Exploring Options for Eradication of Smallmouth Bass in Miramichi Lake

A report prepared for the Working Group on Smallmouth Bass Eradication in Miramichi Lake:

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Executive Summary

Atlantic salmon is the most important fish species economically, recreationally, spiritually and ecologically in the Miramichi River watershed. The Miramichi has been recognized as the "mother of all salmon rivers", reflecting the spectacular nature of this population. Unfortunately, due to low adult returns, Atlantic salmon in the Miramichi River are thought to be below population levels that are sustainable indefinitely. The introduction of invasive smallmouth bass into Miramichi Lake was observed in 2008, the first and only known incidence of this species in the Miramichi River watershed. This introduction has caused significant concern with regards to the potential impacts of predation and competition with wild Atlantic salmon in the Miramichi. A previous scientific review judged the risk to salmon to be moderately high if smallmouth bass colonize the river, although the uncertainty regarding that prediction was also high. Containment and control measures, including a temporary seasonally installed barrier and exhaustive fishing efforts, have been in place in Miramichi Lake since 2008. While populations of smallmouth bass are greatly reduced, these efforts have failed to eradicate the species and they have persisted in the lake up to the present day after a decade of control effort. The general scientific consensus as established by multiple efforts at fish control around the world is that control efforts rarely if ever achieve eradication, and the efforts in Miramichi Lake support that contention. The only feasible method that has a high probability of smallmouth bass eradication in Miramichi Lake is the use of a piscicide, of which rotenone is the most widely used substance and the only piscicide registered for use in Canada. This report describes a detailed plan for the application for rotenone, including limiting non-target species damage, monitoring, mitigation, and remediation to restore native species in the lake. The best timing window for the efficacious rotenone application, considering all factors including mitigation measures, is mid-September. An eradication effort using 0.075 mg/L rotenone is proposed and discussed along with proposed monitoring and mitigation involving removal, holding, and reintroduction of non-target species. The total costs of this eradication effort including the rotenone application, mitigation and monitoring would be approximately a million dollars. Such an action will require a substantial effort devoted to involving the public in the discussion of the relative risks and, the potential ecological and economic consequences (tradeoffs) of using rotenone versus doing nothing.

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1 Introduction

1.1 Background

The Miramichi River is the one of the largest watersheds draining into the Southern Gulf of St. Lawrence. With an area of about 13,500 km^2, the Miramichi watershed occupies nearly 20% of the surface area of the province of New Brunswick. The Miramichi River has long been renowned for its productivity of Atlantic salmon (*Salmo salar*). Often called "the mother of all salmon rivers", declining returns of Atlantic salmon have given rise to concerns regarding the status of the population in the Miramichi. Once thought to be as high as 600,000 individuals, the returns have recently been consistently below 50,000 adults (DFO 2015). Widespread awareness regarding salmon populations dates to the 1970s and 1980s and this led to the reduction of commercial fishing and a move to catch-and-release recreational fisheries. As a likely result of conservation measures, stocks rose from the mid-1980s until 1992. After 1992 however, the Miramichi was barely meeting requirements for adult returns considered to be sustainable in the Southwest Miramichi River (Labadie 2015), while on average only half the adult returns required to maintain a sustainable population have been recorded on the Northwest Miramichi River (Labadie 2015). This information precipitated a catch-and-release only recreational fishery being instituted in New Brunswick in 2015.

Reasons for the decline of adult Atlantic salmon returns are not entirely understood. The Miramichi River seems to have healthy densities of salmon juveniles (Labadie 2015). Smolt production estimates from the river have a high degree of uncertainty (~500,000-5,000,000; Labadie 2015), and about 1.8M smolts are thought to be the requirement to maintain the population. Predators cannot be ruled out as factors influencing smolt survival and subsequent Atlantic salmon returns. For example, the striped bass (*Morone saxatilis*) that has had a dramatic population recovery (from 3,000-5,000 spawning adults in the Northwest Miramichi in the 1990's to over 300,000 at present) and high regional seal populations could also be exerting an influence. Any new predatory risks to juveniles or smolts, from smallmouth bass (*Micropterus dolomieu*) for example, is a significant concern. Research is ongoing to determine the reasons for low adult returns of salmon in the region.

The Southwest Miramichi River occupies about two-thirds of the Miramichi watershed area. Miramichi Lake is a waterbody approximately 2 square kilometers in size that feeds directly into the Southwest Miramichi in the upper part of its watershed via a short watercourse, Lake Brook. In 2008, non-native smallmouth bass were first discovered in Miramichi Lake. While this species has invaded many lakes and rivers in New Brunswick (DFO 2009), this was its first and only appearance in the Miramichi River system. Given the historic and cultural importance of this river system, the potential harm from smallmouth bass to Atlantic salmon, the ecosystem, and the regional economy, the level of concern regarding this invasion is high.

A barrier was placed at the exit to Miramichi Lake in 2008 and since 2009 control measures for smallmouth including extensive net and electrofishing efforts have been ongoing (DFO 2013). The population was dramatically reduced after the first year of effort; however, ongoing control has not eradicated this species from the lake. Several adult female bass have been captured in 2017 (Brian Richard, personal communication) and young-of-the-year bass were observed in 2017 (author's personal observations). This is no surprise as there has been a consensus amongst all parties that capture and control methods generally do not achieve eradication (Halfyard 2010). Therefore, the use of a piscicide such as rotenone has been suggested. A piscicide application does have a reasonably high probability of achieving eradication in Miramichi Lake itself.. In 2016, Provincial Natural Resources and the Miramichi Salmon Association conducted electrofishing and angling surveys in Lake Brook and in the mainstem Southwest Miramichi River near the outlet of Lake Brook to investigate whether bass have escaped the lake. No bass were found during these surveys.

The purpose of this report was in part to explore what other methods exist for eradication of smallmouth bass. However, given that it is quite well-established that chemical eradication is the only currently well-tested and feasible option for complete eradication, this report focused mostly on what such an application would look like and cost. This report did not evaluate in depth whether the risks to Atlantic salmon warrant such an application. The risks of smallmouth bass invasion has been previously evaluated (DFO 2009) and that science will have to be assessed by all stakeholders in making what is a societal decision. This report will outline the logistical, ecological and financial considerations of the application itself, remediation and mitigation for non-target species, and ongoing post-application monitoring. Thus, this report was intended to summarize the existing information on all aspects of this issue and to present a detailed plan for eradication using rotenone, deactivating, and remediating the lake post application in order to assist in the decision making process.

1.2 History and Socio-Economic Importance of Atlantic Salmon in the Miramichi

Atlantic salmon have been historically critical as an aboriginal and commercial fishery. In the pre-colonial period, Mi'kmaq relied upon Atlantic salmon as a food source. Only salmon and eel were reliably seasonally abundant and shaped Mi'kmaq seasonal movements (Weiler et al. 2013). Salmon migration in the fall was a time when smaller groups congregated for the labour-intensive processing of salmon preservation and formed familial and sharing networks crucial to social culture. As a result, salmon has great spiritual significance to the Mi'kmaq which continues to present day. While western culture often seeks to establish narrow protection of fisheries on an economic basis, Mi'kmaq have a broader conservation view defined as netukulimk. Netukulimk is the focus on community health and well-being without threatening the overall integrity of all aspects of the environment. The landmark

Supreme Court decision in (Regina. v. Sparrow, 1990) ruled that First Nations have a right defined in the Constitution Act, 1982, to harvest fish for food, social and ceremonial purposes, and that right takes priority over all others, after conservation. The Miramichi Mi'kmaq maintain a food harvest of Atlantic salmon, though at levels far below allowable quotas. In the interest of conservation of salmon, negotiations are ongoing to replace salmon food harvest with other fisheries such as striped bass and lobster.

Colonial commercial harvest of salmon in Atlantic Canada began as early as the 1600s. Atlantic salmon nearshore sea fishing continued unregulated until the time of the American Revolution. Immediately after the American revolution, commercial salmon interests set up in the Miramichi and fishing effort was so intensive that a local sheriff observed that "the cross nets, while they are set, absolutely stop the whole body of them from getting up to their spawning places and must eventually, much lessen, if not destroy the breed" (Dunfield 1985). The first fishing regulation came into effect on the Miramichi in 1791. By 1815 it was already becoming difficult to catch enough salmon to make the fishing effort worthwhile (Dunfield 1985). The economic boom for 35 years after the war of 1812 imposed many pressures on salmon populations in inland waters from agriculture and forestry. By the 1840s, stocks had been virtually obliterated in most places in Atlantic Canada. Numerous laws were passed in New Brunswick to protect salmon from the river fishery between 1851 and 1863, but there was neither the will nor the resources to enforce them. In 1867, the formation of the Dominion of Canada (including the colony of New Brunswick), gave the responsibility for fish to the federal government, including the establishment of a new Fisheries Board. Canada's first Fisheries Act followed in 1868. Concerted efforts, including the building of hatcheries such as on the Miramichi (1873) led to notable improvements in the stock.

Atlantic salmon were commercially harvested in the Miramichi until recent times. The commercial harvest was discontinued in 1972 in New Brunswick following population collapses, but reopened in 1981 and was subsequently closed again on the Restigouche and Miramichi Rivers in 1984 and on all other New Brunswick rivers in 1985 (Cook and McGaw 1991). Elsewhere in the region, the commercial salmon fishery in New England was shut down in 1948 and in Nova Scotia in 1985. In 1983, the New Brunswick salmon industry had gross revenues of $1.2 million (Cook and McGaw 1991). Licenses were removed through buy-back and attrition and all licenses are now permanently removed. However, over the last 100 years as nearshore commercial fishing declined, commercial fishing in international waters (completely unexploited in the first two centuries of salmon harvesting) became an increasing threat with the adaptation of new fishing gear, larger international fleets, and the ability to preserve fish at sea. This challenge continues, and the decision of Greenland to harvest 45 tonnes of

salmon through 2017 has been controversial. Mixed stock harvests still poses one of the greatest risks to salmon returns.

Around the beginning of the 20th century, the Atlantic salmon recreational fishery became economically important to the region. This is not an isolated phenomenon as it has been observed that recreational fisheries are now the predominant use of inland water fish stocks globally (Arlinghaus et al. 2002). Unfortunately, recreational fisheries are often poorly monitored or understood. It has been estimated that in Canada, recreational fisheries have contributed an average $8.8 billion dollars annually to the national economy (Brownscombe et al. 2014) and socially, nearly one-sixth of the Canadian population engage in recreational angling.

A report detailing the value of wild Atlantic salmon in eastern Canada indicates that the total value to the region is $255 million per year (Gardner Pinfold 2011). Interestingly, this is not far from the estimated GDP of farmed salmon valued at $270 million dollars. In the Miramichi specifically, DFO estimated spending at approximately $16 million dollars per annum in 2005 (corrected for inflation to 2010 dollars). Based on analysis of anglers over time, this was considered to be an underestimate and the annual spending has been subsequently estimated at $20-25 million per year on the Miramichi system (Gardner Pinfold 2010). Perhaps more striking than the economic dollar value, 1 in every 40 jobs in the region and 1 in every 3 jobs in the tourism industry is linked to the recreational salmon fishery (Gardner Pinfold 2010).

1.3 Smallmouth Bass as an Invasive Species

1.3.1 History of Smallmouth Bass in Miramichi Lake and why it is a problem.

Smallmouth bass are a non-native fish species reported to be in eight lakes in the Gulf region, seven in Nova Scotia, and one in New Brunswick - Miramichi Lake (DFO 2009). In the late summer/fall 2008, smallmouth bass were confirmed to have been introduced in Miramichi Lake. Field sampling efforts captured both young-of-the-year and adult bass, and the presence of young-of-the-year was assumed from spawning adults earlier that spring (DFO 2009, Chaput and Caissie, 2010, DFO 2013). Immediately, concerns were raised about the potential impact of smallmouth bass on Atlantic salmon populations. Together, government agencies local watershed groups and wildlife conservation groups (MWMC, MSA, NBWF, NBSC, and ASF) decided that bass must be confined to the lake and quickly eradicated. From 2008/2009 to present, nearly a decade, a containment and control methods has been employed and carried out by DFO in partnership with the Miramichi Watershed Management Committee and various funding agencies. A barrier net was set up at the only outlet in October 2008 to prevent movement into the Southwest Miramichi River. Backpack and boat electrofishing (in the lake and brook), fyke nets, gill nets, and beach seining were used from 2009-2015 in a failed attempt to eradicate

smallmouth bass (DFO 2009, DFO 2013, Biron et al. 2014, Biron 2015). Containment and control efforts have continued, but sexually mature bass were again captured in 2017 (Brian Richard, personal communication), and young of the year have been captured each year including 2017 (author's personal observations).

DFO (2009) put forth a risk assessment concluding that the risk of negative consequences from smallmouth bass 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 smallmouth bass 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 smallmouth bass 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, however, is the high likelihood of downstream dispersal focusing on habitat overlap and the potential for predation on Atlantic salmon. It is believed that juveniles of both species prefer similar riverine habitat features, resulting in direct competition (DFO 2009). The potential for direct competition between juvenile smallmouth bass and Atlantic salmon in streams is unknown, but it is likely since their riverine habitats overlap (Carr and Whoriskey 2009). Smallmouth bass have been discovered within preferred Atlantic salmon habitat in other NB rivers (Curry et al. 2007, Carr and Whoriskey 2009). Carr and Whoriskey (2009) reported adult bass preying upon Atlantic salmon smolts during their outmigration in a section of the Magaguadavic River.

1.3.2 Impacts of Invasive Species on Native Fishes Worldwide

Intentional and unintentional introductions have made fishes one of the world's most introduced groups of aquatic animals (Gozlan et al. 2010). Worldwide, intentional fish introductions have occurred to establish food fisheries, create new recreational fisheries, restore depleted fish stocks, and to control plants, invertebrates, and other fishes (Kolar et al. 2010, van Rensburg et al. 2011). Although such introductions have often resulted in the desired outcome, nonnative fish introductions have had impacts on genetic, individual, population, community, and ecosystem levels in recipient environments (Cucherousset and Olden 2011) through competition, predation, habitat alteration, disease, and hybridization interactions (Moyle 2002, Clarkson et al. 2005). Sport fish enhancement has been a major reason for nonnative fish introductions (Cambray 2003), particularly in areas with predator-poor fish

faunas (Dill and Cordone 1997; Clarkson et al. 2005). Humans living in areas with recreational species-poor fish communities were often unable to resist the temptation to establish nonnative sport fishes, and in many regions nonnative fishes outnumber native species.

The introduction of nonnative sunfishes (Centrarchidae family) in California and throughout the western United States has had major impacts largely through predation on native minnow (Cyprinidae family) populations (Moyle 2002, Clarkson et al. 2005). Similarly, nonnative sunfish and smallmouth bass have been legally and illegally introduced to rivers and lakes in Nova Scotia and New Brunswick, although recent expansion of their range in these provinces has been attributed to dispersal of existing populations through connected waterbodies (DFO 2009). When smallmouth bass are introduced into a waterbody they prey heavily on smaller fishes, may out-complete other fish species, or become a dominant component of the food web (Loppnow et al. 2013). Eradication of nonnative fishes can be costly and controversial (Finlayson et al. 2005), and success often decreases with increasing range of the invading species, as well as the size and complexity of the affected environment (Finlayson et al. 2010, Kolar et al. 2010). Knowing that eradication would likely be a difficult task, and borrowing on previous experiences in North America, the Department of Fisheries and Oceans, provincial officials and affected interested stakeholders began a process a decade ago of assessing options and planning for the management and possible eradication of nonnative smallmouth bass from Miramichi Lake.

1.3.3 Risk of Further Spreading

Overall, there has been an increase in smallmouth bass sightings in New Brunswick and Nova Scotia waters due to increased reporting and illegal planting (LeBlanc 2010). The illegal introduction of chain pickerel (*Esox niger*) in Despres Lake in the Southwest Miramichi River watershed demonstrates the interest of some members of the public in developing alternate recreational fisheries in the Miramichi River watershed (Connell et al. 2002). Watersheds in the Maritime Provinces often have interconnected lakes in close proximity to the main stem of a river. Smallmouth bass introduced in the headwater lake of the Magaguadavic River have spread downstream and distributed throughout the watershed including 10 of its 15 lakes (Carr and Whoriskey 2009). Watersheds in New Brunswick with multiple lakes or reservoirs including the St. John, St. Croix, Musquash, and Bocabec have smallmouth bass. Miramichi Lake is the first confirmed report of smallmouth bass in the Gulf of St. Lawrence New Brunswick watersheds, and their spread into the Southwest Miramichi River is likely (Chaput and Caissie 2010). Although lakes available for colonization by smallmouth bass are far downstream from Miramichi Lake, upstream movement of smallmouth bass is possible (Carr and Whoriskey 2009) and has been observed in the Nashwaak River (Chaput and Jones 2004). Thus, natural spread of smallmouth bass is very likely in the Southwest Miramichi River. It should also be emphasized that base on observations from other

systems in New Brunswick where smallmouth bass have invaded, they are not necessarily dependent on a lake environment but are present in, and therefore are assumed to have established in the riverine environment.

1.3.4 Suppression Versus Eradication of Smallmouth Bass in Miramichi Lake

In 2010, DFO initiated a 3-year containment, control program using physical removal methods (Biron et al. 2014). Between 2010 and 2012, smallmouth bass in Miramichi Lake were removed using boat electrofishing, gillnetting, and fyke-netting: 2,584 smallmouth bass removed in 2010; 523 smallmouth bass removed in 2011; and 46 smallmouth bass 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 such control measures, eradication was not achieved since all life-history stages of smallmouth bass were still present 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 by the authors in late July 2017.

This effort has served to illustrate that eradication of smallmouth bass using physical methods from Miramichi Lake is difficult considering its moderate size (220 ha), seasonally warm water temperatures ($\leq$ 28.7 °C) and ample spawning substrate favorable to smallmouth bass. Several inlets and Lake Brook outlet to the Southwest Miramichi River make effective smallmouth bass containment difficult. Two barrier fences were installed in 2008 near the outlet of Miramichi Lake to contain smallmouth bass 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 seems unlikely given that the barrier may become permeable to young-of-the-year smallmouth bass for short periods due to maintenance for debris removal and fluctuating water levels. Juvenile smallmouth bass were captured in Lake Brook in 2009 and 2010 (DFO 2013); however, no smallmouth bass have been observed in Lake Brook since that time. While eradication has not been the outcome, without control and containment measures the smallmouth bass 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.

1.3.5 Overview of Applicable Laws & Regulations

Canada's Invasive Alien Species Strategy (2004) recognizes that co-ordination of activities between federal and provincial departments is essential for the effective management of invasive species. Fisheries and Oceans Canada, Agriculture and Agri-foods Canada, Environment and Climate Change Canada, and Natural Resources Canada are recognized as the lead agencies. The Federal government is responsible for establishing inter-jurisdictional coordination with the provinces. In co-operation with the provinces, federal departments have a key role in prevention, detection and response, and the management of established invaders. Given the breadth and complexity of invasive species, multiple laws govern their management including the *Plant Protection Act*, *Health of Animals Act*, *Canadian Environmental Protection Act*, *Environmental Assessment Act*, *Seeds Act*, *Pest Control Products Act*, *Forestry Act*, *Natural Resources Act*, *Transportation of Dangerous Goods Act*, *Oceans Act*, *Fisheries Act*, *Canada Wildlife Act*, *Wild Animal and Plant Protection and Regulations of International and Interprovincial Trade Act*, and *Canada National Parks Act*.

Fisheries and Oceans Canada, in co-operation with the provinces and territories, has primary responsibility for aquatic invasive species. The *Aquatic Invasive Species Regulations* defines the tools available for the management of aquatic invasive species under the auspices of the *Fisheries Act*. However, where chemical agents are used, *The Pest Control Products Act* comes into play as it authorizes Health Canada to review and register pesticides for control of invasive pests including fishes. If a product other than those registered for use in Canada is desired, application for a one-year emergency use may be obtained under the *Pest Control Products Act*. Any use and permitting of a pesticide in New Brunswick, including the required Pesticide Applicator Certificate is administered under the New Brunswick *Pesticides Control Act* governed under the Department of Environment and Local Government.

Given the potential that use of a piscicide could cause environmental harm, applications would also be screened under the *Canadian Environmental Assessment Act 2012* to decide whether a full environmental assessment is required. Furthermore, the release of a deleterious substance into the environment, such as in the case of a piscicide, is directly relevant to section 36 of the *Fisheries Act* that prohibits the release of substances that would cause serious harm to fish, which is defined as death or habitat loss. While section 36 of the *Fisheries Act* would be prohibitive to chemical eradication efforts, section 20 of the *Aquatic Invasive Species Regulations* adopted in 2015 authorizes the used of deleterious substances for this purpose provided they are registered, or whose use is authorized under the *Pest Control Products Act*.

2 Eradication Options and Chosen Method

2.1 Eradication Methods

Aquatic invasive species represent a global threat to native biodiversity (Havel et al. 2015). There are several possible suppression methods that may lead to eradication: 1) extensive capture and trapping efforts, 2) predator introduction, 3) pathogens, 4) the use of explosives, 5) dewatering, 6) genetic methods, and 7) chemical means.

Extensive trapping effort is often inadequate for eradication (Havel et al. 2015). Physical methods (i.e., electrofishing and netting) like those used in Miramichi Lake are usually limited to suppression, not eradication. Meronek et al. (1996) found that physical methods successfully reduced targeted species 33% to 57% in 70 case histories, where success was defined as changing some aspect of a fishery. However, there are rare situations where this method may be effective such as the eradication of salmonids from alpine lakes in California using extensive gill netting efforts; in this case the species was introduced into a fishless lake (Knapp and Matthews 1998, Knapp et al. 2007). Yellowstone National Park has embarked on an aggressive program to gill net lake trout (*Salvelinus namaycush*) to suppress but not eradicate their numbers in Yellowstone Lake for the conservation of Yellowstone cutthroat trout (*Oncorhynchus clarki bouveri*, Kaeding et al. 1999). Electrofishing has been applied for removing nonnative fish (Moore et al. 1986; Larson 1986) but removal has had limited success in attaining eradication. Eradication using electrofishing may be limited to relatively small streams and shallow lakes where habitat is not too complex and does not contain woody debris, aquatic macrophytes, multiple channels, undercut banks, or large substrate with abundant and large interstitial spaces (Pacas and Taylor 2015); Miramichi Lake has many of these features. Electrofishing has size bias issues as well, with larger smallmouth bass being captured more readily than smaller smallmouth bass, and this may potentially lead to decreased intraspecific competition/predation and accelerated maturation of juvenile smallmouth bass and ultimately greater recruitment (Ridgeway et al 2002).

Biological control and genetic methods of control may be the only means of control feasible where the extent of the invasion make other methods impossible. Biological control has rarely been used with invasive fish due to the lack of potential, selective control agents (Thresher et al. 2013). Biological methods including the stocking of selected species of fish to control other fish species has been found to be only marginally successful for improving desired aspects of various sport fisheries (Meronek et al. 1996). Generally, this approach is only reliable for some degree of suppression, not eradication. In the Southwest Miramichi River system, any predator that is introduced would undoubtedly prey upon Atlantic salmon too. Thus, biological control carries with it the risk of further introductions if the biological control agent is also not native.

