IR# JRP.96

Inundation and Flood Mapping

Requesting Organization – Joint Review Panel **Information Request No.: JRP.96**

Subject - Inundation and Flood Mapping

References:

EIS, Volume IA, Section 4.5.1.1, 4.5.2.1 (Project Description – Operating Regime) & Section 4.11.3 (Accidents and Prevention – Dam Failure)

Related Comments / Information Requests:

CEAR # 183 (Central Labrador Environmental Action Network)
CEAR # 192 (E. Davis)
CEAR # 200 (Grand Riverkeeper Labrador Inc.)
CEAR # 205 (Government of Newfoundland and Labrador – Water Resources Management Division)

IRs # JRP.6, 28, 33, 34, 35, 36, 37, 71, 72

Rationale:

The EIS Guidelines Section 4.5.2 on Accidents and Malfunctions require the Proponent to provide "(d)etailed plans, measures and systems to reduce the potential occurrence of an accident or malfunction". The Guidelines also indicate that the plans "(s)hall indicate how they will reduce the effects or consequences of an accident or malfunction, should it occur". There is minimal information in the EIS on the inundation and flooding that might result downstream from failure of a dam along the Churchill River.

EIS Volume III, Section 7.5.3 (Community Health) mentions that "(I)n the event of a double breach at Gull Island and Muskrat Falls, flood waters would affect approximately 380 homes in the Happy Valley-Goose Bay/Mud Lake area." The EIS also states that "An Emergency Preparedness Plan will be developed by Nalcor Energy in consultation with potentially affected communities. The purpose of the Plan will be to minimize loss of life through the development of community evacuation procedures. In the event of a dam failure, evacuation and other emergency response procedures will be implemented."

The EIS indicates both that "(i)n order to maximize power and energy output, Gull Island Reservoir will be operated as close to FSL (125 m) as possible" (p. 4-59) and that "(t)he reservoir has the capacity for additional storage in order to handle extreme flood events up to a maximum flood elevation of 127 m" (p. 4-59). Similarly, the EIS indicates that the operating level for Muskrat Falls will be 39 m with additional storage capacity to 44 m during extreme flood events.

With regards to dam failure, the EIS refers to a dam breach study that details the potential consequences of a dam failure at one or both projected sites on various low-lying terrestrial environment habitat and inhabited areas (Happy Valley-Goose Base, Mud Lake) and on transportation and community infrastructure including Black Rock Bridge, water, sewer, power and communications infrastructure) (p. 4-86). In addition, some residents have expressed concerns over the possibility of a "cascading" failure resulting from the breach of the Jakopi structure or other structures associated with Upper Churchill.

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Information Requested:

The Proponent is asked to provide:

a. **clarification as to whether the flood lines that are plotted in the inundation maps provided as Appendix IB-C show the Full Supply Level (125 meters for Gull Island or 39 metres for Muskrat Falls) or Maximum Flood Elevation (127 metres or 44 metres);**

Response:

The flood lines that are plotted in the inundation maps provided as Appendix IB-C, Volume IB of the EIS show the Full Supply Level.

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Information Requested:

The Proponent is asked to provide:

b. explanation of how the differential between Full Supply Level and Maximum Flood Elevation was considered when assessing the Project's environmental effects;

Response:

The Full Supply Level is the normal operating level of the reservoir and was assessed as part of the operational phase of the Project. The maximum flood level is associated with a specific event, the Probable Maximum Flood (PMF) and is therefore assessed as part of accidental events, i.e., flooding and subsequent dam break analysis.

PMF is discussed further in the response to IR# JRP.96(c).

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Information Requested:

The Proponent is asked to provide:

c. an explanation of the analytical methods and any assumptions used to determine the maximum flood elevation and maximum area flooded for both the Gull Island and Muskrat reservoirs;

Response:

The maximum flood level (MFL) on a reservoir is based on the inflow design flood and the reservoir's flood storage and spill capacities. The Canadian Dam Association (CDA) Guidelines (2007) recommend inflow design floods for dams based on the consequence of dam failure. The inflow design flood is subsequently used in the design of hydraulic facilities, e.g., dams and spillways, and for dam safety studies. Additionally, the reservoir's storage and spill capacities are optimized based on technical, environmental and economic considerations, including dam height, flooded area and gate size.

