From: Goebel, Martin
To: Chippett, Jamie
Cc: Khan, Haseen; Shea, Erin
Subject: Evaluation of the Scientific Submissions to the IEC on Mitigation
Date: Friday, April 13, 2018 4:55:00 PM
Attachments: Evaluation of the Scientific Submissions to the IEC on Mitigation.docx

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Jamie,

Please see attached report that I prepared as a part of my review of the "1,200 page report". As you are aware this is the background information that was provided to the IEAC members in preparation for the face to face meeting in HVGB. These documents were prepared or presented by the scientific sub-committee and contracted consultants and specialists. In turn this supports the IEAC's recommendations to the Minister. (except the recommendation for the food security which came up at the Oversight Committee table and was never a part of the Scientific sub-committee discussion). Most of my effort was in the analysis of the Mitigations recommendation but I did complete the files for the Health Management and Monitoring files as well and those notes are at the end of the document. Those two files however, were mostly background material, but some of it did support various arguments in the mitigations file. Sorry about a few rough edges but please let me know if you have any questions.

Regards,

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Evaluation of the Scientific Submissions to the IEC on Mitigation

Prepared by Martin Goebel, Senior Advisor on Methylmercury, April 12, 2018

Forward

All members of the IEAC oversight were provided with an information package containing relevant documents generated by the scientific sub-group (IEC) in advance of the face to face meeting in Happy Valley – Goose Bay on March 8-9, 2018. There were three packages, one on monitoring, one on [health] management and this one on mitigation. This evaluation will list each document and summarize its key findings and implications and where necessary provide commentary where issues of concern are noted.

7 Calder et al. 2016, Future Impacts of Hydroelectric Power Development on Methylmercury Exposures of Canadian Indigenous Communities and

8 Calder et al. 2016, Supporting Information for the above

This paper was published in the peer reviewed Journal of Environmental Science and Technology. Its principle author (Calder R.) was a student under Dr. Amina Schartup (Harvard University) who a year earlier published a similar paper. This paper describes a probabilistic model which models the MeHg enrichment in the reservoir following impoundment, the effect on Lake Melville downstream, then the effect on locally harvested country foods and the impact on Inuit communities. It showed a 10 fold increase in riverine MeHg and a 1.6 to 4 fold increase in the estuary's surface water. It predicted a 1.3 to 10 fold increase in MeHg in local species, which would cause a doubling of MeHg exposure in the Inuit population.

- This probabilistic model cannot be used or applied to any other reservoir system. In other words it cannot be tested in an existing system where the MeHg outcomes have already been observed and are known.
- Peak fluxes used to estimate the amount of MeHg generated are questionable (see 17 Harris)
- The mass balance of MeHg is questionable (see 3 Azimuth)
- The earlier Harvard paper reported a 14 fold increase in MeHg soil flux was not replicated in the more recent soil flux experiment. In fact samples where soil and vegetation were removed had more MeHg flux in 3 of 4 samples (See 4 Balcom)

- Actual MeHg data collected in the system since Oct 2016 had showed a slight increase in average MeHg following the initial impoundment but that signal disappeared quickly and did not even show in the estuary.
- The earlier paper postulated that the fresh water/ salt water boundary layer was a unique feature of Lake Melville and that it would generate much larger MeHg. Actual data comparing the surface samples with the halocline samples show a consistently lower level of MeHg in this layer. Trevor Bell participated in setting up this water quality monitoring program but then never used the data in any of the IEAC work. Why is that?
- The overall MeHg in Lake Melville, with over 350 samples collected, is somewhat lower than the starting value (0.017 µg/l) for MeHg in the model. That Harvard starting value comes from only 24 samples collected in 2012 and 2013.
- Bio-magnification factors for the various species are questionable (see 31, 32 McCarthy)
- The paper stated that 3% of people in Rigolet are already above the HC provisional tolerable daily intake (*p*TDI) of 0.2 - 0.47 µg/Kg BW but that does not seem to fit Calder's own Nunatsiavut hair analysis results.
- The discussion about the safe levels of exposure are confused by quoting US EPA guidelines, exposures to upper 95%ile groups and not distinguishing the "increasing risk" and "at risk" guidance values.

1 AMEC, June 26, 2017, Muskrat Falls Soil Sampling Program 2016

This report was prepared for Nalcor prior to the start of the IEAC work. It conducted a soil sampling program to determine potential concentrations of total mercury, methylmercury and organic soil volume within the existing shallow soil horizons of the future reservoir. It also measured total organic carbon. This work was intended to support further work conducted by others to understand methylation in future flooded soils.

The study looked at 11 different land classifications and had a total of 45 sampling locations. Additional samples were designated from wetlands.

Total mercury concentrations were relatively low within the soil samples analyzed and ranged between non-detect (<0.005 mg/kg) and 0.194 mg/kg. A comparison between THg values and TOC indicate that a weak positive relationship exists. Results that were less than the method detection limit (one sample) were set to the method detection limit of 0.005 mg/kg.

