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NEWFOUNDLAND POWER
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November 1, 2016

Board of Commissioners
of Public Utilities
P.O. Box 21040
120 Torbay Road
St. John's, NL A1A 5B2

Attention: G. Cheryl Blundon
Director of Corporate Services
and Board Secretary

Ladies and Gentlemen:

Re: The Board's Investigation and Hearing into Supply Issues and Power Outages on the Island Interconnected System - Phase Two

Please find enclosed the original and 12 copies of the expert report of Mr. Larry Brockman filed on behalf of Newfoundland Power.

If you have any questions regarding the enclosed, please contact the undersigned at your convenience.

Yours very truly,

Gerard M. Hayes
Senior Counsel

Enclosures

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IN THE MATTER OF the Electrical Power Control Act, 1994, SNL 1994, Chapter E-5.1 (the "EPCA") and the Public Utilities Act, RSNL 1990, Chapter P-47 (the "Act"), as amended, and regulations thereunder; and

IN THE MATTER OF an investigation and hearing into supply issues and power outages on the Island Interconnected system

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Prefiled Evidence of Larry Brockman

Testimony on Behalf of Newfoundland Power

Brockman Consulting

NEWFOUNDLAND POWER
A FORTIS COMPANY

At the hearing into Phase Two of the Board's Investigation and Hearing into Supply Issues and Power Outages on the Island Interconnected System, this report will be adopted by Larry Brockman, President of Brockman Consulting based in Atlanta, Georgia.

An expert profile for Larry Brockman follows.

Larry Brockman

President of Brockman Consulting

Atlanta, Georgia

My name is Larry B. Brockman. I am president of Brockman Consulting in Atlanta, Georgia, where I specialize in providing electric utilities with power system planning and regulatory assistance. I have over 35 years' experience in the electric utility industry as a power system planning engineer, management consultant, rate design expert, regulator, educator, and expert witness. I obtained my degree in engineering from the University of Florida. I later attended graduate school at the same university with a dual major in economics and electrical engineering through the Public Utilities Policy Center at that institution. I have testified before this Board as an expert witness on 11 previous occasions stretching back to 1990.

In my career, I have performed long and short-range transmission studies, including steady-state power flow studies, fault current studies, economic studies, and transient stability studies. I served as the chairman of the Florida Long Range Transmission Task Force, guiding a study to help all the utilities in Florida select the most economical long-range transmission plans for the state. I also participated in the analysis of the steady-state adequacy of the State's transmission system from a thermal overload standpoint and the stability of the system after N-1 and N-2 events.[1] I have also led studies examining the prudence of long range power purchasing in Florida, Illinois and Vermont, as well as a strategic plan for Hydro One in Ontario to export power into the US.

On the generation side, I have performed and reviewed many generation economics studies and integrated resource plans (IRPs), choosing and balancing the least cost generation and demand side management resources which satisfied adequacy and reliability criteria for utilities in the US, in Nova Scotia and Alberta. I have worked on several prudence reviews of large power plants, including two nuclear units in the US. I am currently engaged in examining the prudence of two of only four nuclear plants to be constructed in the US in over 30 years. I have performed studies of the least-cost operation and expansion of generation systems with both fuel, gas pipeline and transmission constraints, including a detailed operational study of a compressed air storage system in Oklahoma.

I have performed or reviewed numerous cost-of-service and rate design studies and appeared as an expert on them in Florida, Newfoundland, and Nova Scotia. A more complete resume of my background is contained in Attachment LBB-1. I have developed and taught industry short courses in both cost of service and rate design, as well as Integrated Resource Planning for Public Utilities Reports.

1 Florida at the time was in some ways similar to Newfoundland, in the sense that it was a long peninsula with few transmission lines connecting it to the North American grid and the need to import relatively large amounts of inexpensive power.

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1. BACKGROUND

In Order No P.U. 3 (2014), the Board summarized the scope of its Investigation and Hearing into Supply Issues and Power Outages on the Island Interconnected System (the "Investigation"). It included matters related to the electrical system events that occurred in 2013 and 2014, as well as those related to system adequacy and reliability up to and after the interconnection with the Muskrat Falls generating facility.

On October 8, 2014, the Board divided the Investigation into Two Phases. Phase One was to address the immediate reliability issues for the Island Interconnected System ("IIS") prior to interconnection with Muskrat Falls. Phase Two is to address reliability issues post-Muskrat Falls.[1]

Hydro's most recent view of near term reliability on the IIS was provided in its Energy Supply Risk Assessment ("ESRA"), filed on May 27, 2016. The ESRA provides Hydro's assessment of its generation and transmission planning criteria under current circumstances and in advance of the integration of the Muskrat Falls project.

On September 29, 2016, the Board issued its Phase One Report on the Investigation. In its report, the Board indicated that it was not satisfied that Hydro has made real progress in addressing the systemic issues that contributed to the outages in 2013, 2014, and 2015. As a result, it would continue to review the matter in Phase Two.[2]

1 See the Board's letter dated October 8, 2014 filed in relation to the Investigation.
2 See the Board's Phase One Report, Page iii.

At the request of the Board, the Liberty Consulting Group ("Liberty") reviewed events that occurred following Liberty's final reports on Phase One of the Investigation issued in December 2014. Liberty also reviewed reliability matters surrounding the integration into the IIS of Muskrat Falls, the Labrador-Island Link ("LIL") and the Maritime Link ("ML"). Liberty's report of that review was issued on August 19, 2016 (the "Phase Two Report").[3]

In keeping with the expanded scope of Phase Two of the Investigation, it is practical to consider reliability on the IIS over two time horizons. First, there are near-term reliability issues in advance of the delivery of power from the Muskrat Falls project. These reliability issues are expected to span the 2016 to 2019 period. Second, there are long-term reliability issues following the integration of Muskrat Falls in or about 2019.

My evidence will address the near term and long term reliability issues on the IIS, and present my opinion as to how the issues should be considered by the Board as elements of the Muskrat Falls project become integrated into the IIS.