Similarly, introduction of pathogens is limited by their availability and carries with it significant risks to non-target species. Disease organisms might be used to reduce numbers of nonnative fish stocks; however, it is unlikely that this type of method will be applied due to environmental concerns. Use of any biological control agent carries some environmental risk (Simberloff and Stiling 1996). There are two parasites that are specific to smallmouth bass, a protozoan (Davis 1937, 1942) and a tapeworm (McCormick and Stokes 1982), but much testing would be required to ensure there would be no impacts to non-target fishes, and that they would effectively kill their host in this environment.

Explosives for the removal of fish are generally not effective at depths greater than 3 m. Detonating cord has been used to control northern pike (*Esox lucius*) in Lake Davis, California with little impact on their population (California Department of Fish and Game 2007). In addition, Metzger and Shafland (1986) found that detonating cord will kill all fish only within 7 meters, which would require precise placement of many kilometers of detonating cord in a parallel or grid-like fashion across the entire lake bottom.

Dewatering of an aquatic environment by breaching a dam or using pumps can result in the eradication of its fishes. However, the target fish will be removed with the water, the process is environmentally disruptive, and typically residual water remains in lower areas requiring additional fish removal through chemical or physical means. In the case of Miramichi Lake, since there is no dam to breach, pumping would be the only option. This is likely impracticable, considering the large lake volume that would need to be pumped, the inflow volume that would need to be pumped continually, and the logistics of finding a closed basin to pump the water into.

Techniques of genetic manipulation continue to be rapidly developed but generally involve the introduction of sterile males or females that will attempt and not be successful in reproductive efforts. Immuno-contraception, where usually a viral agent is introduced to produce an immune reaction against reproductive tissue, rendering the individual sterile is a more recent development. The only easy and readily available method to generate sterile smallmouth bass would be triploidy. However, triploid individuals are not 100% sterile. More sophisticated methods would likely involve releasing genetically modified individuals, an activity that is not likely to be palatable to the public and the development would be costly and take many years. Genetic control methods have only been demonstrated to be effective in simulations and those simulations with introduced carp have shown the stocking activities may be required for a minimum of 20 years (Thresher et al. 2013).

In summary, eradication of a target species from a water body is difficult in many circumstances and usually only attained through the use of chemical means or in theory, dewatering. Rotenone, the most prevalent chemical treatment resulting in eradication of the target species, is more successful than suppression efforts (Meronek et al. 1996). Rotenone is the most widely used eradication method in North

America, and its toxicity to fish has been well documented (Marking and Bills 1976, McClay 2005). Marking et al. (1983) evaluated several chemicals as tools for preventing the invasion of non-indigenous fish species into Canada through a canal and found that rotenone was the most effective of the eight chemicals tested. Exposure times and concentrations necessary to kill fish vary by species, water temperature (Dawson et al. 1991), and other chemical and physical factors. It is recommended that the rotenone formulation chosen be tested with the target species, or surrogate species of similar sensitivity to rotenone (i.e, yellow perch, *Perca flavescens*), in the site water under conditions expected during treatment to ensure the development of an efficacious treatment rate (Finlayson et al. 2010). Rotenone is generally applied to lakes by boat and dispersed throughout the water column using a gas-powered high-pressure pump or venturi system. Rotenone applied to streams is generally dispersed using drip stations over the length of the stream (Finlayson et al. 2010). Liquid formulations of rotenone contain dispersants, solvents and emulsifiers that disperse rotenone vertically and horizontally in the water column, even below a thermocline (Finlayson et al. 2010).

2.2 Feasibility, Practicality, Effectiveness, and Choice of Most Appropriate Solution

Of the methods that have the highest probability of eradication, only the use of rotenone is the feasible and practical for Miramichi Lake. For dewatering to be feasible, a water barrier is needed (i.e., dam with an outlet structure) to keep water from Lake Brook and the Southwest Miramichi River from backfilling into Miramichi Lake. Secondly, the discharge of water from Miramichi Lake is problematic given the relatively low gradient topography of the drainage, long distance to discharge into the Southwest Miramichi River, and ensuring that no live smallmouth bass are discharged downstream. While genetic methods have potential for eradication, largely based on simulation, they are simply not well enough developed to be considered at present. Treatment of Miramichi Lake with rotenone is most likely to eradicate smallmouth bass and eliminate a source of future smallmouth bass invasion to the Miramichi River system.

3 Detailed Description of Eradication Option

3.1 Rotenone as a Fish Management Tool

Rotenone has been used for centuries by native peoples to capture fish for food in areas where rotenone-containing plants are naturally found. Rotenone as a tool in fish management was applied first to ponds and lakes and then to streams by the early 1960s for either complete or partial reclamations. While the first known use of Rotenone in New Brunswick was in 1939 (Smith 1941), the widespread use of rotenone by fisheries management agencies began in the early 1950s. Certain weaknesses have been

identified that limit its effectiveness in eradicating target fish (Finlayson et al. 2010, McClay 2005, Johnsen et al. 2008). These are:

- Poor project planning and staff training leading to inadequate resources and staff performance required for effective rotenone treatment and deactivation;
- Insufficient and inaccurate target species mapping of the treatment area leading to the survival of target fish;
- Insufficient rotenone exposure on target fish from using too low a concentration, treating when water temperatures are too low, or too short an exposure time by not correcting for dilution and degradation of rotenone over time and space thereby allowing target fish to survive in the treatment area;
- Declining treatment success with increasing treatment size and complexity; and
- Insufficient real-time monitoring to allow for changes in rotenone treatment and deactivation rates during and following the treatment.

3.1.1 Lessons Learned

Project planning and training. Many treatments in the past have been done on an emergency basis with little or no time for planning. It is now widely accepted that most rotenone projects require five steps (Finlayson et al. 2010), three of which involve planning: 1) preliminary planning where the concept is developed, information is collected on-site, a feasibility analysis is conducted, and tentative approval is obtained; 2) intermediate planning where public and regulatory agency outreach and scoping results in boundaries and restrictions on the project; and 3) final planning where the specific operation plans for the project are developed. Many projects require the development of a fish salvage plan, rotenone application plan, monitoring plan, site safety and security plan, fish monitoring and disposal plan, spill contingency plan, and rotenone deactivation plan prior to the actual treatment. Consistent with adequate planning is adequate training of all project staff on safety, treatment and deactivation procedures, and the equipment used.

Project area mapping. Complete removal of target fish from an area requires that all habitats capable of supporting target fish are treated with rotenone unless there is conclusive evidence that target fish are absent, or that the area cannot serve as a safe haven for target fish during the treatment. Failed treatments have too often resulted from assuming no fish were present in an area without confirming their absence. It is imperative that the entire treatment area be surveyed for the presence of target fish and water. This includes all tributaries and seeps and springs that are or can be hydraulically connected to the treatment area. The consequences of not treating an area in question often far outweigh those of treating it.

Electrofishing and eDNA (Barnes et al. 2014, Goldberb 2016, Rees et al. 2014) should be used together for determining the presence/absence of smallmouth bass since neither technique by itself has an accuracy of 100%.

Adequate rotenone exposure. The flow of untreated water into the treatment area must be avoided. Ideally, the entire treatment area should contain lethal levels of rotenone concurrently. Lethal levels are determined from bioassays on target fish; generally, a *minimum* of approximately 4 times the LC50 value for the target species is used as a treatment rate. Rotenone must also be applied to seeps, backwater areas and springs via dilute rotenone spray or with a rotenone powder/gelatin/sand mixture. Complex habitats (seeps, springs, backwaters, weedy and woody areas) increase the potential that rotenone will not reach lethal concentrations in all locations with the result that some fish may not be killed.

Project size and complexity. The Norwegian Institute for Freshwater Research assessed the effectiveness of Norwegian Directorate of Nature Management's ectoparasite control program for Atlantic salmon. Johnsen et al. (2008) found a significant difference between the success rate in large rotenone treatment areas (14% success for drainages > 500 km^2) and smaller rotenone treatment areas (81% success rate for drainages < 500 km^2). Given the relatively small Miramichi Lake drainage (43.1 km^2), small lake area (220 ha), shallow lake depth (< 6m) and absence of smallmouth bass in the inlets, size and complexity are not limiting factors in the success of the rotenone treatment.

Treatment monitoring. Until recently, acute lethality fish bioassays were not commonly used during rotenone treatments. Thus, there was no real-time monitoring system in place that would signal whether the treatment and deactivation were effective. To provide for real-time adjustments, cages containing fish are placed at various locations and depths in lakes and downstream of all drip stations on streams to monitor the effectiveness of the rotenone treatment. Similarly, acute lethality bioassays are used to judge the effectiveness of rotenone deactivation. Careful monitoring of bioassay fish during the treatment is used to adjust the rotenone treatment and deactivation rates. This will help ensure maximum fish mortality in the treatment area and minimal off-target impacts. In conjunction with the use of acute lethality bioassays, water samples for rotenone analysis are collected in the treatment area to confirm lethal levels of rotenone were present. Rotenone deactivation is often used in order to limit the spatial extent of toxicity beyond the treatment area. Potassium permanganate, a strong oxidant is used for this purpose as it oxidizes and thereby breaks down the molecular structure of rotenone, eliminating its ability to be toxic. Monitoring for permanganate and rotenone residues in conjunction with caged bioassay fish below the deactivation station are used to judge the effectiveness of deactivating the rotenone.

Minimizing weaknesses. To minimize possible weaknesses in a rotenone treatment:

- Estimate an efficacious treatment rate through the use of a bioassay on the target species, estimated at a *minimum* of 4 times the LC50 value from the bioassay;
- Treat all known standing and flowing water within treatment area capable of supporting fish. At the moment this plan has been restricted to Miramichi Lake and the immediate downstream areas of Lake Brook to a point with about 30 minutes residence time before it enters the Southwest Miramichi River. However, there are other sections of Lake Brook that will not be treated with the current plan, and this is still a matter for further investigation and consideration since there is a risk of these areas acting as refuges for bass.
- Identify and treat all upwelling groundwater (i.e., seeps/springs) with dilute rotenone spray or rotenone powder/sand/gelatin mixture;
- Identify all barriers to fish and water movement including aquatic vegetation, marshy areas, and beaver dams that may require special handling prior to treatment;
- Utilize acute lethality bioassays in strategic locations in the treatment and deactivation areas for real-time monitoring of effectiveness;
- Treat when water temperatures are above 10°C;
- Utilize accurate and up-to-date water volume and flow data in the planning and execution of the treatment;
- Identify physical and chemical characteristics (i.e., pH, turbidity, alkalinity, organic content) of site water that may affect the efficacy of rotenone and potassium permanganate;
- Avoid under treatment and target species survival;
- Avoid overtreatment, excessive rotenone residues, inadequate deactivation and non-target effects;
- Use block nets where appropriate to prevent target fish escapement;
- Train all staff on their responsibilities, proper use of PPE, and equipment operation;
- If deactivating with potassium permanganate, begin deactivation before the rotenone application to exhaust the organic demand of the streambed;
- If deactivating, have a backup system for deactivation should the primary system fail; and
- When deactivating, monitor rotenone and permanganate residues below the deactivation station to assess the operation's ability to deactivate rotenone.

3.1.2 Selected Case Histories

Lentic fish eradications in California and Oregon. Diamond Lake, located near the crest of the Oregon Cascade Range in the Umpqua River Basin, was treated (0.110 mg/L rotenone) with a combination of Prenfish (a.k.a. Noxfish) and Prenfish Fish Toxicant Powder in September 2006 to eradicate non-indigenous tui chub (*Gila bicolor*; 96 h LC50 ~ 0.015 mg/L rotenone). The subalpine lake sits at an elevation of 1580 m, typically stratifies in July and August, and is ice-covered from December to April. At the time of treatment, the 1226 ha lake was not stratified, had a mean depth of 6.9 m, maximum depth of 14.8 m, and water volume of 53.0 x 10^6 m^3 (Table 1; Finlayson et al. 2014). During treatment, the lake was in the middle of a phytoplankton (including cyanobacteria *Anabaena* sp.) bloom, resulting in an elevated pH of 9.7. Dissipation of rotenone concentrations in water and sediment was monitored. The lake water was warm (17-18 °C) during application but declined in temperature about 10°C within 30 days. Rotenone dissipated quickly from Diamond Lake water; approximately 75% was gone within 2 d, and the average dissipation half-life value, estimated by using first-order kinetics, was 4.5 d. Rotenone was below detectable levels (< 0.002 mg/L) within 39 d. There is strong evidence, based on the rotenone monitoring data, mortality of the caged bioassay tui chub and trap netting, beach seining, and backpack and boat electrofishing efforts from 2006–2012, that tui chub was eradicated from Diamond Lake (Finlayson et al. 2014).

Lake Davis, in the northern California Sierra Nevada Range in the Feather River Basin, was treated (0.063 mg/L rotenone) with CFT Legumine in September 2007 to eradicate invasive northern pike (96 h LC50 = 0.002 mg/L rotenone). The subalpine lake sits at an elevation of 1757 m, typically stratifies in July through August, and is ice-covered from December to April. At the time of treatment, the 1188 ha reservoir was not stratified, had a maximum depth of 30 m, mean depth of 4.8 m, and water volume of 51.6 x 10^6 m^3 (Table 1;Vasquez et al. 2012). Dissipation of rotenone concentrations in water and sediment was monitored. The lake water was warm (17°C) during application but declined in temperature about 10 °C within 30 days. Rotenone dissipated from Lake Davis and the average dissipation half-life value, estimated by using first-order kinetics, was 5.6 d. Rotenone was below detectable levels (< 0.002 mg/L) within 34 d. There is strong evidence, based on the rotenone monitoring data (Vasquez et al. 2012), mortality of the acute lethality bioassay species, rainbow trout *Oncorhynchus mykiss* (more rotenone tolerant than northern pike) and netting and boat electrofishing efforts from 2007 to date, that northern pike was eradicated from Lake Davis.

Lentic smallmouth bass eradications in British Columbia. The British Columbia Ministry of Environment treated Gardom Lake and Phillips Lakes in the Thompson River watershed with rotenone to eradicate smallmouth bass and yellow perch. Smallmouth bass (96 h LC50 = 0.004 mg/L rotenone) had been established in Gordom Lake for over 10 years prior to treatment, and smallmouth bass and

largemouth bass (*Micropterus salmoides*; 96 h LC50 = 0.007 mg/L rotenone) had been established in Phillips Lake for approximately 5 to 7 years. Yellow perch (96 h LC50 = 0.003 mg/L rotenone), Goldfish (*Carassius auratus*; 96 h LC50 = 0.025 mg/L rotenone) and other sunfish (Centrarchidae family) (96 h LC50 ~ 0.007 mg/L rotenone) were also present in both lakes. A rotenone treatment rate higher than that necessary to eradicate smallmouth bass was used to remove the more rotenone-tolerant sunfish and goldfish. Deactivation of rotenone with $KMnO_4$ was not necessary since there were no surface water discharges during the treatments.

Gardom Lake has a surface area of 76 ha and a maximum depth of 25 m. The substrate is mostly sand/gravel and mud. Roughly 24% of the lake bottom is within the littoral zone with *Chara* ssp., reeds (Poacae family), and some smartweed (*Polygonum* spp) dominating the benthos. Approximately 20 staff treated the lake over a two-day period in October 2010 at a rotenone concentration of 0.200 mg/L, using equal amounts of CFT Legumine and Prentox Prenfish Fish Toxicant Powder. Most of the CFT Legumine was applied from boats by dispensing diluted CFT Legumine into the prop wash of outboard motors using a venturi system (Finlayson et al. 2010 SOP 11); some CFT was also pumped below the thermocline. The powder was applied by boat using a semi-closed aspirator system (Finlayson et al. 2010 SOP 9). Dilute CFT Legumine was also applied from the shorelines using backpack sprayers (Finlayson et al. 2010 SOP 12).

Phillips Lake has a surface area of 52 ha and maximum depth of 10 m. It has a considerable aquatic vegetation (including cattails) surrounding the shoreline of the lake. A staff of 15 treated the lake in one day in September 2009 at a rotenone concentration of 0.150 mg/L using CFT Legumine.
Both lakes remained toxic to fish for a couple of weeks, and eradication of smallmouth bass and yellow perch was achieved, based on gillnetting and fyke netting for two years posttreatment. To date, neither species have been found.

3.1.3 Assessment of Lentic Rotenone Use

Lake Davis, Diamond Lake, Gordom Lake, and Phillips Lake were chosen as representative lentic waterbodies that have had invasive fish successfully eradicated. These lakes were used to predict the behavior of rotenone in Miramichi Lake (Table 1). The major pathways for rotenone dissipation are hydrolysis, photolysis, and metabolism. Rotenone dissipation appears to increase with increasing water temperature, sunlight penetration, turbidity, pH, and decreasing water depth (Finlayson et al. 2014). Given the warmer and shallower environment of Miramichi Lake, we anticipate a rotenone half-life of ~ 2.5 d and for rotenone to be at undetectable levels within 18 d of application at 0.075 mg/L mg/L rotenone (Table 3.1).

Table 3.1. Comparison of physical parameters of Miramichi Lake with successful lentic fish eradications.

Parameter	Miramichi Lake	Gardom Lake	Phillips Lake	Diamond Lake	Lake Davis
Surface (ha)	225	76	52	1226	1188
Maximum depth (m)	7.3	25	10	14.8	30
Mean depth (m)	3.7			6.9	4.8
Volume (m^3) x 10^6	11.6			53.0	51.6
Temperature range (°C)	15-18			8-17	8-17
pH	7.3			9.7	7.5
Rotenone (mg/L)	0.075	0.200	0.150	0.110	0.063
Rotenone half-life (d)	2.5 (est.)	~2.0	~2.3	4.5	5.6
Rotenone Longevity (d)	18 (est.)	~14	~14	39	34

3.2 Eradication Treatment Effects and Mitigation

3.2.1 Description of Commercial Rotenone Formulations and Public Safety

Three commercial rotenone products may be available (see Appendix I):

- Prentox Noxfish Fish Toxicant (5% rotenone) which is currently registered in Canada (PRMA # 14558) and has recently been reformulated and is waiting Health Canada approval;
- Prentox Nusyn-Noxfish Fish Toxicant (2.5% rotenone) with is currently registered in Canada (PRMA # 19985); and
- Prentox CFT Legumine Fish Toxicant (5% rotenone) which is currently registered in the United States (EPA Reg. No. 89459-48) but not in Canada. There is an emergency Canadian registration for British Columbia pending for control of yellow perch in lakes where odor from the other two formulations is a public concern.

The labels (Appendix I) and safety data sheets (Appendix II for these products have been summarized (Table 3.2). Nusyn-Noxfish was not considered further because of the environmental persistence of the synergist piperonyl butoxide (Finlayson et al. 2001) and the questionable value of the synergist for rotenone on rainbow trout (Finlayson et al. 2009). The prescribed treatment rate of 0.075 mg/L rotenone will kill all smallmouth bass in Miramichi Lake, but other forms of aquatic life present in Miramichi Lake will survive (see Section 3.2.3 below).

The public is protected by prohibiting contact with treated water during application and for a three-day re-entry interval after application until waters are deemed safe. The applicators are protected by wearing personal protective equipment including coveralls over long pants, long-sleeved shirts, chemical-resistant gloves, chemical-resistant footwear, goggles, and a respirator.

3.2.2 Eradication Effects on Atlantic Salmon

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 than smallmouth bass (24 h LC50 value = 0.0047 mg/L rotenone) according to Marking and Bills (1976). The impact can be mitigated through collection of these species prior to application and then re-introduction post application. However, only a portion of the native population is likely to be saved. The habitat is likely to be recolonized because these species are migratory.

Table 3.2. Composition of substances in Noxfish, Nusyn-Noxfish and CFT Legumine fish toxicant products (see Appendix B for product safety data sheets).

Product	Chemical Name	CAS No.	Percentage (%)
Noxfish[&]	Rotenone	83-79-4	5
PMRA #: 14558	Rotenoids other than rotenone	NDA[+]	5
	Solvent naphtha	64742-94-5	52.7
	Naphthalene	91-20-3	0.53
	Benzyl alcohol	100-51-6	20
	Glycols, polyethylenepolypropylene, monobutyl ether (nonionic)	9038-95-3	2.5
	Other ingredients	NDA	Balance
Nusyn-Noxfish	Rotenone	83-79-4	2.5
PMRA #: 19985	Piperonyl butoxide	51-03-6	2.5
	Benzoic acid	65-85-0	1
	Solvent naphtha	64742-94-5	70 – 80
	Naphthalene	91-20-3	<8.5
	Nonylphenol ethoxylate	9016-45-9	2.5 – 2.7
	Other ingredients	NDA	Balance
CFT Legumine[*]	Rotenone	83-79-4	5
EPA Reg. No.:	Rotenoids other than rotenone	NDA	5
89459-48	Methyl pyrrolidinone	872-50-4	10
	Diethylene glycol monoethyl ether	111-90-0	56.7
	Other ingredients	NDA	Balance

[&] Based on recent reformulation submitted by registrant Central Garden and Pet Company to Health Canada in June 2017.

[+] Does not meet the criteria of a substance.

[*] Not currently registered in Canada.

3.2.3 Eradication Effects on Other Species

Other native fishes inhabiting Miramichi Lake and Lake Brook include a variety of cyprinids, percids, killifish, and other species (Table 3.3; 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). None of the fish species present are unique to Miramichi Lake. Fish in Miramichi Lake could be conserved by removing them before rotenone application, holding them in off-site facilities nearby during rotenone deactivation (likely 2-3 weeks), and reintroducing them when the rotenone is no longer present (< 0.002 mg/L).

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. Billman et al. (2011) suggested several management measures to reduce rotenone impacts to amphibians. Larval amphibians could be conserved by removing them before rotenone application and reintroducing them when the rotenone is no longer present. If tadpoles cannot be removed before rotenone application, they can be collected in the first 4 h after treatment before significant mortality occurs and allowed to recover in fresh, untreated water. Exposure to rotenone causes lethargy in tadpoles, making them easy to capture.

Results of studies of the impacts of rotenone on aquatic invertebrates in lentic environments have been highly variable. Overall these results show that planktonic species are very sensitive to rotenone, with recovery of populations sometimes taking several years. Benthic macroinvertebrate assemblages are usually reported to be much less impacted, 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*. 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. With a treatment rate of 0.075 mg/L rotenone, it is likely that planktonic species would be especially vulnerable. One potential way to enhance the recovery of cladoceran, copepod, and rotifer populations is to treat lentic waters in the fall after the overwintering

(epphipial) eggs have been laid (Bradbury 1986). These eggs are postulated to be resistant to rotenone which might explain the quick reappearance in some lakes the spring following a rotenone treatment (Brynildson and Kempinger 1973).