Methylmercury concentrations were very low and ranged between 0.04 and 1.41 ng/g within the subset of soil samples analyzed. These values are generally less than one percent of the THg concentrations. Two locations had MeHg concentrations greater than one percent;

26 Jansen W., Sept 27, 2017, Effects of forestry practices and similar soil disturbance on environmental mercury concentrations (edited March 4, 2018)

This paper describes recent findings from the forestry industry that show MeHg results from forestry practices. This has management implications for Muskrat Falls such as where to construct road, avoiding connections to MeHg hotspots such as wetlands, limiting work to low slope areas, minimizing sedimentation, avoiding stream crossings etc.

- The point is that looking at the additional disturbance that soil and vegetation removal and placement will create right next to the river, MeHg production could be increased as a result.

2 Azimuth Oct 18, 2017, Quantitative Measurement of Labile Carbon in Organic Soils of the Lower Churchill River

This report commissioned by Nalcor is about experiments to determine quantitatively how much carbon can readily be broken down by microorganisms in soils that will be flooded by the Muskrat Falls reservoir. The results suggest that the labile carbon is only a very small fraction (<1%) of the total organic carbon in Churchill Falls soils. This is similar to other sites with organic soil horizons and thus "no greater rate or prolonged duration of mercury methylation should be expected at the Lower Churchill River project compared to other locations."

- This does not provide direct input data into the Calder model, but it speaks to trying to determine how Calder estimated the role of carbon input in his model.

22 IEC,Dec. 2017, IEC, Review Comments and Questions on: 2 Azimuth Oct 18, 2017, Quantitative Measurement of Labile Carbon in Organic Soils of the Lower Churchill River

This is a 4 page table of topics pertaining to the above Azimuth report. This included Extraction Method, Selection of Soil Horizons, Sample Size, Storage, and Location, General Discussion and questions. A commentary was provided by most of the scientists. Note: WJ = Wolfgang Jansen, JK = Jane Kirk, DL=David Lean, TB=Trevor Bell.

- In summary they raised many questions about the report and made suggestions for follow-up investigation

9 Calder R, Dec 7, 2017, Methylmercury Risk Analysis at Muskrat Falls, Webinar 1: Introduction and Comparison of Approaches

This is the first power point presentation by Calder to the IEC. Its goals were to set up a common baseline of understanding of MeHg toxicity, connection to hydro projects and scientific gaps. It discusses the health studies by Nalcor and provides an understanding of the Harvard Model. It further aims to differentiate the Harvard model with respect to Nalcor's scientific findings and implications for human health.

- The presentation starts by showing very provocative images of pure waste being discharged by a pipe next to a crippled victim of Minamata disease. Unfortunately such images shock uninformed audiences who easily believe this is their future with the Muskrat Fall project.
- MeHg; no known safe dose… Again a provocative statement that does not recognize the role of Health Canada which set guidance values in accordance with the same research that is quoted here.
- Slides are presented that quote Nalcor in order to refute or raise scientific uncertainty. Critical of Nalcor's regression based model used for the EIS and lack of modelling downstream into Lake Melville.
- There was a brief introduction of several other Nalcor commissioned papers.
- Criticism of the Human Health study
- The Harvard model is explained. I won't go back over the concerns I identified above.

10 Calder R, Dec 19, 2017, Methylmercury Risk Analysis at Muskrat Falls, Webinar 2: Integrated environment-human health modelling at Muskrat Falls.

This power point presentation appears to be a continuation of the previous presentation. It starts with a recap of the Nalcor and Harvard models. It then aims to go into much more detail about the workings of the Harvard model. This is a very technical presentation showing how the model starts with a baseline estimation of Hg, how it peaks following flooding , is transported downstream and ends up as an increased MeHg exposure to the Inuit downstream. This presentation is perhaps a better way to understand what is described in the original published papers.

- An important take-away from this presentation is the relationship between increased MeHg and organic carbon. Hence the fundamental conclusion that the more carbon ie = vegetation and soil that is removed. The less MeHg will be produced.
- Isotope data was used to determine bioaccumulation factors in various species in Lake Melville and this was compared to other forecasts by Haris et al. Calder generally had higher results.
- The graph showing the result of average hair HG in the Inuit population broken down by community, sex and age groups is presented here. It shows slightly higher values compared to the Canadian population as a whole.
- The next graph shows typical foods and the changes in MeHg content as a result of the project. The presentation ends with predictions of the charged exposure to MeHg particularly for the >95%ile Female and children subgroup in Rigolet. This is the subgroup that will experience the highest possible outcome.
- There are two concerns,
    1. it is not clear how Calder transitioned from hair guidance values to MeHg exposure values.
    2. by expressing the figures as a percentage, we lose sight of the fact that this applies to only a very few individuals.
- It was not made clear that the Calder model makes estimates of the peak MeHg whereas the HC exposure values are based on lifetime exposures (30 years). Comparing data in this manner greatly exaggerates the effect.

