see Re-establishment Plan in APPENDIX D). None of the fish species present are unique to Miramichi Lake.

The treatment will not impact groundwater, riparian areas, or any other fish habitat outside the project site. The treatment will impact surface water of Miramichi Lake, its tributaries a short distance upstream from their confluence with the lake (<500 m), and Lake Brook. Rotenone naturally breaks down rapidly and at the design concentration for this treatment has a half life of 2.5 days and will be undetectable after 18 days. Rotenone will be deactivated with potassium permanganate near the outlet of Lake Brook to prevent impacts to surface water in the Southwest Miramichi River.

Effects on the Use of Fish

A successful eradication will remove SMB from Miramichi Lake and Lake Brook. Fisheries for native species valued for recreational angling in the lake, such as brook trout, white perch or yellow perch which may have been negatively impacted by SMB presence are expected to improve over time after the treatment. SMB eradication results in a positive long-term effect on the use of fish in Miramichi Lake. As required on the rotenone product labels, aquatic recreation (angling, wading, swimming, boating) and access to the treated waters will be restricted for the duration of the 2-day treatment and for an additional 72 h period after the treatment is completed. The brook trout angling season closes on September 15 annually so will be largely unaffected by a fall treatment.

The use of Atlantic salmon will not be impacted by the treatment. Given that the 43.1 km^2 Miramichi Lake sub-watershed represents only 0.3% of the greater Miramichi watershed (13,500 km^2), and contains primarily lacustrine aquatic habitat, the anticipated effects of the treatment on Atlantic salmon and their associated use are negligible at the watershed-scale. Moreover, salmon are not typically targeted/fished within the project area (Miramichi Lake and Lake Brook), thus their use will not be impacted by the treatment. Rapid natural breakdown of rotenone (half life of 2.5 days, undetectable after 18 days at the design concentration) and directed deactivation of rotenone on Lake Brook will prevent impacts to Atlantic salmon and other species outside the project area (i.e., downstream in the Southwest Miramichi River).

Fall treatment timing will avoid impacting alewife and its associated use in the spring commercial fishery 170 km downriver from the lake in the estuary. Post-spawned adults leave the lake in July and YOY emigrate from the lake primarily in July and August. There are no, or negligible, anticipated effects on the use of alewife.

The primary benefit of the eradication is the prevention of an invasive species disaster in the Miramichi watershed, and thus preservation of the ecosystem and its native species that support Indigenous, recreational, and commercial uses of fish.

Impacts to Species at Risk (Listed Under the *Species at Risk Act*)

There is no known presence of SARA-listed species in the lake (UPDATE: see Mussel Survey in APPENDIX C).

Mussel beds were investigated in the lake for the presence of yellow lampmussel and brook floater but neither were found in the samples (UPDATE: see Mussel Survey in APPENDIC C and Re-establishment

Plan in APPENDIX D for details related to brook floater). There are a number of freshwater mussel species in the greater Miramichi basin but significant toxic effects are not expected since the proposed rotenone levels are below known toxicity values for freshwater mussels (see Section 5.1 of this application).

The wood turtle (*Glyptemys insculpta*) is a SARA-listed species; however, its presence is not confirmed within the vicinity of Miramichi Lake. Furthermore, the risk to this species if present is low and negligible for the following reasons:

- Limited potential for exposure to rotenone: the species nests on land and is omnivorous, largely feeding on terrestrial organisms which are not exposed to rotenone
- The United States Environmental Protection Agency (EPA 2006; 2007) uses the sensitivity of birds as a surrogate for reptiles, and rotenone is practically non-toxic to birds because of rapid natural break down and piscivorous birds or mammals are not likely able to consume sufficient quantities of rotenone to result in acute toxicity.
- In British Columbia, painted turtles have been present in several treated lakes. Some have been held captive within active rotenone treatment areas and observed for a period of time post treatment with no mortality or negative effects observed (Steve Maricle *personal communication, Province of BC*).

4.4. Ecosystem health

Please describe here or in an annex outlining any details related to:

- **Impacts to surface water, ground water, riparian areas, and any other fish habitat outside the project site.**
- **Air quality impacts**
- **Any other potential impacts**

Impacts to surface water, ground water, riparian areas, and any other fish habitat outside the project site

The treatment will not impact groundwater, riparian areas, or any other fish habitat outside the project site. The treatment impacts are limited to the surface water of Miramichi Lake, its tributaries a short distance upstream from their confluence with the lake (<500 m), and Lake Brook.

Twenty six wells adjacent to the nine California treatments have been monitored since 1987 for the presence of rotenone formulation constituents (Finlayson et al. 2001). Samples were collected between 1 and 456 days following treatments. All samples proved to be negative. Residues of rotenone or rotenolone were never found in any of the wells monitored. None of the other VOC or semiVOC constituents have been detected in any of the wells monitored. Additionally, four shallow wells adjacent to Diamond Lake, Oregon that was treated in 2006 had no rotenone and rotenolone residues present up to 39 days post-treatment (Finlayson et al. 2014). The ability of rotenone to move through soil is low to slight. Rotenone moves only 2 cm (<1 inch) in most types of soil. An exception would be in sandy soils, where movement is about 8 cm (slightly more than 3 inches). Rotenone binds strongly with organic materials in the soil and degrades rapidly.

Air quality impacts

There will be no rotenone in the air during or after the application due to its low vapor pressure (6 x 10^{-6} Pa) (Huntingdon Life Sciences 2007) and Henry's Law constant (estimated 1.1 x 10^{-13} atm-m^3/mol) (Finlayson et al. 2018). The lack of rotenone in the air following a spray application of CFT Legumine

was documented in an air monitoring study done in California in 2007 (Westervelt 2007). There may be a slight solvent smell around the lake during the two days of the application of Noxfish II. Removal of dead fish from Miramichi Lake will reduce the smell of rotting fish around the lake.

Any other potential impacts
Refer to Section 5.1 of this application for a summary of potential impacts to other organisms in the ecosystem.

4.5. Proposed environmental effects mitigation

Please provide a detailed description of any mitigation measures to be implemented to minimize the negative effects described in the sections 4.3. and 4.4.

The effects to fish and fish habitat described in sections 4.3 and 4.4 will be mitigated by:

1) **Re-introduction Plan** (UPDATE: see stand-alone Re-establishment Plan in APPENDIX D which no longer includes capturing fish from Miramichi Lake and holding on-site)

2) **Deactivation -** Rotenone will be deactivated near the outlet of Lake Brook using potassium permanganate ($KMnO_4$) to prevent impacts to the Southwest Miramichi River ecosystem. The deactivation will take place on Lake Brook at least 30 min water travel time upstream from the confluence with the Southwest Miramichi River using a volumetric feeder powered by a gasoline generator (Finlayson et al. 2018; SOP 7.1). This will protect the Southwest Miramichi River from rotenone toxicity. An expected deactivation at 4 mg/L $KMnO_4$ for 7 days will require approximately 1,089 kg $KMnO_4$ for treating the Lake Brook discharge of 0.45 m^3/s. Additional study during summer 2019 is needed to determine the precise quantity of KMnO4 needed to deactivate rotenone in the highly organic water of Miramichi Lake. (UPDATE: see APPENDIX E for deactivation monitoring)

3) **Treatment Timing -** Treatment timing in September will maximize effectiveness of the treatment on SMB, and will avoid impacts to all life stages of alewife. Post-spawned adult alewife leave the lake after spawning into mid-July (O'Donnell and Reid 2009) and YOY emigrate from the lake in significant numbers in July and August (DFO 2009; 2013). Alewife are expected to be largely not present in the lake by September and therefore have minimized potential for exposure to rotenone. A fall treatment will also enhance the recovery of YOY alewife forage for the following year because planktonic organisms such as cladoceran, copepod, and rotifer populations have laid eggs by fall (Bradbury 1986). These eggs are resistant to rotenone and lakes the spring following a rotenone treatment show rapid plankton resurgence (Brynildson and Kempinger 1973).

4) **Rotenone Exposure to Wildlife** – Dead fish that remain floating in the lake after the rotenone treatment will be removed from the lake and buried in a landfill in accordance with New Brunswick Department of Environment and Local Government (DELG). Remaining dead fish are not a risk to foraging wildlife and will contribute nutrients to the lake, helping to re-establish the food web; leaving dead fish to decompose is the typical practise after rotenone treatments (e.g. Hisata 2002; pers comm Steve Maricle).

Section 5: Protocol and Safety

5.1. Pesticide / drug impact

Please describe here or in an annex outlining any details related to:

- **The toxicity (short-term, long-term, lethal and non-lethal effects; and, any side effects) to fish, invertebrates, plants, mammals, birds, reptiles, amphibians, humans.**
- **The persistence in the environment**
- **Bioaccumulation in the environment**
- **The PMRA label and safety requirements or the Drug label and safety instructions.**

Toxicity (short-term, long-term, lethal and non-lethal effects; and, any side effects) to fish, invertebrates, plants, mammals, birds, reptiles, amphibians, humans

Atlantic salmon and brook trout, *Salvelinus fontinalis,* in Miramichi Lake and its inlets and Lake Brook will be killed during the SMB eradication treatment as these salmonids (24 h LC50 values = 0.0018 and 0.0024 mg/L rotenone) are twice as sensitive to rotenone than SMB (24 h LC50 value = 0.0047 mg/L rotenone) based on published toxicity values (Marking and Bills 1976). The habitat is likely to be recolonized because these species are migratory. The impact will be mitigated through collection of these species prior to application and then re-introduction post application. The re-establishment strategy is provided in detail in Section 7 and will accelerate the recovery of native species. (UPDATE: see stand-alone Re-establishment Plan in APPENDIX D which no longer includes capturing fish from Miramichi Lake and holding on-site)

Miramichi Lake is the spawning area for an alewife stock. A rotenone treatment in the fall would largely avoid impacting alewife, since adults spawn in the spring and then leave the lake by mid July. DFO (2009; 2013) reported that YOY alewives leave the lake in significant numbers in July and August, thus the treatment would avoid impacting both post-spawned adults and most or all juveniles.

Other native fishes inhabiting Miramichi Lake and Lake Brook include a variety of cyprinids, percids, killifish, and other species (Table 2; O'Donnell and Reid 2009; DFO 2013). If present during treatment most these organisms will be killed, although some individuals of tolerant species including brown bullhead (*Ameiurus nebulosus*) and golden shiners (*Notemigonus crysoleucas*) are likely to survive a treatment of 0.075 mg/L rotenone based on published toxicity values (Marking and Bills 1976).

The sensitivity of amphibian eggs to rotenone is undetermined but is likely negligible and similar to fish eggs (rotenone is not able to cross the egg chorion). The larvae (tadpoles) of amphibians are much more sensitive than adults due to their respiration through the gills (Billman et al. 2011). Younger tadpole forms (early Gosner stages) are more sensitive to rotenone than older tadpoles (Billman et al. 2011). A treatment rate of 0.075 mg/L rotenone will be toxic to tadpoles. However, Billman et al. (2012) found no difference in tadpole abundance in rotenone-treated and control wetlands a year after rotenone treatment despite killing all of the tadpoles in the treatment wetlands during rotenone application. This was due to the survival of non-gill-breathing juvenile and adult amphibians in the treated areas as well as immigration of amphibians from adjacent areas. Mitigation strategies to protect amphibians include a fall treatment date, when gill-breathing amphibians are not generally present. Observations in British Columbia include increased amphibian production post rotenone treatments, as competition for food arising from illegally introduced spiny ray fish is eliminated (B.C. Ministry of Environment, 2009).

With a treatment rate of 0.075 mg/L rotenone, it is likely that planktonic species would be especially vulnerable. However, a fall treatment of lentic waters will mitigate impacts and enhance recovery of cladoceran, copepod, and rotifer populations that have laid eggs by fall (Bradbury 1986). These eggs are resistant to rotenone and lakes the spring following a rotenone treatment show rapid plankton resurgence (Brynildson and Kempinger 1973).

Macroinvertebrate assemblages are usually reported to be much less impacted than planktonic species, especially Chironomids. Hobbs et al. (2006) conducted toxicity tests on species which occupy these habitats; they reported LC50 values ranging from <0.003 mg/L rotenone for the cladocerans *Daphnia magna* and *Ceriodaphnia dubia* to about 0.200 mg/L rotenone for the midge *Chironomus tentans* and the amphipod *Hyalella azteca*. Results from studies on multiple lakes (e.g., Eilers 2008, McGann 2018) demonstrate that both plankton and invertebrates recover to pre-treatment levels (or greater) by the following spring post-treatment. Using the existing research, we anticipate there will be an abundant food base in Miramichi Lake by the next spring after treatment.

There are a number of freshwater mussel species in the Miramichi basin but significant toxic effects from rotenone are not expected since the proposed rotenone levels are below known toxicity values. Dolmen et al (1995) studied the impacts of rotenone on the Eastern Pearlshell (*Margaritifera margaritifera*) which is the most abundant freshwater mussel species in the Miramichi River watershed. Studies in both the laboratory and field showed that no mortality to the mussels occurred when exposed to 5 mg/L rotenone formulation (1.5 mg/L rotenone formulation is proposed for Miramichi Lake) for up to 12 hours exposure and then monitored in clean water for up to 7 days (laboratory) or 55 days (field). Six freshwater mollusk species were tested for rotenone sensitivity by Chandler and Marking (1982); the snail *Oxytrema catenaria* was the most sensitive (96-h LC50 value = 0.090 mg/L) and the clam *Corbicula manilensis* was the least sensitive (96-h LC50 value = 0.380 mg/L) to rotenone.

The risk to reptiles and birds is low/negligible for the following reasons:

- Limited potential for exposure to rotenone
- The United States Environmental Protection Agency (EPA 2006; 2007) uses the sensitivity of birds as a surrogate for reptiles, and rotenone is practically non-toxic to birds because of rapid natural break down and piscivorous birds or mammals are not likely able to consume sufficient quantities of rotenone to result in acute toxicity.
- Studies have been conducted on common musk turtles and soft shelled turtles (McCoid and Bettoli 1996) which found negative effects from rotenone when used at 3mg/l of 5% concentration or greater. The proposed treatment level for Miramichi Lake is half that concentration.
- In British Columbia, painted turtles have been present in several treated lakes. Some have been held captive within active rotenone treatment areas and observed for a period of time post treatment with no mortality or negative effects observed (Steve Maricle *personal communication, Province of BC*).

Noxfish II is registered for use in Canada under PMRA # 33247 by Health Canada and in the USA as Prenfish (reformulation 2232) under EPA Reg. No. 89459-45 by the U.S. Environmental Protection Agency. The registrations follow government scientist reviews of rigorous standardized testing results to ensure there are no unreasonable risks to public health or environmental when used according to label directions. The presumption of pesticide registration is that the prescribed use on the label does not constitute unreasonable risks to humans and their environment. There are criminal and

administrative penalties for not following prescribed label directions. The public is protected by prohibiting contact with treated water during application and for a 3-day re-entry interval after application until waters are deemed safe. A certified pesticide applicator team will conduct the treatment according to the product label and standard operating procedures (Finlayson et al. 2018) as described in Sections 5.1 through 5.3.

Persistence in the environment

UPDATE: see stand-alone Monitoring Plan in APPENDIX E

A treatment of rotenone at 0.075 mg/L is expected to result in a half life of 2.5 days and break down to undetectable levels after 18 days (<0.002 mg/L). Rotenone will be deactivated near the outlet of Lake Brook prior to entering the Southwest Miramichi River. Monitoring of rotenone levels and acute toxicity will be conducted throughout the application and post-treatment period. Toxicity monitoring is best conducted as in the Despres Lake, New Brunswick application (Connell et al. 2002) using caged fingerling brook trout to assess toxicity for 24 h periods. Due to the size of this lake, at least three cage locations distributed through the lake should be chosen and bioassays would be conducted after deactivation until such time as trout can survive for 24 h. Cages should also be situated in Lake Brook above any deactivation, below deactivation (at least 30 minutes water travel time), and in the Southwest Miramichi River below Lake Brook. As bioassay results can be assessed immediately, these would provide the best indication of when to begin restocking the lake. If all three locations show 24 h bioassay results with mortality equal to or less than pre-application bioassays, restocking will commence. UPDATE: see Re-establishment Plan in APPENDIX D

After application is complete (time zero), rotenone analysis should be completed thereafter at 1, 2, 4, 8, 16, and 32 days at those same 6 locations. In the past application at Despres Lake, the New Brunswick Research Productivity Council conducted this analysis. UPDATE: see stand-alone Monitoring Plan in APPENDIX E

Bioaccumulation in the environment

Rotenone has low to moderate mobility in soil and sediment (K_d = 3.6-194) (Dawson et al. 1991), and does not penetrate further than 2 cm into sediments, or 8 cm in sandy substrate as it binds strongly with organic materials in the soil and degrades rapidly (Finlayson et al. 2001). It has a relatively low potential for bioconcentrating in aquatic organisms (BCF < 30) (Gingerich and Rach 1985), and is not persistent in the environment due to rapid hydrolysis (Thomas 1983) and photolysis (Draper 2002) with half-lives measured in days and hours, respectively, as described in Finlayson et al. (2018). Hence, rotenone will not persist in the environment for more than several weeks nor bioaccumulate in the environment.

The PMRA label and safety requirements / Drug label and safety instructions

See APPENDIX H (Noxfish Fish Toxicant II PMRA Label) and APPENDIX I (Noxfish Fish Toxicant II SDS)

Applicator Safety Requirements – The applicator is protected from exposure to rotenone through wearing personal protective equipment (PPE) as required on the PMRA label (APPENDIX H) and by adhering to safety procedures describe in SOPs 3.1 and 4.1 of the Rotenone SOP Manual (Finlayson et al. 2018). The applicator must wear chemical-resistant coveralls over long-sleeved shirt and long pants, chemical-resistant gloves, socks and chemical-resistant footwear, goggles or face shield, and either a respirator with a NIOSH-organic-vapor-

removing cartridge with a pre-filter approved for pesticides or a NIOSH-approved canister approved for pesticides during mixing, loading, application, clean-up and repair.

Mixers and loaders (except mixing/loading to support backpack sprayers and drip stations) must use a closed system as described in SOP 8.1 of the Rotenone SOP Manual (Finlayson et al. 2018) that is designed by the manufacturer to remove the product from the shipping container and transfer the product into mixing tanks and/or application equipment. At any disconnect point, the system must be equipped with a dry disconnect or dry couple shut-off device that will limit drippage to no more than 2 ml per disconnect. The closed mixing/loading system must function properly and be used and maintained in accordance with the manufacturer's written operating instructions. SOP 10.1 of the Rotenone SOP Manual (Finlayson et al. 2018) provide guidance on the use of drum pumps for filling drip stations and backpack sprayers.

Public Health Safety Requirements – As required on the PMRA label (APPENDIX H), recreational access by the public (e.g., wading, swimming, boating and fishing) to treated areas during the 2-day rotenone application is prohibited and for 72 hours after the application.

5.2. Labour

Please describe here or in an annex outlining any details related to:

- **The protocol for the deposit of the deleterious substance**
- **Pesticide applicator certification (Provincial Licence)**
- **Contractors, employees, or other staff participating in the project**

The protocol for the deposit of the deleterious substance

Optimal Treatment Timing

Several factors must be considered with regards to application timing to ensure the highest probability of success, as well as to limit impacts on non-target species, facilitate rapid and successful fish reintroduction, and ensure rapid breakdown of rotenone. Mid-September is the optimal timing for various technical reasons (in addition to mitigating impacts to alewife):

- The lake is 15-18°C based on temperature monitoring, ensuring effective toxicity to SMB
- SMB eggs will not be present as spawning is finished in July and egg incubation time is 2-9 days
- Rotenone half-life and duration of acute levels is lower at higher temperatures (i.e., >12°C)
- Deactivation with potassium permanganate is most effective at warmer temperatures (>10°C)

Description of Treatment Rate (UPDATE: see further justification in APPENDIX A in response to DFO questions)

The 24 h LC50 value for Noxfish to young SMB (1 to 1.5 g each) was 0.093 mg/L (0.0047 mg/L rotenone) in tests performed at a temperature of 12°C (Marking and Bills 1976). The minimum effective dose (MED), that which produces 100% mortality, is estimated at twice the LC50 value (Finlayson et al. 2018 SOP 5.1) or 0.0093 mg/L rotenone. Standard operating procedures recommend that the treatment rate be at a *minimum* twice the MED or 0.0186 mg/L rotenone. This minimum rate for Miramichi Lake should be increased to 0.075 mg/L rotenone (1.5 mg/L rotenone formulation) due to:

- Faster degradation of rotenone through increased hydrolysis and photolysis in this warm (15-18 °C temperature) and shallow (<7 m depth) lake;
- The high organic content of the water (evidenced by its brown color) will likely sequester some of rotenone's toxicity;
- Biological variability between SMB tested by Marking and Bills (1976) and those in Miramichi Lake;
- Sequestration of rotenone's toxicity by the abundant, sediment-covered submerged aquatic vegetation along most of the lake shoreline; and
- Time required for rotenone to reach areas of poor water circulation in the lake (lethal levels will persist for approximately 7 days as rotenone is dispersing)

Laboratory toxicity tests using CFT Legumine completed by the Province of New Brunswick and the Atlantic Salmon Federation in 2017 found the 24-h LC50 to small (YOY) SMB at 0.0065 mg/L rotenone in water from Miramichi Lake, whereas Marking and Bills (1976) found the 24-h LC50 value of 0.0047 mg/L rotenone using Noxfish. Thus, the toxicity of rotenone to SMB in Miramichi Lake water may be ≈ 40% less than that reported by Marking and Bills (1976). This lower toxicity of rotenone in Miramichi Lake water supports the treatment rate of 0.075 mg/L rotenone.

The proposed rate of 0.075 mg/L rotenone may be modified based on additional on-site toxicity test(s) with SMB or a surrogate species such as yellow perch prior to the actual treatment. This 24-h test using Miramichi Lake water will test 0.025, 0.0125, 0.0062, 0.0031, and 0.0016 mg/L rotenone to confirm the previous sensitivity of rotenone from CFT Legumine using the new Noxfish II formulation.

Description of Rotenone and Equipment Needs

Rotenone will be applied to the 220 ha Miramichi Lake using outboard motor boats equipped with semi-closed probe application systems (Figure 5.3, van den Heuvel et al. 2017; Finlayson et. al 2010 SOP 8.1). The 1:10 (v:v) dilution of rotenone formulation:water will be applied at or below the water surface. The shallow areas of the lake which have poor water circulation (i.e., backwater, dense aquatic macrophyte, and marshy areas) will be sprayed using a dilute solution (1-2%) of rotenone formulation using a combination of boat-based and backpack spraying (see Figure 5.4 from van den Heuvel et al. 2017). In the tributaries, rotenone will be applied to at least the first 100 m upstream of the lake using drip stations for the duration of the treatment (see Figure 5.5 from van den Heuvel et al. 2017); it is likely that the backwater areas of these will require spraying too. (UPDATE: see APPENDIX B for criteria for drip station placement in the inlets; see APPENDIX E for residue and deactivation monitoring locations in the inlets, the lake, and Lake Brook)

Given the known presence of SMB in Lake Brook, the brook will also be treated. Drip stations located along Lake Brook and the east branch of Lake Brook for rotenone treatment (placement TBD based on flows immediately prior to treatment to ensure target concentration of 0.075 mg/L rotenone is sustained in the brook during treatment. The rotenone will be deactivated in Lake Brook prior to reaching the SW Miramichi River; the deactivation station will be located at least 30 minutes water travel time upstream from the brook's confluence with the SW Miramichi River. Maintaining 4 ppm residual of $KMnO_4$ in the deactivation zone will ensure that rotenone is deactivated by the time it reaches the SW Miramichi River, and that lethal

conditions are sustained in the lower reach of the brook given that SMB distribution includes the brook. Toxicity tests with yellow or white perch will be conducted in summer 2020 with Lake Brook water to ensure this concentration is lethal. Upon flowing into the SW Miramichi River, the 4 ppm $KMnO_4$ will be immediately diluted to non-lethal levels, and the rotenone will have been deactivated. Please see monitoring detail and map locations in APPENDIX E.

Based on the physical size of Miramichi Lake, the treatment rate of 0.075 mg/L rotenone will require 17,372 L of 5% rotenone formulation. During application, a 40 to 50 mm water pump can apply undiluted liquid rotenone at the rate of approximately 1134 L/h. At this rate, it will require approximately 15.3 h to apply the liquid rotenone, not accounting for transport times to/from the staging/docking area and loading time. Rotenone should be applied within a 2 day window to ensure that it won't significantly degrade during application.

Rotenone in Canada is sold in 30-gallon drums that weigh 125 kg each, and a total of 153 drums are needed for the treatment of Miramichi Lake. It would require multiple (2-4) boats to apply this quantity of rotenone evenly with a 2-day window (Table 3; van den Heuvel et al. 2017). To assist in the application, the bathymetric map of Miramichi Lake, available from New Brunswick Department of Energy and Resource Development (Biron 2015), could be used to develop a grid system identifying the volume of water in each grid and amount of rotenone needed to treat each grid.

Table 3. Estimated boat resources required to apply rotenone to Miramichi Lake (Table 5.2 from van den Heuvel et al. 2017).

Parameter	18-Foot Boat	22-Foot Boat
Max Wt. Capacity (kg)	682	1342
Rotenone Wt. Capacity (kg)	501	1160
Number Drums/Trip	4	9
Total Trips	38.2	17
Application Time/Trip (h)	0.4	0.9
Total Trip Time (h)	0.9	1.4
Total Application Time (h)	34.5	23.8
8-h Days Required/Boat	4.3	3

- **Pesticide applicator certification (Provincial Licence)**
  A certified pesticide applicator team will conduct the treatment (likely the Province of New Brunswick).

- **Contractors, employees, or other staff participating in the project**
  Crew Size and Responsibilities
  American Fisheries Society Rotenone SOP Manual (Section 2.3, Finlayson et al. 2018) recommends using an Incident Control System to organize the various treatment functions into teams under the direction of an Incident Commander. In smaller and simpler treatments, one person or several people may perform the responsibilities normally assigned to more than one team in larger and more complex treatments. The treatment of Miramichi Lake is of medium complexity and the staff can be divided as follows below:

Operations Division. The Operations Section is responsible for applying rotenone to the lake and tributaries. This will involve 4-8 staff for the boats (1 applicator and 1 pilot per boat) and 4 staff to operate the drip stations and backpack sprayers for two days. If deactivation is required, the application of KMnO4 to Lake Brook will require a staff of 2 operating 24 hours a day (3 shifts of 6 staff total) for approximately 1 week.

Support Division. The Support Section will service and monitor caged acute lethality bioassay fish located throughout the treatment area to measure the efficacy of the treatment on a real-time basis. They will also collect water samples for chemical analysis, and collect, identify, measure and disposes of dead fish throughout the treatment area. This will involve 2 staff for 2 days and periodically for several weeks.

Logistics Division. The Logistics Section is responsible for obtaining, maintaining, and distributing all equipment and supplies including rotenone. This will involve 1 or 2 staff for 2 days.

Safety Officer. The Safety Officer for 2 days is responsible for providing safety training to the crew, issuing personal protective equipment (PPE), monitoring crew safety, and developing on-site safety procedures including a spill contingency plan.

Public information officer/Liaison. The Public Information/Liaison Officer for 2 days is responsible for communicating with the general public, other government agencies and other interested parties.

5.3. Project safety

Please describe here or in an annex outlining any details related to:

- **Personal protective equipment**
- **Signs, notices, or other warnings to the local community**
- **Facility to store all equipment and deleterious substances related to the project, and the provincial licence.**
- **Transport of dangerous goods protocol**
- **Contractors, employees, or other staff participating in the project**
- **Spill response plan**
- **Pesticide Disposal**
- **Neutralization**
- **Disposal of dead fish**
- **Application hazard and mitigation measures**
- **Vessel or navigation risk**
- **Disruptions to the routine activities of local communities, governments, or businesses.**

- **Personal protective equipment (SOP 3.1, Finlayson et al. 2018)**
  A certified pesticide applicator team will conduct the treatment according to material safety protocols. The crew will require training on techniques and equipment for rotenone application including the label, safety data sheet, rotenone standard operating procedures, and the correct use of personal protective equipment. The applicators are protected by wearing protective equipment including coveralls over long pants, long-sleeved shirts, chemical-resistant gloves, chemical-resistant footwear, goggles, and a respirator.

