Jackfish Bay Remedial Action Plan

Stage 2 Update:

Area in Recovery Status Report 1 for Jackfish Bay

NORTH SHORE
OF LAKE SUPERIOR
REMEDIAL ACTION PLANS

Lakehead University

May 2010

Dedicated to Tom Falzetta

Tom's attention to detail, his passion for the outdoors, and his local knowledge made him an invaluable member of the PARRC committee. For the members of the committee, our memory of Tom lives on in this report as each of us found ourselves reading through the final draft with Tom's critical eye and determination to get this right.

Tom Falzetta
1952-2009

Acknowledgements

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Executive Summary

Background

This document summarizes the work of research completed to date within the Jackfish Bay Area of Concern and finds that, according to the definition provided by the Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem (2007), Jackfish Bay qualifies as an *Area in Recovery* (AiR) (Insert A). While significant improvement has occurred since the area was originally listed as an Area of Concern, additional time is still required for sufficient ecosystem recovery to be detected. Scientific studies on various aspects of the health of Jackfish Bay have provided information about many facets of the ecosystem; however, a focused monitoring program is recommended to conclusively track ecosystem recovery with the long-term goal of removing Jackfish Bay from the list of Great Lakes Areas of Concern (delisting the AOC).

> Insert A: An ***Area in Recovery*** (AiR) is an area that was originally identified as an area of concern where, based on community and government consensus, all scientifically feasible and economically reasonable actions have been implemented and additional time is required for the environment to recover (Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem 2007).

Recognizing that natural recovery would be slow and that parts of the AOC may not recover while industrial effluent is discharged, the Jackfish Bay Public Area in Recovery Review Committee, the Ministry of Environment, the Ministry of Natural Resources, and Environment Canada have recommended that the Jackfish Bay Area of Concern (AOC) be recognized as an Area in Recovery (AiR). This is primarily based on the fact that the Jackfish Bay AOC meets the definition of an AiR in terms of remedial actions having been completed, and because both the Jackfish Bay Remedial Action Plan Team and the Public Area in Recovery Review Committee agree that further remedial actions are not practical or feasible at this time. Although many data gaps exist that inhibit the ability for reviewers to accurately assess the status of Beneficial Use Impairments (Insert B) in the Jackfish Bay AOC, there have been both visible and measurable signs of recovery, and some BUIs have been delisted in this report. Additionally, the quality of the mill effluent has improved and periodic mill shut-downs since the last stage of the Remedial Action Plan process have resulted in noticeable ecosystem improvements.

> Insert B: A ***Beneficial Use Impairment*** (BUI) means a change in the chemical, physical or biological integrity of the Great Lakes System is sufficient to cause restrictions on fish and wildlife consumption, tainting of fish and wildlife flavour, degradation of fish and wildlife populations, fish, bird, or animal tumours or other deformities and reproductive problems, degradation of benthos, restrictions on dredging activities, eutrophication, restrictions on drinking water consumption, beach closures, degradation to aesthetics, degradation of phytoplankton and zooplankton populations, added costs to agriculture or industry or loss of fish and wildlife habitat (Great Lakes Water Quality Agreement, 1978).

Ongoing monitoring and scientific study will be required to determine the level of recovery in the AOC, and if and when Jackfish Bay can be removed from the list of Areas of Concern. The purpose of this report is to provide current status assessment of all the remaining impairments through a review of data collected since the initial stages of the Remedial Action Plan. This report presents these assessments relative to restoration targets, known as *delisting criteria*, and provides recommendations about the monitoring needs required to track progress towards recovery. Input from the Public Area in Recovery Review Committee (PARRC) and general public is critical to the recognition of Jackfish Bay as an Area in Recovery.

Acknowledging that full recovery and delisting of the AOC may not occur as long as Blackbird Creek continues to receive mill effluent, it is expected that incremental progress will continue to proceed based on actions implemented to date. Recognizing the Jackfish Bay Area of Concern as an Area in Recovery and agreeing to follow a natural recovery strategy will require that the current and future mill owners maintain high standards of effluent quality.

Insert C: ***Adaptive Management*** is a systematic process for continually improving management policies and practices by learning from the outcomes of previously employed policies and practices. (Source: Millennium Ecosystem Assessment)

Successfully tracking ecosystem recovery requires the commitment of several government agencies to a long-term monitoring program. This monitoring program should utilize an adaptive management approach (Insert C) and should seek to assess progress towards ecosystem recovery as it relates to the point source of pollution in the AOC. In the event that recovery is not occurring as expected, the agencies should consider additional remedial actions or the use of new or emerging technologies. The monitoring program will allow managers to draw conclusions about recovery and assess whether restoration targets have met the final delisting criteria. It is important that such monitoring objectives are developed through an integrated watershed management approach (Insert D).

Insert D: ***Integrated Watershed Management*** considers local as well as regional issues and is rooted in an ecosystem approach to management that uses the watershed as a water quality planning unit. It results in a better understanding of water quality and quantity and aquatic ecosystem problems, and makes it possible to identify sustainable solutions. Watershed-based management also makes it easier to define action priorities by considering the cumulative impact on aquatic ecosystems.

The Jackfish Bay Public Area in Recovery Review Committee (PARRC) concluded that since the Jackfish Bay AOC could be among the very first Great Lakes AOCs to receive “recovery” status, it may be viewed by others as a model for designation of recovery status across the Great Lakes. Consequently, the committee suggested that standards should be high and that the parties involved in the process should take on a proactive role. In recognition of the preceding fundamental approach, the PARRC stated that, in advance of recovery status designation, the following actions should take place:

- The Ontario Ministry of Environment, the Ontario Ministry of Natural Resources, Environment Canada and any other government agencies concerned should agree to a long-term monitoring program documenting environmental quality in the Jackfish Bay AOC. This plan should lay out both financial and implementation responsibilities.

- All possible efforts should be made to advance environmental recovery. As new technology, methods or systems become available that might reduce current environmental impact, these remedial options be investigated and implemented where appropriate, practical and cost-effective.

- Through the PARRC, open, meaningful, regular, and timely communication should take place between involved government agencies and residents of the Rossport, Schreiber, Terrace Bay and Jackfish communities.

The purpose of this report is to assess progress towards achieving restoration targets for each beneficial use impairment in the Jackfish Bay AOC and to provide recommendations for a long-term monitoring plan to assess ongoing recovery. This report therefore provides an updated resource and platform for community members, the PARRC and responsible government agencies to continue a dialogue about the status of beneficial use impairments in the Jackfish Bay Area in Recovery. This review of information in this report was conducted by a review committee of faculty members from Lakehead University, The Jackfish Bay Remedial Action Plan Team, the Jackfish Bay Technical Team, and the Jackfish Bay Public Area in Recovery Review Committee (PARRC).

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1.0 History of Jackfish Bay Area of Concern

The Jackfish Bay Area of Concern is one of 43 Great Lakes Areas of Concern (AOCs) identified by the governments of Canada and the United States under the Great Lakes Water Quality Agreement (GLWQA, 1978). These areas are locations where environmental quality is significantly degraded, resulting in the impairment of beneficial uses for humans and wildlife. A Beneficial Use Impairment (BUI) means a change in the chemical, physical or biological integrity of the Great Lakes System is sufficient to cause restrictions on a range of beneficial uses outlined in the Great Lakes Water Quality Agreement of 1978. In 1987 Canada and the United States identified Jackfish Bay as an AOC based on a series of impairments to the physical, chemical and biological characteristics of the area.

The impairments in Jackfish Bay were the result of wastewater (effluent) from the kraft mill located in Terrace Bay. Since 1948, the mill has discharged effluent to a canal that flows into Blackbird Creek and then Jackfish Bay (Figure 1.1). In accordance with the GLWQA, government agencies working with local stakeholders have developed Remedial Action Plans (RAPs) for each AOC. These RAPs guide restoration and protection efforts through three stages.

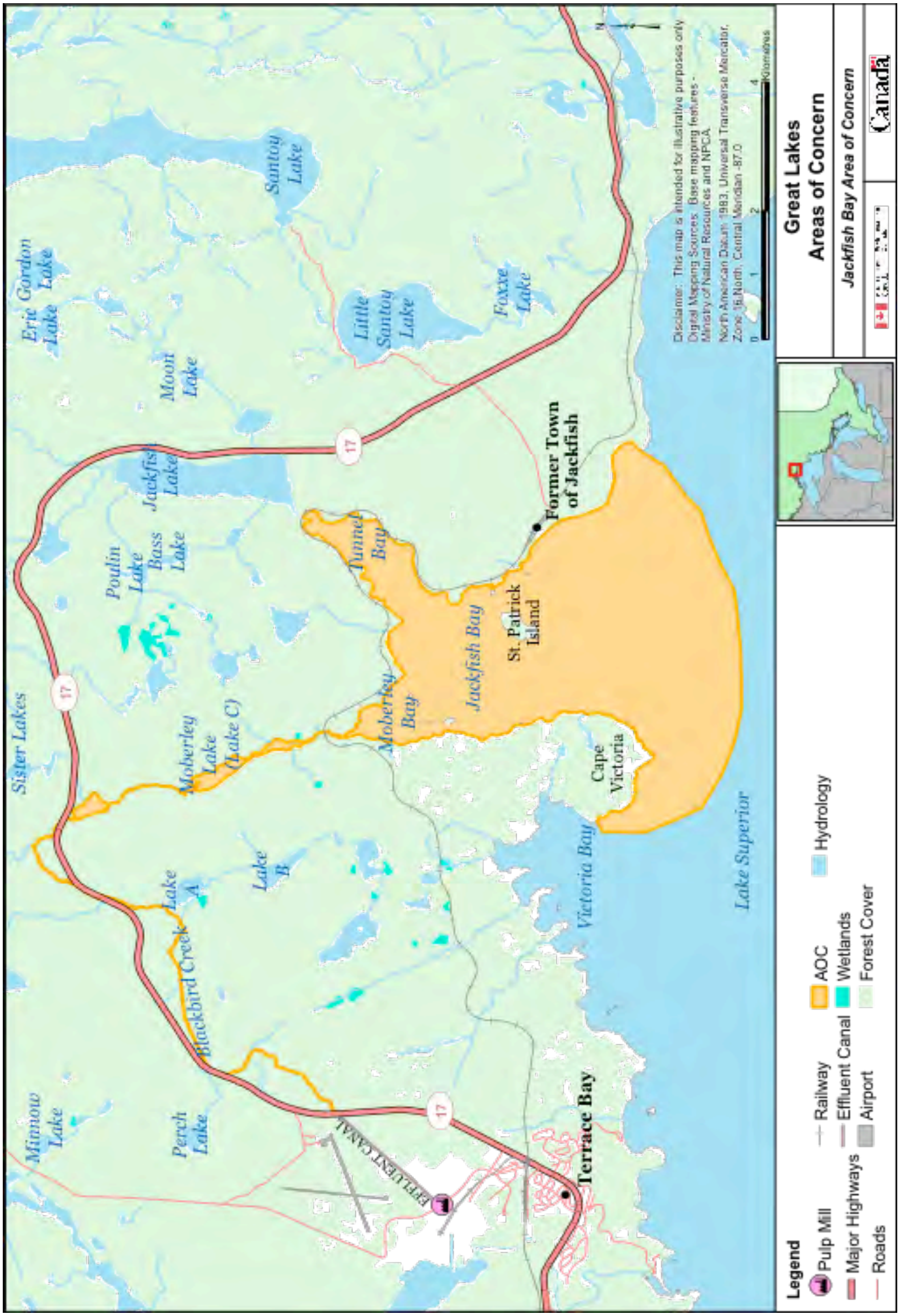
- Stage 1: Identify environmental problems and sources of pollution.
- Stage 2: Evaluate and carry out actions to restore the area.
- Stage 3: Confirm that these actions have been effective and that the environment has been restored.

After monitoring indicates that both beneficial uses and ecosystem health have been restored, the process of removing Jackfish Bay from the list of Great Lakes AOCs can begin. The decision to remove an AOC is called delisting, and the decision is made by the federal, provincial, and local RAP participants, with advice from the International Joint Commission. As of April 2010, of the 17 Areas of Concern in Canada, 3 have been delisted: Collingwood Harbour, Severn Sound, and Wheatley Harbour. As well, Spanish Harbour has been recognized as an Area in Recovery (www.ec.gc.ca/raps-pas). In the United States, Presque Isle Bay has been recognized as an Area in Recovery since 2002 and the Oswega River AOC was delisted in 2006 (www.epa.gov/glnpo/aoc).

1.1 Description of Jackfish Bay

The Jackfish Bay Area of Concern (AOC) is located on the north shore of Lake Superior, approximately 250 kilometres northeast of Thunder Bay. The AOC consists of the 14-kilometre reach of Blackbird Creek between the effluent canal from the kraft mill (Terrace Bay Pulp Inc.) and Jackfish Bay. This area also encompasses Moberly Lake (Lake 'C') as well as Jackfish Bay (Figure 1.1).

Figure 1.1: The Jackfish Bay Area of Concern



The closest town to the AOC is Terrace Bay, which has a population of approximately 1625 in 2006 (Statistics Canada, 2006). The mill was built in 1947 and supported the development of Terrace Bay as a community. At the beginning of the mill's operation the decision was made to discharge mill effluent via the Blackbird Creek system.

The Blackbird Creek watershed drains an area of 62 square kilometres. The creek rises near the town of Terrace Bay and flows in a southeasterly direction for 14 kilometres into the northern tip of Moberly Bay. Blackbird Creek became more visible to the public in 1957, when Highway 17 was constructed east of Terrace Bay and a portion of the creek was re-routed alongside the Trans-Canada highway. In 1989, a large culvert upstream of Highway 17 was installed to alleviate ice and fog formation from the creek, as well as foam and odour that was detected along the highway (Jackfish Bay RAP Team Stage 2, 1992. pg 4).

As Blackbird Creek drains to Jackfish Bay and Lake Superior, historically it passed through two shallow lakes referred to as Lake 'A' and Moberly Lake. Lake 'A' originally covered a surface area of 19 hectares with depths up to 6.1 metres. Due to the accumulation of woody fibre from the effluent, substantial in-filling has occurred. In the 1980s, the flow of Blackbird Creek was redirected to bypass Lake A. From site visits and aerial inspections it appears that much of this lake is now a wetland covered with submerged vegetation. Moberly Lake is 29 hectares in size with an original maximum depth of 6.4 metres. Depth decreased to 0.8 metres due to woody fibre in-filling from the effluent (Jackfish Bay RAP Team Stage 2, 1992).

Blackbird Creek drains into the western side of Jackfish Bay, which contains two inner arms: Moberly Bay on the west and Tunnel Bay on the east. The total surface area of Jackfish Bay is 6.4 square kilometres. The largest islands are: Cody Island, which is located in the extreme southwest of Moberly Bay; Bennett Island, located in southeastern Moberly Bay; and St. Patrick Island, located near the eastern shore of Jackfish Bay.

1.2 Determining the Beneficial Use Impairments (BUIs)

Figure 1.2 provides a timeline of the process used by government agencies and the Jackfish Bay Public Advisory Committee to assess and define the Jackfish Bay AOC. In 1988, the team documented environmental conditions in the Bay, and the identification of a series of potential beneficial use impairments (BUIs) that would define the AOC.

Figure 1.2: Timeline of Jackfish Bay AOC

1985 ---
Jackfish Bay was identified by the International Joint Commission (IJC) as one of 42 Areas of Concern in the Great Lakes Basin.

1988 ---
The Public Advisory Committee (PAC) was formed following the first public input session. The thirteen PAC members included representatives from the public, Kimberly Clark Canada Ltd., Charter Boat Services, the mill union, Jackfish Lake Cottages, the Township of Terrace Bay, Ducks Unlimited, Minnova Mines, and the Ontario Underwater Council.

1990 ---
PAC developed a set of Water Use Goals (WUGs), which were presented to the public in September. Input from the public was involved in creating the finalized WUGs.

1992 ---
Beak Consultants presented findings about Toxic Load of Blackbird Creek system and Alternatives for Rehabilitation.

1995 ---
The RAP team prepared a discussion of the remedial options for Jackfish Bay.

2008 ---
The Public Area in Recovery Review Committee (PARRC) was created with the task of ensuring feedback on the proposed delisting criteria, the Area in Recovery recognition, and that a long term monitoring plan is obtained.

2008 ---
A second meeting of the PARRC occurred in October that was open to the public and discussed the updated status of each Beneficial Use Impairment, the proposed long term monitoring plan, and the arguments for Area in Recovery recognition. The MOE, Environment Canada and the PARRC presented to the Terrace Bay Town Council on the AiR status.

--- 1988
Between 1988 and 1997, Environment Canada and the Ontario Ministry of the Environment developed the Jackfish Bay Remedial Action Plan (RAP), with support from the general public.

--- 1989
The first Public Advisory Committee meeting was held May 9th in Terrace Bay, Ontario. Subsequent meetings were held monthly.

--- 1990
"Making a Great Lake Superior" conference was held March 22-24, in Thunder Bay. It was attended by RAP teams and PACs from the Lake Superior Areas of Concern of Ontario, Minnesota, Wisconsin, and Michigan, as well as scientists, resource managers, industry people and environmentalists from Canada and the United States.

--- 1991
Stage 1 RAP report was created, outlining beneficial use impairments as decided with community input based on a list of 14 possible beneficial use impairments.

--- 1992
IJC Stage 1 Review Teams toured the Lake Superior AOCs.

-- 1998
Stage 2 RAP report was created, recognizing that the mill had upgraded its effluent treatment system and that the toxins did not seem to be accumulating up the food web. The recommendation was to monitor Blackbird Creek Lake A, Lake C and Jackfish Bay for progress towards delisting, with no further intervention to be taken, allowing for natural recovery to occur. The PAC developed Water Use Goals within this report and suggested required monitoring needs.

-- 2009
May 8th, Lake Superior Binational Forum Public Input Sessions were held in Terrace Bay. The PARRC appointed community members to Chair and Vice Chair of the committee. Public input sessions occurred, with presentations from academics, scientists and government employees about the status of Jackfish Bay and information about the Area in Recovery Report that was expected in late 2009.

1.2.1 Stage 1 (1991): Defining the Beneficial Use Impairments

In 1989, a Public Advisory Committee (PAC) was established by local citizens and stakeholder groups from Terrace Bay. The original PAC had 13 members and included representatives from the public, the pulp mill, the town and a range of local stakeholder groups. The Jackfish Bay Technical Team was established to assist the PAC and consisted of members from Environment Canada, Fisheries and Oceans Canada, the Ministry of the Environment and the Ministry of Natural Resources.

In the early stages, the PAC worked with the Technical Team to identify and describe impairments. The Technical Team was responsible for the collection and analysis of data describing each of the beneficial use impairments and to later provide suggestions for remediation actions in Stage 2.

In 1991, the results of this effort were documented in a Stage 1 Report: Environmental Conditions and Problem Definition. The Great Lakes Water Quality Agreement of 1978 provides a list of 14 possible beneficial use impairments. Appendix A shows the specific impairments that the Jackfish Bay Public Advisory Committee (later termed the Public Area in Recovery Review Committee) identified in Stages 1, Stage 2 and the Area in Recovery stage of the Remedial Action Plan.

1.2.2 Stage 2 (1998): Remediation Strategy for the Area of Concern

A variety of strategies for remediation of the Jackfish Bay AOC were developed by the Jackfish Bay Technical Team and presented to the PAC as a review of alternatives for rehabilitation (Technical Report #13: Options for Blackbird Creek). Based on a review of these remediation options, the RAP Stage 2 report was published in 1998 (Stage 2: Remedial Strategies for Ecosystem Restoration). The Stage 2 report outlined the remediation strategies that had been assessed, and recommended the selected remedial actions.

The RAP Team decided that an active remediation strategy was not feasible for this AOC, and selected 'natural recovery' as the preferred option for restoring the Area of Concern. This recommendation was made recognizing the following important factors:

1. The high cost and uncertainties associated with active intervention/remediation.
2. The achievement of higher overall standards of pulp mill effluent quality from 1997-2008, which allowed water quality to improve.
3. An estimated 30-60 year timeframe (minimum) for recovery.
4. That a closed loop process for treatment of mill effluent would be preferable, but not practical.
5. The necessity to revisit and reassess the remedial strategies.

A ten-year period (1998-2008) allowed time for some natural recovery. During this period the results of ongoing monitoring programs in Jackfish Bay were communicated to the public via sport fish consumption advisories and updates from various Lake Superior advisory committees and the Lake Superior Binational Forum.

1.2.3 2010 Area in Recovery Status

In support of the recommendation to continue with monitored natural recovery and pursue an Area in Recovery recognition for this Area of Concern, Environment Canada, together with the Ministry of Environment and the Ministry of Natural Resources, sought to renew community engagement in the AOC. This was carried out through the establishment of the Public Area in Recovery Review Committee (PARRC) to continue in the role of the original Public Advisory Committee (PAC) and oversee the development of this Area in Recovery Status Report. A draft version of revised delisting criteria for the AOC was created and accepted by the Jackfish Bay Public Area in Recovery Committee (PARRC) in September 2008.

The primary justification for designating the Jackfish Bay AOC as an Area in Recovery is based on the clear community and government consensus that all scientifically feasible and economically reasonable actions have been implemented in the AOC, and additional time is still required for the environment to recover (Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem 2007). Although there is a general lack of clear and consistent evidence to support a complete assessment of the status of all BUIs against their respective delisting criteria, there is evidence to support the delisting of some BUIs and evidence that provides signs of ecosystem recovery in the Jackfish Bay AOC. This evidence can be organized into high, medium and low certainty levels based on the type of evidence collected since the beginning of the RAP process:

1. **High Certainty: Evidence from Primary Data Supporting a Particular BUI**
    - Since Stage 2 of the Jackfish Bay Remedial Action Plan there has been consistent scientific evidence to support delisting the BUI pertaining to fish tumours and other deformities. A number of studies from the 1990s through to 2006 have confirmed that the incidence of fish tumours and other deformities in white suckers caught in Jackfish Bay have declined below Lake Superior reference conditions, and are not considered significant.

2. **Medium Certainty: Evidence from Risk-Based Approaches Supporting a Particular BUI**
    - Through a conservative risk-based approach, the BUIs pertaining to wildlife populations have been designated as not impaired. The risk of contaminants from Blackbird Creek to be taken up by moose in the area was determined to be extremely low.
    - Evidence from recent fish community index netting has indicated that Lake Trout in Jackfish Bay are at levels that resemble lakewide conditions and provide an indication of recovery in the fish population BUI.
    - Bowron (2008) found a reduction in the number of liver neoplasms in whitefish caught in Jackfish Bay during periods of mill closure. These results could indicate improvement in the fish populations BUI. The results also provide secondary data supporting the absence of scars in whitefish and the delisting of the fish tumours and other deformities BUI.

3. **Low Certainty: Evidence from Data Sources Requiring Further Assessment**
    - The current Fish Consumption Restrictions are comparable to reference sites outside of the Jackfish Bay AOC. However, further data needs to be collected from within both the AOC and reference sites during the same year, and particularly tested for dioxins and furans.
    - Further evidence supporting the impairment of aesthetics has not been reported since Stage 2 of the Remedial Action Plan process.
    - There are signs of improvement in the BUIs pertaining to Benthos from the 2003 to 2008 studies. However, this BUI is still impaired and further time is required to assess recovery.
    - Overall, improvements to water quality and sediment quality are evident; however, further monitoring is required to assess the water and sediment quality over time, and differences pertaining to when the mill is operating versus when it is shut down.

In an Area in Recovery the government agencies continue to monitor environmental conditions to assess how well recovery is proceeding. A monitoring plan guides data collection and future actions. In the event that recovery is not occurring as expected, the agencies may consider additional remedial actions. The final delisting of the AOC will begin when monitoring shows that the ecosystem has recovered and delisting criteria have been met. Future monitoring should focus on:

- Reducing the overall data gaps in order to assess BUI status in relation to delisting criteria
- Adding to existing baseline to effectively assess the level of natural recovery over time
- Understanding ecosystem recovery during periods of mill operation vs. mill closure
- Examining the severity of historic contamination in Blackbird Creek, which is highly understudied

2.0 Summary of Activities in Support of the RAP

2.1 Short Term Water Use Goal

Impairments in the Jackfish Bay AOC are attributed to historic effluent discharges from the pulp mill in Terrace Bay, and improving the quality of this effluent has the most bearing on ecosystem recovery. As a result, the only short-term goal that was developed in the Stage 2 RAP report stated that:

> "Discharge of toxins, particularly chlorinated organic compounds, from point sources must be reduced to meet or exceed Federal and Provincial standards." (Jackfish Bay RAP Team, Stage 2, 1998, p. 17)

2.1.1 Regulatory Improvements

When the Remedial Action Plan was initiated in the late 1980s, the mill discharged effluent that was typical for a bleached kraft mill. The effluent produced high Biological Oxygen Demand (BOD) loads, organochlorines, elevated colour and nutrients, and a likely source of toxicity. Federal regulations for pulp mills at this time consisted of the federal Pulp and Paper Effluent Regulations passed under the Federal Fisheries Act that limited BOD and Total Suspended Solids (TSS) discharge as well as the stipulation that the discharge not be acutely toxic to rainbow trout. At the provincial level, the Ministry of the Environment regulated effluent quality through the mill's Certificate of Approval that was issued under the Environmental Protection Act.