17 Harris R, Dec 18, 2017, Mercury Modelling Update for Muskrat Falls Reservoir and Downstream

This is a power point presentation given by Reed Harris, Consultant for Nalcor. The modelling at this point is really a work in progress. The presentation compares the different types of models (regression, mechanistic, Calder) as to how they work and what the assumptions are that go into those models. Examples are provided that show how those assumptions can affect the end predictions. One important slide shows why Calder's model had much high MeHg flux assumptions and it has to do with the fact that the soil flux is a function of the top layer not the total amount of carbon. The presentation ended with a proposed plan for the downstream modelling component.

- Unfortunately, further downstream modelling, and its impacts on biota in Lake Melville was never competed in time for the IEC to take that into consideration.
- The presentation discusses and compares the role of carbon as a key component for determining the MeHg loads to water. It shows how this resulted in a much higher soil flux and water diffusion assumption in the Calder model compared to data from the Experimental Lakes Area.

39 SNC Lavalin, Dec 21, 2017, Muskrat falls – Soil and Vegetation Removal from the Future Reservoir Area

This report was prepared by consultants for Nalcor in fulfillment of the first set of IEAC recommendations particularly 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 study considered removing as much vegetation and soil as possible and in the final IEAC mitigation options, it became the basis for *Option 2, full clearing of soils and vegetation.* The report concluded that the project may be achievable with sufficient lead time for planning engineering, procurement and regulatory requirements, but challenging with a high risk of not delivering on schedule.

- The assumptions that went into this were such that if any component could not go as planned, there would be cost over runs and project delays. Cost of potential project delays was not considered.
- Removed material would be placed where it would be just above the full supply lever or just above ele 42 m. Haul distances to be no more than 3 km. In other words, the material would be left adjacent to the reservoir and would not be removed from the

drainage area, as was falsely asserted by Dr. Trevor Bell, one of the IEC scientists, in his presentation to the IEAC oversight committee.

- The amount of over-burden excavation was estimated as 42,935,775 m^3 and the total project cost was estimated to be between $1.2B and $2.3B.

23 IEC Jan16, 2018, Questions (Q) from the Independent Expert Committee (IEC) on document "Muskrat Falls - Soil and Vegetation Removal from the Future Reservoir Area"

This 4 page document is a list of questions that the IEC scientists posed about specific sections in the above report. Exactly who asked which question is not mentioned.

35 Nalcor Energy, Jan 31, 2018 Answers to Questions (Q) from the Independent Expert Committee (IEC) on document "Muskrat Falls - Soil and Vegetation Removal from the Future Reservoir Area"

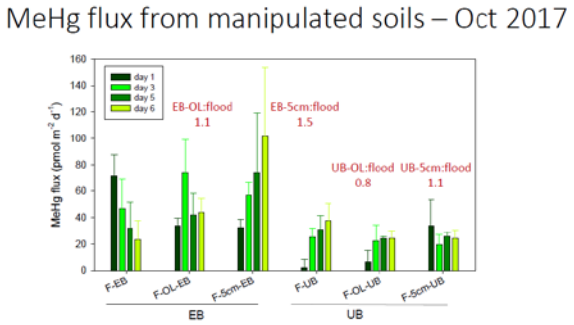
Question by question responses are provided to 23 IEC Jan16, 2018 (above) by Nalcor. It is mostly very much engineering oriented but a final comment is worth noting. Essentially the project could be achieved if enough money and resources are provided but any unforeseen conditions could prevent the project from being delivered on time.

24 IEC Jan23, 2018, Suggestions for Targeted Mitigation Action – Scenarios A and B dated 23 January 2018

This is a two page note in which the IEAC proposed 2 targeted soil Mitigation Scenarios. Scenario A, - Wetland capping, Scenario B, - Targeted soil removal. A revised feasibility study was subsequently provided. See 40, 41, 42 SNC Lavalin, and the targeted soil removal report which was made available later.

4 Balcom P., Jan 27, 2018, Update on Churchill River MeHg Flux Experiments

This is a power point presentation by Harvard Scientist Prentice Balcom that gave a good pictorial overview of the soil flux experiment. Soil samples were collected from various soil types in the future reservoir and MeHg flux was measured experimentally in the lab. This was intended to help inform where soil removal might be more effective or beneficial. It was also intended to demonstrate how vegetation and topsoil removal could reduce MeHg production in the reservoir



- From the onset, this experiment was controversial because a soil experiment in the lab might not reflect all the real world parameters that could affect soil flux. The experiment did however try to simulate field conditions such as temperature, oxygen and flow as best they could, but everyone realized the experiment would only demonstrate relative differences and not absolute soil flux quantities.
- Results of the experiment were widely inconclusive but 3 out of 4 samples actually had more MeHg as a result of vegetation and soil removal.
- The original Harvard paper as well as Calder's paper[7] point to a soil flux experiment where a 14 fold increase in MeHg was observed. This latest experiment completely debunks that.
- This experiment was subsequently swept under the rug and the results were not made know to the IEAC oversight committee members until it was provided in this package.

