Nalcor Energy – Lower Churchill Project

LOWER CHURCHILL PROJECT

LCP Methylmercury Environmental Effects Monitoring Plan: Osprey and River Otter

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1 PURPOSE

The purpose of this Methylmercury Environmental Effects Monitoring Plan (MMEEMP) is to demonstrate how predicted adverse environmental effects related to the Lower Churchill Hydroelectric Generation Project (the Project) will be mitigated, and sets out a program for monitoring the effectiveness of mitigation measures. To comply with regulatory requirements and commitments made in the Environmental Impact Statement (EIS), the Lower Churchill Project's (LCP) EEMP approach includes consideration of:

- mitigation objectives – performance objectives in respect of each predicted adverse environmental effect;
- mitigation – measures planned to achieve the mitigation objectives;
- metrics and targets – specific, quantifiable, relevant and time constrained;
- follow-up or monitoring programs – how the project will include follow-up or monitoring surveys to ensure that mitigation strategies are meeting the mitigation objectives; and
- contingency – plan to be implemented should monitoring reveal that mitigation measures have not been successful.

The LCP's MMEEMP builds on existing information, including:

- the Avifauna Management Plan (AMP) (Stantec 2012);
- raptor baseline studies [Minaskuat Inc. 2008);
- Osprey (*Pandion haliaetus*) and eagle studies (Jacques Whitford 1999);
- mercury concentrations in Osprey and Ecological Risk Assessment [Minaskuat Limited Partnership 2008);
- commitments made in the EIS (Nalcor 2009);
- information request responses (i.e., Nalcor's response to Joint Review Panel JRP.22 Information Request on ecological risk assessment for mercury for Osprey and River Otter [*Lutra canadensis*]); and
- conditions of permits and licenses for the Lower Churchill Hydroelectric Generation Project.

2 SCOPE

This plan addresses the required aspects of the Methylmercury Protection and Environmental Effects Monitoring for the design, and construction, and operation phases of the LCP taking effect in proximity to the Project.

3 DEFINITIONS

Environmental Assessment: An evaluation of a project's potential environmental risks and effects before it is carried out and identification of ways to improve project design and implementation to prevent, minimize, mitigate, or compensate for adverse environmental effects and to enhance positive effects.

Environmental Management: The management of human interactions with the environment (air, water and land and all species that occupy these habitats including humans).

Environmental Management System: Part of an organization's management system used to develop and implement its environmental policy and manage its environmental aspects.

Environmental Protection Plan: Document outlining the specific mitigation measures, contingency plans and emergency response procedures to be implemented during the construction or operations of a facility.

Environmental Effects Monitoring: Monitoring of overall Project effects to confirm the predictions of EA and to fulfill EA commitments.

Environmental Compliance Monitoring: Monitoring of Project activities to confirm compliance with regulatory requirements and commitments made through the EA process.

Integrated Project Delivery Team: The integration of the Nalcor Energy and SNC Lavalin Inc. Environmental and Regulatory Compliance Teams.

4 ABBREVIATIONS AND ACRONYMS

AMP	Avifauna Management Plan
CCME	Canadian Council of the Ministers of the Environment
CEAA	Canadian Environmental Assessment Act
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
C-SEPP	Component-Specific Environmental Protection Plan
CWS	Canadian Wildlife Service

DNA	Deoxyribonucleic acid
EA	Environmental Assessment
EEMP	Environmental Effects Monitoring Plan
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EMS	Environmental Management System
EPP	Environmental Protection Plan
ERA	Ecological risk assessment
ERC	Environment and Regulatory Compliance
HQ	Hazard Quotient
IPD	Integrated Project Delivery
JECFA	Joint FAO/WHO Expert Committee on Food Additives
JRP	Joint Review Panel
KI	Key Indicator
LCP	Lower Churchill Project
LTA	Labrador Transmission Asset
MBCA	*Migratory Birds Convention Act*
MMEEMP	Methyl-Mercury Environmental Effects Monitoring Plan
NE	Nalcor Energy
NLDEC	Newfoundland and Labrador Department of Environment and Conservation
NRC	National Research Council
TRV	Toxicity Reference Value
UNEP	United Nations Environment Program
µg/g	microgram per gram