- **Signs, notices, or other warnings to the local community (SOP 1.1, Finlayson et al. 2018)**

Signage at Miramichi Lake will be posted at all public entry points to notify the public of the treatment. The public will be notified of temporary restriction from contact with treated water during the two-day application and for a three-day re-entry interval after application until waters are deemed safe. Camp owners will also be contacted directly with notification of the temporary five-day restriction and associated dates. The Public Information/Liaison Officer will be responsible for communicating with the general public, other government agencies and other interested parties during the treatment.

- **Facility to store all equipment and deleterious substances related to the project, and the provincial licence (SOP 4.1, Finlayson et al. 2018)**
  The delivery of rotenone can be coordinated with the treatment date so no long-term storage is needed. Rotenone can be delivered to the site a day or two before treatment using normal ground transportation. A 7 by 10 m area, surrounded by hay bales, and lined with a plastic tarp will be used for on-site temporary storage. A short-term storage area that drains into the lake will be selected. The storage area will be fenced with a locked gate, and the entrance will be clearly labeled in a language understandable to all employees with a warning indicating "Warning, Chemical Storage, Authorized Persons Only. All specific storage information on the rotenone label will be followed. Since this short-term (< 5 days) storage area will be part of the project area, it likely will not require a license.

- **Transport of dangerous goods protocol (SOP 4.1, Finlayson et al. 2018)**
  The delivery of rotenone can be coordinated with the treatment date so no long-term storage is needed. Rotenone can be delivered to the site a day or two before treatment using normal ground transportation. The Noxfish II (with Canadian labels) will come from Dallas, Texas (USA), transported via a licensed commercial carrier to the USA-Canadian border, and transported inside Canada in a manner consistent with the Transport of Dangerous Goods Program which includes certified training, emergency response plans and the necessary permits.

- **Contractors, employees, or other staff participating in the project**
  See Section 5.2 above.

- **Spill response plan (SOP 4.1, Finlayson et al. 2018)**

  Spill Prevention - To minimize on-site spillage of Noxfish II, it will be stored on site within a plastic tarp-lined, bermed area adjacent to Miramichi Lake. Any material spilled on the tarp during opening or transferring of material will be rinsed off in the lake using lake water. All spills off-site must be reported to the spill response unit and other units as appropriate. Small spills on-site may be contained and the collected material disposed of according to the product label. If these wastes cannot be disposed of by use according to label instructions, the New Brunswick Department of Environment and Local Government (DELG) will be contacted for guidance.

  Spill Containment - The storage of Noxfish II at Miramichi Lake is at a location that is graded to allow drainage into the lake in case of an accidental spill. The 153 30-gallon containers of Noxfish II are placed on a plastic barrier sloped toward the project water body. A small spill of rotenone is rinsed into the treated water.

The designated storage area on-site is a bermed, 7x10x0.5 m (35 m^3 or 9,246 gallon capacity) enclosure and large enough to contain all 153 30-gallon drums (4,590 gallons). Only one, drum will be open on land at any one time for spraying and drip application. This will allow recovery of all the material following a spill of a container. The drums used for the lake application will be loaded to the boats using a front-end loader or similar piece of equipment. The berm is constructed of straw/hay coir logs and lined with heavy duty plastic fabric that is secured. Absorbent clay, absorbent pads, shovels and buckets and additional personal protective equipment are maintained and readily available in the staging area, adjacent to the storage area, in case of a spill. The Certified Pesticide Applicator in charge of the treatment is responsible for all containers and equipment. Arrangements will be made to (1) provide a person responsible to maintain such control over the containers at all times or (2) store all such containers in a locked enclosure. Either shall be adequate to prevent unauthorized persons from gaining access to any of the material.

Spill Management - In the event that a spill occurs, it is of paramount importance that the spilled material be contained. Shovels and other hand tools will be used for immediate containment or channelization of the spilled material into a containment area. In the event of a spill of Noxfish II in the storage area, an attempt will be made to recover and use in the application. If a ground spill occurs the following actions are taken. The spill is controlled at its source immediately. The spilled material should be diked into pools as appropriate and recovery attempts will commence as soon as possible. Recovery methods include channeling material into the lake, rinsing the tarp in lake water, and using absorbent materials such as clay or absorbent pads to absorb the liquid that cannot be put into the lake. Recovered material is applied to the treatment area, within the limits of regulations.

Spill Contingency Plan - The Miramichi Lake Spill Contingency Plan will contain the following elements:

- Inventory of Noxfish II used in the treatment
- Description of storage area
- Description of staging area
- Precautions
- Chain of Command
- Downstream water users impacted by a major spill
- A list of entities to contact in the event of a reportable spill
- Specific spill containment and recovery procedures
- All treatment personnel to report to Incident Commander via two-way radios/cell phone

- **Pesticide Disposal**

There is no anticipated need for pesticide disposal as all pesticide delivered to the project site will be used in the treatment area, and the rotenone drums will be triple rinsed on site using water from Miramichi Lake. Following triple rinse cleaning, the empty drums will be made unsuitable for further use. The applicators will consult with the New Brunswick Department of Environment and Local Government for guidance in this matter and disposal of the clean drums.

- **Neutralization**
  Rotenone breaks down/deactivates rapidly in nature. At the proposed treatment levels and expected water temperatures, rotenone will have a half-life of 2.5 days and will be undetectable after 18 days (<0.002 mg/L). As an added mitigation measure, directed deactivation of rotenone will occur on Lake Brook using potassium permanganate ($KMnO_4$). The deactivation station will be located on Lake Brook at least 30 min water travel time upstream of the confluence with the Southwest Miramichi River (see APPENDIX E) using a volumetric feeder powered by a gasoline generator (Finlayson et al. 2018 SOP 7.1). A deactivation rate of 4 mg/L $KMnO_4$ for 7 days will require approximately 1,089 kg $KMnO_4$ for treating the Lake Brook discharge of 0.45 m^3/s. Additional testing is required prior to treatment to determine the precise deactivation dosage of $KMnO_4$. Maintaining 4 ppm residual of $KMnO_4$ in the deactivation zone will ensure that rotenone is deactivated by the time it reaches the SW Miramichi River, and that lethal conditions are sustained in the lower reach of the brook given that SMB distribution includes the brook. Upon flowing into the SW Miramichi River, the 4 ppm $KMnO_4$ will be immediately diluted to non-lethal levels, and the rotenone will have been deactivated. Please see monitoring detail and map locations in APPENDIX E.

- **Disposal of dead fish**
  The proponent will comply with all conditions of approval respecting fish disposal as required by the NB Department of Environment and Local Government.

- **Application hazard and mitigation measures**
  Application procedures will comply with hazard protection measures for the applicator and the general public identified on the product label (Appendix A).

  The applicator is protected against exposure to rotenone through wearing personal protective equipment (PPE) as required on the PMRA Noxfish II label (Appendix A) and by adhering to safety procedures described in SOP 3.1 of the Rotenone SOP Manual (Finlayson et al. 2018). The applicator must wear chemical-resistant coveralls over long-sleeved shirt and long pants, chemical-resistant gloves, socks and chemical-resistant footwear, goggles or face shield, and either a respirator with a NIOSH-organic-vapor-removing cartridge with a pre-filter approved for pesticides or a NIOSH-approved canister approved for pesticides during mixing, loading, application, clean-up and repair. No PPE is required after the application is complete.

  The public will be directed to keep away from the treatment area for the two-day application and for a three-day period after that as specified on the Noxfish II label. The application rate is 0.075 mg/L, and the EPA (2007) recommends that safe public contact with water (i.e., swimming) can occur when rotenone ≤ 0.090 mg/L. Rotenone levels are expected to be ≈ 0.020 mg/L after the waiting period, less than the 0.090 mg/L deemed safe for human contact by EPA (2007). As part of the overall project monitoring, rotenone levels will be documented from the day of application until they subside to less than detection (≤ 0.002 mg/L) (UPDATE: see APPENDIX E for Monitoring Plan and protocol). The project area will be placarded with warning signs denying access to the lake and other treated areas during this 5-day period as detailed in SOP 1.1 of the Rotenone SOP Manual (Finlayson et al. 2018).

- **Vessel or navigation risk**
  There are no risks to public vessels or navigation. Vessels used for the treatment will be operated by holders of the Canadian Boater Safety License and be certified pesticide

applicators. There will be no public or private vessels on the Lake, other than those used for the treatment, during the 2-day application and for a 3-day period following treatment.

- **Disruptions to the routine activities of local communities, governments, or businesses.** The public will be temporarily prohibited from contact with treated water during the 2-day application and for a 3-day re-entry interval after application. This will primarily impact camp owners who use the lake recreationally (21 privately owned parcels of land). A September treatment will minimize recreational activity disruption because most use of the lake is throughout summer. No businesses or government activities will be disrupted on account of the treatment.

5.4. Public safety

Please list here or in an annex any public safety concerns associated to the proposed project. Describe the risk to public safety and provide details on any mitigation measures to be implemented.

Noxfish II is registered for use in Canada under PMRA # 33247 by Health Canada and in the USA as Prenfish (reformulation 2232) under EPA Reg. No. 89459-45 by the U.S. Environmental Protection Agency. The registrations follow government scientist reviews of rigorous standardized testing results to ensure there are no unreasonable risks to public health or environmental when used according to label directions. The presumption of pesticide registration is that the prescribed use on the label does not constitute unreasonable risks to humans and their environment. There are criminal and administrative penalties for not following prescribed label directions. The public is protected by prohibiting contact with treated water during application and for a 3-day re-entry interval after application until waters are deemed safe. A certified pesticide applicator team will conduct the treatment according to the product label and standard operating procedures (Finlayson et al. 2018) as described in Sections 5.1 through 5.3.

Twenty six wells adjacent to the nine California treatments have been monitored since 1987 for the presence of rotenone formulation constituents (Finlayson et al. 2001). Samples were collected between 1 and 456 days following treatments. All samples proved to be negative. Residues of rotenone or rotenolone were never found in any of the wells monitored. None of the other VOC or semiVOC constituents have been detected in any of the wells monitored. Additionally, four shallow wells adjacent to Diamond Lake, Oregon that was treated in 2006 had no rotenone and rotenolone residues present up to 39 days post-treatment (Finlayson et al. 2014). The ability of rotenone to move through soil is low to slight. Rotenone moves only 2 cm (<1 inch) in most types of soil. An exception would be in sandy soils, where movement is about 8 cm (slightly more than 3 inches). Rotenone binds strongly with organic materials in the soil and degrades rapidly.

A review by the Washington Department of Fish and Game (Hisata 2002) concluded there is no overall risk to human health and that rotenone is a safe product when applied according to label instructions.

Section 6: Consultations

6.1. Consultations

Please provide here or in an annex any details related to completed consultations, as well as potential consultations. Please include details related to:

- **Completed consultations**
- **Communication strategy**
- **Details of target audience**
  - **Aboriginal**
  - **Stakeholders (e.g. camp owners, community groups, etc.)**
  - **General public**

Completed consultations

Potential consultations are anticipated with both Mi'kmaq and Maliseet First Nation communities. Aboriginal consultations are the legal responsibility of DFO on a nation to nation basis. The proponent will assist DFO to carry out consultations where appropriate with the communities. The NGO partners have consulted with their Boards. For example, the New Brunswick Salmon Council received unanimous consent for eradication with rotenone from its Directors, representing 29 affiliate organizations geographically distributed throughout the Province.

Communication strategy

Public Interaction and Message

UPDATE: Working Group has held several engagement sessions in winter 2020 to present the plan and receive feedback. Experts Brian Finlayson and Steve Maricle were brought in to present and answer questions. The following meetings were held:

- January 26 – Miramichi Lake Camp Owners
- January 27 – DFO and provincial staff
- January 27 – Natoaganeg and Metepenagiag First Nations community meeting in Eel Ground
- January 28 – Provincial Ministers of Natural Resources, Environment and Local Government, and Indigenous Affairs
- February 20 – Miramichi outfitters, guides and fly shop owners
- March 5 – Camp owners steering committee
- March – Miramichi outfitters, camp owners, guides

Obtaining broad public support for SMB eradication in Miramichi Lake will be a precondition for success. A public relations plan has been developed. This plan recognizes the variety of groups/public involved, their roles and realities.

The message that must be communicated is that applying rotenone is the only feasible option to eradicate non-native SMB. While there will be temporary impacts on the lake and river ecosystems, it is necessary to accept temporary harm for the greater good: restoring the lake and river after an illegal introduction, and protecting the ecosystem, cultures, and livelihoods in the greater Miramichi River system. **The thrust of the message will be that a SMB eradication will avoid a permanent disaster for Atlantic salmon in the greater Miramichi watershed. The eradication will help preserve the native**

ecosystem and fisheries that Atlantic salmon support (FSC, recreational), and rural economies and cultures it sustains.

The message will include that chemical eradication is an effective and safe fish management technique used widely in Canada, the United States, and Europe. To not act would risk permanently and negatively affecting the Miramichi River and ecological services it provides. Furthermore, these actions can be taken with essentially no risk to human health.

Communication should be straightforward and honest, not euphemistic. Language should reflect a genuine determination to eradicate SMB from Miramichi Lake, even in the face of opposition. Project partners should anticipate detailed questions from First Nations community members, other groups, and individuals from the public. The expert report (van den Heuvel et al. 2017) should be the source of answers. Informing the public of details about the re-introduction of native species, treatment timing to avoid impacts to alewife, rotenone deactivation in Lake Brook, and rapid return of the lake to its pre-treatment or historic state should be features of communications.

Media Communications

Prior to meeting with, and mailing information letters to communities and stakeholders, the proponent and working group will have discussed this public relations strategy with provincial and federal agencies. A set of key points and responses will be in place to help with unplanned media communication. A logical first planned media communication would be a bilingual commentary from the project proponent and working group published in provincial newspapers. This should be submitted shortly after the mailing and receipt of letters to communities and stakeholders. There will be opportunities for media coverage and questions at each of the scheduled public meetings, as press releases are prepared, or by inquiry. Beyond the actions described in the section *Involved Groups and Likely Concerns* (below) subsequent engagement will be driven by requests and in collaboration with government partners.

Methods to Obtain Public Comment

Public comment and opinion will be noted at each meeting with identified groups, individuals, and communities. Feedback will be shared with working group members and permitting agencies. Material developed for public outreach and notices of meetings will include a dedicated email address where people can submit questions or concerns should they not wish to speak in person.

Develop Invasive Species Information Products

Creating high quality, informative, communication material for use by the public and media will be an early priority of the working group and government partners to reduce risk of future introductions. Examples from other invasive species eradication projects can be obtained (e.g., Maine, BC). Posters, pamphlets, pictures, and videos should be created for distribution through all communication channels. Creative material should also be developed and circulated during the post-eradication period to discourage any re-introduction. Information on rotenone can be obtained from the American Fisheries Society's Rotenone Stewardship Program website: http://rotenone.fisheries.org. Like littering was socially outlawed by the 'litter bug' campaign, it's possible to build awareness of the detrimental effects of invasive species and influence behaviour through marketing and communication. These products will result from collaboration between the proponent, working group partners, and public agencies.

Details of target audience

- Aboriginal

- Stakeholders (e.g. camp owners, community groups, etc.)
- General public

Involved Groups and Likely Concerns

The following groups have been identified as key rights holders and stakeholders because of their presence, interest, and influence in the Miramichi region, New Brunswick, and Canada generally. They are diverse and representative of the local population. The first step should be a meeting or mailed letter to each of these people or organizations describing the working group, our goal, the expert report, and intent to work with regulatory agencies. The letters will open a direct line of communication and include a notification of public meetings that will be jointly hosted by the government regulators, the proponent, and working group partners.

Camp owners: A total of 21 private properties have been identified around Miramichi Lake. Some properties have several owners listed on the provincial property tax database. Owners often share a common family name.

Mi'kmaq First Nations: Receiving agreement from local Indigenous people is imperative. The proponent, the North Shore Micmac Resource Council Inc., represents seven First Nations, two of which are directly present on the Miramichi river system (Metepenagiag and Eel Ground). This has encouraged support for the project to date. Public meetings will be offered in Metepenagiag and Eel Ground, encouraging information sharing and meaningful discussion.

Maliseet First Nations: Maliseet communities will be contacted through the working group member organization, the Maliseet Nation Conservation Council.

New Brunswick Aboriginal People's Council: Other Indigenous people will be contacted broadly through the New Brunswick Aboriginal People's Council. Further meetings could be held to provide information.

Municipalities and Rural Communities: Where municipal councils exist, in Stanley, Upper Miramichi, Doaktown, Blackville, and Miramichi City the working group should arrange to present the findings of this report and the eradication plan. A public meeting should be held in Juniper, the closest community to Miramichi Lake, where no municipal council exists.

NGOs: The following NGOs should be notified of plans for eradication and extended offers to meet and discuss: Conservation Council of New Brunswick, Canadian Parks and Wilderness Society, Nature NB, and the Nature Conservancy of Canada. This list may expand.

Political Leaders: Elected individuals to be directly contacted include, but are not limited to, all area MPs and MLAs, Green Party Leader David Coon, Leader of the N.B. Official Opposition, the Premier, Department of Energy and Resource Development Minister, Department of Environment and Local Government Minister, and the Fisheries and Oceans Minister. The working group has already met with many of these individuals and they are aware of the issue of SMB in Miramichi Lake and the eradication proposal as outlined in the expert report.

Likely concerns include the use of chemicals, impact on the environment, quality of engagement, incorporation of concerns, human health, drinking water, unintended effects on other species, disruption of recreational uses, and respect for traditional knowledge. This list is not exhaustive and may expand over time.

Section 7: Re-establishment strategy

7.1. Re-establishment strategy
Please provide here or in an annex any proposed strategy to re-establish populations of native species to be implemented post-eradication efforts. UPDATE: see stand-alone Re-establishment Strategy in APPENDIX D

Section 8: Monitoring

8.1. Monitoring
Please provide here or in an annex the proposed monitoring plan to evaluate effectiveness and impacts of the control project. UPDATE: see stand-alone Monitoring Plan in APPENDIX E

Section 9: Contingency strategy

9.1. Contingency strategy
If eradication efforts are unsuccessful and the likely cause of failure can be identified and corrective actions are possible, then a second attempt at eradication will be made. Extensive pre- and post-treatment monitoring information on rotenone concentrations, fish toxicity, and fish presence in the treatment area will assist in the identification of conditions not conducive to SMB eradication (UPDATE: see Monitoring Plan in APPENDIX E). All of the monitoring data will be presented in a final report critiquing the performance of the eradication. This will be beneficial in future rotenone treatments.

Section 10: Review

This section is a non-exhaustive checklist of important components for a successful project. Please verify that all the necessary criteria have been met. The proponent is responsible for obtaining the appropriate licences or permits from other federal or provincial agencies in order to complete the proposed project.

Checklist of appropriate licences and conditions (circle appropriate)		
PMRA pesticide Registration	YES ✓	NO
Transportation of Dangerous Goods Act, 1992 s.5 permit	YES*	NO
Pollution prevention plan in compliance with s.56 of the *Canadian Environmental Protection Act, 1999*	YES*	NO
An applicator licence in line with s.10 of the *New Brunswick Pesticides Control Act,* and regulations	YES ✓	NO
The proponents project is considered a *designated project* with the meaning of s.2 of the *Canadian Environmental Assessment Act*	YES*	NO
Protocol defined	YES ✓	NO
Mitigation Measures outlined	YES ✓	NO
Safety measures outlined	YES ✓	NO
Monitoring protocol outlined	YES ✓	NO
Re-Establishment strategy outlined	YES ✓	NO
Is there a possibility the duty to consult with Indigenous peoples will be engaged	YES ✓	NO

*Applications for required permits, both provincial and federal, will be made after this AIS application is processed. This is the first step in the approval and review process.

Section 11: Signature

The undersigned certifies that the information provided in this request is correct and complete to the best of their knowledge.

Print Name: Jim Ward Position Title: General Manager

Signature: _____ Date: 4 April 2019

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APPENDIX A

DFO Request for Additional Information (1) and NSMDC Response

Fisheries and Oceans Canada | Pêches et Océans Canada

Aquatic Invasive Species National Core Program
343 Université Avenue
P.O. Box 5030
Moncton, New Brunswick
E1C 9B6

June 24, 2019

Your file *Votre référence*
19-IGLF-00001

Jim Ward
North Shore Micmac District Council Inc.
38 MicMac Road
Eel Ground, New Brunswick
E1V 4B1

Dear M. Ward

Subject: Additional information is required for the review of your request.

The Aquatic Invasive Species National Core Program (the Program) of Fisheries and Oceans Canada received your proposal on April 9, 2019.

Your proposal is being reviewed to determine whether an authorization should be issued under Section 19 of the *Aquatic Invasive Species Regulations* to deposit a deleterious substance for the purpose of controlling / eradicating an aquatic invasive species (AIS). Your proposal is also being reviewed to determine if it has the potential to result in prohibited effects to species at risk listed under the *Species at Risk Act* as well as serious harm to fish under subsection 35(1) of the *Fisheries Act*.

In order for us to complete the review of your proposal and to determine if an authorization should be issued for the deposit of a deleterious substance to control AIS, we ask that you provide the following additional information:

Requirements under subsection 28(1)(a) of the *Aquatic Invasive Species Regulations* compel the consideration of public safety. Provide the following additional information:

1. Section 4.4 of the project application mentions "treatment will not impact groundwater, riparian areas, or other fish habitat outside of the project site". Provide references to support this statement.

2. Section 4.1 of the project application mentions "unavoidable temporary water quality impacts will occur". Provide information on potential impacts to drinking water in the area. Additionally, provide information on the source of drinking water for cottage owners in the project area (i.e. drawn from the lake or surrounding surface water).

3. Section 5.1 of the project application mentions that the public is prohibited to come into contact with the treated water during application, as well as for three days post application (a total of five days). These timelines apply only to contact with water. Provide timelines/guidelines in relation drinking water being safe for consumption after

application. If drinking water is affected, provide a detailed plan to provide cottage owners access to clean water during project duration and post-treatment.

Requirements under subsection 28(2)(a) of the *Aquatic Invasive Species Regulations* compel the consideration of impacts on fish, fish habitat or the use of fish. Provide the following additional information which pertains to the pesticide treatment:

1. Section 4.2 of the project application mentions that the lake contains organic-rich mud as well as tea colored water due to leaching from humic matter and surrounding bogs. It is also later mentioned in section 5.2 that this high organic content "sequesters rotenone toxicity". Provide context around this sequestration. How does this sequestration impact the Rotenone degradation rate? Is the sequestration by organic content permanent? Can it be released back into the environment? Provide references to support information provided.

2. Section 5.2 of the project application describes treatment rates. DFO's understanding of the information provided is that the recommended treatment rate for NoxFish is 0.0186 mg/L rotenone. However, tests conducted using CFT Legumine with Miramichi Lake water showed an LC50 value of 0.0065mg/L rotenone. This would suggest a recommended treatment rate of 0.026 mg/L rotenone. The proposed treatment rate in this project is 0.075 mg/L rotenone, which is three times the recommended rate based on the LC50 using Miramichi Lake water. Those calculations include the doubling of the minimum effective dose (MED), as suggested by the Standard Operating Procedures cited in your proposed project. Does this doubling of the effective dose already account for some environmental variability, such as temperature, sediment sequestration and biological Smallmouth Bass variability? At what temperature were the laboratory toxicity tests conducted? Provide evidence to justify the proposed substantial increase in the treatment rate.

3. Section 5.2 of the project application also indicates that treatment rate may be modified based on additional on-site toxicity tests. The assessment of the proposed project will performed on the information provided during the regulatory review. Changing the treatment rate post regulatory review may require a re-evaluation of the proposed project. To avoid potential delays, provide sufficient details surrounding potential changes to the treatment rate.

4. Section 4.1 states "Habitat in several intermittent inlet tributaries (< 500 m) and Lake Brook (riverine), and adjacent peripheral wetlands around the lake (palustrine) will be affected by the proposed project" and section 5.2 states "rotenone will be applied to at least the first 100 m upstream of the lake using drip stations". Provide clear and exact location of all product application and affected areas.

5. In section 4.3 of your application, it is mentioned "Rotenone will be deactivated with potassium permanganate near the outlet of Lake Brook to prevent impacts to surface water in the Southwest Miramichi River". Section 4.5 provides details on the proposed deactivation using Potassium Permanganate. The Safety Data Sheet for Potassium Permanganate lists this chemical as having "acute aquatic toxicity" and "chronic aquatic toxicity" meaning it is very toxic to aquatic life and it has long lasting effects. DFO is concerned that the use of this deactivation product for rotenone could potentially have negative impact on Fish and Fish Habitat. Provide details of deactivation protocol that ensures the product will not have any negative impacts caused by the chemical itself.

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Requirements under subsection 28(2)(a) of the *Aquatic Invasive Species Regulations* compel the consideration of impacts on fish, fish habitat or the use of fish. Provide the following additional information which pertains to species at risk:

1. In section 4.3 of your application, it is mentioned that a survey for Yellowlamp Mussel and Brook Floater was conducted. In order for DFO to fully assess project implications on aquatic species at risk, provide a report for the mentioned mussel bed investigations, including survey protocol, locations surveyed and findings.

2. In section 4.3 and 5.1 of your application, it is mentioned that toxic effects to mussels are not expected with the proposed rotenone treatment levels. Provide specific evidence related to any effects on Brook floater.

3. Additional concerns in relation to species at risk is the uncertainty around host species for Brook Floater to complete their life cycle. Currently, host species for Brook Floater have not been identified for NB populations. Some studies (see page 22 of the attached document) have identified potential host fish and six of these species are present in Miramichi Lake. These include the Common shiner (*Luxilus cornutus*); Golden shiner (*Notemigonus crysoleucas*); Fallfish (*Semotilus corporalis*); Brown bullhead (*Ameiurus nebulosus*); White sucker (*Catostomus commersonii*); and Yellow perch (*Perca flavescens*). Of these species, laboratory studies indicated that the Common shiner, Golden shiner and White sucker showed the highest frequency of Brook Floater life cycle completion. Only two of these three species were included as high priority in the re-introduction plan. Additionally, other species in the lake could also serve as potential host species. Provide any additional measures that could address these concerns.

4. How will the suggested temporary effects of treatment on plankton impact the survival of dependent species such as freshwater mussels (including Brook Floater)? How will a reduced food source impact overwintering of these species? Provide references to support information provided.

Requirements under subsection 28(2)(a) of the *Aquatic Invasive Species Regulations* compel the consideration of impacts on fish, fish habitat or the use of fish. Provide the following additional information:

1. In section 4.3 of your application, it is mentioned a fall treatment will also enhance the recovery of planktonic organisms such as cladoceran, copepod, and rotifer populations. Although the provided references suggest that plankton will recover in the spring, what are the expected timelines for populations to fully recover to pre-treatment levels? How will young-of-the-year alewife be affected if plankton populations have not fully recovered? Provide further information on impacts to plankton and more specifically as it relates to alewife.

Provide the following additional information on the proposed re-establishment strategy:

1. In section 7.1 of your application, it is mentioned that "Species that may survive the rotenone exposure are also be given low priority for re-introduction such as brown bullhead and golden shiner." Provide information on any documented effects on fish which have survived rotenone treatments, including changes in feeding and reproduction behavior.

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2. Point of clarification: your application indicates that Golden shiner is considered a tolerant species that is likely to survive treatment and thus will be given a low priority for re-introduction (section 5.1 and 7.1). However, Table 4 in section 7.1 identifies Golden shiner as a high priority. Please clarify this discrepancy.

3. In section 7.1 of your application, it is mentioned that "Anadromous or highly migratory species will colonize the lake on their own within a year, which makes them a lower priority for collection/re-establishment". Provide evidence to support the anticipated timeline for re-establishment of migratory species.

4. The goal of the proposed re-establishment strategy in this project application is focused on "restoring the existing fish community with the exception of SMB". In the application document there is no mention of quantities (or relative proportions) of each fish species to be re-introduced. Re-introduction quantities and sequence of fish species may ultimately affect the resulting fish community structure. Provide details around your re-introduction strategy to achieve your goal of re-establishing the existing community structure (minus SMB).