[3] The August 19, 2016 report by Liberty is entitled *Review of Newfoundland and Labrador Hydro Power Supply Adequacy and Reliability Prior to and Post Muskrat Falls Final Report.*

2. RELIABILITY OUTLOOK

Supply reliability on the IIS in recent years has been inadequate. In the next number of years, the IIS is expected to change significantly with the introduction of Muskrat Falls, the LIL, the ML and the eventual retirement of some of Hydro's thermal generating units. The Board will need to consider a number of critical issues to ensure adequate reliability of the IIS through and following this period of change.

In preparing this report, I have considered the most recently available information on the reliability of the IIS. Except where otherwise indicated, I have principally relied upon Hydro's responses to relevant Requests for Information in this proceeding, the near-term reliability assessment of Hydro contained in the ESRA, and Liberty's assessment of the adequacy and reliability of the IIS contained in the Phase Two Report.

2.1 Reliability Concepts

Reliability planning is concerned with managing the risk of outages on the electrical system. There are 3 aspects to this: (i) the probability of an event affecting system reliability, (ii) the consequences of that event and (iii) the cost of mitigation. A certain amount of judgment is necessary in reliability planning. An event may have a low probability of occurrence. But if the consequences are serious enough, the cost to mitigate those consequences may be acceptable. For example, a utility may have a transmission planning criteria which requires redundancy for an outage to any one transmission line, but not for multiple line outages. However, that utility might choose to relax the criteria in the case of an outage to multiple transmission lines in close proximity if the consequences of such an outage were unacceptable.

The normal procedure for planning a reliable system is as follows:

- Set goals and measures for success.
- Assemble a number of alternatives.
- Create a wide range of scenarios to test.
- Eliminate alternatives which don't meet the goals.
- Determine the cost of the possible alternatives.
- Select best alternative (lowest cost that meets other criteria as well).
- Iterate if necessary.

To simplify the planning exercise, a utility may set planning criteria, including reliability criteria. Reliability criteria usually consider the balance between cost and reliability, and allow system planners to evaluate options without individually analyzing the reliability of each option. However, planning criteria do not eliminate the need to exercise judgment, as the application of the criteria may not be appropriate in all cases.

In summary, reliability planning involves a balance of risk and cost. It is not an exact science. A certain amount of judgment is required. However, to apply proper judgment, planners need to have some degree of certainty regarding the likelihood of outages, the severity of those outages, and the costs to mitigate those outages.

2.2 Hydro's Planning Criteria

Hydro uses specific transmission and generation planning criteria to evaluate the adequacy of its bulk electricity system and the timing of generation and transmission system additions on the IIS.

The basis of Hydro's transmission planning is the N minus 1 ("N-1") criteria.[4] N-1 means that in the event that one transmission element is out of service, flow in all other elements of the power system should be at or below normal rating.[5] In other words, the loss of a single transmission element should not jeopardize the IIS transmission system. Hydro's N-1 criteria applies to the existing bulk transmission system on the IIS. According to Hydro, the decision to focus on N-1 contingencies was a cost-based decision.[6]

Hydro has also established criteria for the IIS that determines the timing of supply source additions. These criteria set the minimum level of capacity and energy utilized on the IIS to ensure an adequate supply of firm capacity. Hydro's generation planning criteria includes three separate aspects.[7]

Capacity: The IIS should have sufficient generating capacity to satisfy a Loss of Load Hours (LOLH) expectation target of not more than 2.8 hours per year.

Energy: The IIS should have sufficient generating capacity to supply all of its firm energy requirements with firm system capability in a dry year.

4 See the response to Request for Information PUB-NLH-186, Attachment 1 for a summary of Hydro's transmission planning criteria.
5 See Hydro's ESRA, Page 6, Lines 6-16.
6 See the response to Request for Information CA-NLH-146, Page 19, Lines 10-13.
7 See Hydro's ESRA, Page 5, Line 12 to Page 6, Line 4.

Reserves: Hydro has recently committed to maintaining a megawatt (MW) reserve of greater than 240 MW, which is based on the largest unit at Holyrood plus 70 MW of additional reserve.

2.3 IIS Timeline

There are a number of significant additions expected to occur on the IIS over the next number of years as Hydro begins to integrate aspects of the Muskrat Falls project into the IIS. These include (i) a new 230kV transmission line (TL267) from Hydro's largest hydroelectric plant on the IIS to the load center on the Avalon Peninsula, (ii) the Maritime Link (ML) which is a transmission line that will connect the IIS to the North American grid via Nova Scotia, (iii) the Labrador Island Link (LIL) which is a transmission line that will connect the IIS to the Muskrat Falls plant and the North American grid via the upper Churchill Falls hydroelectric plant, and (iv) the Muskrat Falls plant itself.

In addition to these system additions, Hydro plans to retire the Holyrood, Hardwoods, and Stephenville thermal plants between 2022 and 2028. An understanding of the timing of these events is important to fully assess near term and long term reliability issues, establish priorities, and to evaluate options such as the introduction of new combustion turbines. A timeline of these events is shown in Figure 1.