5 INTERNAL REFERENCES

LCP-PT-MD-0000-PM-PL-0001-01	LCP Project Execution Plan
LCP-PT-MD-0000-PM-CH-0001-01	LCP Project Charter
LCP-PT-MD-0000-EA-PL-0001-01	LCP Generation Environmental Assessment Commitment Management Plan
LCP-PT-ED-0000-EA-SY-0001-01	Environmental Impact Statement and Supporting Documentation for the Lower Churchill Hydroelectric Generation Project
LCP-PT-ED-0000-EV-RG-0001-01	Lower Churchill Project Permit Registry
LCP-PT-MD-0000-EV-PL-0011-01	Generation /LTA Environmental Protection Plan
LCP-PT-MD-0000-SM-ST-0001-01	Post Environmental Assessment Release
LCP-PT-MD-0000-RT-PL-0001-01	Regulatory Compliance Plan
LCP-PT-ED-000-EN-PH-0031-01	Design Philosophy for Environmental Rehabilitation
LCP-PT-ED-0000-EN-PH-0007-01	Design Philosophy for Environmental Mitigation
LCP-PT-MD-0000-HS-PL-0001-01	Health and Safety Plan
LCP-PT-MD-0000-HS-PL-0004-01.	LCP Emergency Response Plan
LCP-PT-MD-0000-IM-PL-0003-01	Information Management Plan
LCP-PT-MD-0000-CO-PL-0001-01	Communications and Stakeholder Relations Plan
LCP-PT-MD-0000-EV-PL-0002-01	LCP Integrated Environmental Management Plan

6 PROJECT DESCRIPTION

6.1 MUSKRAT FALLS GENERATION

The Muskrat Falls Generation Project will include the following sub-components which are broken down under the five principal areas of the development:

- 22 km of access roads, including upgrading and new construction, and temporary bridges;
- A 1,500 person accommodations complex (for the construction period); and
- A north roller compacted concrete overflow dam;
- A south rock fill dam;
- River diversion during construction via the spillway;
- 5 vertical gate spillway;

- Reservoir preparation and reservoir clearing;
- Replacement fish and of terrestrial habitat;
- North spur stabilization works;
- A close coupled intake and powerhouse, including:
- 4 intakes with gates and trash racks;
- 4 turbine/generator units at approximately 206 MW each with associated ancillary electrical/mechanical and protection/control equipment;
- 5 power transformers (includes 1 spare), located on the draft tube deck of the powerhouse; and
- 2 overhead cranes each rated at 450 Tonnes

Figure 6-1 Muskrat Falls Generating Facility

6.2 LABRADOR TRANSMISSION ASSET (LTA)

LTA consists of the ac transmission line system form Churchill Falls to Muskrat Falls (see Figure 6-2), specifically:

- Churchill Falls switchyard extension;
- Muskrat Falls switchyard;
- Transmission lines from Muskrat Falls to Churchill Falls: double-circuit 315 kV ac, 3 phase lines, double bundle conductor, Single circuit galvanized lattice steel guyed suspension and rigid angle towers; 247 km long;
- 735 kV Transmission Line at Churchill Falls interconnecting the existing and the new Churchill Falls switchyards; and
- Labrador Fibre Project (Nalcor's participation in Aliant led initiative).

