IR# JRP.63

Hydrogeology

Requesting Organization – Joint Review Panel **Information Request No.: JRP.63**

Subject - Hydrogeology

References:

EIS Guidelines, Section 4.4.4.2 (Description of the Existing Environment – Aquatic

Environment) & Section 4.4.4.3 (Description of the Existing Environment – Terrestrial

Environment), Section 4.5 (Environmental Effects)

EIS Volume IA, Project Planning and Description

EIS Volume IB, Project Planning and Description

EIS Volume IIA, Biophysical Assessment

EIS Volume III, Socio-Economic Assessment

Aura Environmental Research and Consulting Ltd. 2008. *Lower Churchill Hydroelectric Generation Project: Community Health Study.* Prepared for Minaskuat Inc., Happy Valley-Goose Bay, NL

Hatch Ltd. 2008. *Sediment Plume Analysis.* Prepared for Newfoundland and Labrador Hydro, St. John's, NL

Hatch Ltd. 2008. *Salt Water Intrusion 3D Model Study*. Prepared for Newfoundland and Labrador Hydro, St. John's, NL

Hatch Ltd. 2008. *Hydraulic Modeling of River.* Prepared for Newfoundland and Labrador Hydro, St. John's, NL

Minaskuat Inc. 2008. *Water and Sediment Quality Modelling in the Lower Churchill River*. Prepared for the Lower Churchill Hydroelectric Generation Project

Northwest Hydraulic Consultants. 2008. *Sedimentation and Morphodynamics Study*. Report prepared for the Lower Churchill Hydroelectric Generation Project

Related Comments / Information Requests:

CEAR # 164 (Unidentified)
CEAR # 169 (A. Lutterman)
CEAR # 174 (V. Kerby
CEAR # 184 (Sierra Club Atlantic)
CEAR # 198 (G. Davis)
CEAR # 202 (Natural Resources Canada)
CEAR # 203 (Hydro-Québec)
CEAR # 205 (Government of Newfoundland and Labrador – Water Resources Management Division)

IRs # JRP. 20, 21, 33, 43, 66, 78, 81, 82, 107

Rationale:

The EIS does not indicate whether there will be impacts to groundwater quality or quantity resulting from Project activities. Groundwater is not included as a Valued Ecosystem Component.

Potential impacts to groundwater cannot be assessed because very little information on the existing aquifer system and groundwater is presented in the documents. Groundwater supplies drinking water in at least two communities: Mud Lake and part of Happy Valley Goose Bay. It is unclear whether there are other groundwater well users in the study area.

The Hydrogeology section of the EIS (Document 6, p.2-21) is sparse and does not provide baseline groundwater data based on several years of data.

An assessment of potential effects to groundwater must consider groundwater-surface water interactions and could be informed by a review of the groundwater-surface water relationship at the Churchill Falls generation facility if data is available. Given the predicted increase in methyl mercury concentration in the Churchill River resulting from reservoir formation (Document 1, p.43; Document 6, p.4-11), there is potential for groundwaters to become contaminated with methyl mercury. Whereas rivers and even reservoirs have relatively short residence times, groundwater often has longer residence times and may mix with deeper water, making groundwater contamination a long-term issue.

There is also inadequate information on the effect of saltwater intrusion in the lower reaches of the Churchill River on groundwater. The Salt Water Intrusion 3D Model Study (Document 6) does not make any reference to groundwater.

Without an accurate understanding of the groundwater system and groundwater-surface water interactions, the proposed dams at Gull Island and Muskrat Falls could be at risk of failure. Modelling of seepage from the reservoir to groundwater and through the dam is required together with a determination of the critical amount of seepage that would cause dam collapse. It is unclear whether groundwater will discharge into the reservoir or whether the reservoir will feed the groundwater system. It is important to document how this relationship may change

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Information Requested:

The Proponent is asked to provide:

a. **a map showing the location of all wells in the study area, including private and municipal drinking water wells, as well as monitoring wells and multi-level piezometers;**

Response:

Available information regarding the well locations in the study area, including private and municipal drinking water wells, monitoring wells and multi-level piezometers were found in various sources (AMEC 2008, BRINCO 1970, BRINCO 1971, SNC-Lavalin, 1982). Locations of the wells can be found in a series of 3 maps (Goose Bay, Gull Island and Muskrat Falls) located in Attachment A.

References:

AMEC Earth & Environmental Ltd. 2008. Commission 52 Monitoring Well Database. Prepared for Defense Construction Canada.

British Newfoundland Corporation Limited (BRINCO). 1970. Gull Island Power Project Geotechnical Report, April 1970.

British Newfoundland Corporation Limited (BRINCO). 1971. Gull Island Power Project Geotechnical Report, January 1971.

SNC-Lavalin Newfoundland Ltd. 1982. Muskrat Falls Dewatering System Engineering Assessment. March 1982.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.63**

Information Requested:

The Proponent is asked to provide:

b. well completion data, water levels and water quality data for all wells;

Response:

Information regarding well completion data and water levels were obtained from monitoring well logs found in various sources (AFN 2002, ADI 2005, AMEC 2001, AMEC 2004, AMEC 2005a, AMEC 2005b; AMEC 2006, AMEC 2007a, AMEC 2007b, AMEC 2007c, AMEC 2008a, AMEC 2008b, AMEC 2008c, AMEC 2008d, AMEC 2008e, AMEC 2008f, BRINCO 1970, BRINCO 1971, Beatty Franz and Associates 1995, CBCL 2005, Dillon 2003, Franz Environmental 2001, Franz Environmental 2006, FracFlow 2004, JWL 2006a, Lower Churchill Consultants 1974, MGI 1998, MGI 2002, MGI 2003, MGI 2005, Neill and Gunter 2006, Serco Environmental Services 2003, SNC-AGRA 1999, SNC-Lavalin 1982, SNC-Lavalin 2005).

The monitoring well logs for each area (Goose Bay, Gull Island and Muskrat Falls) that were taken from the above sources are appended to this document (Attachment B). A monitoring well database for the Goose Bay area is also appended in Attachment C (AMEC 2008a). Due to the size, Attachments B to F are provided electronically.

Available water quality data for the Goose Bay area and the Muskrat Falls area were obtained from various sources (AFN Engineering 2005, FracFlow 2004, JWL 2006b, SNC-Lavalin 2005, SNC-Lavalin 1982). Results are appended to this document (Attachment D). Water quality data for the Gull Island area are not available.

References:

ADI Limited. 2005. Phase III Site Investigation Former Landfill/Asphalt Area-Otter Creek Goose Bay, NL. Prepared for Transport Canada.

AFN Engineering. 2002. Phase I/II Environmental Site Assessment, Otter Creek Cottage Lots Happy Valley Goose Bay, NL. Prepared for Transport Canada.

AMEC Earth & Environmental Ltd. 2001. Phase I/II Environmental Site Assessment, Otter Creek Cottage Lots Happy Valley Goose Bay, NL. Prepared for Transport Canada.

AMEC Earth & Environmental Ltd. 2004. Groundwater Monitoring Well Installation, Sediment Sampling and Barrell Removal Otter Creek, Labrador. Prepared for Transport Canada.

AMEC Earth & Environmental Ltd. 2005a. Site Investigation and Detailed Qualitative Risk Assessment OTT10020: RCAF Surface Landfill 5 Wing Goose Bay, NL. Prepared for Defense Construction Canada.

AMEC Earth & Environmental Ltd. 2005b. Site Investigation and Detailed Qualitative Risk Assessment HAZ6010: Former Hazardous Material Storage Area 5 Wing Goose Bay, NL. Prepared for Defense Construction Canada.

AMEC Earth & Environmental Ltd. 2006. Supplemental Site Investigation for Delineation at the Survival Tank Farm 5 Wing Goose Bay, NL. Prepared for Defense Construction Canada.

AMEC Earth & Environmental Ltd. 2007a. Commission 81.7. Environmental Site Investigation Tanks 1511 and 1516 at the Lower Tank Farm, 5 Wing Goose Bay, NL. Prepared for Defense Construction Canada.

AMEC Earth & Environmental Ltd. 2007b. Environmental Site Investigation Tank 83, 5 Wing Goose Bay, NL. Prepared for Defense Construction Canada.

AMEC Earth & Environmental Ltd. 2007c. AvGas Plume recovery Status Update, October 2006 to March 2007, Upper Tank Farm. Prepared for Defense Construction Canada.

AMEC Earth & Environmental Ltd. 2008a. Commission 52 Monitoring Well Database. Prepared for Defense Construction Canada.

AMEC Earth & Environmental Ltd. 2008b. Groundwater Monitoring Program Northside Property, Goose Bay, NL. Prepared for PWGSC.

AMEC Earth & Environmental Ltd. 2008c. Commission 88.1 Environmental Site Investigation B371 CHPP Tanks, 5 Wing Goose Bay, NL. Prepared for Defense Construction Canada.

AMEC Earth & Environmental Ltd. 2008d. Commission 88.5 Environmental Site Investigation BAS14060: Hangar#5 Area, 5 Wing Goose Bay, NL. Prepared for Defense Construction Canada.

AMEC Earth & Environmental Ltd. 2008e. Commission 89.1 Site Investigation Former Ordnance Storage and Hazardous Material Storage Area, 5 Wing Goose Bay, NL. Prepared for Defense Construction Canada.

AMEC Earth & Environmental Ltd. 2008f. Commission 90.1 Site Investigation Airside Region of Canadian Side, 5 Wing Goose Bay, NL. Prepared for Defense Construction Canada.

Beatty Franz and Associates. 1995. Sediment and Surface Water Remediation at Spring Gulch Wetlands. Prepared for Department of National Defense.

British Newfoundland Corporation Limited (BRINCO). 1970. Gull Island Power Project Geotechnical Report, April 1970.

British Newfoundland Corporation Limited (BRINCO). 1971. Gull Island Power Project Geotechnical Report, January 1971.

CBCL Limited. 2005. Site Investigation and Detailed Qualitative Risk Assessment at the Man Gate and Pipeline Areas. Prepared for Defense Construction Canada.

Dillon Consulting Limited. 2003. Groundwater Monitoring 2003 Tanks 1539 and 1540/41 Lower Tank Farm. Prepared for Defense Construction Canada.

FracFlow. 2004. Well Field Remediation and Wellhead Protection Project (Phase 2 and 3 Activities) Town of Happy Valley Goose Bay. Prepared for the Town of Happy-Valley Goose Bay.

Franz Environmental Inc. 2001. Environmental Baseline Study, Lower and Survival Tank Farms, Final Report. Prepared for Defense Construction Canada.

Franz Environmental Inc. 2006. Hydrogeological Study of the South Escarpment Area, 5 Wing Goose Bay. Prepared for Defense Construction Canada.

Jacques Whitford Limited (JWL). 2006a. Phase III/IV Environmental Site Assessment and Site Specific Risk Assessment Northside Property, Goose Bay, NL. Prepared for Transport Canada.

Jacques Whitford Limited (JWL). 2006b. Periodic Groundwater Sampling Program Final Report December 2004 Monitoring Event Trans Labrador Highway 5 Wing Goose Bay, NL. Prepared for Transport Canada.

Lower Churchill Consultants. 1974. Geotechnical Site Information 1974 Field Investigation Volume 1- Report

MGI Limited. 1998. Environmental Site Assessment Woodward's Oil Leased Property. Uplands Property, Happy Valley Goose Bay, NL. Prepared for Transport Canada.

MGI Limited. 2002. Environmental Investigation Hangar 5, 5 Wing Goose Bay. Prepared for Defense Construction Canada.

MGI Limited. 2003. Phase I/II Environmental Site Assessment Parcel VII, Happy Valley-Goose Bay, NL . Prepared for Defense Construction Canada.

MGI Limited. 2005. Field Study and Preliminary Qualitative Risk Assessment, BOD Range, 5 Wing Goose Bay, NL. Prepared for Defense Construction Canada.

Neill and Gunter Ltd. 2006. Field Survey and Preliminary Qualitative Risk Assessment 5 Wing Goose Bay, NL. Prepared for Defense Construction Canada.

Serco Environmental Services. 2003. Site Investigation for Follow up Baseline study of Lower, Survival and Upper Tank Farms & Associated pipelines. Prepared for Defense Construction Canada.

SNC-AGRA Earth & Environmental Ltd. 1999. Muskrat Falls Hydroelectric Development, Final Feasibility Study, Volume 1 – Engineering Report, January 27, 1999.

SNC-Lavalin Newfoundland Ltd. 1982. Muskrat Falls Dewatering System Engineering Assessment. March 1982.

SNC-Lavalin. 2005. Field Study and Preliminary Qualitative Risk Assessment at the Former Dome Mountain Asphalt Plant. Prepared for Defense Construction Canada. http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/sum_guide-res_recom/chemical-chimiques-eng.php.

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Information Requested:

The Proponent is asked to provide:

c. available information on groundwater quality and levels in this area, since the EIS mentions that drinking water for the Main Accommodation Complex will be obtained from groundwater wells (Document 2, p.4-37);

Response:

In 1975, four boreholes and seven test wells were drilled in the Gull Island campsite area. (Lower Churchill Consultants 1975). Several of these boreholes and wells were drilled specifically to locate suitable water sources in the campsite area. Field permeability tests were also performed to determine the permeability of various strata and to locate a possible aquifer to serve as a source of water supply for the campsite. During the field investigations in 1975, water samples were collected from two of the wells, one located on the campsite terrace and one along the river shoreline. The samples were submitted to (what was at that time) the Newfoundland and Labrador Department of Public Health for chemical and bacteriological analyses. Results from bacteriological analysis indicated the water was drinkable but required chlorination in the wells (Nalcor Energy (Nalcor) was unable to locate these original test results). One of these wells was used to provide a water supply to a temporary camp during the 1975 field investigations. Water levels observed during the field investigations are summarized in Table 1.

Table 1 Observed Water Levels During the 1975 Field Program (Lower Churchill Consultants, 1975)

Test Well/ Borehole	Location	Summarized Water Table Observations
TW-1 TW-2	Campsite Terrace	Small amount of water encountered at bedrock levels. (approximate depths between 90 - 110 feet).
TW-3 TW-4	Shoreline	Drilling abandoned due to drilling problems.
TW-5	Shoreline	Aquifer encountered between depths 110 - 125 feet. Piezometric head 2 feet above ground surface.
TW-6	Shoreline	Aquifer encountered between depths 50 - 65 feet. Piezometric head 2 feet above ground surface.
TW-7	Campsite Terrace	No water table encountered.
CS-1 CS-2	Campsite Terrace	Perched water table encountered between depths 5 - 20 feet. True water table level observed between depths 80 - 160 feet.
CS-3 CS-4	Shoreline	Water table level was observed to be at ground level, and in some cases piezometric head was noted to be approximately 2 feet above ground surface.

Reference:

Lower Churchill Consultants. 1975. Gull Island Hydro-electric Project, Engineering Status, December 1975, Report #5, Field Investigations, Volume II.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.63**

Information Requested:

The Proponent is asked to provide:

d. **information on the system of pumped groundwater wells (the spur) connecting the Muskrat Falls rock knoll to the north bank of the Churchill River is needed (Document 2, p.4-51). The number and location of existing wells, the historical pumping rates, well completion data, and water levels are requested. Any planned changes to the existing spur should be outlined in detail. For example, will new wells be drilled or will pumping rates change;**

Response:

There are 22 wells in the Muskrat Falls pumpwell system. The wells were installed in 1981 at a spacing of 30 m, in a line running along the top of the spur. Each well is equipped with water level sensors and a pump for lowering groundwater levels in the spur. Well completion data is included in Attachment B. A map showing the locations of these wells is provided in Attachment A.

Along the pumpwell system alignment, the water level was originally at about elevation 30 m, at the south end of the spur, rising to elevation 47 m about midway and dropping to about 25 m at the north end. The pumpwell system was anticipated to lower the groundwater level in the spur to elevation 15 m or below. To monitor the groundwater elevations, 17 vibrating wire piezometers were also installed in 1981. In 1984 a lightning strike destroyed these piezometers. In 1997, 12 standpipe piezometers were installed in seven boreholes at various locations along the spur. These piezometers are manually monitored on a regular basis. In recent months, eight additional standpipe piezometers have been installed in five boreholes to supplement the existing system.

There are 19 pumps currently in operation. Most pumps have a maximum capacity of 15 gallons per minute (57 litres per minute) and will cut in and out depending on the groundwater level. There are some lower capacity pumps installed in lower yield wells. Additionally, pumping rates can be adjusted to prevent frequent starting and stopping. Total outflow rates of the pumpwell system are not currently measured on a regular basis; however, during a November 2007 field visit the outflow from the system was measured at approximately 23 litres per minute.

The installation of additional wells is under consideration and will be determined as a result of a recently completed (September, 2009) condition assessment of the well system. Long term stabilization measures will be determined in the detailed design phase of the Project, but will likely include the installation of additional wells and relief drains to lower the groundwater table in the spur, a rockfill berm on the upstream slope, and a rockfill berm and slope trimming/unloading on the downstream slope.

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Information Requested:

The Proponent is asked to provide:

e. **a description of the local groundwater system in as much detail as dictated by available data. Any previous hydrogeological studies conducted in the region should be presented;**

Response:

In order to understand the local groundwater system in the Happy Valley-Goose Bay, Gull Island and Muskrat Falls areas, a literature review was undertaken. Groundwater system descriptions for each of these areas are described below.

Happy Valley-Goose Bay

A description of groundwater underlying the Happy Valley-Goose Bay area is provided in JWL (2008). This report states that "Goose Bay and surrounding areas is underlain by an unconfined aquifer system contained within the overburden material and underlying shallow bedrock. The movement of groundwater through the overburden material is controlled by primary porosity, while groundwater flow within the underlying bedrock can be expected to mainly occur within secondary openings, such as fractures and joints, and will be variable depending on the frequency and interconnection of these structural features.

Shallow groundwater flow is controlled by water table conditions and local variations in topography. Groundwater is thought to be recharging along areas of high ground and discharging along various wet lowland areas, ponds, lakes and rivers, as well as the coastal inlets of Lake Melville and Double Mer. It is expected that the shallow groundwater system will be largely controlled by surface runoff and local recharge, while at moderate depths the flow system may be influenced by lateral inflow of groundwater from surrounding up-gradient areas. Based on a review of water well records for the area, groundwater levels are generally assumed to be within 11 m of the ground surface and to be a subdued reflection of topography."

Several hydrologic divides exist across the overall area. These separate the three main watersheds (Churchill River, Goose River and Terrington Basin/Lake Melville) that exist in the region. Surface and groundwater flow from the north and northwest portion of the 5 Wing Goose Bay Base (Base) would be toward the Goose River, from the northeast toward Terrington Basin and from the south to the Churchill River (AMEC 2008b).

Happy Valley-Goose Bay Well Field Area

The town of Happy Valley-Goose Bay partially derives its drinking water from a well field which consists of 5 wells that are located approximately 6.5 km west of the town. A report prepared by FracFlow (2004) describes the groundwater underlying the area. The report states that "In the area of Happy Valley-Goose Bay well field, the water table is near-surface, being controlled by its location in an area of local to regional groundwater discharge and its proximity to the Churchill River. Northeast of the well field, at the Base, the water table is controlled by the local topography. At the Upper Tank Farm, which is situated more than 30 m above the elevation of Spring Gulch Wetlands, the water table is located about 26 m below ground surface. The elevation of the water table around the well field will fluctuate seasonally and, given the climate and geology, it is expected that fluctuations of 1 to 2 m may be expected.

Low hydraulic gradients, moderate-to-high permeability and moderate porosity are assumed to be typical of surficial material in the area and groundwater velocities will likely be in the range of 0.03 to 0.3 m/day (assumes average gradient of 0.01, porosity of 30 percent).

In the well field area, thin layers of clayey silt are present in the river bank and visible in part of the river bed. The presence of these thin clayey silt layers beneath part of the river bed is of consequence in that they will delay and limit the infiltration of river water into the aquifer as groundwater is being produced at the well field, unless there are 'windows' or holes through clayey silt layers or the thin layers are discontinuous.

The natural water table at the Happy-Valley Goose Bay well field area occurs at a depth of 3 to 5 m below ground surface. The hydraulic heads in the aquifer at 40 m depth are approximately 1.5 m above the river level, which may suggest a lower permeability within the top 40 m of the aquifer system. Both the water table elevation and the increasing hydraulic heads are a result of the proximity of the well field to the Churchill River and its location in an area of local and possibly regional groundwater discharge."

5 Wing Goose Bay Base

AMEC (2008c) describes the groundwater underlying the Base. This report states that "Groundwater beneath 5 Wing Goose Bay Base flows south to southeast towards the Churchill River and northeast to east towards the Goose River from a groundwater divide. The divide is positioned approximately diagonally across the Base. The water table ranges from approximately 10 to 30 mbgs across the terrace and is typically less than 5 mbgs along the low lying lands surrounding the terrace. Annual water table fluctuations beneath the terrace are on the order of 2 m to 3 m. The hydraulic conductivity (K) of the water table aquifer ranges from 2 x 10^{-5} cm/s to 3 x 10^{2} cm/s with a geometric mean of 5 x 10^{-3} cm/sec. The effective porosity reportedly ranges from 0.15 to 0.25. The average groundwater seepage velocity across the terrace is estimated at 75 m/year but is higher near embankments ranging from 100 m/year to 200 m/year."

Gull Island

The following is a summary of the local groundwater system in the area of Gull Island as described in BRINCO (1970) and BRINCO (1971).

In the Gull Island area, there are at least three groundwater tables: a perched water table in the estuarine deposits, an intermediate groundwater water level in the glacial tills, and another in the underlying sands and gravels which have been found to be under some artesian pressure.

The pervious deposits beneath the glacial tills in the deep part of the bedrock valley under the south bank contain groundwater. Analysis of piezometric measurements in this layer indicate that the groundwater flows from the sides of the bedrock valley towards the river and downstream and the pervious strata have direct connection with the river. Piezometer readings in boreholes near the river's edge showed that the groundwater level was approximately at river level.

During the 1969 geotechnical field investigation program for the Gull Island Power Project several water bearing strata were encountered in drilling, in particular in the upper recent sand and silt deposits and the lower sand and gravel deposits. Groundwater was also encountered in local pervious portions or layers within the ablation till stratum. Groundwater levels were observed during drilling and were also measured after completion of some of the holes in the open drill casing or in piezometers.

The upper terrace deposits and local pervious layers in the ablation till are water bearing, but seepage flows would be limited due to the overall semi pervious nature of the deposit. The groundwater level is very nearly coincident with the ground surface; the flow gradient therefore reflects the surface topography, and flow is towards the river. Along the river's edge, groundwater levels fluctuate with the river itself. Recharge to this deposit is from surface infiltration and precipitation and directly from the river.

The lower sand and gravel constitutes a major water bearing deposit. The groundwater flow is towards the river and also in a general downstream direction reflecting river gradient. Very slight artesian heads in the order of one to two feet were observed during drilling along the river's edge. Groundwater levels near the river were noted to fluctuate with the seasonal variations in river level. Recharge to these deposits is primarily from the bedrock and from the river.

Simple falling head water tests, carried out in a few drill holes, indicated that the permeabilities of the estuarine deposits vary from about 10^{-3} cm/sec to 10^{-5} cm/sec with the majority of test results in the 10^{-4} cm/sec to 10^{-5} cm/sec range.

Muskrat Falls

The following is a summary of the local groundwater system in the area of Muskrat Falls as described in SNC-Lavalin (1982), SNC-AGRA (1999) and Hatch (2008). Hydrogeologically, in the Muskrat Falls area, there are two aquifers (upper aquifer and lower aquifer). The water level in the lower aquifer is at elevation (el) +5 m which is considerably higher than the surface of the overlying marine clay unit suggesting confined conditions. Recharge into the upper aquifer is from the northwest, through the upper sand unit and hydraulic connections in the stratified drift.

Geological investigations were carried out during the summer and autumn 1979 in order to study the properties and behaviors of the lower aquifer located in the lower sand unit in the Muskrat Falls area. Groundwater levels in the lower aquifer indicate that the general groundwater flow over the spur is from northwest to southeast. The hydraulic properties determined by means of pumping tests indicated a transmissivity of 7×10^{-3} m/s and a storage coefficient of 3×10^{-3}. The mean hydraulic conductivity permeability of 1.6×10^{-4} m/s was determined from an average aquifer thickness in the order of 44 m. The pump test confirmed that no connection exists between the river and the lower aquifer. The groundwater outflow of the aquifer was estimated to be at 10.5 l/s by means of a water budget and seepage evaluations. A downward gradient was observed in the marine clay unit during the 1979 pumping tests of the lower aquifer.

A series of wells were installed in 1981 for slope stability measures at Muskrat Falls. During a 1996 recovery test, the wells were divided into 3 major zones: Southern (W1 to W-7), Central (W-8 to W-17), and Northern (W-18 to W-22). The major observations of the recovery test were stated as:

- The downstream side contains more pervious sediments than the northern side.
- The recharge feeding the aquifer contained in the unit is mostly from the upland on the left bank and the groundwater flow is from the northwest. Infiltration occurs in the upper sand unit or cap, and through discontinuities or hydraulic windows in the upper low permeability clay member into the lower and more pervious sand layers hosting the aquifer. The clay furnishes a confining effect, but the sand layers are interconnected to the degree which permits groundwater flow through the interconnections.

- In addition to the recharge from the northwest, the Churchill River upstream at el 18 m has an influence on the spur and the groundwater in the rock knoll to a minor degree. The natural groundwater level before pumping was at el 30 m on the south side of the dewatering system and rises to el 47 m near W-13 and decreases to el 25 m on the north towards the existing stream. The piezometric water level at specific points in the formation, approximately along the lines of the wells, is generally between el 20 and 30 m.
- Bulk hydraulic conductivity (m/s):
  - W1 to W7: $1x10^{-5}$
  - W-8 to W-17: $1x10^{-7}$ to $1x10^{-8}$
  - W18 to W-22: $1x10^{-8}$

References:

AMEC Earth & Environmental Ltd. 2008b. Groundwater Monitoring Program Northside Property, Goose Bay, NL. Prepared for PWGSC.

AMEC Earth & Environmental Ltd. 2008c. Commission 88.1 Environmental Site Investigation B371 CHPP Tanks, 5 Wing Goose Bay, NL. Prepared for Defense Construction Canada.

British Newfoundland Corporation Limited (BRINCO). 1970. Gull Island Power Project Geotechnical Report, April 1970.

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FracFlow. 2004. Well Field Remediation and Wellhead Protection Project (Phase 2 and 3 Activities) Town of Happy Valley Goose Bay. Prepared for the Town of Happy-Valley Goose Bay.

Hatch. 2008. The Lower Churchill Project MF1260-Assessment of Existing Pumpwell System Final Report. Prepared for Newfoundland and Labrador Hydro.

Jacques Whitford Limited (JWL). 2008. Hydrogeology of Agricultural Development Areas in Newfoundland and Labrador. Prepared for Government of Newfoundland and Labrador, Department of Environment and Conservation, Water Resources Division.

SNC-AGRA Earth & Environmental Ltd. 1999. Muskrat Falls Hydroelectric Development, Final Feasibility Study, Volume 1 – Engineering Report, January 27, 1999.

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Information Requested:

The Proponent is asked to provide:

f. **any hydrogeological data collected on-site by the Proponent;**

Response:

Hydrogeological data collected on-site by Nalcor is in the form of test pit and borehole investigations. These data are provided in Table 2 below.

Table 2 Hydrogeological Data Collected On-Site

Test Pit ID	Northing	Easting	Water Depth During Drilling (m)	Water Depth After (m)
B10-1-74	n/a	n/a	n/a	18.3
B10-2-74	n/a	n/a	n/a	7.5
B10-3-74	n/a	n/a	n/a	6.8
B10-TP-002-07	5877238	613940	n/a	2.0
B10-TP-010-07	5871093	604151	n/a	2.2
B10-TP-011-07	5871041	604118	n/a	3.0
B10-TP-013-07	5870866	604000	n/a	0.8
B10-TP-035-07	5870706	604383	n/a	2.7
B10-TP-036-07	5870759	604343	n/a	1.1
B10-TP-1017-74	5716	7739	n/a	126.2
B10-TP-1023-74	7214	7624	n/a	225.4
B10-TP-1033-74	5372	7335	n/a	108.2
B10-TP-1038-74	6019	6344	n/a	116.1
B11-1-75	n/a	n/a	n/a	2.0
B2-1-74	n/a	n/a	n/a	4.1
B2-TP-17-69	n/a	n/a	n/a	3.1
B3-TR-301-74	n/a	n/a	n/a	2.7
B3-TR-311-74	n/a	n/a	n/a	2.7
B3-TR-322-74	n/a	n/a	n/a	1.8
B4-1-75	5983.9	2518	n/a	7.3
B5-TP-008-07	5871485	606814	n/a	2.5
B5-TP-010-07	5871503	606885	n/a	4.2
B5-TP-012-07	5871431	607016	n/a	3.3
B5-TP-015-07	5871396	607103	n/a	1.5
B5-TP-018-07	5871501	606914	n/a	2.4
B5-TP-021-07	5870970	605671	n/a	3.0
B5-TP-063-07	5871813	607578	n/a	1.0
B5-TP-064-07	5871633	607165	n/a	3.7
B5-TP-071-07	5872244	606923	n/a	1.9
B5-TP-073-07	5872182	607403	n/a	3.0
B5-TP-074-07	5872291	607656	n/a	1.4
B5-TP-078-07	5871379	606233	n/a	0.6
B5-TP-083-07	5871178	607080	n/a	4.0
B5-TP-084-07	5870989	606971	n/a	2.0

Test Pit ID	Northing	Easting	Water Depth During Drilling (m)	Water Depth After (m)
B5-TP-085-07	5871402	606840	n/a	2.5
B5-TP-087-07	5870992	606714	n/a	1.6
B5-TP-088-07	5871910	607115	n/a	4.3
B5-TP-089-07	5871758	607304	n/a	1.6
B6B-TP-003-07	5876305	608486	n/a	1.7
B6B-TP-012-07	5876143	608409	n/a	1.1
B6-TP-022-07	5877716	613651	n/a	1.0
B6-TP-023-07	5877661	613676	n/a	2.7
B6-TP-024-07	5877619	613670	n/a	1.2
B6-TP-025-07	5877618	613652	n/a	1.8
B6-TP-030-07	5877669	613596	n/a	2.2
B6-TP-037-07	5877854	613573	n/a	1.1
B6-TP-041-07	5877888	613615	n/a	2.2
B6-TP-042-07	5877965	613550	n/a	1.6
B6-TP-043-07	5877985	613486	n/a	3.8
B6-TP-046-07	5877968	613569	n/a	2.5
B6-TP-047-07	5877906	613659	n/a	3.2
B6-TP-048-07	5877843	613737	n/a	2.2
B6-TP-050-07	5877931	613723	n/a	1.7
B6-TP-052-07	5877822	613379	n/a	1.1
B6-TP-053-07	5877855	613314	n/a	3.8
B6-TP-069-07	5878421	612806	n/a	4.5
B6-TP-077-07	5877980	613120	n/a	2.7
B9-TP-003-07	5870385	602922	n/a	2.0
GSY-TP-005-07	5871305	607883	2.5	n/a
GSY-TP-006-07	5871203	607954	4.75	n/a
GSY-TP-011-07	5871208	607714	2.5	n/a
GSY-TP-013-07	5871262	607503	4.75	n/a
GSY-TP-014-07	5871122	607632	2.8	n/a
TLGS-TP-020-07	5871028	607670	4.25	n/a
TLGS-TP-021-07	5871449	608086	1.8	n/a

n/a – not available

Requesting Organization – Joint Review Panel **Information Request No.: JRP.63**

Information Requested:

The Proponent is asked to provide:

g. **background hydrogeological information which could include the extent of aquifers, aquifer thickness, estimates of porosity and hydraulic conductivity, groundwater flow rates and directions, groundwater levels, and groundwater quality data. Information from several years or decades provides the most reliable estimation of baseline conditions;**

Response:

Happy Valley-Goose Bay

FracFlow (2004) describes the groundwater underlying the Happy Valley-Goose Bay well field area. The report states that "In the area of Happy Valley-Goose Bay well field, the water table is near-surface, being controlled by its location in an area of local to regional groundwater discharge and its proximity to the Churchill River. Northeast of the well field, at 5 Wing Goose Bay (5 Wing), the water table is controlled by the local topography. At the Upper Tank Farm, which is situated more than 30 m above the elevation of Spring Gulch Wetlands, the water table is located about 26 m below ground surface. The elevation of the water table around the well field will fluctuate seasonally and, given the climate and geology, it is expected that fluctuations of 1 to 2 m may be expected.