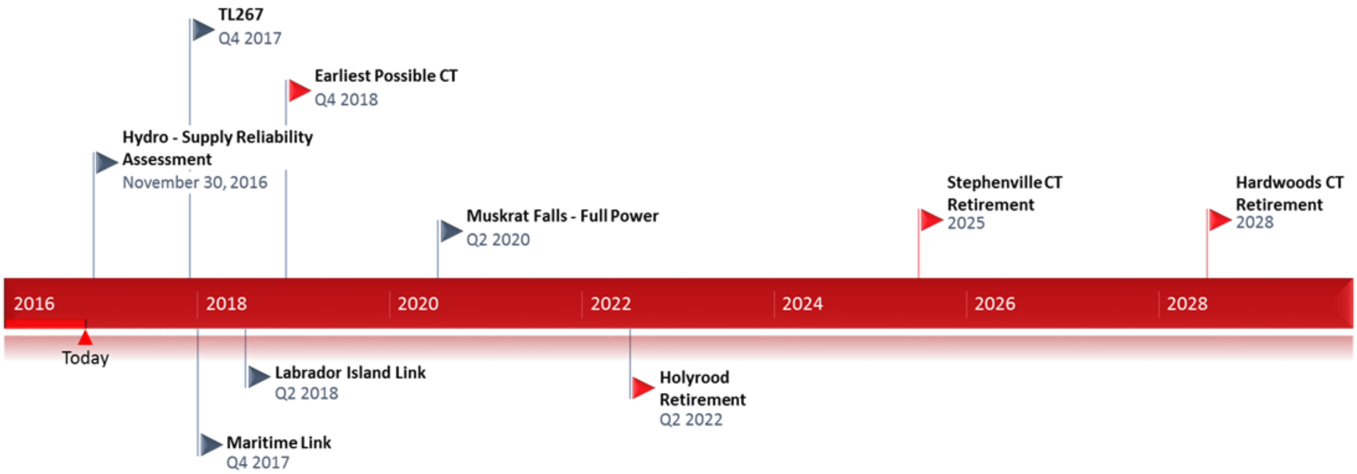

Figure 1 – IIS Timeline

2.4 Hydro's Reliability Outlook

Hydro's most recent reliability outlook was provided in the ESRA. The ESRA provided an evaluation of the reliability of the IIS prior to the interconnection with the North American grid. This was done by assessing the ability of the IIS to meet transmission and generation planning criteria until interconnection using Hydro's most recent load forecast.

The ESRA analysis indicated violations in Hydro's planning criteria for Holyrood de-rated forced outage rates (DAFOR) in excess of 14%.[8] As a result, Hydro evaluated alternatives and options that would mitigate these violations. The alternatives included (i) advancement of the in-service date of TL267, (ii) addition of standby generation on the Avalon Peninsula, (iii) retention of the 12 MW of Holyrood diesel generators concurrent with securing additional curtailable

[8] See Hydro's ESRA, Page 21, Lines 20-21. DAFOR is defined as Derating Adjusted Forced Outage Rate which is the percent of operating plus forced outage time a unit was on a forced outage, adjusted for derating of the unit. It is calculated by dividing the total equivalent forced outage time by the total equivalent forced outage time plus the operating time.

Avalon Peninsula load, and (iv) additional investment in Holyrood plant assets.[9] Hydro used a broad range of forced outage rates on the Holyrood thermal units to fully evaluate the supply risk and to ensure a robust assessment.[10]

The ESRA examined available options to ensure Hydro's reliability criteria are met prior to the interconnection with the North American grid. The ESRA recommended the advancement of TL267, securing additional curtailable load on the Avalon Peninsula, and utilizing the 12MW of diesel generation at Holyrood. Hydro indicates that this alternative "provides the optimal balance in reduction of supply risk and overall cost, making it the best option for customers."[11]

2.5 Liberty's Reliability Outlook

Liberty's Phase Two Report includes a review and recommendations regarding near term reliability on the IIS. Based on its review, Liberty expects that new supply will be needed before Muskrat Falls is in service to mitigate near-term supply issues. According to Liberty, this new supply can be sourced through firm purchases, if available, over the ML or additional new generation on the IIS.[12] Liberty provides three reasons for this assessment. These include (i) the condition of the aged Holyrood plant, (ii) the poor reliability of the Hardwoods and Stephenville gas turbines, and (iii) uncertainty whether the forecast of a significant reduction in Hydro's recent peak demand forecast will actually materialize.[13]

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9 See Hydro's ESRA, Page 25, Lines 6-12.
10 See Hydro's ESRA, Page 10, Lines 21-24.
11 See Hydro's ESRA, Page 32, Lines 5-6.
12 Liberty's Phase Two Report, Page ES-2.
13 See Liberty's Phase Two Report, Pages 10-11.

Liberty stated that, in the long-term, the interconnection of the IIS with the LIL, ML, and Muskrat Falls can represent a state of the art electrical system whose reliability is improved over today's circumstances. However, Liberty observed that more work would be required to assure that accomplishment, including (i) additional power supply, and (ii) expanded organizational capabilities at Hydro.[14]

Liberty expects that additional supply will be needed after Muskrat Falls is in service to mitigate the impact of extended outages of the LIL. Liberty's report indicates that the size of the IIS in comparison to the LIL makes loss of load on a bipole trip inevitable.[15] Further, Liberty indicates that it is not unreasonable to expect a bipole outage of days, or even weeks, from tower failures considering the harsh environment through which the LIL runs.[16] It is Liberty's view that the need for added supply to mitigate loss of load on an extended bipole trip has not been sufficiently considered by Hydro.[17]

2.6 Board-Directed Supply Review

In its Phase One Report, the Board expressed its belief that "further urgent work is required to fully assess the circumstances and risks with a view to determining the measures that are required in relation to supply" on the IIS.[18] In the report, the Board considered and adopted Liberty's recommendation contained in the Phase Two Report that Hydro should conduct a new supply review.

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14 See Liberty's Phase Two Report, Page ES-1.

15 A "bipole" trip or outage on the LIL refers to a trip or outage affecting both current carrying conductors. A bipole outage will effectively disconnect Muskrat Falls from the IIS.

16 See Liberty's Phase Two Report, Page 81.

17 See Liberty's Phase Two Report, Page 87, Conclusion V-5.

18 See the Board's Phase One Report, Page 52, Lines 3-4.

On October 13, 2016, Hydro was directed to file a report by November 30, 2016 on a comprehensive review of the energy supply for the IIS. The energy supply review is to consider all risks and provide a risk-based recommendation on the need, timing and amount, if any, for additional pre-Muskrat Falls supply. The report is to include all current information on Hydro's load forecast and the status of generating units including, specifically, the condition of the thermal units at Holyrood, the combustion turbines at Hardwoods and Stephenville, and the Bay d'Espoir Penstock 1.[19]

[19] See the Board's October 13, 2016 letter, Page 1.

