IEAC INDEPENDENT EXPERT COMMITTEE

RECOMMENDATIONS: MITIGATION

Submitted to the IEAC Oversight Committee

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1. Background

The mission of the Independent Experts Advisory Committee (IEAC) is as follows:

To oversee and provide independent assessment of the adequacy of mitigation, monitoring and management measures, and provide recommendations to the Responsible Ministers with respect to those and addition of any further such measures for the protection of the health of the Indigenous and local population impacted by the Lower Churchill Project, and in particular increases of methylmercury in country foods in the Churchill River near Muskrat Falls and downstream, all along the river and including Lake Melville.

The IEAC is comprised of an Oversight Committee (OC) and an Independent Experts Advisory (IEC) Committee. The IEC is made up of six scientific experts and three indigenous knowledge experts.

The IEAC focuses on three key areas: mitigation, monitoring and management. This Summary report focuses on the activities of the IEC with respect to mitigation.

The mandate of the IEAC with regards to mitigation is:

…to use the best available peer reviewed science and Indigenous knowledge, and may consider other relevant research only in addition to and not instead of the above-mentioned peer reviewed science, to assess and recommend options for mitigation of methylmercury impacts, including but not limited to discussing the feasibility, necessity and potential impacts of further clearing of the Muskrat Reservoir;

The purpose of this document is to summarize the work that the IEC has undertaken since its inception in August 2017, to assess and recommend measures for mitigation of methylmercury impacts. Also attached are the documents that were provided to, or developed by the committee, during its deliberations. A list of these documents can be found at the end of this report.

2. IEC Activities Related to Mitigation

The goal of mitigation is to reduce the amount of methylmercury that will be produced and is available for bioaccumulation due to the flooding of the Muskrat Falls reservoir. The IEC discussed various options that have been considered in the literature (as none have been executed in practice). All soils, in addition to vegetation naturally contain inorganic mercury (a less toxic form) as well as varying amounts of organic carbon. After flooding, the naturally occurring bacteria that are present consume the carbon, deplete the oxygen at the bottom of the reservoir and can convert inorganic mercury into methylmercury. This methylmercury can then flow downstream and enter the food chain. There is also evidence that methylmercury can be produced in the surface waters of Lake Melville. During periods of elevated methylmercury in the environment, many organisms can accumulate it faster than they can excrete it and therefore it can accumulate within them. This can cause the levels of methylmercury to increase up the food chain – with humans being the top-level predator.

Topsoil removal is one way to reduce the amount of carbon that is available for the bacteria to 'eat' thus resulting the in production of less MeHg. It was important to know how much of this carbon can be removed safely. In order to gather site-specific information on option of removing organic carbon from the future reservoir, the IEAC made the following recommendations to the Minister of Municipal Affairs and Environment (NL) on Sept 22, 2017:

IEAC Recommendation #1: The IEAC recommends that a feasibility study be undertaken by December 20, 2017, for the removal of soil and vegetation from the future reservoir area."

This recommendation was accepted by the Minister on September 29, 2017.

On December 22, 2017, the IEC received the draft report "Muskrat Falls – Soil and Vegetation Removal from the Future Reservoir Area", prepared by SNC Lavalin for Nalcor. The following observations were made by the IEC on this draft report:

The report addressed the technical and economic factors associated with the removal of all the vegetation and topsoil from the entire reservoir area, up to 42m asl, which is 3m above the full impoundment level, and did not exclude problematic areas such as steep slopes and unstable soils.

The constructability for full soil and vegetation removal was considered feasible within the project timeline, but was described as very challenging

Points of important note for the committee included: the greater than anticipated minimum depth of soil clearance (0.5 m in summer, 1.5 m in winter), which essentially removes the full soil organic profile; the need to re-profile cleared land, even on moderate slopes (>30%), in order to maintain ground stability; and the widespread erosion potentially associated with such extensive ground disturbance, which could unintentionally stimulate MeHg production.