5. Keeping in mind the above re-establishment goal, the project application also mentions "Miramichi Lake has a highly diverse fish community for a post-glacial Appalachian Lake. This greatly increases the challenges and complexity of restocking from nearby lakes as multiple systems would be required to restore the diversity" and "Rare species are also a low priority as the likelihood of capture for recolonization may require exhaustive fishing effort". Provide clarification on achieving the proposed re-establishment goal if "rare species" are not re-introduced due to the given low priority status.

6. Does the "highly diverse fish community for a post-glacial Appalachian Lake" make Miramichi Lake a unique environment? Provide context around the importance of the fish diversity present in Lake Miramichi as it relates to other lakes in New Brunswick.

7. Provide details around proposed water source for temporary containment of native fish species. More precisely, plans for temporarily diverting a section of spring-fed stream (i.e. water withdrawal).

8. During temporary containment of the fish species, how will fish survival be assured? Are the fish going to be fed during containment? Provide details on protocols that will be used to maintain healthy fish while in containment.

9. Section 7.1 of your application suggests that re-introduction of captured fish could take place as early as 10 days post-treatment. Provide evidence to support the likelihood that re-introduced fish will survive into the next season (i.e. sufficient available food sources prior to overwintering).

Provide the following additional information on the proposed monitoring plan:

1. In section 8.1 of your application, a description of a monitoring plan was provided. The description mostly provides information around what could or may be done for monitoring. Please provide DFO a definitive monitoring protocol for assessment.

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2. In section 8.1 of your application, the use of eDNA was mentioned. Although eDNA might be useful to monitor native species recovery, it will not be able to demonstrate the absence of SMB post treatment (i.e. minimum detection levels). Current SMB population levels are barely detectable by eDNA techniques. Provide details around protocols to monitor the treatment effectiveness.

Other topics to be addressed. Provide the following additional information:

1. In section 7.1 of your application, it is also mentioned that Brook trout, although highly migratory, should be considered as a high priority because of it is highly valued for recreational fishing. It is also mentioned that this will appease camp owners along the lake and serve as risk mitigation against future invasive species introductions. Explain how re-establishing existing trout populations will mitigate against other invasive species introductions.

2. Provide information around the risk of Smallmouth Bass being re-introduced into the lake post-treatment. Include the locations of the closest established Smallmouth Bass populations, information on waterbody connectivity and potential vectors that could lead to re-introduction.

3. Section 5.2 of the project application indicates that the Province will likely apply the pesticide. The Province is not listed as the proponent nor a project partner. The legal responsibility of the Province in the proposed activity is not clear. Please clarify the role of the Province in this project proposal.

4. Section 4.5 of the project application indicates the dead fish be collected and buried in a landfill post treatment. How will the dead fish be collected? Provide the protocol for removing the dead fish.

5. In section 7.1 of your application, it is also mentioned that a Wetland and Watercourse Alteration (WAWA) permit will be required from NB Department of Environment and Local Government (NB DELG) for temporary containment. Has a request been made to the WAWA program?

6. Consult the NB DELG's Environmental Impact Assessment (EIA) program to confirm whether the project might trigger an EIA or not.

To determine whether the proposed project site preparation contains works, undertakings or activities that could results in serious harm to fish that are part of a commercial, recreational or Aboriginal fishery, or to fish that support such a fishery which is prohibited under subsection 35(1) of the Fisheries Act, provide detailed information if any of the following apply:

1. Watercourse crossing construction (permanent or temporary);

2. Shoreline alteration (e.g. dredging, infilling, boat slip construction, etc.);

3. Reductions in water flow (e.g. withdrawals);

4. Habitat alteration associated to fish removal;

5. Fording sites

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As previously mentioned, we have engaged with Aboriginal communities and First Nations. The following concerns were raised:

1. Impacts to native fish communities. As requested above, please provide the necessary information on the proposed re-establishment strategy to address this concern.

2. Long term effects of using Rotenone, especially in relations to invertebrate species, including zooplankton and insect populations. It was mentioned that some studies show that it can take 2-5 years for populations to recover. Some populations never do recover. Please provide more information on the potential recovery of invertebrate populations.

3. The risk level of Smallmouth Bass being re-introduced post-treatment. As requested above, please provide information on the risk of reintroduction.

4. Have less destructive and more targeted means of eliminating Smallmouth Bass been fully considered?

If you have any questions, please contact me directly at our Moncton office at 506-851-7244, or by email at XGLFInvaders@dfo-mpo.gc.ca. Please refer to the file number referenced above when corresponding with the Program.

Yours sincerely,

Daniel Bourque
Aquatic Invasive Species Regional Coordinator Biologist

Cc. Terry Melanson (DFO), Guy Robichaud (DFO)

Response to Aquatic Invasive Species National Core Program of DFO (dated June 24, 2019) Regarding Additional Information for the Application to Eradicate Smallmouth Bass from Miramichi Lake (19-IGLF-00001)

Submitted by: North Shore Micmac District Council Inc.

Submitted to: Fisheries and Oceans Canada (Gulf Region)

Date: Sept 13, 2019

I. *Aquatic Invasive Species Regulations* Section 28(1)(a) Requirements

1. *Impact on Groundwater and Aquatic Areas* – Sediment adsorption and desorption studies by Dawson (1986)[1] using native sediments from USA determined sediment coefficient (k_d) values of <10 (sand) to >100 (high silt and organic sediment) with the average sorption constant K_{oc} >2000, suggesting that the mobility of rotenone in soil is low to slight. Rotenone was most tightly bound to those sediments that had a high silt and organic content, similar to sediments in Miramichi Lake. He found desorption of rotenone was only 3.7% for silty sediments and concluded that the expected leaching distance for most soils would be 0 to 2 cm, suggesting that rotenone is unlikely to be a groundwater contaminant. Several agencies have monitored wells in the vicinity of rotenone treatments since the 1980s. There is no known instance of rotenone being found in those associated groundwaters (Finlayson et al. 2001[2]; Finlayson et al. 2014[3]). Rotenone will be confined to the project site by deactivating rotenone leaving the project area before it enters the Southwest Miramichi River.

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[1] Dawson, V. 1986. Adsorption-desorption of [6a-^{14}C] rotenone by bottom sediments. U.S. Fish and Wildlife Service, National Fishery Research Laboratory, La Crosse, Wisconsin. Report ROT-84-988.02, 136 pp.

[2] Finlayson, B., J. Trumbo, and S. Siepmann. 2001. Chemical residues in surface and ground waters following rotenone application to California lakes and streams. Pages 37-53 in R. Cailteux, L. DeMong, F. Finlayson, W. Horton, W. McClay, R. Schnick, and C. Thompson, editors. Rotenone in fisheries: are rewards worth the risks? American Fisheries Society, Trends in Fisheries Science and Management I, Bethesda, Maryland.

[3] Finlayson, B., Eilers, J. and H. Huchko. 2014. Fate and behavior of rotenone in Diamond Lake, Oregon, USA, following invasive tui chub eradication. *Environmental Toxicology and Chemistry* 33(6):1630-1655.

2. *Drinking Water Impacts* – No drinking water is taken from Miramichi Lake. The cottages on the lake take their drinking water from a small reservoir located upslope from the cottages that will not be treated.
3. *Public Health and Safety* – The water in Miramichi Lake is not a source of drinking and therefore, no plan has been provided for supplying drinking water to the residences. Given the expected half-life (2.5 d) of rotenone in Miramichi Lake during the proposed treatment scenario based on data from Finlayson et al. 2001; Finlayson et al. 2014), the initial 0.075 mg/L rotenone is expected to degrade to 0.0375 mg/L rotenone in 2.5 d, a level below the suggested safe drinking water level of 0.040 mg/L rotenone proposed by EPA (2007)[4].

II. *Aquatic Invasive Species Regulations* Section 28(2)(a) Requirements

1. *Impact of Organics on Treatment Rates* – Section 5.2 states that "*The high organic content of the water (evidenced by its brown color) will likely sequester some of rotenone's toxicity*". This is certainly a possibility, supported by a recent unpublished study in Montana (Skaar and Selch 2018) which found that a pond with tea-colored water and high levels of DOC had LC50 values 70-140% higher than four other unstained and low DOC waters; similar results were obtained in the test recently completed on Smallmouth Bass with water from Miramichi Lake (see below). This phenomenon is also recognized on the labels for rotenone products: the rate table on page 4 of the Noxfish Fish Toxicant II label (PRMA Registration No. 3327) allows the dose for ponds high in organics to be twice that allowed in pond waters not high in organics. Similar adjustments are found on the USA labels. The difference in toxicity values between the test done in Miramichi Lake water and the data of Marking and Bills (1976) may suggest lower rotenone toxicity in Miramichi Lake water (see page 21 of application). We are not aware of any studies looking specifically at the effect of organic loading on rotenone degradation rates. However, Finlayson et al. (2014) suspected that blue-green algae removed rotenone from the water during a bloom in Diamond Lake, Oregon and later released some of the rotenone back into the water when the bloom subsided, likely decreasing the dissipation of rotenone from the water body. The degradation of rotenone is increased by higher water temperatures, greater sunlight penetration, alkaline pH and higher metabolic activity.
2. *Justification of Treatment Rate* – The data of Marking and Bills (1976)[5] suggest a <u>minimum</u> treatment rate for Smallmouth Bass of 0.0186 mg/L rotenone (4 x LC50

[4] EPA, 2007. Registration eligibility decision for rotenone, EPA 38-R-07-005. U.S. Environmental Protection Agency, Prevention, Pesticides and Toxic Substances, Special Review and Registration Division, March 2007.

[5] Marking, L and T. Bills. 1976. Toxicity of rotenone to fish in standardized laboratory tests. *Investigations in Fish Control* 72. U.S. Fish and Wildlife Service, Washington, D.C.

value). You are correct that the toxicity test data using Miramichi Lake water suggest a minimum treatment rate of 0.026 mg/L rotenone, suggesting a 44% reduction in toxicity. The water temperatures averaged 12 °C for the Marking and Bills (1976) tests and 13 °C for those using Miramichi Lake water. The LC100 value is doubled (e.g., 4 x LC50 value) to account solely for biological variability which is why this is the minimum recommended rate. Variability caused by environmental conditions is accounted for in increasing the minimum treatment rate. For example, a deep lake with cool water and low in organics, submerged vegetation and turbidity will require less rotenone than a shallow lake with warm water high in organics, submerged vegetation and turbidity. The minimum treatment rate was increased to 0.075 mg/L rotenone to account for likely possibility that the shallow lake depth will increase the rate of photolysis, the warm water conditions will increase the rate of hydrolysis, and the abundant submerged aquatic vegetation containing high sediment and silt loads will sequester the rotenone, all of which will lower the rotenone concentration and increase the dissipation of rotenone from the water column. Additionally, lethal levels of rotenone must persist long enough to penetrate low water circulation shoreline areas favored by young Smallmouth Bass.

3. *Change in Treatment Rate* – Based on ongoing baseline data collection, if it is deemed necessary to increase the treatment rate, sufficient details will be provided to DFO.
4. *Intermittent Inlet Tributaries* (UPDATE in APPENDIX B with criteria for drip station placement on 5 inlets and electrofishing protocol) – There are 4 inlets to Miramichi Lake (see map in Figure 3 of the AIS application). They will be electro-fished prior to treatment for presence of Smallmouth Bass. In mid-September these are expected to be at or near base-flow conditions if not dry. If no Smallmouth Bass are detected, each tributary will be treated only 100 m upstream from its confluence with the lake to eliminate any refugia for the bass and prevent the intrusion of rotenone-free water into the lake. Coordinates for the drip stations are:
    1) 46°27'32.76"N, 66°57'30.24"W
    2) 46°27'3.46"N, 66°57'25.94"W
    3) 46°27'22.90"N, 66°58'53.36"W
    4) 46°27'49.88"N, 66°59'29.97"W

    Lake Brook – (UPDATE: Given the known presence of SMB in Lake Brook, the brook will also be treated. Drip stations located along Lake Brook and the east branch of Lake Brook for rotenone treatment (placement TBD based on flows immediately prior to treatment to ensure target concentration of 0.075 mg/L

rotenone is sustained in the brook during treatment. The rotenone will be deactivated in Lake Brook prior to reaching the SW Miramichi River; the deactivation station will be located at least 30 minutes water travel time upstream from the brook's confluence with the SW Miramichi River. Maintaining 4 ppm residual of $KMnO_4$ in the deactivation zone will ensure that rotenone is deactivated by the time it reaches the SW Miramichi River, and that lethal conditions are sustained in the lower reach of the brook given that SMB distribution includes the brook. Upon flowing into the SW Miramichi River, the 4 ppm $KMnO_4$ will be immediately diluted to non-lethal levels, and the rotenone will have been deactivated. Please see monitoring detail and map locations in APPENDIX E.)

Lake Brook will be treated and will also contain rotenone-containing water leaving Miramichi Lake. As a precaution to ensure that rotenone does not affect aquatic life in the Southwest Miramichi River, rotenone will be deactivated with potassium permanganate at least 30-minutes water travel time upstream of the confluence of the two streams until rotenone subsides below 0.0375 mg/L in Miramichi Lake. The 35:1 dilution with the Southwest Miramichi River will further lower rotenone concentrations below biological effect and detection levels (< 0.002 mg/L).

Wetlands – Only wetlands that are contiguous with Miramichi Lake will be affected by the treatment, and there are no Provincially Significant Wetlands in the project vicinity.

5. *Deactivation Procedures* – The deactivation procedures are described in detail in SOP 7.1 of the Rotenone SOP Manual (Finlayson 2018)[6] and are based on the rotenone-permanganate kinetic studies of by Engstrom-Heg (1972)[7]. The objective is to keep the oxidation/reduction reaction in balance by maintaining 1 mg/L permanganate residual at a point, 30-minutes downstream of the permanganate injection site (UPDATE in APPENDIX E: residual will be maintained at 4 ppm in the deactivation zone in lower Lake Brook to maintain lethal levels for fish while deactivating rotenone; SMB are now known to be in the brook and lethal conditions are needed throughout its entirety; 4 ppm KNnO4 will be immediately diluted in the SW Miramichi River to non-lethal levels). Adjustments to the injection of permanganate are accomplished through a feed-back loop of directly or indirectly measuring the permanganate residual using a spectrophotometer and relaying the results via radio to the operator of the

[6] Finlayson, B., D. Skaar, J. Anderson, J. Carter, D. Duffield, M. Flammang, C. Jackson, J. Overlock, J. Steinkjer, and R. Wilson. 2018. Planning and Standard Operating Procedures for the Use of Rotenone in Fish Management – Rotenone SOP Manual, 2nd edition. American Fisheries Society, Bethesda, Maryland.

[7] Engstrom-Heg, R. 1972. Kinetics of rotenone-potassium permanganate reactions as applied to the protection of trout streams. New York Fish and Game Journal 19(1):47-58.

deactivation station. Potassium permanganate is toxic to aquatic life at relatively low concentrations in clean laboratory water free of permanganate demand, but the toxicity decreases an order of magnitude in natural water sources (Hobbs et al. 2006[8]; Marking and Bills 1975[9]). Toxic levels of permanganate are reduced through the oxidation of organic components and rotenone when permanganate is in balance with rotenone. When rotenone concentrations subside below 0.0375 mg/l (likely 2-3 days after application) in Miramichi Lake, the deactivation station will be turned off since the expected dilution in the Southwest Miramichi River will eliminate rotenone residues downstream of the confluence. There is an approximate 35:1 dilution of Lake Brook in the Southwest Miramichi River, also lowering the 1.0 mg/L permanganate residual to 0.028 mg/L permanganate, a level far below known aquatic toxicity levels even in clean water (Hobbs et al. 2006). We are unaware of long-lasting effects of using potassium permanganate as described above beyond those already caused by rotenone.

II. *Aquatic Invasive Species Requirements* Section 28(2)(a)

1. *Mussel Bed Investigations* – Mussel beds were investigated in several shallow areas of the lake and samples submitted to provincial specialist for identification. Sites included: 46°27'6.88"N, 66°57'32.06"W; 46°27'45.25"N, 66°59'21.77"W; 46°27'46.67"N, 66°57'59.76"W. No Yellow Lampmussel or Brook Floater were identified. For a more comprehensive approach, a team from Anqotum Resource Management will conduct a systematic mussel survey of the lake, supplemented by eDNA sampling, to identify mussel species in the lake. The survey map has been provided to DFO AIS staff. The work will be completed during the week of September 15, 2019, and results communicated to DFO when finalized. (UPDATE: survey provided in APPENDIX C).
2. *Brook Floater Studies* – There are no tests or evidence on the toxic effects of rotenone specifically to the Brook Floater. Tests and studies have been completed on other freshwater mollusk species and are referenced in the application. We have no evidence that suggests the Brook Floater would respond any differently than the mollusk species previously tested. Furthermore, eradication of invasive Smallmouth Bass eliminates a threat to Brook Floater and

[8] Hobbs, M., R. Grippo, J. Farris, B. Griffin, and L. Harding. 2006. Comparative acute toxicity of potassium permanganate to nontarget aquatic organisms. Environmental Toxicology and Chemistry 25(11):3046-3052.
[9] Marking, l., and T. Bills. 1975. Toxicity of potassium permanganate to fish and its effectiveness for detoxifying antimycin. Transactions of American Fisheries Society 104:579-583.

is in-keeping with the broad strategies outlined in the DFO's Management Plan for the species (DFO 2018)[10].

3. *Brook Floater Host Fish Species* – The Brook Floater mussel has been assessed by COSEWIC (2009)[11] as Special Concern and DFO has developed a Management Plan (DFO 2018) to identify broad strategies for addressing threats. Invasive species such as Smallmouth Bass pose a threat to the Brook Floater primarily through impacts to its host fish species. A persisting Smallmouth Bass population in Miramichi Lake and the risk of its escape into the Southwest Miramichi River poses a threat to existing known assemblages of Brook Floater downriver. The distribution of the mussel in Miramichi Lake is not known. Therefore, surveys will help identify presence/absence and distribution in the area, and eradication of Smallmouth Bass will eliminate the threat to Brook Floater and its host species. A permanent eradication plan will contribute to the protection of the Brook Floater in the Lake (if present) and in the Southwest Miramichi River (known assemblages).

   Host species including Golden Shiner and Brown Bullhead will likely survive the treatment and White Sucker and Yellow Perch are high priorities for re-establishment in Miramichi Lake. If Brook Floater are found to be present in the Lake, known host fish species will be given priority status for reintroduction.

4. *Effects on Plankton* – Freshwater mussels filter feed on algae, detritus, and bacteria. Rotenone at the dosage prescribed for treatment in Miramichi Lake is not toxic to phytoplankton, and no decrease in phytoplankton abundance is expected following the treatment. Two studies suggest that algae as a group are tolerant of rotenone: Maione and Gibbs (1985)[12] exposed alga *Chlamydomonas reinhardi* chloroplasts to 59 mg/L rotenone with no effect on photosynthesis, and van Leeuwen et al. (1992)[13] proposed a QSAR equation for the alga *Selenastrum capricornutum* that results in an estimated 96-h EC50 value of 1.8 mg/L rotenone. To the contrary, there will likely be an increase in phytoplankton

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[10] Department of Fisheries and Oceans Canada (DFO). 2018. Management Plan for the Brook Floater (Alasmidonta varicosa) in Canada. Species at Risk Act Management Plan Series. Department of Fisheries and Oceans Canada, Ottawa. iv + 42 pp.

[11] COSEWIC. 2009. COSEWIC assessment and status report on the Brook Floater *Alasmidonta varicose* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 79 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

[12] Maione, T., and M. Gibbs. 1986. Association of the chlorophastic respiratory and photosynthetic electron transport chains of *Chlamydomonas reinhardi* with photoreduction and the oxyhydrogen reaction. Plant Physiology 80:364-368.

[13] van Leeuwen, D., P. van der Zandt, T. Aldenberg, H. Verhaar and J Hermens. 1992. Application of QSARs, extrapolation and equilibrium partitioning in aquatic effects assessment. I. Narcotic industrial pollutants. Environmental Toxicology and Chemistry 11:267-282.

abundance as nutrients from the decaying fish carcasses are released into the water column. Subsequently, an increase in zooplankton abundance will occur when rotenone subsides to nonlethal levels (Bradbury 1986[14]; Eilers et al. 2011[15]). A reduced food source to overwintering mussel species in Miramichi Lake is not supported by the evidence.

5. [1.] *Impacts to Zooplankton and Alewife* – Section [4.5] of the application suggests a fall treatment will enhance the recovery of YOY alewife forage items (i.e., zooplankton) the following spring. Given the lower abundance of predacious fish in Miramichi Lake following the fall rotenone treatment, it is expected that zooplankton population levels will be higher than normal the following spring providing YOY alewife with a substantial forage base. Eilers et al. (2011) found that the post-treatment recovery of zooplankton and benthic invertebrates exceeded rotenone pre-treatment levels in Diamond Lake, Oregon; invertebrate abundance returned to pre-treatment levels within 1 to 2 years. The evidence suggests zooplankton abundance in Miramichi Lake will recover to pre-treatment, if not greater, levels given the general lack of predators and provide an abundant food source to Alewife the following spring and summer. Our primary concern regarding alewives in Miramichi Lake is DFO's ongoing barrier at the lake outlet which presents a long-term impact to natural migration patterns. With a successful eradication of Smallmouth Bass, the barrier will no longer be required.

III. Additional Information on Reestablishment Strategy

1. *Effects on Fish Surviving Treatment* – To our knowledge, studies specifically looking at the feeding and reproductive behavior of fish surviving rotenone treatments have not been done. Seldom do natural resources management activities involve only a single action, and the effects are often difficult to separate. Nonetheless, it is expected that disruption of food webs and the potential impact on surviving fish will be heavily mitigated by the reduction in numbers of competitors and predators. Brown Bullhead survived the 2007 0.050 mg/L rotenone treatment of Lake Davis, California for Northern Pike eradication (Vasquez et al. 2012)[16], and Golden Shiner likely survived the 2006 0.100 mg/L rotenone treatment of Diamond Lake, Oregon for Tui Chub eradication

[14] Bradbury, A. 1986. Rotenone and trout stocking. A literature review with special reference to Washington Department of Game's Lake Rehabilitation Program. Washington Department of Game, Olympia.

[15] Eilers, J., H. Truemper, L. Jackson, B. Eilers, and D. Loomis. 2011. Eradication of an invasive cyprinid (Gila bicolor) to achieve water quality goals in Diamond Lake, Oregon (USA). Lake and Reservoir Management 27:194-204.

[16] Vasquez M., Rinderneck, J., Newman, J., McMillin, S., Finlayson, B., Mekebri, A., Crane, D., and R. Tjeerdema. 2012. Rotenone formulation fate in Lake Davis following the 2007 treatment. *Environmental Toxicology and Chemistry* 31(5): 1032-1041.

(Finlayson et al. 2014; J. Eilers, MaxDepth Aquatics, personal communication). Eradication of Smallmouth Bass will allow for the recovery of the existing fish species (minus SMB) by eliminating the need for DFO's long-term control and reduce program which impacts these other species.

2. *Clarification on Golden Shiner* – The high priority for re-introducing the Golden Shiner into Miramichi Lake in Table 4 is incorrect. Golden Shiner reintroduction should be a low priority because it will likely survive the treatment.
3. *Timeline for Re-establishment of Migratory species* – Section 4.2 of the application states that several diadromous species have been recorded in Miramichi Lake that include American Eel, Sea Lamprey, Atlantic Salmon, and Alewife. Most notable of these are the Alewife with large spawning runs (tens of thousands) that are known to enter Miramichi Lake each spring with significant numbers of YOY leaving in July and August (DFO 2009[17]; DFO 2013[18]).
4. *Details of Fish Re-introduction Strategy* (UPDATE: Stand-alone Re-establishment Plan provided in APPENDIX D) - Based on a DFO survey from 2010, there are a total of 17 known fish species including Smallmouth Bass present in Miramichi Lake (DFO 2013). The remaining species appear to be native to New Brunswick but not necessarily to Miramichi Lake. Removing the vast majority of the ichthyofauna from Miramichi Lake presents an opportunity to reestablish a community that is closer to what may have been historically present, if such records existed. There is a dire lack of records regarding historic fisheries data from Miramichi Lake and therefore no obvious goal for reintroduction. Instead, this project focuses on restoring the existing ichthyofauna with high priority. High priority was given to those species whose life-cycle is mostly constrained to the lake. There is no literature or guidance on ideal numbers to restock. Obviously, the more fish restocked, the more successful the reintroduction is likely to be, and the quicker the lake should recover. Recolonization is constrained by practicality and cost. The revised Table 4 from the application (see below) lists the proposed numbers and priority for reintroduction based on relative abundance of individuals captured by DFO (2013), and hence is the best available data to represent existing community structure. It is anticipated that these fish will be captured and released back into Miramichi Lake once rotenone subsides to nonlethal levels (< 0.002 mg/L).

[17] DFO. 2009. Potential impact of smallmouth bass introductions on Atlantic Salmon: A Risk Assessment. DFO Canadian. Science Advisory Secretariat Advisory Report 2009/003.
[18] DFO. 2013. Review of control and eradication activities in 2010 to 2012 targeting Smallmouth Bass in Miramichi Lake, New Brunswick. DFO Canadian. Science Advisory Secretariat Science Response 2013/012.

Greater detail will be provided by a formal Fish Reintroduction Plan following approval of the project.

5. *Rare Species Reintroduction* (UPDATE: Stand-alone Re-establishment Plan provided in APPENDIX D with no requirement of holding fish on-site) – As stated above, there is a dire lack of records regarding historic fisheries data from Miramichi Lake and therefore no obvious goal for reintroduction. Instead, the project will focus on restoring the existing ichthyofauna with high priority. Numerically rare species were given a low priority as the likelihood of capture for reintroduction may require exhaustive fishing effort, and there is no evidence that the numerically rare species are native to Miramichi Lake.

Table 4. Proposed priorities and maximum number of fish to be reintroduced into Miramichi Lake. Actual efforts may produce lower numbers due to unforeseen circumstances.

Species	Proposed Numbers	Priority for Reestablishment
1. Yellow Perch	1,000	High
2. White Sucker	1,000	High
3. White Perch	1,000	High
4. Fallfish	200	High
5. Common Shiner	200	Low
6. Gaspereau (Alewife)	0	Low
7. Golden Shiner	200	Low
8. Brown Bullhead	200	Low
9. Banded killifish	200	High
10. American eel	100	Low
11. Brook Trout	0	Low
12. Creek chub	0	Low
13. Lake chub	0	Low
14. Sea lamprey	0	Low
15. Atlantic Salmon	0	Low
16. Pearl dace	0	Low

6. *Highly Diverse Fish Community* – There are few lakes of similar size near Miramichi Lake except for Nashwaak Lake which is not in the Miramichi River watershed, so comparisons of fish diversity and uniqueness are difficult. There is no evidence that Miramichi Lake is a unique environment given that it is open to the Southwest Miramichi River, and fish species including Smallmouth Bass have been illegally introduced. We contend that the entire Southwest Miramichi watershed is a unique environment in that it is a native ecosystem that has not been widely impacted by aquatic invasive species like so many other watersheds throughout the region, and that there is urgency to protect it through eradication of Smallmouth Bass.
7. *Temporary Native Fish Containment Water Supply* (UPDATE: Stand-alone Re-establishment Plan provided in APPENDIX D with no requirement of holding fish on-site) – The temporary, two-week, native fish containment facility that is planned will be in close proximity to the lake and will require a source of cold fresh water. There is a small cold, spring fed stream on the eastern edge of the lake adjacent to the cottages. The stream flows at about 3,000 L/min at a temperature of approximately 12 °C all year. This source of water could be diverted to the temporary containment facility. Alternatively, the water supply to the cottages that comes from a small reservoir above the buildings could be used for the temporary containment facility.
8. *Holding Conditions for Native Fish* (UPDATE: Stand-alone Re-establishment Plan provided in APPENDIX D with no requirement of holding fish on-site) – Fish will be contained in sterilized hatchery tanks supplied by the MSA and set up using a flow through system for a continuous supply of cold water and oxygen. Fish will be fed frozen whole krill, an effective feed for wild fish in captivity.
9. *Survival of Reintroduced Native Fish* (UPDATE: Stand-alone Re-establishment Plan provided in APPENDIX D with no requirement of holding fish on-site) – We cannot predict with any certainty that all of the reintroduced fish will survive to the next season, regardless of food abundance. When rotenone degrades below lethal levels, zooplankton populations will rebound and provide a food source for the reintroduced fish (Bradberry 1986; Eilers et al. 2011). This should be an adequate food source given the small numbers of fish reintroduced to the lake compared to the pre-treatment fish abundance. A study of rotenone used in a New Zealand stream to eradicate Brown Trout documented severe invertebrate density reductions, but invertebrate density returned after one year (Pham et al. 2013)[19]. In this study, the native galaxid species was reintroduced to the system within 10 days, and while a reduction of fish condition was observed, the

[19] Pham, L., D. West, and G. Closs. 2013. Reintroduction of a native galaxid (*Galaxias fasciatus*) following piscicide treatment in two streams: response and recovery of the fish population. Ecology of Freshwater Fishes 22:361-373.

reintroduction was generally successful. We expect the zooplankton population in Miramichi Lake with rotenone-resistant dormant eggs to rebound more quickly than insect populations in lotic environments which generally have complex terrestrial and aquatic life stages.