Under the CDA guidelines, it was determined that the appropriate inflow design flood at Gull Island and Muskrat Falls is the PMF. A PMF is defined by the CDA (2007) as the: "Estimate of hypothetical flood (peak flow, volume and hydrograph shape) that is considered to be the most severe 'reasonably possible' at a particular location and time of year, based on relatively comprehensive hydro-meteorological analysis of critical runoff-producing precipitation (snowmelt if pertinent) and hydrologic factors favourable for maximum flood runoff".

As part of several engineering studies initiated by Nalcor Energy (Nalcor) in 2007, a study was conducted to determine the PMF for the Lower Churchill Project sites. The investigation included a meteorology study to estimate the contributors to the PMF, and detailed hydrologic modeling of the entire Churchill River Basin to estimate Gull Island and Muskrat Falls PMF peaks.

Watershed models for the Upper and Lower Basins were created using the SSARR (Streamflow Simulation and Reservoir Regulation) model. The model uses precipitation, temperature, snowpack information and relationships that define runoff response to predict flows in the Churchill River. Input data were gathered from a variety of sources and included meteorological data from Atmospheric Environment Branch, Environment Canada climate stations at Goose Bay, Churchill Falls, Schefferville and Wabush, snow course, precipitation and lake level data from CF(L)Co. and hydrometric data from 11 Water Survey of Canada (WSC) streamflow stations. The model was then used to test the various combinations of extreme rainfall, temperature and snowpack recommended by the CDA to determine the governing PMF scenario.

Inflow hydrographs generated in SSARR were subsequently routed through the Acres Reservoir Simulation Package (ARSP) operational model. This methodology, applied to the Upper Basin, resulted in the determination of contributory outflows from the Upper Basin. Similarly, SSARR was used to generate PMF inflow hydrographs for the Lower Basin.

The final step in determination of the MFL and the spillway design capacity at each site was the creation of a dynamic HEC-RAS (Hydrologic Engineering Center – River Analysis System) hydraulic model of the Lower Churchill River. This model was used to route the contributory outflows from the Upper Churchill Basin (determined using ARSP) and the Lower Churchill PMF inflow hydrographs (generated by the SSARR model) through the Gull Island and Muskrat Falls reservoirs. With either of the MFL or the spillway capacity fixed, the HEC-RAS model will determine the other. At Gull Island and Muskrat Falls, the MFLs had been pre-determined

in other studies, as described below. The spillway design capacity at each site was then obtained from the HEC-RAS model to correspond to the selected MFL.

In 1998 the MFL for Gull Island was set at 127 MASL to respect CDA criteria for a minimum of 2 m between the crest level of the dam and the MFL for protection against frost action in the dam during maximum extreme flood conditions.

The FSL of the reservoir for Muskrat Falls was set at 39 m, for optimum utilization of the available head on the River, without negative impact on the Gull Island plant. As a result, six options for spillage of the PMF were considered for Muskrat Falls. The six options included different MFLs (based on HEC-RAS flood routing). The two lowest cost options included a MFL of 44 m.

The maximum areas flooded for the Gull Island and Muskrat Falls Projects were determined by superimposing the reservoir FSLs on detailed LiDAR mapping of the Project areas. The maximum flooded area for each project was calculated by subtracting the area of the original river surface from the reservoir surface area bounded by the FSL contour.

Reference:

Canadian Dam Association. 2007. Dam Safety Guidelines 2007.

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Information Requested:

The Proponent is asked to provide:

d. a map of the area(s) to be flooded following a possible dam failure, as detailed in the dam breach study;

Response:

A map of the areas that would be flooded following a possible dam failure, as detailed in the Dam Breach Study (Hatch 2008) (Attachment A). Due to the size, Attachment A is provided electronically.

Reference:

Hatch Ltd. 2008. The Lower Churchill Project: Dam Break Study - Volumes 1 and 2. Prepared for Newfoundland and Labrador Hydro, St. John's, NL.