11 Calder R, Jan 31, 2018, Supplementary information regarding data presented in RSD Calder et al. (2016)

This is a letter and a 3 page technical memo providing supplemental information on the relationship between organic carbon and MeHg content in flooded soils based on other published data from other reservoirs. The key point made here is that his figures suggest that

each additional percent of organic carbon in flooded soils is associated with an additional 0.80 ng/g MeHg.

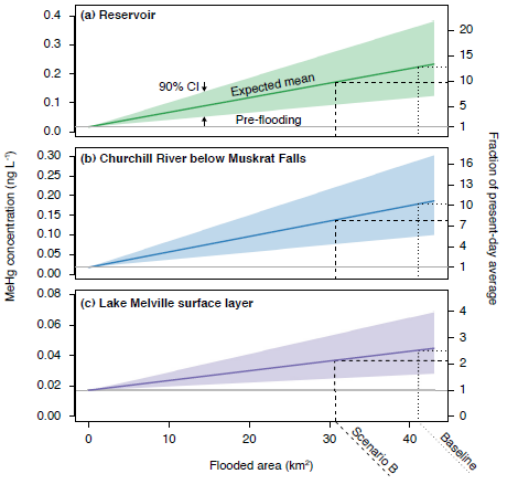
21 Hesslein R, Feb. 21, 2018, Comments on conditions affecting transport of MeHg from flooded soil with application to Muskrat Falls.

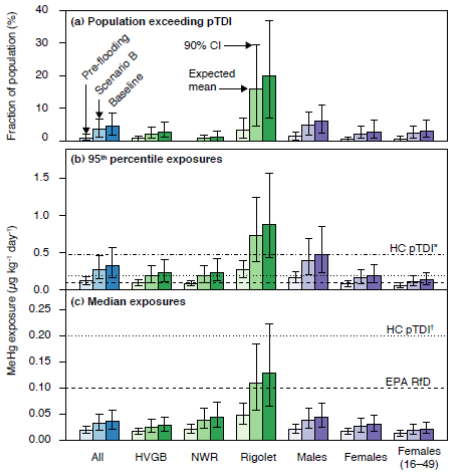
This is a 4 page technical memo wherein there is a description of transport zones consisting of the flooded soil matrix, the diffusive boundary layer, the bottom waters and the surface mixed layer. It explains how MeHg moves through these zones. It is not known who requested this write-up but later Calder presents some counter arguments about some of this material.

- Unfortunately, this is the one paper where I have insufficient knowledge to make any comment. The paper does not seem to provide any conclusions rather it simply presents the science.

12 Calder R, Feb 13, 2018, Effect of soil removal and capping on post-flooding MeHg concentrations in the lower Churchill River environment

This is another letter with a 6 page technical memo wherein impacts on post-flooding MeHg concentrations and human exposures were analyzed. The two scenarios analyzed were t A) capping of wetlands and B) limited soil removal. Because the areal extent of wetland capping was very small, the modelled effect on MeHg levels in the system was considered negligible. In scenario B, using the areal extent of soil removal, estimated at 10.3 km^2, MeHg concentrations were reduced in the reservoir, Churchill River and in Lake Melville. This effect was presented graphically where the scenario B reduction was compared to the baseline as a linear function of reservoir area.





The analysis then continued by estimating the effect this MeHg reduction would have in terms of reducing the *p*TDI on various population subgroups

- Assuming that the increases in MeHg as modeled by Calder are correct in the first place, the MeHg reduction in Lake Melville is around 15%. However as shown in the first graph this reduction is much smaller than the 90% confidence limits.
- The model made the assumption that the organic overburden was removed from the reservoir area but the model was not sophisticated enough to account for the fact that all that material would still be right next to the reservoir.
- The graphs showing the further effect on the *p*TDI show that median exposures, which are below the Health Canada guidelines post flooding, will be reduced somewhat. However, by focusing on the extreme tail end of the population distribution some individuals are over the Health Canada *p*TDI. But the reduction from soil removal improves but does not eliminate their exposure.
- Calder likes to use percentages to illustrate his model. This makes the effect seem larger than it is. There are only a very few actual individuals who are affected. He also likes to use the EPA R*f*D because it is lower than the Canadian *p*TDI equivalent. The difference is actually only because of a difference in safety factor that is added to the reference effect. (5 vs 10)
- Calder neglects to point out that the model provides an estimate of the peak MeHg whereas the guidelines are based on average lifetime exposures so this greatly overstates the real outcome regardless.

30 Lean D., Jan 27, 2018

In this 5 page untitled note David Lean presents a series of observations in support of the notion that the Muskrat falls reservoir will not produce as much MeHg as other speculate it will. The basis for much of this presentation is that Muskrat Falls will be very small in comparison to other reservoirs and also that the flow is large relative to the size. Thus there will be a very fast cycling of water, ie. every 10-15 days.

- Interestingly, Lean closes his paper with the observation the models can only be proven when compared to a similar real reservoir.

25 IEC, Feb 21, 2018, Comments on David Lean's Opinion Document, Circulated as Attachment to e-mail on 27 Jan 2018

The original e-mail from David Lean is referenced but the previous document[30] is what is being discussed in these comments. Relevant sections of Lean's note were reproduced (black font) and followed by questions from the IEC scientific sub-group (red font). Those in turn were followed by responses from Lean (green font). This goes back and forth for 31 pages including illustrations and references.