IV. Additional Information on Monitoring Plans (UPDATE: Stand-alone Monitoring Plan provided in APPENDIX E)

1. *Monitoring Protocols*

Monitoring Sites – Six monitoring sites will be located using GPS on Miramichi Lake at various depths: two sites 10 m from the shoreline, two sites at mid-depth, and two sites at the maximum depth; the six sites will be used for monitoring all parameters in Miramichi Lake. Two sites will be located on Lake Brook, one site immediately upstream of the deactivation station and one site 30-minutes water travel-time downstream at the end of the deactivation zone; the two sites will be used for only monitoring rotenone and potassium permanganate. Two sites will be located on Southwest Miramichi River, one site immediately upstream of Lake Brook and one site 5-minutes water travel-time downstream at the end of the confluence mixing zone; the two sites will be used for only monitoring rotenone and potassium permanganate.

Rotenone – The protocols for analyzing rotenone concentrations in lake and stream water are detailed in SOP 16.1 of Finlayson et al. (2018) and utilize liquid chromatography (LC) as described by Dawson et al. (1983)[20] or Sandvick et al. (2018)[21] or direct injection liquid chromatography/mass spectrometry (LC/MS) as described by Vasquez et al. (2012)[22]; these analyses have a MDL of 0.001 mg/L and RL of 0.002 mg/L rotenone. Water samples will be collected using a Kemmerer bottle in the lake or directly a few inches below the water surface in streams. Samples are put in 250-ml amber glass bottles with Teflon-lined caps, stored chilled (4 °C), and transported to the laboratory for analysis with chain-of-custody forms.

Potassium Permanganate – The protocols for the on-site analysis of potassium permanganate concentrations in water upstream and downstream of the deactivation station are detailed in SOP 7.1 of Finlayson et al. (2018) and utilize

[20] Dawson, V., P. Harmon, D. Schultz, and J. Allen. 1983. Rapid method for measuring rotenone in water at piscicidal concentrations. Transactions of American Fisheries Society 112:725-727.
[21] Sandvik, M., T.Waaler, T. Rundberget, P. Adolfsen, H. Bardal, and R. Sandodden. 2018. Fast and accurate on-site determination of rotenone in water during fish control treatments using liquid chromatography. Management of Biological Invasions 9. Doi: 10.339/mbi.2018.9.1.06.
[22] Vasquez, T., J. Rinderneck, J. Newman, S. McMillin, B. Finlayson, A. Mekebri, D. Crane, and R. Tjeerdema. 2012. Rotenone formulation fate is Lake Davis following the 2007 treatment. Environmental Toxicology and Chemistry 31(5):1032-1041.

either direct (Standard Method 4500-$KMnO_4$ B)[23] or indirect (USEPA DPD Method 8167 for Total Chlorine) colorimetry.

Phytoplankton – Grab water samples (1-L) for phytoplankton will be collected at 0.5 m depth and preserved in Lugol's solution, subsamples will be permanently mounted on slides, and measured transects are scanned at 1000× magnification using a phase-contrast compound microscope and identified to the most practical taxonomic level. Counting will be generally limited to 100 cells per sample. Biovolume estimates are calculated for each algal unit (for filamentous algae, the biovolume unit was standardized to 100 *µ*m length of filament) based on measurements of average algal length and diameter.

Zooplankton – Zooplankton are collected by vertical tows of plankton net from a depth of 3m. The net has a 20 cm opening with a 30 cm reduction collar and a mesh size of 64 *µ*m. Zooplankton will be identified to the most practical level.

Benthic Invertebrates – The rocky bottom of Miramichi Lake will influence the sampling gear used. The benthic macroinvertebrate data will likely be collected in triplicate using a petite PONAR (152 × 152 mm) dredge from the six monitoring sites. The samples will be sieved through a 500-*µ*m mesh and aggregated in major taxonomic groups; some samples will be retained for analysis to species level. When identified to species, samples with more than 500 organisms will be subsampled using a Caton gridded tray with a 500-*µ*m wire mesh and 30 grids to expand raw samples.

Fishes – A combination of electrofishing and netting methods (fyke, seine, minnow trap) will be employed over a 3-year post-treatment monitoring period to evaluate recovery of fish species. The diversity of methods will ensure different size classes of the various fish species are captured. This approach will generate catch per unit effort data to characterize fish community structure and provide relative abundance of the re-establishing fish species.

2. *Post-Treatment Assessment of Smallmouth Bass* – The effectiveness of the treatment in Miramichi Lake will be monitored using a combination of caged sentinel fish of equal or less sensitivity to rotenone than Smallmouth Bass and collecting water samples for rotenone analysis. The sentinel fish will be located at the six monitoring sites listed above at 0.5 m below the water surface and 0.5 m above the lake bottom and will be checked at 2 days after the application. Similarly, water samples will be collected at these sites and depths 2 days after

[23] American Public Health Association. 1998. Standard methods for the examination of water and wastewater, 20th edition. American Public Health Association, Washington, D.C.

the application is complete. Rotenone residues will continue to be monitored at weekly intervals until rotenone is below detection limits (<0.002 mg/L rotenone).

A combination of electrofishing and netting techniques (fyke, seine, minnow trap) for a 3-year post-treatment period will provide data for evaluating the success of eradicating Smallmouth Bass from Miramichi Lake (i.e., the current DFO control program should be continued for 3 years to monitor for SMB). The distribution of Smallmouth Bass in Miramichi Lake is well known so the chance of false negative findings is relatively small. Additionally, samples for eDNA analysis will be collected from these areas of known Smallmouth Bass inhabitation. The absence of Smallmouth Bass from manual fish collection techniques or the lack of Smallmouth Bass eDNA in water are by themselves not conclusive evidence of their absence, but the two techniques used together increases the level of certainty that they are absent.

V. Other Information Requests

1. *Re-establishment of Brook Trout Fishery* (UPDATE: Stand-alone Re-establishment Plan provided in APPENDIX D) – At a meeting between the Proponent, the Working Group, DFO, and the province on August 14, 2018, risk mitigations against future Smallmouth Bass introductions were discussed. The idea of reintroducing Brook Trout and reestablishing a highly valued recreational fish species to appease camp owners was discussed and specifically identified by DFO's Alain Hebert as a good example of a risk mitigation against future AIS introductions. Based on this input from DFO it was included in the AIS application.

2. *Risk of Smallmouth Bass Re-introduction* – It is impossible to determine the level of risk of future illegal reintroductions (by humans) of Smallmouth Bass into the lake. However, the risk can be minimized through pro-active public engagement and public/media messages with educational material on the threat of aquatic invasive species. DFO, the province, and the Working Group all have roles to play to educate the public and reduce the risk of further introductions. Our public engagement plan is available in van den Heuvel et al. 2017[24] and includes public education measures to reduce risk of future AIS introductions. As of September 2017, Miramichi Lake was the only waterbody in New Brunswick that

[24] van den Heuvel, M., C. Pater, B. Finlayson and D. Skaar. 2017. Exploring options for eradication of Smallmouth Bass in Miramichi Lake. Report prepared for the Working Group on Smallmouth Bass Eradication in Miramichi Lake. September 2017.

had a confirmed population of Smallmouth Bass (van den Heuvel et al. 2017[25]; DFO 2013; DFO 2009). The other waterbodies in Gulf Region that contain Smallmouth Bass are in Nova Scotia. To date, there is no other confirmed population of Smallmouth Bass in the Gulf Region of New Brunswick so there is no chance of passive reinvasion via contiguous water bodies. Illegal reintroduction of Smallmouth Bass by humans would be the sole vector for reinvasion into Miramichi Lake.

3. *Role of Province of New Brunswick* – The Province of NB has confirmed that they have equipment and human resources that could be diverted to the project. Pending approval, project logistics would be planned with DFO, the Province and other project partners to determine capacity, expertise and specific roles required for successful execution of the work.

4. *Dead Fish Collection Plan* – A combination of shore-based and boat-based surface collection using dip nets will be used for one week, if necessary longer, following treatment. Effort will be focused on the eastern side of the lake where all of the camps are located. The number of boats and land staff required is dependent on the amount of dead fish present, usually not more than 30% of the itchyofauna present. This will improve theaesthetics around the lake by minimizing the number of dead fish. Two nearby sites on provincial crown land have been identified as potential disposal sites. Both sites are greater than 30m from a watercourse. Site 1 is an old gravel pit approximately 200m to the southeast of the public boat launch with coordinates 46°26'58.57"N, 66°57'28.36"W. Site 2 is located 1.2km to the west of the public boat launch at the end of a forest road at 46°27'3.79"N, 66°58'35.48"W. We will work with the Department of Environment and Local Government to finalize which site is most appropriate and apply for necessary provincial permits.

5. *Permit for Temporary Fish Containment Facility Water Supply* (UPDATE: Stand-alone Re-establishment Plan provided in APPENDIX D with no requirement of holding fish on-site) – An application has not yet been submitted for a provincial WAWA permit, nor is it necessary as a precondition of the AIS application process as identified on the application itself: *"Notwithstanding any Authorization received subsequent to this application, the Proponent must ensure compliance with all other relevant provincial and federal legislation and regulations…*"

[25] van den Heuvel, M., C. Pater, B. Finlayson and D. Skaar. 2017. Exploring options for eradication of Smallmouth Bass in Miramichi Lake. Report prepared for the Working Group on Smallmouth Bass Eradication in Miramichi Lake. September 2017.

6. *Consultation with New Brunswick for Environmental Compliance* (UPDATE: DELG has determined no EIA is required because the risk of further SMB spread and its permanent consequences outweighs the temporary risks of a treatment) – We have established contact with DELG regarding the Environmental Impact Assessment process.

VI. Section 35(1) of Fisheries Act Information

1. *Watercourse Crossing Construction* – No
2. *Shoreline Alteration* – No
3. *Reductions in Water Flow* – No
4. *Habitat Alteration Associated with Fish Removal* – No
5. *Fording Sites* – No

VII. Aboriginal Communities' and First Nations' Concerns

1. *Impacts to Native Fish Communities* – Addressed in the AIS application and in the responses to the request for more information.
2. *Impacts to Aquatic Invertebrate Species* – Addressed in the AIS application and in the responses to the request for more information.
3. *Risk for Smallmouth Bass Reintroduction* – Addressed in the AIS application and in the responses to the request for more information.
4. *Less Destructive Means of Smallmouth Bass Eradication* – In 2010, DFO initiated a 3-year containment, control program using physical removal methods of electrofishing, gillnetting and fyke-netting. Eradication was not achieved since all life-history stages of Smallmouth Bass are still present to this day (DFO 2013). The effort demonstrated that eradication of Smallmouth Bass using physical methods is difficult given the moderate size of Miramichi Lake (220 ha), summer warm water temperatures (≤ 28.7°C) and ample spawning substrate. The control program has had impacts on other species in the lake. The extensive fishing effort with gillnets resulted in the detectable reduction in the abundance of other species including White Perch, White Sucker and Yellow Perch (DFO 30103). Furthermore, DFO's barrier at the lake outlet has an impact on natural migratory patterns of alewives.

   The report prepared for the Working Group on the Smallmouth Bass Eradication in Miramichi Lake, van den Heuvel et al. (2017), assessed several eradication options including the control and reduce method that has been used by DFO from 2009 until present, biological control and genetic methods (i.e., predators and pathogens), explosives (i.e., depth cord), dewatering and genetic manipulation (i.e., sterile fish). In summary they concluded that control and

reduce strategies are ineffective worldwide, and that in many circumstances eradication is only attained through the use of chemical means or in theory, dewatering. It is impractical to dewater Miramichi Lake given its location and geography. Rotenone is the only chemical registered in Canada under PMRA for fish control, and it is more successful than the other suppression efforts in attaining eradication (Meronek et al. 1996[26]). It is safe to use by humans, and is a widely used and well understood method (including in Canada) for controlling unwanted invasive species with a high likelihood of success at Miramichi Lake. In summary, there are no less destructive means of attaining Smallmouth Bass eradication in Miramichi Lake. It is well established that the native ecosystem recovers quickly after a rotenone treatment and the overall impact is temporary; this contrasts to DFO's current long term control and reduce program that is having significant impacts on the lake's fish community.

[26] Meronek, T., P. Bouchard, E. Buckner, T. Burri,. K. Demmerly, D. Hateli, R. Klumb, S. Schmidt and D. Cobel. 1996. A review of fish control projects. North American Journal of Fisheries Management 16:63-74.

APPENDIX B

DFO Request for Additional Information (2) and NSMDC Response

Fisheries and Oceans Canada | Pêches et Océans Canada

Aquatic Invasive Species National Core Program
343 Université Avenue
P.O. Box 5030
Moncton, New Brunswick
E1C 9B6

December 20, 2019

Your file *Votre référence*
19-IGLF-00001

Jim Ward
North Shore Micmac District Council Inc.
38 MicMac Road
Eel Ground, New Brunswick
E1V 4B1

Dear Mr. Ward

Subject: Additional information is required for the review of your request.

The Aquatic Invasive Species National Core Program (the Program) of Fisheries and Oceans Canada submitted a request for additional information to you on June 24, 2019. The Program received your response to this request for additional information on September 13, 2019. The Program has also received your request to increase the scope of your project to include approximately 10 kilometers of the Southwest Miramichi River on November 21, 2019.

On December 19, 2019, a science peer review report entitled "Review of elements of proponent application to use rotenone for the purpose of eradicating Smallmouth Bass (*Micropterus dolomieu*) from Miramichi Lake, New Brunswick. DFO Can. Sci. Advis. Sec. Sci. Resp. 2019/040" has been published on the Canadian Science Advisory Secretariat (CSAS) website (http://www.dfo-mpo.gc.ca/csas-sccs/Publications/ScR-RS/2019/2019_040-eng.html).

The Program has evaluated the information you have provided, as well as the CSAS advice received, to determine if our questions in relations to your initial project application for the deposit of deleterious substance to control Smallmouth Bass in Miramichi Lake have been addressed. Our review has determined that some information and documentation is still required. In order for us to complete the review of your proposal and to determine if an authorization should be issued for the deposit of a deleterious substance to control the targeted aquatic invasive species (AIS), we ask that you provide the following additional information:

Pesticide treatment:

The characterization of the inlet tributaries of the lake identified as being intermittent in the application is not consistent with field observations by DFO staff that have conducted work in the area. For example, the first section of Four Mile Brook is swampy with minimal change in elevation up to about 1 km upstream. Additionally, the channel configuration of the lower section of some of these brooks are complex. All brooks associated to the lake need to be properly surveyed to identify the most appropriate locations for drip stations. We ask that you provide a detailed survey plan to characterize the inlet tributaries, including criteria that will be used for determining drip station locations.

For complete removal of target fish from an area it is imperative that all habitats capable of supporting target fish are treated, unless there is conclusive evidence that the target fish are absent. It is the Programs understanding that you are proposing to conduct an electrofishing survey of all inlets to the lake prior to treatment to assess the presence of Smallmouth Bass. We ask that you provide detailed information on the proposed electrofishing survey, including timelines, extent of the survey and level of effort to be conducted. Please keep in mind that the characterization of inlet tributaries will help inform your electrofishing survey.

Survival of target fish can result from insufficient and inaccurate project area mapping of the treatment area. It is imperative that the entire treatment area be surveyed for potential treatment efficiency weaknesses such as upwelling groundwater (i.e. seeps / springs), barriers to water movement including but not limited to aquatic vegetation, marshy areas, and beaver dams. We ask that you provide all relevant information including location of all potential treatment weaknesses in the treatment area and how they will be addressed to minimize eradication failure.

It is essential to utilize accurate and up-to-date water volume and flow data in the planning and execution of the proposed project. Some physical characteristics and hydrological features provided in your application are not consistent with values reported elsewhere in the literature. The estimated mean annual flow of 0.45 m^3/s provided for Lake Brook does not concord with previously reported estimates. According to Chaput and Caissie (2010), the mean annual lake outflow was estimated to be 1.06 m^3/s and the combined mean annual flow from Miramichi Lake and Lake Brook was 1.38 m^3/s. Additionally, there are discrepancies between available documentation of the estimated volume of Miramichi Lake. The New Brunswick Department of Energy and Resource Development lake depth database reports that Miramichi Lake has a surface area of 2.24 km^2 and a volume of 5.790 million m^3, which is almost half the estimated volume of 11.492 million m^3 provided in your application. The mean annual flows and lake volume estimates of the project need to be verified and validated. We ask that you provide accurate estimates of water flow and lake volume, as well as description of how the estimates were determined.

Species at Risk:

In your response you have indicated that a systematic mussel survey of Miramichi Lake has been conducted by Anqotum Resource Management during the week of September 15, 2019. We ask that you provide a detailed stand-alone report from this investigation. Ensure that the report includes the detailed survey protocols, sampling locations (i.e. map, GPS locations, etc.), level of sampling effort and results.

Re-establishment strategy:

A re-establishment strategy was proposed in your application however, a detailed formal re-establishment strategy has not been provided to the Program. In order to be considered as potential mitigation for impacts to fish and fish habitat, we ask that you provide a formal stand-alone detailed re-establishment plan. In addition to information already provided, the re-establishment plan must include a well-defined objective (i.e. targeted outcome) for the re-establishment efforts, biological information of fish to be reintroduced (e.g. age class, sexual maturity, etc.) and details related to the proposed temporary containment. Sufficient details are required around the proposed stream water diversion to feed the fish holding tanks in order to evaluate the activities against the Fish and Fish Habitat Protection and Pollution Prevention provisions of the *Fisheries Act.* The science peer review mentioned above provides information

.../3

for your consideration in section "Validity of proposed mitigation measures to "offset" the impacts described above, in particular the effectiveness of proposed re-establishment strategy" when addressing this request.

Monitoring:

It is DFO's understanding that you are proposing 3 types of monitoring which can be classified as 1) treatment application monitoring; 2) eradication efficiency monitoring; and 3) environmental impact monitoring. The Program requires an unambiguous stand-alone monitoring plan with associated protocols for our assessment. We ask that you provide monitoring activities broken down by monitoring type described above. Ensure to clearly include monitoring objectives, assessment criteria, sampling locations and frequency, monitoring timelines and any pre-treatment monitoring required for comparison purposes.

Proposed increase of treatment area:

As a result of your request to increase the proposed treatment area to include approximately 10 kilometers of the Southwest Miramichi River where Smallmouth Bass have been confirmed, the Program will require a detailed project description in order to amend the current project. We ask that you provide all project amendment information using the Request to Authorize the Deposit of a Deleterious Substance application form. Ensure to clearly include all changes to the current project application resulting from the proposed amendment.

If it is felt there is a need to clarify the information being requested by the Program, we would be available to discuss in further detail. If this is the case, please let us know and we will schedule a meeting at the earliest convenience.

If you have any questions or want to schedule a meeting, please contact me directly at our Moncton office at 506-851-7244, or by email at XGLFInvaders@dfo-mpo.gc.ca. If any part of your current proposed project has changed please advise the Program immediately referencing your file number above.

Yours sincerely,

Daniel Bourque
Aquatic Invasive Species Regional Coordinator Biologist

Cc. Fabiola Akaishi (DFO), Guy Robichaud (DFO), Paulette Hall (DFO)

Response to Aquatic Invasive Species National Core Program of DFO (dated December 20, 2019) Regarding 2nd Request for Additional Information for the Application to Eradicate Smallmouth Bass from the Miramichi Watershed (19-IGLF-00001)

Submitted by: North Shore Micmac District Council Inc.

Submitted to: Fisheries and Oceans Canada (Gulf Region)

Date: April 7, 2020

Question 1

The characterization of the inlet tributaries of the lake identified as being intermittent in the application is not consistent with field observations by DFO staff that have conducted work in the area. For example, the first section of Four Mile Brook is swampy with minimal change in elevation up to about 1 km upstream. Additionally, the channel configuration of the lower section of some of these brooks are complex. All brooks associated to the lake need to be properly surveyed to identify the most appropriate locations for drip stations. We ask that you provide a detailed survey plan to characterize the inlet tributaries, including criteria that will be used for determining drip station locations.

Response: Characterization of Inlet Tributaries and Drip Station Placement

Inlet tributaries will be surveyed and characterized at the latest by mid-July, with GPS locations and flagging tape identifying the point at which each stream enters the lake. The criterion to identify this confluence point for each inlet tributary includes where the gradient of flowing water from the stream meets the gradient of the lake water level (i.e., where discernible flowing stream water ends and begins to be back-flooded by the lake's water level). This approach ensures that flowing waters are effectively treated with the drip stations, and other non-flowing areas are treated with backpack sprayers as part of the broader lake treatment. These areas include the low gradient complex areas near the mouths of some of the tributaries. Note: a lowering lake level throughout the summer will alter how far upstream each inlet stream is back-flooded; however, our approach is conservative because should the flowing portion of the stream extend slightly further downstream with lowering lake level, it will be encompassed in the area treated by the drip stations located upstream. There will be some overlap with the backpack sprayers to ensure coverage at these confluences. Electrofishing will begin upstream from these identified confluence points to search for SMB and to identify drip station locations based on SMB presence/absence. Criteria for determining drip station locations is associated with electrofishing results, hence is provided in the answer to Question 2.

Question 2

For complete removal of target fish from an area it is imperative that all habitats capable of supporting target fish are treated, unless there is conclusive evidence that the target fish are absent. It is the Programs understanding that you are proposing to conduct an electrofishing survey of all inlets to the lake prior to treatment to assess the presence of Smallmouth Bass. We ask that you provide detailed information on the proposed electrofishing survey, including timelines, extent of the survey and level of effort to be conducted. Please keep in mind that the characterization of inlet tributaries will help inform your electrofishing survey.

Response (relates to questions 1 & 2): Survey to Characterize SMB Presence in Inlets and Criteria for Drip Station Placement

Electrofishing surveys of all inlet streams to Miramichi Lake are conducted in July and immediately prior to treatment in late-August/early-September to investigate for SMB presence and determine drip station location. Electrofishing surveys will begin at each confluence where inlets meet the lake (see criterion in response to Question 1), with surveys progressing upstream. The water temperatures of the inlets are noted during the surveys. A crew of three will install a block net across the mouth of each inlet prior to surveying for fish. One person will operate the electrofisher and the remaining two, one of either side of shocker, will net the stunned fish into plastic buckets. All seeps and springs and channels are surveyed for fish. The survey will continue upstream including all channels until no SMB are found for 300 m. The upstream boundaries of SMB inhabitation are noted using GPS coordinates and flagging. Similar to the collaborative efforts to determine distribution of SMB in the Southwest Miramichi River, it is expected that DFO and NB DNRED staff will be involved in determining the upstream distribution of SMB in the inlets to Miramichi Lake.

The collected fish are identified to species and enumerated on a data collection sheet; the fish, with the exception of SMB, are released back into the stream. All SMB are placed in plastic bags and frozen for submission to DFO and later inspection.

Drip stations, and the upstream extent of treating each inlet, will be 300 m upstream of the last SMB found or 100 m upstream from the stream/lake confluence if no SMB are present in the electrofishing surveys. All flowing inlets will have one drip station at a minimum. If required, additional drip stations are placed at 1-h water travel time intervals downstream of the head station and sentinel fish in cages are placed downstream ahead of the next contiguous station. We anticipate that only 1 drip station is required per inlet tributary since these streams are relatively small. Complex areas near the mouths of streams in areas that are backflooded by the lake and have no flowing water will be sprayed by hand using a backpack sprayer containing a 2% solution of Noxfish II to ensure all areas are treated. The response of the sentinel fish in the inlets will determine whether application adjustments are needed.

Question 3

Survival of target fish can result from insufficient and inaccurate project area mapping of the treatment area. It is imperative that the entire treatment area be surveyed for potential treatment efficiency weaknesses such as upwelling groundwater (i.e. seeps / springs), barriers to water movement including but not limited to aquatic vegetation, marshy areas, and beaver dams. We ask that you provide all relevant information including location of all potential treatment weaknesses in the treatment area and how they will be addressed to minimize eradication failure.

Response: Efforts to Minimize SMB Eradication Failure through Increased Rotenone Exposure

All water flowing into Miramichi Lake will be treated with rotenone. The following include anticipated complex areas that require special attention to minimize treatment weaknesses and maximize likelihood of success:

- The inlets are treated using drip stations and/or sprayers as indicated above, and the success of treating the inlets are monitored by in-situ bioassays with sentinel fish of equal or less sensitivity to rotenone than SMB (i.e., Yellow [Marking and Bills 1976] or White Perch [Wujtewicz et at. 1997]) as outlined in SOP 5.1 (Finlayson et al. 2018). Corrective measures including increasing the rotenone dose or the number or placement of drip stations are employed if the sentinel fish are not responding after several hours during application.
- Other difficult areas where SMB may be located include the emergent aquatic weed beds and marshy areas on the lake's periphery. These are sprayed with a 2% solution of Noxfish II using a boat and a gasoline-powered high pressure pump with a firefighting nozzle (see SOP 8.1; Finlayson et al. 2018).
- Any beaver dams found within the treatment area that are impeding the flow of treated water are breached immediately prior to treatment.
- Any upwelling ground water flowing into the treatment area is treated with a combination of Noxfish II and Vectocarb (50:50) as outlined in SOP 13.1 (Finlayson et al. 2018).
- The small east branch tributary to Lake Brook is remote and will be investigated in summer 2020 for best treatment approach, which may include application via a drip station(s), helicopter, or backpack sprayer.

Question 4

It is essential to utilize accurate and up-to-date water volume and flow data in the planning and execution of the proposed project. Some physical characteristics and hydrological features provided in your application are not consistent with values reported elsewhere in the literature. The estimated mean annual flow of 0.45 m^3/s provided for Lake Brook does not concord with previously reported estimates. According to Chaput and Caissie (2010), the mean annual lake outflow was estimated to be 1.06 m^3/s and the combined mean annual flow from Miramichi Lake and Lake Brook was 1.38 m^3/s. Additionally, there are discrepancies between available documentation of the estimated volume of Miramichi Lake. The New Brunswick Department of Energy and Resource Development lake depth database reports that Miramichi Lake has a surface area of 2.24 km^2 and a volume of 5.790 million m^3, which is almost half the estimated volume of 11.492 million m^3 provided in your application. The mean annual flows and lake volume estimates of the project need to be verified and validated. We ask that you provide accurate estimates of water flow and lake volume, as well as description of how the estimates were determined.

Response: Miramichi Lake Volume, Lake Brook and Inlets Discharges

Lake Brook mean annual flow was determined by van den Heuvel et al. (2017) based on a regional flow model using 13 gauged stations in the region with similar precipitation (both Environment Canada and the author's data); the mean annual flow rate of Lake Brook was estimated to be 0.45 m^3/s. Manual flow measurement at the outlet of Lake Brook on June 22, 2017 showed a flow rate of 0.69 m^3/s (van den Heuvel et al. 2017). Regardless of mean annual flow calculation from models for planning purposes, an up-to-date flow measurement in Lake Brook will be taken manually immediately prior to treatment in order to calculate the accurate quantity of rotenone formulation required to achieve the treatment concentration. The water velocity in Lake Brook measured immediately prior to treatment will determine the number and placement of rotenone drip stations and monitoring sites. Additionally, flows in the inlets to Miramichi Lake will also be measured directly immediately prior to treatment and used to calculate the correct dosing for the flowing water portions of the treatment area.