Low hydraulic gradients, moderate-to-high permeability and moderate porosity are assumed to be typical of surficial material in the area and groundwater velocities will likely be in the range of 0.03 to 0.3 m/day (assumes average gradient of 0.01, porosity of 30 percent).

In the well field area, thin layers of clayey silt are present in the river bank and visible in part of the river bed. The presence of these thin clayey silt layers beneath part of the river bed is of consequence in that they will delay and limit the infiltration of river water into the aquifer as groundwater is being produced at the well field, unless there are 'windows' or holes through clayey silt layers or the thin layers are discontinuous.

The natural water table at the Happy-Valley Goose Bay well field area occurs at a depth of 3 to 5 m below ground surface. The hydraulic heads in the aquifer at 40 m depth are approximately 1.5 m above the river level, which may suggest a lower permeability within the top 40 m of the aquifer system. Both the water table elevation and the increasing hydraulic heads are a result of the proximity of the well field to the Churchill River and its location in an area of local and possibly regional groundwater discharge."

AMEC (2008c) describes the groundwater underlying the Base. This report states that "Groundwater beneath 5 Wing Goose Bay Base flows south to southeast towards the Churchill River and northeast to east towards the Goose River from a groundwater divide. The divide is positioned approximately diagonally across the Base. The water table ranges from approximately 10 to 30 mbgs across the terrace and is typically less than 5 mbgs along the low lying lands surrounding the terrace. Annual water table fluctuations beneath the terrace are on the order of 2 m to 3 m. The hydraulic conductivity (K) of the water table aquifer ranges from 2×10^{-5} cm/s to 3×10^{-2} cm/s with a geometric mean of 5×10^{-3} cm/sec. The effective porosity reportedly ranges from 0.15 to 0.25. The average groundwater seepage velocity across the terrace is estimated at 75 m/year but is higher near embankments ranging from 9100 m/year to 200 m/year."

Gull Island

The following is a summary of background hydrogeological information in the area of Gull Island as described in BRINCO (1970), BRINCO (1971) and Lower Churchill Consultants (1974).

During the period of March to October 1969, an extensive field program was carried out to obtain detailed information on the stratigraphy and engineering properties of the overburden and bedrock at Gull Island. A total of 57 holes were drilled to a minimum of 15 m into bedrock. Groundwater levels were observed in all drill holes, and open casings or piezometers were left in selected holes to observe the fluctuations of groundwater in the various strata.

Several water bearing strata were encountered in drilling, in particular in the upper and recent sand and silt deposits and the lower sand and gravel deposits. Groundwater was also encountered in local pervious portions or layers within the ablation till stratum. Piezometric observations made after drilling are summarized in Table 3.

Table 3 Piezometric Observations During Drilling (BRINCO, 1970)

Hole No.	Stratum	Piezometric Water Level (El –ft)							
		May23	June8	July17	July21	July27	Aug17	Aug 31	Sept1
A-1	Sand and Gravel	139.5				142.7	141.1	140.1	
A-3	Sand and Gravel	135.3	140.9		143.5	139.7	137.8	138.4	
A-7	Sand and Gravel	138.1				141.4	138.4	139	
A-9	Sand	138.6	143.5		145.3	144.8	143.3	143.4	
A-10	Sand and Gravel	139.5				145.2	143.3	141.9	
A-11	Sand and Gravel	160.9	163.3		167.4	167	166.5	166.4	
A-13	Ablation Till		396.7					400.1	
A-14	Ablation Till		373.7		369	369.5	369.6	368.5	
A-17	Ablation Till		217.4		215.4	215.4	215.7	215.8	
A-17	Sand				136.1	135.8	137.5	136.8	
A-19	Ablation Till				129.4		124.5	126.2	
A-20	Basal Till					142.8	140.1	140.2	
A-21	Ablation Till				216.6				
A-21	Basal Till				180.4	179.9	178.2	179.2	
A-22	Basal Till				193.1	192.1	190.8	191	
A-23	Sand and Silt						149.4	148.4	
B-13	Ablation Till					187.2	188.4		188.5
B-16	Ablation Till			302.5		303.6	303.9		303.3
B-18	Sand and Silt			284.8		284.9	285		285.4
B-20	Ablation Till			274.9		278.2	278.3		276.2
B-22	Ablation Till			252.4		255.5	255.6		256
B-23	Ablation Till			235.3		232.9	233.4		232.2
B-24	Ablation Till			156.6		155.4	153.7		153.2

On the basis of these limited observations it has been concluded that:

- The upper terrace deposits and local pervious layers in the ablation till are water bearing, but seepage flows would be limited due to the overall semi pervious nature of the deposit. The groundwater level is very nearly coincident with the ground surface; the flow gradient therefore reflects the surface topography, and flow is towards the river. Along the river's edge, groundwater levels fluctuate with the river itself. Recharge to this deposit is from surface infiltration and precipitation and directly from the river.

- The lower sand and gravel constitutes a major water bearing deposit. The groundwater flow is towards the river and also in a general downstream direction reflecting river gradient. Very slight artesian heads in the order of one to two feet were observed during drilling along the rivers edge. Groundwater levels near the river were noted to fluctuate with the seasonal variations in river level. Recharge to these deposits is primarily from the bedrock and from the river.

Simple falling head water tests, carried out in a few drill holes, indicate that the permeabilities of the estuarine deposits vary from about 10^{-3} cm/sec to 10^{-5} cm/sec with the majority of test results in the 10^{-4} cm/sec to 10^{-5} cm/sec range.

A 1974 field program involved the drilling of 35 holes (Lower Churchill Consultants 1974). Table 4 summarizes the hydraulic conductivity of each of the surficial materials encountered.

Table 4 Hydraulic Conductivity (Lower Churchill Consultants, 1974)

Material	Thickness Range (m)	K (cm/s)
Recent Alluvium	0.6 - 11	$1x10^{-2}$
		$2 - 9x10^{-3}$
		$4x10^{-4}x10^{-3}$
		$6x10^{-5}$
Terrace Deposits (Sand-Silt)	0.9 – 12.8	$1x10^{-2}$
		1 to $3x10^{-3}$
		2 to $8x10^{-4}$
		$3x10^{-5}$
Terrace Deposits (Clay-Silt)	0.2 – 6.7	$3x10^{-5}$
Till	0.9 - 21	2 to $7x10^{-3}$
		1 to 6 x 10^{-4}
		2 to $7x10^{-5}$
Probable Till (River)	2.1 – 12.8	1 to $7x10^{-3}$
		1 to $3x10^{-4}$
Lower Alluvium	3.0 - 38	1 to $4x10^{-2}$
		1 to $6x10^{-3}$
		1 to $6x10^{-4}$
		3 to $9x10^{-5}$

Muskrat Falls

The following is a summary of the local groundwater system in the area of Muskrat Falls as described in SNC-Lavalin (1982) and SNC-AGRA (1999).

Geological investigations were carried out during the summer and autumn 1979 in order to study the properties and behaviors of the lower aquifer located in the lower sand unit. Results indicated that the water level was at el +5 m within the spur of the land. The hydraulic properties determined by means of pumping tests indicated a transmissivity of 7 x 10^{-3} m/s and a storage coefficient of 3 x 10^{-3}. The mean hydraulic conductivity permeability of 1.6 x 10^{-4} m/s was determined from an average aquifer thickness in the order of 44 m. The general groundwater flow over the spur is from northwest to southeast. The groundwater outflow of the aquifer was estimated to be at 10.5 l/s by means of a water budget and seepage evaluations.

The results obtained from the analysis of the pumping test data are presented in Table 5.

Table 5 Muskrat Falls Pumping Test Data (SNC-Lavalin 1982)

Pumping Test Well No.	Observation Well or Piezometer No.	Pumping Test Transmissivity (T, m^2/day)	Recovery Test Transmissivity (T, m^2/day)	Storage Coefficient (S)	Ratio (S/S')
W-3	W-2	21.96	21.37	1.4×10^{-4}	5.4
	W-3	19.80	23.26	-	-
	W-4	26.00	29.1	4.0×10^{-4}	5
	W-5	16.07	22.7	2.1×10^{-4}	1.4
	W-6	32.09	23.3	2.6×10^{-4}	2.4
	P-3	33.50	41.2	6.7×10^{-4}	-
	P-4	24.70	18.8	7.3×10^{-4}	1.75
	P-5	20.40	17.0	1.6×10^{-4}	1.30
	P-15	26.00	24.7	1.8×10^{-4}	1.0
	P-16	38.00	54.9	9.6×10^{-4}	-
	P-17	39.50	61.8	9.2×10^{-4}	-
W-10	W-9	0.54	0.21	5.5×10^{-4}	-
	W-10	0.35	0.10	-	-
W-17	W-17	0.075	0.030	-	-
	W-17A	-	-	-	-

References:

AMEC Earth & Environmental Ltd. 2008c. Commission 88.1 Environmental Site Investigation B371 CHPP Tanks, 5 Wing Goose Bay, NL. Prepared for Defense Construction Canada.

FracFlow. 2004. Well Field Remediation and Wellhead Protection Project (Phase 2 and 3 Activities) Town of Happy Valley Goose Bay. Prepared for the Town of Happy-Valley Goose Bay.

Lower Churchill Consultants. 1974. Geotechnical Site Information 1974 Field Investigation Volume 1- Report

SNC-AGRA Earth & Environmental Ltd. 1999. Muskrat Falls Hydroelectric Development, Final Feasibility Study, Volume 1 – Engineering Report, January 27, 1999.

SNC-Lavalin Newfoundland Ltd. 1982. Muskrat Falls Dewatering System Engineering Assessment. March 1982.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.63**

Information Requested:

The Proponent is asked to provide:

h. **a map indicating directions of groundwater flow and flow velocity. Aquifer recharge and discharge zones should be indicated on the map;**

Response:

Groundwater elevation contour maps indicating directions of groundwater flow were obtained for the areas of Goose Bay and Muskrat Falls. Maps are appended to this document (Attachment E). Information regarding groundwater flow for Gull Island was not located as part of the search for available information. This information is assumed not to exist.

Goose Bay

Regionally, several hydrologic divides exist across the overall area (Base and Town). These separate the three main watersheds (Churchill River, Goose River and Terrington Basin/Lake Melville). Surface and groundwater flow from the north and northwest portion of the Base would be toward the Goose River, from the northeast toward Terrington Basin and from the south to the Churchill River (AMEC 2008a-f).

Groundwater is thought to be recharging along areas of high ground and discharging along various wet lowland areas, ponds, lakes and rivers, as well as the coastal inlets of Lake Melville and Double Mer. Recharge to the shallow groundwater system is by direct infiltration of rainfall, after runoff and the requirements of evaporation and plant transpiration have been met, and is directly related to rainfall, infiltration characteristics and size of recharge zone.

Low hydraulic gradients, moderate-to-high permeability and moderate porosity are assumed to be typical of surficial material in the area and groundwater velocities will likely be in the range of 0.03 to 0.3 m/day (assumes average gradient of 0.01, porosity of 30 percent).

Muskrat Falls

The general groundwater flow over the spur is from northwest to southeast (SNC-Lavalin 1982). Recharge into the upper aquifer is from the northwest, through the upper sand unit and hydraulic connections in the stratified drift.

References:

AMEC Earth & Environmental Ltd. 2008a. Commission 52 Monitoring Well Database. Prepared for Defense Construction Canada.

AMEC Earth & Environmental Ltd. 2008b. Groundwater Monitoring Program Northside Property, Goose Bay, NL. Prepared for PWGSC.

AMEC Earth & Environmental Ltd. 2008c. Commission 88.1 Environmental Site Investigation B371 CHPP Tanks, 5 Wing Goose Bay, NL. Prepared for Defense Construction Canada.

AMEC Earth & Environmental Ltd. 2008d. Commission 88.5 Environmental Site Investigation BAS14060: Hangar#5 Area, 5 Wing Goose Bay, NL. Prepared for Defense Construction Canada.

AMEC Earth & Environmental Ltd. 2008e. Commission 89.1 Site Investigation Former Ordnance Storage and Hazardous Material Storage Area, 5 Wing Goose Bay, NL. Prepared for Defense Construction Canada.

AMEC Earth & Environmental Ltd. 2008f. Commission 90.1 Site Investigation Airside Region of Canadian Side, 5 Wing Goose Bay, NL. Prepared for Defense Construction Canada.

SNC-Lavalin Newfoundland Ltd. 1982. Muskrat Falls Dewatering System Engineering Assessment. March 1982.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.63**

Information Requested:

The Proponent is asked to provide:

i. **information indicating how groundwater levels, flow directions and velocity, and chemistry change throughout the year given that this is a geographical area of seasonal extremes (Document 1, p.9);**

Response:

For the most part, information indicating how groundwater levels, flow directions and velocity, and chemistry change throughout the year is not available. The variation in groundwater levels at Muskrat Falls is the exception.

A description of the variation in water levels throughout the year for the Muskrat Falls area is provided below, with additional information provided in Attachment F.

Muskrat Falls

Water levels were taken in the wells and piezometers, as well as in previous piezometer installation. From analysis of the previous data, water levels in the intermediate aquifer undergo little variation over a year. Measurements taken in piezometers installed were below elevation +30 m and the levels taken in the wells vary from elevations +30 to +47 m (SNC-Lavalin 1982).

The variation of piezometer water elevation for the last 10 years has been plotted by Hatch (2008). These plots are included in Attachment F, along with observations regarding level variations.

References:

Hatch. 2008. The Lower Churchill Project MF1260-Assessment of Existing Pumpwell System Final Report. Prepared for Newfoundland and Labrador Hydro.

SNC-Lavalin Newfoundland Ltd. 1982. Muskrat Falls Dewatering System Engineering Assessment. March 1982.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.63**

Information Requested:

The Proponent is asked to provide:

j. a detailed description of the existing relationship of groundwater with the Churchill River in the vicinity of the proposed Gull Island Facility and the Muskrat Falls Facility. Is the river a gaining river or losing river? How does this relationship change seasonally and what historic changes have occurred;

Response:

Gull Island

Based on observations of geotechnical borehole water levels made by Calvin Miles, P.Geo of AMEC, it is suspected that the Churchill River in the vicinity of the proposed Gull Island Facility is a gaining river. Groundwater in the form of springs is entering the Churchill River in the vicinity of the proposed dam site at Gull Island.

Muskrat Falls

The Churchill River in the vicinity of the proposed Muskrat Falls Facility is suspected to be a gaining river. Groundwater levels in the lower aquifer range from el 7 m to 5 m across the spur from upstream to downstream, indicating that the marine clay deposits are separating it from the river to form an aquiclude. A pump test confirmed that no connection exists between the river and the lower aquifer (SNC-AGRA 1999).

Reference:

SNC-AGRA Earth & Environmental Ltd. 1999. Muskrat Falls Hydroelectric Development, Final Feasibility Study, Volume 1 – Engineering Report, January 27, 1999.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.63**

Information Requested:

The Proponent is asked to provide:

k. data on the groundwater-surface water relationship at the Churchill Falls generation facility if available;

Response:

Data on the groundwater-surface water relationship at the Churchill Falls generation facility was not located as part of the search for available information.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.63**

Information Requested:

The Proponent is asked to provide:

I. an assessment of the potential for groundwaters to become contaminated with mercury;

Response:

Nalcor has conducted an assessment of the potential for groundwaters to become contaminated with mercury. Mercury concentrations in porewaters of flooded sediments and areas where groundwater interacts with the reservoir flood zones are expected to increase for the Project but remain well below the Health Canada guideline for mercury in drinking water (Health Canada 2008). The guideline is 1 microgram per litre, expressed as total mercury. While data are limited for mercury concentrations in groundwater in areas impacted by flooding, observations from experimentally flooded reservoirs at the Experimental Lakes Area, Ontario showed peak concentrations of total mercury in flood zone porewater (where increases in mercury concentrations would be greatest) in the range of 0.04 to 0.07 micrograms per litre for brief periods after flooding (Rolfhus et al. submitted). These values are an order of magnitude below the Health Canada guideline of 1 microgram per litre.

However, it should be noted that in the Happy Valley-Goose Bay well field area, FracFlow (2004) reported that "the aquifer that is supplying fresh groundwater to the Happy Valley-Goose Bay well field is described as a leaky confined aquifer, which means that it is not directly connected to the immediate surface water system (Churchill River). The groundwater source is considered to be non-GUDI (Groundwater Under Direct Influence from Surface Water). In other words, it is not considered to be vulnerable to direct surface water influence in the immediate area of the wells that form the well field." This lack of interaction between the groundwater and the Lower Churchill River would serve to further reduce the potential for groundwaters to become contaminated with mercury.

References:

FracFlow. 2004. Well Field Remediation and Wellhead Protection Project (Phase 2 and 3 Activities) Town of Happy Valley Goose Bay. Prepared for the Town of Happy-Valley Goose Bay.

Health Canada. 2008. Guidelines for Canadian Drinking Water Quality – Summary Table. Prepared by the Federal-Provincial-Territorial Committee on Drinking Water of the Federal-Provincial-Territorial Committee on Health and the Environment.

Rolfhus K., B. Hall, R.A. Bodaly and J. Hurley. (Submitted to STOTEN). Response of Mercury in Boreal Forest Soils to Experimental Inundation.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.63**

Information Requested:

The Proponent is asked to provide:

m. an assessment of the potential for salt-water contamination of the groundwater system;

Response:

Nalcor has conducted and continues to conduct an assessment of the potential for salt-water contamination of the groundwater system.

The only time that the Churchill River below Muskrat Falls would be susceptible to salt water intrusion from Goose Bay would be during the temporary reduction in river flows that would occur in the process of reservoir impoundment. To estimate the extent of any salt water intrusion that could occur, a 3-D numerical model of the Churchill River and Goose Bay estuary was set up in 2008 (Hatch 2008). The model results indicate a potential for salt water intrusion within the last few kilometres nearest the mouth of the Churchill River during impoundment of the Gull Island Reservoir (approximately 2 km upriver of Mud Lake at its maximum extent) and well downstream of Happy Valley Goose Bay. In addition, in the Happy Valley - Goose Bay well field area, FracFlow (2004) reported that “the aquifer that is supplying fresh groundwater to the Happy Valley-Goose Bay well field is described as a leaky confined aquifer, which means that it is not directly connected to the immediate surface water system (Churchill River). The groundwater source is considered to be non-GUDI (Groundwater Under Direct Influence from Surface Water). In other words, it is not considered to be vulnerable to direct surface water influence in the immediate area of the wells that form the well field.” This lack of interaction between the groundwater and the Lower Churchill River would serve to further reduce the potential for salt water contamination of the groundwater system.

The 3D model did not make any reference to groundwater in the zone of salt water intrusion, specifically in reference to the area of Mud Lake. In response to this concern, AMEC will be conducting a study in the fall of 2009 and generating a 3-D numerical groundwater model and a detailed technical report for the area of Mud Lake.

References:

FracFlow. 2004. Well Field Remediation and Wellhead Protection Project (Phase 2 and 3 Activities) Town of Happy Valley Goose Bay. Prepared for the Town of Happy-Valley Goose Bay.

Hatch. 2008. The Lower Churchill Project MF1260-Assessment of Existing Pumpwell System Final Report. Prepared for Newfoundland and Labrador Hydro.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.63**

Information Requested:

The Proponent is asked to provide:

n. **modeling of seepage from the reservoir to groundwater and through the dam in order to assess one of the risk factors of dam failure including consideration of the critical amount of seepage needed to cause dam collapse, whether groundwater would discharge into the reservoir or vice-versa, how this relationship changes seasonally, if this relationship would change over the life of the Project, and how climate change and extreme environmental conditions, natural disasters and accidents/malfunctions would affect this relationship;**

Response:

Modeling of seepage from the reservoir to groundwater and through the dam will be carried out during the detailed design phase. An assessment of the risk factors for dam failure will also be carried out during the detailed design phase and will include:

- consideration of the critical amount of seepage needed to cause dam collapse;
- whether groundwater would discharge into the reservoir or vice-versa;
- how this relationship changes seasonally;
- if this relationship would change over the life of the Project; and
- how climate change and extreme environmental conditions, natural disasters and accidents/ malfunctions would affect this relationship.

This information will be provided to the appropriate regulatory authority when it becomes available.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.63**

Information Requested:

The Proponent is asked to provide:

o. **a complete water balance for the new reservoir including all data used to construct the water balance, long-term climate data calibrated to the study site, all assumptions used in the construction of the water balance;**

Response:

A water balance is the accounting of water input and output and change in storage of the various components of a hydrologic system. In the case of the Project, the inputs would consist of the output from the Churchill Falls generating facility, local inflows from tributaries, precipitation, surface runoff and seepage into the reservoirs from groundwater. The outputs would consist of outflow from the Muskrat Falls facility, and losses due to infiltration to groundwater in areas of groundwater recharge, and evapotranspiration. The difference between total input and total output volumes would be the net change in volume of stored water in the reservoir system.

A complete water balance is typically done for engineering purposes in water resources projects where there are withdrawals from the water system, in the form of environmental losses and/or consumptive or competing demands that are expected to impact the availability of water in the system. Examples include mine tailings ponds, municipal/industrial water supply, agricultural/irrigation reservoirs, or projects in areas of high evaporation potential.

In the case of the Project, a detailed breakdown of water balance components has not been required to confirm the feasibility and optimize the design and operation of the generating facilities. The availability of water in the system is already known from the long-term streamflow records at the Churchill Falls and Muskrat Falls sites, which, as records of runoff, by definition indicate the net water available (all inputs minus all losses) at and between the two locations. There are no consumptive or competing demands. The normal operating level of the reservoirs will be maintained at Full Supply Level; there will be no net change in the volume of stored water from one year to the next; total input will equal total output.

The inputs will not change as a result of the Project. There may be some minor redistribution of losses. It is expected that evaporative losses from the reservoir surface areas will be greater than the evapotranspirative losses from the land surface areas prior to reservoir impoundment. Conversely, infiltration losses during precipitation over the reservoir areas will be minimal compared to the pre-project case. As well, losses via seepage from the reservoir area around or under the dam are, as a rule, small compared to other outputs and difficult to quantify prior to construction (USACE 1997). These effects have not been quantified as they are expected to be within the margin of uncertainty of the existing hydrological records. The mean annual precipitation and potential evapotranspiration of the Churchill River watershed are approximately 1000 mm and 400 mm respectively, while the mean annual runoff to Muskrat Falls is approximately 600 mm (WRD 1992). This suggests comparatively little net subsurface exchange.

In addition to these analyses, as part of a research program at Memorial University being funded through Nalcor, a hydrological model is being developed for one or more of the tributaries of the Lower Churchill River. This hydrological model will be used as a baseline into which climate change data will be entered to determine the effect of climate change on the overall hydrological cycle for the Lower Churchill watershed. The study is using the WATFLOOD program to develop a model of the hydrological cycle and will be calibrated using active water gauges on the tributaries (operated by Water Survey of Canada). The three water gauges being used to calibrate the model have been operated since 1978, 1979 and 1998. Climate data is being used from the Environment Canada climate station at the Goose Bay airport. The WATFLOOD program will consider precipitation, temperature, evapotranspiration, and groundwater interaction. One of the primary assumptions of the research is that the overall hydrological cycle for the Lower Churchill reservoir will be consistent with the hydrological cycle of its sub-basins. The results of this work will be published as it becomes available.

References:

U.S. Army Corps of Engineers (USACE). 1997. Hydrologic Engineering Requirements for Reservoirs. Manual No. EM 1110-2-1420, Washington, DC.

Water Resources Division (WRD). 1992. Water Resources Atlas of Newfoundland. Department of Environment and Lands, Government of Newfoundland and Labrador.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.63**

Information Requested:

The Proponent is asked to provide:

p. sensitivity analysis on the water balance examining at a minimum climatic and operational factors;

Response:

The water balance has not been and will not be completed; therefore a sensitivity analysis has not been completed. However, the studies for the Lower Churchill have been calibrated using the flow data from the hydrometric stations. The design has been verified under various flow conditions and the structure designs are within the conditions for the Environmental Assessment.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.63**

Information Requested:

The Proponent is asked to provide:

q. **detailed information on the proposed wells for control of seepage into work sites (Document 6, p.4-77). Provide well locations and depths, pumping rates, completion data, and estimated drawdown of water table; and**

Response:

Detailed information on the proposed wells for control of seepage into work sites such as well locations and depths, pumping rates, and estimated drawdown of water table will not be available until the detailed design phase. This information will be provided to the appropriate regulatory authority when available. Well completion data will not be available until the construction phase and will be provided to the appropriate regulatory authority.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.63**

Information Requested:

The Proponent is asked to provide:

r. **an assessment of the impacts of changes in groundwater on the aquatic and terrestrial environment, land and resource use, and communities.**

Response:

There are three potential effects of groundwater changes on the aquatic and terrestrial environment, land and resource use, and communities. The possible effects are the increase in mercury levels, salt water intrusion, and an alteration of the hydraulic regime.

The potential for increases in mercury levels and subsequent effects is discussed in part (l) of this IR. Mercury levels in the groundwater are expected to increase temporarily but will remain well below the Health Canada guideline for mercury in drinking water. It should be noted, however, that FracFlow (2004) reported the aquifer that supplies drinking water to Happy Valley-Goose Bay is independent of the Churchill River. Therefore, the potential for mercury contamination of the groundwater supply is further reduced due to the lack of interaction between the river and the groundwater supply for Happy Valley – Goose Bay.

The potential for salt water intrusion and subsequent effects are discussed in part (m) of this IR and applies only to the impoundment periods for Gull Island and Muskrat Falls. A 3-D numerical model of the Churchill River and the Goose Bay estuary was set up in 2008. Results from the model indicate a potential saltwater intrusion approximately 2 km upstream of Mud Lake and well downstream of Happy Valley-Goose Bay. The distance of salt water intrusion was modeled based on no flow release. If flow is released during impoundment the potential for further water intrusion would be reduced. Based on the distance of intrusion, salt water intrusion is not predicted to affect groundwater supplies in Happy Valley-Goose Bay. The 3D model did not however make any reference to groundwater in the zone of salt water intrusion, specifically in reference to the area of Mud Lake. In response to this concern, AMEC will be conducting a study in the fall of 2009 and generating a 3-D numerical groundwater model and a detailed technical report for the area of Mud Lake.

The potential effect of the reservoir formation on the hydraulic regime in the vicinity to the reservoirs is provided in Freeze and Cherry (1979), "The introduction of a reservoir into a valley that is acting as a regional discharge area produces both transient readjustment and long-term permanent change in the hydrogeologic system adjacent to the reservoir. During the initial rise of the reservoir level, a transient flow system is induced in the reservoir banks. As the hydraulic heads are raised at the reservoir boundary, there is a reversal of flow directions and an influx of water from the reservoir into the groundwater system.

The end result of the initial transient readjustment is a set of long-term, permanent changes in the regional hydrogeologic regime. Water tables are higher, hydraulic heads are increased in aquifers, and the rates of discharge from the subsurface flow system into the valley are reduced." These changes are limited to the area of the reservoirs. The Project will not affect the groundwater flow regime downstream of Muskrat Falls.

In the case of this Project the readjustment could potentially result in slumping and bank instability in some areas as a result of higher groundwater tables. The potential for bank instability and slumping due to inundation is discussed in the bank stability component study (AMEC 2008: Hydrology Component Study Report 1 of 8). In the 2008 study the following conclusions were made:

- Raising of the water levels will generally result in a more stable shoreline (with the exception of beach redevelopment) in areas with a homogeneous lithology.
- In areas with layered lithologies increased hydrostatic pressures may occur, resulting in increased pore pressures within the clay layers, thus increasing its instability and result in the reactivation of progressive slides until an equilibrium is re-established
- Minimum shoreline erosion is expected within the Gull Island Reservoir. Slope stability concerns are anticipated to be localized and generally limited to undermining of the shoreline (small slide and falls) during the re-establishment of the shoreline and subsequent beach/bluff development
- Rising of the shoreline for the Muskrat Falls reservoir will result in the establishment of the shoreline and beach/bluff development. Erosion and the ongoing undermining of the post construction/impoundment shoreline will continue, until the redevelopment of a stable shoreline.

This interaction and effect on the aquatic environment was included as part of the environmental assessment and forms part of the compensation strategy being developed with Fisheries and Oceans Canada (discussed in IR# JRP.107).

Due to increase in the groundwater table elevation there is a potential to affect the groundwater flow regime in low lying areas outside of the reservoir limits. Using the Ecological Land Classification completed by Minaskuat (2008), 13 wetlands were identified within 100 m of the new shoreline (representing 0.59 km^2 of wetland habitat). These existing wetlands have the potential to increase in aerial extent or the potential to change vegetation composition. A summary of these existing wetlands is provided in Table 6 below. As well, in rare cases other low lying areas would have the potential to become wetland areas where previously one did not exist.

