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September 12, 2014

The Board of Commissioners of Public Utilities
Prince Charles Building
120 Torbay Road, P.O. Box 21040
St. John's, Newfoundland & Labrador
A1A 5B2

Attention: Ms. Cheryl Blundon
Director Corporate Services & Board Secretary

Dear Ms. Blundon:

Re: Newfoundland and Labrador Hydro – 2015 Capital Budget Application

Further to the filing of Hydro's 2015 Capital Budget Application dated August 1, 2014 and Newfoundland Power's correspondence of September 4, 2014, enclosed please find the original plus eight copies of Hydro's report entitled *Upgrade Circuit Breakers*.

Also enclosed are revisions to Section A, Section B, and Section C. These revisions are necessary to show a change in numbers and have been shaded for ease of reference.

Hydro apologizes for the delay in the filing of this report.

Should you have any questions, please contact the undersigned.

Yours truly,

NEWFOUNDLAND AND LABRADOR HYDRO

Geoffrey P. Young
Senior Legal Counsel

GPY/cp

cc: Gerard Hayes – Newfoundland Power
Paul Coxworthy – Stewart McKelvey Stirling Scales
Thomas Johnson – Consumer Advocate
Leanne O'Leary – Cox & Palmer

A REPORT TO
THE BOARD OF COMMISSIONERS OF PUBLIC UTILITIES

	Electrical
	Mechanical
	Civil
	Protection & Control
	Transmission & Distribution
	Telecontrol
	System Planning

Upgrade Circuit Breakers

September 2014

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SUMMARY

This proposal is for the refurbishment and replacement of 66, 138 and 230 kilovolt (kV) circuit breakers. This report presents the methodology used for determining when a circuit breaker will be refurbished or replaced for air blast, SF_6, and oil circuit breakers.

Hydro has 185 circuit breakers in service that are rated at 66 kV or higher. The majority of these circuit breakers have a service life that is nearing, or in some instances, exceeding the point where a refurbishment or replacement should be completed. This proposal presents an upgrade plan developed by Hydro for all circuit breakers based on service age, condition and duration since their last refurbishment.

Following the events of January 2014, Hydro has also accelerated the replacement of air blast circuit breakers starting in 2015. The plan will see all the current in-service air blast circuit breakers replaced by 2020, the last overhauls completed on air blast circuit breakers in 2015, overhauls completed on SF_6 circuit breakers at approximately mid-life and replaced at or near age 40, and all oil circuit breakers replaced by 2025 to ensure compliance with environmental legislation and the removal of polychlorinated biphenyls (PCBs) contaminated bushings.

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1 INTRODUCTION

Hydro's circuit breaker upgrading project is required to refurbish or replace circuit breakers. The majority of circuit breakers within Hydro's system have been operational for more than 30 years with a significant number in the late stages of, or beyond, their normal lifecycle, typically estimated between 40 to 55 years depending on circuit breaker type. The probability of failure for a circuit breaker increases with age.

Hydro has 185 circuit breakers rated at voltages of 66 kV and above. Figure 1 shows the age distribution of circuit breakers by voltage class.