Significant regulatory changes occurred through the Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem and a provincial/federal commitment to manage persistent toxic substances. The Ministry of the Environment's Municipal Industrial Strategy for Abatement (MISA) regulations, legislated within the Environmental Protection Act, reduced levels of persistent toxic substances in industrial effluent by requiring that:

- Effluent meet prescribed limits based on a daily (i.e. not to exceed value on any day) and monthly average
- Monitoring frequency demonstrate compliance with the limits
- Effluent not be toxic to fish and water fleas
- Each plant prepare an annual report that is made available to the public
- Each plant submit summary quarterly reports to the ministry
- Incidents of non-compliance be reported directly to the ministry.

The effluent limits and monitoring requirements for the pulp and paper sector came into effect in 1996 and required reductions in BOD, TSS, phophorous, chloroform, toluene, phenol, dioxins, furans, and toxicity for rainbow trout and water fleas, an indicator species that is commonly used in toxicity tests.

The first cycle of the federal Pulp and Paper Environmental Effects Monitoring was completed in 1996. This program requires pulp and paper mills to assess the impacts of their effluent on the receiving environment on a three-year cycle. The federal Pulp and Paper Mill Effluent Chlorinated Dioxins and Furan Regulations under the Canadian Environmental Protection Act, 1999 (CEPA 1999) initiated the industry switch from chlorine bleaching to chlorine dioxide bleaching which effectively removed dioxin from pulp and paper mill effluent. In 2004, the federal government implemented more stringent requirements in its Pulp and Paper Effluent Regulations by amending the Fisheries Act, and in 2008, the Environmental Effects Monitoring requirements were altered to improve efficiency and effectiveness of the program (www.ec.gc.ca/esee-eem).

In accordance with the Provisional Certificate of Approval, Terrace Bay Pulp Inc. is licensed to produce 1372 tonnes/day of bleached pulp with a final finished product of 1372 tonne/day (Environmental Protection Act – Ontario Regulation 760/93. Amendment: O. Reg. 233/07). Within this Act, various parameters and their maximum targets are outlined and the Terrace Bay pulp mill has successfully met these regulations (see Appendix B for maximum targets and actual discharge summaries for each parameter pertaining to the Terrace Bay pulp mill).

2.1.2 Mill Processing/Operation Improvements

Mill operations began in 1948 and produced pulp using a “kraft” process. The kraft process converts wood chips into pulp through a chemical process that entails treatment of wood chips with a mixture of sodium hydroxide and sodium sulfide, known as white liquor. The white liquor breaks down the fibre in the wood and produces pulp, known as brown stock. In response to regulatory requirements, the pulp mill owners made the necessary processing and operational upgrades which have led to reduced toxicity of mill effluent today. Table 2.1 outlines the significant process and operational changes, completed upgrades and mill shutdowns since commissioning of the mill (Bowron, 2008).

The most significant change to the mill was the construction of a secondary treatment facility that began operation in September, 1989. Other major improvements to the water treatment facility at the mill included the change of the chlorine generator, which resulted in the production of elemental chlorine-free pulp, and the modification of the pulping process with the installation of an acid activated bleaching stage.

2.1.3 Improvements to Water Quality during the RAP Process

The majority of the improvements in effluent quality were related to turbidity, total suspended solids (TSS), biological oxygen demand (BOD), acidity/alkalinity (pH), phosphorous (P), metals, phenols, resin fatty acids, chloroform, toluene, and dioxins and furans (Table 2.2). The ability to produce elemental chlorine-free pulp removed detectable dioxins and furans from the effluent and the addition of secondary treatment removed resin acids, reduced the chronic toxicity, and virtually eliminated acute toxicity of the mill’s effluent.

Table 2.1: Timeline for the Changes to the Mill Process and Operation

Year	Change
1948	Mill constructed 320 ADMT hardwood
1958	Chloride dioxide added to bleaching
1973	New recovery boiler circuit
1977	Mill expansion and dry debarking added
1979	Clarifier for alkaline sewer circuit
1981	Major reconstruction after a fire; added condensate stripper turpentine decanter, NGC collection and destruction system, domestic sewage treatment plant and clarifier screening system by-pass
1982	Installed cooling water recycle system for kiln/causticizing area
1984	Spill control completed in #2 mill, improved soap recovery, increased chlorine dioxide substitution, #1 mill dedicated to hardwood, polymer feed system for causticizer additional clarifier and improvements to #2
1985	#2 brownstock closure, spill control system for #1, EO stage added to #2 bleachery, new instrumentation for bleachery to decrease chemical
1986	Completed modification of #1 brownstock washer improved soap recovery, foam control and vacuum improvements
1989	Secondary Treatment installed
1990	Increased chlorine dioxide substitution, hypochlorite replaced with Parcycle
1991	Chlorine strength analyzers added, recirculation piping installed, new chip thickness screening plant and hot water stave replaced
1993	Concentrator for #2 recovery boiler (black liquor); steam operated, two effect concentrator increased liquor concentration and moist, low temperature combustion air from the cascade evaporator; low liquor concentration and moist , low temperature combustion air from the cascade evaporators leads to the formation of TRS compounds; resulted in improved air quality
1994	Replaced 250 m section wooden stave piping
1995	Updated chlorine dioxide generator from the re process to R8 allowing the mill to continually produce elemental chlorine-free (ECF) pulp in both the hardwood and softwood mills and lowering the discharge of chlorinated organics. The diversion pond was created to collect discharged untreated process water in the event of a spill, and serve to collect storm water. No untreated effluent has bypassed the ASB and no reported spills since 1995.
1996	More mature wood (purchased) with less lignin, hence less sulfur lignin by-products
1997	Hydrogen peroxide use started in #2 Mill in bleaching sequence E2 stages
1998	Hydrogen peroxide use started in #2 mill in bleaching sequence E) stages. #1 mill switched production to softwood pulp for periodic short campaigns. October #1 mill switched over to 100% ECF bleaching
1999	# 2 mill switched over to 100% ECF bleaching in April
2000	New brownstock washing showers in September
2003	The mill added an acid activated oxygen bleaching stage in the #2 Bleach Plant resulting in reduced chlorine dioxide consumption and an AOX (total absorbable organic halides) reduction of 47%
2005	Hardwood line shut down April 1^{st}, reducing waste water levels by 30%
2006	Mill shutdown February 20 and reopened
2007	Mill was purchased in the Fall and the Hardwood line reopened
2007	#2 mill decreased operations and it only producing softwood pulp
2009	Mill files for credit protection

Modified from: Bowron, L. 2008. Responses of white sucker (Castostomus commerson) populations to changes in pulp mill effluent discharges. MSc. Thesis. The University of New Brunswick.

2.1.4 Evaluation of Water Quality

The water quality in Jackfish Bay has improved based on the sources of water quality data gathered during the RAP process. Table 2.2 summarizes a comparison of organic and inorganic water measurements taken at the beginning of the RAP process, with measurements taken in the last 5 years (Lee, 2009).

Table 2.2: Changes in Water Quality from the Initiation of the RAP to Present

Parameter	Change 1989 - 2009
Colour	no change
Turbidity	improved
Secchi	no change
Dissolved Oxygen (DO)	improved
Total Suspended Solids (TSS)	improved
Biological Oxygen Demand (BOD)	improved
Conductivity	no change
pH	improved
Alkalinity	no change
Phosphorus (P)	improved *
Nitrogen (N)	quality declined
Cu (Copper)	improved
Cd (Cadmium)	improved
Pb (Lead)	improved
Zn (Zinc)	improved
Ni (Nickel)	improved
Hg (Mercury)	improved *
Phenols	improved
Resin Fatty Acids	improved
Chloroform	improved
Toluene	improved
Halogen (AOX)	improved
Dioxins/Furans	improved
Toxicity	improved

Changes in water quality parameters categorized as either no change, improved, or quality declined (* indicates the parameter is below Provincial Water Quality Objectives).

Problems for water quality and the ecosystem still exist for colour, the potential for eutrophication and from the presence of high levels of dioxins and furans. Given that federal regulations dictate that dioxins and furans in effluent must be non-detectable, it is uncertain if these contaminants originate from the sediments in Blackbird Creek (i.e. Lake C / Moberly Lake). Early data includes a 1981 survey by the MOE detailing the types and concentrations of phenolic compounds in the AOC (Kirby 1986), and data collected by the MOE in 1987 and 1988 (Sherman 1991) covered a detailed assessment of inorganic parameters from July and August of both years as well as May of 1988. More recently, in 2004, the Ministry of the Environment completed a survey of water quality in Lake Superior that provided measurements of inorganic and organic parameters (Richman, 2004). Additional water quality information was also available through the Environmental Effects Monitoring Report (EEM Cycle 4 Report) (Farara, 2007).

Preliminary water quality results from an Environment Canada Sediment study of Blackbird Creek in 2006, 2007 and 2008 indicate that water quality in the AOC continues to meet provincial water quality objectives; however, there is evidence of degraded water quality. For example, in 2008, the dissolved oxygen content was 40% near the inflow of Blackbird Creek, but values dropped drastically to 8% downstream. Other sites in the Blackbird Creek system had dissolved oxygen levels less than 1.2%. In the same year, Environment Canada researchers noted that Moberly Lake had a very distinct brown colour and that the lake was degassing by means of small bubbles across the entire surface (Burniston, unpublished). These values provide strong evidence of conditions of significant sediment oxygen demand (SOD), mainly from historic pulp fibre on the creek bottom. Dissolved oxygen will increase during faster creek flows and decrease to critical values during periods of low flows, creating periodic dissolved oxygen declines in portions of the creek.

The creek and foam were sampled for polycyclic aromatic hydrocarbons (PAHs) and polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCCDD/Fs), and nutrients and major ions were sampled at six sites in Lake C (Moberly Lake). Organic foam sampled in the creek had elevated levels of PAHs and the water of Lake C was very dark brown (resembling cola) and was very still and flat. The mill was closed during the 2006 sampling season and was under reduced operation throughout 2008 (Lee, 2009).

2.1.5 Improvements to Sediment Quality during the RAP Process

The Stage 1 report of the Jackfish Bay Remedial Action Plan indicated that good sediment quality was a fundamental requirement for improving water quality problems in Areas of Concern. It is well known that bleached kraft pulp mill effluents cause adverse effects on sediment quality and sediment dwelling aquatic life (i.e. benthic organisms) in the Great Lakes Basin. Sediment quality alone is not one of the 14 beneficial use impairments listed in the Great Lakes Water Quality Agreement, but is the main source of contamination to the degradation to benthic communities, a beneficial use impairment identified in Jackfish Bay. Several contaminants in the sediment of Jackfish Bay exceed low effects levels (LEL) and severe effect levels (SEL) as outlined by the Provincial Sediment Quality Guidelines (Persaud et al. 2003).

2.1.5.1 Inorganic Contaminants

The Jackfish Bay AOC Stage 1 Report found that the mean concentrations of arsenic, cadmium, chromium, copper, iron, mercury, nickel, and zinc exceeded the Open Water Disposal Guidelines (OWDG) (Persaud and Wilkins, 1976). The same metals, as well as manganese and lead, exceeded Lowest Effect Level of the Provincial Sediment Quality Guidelines for effects on aquatic organisms. Although the mean concentrations of these metals were below the Severe Effect Level of the Provincial Sediment Quality Guidelines in all of the depositional basins of the AOC, maximum concentrations of arsenic, mercury and manganese did exceed the Severe Effect Level in some non- depositional locations.

However, the background metal concentration in sediments of the upper Great Lakes is well known to be quite high relative to the provincial guidelines. Today this is addressed by improved assessment methodologies and guidance in the Provincial Sediment Quality Guidelines document. The metal concentrations described in the Stage 1 Report are now considered consistent with natural reference conditions for Lake Superior.

2.1.5.2 Organic Contaminants

The water-sediment plume from the mouth of Blackbird Creek flows along the western side of Moberly Bay; the plume is deflected in that direction by the predominant east-to-west circulation of water in Jackfish Bay (MOE/MNR, 1991; Farara, 2007). This plume is diluted 5:1 within 500 metres of the mouth of Blackbird Creek and 20:1 at a distance of 3.5 kilometres into Jackfish Bay (Farara, 2007). Periods of strong southerly winds will cause the plume to be vertically mixed, whereas periods of lower wind velocity allow an overflow to develop that extends out of Jackfish Bay reaching a 200:1 dilution off Cape Victoria. This information leads to the prediction that contaminant levels in the sediment should be highest on the west side of Jackfish Bay and decrease towards its mouth.

Monitoring data appear to support this prediction. For example, Milani and Grapentine (2009) found that concentrations of oil and grease were highest in Moberly Bay (7600 mg/L) and substantially decreased in Jackfish Bay (1600 mg/kg) and Tunnel Bay (600 mg/kg). Milani and Grapentine also found that the three samples they had from Moberly Bay with high concentrations of organics had dioxin and furan levels above the non-effect level, whereas one from a sandy site did not. Two sites in Jackfish Bay also exceeded the non-effect level. The dioxins and furans are probably associated with organic material on the bottom of Moberly Bay and Jackfish Bay.

Existing data indicates slow deposition of new sediments in the bay. This means that a considerable time span will be required before the sediment is naturally buried by new material. Also, it is important to note that the new sediment could still contain toxic material washed down from Blackbird Creek, or produce oxygen-depleting conditions during low flow periods.

2.1.6 Long-Term Water Quality Goals and Revised Delisting Criteria

A 2003 report by North-South Environmental Inc. documented the progress made by implementing the Remedial Action Plan and outlined how the water use goals were formulated by the PARRC and government representatives. However, because these goals did not provide clearly measurable and achievable targets for delisting the AOC, they were used only as guidance principles for the development of clearly measureable delisting criteria. Environment Canada and the Ministry of Environment then developed a revised set of quantifiable delisting criteria for assessing and measuring progress towards delisting each beneficial use impairment. These revised delisting criteria are based on the principle of comparison to either:

1) A federal or provincial regulation or guideline,
2) A locally derived risk-based target, or
3) An appropriate reference site outside the AOC. This is a site representative of the local environmental quality which can serve as a baseline for sites within the AOC.

Table 2.3 outlines the chosen delisting criteria for each BUI identified in the Jackfish Bay AOC, followed by a brief description of the long-term water quality goals developed by the PARRC. It should be noted that the delisting criteria provide the measurable and implementable targets from which BUIs will be delisted within the AOC. The long-term water quality goals do not have to be reached within the AOC process, but do provide valued goals from which to design remedial actions and ongoing ecosystem management in Jackfish Bay beyond the scope of the RAP process.

Table 2.3: Water Use Goals and Delisting Criteria for Remaining BUIs in the Jackfish Bay AOC

Beneficial Use Impairments (After The Great Lake Water Quality Agreement, Annex 2)	Delisting Criteria	Long-Term Water Quality Goals
Degradation of Aesthetics	This BUI will no longer be impaired when the waters are devoid of any substance which produces a persistent objectionable deposit, unnatural colour or turbidity, or unnatural odour.	Aesthetic values within the Jackfish Bay AOC must be improved to encourage its use for recreation and to improve its tourism value. All fish caught in Blackbird Creek and Jackfish Bay must be safe to consume at any size and in any number. Fish contaminant levels must be less than or equal to background levels for consumption. Fish Habitat and spawning areas in Blackbird Creek and Jackfish Bay must return to a state conducive to healthy fish populations. The Blackbird Creek / Jackfish Bay fishery must form part of a balanced and healthy aquatic community. Water quality should be improved to the point that Jackfish Bay is no longer an Area of Concern. Blackbird Creek can convey mill effluent provided that it does not impair beneficial uses, inhibit indigenous biota, or produce other adverse effects on the ecosystem. Discharge of toxins must be reduced to meet or exceed Federal and Provincial guidelines. Remove Jackfish Bay as an Area of Concern Maintain present water uses in AOC.
Fish Consumption	This BUI will no longer be impaired when the fish consumption advisories in the AOC are no more restrictive than at an appropriate reference site on Lake Superior.	
Body Burdens of Fish	This BUI will no longer be impaired when a statistical analysis can demonstrate that fish body burdens in Jackfish Bay do not differ significantly from those in the open water reference area.	
Degradation of Fish Populations	This BUI will no longer be impaired when monitoring data shows that the fish community at a population level does not differ significantly from a suitable Lake Superior reference site.	
Fish Tumours and other Deformities	This BUI will no longer be impaired when the fish tumour rates / deformities in Jackfish Bay do not statistically exceed rates in suitable reference sites in Lake Superior.	
Loss of Fish Habitat	This BUI will no longer be impaired when the amount and quality of physical, chemical, and biological habitat required to achieve Lake Superior Fish Community Objectives has been established.	
Dynamics of Benthic Populations	The BUI will no longer be impaired when acute and chronic toxicity of sediment, and composition and densities of benthic communities are statistically indistinguishable from suitable reference sites.	
Body Burdens of Benthic Populations	This BUI will no longer be impaired when invertebrate tissue concentrations are below either (a) levels associated with adverse impacts or (b) invertebrate tissue concentrations at reference sites.	
* See Appendix A for detailed table of the status of beneficial use impairments for the Jackfish Bay AOC		

3.0 The Status of Beneficial Use Impairments in Jackfish Bay

Table 3.1: Status of Beneficial Use Impairment in the Jackfish Bay Area of Concern

Beneficial Use Impairments (After The Great Lake Water Quality Agreement, Annex 2)	Status of BUI – Stage 1 1991	Status of BUI – Stage 2 1998	Area in Recovery Status 2010
Degradation of Wildlife Populations	Requires Further Assessment	Requires Further Assessment	Not Impaired
Body Burdens of Wildlife Populations	Requires Further Assessment	Requires Further Assessment	Not Impaired
Bird and Animal Deformities or Reproductive Problem	Requires Further Assessment	Requires Further Assessment	Not Impaired
Degradation of Aesthetics	Impaired	Impaired	Requires Further Assessment
Fish Consumption	Requires Further Assessment	Impaired	Requires Further Assessment
Body Burdens of Fish	Impaired	Impaired	Requires Further Assessment
Degradation of Fish Populations	Impaired	Impaired	Impaired
Fish Tumours and other Deformities	Impaired	Impaired	Not Impaired
Loss of Fish Habitat	Impaired	Impaired	Impaired
Dynamics of Benthic Populations	Impaired	Impaired	Impaired
Body Burdens of Benthic Populations	Impaired	Impaired	Impaired
* See Appendix A for detailed table of the status of beneficial use impairments for the Jackfish Bay AOC			

3.1 The Current Status of Beneficial Uses

The Stage 2 Remedial Action Plan states that: "It was agreed that the AOC should be monitored for incremental progress with no further intervention at this time" (Jackfish Bay RAP Team, 1998; pg. iv). The report also recommends "continued monitoring of the Jackfish Bay AOC to document effects of historic deposits of contaminated material on the ecosystem." It is important to note that an area-specific monitoring program was therefore not implemented in Jackfish Bay. Instead, existing government programs and methodologies were to be used to interpret the status of beneficial uses over time. The monitoring program was to include, but not be limited to, the following programs:

1. *Surface Water Surveillance Program (Ministry of the Environment)* – to monitor sediment and benthos at least once every ten years as part of their regular program, and at the specific request of the Region.
2. *Environmental Effects Monitoring Program (Environment Canada)* – monitor the effects of the mill on fish, benthos, and sediment and water quality every three years (unless the mill is out of operation greater than 8 months during a monitoring period, wherein the three cycles would restart once the mill becomes operational).
3. *Sport Fish Contaminant Monitoring (Ministry of the Environment)* - monitor contaminant levels in sport fish, at a minimum of every five years and annually assess the need for additional collections.
4. *Superior Lakewatch Monitoring Program (Ministry of the Environment)* – citizen-based monitoring to document water transparency in nearshore areas of Lake Superior.

Monitoring in accordance with the above recommendations was completed with the exception of the Superior Lakewatch Program, which was discontinued. In addition to the programs listed above, the Ministry of Natural Resources, Ministry of the Environment and Environment Canada completed monitoring to assess fish populations, benthos populations, and water and sediment quality. Unlike the routine monitoring programs listed above, some of these programs, such as Environment Canada's Benthic Assessment of Sediment (BEAST), were designed to assess specific beneficial use impairments. Data that are routinely collected with specific study objectives in mind have the most benefit in assessing environmental recovery. For resource efficiency, it is essential that government scientists consider the needs of the Remedial Action Plan when conducting research in Jackfish Bay.

3.2 Beneficial Uses

3.2.1 Degradation of Wildlife Populations

Discussions among the AOC stakeholders reflected concerns that Blackbird Creek might attract wildlife during the spring months based on the rationale that the moderating influence of warm creek water could accelerate greening of creek side vegetation. This could expose wildlife, particularly moose, to mill effluent taken up into the plants. Moose activity was interpreted to be high along Blackbird Creek during the spring when the Stage 1 Report was drafted (1991: p. 141), possibly due to precipitation of salts from the effluent on the creek banks. However, no data on the possible impacts to wildlife populations due to contaminants within Jackfish Bay was available at that time.

In 2010, Environment Canada contracted ENVIRON International Corporation to conduct a focused ecological risk evaluation (ERE) of moose that could forage along Blackbird Creek. The objective of this evaluation was to estimate the proportion of time that individual moose could forage along the creek without significant risk of adverse effects (ENVIRON, 2010). This focused ERE evaluated the risks to moose foraging in or along Blackbird Creek from exposure to chemicals of potential concern (COPCs) present in surface water, sediment, and food items. Based on the available data, the results of this focused ERE suggest that the risk of adverse effects to moose feeding in or along Blackbird Creek is quite low, even if they feed exclusively on a daily basis on aquatic plants within Blackbird Creek (rather than supplementing that with browse from trees and shrubs). Therefore, additional evaluation of risks to moose does not appear to be warranted at this time (See Appendix C for full ENVIRON Report).

The only sign of population degradation for colonial waterbirds in general in Jackfish Bay has been the decline in the number of breeding Herring Gulls. The Stage 2 report included a 10-year study of Herring Gulls (*Larus argentatus*) by the Canadian Wildlife Service, which indicated a decline in the number of nesting pairs in the AOC. Nest numbers in Jackfish Bay have declined from a high of 65 at six colony sites in 1989 to 17 at four sites in 1999 and four nests at two sites in 2000 (Morris, Weseloh, & Shutt, 2003). The decline was believed to be the result of repeated nesting failure, which, in 1991 and 1992, was observed to be the result of repeated predation on eggs and young by Common Ravens (Shutt, 1994). In addition, the CWS study indicated that reproductive failure did not appear to be the result of exposure of either eggs or adults to dioxins or halogenated aromatic hydrocarbons, but was the result of a diet change from primarily fish and insects to varied refuse. The degradation to populations of colonial waterbirds was not attributed to causes that were unique to the AOC.

3.2.1.1 Assessment Against Delisting Criteria

This BUI has never been listed as impaired; a delisting target would only have been developed if data indicated that the BUI was impaired and required action. The recent ERE of moose in Blackbird Creek supports that no impairment has been identified, and there has been no monitoring evidence to date that shows that the wildlife community (at a population level) differs from suitable Lake Superior reference sites. This BUI is now listed as ‘No Impairment Identified’.

3.2.2 Body Burdens of Wildlife

The Stage 1 report identified that there was no information on the bioaccumulation of contaminants in wildlife in the AOC, but it was believed that bioaccumulation was occurring in Jackfish Bay and Blackbird Creek. This BUI was assigned a ‘Requires Further Assessment’ status, with plans of the CWS to complete a blood/tissue analysis for toxins in 1993.

Herring gulls eggs collected within the AOC had relatively low levels of dioxins and other organochlorines; levels were similar to background levels found elsewhere on Lake Superior (Shutt 1994). The toxins that were found in the gull eggs were not associated with mill effluent. Contaminant levels did not represent those of fish-eating gulls. If herring gulls had consumed fish with elevated levels of these toxins from the AOC then they would have accumulated significant body burdens of these compounds.