The lake volume of 11.49 million m^3 reported in the application was obtained from van den Heuvel et al. (2017); the authors had originally referenced this value from a bathymetric map produced by the province of New Brunswick in 2009. We have re-checked this value with the province to determine its accuracy and method of calculation. Biologist Christ Connell reported that the volume of 11.49 million m^3 from the provincial document from 2009 was incorrect, and resulted from a default setting in ArcMap in the volume calculation tool. The default setting meant that volume was calculated from a bottom plane upwards to the bathymetric TIN surface, whereas the correct calculation is from an upper plane at the lake's water surface downward to the TIN surface. Chris Connell re-calculated the correct lake volume to be **5.36 million m^3**. This reduces the quantity of rotenone formulation to less than half of the original requirement to achieve the desired treatment concentration of 75 ppb.

Question 5

Species at Risk:

In your response you have indicated that a systematic mussel survey of Miramichi Lake has been conducted by Anqotum Resource Management during the week of September 15, 2019. We ask that you provide a detailed stand-alone report from this investigation. Ensure that the report includes the detailed survey protocols, sampling locations (i.e. map, GPS locations, etc.), level of sampling effort and results.

Response: Mussel Survey

Please see APPENDIX C for the mussel survey and results.

Question 6

Re-establishment strategy:

A re-establishment strategy was proposed in your application however, a detailed formal re-establishment strategy has not been provided to the Program. In order to be considered as potential mitigation for impacts to fish and fish habitat, we ask that you provide a formal stand-alone detailed re-establishment plan. In addition to information already provided, the re-establishment plan must include a well-defined objective (i.e. targeted outcome) for the re-establishment efforts, biological information of fish to be reintroduced (e.g. age class, sexual maturity, etc.) and details related to the proposed temporary containment. Sufficient details are required around the proposed stream water diversion to feed the fish holding tanks in order to evaluate the activities against the Fish and Fish Habitat Protection and Pollution Prevention provisions of the *Fisheries Act.* The science peer review mentioned above provides information for your consideration in section "Validity of proposed mitigation measures to "offset" the impacts described above, in particular the effectiveness of proposed re-establishment strategy" when addressing this request.

Response (Question 6): Re-Establishment Strategy

Please see APPENDIX D for a stand-alone re-establishment strategy.

Question 7

Monitoring:

It is DFO's understanding that you are proposing 3 types of monitoring which can be classified as 1) treatment application monitoring; 2) eradication efficiency monitoring; and 3) environmental impact monitoring. The Program requires an unambiguous stand-alone monitoring plan with associated protocols for our assessment. We ask that you provide monitoring activities broken down by monitoring type described above. Ensure to clearly include monitoring objectives, assessment criteria, sampling locations and frequency, monitoring timelines and any pre-treatment monitoring required for comparison purposes.

Response: Monitoring Plan

Please see APPENDIX E for a comprehensive stand-alone monitoring plan.

Question 8

Proposed increase of treatment area:

As a result of your request to increase the proposed treatment area to include approximately 10 kilometers of the Southwest Miramichi River where Smallmouth Bass have been confirmed, the Program will require a detailed project description in order to amend the current project. We ask that you provide all project amendment information using the Request to Authorize the Deposit of a Deleterious Substance application form. Ensure to clearly include all changes to the current project application resulting from the proposed amendment.

Response

Please see APPENDICES E and F for details related to the expansion of this project to include a section of the SW Miramichi River as a result of SMB being discovered in the river while this application was being reviewed in 2019.

References

Finlayson, B., Skaar, D., Anderson, J., Carter, J., Duffield, D., Flammang, M., Jackson, C., Overlock, J., Steinkjer, J., and Wilson, R. 2018. Planning and standard operating procedures for the use of rotenone in fish management – rotenone SOP manual, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Marking, L., Bills, T. 1976. Toxicity of rotenone to fish in standardized laboratory tests. Investigations in Fish Control 72. U.S. Fish and Wildlife Service, Washington, D.C.

Wujtewicz, D., B. Petrosky, R. Dorene. 1997. Acute toxicity of 5% non-synergized emulsifiable rotenone to White River Crayfish *Procambarus acutus acutus* and White Perch *Morone americana.* Journal World Aquaculture Society 28(3):249-259.

van den Heuvel, M., Pater, C., Finlayson, B., and Skaar, D. 2017. Exploring options for eradication of smallmouth bass in Miramichi Lake. Report prepared for the Working Group on Smallmouth Bass Eradication in Miramichi Lake. September 2017.

APPENDIX C

Miramichi Lake Mussel Survey

Brook Floater Survey of Miramichi Lake (September 18th and 19th, 2019)

Report submitted by Kayla Ward, Field Technician

February 2020

NSMDC Anqotum Resource Management

Anqotum obtained funding to conduct a freshwater mussel survey at Miramichi Lake. The survey was to be completed as part of the application to introduce rotenone into the lake to eradicate the invasive Small Mouth Bass present. We wanted to characterize the species make up in the lake to ensure that there were no species at risk present. To do this we chose to conduct a presence/absence survey.

Methodology

The lake was divided into five sites (figure 1) that were further broken down into subsections (figure 2) based on access and depth. After obtaining our section 52 permit, environmental services program technicians traveled to Miramichi Lake in early fall to perform the survey.

A total of three field technicians conducted the mussel surveys. They accessed each of the sites via canoe/kayak and conducted the surveys by wading in the water with viewing buckets.

Observations

Generally, the water was very clear and in some areas the substrate/specimens could be identified in approximately 2-3 feet of water depth. Visibility was highly variable from site to site. Even within subsections, there was a great amount of variability. Vegetation and depth were the common cause of inhibiting surveys. The dense growth of aquatic plants made it hard to walk in water just a couple feet deep, and masks were required to dive closer to the bottom to properly identify the species present.

Results

In total, seven different fresh water mussel species were identified as inhabiting the lake, including Brook floater. Four specimens were confirmed to be Brook floater (3 live specimens; 1 shell; 1 other potential shell could not be properly identified due to quality of shell). Figure 3 shows our results. Many different species of mussels were viewed and identified. The habitat is perfect for the wide range of species of freshwater mussels. The bed of this lake varies from sandy, to muddy, to mixed sediment, loaded with a wide variety of aquatic vegetation.

eDNA samples were collected and sent to Francis LeBlanc at the Department of Fisheries and Oceans for processing. The results were negative for the presence of Brook floater. There could be many reasons for this result such as it is unknown if the eDNA could be concentrated on the bottom because of the lack of water flow in the lake, and this could alter the results of the surface sampling design. The time of year could also affect the concentration of eDNA released into the water, as they are more active in the spring.

Because of the negative eDNA result, confirmation of visual identifications were completed. Collected shells were studied by Mary Sollows and Donald McAlpine at the New Brunswick

Museum for a second opinion. Upon review, it was confirmed that there was a positive identification for Brook floater. There is another shell that is presumed to be a Brook floater as well, but due to the missing ventral margin, identification could not be provided definitively.

Recommendations

Due to the time of year of the search, it is recommended that additional surveying is needed to get a more accurate depiction of the variety of species. As well, a distribution survey should also be completed as many areas were inaccessible due to the water depth but these could potentially be reached with a snorkel survey and boat. To properly conduct a distribution survey, additional survey days and a larger crew of survey technicians due to the size of the lake would be required. It is probable that, with a more in-depth survey, more species such as the Yellow Lamp mussel may be found, as their host fish is plentiful in this lake.

Figure 1- proposed search sites

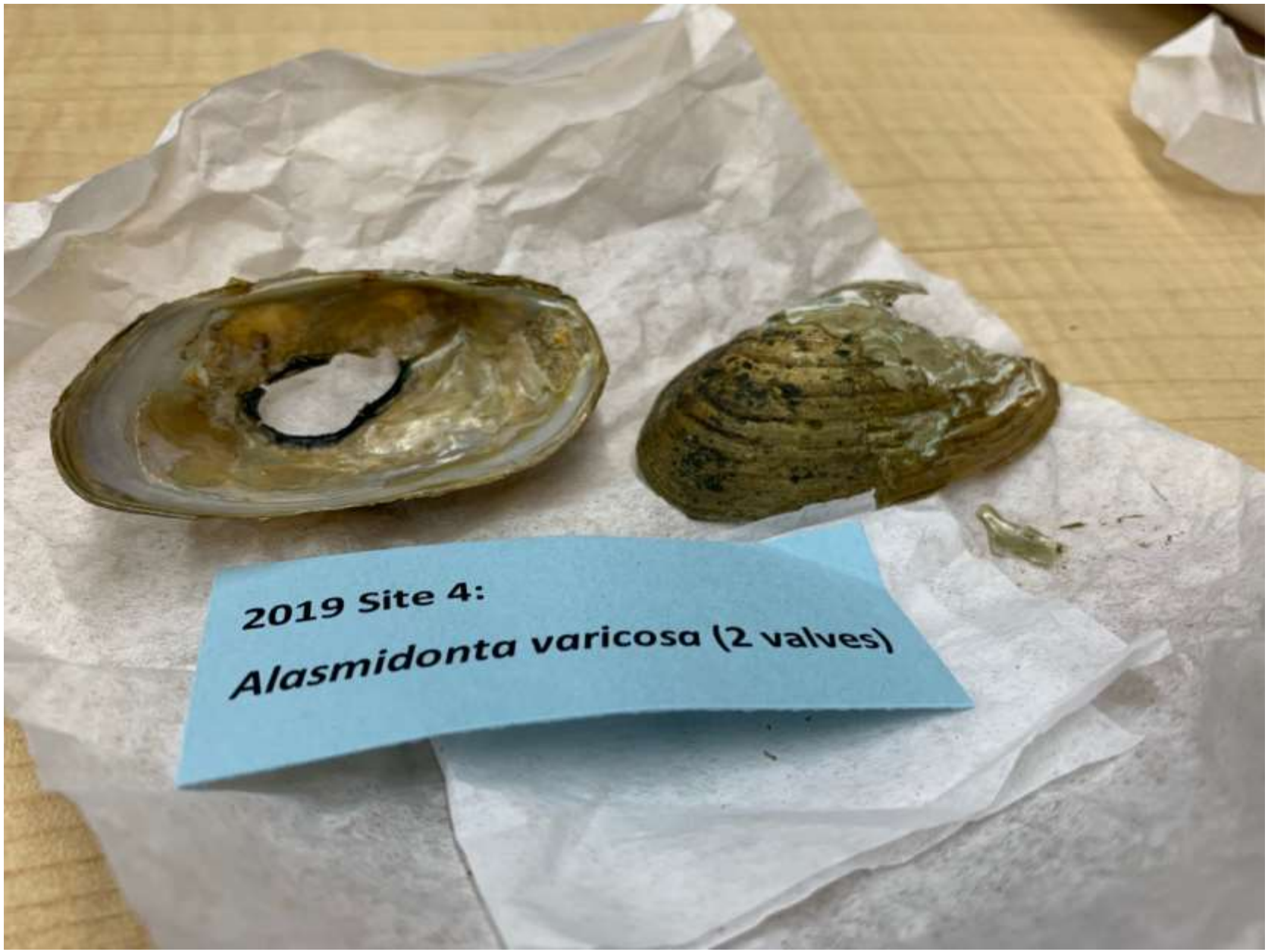
Figure 2- sites searched.

Mussel shell collected identification								
	Site 1 A	Site 1 C	Site 2	Site 2A mouth of lake brook	Site 3	Site 4	Site 5	Site 5.1
Easter Floater	1				2	1	1	
CREEPER		2	2				1	
Easter elliptio	3			1	3			
Eastern Lampmussel	1			1			2	1
Alewife Floater				1	1	2	3	1
Brook Floater		(few live specimens)	(viewed a few live specimens)			1 (shell-confirmed)		live specimen
Triangle Floater		12	4			3		
Site details :	Boat launch: Rocky (small)at the entrance and gradually gets sandier. Less mussels by the shore, they increase as you go to the left& right & further out into the lake.	BEACH- VERY SANDY!!! To the right it is very grassy. Lilly pads everywhere, cannot see bottom of lake bed.	Small rocks, lots of sand. Great mussel habitat.	Bigger rocks in the brook, sandy substrate still. Flow is quick.	lots of grass!	lots of vegetation in the water, soft sandy bottom.	lots of vegetation, substrate sandy. Little rocks. To the side you have tons of vegetation(hard to walk through water)	Very light mud, you sink in an get suctioned to the substrate. Perfect habitat for the floaters.

Figure 3- Details of Shells collected for identification.

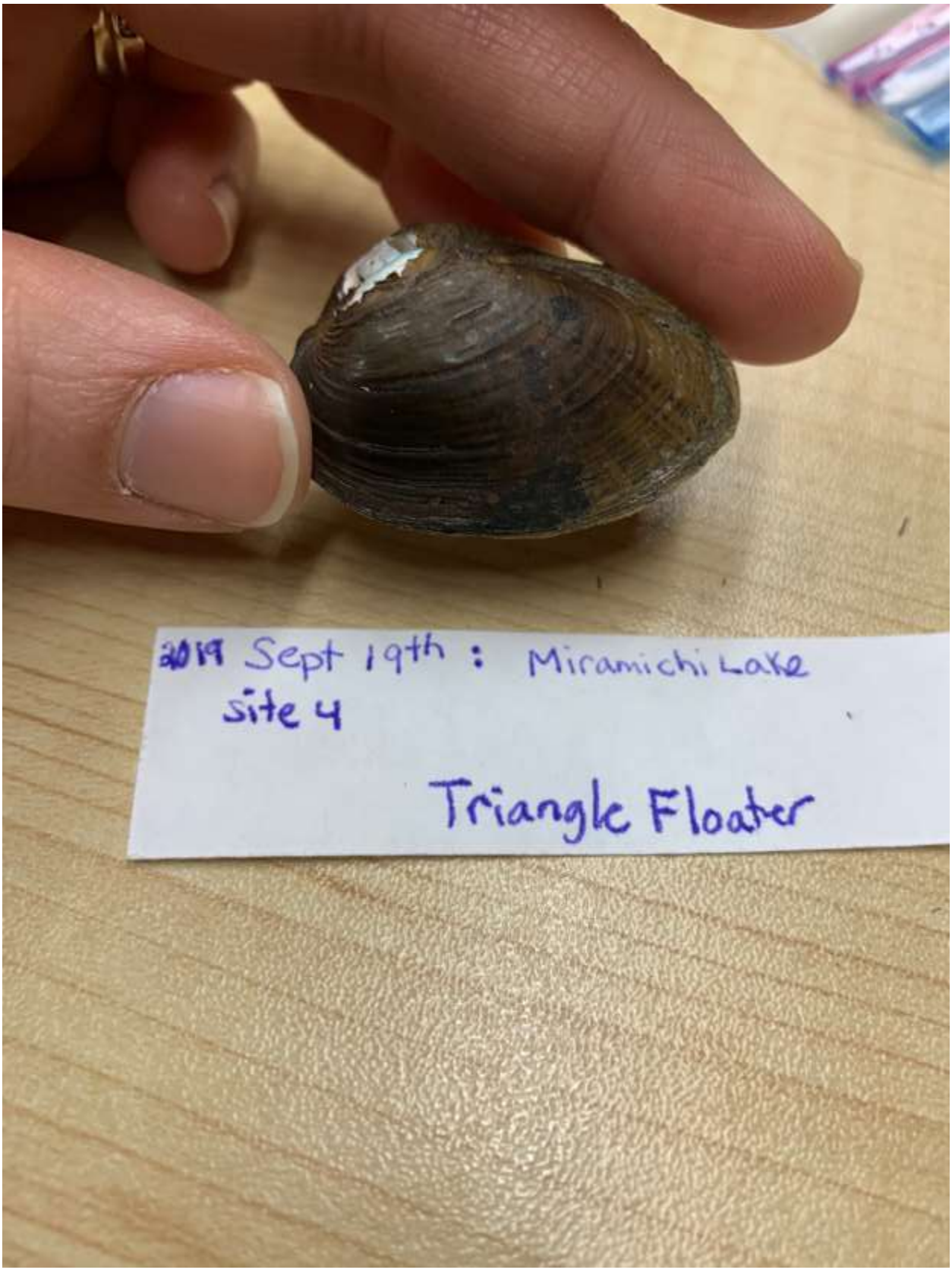
EDNA Sample Location				
Site	Taken by	Sample Time	Substrate type	Coordinates
2A	Kayla	11:10 AM	Rocks, Sand and cobble mixture	46°27'49.1"N 66°57'53.8"W
1c	----	----	sandy, lots of aquatic vegetation	46°27'26.8"N 66°57'27.2"W
1b			ALL Sand	46°27'15.8"N 66°57'24.4"W
1a	Kayla	1:49 PM	Rocks at the entrance, and turns sandy as you move further away from shore.	46°27'02.2"N 66°57'35.3"W
3	----	----	Covered in aquatic vegetation	46°27'51.9"N 66°58'52.7"W
4	----	----	lots of aquatic vegetation, sandy/small rocks	46°27'46.1"N 66°59'25.1"W
5.1	----	----	Light mud area, suctions your boots as you walk. Perfect for floaters mussels	46°27'27.7"N 66°59'05.5"W
5	----	----	mixed substrate, lots of lilly pads to the right .	46°27'26.0"N 66°58'48.3"W

Figure 4- GPS coordinates of surveyed locations.


2019 Site 4:
Alasmidonta varicosa (2 valves)


2019 Site 1c:
Strophitus undulatus


2019 Site 2a: (behind fence)
Lampsilis radiata (2 valves)


2019 Sept 19th : Miramichi Lake
site 4
Triangle Floater


ARM
M.L
5.5
2019 Site 1c:
Anodonta implicata (2 valves)

APPENDIX D

Re-Establishment Strategy

Objectives: (1) Re-establishment of reproducing populations of fish species currently present in the lake and Lake Brook, with the exception of SMB; (2) Ensure that the brook floater mussel (Species at Risk) persists following treatment

Overview: We have reconsidered the approach to the re-establishment strategy based on the advice provided in the DFO science CSAS review (DFO 2019), on feedback and discussion with Miramichi Lake camp owners, and on anticipated food base recovery timing from research on other treated lakes (e.g., Eilers 2008, McGann 2018).

In previous eradication projects throughout North America, where the goal has been to re-establish a fishery (usually native trout), the typical approach has been to restock fish the following spring post-treatment when plankton and invertebrate abundance and diversity has rebounded to provide a food source. Results from studies on multiple lakes (e.g., Eilers 2008, McGann 2018) demonstrate that both plankton and invertebrates recover to pre-treatment levels (or greater) by the following spring post-treatment. Using the existing research, we anticipate there will be an abundant food base in Miramichi Lake by the next spring after treatment.

Our objective is to restore self-sustaining fish populations of species currently in the lake, with the exception of SMB. This is in-keeping with Miramichi Lake camp owners' interests in seeing rapid ecosystem recovery (not the establishment of a fishery).

DFO's CSAS review indicated that none of the species present in the lake are unique to the lake, and recommended natural recolonization post-treatment. We will propose two options that monitor natural recolonization, but also take a pro-active approach to re-establishing non-migratory fish species into the lake to accelerate recovery. Both options eliminate the need for fish holding on-site for several weeks, as proposed in the original application. The options and performance measures are summarized below and in Table D1.

The re-establishment plan will provide each species currently present in the lake (exception: SMB) the opportunity to recolonize; however, community composition in the short and long term will likely differ from its present state because species will recolonize at different rates and relative abundances. Recovery will also occur in the absence of the invasive species and intense control efforts to remove them, which has had collateral impact on other species in the lake since 2008 when control efforts began. We do not expect or aim for the resulting fish community to be the same as the pre-treatment state, but we do expect overall rapid recovery of the ecosystem, consisting of (but not limited to) a food base of plankton and invertebrates, mussel assemblages, and reproducing fish populations.

Option 1

- Fish species recovery will be monitored for 5 years post-treatment (see Monitoring Plan in APPENDIX E)
- Migratory species: no action will be taken to transplant or actively re-establish migratory species, as they are anticipated to recolonize naturally relatively quickly
- Non-migratory species: monitoring will assess presence/absence and reproduction. If there is no evidence of both adults and juveniles by two years post-treatment, 100 individual adults of the species will be collected from a nearby lake within the watershed (e.g., McKiel Lake, Beaver Brook Lake) or from electrofishing sampling in the Southwest Miramichi River including its tributaries and transplanted into Miramichi Lake with the appropriate Introductions & Transfers permit.
- Brook Floater: mussels in general are expected to survive given their high toxicity thresholds to rotenone; however, monitoring will assess presence/absence of Brook Floater adults and juveniles post treatment. If there is no evidence of both adults and juveniles by two years post-treatment, 100 individual adults of the species will be collected from known assemblages in the Miramichi watershed and transplanted into known Brook Floater habitat areas in Miramichi Lake based on the baseline survey (APPENDIX C).
- The performance measure for successful re-establishment will include presence of juveniles, indicating successful reproduction
- Monitoring will continue for 5 years post-treatment, providing at least 3 years to assess re-establishment of transplanted species

Option 2

- Fish species recovery will be monitored for 5 years post-treatment (see Monitoring Plan in APPENDIX E)
- Migratory species: no action will be taken to transplant or actively re-establish migratory species, as they are anticipated to recolonize naturally relatively quickly
- Non-migratory species: the following spring after treatment when the food base is anticipated to have recovered, 100 individual adults of each species will be collected from a nearby lake within the watershed (e.g., McKiel Lake, Beaver Brook Lake) and transplanted into Miramichi Lake with the appropriate Introductions & Transfers permit.
- Brook Floater: mussels in general are expected to survive given their high toxicity thresholds to rotenone; however, monitoring will assess presence/absence of Brook Floater adults and juveniles post treatment. If there is no evidence of both adults and juveniles by two years post-treatment, 100 individual adults of the species will be collected from known assemblages in the Miramichi watershed and transplanted into known Brook Floater habitat areas in Miramichi Lake based on the baseline survey (APPENDIX C).
- The performance measure for successful re-establishment will include presence of juveniles, indicating successful reproduction

- Monitoring will continue for 5 years post-treatment, assessing re-establishment of all species including those that were transplanted

Other Considerations

- Golden shiner and brown bullhead – expected to be present immediately post-treatment given their high toxicity threshold to rotenone
- Alewives (migratory/anadromous) - adult alewives at sea during treatment will be unaffected and will enter the lake and spawn the following spring after treatment (as occurs naturally). Juvenile alewives to be present in the lake during summer months, emigrating in late summer (as occurs naturally).
- Atlantic salmon (migratory/anadromous) - the following summer post-treatment, young of the year juvenile Atlantic salmon are expected to be present in Lake Brook at similar densities compared to pre-treatment since spawning adults holding in the river during the fall (October/November) are not anticipated to be impacted by the lake treatment (August/September). Resulting juvenile densities will depend on a variety of factors that are independent of the application (e.g., adult spawner abundance, spawning conditions, overwintering conditions/survival, etc.).
- American Eel (migratory/panmictic) – juveniles arriving from sea are anticipated to be present in Lake Brook and Miramichi Lake the following year after treatment
- Sea Lamprey (migratory/anadromous) – adults at sea during treatment will be unaffected and are anticipated to enter Lake Brook and/or Miramichi Lake the following spring after treatment

Table D1. Re-establishment strategy and performance measures.

<table>
<tr><th rowspan="2">Category</th><th rowspan="2">Species</th><th colspan="2">Action</th><th colspan="2">Performance Measure</th></tr>
<tr><th>Option 1</th><th>Option 2</th><th>Option 1</th><th>Option 2</th></tr>
<tr><td rowspan="5">Migratory</td><td>Atlantic salmon Salmo salar</td><td rowspan="5">Monitor* natural recolonization</td><td rowspan="5">Monitor* natural recolonization</td><td colspan="2" rowspan="5">Presence of adults and juveniles indicating successful reproduction**</td></tr>
<tr><td>American eel Anguilla rostrara</td></tr>
<tr><td>gaspereau Alosa sp</td></tr>
<tr><td>sea lamprey Petromyzon marinus</td></tr>
<tr><td>white sucker Catostomus commersoni</td></tr>
<tr><td rowspan="11">Non-Migratory</td><td>banded killifish Fundulus diaphanous</td><td rowspan="9">Monitor* and if not present after 2 years post-treatment, 100 adults transplanted from nearby lakes within the watershed (McKiel Lake, Beaver Brook Lake, SW Miramichi or its tributaries) with appropriate Introductions & Transfers permit</td><td rowspan="9">100 adults transplanted the following spring post-treatment from nearby lakes within the watershed (McKiel Lake, Beaver Brook Lake, SW Miramichi or its tributaries) with appropriate Introductions & Transfers permit</td><td colspan="2" rowspan="9">Presence of adults and juveniles indicating successful reproduction</td></tr>
<tr><td>blacknose dace Rhinichthys atratulus</td></tr>
<tr><td>brook trout Salvelinus namaycush</td></tr>
<tr><td>common shiner Luxilus cornutus</td></tr>
<tr><td>creek chub Scardinius atromaculuatus</td></tr>
<tr><td>fallfish Semotilus corporalis</td></tr>
<tr><td>lake chub Couesius plumbeus</td></tr>
<tr><td>pearl dace Margariscus margarita</td></tr>
<tr><td>white perch Morone Americana</td></tr>
<tr><td>yellow perch Perca flavescens</td></tr>
<tr><td>brown bullhead Ameiurus nebulosus</td><td colspan="2" rowspan="2">High toxicity threshold to rotenone and expected to survive treatment; will be monitored and transplanted as required according to the same protocols for options 1 & 2</td><td colspan="2" rowspan="2">Presence of adults and juveniles indicating successful reproduction</td></tr>
<tr><td>golden shiner Notemigonus crysoleucas</td></tr>
<tr><td>Mussels</td><td>brook floater Alasmidonta varicosa</td><td colspan="2">High toxicity threshold to rotenone and expected to survive treatment; will be monitored and if not present after 2 years post-treatment, 100 adults will be transplanted from known assemblages in the Miramichi watershed to the lake</td><td colspan="2">Presence of adults and juveniles indicating successful reproduction</td></tr>
</table>

*Monitoring plan provided in Appendix E

**Exceptions: American Eel is panmictic and spawns at sea; eel presence via immigration will be captured in the monitoring program. Adult Atlantic salmon spawn in late fall and are expected only to be present in Lake Brook for a short period of time; therefore, the measure of recolonization will be young-of-the-year in Lake Brook during summers following treatment.

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APPENDIX E

Monitoring Plan

Overview: The monitoring plan consists of four components associated with the proposed eradication of SMB from the Miramichi Watershed: (1) rotenone treatment monitoring (2) rotenone deactivation monitoring, (3) short-term and long-term SMB eradication monitoring, and (4) ecological recovery monitoring.

Recovery objectives for fishes and mussels that will be monitored are described in the re-establishment strategy (APPENDIX D).

Note that this monitoring plan pertains specifically to the Miramichi Lake/Lake Brook component and does not include the SW Miramichi River component (APPENDICES F and G). Should the river component be approved to take place in conjunction with the lake, the monitoring plans will be integrated for implementation. The preferred and most effective approach is to conduct the lake and river treatments simultaneously.

Roles: NSMDC intends to have indigenous technicians and biologists lead the long-term monitoring program (Component 4), with support as required from project partners and federal/provincial governments. Given that in the absence of the eradication project we are putting forward, DFO would normally be conducting a control and containment program at Miramichi Lake, we expect DFO to continue its program for 5 years post-treatment and fund Indigenous technicians to help lead the program. This includes operating the barrier fence, and sampling for fish using the electrofishing boat, backpack electrofisher, fyke nets, gill nets, beach seine, angling, and additional components such as eDNA assessment in the lake, Lake Brook, and the SW Miramichi River. This expectation is reasonable given DFO's responsibility to manage AIS and its past experience and expertise in carrying out the program.