2.1 Nalcor Modelling

Since full inundation of the reservoir has not yet occurred it is necessary to rely on mathematical models to predict what will happen in the future. The most detailed model to date, and the only one that includes Lake Melville, has been done by Harvard. They predicted that reservoir creation will increase methylmercury inputs in Lake Melville by 25 – 200%. The committee was made aware of a new model that had been commissioned by Nalcor and it was decided that Nalcor would be asked to expedite this. The new modeling is being led by Reed Harris, and is intended to include Lake Melville, incorporate hydrodynamic data dealing with the mixing of water below Muskrat Falls, and further translate this information into the Nalcor human health risk assessment.

To this end the following recommendation was made by the IEC, accepted by the Oversight Committee and sent to the Minister of Municipal Affairs and Environment on September 22, 2017:

IEAC Recommendation #3: The IEC recommends that Nalcor expedite the finalization of their current methylmercury modelling project and complete the work no later than February 15, 2018.

This recommendation was accepted by the Minister on September 29, 2017.

To date (March 2) Nalcor's downstream modelling remains incomplete in that the hydrodynamic aspect of the model is still not ready. Nalcor is unable to provide a schedule for completion.

During a presentation on February 26, 2018, Reed Harris provided the following predictions for methylmercury production in the case of no mitigation:

The peak predicted methylmercury concentrations in reservoir water without mitigation would be approximately 0.1 ng/L. This lasts for a brief period (e.g. days to a month) in simulations.

The maximum predicted one-year average water concentration was about 0.06 ng/L. A time integrated concentration is more appropriate for estimation of fish exposure.

2.2 Harvard Modelling

The IEC commissioned Dr. Ryan Calder for the application of his probabilistic methylmercury model to various mitigation scenarios to evaluate how changes in the area flooded might influence methylmercury production, uptake into country food sources and exposures to Lake Melville Inuit. An overview of this model was provided to the IEC in two presentations in December.

During the same month, Ryan Calder and Reed Harris began an exchange of information and discussions on the uncertainties of both models, in an effort to seek some convergence between and identify the differences in their models. A series of exchanges illustrate professional differences of opinion regarding the inputs to the two models. These include:

A detailed exchange regarding the relationship between organic carbon (OC) and MeHg. In a memo of January 31, 2018 (R. Calder), supplemental data was provided to support the relationship between OC and MeHg established in Calder et al, 2016. In a memo dated February 21, 2018 (comments provided on an earlier date, by email) Reed Harris identified potential inaccuracies in the published data used, although these could not be confirmed by the authors, and additional questions regarding the depth of soil used to estimate the carbon content in Calder et al, 2016 (proposing to selectively exclude soil layers rather than including the mineral soil layer). In a memo dated February 19, 2018 R. Calder 1) demonstrated that a wide range of potential adjustments to published data would have a small influence on the linear regression coefficient derived by Calder et al, 2016, and that similarly, 2) selectively excluding soil OC data using a different depth of soil to estimate carbon content would not result in a substantially different relationship between OC and MeHg, but acknowledging that 3) the large averaging depth at Muskrat Falls, pointed out by R. Harris, would tend to produce conservative (low) MeHg forecasts.

An unsolicited report submitted by Reed Harris on February 25, 2018, entitled "Comments on conditions affecting transport of MeHg from flooded soil with application to Muskrat Falls." (Hesslein, R., February 12, 2018), discussing the diffusion constant used in Ryan Calder's model, which was based on the water velocity in the reservoir and estimated to be higher in the Muskrat Falls Reservoir than at the experimental reservoirs at the Experimental Lakes Area. Hesslein argues that velocity does affect the diffusion through the boundary layer, but would not increase the methylmercury diffusion rate through sediments to the sediment interface. R. Calder responds that conditions affecting transport of MeHg from flooded soil is quite different in hydroelectric reservoirs compared to experiment lakes. He agrees that upward fluxes of MeHg from flooded soils may be constrained by soil-layer molecular diffusion in the experimentally flooded small-scale lake environments studied by Prof. Hesslein but points to more relevant literature for hydroelectric reservoirs. This literature demonstrates how the important erosional processes at the bed of hydroelectric reservoirs cause high-MeHg particles to aggregate at the soil-water interface and therefore soil-layer molecular diffusion is not as important. The decision to consider the diffusive boundary layer as the limiting factor to upward flux in the Muskrat Falls model was made in consideration of the different physical processes controlling transport in hydroelectric reservoirs as compared to experimental lake environments. Due to the lateness of this submission there was no opportunity to seek a rebuttal from Ray Hesslein and Reed Harris.