3.2.2.1 Assessment Against Delisting Criteria

This BUI has never been listed as Impaired; a delisting target would only have been developed if data indicated that this beneficial use was impaired and required action. There has been no evidence to date that suggests that this beneficial use is impaired, and the 1994 data provided by the Canadian Wildlife Service supports listing this BUI as ‘No Impairment Identified’.

3.2.3 Bird or Animal Deformities or Reproductive Problems

This BUI was determined to require further assessment following the Stage 1 report, and the Stage 2 report found that small egg size, low chick survival rate, and the lack of nesting gulls in 1997 indicated a decline in reproductive productivity. However, the Stage 2 report also notes that reproductive impairment in herring gulls over two breeding seasons was comparable to non-contaminated sites in Lake Superior (Shutt 1994 in Jackfish Bay RAP Team, 1991).

Reproductive ability was evaluated for Herring Gulls in 1991 and 1992 (Shutt 1994 in Jackfish Bay RAP Team, 1991) and found to be unsuccessful, but for reasons unrelated to local sources of pollution. This nesting failure was due to heavy predation on near-term eggs and very young hatchlings by common ravens. Thus, it has been determined that the reproductive success of colonial waterbirds was not affected by pollution in the AOC.

The 10 eggs collected in Jackfish Bay in 1991 contained relatively low levels of 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD-dioxin) as compared to other sites on the Great Lakes. Levels of other organochlorines, including p,p' DDE (1,1,1-trichloro-2,2-bis (p-chlorophenyl) ethane), mirex, dieldrin and oxychlordane, were also low. The geometric mean of the sum of 42 Polychlorinated biphenyls (PCBs) congeners was 5.0 mg/kg wet weight, below mean egg levels for most Great Lakes sites. As well, a pooled extract of eggs collected in Jackfish Bay was added to a chick hepatocyte bioassay. Ethoxyresorufin-O-deethylase (EROD) induction was not elevated above background levels, indicating that the eggs were not significantly contaminated with known inducing compounds, including the non-ortho substituted PCBs (Shutt 1994).

Today there are insufficient numbers of colonial waterbirds nesting within Jackfish Bay to make an assessment on the occurrence of deformities. The species most consistently used for deformity assessment is the double-crested cormorant and it does not nest in the area at all. The Herring Gull is an inadequate substitute, and its numbers are too low to be sufficient for such an assessment.

3.2.3.1 Assessment Against Delisting Criteria

This BUI has never been listed as impaired; a delisting target would only have been developed if data indicated that its status was impaired and required action. The poor reproductive success of herring gulls is attributed to natural causes (predation by common raven) rather than human causes (mill effluent). It has not been demonstrated, either currently or historically, that avian wildlife in Jackfish Bay is impaired with respect to the occurrence of deformities. However, data about deformities in the AOC is limited at best and this BUI warrants a follow up study to confirm the not impaired status is still relevant today.

3.2.4 Degradation of Aesthetics

The status of aesthetics has been impaired since Stage 1. At this time, the PAC noted that aesthetics had been continually improving since the early 1970s; however, there were still concerns about the presence of foam and the dark colour in Blackbird Creek and Moberly Bay. Stage 2 continued with an impaired status as conditions had not fully recovered to the satisfaction of the PAC.

Although there have not been any further complaints or reports of degraded aesthetics, it is a common occurrence to detect odour, foam and steam from locations in the AOC. These occurrences are most common in Lake 'C' (Moberly Lake) and Blackbird Creek.

3.2.4.1 Assessment Against Delisting Criteria

This BUI will no longer be impaired when the waters are devoid of any substance which produces a persistent objectionable deposit, unnatural colour or turbidity, or unnatural odour (such as an oil slick or surface scum). Further assessment is required to confirm that aesthetics are not impaired. The BUI is listed as 'Requires Further Assessment'.

3.2.5 Restrictions on Fish Consumption

This impairment was noted in Stage 1 because the 1991 Guide to Eating Ontario Sport Fish (MOE, 1991) included consumption restrictions for lake trout greater than 55 centimetres due to concentrations of dioxins and furans. Lake trout greater than 65 centimetres in length, and whitefish, cisco and white sucker greater than 45 centimetres in length were also restricted due to mercury and polychlorinated biphenyl (PCB) concentrations.

Improvements in the mill's manufacturing processes (see Section 2.1.2) and the addition of secondary treatment improved water quality; however, dioxin increases in lake whitefish suggested that further improvements to water quality may be warranted (Jackfish Bay RAP Team, 1998). In Stage 2 the RAP team listed fish consumption as impaired because consumption restrictions had increased since Stage 1. The Ministry restricted consumption of lake trout over 45 centimetres because of toxaphene levels (not due to mill effluent) and restricted consumption of lake whitefish over 55 centimetres because of dioxin levels. It should be noted that toxaphene is an insecticide, which was never used in the Great Lakes area (Canadian Water Quality Guidelines, 1987) and is not a product of the mill's effluent. Toxaphene was used in the cotton fields of the southeastern U.S., but has been banned since 1986. Any levels in the Great Lakes are likely the result of long range aerial transport of historical contamination.

3.2.5.1 Assessment Against Delisting Criteria

The current consumption restrictions in Jackfish Bay continue to be caused by dioxin-like PCBs (dlPCBs)/dioxins/furans, total-PCB and mercury (Table 3.2). These restrictions apply to lake trout, whitefish, longnose sucker and burbot in Jackfish Bay, which is defined as Block 8 (Figure 3.1 and Table 3.4). Fish consumption advisories continue to be published by the Ministry of the Environment every other year through the *Guide to Eating Ontario Sport Fish,* and restrictions are noted for both general and sensitive populations (women of childbearing age and children under the age of 15) (Ministry of the Environment, 2009). The advisories published in the guide for Jackfish Bay and a reference area can be compared to assess current status of restrictions on fish consumption.

Jackfish Bay is located in Block 8 and the Schreiber/Sewell Point area located in Block 7 serves as a suitable reference area.

Figure 3.1: Sampling block locations for Lake Superior as defined by the Ministry of the Environment Sport Fishing Contaminant Monitoring Program

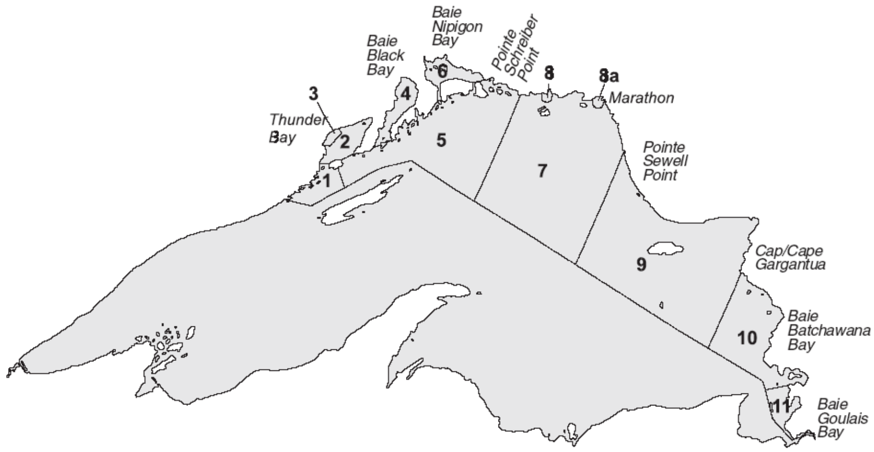


Table 3.2: List of fish consumption restrictions for the Jackfish Bay (Block 8) for general and sensitive (women of child-bearing age and children under 15) populations (MOE 2009)

Sampling site/block	Species	Contaminant	Size	Degree of Restriction
Jackfish Bay (Block 8)	Lake trout	Dioxins	45-65 cm	GP - 4 meals/month
			45-65 cm	SP - 4 meals/month
	Whitefish	Dioxins	50-60 cm	GP - 4 meals/month
			50-60 cm	SP - 4 meals/month
			60-65 cm	GP - 2 meals/month
			60-65 cm	SP – Do not eat

Dioxins include dioxin-like PCBs. Abbreviations- GP=General Population, SP=Sensitive Population

Table 3.3: List of fish consumption restrictions for the open water reference area, Schreiber/Sewell Point area (Block 7) (MOE 2009)

Sampling site/block	Species	Contaminant	Size	**Degree of Restriction**
Schreiber/ Sewell Point area (Block 7)	Lake Trout	Dioxins	50-55 cm	GP - 2 meals/month
			55-60 cm	GP - 1 meals/month
			>60 cm	GP - Do not eat
	Whitefish	Dioxins	50-65 cm	GP - 2 meals/month
			50-65 cm	SP - Do not eat

NOTE: The same abbreviations are used as in Table 3.2.

Table 3.4 Fish Consumption Restrictions (meals/month) for the Jackfish Bay (MOE 2009)

a) General Population

<table>
<tr><th></th><th>15</th><th>20</th><th>25</th><th>30</th><th>35</th><th>40</th><th>45</th><th>50</th><th>55</th><th>60</th><th>65</th><th>70</th><th>75</th><th>>75cm</th></tr>
<tr><td colspan="14">Lake Trout</td></tr>
<tr><td>Block 8 (Jackfish Bay)</td><td></td><td></td><td></td><td colspan="3">8</td><td colspan="4">4</td><td></td><td></td><td></td></tr>
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<tr><td colspan="14">Whitefish</td></tr>
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<tr><td colspan="14">Round Whitefish</td></tr>
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<tr><td colspan="14">Longnose Sucker</td></tr>
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<tr><td colspan="14">White Sucker</td></tr>
<tr><td>Block 8 (Jackfish Bay)</td><td></td><td colspan="6">8</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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b) Sensitive Population

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<tr><td colspan="14">Whitefish</td></tr>
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<tr><td colspan="14">White Sucker</td></tr>
<tr><td>Block 8 (Jackfish Bay)</td><td></td><td colspan="6">8</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Block 7</td><td></td><td></td><td></td><td></td><td></td><td colspan="3">4</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Note: Sensitive Population refers to women of child bearing age and children under 15 years of age.

This BUI will no longer be impaired when the fish consumption advisories in the AOC are no more restrictive than at an appropriate reference site on Lake Superior. Data show that Jackfish Bay advisories are less stringent than advisories in the open water Schreiber/Sewell Point. However, the advisories for Jackfish Bay are based on 2009 measurements while data from Schreiber/Sewell Point are at least five years old (MOE, 2009), because samples were not collected in each area for the same year. Analysis should be conducted on data collected from both sites during the same year. Based on the need for this additional information, the beneficial use impairment has been listed as ‘Requires Further Assessment’.

3.2.6 Body Burdens of Fish

Body burdens of fish were impaired in Stage 1 because white suckers were found to have bioaccumulated tetra-chlorinated dibenzo-p-dioxins (TCDDs) and tetrachlorodibenzofurans (TCDFs) from water and sediment contaminated by the mill effluent. In Stage 1 and 2 lake trout sampled in 1989, 1990, and 1992 had low concentrations of mercury, hexachlorobenzene and several chlorinated pesticides, and were found to have PCB levels that exceeded the Great Lakes Water Quality Agreement (GLWQA) Specific Objective for the protection of fish-eating wildlife. Atmospheric inputs are believed to be the contributing factor since there are no known local sources of contaminants, such as chlorinated pesticides. Additionally, improvements in mill processes have improved water quality since the discharge of toxins, particularly chlorinated organic compounds, from point sources (the mill) have been reduced to meet or exceed Federal and Provincial guidelines; however, the levels of dioxins in lake whitefish have still increased. This could be a result of lakewide issues and not due to dioxin concentrations originating from the AOC.

3.2.6.1 Assessment Against Delisting Criteria

Mercury levels and PCB concentrations in lake trout and lake whitefish (Figs. 3.2, and 3.3) have declined in Jackfish Bay (Block 8) and in Schreiber/Sewell Point (Block 7), which serves as an open water reference area. Limited samples were analyzed for dioxins/furans in Jackfish Bay and Schreiber/Sewell Point and there are some data gaps during the 1990s for Jackfish Bay (Block 8) and lack of historical data (prior to 2000) for Schreiber/Sewell Point (Block 7). This limits the long-term comparison of fish contaminant levels for the two blocks. However, the dioxin/furan measurements that do exist over the last decades suggest significant decline in the fish contaminant levels for Jackfish Bay.

To remove the Jackfish Bay body burdens of fish from an impaired status, a statistical analysis is required to demonstrate that fish body burdens in Jackfish Bay do not differ significantly from those in the open water reference area. Such an analysis could be performed by pooling the 10 years' worth of data collected by the Ministry of the Environment in order to provide comparisons from the AOC and a suitable reference site for the same years. While this could be possible with mercury levels and PCBs specifically, a similar analysis for dioxins/furans may not be possible because there is insufficient data for Block 7 and Block 8 from over the past decade. In this case, new samples should be collected from both Jackfish Bay and the Schreiber/Sewell Point reference site during the same years and analyzed for dioxin/furan concentrations.

Figure 3.2: Average concentrations of Hg, PCB and dioxin/furan in 55-65 cm lake trout from Jackfish Bay (block 8) and Schreiber/Sewell Point area (block 7)

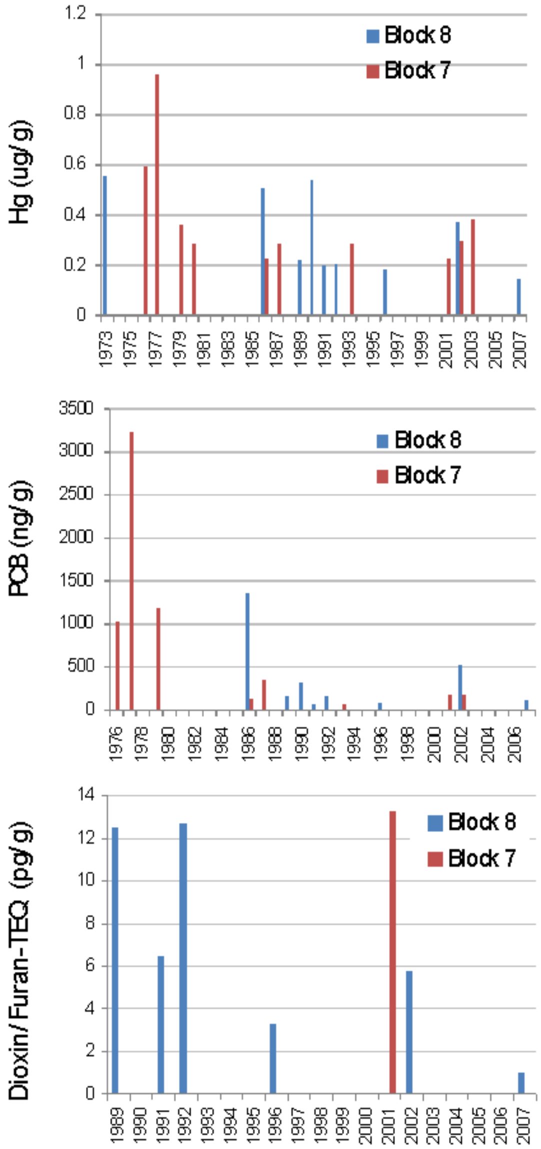
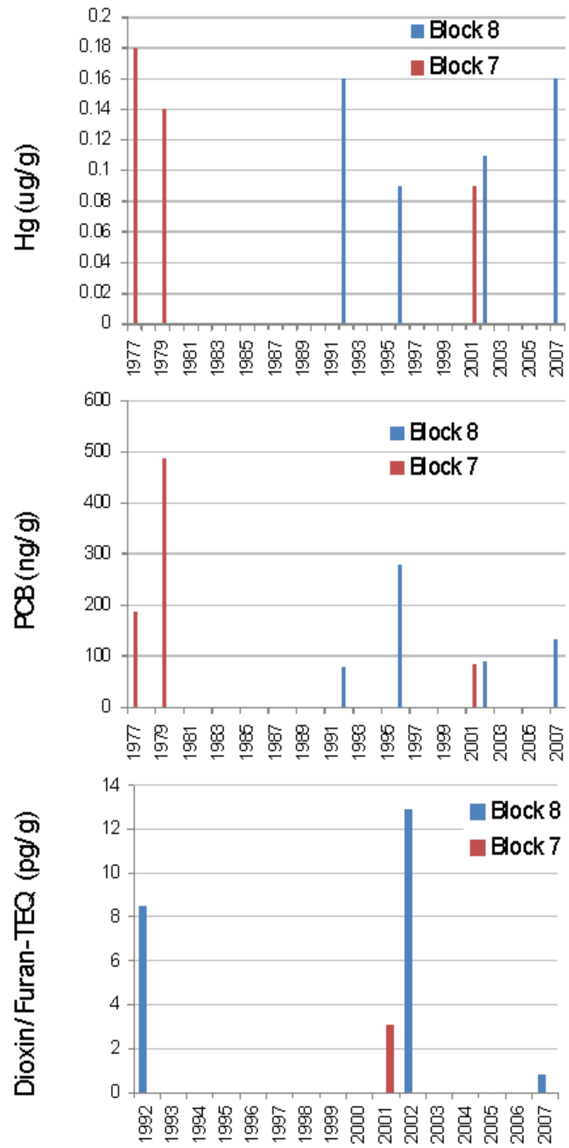


Figure 3.3: Average concentrations of Hg, PCB and dioxin/furan in 50-60 cm lake whitefish from Jackfish Bay (block 8) and Schreiber/Sewell Point area (block 7)



3.2.7 Degradation of Fish Populations

Prior to installation of secondary effluent treatment by the mill in October of 1989, Blackbird Creek fish populations had been totally eliminated as a result of the pulp mill effluent. Similarly, fish populations in Moberly Bay, in the vicinity of Blackbird Creek, had been estimated to have been severely reduced (Hamilton, 1987) and laboratory toxicity tests simulating surface waters up to 1.5 kilometres from the creek mouth indicated that high fish mortality could result from the levels of toxicity found in these waters. Results from laboratory toxicity testing since this time indicate that mill effluent at the outflow pipe is no longer acutely lethal. The Stage 2 report listed the fish populations BUI as impaired with potential signs of improvement, as brook trout and fathead minnows were captured in the creek in 1995. More recently, three-spined stickleback and fathead minnows have been collected in Moberly Lake (Lake C) (McMaster, Pers. Comm.).

3.2.7.1 Assessment Against Delisting Criteria

Since the Stage 1 listing of this BUI, fish population data from within the Jackfish Bay AOC is limited. A 2001 lake trout index netting project compared sites in and around Jackfish Bay and the surrounding waters and indicated that the relative abundance of lake trout in Jackfish Bay is higher than sites outside of the bay. The conclusion of the report indicates that the relative abundance in Jackfish Bay is consistent with a rehabilitated lake trout population (Chong, unpublished). However, this BUI continues to be listed until a more complete inventory of fish community data is available.

Long term studies on target fish species in Jackfish Bay show that exposure to mill effluent causes reproduction alteration (e.g. delayed sexual maturity, reduced gonad size) (Bowron, 2008). There has been a gradual improvement in the condition and organ size of fish since the mid-1990s following the installation of secondary treatment and major changes in the pulping process. During the last few years the mill has experienced multiple closures (ranging in duration from several weeks to many months), and there has been marked improvement in the white sucker populations during these closures. However water quality issues resulting from mill effluent continue to cause reproductive problems (Bowron, 2008).

This BUI will no longer be impaired when monitoring data shows that the fish community at a population level does not differ significantly from a suitable Lake Superior reference site. This BUI requires further assessment to better understand the rate of recovery in the fish community.

3.2.8 Fish Tumours and Other Deformities

This BUI was identified in Stage 1 as impaired because of the abnormal incidence of liver neoplasms (cancers) on white suckers that were collected in Jackfish Bay prior to the implementation of secondary effluent treatment (Munkittrick et al. 1992, Beak 1996, Stage 2). The Stage 1 report states that greater than 20 percent of the lake whitefish in Jackfish Bay had unexplainable external lesions which may be associated with pollutants from the mill effluent. Although there was a higher incidence of liver cancer in the AOC (4-6%) as compared with the rest of Lake Superior (2-3%), it was considered low. Liver enzyme activity remained elevated in white suckers exposed to mill effluent. Increased liver size in lake white fish (Munkittrick, McMaster, Portt, Van Der Kraak, Smith, & Dixon, 1992) and white suckers (Beak Consultants, 1996) had also been reported. These results lead to the impairment of this BUI.

Table 3.5. Neoplasm prevalence in white suckers documented from studies carried out from 1985-90 (Baumann et al. 1996), including sample size for external tumors (E) and for liver tumors (L).

Location	Thunder Bay	Jackfish Bay	Mountain Bay
Sample Size	E=199; L=112	E=300; L=194	E=304; L=75
External Neoplasm %	2.5%	7.6%	3.6%
Liver Neoplasm %	7.1%	7.2%	2.6%

3.2.8.1 Assessment Against Delisting Criteria

White suckers were collected in Jackfish Bay, Thunder Bay and the Mountain Bay reference site in 2006 using electrofishing, gill nets, and trap and hoop nets. Neoplasms were rare and all three locations had a smaller percentage of fish with neoplasms than they had in the late 1980s. Liver neoplasm prevalence declined by over 7% in Jackfish Bay from 1985-2006. The incidence of tumours was not statistically different from the Mountain Bay reference site in the proportion of the population with liver neoplasms. Fisher's Exact Test demonstrates that the liver neoplasm prevalence in the 2006 sample was significantly lower ($p<0.01$) that in the sample from the 1980s used in the Stage 1 report for the Jackfish Bay AOC (Baumann, n.d. Unpublished Report).

Table 3.6 Upper Great Lake AOCs (Thunder and Jackfish Bays and the St. Clair River) and reference locations (Mountain Bay and Lake Huron) tumor prevalence, and the significance of differences between AOCs and reference sites (Baumann, Unpublished Report).

Location	Sample Size	Neoplasm #	% Neoplasms	Significance
Thunder Bay	100	2	2%	None
Mountain Bay	100	0	0%	
Jackfish Bay	100	0	0%	None
Mountain Bay	100	0	0%	

(Source: Baumann, Unpublished Report)

As cited in section 3.2.7.1, under the degradation of fish populations BUI, the Bowron (2008) study indicates that liver size in white suckers has improved in the years the mill experienced multiple closures (ranging in duration from several weeks to many months). Additionally, scars on lake whitefish were not seen in any large numbers in these samples, and the small number of scars detected were comparable to whitefish caught in the Mountain Bay reference site.

The status of this beneficial use impairment can now be considered 'Not Impaired' because the fish tumour rates and other deformities in Jackfish Bay do not statistically exceed rates in suitable reference sites in Lake Superior.

3.2.9 Loss of Fish Habitat

Stage 1 noted that major lake trout spawning grounds had historically been located in Moberly Bay and along the lake shore adjacent to Jackfish Bay and were impaired due to physical alteration (deposition of organic matter) and chemical contamination of sediments. Lake whitefish spawning grounds were identified along Lake Superior's shore immediately east and west of Jackfish Bay. The quality of those shoals had not been assessed. Blackbird Creek had been noted as a brook trout stream prior to the start-up of the mill in 1948.

At Stage 2, the status was still considered impaired from the data summarized in Stage 1. Habitat mapping indicated spawning, nursery, and forage habitat in the Blackbird Creek system; however, water quality in the creek and in Moberly Lake remained impaired. Lake whitefish and lake trout spawning and nursery habitat was located on the eastern shore of Jackfish Bay, and had also been identified in Moberly Bay and the eastern end of Tunnel Bay. However, lake trout stocks were virtually wiped out in the 50s and 60s and there is no reason to expect that newly rehabilitated populations would use historically recognized habitat sites.

3.2.9.1 Assessment Against Delisting Criteria

Much of the data collected to date has been from non-AOC specific programs that utilized a range of methodologies based on the program objectives. As a result, much of the available data for assessing the BUI status of fish habitat is insufficient for a complete community composition survey. Fish population status may be a more effective measure of fish health in the AOC.

This BUI will no longer be impaired when the amount and quality of physical, chemical, and biological habitat required to achieve Lake Superior Fish Community Objectives has been established. The Ministry of Natural Resources' community index netting program could provide a primary source of effective data to be directly applied to decision-making pertaining to the fish habitat BUI.

3.2.10 Dynamics of Benthic Populations

Historically, mill effluent discharged through the Blackbird Creek had a negative impact on benthic communities. Impaired communities were increasing in number and extent between 1969 and 1987. During that period, pollution-intolerant species (*Diporeia,* formerly known as *Pontoporeia hoyi*) have decreased in density and extent, with pollution tolerant species (tubificid worms) increasing in density and extent. Sediments in Moberly Lake (Lake C) were found to be acutely toxic to benthic fauna (Jackfish Bay RAP Team, 1991).