The main thrust of this is that according to Lean, "*Muskrat Falls Project (MFP) might represent one of the best designs for minimizing mercury release*". He states why and this created lots of debate about the short-comings of his assertion and in turn the short-comings of the Calder model. I'm not sure where the strongest arguments were but credentials were called into question.

3 Azimuth, Feb 25, 2018, Evaluation of MeHg Production by Muskrat Falls Reservoir and Implications for Lake Melville – A Top-Down, Mass Balance Approach

This technical memo was commissioned by Nalcor and carried out by their consultant. It examines the Calder et al[7] assumptions that are crucial to support their key conclusions regarding the rate and duration of MeHg flux from the reservoir. The report demonstrated why they feel Muskrat Falls has a weak methylation potential, and that the amount of mercury that is available in the reservoir for transfer to the food web is limited. So to put this another way,

Azimuth estimate that the reservoir can generate a total mass 2.35 kg/yr of MeHg whereas based on Calder's flux rate 7.5 kg/yr would be required. In Lake Melville when using the Calder bioaccumulation factor to achieve the predicted increase in upper trophic level biota Muskrat Falls would have to generate hundreds of kg of MeHg which is not possible. Part of the evidence for these finding was based on actual data from the surface water quality monitoring program.

- It was concluded that while there still may be changes in Lake Melville they would be extremely small so as to be difficult to measure and detect. Food will not be contaminated by Me Hg from Muskrat Falls.
- In my opinion, this is the single most damming piece of evidence that the Calder model is sufficiently flawed that it can no longer be used to predict the effects of Muskrat Falls in the food of the downstream Inuit people.

28 Kirk, J. Feb 28, 2018, Comments on "Evaluation of MeHg Production by Muskrat Falls Reservoir and Implications for Lake Melville – A Top-Down, Mass-Balance Approach" sent on February 25, 2018

In this two page note Kirk is highly critical of the Azimuth[3] report. While some other literature is cited the main argument is that the Calder model is a peer reviewed document and objections to it should be taken up formally with the editor of the journal.

- This dismissive approach to anything but the peer reviewed Harvard study defeats the purpose of the IEAC. Publishing studies in peer reviewed journals is meant to stimulate further research and scientific discussion, and not be taken as the ultimate and indisputable authority on the subject. The Harvard study is only an model and over time it needs to be used in the context of real world data and other new research whether published or not.

19 Harris R, Feb 26, 2018, Mercury Modelling Update for Muskrat Falls Reservoir and Downstream

This power point presentation is similar to the earlier one[17] which presents the results of a modelling exercise for the Muskrat Falls reservoir. This model was calibrated against two existing reservoirs (R. Bourassa Reservoir, QC, and Notigi Reservoir, MB)s to examine MeHg

loads. When applied to the Muskrat Falls reservoir the water peak MeHg was less than half of what Calder predicted. Adult pike fish were not predicted to increase as much as the water itself. Removing organics from the reservoir would reduce the concentration in pike in the reservoir by about 15 % and wetland capping would have little effect at all.

- Again, this model does not speak to any effect downstream or into the food web of Lake Melville.
- The peak MeHg predicted in the Muskrat Falls reservoir is about 0.1 ng/L and less when averaged over a year. Calder's model predicts twice as much roughly 0.2 ng/l.
- Even though the reservoir is already about 25 % flooded the surface water monitoring program shows that the latest water sample results for dissolved Mehg are about 0.013 ng/l for Feb 22. The two downstream sampling sites are <MDL

40, 41, 42 SNC Lavalin, Feb 26, 2018, Muskrat Falls Vegetation Scenario A, B

These three tables provide soil removal assumption and cost updates. They were updated again later in a report that was too late to be included in this package.

38 Reimer K., Feb 19, 2018 Questions and requests for additional analysis and opinion re: February 13 Memo "Effect of Soil Removal and Capping on post-flooding MeHg concentrations in the lower Churchill River environment"

In an email, the Chair is requesting Calder to undertake further modelling with revised soil removal data and the new food web information. Calder was also asked to comment on MeHg production in flooded wetlands.

14 Calder R., Feb 22, 2018, Methylmercury Risk Analysis at Muskrat Falls – Discussion about Scenarios requested on 2/20

This power point presentation present most of the results already discussed in the previous technical memo[12]. The same graphs are used. The presentation also looked at new fish and seal mercury data provided by McCarthy. It was concluded that the data was unlikely

to result in major changes to exposure forecasts but indicated he was willing to try it in the model.

18 Harris R., Feb 21, 2018, Comments on the relationship between carbon and methylmercury in flooded soils

This is an 8 page technical memo as requested by the chair. It starts by explaining in first principles how MeHg is formed and enters into the environment. It then looks at the relationship between carbon in soils and MeHg. It is here that Harris finds an error in the published data that Calder used in his model which he could not have known. Other points are made after which Harris suggests the Calder model should be adjusted with the new data.

