2 Hydrology Studies

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2.1 Introduction

The objective of this analysis was to review the hydrological/hydraulic and energy production components of studies carried out to date for Muskrat Falls and on-island hydroelectric projects (HEPs), including relevance of input source, methodology, accuracy of estimates and/or assumptions, identification of gaps, recommendations on findings and examination of quality assurance mechanisms. Projects evaluated in this Report are:

- Muskrat Falls (Infeed)
- Round Pond (Isolated Island)
- Island Pond (Isolated Island)
- Portland Creek (Isolated Island and Infeed)

The Report covers the review of hydrological/hydraulic and energy production related studies. These studies are far more extensive in the Muskrat Falls case than for the other three HEPs. In the Muskrat Falls case, the topics covered are:

- Hydraulic Modeling of Churchill River
- Construction Flood Estimate
- Probable Maximum Flood (PMF)
- Spillway Design
- Hydraulic Modelling of Structures
- Dam Break Analysis
- Ice Studies
- Energy Estimates

In the case of the island HEPs the review covers:

- Construction Flood Estimate
- Probable Maximum Flood
- Energy Estimates

2.2 Muskrat Falls

2.2.1 Dam Layout

The updated Muskrat Falls dam configuration (Variant 10, Scheme 3b) is comprised of the following structures as outlined in the Muskrat Falls "MF 1050 – Spillway Design Review report"[31].

- South Roller Compacted Concrete (RCC) Dam – approximately 315 m long with a crest elevation of 45.5 m.
- North RCC Overflow Dam – 430 m long with a crest elevation of 39.5 m; capable of passing approximately 8,800 m^3/s at maximum flood level (MFL) of 44 m.
- Four (4) bay gated spillway with submerged radial gates (12.5 m wide by 14.8 m high) with a permanent sill elevation of 5 m; capable of passing 13,305 m^3/s at MFL of 44 m.
- Four (4) unit powerhouse capable of passing 2,667 m^3/s at full load.

2.2.2 Hydraulic Modeling of Churchill River

As part of Muskrat Falls' feasibility studies, Hatch developed a numerical hydraulic model of the Lower Churchill River. The model was originally developed in 2007-2008.[32] However, the corresponding report has not been filed because, since 2007, there have been updates to project layouts and additional bathymetric and hydrometric data which have become available. The current up-to-date model is described in a 2010 update report by Hatch.[33] The model extends from Churchill Falls to the Atlantic Ocean at Grosswater Bay. Bathymetric/topographic cross-sections were obtained from various sources. In total, the numerical model includes 374 cross-sections over a distance of 557 km, which can be considered a detailed model.

Calibration of the model was carried out with the widely used Hydraulic Engineering Centre – River Analysis System (HEC-RAS) water surface profile software package developed by the Hydrologic Engineering Centre of the US Army Corps of Engineers (USACE). The model was calibrated in both steady and unsteady states. Steady state calibration was effected on surveyed water levels and rating curves of gauging stations located on the Churchill River. Except in a few reaches, generally the calibrated surface profile is within a few centimeters of the surveyed profile. The unsteady flow model was calibrated for the 1981 flood observed at Muskrat Falls gauging station and the resulting calibrated flood hydrograph follows closely the observed hydrograph.

A consistency analysis between the steady and unsteady flow models was also carried out. Simulated water levels from the two models for a flow approximately equal to the maximum annual flow were compared. The water levels were within 0.5 m at 95 percent of the cross sections upstream of Goose Bay; the maximum difference between the two models was approximately one meter. It can be concluded that the model is very robust and that both steady and unsteady flow models perform

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[31] Exhibit CE-16 Rev.1 (Public), SNC Lavalin, "Newfoundland and Labrador Hydro Lower Churchill Project Pre-feed Engineering Services - Muskrat Falls Hydroelectric Project MF1050 – Spillway Design Review", December 2007

[32] Exhibit CE-14 (Public), Hatch, "The Lower Churchill Project – GI1190 - Dam Break Study Volume 1", April 2008

[33] Exhibit CE-22 (Public), Hatch, "The Lower Churchill Project MF1330 - Hydraulic Modeling and Studies 2010 Update, Report 1: Hydraulic Studies of the River", October 2010

satisfactorily and can be used for the prediction of velocities and water levels throughout the Lower Churchill River.