The 1969 survey (Beak Consultants, 1988) of Jackfish Bay indicated areas of low density and diversity, particularly at the mouth of Blackbird Creek. The pollution-tolerant species constituted 13% of the community. A gradient of species and abundance occurred across the bay to the control area (Tunnel Bay) where the community was composed of pollution-intolerant species. A distinct difference in benthic communities, clearly related to effluent from the Terrace Bay mill, already existed in 1967.

By 1975 conditions were deteriorating further. The distribution and abundance of the pollution-tolerant species was increasing. The pollution-tolerant species now constituted 21% of the community. As well, the pollution-intolerant species was decreasing in abundance or even absent from some locations near the mouth of Blackbird Creek where this amphipod had been found previously.

Deterioration of Jackfish Bay continued until 1987. The pollution-tolerant species had increased to 48% of the community. In one sample, the pollution-tolerant species were found at densities up to 196,000/m², which was comparable to the impacted benthic community found in Toronto Harbour. The pollution-intolerant species had continued to decrease.

Stage 2 reported that secondary treatment installation at the mill (1989) had improved both density and extent of benthic organisms. Moberly Lake sediments remained acutely toxic to benthic fauna. Resuspension of sediments could severely impact the downstream benthic communities. This BUI remained at an impaired status following Stage 2.

3.2.10.1 Assessment Against Delisting Criteria

The benthic community structure has been studied to assess the effects of mill effluent in Jackfish Bay. The degree of benthic community degradation has been used to track improvement in benthic community, which provides direct evidence of improvement in mill operations. In a 2003 study (Milani and Grapentine, 2007), benthic impairment was evident, most notably in Moberly Bay, with the presence of pollution-tolerant benthic communities and sediment toxicity. Relative to 1987 historical data, pollution-intolerant species appeared to have increased in number and distribution in Jackfish Bay, while the pollution-tolerant species appeared to have decreased, suggesting some benthic improvement. However, Jackfish Bay still showed a gradient of degradation from the mouth of Blackbird Creek to the more distant locations attributable to historical mill effluent. 6 of 15 sites in Jackfish Bay were considered different to very different compared with reference condition at sites selected from around Lake Superior (n = 30).

The benthic community was also assessed with surveys in 1996, 1999, and 2002, which were the result of three separate EEM cycles (1-3) (Stantec, 2004). In 2003, Milani and Grapentine (2007) reported pollution-intolerant species present at very low densities at sites closest to the mouth of Blackbird Creek. Farara's (2007) follow up study in 2006 showed that the benthic communities were considered virtually identical to those found during the 2003 study. The first signs of recovery were documented in the 2008 study by Milani and Grapentine (2009). Sites included 9 stations in Moberly Bay, 4 stations south of Moberly Bay, 1 station in Jackfish Bay, and 1 reference site in Tunnel Bay. 7 of the 15 sites had been previously sampled in Environment Canada's 2003 study (Milani and Grapentine, 2007).

This BUI is considered impaired. The BUI will no longer be impaired when acute and chronic toxicity of sediment, and composition and densities of benthic communities are statistically indistinguishable from suitable reference sites.

3.2.11 Body Burdens of Benthic Populations

Historically, mill effluent discharged through Blackbird Creek resulted in the bioaccumulation of contaminants in benthic invertebrates. Mussels (*Elliptio complanata*) caged in Moberly Bay for 21 days in 1993 showed dioxin and furan body burdens indicating mill effluent to be the major source (Hayton & Hollinger, 1993). Similarly, resident populations of opossum shrimp (*Mysis relicta*) had body burdens of dioxins and furans at concentrations approximating those contained in mill effluent (Jackfish Bay RAP Team, 1998; Sherman, Clement, & Tashiro, 1990). Body burden assessment showed that both opossum shrimp and mussels had a dioxin and furan congener pattern similar to that of the mill effluent. The dominant isomer was 2,3,7,8-tetrachlorodibenzofuran with traces of other congeners including 2,3,7,8-tetrachlorodibenzo-p-dioxin (Jackfish Bay RAP Team, 1991).

3.2.11.1 Assessment Against Delisting Criteria

In a 2003 survey, all sampling sites exceeded the provincial Lowest Effect Level limits for metals in sediments (Milani & Grapentine, 2007). These high concentrations of metals simply reflect local geology and are probably not affecting the health of the benthic community.

However, some organic contaminants in the sediment are toxic and likely to originate from the effluent. Concentrations in near-field sites in Moberly Bay exceeded Probable Effect Levels, whereas some far-field sites only just exceeded the PEL. Polycyclic aromatic hydrocarbons were detected at concentrations below the Lowest Effect Level (LEL) (4000 ng/g) at all the sites. Polychlorinated biphenyls do exceed LEL at some sites in Moberly Bay, but decrease to concentrations below detection with distance southward to the far far-field sites. Solvent extractables decrease with distance southward from Moberly Bay. Organochlorine pesticides were detected at low concentrations in Moberly and Tunnel Bay.

The effluent from the Terrace Bay mill meets all federal and provincial standards. By 2006 the effluent quality in terms of sub-lethal toxicity had not changed notably over the last two cycles of environmental effects monitoring. Four samples showed sub-lethal effects (Farara, 2007). Notable change in sub-lethal toxicity may be expected because the effluent chemistry changed during the last two EEM cycles. Effluent toxicity has remained relatively constant overall; however, differences in biological oxygen demand (BOD), total suspended sediments (TSS) and absorbable organic halogens (AOX) have improved (See Appendix B).

Benthic invertebrates were collected from 6 locations in Jackfish Bay and from 5 reference sites (north shore of Lake Superior) in October 2008. Analysis of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (dioxins and furans) are to be performed on samples composed of organisms from 2 or 3 taxa (i.e., oligochaetes, chironomids and amphipods). Sites in Jackfish Bay included 3 locations in Moberly Bay, 1 south of Moberly Bay, 1 in Jackfish Bay and a single reference site in Tunnel Bay. These sites were sampled in 2003 by Environment Canada (Milani and Grapentine (2007).

Dioxin and furan concentrations in the benthos collected from Jackfish Bay from the October 2008 study were compared to those from the local (Tunnel Bay) and regional (Lake Superior) reference sites. Concentrations, expressed as toxic equivalents (TEQs), were also compared to the CCME Tissue Residue Guidelines (Milani and Grapentine, 2009). One site was severely toxic and two sites were potentially toxic. Twelve sites were considered non-toxic. Toxicity was less severe in Moberly Bay in 2008 than in 2003, possibly indicating that recovery is ongoing; however, some sediments were still toxic to benthos.

This BUI will no longer be impaired when invertebrate tissue concentrations are below either levels associated with adverse impacts (such as potential effects in predator species due to biomagnification) or invertebrate tissue concentrations at suitable reference sites. Impairment of benthos is associated with discharges of effluents from a pulp mill to Blackbird Creek, which flows into Moberly Bay.

4.0 Monitoring Recommendations

The following chapter summarizes the monitoring recommendations provided by the Lakehead University scientific review committee for the future monitoring of beneficial use impairments in the Jackfish Bay Area of Concern. Scientific reviewers were asked to review the existing baseline studies that have been conducted to date to assess each BUI since Stage 1 and comment on the effectiveness of replicating similar techniques or provide additional/alternative techniques that may better assess each BUI over time, and indicate the level of recovery in Jackfish Bay. Specifically, reviewers were asked to recommend monitoring techniques that would build off of the existing baseline data and increase the ability to assess beneficial use impairments as they relate to the point source of pollution in the AOC (i.e. mill effluent). Although the delisting criteria for many of the Jackfish Bay BUIs can be delisted when their condition resembles that of a suitable Lake Superior reference site, the recommendations that follow are based on the assumption that it is necessary to use monitoring techniques that help to determine ecosystem recovery from the impacts of mill effluent being released into Jackfish Bay.

Thus, it is important that a future monitoring program clearly articulates the goal of monitoring in an Area in Recovery. The goal of Recommendation Option #1 is to assess BUIs and compare them to lakewide conditions; the goal of Recommendation Option #2 is to understand ecosystem recovery from the impacts of the mill effluent. This is an important distinction because, under Option #1, delisting could occur as a result of deteriorating lakewide conditions, in which case the impacts of the mill effluent on a particular BUI may not be accounted for. Under Option #2, monitoring techniques seek to understand the level of impairment/recovery as a result of the mill effluent.

It must be made clear here that the recommendations were made by individuals unfamiliar with government budgets and mandates that dictate the implementation of monitoring in the AOC. The reviewers are not experts in the management of the Remedial Action Plan process and were not asked to consider techniques that fit within existing government programs and priorities. Instead, the reviewers prepared their monitoring recommendations with an expert understanding of the tools and techniques that currently exist to rigorously assess ecosystem dynamics, regardless of cost or resources. In situations where government programs cannot implement such recommendations, it should be recognized that regionally-based academic institutions do have the expertise, equipment and shared responsibility to carry out such methods to determine the impacts of the point sources of pollution in the AOC. In cases where monitoring recommendations go beyond the scope and practicality of government programs, these institutions should be approached as partners to assist future monitoring programs.

4.1 Recommendations: Restrictions on Fish Consumption and Body Burdens of Fish

The Ministry of the Environment has fish consumption advisories dating back to the 70s and the consumption guidelines have changed over the years. For example, dioxin and furan concentrations (produced by the mill) were the main contaminants of concern during Stage 1 of the Remedial Action Plan; toxaphene (a lakewide issue) was added during Stage 2; and today, mercury and PCB concentrations (a lakewide issue) are the primary cause of fish consumption restrictions and fish body burdens in Jackfish Bay. Since mercury and PCBs are the main health concern, limited samples have been analyzed for dioxin and furan concentrations in recent years.

<u>Recommendation Option #1</u>:
It is understood that the delisting of these BUIs can be achieved when the fish consumption restrictions and fish body burdens in Jackfish Bay are no more restrictive or different than an appropriate reference site, regardless of the contaminant that caused the fish consumption restriction (i.e. lakewide contaminant or AOC contaminant). Since the current fish consumption advisories for Jackfish Bay are based on 2009 measurements, while data from the reference site are at least five years old (MOE, 2009), analysis could be conducted on data collected from both sites during the same year to achieve the stated delisting criteria. This could be achieved by performing a statistical analysis that pools the last 10 years worth of data collected by the Ministry of the Environment and shows similar results (or better) in the AOC in

comparison to the reference site for the same years. This could be possible with levels of mercury and PCBs, but would not provide lakewide contaminant data to support the delisting of a BUI listed in Stage 1 as a result of dioxins and furans (presumably from mill effluent).

The current criteria for delisting, therefore, does not provide insight about the level of recovery occurring as a result of dioxin and furan concentrations from the mill effluent (AOC issue). If future monitoring is intended to track the recovery of BUIs originally affected by mill effluent, then this BUI should be reassessed using Option #2 and a new delisting criterion that specifies that dioxin and furan concentrations be compared between the AOC and the reference site.

Recommendation Option #2:
The following recommendations for monitoring the fish consumption restrictions BUI and the fish body burdens BUI are intended to reduce the data gap in assessing these BUIs as they relate to the source of pollution found in the AOC.

A temporal trend analysis on contaminant body burden can be used as a surrogate for the assessment of temporal changes in the advisories. It is advisable to continue monitoring of dioxin and furan contaminant burden in fish from the Jackfish Bay and Schreiber/Sewell Point area as part of the Ministry of the Environment sport fish consumption advisory program. Monitoring fish consumption restrictions as a result of the mill effluent requires an analysis of tissue contaminant concentrations that can be compared between two distinct populations of fish: fish of Jackfish Bay, and fish from an appropriate reference population. In order to meet statistical assumptions for an inferential comparative analysis, the two populations must be independent from one another, and apart from the ambient exposure conditions (i.e., the property of interest) all other factors should be equal (or, as close to equal as reasonably possible). However, it is very difficult to know with certainty if the sampled tissues were taken from fish in the same population.

If time and resources allow for a more rigorous study design there are techniques available to help resolve this uncertainty. For example, stable isotope analysis and (or) parasite community analysis are commonly used to establish distinct fish populations. Given that environmental contaminant concentrations can vary widely over relatively short timeframes, the two alleged comparative populations must be sampled in the same season. As well, sample sizes should be suitable to achieve statistical power appropriate to tissue contaminant variability and the size of effect (i.e., contaminant concentration difference between study and reference fish tissues) that would warrant a change in the BUI criterion.

4.2 Recommendations: Degradation of Fish Population

The Stage 1 report was submitted in 1991 and included results collected by researchers working in Jackfish Bay since 1983. These researchers provided a range of data that represented aspects of both fish health and fish community to interpret the impacts of mill effluent on fish populations. Today the delisting criteria for this BUI addresses fish community characteristics of fish populations only. The delisting criteria states that this BUI will no longer be impaired when monitoring data shows that the fish community at a population level does not differ significantly from a suitable Lake Superior reference site. This delisting criteria adequately reflects the status of the fish community in the AOC, but may not reflect fish health as a result of the mill's effluent.

Recommendation Option #1:
As stated in section 4.1, the delisting criteria for this BUI can be technically achieved by comparing the AOC community conditions to a reference site. If the technical delisting of this BUI is desired then the continued data collection by the Ministry of Natural Resources' community index netting program in Jackfish Bay may be adequate, although it may only speak to lakewide conditions. New data from this program can be compared to the 2001 community index data to prove that AOC fish populations at a community level are similar to a suitable reference site.

However, an understanding of the level of recovery to fish health from changes in the mill effluent is needed to understand the impacts of the mill on fish health and fish populations since Stage 1. Further data collection techniques are required and new delisting criteria should include reference to the health of fish populations affected by the mill as compared to fish populations unaffected by the mill. These techniques and recommendations are provided below.

Recommendation Option #2:
Stage 1 identified the degradation of fish populations (fish health and fish community) according to the following: species identification and body measurements after electrofishing; acute toxicity testing using vertebrates and invertebrates; measurement of MFO activity; measurement of organochlorine and metal concentrations in fish; and sublethal effects of mill effluent on fish growth and development. The Stage 1 data also represents a survey of the fish community in the area of the AOC prior to implementation of secondary treatment in 1989. This data can provide a baseline value for determining the natural range of variation in fish size seen in the AOC at the time of the research. However, the same data is not necessarily available for all EEM cycles, as the endpoints used have changed over time. Currently, they include age, condition factor (K), liver weight (LSI), body weight at age, and gonad weight (GSI).

Given the fact that there is a wide range of control data required to understand fish health in Jackfish Bay, choosing one or more ecologically-relevant control sites may help reduce the variability caused by this range. Tunnel Bay (or another location closer to Moberly Bay) that may share many of the ecological features of Moberly Bay could be used, as effluent concentrations there appear to be much less than 1% (Farara, 2007). However, this may only be appropriate for small-bodied fish species (i.e. localized populations) and not white sucker, as they are more mobile, large bodied fish. Other sites along the eastern shore of Jackfish Bay also possess low effluent exposure concentrations, and sites of similar depth and vegetation composition could serve as additional reference sites for the comparison of small-bodied fish. A location closer in proximity to Moberly Bay may be of value for further comparison.

One of the main benefits of this approach is that Jackfish Bay has no other sources of human-derived effluents and additional reference sites within the bay will likely serve to increase the sensitivity of the measured endpoints. One potential problem with using Tunnel Bay as a reference site, however, is the indication that many fish found there (e.g., white sucker) have elevated levels of (undefined or lakewide) contaminants (Bowron, 2008).

One advantage of collecting future monitoring data based on the studies used in the Stage 1 report is that it includes a wide range of fish species, rather than focusing on the two model species (white and longnose suckers) used for the last 3 EEM studies. The netting of smaller fish for calculation of an index of biotic integrity (IBI), as has been performed for other Great Lakes AOCs, could increase the accuracy of the analysis. IBIs were calculated for the Stage 1 data and would be another useful endpoint for evaluation of the AOC. Regular collections in the same areas in Jackfish Bay using the same methods used in Stage 1 are recommended to allow evaluation of species numbers and IBIs over time.

As mentioned in both Bowron and in the McMaster review, it is a good idea to develop new methods of evaluating the health of fish populations because the validity of existing endpoints is so variable and often varies significantly between mills (e.g., LSIs and GSIs in exposed fish can be higher or lower than those at reference sites). To further this goal, Bowron and coworkers use two endpoints in particular that are not emphasized in the EEM studies: plasma steroid concentrations, which control egg production/fertility in females and gonadal development and secondary sex characteristics in males; and CYP1A/EROD/MFO activity, which is a measure of redox stress. The first endpoint focuses on reproductive success in fish. Sex steroid concentrations measurements complement the traditional toxicology endpoint of performing histology of gonads. These are potentially more sensitive, as long as a distinction is made between spawning and non-spawning individuals, as results from these two groups are highly variable. Note that CYP1A activity was calculated for many years (1989-2000) in the AOC, as summarized in the Bowron 2008 thesis. This appears to be a good indicator of environmental stress, as levels were significantly elevated in Jackfish Bay vs. Mountain Bay. Again, however, there is a large year-to-year variation in CYP1A activity at both sites, and the use of a more proximal reference site may help to determine whether this is a physiologically valid endpoint.

Reproduction studies (endpoint 5 of the Stage One data detailed in section 3) are very valuable to add to the traditional 5 EEM toxicology endpoints listed above. This is especially true given the large natural range of variability in these endpoints at sites across Lake Superior. The indirect GSI data collected in the EEM cycles would be complemented by full life cycle or 21-day “Ankley” testing of the effluent in a laboratory using a well-characterized model species such as fathead minnow. These tests may be too expensive for routine monitoring of industrial effluents, but they may be appropriate for EEM studies. PAPRICAN, NWRI and many Canadian academic aquatic toxicology labs have the required facilities and expertise to carry out these tests. As GSI is a rather indirect measure of reproductive success, which is needed to evaluate the health of a population, it is recommended that the 5 EEM endpoints be supplemented with fish species and abundance surveys that replicate the original 1986 electrofishing survey sites. Calculation of IBI values will be extremely valuable to gauge aquatic ecosystem health. As a bonus, this data would give a good indication of the suitability of Tunnel Bay as a reference site within the AOC, which could considerably simplify collection of data for the other endpoints.

AOX was the first class of toxicants suspected of having major influences on reproductive success. Given their potential to persist in sediment, surveying the levels of these chemicals using grab samples in the AOC would be useful. This is especially true since the two sentinel species used for EEM work (white and longnose suckers) are both benthic. Additionally, the high dioxin concentration in Lake C that was measured recently could indicate that these chemicals exist in other reaches of the AOC.

If resources permit, 21-day reproduction studies flow from endpoint 5 of the Stage One report and would provide excellent supplemental data on the effects of the effluent from the AOC on fish fertility. Tissue from exposed fish could subsequently be used for omics studies examining the impact of effluent on the hypothalamic-pituitary-gonadal axis and on the detoxification system in the liver. Omics is an emerging suite of technologies examining gene expression and/or protein levels in effluent-dosed fish which has not been utilized in the past. They are potentially valuable because they may allow a very rapid exposure period to be used rather than the 21-day Ankley or full life cycle studies, but are too costly to be used to routinely monitor effluent quality.

4.3 Recommendations: Loss of Fish Habitat

To determine whether fish habitat remains impaired a recent (2009 or later) summary of the physical, chemical, and biological features may be needed. A comparison can be made between the historical spawning sites described by Goodier (1981) and habitat data collected after secondary treatment was installed at the mill (e.g. data derived through the EEM program). Where possible, such comparisons should be done to quantify both the amount of habitat and the quality of habitat (physical, chemical, and biological). Habitat quality analysis should include important parameters such as water temperature and dissolved oxygen as well as biological parameters such as plankton. However, the methods where current habitat will be compared with past habitat are to be determined once all the available data have been examined.

Future monitoring of this BUI can also draw from the BEAST methodology used by Environment Canada to assess benthic health in AOCs. Benthic species are an important characteristic for fish habitat as they are often a food source to fish. Other sentinel species for the area could involve sculpins or darters for fish habitat surveys. These sedentary, short life cycle species spend their entire life cycle in the affected area; they are not a migratory animal that move in and out of the AOC. Additional gear types must be utilized to try and collect all potential resident species, and this should be done in the summer and not winter and fall.

4.4 Recommendations: Dynamics of Benthic Populations

The assessment of the benthic macroinvertebrate community in Jackfish Bay is an excellent means of evaluating the recovery of the area. The statistical methods applied by Milani and Grapentine are robust.

Benthic invertebrates provide an ideal means of evaluating recovery because they respond quickly to changes in the environment by changing community structure.

The multivariate reference approach used by Milani and Grapentine has been used in other studies with relatively more reference sites. A similar approach is being used by The Ontario Benthos Biomonitoring Network (OBBN) for the rapid assessment of streams (Jones, Sommers, Craig, & Reynoldson, 2004). The OBBN recommends at least 40 suitable reference sites to develop the ellipse for the analysis of the test site. It is recommended that more reference sites be used in future sampling of the AOC, and that these reference sites reflect the geologic and geomorphologic characteristics of Moberly Bay.

Bays located in proximity to Jackfish Bay that have similar sediments and that are at least 10 kilometres from a point source of pollution could be considered as reference sites. New sites could also be established from along the North Shore of Lake Superior. For example, reference fish collections have been made at Mountain Bay, Pays Plat Bay, McKellar Harbour, Terrace Bay, Collingwood Bay, and Kama Bay. These bays are remotely located or sparsely developed and are considered to have no significant anthropogenic influences on their environmental quality. If the sediments in these bays are similar to those of Jackfish Bay, then such sites can be included in the benthic monitoring sampling program and used as reference sites for comparison with the benthic communities of Jackfish Bay.

The sites near St. Patrick Island may not be suitable for comparison. The far far-field sites are similar to communities found in the open water of Lake Superior. The presence of *Stylodrilus heringianus* and *Mesenchytraeus* indicates oligotrophic conditions commonly associated with unimpaired, deep-water areas.

In the Jackfish Bay AOC the Tunnel Bay sites are most comparable to the near-field (Moberly Bay) sites. All these sites share similar sedimentary deposits of silt and clay; however, the near-field sediments are modified by the fluvial action of Blackbird Creek, which has increased the amount of sand in the sediments at the mouth of the creek. Additionally, the recent history related to effluent from the Terrace Bay mill has created differences in habitat. The communities at the Tunnel Bay and Moberly Bay locations may differ greatly from each other because of the organic enrichment and deposition of contaminants in Moberly Bay by mill effluent which creates significant differences.

Even if all effluent stopped, there are still historical sources of contaminants in the AOC that should be investigated, such as the bunker B&C fuel oil identified at the far field sampling site referenced in several Environmental Effects Monitoring reports (Cycles 4 IR, pgs 4.7 and 4.8). Additionally, it should be noted that the near-field communities could continue to be organically enriched by leaf fall because of proximity to the shore and because of the addition of detritus delivered by Blackbird Creek. Another possibility for the continued slow recovery of Jackfish Bay is the historic contamination of Blackbird Creek. High flows during heavy rains or spring runoff could mobilize contaminants that have settled onto the stream bottom. Recovery of the benthic communities would be inhibited regardless of the success of the efforts to reduce contaminants in the effluent.

4.5 Recommendations: Body Burdens of Benthic Populations

The implementation of BEAST (BEnthic Assessment of SedimenT) has facilitated the evaluation of toxic contaminants in the Jackfish Bay AOC. The 2003 and 2008 studies provide a valuable comparison of years using standard methods and are recommended procedure for future monitoring in the AOC. The delisting criteria for this BUI should be achieved through monitoring that compares invertebrate tissue concentrations with concentrations associated with adverse impacts (derived from the CCME Tissue Residue Guidelines); that is, delisting would occur when the organisms no longer experience adverse effects.

However, concentrations at suitable reference sites should also be considered. The effluent from the mill adds known organic contaminants such as dioxins and furans, which at low tissue concentrations may not cause measureable effects. The stress from both organic contaminants and naturally occurring metals in the AOC could combine causing negative effects not entirely related to emissions from the mill. However, the major source of organic contaminants has been identified as effluent from the Terrace Bay mill. It may be worthwhile to examine the feasibility of using studies by Sherman et al. (1990) to help set a baseline for levels of dioxins/furans in the sediments and body burdens of benthic invertebrates in Jackfish Bay. If this is not possible then the recent 2003 and 2008 studies do indicate the presence of dioxins and furans and the concentrations of these toxins in the tissues of the benthos. The 2003 and 2008 studies are more reliable than the earlier studies and will be sufficient to evaluate the current status of the BUI.