Table 3.3. 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
Atlantic salmon	X	X
American eel (*Anguilla rostrate*)	X	X
banded killifish (*Fundulus diaphanous*)	X	
blacknose dace (*Rhinichthys atratulus*)		X
brook trout	X	X
brown bullhead	X	X
common shiner (*Luxilus cornutus*)	X	X
creek chub (*Scardinius atromaculuatus*)	X	X
fallfish (*Semotilus corporalis*)	X	X
gaspereau (*Alosa sp.*)	X	X
golden shiner	X	X
lake chub (*Couesius plumbeus*)	X	X
pearl dace (*Margariscus margarita*)	X	
sea lamprey (*Petromyzon marinus*)	X	X
smallmouth bass	X	X
white perch (*Morone Americana*)	X	
white sucker (*Catostomus commersoni*)	X	X
yellow perch	X	X

[1] "Mummichug", presumably mummichog (*Fundulus heteroclitus*) were recorded in the O'Donnell (2009) report, however killifish are often misidentified as mummichog and it is improbable that mummichog are present here, so we do not consider that identification valid and this species is not shown here.

In 2006, the United States Environmental Protection Agency (EPA) concluded that terrestrial species that consume dead fish that are contaminated with rotenone are the species most at risk than those that do not. However, this risk is significantly tempered since many dead fish sink and will not be available for consumption by birds or mammals, and rotenone rapidly degrades in the environment. Rotenone is slightly toxic to practically non-toxic to birds during acute oral and subacute dietary exposures. The 5 d dietary toxicity (LC50 value) to the mallard duck (*Anas platyrhychos*) was ~ 2300 mg/kg, to the ring-necked pheasant (*Phasianus col*chicus) was 1608 mg/kg and to the Japanese quail (*Coturnix japonica*) was 1882 mg/kg body weight (Hill et al. 1975). Various snakes and turtles may also consume fish as part of their diet, but the EPA uses the sensitivity of birds as a surrogate for reptiles, and rotenone is practically non-toxic to birds. The EPA (2006) concluded that it is not likely that piscivorous birds or mammals would be able to consume sufficient quantities of rotenone to result in acute toxicity. Given the results of EPA's risk characterization, mitigation measures are not necessary for the protection of piscivorous birds or mammals. However, it must be noted that the wood turtle (*Glyptemys insculpta*) is

assessed as threatened by COSEWIC and surveys by MREAC have found sighting of this species in the Southwest Miramichi River. It is unknown if the species is present in the Miramichi Lake sub-watershed, though the species nests on land and is omnivorous, largely feeding on terrestrial organisms. So while relatively toxicity is unknown, risk to this species if present would be relatively how due to limited potential for exposure.

3.2.4 Eradication Effects on Recreation, Aesthetics and Other Water Uses

A successful eradication will remove smallmouth bass from Miramichi Lake; thus, recreational fishing for smallmouth bass will be eliminated. However, fisheries for native species valued for recreational angling, such as brook trout, white perch or yellow perch which may have been negatively impacted by smallmouth bass presence are expected to improve over time. 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 the 2-d treatment and for an additional 72 h after the treatment is completed.

4 Public and Agency Review

4.1 Public Relations Plan

4.1.1 Public Interaction and Message

Obtaining broad public support for smallmouth bass eradication in Miramichi Lake will be a precondition for success. This public relations plan should recognize the variety of groups involved, their roles and realities. Working group members should be respectful of government prerogatives when appropriate.

The message that must be communicated is that applying rotenone is the only feasible option to eradicate non-native smallmouth bass in Miramichi Lake. While there will be temporary impacts on the lake ecosystem, it is necessary to accept temporary harm for the greater good: restoring the lake to its original state after an illegal introduction, and protecting the ecosystem, cultures, and livelihoods in river system. Chemical eradication is an effective fish management technique used widely in Canada, the United States, and Europe. To not act would risk permanently and negatively affecting the Miramichi River ecosystem. Furthermore, these actions can be taken with extremely low risk to human health.

Communication should be straightforward and honest, not euphemistic. Language should reflect a genuine determination to eradicate smallmouth bass from Miramichi Lake, even in the face of opposition. Project partners should anticipate detailed questions from First Nations community members, other groups, and individuals. This expert report should be the source of answers. Informing the public of details about the reintroduction of native species, and quick return of the lake to its pre-treatment or

historic state should be a feature of communications. This may include removing other species that are native to NB but not to Miramichi Lake historically (potentially yellow perch, though this is anecdotal and requires verification) which may help restore brook trout numbers in Miramichi Lake to historic levels

4.1.2 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 mailed letter to each of these people or organizations describing the working group, our goal, the expert report, and intent to work with permitting agencies. The letters will open a direct line of communication and include a notification of public meetings.

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 working group includes an official from the North Shore Micmac Resource Council Inc. that represents seven First Nations, two of which are directly present on the Miramichi river (Metepenagiag and Eel Ground). This will hopefully encourage meaningful discussion and support. Through tailored letters to chief and council it would be appropriate to offer public meetings in Metepenagiag and Eel Ground.

Maliseet First Nations and New Brunswick Aboriginal People's Council: The working group will contact Maliseet communities through the Maliseet Nation Conservation Council, an affiliate of the New Brunswick Salmon Council. Other indigenous people will be contacted broadly through the New Brunswick Aboriginal People's Council. If necessary, further meetings could be held to provide more 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 seek a motion in support of the project during an open session. A public meeting should be held in Juniper, where no municipal council exists.

NGOs: The following NGOs and political leaders 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, Nature Conservancy of Canada, Ducks Unlimited Canada, and the Coalition for Better Salmon Management.

Political Leaders: Elected officials provincially and federally will have a role in deciding whether to eradicate bass from Miramichi Lake. Individuals we should directly contact include, but are not limited to, all area MPs and MLAs, Green Party Leader David Coon, Federal Green Party Leader Elizabeth May, Leader of the N.B. Official Opposition Blaine Higgs, the Premier, Department of Energy and Resource Development Minister Rick Doucet, Department of Environment and Local Government Minister Serge Rouselle, and Fisheries and Oceans Minister Dominic LeBlanc.

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

4.1.3 Media Communications

Prior to mailing stakeholder letters, the working group should have discussed this public relations strategy with provincial and federal agencies. A set of key points and responses should also be in place to help with unplanned media communication. A logical first planned media communication for the working group would be a bilingual commentary from co-chairs Mark Hambrook and Peter Cronin published in provincial newspapers. This should be submitted shortly after the mailing and receipt of letters to 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 *Section B – Involved Groups and Likely Concerns* subsequent engagement will be driven by requests and in collaboration with government partners.

4.1.4 Methods to Obtain Public Comment

Public comment and opinion will be noted at each meeting and in every conversation 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.

4.1.5 Develop Invasive Species Information Products

Creating high quality, informative, communication material for use by the public and media should be an early priority of the working group and government partners. Examples from other invasive species eradication projects can be obtained. 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 reintroduction. 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 should result from collaboration between working group members and public agencies.

5 Preliminary Treatment Plan

5.1. Proposed Eradication Action

5.1.1 Overview of Proposed Action(s)

It is proposed that at the very least, Miramichi Lake and upstream tributaries be treated with 1.5 mg/L 5% rotenone liquid formulation (0.075 mg/L rotenone) in mid-September to eradicate smallmouth bass. Currently, the rotenone treatment of other branches (in particular the eastern branch not directly downstream of Miramichi Lake) of Lake Brook is not included in the plan and costing, but it can easily be added if smallmouth bass are found there or if it is desired to lower the probability of any bass remaining in the Lake Brook system. Given the risks of smallmouth bass refuge in Lake Brook, at a minimum, the treatment of the main stem of Lake Brook is recommended.

A second issue to be determined is whether the discharge from Miramichi Lake into Lake Brook requires chemical deactivation with $KMnO_4$ (potassium permanganate), though given the risk, this would seem prudent and has been included in the costing. Rotenone will dissipate over time and distance during transport from Miramichi Lake through the meandering Lake Brook to the Southwest Miramichi River. However, if following dilution, the resulting rotenone concentrations are expected to be > 0.002 mg/L (a level generally considered safe to non-target organisms by EPA (2007) and Finlayson et al. (2010)) in the Southwest Miramichi River, then chemical deactivation in Lake Brook is recommended. The dilution of rotenone cannot be determined exactly at this time as direct measurement of flow in the required sections of river have not been made, and would in any event be specific to when the application occurs. However, this deactivation could be done at a road access point further down Lake Brook, to allow for the oxidation of rotenone before it reaches the Southwest Miramichi the simultaneous treatment of Miramichi Lake and much of Lake Brook.

The timing of the treatment is examined in detail in Section 5.4.1 below. The ideal treatment window would be mid-September when flows in and out of Miramichi Lake are minimal and the water temperatures have not yet declined significantly (15-18 °C) (Figure 5.2). The sporadic occurrence of minor thermoclines in Miramichi Lake is not a limiting factor to a successful treatment because of the

ability of liquid formulations to penetrate thermoclines and the frequent summer mixing of this relatively shallow polymictic lake.

5.1.2 Permits and Approvals Required

The federal application for the use of rotenone at Miramichi Lake would be made to the Department of Fisheries and Oceans through the Aquatic Invasive Species Regulations (Authorization to Destroy Fish by Means Other than Fishing). In the previous application at Despres Lake, it was the New Brunswick government that was the applicant. At present, New Brunswick has not accepted the authority to control aquatic invasive species in the province. Unlike many provinces, New Brunswick does not have a fish and wildlife act that gives power equivalent to the federal fisheries minister, to the provincial minister, under the *Fisheries Act*/AIS regulations. Thus, rotenone application under the *Fisheries Act* must be approved by the Federal Minister of Fisheries. However, at present there is no confirmed proponent of a rotenone application. It seems that the only possible proponents/applicant would be either DFO itself (to the best of our knowledge DFO has never been the proponent of a rotenone application in Canada and DFO staff feel this is an unlikely option), or the New Brunswick Department of Energy and Resource Development, who oversee inland fish and wildlife in the province, and the Department of Environment and Local Government (DELG), who would permit the application provincially. Clearly without an applicant for a rotenone application, it will never proceed, thus, this is a matter of utmost urgency.

The invasive species regulations allow the use of rotenone as certain formulations are registered for the purpose of controlling invasive fish under the *Pest Control Products Act*. The federal application will elicit a screening under the *Canadian Environmental Protection Act* (managed by Environment and Climate Change Canada) and the results of that screening may or may not trigger a full environmental impact assessment. Provincially, application for a pesticide use permit and for a permit for the disposal of fish remains would be required. The responsible agency would also require a Pesticide Applicator Certificate. If products other than those registered in Canada are desired, application for emergency use must be made under section 18 of the *Pest Management Control Act*. Emergency registrations must be sponsored by the provincial or federal agency involved in the direct management of the pest problem and are only valid for one year. Other miscellaneous permits may be required, for example a permit to dispose of dead fish from the New Brunswick Government, and a permit for alteration of a watercourse is this is done for fish holding purposes.

5.2 Treatment Area

5.2.1 Lake Physical Characteristics

Located approximately 160 km above 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 branch of the Southwest Miramichi River). Miramichi Lake is approximately 2.8 km long with an average width of 0.8 km (Figure 5.1). The surface area is estimated to be 2.21 km^2. Most areas of the lake are moderately shallow (< 4 m) with two deep holes (> 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 brown 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 22nd, 2017 was 7.3 and the conductivity 25 µS/cm. No other records of water chemistry for Miramichi Lake could be found though some likely exist as unpublished data within either DFO or the New Brunswick Government. Given the colour of the lake, it may be useful to have dissolved organic carbon and light attenuation measured as it is likely that this has not been previously measured. 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.

Miramichi Lake has an estimated water volume of 11,491,750 m^3. 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 (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 22nd, 2017 showed a flow rate of 0.69 m^3/s. Based on the total water volume of the lake and the estimated mean annual flow, the residence time of the lake is 0.81 years. Put another way, only 0.28% of the volume of the lake is exchanged per day.

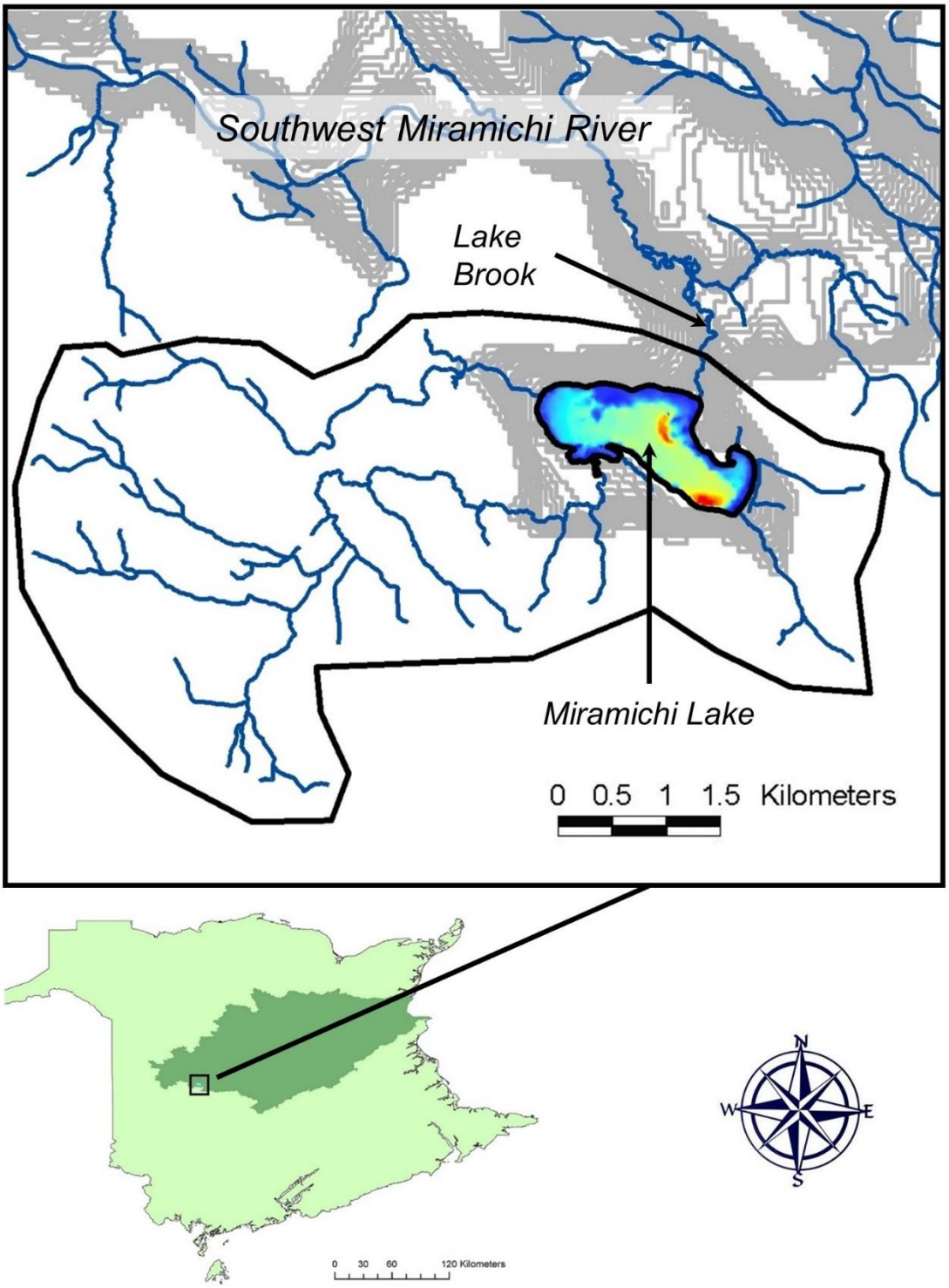

Figure 5.1. Location of Miramichi Lake within the Miramichi River watershed, New Brunswick. The Miramichi Lake sub-watershed is shown by black boundaries and the bathymetry with a colour map (red being the deeper areas). Grey lines show 1 m contours.

Water temperature data was collected by DFO in 2010, 2011 and 2012 from May through October. The Miramichi River Watershed Management Committee took temperature readings in 2016 from mid-June to October (Figure 5.2). 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 5.2). 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. Interestingly, 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.

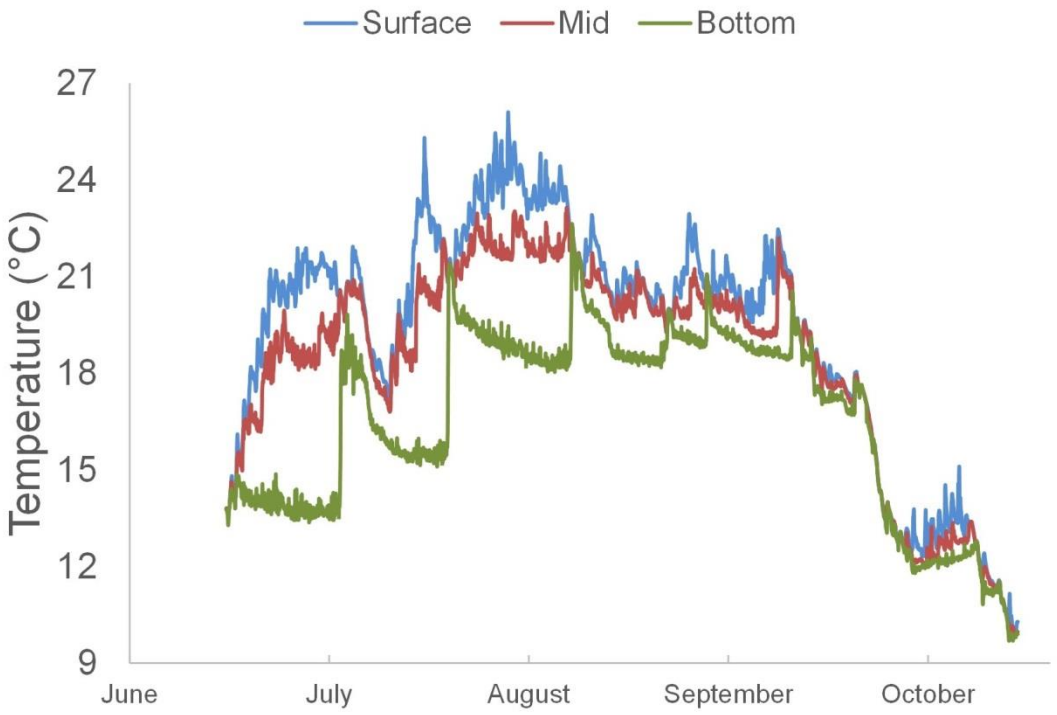

Figure 5.2. Mean (n = 2 loggers) temperature at the surface, mid-depth, and bottom of Miramichi Lake in 2016. Figure created from raw data with the permission of MREAC.

5.2.2 Smallmouth Bass Distribution in Space and Time

In the spring, smallmouth bass 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 (2005) found in other New Brunswick lakes (Oromocto and Mactaquac) embryos hatched and young-of-the-year 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 young-of-the-year smallmouth bass to be concentrated in this region. Three mature female bass were reported caught in this area by local fisherman contracted for control measures in 2017 (Brian Richard, personal communication), and young-of-the-year bass were found in July 2017. Young-of-the-year/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*. young-of-the-year 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 smallmouth bass are also reported to burrow in the mud at temperatures below 7 ˚C (Kerr and Grant 1999). However, smallmouth bass, 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 smallmouth bass from rotenone toxicity since sediment can sequester rotenone (Dawson 1986) thus, temperatures subside below 10 °C should be avoided and such temperatures do not occur in Miramichi Lake till late October.

5.2.3. Non-Target Species Distribution in Space and Time

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). Further details are given in Table 5.1 below in the section on restocking. DFO (2013) used a combination of sampling techniques during their efforts to capture smallmouth bass 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 gaspereau. Most notable of these records would be the gaspereau; large spawning runs of gaspereau (tens of thousands) are known to enter Miramichi Lake each spring with significant numbers of young-of-the-year leaving in July and August (DFO 2009, DFO 2013).

5.3 Native fish and Invertebrate Holding and Reintroduction Plan

There are three overall options with regards to restocking, either take and hold fish from Miramichi Lake, then re-release once toxicity has dissipated, collect fish from other New Brunswick waterways for restocking Miramichi Lake, or let Miramichi Lake restock naturally. This last option would potentially take decades and has no guarantee of similar fish diversity being reached so is not considered a viable option. The option of holding and re-release from Miramichi Lake over stocking from other systems is recommended for a number of reasons: 1) taking fish from the same lake as you are restocking it avoids potential transfer of disease and parasites or of accidental release of unwanted organisms, 2) fish genetics will be maintained by restocking from the same population, in many cases the closest lakes containing these species may be outside of the Miramichi watershed, and genetic diversity would be lost, and 3) 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. 4) If fish holding and restocking is successful, it can be done at significantly less effort and cost than fish transfers from other systems (many months of work at the very least), higher numbers can be re-introduced leading to a much faster recovery of the system. There are few lakes of similar size near Miramichi Lake from which to source fish except for Nashwaak Lake (not in the Miramichi River watershed) and the nearest larger Lakes in the Miramichi watershed are over 60 km to the north and generally only accessible through secondary roads. Similarly lakes in the St. John River watershed are located similar distances to the southeast. Thus stocking by road would be very logistically challenging, expensive, and time consuming and may only be feasible with helicopter transfers. Stocking some species from the Southwest Miramichi River itself is a possibility. If fish holding and re-release were not, or were only partially successful, restocking from other systems would remain as a second option.

5.3.1 Identification of Species and Numbers to be Collected/Held.

Miramichi Lake is a unique ecosystem reported to have incredible diversity of 16 species of fish (excluding bass) including a very substantive run of gaspereau (Table 1). While gaspereau have not been often identified to species (alewife vs. blueback herring) in reports on Miramichi Lake, examination of dead fish in the run occurring June 22nd, 2017 showed that they were alewife. However, a second, later

run into the lake was described by the fisherman contracted for bass control measures and fits the description of blueback herring (Brian Richard personal communication). While migration of blueback herring that far upstream does not seem likely, and two migrations upstream are not indicated by previously collected data (Chaput 1995), this should be further investigated. It is noted that the previous report on Miramichi diadromous fishes (Chaput 1995) did not document penetration of the gaspereau run as far upstream as Miramichi Lake, certainly one of the furthest migrations of gaspereau ever to be observed, so it is not entirely inconceivable that blueback herring migrate to the lake.

In order to restore the full fish community, it would be desirable to target all 16 (or 17) species, with the exception of smallmouth bass. However, some of these species may also have been deliberately introduced, i.e., they are native to New Brunswick but not historically present in Miramichi Lake, such as the yellow perch (Brian Richard personal communication, unconfirmed). Under an eradication scenario using rotenone, there will be the option to reestablish a community that is closer to what may have been contained in the lake historically, assuming such records exist. As previous introductions are unconfirmed and historic fisheries data has not yet been obtained, recommendations on what the post-treatment community would look like is reserved at present and this report focused on restoring the existing fish community.