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Information Requested:

The Proponent is asked to provide:

e. a copy of the Dam Breach Study;

Response:

A copy of the Dam Break Study (Hatch 2008) is provided in electronic format (due to the size of the report) (Hatch 2008), as part of this response. The consequences of a dam failure at Gull Island or Muskrat Falls, or both, have been presented in Volumes 1 and 2 of the 2008 report GI1190 - Dam Break Study (Hatch 2008) for several failure scenarios. Volume 1, Part 7, lists the consequences with respect to potential loss of life, as well as economic, environmental and cultural losses for incrementally inundated areas, for each scenario. Volume 2 presents the flood inundation mapping, including the flood levels that would naturally occur and the incremental flood levels that would result from a dam failure, for each scenario. The inundation mapping shows extensive flooding as far downstream as Hamilton Inlet but little flooding further out into Lake Melville, beyond Sandy Point. Little, if any incremental flooding would be anticipated in the area of the communities of Northwest River and Sheshatshiu.

Reference:

Hatch Ltd. 2008. The Lower Churchill Project: Dam Break Study - Volumes 1 and 2. Prepared for Newfoundland and Labrador Hydro, St. John's, NL.

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Information Requested:

The Proponent is asked to provide:

f. an evaluation and description of the risks and impacts associated with a potential cascade failure involving the Churchill Falls installation/dams. This should include considerations of the potential effects on the communities of Happy Valley-Goose Bay and Mud Lake and associated infrastructure and a map of the area that would be flooded;

Response:

Construction of the Churchill Falls development was completed 38 years ago in 1971, and the dams and dykes associated with the development have been closely monitored since then. CF(L)Co. has retained a consultant to complete a dam failure analysis using the same tools as were used for the dam breach analysis for the Project. Once complete, the results will be integrated with the model used for the Project, and an integrated analysis will be completed for downstream communities, including Happy Valley-Goose Bay, Mud lake, Northwest River and Sheshatshui. Inundation mapping will then be provided for any cascade failure scenarios. This is expected in early 2010.

The results of this follow-up analysis will be provided to appropriate regulators and stakeholders when it is available.

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Information Requested:

The Proponent is asked to provide:

g. the mitigation measures proposed to reduce the effects or consequences of a possible dam break on the communities of Happy Valley-Goose Bay and Mud Lake and associated infrastructure; and

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Response:

The dams and associated spillways for the Lower Churchill project will be designed and built to very high standards. This includes being designed, by eminently qualified engineering consultants, to pass inflow design floods equal to the PMF, which, in Canada, is a criteria set by the CDA for dams with high consequences of failure. Further, it includes construction of the dams, by eminently qualified contractors, in accordance with rigorous quality control procedures.

In addition, during the operational lives of the structures, they will be monitored closely through extensive internal geotechnical instrumentation, together with external quantitative and qualitative surveys and in accordance with a proactive corporate dam safety program, following the Dam Safety Guidelines published by the CDA.

Nalcor has a pro-active dam safety program which follows the CDA Dam Safety Guidelines for inspections and maintenance of its structures. Nalcor retains a Dam Safety Review Board of engineers recognized as experts in the field of dam engineering to oversee its dam safety program.

Prior to the first filling of each reservoir, an effective emergency management process will be in place. The emergency management process will include, for each of the Gull Island and Muskrat Falls developments, an Emergency Response Plan (ERP) and an Emergency Preparedness Plan (EPP). The process will be continuously updated over the life of the dams. Nalcor Energy will prepare the ERPs and the EPPs with full involvement of the communities downstream of the reservoirs.

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Information Requested:

The Proponent is asked to provide:

h. additional information on the Emergency Preparedness Plan (EPP), emergency response procedures and community evacuation procedures including information on the local administrative/community capacities in supporting or participating in emergency response procedures related to such event.

Response:

An ERP will be prepared for each development to document the procedures that the plant operating staff should follow in the event of an emergency at the dam. The ERP will also outline the key emergency response roles and responsibilities, as well as the required notifications and contact information.

The EPP is required for use by external agencies where a dam failure or passage of a major flood could cause loss of life. Nalcor will prepare and maintain an EPP for each development which will describe the various hazards associated with the dams, the associated notifications to be issued and the actions expected of other responders. They will contain inundation maps and flood arrival times and water levels so that local authorities can develop their own response plans.

A sample table of contents for an EPP is included as Attachment B.

NOTE:

Please see accompanying CD for Digital File.

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

JOINT REVIEW PANEL

Attachment A

Dam Break Study Final Report - Volume 1&2

IR# JRP.96

October 2009

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LOWER CHURCHILL PROJECT

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

JOINT REVIEW PANEL

Attachment B
Emergency Preparedness Plan Table of Contents

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