2.3 Other Studies

The IEC also received input, solicited and otherwise, that also informed its deliberations. These include:

2.3.1 Soil Flux Experiments

Newly commissioned research resulting from the September IEAC meeting included the contracting of Harvard University to implement work on "Methylmercury (MeHg) Flux Core Measurements – Fall 2017", which assessed the relative production of methylmercury from different soil types, evaluated the effect of burning, and served to provide additional data to a series of soil flux experiments started in November of 2016. Results were presented to the IEC on February 15 (Balcom, P, 2018).

- Methylmercury (MeHg) fluxes from soil cores collected in fall 2017 that had been submerged for approximately 42 days were approximately three times higher than those observed from unflooded soil.
- MeHg production, particularly below 5 cm, was greater in summer than in the fall.
- Removing leaf litter or top 5 cm of soil (organic matter) did not significantly lower MeHg production in flooded soils.
- MeHg fluxes were consistently low for soils sampled and incubated under cold season conditions. These results suggest that the initial increase in reservoir water levels during the cold season had negligible effects on MeHg production MeHg flux core experiments are useful for comparing the effects of different environmental conditions such as duration of flooding and soil organic carbon content but magnitudes of fluxes should not be used to infer impacts on ecosystems.

2.3.2 AMEC Soil Sampling Program and Azimuth Labile Carbon Report

Two reports on reservoir soil types and organic carbon content were submitted to Nalcor in 2017: "Final Muskrat Falls Soil Sampling Program, 2016" (AMEC Foster Wheeler, June 26, 2017.) and "Quantitative measurements of labile carbon in organic soils of the lower Churchill River" (Azimuth Consulting Group Partnership, October 18, 2017). Members of the IEC reviewed both of these documents and detailed review comments were compiled, (IEC, December 2017) with a greater emphasis on the Azimuth Memo (2017). They are summarized as follows:

- Concerns were raised about the small sample sizes (41 and 6, respectively), the lack of randomness in site selection, the representativeness of soil samples for ecological land classes, and the analytical methods employed.
- In general the IEC opinion is that the data provided in the two reports would provide limited confidence in a reservoir-wide assessment of the average volume and mass of organic carbon, whether in labile form or not.

2.3.3 Opinion Document by David Lean

An opinion piece was provided by IEC member David Lean describing his thoughts on the characteristics of the Muskrat Falls reservoir compared to other reservoirs, and the impact this may have on the resulting production of methylmercury downstream (Lean, D. Jan 27, 2018). All comments received by the Chair were compiled and presented to Dr. Lean for his written and verbal response (IEC, Feb 21, 2018). (This approach followed the procedure that is typically used to review a scientific paper that has been submitted to a refereed journal). Questions were raised as to the validity of the findings and Lean admitted that this was just an opinion, yet to be substantiated.

2.3.4 Azimuth Memo on Mass-Balance

Very late in its deliberations (26 Feb 18) the IEC received an unsolicited report from Nalcor entitled "Evaluation of MeHg Production by Muskrat Falls Reservoir and Implications for Lake Melville – A Top-Down, Mass-Balance Approach" which examines assumptions made by Calder et al, 2016 that were used to support conclusions regarding the rate and duration of MeHg flux from flooded soils and the associated potential increase in the Lake Melville food web. Preliminary feedback from Ryan Calder is summarized as follows:

- R. Calder summarizes a small number of what seem to be biggest errors in the Nalcor memo: 1) the contention that Calder et al. (2016) forecasted a mean sustained flux over a multi-year period when in fact the published paper clearly states they were forecasted peak levels; 2) the contention that the linear relationship between water column MeHg and biota is a large overestimate for post-flooding biotic levels when in fact the published literature suggests that it may be an underestimate for top trophic-level species, due to lengthening of the food chain downstream from hydroelectric facilities; 3) that Calder et al. (2016) do not address demethylation quantitatively when in fact it is explicitly addressed as a parameter in the published model of downstream river and Lake Melville estuary, adapted from Schartup et al. (2015); 4) that the supply of organic carbon limits MeHg production in flooded soils when in fact this is obviously incorrect as known concentrations of organic carbon are nine to ten orders of magnitude greater than my published peak MeHg concentrations; and 5) the contention that Site C and Muskrat Falls hydroelectric reservoirs are very closely related when in fact there are large differences in soil organic carbon content, which strongly impacts forecasts of post-flooding MeHg.

Reed Harris was asked to comment on this memo since the Azimuth memo appears to disagree with his estimates of MeHg production. He provided the following:

- A key conclusion is that there is a large biomass of biota in Lake Melville with a large mass of methylmercury that needs to be considered.
- The amount of methylmercury needed to meaningfully increase concentrations in biota in Lake Melville is large compared to the supply Azimuth estimates is possible from the reservoir.

The IEC noted that the memo provided by Reed Harris states "At this point I don't consider an upper limit to the methylmercury load to water to have sufficient certainty to require reductions to Resmerc predictions."

Feedback from the IEC includes the following general observation, among other comments, which can be found in the Relevant Documents section:

- This document fundamentally disagrees with both the published and peer reviewed work by Calder et al. (2016) but also with the modelling of MeHg in waters and fishes of the Muskrat Falls Reservoir carried out by Reed Harris and contracted by Nalcor (presented to the IEC on Feb 25, 2018). While Harris uses a completely different approach than Calder et al. to predict MeHg levels in water and biota of the Muskrat Falls Reservoir, he predicts peak MeHg water concentrations that are within the 95% confidence interval forecasted by Calder et al, 2016. (Kirk, JL., Feb 28, 2018)

2.4 Targeted Mitigation Scenarios

In November 2017 the IEC struck a Reservoir Subcommittee tasked with examining the characteristics of the future reservoir including its physical geography, ecological land classifications, soil types and organic carbon pools with the goal of informing options for targeted mitigation. An examination of the environmental risks associated with carrying out large-scale soil disturbances was also undertaken, which is detailed in the memo "Effects of forestry practices and similar soil disturbance on environmental mercury concentrations." (Jansen, W., September 27, 2017.)

The committee agreed that an emphasis would be placed on practical considerations such as existing roads/tracks, slopes less than 30% etc., to reduce slope hazards, erosion and runoff

(Jansen, Sept 27, 2018). In January 2018, the Subcommittee completed draft specifications for two Targeted Mitigation Scenarios, which were finalized in cooperation with Nalcor and its contractor SNC Lavalin, forming the basis of a new Statement of Work for Nalcor and its contractor SNC Lavalin. These two scenarios are summarized here:

Scenario A:

- Cap all fen and low shrub bog (but not marsh) wetlands ELC areas between 23.5 and 39 m asl with sediments that are low in total organic carbon, locally available and that will be stable (resistant to erosion from water flow) on the reservoir bed.
- Stability of sediment cap is more important than thickness, but assume 50 cm thick for this scenario. Cap should isolate the organic wetland soils, particularly peat accumulations, from the water column.
- Conduct work during frozen ground conditions to minimize ground disturbance.

Scenario B:

- Remove soil from areas that have been previously cleared of trees and vegetation and are accessible by existing roads, between the 23.5 masl contour and the 39 masl contour.
- Exclude areas of slopes greater than 30% and other areas that would require re-profiling.
- Exclude areas that potentially contain sensitive clays (glaciofluvial and glaciomarine)
- Exclude riparian areas.
- Prioritize work on steeper slopes during frozen ground conditions, moving towards flatter areas during thawed ground conditions (to limit runoff from clearance activities).