Certainly, this re-stocking represents a complex recolonization effort, and some species should be a greater priority than others. Species that will not recolonize immediately, whose life cycle is mostly constrained to this lake, have high relative abundance in the lake, or may take decades to reestablish should be prioritized. Based on this there are 8 species that could be ranked as a high priority. Conversely, anadromous or highly migratory species like the alewife or sea run brook trout will colonize the lake on their own within a year, and while in the worst case they may lose a year class, this would still make them a lower priority for restocking. If a rotenone treatment were carried out in a mid-September window, presumably impacts to gaspereau would be avoided since post-spawned adults and juveniles would have already left the lake (though this is mostly anecdotal and data regarding this has not been documented). Extremely rare species are also a low priority as the likelihood of capture for recolonization may require exhaustive fishing effort (there will only be a very short window to capture fish) and they would perhaps be best reestablished from other locations. Species that may survive the rotenone exposure could also be given low priority such as brown bullhead and golden shiner. There is no literature or guidance with regards to ideal number to restock. The more fish that are restocked, the more successful the reintroduction is likely to be, and the quicker the lake will recover. Thus, recolonization efforts will be constrained by practicality and cost and the number suggested in Table 5.1 represents the maximum numbers that are deemed practical realizing that actual efforts may generate lower numbers to be restocked.

While rotenone is generally considered less toxic to invertebrates than fishes (Oplinger and Wagner 2011), little consideration has been given to invertebrate communities in the lake. As rotenone will almost certainly affect some invertebrates, consideration must be given to protecting unique invertebrates and further study should be made of invertebrate fauna. For example, the lake is reported to contain beds of freshwater mussels (Brian Richard personal communication) that would not quickly or easily recolonize. There are five species of freshwater mussels in the Miramichi basin (http://mreac.org/project/freshwater-mussel-survey/) and one of them, the brook floater (*Alasmidonta varicose*) is considered of special concern by COSEWIC and is known to occur in the Southwest Miramichi near the Taxis River – emphasizing the importance of characterizing some of the invertebrate fauna in the lake. Mussels could be easily collected by divers and held for reestablishment. Tadpoles were also identified in the lake and not identified in DFO reports. These were visually present in June of 2017 and given their size, and the anecdotal descriptions of bullfrog calls, these are almost certainly bullfrogs. While bullfrogs are reported to be less sensitive to rotenone than fishes (Alvarez et al. 2017), given that this is the northern extent of the range of this species, tadpoles could be easily collected and held for reestablishment. Investigations regarding the invertebrate and non-fish vertebrate diversity should commence in 2017 if there is not data on these species.

Unfortunately, there is no literature to guide the reestablishment of fish in terms of numbers. Higher numbers would aid the probability of success and enhance the rate at which reestablishment occurs. The counterpoint to this is that rotenone can be expected to have some impacts on zooplankton and invertebrates, thus reducing the food base for many of the species in the lake. Therefore, greater numbers of fish being stocked may lead to resource limitations and starvation, though unlikely given the current fish biomass in Miramichi Lake. A study of rotenone used in a New Zealand stream to eradicate brown trout, documented severe invertebrate density reductions, however, invertebrate density returned after one year (Pham et al. 2013). In this study, the native galaxiid species was reintroduced to the system within 10 days, and while a reduction of fish condition factor was observed, the reintroduction was generally successful.

Capture from the lake itself is unlikely to represent a challenge, though multiple methods would likely be the most effective. A combination of minnow trapping (shallow, < 1 m), fyke/hoop nets (intermediate depth 0.5-2 m), lake trap nets (deep > 2 m), and boat electrofishing (intermediate depth 0.5-1.5 m) could yield the desired number of fish in less than a week. These methods would have the least stress to the fish captured. While short-term gill netting (1-3h) can, depending on the species, be done with limited mortality, and will work at all depths, it should be kept only as an option if sufficient fish numbers are not captured by other methods.

Table 5.1. Fish inventory of Miramichi Lake. Species are organized by the total individuals captured by all methods combined (DFO) in order to give some sense of relative abundance.

Species	Proposed numbers	Priority for reestablishment
yellow perch	1,000	High
white sucker (*Castostomus commersoni*)	1,000	High
white perch	1,000	High
fallfish	200	High
common shiner	200	Low
gaspereau (confirmed alewife *Alosa pseudoharengus*)	0	Low
golden shiner	200	High
brown bullhead	200	Low
banded killifish	200	High
American eel	100	Low
brook trout	0	Low
creek chub (*Semotilus atromaculatus*)	0	Low
lake chub	0	Low
sea lamprey	0	Low
Atlantic salmon	0	Low
pearl dace	0	Low

5.3.2 Temporary Containment – Facilities Needed/Available

Containment of species for reestablishment is likely to be required for at least two weeks and possibly more. There are three options for containment 1) set up outdoor flow-through, aerated tanks at an appropriate nearby location for fish holding, or 2) set up cages or pens in a nearby water body, or 3) find a nearby hatchery facility. We would consider option 3 to be unlikely even if such a facility existed in close proximity, the potential introduction of pathogens into such a facility would make this option challenging to the hatchery managers – however there may be a streamside flow through system of tanks near Juniper New Brunswick that would be suitable. Either way, the critical factor for the success of holding will be cold temperatures and water temperatures at or below 15°C are essential for any transport and re-stocking and thus this approach is not recommended prior to mid-September.

Holding fishes near to the lake would be an advantage in that this could be achieved within relatively close proximity to the lake reducing stress on fish due to transport time considerably and there is no risk of moving unwanted species or pathogens elsewhere. Given the number of tanks required, it

may even be feasible to dig and line some small ponds and this could be less stressful. There is a small, cold, spring fed stream on the eastern edge of the lake adjacent to the road where the cottages are. This stream is reported to run at less than 12°C all year. With about 3,000 L/min flow, this could be adequate for about 30 large (200-1000 L) tanks with a flow rate of about 10 L per minute if the stream were temporarily diverted for this purpose. However, as water in the area is very soft (25 µS/cm) the ionic stress compounds the stress of capture and transport. The author has found that placing fish from the wild in slightly saline water (0.5 PSU) greatly reduces the stress of transport and aids in the prevention of disease that almost inevitably manifests when wild fish are held in captivity. Certainly frequent treatment with disease preventatives would be required in any event. It is possible that the water supply for the cottages that comes from a reservoir on a hill above the buildings could also be utilized. This water supply likely originates from the same aquifer as the observed stream, though this was not confirmed. Fish tanks would have to be located on private property adjacent to the lake. There are also other stream systems flowing into Miramichi Lake, however as the region is entirely forested and difficult to access, and some of these streams seem to be muskeg-fed, finding a suitable location to site tanks would be challenging without clearing an area.

A second option, floating cages or pens could be easily constructed in a suitable waterbody with wood and vexar mesh and have the advantage of providing a reduced stress environment with ample oxygen for captive fish. While equally or even less costly than a tank set-up, the largest disadvantage of this option is travel time and the stress imposed by that travel. The closest large body of water is 10 km away (its suitability was not assessed). However, given the nature of the gravel roads in this area, this would be one to two hours travel time if transporting fish by vehicular means. The authors have experience with transporting thousands of yellow perch and white sucker over such distances and conditions and while possible, this is very stressful for fish and would not be the recommended option. A helicopter airlift would be a better option. Escape of captive fish is also a possibility, and if such species were not present in the system utilized, this would be an ecological risk. Considerably more local knowledge and exploration would be required to assess all the options. However, based on the author's experience with capturing, holding and transplanting wild fish, holding fish at Miramichi Lake is likely to be most successful provided warm temperatures are avoided, and most cost effective unless a suitable body of water exists very close to Miramichi Lake.

5.3.3 Reintroduction Plan

Reintroduction should begin as soon at the toxicity/residues in the lake have returned to a level that is not lethal (see section 7 for toxicity monitoring). The shorter this period, the less likelihood of disease and mortality in the fish being held. Given an estimated half-life of rotenone of about 2.5 d at

18°C this should be feasible at the earliest in 10 though the previous rotenone application in New Brunswick conducted at colder temperatures would show this to be longer (Connell et al. 2002) and it could be up to 30 days. Fish should be released as close to the habitat in which they were captured as possible. A DFO permit may be required to re-introduce fish back into Miramichi Lake.

5.4. Detailed Treatment Strategy

5.4.1 Optimal 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 and facilitate rapid and successful fish reintroduction. As a result, there are a number of trade-offs when considering treatment timing. While there is some merit in spring treatment before bass spawn, the presence of an enormous and unique gaspereau run into Miramichi Lake in the spring eliminates this entirely as a possibility. Gaspereau have been observed moving across the barrier downstream after spawning into mid-July (O'Donnell 2009) and while the departure of juvenile gaspereau is not as clearly documented, rotenone application should not be conducted until mid-September to ensure the departure of this life stage from the lake. Furthermore, high flows in spring are a significant detriment to treatment. As a result, spring treatment is a not practical and the merits of treating at this time won't be examined further. In addition, application in mid-September should eliminate the possibility that bass will be present as eggs as they normally finish spawning in July and egg incubation time is only 2-9 days. This somewhat simplifies the many considerations with regards to timing and as such this section will focus on treating in mid-September.

Temperature – Temperature is the largest consideration regarding when to treat. Temperature has the potential to affect toxicity, the half-life of rotenone, the efficacy of permanganate deactivation and has a significant influence on the chances of success of holding and reintroduction efforts. Although there is no published evidence that the toxicity of rotenone to smallmouth bass increases (e.g., lower LC50 value) with temperature, the resistance times to a highly lethal level of a toxicant like rotenone are changed by temperature in accordance with van't Hoff's equation (Sprague 1985); survival times decrease by a factor of 2 to 3 for each rise of 10°C largely due to faster toxicokinetics – though there is no theoretical reason to believe that the incipient LC50 (at infinite time) would change based on temperature. A suite of data from fish bioassays has been previously summarized (Oplinger and Wagner 2011) and in many cases bioassays were carried out with the same species at 12 and 17°C and there was no obvious differences in toxicity within this narrow temperature range (5 °C) for the species tested. So based on this evidence, as long as application temperature is above 12°C, rotenone should be sufficiently efficacious as at 17 °C. The treatment of Despres Lake to eradicate chain pickerel with a measured concentration of 0.089 mg/L (slightly higher than the 0.075 mg/L proposed) of rotenone on October 10, 2001 likely occurred at

temperatures below 12°C (exact temperatures not provided) and was successful (Connell et al. 2002), though residual toxicity remained for a period longer than would be desired.

Rotenone half-life and thus the duration of acute levels will be higher at low temperature. Half-life is estimated at 13.9 h at 24°C and 3.5 days at 0°C (Gilderhus et al. 1986, 1988). Based on the application rate suggested it would take 3.3 d at 24°C and 21 d at 0°C to reach non-toxic levels of <0.002 mg/L. However, these numbers were derived from artificial systems and probably underestimate the actual half-life in a lake environment. Measured concentrations in the Despres Lake, New Brunswick rotenone application performed in mid-October suggest long half-life in the order of 14 d (Connell et al. 2002). Despres Lake, New Brunswick was treated October 10, 2001 and toxicity based on brook trout bioassays was reduced, but persisted until at least November 23rd of that year. Application in Norway at Lake Fustvatnet supports a longer half-life as it was treated at 0.035 mg/L rotenone in early October 2012 remained lethal to fish all winter and into the next summer (July 2013) (Stensli and Bardal 2014). Persistent toxicity will also interfere with the success of restocking efforts as the longer fish are held, the more likely for disease and mortality favouring treatment at higher temperature.

Typically, permanganate deactivation works best in warmer water (> 10 °C), and postponing the treatment until October could increase the chance of deactivation failure as and cooler water temperatures prolong the deactivation period and more $KMnO_4$ is required for deactivation. In 1992, Silver King Creek (sub-alpine stream in Sierra Nevada range), California was treated at 0.025 mg/L rotenone in late September 1992, and in 1997, Lake Davis was treated at 0.100 mg/L rotenone in October 1997 (Finlayson et al. 2001). Fish were killed below the 30 min deactivation zone in both treatments likely due to the cold water (< 10 °C) temperatures interfering with efficacious deactivation of rotenone. Based on some classical kinetics experiment with oxalic acid, a 10°C reduction (15°C vs. 25°C) was found to decrease reaction rate by about 50% (Redmon 1934). However, there is conflicting evidence using another hydrophobic organic contaminant in soils to suggest that in the presence of humic material that competes with rotenone oxidation, superior oxidation may occur at low temperatures as the contaminant is more selectively oxidized than the humic material at this temperature (de Weert et al. 2014). As Miramichi Lake is darkly coloured it likely contains significant levels of dissolved organic carbon and there is some uncertainty about this influence on both efficacy and biodegradation.

Consideration must also be given to reestablishment of non-target species that will be captured, removed, and held during the rotenone application. The success of reestablishments efforts will be governed by the ease of capture of the non-target species, successful holding conditions. Fish capture, transport and holding is always enhanced by colder water temperature due to less metabolic oxygen demand and higher oxygen saturation at low temperature. While fish can be held at colder temperatures, warmer temperatures cannot be avoided during fish capture. While it is species specific, attempts to

capture and transport fish if the water temperature is at 20°C will likely largely fail and this should not be attempted. Water temperature of 15°C or less will greatly enhance success.

Recreational Use of Miramichi Lake – The largely summer residents of the lake would use the lake for recreational purposes, and this would for safety be restricted during a rotenone application. Early September (Labour Day weekend) prior to the start of school would likely represent the last peak of recreational activity on the lake which would diminish into the fall.

Flow – While a detailed hydrograph of Lake Brook outflow is not available, examination of 70 years of flow data from the closest Environment Canada hydrographic station (Southwest Miramichi River at Blackville (01BO001) shows that relatively stable low flow occurs between July 1 and early October. This varies with rainfall conditions on annual basis and none of those months have any advantage over another with regards to lower flow – e.g. some year's lowest flow in July and some years it is in October or any month between. Thus on the basis of desired low flow, there are no advantages or disadvantages of mid-September timing being considered.

5.4.2 Description of Equipment Needed

The rotenone will be applied to the 220 ha Miramichi Lake using outboard motor boats equipped with semi-closed probe application systems (Figure 5.3; Finlayson et. al 2008 SOP 8). 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 (Figure 5.4). 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 (Figure 5.5); it is likely that the backwater areas of these will require spraying too.

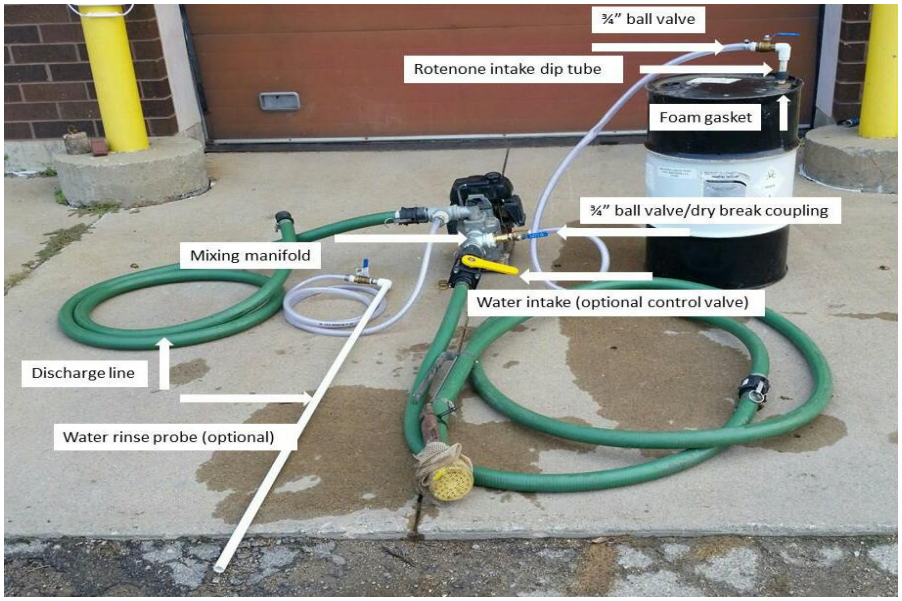

Figure 5.3. Semi-closed probe system used for applying liquid rotenone to lakes (See SOP 8; Finlayson et al. 2010).

Figure 5.4. Backpack sprayer used to apply dilute rotenone solution to backwater and marshy areas of a lake (See SOP 12; Finlayson et al. 2010).

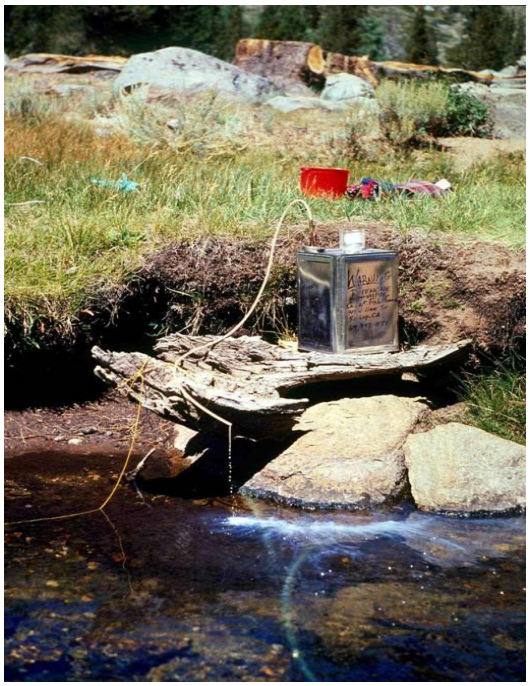

Figure 5.5. Drip station applying rotenone (See SOP 11; Finlayson et al. 2010).

5.4.3 Likely Treatment Rate and On-Site Bioassays

The 24 h LC50 value for Noxfish to young smallmouth bass (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, that which produces 100% mortality, is estimated at twice the LC50 value (Finlayson et al. 2010 SOP 5) or 0.0093 mg/L rotenone. Standard operating procedures recommend that the rotenone treatment rate be at a *minimum* twice the minimum effective dose or 0.0186 mg/L rotenone. This rate should be increased to 0.075 mg/L rotenone (1.5 mg/L rotenone formulation) do to:

- Faster degradation of rotenone through increased hydrolysis and photolysis in this warm (15-18 °C temperature) and shallow (< 7 m depth) lake;
- Biological variability between smallmouth bass tested by Marking and Bills (1976) and those in Miramichi Lake
- Sequestration of rotenone by the abundant, sediment-covered submerged aquatic vegetation along most of the lake shoreline
- Time required for rotenone to reach areas of poor water circulation in the lake, particularly the upstream tributaries (lethal levels will persist for approximately 7 days as rotenone is dispersing)

The proposed rate of 0.075 mg/L rotenone may be modified based on an on-site bioassay with smallmouth bass or a surrogate species such as yellow perch. A 24 h on-site bioassay using site water

should test 0.025, 0.0125, 0.0062, 0.0031, and 0.0016 mg/L rotenone (Figure 5.6) to confirm smallmouth bass (or surrogate) sensitivity of rotenone.

Figure 5.6. Field bioassay using serial dilutions of rotenone in plastic buckets to estimate site-specific toxicity to target species.

5.4.4 Likely Rotenone and Equipment Needs

Based on the physical size of Miramichi Lake (Section 5.2.1), 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 d 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 d window (Table 5.2). 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 5.2. Estimate of boat resources required to apply rotenone to Miramichi Lake.

Parameter	18-Foot Boat	22-Foot Boat
Max Wt. Capacity (kg)	682	1342
Rotenone Wt. Capacity (kg)[1]	501	1160
Number Drums/Trip	4	9
Total Trips	38.2	17
Application Time/Trip (h)	0.4	0.9
Total Trip Time (h)[2]	0.9	1.4
Total Application Time (h)	34.5	23.8
8-h Days Required/Boat	4.3	3

[1] Rotenone weight capacity = [boat maximum weight capacity – 181 kg (2 crew and equipment)].
[2] Total trip time includes 0.5 h for travel and loading times.

It is assumed that the tributaries are not inhabited by smallmouth bass. However, two or three tributaries would need to be treated during the lake application to eliminate any safe haven for fish. This will require spraying of the tributaries if they are not flowing or treatment of the tributaries by drip stations if they are flowing. The treatment of the tributaries should begin in tandem with the treatment of the lake and continue until the lake treatment is complete. It is likely that only the first 100 m upstream from the lake would require treatment for preventing untreated water from entering the lake and will also serve as a barrier to smallmouth bass seeking relief upstream. Treatment of the tributaries would require two or three drip cans (Figure 5.5) or backpack sprayers (Figure 5.4) and a minimal amount of rotenone. The current plan calls for 2-4 boats, each with a high-pressure water pump and semi-closed probe application system, 3 drip stations, and 4 backpack sprayers. A small tractor or loader will be needed to assist with loading the rotenone drums onto the boats.

5.4.5 Likely Deactivation and Equipment Needs

The persistence of rotenone in water is related to time, water temperature, sunlight penetration, pH, oxidation reduction potential, travel time, organic content, turbulence and turbidity (Finlayson et al. 2010 SOP 7; Brown et al. 2011). In lotic systems, the result is decreasing concentrations with increasing distance downstream from points of application (Skaar et al. 2017).

Based on New Brunswick regional equations (Cassie and Robichaud 2009), the 2 year low flow estimate for the Miramichi Lake/Lake Brook outflow is 0.07 m^3/s, and the 2 y low flow estimate for the Southwest Miramichi River (at the confluence with Lake Brook) is 1.47 m^3/s (Chaput and Caissie 2010). However, it is expected that the actual outflow will be closer to 0.45 m^3/s which is the author's estimated mean annual flow from regional flow equations. The mean annual discharge of the Southwest Miramichi River at the confluence with Miramichi Lake and Lake Brook has an estimated dilution factor of 12 based on (Chaput and Caissie 2010). However, based on the author's analysis of the calculated mean annual flow of Miramichi Lake, the remainder of the Lake Brook watershed, and the flow of the Southwest Miramichi River at the confluence of Lake Brook, the dilution of Miramichi Lake water at the confluence

would be 35-fold. Using the more conservative estimated dilution factor, rotenone (0.075 mg/L) from Miramichi Lake is expected to have a maximum concentration of 0.0062 mg/L in the Southwest Miramichi River, not accounting for dissipation over time and distance in Lake Brook. If this was the case, we can expect some, but not great, mortality of rotenone intolerant fish (i.e., salmonids) in the Southwest Miramichi River, deactivation of rotenone to non-toxic levels in Lake Brook prior to water entering the mainstem of the river would be conducted.

More accurate and precise discharge data (not estimates) are required before it can be concluded that chemical deactivation is truly needed. If the dilution factor estimate of 12 is correct, chemical deactivation would only be needed until the mean rotenone concentration in Miramichi Lake dissipated to ≤ 0.025 mg/L (~ 1.5 d half-life or 3-4 d). To err on the side of safety, chemical deactivation in this instance should be planned for 7 d. The cost of chemical deactivation with granular $KMnO_4$ for 7 d has been estimated. The deactivation should be done below the barriers on Lake Brook at least 30 min water travel time upstream of the confluence with the Southwest Miramichi River using a volumetric feeder powered by a gasoline generator (Finlayson et al. 2010 SOP 7). An expected deactivation at 4 mg/L $KMnO_4$ for 7 d will require roughly 1,089 kg $KMnO_4$ for treating the Lake Brook discharge of 0.45 m^3/s.