This water surface profile modeling is an important step in the study as the model is subsequently used in the following studies of Muskrat Falls:

- Probable Maximum Flood (PMF) study
- Construction Design Flood (CDF) study
- Ice study
- Dam Break study

2.2.3 Probable Maximum Flood and Churchill Falls Flood Handling Procedure

In accordance with the Canadian Dam Safety Association (CDA) Guidelines, the Muskrat Falls dam and reservoir are classified in the high risk category for which the required project design flood is the PMF. The PMF is defined as the flood that would be produced by the most adverse combination of flood producing factors possible from both meteorology and hydrology for the region and season of the year.

Various studies have been completed on the PMF for the Lower Churchill River. The most recent are listed below and were reviewed by MHI.

- Acres 1999 Study[34]
- SNC-AGRA 1999 Study[35]
- Hatch 2007 Study[36]
- Hatch 2009 Study[37]
- Hatch 2010 Study[38]

The earlier studies assumed that the Gull Island development would be built before Muskrat Falls. The Hatch 2010 study revisited the PMF and its routing considering the construction of Muskrat Falls first. The study concluded that:

- at 26,060 m^3/s, the pre-project PMF peak inflow of Muskrat Falls is almost the same as the previous estimate (26,020 m^3/s) and the post-project estimate without Gull Island is 25,060 m^3/s with a maximum water level of 44.78 m.

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[34] Exhibits 50 and 51, Acres International, "Churchill River Complex, PMF Review and Development Study, Volumes 1 and 2, Report for Newfoundland and Labrador Hydro", January 1999

[35] Exhibit 19, SNC-AGRA, "Muskrat Falls Hydroelectric Development – Final Feasibility Study Volume 1 – Engineering Report", January 1999

[36] Exhibit CE-13 (Public), Hatch, "The Lower Churchill Project GI1140 – PMF and Construction Design Flood Study", December 2007

[37] Exhibit CE-54 Rev.1 (Public), Hatch, "The Lower Churchill Project GI1141 - Upper Churchill PMF and Flood Handling Procedures Update", August 2009

[38] Exhibit CE-23 (Public), Hatch, "The Lower Churchill Project MF1330 – Hydraulic Modeling and Studies Update 2010 – Report 2: Muskrat Falls PMF and Construction Design Flood Study", December 2010

- Additional work be undertaken to optimize the spillway design.

Conclusions of PMF Review

As a result of the hydrological review of the PMF, MHI finds that:

- A significant amount of work went into the estimation of the PMF, with a total of seven studies and reviews.
- The Probable Maximum Precipitation (PMP), Probable Maximum Snow Pack (PMSP), and the 1:100-year precipitation and snowpack were derived by professional meteorologists from Environment Canada in accordance with recognized procedures and the recommendations of the Canadian Dam Association (CDA) Guidelines.
- The approach for the routing of the PMF is very detailed with the use of the Streamflow Synthesis and Reservoir Regulation model, widely used in analyses of this type, especially when snowpack and snowmelt are present. A second step to refine the routing with HEC-RAS is bringing a supplementary level of accuracy to the routing process.
- The studies contain all the elements that will facilitate the modification of the flood handling procedure of Churchill Falls once Muskrat Falls is operational.

2.2.4 Construction Design Flood

Considering that the construction of Muskrat Falls will last two years, a construction design flood (CDF) study is a necessary component of the hydrology studies. The CDA guideline recommends adoption of the 1:40-year flood for diversion works and the CDF is made up of two components, the Upper Catchment flood inflow, and the unregulated downstream catchment flood.

Various construction design flood studies were performed for Muskrat Falls. These reports were all reviewed by MHI and are as follows:

- SNC-AGRA 1999 Study[39]
- Hatch 2007 Study[40]
- Hatch 2008 Study[41]
- Hatch 2010 Study[42]

[39] Exhibit 19, SNC-AGRA, "Muskrat Falls Hydroelectric Development – Final Feasibility Study Volume 1 – Engineering Report", January 1999
[40] Exhibit CE-13 (Public), Hatch, "The Lower Churchill Project GI1140 – PMF and Construction Design Flood Study", December 2007
[41] Exhibit CE-17 (Public), Hatch, "The Lower Churchill Project MF1130 – River Operation during Construction and Impounding", January 2008
[42] Exhibit CE-23 (Public), Hatch, "The Lower Churchill Project MF1330 – Hydraulic modeling and Studies 2010 Update, Report 2: Muskrat Falls PMF and Construction Design Flood Study", December 2010