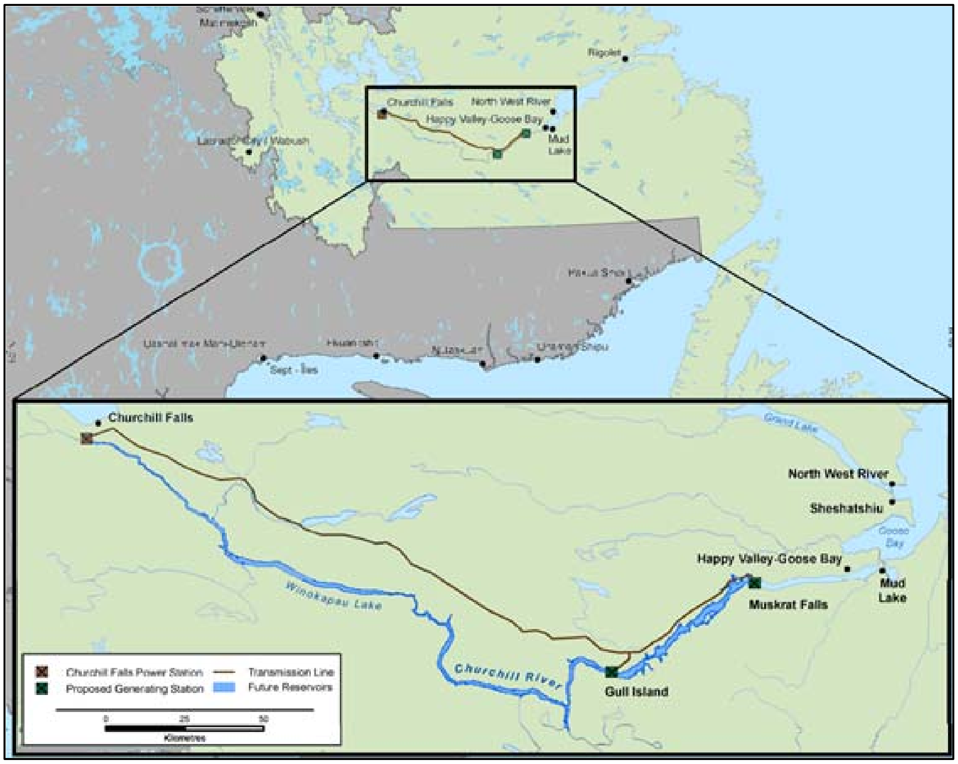

Figure 6-2 Labrador Transmission Asset

7 EXISTING INFORMATION

Existing information regarding the Osprey and River Otter is summarized from data compiled for Nalcor's EIS for the Lower Churchill Hydroelectric Generation Project, which was based on a literature review, Project-specific baseline surveys, other ongoing annual bird surveys conducted in the lower Churchill River region, and other sources (Nalcor 2009).

7.1 OSPREY

Osprey are one of the large raptors known to occur in the lower Churchill River watershed. The primarily fish-eating Osprey is at the top of the food chain and, therefore, like other raptors is a reflection of the status of lower trophic levels.

Osprey have been the subject of a long-term study in the lower Churchill River watershed through annual population monitoring and behavioural investigations associated with the military training at 5 Wing Goose Bay from 1991 to 2007 (Minaskuat Inc 2008). Osprey in Labrador are at the northern extent of their international range (Poole 1989), where there is seasonal pressure to establish territories as soon as ashkui or open water for foraging is available. In central Labrador, Ospreys arrive in May, have median hatch dates of early July, and median fledging dates of early September (Jacques Whitford 1995).

Osprey nests in Labrador are typically within 3 km (mean 435 m) of a water body, commonly on islands in streams, or along the shore of smaller tributaries where trees are taller than the surrounding forest canopy (Jacques Whitford 1995) and provide easy access to productive feeding areas. Osprey nests in the lower Churchill River watershed have been extensively surveyed (Minaskuat Inc. 2008b).

Osprey also nest on large rocks or artificial nesting platforms such as transmission line poles in Labrador (Jacques Whitford 1998, 1999). Osprey's acceptance of artificial nesting sites, which tend to be more stable than natural nesting sites, creates new nesting opportunities. As Osprey's prefer fish as a primary food source, ecological risk associated with methylmercury bioaccumulation in fish tissues may occur as a result of the Project.

As noted in the EIS (Nalcor 2009), the potential effects of methylmercury bioaccumulation in Osprey tissue as a result of the Project were evaluated in detail in: "Existing Mercury Concentrations in Osprey and Ecological Risk Assessment" (Minaskuat Limited Partnership 2008). An ecological risk assessment (ERA) is a scientific tool, endorsed by federal regulatory agencies (i.e., Health Canada, Environment Canada and the Canadian Council of the Ministers of the Environment (CCME)), to evaluate the potential risks, if any, to ecological receptors resulting from exposures to Project-related chemicals of potential concern. Inherent in the risk assessment process is the use of conservative assumptions for exposure when estimating risks. The estimated risks to Osprey exposed to methylmercury in fish was examined based on the following three scenarios: (a) exposure to methylmercury levels under baseline or existing conditions; (b) exposure to methylmercury levels resulting from Project-associated flooding; and (c) exposure to combined methylmercury levels from baseline and Project (i.e., post-construction methylmercury concentrations; Background + Project). Predicted peak methylmercury concentrations in fish (Baseline + Project-related methylmercury) were calculated by Minaskuat Limited Partnership (2008) using screening-level regression models combined with the assessment of mercury trends from existing comparable reservoirs (e.g., Smallwood, Robert Bourassa).

Typically in ERAs, the risk associated with exposures by ecological receptors to Project-related chemicals of potential concern is expressed as a hazard quotient (HQ). The HQ is the ratio of the expected daily intake of methylmercury by Osprey, divided by a Toxicity Reference Value (TRV), the health-protective threshold considered by regulators to be safe. The TRV is determined using a body weight scaling factor (Minaskuat Limited Partnership 2008) The estimated daily intake of methylmercury by Osprey above the TRV is considered to correspond with harmful effects. One pathway of exposure assessed in the ERA (ingestion of fish), considered a single-exposure pathway HQ of 0.8, rather than a multi-exposure pathway HQ of 1.0. Results of the ERA indicate that HQs for Osprey were below 0.8 for all scenarios (Minaskuat Limited Partnership 2008). Given the conservatism inherent in ERA and the protective HQ of less than 1.0, these results suggest that there is a low probability of adverse effects on Osprey because of Project-related methylmercury biomagnification in the aquatic food web (Nalcor 2009).