On February 26, SNC Lavalin provided a brief summary of the preliminary information regarding the feasibility of the 2 Targeted Mitigation Scenarios, and provided costing estimates (SNC Lavalin, Feb 26, 2018 – 3 documents). The conclusions are summarized as follows:

- Both Scenarios A and B were considered feasible within the current July 2019 impoundment schedule
- Scenario B was described as a challenging undertaking to complete within the current July 2019 impoundment schedule.

2.5 Predicting the impact of Targeted Mitigation Scenarios A and B

Targeted Mitigation Scenarios A and B were provided to Ryan Calder (Harvard Model) and Reed Harris (Nalcor Model) for input into their models for the prediction of impacts on the reservoir, downstream environment and human exposure to methylmercury through the consumption of country foods.

The summary of their findings are as follows:

2.5.1 Nalcor Model Predictions:

Scenario A:

- Covering 60ha of wetland predicted to have little effect because of small area (about 2% of flood zone).

Scenario B:

- Predicted to reduce peak Hg concentrations in adult Northern Pike in the reservoir by about 0.1 µg/g (from approx. 0.64µg/g to approx. 0.54µg/g, about a 15-17% reduction in concentration). Predicted short term peak concentration of methylmercury in water reduced by 0.02 ng/L (about 20-23%). Predicted maximum one-year average concentration reduced about 0.01 ng/L (15-20%).
- Nalcor was unable to make downstream predictions due to their model being incomplete.

The impact on human exposure was not predicted by Reed Harris because his model is not designed to do so.

2.5.2 Harvard Model Predictions:

Scenario A:

- Capping wetlands would reduce MeHg peak production proportional to area (2%)
- Based on available data, methylmercury production in flooded wetlands appears to peak at roughly the same overall level for Muskrat Falls. However, as acknowledged by Dr. Calder during his presentation to the IEC on March 1, 2018, the model only predicts the peak production rate of MeHg in flooded soils and not its temporal extent. This potentially underestimates the importance of flooded wetland soils for the overall production of methylmercury in newly flooded reservoirs (Jansen, memo of March 1, 2018).

Scenario B:

Initial outputs -

- Soil removal carried out under Scenario B would reduce peak MeHg levels in the lower Churchill River environment relative to baseline by 23% in the reservoir and river below Muskrat Falls, and 15% in the surface layer of Lake Melville. The reduction of the peak MeHg increase would be proportional to the surface area removed (about ¼)
- Under Scenario B, the new population-wide median MeHg exposures would be approximately 0.031 µg kg^{-1} day^{-1}, reduced from the predicted 0.035 µg kg^{-1} day^{-1}. The fraction of women of childbearing age who will be over the Health Canada guidelines for MeHg exposure will be reduced from > 5% to about 5%.

Further Refinements –

- New data for seal and fish MeHg concentrations from the Nalcor baseline monitoring program (1999-2016) were provided to Ryan Calder. In addition, a report on species abundance and distributions in the Churchill River, Goose Bay and Lake Melville (McCarthy, J., February 2, 2018) and alternative habitat foraging fractions for certain species of fish (Atlantic salmon, ouananiche and lake trout) were suggested based on input from Indigenous Knowledge experts (J. McCarthy et al., February 27, 2018). The IEC asked how these new and alternative parameter inputs might impact his model predictions. The exposure model developed by Calder et al (2016) was re-run using these alternate inputs for the present day, under post-flooding conditions assuming the original flooded area and under the soil capping/removal Scenarios A and B, and resulted in modestly reduced forecasts for peak post-flooding MeHg exposures among Lake Melville Inuit. The effects of Scenario B using these alternative model parameters are similar to those presented earlier using the original model parameter inputs (Calder, February 13, 2018).
- The Nalcor Model prediction for peak and 1-year mean MeHg concentrations in the reservoir water under the various mitigation scenarios was provided to Ryan Calder for the examination of downstream impacts using his model. The resulting outputs are provided in Table 1 below.