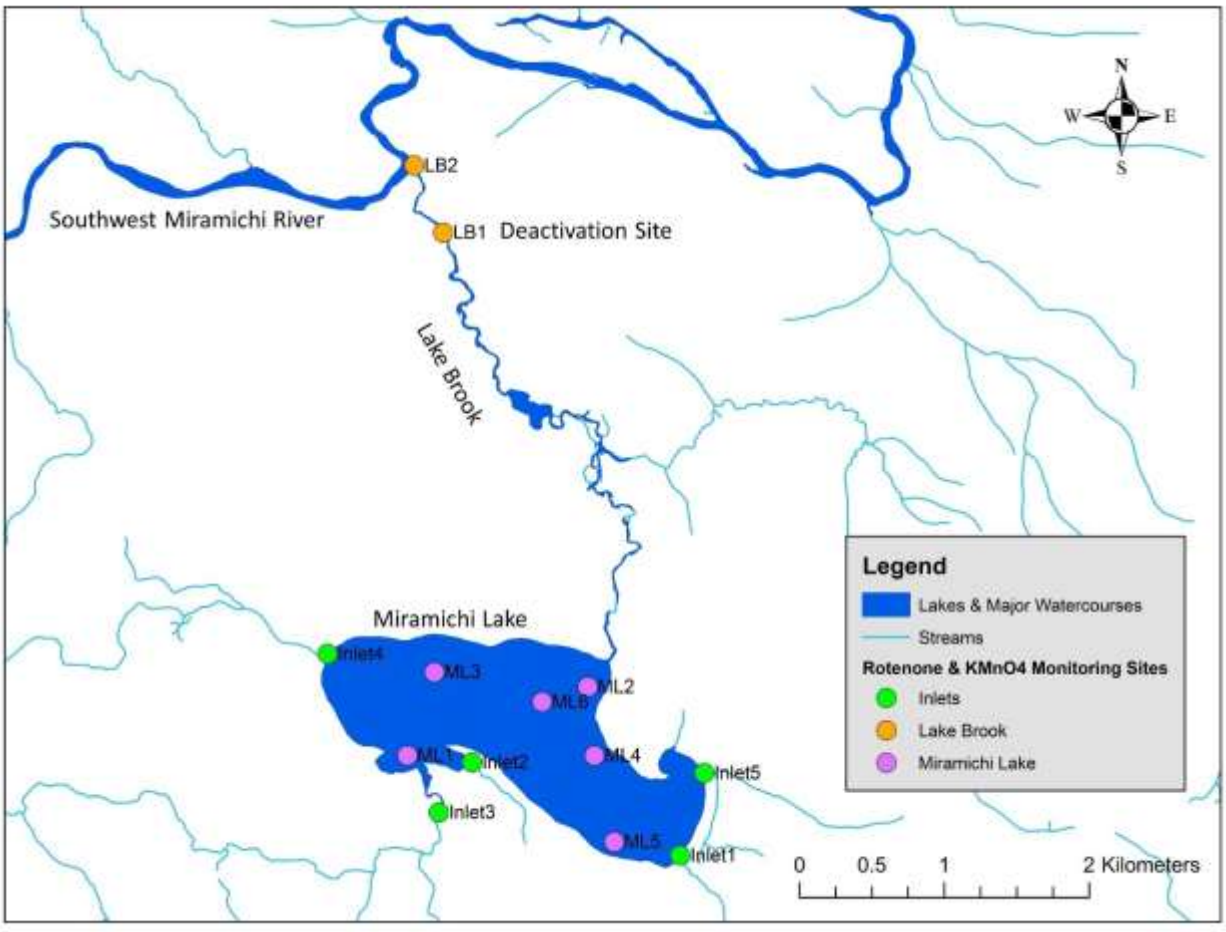
<u>Component 1</u> - Rotenone Treatment Monitoring

Overview: Rotenone treatment monitoring consists of measuring (1) responses of sentinel fish to rotenone and (2) collecting samples for rotenone analysis in Miramichi Lake, Lake Brook and the SW Miramichi River.

Objectives: (1) Allow for adjustments to the treatment strategy during application and provide a record of efficacy throughout the treatment area; (2) Provide an analytical record of rotenone levels in Miramichi Lake, Lake Brook and the SW Miramichi River during treatment and the breakdown of rotenone over time in the lake; (3) Ensure that SMB are eliminated from the area.

Monitoring Sites (see Map E1 and Table E1)

- One site per inlet is located on the five tributaries to Miramichi Lake immediately upstream of their confluence with the lake (Inlet1 to Inlet5)
- Six monitoring sites are located at various depths in Miramichi Lake:
    - two sites 10 m from the shoreline (ML1 & ML2)
    - two sites at mid-depth (ML3 & ML4)
    - two sites at the maximum depth (ML5 & ML6)
- The deactivation site is located at least 30 min water travel time upstream from the confluence of Lake Brook with the SW Miramichi River (LB1; deactivation location subject to change if river is treated simultaneously); final placement to be determined immediately prior to treatment based on current water velocities.
- One site is located at the mouth of Lake Brook at the confluence with the SW Miramichi River (LB2)



Map E1. Rotenone treatment monitoring sites and deactivation monitoring in Lake Brook.

Table E1. Coordinates of monitoring sites for treatment and deactivation of rotenone.

ID	Latitude	Longitude
Inlet1*	46.451433	-66.958524
Inlet2*	46.457310	-66.977624
Inlet3*	46.456995	-66.981503
Inlet4*	46.463819	-66.990329
Inlet5*	46.456160	-66.956251
ML1	46.464960	-66.980364
ML2	46.458137	-66.976645
ML3	46.461588	-66.983960
ML4	46.453477	-66.961996
ML5	46.456339	-66.967070
ML6	46.460913	-66.970390
LB1	46.490017	-66.980168
LB2	46.494170	-66.982804

*Final placement to be determined prior to treatment based on criteria of confluence identification explained in APPENDIX B.

Rotenone: The protocols for analyzing rotenone concentrations in water are detailed in SOP 16.1 of Finlayson et al. (2018) and utilize liquid chromatography (LC) as described by Dawson et al. (1983) or Sandvick et al. (2018) or direct injection liquid chromatography/mass spectrometry (LC/MS) as described by Vasquez et al. (2012); these analyses have a MDL of 0.001 mg/L and RL of 0.002 mg/L rotenone. Water samples are collected using a Kemmerer bottle in the lake or directly a few centimetres below the water surface in streams and shallow lake sites. Samples are put in 250-ml amber glass bottles with Teflon-lined caps, stored chilled (4 °C), and transported to the laboratory for analysis with chain-of-custody forms.

Assessment Criteria and Monitoring Timelines –

- **Sentinel Fish:** Cages containing sentinel fish (yellow perch) are placed in the lake one day before application and within two hours pretreatment for flowing waters (5 inlets and Lake Brook). The sentinel fish are checked in the lake 24 hours after the application is complete and are checked in the flowing sections throughout the treatment.
- **Miramichi Lake:** Verifying that (1) the dosage target of 75 ppb rotenone was obtained, (2) rotenone levels ≥ 19 ppb are present for ≥ 4 days, and (3) rotenone degrades to undetectable levels (< 2 ppb) in ≤ 3 weeks. Samples for rotenone analysis are collected at 1, 2, 4, 7, 14 and 21 days post-treatment or until levels become undetectable.
- **Lake Brook:** Verifying that the dosage target of 75 ppb rotenone was obtained for 6 h in Lake Brook. Samples for rotenone analysis are collected at 2 and 4 h after treatment begins in the treatment area (LB1).

<u>Component 2</u> - Deactivation Monitoring in Lake Brook

Overview: Deactivation monitoring consists of (1) real-time responses of sentinel fish upstream and downstream of the deactivation station at the mouth of Lake Brook, (2) collecting samples for rotenone analysis above and below the deactivation station, and (3) collecting and analyzing samples for $KMnO_4$ residual below the deactivation station.

Objectives: (1) Allow for adjustments to the deactivation strategy of applying $KMnO_4$ by monitoring the response of sentinel fish and $KMnO_4$ residues; (2) Provide an analytical record of rotenone concentrations upstream and downstream of the deactivation station during and following the treatment to Lake Brook; (3) Maintain a 4 ppm $KMnO_4$ residual and an analytical record of $KMnO_4$ levels at the mouth of Lake Brook (LB2) 30 min water travel time downstream of the deactivation station; (4) Ensure that rotenone concentrations (> 2 ppb) are absent downstream of the mouth of Lake Brook (LB2)

Monitoring Sites (see Map E1)

- Two sites are located on Lake Brook:
    - LB1 – deactivation site located at least 30 min water travel time upstream of the mouth of Lake Brook
    - LB2 – located at the mouth of Lake Brook

Rotenone: See Component 1

Potassium Permanganate: The protocols for the on-site analysis of potassium permanganate concentrations in water upstream and downstream of the deactivation station are detailed in SOP 7.1 of Finlayson et al. (2018) and utilize either direct (Standard Method 4500-$KMnO_4$ B; American Public Health Association 1998) or indirect (USEPA DPD Method 8167 for Total Chlorine) colorimetry.

Assessment Criteria and Monitoring Timelines –

- **Rotenone:** Verifying that rotenone is oxidized to < 2 ppb at least 30-minutes water travel time downstream of the deactivation station by collecting and analyzing samples for rotenone upstream (LB1) and downstream (LB2) of the deactivation station every 2 h during treatment
- **$KMnO_4$:** Verifying that $KMnO_4$ residual is maintained at 4 ppm at LB2 by collecting and analyzing samples for $KMnO_4$ analysis every 30 minutes downstream of the deactivation station and relaying the results to the deactivation station (LB1) for adjustment of $KMnO_4$ input. Maintaining 4 ppm residual at LB2 will ensure that rotenone is deactivated by the time it reaches the SW Miramichi River, and that lethal conditions are sustained in the lower reach of the brook given that SMB distribution includes the brook. Upon flowing into the SW Miramichi River, the 4 ppm $KMnO_4$ will be immediately diluted to non-lethal levels, and the rotenone will have been deactivated.
- **Criteria for Beginning Deactivation:** Deactivation begins at a minimum of several hours before the rotenone treatment to reduce the $KMnO_4$ demand of the streambed in the 30-minute section below LB1. Injecting $KMnO_4$ until residues stabilize will ensure that the streambed is fully oxidized prior to contact with rotenone. Deactivation begins concurrently with the

rotenone treatment, and the reaction of sentinel fish at LB1 signals the arrival of rotenone at the deactivation station.

- **Criteria for Terminating Stopping:** The survival of sentinel fish upstream of the deactivation site in Lake Brook for 4 h signals the lack of need for deactivation and the termination of $KMnO_4$ input.
- **Effectiveness:** Measured by (1) maintaining a 4 ppm $KMnO_4$ residual and (2) sentinel fish not surviving 30 minutes downstream of the deactivation site in Lake Brook, and (3) rotenone concentrations of < 2 ppb in the SW Miramichi River.

<u>Component 3</u> - Short-Term & Long-Term SMB Eradication Monitoring

Overview: Monitoring of sentinel fish during and immediately following treatment are the first indicators of eradication success and continued monitoring using eDNA, electrofishing, and netting techniques for 5 years post-treatment are longer term evidence of SMB eradication.

***Objectives*:** (1) Provide a report on the treatment that contains short-term evidence that SMB were eliminated from Miramichi Lake and Lake Brook using sentinel fish and rotenone analysis results and treatment statistics; (2) Provide annual post-treatment assessment reports using monitoring results that demonstrate SMB are absent from Miramichi Lake and Lake Brook.

Short-Term Eradication Monitoring –

- **Sentinel Fish & Rotenone Concentrations** - The effectiveness of the treatment is documented using a combination of caged sentinel fish (Yellow or White Perch) results and rotenone concentrations in the treatment area described in Component 1.
- **Application Statistics:**
    - The lake is divided into quadrants, volume of each quadrant calculated using computer assisted bathymetry, rotenone dosage calculated for each quadrant based on volume, and an applicator boat assigned to each quadrant. The application from boats is monitored using GPS tracking and recording the volume of rotenone applied to each quadrant. Sprayers from boats will spray the shoreline areas and the emergent weed beds around the lake and its use also GPS tracked. It is expected that the application will require one to two days to complete.
    - The flowing water segments are treated using drip stations (see criteria for placement in APPENDIX B) in low flow areas such as the inlets to Miramichi Lake and Lake Brook and using peristaltic pumps in higher flow areas such as the SW Miramichi River. Flows at these sites are taken immediately prior to treatment to ensure the correct rotenone dose. The applications from these devises are monitored continually throughout application period of 6 h. The volumes discharged from the cans are checked every 30 minutes using a volumetric cylinder and stopwatch while the volumes from the peristaltic pumps are checked every 30 minutes by reading the attached flowmeter. All measurements are recorded for use in treatment assessment.

Long-Term Eradication Monitoring – A combination of eDNA, boat electrofishing, and netting techniques (fyke, seine, gillnet, boat electrofishing, backpack electrofishing, angling) for a 5-year post-treatment period will provide data for evaluating the success of eradicating SMB from Miramichi Lake, Lake Brook and the SW Miramichi River. The techniques and sampling locations employed by DFO (e.g., Biron 2015) in the control and monitoring program for the lake will be used. Using this approach will serve the dual purpose of eradication monitoring and long-term recovery monitoring (see Component 4 below). It also enables comparison with pre-treatment catch-per-unit-effort and community composition data.

The distribution of SMB in both the lake and the river are well known and these areas will be a focus. Samples for eDNA analysis will be collected from areas of known SMB inhabitation in the lake, and also in Lake Brook and at intervals in the SW Miramichi River according to the DFO sampling locations established in fall 2019 eDNA surveys. The absence of SMB from manual fish collection techniques or the lack of SMB eDNA in water are by themselves not conclusive evidence of their absence, but the two techniques used together increases the level of certainty that SMB are absent.

<u>Component 4</u> - Ecological Recovery Monitoring

Overview: Long-term monitoring of the lake will begin prior to rotenone application for pre-treatment conditions. Monitoring will be carried out for 5 years post-treatment to document the recovery of the aquatic community in Miramichi Lake and Lake Brook, including zooplankton, invertebrates, mussels, and fishes. The study will employ a before-after-control-impact (BAACI) sample design which is well suited to detecting changes due to rotenone treatments. Sampling will be restricted to the treatment area both before and after treatment.

Objectives: (1) Monitor for 5 years and provide an annual report on the recovery of the aquatic community in Miramichi Lake and Lake Brook, including zooplankton, invertebrates, mussels, and fishes; (2) Compare pre-treatment conditions with annual post-treatment results; (2) Monitor for presence of adults and juveniles of each fish species and for presence of brook floater mussel to inform triggers of transplantation for non-migratory fishes and brook floater at the 2-year post-treatment mark (as set out in “Option 1” of the Re-establishment Plan in APPENDIX D).

Sampling Intervals: Sampling will be carried out beginning at least one-week pre-treatment, one-week post-treatment, and annually post-treatment for 5 years. The fish sampling will be conducted during summer and into fall similar to DFO’s protocol that has been employed at the lake since 2009 to ensure comparability.

Sample Parameters**:** Water quality, zooplankton, benthic invertebrates, mussels and fishes

Water Quality: Turbidity, water clarity, temperature, pH, total dissolved solids and conductivity are recorded at each sampling event. Water clarity or transparency is measured using a Secchi disk (30-cm),

turbidity is measured using a turbidity meter, and conductivity, pH, total dissolved solids and water temperature are measured *in-situ* using a portable multi-parameter probe.

Zooplankton: Zooplankton are collected by vertical tows of plankton net from a depth of 3m with 4 tows per sampling event. The net has a 20 cm opening with a 30 cm reduction collar and a mesh size of 64 μm. The samples are preserved in 70% ethanol. Zooplankton are identified to the most practical level. Zooplankton are quantified by counting abundances in five 10-mL subsamples using an inverted light microscope at 100× and 200× magnification from each site and the mean value is recorded. Based on previous studies of rotenone treatments in lakes (e.g., McGann 2018), we anticipate that zooplankton diversity and abundance will have recovered to at least pre-treatment levels within 1-year post-treatment.

Benthic Invertebrates: The rocky bottom of Miramichi Lake will influence the sampling gear used. The benthic macroinvertebrate data are collected in triplicate using a petite PONAR (152 × 152 mm) dredge from the monitoring sites. The samples are sieved through a 500-μm mesh and aggregated in major taxonomic groups; some samples are retained for analysis to species level. Samples are preserved in 99% ethanol. When identified to species, samples with more than 500 organisms are subsampled using a Caton gridded tray with a 500-μm wire mesh and 30 grids to expand raw samples. Based on previous studies of rotenone treatments in lakes (e.g., Eilers 2008), we anticipate that invertebrates will have recovered to at least pre-treatment levels within 1-year post-treatment.

Mussels – The sampling protocol described in APPENDIX C will be employed to carry out mussel surveys throughout the Lake during the 5-year monitoring period, with particular focus on brook floater, a Species at Risk. Freshwater mussels generally have a high toxicity threshold to rotenone, and we anticipate mussels to survive the treatment. Monitoring results within the 2 years post-treatment will inform whether triggers are met for re-introduction of brook floater from donor colonies within the Miramichi watershed with appropriate permits (see Re-establishment Strategy in APPENDIX D).

Fishes – A combination of electrofishing (boat and backpack), netting methods (fyke, seine, gillnet, minnow trap), and angling will be employed over a 5-year post-treatment monitoring period to evaluate recovery of fish species in Miramichi Lake and Lake Brook. Fish recolonization monitoring will overlap with the long-term eradication efficiency monitoring. The diversity of methods will ensure different size classes of the various fish species are captured. This approach will generate presence/absence and catch per unit effort data to characterize fish community structure, compare to pre-treatment data, and provide relative abundance of the re-establishing fish species.

The fish sampling protocol employed by DFO since 2009 (e.g., DFO 2013, Biron 2015) in the control and monitoring program will be used. This approach will serve the dual purpose of eradication monitoring and long-term recovery monitoring. It also enables comparison with pre-treatment catch-per-unit-effort data. Monitoring will be carried out by Indigenous technicians under the direction of DFO staff who have worked on the control program to date; this will ensure consistency with sampling pre-treatment and comparability of the data.

Monitoring results will indicate whether fish species are successfully reproducing and re-colonizing the lake and Lake Brook. Presence/absence of adults and juveniles of each fish species will inform triggers of transplantation for non-migratory fishes at the 2-year post-treatment mark (as set out in Option 1 of the Re-establishment Strategy in APPENDIX D). Should transplantation be required after 2 years post-treatment, the remaining 3 years of the monitoring program will enable assessment of whether the transplanted species are demonstrating successful reproduction.

Special Considerations for Fish Monitoring

- Golden shiner and brown bullhead – expected to be present immediately post-treatment given their high toxicity threshold to rotenone
- Alewives (migratory/anadromous) – adult alewives at sea during treatment will be unaffected and will enter the lake and spawn the following spring after treatment (as occurs naturally). Juvenile alewives expected to be present in the lake during summer months, emigrating in late summer (as occurs naturally).
- Atlantic salmon (migratory/anadromous) – the following summer post-treatment, young of the year juvenile Atlantic salmon are expected to be present in Lake Brook at similar densities compared to pre-treatment since spawning adults holding in the river during the fall (October/November) are not anticipated to be impacted by the lake treatment (August/September). Resulting juvenile densities will depend on a variety of factors that are independent of the application (e.g., adult spawner abundance, spawning conditions, overwintering conditions/survival, etc.).
- American Eel (migratory/panmictic) – juveniles arriving from sea are anticipated to be present in Lake Brook and Miramichi Lake the following year after treatment
- Sea Lamprey (migratory/anadromous) – adults at sea during treatment will be unaffected and are anticipated to enter Lake Brook and/or Miramichi Lake the following spring after treatment. During DFO SMB control efforts since 2009, very few sea lamprey have been captured; therefore, we anticipate low catches of this species during monitoring. This is likely due to the significant distance of Miramichi Lake and Lake Brook from salt water (>100 km).

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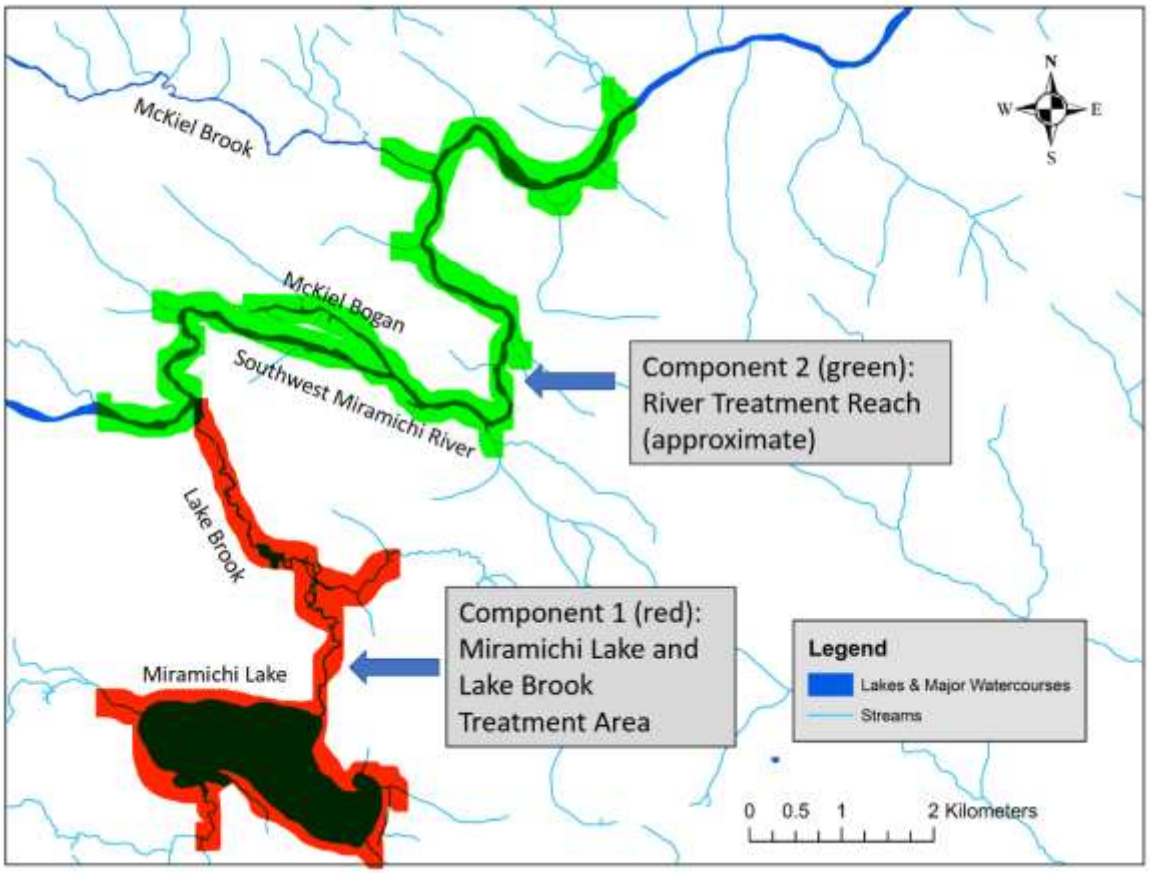
APPENDIX F

Southwest Miramichi River Eradication Planning

Purpose of this Appendix: The intent of including this section is to demonstrate that we are developing a river eradication plan. Field data will be collected once conditions permit and the resultant physical river characterization will inform the development of a detailed eradication plan which will be submitted to DFO during the summer of 2020. Our aim is to receive approvals to carry out both the lake and the river treatment components simultaneously for the best chance of success.

Overview: In August 2019, SMB were found in the SW Miramichi River. The first observation was on 22 August 2019 at Tent Pool, approximately 8.5 km downriver of the confluence with Lake Brook. Four SMB were angled on 1 September 2019 at McKiel Pond Pool, approximately 7 km below the confluence with the brook. Stable isotope analysis is being performed by the University of New Brunswick to potentially determine the origin of the bass, i.e., whether they came from the lake or have been rearing in the river. The discovery of bass in the river is an inevitable result of the ineffective containment measures employed by DFO at the outlet of Miramichi Lake. The failure of such methods were apparent in a number of years since 2008 when YOY bass were found below the barrier in Lake Brook during DFO electrofishing surveys.

Objectives: (1) To eradicate SMB from approximately a 15 km reach of the SW Miramichi River where SMB have been identified to be present (see Map F1; final treatment reach dependent on latest eDNA and physical surveys in summer 2020); (2) To carry out the river treatment simultaneously with the Miramichi Lake and Lake Brook treatment



Map F1. Smallmouth Bass eradication components: (1) Miramichi Lake and Lake Brook (red); (2) reach of the Southwest Miramichi River (green).

Control Efforts To Date: Short-term control efforts ensued in the fall of 2019 and included snorkelling and eDNA surveys to map the distribution of bass in the river system. It also included angling, electrofishing, seining and gillnetting in an effort to remove as many bass as possible from Lake Brook and the river in order to minimize risk of spread and spawning the following spring. In total 22 SMB juveniles and adults were removed from the river at McKiel Pond Pool on the main stem of the SW Miramichi River, and 14 SMB juveniles were removed from Lake Brook via backpack electrofishing. While control efforts are important in the short-term, we remain focused on the urgent objective of eradicating SMB from the system before they spread further and the problem becomes more complicated.

Feasibility of Rotenone Treatment: Fish Control Solutions Ltd. were contracted to conduct a scoping exercise of the feasibility of treating a section of the SW Miramichi River to eradicate SMB. The report, found in APPENDIX G, outlines a draft treatment and deactivation plan for the approximate reach of river shown in Map F1, from upriver of the confluence with Lake Brook and extending approximately 15 km to below the mouth of McKiel Brook. This encompasses the area where SMB were detected using eDNA in the fall of 2019.

Note: The scoping exercise was to develop an approach and framework for a river treatment. The extents of approximately a 15 km stretch of river was for preliminary planning purposes. The actual treatment extents will be based on the most up to date eDNA data from summer 2020 and may include more or less than the 15 km reach, with a buffer on either end of the confirmed SMB distribution zone to be conservative.

***Information to be Collected*:** Table F1 summarizes the informational items that have been, or will be gathered from January - July 2020 through a combination of desktop exercises and field work to physically characterize the river. The information will be used to develop the detailed eradication plan for the river.

Table F1. List of information to be collected to inform the SW Miramichi River smallmouth bass eradication plan.

Feature	Description	Status
Map (desktop)	Detailed topographic map of Southwest Miramichi River, showing the section from (3 km) upstream of the Ice Bridge to (3 km) downstream of the confluence with McKiel Brook. The map will show the confluence with Lake Brook and Miramichi Lake.	In progress
Map (desktop & fieldwork)	Identification all known seeps, springs, beaver ponds, wetlands and tributaries contiguous with the affected area. Thermal imagery and/or field investigation will be used to identify these features. All access (i.e., roads) points to the river section will also be identified on the map.	In progress; fieldwork component to be completed spring/summer 2020
Hydraulics (desktop & fieldwork)	Metrics of water depth, water travel time, and stream channel width at 10, equally-spaced transects along the river section	In progress; fieldwork component to be completed spring/summer 2020
Hydraulics (desktop & fieldwork)	Stream survey of the affected river section describing the amount of open canopy on the river, pool-to-riffle ratio, and slope	In progress; fieldwork component to be completed spring/summer 2020
Hydrology (desktop)	Metrics of stream discharge of the Southwest Miramichi River and all known inlets during late-August to late-September period for the last ten plus years for this river section. The flows and velocities in the SW Miramichi River during late-August/early September have been estimated for planning purposes using historic flows in the SW Miramichi River at Blackville Environment Canada hydrological gauge and the nearby Nashwaak River gauge prorated by the respective catchment areas. These estimated flows are compared and calibrated to actual flows measured on-site in summer 2020.	Partially complete; flows calculated by prorated watershed area; to be validated in field in 2020 just prior to treatment to achieve accurate treatment concentration
SMB Distribution (fieldwork, lab)	Surveys from the Southwest Miramichi River and contiguous waterbodies assessing the up-to-date distribution of SMB using both eDNA and manual (i.e., electrofishing) methods.	Not complete; eDNA surveys to be conducted by DFO in summer 2020; electrofishing in summer 2020
Water quality (fieldwork)	Metrics of water temperature, pH, dissolved oxygen, turbidity, alkalinity, conductivity and organic content from late-August to late-September for the river section.	Not complete; summer 2020

Mitigation: A variety of mitigation measures are being explored for the river treatment and will be included in the detailed treatment plan. Options considered to date include:

- Erecting a temporary barrier near the lower end of the treatment area in August prior to treatment to prevent adult Atlantic salmon from ascending into the reach
- Seining known salmon holding pools to remove adults from the treatment area; the only known major cold water holding pool in the reach is Tent Pool below the mouth of McKiel Brook. This is where the majority of adults in the reach are expected to be aggregated during warm river temperatures in August. They will be seined when temperatures are safe for handling prior to treatment, and placed in a reach of McKiel Brook outside of the treatment area and isolated with a downstream barrier.

