Q. Please describe how steps will be taken to minimise the consequences of the following events on the performance of the Labrador Island Link. Please also state the predicted contribution to the outage rate and unavailability (monopolar and bipolar) of the Labrador Island Link of each of the following events.

1. Tripping of one or more AC lines at Muskrat Falls converter station.
2. Tripping of one or more AC lines at Soldiers Pond converter station.
3. Delayed clearing of faults in close proximity to the Muskrat Falls and Soldiers Pond converter stations, e.g. because of breaker failure.
4. Major faults, e.g. fire or extensive insulation damage to one or more high inertia synchronous condensers, requiring major and prolonged repair at times of high loading on the Labrador Island Link.
5. Operator errors.
6. Major fires in the converter stations.
7. Major failure of 2 or more converter transformers, requiring factory repair (such faults could be caused by latent defects or design errors not detected at type and routine testing).

A. The transmission planning criteria used to assess the impacts were provided in Hydro's response to PUB-NLH-217. The events, or contingencies, proposed in this RFI extend beyond those considered in the normal course of analysis to determine system impacts in most cases. As a result, detailed studies have not been performed to assess the entirety of potential impacts. To this end, the response herein considers the existing Hydro transmission planning criteria, potential for operating procedures/restrictions and NERC transmission planning standards (TPL) associated with system performance following loss of Bulk Electric System (BES) element(s) Table 1 of acceptable impacts. The response is qualitative in nature.

Tripping of one or more AC lines at Muskrat Falls converter station

The tripping of one 315 kV transmission line at Muskrat Falls will have no negative impact on the performance of the Labrador – Island HVdc Link (LIL), its outage rate or unavailability (i.e., NERC TPL Table 1 Category B – Event resulting in loss of a single element).

Tripping of both 315 kV transmission lines between Muskrat Falls and Churchill Falls will result in the Muskrat Falls Generating Station and converter station becoming electrically isolated from the Labrador Interconnected System. The 315 kV transmission system between Churchill Falls and Muskrat Falls is comprised of two single circuit 315 kV transmission lines (L3501 and L3502). The loss of both 315 kV transmission lines can be assessed using two different scenarios. Scenario One has one 315 kV transmission line fail followed by the second 315 kV line a short time later. The NERC TPL Table 1 lists this scenario as a category C event – event(s) resulting in the loss of two or more (multiple) elements. Category C events are permitted to result in planned/controlled load loss but cascading outages must be avoided. In the context of the LIL, the impact on load supply is dependent upon the power flow on the 315 kV system. For example, if the power flow on the 315 kV is from Muskrat Falls to Churchill Falls, the loss of the 315 kV would result in excess generation at Muskrat Falls and increased frequency at the Muskrat Falls Terminal Station. Governor action in the Muskrat Falls plant would return the station frequency to normal. There is no overall negative impact on power supply to the Island Interconnected System or outage rates and performance of the LIL. If power flow is from Churchill Falls to Muskrat Falls prior to the event, loss of the 315 kV would result in a power deficit at Muskrat Falls resulting in a reduction in frequency on the isolated network. Depending upon the magnitude of the deficit and generation levels at Muskrat Falls, governor action at Muskrat Falls would return the frequency to normal, or reduction of the power delivery to the Island may be required. Reduction of power delivery to the Island could result in load shed on the Island.

Given that Scenario One considers the sequential loss of 315 kV circuits, potential mitigation strategies for negative impact on the LIL and power deliveries to the Island could consider the potential re-dispatch of generation resources (both in Labrador and on the Island) such that the flow on the remaining 315 kV line is minimized to avoid negative impacts.

Scenario Two considers the simultaneous loss of both 315 kV transmission lines. Given that the lines are located on separate structures in a common right-of-way, the scenario would be a NERC TPL Table 1 Category D - extreme event. The standard for Category D requires evaluation for risks and consequences. The standard recognizes that the event "may involve substantial loss of customer demand and generation in a widespread area or areas". In addition, "portions or all of the interconnected systems may, or may not achieve a new, stable operating point". Again, the impact on the LIL performance will be dependent upon the pre-event power flow on the 315 kV transmission system and the online generation at Muskrat Falls. High flows from Churchill Falls to Muskrat Falls with minimal number of units on at Muskrat Falls are expected to result in below normal frequency at Muskrat Falls and subsequently load shed on the Island Interconnected System. Flows from Muskrat Falls to Churchill Falls with three to four units on at Muskrat falls is expected to have no major negative impact on LIL performance and supply to the Island.

Tripping of one or more AC lines at Soldiers Pond Converter Station

System studies to date demonstrate that the tripping of any one 230 kV transmission line connecting the Soldiers Pond Terminal Station does not result in a negative impact on the performance of the Labrador – Island HVdc Link (LIL), its outage rate or unavailability (i.e., NERC TPL Table 1 Category B – Event resulting in the loss of a single element).