5.0 Public Area In Recovery Review Committee (PARRC) Recommendations

This chapter provides a summary of the key recommendations made by the PARRC during community meetings that took place in October 2008, May, November and December 2009, and the final PARRC review meetings in March and May of 2010. Two public input sessions were also held during this time and the topic of AiR status for Jackfish Bay headlined the Lake Superior Binational Forum Meetings in the spring of 2009. The PARRC agreed that the following recommendations deserve immediate attention by the government agencies involved in managing the Jackfish Bay RAP. The PARRC's overall acceptance of the Area in Recovery status as part of the Jackfish Bay Area of Concern was conditional on meeting these recommendations.

5.1 A Phased Approach to Understanding Area in Recovery Status

Overall, there was much confusion by PARRC members in understanding exactly what the difference between the newly designated Area in Recovery status meant in comparison to the existing Jackfish Bay Area of Concern. PARRC members continually insisted that the change in status should result in more action or effort devoted to monitoring and remediating BUIs since the AOC has already been in a stage of natural recovery following Stage 2 of the Remedial Action Plan.

To help reduce the overall confusion that members and the public had in understanding the actual meaning of Area in Recovery status, the following three-phased approach is suggested to ensure that the Area in Recovery status is unique and progresses along a continuum of ongoing action. This approach will better allow future RAP Team members, PARRC members and the public to better communicate progress towards the eventual delisting of the Area of Concern over the time devoted to monitoring Area in Recovery status.

Phase 1: Remediation Strategies Complete (Natural Recovery)	***Phase 2: Monitoring Plan Shows Signs of Ecosystem Recovery***	***Phase 3: Level of BUI Recovery Confirmed / Estimated***

A Phased Approach to Proceed Through Area in Recovery Status for Jackfish Bay

1. The first phase of AiR status occurs when the AOC meets AiR status by completing remediation strategies set out in the Stage 2 report and all scientifically feasible and economically reasonable actions have been implemented and additional time is required for the environment to recover (Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem 2007). For Jackfish Bay, this phase has been ongoing since the end of Stage 2 since no remediation actions were chosen following the necessary mill upgrades that had been competed at that time.

2. The second phase of AiR status occurs when an effective monitoring program is in place that collects new data about the level of BUIs caused by point sources in the AOC and can compare that data to the existing baseline of data outlined throughout this report. Ideally, this new data should show improved signs of recovery and indicate progress in the AiR status. However, if monitoring detects increased impairment (i.e. backsliding or negative recovery), the AiR status should be reassessed as it exists along this continuum, and communicated to the community and RAP stakeholders.

3. The third phase of AiR status occurs when monitoring data continues to confirm that BUIs are in a state of recovery and an estimate can be made about when these BUIs might meet delisting

targets. Once these estimates have been realized and BUIs are progressively being delisted, the AiR can proceed to the Stage 3 delisting of the Jackfish Bay AOC.

The PARRC felt that a continuum was important to formulate a shared understanding of what AiR status means and to communicate how it would be distinct from the previous stage of natural recovery that has existed since Stage 2. A continuum of progress in the AiR status also allows RAP stakeholders to establish priority actions to improve the rate of recovery in the AOC, or to address negative progress (rather than assuming that recovery will be a linear process to delisting).

The PARRC concluded that since the Jackfish Bay AOC could be among the very first of the Great Lakes AOCs to receive "recovery" status, it may be used as precedent in the designation of other potential Areas in Recovery. As such, it was decided that standards for Jackfish Bay should be high. PARRC members also agreed that the recovery process should be an active one, rather than a passive one, for all involved parties. In recognition of the preceding fundamental approach, the PARRC stated that, in advance of AiR status designation, the following actions should take place:

- The Ontario Ministry of Environment, Ontario Ministry of Natural Resources, Environment Canada and any other government agencies concerned should agree to a long-term monitoring program documenting environmental quality in the Jackfish Bay AOC. This plan should lay out both financial and implementation responsibilities with both government, academic and community partners. The PARRC encourages implementation of the monitoring program prior to official receipt of recovery status.

- All possible efforts should be made to advance environmental recovery. As new technology, methods or systems become available that might reduce current environmental impacts, these remedial options should be investigated and implemented where appropriate, practical and cost-effective.

- Through the PARRC, open, meaningful, regular and timely communication should take place between involved government agencies and residents of the Rossport, Schreiber, Terrace Bay and Jackfish communities.

5.2 Conditions and Criteria of the Area in Recovery Status

The PARRC agrees with the Jackfish Bay Technical Team and the recommendations in this report: that the Jackfish Bay AOC has met the criteria of an Area in Recovery. This designation can proceed based on the fact that communities representing the Jackfish Bay AOC, the PARRC, and technical representatives on RAP Teams all agree that RAP implementation is complete and all reasonable intervention has been taken at this point in time. Furthermore, the PARRC has specified the following principles/criteria that were originally established for an AOC entering the 'natural recovery' mode (Canada-Ontario Agreement RAP Steering Committee, 1988) to continue to be applied to the 'Area in Recovery' designation:

- That the initial RAP implementation outlined in Stage 2 of the process is complete and that the area of concern is in a mode of natural recovery, but is not delisting as an Area of Concern.

- The Jackfish Bay Area in Recovery is in a mode of monitored natural recovery as a result of completing all reasonable intervention for all identified beneficial uses and time is required for the environment to fully respond to meet the delisting targets for all beneficial uses indentified in this report.

- Monitoring and surveillance commitments are a requirement of entering the Area in Recovery status, to continue to assess progress towards achievement of delisting targets. This commitment should provide a method of determining the state of natural recovery, whether the recovery can be accelerated based on new science and technology, and measuring the achievement of delisting criteria.

- There should be commitment from the government to intervene if recovery rates are unacceptable and do not measure progress towards the delisting targets.

- A mechanism is established to report systematically to the public the monitoring actions and results that are achieved during the Area in Recovery status, and to ensure that the public and the PARRC are satisfied with the current conditions of natural recovery.

- Entering Area in Recovery status under the monitored natural recovery mode must be accompanied by a commitment of governments or other partners to maintain their responsibilities. Governments will continue to undertake environmental improvements as part of their mandates, beyond the needs of the RAPs.

- A process is in place to respond to future development pressures and emerging technologies such that environmental recovery is sustainable and further intervention can take place if warranted.

- The continued presence of the agencies should maintain commitments to the Canada Ontario Agreement and the Great Lakes Water Quality Agreement, and offer the potential to adapt the management strategy as new opportunities and technologies emerge.

The following sections provide more specific recommendations that follow from the broader recommendations above, and are meant to ensure that an effective monitoring plan can be developed to overcome the existing data gaps and to build on an adequate baseline of information that is relevant to the assessment of delisting targets. The key PARRC considerations and recommendations in this chapter pertain to:

- BUI Status and Terminology
- Monitoring Plans and a Commitment to Addressing Data Gaps
- The Implications of Natural Recovery and Defining AiR Status
- The Implications of Mill Operation to the AiR Status
- The Implications of Historic Contaminants in Blackbird Creek to the AiR Status
- Commitment to Ongoing Community Participation and Education

5.2.1 BUI Status and Terminology

In cases when there was an absence of evidence PARRC members preferred the use of the term 'No Impairment Identified' when describing the status of a BUI, rather than the commonly used term 'Not Impaired'. The members agreed that 'No Impairment Identified' more accurately captured the more subjective rational for changing the status of a specific BUI in Jackfish Bay, and could still support a decision to delist.

For example, members of the PARRC discussed the BUIs pertaining to wildlife populations. One PARRC member noted that 'there is no firm evidence of wildlife impairment in the Jackfish Bay AOC, even 30 years ago, and the fact that no one was initially looking for a problem makes using the term 'Not Impaired' misleading. Use of this term appears to give credit to monitoring work or remediation actions that have not been done. In such cases, the term 'No Impairment Identified or Expected' should be used. Another member suggested that 'Requires Further Assessment' be used, as was the case in Stages 1 and 2, so that the AOC could still proceed to Area in Recovery status and ensure through monitoring that no impairment exists.
PARRC members agreed that continued efforts under Area in Recovery status should focus more on the BUIs related to water quality issues, specifically fish populations and benthic populations. The PARRC members agreed that the AOC process should continue to move forward with the AiR status, but that they

did not want a sudden drop in funding and monitoring attention to result after AiR designation. The committee recommended that the Area in Recovery status should ensure that community and government cooperation continues to monitor and investigate impairments over time.

***<u>PARRC RECOMMENDATION #1</u>*: Consideration of the term 'No Impairment Identified or Expected' - If direct evidence is not found to prove that a specific BUI is listed as 'Not Impaired', then it would be inaccurate to say so. BUIs listed as 'No Impairment Identified or Expected' should be used to ensure that the public understands that there is no indication of a problem.**

5.2.2 Monitoring Plans and Commitment to Address Data Gaps

The PARRC referred to a discussion at the May 2009 meeting around comments made by senior level federal and provincial representatives that indicated that monitoring was one of several important steps of an AiR on the path to delisting an AOC. Federal representatives in particular recognized that a better job of monitoring could be done and talked about the 2011 year of coordinated monitoring for Lake Superior as a means of increasing the monitoring effort for the AOC.

The PARRC members noted the benefits of the Environmental Effects Monitoring (EEM) Program to their understanding of the improvements to water quality, fish and benthic organisms in the AOC. However, they were concerned that this program would only be in place while the mill is in operation. They recommended that, under a new AiR status, continued monitoring should also occur while the mill is not in operation, in order to ensure that gaps in data collection do not occur as they have since Stage 2 of the RAP. The PARRC realized that the EEM program is not designed for AOC monitoring and may not always exist or operate during times of mill shutdown, but some form of monitoring should replace any data collection shortfalls that may arise during the Area in Recovery phase. Thus, this continued monitoring effort does not have to replicate the EEM approach, but should be linked with regulatory-based data to provide a consistent measure of ecosystem recovery whether the mill is operating or not.

<u>Additional PARRC Comments about Monitoring</u>

- Need to plan, fund, and implement, in a timely fashion, a rigorous and effective program of monitoring to determine the rate of environmental recovery or otherwise in the Jackfish Bay AOC.
- Prior to recovery status being agreed upon, this plan should be communicated to the PARRC.
- Need to take steps to ensure this monitoring program will be carried out on an ongoing basis for the period of time necessary to document recovery.
- Need to engage the Town of Terrace Bay and other area partners to ensure this monitoring continues over the long term and in a way that will support decision-making.
- In addition to monitoring, there is a need to continue a program of meaningful, effective community engagement to residents of the Rossport, Schreiber, Terrace Bay and Jackfish areas with special emphasis on communication and public input regarding monitoring.
- Need to reinforce the emphasis on monitoring to all parties involved, including the town of Terrace Bay (i.e. could be better to designate Jackfish Bay AOC as an Area of Monitored Recovery, or AMR, rather than an Area in Recovery).

***<u>PARRC RECOMMENDATION #2</u>*: Committed Monitoring Is Needed To Build from a Strong BUI Baseline – A phased monitoring framework should include contingency plans to address changes in monitoring programs, government funding for monitoring, and the ability to incorporate new information about impaired BUIs from secondary sources to avoid data gaps over the long-term. The use of the term Area of Monitored Recovery was more accurate for Jackfish Bay over the term Area in Recovery.**

5.2.3 The Implications of Natural Recovery and Defining AiR Status

The PARRC was challenged with the task of defining an Area in Recovery status at a period when the mill is in shutdown, as there is great uncertainty about the mill reopening in the near future. In addition to the existence of historic contaminants in the AOC (particularly Blackbird Creek and Lake C (Moberly Lake), PARRC members could not reach agreement that AiR status could apply to an area that continues to undergo degradation of water quality. PARRC members and scientists often agreed that there may not be any hope of delisting all of the impairments in the AOC while discharge from the mill continued because some of the improved environmental conditions in the Jackfish Bay AOC correlated to extended mill shutdowns.

<u>PARRC RECOMMENDATION #3</u>: Differentiate Levels of Recovery – In some instances it is uncertain whether ecosystem recovery is occurring as a result of mill upgrades to effluent quality versus prolonged periods of mill shutdown when effluent does not enter the AOC. As a result, monitoring should be designed to compile data to help differentiate the levels of ecosystem recovery that occurs when the mill is not operating versus ecosystem recovery that occurs when the mill is operating.

5.2.4 The Implications of Mill Operation to the AiR Status

PARRC members commended the mill for its original phase of upgrades during the RAP, and agreed that the original changes to the kraft bleaching process and the addition of secondary treatment did allow the mill to reduce the impact of the effluent far above MOE guidelines at the time. However, the PARRC noted that since these initial upgrades, the mill has not continued to invest in the most modern of technologies and procedures to ensure this high standard.

<u>Specific Recommendations Pertaining to Mill Effluent</u>

- Need for mill to continually strive to improve effluent quality and treatment efficiency (implementation of Best Management Practices) for as long as mill or any other effluent enters the Blackbird Creek system, Lake Superior, or any waters in or around the AOC
- Need for mill to work in co-operation with government enforcement agencies, lobby for and be aware of improved effluent regulations, and to periodically review mill effluent limits to ensure that the environment is protected and best practices are used.

<u>PARRC RECOMMENDATION #4</u>: Minimize Nutrient Discharge from Future Mill Operations – An additional short-term goal for Jackfish Bay should be to minimize nutrient discharges from the mill effluent once the mill recommences production. Remedial measures would involve the implementation of Best Management Practices (BMP) for nutrient control.

5.2.5 The Implications of Historic Contaminants in Blackbird Creek to AiR Status

There is great concern about the status of the AOC based on the potential existence of historic contaminants in Blackbird Creek, including Lake A and Lake C, and the threat this could have on the status of recovery. PARRC members responded that the potential for severe rainfall events to flush contaminants into Jackfish Bay may exist, and requested further investigation into such an event and its implications for AiR status. PARRC members were uncertain if Blackbird Creek should be part of the AiR as some considered the creek to be an effluent channel, and others viewed the creek as an historically impaired ecosystem that requires remediation.

PARRC members suggested that the AiR designation could be used as a rationale to revisit technological advances and encourage research on new technologies that could be used to prevent or reduce the flushing of contaminants through the Blackbird Creek ecosystem. For example, modern stormwater management techniques and sediment management techniques include "sinks" or settling basins to trap sediments. Overall, these discussions lead to the following requirements:

- Need to better characterize contaminants, especially in the Blackbird Creek system and to determine if movement of these contaminants is occurring (i.e. due to natural causes such as major storm events) and whether this movement substantially impacts the ability for the AOC ecosystem to recover.

- If substantial movement of contaminants is detected, and if this movement is having a negative environmental impact, there is a need to revisit the sediment management options analysis provided in the Stage 2 Report for Jackfish Bay.

<u>PARRC RECOMMENDATION #5</u>: Further Assessment of Blackbird Creek – There is a need to complete further study of Blackbird Creek to better characterize the potential for historic contaminants to affect the AOC. The COA Sediment Management Decision-Making Framework should be applied specifically to the Blackbird Creek system.

5.2.6 Commitment to Ongoing Community Participation and Education

PARRC members commended EcoSuperior and Lakehead University for their objective approach to determining the status of the Jackfish Bay AOC and involving the communities of Terrace Bay – Schreiber, Rossport and Jackfish. The PARRC strongly recommended that these stakeholders continue to be involved in the community and to assist Environment Canada and the Ontario Ministry of Environment in actions to manage the Jackfish Bay Area of Concern.

PARRC representatives showed a long-term commitment to assisting government in working toward a resolution of what AiR status means and to map out a plan for delisting the AOC. However, they questioned if it was reasonable or viable to continue with this AOC process for another decade or two without it meaning something to the community (i.e. providing a benefit). There is fear in the town that AOC status could result in a loss of economic opportunity. The PARRC encouraged dialogue about environmental upgrades and monitoring results during AiR status in order to remedy such fears and attract opportunity in the region by promoting environmental stewardship. Some ideas included:

- Ongoing public input sessions in the region, with the involvement of the Lake Superior Binational Forum and the Lake Superior National Marine Conservation Area stakeholders in a facilitated monitoring workshop, to further develop a monitoring framework that includes the community/government/non-government partnerships active in the area.

- Development of an AiR education piece in the schools to integrate the community's economic and environmental history.

- Promotion of the region as an area of economic revitalization and ecosystem remediation through interpretive civic displays.

- Educational opportunities to learn about ecosystem health and management, potentially achieved through community-based efforts to observe or even monitor some of the indicators that inform BUI decision-making.
- Utilization of the Terrace Bay Schreiber News, and online websites such as the North Shore of Lake Superior Remedial Action Plans website (www.NorthshoreRAP.ca), the Lake Superior Binational Forum's website (www.superiorforum.org) and EcoSuperior's website (www.ecosuperior.org) was recommended to provide for an increase in community information sharing about the developments in the AOC and facilitate a dialogue about AiR status over time.

<u>PARRC RECOMMENDATION #6</u>: Ensure Ongoing Community Participation and Education during AiR Status - Re-establishing interest about Jackfish Bay through education and participation

would help to develop an understanding of the process of an Area in Recovery as it supports the economic and environmental goals of Jackfish Bay and the region.

6.0 Glossary

Acute Toxicity - Acute toxicity describes the adverse effects of a substance which occur over a short period of time (hours or days) as a result of either from a single exposure or from multiple exposures.

Ankley Test – Short term assay (test) used to identify chemicals that exert reproductive toxicity to fish, by disruptions to the endocrine system.

Areas of Concern (AOC) - The 43 severely degraded geographic areas in the Great Lakes Basin where water uses for humans and wildlife (e.g., fish consumption and habitat degradation) are impaired. There are 26 AOCs located entirely within the United States, 12 located wholly within Canada, and 5 that are shared by both countries. There are 3 Canadian AOCs that have been delisted and 1 U.S. AOC, leaving 25 AOCs remaining on the U.S. side of the border, 9 on the Canadian side, and 5 shared by both countries.

Beneficial Use - The ability of living organisms to use the Great Lakes Basin Ecosystem without adverse consequence (includes the 14 uses identified in Annex 2 of the Canada-United States Great Lakes Water Quality Agreement).

Beneficial Use Impairment (BUI) - A change in the chemical, physical or biological integrity of the Great Lakes System that is sufficient to cause restrictions on fish and wildlife consumption, tainting of fish and wildlife flavour, degradation of fish and wildlife populations, fish, bird or animal tumours or other deformities and reproductive problems, degradation of benthos, restrictions on dredging activities, eutrophication, restrictions on drinking water consumption, beach closures, degradation to aesthetics, degradation of phytoplankton and zooplankton populations, added costs to agriculture or industry or loss of fish and wildlife habitat (Great Lakes Water Quality Agreement, 1978).

Benthos - Organisms (animals and plants) that live on, in, or attached to the bottom of a lake or water body.

Biological Oxygen Demand (BOD) - Measure of the amount of dissolved oxygen in a water sample required by aerobic biological organisms to break down organic material at a specific temperature and over a specific time period. Often used as a common water quality indicator.

Chronic Toxicity - A property of a substance that has toxic effects on a living organism, when that organism is exposed to the substance repeatedly over an extended period of time (weeks or months).

Ecosystem and Ecosystem Approach - Ecosystems are composed of a variety of organisms, including plants, fish and wildlife, and people, that function in an interrelated way with one another and the surrounding environment (air, water and land). An ecosystem approach recognizes the interactive system of biological communities, their non-living components, their associated activities, and the interconnectedness of air, water, land and living things.

Environmental Effects Monitoring (EEM) - Environment Canada's national program for the monitoring of environmental effects of operations in the pulp and paper and metal mining sectors. Environmental effects monitoring is an assessment and decision making tool to protect aquatic ecosystems.

Endocrine Systems and Endocrine Disrupting Substances - Endocrine systems are complex mechanisms coordinating and regulating internal communication among cells. Endocrine disrupting substances interact with endocrine systems and can cause a disruption to normal functions, adversely affecting their growth, reproduction and development. Even at very low levels many of these chemicals may have biological impacts on the health and sustainability of wildlife populations.

Ecological Risk Evaluation (ERE)- Evaluation of possible injury, harm, or other adverse or unwanted effects to ecological condition using a modeling scenario. Model parameters are derived from what is known to predict outcome of unknowns.

Eutrophication – Non-natural nutrient enrichment of a waterbody with compounds of nitrogen, phosphorus, iron, sulphur and/or potassium. Nutrient enrichment can lead to algae or cyanobacteria blooms, which harm the aquatic organisms by consuming significant amounts of dissolved oxygen.

Fish Community Objectives - The objectives that relate to desirable fish community habitat, providing a common framework for agencies to develop and implement complementary fishery management programs.

Harmful Pollutants - The substances that have a damaging impact on the health/functioning of the ecosystem. The harmful pollutants are substances on the Tier I and Tier II substance list, as well as the Criteria Air Pollutants (information available online at www.on.ec.gc.ca/coa).

Industrial Effluent - Released liquid discharge produced by industrial processes.

LaMP (Lakewide Management Plan) - A binational plan to address threats to the Lake Superior ecosystem. The LaMP embodies a systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses. It will be developed in four stages. The Stage I LaMP (current version) applies only to the nine designated critical pollutants from the zero discharge demonstration program for point source discharges. Later stages of the LaMP will address these and additional critical pollutants that are designated during the LaMP process, for point and nonpoint sources. See also State of the Lake Superior Basin Reporting Series. Related Programs - Great Lakes Water Quality Agreement, Binational Program

Loading - The amount (concentration multiplied by flow rate) of a substance being emitted or discharged.

Non-Point Source - The diffuse sources of pollution, including combined sewer overflows and urban and rural runoff (that is, not attributable to one specific source).

PAH (Polycyclic aromatic hydrocarbons) - A group of chemicals that are formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances.

PDBE (Polybrominated diphenyl ether flame retardants) - Organobromine compounds that are used as flame retardants. Like other brominated flame retardants, PBDEs have been used in a wide array of products, including building materials, electronics, furnishings, motor vehicles, airplanes, plastics, polyurethane foams, and textiles.

PCBs (Polychlorinated biphenyls) - A family of man-made chemicals that contain 209 individual compounds with varying levels of toxicity. Some are recognized carcinogens. Eating contaminated fish is a major source of PCB exposure for humans because of the bioaccumulation of PCBs in some species of fish found in contaminated waters.

Remedial Action Plan (RAP) - Plans set up to restore severely degraded areas within the Great Lakes Basin. RAPs are being developed and implemented at 43 AOCs (3 of which have been delisted) on the Great Lakes.

Remediation - A plan describing environmental problems, their causes and remedial measures required to restore beneficial uses in the Area of Concern. RAPs must also include a process for evaluating effectiveness and a description of monitoring plans to confirm environmental recovery.

Riparian Habitat - Areas of vegetation on the banks/sides of streams, rivers and other bodies of water. These areas help remove sediments from water, reduce erosion and flooding, and support wildlife populations, including providing fisheries habitat.

Total Suspended Solids (TSS) - A water quality measure of the amount of suspended solids in effluent, waterwater, or a waterbody. Suspended solids are isolated from the sample using a filtration technique.

Trace Organics - Industrial contaminants formed during the incomplete combustion of organic carbons, e.g., polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), hydrocarbons, and chlorinated organics.

Transboundary Transport - The movement of pollutants across political and geographic borders and boundaries. Transboundary transport can result in the creation of pollution problems over which a jurisdiction may have little control since the source is outside its boundaries.

Virtual Elimination - No measurable release of a substance, or release of only trace amounts of a substance, into the environment.

Volatile Organic Compounds - Chemicals that contain carbon and elements such as hydrogen, oxygen, fluorine, chlorine, bromine, sulphur or nitrogen. Examples are gasoline, benzene, formaldehyde and toluene, as well as chemicals used in dry cleaning.