3. RELIABILITY ASSESSMENT

The Board's Phase One report sets out the circumstances surrounding the 2013, 2014 and 2015 outages on the IIS and the Board's views as to the causes and contributing factors. The Board's report acknowledged that Hydro has implemented, or is in the process of implementing, numerous reliability improvements to the IIS, many of which were recommended by the Board. These include increased emphasis on maintenance and reliability of thermal units, securing additional interruptible load, acceleration of TL267, and finalization of arrangements to ensure import capability from the ML. However, the Board concluded that there are still significant continuing risks to the adequacy and reliability of supply on the IIS.[20]

In relation to the continuing supply risks, the Board specifically noted Liberty's observations in its Phase Two Report that continued reliance on Hydro's aging thermal units and the delayed in-service date of the Muskrat Falls project increase the risk of outages on the IIS. In order to fully assess the circumstances and risks with a view to determining what further measures are required in relation to supply, the Board has directed Hydro to complete a supply review as recommended in Liberty's Phase Two Report.[21]

Other than the recommendations in the ESRA, Hydro has not recommended any further generation or transmission additions prior to the interconnection of the Muskrat Falls project. In the Phase Two Report, Liberty indicated that what Hydro indicated in the ESRA will not be sufficient. Liberty suggests that additional supply will likely be required both before and after the interconnection of the Muskrat Falls project.

[20] See the Board's Phase One Report, Page 51.
[21] See the Board's Phase One Report, Page 52.

The following are my observations and opinions regarding supply reliability on the IIS both before and after the interconnection with Muskrat Falls.

3.1 IIS Capacity Analysis

Hydro has adopted a reserve criteria of 240 MW as part of its planning process. The 240 MW reserve provides the ability to withstand the most onerous single contingency (loss of Holyrood Unit 1 or 2) while maintaining a spinning reserve of 70 MW.[22] For the purposes of this report, I performed a capacity reserve analysis using data from Hydro's ESRA. In an analysis of this sort, it is assumed that the excess of installed capacity making up the reserve is reliable enough to respond to any supply failure, as and when required.

Table 1 shows the installed capacity and import capability available to the IIS together with Hydro's forecast P90 load for the indicated periods. Table 1 indicates the net balance, or reserve capacity, for each period based on the most recent information provided by Hydro.

[22] See Hydro's ESRA, Page 6, Lines 3-4.

Table 1
Reserve Analysis
(MW)

	Existing (2016-2017)	**Pre-Muskrat (2018-2019)**	**Post-Muskrat (2019–2020)**	**Post Muskrat (2022)**
IIS Supply[23]	2,009	2,009	2,009	1,519
ML	-	300	300	300
LIL[24]	-	110	673	673
Total	2,009	2,419	2,982	2,492
Load[25]	1,801	1,819	1,827	1,827
Reserve	**208**	**600**	**1,155**	**665**
Interruptible Load[26]	90	90	90	90
Reserve with Interruptible Load	**298**	**690**	**1,245**	**755**

The *Existing (2016-2017)* column illustrates the conditions on the IIS pre-Muskrat Falls using 2016-2017 island load and generation before ML and LIL go into service. Under these conditions, the net reserve on the IIS is 298 MW after interruptible load is taken into account. The *Pre-Muskrat (2018-2019)* column includes the ML import capacity of 300 MW and the 110 MW of capacity associated with the recall power transmitted over the LIL. Under these conditions, the net reserve improves to 690 MW. The *Post Muskrat (2019-2020)* column shows the addition of the Muskrat Falls capacity, which further improves the net reserve available to the

23 See Hydro's ESRA, Appendix A. IIS Supply in the Post Muskrat (2022) period includes a reduction of 490 MW on account of the decommissioning of Holyrood.

24 Hydro indicates that 110 MW of firm recall power would be available on the LIL in advance of Muskrat Falls on Page 20, Lines 25-26 of the ESRA. In the response to Request for Information PUB-NLH-217, Hydro indicates that a full loss of the LIL will result in a maximum loss of 673 MW of capacity on the IIS.

25 The basis of IIS Load used in Table 1 is the P90 Fully Stressed Reference Case in *Table 7 – Reserve Margin Analysis* on Page 22 of the ESRA. No load growth is assumed between the Winter 2019-2020 period and 2022.

26 See Hydro's ESRA, Page 21, Lines 7-9.

IIS. The final column in Table 1 shows the effect of the expected decommissioning of Holyrood in 2022.

Table 1 assumes the Holyrood units can operate at nameplate capacity.[27] Relative to Hydro's 240 MW reserve requirement, Hydro's reserve prior to 2018 is tight and dependent on interruptible load for meeting its reserve criteria. Beyond 2019, the 240 MW reserve is significantly exceeded suggesting the level of supply is adequate based on Hydro's pre-Muskrat 240 MW reserve criteria.

Table 2 illustrates the impact on IIS reserves of a bipole outage of the LIL under two scenarios. The first scenario assumes the availability of 300 MW of capacity from Nova Scotia. The second scenario assumes the ML is not available.

Table 2
Reserve Scenario Analysis
(MW)

	Pre-Muskrat (2018-2019)	**Post-Muskrat (2019–2020)**	**Post-Muskrat (2022)**
LIL Bipole Outage	580	572	82
LIL Bipole Outage with ML Unavailable	280	272	-218

27 In 2016, Holyrood units 1, 2 and 3 were de-rated due to boiler tube issues. It is expected that following repairs on units 1 and 2, these units will be returned to nameplate capacity. On October 20, 2016, unit 3 was returned to full nameplate capacity.

The *Pre-Muskrat (2018-2019)* and *Post-Muskrat (2019-2020)* columns both show that, with the loss of the LIL, the reserve margins exceed Hydro's 240 MW reserve criteria without the need to resort to the import capability of the ML. This is because Holyrood has not yet been decommissioned.

As Table 2 shows, a bipole outage in 2022, after Holyrood is decommissioned, and assuming 300 MW of import power over the ML, will reduce the reserve to 82 MW. This assumes that 90 MW of interruptible load has already been used to reduce peak. This leaves little margin to endure further supply problems on the system. For example, if either the 120 MW Holyrood CT or the 154 MW unit at Bay d'Espoir becomes unavailable under peak load conditions during a bipole outage scenario, rotating power outages would be required.[28]

Table 2 clearly demonstrates the importance of the ML once Holyrood is decommissioned. If the ML import capability of 300 MW is not available during peak, a bipole outage on the LIL will result in a capacity shortfall on the IIS of 218 MW, even with the benefit of peak reductions provided by 90 MW of interruptible load. Under such conditions, rotating power outages would be required until such time as the LIL bipole outage is corrected or power can be obtained over the ML.

[28] Once Holyrood is decommissioned, there is a 23% likelihood that 80 MW or more of capacity will be out of service according to Table 2 of the response to Request for Information NP-NLH-153.