Mitigation measures will be focused on adult Atlantic salmon. It is practical and possible to remove and protect most of these fish in the reach that are anticipated to be holding in Tent Pool. Recovery of all aquatic species (i.e., invertebrates, fishes, mussels) in the reach of river is expected to be rapid (i.e., within 1-2 years) given that the reach is open ended.

Monitoring: The river monitoring plan will be included in the detailed treatment plan and, similar to the lake monitoring plan, will include four components: (1) rotenone treatment monitoring (2) rotenone deactivation monitoring, (3) short-term and long-term SMB eradication monitoring, and (4) ecological recovery monitoring.

APPENDIX G

Feasibility Assessment of
Rotenone Treatment of the Southwest Miramichi River

Feasibility Assessment of
Rotenone Treatment of the Southwest Miramichi River

Brian Finlayson and Don Skaar
Fish Control Solutions, LLC

Summary: Electrofishing and eDNA results from Fisheries and Oceans Canada (DFO) confirm that Smallmouth Bass *Micropterus dolomieu* (SMB) inhabit the Southwest Miramichi River (SWMR) in the approximate 15-km section between upstream of Lake Brook (LB) downstream to below McKiel Brook (MB) (Figure 2). This section may increase or decrease based on SMB distribution from eDNA and physical surveys in summer 2020. Two possible solutions to treat the 15-km section of SWMR are either concurrently with the proposed treatment of Miramichi Lake (ML) and LB in mid-August to early-September (Scenario 1) or separately, post-treatment of ML and LB (Scenario 2). In Scenario 1, ML, LB, and SWMR are treated concurrently with deactivation of the SWMR occurring downstream of MB. Whereas in Scenario 2, ML and LB are treated concurrently with deactivation of LB occurring 30 minutes upstream of the confluence with SWMR, and in a separate treatment, the SWMR is treated with deactivation occurring downstream of MB. The anticipated resources for river treatment are outlined below. In order to refine this analysis into an operational protocol, the following actions in the river basin are required: (1) identify areas harboring SMB, (2) identify tributaries, seep/springs and other areas requiring treatment, (3) establish water velocities at different river flows, and (4) calibrate flows estimated from the Environment Canada Hydrometric Website.

In either scenario, five to 10 application sites on the SWMR from upstream of LB confluence to downstream of MB confluence apply rotenone at the resulting concentration of 75 ppb for 6 h. At the end of the treatment stretch, the rotenone is deactivated with $KMnO_4$ for up to 24 h. The rotenone treatment and deactivation process will be monitored using sentinel fish and collecting samples for rotenone and $KMnO_4$ analyses.

Expected Environmental Conditions:

Flow: Chaput and Caissie (2010) using equations of Caissie and Robichaund (2009) estimated that the 2-y low-flow estimate for the SWMR at the confluence with LB was 1.47 $m^{3/}s$. However, we estimate the stable flow (excluding storm flows, obvious data errors and flows over 10.0 m^3/s) during late-August to early-September in the range of 1.9 to 9.2 m^3/s (5.3 m^3/s average) using historic flow data from the

SWMR at the Blackville Gauge and flow data from nearby Nashwaak River Gauge[1]. Flows were prorated based on upstream catchment areas. Actual flow data collected during summer 2020 using the U.S. Geological Survey *Weighted Area Method* is used to calibrate the estimated flow data from the Environment Canada Hydrometric Website. This will allow for a better estimate of the flows expected during the treatment period and a better estimate of rotenone quantity.

Temperature: Water temperatures in the SWMR occasionally exceed 25 °C and exceed 20 °C for an extended period of time from July through August. Water temperatures generally reach 15 °C by early June and decline to < 15 °C by later September (Caput and Caissie 2010). Treating in mid-August to early-September when water temperatures are ≥ 15 °C is ideal since rotenone is more effective and susceptible to breakdown (Finlayson et al. 2018).

Rotenone Injection Sites: Water velocity, depth, temperature and solar radiation in the SWMR will determine the number of rotenone injection sites along the treatment course, with injection sites placed at 1.6- (1-h travel time) to 3.2-km (2-h travel time) intervals (Finlayson et al. 2018). If the velocity is about 1.6 km/h, the 15-km reach of the SWMR will likely require 5 to 10 rotenone injection sites. A dye study on this stretch is needed to assist in the specific placement of the injection sites.

Rotenone Treatment Plan: The 6-h treatment will involve five to ten rotenone injection sites (one every 1.6 to 3.2 km), applying at 75 ppb rotenone (derived from van den Heuvel et al. 2017) to the 15-km stretch of the SWMR between 2 km upstream of the confluence with LB to 3-km downstream of MB[2]. Backwater and shore areas of this stretch are sprayed with rotenone using either land- or boat-based crews. The river will need to be surveyed to identify flowing tributaries, seeps and springs that may require special attention and may harbor SMB. At the end of the 15-km stretch downstream of the confluence with MB, a deactivation station will apply potassium permanganate ($KMnO_4$) at a resulting concentration of 4 ppm to maintain a 1 ppm residual $KMnO_4$ at 30 minutes downstream[3].

Assumptions:

SWMR outflow @ 1.9 to 9.2 m^3/s & velocity of 1.6 km/h
Treat with Noxfish Fish Toxicant II (PMRA 33247) @ 75 ppb rotenone for 6 h
Space injections sites @ 1.6 to 3.2 km (5 to 10 sites)

[1] Environment Canada Hydrometric Website
https://wateroffice.ec.gc.ca/mainmenu/real_time_data_index_e.html
[2] Additional flow and velocity measurements collected in spring and summer 2020 will determine the exact location of the five to ten injection sites and the location of the deactivation site.
[3] Additional deactivation testing in spring and summer 2020 will determine the exact dosage of $KMnO_4$ needed to deactivate rotenone in the organic containing SWMR water.

No tributaries or seeps/springs that require treatment
Estimated river flushing time @ 15 km/1.6 km/h = 9.4 h
Estimated duration of deactivation injection (9.4 h x 2) + 6 h = 24.75 h
Deactivate @ 4 ppm $KMnO_4$

Noxfish Fish Toxicant II (PMRA 33247) & Equipment Requirements: Estimates were derived using SOPs 5.1 and 11.1 (Finlayson et al. 2018).

Minimum Noxfish = 1.9 (m^3/s) x 1.2 x 75 (ppb rotenone) = 171 ml /min
171 ml/min x 60 min/h x 6 h = 61.56 L per site
Total for 5-10 sites 307.8 – 615.6 L [81.3 – 162.6 gal]

Maximum Noxfish = 9.2 (m^3/s) x 1.2 x 75 (ppb rotenone) = 828 ml/min
828 ml/min x 60 min/h x 6 h = 298.1 L per site
Total for 5-10 sites 1,490 – 2,981 L [393.7 – 787.6 gal]

Equipment = Treating the river with undiluted Noxfish II can be accomplished using one of two methods. Three to four dripcans are spaced at equal intervals across the width of the river at each site; this will work at sites shallow enough for foot access and to securely position the cans. Alternatively, a peristaltic pump (with flowmeter) capable of delivering 100 to 1,000 ml/min injects rotenone into a long PVC pipe that is elevated over the river's width and having evenly spaced emitters. The dripcan method requires no additional support equipment whereas the peristaltic pumps may require a generator for power at each site if adequate battery powered pumps are unavailable. This would be a new expense.

Granular $KMnO_4$ & Equipment Requirements: Estimates were derived using SOP 7.1 (Finlayson et al. 2018).

Minimum $KMnO_4$ = 4 ppb $KMnO_4$ x 60.02 x 1.9 m^3/s = 456.2 g/min
Total of 456.2 g/min x 60 min/h x 24.75 h = 677.5 kg $KMnO_4$

Maximum $KMnO_4$ = 4 ppb $KMnO_4$ x 60.02 x 9.2 m^3/s = 2,208.7 g/min
Total of 2,208.7 g/min x 60 min/h x 24.75 h = 3,279.9 $KMnO_4$

Equipment = Two (one used as a backup) volumetric feeder(s) capable of delivering 300 to 3,000 g/min of granular $KMnO_4$ placed on a platform in middle of a shallow section of the river and a generator for power. This expense was included in the estimate for treating Miramichi Lake.

Rotenone Treatment Monitoring in SWMR:

Overview: Rotenone treatment monitoring consists of measuring (1) responses of sentinel fish to rotenone and (2) collecting samples for rotenone analysis in the SWMR.

Objectives: (1) allow for adjustments to the treatment strategy during application and provide a record of efficacy throughout the treatment area, (2) provide an analytical record of rotenone levels in the SWMR during treatment, and (3) ensure that SMB are eliminated from the area.

***Monitoring Sites*:** The monitoring sites are sighted immediately upstream of the five to ten rotenone injection sties during summer 2020; one site is a control upstream of the first injection site. All sites will have caged sentinel fish and half of the sites will have samples collected for rotenone analysis.

Rotenone: The protocols for analyzing rotenone concentrations in water are detailed in SOP 16.1 of Finlayson et al. (2018) and utilize liquid chromatography (LC) as described by Dawson et al. (1983) or Sandvick et al. (2018) or direct injection liquid chromatography/mass spectrometry (LC/MS) as described by Vasquez et al. (2012); these analyses have a MDL of 0.001 mg/L and RL of 0.002 mg/L rotenone. Water samples are collected using a Kemmerer bottle in the lake or directly a few cm below the water surface in streams and shallow lake sites. Samples are put in 250-ml amber glass bottles with Teflon-lined caps, stored chilled (4 °C), and transported to the laboratory for analysis with chain-of-custody forms.

Assessment Criteria and Monitoring Timelines –

- **Sentinel Fish:** Yellow Perch *Perca flavescens* or White Perch *Morone americana* are used as sentinel fish surrogates for SMB. Cages containing sentinel fish are placed in the river within two hours pretreatment. The sentinel fish are checked hourly throughout the 6-h treatment.
- **Rotenone:** Verifying that the target dosage of 75 ppb rotenone was obtained for 6 h in the SWMR from upstream of LB confluence downstream to below MB confluence. Samples for rotenone analysis are collected at 2 and 4 h after treatment begins at the four monitoring sites.

Deactivation Monitoring in SWMR:

Overview: Deactivation monitoring consists of (1) real-time responses of sentinel fish upstream and downstream of the deactivation station, (2) collecting samples for rotenone analysis above and below the deactivation station, and (3) collecting and analyzing samples for $KMnO_4$ residual below the deactivation station.

Objectives: (1) allow for adjustments to the deactivation strategy of applying $KMnO_4$ by monitoring the response of sentinel fish and $KMnO_4$ residues, (2) provide an analytical record of rotenone concentrations upstream and downstream of the deactivation station during and following the treatment to SWMR, (3) maintain a 1 ppm $KMnO_4$ residual at the 30 minute mark and an analytical record of $KMnO_4$ levels in the SWMR downstream of the deactivation station, and (4) ensure that rotenone concentrations (> 2 ppb) are absent from the SWMR downstream of the deactivation station.

Monitoring Sites **(sighted during summer 2020)** –

- one site immediately upstream of deactivation site (SWMR5)
- one site 30 minutes downstream of the deactivation site (SWMR6)

Rotenone: **See Rotenone Treatment Monitoring in SWMR**

Potassium Permanganate: The protocols for the on-site analysis of potassium permanganate concentrations in water upstream and downstream of the deactivation station are detailed in SOP 7.1 of Finlayson et al. (2018) and utilize either direct (Standard Method 4500-$KMnO_4$ B)[4] or indirect (USEPA DPD Method 8167 for Total Chlorine) colorimetry.

Assessment Criteria and Monitoring Timelines:

- **Rotenone:** Verifying that rotenone is oxidized to < 2 ppb 30 minutes downstream of the deactivation station by collecting and analyzing samples for rotenone upstream (SWMR5) and downstream (SWMR6) of the deactivation station every 2 h during treatment and for the river flushing period afterwards (estimated 24.75 h total).
- **$KMnO_4$:** Verifying that $KMnO_4$ residual is maintained at 1 ppm by collecting and analyzing samples for $KMnO_4$ analysis every 30 minutes downstream of the deactivation station and relaying the results to the deactivation station for adjustment of $KMnO_4$ input.
- **Criteria for Beginning Deactivation:** Deactivation begins at a minimum of several hours before the rotenone treatment to reduce the $KMnO_4$ demand of the streambed in the 30-minute section below SWMR5. Injecting $KMnO_4$ until residues stabilize will ensure that the streambed is fully oxidized prior to contact with rotenone. Deactivation begins concurrently with the rotenone

[4] American Public Health Association. 1998. Standard methods for the examination of water and wastewater, 20th edition. American Public Health Association, Washington, D.C.

treatment, and the reaction of sentinel fish at SWMR5 signals the arrival of rotenone at the deactivation station.

- **Criteria for Terminating Stopping:** The survival of sentinel fish unstressed at SWRM5 for 4 h signals the lack of need for deactivation and the termination of $KMnO_4$ input.

- **Effectiveness:** Measured by the ability of caged sentinel fish to survive in water downstream from the 30-minute contact zone by maintaining a 1 ppm $KMnO_4$ residual.

Short-Term & Long-Term SMB Eradication Monitoring:

The plan developed and outlined in Component 3 of Appendix E will be modified to include SWMR habitat.

Ecological Recovery Monitoring:

The plan developed and outlined in Component 4 of Appendix E will be modified to include SWMR habitat. The Objectives and the Sample Parameters will reflect recovery of water quality, mussels, fishes and benthic invertebrates.

Additional Treatment:

It is prudent to treat flowing areas twice (Finlayson et al. 2018). The rationale for this is that the 6-h treatment is short compared to exposure in the lake and some fish may occupy areas not susceptible to adequate rotenone exposure. Re-treating the area will help expose those fish that missed exposure during the first treatment. The second treatment should occur ≥ one week ≤ four weeks after the first treatment.

References:

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2017-3386
2018-11-01

NOXFISH® FISH TOXICANT II

LIQUID EMULSIFIABLE
RESTRICTED

For control of fish in lakes, ponds, reservoirs and streams

ACTIVE INGREDIENT: Rotenone..... 5.0%

This product contains aromatic solvents and petroleum distillates.

REGISTRATION NO. 33247 PEST CONTROL PRODUCTS ACT

DANGER

POISON
FLAMMABLE

EYE AND SKIN IRRITANT

READ THE LABEL BEFORE USING

NET CONTENTS _____ LITRES

Wellmark International D.B.A. Central Life Sciences
Suite 200 West
1501 East Woodfield Road
Schaumburg IL 60173
1-888-241-8088

FIRST AID:
IF SWALLOWED: Call a poison control centre or doctor immediately for treatment advice. Do not induce vomiting unless told to do so by a poison control centre or doctor. Do not give **any** liquid to the person. Do not give anything by mouth to an unconscious person.
IF ON SKIN OR CLOTHING: Take off contaminated clothing. Rinse skin immediately with plenty of water for 15–20 minutes. Call a poison control centre or doctor for treatment advice.
IF INHALED: Move person to fresh air. If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably by mouth-to-mouth, if possible. Call a poison control centre or doctor for further treatment advice.
IF IN EYES: Hold eye open and rinse slowly and gently with water for 15–20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control centre or doctor for treatment advice.
Take container, label or product name and PCP Registration Number with you when seeking medical attention.

TOXICOLOGICAL INFORMATION:
Contains petroleum distillate - vomiting may cause aspiration pneumonia. Treat symptomatically.

PRECAUTIONS:
KEEP OUT OF REACH OF CHILDREN. Fatal or poisonous if swallowed. May be harmful if absorbed through skin. Fatal if inhaled. Causes eye and skin irritation. DO NOT inhale sprays or vapours. Do not get in eyes, on skin or on clothing. In case of contact, wash immediately with soap and water. Wash all contaminated clothing with soap and hot water before reuse. Avoid contamination of feed and foodstuffs. Apply this product only as specified on this label. Do not contaminate water by cleaning of equipment or disposal of wastes.

Do not allow recreational access (e.g., wading, swimming, boating and fishing) to treated areas while rotenone is being applied. Do not allow swimming or wading in treated water for 72 hours after last application.

Wear chemical-resistant coveralls over long-sleeved shirt and long pants, chemical-resistant gloves, socks and chemical-resistant footwear, goggles or face shield, and either a respirator with a NIOSH-organic-vapour-removing cartridge with a prefilter approved for pesticides or a NIOSH-approved canister approved for pesticides during mixing, loading, application, clean-up and repair.

Engineering Controls for Mixing/Loading:
Mixers and loaders (except mixing/loading to support backpack sprayers) must use a closed system that is designed by the manufacturer to remove the product from the shipping container and transfer the product into mixing tanks and/or application equipment. At any disconnect point, the system must be equipped with a dry disconnect or dry couple shut-off device that will limit drippage to no more than 2 ml per disconnect. The closed mixing/loading system must function properly and be used and maintained in accordance with the manufacturer’s written operating instructions.

ENVIRONMENTAL HAZARDS:
Toxic to aquatic organisms.

GENERAL INFORMATION:
NOXFISH FISH TOXICANT II is a specially formulated product containing rotenone to be used in fisheries management for the eradication of fish from lakes, streams, ponds and reservoirs. NOXFISH FISH TOXICANT II will not solidify nor show any separation at temperatures above 4.5°C and is stable for a minimum of one year when stored in sealed drums at 21°C.

NOTICE TO USER:
This pest control product is to be used only in accordance with the directions on the label. It is an offense under the Pest Control Products Act to use this product in a way that is inconsistent with the directions on the label.

NATURE OF RESTRICTION:
This product is to be used only in the manner authorized; consult local pesticide regulatory authorities about use permits that may be required. Apply this product only as specified on this label. NOXFISH FISH TOXICANT II is registered for use by or under permit from and after consultation with Provincial and Federal Fish and Wildlife Agencies.

RESTRICTED USES

USE LIMITATIONS:
Use against fish in streams, , ponds, lakes or reservoirs. Since such factors as pH, temperature, depth, and turbidity will change effectiveness, use this product only at locations, rates and times authorized and approved by appropriate Provincial and Federal agencies. Rates must be within the range specified in the labeling. Properly dispose of dead fish and unused product. Do not use dead fish for food or feed. Do not use water treated with rotenone to irrigate crops or release within ½ km upstream of a potable water or irrigation water intake in a standing body of water, such as a lake, pond, or reservoir.

DIRECTIONS FOR USE:
FOR USE IN PONDS, LAKES, AND RESERVOIRS
Under appropriate circumstances application can be made from shore, by boat, jet boat, helicopter or fixed-wing airplane.
Application of product by backpack should be limited to areas not treatable by other methods.
When applying by boat, product must be released below the water's surface.
Avoid contamination downstream/downlake of the treatment area, through release of rotenone-treated water, during or after treatment.

SPECIAL INSTRUCTIONS: Water alkalinity, temperature and turbidity are usually different in each type of water. Because these factors change the effectiveness of pesticides, consult your Provincial Game & Fish representative before use to determine the correct concentration of this product needed for the type of kill desired. NOXFISH FISH TOXICANT II disperses readily in

water both laterally and vertically, and will penetrate below the thermocline in thermally stratified bodies of water.

COMPUTATION OF CUBIC METRES: To determine the number of cubic metres in a given body of water, make a series of transects across the water surface taking depth measurements with calibrated pole or weighted line. Add the soundings and divide by the number of measurements made to determine the average depth. Multiply this average depth by the total surface area to find the number of cubic metres to be treated. If the surface area is unknown, contact your local Soil Conservation Service, which can determine this from aerial photographs.

AMOUNT OF NOXFISH FISH TOXICANT II NEEDED FOR SPECIFIC USES: To determine the appropriate number of litres of NOXFISH FISH TOXICANT II (5% Rotenone) needed, find your "Type of Use" in the first column of the table below and then divide the corresponding numbers in the third column, "Number of Cubic Metres Covered by One Litre" into the number of cubic metres in the body of water being treated.

Type of Use	Parts Per Million of NOXFISH FISH TOXICANT II	Number of Cubic Metres Covered by One Litre
Selective treatment	0.10 to 0.13	9,777 to 7,821
Normal pond use	0.5 to 1.0	1,955 to 978
Remove bullheads or carp	1.0 to 2.0	978 to 489
Remove bullheads or carp in rich organic ponds	2.0 to 4.0	489 to 244
Preimpoundment treatment above dam	3.0 to 4.0	244 to 196

Note: The maximum application rate for ponds, lakes and reservoirs is not to exceed 0.2 ppm rotenone. The maximum application rate for streams is not to exceed 0.05 ppm rotenone.

PRE-MIXING AND METHOD OF APPLICATION: Pre-mix with water at a rate of one litre NOXFISH FISH TOXICANT II to 10 litres of water. Uniformly apply over water surface or bubble through underwater lines.

DETOXIFICATION: NOXFISH FISH TOXICANT II treated waters detoxify under natural conditions within 1 week to 1 month, depending upon temperatures, alkalinity, etc. Rapid detoxification can be accomplished by adding chlorine or potassium permanganate to the water at the same rate as NOXFISH FISH TOXICANT II in parts per million, plus enough additional to meet the chlorine demand of the untreated water.

REMOVAL OF TASTE AND ODOUR: NOXFISH FISH TOXICANT II treated waters do not retain a detectable taste or odour for more than a few days to a maximum of one month. Taste and odour can be removed immediately by treatment with activated charcoal at a rate of 30 ppm for each 1 ppm NOXFISH FISH TOXICANT II remaining. (Note: As NOXFISH FISH TOXICANT II detoxifies, less charcoal is required.)

RESTOCKING AFTER TREATMENT: Wait 2 to 4 weeks after treatment. Place a sample of fish to be stocked in wire cages in the coolest part of the treated waters. If the fish are not killed within 24 hours, the water may be restocked.

FOR USE IN STREAMS, IMMEDIATELY ABOVE PONDS, LAKES, OR RESERVOIRS: Allow NOXFISH FISH TOXICANT II to drain from drum directly into centre of stream at a rate of 0.9-1.8cc per minute for each 30 litres of water flowing per second in the stream (0.5-1.0 part per million NOXFISH FISH TOXICANT II or 0.025-0.05 ppm rotenone). Product must be released below the water's surface.

AERIAL APPLICATIONS:
Apply by fixed-wing or rotary aircraft equipment which has been functionally and operationally calibrated for the atmospheric conditions of the area and the application rates and conditions of this label. Apply at the rate determined above for the specific "Type of Use". Apply only when meteorological conditions at the treatment site allow for complete and even coverage. Apply only under conditions of good practice specific to aerial applications, as outlined in the National Aerial Pesticide Application Manual, developed by the Federal/Provincial/Territorial Committee on Pest Management and Pesticides. Avoid drifting of spray onto land or other non-target areas. Coarse sprays are less likely to drift, therefore, avoid combinations of pressure and nozzle type that will result in fine particles (mist). Do not apply during periods of dead calm or when wind velocity and direction pose a risk of spray drift. Do not spray when the wind is blowing towards nearby sensitive crops, terrestrial habitats or non-target aquatic habitats.

OPERATOR PRECAUTIONS: Do not allow the pilot to mix chemicals to be loaded onto the aircraft. Loading of premixed chemicals with a closed system is permitted. Pilot must be in an enclosed cockpit and wear a long-sleeved shirt, long pants, shoes and socks.

It is desirable that the pilot have communication capabilities at each treatment site at the time of application.

The field crew and the mixer/loaders must wear chemical-resistant coveralls over a long-sleeved shirt and long pants, chemical-resistant gloves, socks and chemical-resistant footwear, goggles or face shield, and either a respirator with a NIOSH-approved organic-vapour-removing cartridge with a prefilter approved for pesticides or a NIOSH-approved canister for pesticides during mixing, loading, clean-up and repair. Follow the more stringent label precautions in cases where the operator precautions exceed the generic label recommendations on the existing application equipment label.

All personnel on the job site must wash hands and face thoroughly before eating and drinking. Protective clothing, aircraft cockpit and vehicle cabs must be decontaminated regularly.

DISPOSAL

1. Triple-or pressure-rinse the empty container. Add the rinsings to the spray mixture in the tank.
2. Follow provincial instruction for any required additional cleaning of the container prior to its disposal.

3. Make the empty container unsuitable for further use.
4. Dispose of the container in accordance with provincial requirements.
5. For information on disposal of unused, unwanted product, contact the manufacturer or the provincial regulatory agency. Contact the manufacturer and the provincial regulatory agency in case of a spill, and for clean-up of spills.

Noxfish Fish Toxicant II

Safety Data Sheet

Date of issue: 11/14/2018 Version: 1.0

SECTION 1: Identification

1.1. Identification

Product form : Mixture

Trade name : Noxfish Fish Toxicant II

Synonyms : PMRA # 33247; RF2232 LIQUID FT

1.2. Recommended use and restrictions on use

Recommended use : Piscicides.

Restrictions on use : Keep out of reach of children. Avoid inhalation of vapors or fumes. Use in well ventillated area. Avoid all contact with skin, eyes, or clothing.

1.3. Supplier

Wellmark International, dba Central Life Sciences

1501 East Woodfield Road, Suite 200 West

Schaumburg, IL 60173

www.zoecon.com

1.4. Emergency telephone number

Emergency number : 1-800-248-7763
1-800-424-9300 - CHEMTREC
1-703-527-3887 - CHEMTREC - Outside North America - Collect Calls Accepted

SECTION 2: Hazard(s) identification

2.1. Classification of the substance or mixture

GHS-US classification

Acute toxicity (oral) Category 3	Toxic if swallowed
Acute toxicity (inhalation) Category 2	Fatal if inhaled
Serious eye damage/eye irritation Category 2B	Causes eye irritation
Carcinogenicity Category 2	Suspected of causing cancer
Specific target organ toxicity (single exposure) Category 3	May cause drowsiness or dizziness
Specific target organ toxicity (single exposure) Category 3	May cause respiratory irritation
Aspiration hazard Category 1	May be fatal if swallowed and enters airways

2.2. GHS Label elements, including precautionary statements

GHS-US labeling

Hazard pictograms (GHS-US) :

GHS06 GHS07 GHS08

Signal word (GHS-US) : Danger

Hazard statements (GHS-US) : Toxic if swallowed
May be fatal if swallowed and enters airways
Causes eye irritation
Fatal if inhaled
May cause respiratory irritation
May cause drowsiness or dizziness
Suspected of causing cancer

Precautionary statements (GHS-US) : Obtain special instructions before use.
Do not handle until all safety precautions have been read and understood.
Do not breathe dust/fume/gas/mist/vapors/spray.
Wash hands, forearms and face thoroughly after handling.
Do not eat, drink or smoke when using this product.
Use only outdoors or in a well-ventilated area.
Wear protective gloves/protective clothing/eye protection/face protection.
If swallowed: Immediately call a poison center or doctor.
If inhaled: Remove person to fresh air and keep comfortable for breathing.
If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.

If exposed or concerned: Get medical advice/attention.
Immediately call a poison center or doctor.
Rinse mouth.
Do NOT induce vomiting.
If eye irritation persists: Get medical advice/attention.
Store in a well-ventilated place. Keep container tightly closed.
In case of inadequate ventilation wear respiratory protection.
Store locked up.
Dispose of contents/container to in accordance with local/regional/national/international regulations.

2.3. Other hazards which do not result in classification

Other hazards not contributing to the classification : This product is extremely toxic to fish and other aquatic organisms. Under United States Regulations (29 CFR 1910.1200 - Hazard Communication Standard), this product is considered hazardous.