5.4.6 Health and Safety Plan

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 personnel protective equipment (Finlayson et al. 2010 SOP 3). The delivery of rotenone can be coordinated with the treatment date so no long-term storage may be needed. Rotenone can be delivered to the site a day or two before treatment using normal ground transportation. The likely storage and staging area for the treatment is at the public launching area near the end of Miramichi Lake Road just at the start of the private cottage road on the southeast side of the lake. As no public dock is available for servicing 18-22 foot boats with drums of rotenone, either one of the primate docks should be used, or then a portable dock will be installed. A 7 by 10 m area, surrounded by hay bales, and lined with a plastic tarp could suffice for on-site temporary storage. A site-specific spill contingency plan will be developed to prevent spills from occurring and to contain and manage a spill should one occur (Finlayson et al. 2010 SOP 4).

5.4.7 Dead Fish Removal

Under New Brunswick law dead fish will need to be removed and buried and a permit required for their disposal. Dead fish that are floating and available for safe retrieval can be collected from shore or collected in the boats used for application when that is completed.

5.5 Crew Size and Responsibilities

American Fisheries Society Rotenone SOP Manual 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 $KMnO_4$ 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.

6 Monitoring and Adaptive Management

6.1 Application Monitoring

Pre-treatment, rotenone should be measured at three locations in the lake immediately prior to application (largely to detect background in any chosen analytical methods). This should be repeated immediately after, and 2 days post application. The water temperature and smallmouth bass activity along with inflow to and outflow from Miramichi Lake are also significant pre-treatment monitoring parameters for predicting when the treatment should begin. The most up-to-date discharges of inlets, Lake Brook, and the Southwest Miramichi River at the confluence with Lake Brook are also needed along with the travel time estimate for water traveling from Miramichi Lake to the Southwest Miramichi River.

Monitoring of rotenone levels and acute toxicity should be conducted throughout the application and reintroduction. 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 showed 24 h bioassay results with mortality equal to or less than pre-application bioassays, restocking should commence.

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 using an in-house method, however the turn-around time of this analysis is not known. This could be important to help inform the decision of when to restock the lake if rapid sample turnover can be achieved. As an option, a LC/HRMS methods could be adapted at UPEI and might allow for 24 h turnover of sample analysis and have a vastly superior detection limit (and could possibly employ metabolite quantification) during the period just prior and after the application.

6.2 Pre and Post Application Ecological Monitoring

An intra-disciplinary team of interested government agencies and/or academic partners (aspects of monitoring can be done as graduate student or post-doctoral studies) should be established to document the impacts and recovery associated with the rotenone application. Monitoring would include a pre-rotenone monitoring period followed by at least annual monitoring for up to 5 years, or until the system recovers to a stable or pre-application state. While one year pre-treatment evaluation does not provide an indication of year-to-year variability, waiting longer increases the risk of smallmouth bass expansion. However, if sample collection were made and samples preserved in 2017, and additional collection could be made in 2018 prior to treatment, resulting in two years of background data. This would be the recommended approach, so while decisions and approvals will not be completed in 2017, some collection, but not analysis can be made at fairly low cost. This may also allow for uncertainties, such as the presence or absence of COSEWIC-listed mussels to be evaluated. As biota will vary seasonally, to make a monitoring program of practical size and effort, most monitoring efforts should be restricted to the time of the year at which application takes place (potentially October).

6.2.1 Phytoplankton/Zooplankton

As phytoplankton and zooplankton are critical to the food web with regards to food for larval fishes, monitoring these communities would be essential do document recovery. As Miramichi Lake is generally shallow and the lake would certainly have turned over by a fall application time, monitoring would not have to be conducted over a vertical gradient. Subsurface, 0.5 m samples should give a good indication of the phytoplankton/zooplankton community. Phytoplankton could be evaluated quantitatively in 1 L grab samples, examined for cell counts using manual or flow cytometry counting, and identified microscopically to the most practical taxonomic level (DNA sampling is also a possibility as e-DNA methods are not substantially different than the cost of microscopic examinations, although not as quantitative). Zooplankton assessment depends on the abundance, and while grab sampling of small volumes is best for quantitative analysis, larger quantities of water could be filtered in the field if abundance is low, or zooplankton nets can be towed to give relative abundance. For zooplankton and phytoplankton, sampling would be conducted at 10 stations in the lake.

6.2.2 Invertebrates

Invertebrate monitoring should be conducted one-year prior to rotenone application at the same time that rotenone is planned to be applied. Invertebrates would again be examined immediately prior to rotenone application, and then after rotenone application corresponding with fish reintroduction. This would be repeated each subsequent year. The rocky/gravel bottom of Miramichi Lake provides challenges for the quantitative monitoring of invertebrates. Ekman dredge, more suitable for soft-bottom substrate would not likely be effective in most parts of the lake. A Ponar dredge may provide better sampling, but this would have to be evaluated. Failing this, the use of artificial substrates for invertebrate colonization may have to be considered. Sampling should be conducted from at least 10 stations evenly distributed through the lake, with sampling to take place at 1 and 3 m depths, effectively representing most of the lake area. Samples would be sorted and identified to the lowest practical taxa. Invertebrate monitoring would be conducted annually at time of the pre-treatment sampling for at least three years. Special consideration may be given to freshwater mussels if they are to be reintroduced. SCUBA diving and direct examination of quadrats placed on the bottom may be the only means of quantifying this species.

6.2.3 Fishes

Fish surveys serve the dual purpose of monitoring recovery and examining for the presence of bass. For the examination of bass presence, netting efforts described below are only part of the solution. The use of eDNA should also be used as confirmation with monitoring for a period of three years. To examine recovery, fish community, demographics and physiological endpoint evaluation should be

conducted one-year previous to rotenone application and just prior to the time period at which rotenone is planned to be applied. The littoral fish community would be examined by the use of a large seine net (50 m long by 4 m deep) from a boat (Roloson et al. 2017). This is the only method to practically quantify fish absolute density. Catch-per-unit-effort evaluation can also be conducted using fyke nets, baited minnow traps, and possibly boat electrofishing.

7 Cost Analysis

The cost estimates for rotenone treatment itself (Table 7.1) are based on a number of assumptions including the physical parameters of Miramichi Lake, Lake Brook and the Southwest Miramichi River during the expected low inflow and outflow season. At this point, additional treatment of the eastern branch of Lake Brook has nor whole lake deactivation has been included in the costs. It is also assumed that four boats, a tractor/loader, and a sufficient dock are available to assist with the application of rotenone to Miramichi Lake within a 2 d window. Using these assumptions, the costs for the application of rotenone to Miramichi Lake were estimated in USD (Table 7.1) and converted to Canadian dollars shown below using the current exchange rate of 1.26:

Noxfish	$436,375
or	
CFT Legumine	$560,719
equipment	$5,002
staff and travel expenses	$34,227
monitoring rotenone residues	$5,040

Total costs

Noxfish	$480,685
or	
CFT Legumine	$605,028

Costs of fish disposal are likely to be significant given the scale of Miramichi Lake and the number of fish present. The following cost estimate presumes that disposal could be conducted at a nearby site by burial. Estimates assume that most dead fish could be collected within 10 days.

Fish collection 8 persons for 10 days@$20/h	$12,800
Fish disposal excavator with operator, 10 days@$100/h	$8,000
Fish disposal transport truck with operator, 10 days@100/h	$8,000

Total Fish disposal costs	**$28,800**

Costs of fish restocking are based on the option of capturing, holding near site and reintroducing fish to Miramichi Lake.

Fish collection and transport 4 persons for 10 days@$20/h	$6,400
Holding infrastructure, tanks, pumps, plumbing	$12,000
Holding maintenance, 2 persons for 20 days@$20/h	$6,400
Fish reintroduction 4 persons for 4 days@$20/h	$2,560
Travel costs	$5,000
Total fish reintroduction costs	**$32,360**

Costs of providing project management from Fish Control Solutions for the preliminary and post treatment investigations needed for developing treatment, safety, deactivation and efficacy monitoring plans, attending planning and public meetings, and providing oversight management for the project have been estimated (amounts are in Canadian Dollars):

Preliminary rotenone and potassium permanganate efficacy studies	$1,700
Developing treatment, safety, deactivation and efficacy monitoring plans	$5,075
On-site oversight management of project	$8,450
Attendance at meetings	$10,400
Travel costs	$11,250
Total project management costs	**$36,875**

The pre- and post treatment monitoring are based on the CRI doing monitoring work as a research project involving graduate students with some lower intensity monitoring to be done by academic technical staff. The former are based on general estimates or graduate student costs per year ($20,000 stipend, 10,000 travel for field work, $3,000 equipment and maintenance, and $10,000 consumables, $7,000 university overhead costs – field based graduate projects generally don't deviate significantly from these costs unless significant specialized equipment or significant technical time or analysis is required).

As it has not been established whether government, consulting or academia would conduct such monitoring, this is to be considered as a general estimate only. Amounts are shown in Canadian Dollars.

Graduate student for phytoplankton, zooplankton and invertebrate monitoring 3 years @ 50,000	$150,000
Graduate student for fish monitoring, 3 years @$50,000	$150,000
Technical time for 3 years of 0.2 FTE@$60,000 (including overheads)	$36,000
Technical time at for 2 years of 0.4 FTE@$60,000 (including overheads)	$48,000
Technicial travel time for 2 years	$10,000
Additional services cost, electrofishing, residue analysis, e-DNA	$40,000
Total monitoring costs	**$434,000**

The grand total of costs for rotenone eradication would be:

Noxfish	**1,012,720**
or	
CFT Legumine	**1,137,063**

Table 7.1. Assumptions used in the cost estimate (USD) of treating Miramichi Lake.

Parameter	Description
Miramichi Lk Surface Area	225 ha (558 acres)
Miramichi Lk Volume	11.6 x 10^6 m^3 (9388 AF)
Lake Brook Discharge m^3/s	0.07 m^3/s @ Southwest Miramichi Rv
Miramichi Lk Mean H_2O Residence Time	0.81 years
Miramichi Lk Temperature	> 15 °C
Miramichi Lk pH	> 7.0
Rotenone Treatment Level	0.075 mg/L rotenone
Noxfish/CFT Treatment Level	1.5 mg/L Noxfish/CFT
ROTENONE (preliminary estimate)	153 @ $2250/3000 each
30-gallon Noxfish/CFT Legumine Drums	= $344,250/459,000 total
EQUIPMENT – LAKE	4 @ $700 each = $2100
Semi-closed Application Systems	
Honda WX15 High Pressure Pump	
EQUIPMENT – LAND	3 @ $250 each = $750
Land Dripcans/Sprayer	
EQUIPMENT – SAFETY	2 sets/application staff @ $40/set
Respirator, goggles, coveralls & gloves,	14 staff x 2 sets x $40 = 1,120
OPERATIONS STAFF	
A. Boat Staff @ 2/boat & 4 boats = 8 staff	A. 8 staff x 8 h/d x 3 d = 192 h
2 Application + 1 Travel Day	192h x $60/h = $11,152
B. Land Staff @ 3 staff (dripcan/sprayer)	B. 3 staff x 8h/d x 3d = 72 h
2 Application + 1 Travel Day	72h x $60/h = $4320
SUPPORT/LOGISTCS STAFF	2 staff x 8/h/d x 3d = 48 h
2 Application + 1 Travel Day	48h x $60/h = $2880
SUPERVISOR/SAFETY STAFF	1 staff x 8/h/d/ x 3d = 24 h
2 Application + 1 Travel Day	24h x $120 /h = $2880
TRAVEL (lodging & per diem)	14 staff x 3 d x $142/d = $5,964
Lodging @ $91 d	
Per diem @ $51/Travel Day	
Monitoring Rotenone Residues	20 samples @ $200 sample = $4,000

This estimate does not include the deactivation of Lake Brook. The cost estimates (Table 7.2) to deactivate the discharge from Lake Brook prior to discharge in the Southwest Miramichi River would be (in USD):

$14,374 for $KMnO_4$
$3,100 for equipment
$26,124 for staff and travel expenses
Total $43,598

Table 7.2. Assumptions used in the cost estimate (USD) of deactivating Lake Brook discharge with 4 mg/L $KMnO_4$.

Parameter	Description
Lake Brook Discharge m^3/s	0.45 m^3/s @ Southwest Miramichi Rv
$KMnO_4$ @ 4 mg/L for 1 week	
g/min = 4(60.02 x 0.45) = 108 g/min	
108 g/min x 60 min/h x 24 h/d = 155.6 kg/d	1089 kg x $13.20/kg = $14,374
155.6 kg/d x 7 d = 1089 kg	
OPERATIONS STAFF	
24 h/d x 7 d x 2 staff = 336 h	336 h x $60/h = $20,160
TRAVEL (lodging & per diem)	
Lodging @ $91/d	6 staff x 7 d x $142/d = $5964
Per diem @ $51/Travel Day	
EQUIPMENT	
Volumetric feeder	Acrison Model 101 ~ $2000
Generator	Honda 2000 watt ~ $1100

8 References

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Appendix I: Noxfish Product Labels

PRECAUTIONS

KEEP OUT OF REACH OF CHILDREN. Poisonous if swallowed or absorbed through skin. 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.

During mixing and loading: Wear coveralls over long sleeved shirt and long pants, chemical resistant gloves, chemical resistant footwear plus socks and either a respirator with a NIOSH/MSHA/BHSE approved organic-vapour-removing cartridge with a prefilter approved for pesticides or a NIOSH/MSHA/BHSE approved canister for pesticides; a NIOSH-approved helmet; or a MSHA/NIOSH approval hood-style respirator with a dust/mist filter.

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.

During application: Wear coveralls over long sleeved shirt and long pants, chemical resistant gloves, chemical resistant footwear plus socks, and a half-face dust/mist respirator during application.

ENVIRONMENTAL HAZARDS

Toxic to aquatic organisms.

GENERAL INFORMATION

Prentox® Noxfish® Fish Toxicant is a specially formulated product containing rotenone to be used in fisheries management for the eradication of fish from lakes, streams and reservoirs. Prentox® Noxfish® Fish Toxicant 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. The user assumes the risk to persons or property that arises from any such use of this product.

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. Prentox Noxfish Fish Toxicant 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. Prentox Noxfish Fish Toxicant 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 PRENTOX NOXFISH FISH TOXICANT NEEDED FOR SPECIFIC USES:** To determine the appropriate number of litres of Prentox Noxfish Fish Toxicant (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.

PRENTOX® NOXFISH® FISH TOXICANT

LIQUID EMULSIFIABLE

RESTRICTED

GUARANTEE: Rotenone 5.0%
This product contains aromatic solvents.

REGISTRATION NO. 14558 PEST CONTROL PRODUCTS ACT

CAUTION

FLAMMABLE **POISON**

READ THE LABEL BEFORE USING

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.	

Prentox and Noxfish are registered trademarks of Wellmark International.

Manufactured for:

Wellmark International
1501 East Woodfield Road 200W
Schaumburg, Illinois 60173

NET CONTENTS __________ LITRES

Type of Use	Parts Per Million of Prentox® Noxfish® Fish Toxicant	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 Prentox® Noxfish® Fish Toxicant to 10 litres of water. Uniformly apply over water surface or bubble through underwater lines. **DETOXIFICATION:** Prentox® Noxfish® Fish Toxicant 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 Prentox® Noxfish® Fish Toxicant in parts per million, plus enough additional to meet the chlorine demand of the untreated water.

REMOVAL OF TASTE AND ODOUR: Prentox® Noxfish® Fish Toxicant 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 Prentox® Noxfish® Fish Toxicant remaining. (**Note:** As Prentox® Noxfish® Fish Toxicant 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 Prentox® Noxfish® Fish Toxicant 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 Prentox® Noxfish® Fish Toxicant 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.

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 gloves, coveralls and goggles or face shield during mixing/loading, cleanup 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.

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PRECAUTIONS

KEEP OUT OF REACH OF CHILDREN. Poisonous if swallowed, or absorbed through skin. 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 reuse drum. Return to drum conditioner or refer to disposal instructions.

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.

During mixing and loading: Wear coveralls over long sleeved shirt and long pants, chemical resistant gloves, chemical resistant footwear plus socks and either a respirator with a NIOSH/MSHA/BHSE approved organic-vapour-removing cartridge with a prefilter approved for pesticides or a NIOSH/MSHA/BHSE approved canister for pesticides; a NIOSH-approved helmet; or a MSHA/NIOSH approval hood-style respirator with a dust/mist filter.

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.

During application: Wear coveralls over long sleeved shirt and long pants, chemical resistant gloves, chemical resistant footwear plus socks, and a half-face dust/mist respirator during application.

ENVIRONMENTAL HAZARDS

Toxic to aquatic organisms.

GENERAL INFORMATION

Prentox® Nusyn-Noxfish® Fish Toxicant is a specially formulated product containing rotenone and piperonyl butoxide to be used in fisheries management for the eradication of fish from lakes, streams and reservoirs. Prentox® Nusyn-Noxfish® Fish Toxicant will not solidify nor show any separation at temperatures down to 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 offence under the Pest Control Products Act to use this product in a way that is inconsistent with the directions on the label. The user assumes the risk to persons or property that arises from any such use of this product.

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. Prentox® Nusyn-Noxfish® Fish Toxicant 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 kill desired. Prentox® Nusyn-Noxfish® Fish Toxicant 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 Prentox® Nusyn-Noxfish® FISH TOXICANT NEEDED FOR SPECIFIC USES:** To determine the appropriate number of litres of Prentox® Nusyn-Noxfish® Fish Toxicant (2.5% Synergized 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 Prentox® Nusyn-Noxfish® Fish Toxicant	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 Prentox® Nusyn-Noxfish® Fish Toxicant to 10 litres of water. Uniformly apply over water surface or bubble through underwater lines. **DETOXIFICATION:** Prentox® Nusyn-Noxfish® Fish Toxicant 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 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.

REMOVAL OF TASTE AND ODOUR: Prentox® Nusyn-Noxfish® Fish Toxicant 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 Prentox® Nusyn-Noxfish® Fish Toxicant remaining. (Note: As Prentox® Nusyn-Noxfish® Fish Toxicant 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 Prentox® Nusyn-Noxfish® Fish Toxicant to drain from drum directly into centre of stream at a rate of 0.9-1.8 cc per minute for each 30 litres of water flowing per second in the stream (0.5-1.0 part per million Prentox® Nusyn-Noxfish® Fish Toxicant or 0.0125-0.025 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.

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 gloves, coveralls and goggles or face shield during mixing/loading, cleanup 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.

300518382

PRENTOX® NUSYN-NOXFISH® FISH TOXICANT

LIQUID EMULSIFIABLE

RESTRICTED

GUARANTEE: Rotenone ..... 2.5% w/w

Piperonyl Butoxide ..... 2.5% w/w

This product contains aromatic solvents.

REGISTRATION NO. 19985 PEST CONTROL PRODUCTS ACT

CAUTION

POISON

READ THE LABEL BEFORE USING

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 Pest Control Registration Number with you when seeking medical attention.

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

NET CONTENTS _____ LITRES

Manufactured for:

Wellmark International

dba Central Life Sciences

1501 East Woodfield Road 200W

Schaumburg, Illinois 60173

Appendix II – CFT Legumine Product Label

CFT Legumine

Fish Toxicant

SHAKE WELL BEFORE USING

RESTRICTED USE PESTICIDE

Due to acute inhalation, acute oral and aquatic toxicity. For retail sale to, and use only by, Certified Applicators or persons under their direct supervision and only for those uses covered by the Certified Applicator's certification.

THE APPLICATOR IS RESPONSIBLE FOR CONFORMING TO THE LABEL. IMPORTANT GUIDANCE ON THE SAFE AND EFFECTIVE USE OF THIS PRODUCT IS PROVIDED IN THE *ROTENONE SOP MANUAL*, AVAILABLE FROM THE REGISTRANT OR THE AMERICAN FISHERIES SOCIETY AT *www.fisheries.org/units/rotenone*

FOR CONTROL OF: Fish in Lakes, Ponds, Reservoirs and Streams

SPECIMEN LABEL

ACTIVE INGREDIENTS:

Rotenone	5% w/w
Cube Resins other than rotenone	5%
OTHER INGREDIENTS*	90%
TOTAL:	100%

*Contains Petroleum Distillates

KEEP OUT OF REACH OF CHILDREN

WARNING

See Additional First Aid, Precautionary Statements and Directions for Use including Storage and Disposal Instructions

EPA Reg.No.
Ⓐ 89459-48 Ⓑ
EPA Est. No. 44616-MO-1 44616-MO-2

PRECAUTIONARY STATEMENTS – HAZARDS TO HUMANS AND DOMESTIC ANIMALS – WARNING

May be fatal if inhaled. Do not breath the vapors or spray mists. May be fatal if swallowed. Causes moderate eye irritation. Harmful if absorbed through skin. Do not get in eyes or on skin or clothing.

FIRST AID Have product container or label with you when obtaining treatment advice.	
If inhaled	• Move person to fresh air. • If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth, if possible. • Call a poison control center or doctor for further treatment advice.
If swallowed	• Call a poison control center or doctor immediately for treatment advice. • Do not give any liquid to the person. • Do not induce vomiting unless told to do so by the poison control center or doctor. • Do not give anything by mouth to an unconscious person.
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 center or doctor for treatment advice.
If on skin or clothing	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a poison control center or doctor for treatment advice.
Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may contact 1-800-248-7763 for emergency medical treatment information. You may also contact the National Pesticide Telecommunication Network at 1-800-858-7378 for information including health concerns, medical emergencies or pesticide incidents.	
NOTE TO PHYSICIAN: Contains petroleum distillate. Vomiting may cause aspiration pneumonia. Symptoms of exposure include numbness, lethargy and incoordination. Decontamination, symptomatic and supportive treatment is recommended.	

Personal Protective Equipment (PPE)
Some materials that are chemical resistant to this product are Barrier Laminate, Nitrile Rubber, Neoprene Rubber or Viton. If you want more options, follow the instructions for Category E on EPA chemical-resistance category selection chart.

All mixers, loaders, applicators, and other handlers (except pilots) must wear at a minimum, the following PPE: (1) coveralls, over long-sleeved shirt and long pants; (2) chemical-resistant gloves; (3) chemical-resistant footwear plus socks; (4) protective eyewear; and (5) a dust/mist respirator.

In addition, mixers, loaders, and others exposed to the concentrate, through cleaning equipment or spills must wear a chemical-resistant apron.

Exception: waterproof waders may be worn in place of coveralls, chemical-resistant apron and chemical-resistant footwear.
See Engineering Controls for additional requirements and exceptions.

User Safety Requirements
Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables exist, use detergent and hot water. Keep and wash PPE separately from other laundry. Discard clothing and other absorbent materials that have been drenched or heavily contaminated with this product's concentrate; do not reuse them. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco or using the toilet. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals.

Engineering Controls for Mixing/Loading/Applying Liquid Formulations Packaged in Containers > 5 Gallons
Mixers/loaders/applicators must either:
(1) Use a closed system that meets the requirements listed in Worker Protection Standard (WPS) for dermal protection of agricultural pesticides [40 CFR 170.240(d)(4)], or
(2) Use the Semi-Closed Probe Mixing/Loading/Applicator System described below.