A key question is what depth of soil should be used? While the organic layer can be deep, it is only the top few centimeters from which MeHg can flux to water. Below that MeHg does not pass upwards through the soil because there is no flow. This has a significant impact on estimating the amount of carbon that will be available.

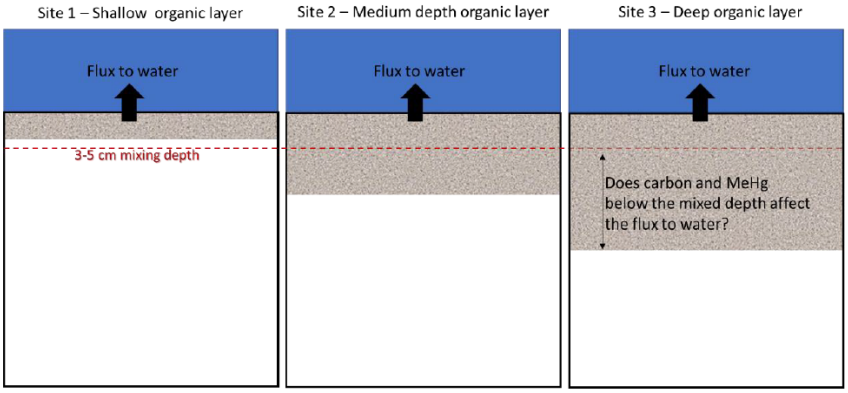


Figure 2. Conceptual diagram showing three sites with different depths of organic soils

- In terms of soil removal, one needs to remove all of it because otherwise a new 3-5 cm lay of carbon is available for methylation and removing the top layer will have accomplished nothing.

13 Calder R., Feb 19, 2018, Reed Harris's comment on soil carbon submission from January 31st, 2018

In this letter to the IEAC Chair, Calder responds to Reed Harris[18] . Calder pretty well refutes everything.

31 McCarthy J., Feb 2, 2018, Aquatic Species Habitat Utilization Overview Churchill River, Goose Bay, and Lake Melville 1998-2016

This is a 55 page paper that aims to provide additional species summary information related to fish species identified in the Human Health Risk Assessment. It uses baseline data collected since 1998 for sampling data for total mercury concentrations in fish and seal samples. It describes the various riverine habitats and notes that the data includes data from the Environmental Effects Monitoring programs. In total there are over 15,600 fish sampled from approximately 29 species to present. The report discussed in the detail the life cycle of the more important species and reports on their history of mercury content.

- This data must be taken into account when determining the MeHg exposure to humans who eat some of these species.

32 McCarthy J., Feb 15, 2018, General Species Distribution, Abundance, and Existing Hg Concentrations, Considerations for Modelling Potential Human Consumption/Risks

This power point presentation is a based in part on the previous paper[31]. It starts with the simple assertion that a model is not equal to the real world. There was a brief explanation of risk assessment which is a tool for estimating potential adverse impacts. The bulk of the presentation was about a species by species review of their lifecycle and how they could be affected by the Muskrat Falls reservoir. Based on exposure to MeHg and traditional knowledge about the various species, McCarthy provided revised bio accumulation factors (BAF). Information was provided for Arctic Char, Atlantic Cod, Atlantic Salmon, Brook Trout, Capelin, Lake Trout, Ouananiche, and Seal. In the Calder Model BAF range from 1.3 to 10 fold.

- Real World data suggests is a better way to calculate BAF compared to a modelled approach (isotope data) which was used to estimate the faction of a species lifespan spent in the freshwater vs marine environment

34, 33 McCarty J., Feb 27, 2018, Rationale for Revised Species Lifespan Table (McCarthy J et al, Feb 27, 2018)

In this email, McCarthy provides supplement information about the life cycle of Atlantic Salmon and where they feed. This is very important for estimating bio-magnification factors for MeHg. Since Atlantic Salmon are shown not to feed when in Lake Melville, MeHg increases in the food chain will have no bearing on this fish species. The other document is just a table of BAF values based on lifespan in various feeding environments.

- The table is complied with considerable input from the 3 traditional knowledge experts.

27 Jansen W, Feb17, 2018, Baseline mercury (Hg) concentrations in fish species harvested from the Lake Melville region used in Calder et al. 2016 (Table S6a) to model estimate post-Project hair concentrations in humans compared to Hg concentrations from the Muskrat Falls Aquatic Effects Monitoring Pogram (AEMP) for years 2011-2016 (2013-2016 for seals).

This is a table showing the total mercury in some fish species and fish. I am not sure why this is attributed to Jansen. There was no commentary on this table

15 Calder R, Feb 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.

In this letter/memo Calder reported the results of re-running his model using McCarthy's data for the various fish species and then testing the effect in terms of the wetland capping and soil removal options. The outcome was presented in a graph similar to the ones that were used before in presentations and technical memos[12, 14].

- The differences are not readily apparent from the revised graphs but it is also very unclear how the McCarthy data was actually used.
- Never the less Calder states that the mean peak MeHg exposure increase from present is 1.9x in the original model and 1.6x in the adjusted model.