3.2 Pre-Muskrat Reliability

In the pre-Muskrat time period, it appears that reliability on the IIS is acceptable, based on my reserve analysis in Section 3.1. However, there are a number of factors that suggest this may be an overly optimistic view. The analysis assumes that Hydro's reserve criteria of 240 MW is sufficient to respond to anticipated supply failures. It also assumes that all planned transmission additions will be completed on schedule. Finally, it assumes that Hydro's thermal units (i.e., Holyrood, Hardwoods and Stephenville) are reliable enough to respond to supply failure as and when required.

Based on Liberty's review and Hydro's statements in the ESRA, there appears to be considerable uncertainty as to whether Hydro can ensure the reliability of its thermal units.[29] It is Liberty's view that uncertainty regarding the reliability of Holyrood, Hardwoods, and Stephenville puts the IIS at significant risk of a supply shortage prior to interconnection of Muskrat Falls.

I agree with Liberty's view that the reliability of Hydro's existing supply is uncertain. The large scale outages in 2013, 2014 and 2015, combined with the recent boiler tube issues at Holyrood, penstock issues at Bay d'Espoir, and ongoing problems at both Hardwoods and Stephenville, suggest the risk of customer outages on the IIS remains high. It is unlikely, however, that this risk can be addressed in the short term by adding more backup generation.

The lead time required to acquire and install a new combustion turbine on the IIS is likely about two years. If a new combustion turbine was approved in December 2016, it would therefore not

[29] See Hydro's ESRA Page 28 Line 16 to Page 29 Line 1.

be in service until December 2018. By that date, the ML and LIL are scheduled to already be in service. This may eliminate the need to add backup generation at that time. Since there is no practical way to add capacity prior to the scheduled integration of the ML and LIL, it is critical that Hydro focus on maintaining its existing supply sources to ensure they are available for the upcoming winter seasons.

The timing of the interconnection of the LIL, ML, and Muskrat Falls is an important aspect of the reliability of the IIS in the near term. The ML is expected to be integrated into the IIS prior to the winter of 2017-2018. The LIL is expected to be integrated into the IIS before the winter of 2018-2019. Power from either the ML or LIL can improve the near-term reliability outlook on the IIS. In the near term, Hydro needs to ensure that these planned additions to the IIS are completed in a timely manner.

If there is any likelihood that any of these additions may be delayed, the preliminary work required to acquire a new combustion turbine should be commenced. Such preliminary work should include determining a possible location, estimating costs and construction timelines, and assessing market availability of appropriate units. This will shorten the implementation schedule if it is ultimately determined that a combustion turbine is required.

3.3 Post-Muskrat Reliability

From a customer outage perspective, a primary concern regarding the post-Muskrat Falls IIS is an extended bipole outage on the LIL. In the Phase Two Report, Liberty concluded that the need for added supply to mitigate loss of load on an extended bipole trip has not been sufficiently considered by Hydro.[30]

A bipole outage of the LIL overhead transmission line could range from a shorter outage due to equipment failure at the converter station to a longer outage caused by tower failures under ice or wind loading. In the Phase Two Report, Liberty expressed the view that it is not unreasonable to expect a bipole outage of days, or even weeks, from tower failures considering the harsh environment through which the LIL runs. For planning purposes, Hydro has assumed that repairs of ice and wind damage on the LIL could take as long as 2 weeks.[31]

There is also evidence filed in this proceeding that a bipole outage related to structural failure on the LIL may be more likely than anticipated by Hydro. Hydro's estimated bipole failure rates are based on meteorological return periods of 1:500 years for the Avalon Peninsula and 1:150 years for other sections of the line.[32] In his report, *Reliability Assessment of the Labrador-Island Link*, Elias Ghannoum estimates a reliability level for the LIL overhead transmission line that is much lower.[33] This is consistent with Liberty's view that there will be more LIL bipole outages than estimated by Hydro.[34]

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30 See Liberty's Phase Two Report, Page 87, Conclusion V-5.
31 See the response to Request for Information PUB-NLH-299.
32 See the response to Request for Information NP-NLH-133.
33 See Page 27 of the *Reliability Assessment of the Labrador Island Link* filed by Newfoundland Power.
34 See Liberty's Phase Two Report, Page ES-3.

From a transmission planning perspective, Hydro does not consider the simultaneous failure of both poles on the LIL to be an N-1 contingency. Because the LIL contains two current carrying conductors that can operate in isolation from each other, a bipole outage on the LIL is considered to be an N-2 contingency. Hydro does not design its system to prevent loss of load under a scenario that is beyond N-1. Therefore, Hydro has not designed its system to fully absorb the contingency of a bipole failure on the LIL. Effectively, customer outages are deemed to be acceptable in the case of a bipole failure. The extent and duration of customer outages resulting from a bipole failure will depend on the effectiveness of operational response, including under frequency load shedding, and the amount of available reserve, or backup capacity on the IIS.

In the Phase Two Report, Liberty acknowledged that certain consequences associated with bipole outages are inherent in Hydro's design of Muskrat Falls and the LIL. Liberty observes that the relatively large size of the supply from the LIL in relation to the IIS means that an under frequency load shedding event is likely unavoidable following a bipole trip. It is Liberty's view, however, that more extended customer outages, such as may result from tower failures on the LIL, are "obviously unacceptable." Liberty points out that the length of such an outage exposes the IIS to the risks of another contingency, which could result in a catastrophic scenario.[35]

I agree with Liberty in that regard. The consequences of an extended bipole failure in winter, when loads are high and other system components are also threatened by weather hazards may be particularly severe. The system events of January 2014 highlighted the seriousness of

[35] See Liberty's Phase Two Report, Page 84.

widespread winter outages on the IIS. As Liberty noted in their Interim Report dated April 24, 2014:

> "Recurring bouts of harsh weather on the Island portion of the Province and its strong and increasing dependence on electricity for heat make prolonged electric outages potentially a matter of life and death, as opposed to an inconvenience."[36]

As Table 2 shows, in the event of a bipole outage, the capacity reserve on the IIS after Holyrood is decommissioned will be 82 MW, based on Hydro's current system plan. The system would be very vulnerable at that level of reserve. Further, it would require that 300 MW of capacity be available over the ML, in addition to all of the currently installed supply capacity on the IIS.