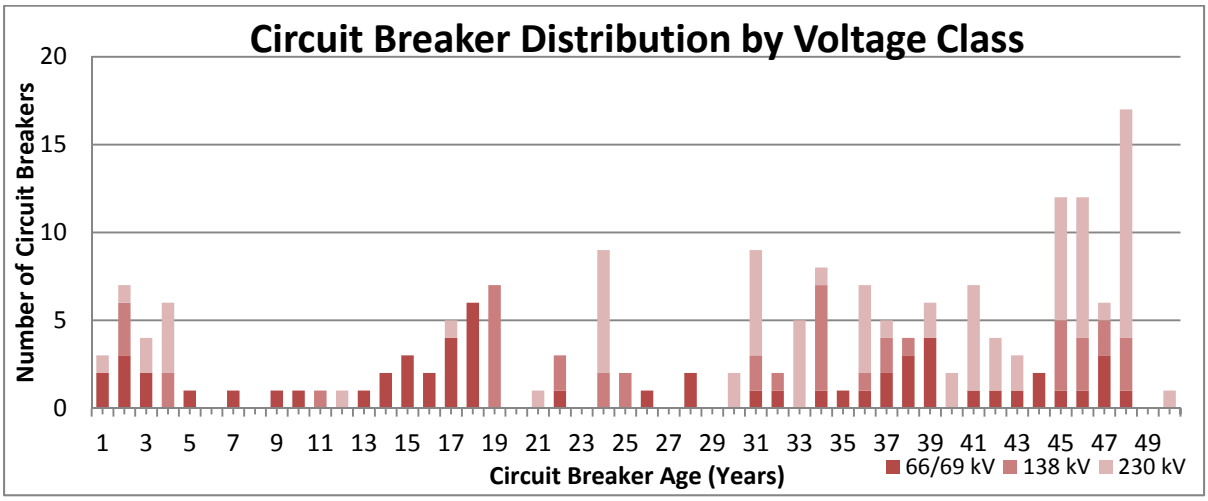

Figure 1: Circuit Breaker Distribution by Age and Voltage Class

The circuit breaker is a critical component of the power system. Located in a terminal station, each circuit breaker performs switching actions to complete, maintain, and interrupt current flow under normal or fault conditions. The reliable operation of all circuit breakers through its fast response and complete interruption of current flow are essential to protect the power system and to maintain the stability of the system. Currently, Hydro maintains three different types of circuit breakers at three voltage levels that include:

1. Air Blast Circuit Breakers (ABCB);

2. Oil Circuit Breakers (OCB); and
3. Sulphur Hexafluoride (SF_6) Circuit Breakers.

The three voltage levels used by Hydro with its terminal station circuit breakers are 66/69 kV, 138 kV and 230 kV. The SF_6 circuit breaker is the newest design.

Each type of circuit breaker has unique operating characteristics. Air blast circuit breakers offer features such as fast response and automatic reclosing. They are widely used where repeated operation is essential. Unlike air blast breakers, which extinguish the current arc created inside the circuit breaker with air as its medium, oil circuit breakers extinguish the arc using insulating oil. SF_6 circuit breakers use SF_6 gas which has a higher density than air allowing SF_6 to be a highly reliable dielectric for extinguishing the current arc created during switching. The trend in the utility industry is towards the SF_6 circuit breakers because of the superiority of the new technology, availability and its operating characteristics. Figure 2 shows photos of the three types of circuit breakers.

Figure 2: Circuit Breakers - Air Blast (top left), Oil (top right) and SF_6 (bottom)

The circuit breaker is comprised of two major component areas:

- the interrupting device which includes the stationary contact, moving contact, arc quenching medium; and
- the insulating material along with the operating mechanism.

The air blast, oil and SF_6 circuit breakers are very different in design and construction and, as such, their refurbishment varies with each type. For air blast circuit breakers, both the interrupting device and operating mechanism require a mid-life refurbishment of seals, O-rings, and lubrication.

SF_6 circuit breakers typically require an operating mechanism refurbishment at mid-life as the interrupter is a sealed unit.

Oil circuit breakers will be replaced and not refurbished under this upgrading project due to environmental legislation for polychlorinated biphenyls (PCBs) that are contained in the oil circuit breaker's bushings.

2 PROJECT DESCRIPTION

With the circuit breaker being a critical and high-cost capital asset, Hydro, has been working to maximize the life of its in-service units. In recent years, Hydro has been replacing aging circuit breakers, upgrading air blast circuit breakers, refurbishing operating mechanisms associated with SF_6 circuit breakers, and dealing with the phase out of bushings containing PCBs, such as those associated with oil circuit breakers (OCBs). Because of supply issues and power outages on the island interconnected system in January of 2014, Hydro has reviewed its air blast breaker replacement plan and has accelerated this program. This proposal will address the critical areas noted above by outlining the work plan for each type of circuit breaker.

2.1 Air Blast Circuit Breaker

Up until 2014, Hydro had an on-going program to replace all air blast circuit breakers with SF_6 circuit breakers by 2031 and an overhaul program which typically occurred at the 35 to 40 year period of the service lifecycle. Although historically the performance of air blast circuit breakers has been reasonable, Hydro experienced significant events in January 2013 and January 2014 that involved air blast circuit breakers. As a consequence, Hydro now plans to initiate a program to complete overhauls on all remaining breakers by 2015 and carry out the replacement of air blast circuit breakers on an accelerated schedule to have all air blast circuit breakers replaced by the end of 2020.

The strategy and details of this accelerated air blast circuit breaker replacement plan is outlined in the report “Accelerated Air Blast Circuit Breaker Replacement Program”, completed by AMEC Americas Limited, which is included in Appendix F.

2.2 Oil Circuit Breakers

Oil circuit breakers will not be refurbished and are scheduled for replacement prior to 2025 due to Environment Canada Regulations. The existing oil circuit breakers have sealed

bushings with an unknown quantity of PCB concentration. Based on the date of manufacture, these bushings could potentially have PCBs greater than 500 mg/kg.