28 Jansen W, Feb 28, 2018, Short review of the potential importance of wetlands as a source of MeHg releases from the Muskrat Falls reservoir in the context of the different view taken by Ryan Calder

The 3 page technical memo challenges some of the assumptions and interpretations of the existing literature as summarized in Calder (2018) and provides a rationale why bog and fen wetlands, despite their relatively small area with in the reservoir, should not be overlooked when providing estimates of the potential benefits of wetland capping as a mitigation measure for the Muskrat Falls project.

- This short memo provides good qualitative reasons for wetland capping despite the relatively small areal extent of wetlands that could be capped. Therefore it is difficult to include such beneficial effects because they cannot be quantified in the modelling approaches used to compare relative benefits.

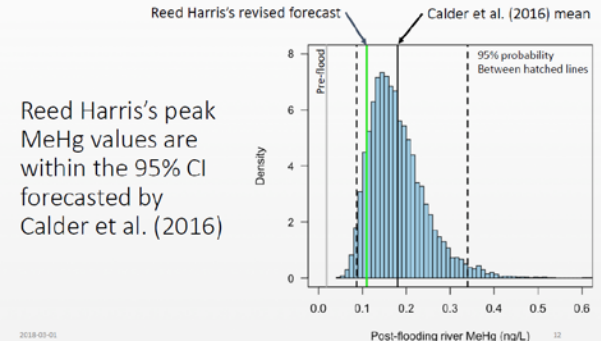
20 Harris R., Feb 28, 2018, Comments on Azimuth February 25, 2018 memorandum titled Evaluation of MeHg Production by Muskrat Falls Reservoir and Implications for Lake Melville – A Top-Down, Mass-Balance Approach"

This is a two page letter by Reed Harris that was prepared at the request of Nalcor. In it Harris reviews the Azimuth[3] paper and essentially agrees that the mass balance issue that was identified is a key issue that should be considered when estimating the response of MeHg in Lake Melville. He gives some other suggestions as well.

16 Calder R, Mar 1, 2018, Methylmercury Risk analysis at Muskrat Falls, Alternative model inputs and remediation scenarios

This power point presentation is a repeat some of what was already discussed in the technical memo[15]. Again, the same graphs are presented. Slide 7 notes that the soil removal option provides "some" mitigation. Calder also uses this opportunity to rebut the technical memo by Hesslein and the Azimuth Document. He also tries to negate Reed Harris' peak MeHg values as being within the 95% confidence limits.

- Using confidence limits to say that another result is “essentially “ the same (it was roughly half of his) and not use that same argument throughout his own presentations is rather lop-sided.



36, 37 NL Hydro, December 23, 2008 (2 parts), Project Area Ecological Land Classification

These are the final reports prepared by Jacques Whitford and Innu Environmental Limited Partnership for NL Hydro. Given that this report was prepared 10 years ago it serves as background and data for the further work that was undertaken in classifying the land types in the reservoir, and helping to inform soil types for organic carbon content. The report was not intended to address MeHg issues.

5, 6 Balcom, P., Sunderland, E., March 5, 2018, final report – Churchill River soil flux core experiments, October 2017

This report and supporting documentation is the write up corresponding to the presentation[4] on the soil flux experiments that was given earlier. As noted previously one of the conclusions was

3) Removing the leaf litter layer or top 5 cm of soil (organic matter) did not lower MeHg flux from flooded soils in Oct 2017. Harvard pore water experiments (Aug 2017) also showed higher pore water MeHg concentrations below 5cm.

Evaluation of the Scientific Submissions to the IEC on Monitoring

3 IEAC Sept 18, 2017, Recommendations on changes to the scope and quality of the Muskrat Falls Aquatic Monitoring Program

This 11 page paper looked at the Aquatic Environmental Effects Monitoring Progam (AEEMP) for Muskrat Falls. The authors commented that it was an exceptional program compared to similar monitoring programs in Canada. But there is always room for improvement so it made a few good recommedations such as measuring lower detection limits and making more effort to monitor MeHg in biota rather than jus surface water and sediment. All sic scientists had a hand in writing or reviewing this note.

- This paper was the basis for the IEAC's recommendation on monitoring that were presented to the Minister in September 2017
- Changes were implemented immediately by Nalcor and the WRMD.

1 Azimuth, Nov. 6, 2017, Relationship Between Muskrat Falls Reservoir Elevation and Mercury Concentrations, Lower Churchill River October 2016 – September 2017

This report prepared for Nalcor aims to determine if water column MeHg concentrations increased due to partial impoundment of water at Muskrat Falls. At the time the impoundment was 27% of the full impoundment for the final reservoir. The empirical data was obtained from surface water monitoring carried out as per the plan that was approved by the early IEAC members . The Plan had an upstream "control" station,several reservoir stations, then there were downstream and Lake Melville Stationss. The report only analyzed the data to the mouth of Churcill River at Goose Bay because the observations were even less.