In the Hatch 2010 study, Hatch updated the CDF study to reflect that Muskrat Falls will be built first. The update was substantial as it included the following changes:

- Updated the statistical flood frequency estimate of the CDF peak flow using the additional available years of record for Muskrat Falls, from Water Survey of Canada hydrometric stations. The observation sample consisted of 30 annual flood peaks during the period over which Churchill Falls was in operation. The resulting 1:20 and 1:40-year peak discharges are respectively 5,910 m^3/s and 6,250 m^3/s, being very close to the values estimated in the 2007 study; and
- Adoption of HEC-RAS as opposed to the Acres Reservoir Simulation Package (ARSP) model, in order to route 1:20 and 1:40-year flood hydrographs through the river channel and diversion facilities.

As in the 2008 study, the flood hydrograph of 1998 was pro-rated to the flood peak of the 1:20-year flood and routing with HRC-RAS resulted in a maximum water level of 22.8 m as opposed to 22.7 m which was reported in the earlier study, thus confirming the results of this prior study. The report presents no similar result for routing of the 1:40-year flood, but the maximum water level is likely very close to the 23.8 m level found in the 2008 study. The Hatch 2010 study concludes that the CDF peak outflow is 5,890 m^3/s and the peak water level is 22.78 m.

Conclusions of Construction Design Flood Review

As a result of the hydrological review of the CDF, MHI finds that:

- As with the PMF analysis, a number of studies have refined the CDF estimate over time. In particular, the analysis carried out in 2007 shows that floods do not occur simultaneously in the Upper and Lower catchments.
- The Lower Catchment flood peak estimation follows a classical flood frequency analysis procedure. With 30 years of observations, the sample is adequate to estimate the 1:40-year flood.
- The CDF analysis has been done in detail using all available information and can be considered final.

2.2.5 Ice studies

The formation of ice below Muskrat Falls will have an impact on how the plant is constructed. Large quantities of frazil and pan ice form in the reach between Gull Island and Muskrat Falls and this ice drifts downstream to the pool below Muskrat Falls where it accumulates forming a very large hanging dam. As a consequence water levels rise to eventually drown out the upper Muskrat Falls. This is an event that has occurred in 1978 and 1979.

This section documents the various ice studies performed for Muskrat Falls and reviewed by MHI. Based on the documents that were reviewed, ice studies were completed in 1999, 2007 and 2010. (Note: The Hatch 2007 study was superseded by the Hatch 2010 study. As such, the 2007 study was not filed by Nalcor).

- SNC-AGRA 1999 Study[43]
- Hatch 2010 Study[44]

The Hatch 2010 update assumed that Muskrat Fall was to be built before Gull Island. The same methodology and approach was adopted as the Hatch 2007 study with calibration of the ICESIM (Ice Simulation) model validated for the 1990-91 and 1991-92 winter seasons which were both colder than usual and with flows lower than average. ICESIM simulated level results were acceptable when compared with actual conditions.

The Hatch 2010 study concluded that results from the 2007 ice study remained valid as follows:

- "It is very unlikely that the water would rise to 20 meters above which flooding becomes a concern."
- "The water level required at the cofferdam to provide appropriate hydraulic conditions for an upstream cover to form was determined through ice modeling to be 25 m."

The Hatch 2010 report recommended:

- "Due to the complexity of the velocity regime expected at the Muskrat Falls cofferdam and the small ice accumulation predicted just upstream of the cofferdam, it is recommended that the 25 m water level determined in this study be optimized during FEED[45] studies.
- The implications of part of the upstream ice cover being lost during the winter should also be considered during future studies. In the event that even a part of this upstream cover breaks up and passes through the spillway, it could lead to rapid water level increases downstream of the plant that may impact any ongoing construction activities in that area."

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[43] Exhibit 19, SNC-AGRA, "Muskrat Falls Hydroelectric Development – Final Feasibility Study Volume 1 – Engineering Report", January 1999

[44] Exhibit CE-25 (Public), Hatch, "Lower Churchill Project MF 1330 – Hydraulic Modeling and Studies 2010 Update, Report 4: Muskrat Falls Ice Studies", March 2011

[45] FEED is defined as Front End Engineering Design

These findings and recommendations should be addressed in the detailed design phase and are relevant as they may impact the cofferdam design, and thus the overall cost of the Muskrat Falls development.