Table 6 Wetlands within 100 m of the New Shoreline of the Reservoirs

Wetland ID	Type	Existing Aerial Extent (km^2)	Underlying Substrate
1	Unknown	0.05	till, undifferentiated
2	Unknown	0.01	till, undifferentiated
3	Unknown	0.02	glaciofluvial
4	Unknown	0.02	till, undifferentiated
5	Unknown	0.00	till, undifferentiated
6	Unknown	0.08	till, undifferentiated
7	Unknown	0.07	glaciomarine and marine
8	Unknown	0.03	glaciomarine and marine
9	Bog	0.14	glaciomarine and marine
10	Bog	0.09	till, undifferentiated
11	Unknown	0.01	till, undifferentiated
12	Bog	0.04	glaciomarine and marine
13	Unknown	0.04	glaciofluvial
Total		0.59	

The resulting effect of the changes in groundwater flow regime noted above on the aquatic and terrestrial environment, land and resource use, and communities are summarized in Table 7 below.

Table 7 Summary of Potential Effects from Changes in Groundwater Flow Regime

Valued Environmental Component	Environmental Effect
Aquatic Environment	Aside from bank stability (previously discussed), no likely effect.
Terrestrial Environment	Effect on aerial extent of existing wetlands and creation of new wetlands. This effect is both adverse from the perspective of flooding upland areas and positive from the perspective of creating new wetlands Nature: neutral Magnitude: low Geographic Extent: site specific Duration/Frequency: long-term Reversibility: reversible Ecological Context: undisturbed Certainty of Knowledge: high **Not likely significant effect**
Land and Resource Use	There is a potential for land and resource use to change on a local scale based on modification to existing wetlands or creation of new wetlands. Nature: adverse Magnitude: low Geographic Extent: site specific Duration/Frequency: long-term Reversibility: irreversible Ecological Context: undisturbed Certainty of Knowledge: high **Not likely significant effect**
Communities	No effect on groundwater levels downstream of Muskrat Falls, therefore there will be not hydro geological effects in Happy Valley – Goose Bay or Mud Lake. N/A

References:

Freeze, R. A. and J. A. Cherry. 1979. Groundwater. Englewood Cliffs, N.J. Prentice Hall.

Minaskuat Inc. 2008. Project Area Ecological Land Classification. Prepared for the Lower Churchill Hydroelectric Generation Project.

INFORMATION RESPONSES
LOWER CHURCHILL PROJECT
CEAA REFERENCE NO.07-05-26178

JOINT REVIEW PANEL

Attachment A

Groundwater Well Location Maps

IR# JRP.63

October 5, 2009

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JRP.63
Attachment B
Part 1

Note: No file available (corrupt on CEAR)

JRP .63
Attachment B
Part 2

(Click above link to go to file)

JRP .63
Attachment B
Part 3

(Click above link to go to file)

JRP.63
Attachment B
Part 4

(Click above link to go to file)

JRP.63
Attachment B
Part 5

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JRP.63
Attachment B
Part 6

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Part 7

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Attachment B
Part 8

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Part 9

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Part 10

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JRP.63
Attachment B
Part 11

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JRP.63
Attachment B
Part 12

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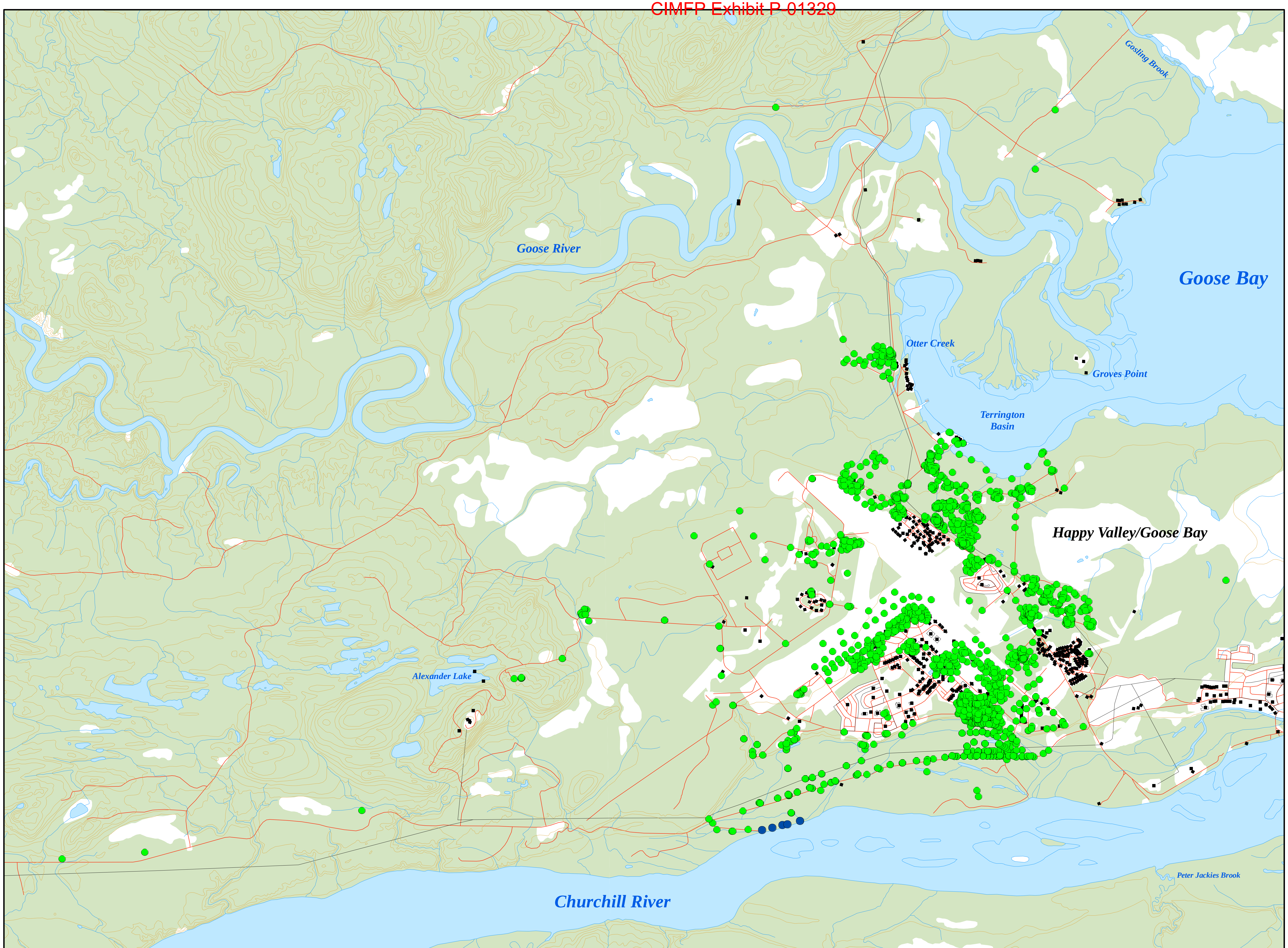
JRP.63
Attachment B
Part 13

(Click above link to go to file)

JRP.63
Attachment B
Part 14

(Click above link to go to file)



NOTES

1. ALL DIMENSIONS ARE IN METRES.
2. DO NOT SCALE FROM DRAWING.
3. THIS DRAWING IS INTENDED TO SHOW RELATIVE LOCATIONS AND CONFIGURATION OF THE STUDY AREA IN SUPPORT OF THIS REPORT.
4. ALL LOCATIONS, DIMENSIONS, AND ORIENTATIONS ARE APPROXIMATE.
5. THIS DRAWING WAS PRODUCED FROM 2000 AIRPHOTOS SUPPLIED BY JACQUES WHITFORD LIMITED.
6. MTM NAD 83 ZONE 2 MAPPING

No.	Date	Description	Drawn	Chk'd	App'd

LEGEND

- Monitoring Well/Piezometer Locations
- Municipal Drinking Water Well Locations
- Existing Roads

amec
AMEC Earth & Environmental
AMEC Americas Limited

CLIENT
nalcor energy

PROJECT
Organization IR# - JRP.63
Section A

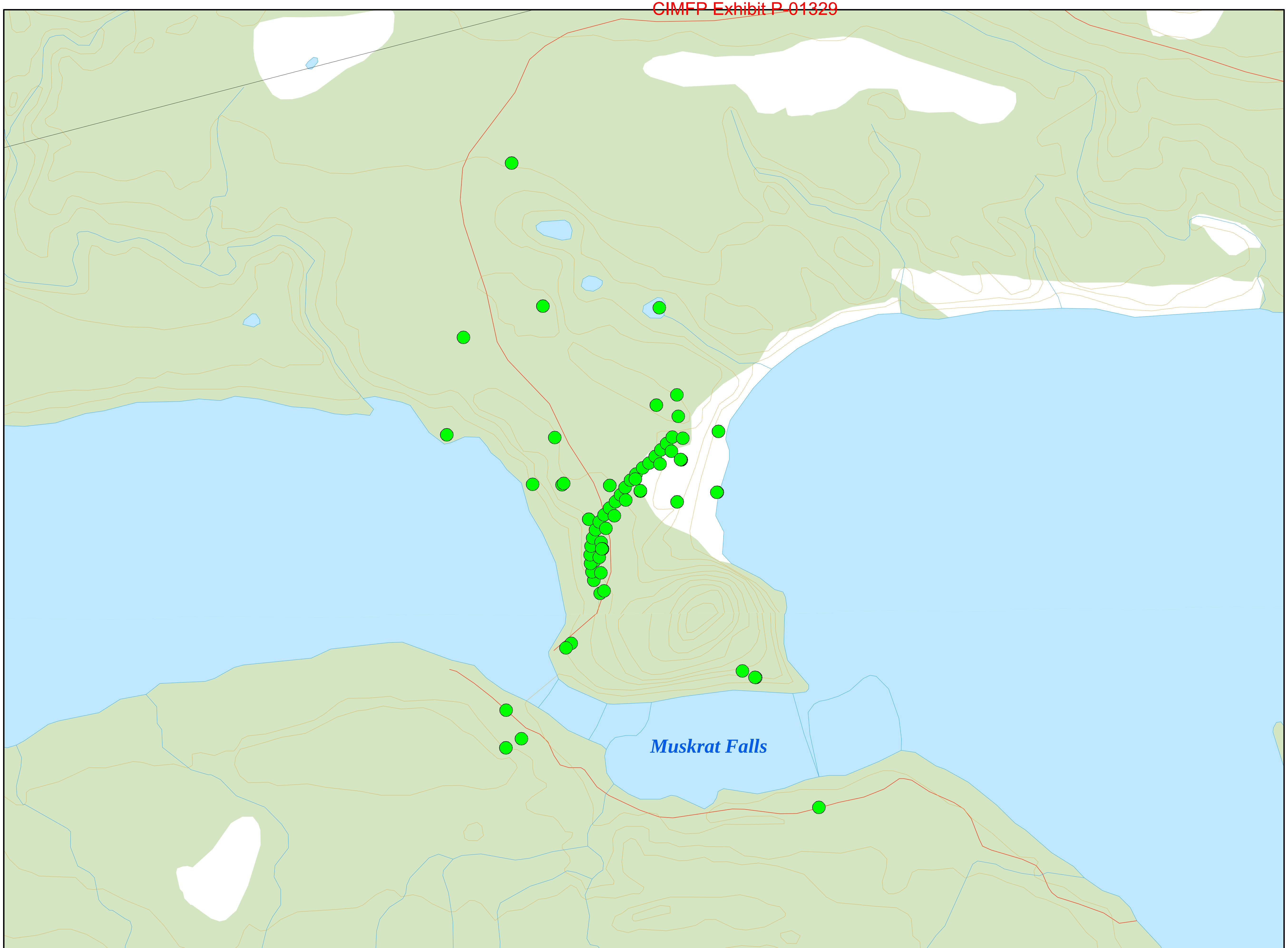
DRAWING TITLE
Drinking Water Wells, Monitoring Wells, and Piezometers Locations - Goose Bay

PROJECT NUMBER
TF9114066.3000

SCALE
Kilometers
0 1 2

DRAWN BY	APPROVED BY	REVIEWED BY
M.Day		

DRAWING NO.	DATE	REV
	August 2009	0



NOTES

1. ALL DIMENSIONS ARE IN METRES.
2. DO NOT SCALE FROM DRAWING.
3. THIS DRAWING IS INTENDED TO SHOW RELATIVE LOCATIONS AND CONFIGURATION OF THE STUDY AREA IN SUPPORT OF THIS REPORT.
4. ALL LOCATIONS, DIMENSIONS, AND ORIENTATIONS ARE APPROXIMATE.
5. THIS DRAWING WAS PRODUCED FROM 2000 AIRPHOTOS SUPPLIED BY JACQUES WHITFORD LIMITED.
6. MTM NAD 83 ZONE 2 MAPPING

No.	Date	Description	Drawn	Chk'd	App'd

LEGEND

Monitoring Well/Piezometers Locations

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PROJECT
Organization IR# - JRP.63
Section A

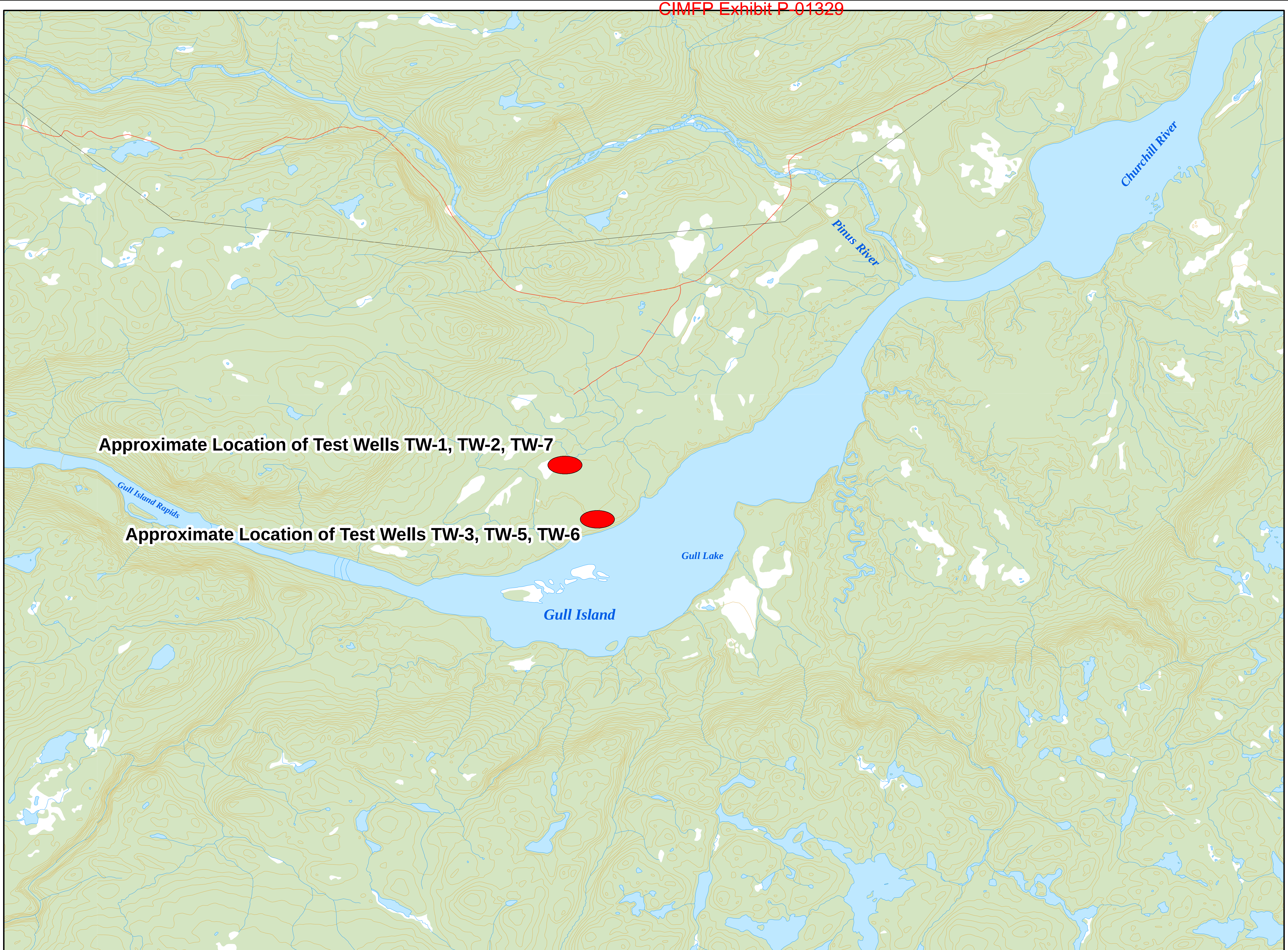
DRAWING TITLE
Test Well Locations - Muskrat Falls

PROJECT NUMBER
TF9114066.3000

SCALE
Kilometers
0 0.25 0.5

DRAWN BY	APPROVED BY	REVIEWED BY
M.Day		

DRAWING NO.	DATE	REV
	August 2009	0



NOTES

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3. THIS DRAWING IS INTENDED TO SHOW RELATIVE LOCATIONS AND CONFIGURATION OF THE STUDY AREA IN SUPPORT OF THIS REPORT.
4. ALL LOCATIONS, DIMENSIONS, AND ORIENTATIONS ARE APPROXIMATE.
5. THIS DRAWING WAS PRODUCED FROM 2000 AIRPHOTOS SUPPLIED BY JACQUES WHITFORD LIMITED.
6. MTM NAD 83 ZONE 2 MAPPING

No.	Date	Description	Drawn	Chk'd	App'd

LEGEND

Approximate Location of Test-Wells

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PROJECT
Organization IR# - JRP.63
Section A

DRAWING TITLE
Test Well Locations - Gull Island

PROJECT NUMBER
TF9114066.3000

SCALE
Kilometers
0 1 2

DRAWN BY	APPROVED BY	REVIEWED BY
M.Day		

DRAWING NO.	DATE	REV
	August 2009	0

NOTE:

Please see accompanying CD for Digital File.

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JOINT REVIEW PANEL

Attachment B

Monitoring Well Logs

IR# JRP.63

October 5, 2009

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JOINT REVIEW PANEL

Attachment C

Monitoring Well Database for the Goose Bay Area

IR# JRP.63

October 5, 2009

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JOINT REVIEW PANEL

Attachment D

Available Water Quality Data for Goose Bay Area and Muskrat Falls

IR# JRP.63

October 5, 2009

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JOINT REVIEW PANEL

Attachment E

Groundwater Elevation Contour Maps

IR# JRP.63

October 5, 2009

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NOTE:

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JOINT REVIEW PANEL

Attachment F

Variation in Water Levels through the Year at Muskrat Falls

IR# JRP.63

October 5, 2009

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IR# JRP.64

Impacts of Water Depth on Insects

Requesting Organization – Joint Review Panel **Information Request No.: JRP.64**

Subject: Impact of Water Depth on Insects

References:

EIS Guidelines 4.4.4.2 (Aquatic Environment) & 4.4.4.3 (Terrestrial Environment)

EIS Volume IIB, Section 5.7.12 (Harlequin Duck) pg. 5-28, Section 5.14.13.2 (Operation and Maintenance) pg. 5-99

Related Comments / Information Requests:

CEAR#151 (G. Sabau)
CEAR # 173 (Environment Canada)

IR#JRP.105

Rationale:

This EIS indicates that Harlequin Duck forages in shallow water and consumes insect larvae. However, there is no information in this document regarding how insect abundance, eruption time, density, types, etc. may be affected locally by an increase in water depth. This is relevant for the Harlequin Duck and also very relevant for aerial insectivores such as the Common Nighthawk (Section 5.11.2.17) and Bank Swallows.

This EIS also states that Harlequin Ducks will be able to adapt relatively easily to changes in the hydrology of the Lower Churchill (Volume IIB, Section 5.14.13.2 (Operation and Maintenance) pg. 5-99), however the Canadian Wildlife Service has indicated that this may not be the case (CEAR # 173 — Environment Canada). Harlequin Ducks are creatures of habit and tend to be very faithful to their moulting, wintering and staging areas, returning there year after year. If these areas are lost, and consequently they select a new staging area there is a possibility that they will not return to their breeding rivers.

If increased water depth alters insect loading at breeding and staging sites, this could also affect the ability of Harlequin Ducks to fat load in these areas just before they breed. The EIS does not address this issue.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.64**

Information Requested:

The Proponent is asked to assess:

a. **impacts of increasing water depth on insect abundance, eruption time, density, types, etc.; and**

Response:

In order to answer how increasing water depth throughout the proposed reservoirs could affect insect abundance, eruption time, density, and types, a general description of the overall change in habitat is needed. This would include changes in water velocity, location of littoral or shallow-water habitat and substrate, all important to benthic invertebrates.

While mean and maximum water depths will increase throughout the reservoir, it is important to note that the near-shore areas throughout each will have water depths similar to those currently in the lower Churchill River. However, mean velocities will be lower. The general understanding of reservoir creation and operation for the lower Churchill River prior to the HEC-RAS hydraulic modeling completed in 2006 to 2007 was that of a large lentic (lacustrine) habitat throughout. Hydraulic modeling and additional information on the operation of the proposed Project show that post-Project habitat will have water velocity in many areas (see pages 78-109 and Appendix D of the Habitat Quantification component study (AMEC and Sikmiut 2007), appended to the EIS and Figures 4-8 to 4-11 on pages 4-31 to 4-34 of Volume IIA of the EIS).

Lower Churchill River Tributaries

The benthic fauna of the smaller tributaries to the lower Churchill River tend to support more species of mayflies and stoneflies than the main stem (Jacques Whitford 1999). As stated in the response to IR# JRP.50 and IR# JRP.48, the mouths of tributaries will change in terms of location, being shifted upstream to the confluence of the new reservoir shoreline; however other habitat attributes of tributaries will be unaffected. Existing benthic taxa would be anticipated to remain within the tributaries.

Gull Island Reservoir

Based on predicted changes in substrates, velocities and depths, benthic invertebrate composition in most areas of Gull Island Reservoir, from the confluence of Cache River to the tailrace of the Churchill Falls Power Station, would be relatively unaffected by changes in habitat.

The surficial geology of the lower Churchill River indicates that the material along the Gull Island reservoir shoreline is similar to that which currently exists. Given the existing larger-sized substrate composition, excessive deposition of fine material along the Gull Island reservoir shorelines will not likely occur. The substrate within the river reach between Cache River and the tailrace of the Churchill Falls Power Station will therefore be much like that occurring presently. While mean and maximum water depths would increase, the nearshore composition of the area described above within the Gull Island Reservoir would remain similar to current conditions. Existing benthic taxa would be anticipated to remain within this river section.

The Gull Island Reservoir will have two areas that will behave lake-like; Winokapau Lake and a 76 km-long reach just upriver of the Gull Island dam (see Figure 4-5 in Volume IIA of the EIS). Winokapau Lake will not change in terms of substrate composition or substantially in terms of velocity or depth (change in mean velocity negligible and increase in current maximum depth of 208m by approximately 11.8m). Existing benthic taxa would be anticipated to remain within this river section.

The greatest change in habitat would be located between the Gull Island dam and the confluence of Cache River which would be changed from riverine to more-lacustrine. The new lacustrine habitat upriver of the Gull Island dam would be up to 97m in depth with a mean velocity less than 0.15m/s (see Figure 4-7 of Volume IIA of the EIS and Section 5.1.1.1 in AMEC and Sikmiut 2007). It would be anticipated that the profundal area of the new lacustrine habitat would be depositional for finer material and organics and hence would change from a riverine to a lacustrine invertebrate composition. While the nearshore areas will have similar water depths and substrate composition as currently present in this reach of river, it would become lacustrine in nature with reduced velocities.

In this area, benthic invertebrate composition would be altered. According to the benthic invertebrate component study completed by Jacques Whitford (1999), changing lotic (riverine) habitat into lentic (lacustrine) habitat would alter invertebrate species composition. Species adapted to flowing water with larger substrate types would be replaced by species adapted to still, deep waters with finer substrate composition within the deep-water areas. For example, species such as mayflies, stoneflies and caddis flies would generally be replaced by *oligochaete* worms and *chironomids* (Jacques Whitford 1999). Lotic (riverine) habitats are generally more species rich than lentic (lacustrine) habitats.

It should be noted that large lakes also typically export plankton that can be exploited by filter-feeders downstream. Slight increases on species richness and total abundance were recorded in the benthos below the Churchill Falls tailrace and in the lower reaches and below Winokapau Lake (Jacques Whitford 1999). This may occur within the Gull Island tailrace.

Muskrat Falls Reservoir

Based on predicted changes in substrates, velocities and depths, the benthic invertebrate composition in Muskrat Falls reservoir would be relatively unaffected by changes in habitat.

The general sandy nature of the lower Churchill River limits the number of taxa found there, as well as their abundance. Jacques Whitford (1999) found that the most abundant taxonomic group was the *Chironomidae*, followed by *Oligochaeta* (page 34). These taxa would be anticipated in the Muskrat Falls reservoir. The majority of the habitat classification would remain as Main Stem Slow Velocity (see AMEC and Sikmiut 2007 and Figure 4-11 in Volume IIA of the EIS), however mean velocities throughout much of the reservoir will be reduced and mean depths increased (see Appendix D of AMEC and Sikmiut 2007)). While mean and maximum water depths would increase, the nearshore composition of the Muskrat Falls reservoir would remain similar in composition to current conditions; similar water depths predominated by slow velocity and finer material such as sand with faster velocity and larger substrate remaining at the proposed Gull Island tailrace.

Thermal Regime

Potential changes in the thermal regime both within and below the proposed reservoirs is presented in the EIS (Figures 4-12 and 4-13 in Volume IIA of the EIS shows the within-reservoir thermal changes and Figures 4.2 and 4.3 in AMEC and Sikmiut 2007 presents the thermal changes predicted downstream of Muskrat Falls reservoir). The general change in thermal regime related to benthic invertebrates and their inter-relationship with avifauna would be the shift in the warming period during the spring. Modeling shows that there may be a two-week delay in warming during spring due to the thermal capacity of the reservoirs. The development of benthic invertebrates is dependent on water temperature. This shift in warming would also shift the development timing of benthic invertebrates. This could delay the adult emergence of some species. The potential effect of a slight change in emergence timing of adult stages on avifauna is provided in IR# JRP.64(b).

References:

AMEC Earth & Environmental Ltd.-Sikumiut Environmental Management Ltd. 2007. Lower Churchill Hydroelectric Generation Project Habitat Quantification. Prepared for Newfoundland and Labrador Hydro, St. John's, NL.

Jacques Whitford. 1999. Benthic Invertebrate Study of the Churchill River. Jacques Whitford Environment Limited report prepared for Newfoundland and Labrador Hydro, St. John's, NL.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.64**

Information Requested:

The Proponent is asked to assess:

b. **the potential effects on bird populations that depend on insects as a food source.**

Response

Provided below is a summary table of potential effects on bird populations that depend on insects as a food source due to changes in benthic macroinvertebrate species composition and/or emergence.

Avifauna species	Aquatic habitats used in the lower Churchill River watershed	Benthic fauna consumed	Affected by the Project	Implications on species or species group
Canada Goose	Marshes and other wetlands along the lower Churchill River, and less commonly also in upland wetlands	Minimal – almost entirely herbivorous (Mowbray et al. 2002)	Not with respect to changes to benthic invertebrates	Inconsequential
Surf Scoter	Lower Churchill River (staging) and some upland wetlands (breeding)	Ducklings from northern Quebec fed on: *Nematoda, Amphipoda, Hemiptera, Coleoptera, Ephemeroptera, Diptera, Trichoptera, Odonata, Arachnida, Hirudinea, Pelecypoda*. Adults reported to overwhelmingly favour mussels when available. (Savard et al. 1998)	Yes. The area upstream of Gull Island has been used for spring staging, and a change/decline in lotic benthic invertebrates in this area could reduce its suitability for Surf Scoter.	Some adjustment of the use of traditional spring staging sites along affected portions of the Churchill River may occur
Harlequin Duck	Primarily tributaries of the lower Churchill River	Primarily crustaceans; also some mollusks and various aquatic insects. Among crustaceans, decapods, amphipods, and isopods are particularly favoured. Diet of ducklings is similar, but with an emphasis on larvae of midges and caddisflies (Robertson and Goudie 1999)	Limited to spring staging on the lower Churchill River	As for most of the breeding season Harlequin Ducks are limited to tributaries of the Churchill River, that will remain largely unchanged. Some adults may briefly stage on the lower Churchill River in spring, but the period is sufficiently short that changes in benthic invertebrate abundance are unlikely to be a concern.
Osprey	Associated with the lower Churchill River and other major streams and lakes	None (Poole et al. 2002)	Not with respect to changes to benthic invertebrates.	Inconsequential
Ruffed Grouse	None	None (Rusch et al. 2000)	No	None
Common Nighthawk	None	None (Poulin et al. 1996)	No	None
Olive-sided Flycatcher	Wetland edges both along the lower Churchill River and in upland areas	Primarily Hymenoptera; also some *Odonata, Diptera, Lepidoptera, Orthoptera* (Altman and Sallabanks 2000)	Unlikely	Species forages primarily along forest/wetland edges and shows low dietary reliance on benthic fauna
Gray-cheeked Thrush	None	None (Lowther et al. 2001)	No	None

Avifauna species	Aquatic habitats used in the lower Churchill River watershed	Benthic fauna consumed	Affected by the Project	Implications on species or species group
Rusty Blackbird	Marshes and other wetlands along the lower Churchill River, as well as in upland areas	Various insect larvae and crustaceans, including caddisflies (Avery 1995)	Possible	Breeding density in the valley bottom is limited and foraging is generally along the edge of smaller water bodies.
Wetland sparrows	Primarily marshes and other wetlands along the lower Churchill River	Larvae, pupae, and adults of various insect orders, including *Coleoptera, Diptera, Homoptera, and Ephemeroptera*, as well as some snails and crustaceans (Ammon 1995, Arcese et al. 2002, Mowbray 1997, Wheelwright and Rising 2008)	Unlikely	Though implications vary somewhat by species. Swamp Sparrow is the most insectivorous, but forages along the river edge infrequently. Song Sparrow is most often along the river, but has a more diverse diet and can therefore be expected to adapt readily to a reduction in benthic fauna. Lincoln's and Savannah Sparrows forage primarily in stagnant wetlands, and in terms of foraging would be largely unaffected by changes from riverine to lacustrine habitat.