Plots and statistical models indicate that dissolved MeHg was generally elevated over the summer months (June to September) in the impoundment (N4) relative to upstream (N1). Furthermore, although DMeHg has increased (naturally) at N1 since February, the slope of increase over time has been steeper at N4 than at N1. Evidence of these patterns persisting downstream of the impoundment at N5 to N7 is limited, and nonexistent at N8. We would expect that the pattern at N4 could persist downstream to some extent, but is presumably difficult to discern because the differences compared to N1 are small relative to random variation in the data.

- The data used in this report is posted on a public web site
- Since this report was written there is considerably more data available but looking at simple statistics it has not changed much.
- A further analysis of the downstream Lake Melville stations would have been useful.

4 Koch I, Dec 9 2017, Measurement Uncertainty

This is a 37 slide presentation which discusses the measurement uncertainty of the data used in the above report. It concluded that the estimated uncertainty is 38% for dissolved MeHg and 41% for total MeHg obscures the conclusions of the Azimuth[1] report.

- Unfortunately, this was effort was not expended on further actual data analysi that I had hoped would be carried out.

5 Koch I, Dec 12, 2017 TECHNICAL MEMORANDUM

A written memo to be read in conjunction with the above presentation.

2 Azimuth, Dec 20, 2017, Clarification of the Effect of Measurement Error on Analyses of Methylmercury concentrations in the Lower Churchill River/

This 4 page technical memo agreed with Koch[4,5] in terms of experimental error but pointed out that the error applies to an individual measurement and not to the mean of many measurements. That is why the sampling frequency was set at a high number. Azimuth provides a lot of statistical analysis and concludes, *"water quality sampling program for the Lower Churchill River is a powerful tool for detecting changes to water column MeHg concentrations."*

6 Koch I, Feb 8, 2018 **TECHNICAL MEMORANDUM**

Koch replies to Azimuth with 5 more pages of statistical discussion.

- Having poured over all of this my only point is look at the actual data. Does anyone see any MeHg increases or changes?

8 Stow J., Feb 28, 2018, Re: Northern Contaminants Program (NCP) Monitoring Program

This is just an email that talks about optimum sampling size in general. Basically it is a background document.

7 Macdonald C, March 2014 PERFORMANCE ASSESSMENT OF TEMPORAL TREND MONITORING DATAFOR THE NORTHERN CONTAMINANTS PROGRAM

This is a 36 page document that was provided to the IEC for background information.

Evaluation of the Scientific Submissions to the IEC on [Health Management]

Note this set of documents was provided to Darryl Johnson for information and future use.

3 Calder et al. 2016, , Future Impacts of Hydroelectric Power Development on Methylmercury Exposures of Canadian Indigenous Communities

This paper was already discussed under Mitigations. It has Health related information based on a probabilistic modelling approach.

5 Ollson C, Jan 23, 2018, Review of MeHg Biomonitoring and Prospective Risk Assessments for Muskrat Falls

This presentation is scoped as an independent scientific review of health assessments that have been completed for the Muskrat Falls project. It reviews the MeHg in hair biomonitoring carried out for Nalcor and the work done for the Calder paper. Both studies were credible and came up with very similar results. Most people were well below the Health Canada guidance values but there were a few outliers. This means that current food consumption levels are safe. Risk assessments indicate that there is a potential increase in MeHg in country foods.

6 Ollson C, Mar 1, 2018, Review of Methyl Mercury Biomonitoring Programsfor the Muskrat Falls Project

This This is the full report prepared by Dr. Ollson which was presented above[5]. The message is the same

1 Baike M, Feb 8, 2018 Muskrat Falls and Methylmercury, the Public Health Perspective

In this 55 slide presentation Dr. Baike reviewed the issue of MeHg though a public Health lens. The deck brought out many valuable points for why there should be concern for

MeHg but also that exaggeration of the issue would drive people away from eating country foods where there are many nutritional and social benefits. It was concluded that there is no need to change current consumption and harvesting patterns.

2 Baike M, Feb 8, 2018 Muskrat Falls and Methylmercury, the Public Health Perspective

This is the full report prepared by Dr. Baike which was presented above[1]. The message is the same

4 Chan LHM, Feb 15, 2018 Risk Assessment on Mercury Exposure

This 76 slide presentation offers a more world-wide perspective on the issues of MeHg , and impacts on health , derivation of guidance values and dietary intake. It did not get into any specifics with respect to Muskrat Falls and therefore this provides background information. Many slides were very pictorial and the accompanying talk probably would make some of the material more clear.

7 Weihe P, Feb 19, 2018 Mercury Health Food

Dr. Weihe was an invited speaker. He brought forward a report on MeHg from the Faroe Islands which looked at the impact of MeHg on children. Some Faroe Island residents have relatively high levels of MeHg due to a diet that includes a significant amount of whale meat. The studies found some neurological dysfunction at lower MeHg levels. This suggests a need for lower guidance values.

- A similar study in the Scheylles did not find similar effects.
- Health Canada is aware of this and many other studies. They are reviewed and if required, guidance values will be adjusted. Current Health Canada guidance values are considered protective.