7.2 RIVER OTTER

The River Otter is native to both Newfoundland and Labrador, and prefers shores of deep, clear water in lakes, rivers, marshes and ocean bays (Newfoundland and Labrador Department of Environment and Conservation [NLDEC] 2012, Internet site). The primary diet of River Otter consists of fish such as minnows and trout but they will also feed on dragonfly nymphs, water beetles, bugs, frogs, tadpoles, newts and even mammals such as muskrat, meadow voles, shrews and beavers. The River Otter is aquatic, but may travel several miles over land to reach another stream or lake, and typically has a home range of 24 km^2 or greater (Burt and Grossenheider 1952).

Because River Otter feed largely on aquatic organisms, including fish, it is a candidate for assessing the effect of methylmercury bioaccumulation following inundation of the Project reservoir. The potential effects of methylmercury bioaccumulation on River Otter as a result of the Project were evaluated in: “Existing Mercury Concentrations in Osprey and Ecological Risk Assessment” (Minaskuat Limited Partnership 2008). The ERA results suggest that River Otter is unlikely to experience harmful effects after eating fish containing predicted levels of methylmercury. The ERA findings indicated that the HQ (0.81) associated with the River Otter exposure to the combined methylmercury levels from baseline and the Project was above 0.8 (a protective HQ set to account for nominal pathways on top of the primary fish consumption pathway) for River Otter. While there is marginal exceedance, the ERA incorporates conservatism into the calculations to err on the side of caution when assessing risk; however, the levels of uncertainty with the ERA are acceptable.

8 REGULATORY COMPLIANCE

Osprey and River Otter are not currently listed by the provincial or federal agencies. River Otter are considered "secure" by the NLDEC (2013, Internet site); both species are considered "secure" by the General Status of Species in Canada initiative (General Status of Species in Canada, http://www.wildspecies.ca). Osprey are not protected under the *Migratory Birds Convention Act* (MBCA); however they are protected under the *Wild Life Act* (RSNL1990 CHAPTER W-8). Osprey and River Otter are species of interest for the LCP in relation to this Project, for the potential for methylmercury bioaccumulation due to their position in the food chain (i.e., primary food source is fish). Osprey were identified as a Key Indicator (KI) in the EIS (Nalcor 2009) and the River Otter was evaluated, along with Osprey, in an ERA (Minaskuat Limited Partnership 2008) conducted by the LCP in anticipation of an EA for the Project.

As noted in the EIS (Nalcor 2009), reservoir creation has been documented to result in increased fish methylmercury concentrations (Canada and Manitoba Governments 1987; Bodaly et al. 1997; Schetagne et al. 2003; Jacques Whitford 2006; Bodaly et al. 2007). Decomposition associated with flooding causes increased activity by microbes that convert inorganic mercury into methylmercury, a toxic form of mercury that bioaccumulates in fish. This is a concern because consumption of fish with elevated methylmercury concentrations can represent a health risk to people and wildlife (NRC 2000; JECFA 2003, Internet site; United Nations Environmental Programme 2004, Internet site; Mergler et al. 2007; Scheuhammer et al. 2007).

The duration of elevated fish methylmercury concentrations in boreal reservoirs can last up to three decades after flooding. Peak concentrations, especially in top predatory fish, can be two to seven times greater than background levels (Schetagne et al. 2003; Bodaly et al. 2007), often exceeding the Canadian limit of 0.5 µg/g for domestic commercial sale (Health Canada 2007, Internet site) in higher trophic level species such as northern pike. Unusually high percentage increases of methylmercury in some fish species have been observed immediately downstream from hydroelectric turbines. Schetagne et al. (2003) attributed this phenomenon to injury or mortality of fish passing through turbines, allowing downstream fish such as lake whitefish and longnose sucker an opportunity to switch to piscivory, resulting in higher methylmercury concentrations in the diet.

To comply with commitments made in the EIS (Nalcor 2009) and the responses to information requests the LCP has, or will:

- conduct a follow-up program to validate the predictions made in the EIS; and

- if required, implement contingency plans if the mitigation is found to be unsuccessful (i.e., adaptive management).

The intent of the MMEEMP is to allow the LCP to evaluate and respond appropriately to the findings relating to the effects of Project operations on methylmercury accumulation in Osprey and River Otter.