The 300 MW import capacity of the ML therefore becomes an especially critical element of Hydro's IIS system plan after Holyrood is decommissioned. However, the ability to get 300 MW from Nova Scotia through the ML is unconfirmed at this time. Hydro has not indicated whether the 300 MW is available from Nova Scotia. In addition, there appear to be significant limitations on the firm power transfer capabilities between New Brunswick and Nova Scotia, which could limit the availability of import capacity from beyond Nova Scotia.[37]

Unless firm access to 300 MW through the ML is available by the time Holyrood is decommissioned, additional CT generation will almost certainly be necessary to ensure adequate reserves on the IIS. The availability of the ML import capability should therefore be confirmed at the earliest possible time.

[36] See Liberty's Interim Report, Page 18.
[37] See response to Request for Information NP-PUB-009, Attachment 1, Page 7.

Even if it can be demonstrated that 300 MW will be available through the ML, the long transmission distance and the risk of multiple line failures through the Isthmus of Avalon may still warrant additional backup emergency generation on the Avalon Peninsula. However, the amount of such generation and the size of the generating units may be different.

At this time, there is inadequate information, especially with respect to the availability of the 300 MW, to do system planning for the post Muskrat Falls environment and to properly assess the need for additional CT generation.

4. CONCLUSIONS

The completion of Muskrat Falls and the interconnection of the IIS through the LIL and the ML will significantly change the composition of the power supply on the IIS. Phase Two of the Investigation will consider the adequacy and reliability of supply on the IIS both before and after those interconnections are completed.

Liberty's Phase Two Report concluded that the interconnection of the IIS with Muskrat Falls and the ML can "represent a state-of-the-art electrical system whose reliability is improved over today's circumstances."[38] In the meantime, however, while many of the reliability concerns identified in Phase One of the Investigation have been addressed by actions undertaken by Hydro, the Board's Phase One report concluded that "there continue to be significant risks in relation to the adequacy and reliability of supply on the Island Interconnected system".[39]

My analysis shows that acceptable reliability on the IIS in the pre-Muskrat period is dependent on Hydro's thermal units being available when called upon, and on Hydro completing all planned new supply additions on time. However, continuing problems with Hydro's thermal units and the delayed in-service date for Muskrat Falls suggest that the risk of supply related outages on the IIS will continue until Muskrat Falls comes online.

It is not likely that a new combustion turbine could be installed before late 2018 at the earliest. By that time, the ML and LIL are due to be in service. As of this writing, the availability of firm capacity over the ML is uncertain. For this reason, Hydro should focus on confirming the

[38] See Liberty's Phase Two Report, Page ES-1.
[39] The Board's Phase One Report, Page 51.

availability of power for import over the ML and completing the construction of both lines on schedule. If there is any likelihood that any of these supply additions may not be available as scheduled, the preliminary work required to acquire a new combustion turbine should be undertaken.

The most significant factor affecting reliability of the IIS in the post-Muskrat period is the reliability of the LIL. The import capability of the ML is another critical element of the post-Muskrat IIS. Even with firm capacity of 300 MW available over the ML, capacity reserves on the IIS will be less than 100 MW in the event of a bipole failure of the LIL under peak load in 2022. In the case of an extended bipole failure, the IIS would remain exposed to the risk of other contingencies, and a potentially catastrophic extended supply disruption at what may be the coldest time of year. In my view, the need for additional supply on the IIS to mitigate loss of load in the case of an extended bipole outage ought to be considered.[40]

Reliability planning involves consideration of the likelihood of outages, the severity of consequences of those outages, and the cost of measures required to mitigate those outages. It also requires the application of judgment to determine the appropriate balance of cost and reliability. The decisions required of the Board to ensure the adequacy and reliability of the IIS, both before and after the interconnection of Muskrat Falls, will require more information than is currently available. It is imperative that Hydro complete all outstanding studies and operational plans related to the integration of Muskrat Falls, the LIL, and ML in a timely manner.

[40] For Hydro’s current views on the generation additions needed to meet demand on the IIS in the absence of the LIL and/or the ML, and related cost estimates and customer impacts, see responses to Requests for Information PUB-NLH-542 and PUB-NLH-543.

5. RECOMMENDATIONS

Near-Term

- Options to improve the near-term supply reliability outlook are limited by the time constraints associated with construction of a new combustion turbine. Since there is no practical way to add capacity prior to the scheduled integration of the ML and LIL, it is critical that Hydro focus on maintaining its existing supply sources to ensure they are available for the upcoming winter seasons.
- If there is any likelihood that the LIL or ML may not be available as scheduled, the preliminary work required to acquire a new combustion turbine should commence as soon as possible.
- The near-term reliability outlook will be improved with the commissioning of the LIL and ML. Hydro should focus on completing these projects on schedule. The Board should require that Hydro report regularly to the Board on construction progress and the status of arrangements for the acquisition of firm import power over the ML.

Longer-Term

- Hydro should complete all outstanding studies and operational plans related to the integration of Muskrat Falls, the LIL, and ML in a timely manner. The Board should require regular reports on progress.
- The Board should require Hydro to provide a full analysis, including costs, of all options available to mitigate the consequences of a bipole outage on the LIL.

- Once all studies and analysis are completed, the Board should open a system planning process to determine the level of backup generation required, if any, to address any outstanding reliability concerns on the IIS.

Exhibit LBB-1: Resume of Larry B. Brockman

Larry B. Brockman Resume

Name
Larry B. Brockman

Present Position
President, Brockman Consulting

Qualifications Summary
Mr. Brockman has over 36 years experience as a utility rate designer, planner, consultant, regulator, educator, and expert witness. He specializes in cost of service and rate design, strategic planning, regulatory assistance, competitive market assessments, bid evaluation processes, merger and acquisition analysis, and computer simulation, to help utilities meet their strategic goals and maintain competitive advantage.

Education
Mr. Brockman earned a bachelor's degree in engineering from the University of Florida in 1973. He subsequently completed 35 quarter-hours towards a master's degree in electrical engineering, with a minor in regulatory economics at the University of Florida.