2.3 Sulfur Hexafluoride (SF_6) Circuit Breaker

The refurbishment of SF_6 circuit breakers will typically be scheduled after 20 years of service. With the development of the upgrading program, a number of the existing SF_6 circuit breakers have already reached a service life greater than 20 years. SF_6 circuit breakers in this category have been given a priority for refurbishment. The remaining SF_6 circuit breakers are planned to be refurbished at or near the 20 year service life period. This approach has been taken to help balance financial costs and operational risks while minimizing the number of customer outages and ensuring constructability in terms of available resources, physical work space, etc. The plan for replacement will be after 40 years of service. Some SF_6 circuit breakers will require replacement before the 40 year service life period based upon their condition and operational history. For example, Hydro has replaced SF_6 circuit breakers in recent years due to gas leaks and problems with the operating mechanisms. In addition, with the air operated type of SF_6 circuit breakers there has been corrosion of air receiver tanks. Some of the SF_6 circuit breakers recently replaced due to the above conditions include:

- SF_6 circuit breaker in Howley in 2009;
- SF_6 circuit breaker in Bottom Brook in 2010; and
- SF_6 circuit breaker in St. Anthony in 2011.

The main objective for this upgrading plan is to take an overall strategic approach for all existing circuit breakers. This approach supports the corporate asset management philosophy, complies with current legislation and plans to minimize customer outages.

It is important to note that some items are not included in this plan. These include

- 66 kV SF_6 circuit breakers.

There will be no refurbishments on 66 kV voltage level SF_6 circuit breakers as their replacement is the more cost effective solution. The replacement of this circuit breaker type will typically occur after 40 years of service. The actual replacement will be based on the condition of the individual circuit breaker.

3 JUSTIFICATION

As illustrated in Figure 3, 27% of Hydro's circuit breakers are between 31 and 40 years of age and 34% are greater than 41 years of age.

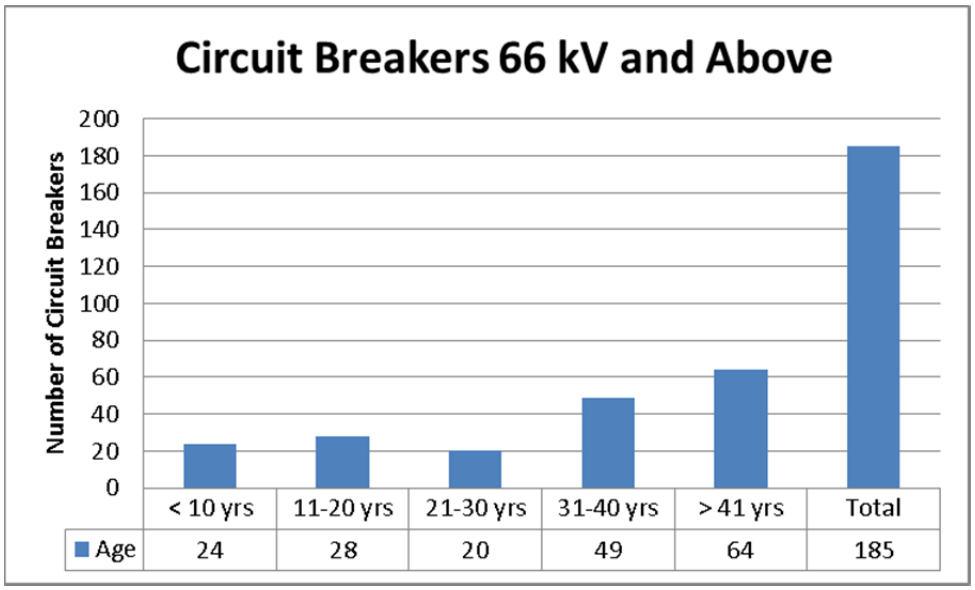

Figure 3: Age Distribution of 66 kV and above Circuit Breakers

To bring forward a consolidated and coordinated long term care program for circuit breakers, the first plan was developed in 2011 with updates up to and including 2014 that include the following:

- Air blast circuit breaker refurbishment of types DCF, DCVF and DLF circuit breakers to be completed by 2015;
- SF_6 operating mechanism refurbishment; and
- Oil circuit breaker replacements to replace aging assets and comply with environmental legislation (deals with possible PCB contaminated bushings);
- SF_6 circuit breaker replacements; and
- Air blast circuit breaker replacements on an accelerated schedule.

A long term plan is required to maintain the reliability of all Hydro's in-service circuit

breakers. This plan has timeframes that balance reliable operation with financial impacts, and considers constructability as well as system outage constraints for a large quantity of aged circuit breakers that require either refurbishment or replacement. Even though this balanced approach will continue for SF_6 and oil circuit breakers, the acceleration of the air blast circuit breaker program will result in increased capital expenses until all are replaced in 2020.