2.2.6 Numerical Modeling of Structures

Numerical modeling of structures is an important tool utilized to assess the performance of the various structures in the river system that comprises the Muskrat Falls development.

This section summarizes findings from the numerical modelling analysis undertaken in the studies noted below and reviewed by MHI.

- SNC-AGRA 1999 Study[46]
- SNC Lavalin 2008 Study[47]

In the SNC-AGRA 1999 study three variants were evaluated: variants 7, 10 and 11 with variant 7 as the recommended variant since it did not require a road to the south side of the proposed complex. Since the SNC-AGRA study, a highway bridge was constructed across the Churchill River 18 km downstream of the site.[48] Following an analysis of comparative costs, schedule and risks, variant 10 proved to be the most attractive development layout.[49] In 2008, SNC-Lavalin was retained by NLH to conduct a numerical modeling study of Muskrat Falls based on variant 10. This study numerically modelled in 3-dimensions the flows for the following hydraulic facilities:

- Diversion channels;
- Powerhouse (approach channel and tailrace channel); and
- Spillway (sluices and overflow crest).

MHI concurs with the findings of the reports reviewed as follows:

- The numeric model was calibrated in natural conditions with water levels of four hydrometric stations in the vicinity of the dam site. Simulated levels were about one meter off from observed levels for a range of discharges indicating a potential issue with the bathymetry at the control section.
- Simulation of diversion facilities indicate the right angle at the upstream end of the retaining wall of the upstream cofferdam generates a zone of low velocity, which reduces the capacity of sluice no. 1. In an improved layout, the right angle is curved with a 75 m radius and the flow through sluice No. 1 improves to the desired level.
- For the power intake facilities, an eddy is shown to occur near units 1 and 2 which could become a vortex and could eventually affect the efficiency of these units. An improved design

[46] Exhibit 19, SNC-AGRA, "Muskrat Falls Hydroelectric Development – Final Feasibility Study Volume 1 – Engineering Report", January 1999
[47] Exhibit CE-18 (Public), SNC Lavalin, "Lower Churchill Project MF1250 – Numerical Modeling of Muskrat Falls Structures", May 2008
[48] Exhibit CE-15 Rev.1 (Public), SNC Lavalin, "Lower Churchill Project MF1010 – Muskrat Falls Hydroelectric Project Review of Variants", March 2008
[49] Exhibit 30, Nalcor, "Technical Note: Lower Churchill Design Progression 1998 to 2011", July 2011

would consist of adding a 39m curved wing wall between the power intake and the spillway together with a longer approach channel.

- For the numerical analysis of the spillway, the PMF adopted in Variant 10, with a peak of 22,100 m^3/s is also considered in the numerical analysis. However, the SNC Lavalin 2008 study recognizes that since the earlier study, the PMF value has been updated and that the updated PMF should be considered in any future update of the study. Simulation results for the PMF conditions show no major problem. However, at maximum normal operating level, a significant vortex forms upstream of sluice no. 1 which may reduce the capacity of this sluice. With a possible increase of the PMF at Muskrat Falls, a fifth sluice could be introduced. It will increase the spill capacity of the system and will give more flexibility during construction. It should be noted that this is also the recommendation of the Hatch 2010 flood review study.

MHI finds that the numerical modeling of the Muskrat Falls structure that was done was appropriate and that the SNC Lavalin 2008 study has identified undesired flow patterns that require adjustments in the final layout.

2.2.7 Spillway Design

Spillway design was studied in the SNC Lavalin 2007 report[50]. This study essentially sizes the spillway gates and estimates the cost of the spillway facility based on the preferred variant 10. This study requires an update to reflect the latest findings on the PMF.

2.2.8 Dam Break Analysis

A dam break analysis of Muskrat Falls was prepared by Hatch in 2010 with Muskrat Falls built first before any Gull Island development.[51] The HEC-RAS model was used to simulate the flood wave downstream of Muskrat Falls as a result of a dam breach. Two scenarios were prepared in accordance with CDA Guidelines (2007):

- dam breach under fair weather conditions, and
- dam breach under PMF conditions using the PMF hydrograph from the Hatch 2010 flood studies update.