Prior Experience
During his career, Mr. Brockman has performed, and managed a broad range of consulting projects, including:

Cost of Service and Rate Design
Numerous Cost of service and Rate Design projects for Canadian and US utilities, assisting the utilities with marginal and embedded cost-of-service and rate designs for their ability to meet the utilities' strategic and regulatory goals, and pass regulatory scrutiny. In many of these examinations, Mr. Brockman has appeared as an expert witness. These cases are delineated in the Appendix.

Co-Developer and Instructor of the Public Utilities Reports, industry short course on Rates and Regulation for 5 years. In these courses, Mr. Brockman taught hundreds of utility rate designers, regulators, attorneys and Commission staff the principles of rate design and regulation.

Review of a restructured utility's shared services costs of service separation study to allocate the costs between regulated and unregulated subsidiaries, and procedures for tracking the costs in the future.

Financial Analysis and Asset Valuation
Construction of detailed utility financial simulation models to forecast regional bulk-power prices and profits for Utilities and Independent Power Producers to judge market entry positions and create successful negotiating strategies for purchases and sales in unregulated generation markets.

A profitability study for an electric utility to assess effects on shareholder returns and economic value added (EVA), of various marketing activities of the utility. These studies resulted in re-engineering the marketing department to yield higher returns and be more consistent with corporate goals.

Several asset valuation studies for electric utilities to determine whether a market existed to sell existing generating assets, what they were worth, and whether they would be competitive with existing and new generation in the region. Results were presented to senior management and used to revise the strategic planning direction.

Competitive Market Assessments
Expert testimony to the Arkansas and Louisiana Public Service Commissions on the market clearing prices for generation in a competitive market, and the relative competitive positions of many of the generating companies in the SPP and ERCOT regions. To perform this work, Mr. Brockman used sophisticated computer models and a database containing over 120,000 MW of capacity in the region.

A study on the effects of retail competition on the states of North and South Carolina, presented to the South Carolina Legislature and performed for Carolina Power and Light Company. The study required research on the behavior of prices in other formerly regulated industries and detailed modeling of the market prices and financial effects on the utilities, as well as the effects on state and local taxes.

An independent review of the effectiveness and reliability of a large Mid-Western utility's Power Marketing and Purchases Department in deregulated generation markets, performed as a joint project with the utility and the state's attorney general.

Numerous market outlook and generator profitability studies of the ERCOT, Eastern Interconnect, and WSCC markets for merchant plant developers, using the GEMAPS transmission-constrained production cost simulation tool.

An analysis for a large Canadian utility of the profitability of increased transmission line investments to move power into various competitive markets in the US and Canada.

Computer Simulation of Power Systems
Mr. Brockman is an expert in the use of utility simulation software for: planning; operations; and financial analysis including: PROMOD; PROVIEW; PROSCREEN II; PMDAM; PROSYM; EVALUATOR; GEMAPS, IREMM, and several Power Flow programs.

Strategic Planning
A strategic planning project for a large South-Eastern electric utility identifying strengths, weaknesses, opportunities, and threats, in competitive open-access power markets. For each utility in the region, the project identified which customers would be gained and lost, and assessed the impacts of alternative transmission, and contracting strategies. The entire South Eastern US generating and major transmission systems were simulated. Over $1.5 Billion of potential customer revenue migration was identified at the client utility. Strategies for maintaining the utility’s profitability were recommended and accepted by senior management.

Development of several successful strategies and power supply bid evaluation procedures in use at investor owned and rural electric cooperatives, to ensure that winning bids are consistent with the utility’s business goals and objectives.

Operational Studies
A salt dome natural gas storage study for a South Central electric utility. The study identified the hourly operational characteristics necessary for favorable economics of the required storage facility. Estimated savings in excess of $100 Million were identified. The facility was constructed and has been successfully benchmarked against the study results.

Merger and Acquisition Analysis
Mr. Brockman has participated in several merger and acquisition studies assessing the production cost and planning and operational synergies arising from the merger. He testified before the FERC on the accuracy and appropriateness of the production costing computer simulations a merger application. He also participated in a regulated/non-regulated cost separation study for a shared services group of a major utility.

Expert Litigation Assistance
Project manager of an anti-trust case involving investigation of all phases of power supply planning covering a 40 year historical period and a successful defense against over $3 Billion damage suit involving alleged actions by an investor owned utility.

Managed a successful defense against a cogenerator seeking to convince regulators that a utility's ratepayers should pay over $1.5 Billion in unnecessary and uneconomic new generation avoided costs by the cogenerator.

Project manager for a precedent setting FERC case defending a utility from an attempt to abrogate a long term bulk power contract worth over $400 Million. Mr. Brockman's team was able to convince the FERC that contract abrogation was not in the public interest, that the plaintiff was not going bankrupt, and that the plaintiff's difficulties were the result of arbitrary and capricious state regulation.

Prior Positions Held
Managing Consultant PA Consulting, 2000-2002. Mr. Brockman managed a group of consultants engaged in the analysis of transmission-constrained competitive generation markets, as well as managing several litigation cases involving electric utilities.

President of Brockman Consulting 1997-2000. Mr. Brockman assisted clients with strategic planning and regulatory assistance.

Managing Director and Vice President 1994-1996, EDS Management Consulting Services (formerly EMA). Responsible for the Atlanta office, engaged in providing technical consulting services in planning, regulatory assistance, marketing, competitive assessments, reliability, bid evaluation, financial simulation, and expert testimony.

Vice President Energy Management Associates (EMA) Consulting Department 1985-1994. Started as lead consultant and rose to position of Vice President. He marketed and provided strategic planning, regulatory assistance, and operational consulting to electric and gas utilities worldwide.

Assistant Director Electric and Gas Department, Florida Public Service Commission 1981-1985. Supervised 48 employees engaged in all phases of electric and gas regulation. Made recommendations to the Commission on rate cases and resource planning dockets for all electric and gas utilities in Florida. Responsible for financial and management audit scopes, prudence reviews of rate base, expenses, revenue requirements, and final rate design. Also advised Commission on economic effects of regulatory and energy policy actions.