NL Reg. 18/12, also referred to as the *Lower Churchill Hydroelectric Generation Project Undertaking Order* releases the LCP from environmental assessment and sets conditions for this release that LCP must meet. The release of the Project from environmental assessment under section 3 is subject to the following conditions:

(a) Nalcor Energy shall abide by all commitments made by it in the Environmental Impact Statement dated February 2009, and all the Environmental Impact Statement Additional Information Requests made by the Lower Churchill Hydroelectric Generation Project Environmental Assessment Panel and consequently submitted by Nalcor Energy, and the submissions made by Nalcor Energy during the panel hearings and, subsequent to the hearings, to the panel, unless one or more of the commitments, or a part of a commitment is specifically waived by the minister;

(e) Nalcor Energy shall prepare and abide by the requirements of environmental effects monitoring plans for all phases of the project, and those plans shall be submitted to and approved by the Minister of Environment and Conservation or the appropriate minister of the Crown before the commencement of an activity which is associated with or may affect one or more of the following matters:

(iv) methylmercury

Submission of this MMEEMP satisfies the condition/requirement in NL Reg. 18/12 that Nalcor Energy prepare and submit to the Minister of Environment and Conservation or the appropriate minister of the Crown, an environmental effects monitoring plan for all phases of the project, before the commencement of an activity which is associated with or may affect the following matters:

(iv) methylmercury

9 ENVIRONMENTAL EFFECTS MANAGEMENT

The inundation of the upper Churchill River watershed as a result of the Churchill Falls Power Station caused increases in methylmercury concentrations in fish within the reservoir and downstream in the lower Churchill River. Sampling has been conducted over the last 35 years and the results show that methylmercury concentrations in fish have declined over time and recent sampling shows that methylmercury concentrations are approaching baseline levels. Therefore, Smallwood Reservoir is no longer causing increases in fish methylmercury concentrations (Nalcor 2009).

Increased methylmercury in lower trophic levels during operation and maintenance will be transferred to species at higher trophic levels in the food chain (i.e., Osprey and River Otter). Modelling predicts that after a period of approximately 15 years, levels of methylmercury in the ecosystem will begin to decline. The initial increase of methymercury is not anticipated to cause significant adverse environmental effects on the terrestrial KIs evaluated for the Project (Nalcor 2009).

The effects management plans (i.e., mitigation measures) executed (or planned) by the LCP to address the methymercury issue as a result of the reservoir inundation include:

- A methylmercury workshop in Happy Valley – Goose Bay on May 20, 2008.
- Baseline work on methylmercury levels in the lower Churchill River and in fish (Nalcor 2009).
- Removal of vegetation during reservoir preparation will reduce the release of nutrients into the aquatic system.
- A separate methylmercury sampling program is being undertaken for fish and seals as part of the Aquatic Environmental Effects Monitoring Program (AMEC 2013).
- The LCP completed an ERA (Minaskuat Limited Partnership 2008) to investigate the health concern for wildlife within the food chain. A regression model to predict levels of methylmercury was developed; the predicted methylmercury concentrations in fish in the lower Churchill River system were established using screening-level regression models based on the extent of proposed flooding and flow rates. These results were combined with an assessment of trends from existing reservoirs to estimate the likely timing and magnitude of increased fish methylmercury concentrations.
- Sampling protocols will be confirmed with Environment Canada.

The LCP evaluated other potential mitigation options to reduce the net production of methylmercury. Mitigation options included reservoir clearing, vegetation burning, soil stripping, covering flooded soils with low mercury material, maintaining sediments in suspension and enhanced demethylation. The removal of mercury-rich and carbon-rich surface soil horizons was identified as not being a feasible option for several reasons including cost, emissions during clearing, erosion control required, and additional disturbances for soil storage on a large scale for this Project.

10 ENVIRONMENTAL EFFECTS MONITORING

This MMEEMP contains a follow-up program:

The results of the follow-up program may lead to the LCP implementing their adaptive management approach to effectively address environmental issues. The LCP is proposing to use best management practices and accepted, proven mitigation options to avoid or limit the effects of the Project. Through their adaptive management approach, the LCP will assess issues that arise (i.e., where unexpected adverse environmental effects occur or mitigation that is implemented does not effectively address an issue), and make appropriate changes to address the documented issue effectively in a timely manner.

10.1 SURVEY PROTOCOLS

The environmental baseline study of mercury concentration in the terrestrial ecosystem conducted by Minaskuat (2008), had an initial objective of sampling upper forms of wildlife in the aquatic food chain. Two primary carnivores, Osprey and River Otter were selected as candidates for the sampling program. Feathers were collected from Osprey nests (post-fledging) that were accessible in the lower Churchill River valley. The intent had been to collect samples of otter fur from trappers in the same area. However, a combination of lowered trapping activity in this same area, and a focus on trapping other species such as marten, resulted in a lack of potential samples.