The study assumes that the worst case breach scenario would be by sliding or overturning of the North Roller Compacted Concrete (RCC) Overflow Dam, which is 430 m long and has a bottom elevation of 4.0 m. Due to the relatively rapid nature of the failure mechanism, the breach was assumed to be fully formed within one hour of breach initiation.

General findings from the study under fair weather conditions are:

- Outflow immediately downstream of the dam would increase from an initial flow of approximately 1,800 m^3/s (assumed turbine flow) to a peak flow of approximately 70,500 m^3/s.

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[50] Exhibit CE-16 Rev.1 (Public), SNC Lavalin, "Lower Churchill Project Muskrat Falls Hydroelectric Project MF1050 – Spillway Design Review", December 2007

[51] Exhibit CE-24 (Public), Hatch, "Lower Churchill Project MF 1330 – Hydraulic Modeling and Studies 2010 Update, Report 3: Muskrat Falls Dam Break Study", December 2010

- Incremental water level increases would range from approximately 12.8 m downstream of Muskrat Falls to approximately 4.7 m near Mud Lake.
- There would be approximately 1.4 to 1.7 hours of warning time available between the initiation of the breach and the flood wave reaching the populated areas of the downstream reach (Happy Valley - Goose Bay, Mud Lake).

General findings for a breach under PMF conditions are:

- Outflow immediately downstream of the dam would increase from an initial flow of approximately 25,100 m^3/s to a peak flow of approximately 110,900 m^3/s.
- Incremental water level increases would range from approximately 9.7 m downstream of Muskrat Falls to approximately 3.3 m near Mud Lake.
- There would be approximately 0.8 to 1.2 hours of warning time available between the initiation of the breach and the flood wave reaching the populated areas

The report also outlines the consequences of failure in terms of potential loss of life and economic damages. Finally, the report recommends updating the dam break study before preparing the Emergency Preparedness Plan (EPP) to account for any changes in project layout.

MHI finds that the dam break study was carried out following good utility practices.

2.2.9 Energy Estimates

Various energy estimate studies have been completed for the Muskrat Falls development. The most recent of which are listed below. These confidential reports were reviewed by MHI.

- Acres 1998 Study[52]
- Acres 1999 Study[53]
- Hatch 2011 Report on Regulation Study[54]
- Hatch 2011 Report on Firm Energy Production[55]
- Nalcor 2011 Summary Report[56]

The Nalcor 2011 summary report summarizes the various studies related to Muskrat Falls' energy production.

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[52] Exhibit CE-28 Rev.1 (Public), Acres International, "Churchill River Complex: Power and Energy Modeling Study Final Report ", July 1998
[53] Exhibit CE-29 Rev.1 (Public), Acres International, "Churchill River Complex: Optimization Study Volume 1", January 1999
[54] Exhibit CE-26, Hatch, "The Lower Churchill Project MF1330 – Hydraulic Modeling and Studies 2010 Update, Report 6: Muskrat Falls Regulation Study", May 2011
[55] Exhibit CE-21, Hatch, "Estimate the Firm Generation Potential of the Muskrat Falls Development - Final Report for Nalcor Energy", June 2011
[56] Exhibit CE-27 Rev.1 (Public), Nalcor, "Muskrat Falls Hydroelectric Development Summary of Studies on Firm and Average Energy Production", June 2011

The report identifies the provisions of the Water Management Agreement between CF(L) Co which manages Upper Churchill, and Nalcor Energy facilities (Lower Churchill) that are contained in the recent studies.

Finally, the Nalcor report states that so far, the energy studies have considered propeller units whereas in the final design and optimization, Kaplan units will be considered and that efficiencies and energy production estimates will therefore increase. Although not stated explicitly, the implication is that at that stage, the energy study of Muskrat Falls will require an update, as recommended by Hatch.

Conclusions with Respect to Muskrat Falls Energy Studies

MHI concludes from the review of the energy studies that:

- The contribution of Muskrat Falls to the Churchill River Complex in terms of firm and average energy has varied little within the studies despite the fact that different periods have been considered for the flow sequence input. The firm energy available at Muskrat Falls is estimated at 4.47 TWh annually.

- A comprehensive power generation and energy production model of the Churchill River Complex has been prepared which can be used to update the energy estimates once the characteristics of the turbines have been finalized. Energy production of Muskrat Falls will increase especially if in the final design, double regulated Kaplan units are selected with variable pitch blades and wicket gates. These types of units have very flat efficiency curves thereby increasing the energy output.