References:

Altman, B. and R. Sallabanks. 2000. Olive-sided Flycatcher (*Contopus cooperi*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu.bnaproxy.birds.cornell.edu/bna/species/502

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Rusch, D.H., S. Destefano, M.C. Reynolds and D. Lauten. 2000. Ruffed Grouse (*Bonasa umbellus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu.bnaproxy.birds.cornell.edu/bna/species/515

Savard, J-P.L., D. Bordage and A. Reed. 1998. Surf Scoter (*Melanitta perspicillata*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu.bnaproxy.birds.cornell.edu/bna/species/363

Wheelwright, N.T. and J.D. Rising. 2008. Savannah Sparrow (*Passerculus sandwichensis*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu.bnaproxy.birds.cornell.edu/bna/species/045

IR# JRP.65

Waterfowl

Requesting Organization – Joint Review Panel **Information Request No.: JRP.65**

Subject - Waterfowl

References:

LGL Limited. 2008. *Waterfowl in the Lower Churchill River Are*a. Prepared for Minaskuat Inc. and Newfoundland and Labrador Hydro, Lower Churchill Hydroelectric Generation Project, St. John's, NL.

AGRA Earth and Environmental and Harlequin Enterprises. 1999. *Churchill River Power Project Waterfowl Final Report*. Prepared for Lower Churchill Hydroelectric Generation Project, St. John's, NL.

Related Comments / Information Requests:

CEAR # 173 (Environment Canada)
CEAR # 206 (K. Lethbridge)

IR # JRP.94

Rationale:

In the waterfowl component study LGL Limited (2008) summarizes work done in 2006 and 2007, which was mainly focused on the Lower Churchill River Area, and AGRA Earth and Environmental and Harlequin Enterprises (1999) summarizes work done in 1998 on the Lower Churchill and River transmission line corridor to the Island of Newfoundland.

The survey areas for the waterfowl component studies need to be clearly defined and placed in context with the Lower Churchill Project footprint and study area for the environmental assessment. The written description of the survey area on pg. 4-1 of LGL Limited (2008) is not clear and the maps provided (Figures 4-1, 4-2 and 4-3) do not indicate the Project study area, only individual survey locations. Maps should clearly indicate the Project study area and relevant geographic descriptors including survey blocks and other survey locations.

The proponent has identified use of early open water areas on the Lower Churchill (ashkui) by staging scoters and other waterfowl in spring. These sites may provide the last opportunity for breeding pairs to acquire nutrients before arriving at their breeding site. It is predicted that many of the current areas being used for staging will be lost by the flooding of the reservoirs. Additional work is required to determine how these sites are used spatially and temporally and the behaviours of the birds using them (e.g., foraging).

The EIS indicates (Volume IIB, Table 7-3, Proposed Follow-up & Monitoring Programs) that aerial surveys of the Churchill River and surrounding locations will be undertaken to examine use of ashkui in reservoirs and other locations by waterfowl and to determine changes in spring habitat quality and use.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.65**

Information Requested:

The Proponent is asked to:

a. **clarify the written description of the survey area in LGL Limited (2008) (p. 4-1);**

Response:

To clarify the written description of the survey area in LGL Limited (2008), survey type, date, and the location of each survey is presented in Table 1. Also, refer to revised Figures 4-1 to 4-3 in Attachment A.

Table 1 Environmental Baseline Surveys for Waterfowl during 2006-2007

Waterfowl Survey	Location
Indicated breeding pairs (mid-June 2006)	Lower Churchill River – Geyts Point to Unknown River – shorelines, islands, and adjacent wetlands searched (Figure 4-1)
Late-nesting waterfowl broods (early August 2006)	Lower Churchill River – Geyts Point to Unknown River – shorelines, islands, and adjacent wetlands searched (Figure 4-1)
Spring staging waterfowl (late May 2007)	Lower Churchill River – Geyts Point to Unknown River – shorelines, islands, and adjacent wetlands searched (Figure 4-1)
Spring staging waterfowl (late May 2007)	The terminus of the lower Churchill River to include the inner coastline of Lake Melville and Goose Bay from Paddon Point near Sebaskachu Bay to Epinette Point adjacent to Carter Basin (Figure 4-2 and 4-3)
Breeding pair (early June 2006)	Three 100 km^2 permanent waterfowl sample plots, Mud Lake (BDJV 24), Joir River (DND 1) and Minipi Lake (DND 3) (Figure 4-1)
Indicated breeding pairs (early June 2007)	Three 100 km^2 permanent waterfowl sample plots, Mud Lake (BDJV 24), Joir River (DND 1) and Minipi Lake (DND 3) (Figure 4-1)
Indicated breeding pairs (early June 2007)	Along the existing power transmission line right-of-way between Muskrat Falls and Gull Island (Figure 4-1)
Indicated breeding pairs (early June 2007)	1.6 km wide corridor along the proposed interconnecting transmission line (Figure 4-1)
Harlequin Duck surveys (early June 2007)	Upper stretches (approximately 5 km) of the Metchin River and Cache River in conjunction with the transmission corridor survey (Figure 4-1)
Brood surveys (early July 2006; early August 2006)	Three 100 km^2 permanent waterfowl sample plots, Mud Lake (BDJV 24), Joir River (DND 1) and Minipi Lake (DND 3) (Figure 4-1)
Brood surveys (early August 2006)	Lower Churchill River – Geyts Point to Unknown River – shorelines, islands, and adjacent wetlands searched (Figure 4-1)
Harlequin Duck brood surveys (early August 2006)	Minipi River, Beaver Brook, Cache River and stretches of the Fig River (Figure 4-1)
Brood surveys (mid-July 2006)	Along the lower Churchill River from Gull Lake to the confluence with Goose Bay (Figure 4-1), and within the interior waters of Goose Bay and Mud Lake (Figure 4-2), with coverage extending from Gosling Brook to Muskrat Falls
Brood surveys (late July-early August)	Gull Island rapids to Muskrat Falls (Figure 4-1)

Requesting Organization – Joint Review Panel **Information Request No.: JRP.65**

Information Requested:

The Proponent is asked to:

b. **improve the maps provided in LGL Limited (2008) (Figures 4-1, 4-2 and 4-3) to clearly indicate the Project study area and relevant geographic descriptors including survey blocks and other survey locations;**

Response:

Please see revised Figures 4-1 to 4-3 from LGL Limited (2008) in Attachment A.

Reference:

LGL Limited. 2008. Waterfowl in the Lower Churchill River Area. Prepared for Minaskuat Inc. and Newfoundland and Labrador Hydro, Lower Churchill Hydroelectric Generation Project, St. John's, NL.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.65**

Information Requested:

The Proponent is asked to:

c. indicate the scope and timeframe for completion of additional work to determine how the important open water ashkui sites are used by waterfowl, such as surf scoter, in spring (e.g., foraging); and

---

Response:

As part of the Project's proposed Follow-up and Monitoring (Chapter 7.0 in Volume IIB), aerial surveys to locate ashkui (likely in conjunction with the surveys referred to in IR# JRP.48) will be undertaken periodically from late March through May, that will document species present, their abundance and use of sites. To determine the importance of ashkui to key waterfowl species such as Surf Scoter, the following protocol is proposed: an aerial reconnaissance will be undertaken in late March to identify ashkui in the lower Churchill River watershed study area. From the identified ashkui, one site will be selected where there are substantial numbers (>20) of Surf Scoter observed. A behavioural study will be conducted at appropriate intervals (to be defined in the Follow-up and Monitoring Program) from late March through May. Time-activity budgets of birds using this ashkui site will be compiled, following methodology described by Newbury (2006). The activity budget will provide data on how the site is being used by waterfowl (e.g., Surf Scoter) and provide additional insight into its importance for foraging waterfowl.

Reference:

Newbury, T.L. 2006. Effect of low-level military aircraft on the behaviour of spring-staging waterfowl at Lac Fourmont ashkui, Labrador, Canada. M.Sc. thesis, McGill University, 85 pp.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.65**

Information Requested:

The Proponent is asked to:

d. **outline how the Proponent will respond to the various possible outcomes of baseline in terms of mitigation, adaptive management, and changes to Project design.**

Response:

Specific Monitoring and Follow-up Programs (outlined in Table 7-3 in Volume IIB) will be designed and implemented to verify effects predictions, as outlined in the response to IR# JRP.112. Typically the results of a Monitoring and Follow-up Program might indicate a requirement for additional, or a refinement of, proposed mitigation measures. The Project's adaptive management process will be used to refine and optimize mitigation measures if a need to do so is identified during the Monitoring and Follow-up Programs. Changes in Project design are not always feasible once operations begin; however, where possible, operations would be evaluated to determine if changes could be reasonably and safely adopted, to facilitate mitigation.

For example, regarding the baseline case of ashkui and their formation during the operation and maintenance phase (IR# JRP.48), reservoir preparation work for fish habitat at tributary confluences (Section 4.10.2.4 in Volume IIA) during construction would also benefit the formation of ashkui. Follow-up and Monitoring will evaluate waterfowl use of these new sites (Table 7-3 in Volume IIB; part (c)). As outlined in IR# JRP.112 all follow-up programs will be used in conjunction with an adaptive management process to modify mitigation measures if the original design did not work or did not reach the expectations placed on it in the Environmental Impact Statement (EIS). If the results of the follow-up program confirmed the ashkui formation did occur and waterfowl use of the area reached expectations no further action would be taken. If expectations were not met adaptive management measures could be developed based on the data collected to address changes in the mitigation.

INFORMATION RESPONSES
LOWER CHURCHILL PROJECT
CEAA REFERENCE NO.07-05-26178

JOINT REVIEW PANEL

Attachment A
Waterfowl Figures

IR# JRP.65

October 5, 2009

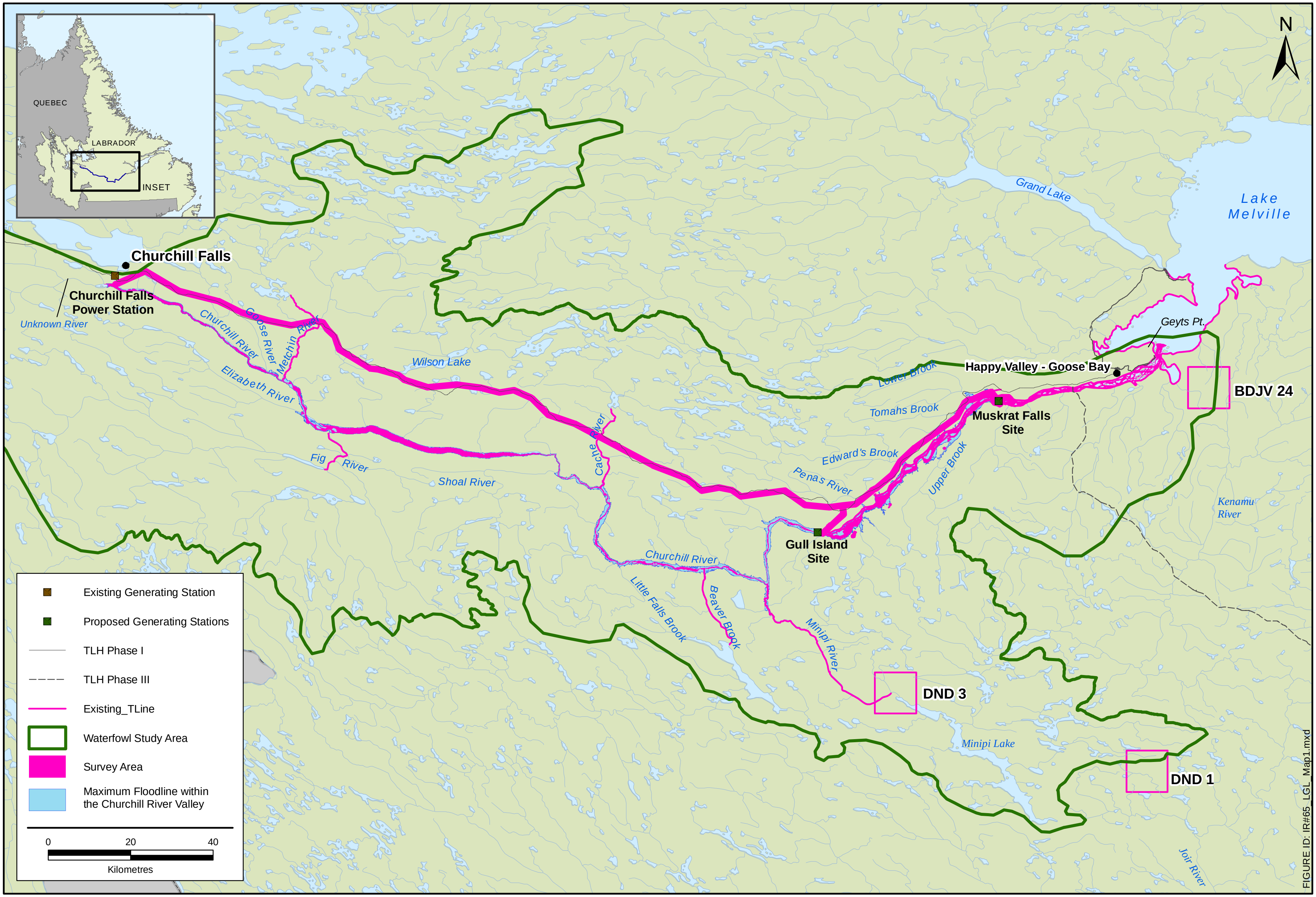

FIGURE NO: IR#JRP.65	**Revised Figure 4-1 from LGL Limited 2008** Waterfowl Surveys during 2006-2007 - Lower Churchill Watershed	DRAFT DATE: ------- REVISION DATE: -------

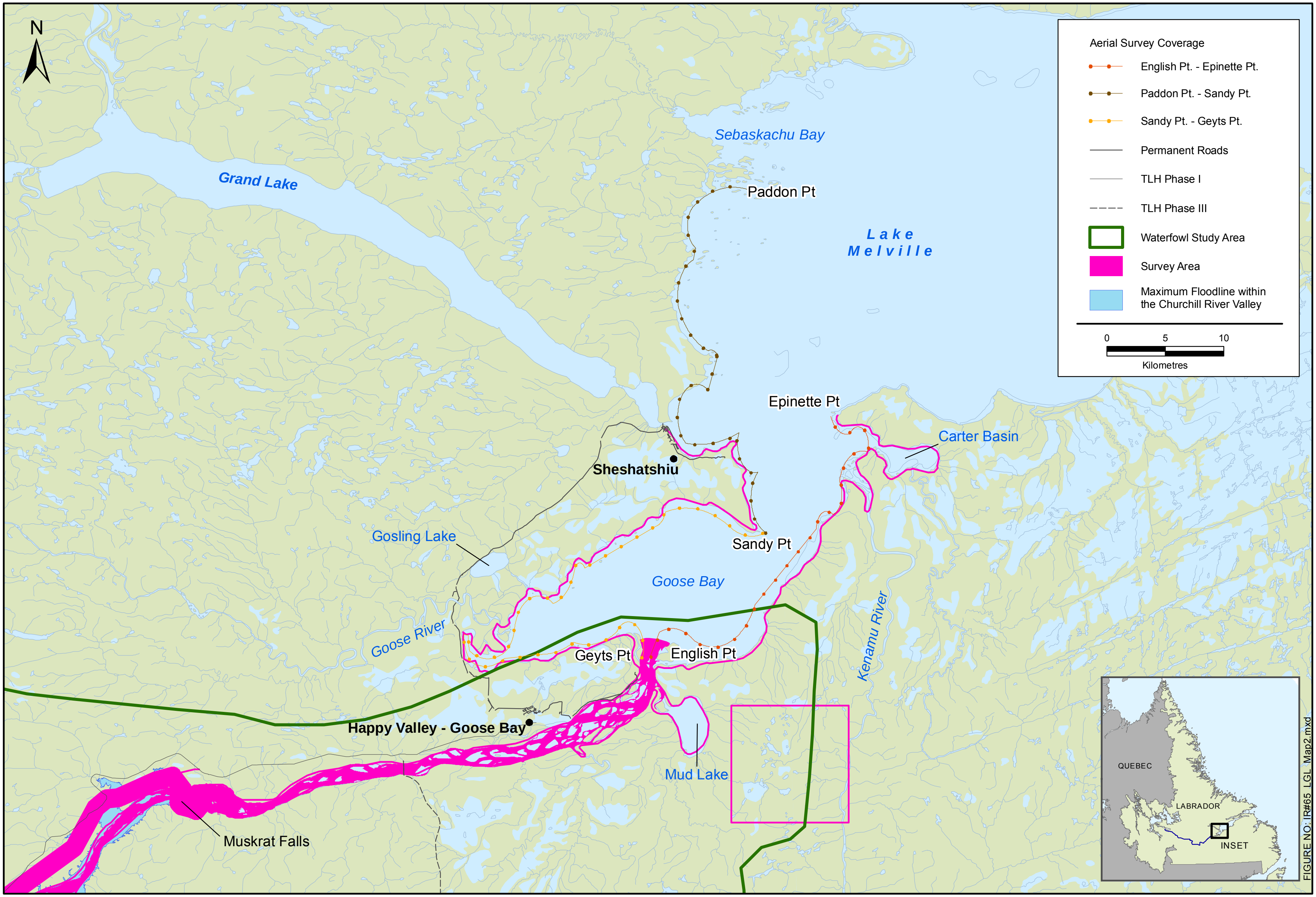

FIGURE NO:		DRAFT DATE:
IR#JRP.65	**Revised Figure 4-2 from LGL Limited 2008** Waterfowl Surveys during 2006-2007 – Goose Bay and Upper Lake Melville	------ REVISION DATE: ------

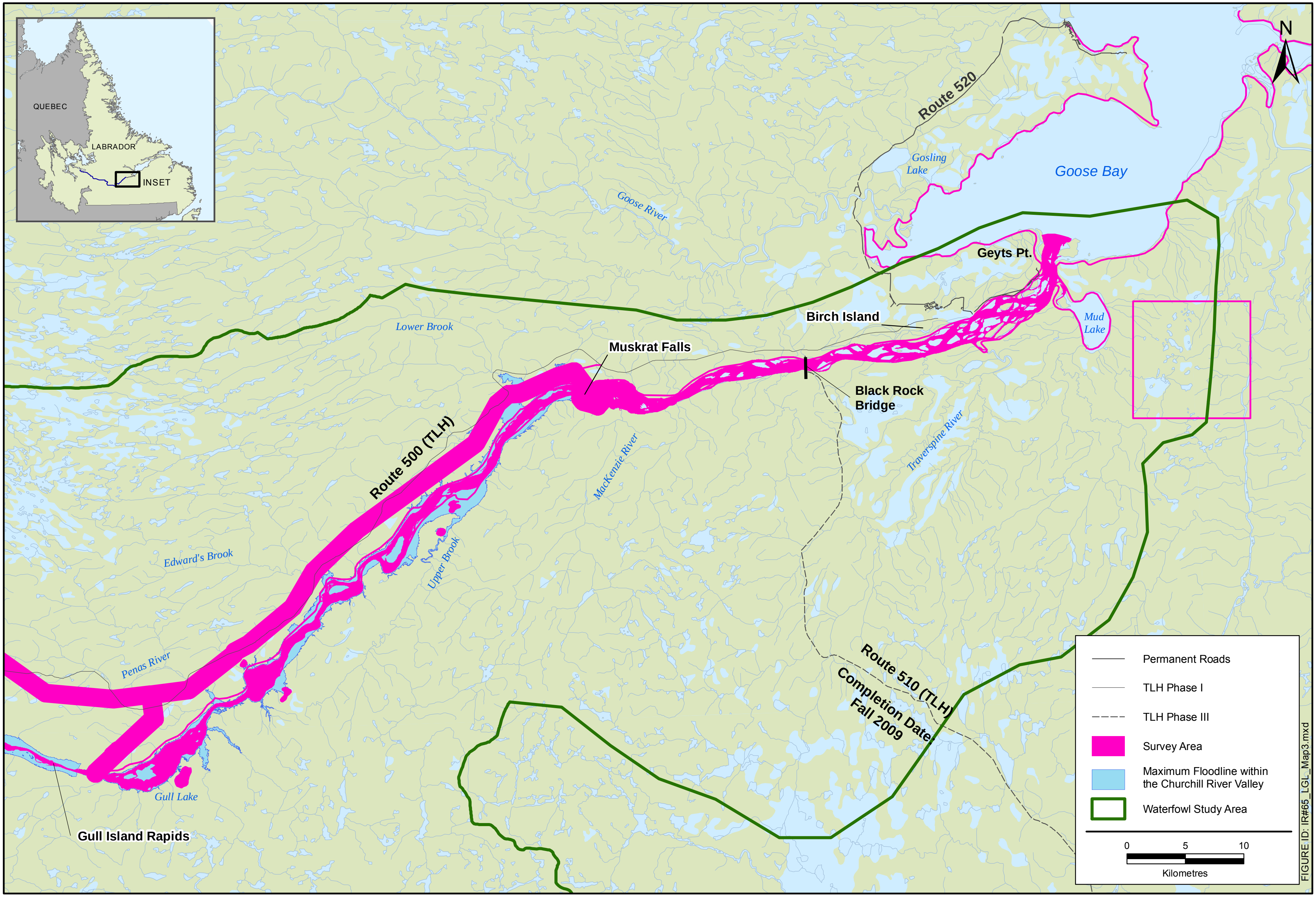

FIGURE NO:		DRAFT DATE:
IR#JRP.65	**Revised Figure 4-3 from LGL Limited 2008**	------
		REVISION DATE: ------

Waterfowl Surveys during 2006-2007 – Vicinity of Muskrat Falls

IR# JRP.66

Surficial Geology and Geochemistry – Mercury

Requesting Organization: Joint Review Panel **Information Request No.: JRP.66**

Subject: Surficial Geology and Geochemistry - Mercury

References:

EIS Guidelines, Section 4.6.1 (Mitigation)

EIS Executive Summary

EIS Volume IA, Section 1.0 (Introduction), Section 3.0 (Project Planning), Section 4.0 (Project Description)

EIS Volume IIA, (Biophysical Assessment)

EIS Volume IIB, (Biophysical Assessment)

R. Harris and D. Hutchinson (2008) *Lower Churchill Hydroelectric Generation Project - Environmental Baseline Report, Report 1: Assessment of the Potential for Increased Mercury Concentrations*.

Jacques Whitford (2006) *Lower Churchill Hydroelectric Generation Project — Environmental Impact Baseline Report, Report 4: Statistical Analysis of Mercury Data from Churchill Falls (Labrador) Corporation Reservoirs.*

Additional References:

Harris, R.C. 2005. *Reservoir Hg cycling: Modeling the FLUDEX and ELARP sites*. Presentation at workshop on Hg cycling and bioaccumulation in reservoirs, Winnipeg, Manitoba, September 26, 2005.

Johnston, T.A., R.A. Bodaly, and J.A. Mathias 1991. Predicting fish mercury levels from physical characteristics of boreal reservoirs. *Can. J. Fish. Aquat. Sci.* 48: 1468-1475

Parent, M., Lafleche, M.R., Paradis, S.J., Tremblay, C., Boisvert, E, 1995 Géochimie régionale du till, region de Ia Petite rivière de la Baleine, Québec nordique. Geological Survey of Canada, *Open File 2871*, 82 p.

Parent, M., Lafleche, M.R., Paradis, S.J., Boisvert, E. 1996. Géochixnie régionale du till, region de Kuujuarapik-Whapmagoostui, Québec nordique. Commission geologique du Canada, *Open File 3269*, 74 p.

Poly-Geo. 2008. Complexe de Ia Romaine. Evaluation des concentrations de mercure dans les sols de l'aire inondable des reservoirs projetés. Rapport sectoriel final présente a Hydro-Québec Equipement. Saint-Lambert, *Poly-Géo.35* p. et ann.

Thérien, N. 2006. Modèle prévisionnel du mercure applicable aux reservoirs hydroélectriques du Moyen-Nord quebécois. Validation et consolidation des logiciels HQEAU, HQHG et HQRIV.Rapport final presenté a l'unité Environnement, *Hydro-Quebec Production*. 113p.

Related Comments / Information Requests:

CEAR# 173 (Environment Canada)
CEAR # 180 (D. Steele - Memorial University of Newfoundland, Natural History)
CEAR# 199 (S. Davis)
CEAR # 202 (Natural Resources Canada)

IRs # JRP.20, 21, 33, 43, 63, 78, 81, 82, 107

Rationale

The EIS Guidelines require the EIS to identify and discuss the mitigation measures which would be taken to reduce or offset adverse effects of increased mercury and methylmercury (MeHg) concentrations in fish, fish-eating wildlife, and human consumers of fish and fish-eating wildlife.

While the EIS recognizes that the creation of two reservoirs in the Lower Churchill valley will lead to increased mercury concentrations in the aquatic food chain and in spite of the significant to the exposed local communities, the EIS proposes no mitigation measures other than monitoring mercury concentrations in fish and issuing consumption advisories when deemed appropriate.

NRCan has indicated that methylmercury (MeHg) contamination in reservoir ecosystems arises essentially from the decomposition of soil and plant organics in flooded terrains. This decomposition leads to the microbial conversion of inorganic mercury into methylmercury, a toxic form that bioaccumulates in fish. The pathway to successful mitigation of the methylmercury problem should include actions that will reduce either the availability of plant and soil organics promoting microbial growth and methylmercury production in flooded terrain or the overall mercury burden in flooded terrains.

The EIS (Document 5: Harris and Hutchinson, 2008) states that there is an “absence of demonstrated viable large scale mitigation options”, but indicates willingness to “remove vegetation to moderate nutrient release into the aquatic ecosystem” (Document. 1: Executive summary, p. 44).

Natural Resources Canada has provided the following detailed comments on the EIS:

Baseline characterization

EIS Volume IIA p. 2-80, section 2.4.2.11

The EIS indicates that ... “70 soil samples were taken for chemical and physical analyses from 22 sites within the potential flood zone area (Minaskuat Inc. 2008b). Of 53 samples analysed from upland mineral soils, mercury levels ranged from less than 0.01 up to 0.04 mg/kg. Eleven samples from upland forest floor horizons ranged between 0.04 and 0.21 mg/kg. Six samples from wetland organic soils had values between 0.04 to 0.10 mg/kg. Overall, mercury levels in these soils were on the low end of typical values reported for terrestrial sites in Canada (0.01 to 0.40 mg/kg) (CCME 1 999a).” Considering that the mercury contamination problem in hydro-electric reservoirs comes from flooded soils, this type of characterization is inadequate. Mercury concentrations in upland soils are not only strongly related to soil types and horizons but also to the nature and age of the vegetation cover (Parent et al., 1995, 1996; Poly-Géo, 2008). Such information should be provided in the EIS not only as baseline characterization but also as information required for the application of mitigation measures.

Mobility, transport and fate

Through document # 5 (Harris and Hutchinson, 2008), the EIS provides a clear presentation of the Proponent’s methodology and rationale for assessing the potential increase in mercury (and methylmercury) concentrations in fish. The predictive tool chosen by the Proponent is the Johnston et al. (1991) regression models rather than the more recent mechanistic models being developed at Manitoba Hydro (Harris 2005) or at Hydro-Québec (Thérien 2006). The reason given is that the more recent models have yet to be published in the peer literature. In fact, the Proponent has concentrated all its efforts in estimating the increase and duration of elevated mercury concentrations in fish and has given little or no attention to mitigation measures that may counter this contamination of reservoir biota. The fairly sophisticated Thérien model, which has recently been applied by

Hydro-Quebec for its La Romaine project, opens the possibility of assessing and testing mitigation measures in a regional context that is quite similar to the Lower Churchill Project.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.66**

Information Requested:

The Proponent is asked to provide information on:

a. **baseline characterization of the flooded soils with respect to measured mercury concentrations and information on the vegetation cover that is required for the application of mitigation measures; and**

Response:

Full mercury sampling conducted in soils is presented in Appendix E of the Project Area Ecological Land Classification (Minaskuat 2008 - Report 5 of 5 of the Air Quality, Timber Resources and Other Component Studies). Further baseline characterization of soil mercury levels was not deemed necessary as large-scale mercury attenuation related to soil mitigations were deemed unfeasible. Also, the regression modeling to predict peak fish mercury concentrations used site information related to flooded area, total area and flow (Tetra Tech 2008), but did not rely on soil mercury concentrations as a factor. The reader is referred to part (b) of this response and the response to IR# JRP.33 for additional details on the lack of feasibility to carry out large scale soil removal.

The vegetation cover as well as soil types and ecological land classification within the assessment area are described and delineated in the Project Ecological Land Classification report (Minaskuat 2008 - Report 5 of 5 of the Air Quality, Timber Resources and Other Component Studies). Descriptions of vegetation cover are described using various measures such as vegetation type (eg. Herb, Shrub, Deciduous, Coniferous) and percent cover/crown closure. Soil types are also described in terms of occurrence, texture and extent.

References:

Minaskuat 2008. Environmental Baseline Report LCP535722. Prepared for Newfoundland and Labrador Hydro.

Tetra Tech Inc. (2008) Lower Churchill Hydroelectric Generation Project Environmental Baseline Report: Assessment of the Potential for Increased Mercury Concentrations

Requesting Organization – Joint Review Panel **Information Request No.: JRP.66**

Information Requested:

The Proponent is asked to provide information on:

b. **ability of the Proponent to apply measures such as the removal of mercury-rich and carbon- rich surface horizons, which are likely to reduce the production of methylmercury in its proposed reservoirs.**

Response:

The response to IR# JRP.33(c) provides a detailed description of the potential mitigation options to reduce the net production of methylmercury. Mitigation options include reservoir clearing, vegetation burning, soil stripping, covering flooded soils with low Hg material, maintaining sediments in suspension and enhanced demethylation. The removal of mercury-rich and carbon-rich surface horizons was identified as not being a feasible option for several reasons including cost, emissions during clearing and additional disturbances for soil storage on a large scale for this Project.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.66**

Information Requested:

The Proponent is asked to identify and discuss:

c. all potential mitigation measures that could be taken to reduce or offset the adverse effects of increased mercury concentrations in fish, fish-eating wildlife, and human consumers of fish and fish-eating wildlife; and

Response:

In addition to mitigation options listed above to potentially reduce net production of methylmercury, IR# JRP.33(c) discusses additional mitigation options to reduce mercury bioaccumulation in fish, including addition of selenium, addition of nutrients, and intensive fishing.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.66**

Information Requested:

The Proponent is asked to identify and discuss:

d. discuss which of those presented are feasible.

Response:

Descriptions of mercury mitigation measures within response to IR# JRP.33(c) include a determination on the ability of the Proponent to apply such measures.

Several mitigation options have been considered to reduce mercury levels after flooding, but none have been demonstrated to be technically and economically viable on a large scale. Some options (e.g., selenium additions) also have potential side effects on the health of aquatic biota and wildlife.