The most common biological samples analyzed for mercury are blood, urine and scalp hair (US Environmental Protection Agency 1997). The use of feces to analyze mercury content in mammals is being investigated (Gupta and Bakre 2013); however, this is not a common practice, and is not considered necessary in relation to this Project because fish and seal tissue are being analyzed for mercury as part of the Aquatic Environmental Effects Monitoring Program (AMEC 2013).

The LCP will conduct follow-up surveys for Osprey and River Otter to determine the validity of the predictions made in the EIS (Nalcor 2009), in the Ecological Risk Assessment (Minaskuat Limited Partnership 2008), and in responses to information requests. The results will be used to determine if expansion or reduction or deletion of the indicated programs is appropriate (with justification). This will apply to Osprey and Otter, and involve collection of data for baseline (i.e., pre-impoundment) and post-impoundment conditions, during operations.

Protocols for the Osprey and River Otter follow-up surveys are described in the following subsections. Data will include collection of metrics that are species specific, quantifiable, relevant and time constrained. The goal is to collect meaningful data using a focused, defendable, repeatable approach, within a timeline that is reasonable, to evaluate the effectiveness of mitigation applied and to validate the predictions made in the EIS (i.e., the increase in methylmercury is not anticipated to cause significant adverse effects on Osprey or River Otter). Where it is determined that the mitigation is not effective, a contingency plan will be presented that the LCP could incorporate in accordance with their adaptive management approach.

10.2 OSPREY MERCURY FOLLOW-UP PROGRAM

Potential exposure of Osprey to increased methylmercury levels resulting from the construction and operation of the proposed Project will be assessed through a phased approach that considers the following:

- the available habitat, and thereby, the local population that could be exposed during sensitive life stages (i.e., nesting period);
- increases in fish tissue residues, if any, as a result of the Project; and
- tissue accumulation of methylmercury by Osprey under future exposure conditions.

The approach is based on the assumption that any increase in fish tissue concentrations of methylmercury will result in a corresponding increase in exposure of fish-eating birds. Osprey represents a high level consumer given these birds prey upon adult fish and are likely to be exposed to greater concentrations than other fish-eating birds that prey upon smaller forage fish or young fish that would typically accumulate lower tissue residues.

To assess any future changes in Osprey exposure to mercury, baseline conditions need to be assessed. This will include assessing existing fish tissue residue data, as a means of assessing current exposure of Osprey. Accepted mercury sampling methods available to assess baseline conditions include the following:

- direct blood sampling (invasive method);
- egg sampling (destructive method); and
- feather sampling (non-destructive method).

As mercury is transported via the blood, direct sampling of blood from adult birds is the preferred method. Direct blood sampling presents numerous difficulties related to handling the birds, is stressful for the birds, and can be hazardous for personnel, and is an invasive method. When egg sampling has been used, maternal transfer has been a major concern with mercury exposure in birds. Egg sampling, however, is a destructive method that involves sacrificing eggs, and is not recommended for birds that typically have small clutch sizes and relatively small populations. The LCP is therefore proposing to use a non-invasive means to assess Osprey exposure to methylmercury, non-destructive approach is to collect recently shed adult and juvenile feathers from Osprey nests for tissue analysis. Analysis of feathers is an acceptable approach that has been used in a number of studies (UNEP 2002). The baseline conditions may not accurately represent methylmercury level in other tissue and internal organs, but will provide a baseline against which any future increase in exposure will be assessed, since increased exposure through diet would be expected to increase methylmercury concentrations in all tissues, including feathers, served by the circulatory system.

10.2.1 Feather Sampling Approach:

1) All occupied or recently vacated nests in the study area will be sampled for adult and juvenile feathers. Three (3) to 10 individual feathers will be obtained from each nest and, if possible, five replicate analyses will be performed to understand the natural variability in tissue concentrations. This approach recognizes that existing tissue residues in the birds could be obtained from areas throughout their normal migratory range.
2) Fish tissue residue data will be used to establish a baseline for fish tissues (see Aquatic EEMP). This will enable any changes in methylmercury concentrations in Osprey feathers to be assessed against any changes in methylmercury concentrations in fish tissues. Since Osprey could be exposed to methylmercury in other parts of their migratory range, this provides a means to assess whether any increase in tissue residues could be related to increased exposure from fish in the local area.
3) Steps 1 and 2, will be conducted during the baseline (i.e., pre-impoundment) study program from occupied or recently occupied nests in the reservoir area and downstream, and repeated in year five following inundation of the reservoir (i.e., post-impoundment). This protocol will be adjusted, as necessary, through an adaptive management approach, based on results of fish tissue and water quality sampling programs.
4) All analyses will be for total mercury. Methylmercury is the most bioaccumulative form of mercury, and studies have shown that over 90% of the mercury in fish tissues is methylmercury. Therefore, most regulatory agencies have made the assumption that all mercury in fish tissue is in the methylated form. As a result, mercury accumulated in Osprey from their diet would similarly be assumed to be mainly methylmercury. The

advantage of this approach is that most laboratories can undertake mercury analysis for total mercury, whereas specialized labs are usually required for methylmercury. Osprey feathers will be submitted to an accredited laboratory for mercury analysis.