Remove plug from bung of drum containing this product only when drum is sitting on the ground or on a secure level platform, with the drum pointed up. Do not pour this product from its drum.
Transfer product from the drum of the mixing tank by use of a suction hose connected to one end of the suction pump on the mixing tank and connected at the other end to a probe/dip tube. Remove the plug from the bung of the drum and insert the probe/drip tube into the bung of the drum until the foam ring/gasket fits snugly around the bung opening to minimize leakage of liquid rotenone. The probe/dip tube should be specifically sized to insure a snug fit into the bung which incorporates an anti-drip flange to remove excess liquid rotenone when the probe/dip tube is removed. In addition, the foam ring/gasket on the probe/dip tube insures a snug fit to minimize leakage of liquid rotenone. Do not handle the probe/dip tube in a manner that allows dripping or splattering of the product onto yourself or any other person. Do not touch the portion of the probe/dip tube that has been in contact with this product until the probe has been triple rinsed with water. See Rotenone SOP Manual (SOP 8) for further information on the operation of the Semi-Closed Probe system.

If the entire product is removed from the drum, then triple rinse the probe while it remains inside of the drum if possible. If not, remove the aspirator probe and triple rinse it and all parts of the aspirator in site water. If an unrinsed probe must be removed from the drum, triple rinse it and all parts of the aspirator in treated site water. The anti-drip flange must be designed to remove excess rotenone product from the probe as it is extracted from the drum. Take the following steps if the probe must be disconnected from the suction hose before both the probe and the hose have been triple rinsed: (1) equip the probe end of the hose with a shutoff valve; (2) install a dry-brake coupling between the valve and the probe, and then close the shut off valve before disconnecting the probe. See Rotenone SOP Manual (SOP 8) for further information on unrinsed probes.

Mixers/loaders/applicators using all systems must wear PPE as required in the PPE section of this labeling for mixers/loaders. All systems must be capable of removing the pesticide from the shipping container and transferring it into mixing tanks and/or application equipment. At any disconnect point, the system must be equipped with a dry disconnect or dry-couple shutoff device to minimize drips.

Transferring (Mixing/Loading) Liquid Formulations
Mixers and loaders must transfer product from original to mixing tank or secondary container using a measuring device, inside a plastic-lined bermed area or other secondary confinement area capable of recovering spilled product. Wash plastic liner or other secondary confinement area and dispose of into treated site water. Do not handle this product in a manner that drips or splatters the product onto yourself or any other person. See Rotenone SOP Manual (SOP 10) for further guidance.

Product Containers <u>≤</u> 5 Gallons – Transfer product from original container into measuring device, within secondary confinement area, by pouring or using pump or pipette-type device. See Rotenone SOP Manual (SOP 10) for further guidance.

Product Containers > 5 Gallons – Do not pour rotenone concentrate from containers > 5 gallons. Transfer product from original container into measuring device, within secondary confinement area, using hand or electric drum pump. See Rotenone SOP Manual (SOP 10) for further guidance.

Engineering Controls for Applying Liquid Formulations
Applications using a boom or other mechanized equipment must release this product below the water surface. Applications made with aircraft, backpack sprayer, drip can, or handheld or hand-directed nozzle may release this product above the water surface.

Engineering Controls for Aerial Applications
Open cockpits are prohibited. Pilots must use a cockpit that has a nonporous barrier that totally surrounds the cockpit occupants and prevents contact with pesticides outside the enclosed area. Pilots in enclosed cockpits may wear a long-sleeved shirt, long pants, shoes, and socks instead of the PPE required for applicators in the PPE section of this labeling.

Engineering Controls for Boat Applications
When boat pilots or others on the application boat are located within an enclosed area that has a nonporous barrier that totally surrounds the occupants and prevents contact with pesticides outside the enclosed area; they: (1) may wear long-sleeved shirt, long pants, shoes, and socks, instead of the PPE required for applicators in the PPE section of this labeling; (2) must be provided and have immediately available in the use of an emergency when they must exit the enclosed area while the application is taking place, the PPE required for applicators of the PPE section of this labeling; (3) must take off any PPE that is worn while outside the enclosed area before reentering the enclosed area; and (4) store all used PPE in a chemical-resistant container, such as a plastic bag, to prevent contamination of the enclosed area.

User Safety Recommendations

Certified Applicators applying or supervising any aspect of the application of this product should attend a training program for the Rotenone SOP Manual. The American Fisheries Society offers this training: go to www.fisheries.org/units/rotenone for current schedule of training.

Users should remove clothing/PPE if pesticide gets inside. Then wash thoroughly and put on clean clothing. Users should remove PPE immediately after handling this product. Wash the outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

ENVIRONMENTAL HAZARDS

This product is extremely toxic to fish and other aquatic organisms. Fish kills are expected at recommended rates. Consult your State Fish and Game Agency and other agencies before applying this product to public waters to determine if a permit is needed for such an application. Do not contaminate water outside of the treatment area by cleaning of equipment or disposal of equipment washwaters. Do not contaminate water outside of the treatment area, food or feed by storage or disposal. Do not discharge effluent containing this pesticide into sewage systems without notifying the sewage treatment plant authority (PTOW).

PHYSICAL AND CHEMICAL HAZARDS

Flammable. Keep away from heat and open flame.

DIRECTIONS FOR USE

RESTRICTED USE PESTICIDE

IT IS A VIOLATION OF FEDERAL LAW TO USE THIS PRODUCT IN A MANNER INCONSISTENT WITH ITS LABELING, INCLUDING BOTH THE CONTAINER LABEL AND THE ROTENONE STANDARD OPERATION PROCEDURES MANUAL (SOP) available from the registrant or the American Fisheries Society at www.fisheries.org/units/rotenone. THIS PRODUCT MUST BE ACCOMPANIED BY AN EPA-APPROVED ROTENONE SOP MANUAL. READ THE CONTAINER LABEL AND ROTENONE SOP MANUAL PRIOR TO USE. THE APPLICATOR IS RESPONSIBLE FOR FOLLOWING THE DIRECTIONS FOR USE CONTAINED WITHIN BOTH THE CONTAINER LABEL AND THE SOP MANUAL.

This product is registered for use by or under permit from, and after consultation with State and Federal Fish and Wildlife and/or Natural Resource Agencies.

GENERAL INFORMATION

This product is a specially formulated product containing rotenone to be used in fisheries management for the eradication of fish from lakes, ponds, reservoirs, rivers and streams. Properly dispose of 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 mile upstream of an irrigation water intake in a standing body of water such as a lake, pond, or reservoir.

General Application Precautions and Restrictions: The Certified Applicator supervising the treatment must remain on site for the duration of the application. Do not allow recreational access (e.g., wading, swimming, boating, and fishing) within the treatment area while rotenone is being applied (see Placarding of Treatment Areas). In streams/rivers/lakes/reservoirs/ponds, do not apply this product in a way that will result in active rotenone concentrations > 200 parts per billion/0.2 ppm (> 4.0 ppm 5% rotenone formulation). Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application (see Placarding Treatment Areas and Re-entering of Treatment Area). This product must not be applied to estuarine or marine environments. Where practical, users should collect and bury dead fish.

Applications using a boom or other mechanized equipment must release this product below the water surface. Applications made with aircraft, backpack sprayer, drip can, or hand-held or hand-directed nozzle may release this product above the water surface.
Mixers/loaders of liquid rotenone product containers of 5 gallons or less should not handle more than 25 gallons of undiluted product per day.

Re-entering the Treatment Area: For applications that result in concentrations greater than 0.09 ppm active rotenone (when applying at a rate of > 1.8 ppm of 5% rotenone formulation), handlers reentering treated water, must wear, at a minimum, the following PPE: (1) coveralls over long-sleeved shirt and long pants; (2) chemical-resistant gloves; (1) chemical-resistant footwear plus socks; and (4) Chemical-resistant apron. Duration of PPE requirements for handlers re-entering treated water exactly corresponds to duration of placarding requirements (e.g., PPE requirements end when placards are removed; see Placarding of Treatment Areas section of this labeling). Exception: waterproof waders may be worn in place of coveralls, chemical-resistant apron and chemical-resistant footwear.

Placarding of Treatment Areas: The Certified Applicator in charge of the application (or someone under his/her supervision) must placard all access areas to the treatment area. Detailed instructions for placarding are presented in the Rotenone SOP Manual. Placards must be placed every 250 feet along the shoreline of the treated area OR, at public access points (e.g., trailheads, roads and trails). Placards must contain the following information: (1) DANGER/PELIGRO; (2) DO NOT ENTER WATER/NO ENTRE AGUA; Pesticide Application; (3) CTF Legumine Fish Toxicant; (4) the purpose of the application; (5) the start date and time of application; (6) end date and time of application; (7) "Recreational access (e.g., wading, swimming, boating, fishing, etc.) within the treatment area is prohibited while rotenone is being applied"; (8) "Do not swim or wade in treated water while placard is displayed"; (9) "Do not consume dead fish from treated water"; and (10) the name, address, and telephone number of the responsible agency or entity performing the application.

Signs must remain legible during the entire posting period. For lotic (flowing water) and lentic (standing water) applications of ≤ 0.09 ppm active rotenone (≤ 1.8 ppm 5% formulation), signs can be removed once application is complete. For lotic applications > 0.09 ppm active rotenone (> 1.8 ppm 5% rotenone formulation), signs can be removed 72 hours after application is complete. For lentic applications > 0.09 ppm active rotenone (> 1.8 ppm 5% rotenone formulation), signs can be removed following 24-hour bioassay demonstrating survival of bioassay sentinel fish or 14 days, whichever is less.

Monitoring and Notification Requirements for Water Aquaculture: For treated water bodies used for aquaculture, the Certified Applicator or designee under his/her direct supervision must prohibit the restocking of fish unless monitoring samples confirm rotenone concentrations are below the level of detection for 3 consecutive samples taken no less than 4 hours apart. Detailed guidance for monitoring levels of rotenone in water is presented in the Rotenone SOP Manual (SOP 16).
Drinking Water: For applications > 40 ppb or 0.04 ppm active rotenone (> 0.8 ppm 5 % rotenone formulation) in waters with drinking water intakes or hydrologic connections to wells, 7 to 14 days prior to

application, the Certified Applicator or designee under his/her direct supervision must provide notification to the party responsible for the public water supply or individual private water users against the consumption of treated water until: (1) active rotenone < 0.04 ppm as determined by analytical chemistry, or (2) fish of the *Salmonidae* or *Centrichidae* families can survive for 24 hours, or (3) dilution with untreated water yields a calculation that active rotenone is < 0.04 ppm, or (4) distance or travel time from the application sites demonstrates that active rotenone is < 0.04 ppm. See Rotenone SOP Manual (SOP 16) for guidance on notification and bioassay and chemical analysis techniques and dilution, distance, and travel time criteria.

Specifications to Control Spray Drift

RELEASE HEIGHT: Spray must be released at the lowest height consistent with pest control and flight safety.

BOOM LENGTH: The boom length must not exceed 75% of the wing span or 90% of the rotor blade diameter. Orient nozzles backward with minimal downward angle into slip stream.

SWATH ADJUSTMENT: When applications are made with cross wind, the swath will be displaced downwind. The applicator must compensate for this displacement at the downwind edge of the application area by adjusting the path of the aircraft upwind. Leave at least one swath unsprayed at the downwind edge of the treated area.

DROPLET SIZE: Use low drift nozzles designed to produce larger spray droplets with fewer driftable fines. Apply as a medium or coarser spray (ASAE standard 572).

WIND SPEED: Do not apply when wind speeds are >12 miles per hour.

DETERMINING TREATMENT RATE

Use this product only at locations, rates, and times authorized and approved by appropriate State and Federal Fish and Wildlife and/or Natural Resource Agencies. The actual treatment rate and rotenone concentration needed to control fish varies widely, depending on the type of water environmental factors including pH, temperature, depth, turbidity, and the target species. The tables below are a general guide for the proper rates and concentrations for complete kills of target species. The Certified Applicator must conduct bioassays using site water (or water of similar quality) and target species (or surrogate species of similar sensitivity) to refine the treatment rate with the maximum limit allowed. Detailed guidance bioassays and designing treatment for complete kills of target species are presented in the Rotenone SOP Manual (SOP 5). Rates must be within the range specified on the label.

FOR USE IN PONDS, LAKES, AND RESERVOIRS

The tables in this booklet are a general guide for the proper rates and concentrations. This product disperses readily, laterally and vertically. For complete coverage, it is best to apply this material to water bodies that are not thermally-stratified. However, this material will eventually penetrate below the thermocline in thermally-stratified bodies of water.

Computation of Water Body Volume: To determine volume of any given body of water, make a series of transects across the body of water taking depths at regular intervals. Add the depths and divide by the number of measurements made to determine the average depth. Multiply this average depth by total surface area in order to determine the volume to be treated. Volume is expressed as acre-feet (AF) or cubic meters (m^3). Surface area can be determined by Global Positioning System (GPS) instrumentation and topographic maps. See Rotenone SOP Manual for further guidance.

Amount of CFT Legumine Fish Toxicant Needed for Specific Uses: To determine the approximate number of gallons (or liters) needed, find your "Type of Use" in the first column of the tables below and then divide the corresponding numbers in the fourth column, "AF (or m^3) per Gallon (or Liter) Liquid" into the number of AF or m^3 in your body of water. For example, a normal use of 0.05 ppm active rotenone will require 33 gallons of 5% active rotenone liquid for 100 AF.

Table – Recommended rotenone treatment concentrations and number of acre-feet (AF) standing water covered by one gallon (5% A.I.) product. Adjust amount of product according to the actual rotenone content on Ingredient Statement on label.

Type of Use	Parts per Million (ppm)		AF Per Gallon Liquid
	Product (5% A.I.)	Active Rotenone	
Normal	0.5 – 1.0	0.025 – 0.05	6.0 to 3.0
Tolerant Species	1.0 – 3.0	0.05 – 0.15	3.0 to 1.0
Tolerant Species in Organic Ponds	2.0 – 4.0	0.10 – 0.20	1.5 to 0.75

Table – Recommended rotenone treatment concentrations and number of cubic meters (m^3) standing water covered by one liter of (5% A.I.) product. Adjust amount of product according to the actual rotenone content on Ingredient Statement on label.

Type of Use	Parts per Million (ppm)		m^3 per Liter Liquid
	Product (5% A.I.)	Active Rotenone	
Normal	0.5 – 1.0	0.025 – 0.05	2000 to 1000
Tolerant Species	1.0 – 3.0	0.05 – 0.15	1000 to 333
Tolerant Species in Organic Ponds	2.0 – 4.0	0.10 – 0.20	500 to 250

Recommended Pre-Mixing and Method of Application: Pre-mix with water at a rate of 10% of product to site water. Uniformly apply over water surface or through underwater lines. Divide water body into manageable sections, delineated by marker buoys or flags or GPS coordinates, and treat within 48 hours to avoid deactivation. See Rotenone SOP Manual (SOP 8) for additional guidance.

Deactivation: Water treated with this product will deactivate (neutralize) under natural conditions within one week to one month depending upon temperatures, alkalinity, etc. Rapid deactivation can be accomplished by adding potassium permanganate to the water at the same rate as CFT Legumine Fish Toxicant in parts per million, plus enough additional to meet the organic demand of the untreated water. See Rotenone SOP Manual (SOP 6 and 7) for guidance.

Restocking after Treatment: Typically, wait 2 to 4 weeks after treatment prior to restocking. 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.

USE IN STREAMS AND RIVERS

In order to treat a stream you must: (1) Select the concentration of active rotenone; (2) Compute the flow rate of the stream; (3) Select an exposure time; (4) Select dilution of product and calculation of application rate; (5) Estimate the amount of product needed; and (6) Follow the method of application. For practicality, flows > 25 ft^3/s (> 0.708 m^3/s) should have undiluted product applied, and flows < 25 ft^3/s (< 0.708 m^3/s) should have diluted product applied. For streams associated with a treatment of a standing body of water, to prevent movement of fish from the pond, lake, or reservoir, the stream treatment should begin before and continue throughout treatment of the pond, lake or reservoir until mixing has occurred.

Concentration of Active Rotenone

Select the concentration of active rotenone based on the type of use from those listed on the tables on the next page. Example: If you select "normal use", you could select a concentration of 0.025–0.05 parts per million.

Table – Recommended rotenone treatment concentrations and number of cubic feet per second (ft^3/s) flowing water treated for 4- and 8-hour periods with one gallon of (5% A.I.) product. Adjust amount of product according to the actual rotenone content on Ingredient Statement on label.

Type of Use	Parts per Million (ppm)		ft^3/s per Gallon (4-hr)	ft^3/s per Gallon (8-hr)
	Product (5% A.I.)	Active Rotenone		
Normal	0.5 – 1.0	0.025 – 0.05	18.4 to 9.2	9.2 to 4.6
Tolerant Species	1.0 – 3.0	0.05 – 0.15	9.2 to 3.1	4.6 to 1.6
Tolerant Species in Organic Waters	2.0 – 4.0	0.10 – 0.20	4.6 to 2.3	2.3 to 1.2

Table – Recommended rotenone treatment concentrations and number of cubic meters per second (m^3/s) flowing water treated for 4- and 8-hour periods with one liter of (5% A.I.) product. Adjust amount of product according to the actual rotenone content on Ingredient Statement on Label.

Type of Use	Parts per Million (ppm)		m^3/s per Liter (4-hr)	m^3/s per Liter (8-hr)
	Product (5% A.I.)	Active Rotenone		
Normal	0.5 – 1.0	0.025 – 0.05	0.138 to 0.069	0.069 to 0.034
Tolerant Species	1.0 – 3.0	0.05 – 0.15	0.069 to 0.024	0.034 to 0.013
Tolerant Species in Organic Waters	2.0 – 4.0	0.10 – 0.20	0.034 to 0.018	0.018 to 0.008

Measurement of Flow Rate for Stream

Select a cross section of the stream where the banks and bottom are relatively smooth and free of obstacles and the flow appears laminar. Best discharge measurements are achieved with an electronic flow meter and use of the United States Geological Survey *Weighted Area Method*. Alternatively, divide the stream surface width into 3 equal sections and determine the water depth and surface velocity at the center of each section. Determine the velocity by dropping a float and measure the time required to move 10 feet or more. Take at least three readings at each point. To calculate the flow rate from the information obtained above, use the following formula:

$$F = \frac{Ws \times D \times L \times C}{T}$$

Where F = flow rate (ft^3/s or m^3/s), Ws = surface width (ft or m), D = mean depth (ft or m), L = mean distance traveled by float (ft or m), C = Constant (0.8 for rough bottoms and 0.9 for smooth bottoms), T = mean time (s) for float to travel distance.

Exposure Time and Spacing

Apply rotenone as a drip for 4 to 8 hours to the flowing portion of the stream. Multiple application sites are used along the length of the treated stream, spaced approximately ½ to 2 miles apart depending on the water flow travel time between sites. Multiple sites are used because rotenone is diluted and detoxified with distance. Application sites are spaced at no more than 2 hours or at no less than 1-hour travel time intervals. This assures that the treated stream remains lethal to fish for a minimum of 2 hours. A non-toxic dye such as Rhodamine-WT or fluorescein can be used to determine travel times. Cages containing live fish placed immediately upstream of the downstream application sites can be used as sentinels to assure that lethal conditions exist between sites.

Amount of Product and Calculation of Application Rate of Undiluted Product:

$$X = F1\ (1.699\ B) \text{ or } X = F2\ (59.99\ B)$$

X = ml per minute of undiluted CFT Legumine Fish Toxicant applied to the stream, F1 = the flow rate (ft^3/s) and F2 the flow rate (m^3/s) (see Measurement of Flow Rate for Stream on this labeling), B = parts per million desired concentration of CFT Legumine Fish Toxicant. Total amount of product needed:

$$Y = X(60)H$$

Y = total ml of undiluted CFT Legumine Fish Toxicant required for treatment, X = ml per minute of undiluted product, and H = duration (hours) of treatment.

Amount of Product in Drip Can and Flow Rate of Diluted Product:

$$Y = B(102\ F1)H \text{ or } Y = B(3,\ 602\ F2)H$$

Y = ml of undiluted product in the reservoir, B = parts per million desired concentration of CFT Legumine Fish Toxicant, F1 = the flow rate (ft^3/s) and F2= flow rate (m^3/s) (see Measurement of Flow Rate for Stream in this labeling), and H = duration (hours) of treatment.

Discharge of the diluted product:

$$X = Z/60/H$$

X = ml per minute of diluted CFT Legumine Fish Toxicant applied to the stream from drip can, Z = volume (ml) of drip can, and H = duration (hours) of treatment.

Method of Application

The unique nature of every application site could require minor adjustments to the method and rate of application. Should these unique conditions require major deviation from the use directions, a Special Local Need 24(c) registration should be obtained from the state. Before application, authorization must be obtained from state or federal Fish and Wildlife and/or Natural Resource agencies. Since local environmental conditions will vary, consult with the state Fish and Wildlife and/or Natural Resource agency to ensure the method and rate of application are appropriate for that site.

Contact the local water department to determine if any water intakes are within one mile downstream of the section of stream, river, or canal to be treated. If so, coordinate the application with the water department to make sure the intakes are closed during treatment and detoxification.

CFT Legumine Fish Toxicant can drain directly into the center of the stream. Flow should be checked at least hourly. Backwater, stagnant, and spring areas of streams should be sprayed by hand with a 1 to 2 % v/v solution of 5% rotenone product to assure complete coverage. Streams should be treated for 4 to 8 hours in order to clear the treated section of stream of fish. See Rotenone SOP Manual for detailed guidance on application equipment, methods, and strategies.

DEACTIVATION

Flow in a stream and outflow from a treated lake beyond the treatment area must be deactivated with potassium permanganate to minimize exposure beyond the treatment area unless unnecessary. (See Rotenone SOP Manual [SOP 6] for the definition of treatment area, examples when deactivation with potassium permanganate is unnecessary and detailed guidance for deactivating with potassium permanganate [SOP 7].)

Within 1 to 2 hours travel time from the furthest downstream rotenone application site, the rotenone can be deactivated with a potassium permanganate solution or granules at a resultant stream concentration of 2 to 4 parts per million, depending on rotenone concentration and organic demand of the water. A 2.5% (10 pounds potassium

permanganate to 50 gallons of water) permanganate solution is dripped in at a continuous rate using the equation:

X = Y(70 F1) or X = Y(2, 472 F2)

X = ml of 2.5% permanganate solution per minute, Y = ppm of desired permanganate concentration, F1= stream flow (ft^3/s) or F2 = stream flow (m^3/s) or, granular potassium permanganate is applied at a continuous rate using the equations:

Z = Y(1.7 F1) or Z = Y(60.02 F2)

Z = grams of granular potassium permanganate per minute, Y= ppm of desired permanganate concentration, F1 = stream flow (ft^3/s) or F2 = stream flow (m^3/s).

Flow of permanganate should be checked at least hourly. Live fish in cages placed immediately above the permanganate application site will show signs of stress signaling the need for beginning deactivation. Deactivation can be terminated when replenished fish survive and show no signs of stress for at least four hours.

Deactivation of rotenone by permanganate requires between 15 to 30 minutes contact time (travel time). Cages containing live fish can be placed at these downstream intervals to judge the effectiveness of deactivation. At water temperatures less than 50°F, deactivation may be retarded, requiring a longer contact time.

STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage or disposal.

PESTICIDE STORAGE: Store only in original containers, in a dry place inaccessible to children and pets. This product will not solidify nor show any separation at temperatures down to 40°F and is stable for a minimum of one year when stored in sealed drums at 70°F.

PESTICIDE DISPOSAL: Pesticide wastes are acutely hazardous. Improper disposal of excess pesticide, spray mixture, or rinsate is a violation of Federal law. If these wastes cannot be disposed of by use according to label instructions, contact your state pesticide or Environmental Control Agency, or the Hazardous Waste representative at the nearest EPA Regional office for guidance.

CONTAINER HANDLING: Nonrefillable container. Do not reuse or refill this container. Clean container promptly after emptying.
{For Containers equal to or less than 5 Gallons:} Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank and drain for 10 seconds after the flow begins to drip. Fill the container ¼ full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times. Offer for recycling, if available or puncture and dispose of in a sanitary landfill, or by incineration, or if allowed by state and local authorities, by burning. If burned, stay out of smoke.

{For Containers greater than 5 Gallons:} Triple rinse as follows: Empty the remaining contents into application equipment or a mix tank and drain for 10 seconds after the flow begins to drip. Fill the container ¼ full with water. Replace and tighten closures. Tip container on its side and roll it back and forth, ensuring at least one complete revolution, for 30 seconds. Stand the container on its end and tip it back and forth several times. Turn the container over onto its other end and tip it back and forth several times. Empty the rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Repeat this procedure two more times. Offer for recycling if available or puncture and dispose of in a sanitary landfill, or by incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke.

WARRANTY STATEMENT

Our recommendations for the use of this product are based upon tests believed to be reliable. The use of this product being beyond the control of the manufacturer, no guarantee, expressed or implied, is made as to the effects of such or the results to be obtained if not used in accordance with directions or established safe practice. To the extent consistent with applicable law, the buyer must assume all responsibility, including injury or damage, resulting from its misuse as such, or in combination with other materials.

Circled letter in front of the EPA Est No. corresponds to the first letter in lot number on bottom of container.
Central Garden & Pet Company, 1501 East Woodfield Road, 200W, Schaumburg, Illinois 60173
NOTE: This specimen label is for informational purposes only. All uses may not be approved in all states. See product labeling for use directions.

VEC 15-036

December, 2015
Schaumburg, IL

Appendix II: Product Material Safety Data Sheets

Safety Data Sheet

Section 1: Identification

Product identifier

Product Name • **Prentox Noxfish Fish Toxicant**

Synonyms • 100209007; PMRA #: 14558

Product Description • Clear amber-brown liquid which may contain particulate matter.

Relevant identified uses of the substance or mixture and uses advised against

Recommended use • Liquid emulsifiable fish toxicant for control of fish in streams, ponds, lakes or reservoirs.

Restrictions on use •

KEEP OUT OF THE REACH OF CHILDREN. Avoid contact with eyes, skin and clothing. Do not use or store near heat or open flame. Avoid release to the environment. Do not take internally. Use in well ventilated area. Avoid inhalation of vapors or fumes.

Details of the supplier of the safety data sheet

Manufacturer • Wellmark International

100 Stone Road West, Suite 111
Guelph ON N1G 5L3
Canada

Emergency telephone number

Manufacturer • 1-800-688-7378

Manufacturer (Transportation) • 1-800-424-9300 - Chemtrec

Manufacturer (Transportation) • 1-703-527-3887 - Chemtrec - outside the US, collect calls accepted

Section 2: Hazard Identification

United States (US)

According to: OSHA 29 CFR 1910.1200 HCS

Classification of the substance or mixture

OSHA HCS 2012 • Aspiration 1
Eye Irritation 2A
Flammable Liquids 4
Skin Irritation 2
Carcinogenicity 2
Specific Target Organ Toxicity Single Exposure 3: Respiratory Tract Irritation
Specific Target Organ Toxicity Single Exposure 3: Narcotic Effects
Acute Toxicity Oral 4
Acute Toxicity Inhalation 2

Label elements

OSHA HCS 2012

DANGER

Hazard statements

- Causes serious eye irritation
- Causes skin irritation
- May be fatal if swallowed and enters airways
- Combustible liquid
- Fatal if inhaled
- May cause respiratory irritation
- May cause drowsiness or dizziness
- Suspected of causing cancer.
- Harmful if swallowed
- Very toxic to aquatic life with long lasting effects

Precautionary statements

Prevention

- Wash thoroughly after handling.
- Contaminated work clothing should not be allowed out of the workplace.
- Wear protective gloves/protective clothing/eye protection/face protection.
- Avoid breathing dust, fume, gas, mist, vapors and/or spray.
- Keep away from heat, sparks, open flames and/or hot surfaces. - No smoking.
- Obtain special instructions before use.
- Do not handle until all safety precautions have been read and understood.
- Do not eat, drink or smoke when using this product.
- Use only outdoors or in a well-ventilated area.
- Wear respiratory protection.

Response

- IF ON SKIN: Wash with plenty of soap and water.
- Specific treatment, see supplemental first aid information.
- If skin irritation occurs: Get medical advice/attention.
- Take off contaminated clothing and wash before reuse.
- IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
- IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician.
- Do NOT induce vomiting.
- If eye irritation persists: Get medical advice/attention.
- In case of fire: Use appropriate media Water fog, foam, dry chemical or carbon dioxide (CO2). for extinction.
- Immediately call a POISON CENTER or doctor/physician.
- IF exposed or concerned: Get medical advice/attention.
- IF INHALED: Remove person to fresh air and keep comfortable for breathing. Call a poison control center or doctor if you feel unwell.

Storage/Disposal

- Dispose of content and/or container in accordance with local, regional, national, and/or international regulations.
- Store in a well-ventilated place. Keep cool.
- Store locked up.
- Keep container tightly closed.

Other hazards

OSHA HCS 2012

- This product is toxic to aquatic organisms. Under United States Regulations (29 CFR 1910.1200 - Hazard Communication Standard), this product is considered hazardous.

Section 3 - Composition/Information on Ingredients

Substances

- Material does not meet the criteria of a substance.

Mixtures

Composition		
Chemical Name	**Identifiers**	**%**
Rotenone	**CAS:**83-79-4	5%
Cube Resins other than rotenone	NDA	7.5%
Solvent naphtha (petroleum) Heavy aromatic	**CAS:**64742-94-5	80.5%
Naphthalene	**CAS:**91-20-3	< 0.72%
Nonylphenol ethoxylate	**CAS:**9016-45-9	2.63% TO 3.23%
Benzoic acid	**CAS:**65-85-0	1%
Phenylsulfonate	**CAS:**70528-83-5	1.05% TO 1.65%
Other ingredients	NDA	Balance

Section 4: First-Aid Measures

Description of first aid measures

Inhalation

- IF INHALED: Remove person to fresh air and keep at rest in a position comfortable for breathing. Immediately call a POISON CONTROL center or doctor.

Skin

- IF ON SKIN: Wash with plenty of soap and water. If irritation or rash occurs, get medical advice/attention. Take off contaminated clothing and wash before reuse.

Eye

- 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/attention.

Ingestion

- IF SWALLOWED: Immediately call a poison control center or doctor. Aspiration hazard - if swallowed, do NOT induce vomiting.

Most important symptoms and effects, both acute and delayed

- Aspiration hazard, harmful if swallowed, fatal if inhaled, causes dizziness or drowsiness if inhaled, causes respiratory irritation, causes serious eye irritation, causes skin irritation, suspected of causing cancer. Refer to Section 11 - Toxicological Information.

Indication of any immediate medical attention and special treatment needed

Notes to Physician

- Treat symptomatically and supportively.

Section 5: Fire-Fighting Measures

Extinguishing media

Suitable Extinguishing Media

- LARGE FIRE: Water spray, fog or regular foam.
  SMALL FIRES: Dry chemical, CO_2, water spray or regular foam.

Unsuitable Extinguishing Media

- Avoid heavy hose streams.

Firefighting Procedures

- Do not allow fire fighting water to escape into waterways or sewers.
  LARGE FIRES: Dike fire control water for later disposal; do not scatter the material.
  LARGE FIRES: Move containers from fire area if you can do it without risk.
  Stay upwind.
  Ventilate closed spaces before entering.
  Do not breathe gas/fumes/vapor/spray.
  Keep unauthorized personnel away.

Special hazards arising from the substance or mixture

Unusual Fire and Explosion Hazards

- Combustible liquid.
  Containers may explode when heated.
  Vapors are heavier than air and will spread along ground and collect in low or confined areas (sewers, basements, tanks) and may reach remote ignition sources causing a flashback fire danger.

Hazardous Combustion Products

- Combustible liquid - may produce carbon dioxide and/or carbon monoxide.

Advice for firefighters

- Wear positive pressure self-contained breathing apparatus (SCBA).

Section 6 - Accidental Release Measures

Personal precautions, protective equipment and emergency procedures

Personal Precautions

- Do not walk through spilled material. Ventilate enclosed areas. Wear appropriate personal protective equipment, avoid direct contact. Avoid breathing fumes. Keep all sources of ignition away.

Emergency Procedures

- ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). Ventilate closed spaces before entering. Avoid release into the environment. Keep out of low areas. Keep unauthorized personnel away. Stay upwind. Take precautionary measures against static discharge. Turn off electric power to area.

Environmental precautions

- LARGE SPILLS: Prevent entry into waterways, sewers, basements or confined areas.

Methods and material for containment and cleaning up

Containment/Clean-up Measures

- Absorb spills with an inert material, clay granules or other inert absorbent material and put in container for disposal.
  All equipment used when handling the product must be grounded.
  LARGE SPILLS: Dike far ahead of spill for later disposal.
  Stop leak if you can do it without risk.
  SMALL SPILLS: Take up with sand or other non-combustible absorbent material and place into containers for later disposal.
  Use appropriate Personal Protective Equipment (PPE)

Section 7 - Handling and Storage

Precautions for safe handling

Handling

- Keep away from fire - No Smoking. Avoid breathing fumes. Use only in well ventilated areas. Wear appropriate personal protective equipment, avoid direct contact. Avoid contact with skin or eyes.

Conditions for safe storage, including any incompatibilities

Storage

- Store locked up. Store in a cool/low-temperature, well-ventilated dry place away from

heat and ignition sources. Keep from freezing. Keep container tightly closed. Avoid extreme temperatures.

Incompatible Materials or Ignition Sources
- Heat, sparks, open flame.

Other Information
- See product label for additional information.

Section 8 - Exposure Controls/Personal Protection

Control parameters

Exposure Limits/Guidelines
- No data available.

Exposure Limits/Guidelines

	Result	ACGIH	Canada Ontario	NIOSH	OSHA
Naphthalene (91-20-3)	STELs	Not established	15 ppm STEL	15 ppm STEL; 75 mg/m3 STEL	Not established
	TWAs	10 ppm TWA	10 ppm TWA	10 ppm TWA; 50 mg/m3 TWA	10 ppm TWA; 50 mg/m3 TWA
Rotenone (83-79-4)	TWAs	5 mg/m3 TWA (commercial)	5 mg/m3 TWA (commercial)	5 mg/m3 TWA	5 mg/m3 TWA

Exposure Control Notations

Canada Ontario

•Naphthalene (91-20-3): **Skin:** (Danger of cutaneous absorption)

ACGIH

•Rotenone (83-79-4): **Carcinogens:** (A4 - Not Classifiable as a Human Carcinogen (commercial))

•Naphthalene (91-20-3): **Carcinogens:** (A3 - Confirmed Animal Carcinogen with Unknown Relevance to Humans) | **Skin:** (Skin - potential significant contribution to overall exposure by the cutaneous route)

Exposure Limits Supplemental

ACGIH

•Rotenone (83-79-4): **TLV Basis - Critical Effects:** (CNS impairment; eye and upper respiratory tract irritation)

•Naphthalene (91-20-3): **TLV Basis - Critical Effects:** (cataracts; upper respiratory tract irritation; hemolytic anemia)

Exposure controls

Engineering Measures/Controls
- Adequate ventilation systems as needed to control concentrations of airborne contaminants below applicable threshold limit values.

Personal Protective Equipment

Pictograms
- 

Respiratory
- If handling without sufficient ventilation, wear a NIOSH approved respirator. See product label for specific respiratory protection instructions.

Eye/Face
- Wear chemical splash safety goggles.

Hands
- Wear chemical resistant gloves.

Skin/Body
- Coveralls over long-sleeved shirt, long pants and chemical resistant footwear plus socks required.

Environmental Exposure Controls

- This product is extremely toxic to fish. Keep out of lakes, streams or ponds except under use conditions. Follow best practice for site management and disposal of waste.

Other Information

- See product label for specific use PPE instructions.

Section 9 - Physical and Chemical Properties

Information on Physical and Chemical Properties

Material Description			
Physical Form	Liquid	Appearance/Description	Clear amber-brown liquid which may contain particulate matter.
Color	Amber-brown	Odor	Solvent type.
Odor Threshold	No data available		
General Properties			
Boiling Point	No data available	Melting Point/Freezing Point	No data available
Decomposition Temperature	No data available	pH	4 (1% aqueous solution)
Specific Gravity/Relative Density	= 0.92 Water=1	Density	No data available
Water Solubility	Not soluble	Viscosity	< 100 Centipoise (cPs, cP) or mPas
Critical Temperature	No data available		
Volatility			
Vapor Pressure	No data available	Vapor Density	No data available
Evaporation Rate	No data available		
Flammability			
Flash Point	> 61°C (141.8°F)	UEL	No data available
LEL	No data available	Autoignition	No data available
Flammability (solid, gas)	No data available		
Environmental			
Octanol/Water Partition coefficient	No data available		

Section 10: Stability and Reactivity

Reactivity

- Non-reactive under normal handling and storage conditions.

Chemical stability

- Stable

Possibility of hazardous reactions

- Hazardous polymerization will not occur.

Conditions to avoid

- Excessive heat >110°F. Heat, sparks, open flame, other ignition sources, and oxidizing conditions. Keep away from fire.

Incompatible materials

- Strong oxidizing agents and strong acids.

Hazardous decomposition products

- Thermal decomposition may produce oxides of carbon.

Section 11 - Toxicological Information

Information on toxicological effects

Components		
Rotenone (5%)	83-79-4	**Acute Toxicity:** Ingestion/Oral-Rat, adult female LD50 • 39.5 mg/kg; Ingestion/Oral-Rat, adult male LD50 • 102 mg/kg; Inhalation-Rat LC50 • 0.0212 mg/L 4 Hour(s); Skin-Rabbit LD50 • >5000 mg/kg; **Irritation:** Eye-Rabbit • Essentially non-irritating; Skin-Rabbit • Essentially non-irritating

GHS Properties	Classification
Acute toxicity	**OSHA HCS 2012** • Acute Toxicity - Dermal - Classification criteria not met; Acute Toxicity - Inhalation 2; Acute Toxicity - Oral 4
Skin corrosion/Irritation	**OSHA HCS 2012** • Skin Irritation 2
Serious eye damage/Irritation	**OSHA HCS 2012** • Eye Irritation 2A
Skin sensitization	**OSHA HCS 2012** • Classification criteria not met
Respiratory sensitization	**OSHA HCS 2012** • Classification criteria not met
Aspiration Hazard	**OSHA HCS 2012** • Aspiration 1
Carcinogenicity	**OSHA HCS 2012** • Carcinogenicity 2
Germ Cell Mutagenicity	**OSHA HCS 2012** • Not classified - data lacking
Toxicity for Reproduction	**OSHA HCS 2012** • Classification criteria not met
STOT-SE	**OSHA HCS 2012** • Specific Target Organ Toxicity Single Exposure 3: Narcotic Effects; Specific Target Organ Toxicity Single Exposure 3: Respiratory Tract Irritation
STOT-RE	**OSHA HCS 2012** • Classification criteria not met

Potential Health Effects

Inhalation

Acute (Immediate)
- Fatal if inhaled. May cause respiratory irritation. May affect the central nervous system. Symptoms may include dizziness or drowsiness.

Chronic (Delayed)
- No data available

Skin

Acute (Immediate)
- Causes skin irritation.

Chronic (Delayed)
- No data available

Eye

Acute (Immediate)
- Causes serious eye irritation.

Chronic (Delayed)
- No data available

Ingestion

Acute (Immediate)
- Harmful if swallowed. Aspiration hazard - small amounts of liquid aspirated into the lungs during ingestion or from vomiting may cause chemical pneumonitis or pulmonary

edema.

Chronic (Delayed) • No data available

Mutagenic Effects • Rotenone is not mutagenic.

Carcinogenic Effects •

Naphthalene is listed as a suspected human carcinogen by NTP and IARC. No other component of this product present at 0.1% or greater is listed by IARC, OSHA or NTP.

Reproductive Effects • Rotenone has been tested and does not cause birth defects.

Section 12 - Ecological Information

Toxicity

Components		
Rotenone (5%)	83-79-4	**Aquatic Toxicity-Fish:** 96 Hour(s) LC50 *Rainbow Trout* 0.00194 mg/L [Acute] NOEC *Rainbow Trout* 0.00101 mg/L [Chronic] **Aquatic Toxicity-Crustacea:** NOEC *Daphnia magna* 0.00125 mg/L [Chronic] 96 Hour(s) EC50 *Daphnia magna* 0.0037 mg/L [Acute]

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.

Bioaccumulative potential

• Rotenone has a relatively low potential for bioconcentrating in aquatic organisms.

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.

Other adverse effects

Potential Environmental Effects • Toxic to aquatic organisms.

Section 13 - Disposal Considerations

Waste treatment methods

Product waste •

Dispose of content and/or container in accordance with local, regional, national, and/or international regulations. Never place unused product down any indoor or outdoor drain.

Packaging waste •

Dispose of content and/or container in accordance with local, regional, national, and/or international regulations. See product label for disposal instructions. Nonrefillable container.

Section 14 - Transport Information

	UN number	UN proper shipping name	Transport hazard class (es)	Packing group	Environmental hazards
DOT	UN2902	Pesticides, liquid, toxic, n.o.s. (Rotenone)	6.1	II	Marine Pollutant
IMO/IMDG	UN2902	Pesticide, liquid, toxic, n.o.s. (Rotenone)	6.1	II	Marine Pollutant
IATA/ICAO	UN2902	Pesticide, liquid, toxic, n.o.s. (Rotenone)	6.1	II	Not Applicable

Special precautions for user • None specified.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code • No data available

Other information

• The calculated 1-hour acute toxicity for inhalation LC50 = 1.7 mg/L.

DOT • Environmental Hazards: RQ (Naphthalene = 100 lb). Environmental Hazards: RQ (Benzoic acid = 5000 lb).

IMO/IMDG • No data available

IATA/ICAO • No data available

Section 15 - Regulatory Information

Safety, health and environmental regulations/legislation specific for the substance or mixture

SARA Hazard Classifications • Acute, Chronic, SARA Title III Section 313, Fire

FIFRA – Pesticide Labeling

CAUTION

POISON

Precautionary Statements • KEEP OUT OF THE REACH OF CHILDREN.
FLAMMABLE POISON

Hazards to Humans and Domestic Animals • PMRA Label: PRECAUTIONS: KEEP OUT OF REACH OF CHILDREN. Poisonous if swallowed or absorbed through skin. 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.

First Aid •

rinsing eye. Call apoison control centre or doctor for treatment advice.Take container, label or product name and PCP Registration Number with you whenseeking medical attention.
TOXICOLOGICAL INFORMATION: Contains petroleum distillate - vomiting may cause aspiration pneumonia. Treat symptomatically.

Environmental Hazards • Toxic to aquatic organisms.

Inventory		
Component	**CAS**	**TSCA**
Benzoic acid	65-85-0	Yes
Naphthalene	91-20-3	Yes
Phenylsulfonate	70528-83-5	Yes
Nonylphenol ethoxylate	9016-45-9	Yes
Rotenone	83-79-4	No
Solvent naphtha (petroleum) Heavy aromatic	64742-94-5	Yes

United States

Environment

U.S. - CAA (Clean Air Act) - 1990 Hazardous Air Pollutants

• Naphthalene	91-20-3	
• Benzoic acid	65-85-0	Not Listed
• Nonylphenol ethoxylate	9016-45-9	Not Listed
• Solvent naphtha (petroleum) Heavy aromatic	64742-94-5	Not Listed
• Phenylsulfonate	70528-83-5	Not Listed
• Rotenone	83-79-4	Not Listed

U.S. - CERCLA/SARA - Hazardous Substances and their Reportable Quantities

• Naphthalene	91-20-3	100 lb final RQ; 45.4 kg final RQ
• Benzoic acid	65-85-0	5000 lb final RQ; 2270 kg final RQ
• Nonylphenol ethoxylate	9016-45-9	Not Listed
• Solvent naphtha (petroleum) Heavy aromatic	64742-94-5	Not Listed
• Phenylsulfonate	70528-83-5	Not Listed
• Rotenone	83-79-4	Not Listed

U.S. - CERCLA/SARA - Section 313 - Emission Reporting

• Naphthalene	91-20-3	0.1 % de minimis concentration
• Benzoic acid	65-85-0	Not Listed
• Nonylphenol ethoxylate	9016-45-9	Not Listed
• Solvent naphtha (petroleum) Heavy aromatic	64742-94-5	Not Listed
• Phenylsulfonate	70528-83-5	Not Listed
• Rotenone	83-79-4	Not Listed

U.S. - RCRA (Resource Conservation & Recovery Act) - Basis for Listing - Appendix VII

• Naphthalene	91-20-3	Included in waste streams: F024, F025, F034, F039, K001, K035, K060, K087, K145
• Benzoic acid	65-85-0	Not Listed
• Nonylphenol ethoxylate	9016-45-9	Not Listed

• Solvent naphtha (petroleum) Heavy aromatic	64742-94-5	Not Listed
• Phenylsulfonate	70528-83-5	Not Listed
• Rotenone	83-79-4	Not Listed

U.S. - RCRA (Resource Conservation & Recovery Act) - Hazardous Constituents - Appendix VIII to 40 CFR 261

• Naphthalene	91-20-3	waste number U165
• Benzoic acid	65-85-0	Not Listed
• Nonylphenol ethoxylate	9016-45-9	Not Listed
• Solvent naphtha (petroleum) Heavy aromatic	64742-94-5	Not Listed
• Phenylsulfonate	70528-83-5	Not Listed
• Rotenone	83-79-4	Not Listed

U.S. - RCRA (Resource Conservation & Recovery Act) - List for Hazardous Constituents

• Naphthalene	91-20-3	
• Benzoic acid	65-85-0	Not Listed
• Nonylphenol ethoxylate	9016-45-9	Not Listed
• Solvent naphtha (petroleum) Heavy aromatic	64742-94-5	Not Listed
• Phenylsulfonate	70528-83-5	Not Listed
• Rotenone	83-79-4	Not Listed

U.S. - RCRA (Resource Conservation & Recovery Act) - U Series Wastes - Acutely Toxic Wastes & Other Hazardous Characteristics

• Naphthalene	91-20-3	waste number U165
• Benzoic acid	65-85-0	Not Listed
• Nonylphenol ethoxylate	9016-45-9	Not Listed
• Solvent naphtha (petroleum) Heavy aromatic	64742-94-5	Not Listed
• Phenylsulfonate	70528-83-5	Not Listed
• Rotenone	83-79-4	Not Listed

U.S. - RCRA (Resource Conservation & Recovery Act) - Waste Minimization Priority Chemicals

• Naphthalene	91-20-3	
• Benzoic acid	65-85-0	Not Listed
• Nonylphenol ethoxylate	9016-45-9	Not Listed
• Solvent naphtha (petroleum) Heavy aromatic	64742-94-5	Not Listed
• Phenylsulfonate	70528-83-5	Not Listed
• Rotenone	83-79-4	Not Listed

Section 16 - Other Information

Revision Date
- 04/March/2016

Last Revision Date
- 04/March/2016

Preparation Date
- 04/March/2016

Disclaimer/Statement of Liability
- The information and statements herein are believed to be reliable but are not to be construed as a warranty or representation for which we assume legal responsibility. Users should undertake sufficient verification and testing to determine the suitability for their own particular purpose of any information or products referred to herein. NO WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE IS MADE.