2.3 Round Pond

The 18 MW Round Pond development is part of the Isolated Island Option with an in-service date of 2020. For Round Pond, the 1988 Feasibility Study report by Shawinigan/Fenco is documented below. This study did not carry out any hydrological analyses as these were readily available from the general Bay d'Espoir regulation study carried out by Acres in 1985. The main report of this earlier study has been filed and reviewed.

- Acres 1985 Study on Bay D'Espoir Flood Analysis[57]

  In 1985, Acres completed a study of Bay D'Espoir hydropower system flood analysis and alternatives study. The main objective, as stated in the study, included the "determination of the extreme flood hydrology for the Bay d'Espoir basin, the analysis of the response of the reservoir system to extreme flood events, and the examination of remedial measures to alleviate unacceptable flooding conditions in the Salmon basin".

- Shawinigan/Fenco 1988 Round Pond Feasibility Study[58]

  The Shawinigan/Fenco study used the results of previous studies, in particular the Acres 1985 Flood Study. In addition, a model of the Bay d'Espoir system was developed as part of the regulation study that was calibrated against the existing Bay d'Espoir system. The model had the capability to add new developments such as Round Pond.

Conclusions on Round Pond Hydrology

MHI concludes from the review of the Round Pond hydrology studies that, as the Shawinigan/Fenco study is over 20 years old, should the Isolated Island Option become the preferred alternative, the Round Pond study needs to be updated to benefit from more recent hydrometeorological and operation data in the Bay d'Espoir System. At that time, a decision should be made to assess whether or not the PMP/PMF study should be updated. In particular the following may need attention:

- The PMP is based on historic maximum snowpack and PMP storm event. Current CDA Guidelines dictate that two cases have to be considered, PMP with 1:100-year snowpack and PMSP with 1:100-year rainfall.
- In the 1985 flood study, the PMP was routed through the watershed by unit hydrograph techniques in order to obtain PMF inflows. The associated methodology treats the rainfall/runoff process as essentially linear whereas the process is non-linear indicating the unit hydrograph approach may need to be replaced by a comprehensive watershed model.
- The Acres 1985 study concludes that some of the existing structures are not competent to pass the PMF. Unless this issue has already been attended to, the impact of routing should be reassessed.

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[57] Exhibit 54, Acres International, "Bay D'Espoir Flood Analysis and Alternatives Study Report for Newfoundland and Labrador Hydro", December 1985

[58] Exhibit 5d, Shawinigan/Fenco Newfoundland Limited, "Newfoundland and Labrador Hydro Feasibility Study - Round Pond Development – Summary Report", September 1988

2.4 Island Pond

The 36 MW Island Pond development is part of the Isolated Island Option with an in-service date of 2015. The proposed development would be located on the North Salmon River within the watershed of the Bay d'Espoir Development, between the existing Meelpaeg Reservoir and the Upper Salmon Development.

MHI has reviewed the following reports as part of its hydrology review:

- Shawmont Newfoundland 1988 Final Feasibility Study[59]
- AGRA-Shawmont 1997 Re-Optimization Study[60]
- SNC-Lavalin 2006 Study[61]

Conclusion on Island Pond Hydrology

MHI concludes that:

- should the Round Pond flood hydrology require an update, then the capability of the diversion canal from Island Pond into Meelpaeg Reservoir may need to be re-assessed to pass an updated PMF.
- the energy figure estimated in the 1997 study, 188 GWh/year is quoted in the report and a single Kaplan unit is recommended with a nominal capacity of 36 MW. Due to the particularly flat characteristics of such units, marginal improvement in power generation can be obtained over Francis units.

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[59] Exhibit 53, Shawmont Newfoundland Limited, "Island Pond Development Final Feasibility Study Volume 1 - Report for Newfoundland and Labrador Hydro", January 1988

[60] Exhibit 52, AGRA ShawMont Ltd, "Island Pond/Granite Canal Re-Optimization and Cost Update Study - Report for Newfoundland and Labrador Hydro", January 1997

[61] Exhibit 5b, SNC Lavalin, "Studies for Island Pond Hydroelectric Project - Final Report for Newfoundland & Labrador Hydro", December 2006

2.5 Portland Creek

The 23 MW Portland Creek development is part of both Options with an in-service date of 2036 for the Infeed Option, and 2018 for the Isolated Island Option.