5) Statistical analysis will be employed to determine any changes relative to natural variability in both Osprey tissues and fish tissues pre- and post-impoundment.

10.3 OTTER MERCURY FOLLOW-UP PROGRAM

Similar to Osprey, potential exposure of River Otter to increased methylmercury levels resulting from the construction and operation of the Project will be assessed through a phased approach that considers the following:

- the available habitat, and thereby, the local population that could be exposed during sensitive life stages;
- increases in fish tissue residues, if any, as a result of the Project; and
- tissue accumulation of methylmercury by River Otter under future exposure conditions.

This approach is based on the assumption that any increase in fish tissue concentrations of methylmercury will result in a corresponding increase in exposure of fish-eating carnivores like River Otter. River Otter are high trophic piscivorous mammals that can provide an integrated signal of local food web biomagnification. River Otter accumulate Methylmercury through the consumption of fish and can therefore be at risk for mercury exposure.

To assess any future changes in River Otter exposure to mercury, baseline conditions need to be assessed. This will include assessing existing fish tissue residue data, as a means of assessing current exposure of River Otter. Accepted mercury sampling methods available to assess baseline conditions include the following:

- direct blood sampling (destructive method); and
- hair sampling (non-destructive method).

The LCP is proposing to use the non-destructive technique of hair sampling to assess the exposure of River Otter to methylmercury. Hair has been extensively used for monitoring mercury contamination in otter as there are high correlations between mercury levels in hair and levels in liver and brain; two tissues particularly sensitive to Hg (Mierle et al. 2000; Fortin et al. 2001).

The ability of hair to resist chemical change provides a unique tool to monitor trace metal accumulation in mammals. Unlike blood or other biological tissues that are used in eco-toxicological studies and have continuously evolving composition, hair is resistant to hydrolysis and/or enzyme activity and has a stable composition (Hopps 1977). Metals obtained from the diet are accumulated in mammalian hair as it grows and, once deposited, metal concentrations will remain unchanged. Hair therefore preserves a record of metal intake over the growth period of a given segment. Detailed analysis can be used to determine changes in exposure over time, while bulk analysis can provide information on the total body intake over an extended period of time. In addition, unlike most biological tissues, hair can be non-invasively sampled and requires no special storage or handling. Laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) is a powerful technique allowing multi-element analysis of trace elements using a single hair. The spatial resolution achieved by LA-ICP-MS translates into a high time resolution of trace element levels for short intervals.

River Otter has two cycles of hair shedding and replacement during the year. From May through August, otters shed and replace underfur and from August to November they shed and replace guard hair (Ben-David et al. 2000, 2005). Sampling of fully grown guard hair could therefore provide a four-month window of mercury exposure.

10.3.1 Sampling Approach:

1) River Otter field sampling technique will involve non-destructive sampling in the collection of hair. Working in the lower Churchill River watershed, modified body snare and foot-hold traps (Depue and Ben-David 2007) would be established at eight tributaries accessed from the Trans-Labrador Highway (e.g., Metchin River, Cache River. Edward's Brook, Lower Brook, Pinus River, Diver Brook, Wilson River, Otter Brook). This technique has demonstrated success and resulted in no injury to animals. Approximately 15+ hairs are anticipated to be collected (all samples collected will be analyzed for mercury) from each otter that comes into contact with the hair snag trap (note that animals are able to easily escape from these modified traps). The hair collection would be completed in summer to coincide with the presence of fully grown guard hairs. At each of the proposed eight sites, one to three traps would be set and checked every three days over a two-week period. Additional opportunities for collection could occur if any otters are accidentally killed through vehicle collisions or from trappers. The Study Team will attempt to collect at least 15 samples for methylmercury analysis in each year of this baseline program. It is assumed that eight field sampling days will be required to collect an adequate number of samples.
2) Mercury in whole hair will be analyzed in all samples collected and sent to a certified lab (ALS Environmental). This will also act as QA/QC for the more detailed analyses.

a) Laser ablation (LA-ICP-MS) will be conducted on a subset of 12 hairs to provide temporal examination of overall mercury exposure to help assess baseline, dietary and exposure changes over the four month period represented by the full-grown hair. LA-ICP-MS being a powerful technique to gather information on other metals such as cadmium, lead, copper, iron and zinc on the same single hair, which can help again with dietary information and interpretation of results.

b) A subsample of each hair sample will be sent to the University of Winnipeg, MB, for the determination of nitrogen and carbon isotopes. Mercury concentrations are well known to increase with trophic level. Stable isotopes are useful indicators of diet and could help understand if mercury variations observed in otter, and if the variations are a result of changes in the diet, changes in food web structure or changes in actual Methylmercury concentrations over time.