The loss of two 230 kV transmission lines at Soldiers Pond may result in the thermal overloading of remaining transmission lines under steady state conditions depending upon load conditions and ambient temperatures. Considering sequential line losses at Soldiers Pond (i.e. NERC TPL Table 1 Category C event), thermal overloading issues may be mitigated following the first line loss through re-dispatch of generation and start-up of local standby combustion turbines, prior to the second line loss.

Simultaneous loss of two 230 kV transmission lines at Soldiers Pond (i.e., NERC TPL Table 1 Category D event) may result in system interruption due to low voltage or line overload, requiring the restoration of a portion of the system and customers. This would be no different than the simultaneous loss of both 230 kV transmission lines crossing the Isthmus of Avalon today.

Delayed clearing of close proximity faults at Muskrat Falls and Soldiers Pond converter stations - breaker failure

Breaker fail resulting in the loss of two elements at a station has not historically been considered in the Hydro transmission planning criteria. However, Hydro protection and control designs incorporate breaker fail schemes. Breaker fail is a NERC TPL Table 1 Category C event that may result in planned/controlled load loss. The application of breaker-and-one-third arrangements at both Muskrat Falls and Soldiers Pond along with consideration of line termination points assist in the mitigation of severe impacts. For example, the 315 kV station layout at Muskrat Falls is such that a 315 kV breaker failure would result in the loss of one Muskrat

Falls generator and one 315 kV transmission line instead of two generators or two transmission lines. It is recognized that a line fault with breaker failure may result in the tripping of a converter pole. However, the LIL is designed with overload capacity in monopolar mode such that there is no negative impact on delivery to the Island Interconnected System. Further studies to date have included single contingency line trips with the LIL in monopolar mode and demonstrate no adverse impact on LIL performance.

Major faults to one or more high inertia synchronous condensers, requiring major and prolonged repair at times of high loading on the Labrador-Island Link

Failure of multiple high inertia synchronous condensers at Soldiers Pond is considered a NERC TPL Table 1 Category C event when planned/controlled loss of load is permissible.

The system model for integration of the LIL includes two synchronous condensers at Holyrood and three high inertia synchronous condensers at Soldiers Pond. Studies to date have assumed two synchronous condensers on line at each of Holyrood and Soldiers Pond. Under normal operation during peak load periods it is expected that all five synchronous condensers are in service. Having completed studies with one high inertia machine out of service in the base cases demonstrates that when starting from a point with all five machines in service (normal peak operating mode), system contingencies will not have an adverse impact on system performance. In addition the base cases consider the loss of one high inertia synchronous condenser with one out of service at peak. The results demonstrate that there is no adverse impact on system performance for loss of two high inertia synchronous condensers. Failure of one high inertia synchronous condenser during peak does not require adjustment to the operation. Failure of the second high inertia synchronous condenser would, in turn, result in no negative impact on performance. Following failure of the second high inertia synchronous condenser re-dispatch of generation and LIL loading levels may be required to position the system to minimize system outages for a potential loss of the third high inertia synchronous condenser.

Operator errors

In order to minimize the risk of operator errors having an adverse impact on the performance of the LIL, Energy Control Centre (ECC) operators will be trained on the operation of the equipment using the Energy Management System (EMS) Operator Training Simulator (OTS) prior to the in service date of the LIL.

Major fires in the converter stations

A major fire in a converter station is considered a major event that in all likelihood would result in the loss of customer load. The same is true for a major fire in any utility generating station. To minimize the risk of impact due to a major fire in a converter station, fire suppression systems are employed. As well, each pole of the bipolar scheme is housed in a separate valve hall building such that a fire in the valve group of one pole does not spread to the second pole.

Major failure of two or more converter transformers requiring factory repair

Hydro's mitigation strategy for converter transformer failure begins with a design having one spare converter transformer at each converter station. In addition, fire separation walls are used between converter transformers to minimize damage to adjacent units. The loss of the second converter transformer at a converter station results in the LIL being operated in monopolar mode until such time that transformer repairs can be completed. Depending upon system load conditions and repair durations, re-dispatch of Island generation, start-up of on Island generation and purchases from the Maritimes via the Maritime Link may be necessary. Beyond the loss of two converter transformers, the LIL is able to operate in monopolar mode with three of the seven single phase converter transformers connected to one pole. It is noted that this may require the physical relocation of units within the station depending upon the location of the failed units.

Attachment 2 included in Hydro's response to PUB-NLH-212, entitled *Reliability & Availability Assessment of the HVdc Island Link* dated April 10, 2012 completed by SNC- Lavalin provides insight on the outage rates of converter transformers.