A feasibility study of Portland Creek hydropower development was completed in 2006 by SNC-Lavalin.[62] The 2006 SNC-Lavalin study contains the latest hydrological analysis.

Conclusions of Portland Creek Hydrology

MHI notes the following conclusions from the hydrology review of Portland Creek:

- Optimization studies indicate that estimated energy production from the development is 141.5 GWh with an installed capacity of 23 MW.
- The report recommends that NLH consider installing a flow gauge in Portland Creek to confirm the yield of this basin as there is anecdotal evidence of higher precipitation, hence greater runoff in Portland Creek catchment than that indicated by the hydrometric station in the Greavett Brook catchment.
- The 2006 SNC Lavalin study is considered adequate to proceed to detailed design with one caveat. The regional flood index method is preferable to the at-site flood frequency analysis. The analysis presented in the SNC-Lavalin report is based on 22 years of flood peaks to yield the 1:1,000-year flood. Typically, the range of credible extrapolation for annual exceedance probability is 1:100 to 1:200 year return period when using at-site stream flow data while it is 1:500 to 1:1,000-year when using regional streamflow data.

[62] Exhibit 5c, SNC Lavalin, “Feasibility Study For Portland Creek Hydroelectric Project”, January 2007

2.6 Conclusions and Key Findings

MHI has reviewed the various hydrology studies provided by Nalcor to determine if they were conducted with due diligence, skill, and care consistent with acceptable utility practices. The hydrological/hydraulic and energy production review of the studies carried out was an examination of Muskrat Falls and the three on-island hydroelectric projects for relevance of input source, methodology, accuracy of estimates and/or assumptions, identification of gaps, recommendations and findings, and examination of quality assurance mechanisms.

The key finding from the hydrology reviews is as follows:

- The Muskrat Falls studies were conducted in accordance with utility best practices, comprehensively, and with no apparent demonstrated weaknesses. Also, the energy and capacity estimates for Muskrat Falls and the three small hydroelectric facilities on the island, which were prepared by various consultants using industry accepted practices, were reviewed and confirmed to be reasonable for DG2.

Other findings from the hydrology reviews are provided for information:

- The Muskrat Falls studies were comprehensive and detailed, with no apparent weaknesses identified. However, some of the analyses need to be finalized as part of the detailed design:
    - Finalization of spillway design in accordance with the latest probable maximum flood results and results of 3-D modeling of structures.
- The 3-D numerical model was calibrated in natural conditions and simulated levels were about one meter from observed levels for a range of discharges indicating some problems likely with the bathymetry at the control section of both waterfalls that may not reflect actual conditions. The consultant who carried out the analysis should specify to what extent this deviation from actual conditions affects the modeling results.
- It may be necessary to increase the proposed diversion capacity of Muskrat Falls, since the flood peak has increased by some 500 m^3/s above the value estimated in the feasibility study.
- A minimum acceptable turbine flow at Churchill Falls during construction should be established in consultation with CF(L)Co.
- The layout needs to be modified in accordance with the findings of the numerical modeling of structures, in particular the shape of the wingwall between the intake and the spillway, sizing and modifications should be tested with the model.
- The dam break analysis needs to be updated with the final layout before implementing the EPP, an activity likely to take place once the project is built or near completion;
- The power and energy generation model needs to be re-run once the relevant parameters have been finalized.

The following conclusions are noted for the small hydroelectric plant hydrological reviews:

- Because the Round Pond study is more than 25 years old, it should be reviewed in light of new data and the possibility of a change in the operation of the Bay d'Espoir System. Since the probable maximum flood part of the study was carried out before current Canadian Dam Association guidelines took effect, possible implications of the guidelines for the probable maximum flood estimate should be investigated.
- For the Island Pond project, should the Round Pond flood hydrology require an update, it may be necessary to reassess the ability of the diversion canal from Island Pond into the Meelpaeg Reservoir to pass an updated probable maximum flood.
- A feasibility study of the Portland Creek development completed in 2006 by SNC-Lavalin is considered adequate to proceed to detailed design. However, the design flood selected as the 1:1000 year flood was estimated from a limited sample of 22 observations. It is possible that a regional flood analysis, such as an Index Flood Method, would provide a more robust estimate.