IR# JRP.67

Wetlands (Text Only)

Requesting Organization – Joint Review Panel **Information Request No.: JRP.67**

Subject - Wetlands

References:

EIS Guidelines Section 4.4.4.3 (Terrestrial Environment)

Component Study: Minaskuat Inc. 2008. Wetland Assessment and Evaluation. Prepared for Newfoundland and Labrador Hydro, Lower Churchill Hydroelectric Generation Project, St. John's, NL

Related Comments / Information Requests:

CEAR # 173 (Environment Canada)
CEAR # 205 (Government of Newfoundland and Labrador – Wildlife Division)

Rationale:

The EIS Guidelines (Section 4.4.4.3) require the Proponent to provide information on the composition, distribution and abundance of wetlands as classified using the Canada Wetland Classification System, and further characterize these wetlands in terms of a functional analysis (e.g., habitat, water flow regulation, groundwater recharge). This information is incomplete within the EIS.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.67**

Information Requested:

The Proponent is asked to provide:

a. **a table that lists the identifier, location, size, class, form etc. of each wetland;**

Response:

All of the wetlands identified were classified into one of the five classes of wetlands described by the Canadian Wetland Classification System. These include Bog, Fen, Marsh, Swamp, and Shallow Water wetlands (National Wetlands Working Group 1997). A map that shows all the wetlands within the Study Area and their classification, completed as per the Canada Wetland Classification System is provided in the response to part (b) of this information request. The wetlands sampled, as per typical assessment procedure, and the information collected, are listed in Table 1 at the end of this response. It is from these mapped wetlands, that the field program was undertaken to sample the wetland classes and collect relevant information for consideration during the environmental assessment. In total, 103 representative wetlands were assessed in detail.

Reference:

National Wetlands Working Group. 1997. The Canadian Wetland Classification System. Second Edition. Edited by B.G. Warner and C.D.A Rubes, Wetlands Research Centre, University of Waterloo, Waterloo, ON.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.67**

Information Requested:

The Proponent is asked to provide:

b. a map of the location of each identified wetland;

Response:

Maps showing the locations and classes of the identified wetlands in the Project ELC Area are provided in Attachment A (Volume 7) of this submission.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.67**

Information Requested:

The Proponent is asked to provide:

c. an aerial photograph of each identified wetland;

Response:

The aerial photographs for each of the wetlands sampled are provided in Attachment A (Volume 7) of this submission. Note that a suitable aerial photograph for wetland 1063 is not available as it is well outside of the ELC Study Area. A satellite image has been used to provide the best available image for that wetland.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.67**

Information Requested:

The Proponent is asked to provide:

d. a summary, in plain language, of the functional analysis of each wetland.

Response:

A total of 103 representative wetlands were sampled during the dedicated Wetland field program and another 19 wetlands were sampled during the general Ecological Land Classification field program within the lower Churchill River study area. All sampled wetlands within the lower Churchill River study area were classified into one of the five classes of wetlands described by the Canadian Wetland Classification System. These include Bog, Fen, Marsh, Swamp, and Shallow Water wetlands (National Wetlands Working Group 1997). A general Wetland classification was used for wetlands that were not field sampled nor distinguishable from the aerial photographs. The generic wetland classification applied primarily to the Bog and Fen classes as they are often visually similar on aerial photographs. An overview map that shows all the sample sites of the dedicated Wetland field program within the study area is provided in the response to part (b) of this information request. Information on the wetlands sampled, as per typical environmental assessment procedure, which includes the area, the Canada Wetland Classification System class, form, and subform, ELC interpretation, and notes related to general site conditions is included as Table 1. This table also contains a summary of functions provided by each wetland class as defined by the National Wetlands Working Group (1997) and adapted from Jacques Whitford (2007).

Bog

Bog wetlands are organic (peat) landforms which are level or raised in comparison with surrounding terrain. Hydrologically, bogs are classed as ombrotrophic, meaning they are virtually unaffected by runoff water or ground water from surrounding mineral soils. Precipitation, fog, and snowmelt are the main sources of water and, as a result, bogs are typically acidic and low in nutrients (oligotrophic). This low nutrient status is reflected in bog vegetation which is usually dominated by sphagnum moss (*Sphagnum* spp.) and ericaceous shrubs. Where trees occur, they are usually stunted and open grown.

Typically, bogs have two main soil layers, a surface organic layer which is hydrologically and biologically active, and a deeper organic layer which is water-logged and low in (or devoid of) oxygen. The range of processes active in the surface layer, together with landscape setting, gives rise to different forms of bog wetland.

Five bog forms were classified in the study area:

- Basin bog characterized by a flat surface with the deepest peat generally in the middle of the basin. There is some runoff input from the immediate edges of the basin, but the main water source is still precipitation;
- (Northern) Plateau bog characterized by a raised surface with edges that slope down to adjacent landforms. These bogs usually have numerous water pools scattered across the surface;
- Riparian (Shore) bog found adjacent to a surface water body. These bogs are raised at least 0.5 m above the local water table, but also have a flat surface;

- Slope bog found on sloping terrain. Water sources include precipitation and some upslope drainage waters which are low in dissolved minerals; and
- String bog characterized by ridges of peat running at right angles to the direction of drainage in the wetland. The peat ridges are generally 2 to 3 m wide and less than 1 m high, with pools of water in between. Despite flows through this wetland, water and peat are still low in dissolved minerals because flows originate from other ombrotrophic wetlands.

Fen

Fen wetlands are organic landforms which have a fluctuating water table and are hydrologically connected via surface flow and/or ground water to mineral soils (classed as minerotrophic rather than ombrotrophic). This connection results in waters with greater quantities of dissolved minerals and therefore a richer nutrient regime than bog wetlands (generally classed as intermediate or mesotrophic). Fen vegetation can be variable, reflecting differences in water table depth and chemistry. Graminoid species (especially sedges) dominate wetter fens, whereas various shrub species also occur in drier fens. Trees can also be found on drier hummocks. Richer fens are dominated by sedges and brown mosses, but so-called poor fens also have bog-like vegetation present (i.e., sphagnum moss and ericaceous shrubs). Fen soils are mainly sedge and brown moss derived peat over mineral deposits.

Fen wetland forms differ by surface conditions, proximity to water bodies, and/or basin topography. Three fen forms were classified in the study area:

- Basin fen is characterized by a defined basin with no inflow streams (however, outflows may be present). Water sources include precipitation, runoff input from surrounding slopes, and ground water. Peat depths are often 2 m or more;
- Riparian (Floating/Shore) fen found floating on top of and/or adjacent to a surface water body. These fens are influenced by water table heights in the adjacent water body and may be subject to periodic flooding; and
- String (Atlantic ribbed) fen found on sloping terrain and characterized by ridges of peat running at right angles to the direction of slope (drainage). The peat ridges are generally less than 1 m wide and 1.5 m deep with pools of water in between.

Marsh

Marsh wetlands have surface water that fluctuates periodically (i.e., daily, seasonally, annually) in response to flooding, ground water recharge, seepage, tides, and/or evapotranspiration. Besides precipitation, marshes can receive water from surface runoff, stream inflow, ground water, longshore currents, and/or tidal action. As a result, marshes are classed as mineratrophic and are also usually rich (eutrophic) in relation to other wetland types. This is due, in part, to mineralization of organic material during low water periods. Vegetation is generally dominated by graminoids (cattails, rushes, sedges, grasses), shrubs, and herbaceous species. Marsh soils can be mineral (more common) or well decomposed organic, depending on landscape setting and hydrological regime.

Marsh wetland forms differ by water source and basin topography. Three marsh forms were classified in the study area:

- Basin marsh characterized by a defined basin with a variety of potential inflows (runoff, stream, ground water, flooding);

- Riparian marsh found adjacent to streams and rivers which act as the main water sources for these wetlands; and
- Lacustrine marsh found adjacent to freshwater lakes and open water bodies. Water sources can include the adjacent water body, nearby streams, ground water, and surface runoff.

Swamp

Swamps are organic or mineral wetlands characterized by shrub and/or tree cover. Along with precipitation, these wetlands receive water from surface runoff, stream inflow, and/or ground water inputs. As a result, swamps are classed as mineratrophic, but can range in fertility from poor (oligotrophic) to rich (eutrophic) depending on water quality and pH. Vegetation is dominated by shrubs (low or tall) and/or coniferous, mixedwood, and deciduous tree cover. Deciduous treed swamps tend to be associated with richer sites, whereas coniferous treed swamps can be found on a full range of sites from poor to rich. Poor coniferous treed swamps can also grade into ombrotrophic treed bogs.

Swamp wetland forms differ by landscape setting and hydrological system. Only one swamp form was classified in the study area:

- Riparian (Floodplain) swamp found adjacent to a surface water body and influenced by this water body, mainly through periodic flooding events.

Shallow Water

Shallow water wetlands are transitional between seasonally saturated or inundated wetlands (i.e., bogs, fens, marshes, swamps) and permanent, deep water bodies (e.g., lakes and ponds). By definition, shallow water wetlands have standing or flowing water less than 2 m deep in mid-summer. Vegetation cover is low, generally restricted to emergent plants, hydrophytic shrubs and trees, and floating mats.

Shallow water wetland forms differ by basin topography and proximity to different types of open water. Two shallow water forms (both freshwater) were classified in the study area:

- Basin shallow water found in topographic low positions. These wetlands are often fed by ground water recharge, but other inputs can include surface runoff, stream inflow, and snowmelt; and
- Riparian shallow water found in riparian zones of streams and rivers. The level of water in these wetlands is typically controlled by water levels in the adjacent water body.

A wetland type is determined by several factors, including its location, the depth of water, the source of the water, the mineral and nutrient level of the water, the movement of water, the destination of the water, the adjacent soil and the resulting vegetation composition. Together, these result in a physical-hydrological function, a biogeochemical function, and a habitat function. When the assessment found that wetlands would be lost, mitigation was developed to create wetlands. The wetland functions were considered when determining the types of wetland that could be created and the locations (e.g., terrain, exposure, adjacent habitat, soil types, water depths). That is to say, that to achieve comparable functions, the wetland creation mitigation will use appropriate techniques and select suitable locations.

Table 1 Summary of Functions Provided by Wetlands in Canada by Wetland Type (adapted from Jacques Whitford 2007)

Wetland Function	Wetland Value	Attributes	Wetland Sub-Forms	Probable Performance of Function
		BOG		
Physical - Hydrological Functions	Water Flow Moderation Services (flood and storm protection)	Capacity for storm water regulation is the volume difference between the maximum high-water and the regular water level in the wetland and the size of the wetland compared to the size of the watershed. The storm water dampening effect can be measured by monitoring the change discharge in relation to recharge during storm events. Value increases in relation to down-watershed development conditions (*e.g.,* coastal wetland value is low)	Applies generally to all subforms	Generally low performance. Bogs are typically isolated from surface water inputs. A large proportion of studies find that headwater wetlands increase the immediate response of rivers to rainfall because saturated soils convey rainfall rapidly
	Groundwater Recharge	Variable and difficult to quantify, and depends on basin shape, location within the watershed, substrate, local groundwater gradients, *etc.*	Bogs in permafrost regions, riparian, floating, shore, and slope	Performance is low. Bogs in permafrost regions provide little opportunity for groundwater recharge. Riparian, shore and slope bogs may be located in areas of groundwater discharge. Floating bogs have no potential to directly recharge groundwater
			Mound, dome, plateau, collapse, or scar	Variable performance expected. Areas of groundwater recharge and discharge may be located in a single bog. Recharge may occur at the bog perimeter, or within the bog where underlying soils are permeable and the flow gradient is towards groundwater. Bogs located in topographic highs with thin peat deposits may have a higher probability of performance compared to bogs in low-lying areas
	Shoreline and Erosion Protection	Presence/absence of wetland in shoreline area. Erodability of terrestrial region inland of wetland is related to composition of substrate and energy of adjacent water body. Value related to the use of terrestrial land adjacent to wetland	Applies generally to all subforms	Generally low performance. Bogs are typically present in low energy environments where erosion is not expected to be significant
	Climate Regulation	May be related to evapotranspiration rates and the size of the wetland	Applies generally to all subforms	Generally low performance. Bog communities have adapted to retain surface water, perched above local water tables and may be associated with low evapotranspiration rates

Table 1 Summary of Functions Provided by Wetlands in Canada by Wetland Type (adapted from Jacques Whitford 2007)

Wetland Function	Wetland Value	Attributes	Wetland Sub-Forms	Probable Performance of Function
BOG				
Biogeochemical Functions	Water Quality Treatment	Physical, chemical and biological water quality treatment is a function of the constituents of concern, the loading rates, water balance and hydroperiod, the substrate and vegetation assemblages. The performance can be estimated through chemistry monitoring and water budget estimates. The value is related to the sensitivity or use of receiving waters	Applies generally to all subforms	Generally low performance. Bogs are typically isolated from surface water inputs
	Nutrient and Organic Export	Export of nutrients and organic carbon to streams can fuel bacteria and subsequently the aquatic food chain. Peat lands and swamps are known to contribute to metabolism in stream ecosystems in this way; however, the internal dynamics are complex and not well understood	Applies generally to all subforms	Potentially high performance. Soluble, partially decomposed organic matter and associated nutrients produced in pore waters are flushed to down gradient water bodies during precipitation and high water events. May be a sink for nutrients (low export)
	Carbon Sequestration and Storage	The key attributes are the volume and degree of decomposition (humification) of peat, and volume of woody and ericaceous biomass. Carbon balance studies of wetland types in various climates may provide estimates of uptake; carbon uptake rates are highly variable within and between wetlands	Applies generally to all subforms	Potentially high performance. Atmospheric carbon is stored in peat and woody biomass on the order of decades to millennia. Moderately decomposed sphagnum peat with buried woody remains offers high potential for release of carbon if the wetland is disturbed or altered
Habitat Functions	Biological Productivity and Support for Biodiversity	Presence or absence of important species, and abundance of important species. Important species include species at risk, species related to recreation or subsistence, and commercially valued species	Applies generally to all subforms.	Performance is highly variable, and does not fit into a categorical framework of function. Assessment requires site specific evaluation of the presence and abundance locally valued species. Sources may include local museums, interviews with relevant stakeholders, site visits, local and provincial rare species databases, *etc.*

Table 1 Summary of Functions Provided by Wetlands in Canada by Wetland Type (adapted from Jacques Whitford 2007)

Wetland Function	Wetland Value	Attributes	Wetland Sub-Forms	Probable Performance of Function
FEN				
Physical - Hydrological Functions	Water Flow Moderation Services (flood and storm protection)	Capacity for storm water regulation is the volume difference between the maximum high-water and the regular water level in the wetland and the size of the wetland compared to the size of the watershed. The storm water dampening effect can be measured by monitoring the change discharge in relation to recharge during storm events. Value increases in relation to down-watershed development conditions (*e.g.,* coastal wetland value is low)	Applies generally to all subforms	Low to moderate performance. Small water table fluctuation provides some opportunity for additional storm flow storage; however, performance is seasonal and variable depending on morphology and placement within the watershed
	Groundwater Recharge	Variable and difficult to quantify, and depends on basin shape, location within the watershed, substrate, local groundwater gradients, *etc.*	Applies generally to all subforms	Variable to low performance expected. Highly decomposed gramminoid peat provides an impermeable layer to vertical flow. Recharge may occur at the margins of the peat
	Shoreline and Erosion Protection	Presence/absence of wetland in shoreline area. Erodability of terrestrial region inland of wetland is related to composition of substrate and energy of adjacent water body. Value related to the use of terrestrial land adjacent to wetland	Applies generally to all subforms	Generally low performance. Fens are typically present in low energy environments where erosion is not expected to be significant
	Climate Regulation	May be related to evapotranspiration rates and the size of the wetland	Applies generally to all subforms	Potentially moderate performance. A mix of emergent herbaceous plants and shrubs may be associated with moderate rates of evapotranspiration

Table 1 Summary of Functions Provided by Wetlands in Canada by Wetland Type (adapted from Jacques Whitford 2007)

Wetland Function	Wetland Value	Attributes	Wetland Sub-Forms	Probable Performance of Function
FEN				
Biogeochemical Functions	Water Quality Treatment	Physical, chemical and biological water quality treatment is a function of the constituents of concern, the loading rates, water balance and hydroperiod, the substrate and vegetation assemblages. The performance can be estimated through chemistry monitoring and water budget estimates. The value is related to the sensitivity or use of receiving waters	Applies generally to all subforms	Potentially high performance due to a combination of physical processes, high interaction between water and root-bacteria assemblages, flow through substrate, and heterogeneity in oxidation. Performance may be estimated through inflow and outflow constituent monitoring, taking into account dilution, storm events discharges, and seasonal vegetation die off. Performance is largely dependent on loading rates and the particular constituents of concern. Generalizations are not possible
	Nutrient and Organic Export	Export of nutrients and organic carbon to streams can fuel bacteria and subsequently the aquatic food chain. Peat lands and swamps are known to contribute to metabolism in stream ecosystems in this way; however, the internal dynamics are complex and not well understood	Applies generally to all subforms	Potentially high performance. Soluble, partially decomposed organic matter and associated nutrients produced in pore waters are flushed to down gradient water bodies during precipitation and high water events. May be a sink for nutrients (low export)
	Carbon Sequestration and Storage	The key attributes are the volume and degree of decomposition (humification) of peat, and volume of woody and ericaceous biomass. Carbon balance studies of wetland types in various climates may provide estimates of uptake; carbon uptake rates are highly variable within and between wetlands	Applies generally to all subforms	Potentially high performance. Atmospheric carbon is stored in peat and woody biomass on the order of decades to millennia. Highly decomposed peat and the general lack of trees suggest lower carbon storage than the bog form
Habitat Functions	Biological Productivity and Support for Biodiversity	Presence or absence of important species, and abundance of important species. Important species include species at risk, species related to recreation or subsistence, and commercially valued species	Applies generally to all subforms	Performance is highly variable, and does not fit into a categorical framework of function. Assessment requires site specific evaluation of the presence and abundance locally valued species. Sources may include local museums, interviews with relevant stakeholders, site visits, local and provincial rare species databases

Table 1 Summary of Functions Provided by Wetlands in Canada by Wetland Type (adapted from Jacques Whitford 2007)

Wetland Function	Wetland Value	Attributes	Wetland Sub-Forms	Probable Performance of Function
MARSH				
Physical - Hydrological Functions	Water Flow Moderation Services (flood and storm protection)	Capacity for storm water regulation is the volume difference between the maximum high-water and the regular water level in the wetland and the size of the wetland compared to the size of the watershed. The storm water dampening effect can be measured by monitoring the change discharge in relation to recharge during storm events. Value increases in relation to down-watershed development conditions (*e.g.,* coastal wetland value is low)	Tidal, estuarine, riparian, lacustrine, slope	Generally low performance. Marshes that lack basin morphology have a low probability of collecting and retaining large amounts of storm flow from the adjacent landscape. Marshes adjacent to watercourses, lakes and the ocean generally derive water from flood events in that body of water rather than from landscape runoff inputs. Riparian and floodplain marshes may provide considerable storm water retention if there is a large area of marsh present on the watercourse. The location of the marsh at the bottom of a watershed or on the shore of a large water body suggests that any storm flow moderation services would be iinconsequential in the context of the watershed size of the receiving body
			Basin hummock, spring	Potentially high performance. Fluctuations in water level and the size of the wetland provide an indication of the capacity for the wetland to store storm flow. Marshes located high in the watershed, up-gradient of developed areas can be expected to provide considerable storm flow moderation services
	Groundwater Recharge	Variable and difficult to quantify, and depends on basin shape, location within the watershed, substrate, local groundwater gradients, *etc.*	Tidal, estuarine, riparian, spring, lacustrine, slope, some basin marshes	Low performance expected. Fringe marshes located adjacent to water bodies are likely to have upward gradients in subsurface water. Wetlands located in topographic lows are typically sites of groundwater discharge. Recharge may occur in seasonal dry periods
			Basin, hummock marshes	Moderate to variable performance expected. Basins are typically areas of groundwater discharge; however, marshes located in prairie potholes, craters, cirques and vernal pools have demonstrated groundwater recharge potential. Marshes located in topographic highs may raise local water tables through recharge
	Shoreline and Erosion Protection	Presence/absence of wetland in shoreline area. Erodability of terrestrial region inland of wetland is related to composition of substrate and energy of adjacent water body. Value related to the use of terrestrial land adjacent to wetland	Tidal, riparian, lacustrine, estuarine	Potentially high performance. Tidal marshes and those riparian marshes adjacent to channels, floodplains, lakes and rivers are particularly important for capturing and depositing sediment (land creation), dissipating high-energy flows and waves, and maintaining cohesion of shoreline materials. Other marsh sub-forms have variable roles in shoreline and erosion protection in comparison to terrestrial and engineered systems, depending on site specific conditions

Table 1 Summary of Functions Provided by Wetlands in Canada by Wetland Type (adapted from Jacques Whitford 2007)

Wetland Function	Wetland Value	Attributes	Wetland Sub-Forms	Probable Performance of Function
MARSH				
Biogeochemical Functions	Climate Regulation	May be related to evapotranspiration rates and the size of the wetland	Applies generally to all subforms	Potentially high performance. Dense communities of herbaceous plant species adapted to fluctuating water tables may be associated with high rates of evapotranspiration
	Water Quality Treatment	Physical, chemical and biological water quality treatment is a function of the constituents of concern, the loading rates, water balance and hydroperiod, the substrate and vegetation assemblages. The performance can be estimated through chemistry monitoring and water budget estimates. The value is related to the sensitivity or use of receiving waters	Applies generally to all subforms	Potentially high performance due to a combination of physical processes, high interaction between water and root-bacteria assemblages, flow through substrate, and heterogeneity in oxidation. Performance may be estimated through inflow and outflow constituent monitoring, taking into account dilution, storm events discharges, and seasonal vegetation die off. Performance is largely dependent on loading rates and the particular constituents of concern. Generalizations are not possible
	Nutrient and Organic Export	Export of nutrients and organic carbon to streams can fuel bacteria and subsequently the aquatic food chain. Peat lands and swamps are known to contribute to metabolism in stream ecosystems in this way; however, the internal dynamics are complex and not well understood	Applies generally to all subforms	Variable performance. Actual performance due to a combination of both physical processes, high interaction between water and root-bacteria assemblages, flow through substrate, and heterogeneity in oxidation. These wetlands may mitigate upstream nutrient inputs, resulting in a net sink. Performance may be estimated through inflow and outflow constituent monitoring, taking into account dilution, storm events discharges, and seasonal vegetation die off
	Carbon Sequestration and Storage	The key attributes are the volume and degree of decomposition (humification) of peat, and volume of woody and ericaceous biomass. Carbon balance studies of wetland types in various climates may provide estimates of uptake; carbon uptake rates are highly variable within and between wetlands	Tidal, lacustrine, and riparian marshes	Moderate to low performance. Fluctuating water levels allow soil oxidation and release of stored carbon. High productivity of biomass provides sequesters considerable atmospheric carbon; however, rates of decomposition and metabolism are high and, thus, on an annual basis sequestration is typically low. Seasonally high productivity results in high overall carbon sources to the atmosphere from marshes, particularly in the form of methane

Table 1 Summary of Functions Provided by Wetlands in Canada by Wetland Type (adapted from Jacques Whitford 2007)

Wetland Function	Wetland Value	Attributes	Wetland Sub-Forms	Probable Performance of Function
Habitat Functions	Carbon Sequestration and Storage	The key attributes are the volume and degree of decomposition (humification) of peat, and volume of woody and ericaceous biomass. Carbon balance studies of wetland types in various climates may provide estimates of uptake; carbon uptake rates are highly variable within and between wetlands	Riparian, hummock, lacustrine, spring, and slope marshes	Moderate performance. Under persistent inundation organic soils may accumulate. Vegetation productivity in rich conditions may be greater than decomposition in persistent anaerobic conditions. Only lacustrine and riparian marshes with stable water levels typically accumulate organic matter
	Biological Productivity and Support for Biodiversity	Presence or absence of important species, and abundance of important species. Important species include species at risk, species related to recreation or subsistence, and commercially valued species	Applies generally to all subforms	Performance is highly variable, and does not fit into a categorical framework of function. Assessment requires site specific evaluation of the presence and abundance locally valued species. Sources may include local museums, interviews with relevant stakeholders, site visits, local and provincial rare species databases
SWAMP				
Physical - Hydrological Functions	Water Flow Moderation Services (flood and storm protection)	Capacity for storm water regulation is the volume difference between the maximum high-water and the regular water level in the wetland and the size of the wetland compared to the size of the watershed. The stormwater dampening effect can be measured by monitoring the change discharge in relation to recharge during storm events. Value increases in relation to down-watershed development conditions (*e.g.,* coastal wetland value is low)	Discharge swamp, mineral rise swamp, raised peatland, slope swamp, tidal swamp	Generally low performance. The typical topography and watershed position of these wetlands suggest that they have little capacity to capture and store storm water
			Riparian flat swamp, inland salt swamp	Potentially high performance. Treed riparian areas with a full understory act to capture flood waters, slow velocities and store flood water on the order of days to weeks, depending on the size, morphology and location within the watershed. The location of the swamp at the bottom of a watershed or on the shore of a large water body suggests that any storm flow moderation services would be inconsequential in the context of the watershed size of the receiving body. Flat swamps are generally fed by surface runoff and experience water level fluctuations, indicating a capacity during low water periods to accommodate additional storm water inputs

Table 1 Summary of Functions Provided by Wetlands in Canada by Wetland Type (adapted from Jacques Whitford 2007)

Wetland Function	Wetland Value	Attributes	Wetland Sub-Forms	Probable Performance of Function
SWAMP				
Physical - Hydrological Functions	Groundwater Recharge	Variable and difficult to quantify, and depends on basin shape, location within the watershed, substrate, and local groundwater gradients	Discharge, riparian, tidal, inland salt swamp or slope swamp	Generally low performance. The typical hydrology giving rise to these systems suggests that groundwater recharge potential is low.
			Raised peatland, flat or mineral-rise swamp	Unknown potential for performance. Depends on site specific morphology, substrate, and location within the watershed flow system
	Shoreline and Erosion Protection	Presence/absence of wetland in shoreline area. Erodability of terrestrial region inland of wetland is related to composition of substrate and energy of adjacent water body. Value related to the use of terrestrial land adjacent to wetland	Riparian and tidal swamps	Potentially high performance. Tidal swamps and those riparian swamps adjacent to channels, floodplains, lakes and rivers are particularly important for capturing and depositing sediment (land creation), dissipating high-energy flows and waves, and maintaining cohesion of shoreline materials. Other swamp sub-forms have variable roles in shoreline and erosion protection in comparison to terrestrial and engineered systems, depending on site specific conditions
	Climate Regulation	May be related to evapotranspiration rates and the size of the wetland	Applies generally to all subforms	Potentially moderate performance. A mix of emergent herbaceous plants and shrubs may be associated with moderate rates of evapotranspiration
Biogeochemical Functions	Water Quality Treatment	Physical, chemical and biological water quality treatment is a function of the constituents of concern, the loading rates, water balance and hydroperiod, the substrate and vegetation assemblages. The performance can be estimated through chemistry monitoring and water budget estimates. The value is related to the sensitivity or use of receiving waters	Applies generally to all subforms	Potentially high performance due to a combination of physical processes, high interaction between water and root-bacteria assemblages, flow through substrate, and heterogeneity in oxidation. Performance may be estimated through inflow and outflow constituent monitoring, taking into account dilution, storm events discharges, and seasonal vegetation die off. Performance is largely dependent on loading rates and the particular constituents of concern. Generalizations are not possible
	Nutrient and Organic Export	Export of nutrients and organic carbon to streams can fuel bacteria and subsequently the aquatic food chain. Peat lands and swamps are known to contribute to metabolism in stream ecosystems in this way; however, the internal dynamics are complex and not well understood	Applies generally to all subforms	Variable performance. Actual performance due to a combination of both physical processes, high interaction between water and root-bacteria assemblages, flow through substrate, and heterogeneity in oxidation. These wetlands may mitigate upstream nutrient inputs, resulting in a net sink. Performance may be estimated through inflow and outflow constituent monitoring, taking into account dilution, storm events discharges, and seasonal vegetation die off

Table 1 Summary of Functions Provided by Wetlands in Canada by Wetland Type (adapted from Jacques Whitford 2007)

Wetland Function	Wetland Value	Attributes	Wetland Sub-Forms	Probable Performance of Function
Biogeochemical Functions	Carbon Sequestration and Storage	The key attributes are the volume and degree of decomposition (humification) of peat, and volume of woody and ericaceous biomass. Carbon balance studies of wetland types in various climates may provide estimates of uptake; carbon uptake rates are highly variable within and between wetlands	Applies generally to all subforms	Moderate to high performance. Decomposed peat and woody vegetation store atmospheric carbon on the order of years to centuries. Seasonal cycles of fluctuating water table allow biomass and soil decomposition; however, high biomass productivity due to rich soils and porewater may offset decomposition in some swamps
Habitat Functions	Biological Productivity and Support for Biodiversity	Presence or absence of important species, and abundance of important species. Important species include species at risk, species related to recreation or subsistence, and commercially valued species	Applies generally to all subforms	Performance is highly variable, and does not fit into a categorical framework of function. Assessment requires site specific evaluation of the presence and abundance locally valued species. Sources may include local museums, interviews with relevant stakeholders, site visits, local and provincial rare species databases, *etc.*
SHALLOW WATER				
Physical - Hydrological Functions	Water Flow Moderation Services (flood and storm protection)	Capacity for storm water regulation is the volume difference between the maximum high-water and the regular water level in the wetland and the size of the wetland compared to the size of the watershed. The storm water dampening effect can be measured by monitoring the change discharge in relation to recharge during storm events. Value increases in relation to down-watershed development conditions (*e.g.,* coastal wetland value is low)	Basin	Potentially high performance. Fluctuations in water level and the size of the wetland provide an indication of the capacity for the wetland to store storm flow. The location of the shallow water wetland at the bottom of a watershed suggests that any storm flow moderation services would not be remarkable in the context of the watershed size of the receiving body
			Tidal estuarine, lacustrine riparian	Generally low performance. Shallow water wetlands without basin morphology have a low probability of collecting and retaining large amounts of storm flow from the adjacent landscape. The location of the wetland at the bottom of a watershed or on the shore of a large water body suggests that any storm flow moderation services would not be remarkable in the context of the watershed size of the receiving body
	Groundwater Recharge	Variable and difficult to quantify, and depends on basin shape, location within the watershed, substrate, local groundwater gradients, *etc.*	Applies generally to all subforms	Unknown potential for performance. Depends on site specific conditions

Table 1 Summary of Functions Provided by Wetlands in Canada by Wetland Type (adapted from Jacques Whitford 2007)

Wetland Function	Wetland Value	Attributes	Wetland Sub-Forms	Probable Performance of Function
			SHALLOW WATER	
Physical - Hydrological Functions	Shoreline and Erosion Protection	Presence/absence of wetland in shoreline area. Erodability of terrestrial region inland of wetland is related to composition of substrate and energy of adjacent water body. Value related to the use of terrestrial land adjacent to wetland	Estuarine, lacustrine and riparian	Potentially moderate performance. Submerged vegetation may contribute to dissipating and buffering high energy flows and wave activity prior to entering adjacent emergent wetland system
			Basin	Generally low performance. Basin form shallow water wetlands are not typically in a position in the landscape to provide shoreline and erosion protection
	Climate Regulation	May be related to evapotranspiration rates and the size of the wetland	Applies generally to all subforms	Potentially moderate performance. Standing open water and a mix of emergent and submergent plant species may be associated with moderate rates of evapotranspiration
Biogeochemical Functions	Water Quality Treatment	Physical, chemical and biological water quality treatment is a function of the constituents of concern, the loading rates, water balance and hydroperiod, the substrate and vegetation assemblages. The performance can be estimated through chemistry monitoring and water budget estimates. The value is related to the sensitivity or use of receiving waters	Applies generally to all subforms	Potentially high performance due to settling, photo-degradation and aeration. Performance is largely dependent on loading rates and constituents of concern. May be estimated through inflow and outflow constituent monitoring, taking into account dilution and seasonal events such as water column turnover and vegetation die off
	Nutrient and Organic Export	Export of nutrients and organic carbon to streams can fuel bacteria and subsequently the aquatic food chain. Peat lands and swamps are known to contribute to metabolism in stream ecosystems in this way; however, the internal dynamics are complex and not well understood	Applies generally to all subforms	Generally low performance. Labile organic matter and nutrients released from root exudates and the decomposition of biomass are circulated and used within the water column

Table 1 Summary of Functions Provided by Wetlands in Canada by Wetland Type (adapted from Jacques Whitford 2007)

Wetland Function	Wetland Value	Attributes	Wetland Sub-Forms	Probable Performance of Function
SHALLOW WATER				
Biogeochemical Functions	Carbon Sequestration and Storage	The key attributes are the volume and degree of decomposition (humification) of peat, and volume of woody and ericaceous biomass. Carbon balance studies of wetland types in various climates may provide estimates of uptake; carbon uptake rates are highly variable within and between wetlands	Applies generally to all subforms	Moderate to low performance. Considerable seasonal productivity of biomass results in seasonal uptake. Rates of decomposition and metabolism are high and, thus, on an annual basis sequestration is typically low
Habitat Functions	Biological Productivity and Support for Biodiversity	Presence or absence of important species, and abundance of important species. Important species include species at risk, species related to recreation or subsistence, and commercially valued species	Applies generally to all subforms	Performance is highly variable, and does not fit into a categorical framework of function. Assessment requires site specific evaluation of the presence and abundance locally valued species. Sources may include local museums, interviews with relevant stakeholders, site visits, local and provincial rare species databases

References:

Jacques Whitford 2007. Wetland Valuation in Atlantic Canada. Report prepared for Strategic Analysis and Policy Division, Environment Canada. Dartmouth, NS.