Table 1 (next page) provides a breakdown of the predicted change in exposures under each mitigation scenario for the 95^{th} percentile of females age 16-49 and children under 12 years living in Rigolet. See caption for details.

Table 1:

Caption: Table showing expected mean percent change in MeHg intake for the 95th percentile of the most vulnerable population subgroup (female age 16-49 plus male/female ≤12 years) living in Rigolet, the Lake Melville community with the highest consumption of country food, due to: (1) flooding without any IEAC-directed mitigation of reservoir, *relative to* baseline MeHg intake (here referred to as the *no-mitigation* MeHg scenario); and (2) flooding following application of targeted mitigation in reservoir *relative to* default MeHg scenario (here referred to as the *mitigation* MeHg scenarios). For example, in the no-mitigation scenario a 100% change corresponds to a doubling of exposures, whereas in the mitigation scenarios, a change of –100% would be complete mitigation of all additional exposures. The MeHg intake scenarios in each case are generated by the Calder et al. (2016) Lake Melville accumulation, biomagnification and human exposure model, but driven by: (a) modeled reservoir water MeHg peak production value derived from Calder et al. (0.19 ng/L in the reservoir; 2016); (b) modeled reservoir water MeHg peak production value derived by Reed Harris (0.11 ng/L; as calculated using equation on slide 5, February 26 presentation, 2018); and (c) modeled reservoir water MeHg maximum one-year average production value derived by Reed Harris (0.067 ng/L; as calculated using equation on slide 5, February 26, presentation, 2018). The mitigation scenarios examine the effects of wetland capping (A) and upland soil removal (B) and subdivided by parameter values used in Calder's Lake Melville accumulation, biomagnification and human exposure model.

Modeled MeHg production (reservoir)	**% Change in MeHg intake for Rigolet subgroup (F 16-49; M/F <12)**					
	(1) *No-mitigation* MeHg scenario#		(2) *Mitigation* MeHg scenarios*			
	1	2	Wetland A1	Wetland A2	Soil Removal B1	Soil Removal B2
(a) Calder peak	+195%	+146%	-2%	-2%	-25%	-26%
(b) Nalcor peak	+92%	+64%	-2%	-2%	-22%	-26%
(c) Nalcor 1-yr mean	+52%	+31%	-1%	-2%	-18%	-24%

No-mitigation MeHg intake scenarios are differentiated based on using either Calder input parameters as in published paper (1) or Calder input parameters as modified by IEC directive (2).

* Mitigation Scenario **A** refers to capping of wetland (non-marsh) representing 2% of flooded reservoir area (37-41 km^2), and using either Calder input parameters as in published paper (A1) or Calder input parameters as modified by IEC directive (A2).

* Mitigation Scenario **B** refers to the removal of 10.3 km^2 of upland soil (~25-28% of 37-41 km^2 reservoir area) from reservoir, and using either Calder input parameters as in published paper (B1; see text for details) or Calder input parameters as modified by IEC directive (B2; see text for details).

3. Recommendations

This section describes mitigation options considered by the IEC to have the potential to decrease the production of methylmercury in the Muskrat Falls reservoir, and thus to reduce rates of bioaccumulation into biota within the reservoir and in the downstream environment. To be effective, these physical measures will have to be completed prior to the start of final inundation of the reservoir. As such they are pre-Project mitigation measures.

Although the IEC is aware of some mitigation measures based on chemical additions to change methylation conditions, or special materials designed to absorb MeHg and that have shown some success in relatively small systems, it was decided that focus would be placed on pre-impoundment options for mitigation.

All the options considered by the IEC for pre-project mitigation are based on the well-established, positive, linear relationship between concentrations of organic carbon in flooded soils and associated lower vegetation, and the rate of mercury methylation. In addition to the scientific justification for the mitigation measures, the IEC took into account the feasibility of implementing these measures; this included safety considerations, the risk of un-wanted side-effects (which might cause production of methylmercury), amongst others.