2.4. Unknown acute toxicity (GHS US)

Not applicable

SECTION 3: Composition/Information on ingredients

3.1. Substances

Not applicable

3.2. Mixtures

Name	Product identifier	%
Rotenone	(CAS-No.) 83-79-4	5
Cube Resins other than rotenone	(CAS-No.) N/A	5
Benzyl alcohol	(CAS-No.) 100-51-6	20
Propylene Glycol	(CAS-No.) 57-55-6	10
Solvent naphtha	(CAS-No.) 64742-94-5	52.79
Naphthalene	(CAS-No.) 91-20-3	0.53
Other ingredients	(CAS-No.) N/A	Balance

SECTION 4: First-aid measures

4.1. Description of first aid measures

First-aid measures general : Call a physician immediately.

First-aid measures after inhalation : IF INHALED: Remove person to fresh air and keep comfortable for breathing. Call a physician immediately. Call a doctor. Call a POISON CENTER or doctor/physician if you feel unwell.

First-aid measures after skin contact : IF ON SKIN: Wash with plenty of soap and water. If skin irritation or rash occurs: Get medical advice/attention.

First-aid measures after eye contact : IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If eye irritation persists: Get medical advice and attention.

First-aid measures after ingestion : IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell. Rinse mouth. Call a physician immediately. Do not induce vomiting. Do NOT induce vomiting unless directed to do so by medical personnel.

4.2. Most important symptoms and effects (acute and delayed)

Symptoms/effects : May cause drowsiness or dizziness.

Symptoms/effects after inhalation : Fatal if inhaled. Causes dizziness or drowsiness if inhaled at non-lethal doses. Causes respiratory irritation if inhaled at non-lethal doses.

Symptoms/effects after eye contact : Mild eye irritation.

Symptoms/effects after ingestion : Toxic if swallowed. Risk of lung edema.

Chronic symptoms : May cause cancer.

4.3. Immediate medical attention and special treatment, if necessary

Contains petroleum distillate vomiting may cause aspiration pneumonia. Treat symptomatically.

SECTION 5: Fire-fighting measures

5.1. Suitable (and unsuitable) extinguishing media

Suitable extinguishing media : Water spray. Dry powder. Foam. Carbon dioxide.

Unsuitable extinguishing media : Avoid heavy hose streams.

5.2. Specific hazards arising from the chemical

Reactivity : The product is non-reactive under normal conditions of use, storage and transport.

5.3. Special protective equipment and precautions for fire-fighters

Firefighting instructions : Do not allow fire fighting water to escape into waterways or sewers. LARGE FIRES: Move containers from fire area if you can do it without risk. Ventilate closed spaces before entering. Do not breathe gas/fumes/vapor/spray. Keep unauthorized personnel away.

Protection during firefighting : Do not attempt to take action without suitable protective equipment. Self-contained breathing apparatus. Complete protective clothing.

SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures

6.1.1. For non-emergency personnel

Emergency procedures : Do not breathe dust/fume/gas/mist/vapors/spray. Only qualified personnel equipped with suitable protective equipment may intervene.

6.1.2. For emergency responders

Protective equipment : Do not attempt to take action without suitable protective equipment. For further information refer to section 8: Exposure controls/personal protection.

Emergency procedures : As an immediate precautionary measure, isolate spill or leak area for at least 50 meters (150 feet) in all directions. Do NOT wash away into sewer. Avoid release to the environment. Evacuate unnecessary personnel. Stay upwind. Stop leak if safe to do so. Wear appropriate personal protective equipment, avoid direct contact.

6.2. Environmental precautions

Avoid release to the environment. Do not allow runoff into water, storm drains or drainage ditches.

6.3. Methods and material for containment and cleaning up

Methods for cleaning up : Absorb spills with an inert material, clay granules or other inert absorbent material and put in container for disposal. Do not flush to sewer or allow to enter waterways. Wear appropriate personal protective equipment, avoid direct contact. Notify authorities if product enters sewers or public waters.

SECTION 7: Handling and storage

7.1. Precautions for safe handling

Precautions for safe handling : Do not handle until all safety precautions have been read and understood. Wear personal protective equipment. Use only outdoors or in a well-ventilated area. Do not breathe dust/fume/gas/mist/vapors/spray. Avoid contact with skin and eyes.

Hygiene measures : Do not eat, drink or smoke when using this product. Always wash hands after handling the product.

7.2. Conditions for safe storage, including any incompatibilities

Storage conditions : Do not store near heat or open flame. Keep from freezing. Keep only in original container. Protect from sunlight. Store locked up. Store in a well-ventilated place. Keep container tightly closed. Store in a well-ventilated place. Keep cool.

Incompatible materials : Strong acids. Strong oxidizers. Heat, sparks, open flame.

SECTION 8: Exposure controls/personal protection

8.1. Control parameters

Rotenone (83-79-4)		
ACGIH	ACGIH TWA (mg/m³)	5 mg/m³ (commercial)
ACGIH	Remark (ACGIH)	URT & eye irr; CNS impair
OSHA	OSHA PEL (TWA) (mg/m³)	5 mg/m³
IDLH	US IDLH (mg/m³)	2500 mg/m³
NIOSH	NIOSH REL (TWA) (mg/m³)	5 mg/m³

Benzyl alcohol (100-51-6)		
AIHA	WEEL TWA (ppm)	10 ppm

Propylene Glycol (57-55-6)		
AIHA	WEEL TWA (mg/m³)	10 mg/m³

Naphthalene (91-20-3)		
ACGIH	ACGIH TWA (ppm)	10 ppm

Naphthalene (91-20-3)		
ACGIH	Remark (ACGIH)	Hematologic eff; URT & eye irr; Skin; A3 (Confirmed Animal Carcinogen with Unknown Relevance to Humans: The agent is carcinogenic in experimental animals at a relatively high dose, by route(s) of administration, at site(s), of histologic type(s), or by mechanism(s) that may not be relevant to worker exposure. Available epidemiologic studies do not confirm an increased risk of cancer in exposed humans. Available evidence does not suggest that the agent is likely to cause cancer in humans except under uncommon or unlikely routes or levels of exposure)
OSHA	OSHA PEL (TWA) (mg/m³)	50 mg/m³
OSHA	OSHA PEL (TWA) (ppm)	10 ppm
IDLH	US IDLH (ppm)	250 ppm
NIOSH	NIOSH REL (TWA) (mg/m³)	50 mg/m³
NIOSH	NIOSH REL (TWA) (ppm)	10 ppm
NIOSH	NIOSH REL (STEL) (mg/m³)	75 mg/m³
NIOSH	NIOSH REL (STEL) (ppm)	15 ppm

8.2. Appropriate engineering controls

Appropriate engineering controls : Adequate ventilation systems as needed to control concentrations of airborne contaminants below applicable threshold limit values.

Environmental exposure controls : Avoid release to the environment.

8.3. Individual protection measures/Personal protective equipment

Hand protection:

Wear chemical resistant gloves made out of barrier laminate, nitrile rubber < or equal to 14 mils, neoprene rubber < or equal to 14 mils or Viton < or equal to 14 mils

Eye protection:

Wear chemical splash safety goggles. Safety glasses

Skin and body protection:

Coveralls, over long-sleeved shirt and long pants

Respiratory protection:

Mixers loaders, applicators and other handlers (except pilots): wear a NIOSH approved particulate respirator with any N, R or P filter with NIOSH approval prefix TC-84A or NIOSH approved powered air purifying respirator with HE filter with NIOSH approval prefix TC-21C. Wear respiratory protection. In case of insufficient ventilation, use NIOSH approved respiratory protection.

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

Physical state : Liquid

Appearance : Clear amber liquid

Color : Amber

Odor : Strong, unpleasant, petroleum gas-like

Odor threshold : No data available

pH : 6.87 @ 23.4°C

Melting point : Not applicable

Freezing point : No data available

Boiling point : No data available

Flash point	:	112ºC (233.6ºF)
Relative evaporation rate (butyl acetate=1)	:	No data available
Flammability (solid, gas)	:	Not applicable
Vapor pressure	:	No data available
Relative vapor density at 20 °C	:	No data available
Relative density	:	1.0336 g/ml @ 20ºC
Solubility	:	Insoluble
Log Pow	:	No data available
Auto-ignition temperature	:	No data available
Decomposition temperature	:	No data available
Viscosity, kinematic	:	No data available
Viscosity, dynamic	:	<20 cPs @ 25ºC
Explosion limits	:	No data available
Explosive properties	:	Not explosive
Oxidizing properties	:	Not applicable

9.2. Other information

No additional information available

SECTION 10: Stability and reactivity

10.1. Reactivity

The product is non-reactive under normal conditions of use, storage and transport.

10.2. Chemical stability

Stable under normal conditions.

10.3. Possibility of hazardous reactions

No dangerous reactions known under normal conditions of use.

10.4. Conditions to avoid

Heat, sparks, open flame. Excess heat. Protect from sunlight. Do not freeze.

10.5. Incompatible materials

Strong acids. Strong oxidizing agents.

10.6. Hazardous decomposition products

Under normal conditions of storage and use, hazardous decomposition products should not be produced.

SECTION 11: Toxicological information

11.1. Information on toxicological effects

Noxfish Fish Toxicant II	
pH	6.87 @ 23.4ºC

Rotenone (83-79-4)	
LD50 oral rat	39.5 mg/kg female, LD50 102 mg/kg male
LD50 dermal rabbit	> 5000 mg/kg
LC50 inhalation rat (mg/l)	0.0212 mg/l/4h

Benzyl alcohol (100-51-6)	
LD50 oral rat	1620 mg/kg
LD50 dermal	> 2000 mg/kg
LC50 inhalation rat (mg/l)	> 4.2 mg/l/4h

Solvent naphtha (64742-94-5)	
LD50 oral rat	> 5000 mg/kg
LD50 dermal rabbit	> 2000 mg/kg
LC50 inhalation rat (mg/l)	> 4.778 mg/l/4h

Naphthalene (91-20-3)	
LD50 oral rat	490 - 2600 mg/kg
LD50 dermal	> 2000 mg/kg
IARC group	2B - Possibly carcinogenic to humans

Naphthalene (91-20-3)	
National Toxicity Program (NTP) Status	Evidence of Carcinogenicity, Reasonably anticipated to be Human Carcinogen
In OSHA Hazard Communication Carcinogen list?	Yes

GHS-US Properties	Classification
Acute toxicity	Oral: Toxic if swallowed. Inhalation: Fatal if inhaled.
Skin corrosion/irritation	Not classified
Serious eye damage/irritation	Causes eye irritation.
Respiratory or skin sensitization	Not classified
Germ cells mutagen	Not classified
Carcinogenicity	Suspected of causing cancer.
Reproductive toxicity	Not classified
Specific target organ toxicant (single exposure)	May cause drowsiness or dizziness. May cause respiratory irritation.
Specific target organ toxicant (repeated exposure)	Not classified
Aspiration hazard	May be fatal if swallowed and enters airways.

SECTION 12: Ecological information

12.1. Toxicity

Rotenone (83-79-4)	
LC50 Acute fish 1	0.00194 mg/l (Exposure time: 96h - Rainbow trout)
EC50 Daphnia 1	0.0037 mg/l (Exposure time: 96h - Daphnia magna)
NOEC Chronic fish 1	0.00101 mg/l (Rainbow trout)
NOEC Chronic crustacea 1	0.00125 mg/l (Daphnia magna)

Benzyl alcohol (100-51-6)	
LC50 Acute fish 1	460 mg/l (Exposure time: 96h - Fathead minnow)
LC50 Acute fish 2	> 100 mg/l (Exposure time: 96h - Japanese kilifish)
LC50 Acute crustacea 1	230 mg/l (Exposure time: 48h - Daphnia magna)

12.2. Persistence and degradability

Rotenone (83-79-4)	
Persistence and degradability	Rotenone is not persistent in the environment and its low vapor pressure (6.9x10-10 torr) and Henry's Law constant (1.1x10-13 atm-m3 mol-1) limit its volatility. If released to water, rotenone generally degrades quickly through abiotic (hydrolytic and photolytic) mechanisms.

12.3. Bioaccumulative potential

Rotenone (83-79-4)	
Log Pow	4.1
Bioaccumulative potential	Rotenone has a relatively low potential for bioconcentrating in aquatic organisms.

12.4. Mobility in soil

Rotenone (83-79-4)	
Mobility in soil	Rotenone is mobile to moderately mobile in soil and sediment with a half-life of a few days to several weeks or longer depending on water temperature

12.5. Other adverse effects

Noxfish Fish Toxicant II	
Ecological Fate	This product is extremely toxic to fish and other aquatic organisms.

SECTION 13: Disposal considerations

13.1. Disposal methods

Product/Packaging disposal recommendations : Dispose of content and/or container in accordance with local, regional, national, and/or international regulations.

SECTION 14: Transport information

	UN number	Proper Shipping Name	Transport hazard class(es)	Packing group	Environmental hazards
DOT	UN2902	Pesticides, liquid, toxic, n.o.s. (Rotenone)	6.1	II	RQ: Naphthalene 100 lbs. Marine pollutant
IMDG	UN2902	Pesticides, liquid, toxic, n.o.s. (Rotenone)	6.1	II	Marine pollutant
IATA	UN2902	Pesticides, liquid, toxic, n.o.s. (Rotenone)	6.1	II	Acute aquatic toxicity

Other Information : The calculated 1-hour acute toxicity for inhalation LC50 = 1.588 mg/L

SECTION 15: Regulatory information

15.1. US Federal regulations

Benzyl alcohol (100-51-6)	
Listed on the United States TSCA (Toxic Substances Control Act) inventory	

Propylene Glycol (57-55-6)	
Listed on the United States TSCA (Toxic Substances Control Act) inventory	

Solvent naphtha (64742-94-5)	
Listed on the United States TSCA (Toxic Substances Control Act) inventory	

Naphthalene (91-20-3)	
Listed on the United States TSCA (Toxic Substances Control Act) inventory Subject to reporting requirements of United States SARA Section 313	
CERCLA RQ	100 lb
SARA Section 313 - Emission Reporting	0.1 %

PMRA Labelling	
PMRA Registration Number	PMRA # 33247
PMRA INFORMATION: This chemical is a pesticide registered by the Pest Management Regulatory Agency and is subject to certain labeling requirements under the Pest Control Products Act.	
PMRA Pictogram	
PMRA Signal word	**Danger**
PMRA Precautionary Statement	KEEP OUT OF REACH OF CHILDREN.
PMRA Hazards to Humans and Domestic Animals	TOXICOLOGICAL INFORMATION: Contains petroleum distillate - vomiting may cause aspiration pneumonia. Treat symptomatically. KEEP OUT OF REACH OF CHILDREN. Fatal or poisonous if swallowed. May be harmful if absorbed through skin. Fatal if inhaled. Causes eye and skin irritation. DO NOT inhale sprays or vapours. Do not get in eyes, on skin or on clothing. In case of contact, wash immediately with soap and water. Wash all contaminated clothing with soap and hot water before reuse. Avoid contamination of feed and foodstuffs. Apply this product only as specified on this label. Do not contaminate water by cleaning of equipment or disposal of wastes. Do not allow recreational access (e.g., wading, swimming, boating and fishing) to treated areas while rotenone is being applied. Do not allow swimming or wading in treated water for 72 hours after last application. Wear chemical-resistant coveralls over long-sleeved shirt and long pants, chemical-resistant gloves, socks and chemical-resistant footwear, goggles or face shield, and either a respirator with a NIOSH-organic-vapour-removing cartridge with a prefilter approved for pesticides or a NIOSH-approved canister approved for pesticides during mixing, loading, application, clean-up and repair.

PRMA First Aid	FIRST AID: IF SWALLOWED: Call a poison control centre or doctor immediately for treatment advice. Do not induce vomiting unless told to do so by a poison control centre or doctor. Do not give any liquid to the person. Do not give anything by mouth to an unconscious person. IF ON SKIN OR CLOTHING: Take off contaminated clothing. Rinse skin immediately with plenty of water for 15–20 minutes. Call a poison control centre or doctor for treatment advice. IF INHALED: Move person to fresh air. If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably by mouth-to-mouth, if possible. Call a poison control centre or doctor for further treatment advice. IF IN EYES: Hold eye open and rinse slowly and gently with water for 15–20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control centre or doctor for treatment advice. Take container, label or product name and PCP Registration Number with you when seeking medical attention.
PMRA Environmental Hazards	Toxic to aquatic organisms.

15.2. US State regulations

No additional information available

SECTION 16: Other information

Date of issue : 14 November 2018

SDS US (GHS HazCom 2012) - CGP

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APPENDIX J

Assembly of First Nations Resolution on Invasive Alien Species

AFN INVASIVE ALIEN SPECIES
Report 2007-08

Policy Area

Aquatic Alien Species

Invasive alien species are the second most significant threat to biodiversity, after habitat loss. Once they are introduced, invasive alien species become predators, competitors, parasites, hybridizers, and diseases of our native and domesticated plants, animals and marine life. The impact of invasive alien species on native ecosystems, habitats and species can be severe and often irreversible, and can cost billions of dollars each year. The need for Canada to take measures to address invasive alien species and protect and conserve Canada's natural resources and associated industries as well as the health of wildlife and humans, is essential.

What is an Invasive Alien Species?

Alien species are species of plants, animals, and micro-organisms introduced by human action outside their natural past or present distribution. *Invasive alien species* are those harmful alien species whose introduction or spread threatens the environment, the economy, or society, including human health. Invasive alien species can originate from other continents, neighbouring countries, or from other ecosystems within Canada. There are wide assortments and types of species that are classified as "alien species", and while many of these species do not pose any immediate risk, and may even provide important benefits, many others, such as Purple Loosestrife, the Emerald Ash Borer and the Green Crab can cause very significant ecological, economic and environmental damage. These species are known as "invasive" alien species.

How are Invasive Alien Species Spread?

The ways in which invasive alien species are introduced or spread, are called *pathways.* Introductions can be both intentional (purposeful) or unintentional (accidental) and they can be "authorized" or "unauthorized" (illegal). There are many pathways of introduction (vectors) including ballast water, recreational boating, aquarium trade, pet trade, horticultural trade, "hitchhikers" on commodities, stowaways in various modes of transportation, and disease in wildlife. Canada's strategic approach to address invasive alien species focuses primarily on pathways of introduction.

First Nations impacted by Alien Species and Alien Invasive Species?

Alien Species and Alien Invasive Species threats to the health and abundance of indigenous species and the recorded degradation to their habitat are inescapable and supportable facts. These changes in turn can restrict First Nations socio-economic practices such as; food and commercial fisheries, societal gatherings, and other related events and spiritual practices such as a rite of observance, sacred offerings, or memorial services. These restrictions can *unjustifiably infringe* upon constitutionally protected Aboriginal and Treaty Rights. The Supreme Court of Canada has found that when a legislative measure limits the exercise of an existing aboriginal right, there is *prima facie* infringement of section 35 of the *Constitution Act, 1982*. The added obligation to First nations adds to the need for Canada to take measures to address invasive alien species and protect and conserve natural resources as well as the health of wildlife and humans, is essential.

Mandate

Resolution No. 22 Subject: National Fisheries Strategy (NFS) passed at the Confederacy Of Nations on April 4, 5 & 6, 2000 Ottawa, Ontario is based upon a previous AFN Chiefs Committee on Fisheries (AFN-CCF) meeting in Halifax Nova Scotia on March 28 & 29, 2000.

This resolution identified a full range of common issues and regional concerns that in conclusion recognized the need for a *National Fisheries Strategy.* This resolution supported the development of a strategy that led to a strategic plan based on the following elements. First Nations Fisheries rights and interests in International activities, consultation with First Nations concerning conservation and environment, fisheries management, Department of Fisheries conduct and engagement of First Nations, AFN role and presence in processes, media and public education, litigation and in federal policy initiatives

This NFS would provide support and complements the regional initiatives of First Nations by opening discussions with the federal government on the need for a general review of the federal policies with respect to coastal and inland fisheries, as well as to promote a more expansive nation-to-nation dialogue.

Key Issues and Activities

First Nations interests

In an increasingly complex landscape, federal authorities must to cognizant of the socio-economic realities and rights based interests of Aboriginal peoples. These interests are heavily impacted or infringed by competitive realities of foreign and domestic trade overlaid by a domestic legal landscape characterized by shared legal jurisdictions and yet to be defined over-arching constitutional questions. This requires federal, provincial and territorial authorities to extensively consult with First Nations in initiatives that potentially fringe upon Aboriginal and Treaty Rights to seek to accommodate First Nations interests in the earliest phasing of planning.

Consultation

The existence of the potential to infringe upon a substantive First Nations right or interest in the process of introducing an aquatic Alien Species whose introduction or spread poses a threat to the aquatic environment and inadvertently to First Nations requires a high degree of consultation. This dialogue is vital for both government and First Nations to fully determine the scope and content of the proposed listing or to determine the potential outcome. Consultation is therefore a vital requirement to properly gauge the seriousness of the adverse effect on a First Nations right or substantive interests and to develop an effective response or accommodation.

When Should Consultation Take Place

The duty to consult is significantly elevated when the claimed Aboriginal right or interest is very compelling and the impacts of the proposed project, activity or action is unknown, potentially severe or permanent. At this point it moves beyond an issue of reconciliation or of balancing Aboriginal rights with the interests of other Canadians. It is about avoiding action that may constrain or led to the *extirpation* or *extinction* of a species that represents an *extinguishment* of specific First Nations Rights.

Loss of Biodiversity

First Nations who share common inherent rights and interests in lands and resources have grave concerns over the intentional and unintentional introduction of Alien Species into the ecosystems across Canada. These concerns are born out of having witnessed and experienced first hand the detrimental physiological effects to the overall health of the ecosystem once alien species have been introduced the environment and waterways. This has resulted in continued systematic loss of indigenous species that are intrinsic to our way of life including for food, social and ceremonial practices.

Provincial Practices of Alien Species Introduction

Provincial governments are the very worst practitioners of alien species introduction and aggressively plant alien species for the purposes of sports and recreational fisheries. The provinces in turn rely heavily on the *Federal Fisheries Act* to justify the management of these species as an identified fishery. A majority of those species classified as game fish are piscivorous species that upon maturity rely heavily on indigenous aquatic species as a food source. These indigenous aquatic species are important culturally and commercially to First Nations people. This example helps illustrate a conflict between protection of indigenous species Vs commercial and recreational interests.

Reasons for Introduction

While there are certain benefits to the introduction and propagation of alien species for human use and consumption, First Nations are concerned over are the lack of political will and policy to ensure that alien species are contained within a tightly controlled environment. This precautionary measure is necessary to limit the negative spread and proliferation of *alien species* that upon reaching a certain threshold are re-classified as being *Invasive Alien Species*. The environmental degradation caused by the proliferation of Invasive Alien Species is often irreversible resulting in the loss of overall biological diversity and available habitat resulting in the decline and extinction of indigenous species.

Effects of Continued losses of Biodiversity

The loss of biodiversity to First Nation represents the systematic erosion and infringement of constitutionally protected rights of priority access to resources for food, social and ceremonial purposes. First Nations traditional diets once rich, varied and protein based utilized a wide array of marine and fresh water species, and animal and plant life. This has resulted in the fragmentation or loss of traditional diet is now being researched to better understand the relationship between First Nations and the environment. What is known is disturbing, especially when considering First Nations are at the lowest income levels in Canadian society. What this means is that in most cases First Nations are only able to afford a diet laden with fats, starches and carbohydrates with very little fresh fruit, vegetables, wild game or aquatic species.

Resulting Outcome for First Nations

First Nations are in fact subsidizing federal, provincial and territorial mismanagement of our aquatic resources. This subsequent mismanagement has resulted in the failure to protect and ensure First Nations priority rights of access to our indigenous species. This has resulted in the continuous and forced subsidization as First Nations seek to substitute their traditional diet or medicines with the poorest of replacements based upon the lowest incomes. This fact further marginalizes First Nations who are unable to meet minimal daily customary dietary requirements. This is resulting in alarming rises of diabetes, related heart ailments and a growing potential link to certain forms of cancers. This translates into multigenerational health care costs, losses of productivity and escalating costs due to an aging population, all at time when First Nation peoples will constitute 24% of the future workforce in Canada.

Approaches to Protection Biodiversity

Canada has moved to in policy and has proposed legislative changes to existing legislation to manage aquatic invasive species by prohibiting the release or transport of invasive species. It is viewed that the importance of this general “catch-all” definition of what constitutes an “aquatic invasive species” be included in the regulation or, preferably, in the Act directly. A general prohibition against the release of aquatic invasive species, defined broadly, would promote due diligence in relation to activities that may result in adverse impacts to endemic fish populations and fish habitat, notwithstanding whether or not a specific species has been defined as invasive. For added clarity specific species that are invasive should still be enumerated in the regulation, while for those invasive species that are not enumerated a broad statutory prohibition would apply.

(*Summary of Canada’s response to the risk of Invasive Alien Species for additional information on Alien Species http://www.cbd.int/doc/submissions/ias/ias-ca-2007-en.pdf*)

Added Weight of First Aboriginal and Treaty Rights

While the Supreme Court of Canada has found that the Crown may infringe on Aboriginal rights for reasons of conservation and economic purposes, the Crown must justify its infringement. International trade is a prime example of the potential to infringe that has been responsible for both the intentional and accidental introduction of a host of invasive alien species in our waters and lands. Today in Canada, about 5 percent of mammal species and 27 percent of vascular plant species are alien species, but the true number of many other alien species is not yet known. These species have resulted in the destruction of hundreds of thousands of hectares of forestlands, grasslands, wetlands and aquatic environs in Canada.

Addressing Substantive First Nations Interests

Systemic approaches are required to ensure First Nations full and effective participation in the development of policy, participation in scientific research and implementation. This requires at a minimum, resources to conduct reviews of the existing regimes at the national and international levels and the success of the existing regimes in responding to threats. This requirement is necessary to develop proposals for amendments, and to establish various cross jurisdiction forums, which include First Nations' and governments, to discuss proposals for action. These decisions should lead to developing a regime or amending existing regime, and resources made available to put into effect the new regime.

First Nations Experience

We have a wealth of experience in cooperative measures such as the Circumpolar Council that has been in existence since 1976, current initiatives of aboriginal participation in the Pacific Salmon Commission (PSC) under the auspices of the Pacific Salmon Treaty (PST) and future participation in processes initiated by the International Joint Commission. This is farther complimented by our own International processes amongst Aboriginal Peoples' such as the Artic Council and the *Declaration of Kinship and Cooperation among the Indigenous Peoples and Nations of North America,* Vancouver, British Columbia, Canada on Friday, July 23, 1999.

International Agreements with Other Indigenous Authorities

The agreement between the National Congress of American Indians (NCAI) and the Assembly of First Nations (AFN) was reaffirmed in duly convened joint executive meeting on June 19th 2004 in Uncasville, Connecticut, USA. The purpose of the meeting was to renew the 1999 work plan, jointly advance the '*Declaration of Kinship and Cooperation'* and work on protocol issues and discuss how to work together on the declaration. *The declaration is confirmation of our rights as indigenous Peoples' to sign international agreements of cooperation of other sovereign powers.*

Anticipated Actions

First Nations requests for Participation

One solution put forward by First Nations is to identify and mandate an independent scientific panel or body with full and effective First Nations participation and are of responsible for the preparation of *Alien Species Status Reports*. This independent scientific panel or body shall be responsible for the preparing detailed scientific information relating to *alien species* taxonomy, purpose of propagation, potential of proliferation and available methods to control alien species promulgation. The final report is then presented to a responsible authority or authorities as to the classification re-classification to Invasive alien species status that ensures constant vigilance supported by tight regulations and policy with full and effective First Nations participation.

Purpose of Two Tier Process

This two tier process is to provide an acceptable level of certainty that substantive First Nations interests will be accommodated in host of decisions regarding the introduction, management and control of alien or invasive alien species. These species once introduced possess the capability to potentially prey upon, displace or compete with indigenous species for scarce available habitat and may result in the costly intervention to save both habitat and species with questionable outcomes. In certain instances this may be construed as a significant infringement of our Aboriginal rights, title and impede our priority access to our resources. First Nations are of the opinion that the Crown has failed to adequately ensure First Nations priority access in favour of unimpeded commercial and or recreational interests.