National Wetlands Working Group. 1997. The Canadian Wetland Classification System. Second Edition. Edited by B.G. Warner and C.D.A Rubes, Wetlands Research Centre, University of Waterloo, Waterloo, ON.

JRP.67 PART 1

(Click above link to go to file)

JRP.67 PART 2

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JRP.67 PART 3

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JRP.67 PART 6

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IR# JRP.68

Impacts on Bank Swallows

Requesting Organization – Joint Review Panel **Information Request No.: JRP.68**

Subject - Impacts on Bank Swallows

References:

Minaskuat Inc. 2008. Forest Songbird Surveys. Prepared for Newfoundland and Labrador Hydro, Lower Churchill Hydroelectric Generation Project, St. John's, NL.

Related Comments / Information Requests:

CEAR # 151 (G. Sabau)
CEAR # 173 (Environment Canada)

IR # JRP.95

Rationale:

According to the Avifauna Component Study of the Lower Churchill Hydroelectric Generation Project EIS, Bank Swallows were found nesting within the Project area. Bank Swallows nest in colonies and usually lay their eggs in holes along shorelines. This species returns to the same nesting colony year after year. The EIS does not discuss impacts on or mitigation measures for bank swallows or other bank-nesting birds if the nest sites are to be flooded.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.68**

Information Requested:

The Proponent is asked to provide:

a. a discussion of impacts of flooding on bank-nesting birds in general;

Response:

Bank Swallow (*Riparia riparia)* is the most common bank nesting species in the lower Churchill River watershed and nests in colonies. Less common in the area, but known to nest in similar habitat as a solitary nester, is the Belted Kingfisher (*Megaceryle alcyon*). Bank Swallows usually nest in tunnels at the top of sand or gravel banks. Their scientific name refers to their association with rivers during migration and their predilection for nesting along sandy gravelly river banks (Alsop 2001). The areas used by Bank Swallows are often relatively dynamic in that they may be continually reworked naturally. Nesting banks used are often devoid of vegetation and relatively steep, presumably to reduce depredation of burrows which can be a metre in length. These birds tend to nest at the top of embankments as it is believed that burrows are more easily excavated there rather than on the more compressed lower areas.

It is anticipated that some areas currently used for nesting by Bank Swallows would be subject to inundation and later seasonal fluctuations in the reservoir level. Once the reservoirs are established, it is unlikely birds would establish nest sites in the flood zone. Nest sites located below the flood line would be destroyed. Depending on the configuration of the embankment it would likely be subject to further slumping which could result in the formation of additional suitable habitat to provide new nest sites.

Reference:

Alsop, F.J. III. 2001. Birds of North America - Eastern Region. DK Publishing, Inc. New York.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.68**

Information Requested:

The Proponent is asked to provide:

b. an assessment of whether Bank Swallow or other bank-nesting bird nests / colonies will be flooded (including the location and how many will be impacted); and

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Response:

Consideration was given in the Environmental Impact Statement (EIS) to the potential effects of inundation and habitat alteration on avifauna species. Specifically, this issue was addressed for a number of Key Indicator (KI) species including Canada Goose, Wetland Sparrows, Harlequin Ducks and Other Species of Concern (Common Nighthawk, Rusty Blackbird Olive-sided Flycatcher and Gray-cheeked Thrush). Eight of the species identified as KIs are passerines, as are Bank Swallows, and therefore consistent with the approach outlined in the EIS, serve as an appropriate surrogate for this species.

Colonies of Bank Swallows were recorded on eroding banks located on the Minipi River, south of the Churchill River; at the confluence of the Metchin River and Churchill River; and approximately 3 km west of the Metchin River on the Churchill River. Each of these locations occurs within the projected area of the reservoirs. There are many areas, particularly at the lower end of the lower Churchill River, which are used as nesting areas by Bank Swallows.

As noted in part (a) it is expected that some nesting locations will be flooded. To address this issue, it was indicated in the EIS that a management plan will be designed and implemented to reduce the possibility of incidental take (loss or disturbance to active nests). Bank nesting birds would also be the subject of species specific surveys. This would require a survey along the areas to be flooded to document suitable nesting habitat and confirmation of the nesting activity. This survey would be timed to coincide with the breeding season as active colonies can be easily recognized. Until this survey has been completed, it is not possible to say how many colonies will be affected by inundation.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.68**

Information Requested:

The Proponent is asked to provide:

c. **mitigation measures to be implemented.**

Response:

As noted, the management plan mentioned in part (b) above would be designed to also address issues related to bank nesting birds.

Depending on the circumstances, as noted in the response to part (a) above, no mitigation may be required depending on the nature of the site being utilized and its exposure to flooding. The site itself may be prone to further slumping due to the higher water levels and suitable habitat may be created in response to the flooding. If this is not the case, it would be possible to create or enhance habitat that is able to support Bank Swallow colonies as they are noted to utilize industrial sand piles and gravel pits which have been anthropogenically created. Nalcor Energy will leave borrow areas near reservoirs sloped to so as to encourage their use by Bank Swallows or expose or shape sand banks in appropriate locations to enhance potential nesting locations.

IR# JRP.69

Species at Risk

Requesting Organization – Joint Review Panel **Information Request No.: JRP.69**

Subject - Species at Risk

References:

EIS Guidelines 4.4.4.3 (Terrestrial Environment)

EIS, Volume II A Section 2.4.16.2 Baseline Conditions for Other Species of Concern pg. 2-175

Related Comments / Information Requests:

CEAR # 173 (Environment Canada)
CEAR # 205 (Government of Newfoundland and Labrador – Wildlife Division)

Rationale:

Environment Canada has indicated that more data is available for Central Labrador on several species at risk than are included in the EIS. Species and sources are listed below:

- Olive–sided Flycatcher -- "Its presence has been noted on the Happy Valley Breeding Bird Survey route…."

They have also been found on the Ossok Breeding Bird Survey (BBS) route, Orma Road BBS route, and Churchill Falls BBS route: http://www.pwrc.usgs.gov/bbs/RawData/Choose- Method.cfm

- Gray-cheeked Thrush – "This species was not recorded on the Happy Valley Breeding Bird Survey route (Sauer et al. 2007).

This species is a regular breeder in central Labrador - also been found on the Ossok BBS route, Orma Road BBS route, and Churchill Falls BBS route:

http://www.pwrc.usgs.gov/bbs/RawData/Choose-Method.cfm

- Rusty Blackbird – "It is generally uncommon, with only four individuals recorded on the Happy Valley Breeding Bird Survey route over 13 years (Sauer et al. 2007)."

See the other BBS routes in central Labrador - This species is a regular breeder in central Labrador - also been found on the Ossok BBS route, Orma Road BBS route, and Churchill Falls BBS route: http://www.pwrc.usgs.gov/bbs/RawData/Choose-Method.cfm

Requesting Organization – Joint Review Panel **Information Request No.: JRP.69**

Information Requested:

The Proponent is asked to:

a. **update the document with data from the BBS sources indicated;**

Response:

Breeding Bird Survey (BBS) data were originally reviewed for only the Happy Valley BBS route, as the other three routes in the Churchill Falls area are partly to largely outside the lower Churchill River watershed. While the same is true of the Happy Valley route, the habitat surveyed is comparable to that along nearby portions of the lower Churchill River watershed. In contrast the Ossok, Orma Road, and Churchill Falls BBS routes largely survey upland areas. While these are also represented in the upper regions of the lower Churchill River watershed, they are less similar to the habitat in the lower Churchill River valley that might be affected by the Project. Regardless, as the Terrestrial Environment Assessment Area is defined as the lower Churchill River watershed, it is appropriate to reference the data from all four BBS routes. Accordingly, the relevant sections of Volume IIA, Section 2.4.16.2 are updated as follows (cited references appear as in the EIS):

Olive-sided Flycatcher

The northeastern range of the Olive-sided Flycatcher extends into Labrador, as far as the lower Churchill River watershed (Godfrey 1986; Dunn and Alderfer 2007; NatureServe 2007, Internet site). Its presence has been noted on the Happy Valley Breeding Bird Survey route, with single individuals recorded during its first five years (1978, 1994 to 1997), and another three individuals in 1999, but none at all during the seven occasions the route was covered between 2000 and 2007 (USGS 2009). The species is more regular on the Ossok BBS route, having been observed in 7 of 11 years, but is rare along the Orma Road (two records over 14 years) and Churchill Falls (one record over nine years) BBS routes (USGS 2009). Overall, the BBS data suggest Olive-sided Flycatcher is a rare and somewhat irregular breeder in Central Labrador, and while the numbers are too small to statistically evaluate, they are consistent with the pattern of decline observed across the range of the species.

The Olive-sided Flycatcher was designated Threatened by COSEWIC in 2007, having not previously been considered a Species of Conservation Concern (COSEWIC 2007). Since 2004, it has been considered near-threatened by the World Conservation Union (IUCN 2007, Internet site). The Canadian breeding population declined at an average annual rate of 3.94 percent between 1966 and 2006, for a cumulative loss of over 80 percent of the population during that period. Although loss of breeding habitat is a proposed cause of this decline, the preference of the species for fragmented forests and edge habitat suggests that other factors are also involved. Loss or alteration of wintering habitat may be a greater concern. This species overwinters in northern South America and Central America (Volume IIA, Figure 2-54) (Altman and Sallabanks 2000, Internet site).

Gray-cheeked Thrush

The Gray-cheeked Thrush has not been reviewed by COSEWIC, but is provincially designated as Vulnerable under NLESA. Its range extends across much of Labrador (Volume IIA, Figure 2-54) and includes the lower Churchill River watershed (Todd 1963; Godfrey 1986; Lowther et al. 2001, Internet site). Although there are fewer than five documented reports each from Happy Valley-Goose Bay and North West River (Dalley et al. 2005), this likely reflects a general lack of documentation of songbirds, rather than an accurate inventory regarding the abundance of Gray-cheeked Thrush. It was reported annually on the Happy Valley BBS route between 1994 and 1999, but has not been observed in the seven years the route has been surveyed since (USGS 2009). On the Ossok, Orma Road, and Churchill Falls BBS routes the species is more regular and common, being observed almost annually on each route, with a mean annual count of 4 to 12 individuals per route (USGS 2009).

Rusty Blackbird

The Rusty Blackbird occurs across most of Labrador except the far north (Godfrey 1986; NatureServe 2007, Internet site). Along the Happy Valley BBS route it is uncommon, with only four individuals recorded over 14 years, with the last record in 1996 (USGS 2009). On the Ossok, Orma Road, and Churchill Falls BBS routes it is more regular and common, having been observed annually on each, except for Churchill Falls in 2008, and with mean annual counts ranging from 3 to 11 individuals per route. The Churchill Falls BBS data show a sharp decline between a mean of 10 individuals annually from 1973 to 1978 to a mean of one individual annually from 2006 to 2008 (USGS 2009).

The Rusty Blackbird was designated a Species of Special Concern by COSEWIC in 2007, having not previously been considered at risk (COSEWIC 2007). The species has undergone a widespread and substantial decline across its range. The factors behind its decline remain poorly understood but likely include the loss of both breeding and wintering habitat, and possibly methylmercury contamination and mortality from blackbird control efforts on its wintering grounds (Volume IIA, Figure 2-54) (COSEWIC 2006, Internet site; IUCN 2007, Internet site). The magnitude and rate of decline are sufficient for the World Conservation Union to consider the species globally vulnerable (IUCN 2007, Internet site).

References:

Altman, B. and R. Sallabanks. 2000. Olive-sided Flycatcher (*Contopus cooperi*). In: A. Poole (ed.). The Birds of North America Online. Cornell Lab of Ornithology; Ithaca, NY. Available at: http://bna.birds.cornell.edu.bnaproxy.birds.cornell.edu/bna/species/502doi:bna.502.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2007. Canadian Species at Risk. Committee on the Status of Endangered Wildlife in Canada. 84 pp.

Dalley, K., K. Powell and D. Whitaker. 2005. The Status of Gray-cheeked Thrush (Catharus minimus) in Newfoundland and Labrador. Prepared for the Newfoundland and Labrador Species Status Advisory Committee. 19 pp.

Dunn, J.L. and J. Alderfer (Eds). 2007. Field Guide to the Birds of North America. Fifth Edition. National Geographic Society, Washington, DC.

Godfrey, W.E. 1986. Birds of Canada, Revised edition. National Museum of Natural Sciences, Ottawa, ON.

IUCN (International Union for the Conservation of Nature). 2007. The 2007 IUCN Red List of Threatened Species. International Union for the Conservation of Nature and Natural Resources. Available at: http://www.iucnredlist.org.

Lowther, P.E., C.C. Rimmer, B. Kessel, S.L. Johnson and W.G. Ellison. 2001. Gray-cheeked Thrush (*Catharus minimus*). In: A. Poole (ed.). The Birds of North America Online. Cornell Lab of Ornithology, Ithaca, NY. Available at: http://bna.birds.cornell.edu.bnaproxy.birds.cornell.edu/bna/species/591doi:bna.591.

NatureServe. 2007. NatureServe Explorer: An Online Encyclopedia of Life. Version 6.2. NatureServe, Arlington, Virginia. Available at http://www.natureserve.org/explorer.

Todd, W.E. 1963. Birds of the Labrador Peninsula and Adjacent Areas. University of Toronto Press, Toronto, ON.

USGS Patuxent Wildlife Research Center. 2009. North American Breeding Bird Survey Internet data set, 12 July 2009 (http://www.pwrc.usgs.gov/bbs/retrieval/)

Requesting Organization – Joint Review Panel **Information Request No.: JRP.69**

Information Requested:

The Proponent is asked to:

b. re-visit the impact analysis presented for species of concern given the new information; and

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Response:

The effects analysis was based on the extent of changes to available nesting habitat within the lower Churchill River watershed (Volume IIB, Section 5.11). Olive-sided Flycatcher, Grey-cheeked Thrush and Rusty Blackbird were documented as occurring in small numbers in the watershed through point count surveys conducted for the Project, and these results contributed to the designation of primary, secondary, and tertiary habitats for each species within the survey area. While the BBS data provide additional records of these species in and adjacent to the Assessment Area, they have no associated habitat data, and therefore offer no new information which could be used to update the effects analysis.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.69**

Information Requested:

The Proponent is asked to:

c. **indicate whether changes to the impact analysis are required, and indicate how and where these changes were made and any implications.**

Response:

Changes are not required, as the effects analysis was assessed on the basis of expected changes in habitat availability (Volume IIB, Section 5.11), which is unaffected by the actual abundance of these species in adjacent areas.

IR# JRP.70

Medicinal Herbs and Plants and Country Food Plants

Requesting Organization – Joint Review Panel **Information Request No.: JRP.70**

Subject - Medicinal Herbs and Plants and Country Food Plants

References:

EIS Guidelines, Section 4.4.4.3 (Description of the existing environment – Terrestrial environment) & Section 4.4.4.4. (Land and Resource Use)

EIS Volume IB, Appendix IB-H (Report of the Work of the Innu Traditional Knowledge Committee)

EIS Volume IIA, Section 2.1 (The Landscape) & Section 2.4.2.10 (Rare or Uncommon Plants)

Volume III, Section 5.5.1 (Environmental Effects Assessment – Land and Resource Use) & Section 5.6 (Summary of Residual Environmental Effects and Evaluation of Significance)

Related Comments / Information Requests:

IRs # JRP. 74, 81, 91, 103

Rationale:

The EIS Guidelines require the Proponent to describe the composition, distribution, and abundance of medicinal herbs and plants harvested by affected Aboriginal communities. The Biophysical Assessment provides some discussion of harvesting of Canada Yew (Volume IIA, p2-79), of berries in the Muskrat Falls to Lake Melville area (Volume IIA, p. 2-5), and of country medicine (Appendix IB-H p.64, p.88) but there is no information on overall baseline composition, distribution and abundance of medicinal plants presented in the description of the existing environment.

The EIS Guidelines (Section 4.4.4.4) also require the Proponent to describe "other rural land and resource use including existing and potential recreational and commercial fishing and hunting, **gathering of country food and collection of plant propagules**" (p. 28) (emphasis added).

Impacts to berry picking and medicinal plants, as measured by changes in berry picking areas and areas with medicinal plants, are selected as a measurable parameter for the land and resource use assessment (Volume III, p.5-7). The EIS states that "[t]he Project will result in the loss of several hectares of burn-over that provide suitable conditions for berry growth and berry picking. However, this represents a small portion of such areas available throughout the Assessment Area, and berry populations will remain sustainable" (p.5-15). In addition, the EIS states that "[p]opulations of other medicinal plants (e.g., willow, dogberry or northern mountain ash, redberries, mushrooms) will remain sustainable in the Assessment Area" (p.5-16). Little baseline information is provided on medicinal herbs and plants or likely areas for gathering of these and other plant propagules. Therefore it is not possible to assess the accuracy of these statements and follow the theory or rationale that led to the determination that "habitat loss will be localized and is not anticipated to be of sufficient scale or magnitude to cause a reduction in the level of these activities [medicinal plant and country food plant] within the Assessment Area" (p.5-35).

Requesting Organization – Joint Review Panel **Information Request No.: JRP.70**

Information Requested:

The Proponent is asked to provide additional information on:

a. **the composition, distribution, and abundance of medicinal herbs and plants (including fungi) including habitat association(s);**

Response:

Primary data regarding the present importance and frequency of medicinal plant and country food plant gathering activities to local Aboriginal communities was not available for this Project (please refer to IR# JRP.1 and IR# JRP.2).

Secondary source information indicates that Aboriginal groups including Labrador Innu and Labrador Métis collect plant species for medicinal purposes and for food in the vicinity of the Project. A comprehensive additional literature review identified no information on the present importance and frequency of medicinal plant and country food plant gathering activities to the local Aboriginal communities (the Labrador Innu, Labrador Inuit, the Labrador Métis, or the Quebec Innu) beyond that presented in the EIS.

Sources that were searched for information on medicinal plant species are provided in the "References" section at the end of this response. The plant species listed in Table 1 have been identified by various sources as having been used for medicinal purposes. The importance and frequency of use was not documented.

Table 1 Plant Species used for Medicinal Purposes

Local Name	Likely Species	Information Source
Balsam Fir	*Abies balsamea*	Innu Nation 2007 Lethbridge 2007
Bay Bush	*Myrica gale*	Lethbridge 2007
Birch	*Betula cordifolia* or *B. papyifera*	Innu Nation 2007
Black Spruce	*Picea mariana*	Innu Nation 2007 Lethbridge 2007
Canada Yew	*Taxus canadensis*	Innu Nation 2007
Ground Juniper	*Juniperus communis*	Lethbridge 2007
Labrador Tea	*Rhododendron groenlandicum*	Innu Nation 2007
Mushrooms (species not identified)	Unidentified Species	Innu Nation 2007
Northern Mountain Ash (Dogberry)	*Sorbus decora*	Innu Nation 2007
Poplar/Aspen	*Poplus tremuloides*	Innu Nation 2007
Puffball	Unidentified Species	Lethbridge 2007
Tamarack	*Larix laricina*	Innu Nation 2007 Lethbridge 2007
White Spruce	*Picea glauca*	Innu Nation 2007 Lethbridge 2007
Willow	*Salix* spp.	Innu Nation 2007

In addition to the species listed in Table 1, others are referenced in Clement 1990. However, these were collected in the Mingan area of Quebec, over 400 km southwest of Happy Valley-Goose Bay, and were not found in other references for the lower Churchill River valley area. The referenced sources did not indicate that Quebec Innu or Labrador Inuit harvest plants for medicinal purposes in the vicinity of the Project.

Information regarding the distribution and abundance of these species, as well as habitat associations, within the lower Churchill River valley is provided in Table 2. The interconnecting transmission line route has not yet been finalized and therefore the precise location of the cleared right-of-way with associated habitat types cannot be defined. Juniper and mountain ash were observed in low numbers during the baseline surveys; mountain ash was observed in most of the forested ecotypes and juniper was observed in one or two ecotypes. The locations of these species were not documented in the source references and therefore it is not known where these species were most commonly collected. With the exception of Canada yew, the other recorded species are common throughout this area. Favoured habitat associations of these species were selected based on ground cover and frequency of occurrence within an ecotype, as presented in the Ecological Land Classification (Minaskuat 2008).

Table 2 Distribution, Abundance and Habitat Association of Medicinal Plant Species in the Lower Churchill River Valley

Species	Innu Name	Criteria	Ecotypes	Area (Ha)	Area That Will Be Inundated (Ha)	Proportion of Ecotype That Will Be Inundated (percent)
Balsam Fir (*Abies balsamea*)	Innasht	At least 10 percent average ground cover and occurs in ecotype at least 60 percent of time	Mixedwood Forest	6,619	1,047	16
			Fir-White Spruce Forest	5,931	1,725	29
			Spruce-Fir/ Feathermoss Forest	8,735	1,052	12
			Balsam Fir Total	**21,285**	**3,824 (Total of 18 percent)**	
Bay Bush (*Myrica gale*)		2.5 percent cover; 50 percent occurrence in ELC	Marsh	259	146	56
			Fen	760	41	5
			Riparian Meadow	481	99	21
			Riparian Thicket	1,840	1,304	71
			Undifferentiated Wetland	3,581	52	1
			Bay Bush Total	**6,921**	**1,642 (Total of 24 percent)**	
Birch (*Betula cordifolia* or *B. papyrifera*)	Ushkuai (*B. papyifera*)	10 percent cover; 60 percent occurrence in ELC	Mixedwood Forest	6,618	1,047	16
			Hardwood Forest	2,561	226	9
			Birch Total	**9,179**	**1,273 (Total of 14 percent)**	
Black Spruce (*Picea mariana*)	Sheshekatik[u]	At least 10 percent average ground cover and occurs in ecotype at least 60 percent of time	Black Spruce/ Lichen Woodland	35,563	1,135	3
			Black Spruce/ Sphagnum Woodland	1,514	75	5
			Black Spruce/ Feathermoss	65,033	4,687	7
			Mixedwood Forest	6,619	1,047	16
			Spruce-Fir/ Feathermoss Forest	8,735	1,052	12
			Black Spruce Total	**117,464**	**7,996 (Total of 7 percent)**	
Canada Yew (*Taxus canadensis*)	Assiuashik[u]	Any observed occurrence	NA*	NA	NA	NA
Ground Juniper (*Juniperus communis*)		1 percent cover; 50 percent occurrence in ELC	NA*	NA	NA	NA
Labrador Tea (*Rhododendron groenlandicum*)	Ikuta	10 percent cover; 60 percent occurrence in ELC	Black Spruce/ Lichen Woodland	35,563	1,135	3
			Black Spruce/ Sphagnum Woodland	1,514	75	5
			Black Spruce/ Feathermoss	65,033	4,687	7
			Labrador Tea Total	**102,110**	**5,897 (Total of 6 percent)**	

Species	Innu Name	Criteria	Ecotypes	Area (Ha)	Area That Will Be Inundated (Ha)	Proportion of Ecotype That Will Be Inundated (percent)
Mushrooms (Puffball)		Habitat That Likely Contains Puffballs	Black Spruce/ Lichen Woodland	35,563	1,135	3
			Black Spruce/ Sphagnum Woodland	1,514	75	5
			Black Spruce/ Feathermoss	65,033	4,687	7
			Mixedwood Forest	6,619	1,047	16
			Spruce-Fir/ Feathermoss Forest	8,735	1,052	12
			Hardwood Forest	2,561	226	9
			Puffball Total	**120,025**	**8,222 (Total of 7 percent)**	
Northern Mountain Ash (*Sorbus decora*)		At least 1 percent average ground cover and occurs in ecotype at least 50 percent of time	NA*	NA	NA	NA
Poplar (*Poplus tremuloides*)		10 percent cover; 50 percent occurrence in ELC	Hardwood Forest	2,561	226	9
			Poplar Total	**2,561**	**226 (Total of 9 percent)**	
Tamarack (*Larix laricina*)	Uatshinakan	10 percent cover; 60 percent occurrence in ELC	Black Spruce/ Sphagnum Woodland	1,514	75	5
			Fen	760	71	9
			Bog	272	41	15
			Undifferentiated Wetland	3,581	52	1
			Tamarack Total	**6,127**	**239 (Total of 4 percent)**	
White Spruce (*Picea glauca*)	Minaik[u]	10 percent cover; 60 percent occurrence in ELC	Fir-White Spruce Forest	5,931	1,725	29
			White Spruce Total	**5,931**	**1,725 (Total of 29 percent)**	
Willow (*Salix* spp.)	Uapineu-mitshim	At least 2.5 percent average ground cover and occurs in ecotype at least 50 percent of time	Marsh	259	146	56
			Riparian Meadow	481	99	21
			Riparian Thicket	1,840	1,304	71
			Willow Total	**2,580**	**1,549 (Total of 60 percent)**	

Notes:

NA – Not Applicable because criteria were not met

The interconnecting transmission line route has not yet been finalized and therefore the precise location of the cleared right-of-way with associated habitat types cannot be defined.

References:

Clement, Daniel. 1990. L'Ethnobotanique montagnaise de Mingan. Centre d'etudes Nordiques, Universite Laval, Collection Nordicana No. 53.

DND (Department of National Defence). 1994. An Environmental Impact Statement on Military Flying Activities in Labrador and Quebec. Chapter 8 Human Environment.

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Department of Works, Services and Transportation. 2003. Trans Labrador Highway – Phase III Environmental Impact Statement. Prepared by Jacques Whitford Environment Limited.

Innu Nation. 2007. Innu Kaishitshissenitak Mishta-shipu (Innu Environmental Knowledge of the Mishta-shipu (Churchill River) Area of Labrador in Relation to the Proposed Lower Churchill Project). Report of the work of the Innu Traditional Knowledge Committee prepared by Wolverine & Associates, Inc. for Innu Nation.

Innu Nation. 1990. Land Use and Occupancy among the Innu of Utshimassit and Sheshatshit. Prepared by Peter Armitage. Prepared for Innu Nation (Naskapi-Montagnais Innu Association) and Sheshatshit and Utshimassits Nitassinan (Labrador-Québec).

Labrador Inuit Association. 1977. Our Footprints are Everywhere. Director and General Editor: Carol Brice-Bennett. Dollco Printing Ltd. Canada.

Lethbridge, E. Chesley G.K. 2007. A Life of Challenge (One Labradorian's Experience). Edited by Patricia Way. Published by: E. Chesley, G.K. Lethbridge.

Minaskuat Inc. 2008. Project Area Ecological Land Classification. Prepared for the Lower Churchill Hydroelectric Generation Project.

Naskapi Montagnais Association. 1989. Homeland or Wasteland? Contemporary Land Use and Occupancy Among the Innu Nations of Utshimassit and Sheshatshit and the Impact of Military Expansion. Prepared by Peter Armitage.

Petro Canada Explorations Ltd. 1982. Bounty of a Barren Coast. Resource Harvest and Settlement in Southern Labrador. Phase One. Written and Edited by Lawrence Jackson.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.70**

Information Requested:

The Proponent is asked to provide additional information on:

b. **the composition, distribution, and abundance of individual country food species, including habitat association(s);**

Response:

Sources that were searched for information on plant food species are provided in the "References" section at the end of the response to IR# JRP.70a. The plant species listed in Table 3 have been identified by various sources as having been used for food. The importance and frequency of use was not documented.