3) Steps 1 and 2 will be conducted during the baseline (i.e., pre-impoundment) study program from key habitat areas repeated in year five following inundation of the reservoir (i.e., post-impoundment). This protocol will be adjusted, as necessary, through an adaptive management approach, based on results of fish tissue and water quality sampling programs.

4) All analyses will be for total mercury. Methylmercury is the most bioaccumulative form of mercury, and studies have shown that over 90% of the mercury in fish tissues is methylmercury. Therefore, most regulatory agencies have made the assumption that all mercury in fish tissue is in the methylated form. As a result, mercury accumulated in River Otter from their diet would similarly be assumed to be mainly methylmercury. The advantage of this approach is that most laboratories can undertake mercury analysis for total mercury, whereas specialized labs are usually required for methylmercury.

5) Statistical analysis will be employed to determine any changes relative to natural variability pre- and post-impoundment.

10.4 REPORTING

The results of the pre-impoundment Osprey and River Otter mercury level will be prepared following completion of the mercury analysis. A second report will be prepared to present results of the follow-up program (post-impoundment), and will include a comparison with the pre-impoundment (baseline) data. The report will discuss the findings presented in the Aquatic Environmental Effects Monitoring Program, as they relate to the Osprey and River Otter mercury levels. As appropriate, recommendations related to methylmercury environmental effects on Osprey and River Otter for the LCP to consider in their adaptive management approach will be presented. Additional research may be pursued regarding species health and the methylmercury pathway. The reports will be provided to Environment Canada and NLDEC for information and review. Reports will also be available for public viewing through the LCP website.

11 SUMMARY

Table 11-1 Summary of the Methylmercury EEMP

Avian group	Survey Type	Survey Objective	Location	Timing	Frequency	Contingency
Pre-Construction / Pre-Impoundment						
RAPTOR (Osprey)	Pre-impoundment Mercury Level	• to collect baseline data on mercury levels in Osprey and their prey • to note incidental observations of all wildlife, including signs	identified occupied Osprey nests along the lower Churchill River and downstream of the reservoir within the Study Area indicated in the Aquatic EEMP.	Feathers will be collected from areas of known active nests in early fall before leaves are down.	one survey pre-impoundment to collect feather samples	results of the baseline mercury levels will be provided to the NLDEC and Environment Canada
SEMI-AQUATIC FURBEAER	Pre-impoundment Mercury Level	• to collect baseline data on mercury levels in River Otter and their prey • to note incidental observations of all wildlife, including signs	Identified and suspected locations such as tributary estuaries along the lower Churchill River and downstream of the reservoir within the Study Area indicated in the Aquatic EEMP.	Hair will be collected from snagging sites	One survey pre-impoundment to collect hair samples	results of the baseline mercury levels will be provided to the NLDEC and Environment Canada
Post-Construction / Post-Impoundment						
RAPTOR (Osprey)	Post-impoundment Mercury Level	• to evaluate mercury levels in Osprey likely exposed to fish from the reservoir • to allow comparison with mercury levels in Osprey and their prey following five years of reservoir presence • to note incidental observations of all wildlife, including signs	Identified occupied Osprey nests along the Lower Churchill River and downstream of the reservoir area within the Study Area indicated in the Aquatic EEMP.	late May to early July (timing to be determined after the aerial nest surveys). Feathers will be collected from areas of known active nests in early fall before leaves are down.	five years post-impoundment one survey	results of the operational mercury levels will be provided to the NLDEC and Environment Canada

SEMI-AQUATIC FURBEAER	Post-impoundment Mercury Level	• to evaluate mercury levels in River Otter likely exposed to fish from the reservoir • to allow comparison with mercury levels in River Otter and their prey following five years of reservoir presence • to note observations of all wildlife, including signs	Identified and suspected locations such as tributary estuaries along the lower Churchill River and downstream of the reservoir within the Study Area indicated in the Aquatic EEMP.	Hair will be collected from snagging sites	One survey post-impoundment to collect hair samples	results of the operational mercury levels will be provided to the NLDEC and Environment Canada

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