7.0 References

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8.0 Appendix A

Note: RFA = Requires Further Assessment, N/A = Not Applicable			
Impairment	**Reason for Status of Impairment**	**Impairment Status**	**Delisting Criteria**
Restrictions on fish and wildlife consumption	The evaluation of this impairment is broken into two components (Fish Consumption and Wildlife Consumption)		
Fish consumption	Consumption of lake trout up to 65 cm in length was unrestricted with regard to mercury and PCB concentrations, and the consumption of whitefish, cisco, and white sucker to 45 cm in length was also unrestricted (1991 "Guide to Eating Ontario Sport Fish"). However, the guide indicated that consumption of lake trout greater than 55 cm could be restricted due to concentrations of dioxins and furans expressed as toxic equivalents of 2,3,7,8-tetrachlorodibenzo-p-dioxin (Stage1, 1991).	Stage 1: RFA	This BUI will no longer be impaired when the fish consumption advisories in the AOC are no more restrictive than at an appropriate reference site on Lake Superior.
	Consumption restrictions exist for lake trout (*Salvelinus namaycush*) over 45 cm because of tissue concentrations of toxaphene (MOEE 1997). The apparent increase in dioxin levels for lake whitefish (*Coregonus clupeaformis*) greater than 55 cm is reflected in the latest consumption guide (MOEE 1997). (Stage 2, 1998)	Stage 2: Impaired	
	The consumption restrictions in Jackfish Bay are caused by dioxin-like PCBs (dlPCBs), dioxins/furans, total-PCB and mercury. These restrictions apply to lake trout, whitefish, longnose sucker and ling in Jackfish Bay. The restrictions data published in the most recent Guide to Eating Ontario Sport Fish shows that Jackfish Bay advisories are less stringent than advisories in the open water Schreiber/Sewell Point, however the advisories for Jackfish Bay are based on the latest measurements while data from Schreiber/Sewell Point are at least five years old (MOE 2009). This inconsistency creates a situation where direct comparison is not a suitable technique and data from the same year should be regularly collected to establish the proper Impairment Status through comparison.	AiR Status: RFA	
Wildlife consumption	No restriction exist (Stage1, 1991)	*Not Originally listed as Impaired*	

<table>
<tr><td>Tainting of fish and wildlife flavour</td><td>There has not been reports of tainting by the public or by fisheries/wildlife personnel (Stage1, 1991)</td><td colspan="2">Not Originally listed as Impaired</td></tr>
<tr><td>Degradation of fish wildlife populations</td><td colspan="3">The evaluation of this impairment is broken into four components
(Degradation of fish populations, body burdens of fish, degradation of wildlife populations and body burdens of wildlife)</td></tr>
<tr><td rowspan="2">Degradation of fish populations</td><td>Prior to installation of secondary effluent treatment by the mill (October 1989), Blackbird Creek fish populations had been totally eliminated as a result of the pulp mill effluent. Similarly, fish populations in Moberly Bay, in the vicinity of Blackbird Creek, have been severely reduced and toxicity tests on surface waters up to 1.5km from the creek mouth resulted in 100 percent fish mortality. Results from toxicity testing since this time indicate that mill effluent is no longer acutely lethal. However, degraded water quality, harvesting, the sea lamprey and introduction of exotic fish species have all directly depressed fisheries production in Jackfish Bay. The zone of influence, which radiates south from the mouth of Blackbird Creek, has diminished fisheries potential in the entire Jackfish Bay area, and although the degree of impact has not been determined, species diversity and densities in the northern portion of Moberly Bay are among the lowest found in Lake Superior. (Stage 1, 1991)</td><td>Stage 1: Impaired</td><td rowspan="2">This BUI will no longer be impaired when monitoring data shows that the fish community at a population level does not differ significantly from suitable Lake Superior reference site.</td></tr>
<tr><td>Lake trout populations have declined since the mid-1950s, probably because of the accidental introduction of sea lamprey (Petromyzon marinus) and other exotic species into Lake Superior, Kimberly-Clark mill operations, and over-harvesting. Blackbird Creek fish populations were eliminated as a result of pulp mill effluent; however, brook trout (Salvelinus fontinalis) and fathead minnows (Pimephales promelas) were captured in the creek in 1995. Fish populations in Moberly Bay have also declined. (Stage 2, 1998)</td><td>Stage 2: Impaired</td></tr>
</table>

	Since the Stage 1 listing of this BUI, fish population data from within the Jackfish Bay AOC has been limited. A 2001 lake trout index netting project compared sites in and around Jackfish Bay and the surrounding waters and indicates that the relative abundance of lake trout in Jackfish Bay is higher than sites outside of the bay. The conclusion of the report also indicates that the relative abundance in Jackfish Bay is consistent with a rehabilitated lake trout population (Chong, unpublished). However, this BUI continues to be listed until a more complete inventory of fish community data is available. Long term studies on target fish species in Jackfish Bay show that exposure to mill effluent causes reproduction alteration (e.g. delayed sexual maturity, reduced gonad size) (Bowron, 2008). There has been a gradual improvement in the condition and organ size of fish since the mid-1990s following the installation of secondary treatment and major process changes in the pulping process. During the last few years the mill has experienced multiple closures (ranging in duration from several weeks to many months), and there has been marked improvement in the white sucker populations during these closures. However, water quality issues resulting from mill effluent continue to cause reproductive problems (Bowron, 2008).	AiR Status: Impaired	
Body burdens of fish	White suckers had bioaccumulated TCDDs and TCDfs from water and sediment contaminated by the mill effluent. Lake trout also had low concentrations of mercury, hexachlorobenzene and several chlorinated pesticides. The GLWQA Specific Objective for the protection of fish-eating wildlife from PCBs was exceeded in lake trout collected in 1989.(Stage 1, 1991)	Stage 1: Impaired	This BUI will no longer be impaired when a statistical analysis can demonstrate that fish body burdens in Jackfish Bay do not differ significantly from those in the open water reference area
	Low levels of hexachlorobenzene, mercury, and chlorinated pesticides were found in lake trout. The GLWQA Specific Objectives for the protection of fish-eating wildlife from PCBs was exceeded in lake trout sampled in 1989, 1990, and 1992. Atmospheric inputs are believed to be the contributing factor. Improvements in mill processes have enhanced water quality; however, the recent increase in dioxins in lake whitefish suggests that further improvements may be warranted. (Stage 2, 1998)	Stage 2: Impaired	

	Mercury levels and PCB concentrations in lake trout and lake whitefish have declined in Jackfish Bay and in the Schreiber/Sewell Point reference site. Limited samples were analyzed for dioxins/furans in Jackfish Bay and Schreiber/ Sewell Point and there are some data gaps during the 1990s for Jackfish Bay and lack of historical data (prior to 2000) for Schreiber/Sewell Point. This limits the long-term comparison of fish contaminant levels for the two blocks. However, the dioxin/furan measurements that do exist over the last decades suggest significant decline in the fish contaminant levels for Jackfish Bay.	AiR Status: RFA	
Degradation of wildlife populations	It was felt that Blackbird Creek might attract wildlife during the spring months as the moderating influence of warm creek water tends to accelerate greening of creek side vegetation. Moose activity in particular appeared to be abnormally high along Blackbird Creek during the spring. There are no data on possible impacts to wildlife populations due to contaminants within the AOC. (Stage 1, 1991)	Stage 1: RFA	This BUI has never been listed as Impaired - a delisting target will only be developed when data indicates that its status is Impaired and requires action.
	The only sign of population degradation for colonial waterbirds in Jackfish Bay has been the decline in the number of breeding Herring Gulls at that location. The nest numbers in Jackfish Bay have declined from a high of 65 at 6 colony sites in 1989 to 17 at 4 sites in 1999 and 4 nests at 2 sites in 2007 (Morris et al. 2003; Canadian Wildlife Service, Environment Canada, unpublished data). This decline has probably resulted from repeated nesting failure, which in 1991 and 1992, was observed to be the result of repeated predation on eggs and young by Common Ravens (Shutt 1994). Repeated nest failure can cause Herring Gulls to desert a given nesting area. (Stage 2, 1998)	Stage 2: RFA	
	A 2010 study evaluated the risks to moose foraging in or along Blackbird Creek from exposure to chemicals of potential concern (COPCs) present in surface water, sediment, and food items. The results were conservative and focused and suggest that the risk of adverse effects to moose feeding in or along Blackbird Creek are quite low, even if they feed exclusively on a daily basis on aquatic plants within Blackbird Creek.	AiR Status: Not Impaired	

Body burdens of wildlife	Bioaccumulation of contaminants in the wildlife might have been occurring in portions of Jackfish Bay and the Blackbird Creek system; however, there is no data on contaminant burdens in wildlife. (Stage 1, 1991)	Stage 1: RFA	This BUI has never been listed as Impaired - a delisting target will only be developed when data indicates that its status is Impaired and requires action.
	Herring gull eggs collected from the AOC had relatively low levels of dioxins and other organochlorines, similar to background levels found elsewhere on Lake Superior (Shutt 1994). The gull eggs were not significantly contaminated with toxins normally associated with pulp mill effluent. Contaminant levels probably do not represent those of fish-eating gulls. If herring gulls had consumed fish from the AOC with elevated levels of toxins then they would have accumulated significant body burdens of these compounds. (Stage 2, 1998)	Stage 2: RFA	
	No further data has been collected since the 1991 study; however, the Stage 2 data has been used to justify a decision to delist this BUI. The 10 eggs collected in Jackfish Bay in 1991 contained relatively low levels of 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD-dioxin) compared to other sites on the Great Lakes. Levels of other organochlorines including p,p' DDE (1,1,1-trichloro-2,2-bis (p-chlorophenyl) ethane), mirex, dieldrin and oxychlordane were also low. The geometric mean of the sum of 42 Polychlorinated biphenyls (PCBs) congeners was 5.0 mg/kg wet weight, below mean egg levels for most Great Lakes sites. A pooled extract of eggs collected in Jackfish Bay was added to a chick hepatocyte bioassay. Ethoxyresorufin-O-deethylase (EROD) induction was not elevated above background levels, indicating the eggs were not significantly contaminated with known inducing compounds, including the non-ortho substituted PCBs.	AiR Status: Not Impaired	
Fish tumors and other deformities	Although incidences of external fish tumours or other deformities had not been reported, white suckers collected from Jackfish Bay in the summer of 1988 (prior to secondary treatment) had an abnormal incidence of liver neoplasms (cancers). Also, greater than 20 percent of lake whitefish had unexplainable external lesions which might have been associated with pollutants contributed from mill effluent. (Stage 1, 1991)	Stage 1: Impaired	This BUI will no longer be impaired when the fish tumour rates / deformities in Jackfish Bay do not statistically exceed rates in suitable reference sites in Lake Superior

	White suckers sampled from Jackfish Bay, prior to secondary treatment at Kimberly-Clark mill (1989), had an increased incidence of liver cancer (4-6%). Although the frequency of occurrence is greater in the AOC than in reference fish from Lake Superior (2-3%), it is still considered to be low (K. Munkittrick). Liver enzyme activity remains elevated in white suckers exposed to mill effluent. Increased liver size in lake whitefish (Munkittrick et al: 1992) and white suckers (Beak 1996) has also been reported. (Stage 2, 1998)	Stage 2: Impaired	
	White suckers were collected in Jackfish Bay, Thunder Bay and the Mountain Bay reference site in 2006 using electrofishing, gill nets, and trap and hoop nets. Neoplasms were rare and all three locations had a smaller percentage of fish with neoplasms than they had in the late 1980s. Liver neoplasm prevalence declined by over 7% in Jackfish Bay and was not statistically different from the Mountain Bay reference site in the proportion of the population found to have liver neoplasms. Fisher's Exact Test demonstrates that the liver neoplasm prevalence in the 2006 sample was significantly lower (p<0.01) that in the sample from the 1980s used in the Stage 1 report for the Jackfish Bay AOC (Baumann, n.d. Unpublished Report).	AiR Status: Not Impaired	
Bird or animal deformities or reproductive problems	Incidents of bird or animal deformities had not been reported in the AOC. However, indications of reproductive dysfunction in white sucker, longnose sucker and lake whitefish populations in the Jackfish Bay AOC had been reported. (Stage 1, 1991)	Stage 1: RFA	This BUI has never been listed as Impaired - a delisting target will only be developed when data indicates that its status is Impaired and requires action
	Incidents of bird and animal deformities have not been reported in the AOC. Reproductive impairment in Herring Gulls over two breeding seasons was comparable to non-contaminated sites in Lake Superior (Shutt 1994). However, small egg size, low chick survival rate, and the lack of nesting of gulls in 1997 indicate a decline in reproductive productivity. (Stage 2, 1998)	Stage 2: RFA	
	The poor reproductive success of Herring Gulls is attributed to natural causes (predation by Common Raven) rather than human causes e.g. mill effluent. It has not been demonstrated, either currently or historically, that avian wildlife in Jackfish Bay is impaired with respect to the occurrence of deformities	Stage 3: Not Impaired	

Degradation of benthos	The evaluation of this impairment is broken into two components (Dynamics of populations and body burdens of Benthos)		
Dynamics of benthic populations	The benthic fauna had been impacted in Moberly, Jackfish and Tunnel Bays as shown by the presence of impaired communities which had increased in number and extent between 1969 and 1987. During this period, pollution-intolerant species (*Pontoporea hoyi*) had decreased in density and extent whereas pollution-tolerant species (tubificids) had increased in density and extent. Sediments in Moberly Lake were found to be acutely toxic to benthic fauna. (Stage 1, 1991)	Stage 1: Impaired	The BUI will no longer be impaired when acute and chronic toxicity of sediment, and composition and densities of benthic communities are statistically indistinguishable from suitable reference sites
	Benthic communities in Moberly, Tunnel, and Jackfish Bays were severely impacted as a result of mill effluent. Following the installation of secondary treatment at the mill (1989), both density and diversity of benthic organisms has improved (Beak 1991a). Moberly Lake sediments remain acutely toxic to benthic fauna. Resuspension of sediments could severely impact downstream benthic communities (Beak 1991a) (Stage 2, 1998)	Stage 2: Impaired	
	The benthic community structure has been studied to assess the effects of mill effluent in Jackfish Bay. The degree of benthic community degradation has been used to track improvement in benthic community which provides direct evidence of improvement in mill operations. In a 2003 study (Milani and Grapentine, 2007), benthic impairment was evident, most notably in Moberly Bay, with the presence of pollution-tolerant benthic communities and sediment toxicity. Relative to 1987 historical data, pollution-intolerant species appeared to have increased in number and distribution in Jackfish Bay while the pollution-tolerant species appeared to have decreased, suggesting some benthic improvement. However, Jackfish Bay still showed a gradient of degradation from the mouth of Blackbird Creek to the more distant locations attributable to historical mill effluent. 6 of 15 sites in Jackfish Bay were considered different to very different compared with reference condition at sites selected from around Lake Superior (n = 30). The benthic community was also assessed with surveys in 1996, 1999, and 2002 which were the result of three separate EEM cycles	AiR Status: Impaired	

	(1-3) (Stantec, 2004). In 2003, Milani and Grapentine (2007) reported D. hoyi present at very low densities at sites closest to the mouth of Blackbird Creek. Farara's (2007) follow up study in 2006 showed that the benthic communities were considered virtually identical to those found during the 2003 study. The first signs of recovery were documented in the 2008 study by Milani and Grapentine (2009). Sites included 9 stations in Moberly Bay, 4 stations south of Moberly Bay, 1 station in Jackfish Bay, and 1 reference site in Tunnel Bay. 7 of the 15 sites were previously sampled in Environment Canada's 2003 study (Milani and Grapentine, 2007).		
Body burdens of benthic populations	Opossum shrimp (*Mysis relicta*) and introduced caged mussels (*Elliptio complanata*) collected in Moberly Bay had a dioxin and furan congener pattern similar to that of the mill effluent. The dominant isomer was 2,3,7,8-tetrachlorodibenzofuran with traces of other congeners including 2,3,7,8-tetrachlorodibenzo-p-dioxin. (Stage 1, 1991)	Stage 1: Impaired	This BUI will no longer be impaired when invertebrate tissue concentrations are below either (a) levels associated with adverse impacts or (b) invertebrate tissue concentrations at reference sites
	Mussels (Elliptio complanata) and opossum shrimp (Mysis relicta) caged in Moberly Bay showed body burdens of dioxins and furans in concentrations approximating those contained in mill effluent (Sherman et al. 1990). (Stage 2, 1998)	Stage 2: Impaired	
	Benthic invertebrates were collected from 6 locations in Jackfish Bay and from 5 reference sites (north shore of Lake Superior) in October 2008. Analysis of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (dioxins and furans) are to be performed on samples composed of organisms from 2 or 3 taxa (i.e., oligochaetes, chironomids and amphipods). Sites in Jackfish Bay included 3 locations in Moberly Bay, 1 south of Moberly Bay, 1 in Jackfish Bay and a single reference site in Tunnel Bay. These sites were sampled in 2003 by Environment Canada (Milani and Grapentine, 2007). Dioxin and furan concentrations in the benthos collected from Jackfish Bay from the October 2008 study were compared to those from the local (Tunnel Bay) and regional (Lake Superior) reference sites. Concentrations, expressed as toxic equivalents (TEQs), were also compared to the CCME Tissue Residue	AiR Status: Impaired	

	Guidelines (Milani and Grapentine, 2009). One site was severely toxic and two sites were potentially toxic. 12 sites were considered non-toxic. Toxicity was less severe in Moberly Bay in 2008 than in 2003 possibly indicating that recovery is ongoing; however, some sediments were still toxic to benthos.		
Restrictions on dredging activities	Sediments in the Jackfish Bay AOC, particularly within Moberly and Jackfish Bays, contained concentrations of several contaminants (oil and grease, total organic carbon, TKN, total phosphorus, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, zinc, hexachlorobenzene and total PCBs) which exceeded OMOE Open Water Dredged Material Disposal Guidelines (OWDMDG) and/or Provincial Sediment Quality Guidelines as of 1987/88. (Stage 1, 1991)	Stage1: Impaired	The ability to delist this BUI has been based on the fact that, despite the levels of sediment contamination in the AOC, there have been no plans to dredge in Jackfish Bay. Therefore the contaminated sediment condition does not impair a beneficial use related to dredging and will be remediated through the BUIs related to Benthos
	In a well designed study, Sibley et al. (1997) found the toxicity decreased away from the mouth of Blackbird Creek and the main factor correlated with toxicity was the amount of extractable organic chlorines in the sediment. However, other organic contaminants mimic the distribution of extractable organic chlorines and may also be significant factors. Sediments in the AOC contain several contaminants that exceed guidelines for dredging and open water disposal. However, without the demand for navigational or other dredging activities, contaminated sediments should be considered in the context of other ecosystem impairments. (Stage 2, 1998)	Stage 2: Not Impaired	
	Currently several contaminants are above the Provincial Sediment Quality Guidelines for dredging and open water disposal. However, since Stage 2 the RAP Team for Jackfish Bay has concluded that dredging is unlikely to take place and that this BUI is not applicable to the AOC.	AiR Status: N/A	
Eutrophication or undesirable algae	No nuisance algal growths had been reported. (Stage 1, 1991)	*Not Originally listed as Impaired*	

Restrictions on drinking water consumption or taste and odour problems	Drinking water for the Town of Terrace Bay was obtained from Lake Superior west of Jackfish Bay. There had been no consumption restrictions or reported taste and odour problems for treated drinking water. However, cottages are located in the old community of Jackfish and, on occasion, the effluent drifts in this direction, making non-treated water unsuitable for consumption. (Stage 1, 1991)	Stage1: Impaired	This BUI was Not Impaired since Stage 2, so no delisting criteria was established.
	Drinking water for the town of Terrace Bay is obtained from Lake Superior, west of Jackfish Bay. There have been no consumption restrictions or reported taste and odour problems for treated drinking water. However, on occasion, the mill effluent plume drifts towards cottages located in the old community of Jackfish, making non-treated water unsuitable for consumption. (Stage 2, 1998) This impairment was removed because, with proper treatment, it was found not to be an issue and it is not recommended to drink untreated water from the Great Lakes.	Stage 2: Not Impaired	
	The restrictions on drinking water have not changed since the Stage 2 report, and the drinking water obtained for Terrace Bay is still not drawn from Jackfish Bay. It is still recommended not to drink untreated water from the Great Lakes.	AiR Status: N/A	
Beach closings	Bacterial densities had periodically been elevated in the vicinity of the Terrace Bay Beach as a result of the mill discharge; however, this condition had not led to any beach closings and there are no other public beaches within the Jackfish Bay AOC. (Stage 1, 1991)	*Not Originally listed as Impaired*	
Degradation of aesthetics	Conditions had improved since the early 1970s; however, concerns continue to be expressed regarding the presence of foam and dark colour in Blackbird Creek and Moberly Bay. (Stage 1, 1991)	Stage 1: Impaired	This BUI will no longer be impaired when the waters are devoid of any substance which produces a persistent objectionable deposit, unnatural colour or turbidity, or unnatural odour
	Conditions have improved since the early 1970s; however, the presence of foam and dark coloured water in Blackbird Creek and Moberly Bay is still a concern. (Stage 2, 1998)	Stage 2: Impaired	
	Aesthetics in the Bay are still currently impaired, including but not limited to foam in Blackbird Creek. Although there have not been any further complaints or reports of degraded	AiR Status: RFA	

	aesthetics, it is a common occurrence to detect odour, foam and steam from locations in the AOC. These occurrences are most common in Lake 'C' (Moberly Lake) and Blackbird Creek.		
Added costs to agriculture or industry	There were no agricultural or industrial activities which utilized water from Jackfish Bay AOC. (Stage 1, 1991) There are no agricultural or industrial activities that utilize water from the AOC. Water intake for the mill and the town of Terrace Bay is located in open Lake Superior approximately 10 km west of Jackfish Bay. (Stage 2, 1998)	*Not Originally listed as Impaired*	
Degradation of phytoplankton and zooplankton populations	There were no widespread effects within the AOC, although community structures were likely altered in the immediate area of the discharge. No detailed information existed. (Stage 1, 1991)	Stage 1: RFA	This BUI was Not Impaired since Stage 2, so no delisting criteria was established.
	There have been no reported effects of contaminants on plankton populations in the AOC; however, community structure is likely altered in the vicinity of the mill discharge. Daphnia spp. are present in Blackbird Creek and in the secondary treatment system at the mill. (Stage 2, 1998)	Stage 2: Not Impaired	
Loss of fish habitat	Major lake trout spawning grounds were located in Moberly Bay and along the shore of Lake Superior adjacent to Jackfish Bay and were impaired due to physical alteration (deposition of organic matter) and chemical contamination of sediments. Lake whitefish spawning grounds were identified along Lake Superior's shore immediately east and west of Jackfish Bay. The quality and use of these shoals had not been assessed. Blackbird Creek was noted as a brook trout stream prior to the start-up of the mill in 1948. (Stage 1, 1991)	Stage 1: Impaired	This BUI will no longer be impaired when the quantity and quality of physical, chemical, and biological habitat required to achieve Lake Superior fish community objectives have been established and protected. These fish community objectives are outlined in a document entitled Fish-Community Objectives for Lake Superior (2003).
	Habitat mapping indicated spawning, nursery, and forage habitat in the Blackbird Creek system; however, water quality in the creek and in Moberly Lake remains impaired. Lake whitefish and lake trout spawning and nursery habitat was located on the eastern shore of Jackfish Bay. Contamination of existing habitat is not a limiting factor for fish populations in Lake Superior. (Stage 2, 1998)	Stage 2: Impaired	

	Much of the data collected to date has been from non-AOC specific programs that utilized a range of methodologies based on the program objectives. As a result, much of the available data for assessing the BUI status of fish habitat is insufficient for a complete community composition survey and fish population status may be a more effective measure of fish health in the AOC.	AiR Status: Impaired	