Table 3 Plant Species Used for Food

Local Name	Likely Species	Information Sources
Alexander	Unknown	Lethbridge 2007
Bakeapple	*Rubus chamamorus*	Innu Nation 2007 Petro Canada Explorations 1982 Department of Works, Services and Transportation 2003
Blueberries	*Vaccinium angustifolium*; *V. boreale*; *V. cespitosum*; *V. myrtilloides*; *V. ovalifolium*; *V. uliginosum*	Innu Nation 1990 Petro Canada Explorations 1982 Department of Works, Services and Transportation 2003
Cranberries	*Vaccinium macropon*	Department of Works, Services and Transportation 2003
Currants	*Ribes* spp.	Petro Canada Explorations 1982
Partridgeberries	*Vaccinium vitis-idaea*	Innu Nation 1990 Petro Canada Explorations 1982
Raspberry	*Rubus idaeus*	Petro Canada Explorations 1982 Department of Works, Services and Transportation 2003
Red berry	*Vaccinium vitis-idaea*	Innu Nation 2007 Innu Nation 1990
Skunk currant	Unidentified Species	Innu Nation 2007
Squashberry	*Viburnum edule*	Innu Nation 2007 Petro Canada Explorations 1982

Similar to medicinal plant species, species in addition to those listed in Table 2 referenced in Clement (1990) were not found in other references for the lower Churchill River valley. These references did not indicate that Quebec Innu nor Labrador Inuit harvest plants for food in the vicinity of the Project.

Information regarding the distribution and abundance of these species, as well as their habitat association, within the lower Churchill River valley, based on the Project Area ELC Report (Minaskuat 2008), is provided in Table 4. Cranberry was not observed during the conduct of baseline surveys, and the locations of this species were not documented in the source references. With the exception of currant, the other species are common throughout the lower Churchill River valley. Favored habitat associations were selected based on ground cover and frequency of occurrence within an ecotype, as presented in the Project Area ELC (Minaskuat 2008).

Table 4 Distribution, Abundance and Habitat Association of Plants Used for Food in the lower Churchill River Valley

Species	Innu Name	Criteria	Ecotypes	Area (Ha)	Area That Will Be Inundated (Ha)	Proportion of Ecotype That Will Be Inundated (percent)
Bakeapple (*Rubus chamamorus*)	Shikuteuminanakashi	At least 1 percent average ground cover and occurs in ecotype at least 50 percent of the time	Black Spruce/ Sphagnum Woodland	1,514	75	5
			Bog	272	41	15
			Undifferentiated Wetland	3,581	52	1
			Bakeapple Total	**5,367**	**168 (Total of 3 percent)**	
Blueberries (*Vaccinium angustifolium*; *V. boreale*; *V. cespitosum*; *V. myrtilloides*; *V. ovalifolium*; *V. uliginosum*)	Nitshikuminakashi (*V. myrtilloides*)	At least 2.5 percent average ground cover occurs in ecotype at least 50 percent of the time	Black Spruce/ Feather Moss	65,033	4,687	7
			Hardwood Forest	2,561	226	9
			Blueberries Total	**67,594**	**4,913 (Total of 7 percent)**	
Raspberry (*Rubus idaeus*)		At least 2.5 percent average ground cover and occurs in ecotype at least 50 percent of the time	Riparian Thicket	1,840	1,304	71
			Raspberry Total	**1,840**	**1,304 (Total of 71 percent)**	
Redberry (*Vaccinium vitis-idaea*)	Uishatshiminakashi	At least 0.5 percent average ground cover and occurs in ecotype at least 50 percent of the time	Black Spruce/ Feather Moss	65,033	4,687	7
			Mixedwood Forest	8,075	1,047	13
			Red Berry Total	**73,108**	**5,734 (Total of 8 percent)**	
Squashberry (*Viburnum edule*)	Mushuminakashi	At least 2.0 percent average ground cover and occurs in ecotype at least 50 percent of the time	Mixedwood Forest	6,619	1,047	16
			Hardwood Forest	2,561	226	9
			Squashberry Total	**9,180**	**1,273 (Total of 14 percent)**	

Note:
The interconnecting transmission line route has not yet been finalized and therefore the precise location of the cleared right-of-way with associated habitat types cannot be defined.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.70**

Information Requested:

The Proponent is asked to provide additional information on:

c. **the present importance and frequency of practice of medicinal plant and country food plant gathering activities to the local Aboriginal communities;**

Response:

Primary data regarding the present importance and frequency of practice of medicinal plant and country food plant gathering activities to local Aboriginal communities was not available for this Project (please refer to IR# JRP.1 and IR# JRP.2). Secondary source information indicates that Aboriginal groups including Labrador Innu and Labrador Métis collect plant species for medicinal purposes and for food in the vicinity of the Project (please refer to species, abundance and distribution information in the response to parts (a) and (b). A comprehensive additional literature review (indicated in the "References" section) identified no information on the present importance and frequency of practice of medicinal plant and country food plant gathering activities to the local Aboriginal communities (the Labrador Innu, Labrador Inuit, the Labrador Métis, or the Quebec Innu) beyond that presented in the EIS.

For a detailed presentation of on-going consultation and data collection efforts, please refer to IR# JRP.1 and IR# JRP.2. In summary:

- Nalcor Energy (Nalcor) has, and continues, to encourage the Innu to bring perspectives and information on Innu land use and potential effects directly to the EA Panel process.
- Nalcor has elicited information respecting the effect of the Project upon Labrador Inuit directly from the Nunatsiavut Government through the provision of Project-related information on an ongoing basis.
- Nalcor has developed a template for a draft community consultation agreement which has been offered to each of the enumerated Quebec Innu Communities and the Labrador Metis Nation. Consistent with the Canadian Environmental Assessment Act Agency's "Considering Aboriginal traditional knowledge in environmental assessments conducted under the *Canadian Environmental Assessment Act* -- Interim Principles", one of the objectives is to identify potential environmental impacts of the Project upon current land and resource use. A final assessment of the Project's anticipated effects on the current use of lands and resources for traditional purposes by the enumerated Quebec Innu communities and the Labrador Metis Nation is in progress by Nalcor and representatives of the Quebec Innu communities and Labrador Metis Nation.

The importance and frequency of practice of medicinal plant and country food plant gathering activities to the local Aboriginal communities will be included as an item in on-going data collection efforts.

References:

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Bennett, J. and S. Rowley (eds). 2004. Uqalurait: An Oral History of Nunavut. Montreal: McGill-Queen's University Press.

Courtois, V. no date. Sustaining Nitassinan Forests: The Innu Nation Forest Guardians and Ecosystems-Based Forest Management in Labrador. Innu Nation Environment Office, Sheshatshiu, NL. Available at www.innu.ca. Accessed 7 July, 2009.

Hanrahan, M. 2000. Industrialization and the Politicization of Health in Labrador Metis Society. The Canadian Journal of Native Studies, 20(2):231-250.

Innu Nation. 1990. Land Use and Occupancy among the Innu of Utshimassit and Sheshatshit. Prepared by Peter Armitage. Prepared for Innu Nation (Naskapi-Montagnais Innu Association) and Sheshatshit and Utshimassits Nitassinan (Labrador-Québec).

Kuhnlein, H. and N. Turner. 1991. Traditional Plant Foods of Canadian Indigenous Peoples: Nutrition, Botany and Use. Philadelphia, Pennsylvania: Gordon and Breach Publishers.

Tait, H. 2006. Harvesting and community well-being among Inuit in the Canadian Arctic: Preliminary findings from the 2001 Aboriginal Peoples Survey - Survey of Living Conditions in the Arctic. Statistics Canada: Social and Aboriginal Statistics Division, Ottawa, Canada. Available at http://www.statcan.gc.ca/pub/89-619-x/89-619-x2006001-eng.pdf. Accessed 14 July, 2009.

Tait, H. 2008. Aboriginal Peoples Survey, 2006: Inuit Health and Social Conditions. Statistics Canada: Social and Aboriginal Statistics Division, Ottawa, Canada. Available at http://dsp-psd.pwgsc.gc.ca/collection_2008/statcan/89-637-X/89-637-x2008001-eng.pdf. Accessed 14 July, 2009.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.70**

Information Requested:

The Proponent is asked to provide additional information on:

d. the percentage of the medicinal plant and country food plant gathering area(s) that would be lost after impoundment of the dam and clearing of the transmission line corridor; and

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Response:

Innu Nation wild-fruit gathering locations, as documented by NMA (1989), are outside the lower Churchill River valley, to the north and east, and will not be affected by flooding. This information can be found in Volume III, Section 2.8.12, and is shown in Figure 2-29.

Two areas are known for berry picking within the lower Churchill River valley, one near Muskrat Falls, on the north side of the river, and the other in the Gull Island area, also on the north side of the river. These locations are above the reservoir limits and will not be flooded. Berries and medicinal plants are often sought in areas where access by water or by land is available. Most shorelines and riparian areas along the lower Churchill River can be accessed by water and can be accessed for collecting plants. Plants are collected as they are encountered coincidentally during other activities, or sought out deliberately (e.g., red berries or blueberries for food, Canada yew for medicinal purposes). Land access is available wherever there is a trail or a road within the watershed and one can expect that they may be accessed to collect plants in a similar fashion. If someone is seeking a specific plant, they may either go to locations where they have encountered the plant previously, or will search areas known to be of similar habitat.

Based on the response to parts (b) and (c) of this IR, the total area of the ecotypes where medicinal and food plant species can be found within the lower Churchill River Valley is 163,544 ha (Minaskuat 2008). Of this, 22,327 ha of those ecotypes will be inundated, representing approximately 14 percent of the area of those ecotypes that will be lost after impoundment.

The interconnecting transmission line route has not yet been finalized and therefore the precise location of the cleared right-of-way with associated habitat types cannot be defined.

References:

Minaskuat Inc. 2008. Project Area Ecological Land Classification. Prepared for the Lower Churchill Hydroelectric Generation Project.

NMA (Naskapi Montagnais Association). 1989. Homeland or Wasteland? Contemporary Land Use and Occupancy Among the Innu Nations of Utshimassit and Sheshatshit and the Impact of Military Expansion. Prepared by Peter Armitage.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.70**

Information Requested:

The Proponent is asked to provide additional information on:

e. the distances community members would need to travel to access similar resource areas after impoundment.

Response:

Of the ecotypes that will be partially inundated, alternate areas remain for the following ecotypes:

- Black Spruce/Feathermoss
- Black Spruce/Lichen Woodland
- Black Spruce/Sphagnum Woodland
- Bog
- Fen
- Fir-White Spruce Forest
- Hardwood Forest
- Marsh
- Mixedwood Forest
- Riparian Meadow
- Riparian Thicket
- Spruce-Fir/Feathermoss Forest
- Undifferentiated Wetland

There is no single ecotype that will be completely lost as a result of the Project.

Canada yew will be transplanted to an, as yet, unidentified location(s) within the Project area (please refer to the response to IR# JRP.103).

Access to these ecotypes will remain by water through replacement of boat launches in locations as close as possible to existing boat launches (see response to IR# JRP.34d). There will be a small increase in access by road. Based on available information, therefore, the distance community members will have to travel to access similar resource areas after impoundment will be approximately the same.

IR# JRP.71

Winter Travel – Mud Lake and Reservoirs

Requesting Organization – Joint Review Panel **Information Request No.: JRP.71**

Subject - Winter Travel – Mud Lake and Reservoirs

References:

EIS Guidelines, Section 4.4.4.4 (Description of the Existing Environment – Land and Resource Use)

EIS, Volume III, Section 5.5.5.2 (Environmental Effects Analysis and Effects Management – Operation and Maintenance)

Hatch Ltd. 2008. *Further Clarification and Updating of the 2007 Ice Dynamics* Report. Prepared for Newfoundland and Labrador Hydro, St. John's, NL

Rosenberg, D. M. Environmental and Social Impacts of Large Scale Hydroelectric Development: Who is Listening? Global Environmental Change; Vol. 5, no. 2, p. 127-148. 1995

Related Comments / Information Requests:

CEAR # 163 (D. Raeburn)
CEAR # 164 (Unidentified)
CEAR # 174 (V. Kerby)
CEAR # 175 (M. Broomfield)
CEAR # 183 (Central Labrador Environmental Action Network)
CEAR # 184 (Sierra Club Atlantic)
CEAR # 193 (Mud Lake United Church Women)
CEAR # 200 (Grand Riverkeeper Labrador Inc.)

IR # JRP.76, 96

Rationale:

The EIS Guidelines require the Proponent to describe relevant land and resource use within the study area, including current winter travel patterns on the river.

The EIS mentions that, while residents of Mud Lake are particularly dependent upon river ice for winter roads, ice modelling predictions have concluded that adverse environmental effects on river travel are not anticipated and simulations have shown “a potential delay of two weeks for ice formation at the 15 to 20 km mark of the river” (Volume III, p. 5-19). The delay could potentially be longer farther upstream. Other river winter travel hazards may also occur as a result of changing water flow regime in the Churchill River, such as the hanging-ice conditions.

Information presented in Hatch (2008) indicates that “there will be a delay in the formation of the ice bridge in the order of two weeks, **depending upon climatic conditions in any given year**” (p. 3-8) (emphasis added).

Requesting Organization – Joint Review Panel **Information Request No.: JRP.71**

Information Requested:

The Proponent is asked to provide the following information:

a. a map to show where residents of Mud Lake and local users cross the Churchill River in the wintertime in relation to the "15 to 20 km mark" portion of the river where the Proponent anticipates that delays in ice formation may occur;

Response:

See map in Attachment A showing the location of the Mud Lake winter crossing route over the Churchill River.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.71**

Information Requested:

The Proponent is asked to provide the following information:

b. **estimates of the average number of crossings of the Churchill River by Mud Lake residents by season on section(s) of the river where the ice cover may be affected by the Project;**

Response:

During the winter season when the river is ice covered, approximately 20 snowmobiles from Mud Lake cross the river between four and seven times per week. This equates to between 80 and 140 snowmobile crossings per week. The majority of the snowmobile crossings are on the main trail shown in Attachment A. It is safer and requires less effort to travel on the main trail which is packed down and marked with trees. Late in the season when ice conditions are considered safer, a second route is often marked from the head of "Whitefish Trail" (which goes west from the community of Mud Lake to the Churchill River via an overland trail as shown on the map in Attachment A) to the same location on the north bank of the Churchill River where people leave their vehicles to travel into Happy Valley-Goose Bay. This route is slightly shorter than the main trail. Occasionally Mud Lake residents (mostly those who do not have vehicles) will travel directly from the head of "Whitefish Trail" to Happy-Valley Goose Bay but this does not happen until late in the season when the ice conditions are considered to be very safe (D. Raeburn, pers. comm.).

During the open-water season, approximately 13 boats from Mud Lake cross the river between four and seven times per week. This equates to between 50 and 91 crossings per week.

Reference:

Raeburn, D. Resident of Mud Lake.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.71**

Information Requested:

The Proponent is asked to provide the following information:

c. estimates of average number of river crossings by other land and resource users by season;

Response:

Non-Mud Lake residents also travel by snowmobile over the ice on the Churchill River mostly for recreational purposes (ice-fishing, sight-seeing, informal snowmobile racing, etc.). The frequency of use is very dependent on weather conditions and is highest in late February/early March when the ice conditions are considered to be safe and the weather is more agreeable. Between December and mid-February the weather conditions are very harsh and few people travel on the Churchill River for recreation. Weekend use is highest and 15 to 20 snowmobiles one after another in a single day have been observed (D. Raeburn, pers. comm.).

Reference:

Raeburn, D. Resident of Mud Lake.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.71**

Information Requested:

The Proponent is asked to provide the following information:

d. **an average date on which the ice roads located over portion(s) of the river where the ice cover could be affected by the Project open and close;**

Response:

A record has been kept of the first date on which Mud Lake residents crossed the Churchill River (by boat in the spring and by snowmobile in the fall) in 1972 and each year since 1975. This record is summarized in Table 1 below (G. Chaulk, pers. comm.).

Table 1 Record of Break-up and Freeze Up in Mud Lake

Year	Date	
	Break-up (first boat crossing)	Freeze-up (first snowmobile crossing)
1972	5-Jun-72	22-Nov-72
1973	-	-
1974	-	-
1975	30-May-75	25-Nov-75
1976	17-May-76	17-Nov-76
1977	15-May-77	30-Nov-77
1978	27-May-78	19-Nov-78
1979	14-May-79	24-Nov-79
1980	17-May-80	29-Nov-80
1981	15-May-81	23-Dec-81
1982	1-Jun-82	28-Nov-82
1983	14-May-83	29-Nov-83
1984	15-May-84	23-Nov-84
1985	28-May-85	18-Nov-85
1986	7-May-86	13-Nov-86
1987	23-Apr-87	28-Nov-87
1988	12-May-88	1-Dec-88
1989	15-May-89	24-Nov-89
1990	22-May-90	1-Dec-90
1991	26-May-91	2-Dec-91
1992	27-May-92	19-Nov-92
1993	17-May-93	13-Nov-93
1994	22-May-94	27-Nov-94
1995	11-May-95	29-Nov-95
1996	4-May-96	1-Dec-96
1997	24-May-97	23-Nov-97
1998	12-May-98	30-Nov-98
1999	10-May-99	23-Nov-99
2000	11-May-00	25-Nov-00
2001	14-May-01	4-Dec-01
2002	22-May-02	22-Nov-02
2003	17-May-03	7-Dec-03
2004	18-May-04	7-Dec-04

Table 1 Record of Break-up and Freeze Up in Mud Lake

Year	Date	
	Break-up (first boat crossing)	**Freeze-up (first snowmobile crossing)**
2005	8-May-05	11-Dec-05
2006	4-May-06	4-Dec-06
2007	19-May-07	30-Nov-07
2008	7-May-08	5-Dec-08
Average	**May 17**	**November 28**

From this record, the average first date of crossing by boat in the spring is May 17th and the average first date of crossing by snowmobile in the fall is November 28th. There is considerable year to year variability in this record reflecting natural climate variability. The earliest and latest first spring crossings by boat were April 23 (1987) and June 5 (1972), respectively. In the fall, the earliest and latest first crossings by snowmobile were November 13 (1993) and December 23 (1981). The standard deviation of the break-up and freeze-up data sets are nine days and eight days, respectively.

Reference:

Chaulk, G. Resident of Mud Lake.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.71**

Information Requested:

The Proponent is asked to provide the following information:

e. **a description, based on ice modelling predictions, of the proportion of current crossings (mentioned in b and c above) that could be affected by the Project;**

Response:

Hydraulic conditions downstream of Muskrat Falls are not expected to change as a result of the Project; therefore, no effect on the river crossings during the ice-free parts of the year is predicted.

Based on the ice modeling completed to date (described in Report 5 of the Hydrology Component studies [Hatch 2008]), it is predicted that downstream of Muskrat Falls, in the area of Mud Lake, the freeze up date would be delayed by two weeks and the break up date would occur one week later. As a result, at the Mud Lake crossing, boats would be used to cross the river for two weeks longer in the fall and snowmobiles would be used one week longer in the spring. In addition to the predicted effect on the start of freeze-up and break-up, predictions have also been made regarding the period of time that it would take from the start of freeze up to the time when the ice cover would be stable enough for a crossing to be made by snowmobile. The same prediction has also been made for the spring of the year regarding the period of time from when the ice begins breaking up until the river is ice-free, allowing crossings by boat. Under current conditions these transition periods occur each year and during this time travel by boat or snowmobile is not possible. Ice modeling was conducted to determine if the Project would extend the duration of the transition period during the fall and spring, therefore extending the period of time that Mud Lake residents would be unable to travel across the river. As indicated in Volume III, Section 5.5.5.2 of the EIS, the ice modeling prediction does not forecast a longer transition period; therefore crossing of the river is not expected to be affected by the Project. In order to verify in this prediction, observation programs are ongoing to develop a better understanding of the existing processes which lead to a stable ice cover over which Mud Lake residents can safely pass. In addition, further modeling is being carried out to determine the timing of ice formation in Mud Lake channel in relation to the formation of ice in the Churchill River for post-Project conditions.

Upstream of Muskrat Falls, hydraulic conditions will change as a result of the Project with the formation of reservoirs. Under existing conditions, river crossings by snowmobile are infrequent due to the prevalence of open water. Based on the ice modeling completed to date (described in Report 4 of the Hydrology Component studies [Hatch 2007]) it is expected that snowmobile crossings under post-Project conditions will be safer and more reliable than under existing conditions as a result of the thermal ice covers that will form on the reservoirs.

References:

Hatch Ltd. 2007. Ice Dynamics of the Lower Churchill River. Prepared for Newfoundland and Labrador Hydro, St. John's, NL

Hatch Ltd. 2008. Further Clarification and Updating of the 2007 Ice Dynamics Report. Prepared for Newfoundland and Labrador Hydro, St. John's, NL.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.71**

Information Requested:

The Proponent is asked to provide the following information:

f. **a description, based on ice modelling predictions, of the average and range of start and end dates of the potential delay in ice formation and the ability of ice conditions to produce an ice bridge;**

Response:

The data available related to the formation of the ice bridge downstream of the Mud Lake channel are insufficient to model the phenomenon with this level of precision and therefore predictions related to the timing of formation have not been made. Ice bridging is further discussed in part (g) of the this IR.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.71**

Information Requested:

The Proponent is asked to provide the following information:

g. a discussion on whether the dam at Muskrat Falls will eliminate the flow of any ice pans to the Mud Lake area and how this will impact the formation of an “ice bridge” at Mud Lake that is necessary for safe travel across the river;

Response:

Under existing conditions, ice bridging generally occurs at approximate chainage 0.2 km and the ice cover progresses upstream from that point. Under post-Project conditions, the volume of ice arriving at that point will be reduced as a result of the Muskrat Falls Dam which will act as a physical barrier to ice transport from the upstream to the downstream reach. A hydraulic analysis was completed to assess the potential for the ice bridge to form under post-Project conditions despite the reduction in ice volume inflow rate. Results suggested that the volume of ice generated in the reach downstream of Muskrat Falls is sufficient for the formation of an ice bridge. That analysis is described in Report 5 of the Hydrology Component studies (Hatch 2008). This issue continues to be studied and observation programs during the freeze-up period will attempt to gain additional information on the ice bridging process which should help to verify in the post-Project predictions.

Reference:

Hatch Ltd. 2008. Further Clarification and Updating of the 2007 Ice Dynamics Report. Prepared for Newfoundland and Labrador Hydro, St. John's, NL.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.71**

Information Requested:

The Proponent is asked to provide the following information:

- **h. a discussion of how climate conditions were taken into consideration during the ice modeling and the formation of the ice bridge, and how climatic conditions in a given year may impact the availability of the ice-bridge; describe specifically how potential climate change scenarios for Labrador might affect ice modeling predictions;**

Response:

As mentioned in part (f), the phenomenon cannot be modeled with the requested level of precision. The formation of the ice bridge is highly variable, as indicated by the results in part (d).

The EIS describes anticipated changes in temperature and precipitation in Labrador over the next 80 to 100 years. In general, temperatures at Happy Valley-Goose Bay are predicted to be much warmer in the summer, fall and winter, with less change in the spring. There is less agreement between models regarding changes to the amount of precipitation, with estimates ranging from slight decreases to increases of greater than 10 percent (Volume IA of the EIS, Chapter 10, page 10-15).

Increased temperatures in the fall, winter and spring will no doubt have an effect on the ice conditions of the Churchill River. In theory, higher air temperatures would correspond to a lower rate of ice generation, which would correspond to a decreased potential for bridging. Increased temperatures would also increase the period of time that the river has open water, and this would increase the relative use of boat transportation.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.71**

Information Requested:

The Proponent is asked to provide the following information:

i. a description of alternates that would be available to replace the need for residents of Mud Lake to use the "ice bridge" if conditions do not allow for travel across the Lower Churchill River;

Response:

Nalcor Energy (Nalcor) is still in the process of identifying alternatives that would be available to replace the need for residents of Mud Lake to use the "ice bridge" if conditions do not allow for travel across the lower Churchill River by snowmobile, i.e., in the event that the transition period is extended as a result of the Project, as previously described in part (e). As discussed in part (e) of this response, if the start of freeze up is delayed then boats would be used to cross the river for a longer period of time than they are in current conditions. Nalcor will continue to consult with the residents of Mud Lake to discuss alternative means of traveling to Happy Valley-Goose Bay, if the duration of the transition period is extended by the Project.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.71**

Information Requested:

The Proponent is asked to provide the following information:

j. a description of the predicted ice conditions on and below the reservoirs (including the timing of ice formation and break-up and predicted thickness) and discussion of how these differ from current conditions experienced by snowmobilers; and

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Response:

A discussion of the timing and extent of ice covers on the post-Project reservoirs is provided in Section 3.4 of Report 5 of the Hydrology component studies (Hatch 2008). The end-of-winter thickness of ice on the post-Project reservoirs is expected to be in the order of one metre. Existing conditions upstream of Muskrat Falls do not lend well to snowmobile travel, except on a few lakes and possibly other slow-moving reaches where a thermal ice cover is formed. Post-Project conditions should be more favorable for snowmobile traffic as a result of the thermal covers that are expected to form on both reservoirs.

Reference:

Hatch Ltd. 2008. Further Clarification and Updating of the 2007 Ice Dynamics Report. Prepared for Newfoundland and Labrador Hydro, St. John's, NL.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.71**

Information Requested:

The Proponent is asked to provide the following information:

k. a discussion of the potential for hanging-ice/hinge-ice conditions to be created on and below the reservoir, how likely these conditions are to occur, and their frequency and duration, and measures to reduce these ice conditions and to warn people that such conditions exist.

Response:

Ice hinging during operation of the reservoirs is described in Section 3.2 of Report 5 of the Hydrology Component studies (Hatch 2008). Little ice hinging is expected because the reservoirs will be maintained at a constant level throughout the winter. The potential for hinging downstream of the reservoirs is expected to be unchanged from existing conditions.

Hanging dams typically occur when a large volume of frazil ice flows into a slow moving, ice-covered reach. Hanging dams are not expected in the post-Project reservoirs since there will be no frazil ice flowing into the reservoirs. It is unlikely that hanging dams would occur downstream of the Muskrat Falls reservoir since the volume of frazil ice generated at Muskrat Falls will be greatly reduced in the Post-Project case.

Reference:

Hatch Ltd. 2008. Further Clarification and Updating of the 2007 Ice Dynamics Report. Prepared for Newfoundland and Labrador Hydro, St. John's, NL.

INFORMATION RESPONSES
LOWER CHURCHILL PROJECT
CEAA REFERENCE NO.07-05-26178

JOINT REVIEW PANEL

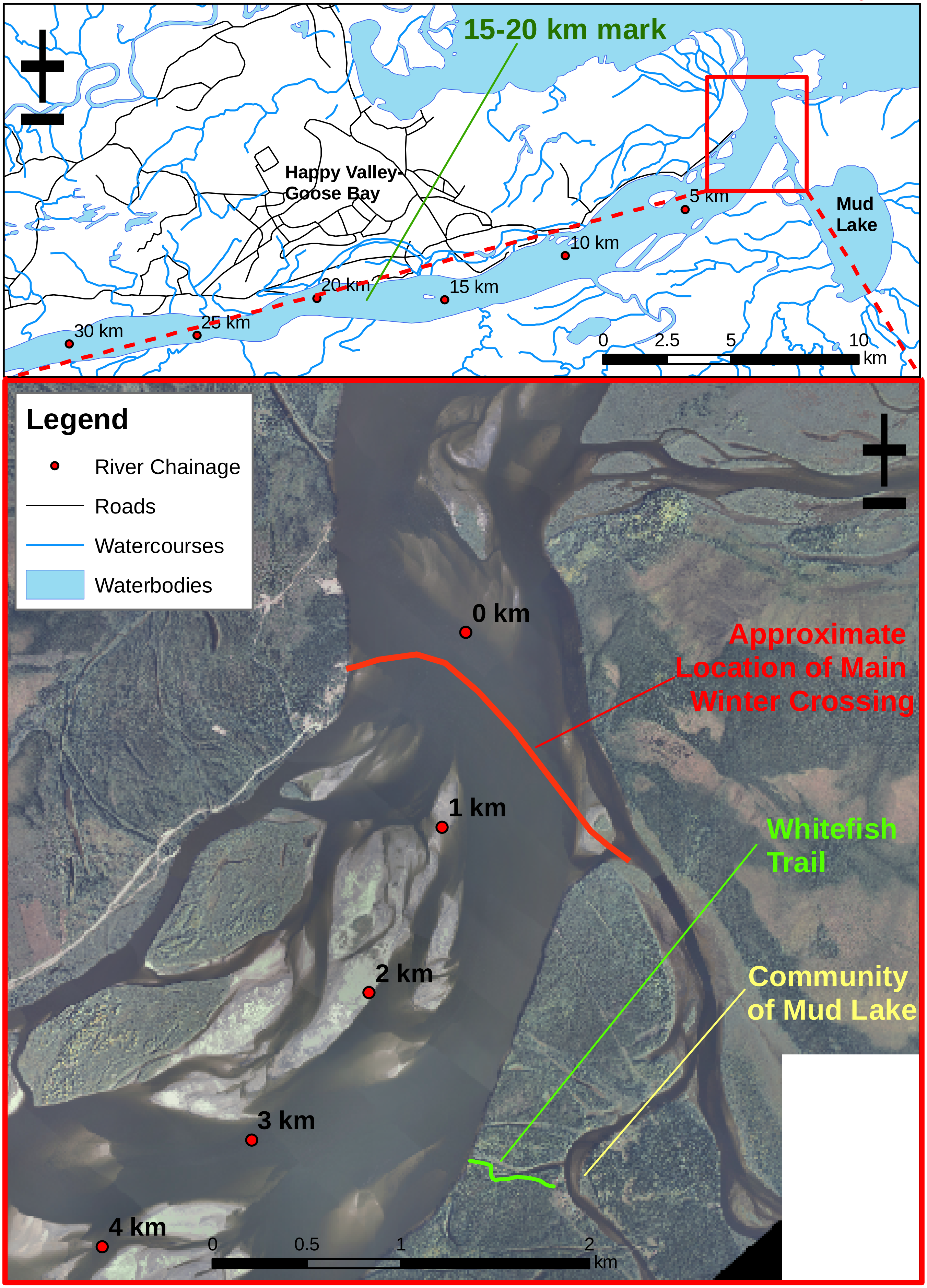
Attachment A

Mud Lake Crossing Map

IR# JRP.71

October 5, 2009

nalcor energy
LOWER CHURCHILL PROJECT



15-20 km mark
Happy Valley-Goose Bay
Mud Lake
5 km
10 km
15 km
20 km
25 km
30 km
0
2.5
5
10
km
Legend
River Chainage
Roads
Watercourses
Waterbodies
0 km
1 km
2 km
3 km
4 km
Approximate Location of Main Winter Crossing
Whitefish Trail
Community of Mud Lake
0
0.5
1
2
km

IR# JRP.72

Land and Resource Use – Access

Requesting Organization – Joint Review Panel **Information Request No.: JRP.72**

Subject - Land and Resource Use – Access

References:

EIS, Volume III, Section 8.4.2 (The Capacity of Renewable Resources that are likely to be Significantly Affected).