Option 1 – No further action for mitigation

It is noted that greater than 50% of the future reservoir area has been cleared of trees which has reduced some of the organic carbon and possibly reduced future methylmercury production.

Option 2 – Full clearing of soils and vegetation

As the relationship between organic carbon and methylmercury production is linear, full removal will result in the greatest reduction in methylmercury production. It is unlikely that all material can be removed (due to engineering constraints) so the reduction will not be to zero. The IEC also noted that the very aggressive schedule that would be needed to achieve this objective could result in undesired side-effects, such as possible stimulation of methylmercury production.

Option 3 – Targeted removal of soils and vegetation (Scenario B described in Section 2.4 of this document)

The organic carbon (OC) distribution within the reservoir footprint is heterogeneous; there are patches with no/low OC content and patches with high/very high OC content, such as bog and fens. The initial rationale was to pick areas with soils of high OC content. However, the available data did not allow a clear separation of forest soils based on their OC content and/or depth of humic layer. Furthermore, the removal depth of the proposed equipment (0.5 m in summer, 1.5 m under frozen conditions) removed any options of a targeted soil removal based on soil depth. Consideration was also given to take advantage of areas where there are existing roads/tracks and to avoid steep areas. It is expected that undesired side effects would be reduced with this option (due to the avoidance of unstable soils, steep slopes and riparian areas), but not completely eliminated. For predictions on the impact of Option 3 to human exposure, please see Table 1 in Section 2.5.2 above.

Option 4 – Capping of wetlands (Scenario A, described in Section 2.4 of this document)

Removal of the OC sequestered in wetlands is not practical and will have unwanted-side effects (e.g., releasing soil pore water, break up of peat). One other way of 'removing' OC is to make it physically unavailable to methylating bacteria (refer to Jansen, February 28, 2018, capping methodology). Since the percentage of the landmass in this category is small, this had the smallest effect of reducing methylmercury production but there is other evidence (Jansen, W., February 28, 2018) to indicate that isolating the carbon is these areas will decrease the duration of methylmercury production. For predictions on the impact of Option 4 to human exposure, please see Table 1 in Section 2.5.2 above.

Option 5 – Combination of Options 3 and 4

This would reduce both the amount and duration of methylmercury production as noted above.

IEC Recommendation

After careful consideration of the potential benefits and associated risks of the five options considered above, the recommendations of the Independent Expert Committee is described as follows:

Six IEC members recommended some sort of pre-impoundment mitigation, with one recommending wetland capping only (Option 4), and five recommending both wetland capping and targeted soil removal (Option 5). Three members recommended no further action on mitigation (Option 1).

Each member provided a brief justification for their decision, which is provided in a separate document entitled Opinions of the IEAC Independent Expert Committee on Mitigation.

List of Relevant Documents

(All documents are provided in attached zip file.)

AMEC Foster Wheeler, June 26, 2017. FINAL Muskrat Falls Soil Sampling Program, 2016. Submitted to Nalcor Energy.

Azimuth Consulting Group Partnership, October 18, 2017. Quantitative Measurement of Labile Carbon in Organic Soils of the Lower Churchill River. Submitted to Peter Madden, Nalcor Energy

Azimuth Consulting Group Partnership, February 25, 2018. Evaluation of MeHg Production by Muskrat Falls Reservoir and Implications for Lake Melville – A Top-Down, Mass-Balance Approach. Submitted to Peter Madden, Nalcor Energy. 32 pages.

Balcom, P., January 27, 2018. Update on Churchill River MeHg flux experiments. Presented to the IEC by Jane Kirk, February 15, 2018.

Balcom P., E. Sunderland, March 5, 2018a. Churchill River Soil Flux Core Experiments: October 2017. 9 pages

Balcom P., E. Sunderland, March 5, 2018b. Churchill River Soil Flux Core Experiments: October 2017. Supporting Information. 4 pages

Calder, R. et al, 2016. Future Impacts of Hydroelectric Power Development on Methylmercury Exposures of Canadian Indigenous Communities. Environmental Science and Technology. 8 pages.