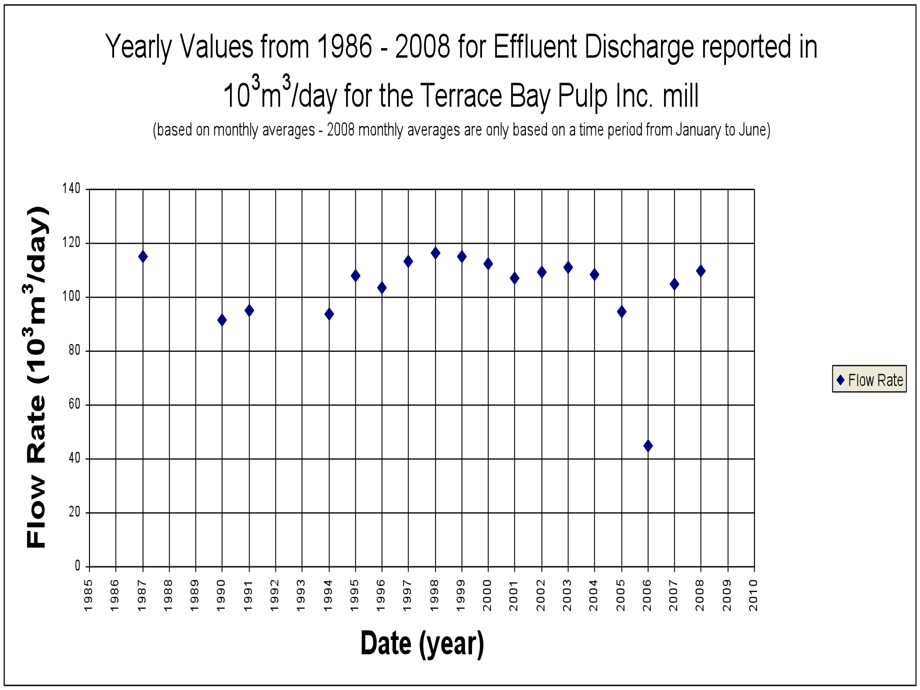
9.0 Appendix B

Environmental Protection Act Parameters and Maximum Targets for Mill Effluent

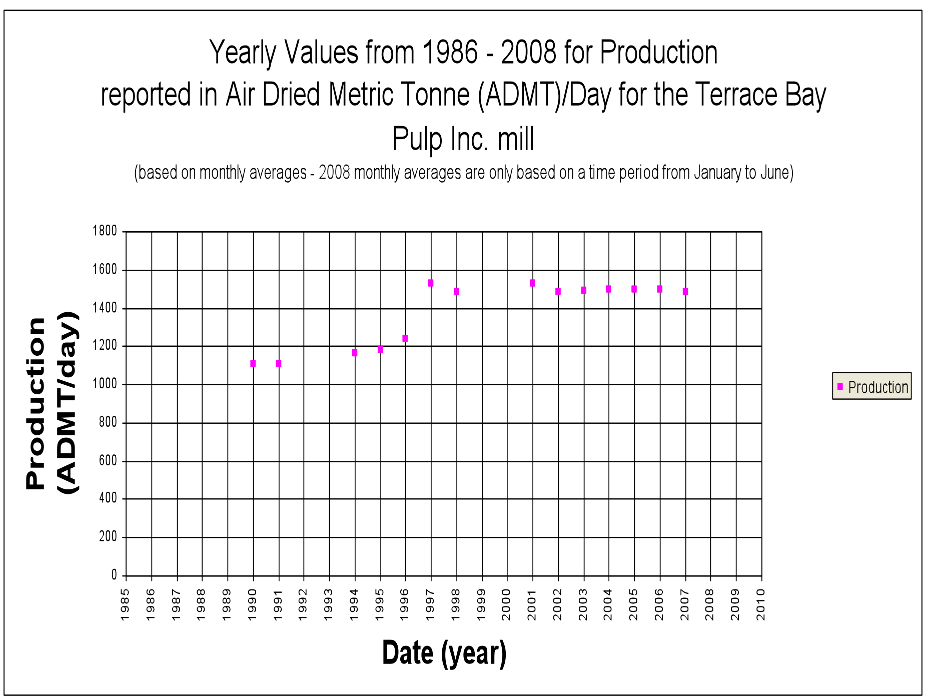
	1995 to 1998		1999 to present	
Reference production rate	**1530 ADMT**		**1484 ADMT**	
	Daily (kg/day)	**Monthly (kg/day)**	**Daily (kg/day)**	**Monthly (kg/day)**
BOD	15,300	7,650	15,300	7,650
Phosphorous	428	260	428	260
TSS	20,500	12,000	20,500	12,000
Chloroform	5.69	2.88	5.69	2.88
Toluene	0.329	0.329	0.329	0.329
Phenol	0.632	0.632	0.632	0.632
AOX	2,960	2,300	**1,580**	**1,200**

Yearly Values from 1986-2008 for a) Flow Rate, b)Production, c) Biological Oxygen Demand, and d) Phosphorus From Terrace Bay Mill

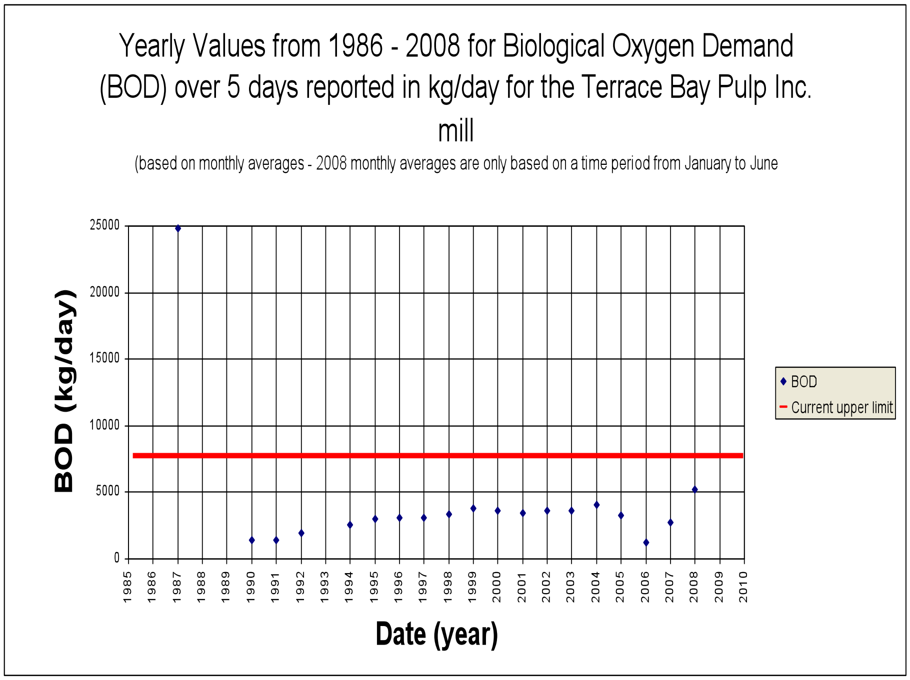
a) Flow Rate



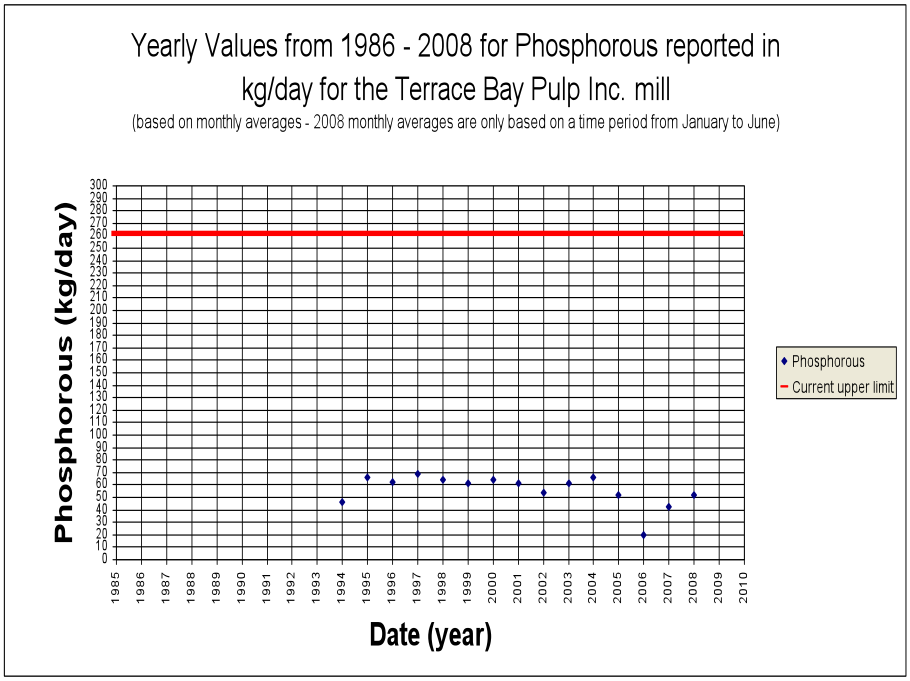
b) Production



c) Biological Oxygen Demand

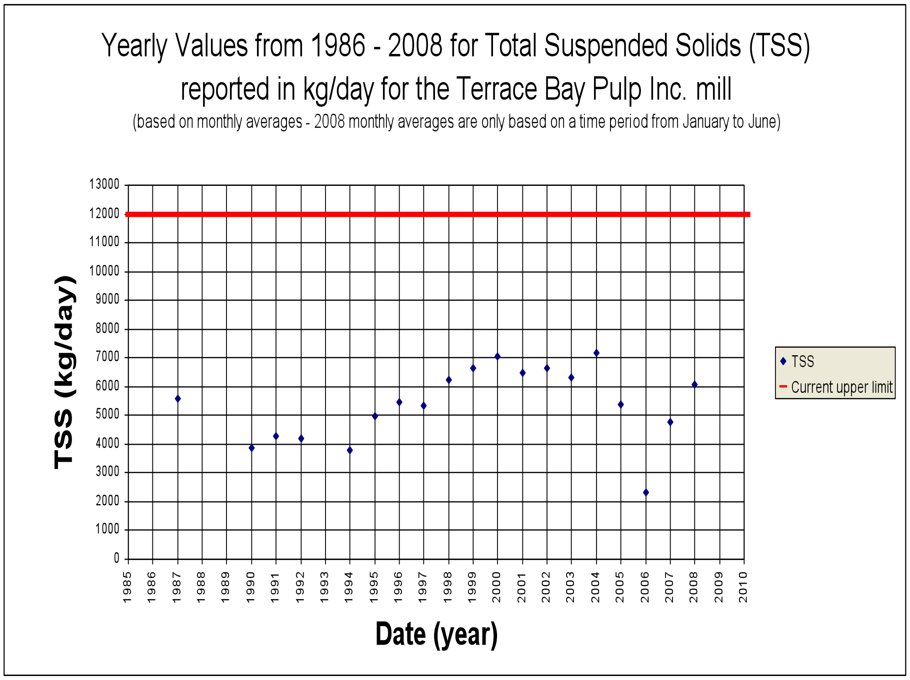


d) Phosphorus From Terrace Bay Mill

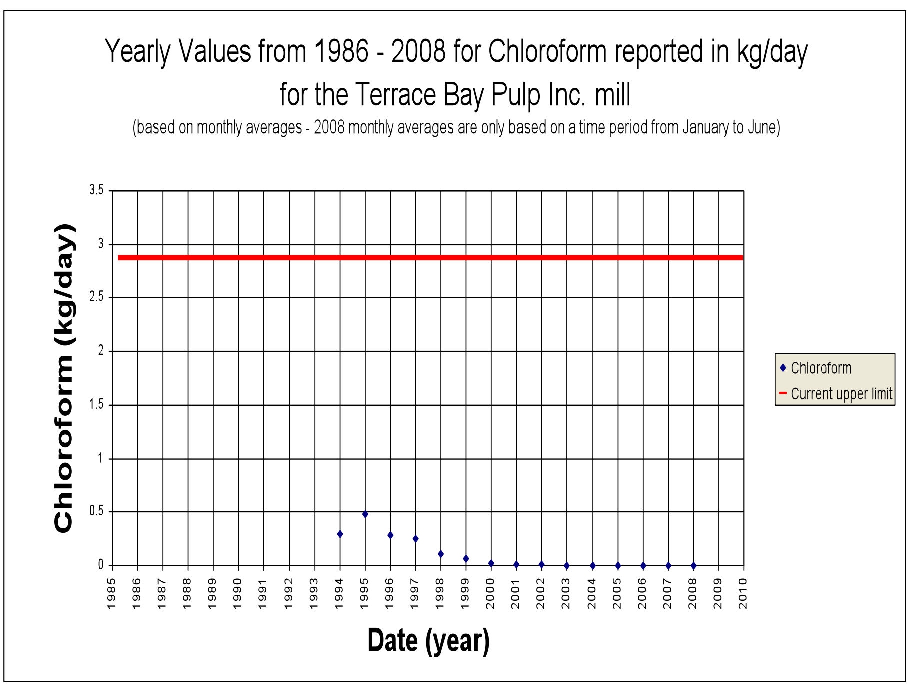


Yearly Values from 1986-2008 for a) Total Suspended Solids, b) Chloroform, c) Toluene, and d) Phenol From Terrace Bay Mill

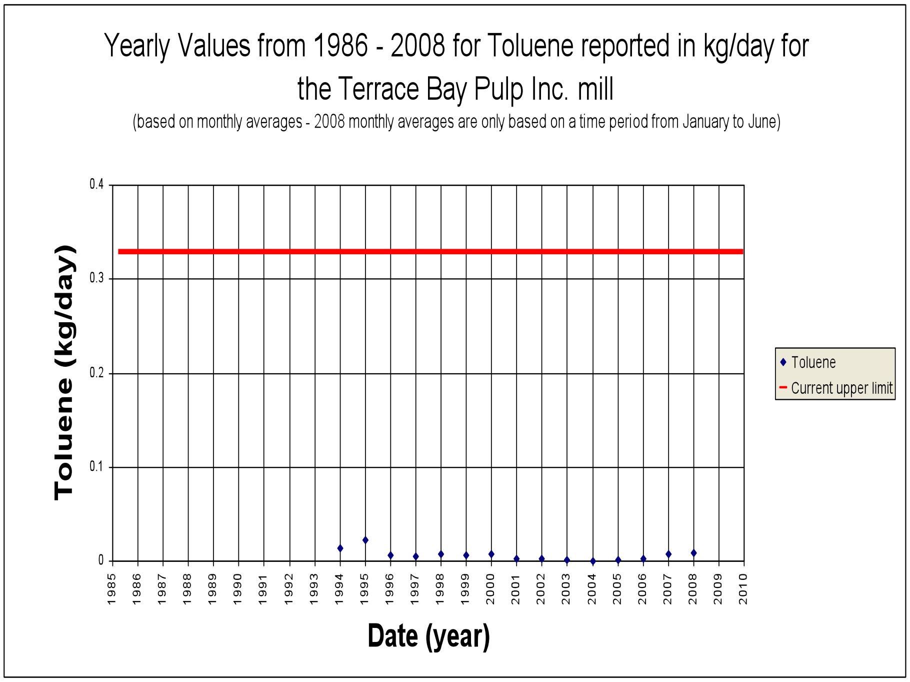
a) Total Suspended Solids



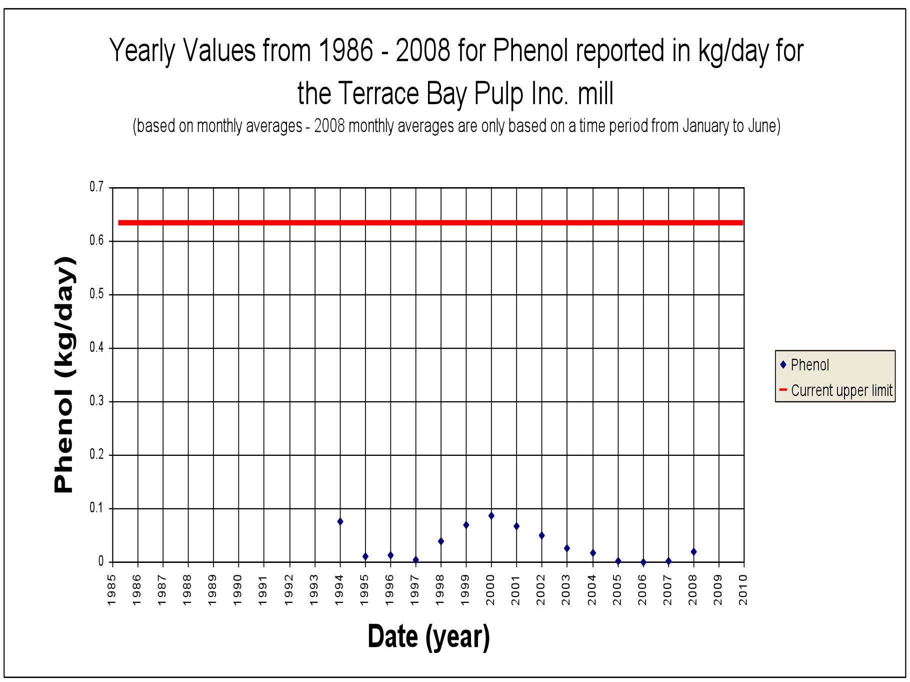
b) Chloroform



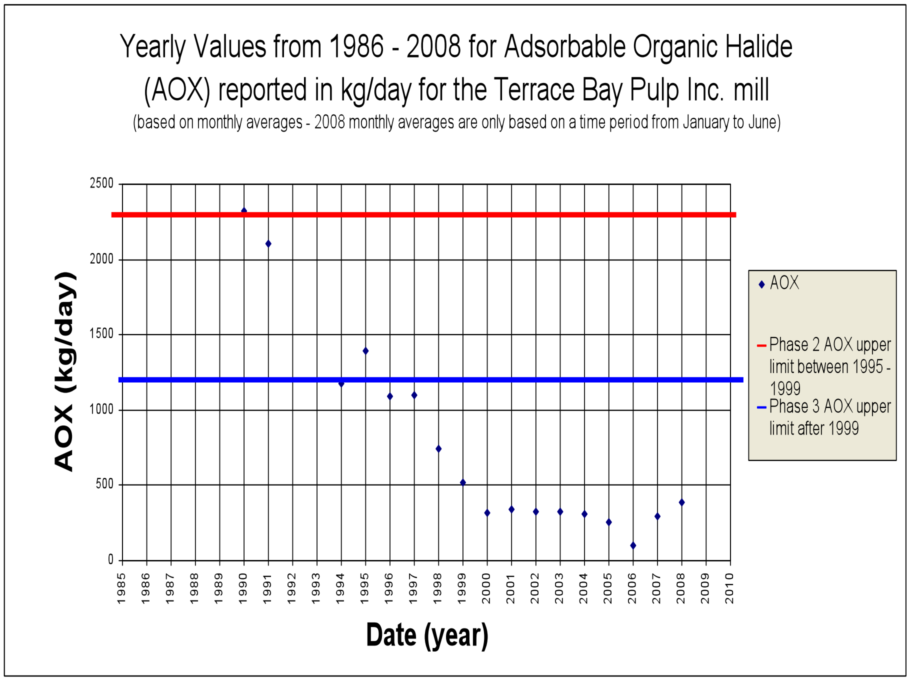
c) Toluene



d) Phenol



Yearly Values from 1986-2008 for Absorbable Organic Halide From Terrace Bay Missing



Toxicity Failure for Rainbow Trout and Daphnia Exposed to Mill Effluent

January 3rd, 2005	Toxicity Failure – 100% mortality of Rainbow trout test
February 4th ,2008#	Toxicity Failure – 90% mortality of Rainbow trout test
February 11th , 2008#	Toxicity Failure – LC50 of Rainbow trout
February 12th, 2008#	Toxicity Failure – Rainbow trout
February 18th, 2008#	Toxicity Failure – LC50 Rainbow trout (mill hired specialist and began to add supplemental nutrients to the system – supplement stopped in March 2008)
February 25th, 2008#	Toxicity Failure – Rainbow trout and daphnia
March 3rd and 10th, 2008#	Toxicity Pass – LC50 for Rainbow trout and daphnia
March 17th , 2008#	Toxicity Pass – for both Rainbow trout and daphnia

* Correspondence between the mill and MOE
# Written statement from Monika Holenstein
LC50 = Lethal Concentration 50% (the concentration of the chemical in the water instead of the organism being exposed to the whole dose. A failure occurs if more than 50% of the organisms, either Rainbow Trout or daphnia, die).

10.0 Appendix C

ENVIRON Focused Ecological Risk Evaluation (ERE) of Moose Foraging in Blackbird Creek

March 18, 2010

ENVIRON is pleased to provide Environment Canada with this letter report on the focused ecological risk evaluation (ERE) of moose that could forage along Blackbird Creek, near Terrace Bay, Ontario. The objective of this evaluation is to estimate the proportion of time that individual moose could forage along the creek without significant risk of adverse effects.

Since 1948, a pulp mill in Terrace Bay, Ontario has discharged kraft mill effluent into a canal that flows into Blackbird Creek, which in turn flows into Jackfish Bay (Figure 1). Jackfish Bay is one of four Areas of Concern (AOCs) on the Canadian north shore of Lake Superior. The other three AOCs are Peninsula Harbour, Nipigon Bay, and Thunder Bay. These four areas have sometimes been grouped together under the "North Shore of Lake Superior Remedial Action Plan" program. Jackfish Bay AOC is located on the north shore of Lake Superior, approximately 250 kilometres (km) northeast of Thunder Bay. The AOC consists of a 14 km reach of Blackbird Creek between the pulp mill and Jackfish Bay, including Lake C (Moberly Lake), and Jackfish Bay. Blackbird Creek is the focus of this ERE.

The purpose of this focused ERE is to answer the risk question: "Are moose foraging in or along Blackbird Creek at risk as a result of exposure to chemicals of potential concern (COPCs) present in surface water, sediment, or food items and, if so, what fraction of time or diet would be associated with an unacceptable risk of adverse effects?"

The discharged effluent causes the temperature of Blackbird Creek to be warmer than naturally occurring waters, resulting in delayed freezing and earlier melting of the creek, and earlier greening of vegetation along the creek in the spring. Consequently, Blackbird Creek may attract wildlife (particularly moose [*Alces Alces*] sometimes referred to as *Alces Americana*) during the spring months.

This focused ERE presents: 1) a brief site description; 2) a data summary and identification of COPCs; 3) exposure assessment; 4) toxicity assessment; 5) risk characterization; 6) uncertainty evaluation; and 7) conclusions and recommendations.

1. Site Description

A detailed site description is provided in Jackfish Bay Stage I report (Jackfish Bay Public Advisory Committee 1991); most of the following description is excerpted from that report.

The Blackbird Creek watershed drains an area of 62 square km. The creek rises near the town of Terrace Bay and flows in a southeasterly direction for 14 km into the northern tip of Moberly Bay (Figure 1). Beak Consultants (1991) report that the effluent from the mill may comprise up to 70% of the flow of Blackbird Creek. As Blackbird Creek drains to Jackfish Bay and Lake Superior, it passes through two wetlands. Both wetlands were historically shallow lakes and were referred to as Lake A and Lake C (Moberly Lake).

Lake A originally covered a surface area of 19 hectares (ha) with depths up to 6.1 metres (m). Due to the accumulation of woody fibre from the effluent, substantial in-filling occurred. In the 1980s, the flow of Blackbird Creek was redirected to bypass Lake A. From site visits and aerial inspections, it appears that much of this lake is now a wetland covered with submerged vegetation. Lake C (Moberly Lake) is 29 ha in area, with an original maximum depth of 6.4 m. Depth decreased to 0.8 m due to woody fibre in-filling from the effluent.

Blackbird Creek drains into the western side of Jackfish Bay, which contains two inner arms: Moberly Bay on the west and Tunnel Bay on the east. A constructed tunnel connects Jackfish Lake with Tunnel Bay. Jackfish Lake receives runoff from a small drainage basin, which extends to the north of the lake. The total surface area of Jackfish Bay is 6.4 square km. The largest islands in Jackfish Bay are: 1) Cody Island, located in the extreme southwest of Moberly Bay; 2) Bennett Island, located in southeastern Moberly Bay; and 3) St. Patrick Island, located near the eastern shore of Jackfish Bay.

The Jackfish Bay AOC lies within the Superior Forest Section of the Boreal Forest Region. Forests of white spruce (*Picea glauca*), balsam fir (*Abies balsamea*), white birch (*Betula. papyrifera*), and trembling aspen (*Populus tremuloides*) are found in the valleys. The same species are found on the thin till slopes and tops of low hills, although birch is more prominent than in the valleys and some black spruce (*Picea mariana*) is present. Jack pine (*Pinus banksiana*), white birch and poor quality black spruce are characteristic of higher rocky elevations and coarser valley soils. Lowland areas support high quality stands of black spruce, along with tamarack (*Larix laricina*) and eastern white cedar (*Thuja occidentalis*). On shorelines, spikerushes (*Eleocharis spp.*) occupy the zone closest to the water, with more robust sedges (*Carex spp*.) and, in some places, cattails (*Typha latifolia*) above them. A band of speckled alders (*Alnus rugosa*) is typically found upgradient from these emergent species.

A heterogeneous pattern of shrub hummocks surrounded by graminoid-filled lows or open water channels is present in two large thicket/marsh complexes in the upper portion of Blackbird Creek, as well as upgradient of Lake C (Moberly Lake). Speckled alder is the principal shrub present, although scattered red osier dogwood (*Cornus stolonifera*) is also present. The principal graminoid is a robust sedge of the genus Carex (a lucsutris or rostrata-type). A beaver (*Castor canadensis*) pond and meadows present in the area also contain prevalent common cattail.