Safety Data Sheet

Section 1: Identification

Product identifier

Product Name • **Prentox Nysyn-Noxfish Fish Toxicant**

Synonyms • 100209008; PMRA #: 19985

Product Description • Amber colored liquid which may contain particulate matter.

Relevant identified uses of the substance or mixture and uses advised against

Recommended use • Liquid fish toxicant for control of fish in streams, ponds, lakes or reservoirs.

Restrictions on use •

KEEP OUT OF THE REACH OF CHILDREN. Avoid contact with eyes, skin and clothing. Do not use or store near heat or open flame. Avoid release to the environment. Do not take internally. Use in well ventilated area. Avoid inhalation of vapors or fumes.

Details of the supplier of the safety data sheet

Manufacturer • Wellmark International

100 Stone Road West, Suite 111
Guelph ON N1G 5L3
Canada

Emergency telephone number

Manufacturer • 1-800-688-7378

Manufacturer (Transportation) • 1-800-424-9300 - Chemtrec

Manufacturer (Transportation) • 1-703-527-3887 - Chemtrec - outside the US, collect calls accepted

Section 2: Hazard Identification

United States (US)

According to: OSHA 29 CFR 1910.1200 HCS

Classification of the substance or mixture

OSHA HCS 2012 •

Aspiration 1
Eye Irritation 2A
Flammable Liquids 4
Skin Irritation 2
Carcinogenicity 2
Specific Target Organ Toxicity Single Exposure 3: Narcotic Effects
Acute Toxicity Oral 4
Acute Toxicity Inhalation 3

Label elements

OSHA HCS 2012

DANGER

Hazard statements •
Causes serious eye irritation
Causes skin irritation
May be fatal if swallowed and enters airways
Combustible liquid
May cause drowsiness or dizziness
Suspected of causing cancer.
Harmful if swallowed
Toxic if inhaled
Very toxic to aquatic life with long lasting effects

Precautionary statements

Prevention •
Wash thoroughly after handling.
Contaminated work clothing should not be allowed out of the workplace.
Wear protective gloves/protective clothing/eye protection/face protection.
Avoid breathing dust, fume, gas, mist, vapors and/or spray.
Keep away from heat, sparks, open flames and/or hot surfaces. - No smoking.
Obtain special instructions before use.
Do not handle until all safety precautions have been read and understood.
Do not eat, drink or smoke when using this product.
Use only outdoors or in a well-ventilated area.
Wear respiratory protection.

Response •
IF ON SKIN: Wash with plenty of soap and water.
Specific treatment, see supplemental first aid information.
If skin irritation occurs: Get medical advice/attention.
Take off contaminated clothing and wash before reuse.
IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician.
Do NOT induce vomiting.
If eye irritation persists: Get medical advice/attention.
In case of fire: Use appropriate media Water fog, foam, dry chemical or carbon dioxide (CO2). for extinction.
Immediately call a POISON CENTER or doctor/physician.
IF exposed or concerned: Get medical advice/attention.
IF INHALED: Remove person to fresh air and keep at rest in a position comfortable for breathing.
Call a POISON CENTER or doctor/physician.

Storage/Disposal •
Dispose of content and/or container in accordance with local, regional, national, and/or international regulations.
Store in a well-ventilated place. Keep cool.
Store locked up.
Keep container tightly closed.

Other hazards

OSHA HCS 2012 •
This product is toxic to aquatic organisms. Under United States Regulations (29 CFR 1910.1200 - Hazard Communication Standard), this product is considered hazardous.

Section 3 - Composition/Information on Ingredients

Substances

Mixtures

- Material does not meet the criteria of a substance.

Composition		
Chemical Name	**Identifiers**	**%**
Rotenone	**CAS:**83-79-4	2.5%
Piperonyl butoxide	**CAS:**51-03-6	2.5%
Benzoic acid	**CAS:**65-85-0	1%
Solvent naphtha (petroleum), heavy aromatic	**CAS:**64742-94-5	70% TO 80%
Naphthalene	**CAS:**91-20-3	< 8.5%
Nonylphenol ethoxylate	**CAS:**9016-45-9	2.5% TO 2.7%
Other ingredients	NDA	Balance

Section 4: First-Aid Measures

Description of first aid measures

Inhalation

- IF INHALED: Remove person to fresh air and keep at rest in a position comfortable for breathing. Immediately call a POISON CONTROL center or doctor.

Skin

- IF ON SKIN: Wash with plenty of soap and water. If irritation or rash occurs, get medical advice/attention. Take off contaminated clothing and wash before reuse.

Eye

- 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/attention.

Ingestion

- IF SWALLOWED: Immediately call a poison control center or doctor. Aspiration hazard - if swallowed, do NOT induce vomiting.

Most important symptoms and effects, both acute and delayed

- Aspiration hazard, harmful if swallowed, fatal if inhaled, causes dizziness or drowsiness if inhaled, causes serious eye irritation, causes skin irritation, suspected of causing cancer. Refer to Section 11 - Toxicological Information.

Indication of any immediate medical attention and special treatment needed

Notes to Physician

- Treat symptomatically and supportively.

Section 5: Fire-Fighting Measures

Extinguishing media

Suitable Extinguishing Media

- LARGE FIRE: Water spray, fog or regular foam.
  SMALL FIRES: Dry chemical, CO2, water spray or regular foam.

Unsuitable Extinguishing Media

- Avoid heavy hose streams.

Firefighting Procedures

- Do not allow fire fighting water to escape into waterways or sewers.
  LARGE FIRES: Dike fire control water for later disposal; do not scatter the material.

LARGE FIRES: Move containers from fire area if you can do it without risk.
Stay upwind.
Ventilate closed spaces before entering.
Do not breathe gas/fumes/vapor/spray.
Keep unauthorized personnel away.

Special hazards arising from the substance or mixture

Unusual Fire and Explosion Hazards

- Combustible liquid.
  Containers may explode when heated.
  Vapors are heavier than air and will spread along ground and collect in low or confined areas (sewers, basements, tanks) and may reach remote ignition sources causing a flashback fire danger.

Hazardous Combustion Products

- Combustible liquid - may produce carbon dioxide and/or carbon monoxide.

Advice for firefighters

- Wear positive pressure self-contained breathing apparatus (SCBA).

Section 6 - Accidental Release Measures

Personal precautions, protective equipment and emergency procedures

Personal Precautions

- Do not walk through spilled material. Ventilate enclosed areas. Wear appropriate personal protective equipment, avoid direct contact. Avoid breathing fumes. Keep all sources of ignition away.

Emergency Procedures

- ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). Ventilate closed spaces before entering. Avoid release into the environment. Keep out of low areas. Keep unauthorized personnel away. Stay upwind. Take precautionary measures against static discharge. Turn off electric power to area.

Environmental precautions

- LARGE SPILLS: Prevent entry into waterways, sewers, basements or confined areas.

Methods and material for containment and cleaning up

Containment/Clean-up Measures

- Absorb spills with an inert material, clay granules or other inert absorbent material and put in container for disposal.
  All equipment used when handling the product must be grounded.
  LARGE SPILLS: Dike far ahead of spill for later disposal.
  Stop leak if you can do it without risk.
  SMALL SPILLS: Take up with sand or other non-combustible absorbent material and place into containers for later disposal.
  Use appropriate Personal Protective Equipment (PPE)

Section 7 - Handling and Storage

Precautions for safe handling

Handling

- Keep away from fire - No Smoking. Avoid breathing fumes. Use only in well ventilated areas. Wear appropriate personal protective equipment, avoid direct contact. Avoid contact with skin or eyes.

Conditions for safe storage, including any incompatibilities

Storage

- Store locked up. Store in a cool/low-temperature, well-ventilated dry place away from heat and ignition sources. Keep from freezing. Keep container tightly closed. Avoid extreme temperatures.

Incompatible Materials or Ignition Sources
- Heat, sparks, open flame.

Other Information
- See product label for additional information.

Section 8 - Exposure Controls/Personal Protection

Control parameters

Exposure Limits/Guidelines
- No data available.

Exposure Limits/Guidelines					
	Result	**ACGIH**	**Canada Ontario**	**NIOSH**	**OSHA**
Rotenone (83-79-4)	TWAs	5 mg/m3 TWA (commercial)	5 mg/m3 TWA (commercial)	5 mg/m3 TWA	5 mg/m3 TWA
Naphthalene (91-20-3)	STELs	Not established	15 ppm STEL	15 ppm STEL; 75 mg/m3 STEL	Not established
	TWAs	10 ppm TWA	10 ppm TWA	10 ppm TWA; 50 mg/m3 TWA	10 ppm TWA; 50 mg/m3 TWA

Exposure Control Notations

Canada Ontario

•Naphthalene (91-20-3): **Skin:** (Danger of cutaneous absorption)

ACGIH

•Rotenone (83-79-4): **Carcinogens:** (A4 - Not Classifiable as a Human Carcinogen (commercial))

•Naphthalene (91-20-3): **Carcinogens:** (A3 - Confirmed Animal Carcinogen with Unknown Relevance to Humans) | **Skin:** (Skin - potential significant contribution to overall exposure by the cutaneous route)

Exposure Limits Supplemental

ACGIH

•Rotenone (83-79-4): **TLV Basis - Critical Effects:** (CNS impairment; eye and upper respiratory tract irritation)

•Naphthalene (91-20-3): **TLV Basis - Critical Effects:** (cataracts; upper respiratory tract irritation; hemolytic anemia)

Exposure controls

Engineering Measures/Controls
- Adequate ventilation systems as needed to control concentrations of airborne contaminants below applicable threshold limit values.

Personal Protective Equipment

Pictograms
- 

Respiratory
- If handling without sufficient ventilation, wear a NIOSH approved respirator. See product label for specific respiratory protection instructions.

under use conditions. Follow best practice for site management and disposal of waste.

Other Information

- See product label for specific use PPE instructions.

Section 9 - Physical and Chemical Properties

Information on Physical and Chemical Properties

Material Description			
Physical Form	Liquid	Appearance/Description	Amber colored liquid which may contain particulate matter.
Color	Amber	Odor	Solvent type.
Odor Threshold	No data available		
General Properties			
Boiling Point	No data available	Melting Point/Freezing Point	No data available
Decomposition Temperature	No data available	pH	No data available
Specific Gravity/Relative Density	0.87 to 0.97 Water=1	Density	No data available
Water Solubility	Insoluble	Viscosity	No data available
Critical Temperature	No data available		
Volatility			
Vapor Pressure	No data available	Vapor Density	No data available
Evaporation Rate	No data available		
Flammability			
Flash Point	61°C (141.8°F)	UEL	No data available
LEL	No data available	Autoignition	No data available
Flammability (solid, gas)	No data available		
Environmental			
Octanol/Water Partition coefficient	No data available		

Section 10: Stability and Reactivity

Reactivity

- Non-reactive under normal handling and storage conditions.

Chemical stability

- Stable

Possibility of hazardous reactions

- Hazardous polymerization will not occur.

Conditions to avoid

- Excessive heat >110°F. Heat, sparks, open flame, other ignition sources, and oxidizing conditions. Keep away from fire.

Incompatible materials

- Strong oxidizing agents and strong acids.

Hazardous decomposition products

- Thermal decomposition may produce oxides of carbon.

Section 11 - Toxicological Information

Information on toxicological effects

Components		
Rotenone (2.5%)	83-79-4	**Acute Toxicity:** Ingestion/Oral-Rat, adult female LD50 • 39.5 mg/kg; Ingestion/Oral-Rat, adult male LD50 • 102 mg/kg; Inhalation-Rat LC50 • 0.0212 mg/L 4 Hour(s); Skin-Rabbit LD50 • >5000 mg/kg; **Irritation:** Eye-Rabbit • Essentially non-irritating; Skin-Rabbit • Essentially non-irritating
Piperonyl butoxide (2.5%)	51-03-6	**Acute Toxicity:** Ingestion/Oral-Rat • 4300 mg/kg; Inhalation-Rat • >5 mg/L 4 Hour(s); Skin-Rat LD50 • >2000 mg/kg; **Irritation:** Eye-Rabbit • Essentially non-irritating; Skin-Rabbit • Essentially non-irritating

GHS Properties	Classification
Acute toxicity	**OSHA HCS 2012** • Acute Toxicity - Dermal - Classification criteria not met; Acute Toxicity - Inhalation 3; Acute Toxicity - Oral 4
Skin corrosion/Irritation	**OSHA HCS 2012** • Skin Irritation 2
Serious eye damage/Irritation	**OSHA HCS 2012** • Eye Irritation 2A
Skin sensitization	**OSHA HCS 2012** • Classification criteria not met
Respiratory sensitization	**OSHA HCS 2012** • Classification criteria not met
Aspiration Hazard	**OSHA HCS 2012** • Aspiration 1
Carcinogenicity	**OSHA HCS 2012** • Carcinogenicity 2
Germ Cell Mutagenicity	**OSHA HCS 2012** • Not classified - data lacking
Toxicity for Reproduction	**OSHA HCS 2012** • Classification criteria not met
STOT-SE	**OSHA HCS 2012** • Specific Target Organ Toxicity Single Exposure 3: Narcotic Effects
STOT-RE	**OSHA HCS 2012** • Classification criteria not met

Potential Health Effects

Inhalation

Acute (Immediate) • Toxic if inhaled. May affect the central nervous system. Symptoms may include dizziness or drowsiness. May cause respiratory irritation.

Chronic (Delayed) • No data available

Skin

Acute (Immediate) • Causes skin irritation.

Chronic (Delayed) • No data available

Eye

Acute (Immediate) • Causes serious eye irritation.

Chronic (Delayed) • No data available

Ingestion

Acute (Immediate) • Harmful if swallowed. Aspiration hazard - small amounts of liquid aspirated into the lungs during ingestion or from vomiting may cause chemical pneumonitis or pulmonary edema.

Chronic (Delayed) • No data available

Mutagenic Effects •

Rotenone is not mutagenic. Piperonyl butoxide was not genotoxic in several tests, including the Ames mutagenicity assay, chromosome aberration in Chinese hamster ovary (CHO) cells, CHO/HGPRT assay with S9 activation and in the unscheduled DNA synthesis (UDS) assay in cultured human liver cells.

Carcinogenic Effects

- Naphthalene is listed as a suspected human carcinogen by NTP and IARC. No other component of this product present at 0.1% or greater is listed by IARC, OSHA or NTP.

Reproductive Effects

- Rotenone has been tested and does not cause birth defects. Piperonyl butoxide did not produce any birth defects or adverse effects on reproductive parameters in tests with rats and rabbits.

Section 12 - Ecological Information

Toxicity

Components		
Rotenone (2.5%)	83-79-4	**Aquatic Toxicity-Fish:** 96 Hour(s) LC50 *Rainbow Trout* 0.00194 mg/L [Acute] NOEC *Rainbow Trout* 0.00101 mg/L [Chronic] **Aquatic Toxicity-Crustacea:** NOEC *Daphnia magna* 0.00125 mg/L [Chronic] 96 Hour(s) EC50 *Daphnia magna* 0.0037 mg/L [Acute]
Piperonyl butoxide (2.5%)	51-03-6	**Aquatic Toxicity-Fish:** LC50 *Rainbow Trout* 1.9 mg/L [Acute] LC50 *Sheephead minnow* 3.94 mg/L [Acute] NOEC *Fathead minnow* 0.04 mg/L [Chronic] **Aquatic Toxicity-Crustacea:** LC50 *Gammarus fasciatus (amphipod)* 0.51 mg/L [Acute] LC50 *Mysid shrimp* 0.49 mg/L [Acute] NOEC *Daphnia magna* 0.03 mg/L [Chronic]

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.

Bioaccumulative potential

- Rotenone has a relatively low potential for bioconcentrating in aquatic organisms.

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.

Other adverse effects

Potential Environmental Effects

- Toxic to aquatic organisms.

Section 13 - Disposal Considerations

Waste treatment methods

Product waste

- Dispose of content and/or container in accordance with local, regional, national, and/or international regulations. Never place unused product down any indoor or outdoor

Packaging waste •

Dispose of content and/or container in accordance with local, regional, national, and/or international regulations. See product label for disposal instructions. Nonrefillable container.

Section 14 - Transport Information

	UN number	UN proper shipping name	Transport hazard class (es)	Packing group	Environmental hazards
DOT	UN2902	Pesticides, liquid, toxic, n.o.s. (Rotenone)	6.1	III	Marine Pollutant
IMO/IMDG	UN2902	Pesticide, liquid, toxic, n.o.s. (Rotenone)	6.1	III	Marine Pollutant
IATA/ICAO	UN2902	Pesticide, liquid, toxic, n.o.s. (Rotenone)	6.1	III	Not Applicable

Special precautions for user • None specified.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code • No data available

Other information

• The calculated 1-hour acute toxicity for inhalation LC50 = 3.57 mg/L.

DOT • Environmental Hazards: RQ (Naphthalene = 100 lb). Environmental Hazards: RQ (Benzoic acid = 5000 lb).

IMO/IMDG • No data available

IATA/ICAO • No data available

Section 15 - Regulatory Information

Safety, health and environmental regulations/legislation specific for the substance or mixture

SARA Hazard Classifications • Acute, Chronic, SARA Title III Section 313, Fire

FIFRA – Pesticide Labeling

CAUTION

Precautionary Statements • KEEP OUT OF THE REACH OF CHILDREN.
FLAMMABLE POISON

Hazards to Humans and Domestic Animals •

PMRA label: KEEP OUT OF REACH OF CHILDREN. Poisonous if swallowed, or absorbed through skin. 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 reuse drum. Return to drum conditioner or refer to disposal instructions.

advice.Do not induce vomiting unless told to do so by a poison control centre or doctor. Do notgive any liquid to the person. Do not give anything by mouth to an unconscious person. IFON SKIN OR CLOTHING: Take off contaminated clothing. Rinse skin immediately withplenty of water for 15–20 minutes. Call a poison control centre or doctor for treatmentadvice.IF INHALED: Move person to fresh air. If person is not breathing, call 911 or anambulance, then give artificial respiration, preferably by mouth-to-mouth, if possible. Calla 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 apoison control centre or doctor for treatment advice.Take container, label or product name and PCP Registration Number with you whenseeking medical attention.
TOXICOLOGICAL INFORMATION: Contains petroleum distillate - vomiting may cause aspiration pneumonia. Treat symptomatically.

Environmental Hazards • Toxic to aquatic organisms.

Inventory		
Component	**CAS**	**TSCA**
Benzoic acid	65-85-0	Yes
Nonylphenol ethoxylate	9016-45-9	Yes
Naphthalene	91-20-3	Yes
Piperonyl butoxide	51-03-6	Yes
Rotenone	83-79-4	No
Solvent naphtha (petroleum), heavy aromatic	64742-94-5	Yes

United States

Environment

U.S. - CAA (Clean Air Act) - 1990 Hazardous Air Pollutants

• Naphthalene	91-20-3	
• Benzoic acid	65-85-0	Not Listed
• Nonylphenol ethoxylate	9016-45-9	Not Listed
• Solvent naphtha (petroleum), heavy aromatic	64742-94-5	Not Listed
• Rotenone	83-79-4	Not Listed
• Piperonyl butoxide	51-03-6	Not Listed

U.S. - CERCLA/SARA - Hazardous Substances and their Reportable Quantities

• Naphthalene	91-20-3	100 lb final RQ; 45.4 kg final RQ
• Benzoic acid	65-85-0	5000 lb final RQ; 2270 kg final RQ

U.S. - CERCLA/SARA - Section 313 - Emission Reporting

• Naphthalene	91-20-3	0.1 % de minimis

• Piperonyl butoxide	51-03-6	1.0 % de minimis concentration

U.S. - RCRA (Resource Conservation & Recovery Act) - Basis for Listing - Appendix VII

• Naphthalene	91-20-3	Included in waste streams: F024, F025, F034, F039, K001, K035, K060, K087, K145
• Benzoic acid	65-85-0	Not Listed
• Nonylphenol ethoxylate	9016-45-9	Not Listed
• Solvent naphtha (petroleum), heavy aromatic	64742-94-5	Not Listed
• Rotenone	83-79-4	Not Listed
• Piperonyl butoxide	51-03-6	Not Listed

U.S. - RCRA (Resource Conservation & Recovery Act) - Hazardous Constituents - Appendix VIII to 40 CFR 261

• Naphthalene	91-20-3	waste number U165
• Benzoic acid	65-85-0	Not Listed
• Nonylphenol ethoxylate	9016-45-9	Not Listed
• Solvent naphtha (petroleum), heavy aromatic	64742-94-5	Not Listed
• Rotenone	83-79-4	Not Listed
• Piperonyl butoxide	51-03-6	Not Listed

U.S. - RCRA (Resource Conservation & Recovery Act) - List for Hazardous Constituents

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• Solvent naphtha (petroleum), heavy aromatic	64742-94-5	Not Listed
• Rotenone	83-79-4	Not Listed
• Piperonyl butoxide	51-03-6	Not Listed

U.S. - RCRA (Resource Conservation & Recovery Act) - U Series Wastes - Acutely Toxic Wastes & Other Hazardous Characteristics

• Naphthalene	91-20-3	waste number U165
• Benzoic acid	65-85-0	Not Listed
• Nonylphenol ethoxylate	9016-45-9	Not Listed
• Solvent naphtha (petroleum), heavy aromatic	64742-94-5	Not Listed
• Rotenone	83-79-4	Not Listed
• Piperonyl butoxide	51-03-6	Not Listed

U.S. - RCRA (Resource Conservation & Recovery Act) - Waste Minimization Priority Chemicals

• Naphthalene	91-20-3	
• Benzoic acid	65-85-0	Not Listed
• Nonylphenol ethoxylate	9016-45-9	Not Listed
• Solvent naphtha (petroleum), heavy aromatic	64742-94-5	Not Listed
• Rotenone	83-79-4	Not Listed
• Piperonyl butoxide	51-03-6	Not Listed

Section 16 - Other Information

Revision Date • 04/March/2016

Last Revision Date • 04/March/2016

Preparation Date • 04/March/2016

Disclaimer/Statement of •

Liability

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