Calder, R. et al, 2016. Future Impacts of Hydroelectric Power Development on Methylmercury Exposures of Canadian Indigenous Communities. Environmental Science and Technology. Supporting Information. 26 pages.

Calder, R., December 7, 2017. Methylmercury Risk Analysis at Muskrat Falls Webinar 1: Introduction and Comparison of Approaches. Presentation to the IEAC.

Calder, R et al, December 19, 2017. Methylmercury Risk Analysis at Muskrat Falls Webinar 2: Integrated environment-human health modeling at Muskrat Falls. Presentation to the IEAC.

Calder, R., January 31, 2018. Supplementary information regarding data presented in RSD Calder et al (2016). Memo submitted to the IEC. 4 pages

Calder, R., February 13, 2018. Effect of soil removal and capping on post-flooding MeHg concentrations in the lower Churchill River environment. Memo submitted to the IEC. 7 pages

Calder, R, February 19, 2018. Reed Harris' comment on soil carbon submission from January 31, 2018. Memo submitted to the IEC. 4 pages

Calder, R., February 22, 2018. Conversation with IEAC about 2-19 Scenarios. Presentation to the Independent Expert Advisory Committee.

Calder, R., February 28, 2018. Methylmercury exposure forecasts among Lake Melville Inuit under hypothetical scenarios for soil removal at Muskrat Falls and using certain updated and alternative model parameter inputs. Memo submitted to the IEC. 6 pages.

Calder, R., March 1, 2018. Alternate model inputs, remediation scenarios, Nalcor documents. Presentation to the IEC.

Harris, R., December 18, 2017. Mercury Modeling Update for Muskrat Falls Reservoir and Downstream. Presentation to the Independent Expert Committee.

Harris, R., February 21, 2018. Comments on the relationship between carbon and methylmercury in flooded soils. 8 pages

Harris, R., February 26, 2018. Mercury Modeling Update for Muskrat Falls Project. Presentation to the Independent Expert Committee.

Harris, R. February 28, 2018. Comments on Azimuth February 25, 201 memorandum titled "Evaluation of MeHg Production by Muskrat Falls Reservoir and Implications for Lake Melville – A Top-Down, Mass-Balance Approach. Memo submitted to the IEC. 2 pages.

Hesslein, R, February 12, 2018. Comments on conditions affecting transport of MeHg from flooded soils with application to Muskrat Falls. Submitted to the IEC by Reed Harris on February 25, 2018.

Independent Expert Committee, December 2017. Compiled Review Comments and Questions on "Azimuth Consulting Group Partnership. 2017. Quantitative measurements of labile carbon in organic soils of the lower Churchill River. Technical Memorandum NE 16-01 produced for Peter Madden, Nalcor Energy, October 18, 2017.

Independent Expert Committee, January 16, 2018. Questions from the Independent Expert Committee (IEC) on document "Muskrat Falls - Soil and Vegetation Removal from the Future Reservoir Area".

Independent Expert Committee, January 23, 2018. Independent Expert Advisory (IEC) Committee Suggestions for Targeted Mitigation Action – Scenarios A and B dated 23 January 2018.

Independent Expert Committee, February 21, 2018. Comments (and Responses) to David Lean's Opinion Piece. 31 pages.

Jansen, W., September 27, 2017. Effects of forestry practices and similar soil disturbance on environmental mercury concentrations. Memo submitted to the IEC.

Jansen, W., February 17, 2018. Fish seal Hg concentrations from AEMP 1999-2016 Baseline compared to Calder et al, 2016.

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<u>Reference documents added on March 31, 2018:</u>

The following documents were received by the IEAC Chair after the date of final compilation of Independent Expert Committee (IEC) recommendations, and therefore have not been reviewed by the IEC. (They are referred to as "A, B and C" in the references package.)

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