Wildlife found in the area of Jackfish Bay include species well adapted to the harsh climatic conditions. In addition to moose, mammalian species in the area may include deer (*Odocoileus virginians*), woodland caribou (*Rangifer tarandus carabou*), timber wolf (*Canis lupus*), fox (*Vulpes vulpes*), lynx (*Lynx canadensis)*, black bear (*Ursus americanus*), mink (*Mustela vison*), fisher (*Mustela pennanti*), marten (*Martes americana*), muskrat (*Ondatra zibethicus*), beaver, porcupine (*Erethizon dorsatum*), skunk (*Mephitis mephitis)*, snowshoe hare (*Lepus americanus*), and red squirrel (*Tamiasciurus hudsonicus*). Shrew (*Sorex spp., Blarina brevicauda*), mouse (*Peromyscus spp*) and vole (*Microtus pennsylvanicus*) populations are also found in the area. Birds that occur in the area include peregrine falcon (*Falco peregrinus*) and bald eagle (*Haliaeetus leucocephalus*), as well as a variety of upland gamebirds, shorebirds, and songbirds.

2. Data Summary and Selection of Chemicals of Potential Concern

Chemistry data considered in this ERE are sediment data from Blackbird Creek and effluent data. Effluent samples were collected from the pipe at the point where it discharges to the canal. Historic surface water, sediment, and effluent data were not used because they do not reflect current conditions.

The main COPCs in Blackbird Creek are polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans (PCDD/Fs) and dioxin-like polychlorinated biphenyls (PCBs). However, analytical data for metals, pesticides, and polycyclic aromatic hydrocarbons (PAHs) are also available and are considered in this ERE. Given their low toxicity at high concentrations and their ubiquitous distribution in the environment, essential nutrients (e.g., calcium, iron, magnesium, phosphorus, potassium, sodium) were not evaluated in this ERE. Raw data are included in Attachment 1.

Available surface water, sediment, and effluent data are discussed below. PCDD/Fs and PCBs are hydrophobic and therefore tend to occur in sediment rather than in surface water. Therefore focus of this evaluation is on sediment data, although other available data are also mentioned below.

<u>Surface Water.</u> Environment Canada has limited their recent evaluation of surface water to locations from Lake C (Moberly Lake), which have been analyzed only for nutrients and major ions (calcium, magnesium, and sodium). These data were not summarized, as these analytes are essential nutrients to mammals and are unlikely to pose a risk to moose. Environment Canada also collected a foam sample from Blackbird Creek in 2008 and analyzed it for PCDD/Fs and dioxin-like PCBs. Data from the foam sample was not included in this evaluation as it was not considered representative of surface water conditions.

<u>Sediment.</u> Environment Canada collected sediment samples in 2005 (one surface grab from Blackbird Creek), 2006 (six surface grabs from Blackbird Creek), 2007 (five surface grabs from Blackbird Creek), and 2008 (one surface grabs from Blackbird Creek, six surface grabs and one core from Lake C [Moberly Lake]). Deeper sediment samples were not used as moose are unlikely to contact these sediments.

Samples were analyzed for metals (2005, 2006, 2008), PAHs (2008), organochlorine pesticides (2005), and PCDD/Fs and dioxin-like PCBs (2005, 2006, 2007, 2008). Grab samples were included in the analysis and only the top depth interval (0 to 2 centimetres) of the core was included in the evaluation. In total, there were six locations in Lake C (Moberly Lake) and six locations in Blackbird Creek that were visited in 2006, 2007, and 2008. The 2005 Blackbird Creek sample was not revisited in subsequent years.

Figure 2 illustrates the sediment sampling locations that serve as the basis for this ERE. Table 1 summarizes sediment data evaluated in this ERE, including chemicals analyzed for but never detected.

Table 2 is a screening table for detected analytes. Individual PAHs are listed in Table 2 whether they were detected or not, because this ERE evaluates PAHs as total PAHs.

Screening values used to refine the list of COPCs include Environment Canada's Interim Sediment Quality Guidelines (ISQGs) (http://www.ec.gc.ca/ceqg-rcqe/English/Pdf/sediment_summary_table.pdf) and Ontario Ministry of the Environment (MOE) Sediment Quality Guideline Lowest Effect Levels (LELs) (http://www.ene.gov.on.ca/publications/6658e.pdf). Although these screening values are based largely upon protection of aquatic organisms (rather than protection of wildlife), it is reasonable to assume that chemicals present at levels below these values are less likely to pose a risk to moose than are those chemicals present at levels exceeding these values. Uncertainties associated with limiting the list of COPCs are discussed in the uncertainty evaluation.

PCDD/Fs and PCBs commonly occur as complex mixtures in the environment. Presently, evidence is sufficient to conclude that a common mechanism of action, involving binding of the chemicals to the aryl hydrocarbon receptor (AhR) as the initial step, underlies 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)-like toxicity elicited by these PCDD/Fs and PCBs (Van den Berg et al. 1998, Hahn 1998). Assessment of human or ecological risk requires a means of quantifying the cumulative effects of PCDD/Fs and PCBs. A toxic equivalency approach is used, in which toxicity of other PCDD/Fs and dioxin-like PCBs can be estimated relative to 2,3,7,8-TCDD. The World Health Organization (WHO 2005) published toxic equivalency factors (TEFs) for mammals that can be applied to other congeners to develop a toxic equivalency (TEQ), which is the sum of each adjusted congener concentrations adjusted for their toxicity relative to 2,3,7,8-TCDD. TEQ concentrations used in this ERE were calculated for PCDD/Fs and dioxin-like PCBs. Table 3 summarizes TEQs for PCDD/Fs and dioxin-like PCBs.

The screening evaluation involved comparison of maximum detected concentrations to chemical-specific screening values. Based on this screening, COPCs in sediment include PCDD/Fs and dioxin-like PCBs, PAHs (to be evaluated as total PAHs), and cadmium, chromium, copper, mercury, manganese, nickel, and zinc. Several additional detected metals were not selected as COPCs despite a lack of screening values. Of these, calcium, magnesium, sodium, and phosphorus are essential nutrients and are not likely to pose a risk to moose. Aluminum, barium, beryllium, bismuth, gallium, lanthanum, lithium, molybdenum, rubidium, antimony, selenium, strontium, titanium, thallium, uranium, vanadium, and yttrium also do not have screening values, and risks associated with these metals were not evaluated due to very limited mammalian ecotoxicity information. This uncertainty is discussed in the uncertainty evaluation.

Effluent. The mill collects effluent samples and supplies the data to MOE as part of the Municipal/Industrial Strategy for Abatement (MISA) program. Samples are collected quarterly (when the mill is operating) from the mill discharge pipe and analyzed for a variety of chemical parameters, including selected volatile organic compounds (VOCs) and 2,3,7,8-TCDD/2,3,7,8-Tetrachlorodibenzofuran (TCDF). Samples are not collected if effluent is not being discharged to the creek. The mill was idled indefinitely in March 2009. The most recent data, reported to MOE in 2007 and 2008, were used in this ERE. This time period also corresponds with Environment Canada's sample collection time period for sediment samples from Lake C/Moberly Lake. The 2,3,7,8-TCDD and 2,3,7,8-TCDF data were used to calculate the WHO mammalian TEQs. Table 4 presents a summary of effluent data. Since only two congeners were analyzed, the resultant TEQs may underestimate the actual TEQ. The effect of this limitation is discussed in the uncertainty evaluation.

3. Exposure Assessment

At the request of Environment Canada, this ERE focuses on the moose as the sole receptor of interest or valued ecological component. Other potential ecological receptors (e.g., benthic invertebrates, fish, birds, other mammals) may be considered in other analyses. The moose is the largest member of the deer family. It is present throughout most of Canada and northern portions of North America. It is primarily herbivorous, feeding mainly on leaves and twigs of various trees and shrubs, as well as upland and aquatic plants. When food becomes scarce, as it often does toward spring, moose strip bark from trees, especially poplars (Canadian Wildlife Service & Canadian Wildlife Federation 2003). The Blackbird Creek system, which has an abundance of trees, shrubs, and grasses, appears to be highly suitable habitat for moose.

In this exposure assessment, magnitude, frequency, and duration of exposure to COPCs are evaluated. Measures of both central tendency (arithmetic mean) and upper bound (maximum observed values) exposures are evaluated. Arithmetic mean concentrations reflect central tendency exposures, while maximum concentrations are a conservative representation of upper bound exposures. For each complete exposure pathway evaluated, the average and maximum exposure point concentrations (EPCs) were developed using available data (Environment Canada sediment data, and MOE/MISA effluent data). Exposure routes evaluated in this ERE include ingestion of water, ingestion of food, and incidental ingestion of sediment by moose. Development of EPCs for sediment, plants, and surface water are discussed below.

Table 5 lists mean and maximum concentrations of COPCs in sediment, which are used as sediment EPCs in this ERE.

In the absence of any recent measurements of COPC concentrations in plants, we estimated concentrations of PCDD/Fs in plants based on measured sediment concentrations and homologue-specific sediment-to-plant bioaccumulation factors (BAFs) developed by Coote (1996) from paired sediment and plant concentrations collected from Lake A and Lake C (Moberly Lake). Although BAFs were provided for submergent and emergent vegetation, only the submergent BAFs were used in this ERE because submergent vegetation tends to be the preferred dietary item for moose foraging in wetlands and aquatic environments (USFWS 1987). Table 6 presents the BAFs for two plant species (*Utricularia vulgaris* and *Potamogeton pusillus*), and the arithmetic mean BAF for each homologue group, which was used to estimate the concentration of each congener in plants.

Concentrations of other COPCs in plants were estimated by applying literature-derived uptake factors to sediment EPCs. The uptake factors were drawn from USEPA's (2007) Ecological Soil Screening Level (Eco-SSL) document (Attachment 4-1, Tables 4a and 4b http://www.epa.gov/ecotox/ecossl/SOPs.htm). Table 7 lists EPCs for plants developed by applying these BAFs.

Mean and maximum effluent concentrations serve as surface water EPCs for PCDD/Fs. For total PAHs, effluent concentrations are not available, and therefore surface water EPCs for PAHs were estimated based on organic carbon partitioning coefficients (Koc) calculated from octanol-water partitioning coefficients (Kow) from EPIWIN physical properties database (http://www.epa.gov/oppt/exposure/pubs/episuitedl.htm). For PAHs, Kow values in the database were from studies conducted as standard temperature (25°C). Koc was calculated using the following standard equation developed by Karickhoff (1981):

Eqn. 1

$$logKoc = 0.41 * logKow$$

Surface water EPCs for metals were estimated based on the median sediment to water partition coefficents from Allison and Allison (2005; Table 1 (http://www.epa.gov/athens/publications/reports/Ambrose600R05074PartitionCoefficients.pdf). Table 8 lists surface water EPCs for all COPCs.

Risks to moose were evaluated by comparing the modeled dietary intake (dose) of a COPC to a dose reported in the literature as a threshold for adverse effects on survival or reproduction. Dose was calculated using the equation:

Eqn. 2

$$Dose = (Csw \times WIR) + (Csd \times SIR) + (Cp \times Pp \times FIR) \times AUF \times 1/BW$$

Where:

Dose = Dose (milligram per kilogram body weight per day or mg/kg-day)

Csw = concentration in surface water (milligrams per litre or mg/L)

WIR = water ingestion rate (litre per day or L/day)

Csd = concentration in sediment (milligrams per kilogram or mg/kg)

SIR = sediment ingestion rate (kilogram per day or kg/day)

Cp = concentration in plant (mg/kg)

Pp = fraction of diet as plant (unitless)

FIR = food ingestion rate (kg/day)

AUF = area use factor (unitless)

BW = body weight (kg)

Because moose are not included in USEPA's (1993) *Wildlife Exposure Factors Handbook* other sources of information were sought for representative exposure factors for moose. Exposure assumptions used to estimate a dose for moose are summarized in Table 9. The basis for key assumptions listed in those tables is further explained below.

An average body weight of 365 kg was used in this ERE, based on the average weight of a female moose reported by the U.S. Fish & Wildlife Service (USFWS) in the Habitat Suitability Index Model for Moose in the Lake Superior Region (USFWS 1987). Female body weight is used because the mammalian TRVs used for PCDD/Fs and most other COPCs in this ERE are based on effects to females rather than males.

Calculated and measured food ingestion rates are presented in Table 10. Empirical data on food ingestion rate (FIR) of moose were obtained from a study by Reneker and Hudson (1985), who report a dry matter daily intake for two free-ranging moose ranging from 37.8 grams per kilogram body weight (g food/kgBW$^{0.75}$) in January to 128.5 g food/kgBW$^{0.75}$ in July. Ingestion rates were converted to a wet weight basis based on an average water content of 85% for terrestrial dicot plant leaves (USEPA 1993). Based on this study, measured FIR for moose range from 0.06 grams food per grams of bodyweight per day (gfood/gBW-day) to 0.19 gfood/gBW-day. Ingestion rates were converted to a wet weight basis based on an average water content of 85% for terrestrial dicot plant leaves (USEPA 1993), which were the primary food source for the moose in the Reneker and Hudson (1985) study.

The FIR may also be estimated based on free metabolic rate (FMR) using following equation from USEPA (1993):

Eqn. 3

$$NIR = \frac{NFMR}{ME \times Pi}$$

Where:

NIR	=	body-weight normalized ingestion rate (gfood/kgBW-day)
NFMR	=	free metabolic rate (kiloJoule per kgBW or kJ/kgBW)
ME	=	metabolic energy (kilocalorie per gram or kcal/g)
Pi	=	fraction of diet as item i (unitless)

Renecker and Hudson (1986) report daily resting energy expenditures ranging from 940 kiloJoule per kilogram body weight (kJ/ kgBW$^{0.75}$) in spring-early summer to 430 kJ/ kgBW$^{0.75}$ in winter. By applying a standard conversion factor of 0.239 kcal per kJ, a FMR of 225 kcal/kgBW$^{0.75}$ is calculated. At the average moose body weight of 365 kg, the conversion factor for converting kgBW$^{0.75}$ to kgBW is 0.229, resulting in a NFMR of 51 kcal/kgBW-d.

Metabolic energy is calculated by multiplying a gross energy for each dietary item (in this case, aquatic plants) by the assumed assimilation efficiency (percentage). Using a gross energy of 0.83 kcal/g wet weight reported for aquatic macrophytes and emergent vegetation in USEPA (1993), and an assimilation efficiency of 76% for herbivorous rabbits/voles/rats (USEPA 1993)(values are not available for moose), an estimated metabolic energy of 0.63 kcal/g wet weight food is calculated. Dividing the NFMR by the ME results in a NIR of 82 g food/kgBW-day, or 0.082 g/gBW-day.

The derivation of the estimated NIR value for moose is provided in Table 10. As shown there, the estimated daily NIR of 0.082 g food/gBW-day falls within the empirical range reported by Reneker and Hudson (1985). For this ERE, the normalized FIR of 0.082 g food (wet weight)/g BW-day was used for all subsequent calculations.

Beyer et al (1994) published sediment and soil ingestion rates for a variety of wildlife species, including moose. For moose, a soil ingestion rate of 2% of ingested food (dry weight) was reported and sediment ingestion was assumed to equal soil ingestion for this ERE. The percentage relative to diet was converted from a dry weight diet to a wet weight diet basis by multiplying by a conversion factor of 0.2 (assuming 80% water content of the diet consisting of aquatic plants). The FIR (wet weight) was then multiplied by the wet weight sediment percentage to calculate the sediment ingestion rate. The sediment ingestion rate is included in Table 9.

A surface water ingestion rate (WIR) was calculated using the following allometric equation for mammals provided by USEPA (1993):

Eqn. 4

$$WI\ (L/day) = 0.099 \times BW^{0.90}\ (kg)$$

Where:

WIR = water intake rate (L/day)

BW = body weight (kg)

Based on this equation, a surface water ingestion rate of 20 L/day is used in this ERE.

In exposure assessment, area use factors (AUFs) are often applied to an exposure estimate when the foraging area of a receptor is larger than the area being assessed. Moose forage over very large areas. However, here it was assumed that, for at least a portion of time in the spring, moose may forage exclusively on vegetation in Blackbird Creek. Therefore, an AUF of 1 was applied. This is a conservative assumption because moose tend to be primarily browsers (of leaves and twigs), rather than grazers of emergent or submerged vegetation. That said, they may forage heavily on aquatic vegetation particularly during warm summer months. Had risks been predicted to be significant based on an AUF of 1, the AUF would have been iteratively reduced to find the amount of time that a moose could forage in Blackbird Creek without posing significant risks.

Based on the EPCs, exposure parameters, and exposure assumptions described above, daily dose for each COPC was estimated; dose is presented in Table 11.

4. Toxicity Assessment

The purpose of the toxicity assessment is to present and describe effects data and toxicity reference values (TRVs) that were used to evaluate the likelihood of adverse effects in the risk characterization.

TRVs were derived based on the general methodology of Sample et al. (1996) and Sample and Arenal (1999). No observed adverse effect levels (NOAELs) and lowest observed adverse effect levels (LOAELs) are commonly reported endpoints that may be considered in the selection of the test species dose. NOAELs and LOAELs considered in TRV derivation are reported on—or converted to—a mg COPC/kg body weight/day (mg/kg-day) basis. These dose units allow comparisons among organisms of different body sizes (Sample et al. 1996). In cases where the critical study states the lowest effect level as a dietary concentration (i.e., in units of mg COPC/kg food), the test species dose is calculated as:

Eqn. 5

$$Dose = \frac{C \times FIR}{BW}$$

Where:

Dose	=	test species dose of COPC (mg/kg-day)
C	=	concentration of COPC in food (mg/kg)
FIR	=	food ingestion rate of food or water by the test species (kg/day)
BW	=	body weight of the test species (kg)

Extrapolation factors and uncertainty factors are typically identified based on three characteristics of the experimental conditions associated with the test species dose: 1) the duration of exposure; 2) the endpoint measured; and 3) differences in body weight among test and receptor species (Calabrese and Baldwin 1993, Ford et al. 1992, Opresko et al. 1994, Sample and Arenal 1999, Sample et al. 1996, USEPA 1996, Watkin and Stelljes 1993, Wentsel et al. 1994).

Toxicity data for moose were not located in the available literature; in fact, toxicity data for large mammals are quite scarce. Available mammalian toxicity data are summarized in Table 12, and values used in this ERE are highlighted. For the TEQ, a previous compilation of studies and data presented in the *Ecological Risk Assessment For General Electric (GE)/Housatonic River Site, Rest Of River* (USEPA 2004) was used. They developed effect doses for TEQ using rat study results of Khera and Ruddick (1973) and Sparschu et al. (1971). These studies were combined for the derivation of the dose-response curve for rats exposed to TEQ. Both studies investigated reproduction effects in rats by administering TCDD on gestation days 6 to 15. The studies used similar protocols and when combined yielded a data set with 17 treatment levels. The dose response curve for reproductive fecundity of rats exposed to TEQ, as well as the data used to develop the dose response curve, are included as Attachment 2 of this ERE. The dose-response curve indicated that 10% and 20% declines in fecundity would be expected at does of 156 and 330 ng/kgBW-d TEC, respectively. These values were included as NOAEL and LOAEL TRVs for purposes of this ERE.

5. Risk Characterization

The risk characterization describes the likelihood, severity, and spatial extent of any adverse effects in moose exposed while foraging along or in Blackbird Creek. Risks are characterized primarily by the calculation of hazard quotients (HQs), which compare doses to TRVs. HQs are calculated by dividing the estimated dose of a given COPC by the corresponding TRV, to yield a quotient. HQ values at or below 1 indicate that concentrations or doses are predicted to be below levels associated with adverse effects, whereas HQ values greater than 1 indicate that a more refined investigation is required to determine if adverse effects are likely.

Table 13 presents HQs for moose. All HQs for moose are below 1, indicating that moose are unlikely to be adversely affected from exposure to PCDD/Fs or other COPCs in sediment, surface water, or plants in Blackbird Creek.

6. Uncertainty Evaluation

Uncertainty can be introduced into an ERE at every step in the process. Conservative assumptions were generally employed in this ERE to compensate for that uncertainty, to ensure the protectiveness of the overall assessment. Major sources of uncertainty and their expected effects on the ERE conclusions are discussed below.

Several uncommon metals were not included in the ERE calculations due to lack of toxicity or exposure data. However, compared to the potential toxicity and risks associated with PCDD/Fs, these metals are unlikely to represent a risk to moose in the vicinity of Blackbird Creek. Therefore, exclusion of these metals from the ERE is not likely to have resulted in a significant underestimation of risk in this ERE.

Sediment screening values were used to refine the list of COPCs carried through the ERE. These values are based largely upon protection of aquatic organisms (rather than protection of wildlife), and it is possible that elimination of some of these chemicals resulted in underestimation of risks to moose. Chemicals excluded based on this comparison are limited to silver, arsenic, cobalt, and lead. Maximum concentrations of silver, arsenic, cobalt, and lead were 0.5, 4.0, 8.5, and 11 mg/kg, respectively. These levels are at or below concentrations identified as background concentrations reported in the *Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act* (MOE 2004). As the concentrations are at or below background concentrations, risks to moose are not likely to be different from background, and the overall impact on the conclusions of this ERE is negligible.

The surface sediment data used in the ERE likely reflect a combination of periods of mill operation and shutdown. Exclusion of sediment data from deeper layers is appropriate for the evaluation of current risks to moose, as moose are not likely to come into contact with these sediments. However, deeper layers of sediment in the creek may contain higher concentrations of COCs reflective of higher historic discharges. Moose could be exposed to these deeper sediments in the future if these sediments become exposed as a result of erosion processes, major floods, or other disturbances. However, these deeper layers tend to be in depositional areas rather than in areas subject to erosion. Given that the mill is idled indefinitely, the ongoing deposition of relatively clean sediment over these historic sediments will result in gradually lower surficial sediment concentrations over time.

The lack of recent surface water and plant data introduces a great degree of uncertainty into the ERE, in that it was necessary to model concentrations of PAHs and metals in surface water and in plants based on sediment concentrations. For dioxins/furans, surface water EPCs were estimated based on measured effluent concentrations of 2,3,7,8-TCDD and 2,3,7,8-TCDF, rather than the full suite of congeners. The resultant TEQs may have underestimated the actual TEQ in surface water. The most recent effluent data from the mill (for dioxins/furans) were used to represent surface water concentrations for the moose ERE (i.e., no dilution factor was applied); this likely overestimates exposure and risk to moose from surface water ingestion. Effluent samples were collected quarterly during 2007 and 2008, and it is possible that some of these events occurred when the mill was temporarily shut-down or only partially operational, which may result in lower concentrations of dioxins/furans in the effluent. However, the use of undiluted effluent concentrations collected from the discharge pipe near the mill as surface water EPCs for all of

Blackbird Creek likely significantly overestimates exposure and risk to moose from these TEQs, and therefore this analysis is still reasonably conservative. Application of dilution factors would have resulted in even lower exposure and risk estimates for the surface water exposure pathway. Given that PCDD/Fs are hydrophobic, the overall contribution to risk from the surface water ingestion pathway for these COPCs is likely negligible.

Given the lack of plant tissue data, accumulation factors were required to estimate tissue concentrations. For PCDD/Fs, AOC-specific accumulation factors were available from previous studies and this reduces the uncertainties associated with the estimated tissue concentrations. Compared to all other COPCs, PCDD/Fs are considerably more toxic. Therefore, the use of effluent data and AOC-specific accumulation factors for PCDD/Fs is an important source of conservatism in this ERE.

Perhaps one of the most conservative assumptions employed in this ERE was that moose obtain their entire daily food intake from aquatic plants within Blackbird Creek, rather than supplementing that with browse from trees and shrubs. Even in winter and spring, when the moose's exposure to creek sediment and plants is likely greatest, moose are unlikely to obtain all of their food (estimated to be roughly 30 kg wet weight per day) from within the creek.

There is considerable uncertainty associated with the lack of species-specific toxicity data and the resultant need to extrapolate between species. When possible, data from relatively large mammals (e.g., dogs) were used; however, for most chemicals, and certainly for PCDD/Fs, effects data were limited to smaller laboratory species, such as rats and mice. The degree to which effects data for rodents are representative of larger mammals is not known. Lastly, moose are ruminant species, meaning that they chew a cud. The degree to which this re-mastication and re-ingestion of plant material renders COPCs more bioavailable is unknown.

7. Conclusions and Recommendations

This focused ERE evaluated the risks to moose foraging in or along Blackbird Creek from exposure to chemicals of potential concern (COPCs) present in surface water, sediment, and food items. Based on the available data, the results of this focused ERE suggest that the risk of adverse effects to moose feeding in or along Blackbird Creek is quite low, even if they feed exclusively on a daily basis on aquatic plants within Blackbird Creek (rather than supplementing that with browse from trees and shrubs). Therefore, additional evaluation does of risks to moose does not appear to be warranted at this time.

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