Corporate Planning Engineer 1979-1981, Gainesville Regional Utilities. Developed, analyzed, and presented to senior management and the City Council, ideas, plans, and studies affecting the growth, financial well-being and efficient operation of the city owned electric system. Performed detailed simulations and studies of new generation, substations, transmission lines, voltage conversions, re-conductoring, and power factor correction. Mr. Brockman conducted public hearings and testified before the City Council on proposed transmission lines, substations, and rate designs.

Special Consultant 1979-1980, University of Florida Public Utilities Research Center. Under a grant from Florida Power Corporation and the Florida Public Service Commission, performed a detailed review of marginal cost study techniques for electric utilities and completed a marginal cost study for Florida Power Corporation.

Transmission Planning Engineer 1973-1976, Jacksonville Electric Authority. Responsible for bulk transmission planning, including extensive use of power-flow, fault current and transient stability computer programs. Chairman of the Florida Electric Coordinating Group's Long Range Transmission Planning Task Force 1974.

Adjunct Faculty Member 1976, University of North Florida. Taught courses in industrial and commercial building wiring design and conformance with National Electrical Codes.

Expert Witness Appearances
City of Gainesville City Council, 1980, testified on behalf of Gainesville Regional Utilities concerning a joint utility and citizen's collaborative effort on rate design.

City of Gainesville City Council, 1981, testified concerning a Long-Range Transmission and Distribution Plan and proposals to construct a new substation.

Florida Public Service Commission, Florida Power and Light, 1981 Docket No. 810002, Rate Case, testified on cost-of-service.

City of Tallahassee - Surcharge Outside the City Limits, 1983. Testified concerning marginal and embedded costs inside and outside the city limits.

Florida Public Service Commission, 1988, West Florida Natural Gas Company. Testified on cost-of-service and rate design and why the utility needed flexibility to meet competition.

Oklahoma Corporation Commission, 1988, Avoided Cost Proceeding. Testified on the appropriate use of computer models to determine avoided cost of generation.

Nova Scotia Board of Commissioners of Public Utilities, 1989, Nova Scotia Power Rate Case. Testified on cost of service and rate design.

Nova Scotia Board of Commissioners of Public Utilities, 1990, Nova Scotia Power Rate Case. Testified on integrated resource planning, cost of service and rate design.

Nova Scotia Board of Commissioners of Public Utilities, 1993, Nova Scotia Power Rate Case. Testified on cost of service and rate design.

Board of Commissioners of Public Utilities of the Province of Newfoundland and Labrador, 1990. Newfoundland and Labrador Hydro rate case. Testified on integrated resource planning and rate design.

Board of Commissioners of Public Utilities of the Province of Newfoundland and Labrador, 1992, Newfoundland and Labrador Hydro rate case. Testified on Cost of Service and Rate Design.

Board of Commissioners of Public Utilities of the Province of Newfoundland and Labrador, 1992, Generic Hearing on Cost of Service and Rate Design.

Board of Commissioners of Public Utilities of the Province of Newfoundland and Labrador, 1995, In the Matter of an Inquiry Into Issues Relating to Rural Rate Subsidies.

Public Service Commission Colorado, 1994, testified on behalf of Public Service Company of Colorado on the proper use of dynamic programming models in the utility's integrated resource planning process.

Federal Energy Regulatory Commission, 1994, Merger Case, Testified on behalf of Central and Southwest utility concerning production cost merger benefits.

Nova Scotia Board of Commissioners of Public Utilities, 1995, Nova Scotia Power Rate Case. Testified on cost of service and rate design.

Board of Commissioners of Public Utilities of the Province of Newfoundland and Labrador, 1996, Newfoundland Power Rate Case, testified on cost of service and rate design.

Arkansas Public Service Commission, 1997, Arkansas Power and Light Rate Case, testified concerning the market clearing prices for power in deregulated markets and the relative competitive positions of various generators in such markets.

Board of Commissioners of Public Utilities of the Province of Newfoundland and Labrador, 2001, Newfoundland and Labrador Hydro rate case, on behalf of Newfoundland Power concerning Cost of Service and Rate Design.

Board of Commissioners of Public Utilities of the Province of Newfoundland and Labrador, 2003, Newfoundland and Labrador Hydro rate case, on behalf of Newfoundland Power concerning rate design and marginal costs.

Board of Commissioners of Public Utilities of the Province of Newfoundland and Labrador, 2003, Newfoundland Power rate case, concerning Cost of Service and Rate Design.

North Carolina Docket No. E-22, Sub 412. Draft testimony on behalf of Dominion North Carolina, February 2005, concerning rates to a large steel company. Case was settled before final evidence was submitted.

Board of Commissioners of Public Utilities of the Province of Newfoundland and Labrador, 2006, Newfoundland and Labrador Hydro rate case, on behalf of Newfoundland Power concerning rate design and marginal costs.

Board of Commissioners of Public Utilities of the Province of Newfoundland and Labrador, 2009, on behalf of Newfoundland Power concerning Newfoundland and Labrador Hydro's Industrial Rates.

Board of Commissioners of Public Utilities of the Province of Newfoundland and Labrador, 2014, on behalf of Newfoundland Power concerning Newfoundland and Labrador Hydro's proposal for a refund of the Newfoundland Power RSP Surplus.

Clients Mr Brockman has Performed Consulting Services for Include:

Ahlstrom Pyro Power

Alabama Electric Cooperative

Alberta Power Company

Balch and Bingham

Black and Veatch

California Energy Commission

Carolina Power and Light Company

Central and Southwest Company

Central Vermont Power Company

Chugach Electric Cooperative

Cincinnati Gas and Electric Company

Citibank

Commonwealth Edison Company

Duke Power Company

Enron

Entergy

Florida Public Service Commission

Georgia Power Company

Gainesville Gas Company

Hawaiian Electric Company

Howery and Simon

Hydro One

McKinsey and Company

Mission Energy

Nevada Power Company

New Brunswick Power Company

New York State Electric and Gas

Newfoundland Power

Niagara Mohawk

Nova Scotia Power Company

Oklahoma Gas and Electric Company

Ontario Power Generation

Pacific Gas and Electric Company

Public Service Company of Colorado

Public Service Company of New Mexico

Rochester Gas and Electric

SCANA

Southern California Edison

Tampa Electric Company

The City of Austin

The Southern Company

TransEnergie

West Florida Natural Gas Company

The World Bank