Related Comments / Information Requests:

IRs # JRP.6, 28, 33, 34, 35, 36, 37, 96

Rationale:

The EIS assesses the pressures on resources due to increased access to the land via roads and transmission line corridors. The EIS notes that "[w]hen the Project is operational, the potential for boat and snowmobile travel will increase as a result of reduced flows and increased ice cover" (p. 8-10) but does not assess the implications of this aspect of increased access.

The EIS also states that "[t]hrough effects management measures for both biophysical and socio-economic environments and the application of good utility practices, renewable resources will be available for use by current and future generations"(p. 8-10).

Requesting Organization – Joint Review Panel **Information Request No.: JRP.72**

Information Requested:

The Proponent is asked to provide:

a. **a detailed description of the expected use of the reservoirs by boat or snowmobile (including frequency, timing, purpose and type of vehicles);**

Response:

Information on the current use of the lower section of the Churchill River by boat and snowmobile was collected during the preparation of the Land and Resource Use Baseline Report (Minaskuat 2009), and is provided below.

Boating:

Timing: Spring/Summer/Fall

Duration of Trips: Primarily day trips or trips of three to four days. Longer trips occur less frequently.

Location: Upper Lake Melville Residents – Boat use for fishing and hunting is concentrated between Muskrat Falls and Goose Bay (downstream of proposed reservoirs) with some use between Muskrat Falls and Gull Island. Recreational boating occurs along the entire river (canoes), but is concentrated between Muskrat and Goose Bay (power boats and canoes).

Lab West Residents – Churchill Falls to Gull Island, concentrated in the section west of Metchin River.

Purpose: Recreational/subsistence harvesting (fishing, trapping, hunting); recreation; tourism guides; travel between communities. Most users are concentrated between Muskrat Falls and Goose Bay (downstream of proposed reservoirs), some extending as far as Gull Island. Few users make use of the entire river (two or three of the interviewees), although when using the entire river, they tend to use canoes, not powerboats.

Type of Vehicles: Mostly aluminum boats with outboard motors, or canoes

Information on frequency of use was not explicitly provided.

Likely Changes as a Result of the Project

During construction, access to the river upstream of the work sites will be restricted by safety booms. After impoundment, reduction in flow velocities and reduced variation in flow velocities upstream of Muskrat Falls will increase navigability and therefore will provide an increased opportunity for use by boats.

Snowmobiling:

Timing: October to May, due to easy access; most travel on the river, but some stay close to the shoreline because of fears of thin ice, especially near tributaries.

Location: Upper Lake Melville Residents – Concentrated between Muskrat Falls and Goose Bay (downstream of proposed reservoirs) on the river, and along the highway (drive in truck then use snowmobile). From the interviews, it appears that Upper Lake Melville residents tend to travel alone and camp when spending the night in the country.

Lab West Residents – Churchill Falls to Gull Island, concentrated west of Metchin River. It appears that Lab West residents tend to travel in groups, traveling to cabin areas year-round (by boat and by truck/snowmobile).

Duration of Trips: Day trips; two to three nights, staying in tents/cabins/tilts

Purpose: Recreational/subsistence harvesting (travel to areas for hunting, trapping, cutting/hauling wood, ice fishing), recreation, travel between communities. Many bring their snowmobiles along the highway by truck and then travel inland.

Information on frequency of trips and types of snowmobiles was not provided.

Likely Changes as a Result of the Project

The creation of a more stable ice cover upstream of Muskrat Falls will provide increased opportunity for snowmobile use.

Reference:

Minaskuat Inc. 2009. Current Land and Resource Use in the Lower Churchill River Area. Report prepared for the Lower Churchill Hydroelectric Generation Project.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.72**

Information Requested:

The Proponent is asked to provide additional information on:

b. the details of any plans to monitor boat and snowmobile travel on the reservoirs; and

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Response:

Currently there are no plans to monitor boat and snowmobile traffic.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.72**

Information Requested:

The Proponent is asked to provide:

c. a discussion of the potential for new access roads in the Lower Churchill River Valley to lead to increased traffic on the Churchill River and to influence the regional use of the Churchill River as a water/ice transportation corridor

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Response:

The Project will include the construction or upgrading of approximately 375 km of road of which only 15 to 30 km will remain at the completion of the construction phase. Due to concerns expressed from stakeholders related to increased access and uncertainty related to the level and nature of resulting land use, Nalcor Energy (Nalcor) will, in the long-term (i.e., post-construction) and where feasible, maintain existing access and travel routes but prevent opening up new ones, i.e., maintain the status quo to the extent possible.

During construction, Nalcor will restrict access to Project roads and work areas (please see response to part (d) of this IR) and remove stream crossings along access roads once construction and reservoir preparation is completed. Access to the construction sites and sections of the river will be restricted depending on the location of reservoir preparation activities and will vary as reservoir preparation progresses. As described above, most of the access roads will eventually be rehabilitated.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.72**

Information Requested:

For the construction phase the Proponent is asked to:

d. describe the type, timing, duration and location of access restrictions that would be put in place throughout the construction phase;

Response:

Access to all work sites, including active haul roads, will be restricted by security barriers for the duration of the construction phase. Restrictions to navigation on the river are described in IR# JRP.34(b).

Requesting Organization – Joint Review Panel **Information Request No.: JRP.72**

Information Requested:

For the construction phase the Proponent is asked to:

e. **compare and contrast how access restrictions during the construction phase may affect Aboriginal and non Aboriginal land and resource users differently; and**

Response:

Access restrictions at the work sites during the construction phase will be put in place to protect the safety of the general public, and therefore there will be no distinction between Aboriginal and non-Aboriginal land and resource users in this regard.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.72**

Information Requested:

For the construction phase the Proponent is asked to:

f. **state whether construction activities pose particular safety issues to land and resource users other than Project workers and indicate how the Proponent would ensure that these increased safety concerns during hunting season are properly managed and/or avoided given that the EIS mentions that "[a]n increase in hunters in an area can also result in increased safety issues during hunting season" (p. 5-12).**

Response:

Construction activities will not pose particular safety issues to land and resource users provided that the access restrictions outlined in part (d) of this IR are adhered to.

The Minister of Environment and Conservation has the authority to impose hunting restrictions pursuant to the *Wild Life Act.* Nalcor will request that hunting be restricted in and around active construction areas as is the practice at other resource development and logging sites throughout the Province.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.72**

Information Requested:

For the operation phase the Proponent is asked to:

g. **describe the thresholds at which increased access to land resources warrant increased management and enforcement by responsible authorities; and**

Response:

The thresholds at which increased access to land resources will warrant increased management and enforcement by responsible authorities will be determined by responsible authorities. As part of the management of the Province's natural resources, agencies such as the Wildlife Division, Newfoundland and Labrador Department of Environment and Conservation, must consider a number of factors in managing specific wildlife populations, including population status, hunting levels and potential for increased access from a variety of activities, including private developments, forestry and provincial highways. Likewise, management of wildlife populations in the vicinity of the lower Churchill River are subject to adaptive management strategies that have already and will continue to take into account changing land use patterns due to this and other projects, such as the various phases of the TLH. Nalcor will contribute to these management efforts by supplying appropriate regulatory authorities with the location and condition/status of new access and the results of any monitoring programs conducted by Nalcor related to wildlife populations in the area.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.72**

Information Requested:

For the operation phase the Proponent is asked to:

h. explain what is meant by "community-level stewardship initiatives"? Provide details of examples, based on experience from previous projects if possible.

Response:

In the discussion of increased access in Volume III, Section 5.5.5.1 of the EIS, Nalcor committed to a number of mitigation measures which are reiterated in response to part (c) of this IR. This section of the EIS also states that "Alternately, increased access may also provide opportunities for community-level stewardship initiatives". Nalcor is not assuming or relying in any way on these initiatives occurring to mitigate the effects of the Project. The EIS is only highlighting that this is something that may occur in the region.

Community-level stewardship is a "grass roots" initiative directed by local, not-for-profit organizations to encourage the sustainable use or protection of land and/or resources. An example in the Province of community-level stewardship is occurring in the Indian Bay region on the Island of Newfoundland. The Indian Bay Ecosystem Corporation (IBEC) is a non-profit volunteer organization made up of local residents, who are actively involved in the conservation, protection and sustainable development of the watershed. Additionally, IBEC has input on how the watershed is managed and participates in forest harvest activities and tourism development. The Indian Bay Watershed covers approximately 700 square kilometres and comprises 14 large ponds and a number of smaller ponds in the Bonavista North area (http://www.releases.gov.nl.ca/releases/2007/env/0321n02.htm).

There are other examples of community stewardship groups throughout Atlantic Canada that have focused on local watersheds, such as the Annapolis River in Nova Scotia (http://www.annapolisriver.ca/aboutcarp.php). The Clean Annapolis River Project (CARP) is a program under Environment Canada's Atlantic Coastal Action Program (ACAP). ACAP is a community-based program that relies on local involvement and support. ACAP includes 16 sites across Atlantic Canada - two in Newfoundland, two in Labrador, two in Prince Edward Island, five in Nova Scotia, and five in New Brunswick. Each site has formed an incorporated, non-profit organization. While Environment Canada contributes to project funding, community stakeholders contribute most of the resources through volunteer labor, in-kind contributions, and financial support (http://atlantic-web1.ns.ec.gc.ca/community/acap/default.asp?lang=En&n=17F60AA9-1). The two ACAP community groups in Labrador are the Central Labrador Environmental Action Network and the Labrador Southeast Coastal Action Program Inc.

IR# JRP.73

Land and Resource Use – Commercial, Recreational and Aboriginal Fisheries

Requesting Organization – Joint Review Panel **Information Request No.: JRP.73**

Subject - Land and Resource Use – Commercial, Recreational and Aboriginal Fisheries

References:

EIS Guidelines: Section 2.3 (Aboriginal Traditional Knowledge and Community Knowledge), Section 4.4.4 (Description of the Existing Environment), Section 4.4.4.4 (Land and Resource Use)

EIS Volume IA, Section 1.5 (Land Claim Agreements & Interim Agreements)

EIS Volume III, Section 2.8 (Land and Resource Use)

Related Comments / Information Requests:

CEAR # 166 (Torngat Joint Fisheries Board)
CEAR # 170 (Fisheries and Oceans Canada)
CEAR # 169 (A. Lutterman)
CEAR # 180 (D. Steele, Memorial University of Newfoundland, Natural History)
CEAR # 185 CEAR #185 (S. Pottle -Memorial University of Newfoundland, Faculty Submission)
CEAR #200 (Grand Riverkeeper Labrador Inc.)
CEAR #203 (Hydro Québec)

IR# JRP.79, 82

Rationale:

The EIS Guidelines require the EIS to "identify the study area for each VEC and include a description of the existing biophysical and socio-economic environment and the resources within it that will be affected or that might reasonably be expected to be affected, directly or indirectly, by the Project." (p. 25).

The EIS Guidelines further direct the proponent to "describe relevant land and resource use within the study area of the VECs, including the following: (…) (b) Current use of land and resources (including aquatic resources) by Aboriginal persons for traditional purposes, including location of camps, harvested species and transportation routes; (c) Current use of land and resources by other land users; and (d) Other rural land and resource use including existing and potential recreational and commercial fishing and hunting (…)." (p. 28)

Volume III, Section 2.8.5 does not adequately address the importance of fishing activity in Upper Lake Melville and the Lower Churchill River. The EIS limits the study area to the mouth of the Churchill River ignoring the fact that the rivers flowing into the Lower Churchill River (below Muskrat Falls) are important anadramous fish producing rivers that add significantly to the fish production in Lake Melville and thus impacts on the net fishery

The EIS states "[t]he influence of the Project does not extend beyond the mouth of the Churchill River and, consequently, there is no reasonable possibility that the Project would have an adverse impact on the Labrador Inuit Settlement Area" (Volume IA, p. 1-16). The EIS would need to assess Project effects on fish & fish habitat and related fishing activity in Lake Melville beyond the mouth of the Churchill River if this statement were to be substantiated.

Volume III, Section 2.8.5 references management measures implemented for the Churchill River but does not acknowledge that DFO identified the 'Churchill River Drainage Basin Watershed' as an area that needed additional protection. This information is readily available in DFO's 2008 Angler's Guide. The EIS also makes reference to the 'Churchill River Basin' but does not adequately define / describe this area

During community consultations in the Rigolet and Upper Lake Melville areas by the Torngat Joint Fisheries Board, residents attributed long-term changes to the Lake Melville ecosystem to the Upper Churchill development, and expressed concern that the Lower Churchill Project would create additional negative impacts. Many of these residents still rely heavily on the aquatic resources in Lake Melville, such as ringed seal and salmon for subsistence and cultural purposes and are in a position to be directly affected. The Torngat Joint Fisheries Board has indicated that there be an extension of the study area to include the entire Lake Melville area, and that Inuit Traditional Knowledge and non-aboriginal Local Ecological Knowledge be incorporated in the analysis.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.73**

Information Requested:

The Proponent is asked to provide:

a. **detailed information on existing recreational, commercial and aboriginal fisheries in Lake Melville and the relationship between these various fisheries and the Churchill River and its tributaries;**

Response:

In addition to the information provided in Volume III, Section 2.8.3.6 (Seals) and Section 2.8.5 (Fishing) of the EIS, the following is provided:

Recreational

Sea-run brook trout and Atlantic salmon are taken in the domestic gillnet fishery in Lake Melville. Major netting sites for both trout and salmon include the mouths of Kenamu River and North West River and the area between Sebaskachu River and Mulligan River. Sites netted for both trout and salmon on a more sporadic basis include the mouth of the Churchill River, Sandy Point and the shorelines adjacent to the numerous cabins located throughout Lake Melville. Salmon are also taken in Valley Bay and the Backway in outer Lake Melville. Arctic char are occasionally captured in the domestic gillnet fishery.

The northern resident (non-Aboriginal) gillnet fishery in Lake Melville is limited to 160 licences annually. Participants are restricted to an annual catch of 50 brook trout and four salmon; participants must suspend operations once the limit of four salmon is reached. In addition, an in-season closure is implemented annually to conserve multi-seawinter salmon (W. King, pers. comm.).

Brook trout, smelt and rock cod are taken during the ice fishing season (from October to May). Brook trout and smelt are caught on hook and line and rock cod are taken by jigger in deeper water.

Seals (ringed seals and harp seals) are harvested in Lake Melville. Seals are mainly harvested in the spring with lesser numbers taken in the winter. Seals are primarily harvested in the Sebasachu Bay/Mulligan Bay area, Valley Bay, the Backway and Etagaulet Bay. All species of seals can be harvested at any time in Lake Melville for food purposes (W. King pers. comm.)

The Newfoundland and Labrador Angler's Guide 2009/10 (DFO 2009) states that smelt angling in coastal waters (i. e. Lake Melville) is permitted throughout the year, and that there is no bag limit or possession limit for smelt.

Commercial

The season for the commercial harvest of harp seals is May 15 to November 15; the season for commercial harvest of ring seals is April 25 to December 1.

There are licences available for a commercial trout fishery in Lake Melville. This fishery typically caters to a small, local market and in 2009, due to the very limited activity, no quota was established (W. King, pers. comm.). Historically, in 1979, an experimental fishery harvested 32,000 kg of rock cod in Lake Melville.

Aboriginal

Season dates, closed times and upper harvest limits for trout and salmon gillnet fisheries in Lake Melville are negotiated with Aboriginal groups on an annual basis.

There are no closed times or quotas for seal harvests by Aboriginal groups in Lake Melville.

Relationship to Churchill River

In the EIS (Volume III, Section 2.8.5) a total of five fish species (Atlantic salmon, Arctic char, brook trout, rock cod and rainbow smelt) were reported in Lake Melville. Four of these species (excluding rock cod) were reported in the Churchill River watershed by Anderson (1985); three of these species (excluding rock cod and Arctic char) were reported in the Churchill River watershed by Innu Nation (2007). None of the anadromous species migrate upriver past Muskrat Falls as it is a barrier to upstream migration (see additional description in response to IR# JRP.52). In terms of the relationship between these various fisheries and the Churchill River and its tributaries, the Churchill River below Muskrat Falls would represent a portion of the habitat for four species (brook trout, Atlantic salmon, Arctic char and rainbow smelt). Some spawning activity by rainbow smelt would occur in the lower Churchill River; as flows will be virtually unchanged (refer to the response for IR# JRP.43), effects on subsequent juvenile rearing by all salmonid species are not anticipated. Scruton et al. (1997) reported that spawning activity by rainbow smelt occurs shortly after ice-out (early May to mid June in Labrador). Anadromous smelt typically spawn in the lower reaches of streams and rivers in moderate flowing, gravel-bottomed habitat (Bradbury et al. 1999). Innu Nation (2007) reported seals in the Churchill River (possibly ringed, harp or hooded).

References:

Personal Communications:

King, W. Senior Area Representative for Labrador Conservation and Protection Branch, DFO

Literature Cited:

Anderson, T. C. 1985. The rivers of Labrador. Can. Spec. Publ. Fish. Aquat. Sci. 81: 389p.

Bradbury, C., M.M. Roberge and C. K. Minns. 1999. Life history of freshwater fishes occurring in Newfoundland and Labrador, with emphasis on lake habitat requirements. Can. MS Rep. Fish. Aquat. Sci. 2485:vii+150p.

DFO. 2009. Newfoundland and Labrador Angler's Guide 2009/10. Department of Fisheries and Oceans. http://www.nfl.dfo-mpo.gc.ca/folios/00090/docs/anglersguide_guidedepecheur_2009-10-eng.pdf.

Innu Nation. 2007. Innu Kaishitshissenitak Mishta-shipu (Innu Environmental Knowledge of the Mishta-shipu (Churchill River) Area of Labrador in Relation to the Proposed Lower Churchill Project). Report of the work of the Innu Traditional knowledge Committee prepared by Wolverine & Associates, Inc. for Innu Nation.

Scruton, D. A., D. R. Sooley, L. Moores, M. A. Barnes, R. A. Buchanan and R. N. McCubbin 1997. Forestry guidelines for the protection of fish habitat in Newfoundland and Labrador. DFO, St. John's, NF. 63p.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.73**

Information Requested:

The Proponent is asked to provide:

b. a list of scheduled rivers referenced in Volume IIA, page 2-23;

Response:

The scheduled rivers referenced in Volume IIA, page 2-33, are not within the Lake Melville area. The nearest DFO scheduled rivers are Tom Luscombe River and tributary streams, located approximately 120 km from Muskrat Falls, east of Rigolet, and Double Mer & tributary streams , located approximately 210 km from Muskrat Falls, at the head of Double Mer, just west of Rigolet (DFO no date).

Reference:

DFO. No date. http://www.nfl.dfo-mpo.gc.ca/folios/00090/docs/Scheduled_Salmon_Rivers_Map-eng.pdf.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.73**

Information Requested:

The Proponent is asked to provide:

c. a description of existing fisheries management measures, including an expanded description of the Churchill Basin (including the waterways within) as well as reference to the special trout management plan for EIS Volume III, Sections 2.8.5 and 2.3.1 respectively; and

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Response:

The fisheries management zones, and their associated management measures, within the lower Churchill River are described in Volume IIA of the EIS, Section 2.3.1.1 with the following exception for the Churchill River Drainage Basin Watershed provided below.

The 2009/10 Angler's Guide (DFO 2009) presents two Special Trout Management Areas within portions of the Churchill River basin. Within Special Trout Management Areas, typical management measures such as season dates, bag limits and possession limits may vary.

Eagle Plateau Management Zone (Labrador)

The range of the Eagle River Management Zone is outlined in the DFO Angler's Guide (page 21, DFO 2009). Although outside the ecological boundary of the Aquatic Environment assessment, it includes portions of the upper Minipi drainage as well as portions of the upper drainages of other rivers and streams to the east of Minipi River. The management measures that have been adjusted from standard province-wide measures include a change in season date (February 1 to September 15, 2009) a change in bag limit (six brook trout, or 2.5 pounds, plus one fish, whichever is reached first). The possession limit is also adjusted to equal the daily bag limit.

Churchill River Drainage Basin Watershed (Labrador)

The Churchill River Drainage Basin Watershed Includes the West Forebay, Sandgirt, Atikonak Lake, Sims Lake, Winokapau Lake, Lobstick Lake, Ashuanipi Lake, Lake Joseph, Smallwood Reservoir, Ossakamannon Reservoir, Gabbro and Shabogamo Lake. The management measures that have been adjusted from standard province-wide measures include a change in season date (February 1 to September 7, 2009) and a change in the minimum size limit for Lake Trout (60 cm) (DFO 2009).

Reference:

DFO. 2009. Newfoundland and Labrador Angler's Guide 2009/10. Department of Fisheries and Oceans. http://www.nfl.dfo-mpo.gc.ca/folios/00090/docs/anglersguide_guidedepecheur_2009-10-eng.pdf.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.73**

Information Requested:

The Proponent is asked to provide:

d. an assessment of the effects of the Project on these fisheries (including salmon fishing & seal hunting for subsistence & cultural purposes) incorporating Aboriginal Traditional Knowledge and non-Aboriginal Local Ecological Knowledge in the analysis.

Response:

As detailed in the response to IR# JRP.43, flow patterns, nutrients/water quality, temperature, ice cover, and substrate morphology will not be affected in Lake Melville as a result of the Project, and therefore there will be no measurable Project-related effects to fish or seals in Lake Melville. Therefore there will be no measurable effects on these fisheries.

IR# JRP.74

Country Food

Requesting Organization – Joint Review Panel **Information Request No.: JRP.74**

Subject - Country Food

References:

EIS, Volume III, Section 2.8.16 (Existing Environment – Innu Land and Resource Use) and Section 5.2 (Land and Resource Use – Existing Knowledge)

Aura Environmental Research and Consulting Ltd. 2008. *Lower Churchill Hydroelectric Generation Project: Community Health Study.* Prepared for Minaskuat Inc., Happy Valley-Goose Bay, NL

Related Comments / Information Requests:

IRs # JRP.41, 42, 70, 81, 91

Rationale:

The Community Health Study prepared for the Project mentions that "(…) [n]evertheless, unlike many other Aboriginal populations in Canada, the Innu continue to hunt, though at a reduced level, and are able to mix healthier country foods with unhealthy processed foods obtained in their communities." (p. 6-4)

Table 2-14 (Volume III, p. 2-83) shows Country Food as a Percentage of Total Food **Production** for Labrador Innu, however no information is provided on country food as a percentage of total food consumption by Labrador Innu, to help validate the previous statement.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.74**

Information Request:

The Proponent is asked to provide additional information with respect to the amount of country food consumed as a proportion of total food consumption.

Response:

Additional information pertaining to country food consumption is summarized below. A review of the literature has not located other studies other than that presented in the EIS that provide explicit information on the amount of country food consumed as a proportion of total food consumption. The information used in the EIS was based on an earlier study by Armitage (1989) - the source for Table 2-14 referenced in the Rationale section of this IR. This report does not indicate explicitly if the food hunted was consumed. However, because there is no known commercial Innu harvest, it is thought that the food was consumed.

Samson and Pretty (2005) indicate that country foods continue to constitute an important part of the diet of the Labrador Innu, but that country food harvesting has declined dramatically since funding for the Outpost Program was withdrawn. According to Armitage (1990), the total amount of edible country meat harvested by residents of Sheshatshit (Sheshashiu) in 1987 was approximately 25,000 kg, which averages approximately 34 kg per member of the population of Sheshatshit. According to the same source, the residents of Utshimassit (Davis Inlet) harvested approximately 40,000 kg of country meat in 1987, representing roughly 100 kg per resident. According to FAO (2004), the average Canadian consumed roughly 100 kg of meat in 1987. The harvest of country meat by the Sheshatshit Innu in 1987 may, therefore, represent roughly 30 percent of the meat consumed there in that year, whereas the harvest of country meat by the Utshimassit Innu in the same year may represent approximately 100 percent of the meat consumed in that community. It is probable that some food also came from the gathering of plants and berries.

It seems that non-country food constituted a large part of the food consumed by the Labrador Innu in 1987, and therefore it seems reasonable to conclude that non-country food provides a large part of the food consumed by the Labrador Innu today.

In a recent study undertaken by Mergler et al. (2004), information on fish consumption patterns for five Aboriginal populations was collected through questionnaires administered by interviews. One of the Aboriginal groups was the Labrador Innu of Sheshatshiu. Local fish consumption was reported as number of meals per season. The reported value for Labrador Innu was significantly higher than any of the other Boreal Forest Ecosystem communities. The average reported number of fish meals per season for the Labrador Innu of Sheshatshiu was 38.4 (+/- 65.9) as compared to 5.6 +/- 6.8. The fish reported as most consumed by Labrador Innu were salmon, trout and smelt.

As indicated in the response to IR# JRP.1, Nalcor's efforts to obtain resource use information from Innu Nation, and therefore current information on the consumption of country food by Labrador Innu is not available. Nalcor has, and continues, to encourage the Innu to bring any such perspectives and information on Innu resource use directly to the Joint Review Panel.

References:

Armitage, P. 1990. Contemporary Land use and Occupancy Among the Innu of Utshimassit and Sheshatshit. Preliminary Report. Innu Nation (Naskapi-Montagnais Innu Association) and Sheshatshit and Utshimassit Nitassinan (Labrador-Québec).

FAO (Food and Agriculture Organization of the United Nations). 2004. FAOSTAT on-line statistical service, "Meat Consumption: Per Capita." Rome, Italy. Available at http://earthtrends.wri.org. Accessed 12 July, 2009

Innu Nation 1998; Survey of Mushuau Innu Land Use at Emish (Voisey's Bay) since 1991. Report tabled with Voisey's Bay Project Environmental Assessment Panel5 pp.

Mergler. D., S. de Grosbois, L. Chan, C. Vanier, M. Legrand, L. Atikesse, M. St. Jean, J. Charron, N. Abdelouahad, G. Beauchamp, A. Pull, I. Rheault, M. Lucotte. 2004 Maximizing nutrition from fish consumption and minimizing toxic risk: an ecosystem approach to mercury in Canadian communities.7th Annual Conference on Mercury as a Global Pollutant, Slovenia. June 27-July 2 2004.

Samson, C. and J. Pretty. 2005. Environmental and Health Benefits of Hunting Lifestyles and Diets for the Innu of Labrador. Presented at British Association of Canadian Studies, First Nations, First Thoughts Conference, Edinburgh, Scotland, 6 May, 2005.

IR# JRP.75

Palaeontological Resources in the Study Area

Requesting Organization – Joint Review Panel **Information Request No.: JRP.75**

Subject - Palaeontological Resources in the Study Area

References:

EIS Guidelines, Section 4.4.4.5 Cultural Heritage Resources

EIS, Volume III, Section 1.4 Cultural Heritage Resources

EIS, Volume III, Section 2.9.2 Palaeontological Resources

EIS, Volume III, Section 6.1.1 Palaeontological Resources

EIS, Volume III, Section 6.3 Selection of Key Indicators

Related Comments / Information Requests:

CEAR # 205 (Government of Newfoundland and Labrador – Provincial Archaeology Office)

Rationale:

The EIS Guidelines require the Proponent to "describe relevant cultural heritage resources in the study areas of the VECs, including the following: … (c) Paleontological resources …"

Sections 1.4 (p.1-4), 2.9.2 (p.2-86), 6.1.1 (p.6-1) and 6.3 (p.6-3) of Volume III indicate that palaeontological resources are absent or have not been recorded in the Assessment Area. The Provincial Departments of Tourism, Culture and Recreation, and Natural Resources advise that:

> *"The section on Palaeontological Resources is broadly accurate but it does ignore the very real potential of Quaternary marine fossils in the glaciomarine sediments that are spectacularly exposed below Muskrat Falls and possibly also higher up. There are radiocarbon dates on post-glacial marine shells from this locality (radiocarbon date # GSC-1254, 7490 YBP on marine shells) and personnel from the Geological Survey of NL have observed material there. The known occurrences lie below Muskrat Falls and likely will not be affected by the Project. There are potentially other sites above the falls but there has not been much formal investigation of this area. These fossils are common in marine sediments across the province and are not particularly rare or unusual, but they should be mentioned for the sake of completeness."*

Requesting Organization – Joint Review Panel **Information Request No.: JRP.75**

Information Requested:

The Proponent is asked to provide complete information on paleontological resources in the study area including:

a. **identification of specific paleontological sites and whether these sites will be lost during inundation; and**

Response:

The following information is provided in addition to that presented in Volume III of the EIS, Section 2.9.2.

The only recorded palaeontological sites near the study area are glaciomarine shells in Holocene sediments, exposed below Muskrat Falls. These sites will not be lost during inundation.

Background

Reconnaissance of the lower Churchill River valley was carried out in 1997-1998 (Catto 1998). Efforts to locate marine or brackish-water fossils in the exposed sediment bluffs between Muskrat Falls and the confluence with the Minipi River were unsuccessful. Fossils would have been extremely useful in dating the course of Quaternary post-glacial events, so considerable effort was expended to search for them. Subsequent visits by the same researcher have also failed to locate any marine or brackish-water fossils. All exposures of sediment along the river between Muskrat Falls and the Minipi River have been investigated.

Previous researchers have also looked for marine or brackish water fossils, without success. These efforts were summarized in Catto (1998), along with the implications for interpretation of the immediate post-glacial environment. Some previous researchers have suggested that water conditions (primarily low salinity) in the embayment between Muskrat Falls and Gull Island Rapids would prevent occupation of the area by the mollusc and barnacle species found below Muskrat Falls in younger (Holocene) sediments.

Reference:

Catto, N.R. 1998. Geomorphology and Sea Level History, Lower Churchill River- Lake Melville region, Labrador. Prepared for Jacques Whitford Environment Limited.

Requesting Organization – Joint Review Panel **Information Request No.: JRP.75**

Information Requested:

The Proponent is asked to provide complete information on paleontological resources in the study area including:

b. information on the cultural significance of these fossils and fossil locations available.

Response:

Holocene mollusc shells and barnacles occur in marine terraces in the Goose Bay area, as noted by several workers (e.g., Liverman 1997 who looked at the area around Happy Valley-Goose Bay and North West River). Similar fossils have been found in marine sediments across the Province, indicating that these fossils are not particularly rare or unusual. The primary value of these fossils is their usefulness for 14C dating, allowing determination of post-glacial environmental history. No cultural use of these fossils has been documented.

No fossil localities have been found in either river bluff exposures or road cuts along the Trans-Labrador Highway above Muskrat Falls.

Reference:

Liverman, D.G.E., 1997. Quaternary Geology of the Goose Bay area. Newfoundland Department of Mines and Energy, Current Research, Geological Survey Report 97-1, 173-182.