3.1 Existing System

This proposal is required to refurbish or replace aging circuit breakers Hydro has in service.

The demographics from Figure 3 highlight the following:

1. The average age of the entire circuit breaker population is well past the estimated circuit breaker midlife of 20 years and is fast approaching the manufacturers' specified design end-of-service life of 40 years.
2. The number of circuit breakers 40 years old and greater is 66 . This does not include breakers planned for replacement in 2014.
3. To maintain the circuit breaker asset below a 40 year lifecycle period would require a large financial capital cost to replace the 66 circuit breakers mentioned above and the numerous quantities of circuit breakers annually that would continue to reach this benchmark. This approach is not feasible and as a result, an alternate plan for rehabilitation was considered.
4. Up until the events in January of 2013 and 2014, air blast circuit breakers have, in general, proven to be reliable circuit breakers over their service life. However, due to the concerns with reliability Hydro has decided to have all air blast breakers replaced by 2020. SF_6 circuit breakers will typically be replaced after 40 years of service and all oil circuit breakers will be replaced by 2025.

3.1.1 Air Blast Circuit Breaker Refurbishments

Since 1999, refurbishments have been completed on air blast circuit breakers. It is expected that by the end of 2015, all remaining air blast circuit breakers will be refurbished. The circuit breaker replacement plan, shown in Appendix A, includes the updated accelerated air blast breaker replacement plan.

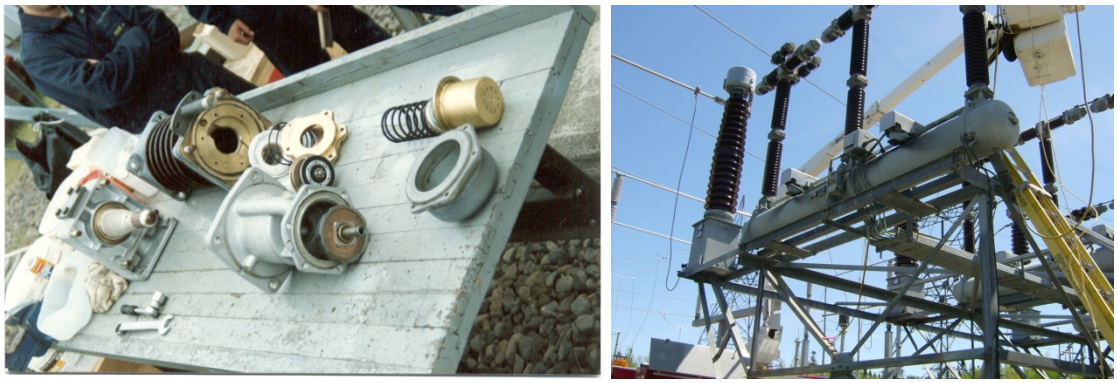

Figure 4: Air Blast Circuit Breaker during a Refurbishment

3.1.2 SF_6 Circuit Breaker Refurbishments

In 2004, Hydro adopted a philosophy of refurbishing operating mechanisms associated with 230 kV and 138 kV SF_6 circuit breakers. By the end of 2014, 22 SF_6 circuit breakers will have been refurbished. The plan is to complete three to five refurbishments per year for a total of 39 circuit breakers refurbished by the end of 2019. See Appendix B for a complete listing of SF_6 circuit breakers with their planned refurbished and replacement dates.

Figure 5: SF_6 Circuit Breaker during a Refurbishment

3.1.3 Oil Circuit Breakers

There has been no major refurbishment work performed with oil circuit breakers. Hydro's intention is to replace all OCBs by 2025 to ensure Hydro is compliant with the latest PCB regulations. The replacement plan for OCBs is included in Appendix C of this report.

Typically, older OCBs will be given a priority to be replaced first followed by OCBs with known problems that include high contact resistance or poor electrical testing results.

3.2 Operating Experience

The majority of circuit breakers within Hydro's system have been operational for more than 30 years with a significant number in the late stages of, or beyond their normal lifecycle, typically estimated between 40 to 55 years depending on circuit breaker type. The probability of failure for a circuit breaker increases with age.

3.2.1 Outage Statistics

For the purpose of determining how well an asset is performing, Hydro compares the asset against the national average of performance for that type of asset. This national average is based on a combination of data collected by the Canadian Electricity Association (CEA) which includes: forced outages, frequency of failure, and the availability of the asset. Table 1 lists the performance data for each criterion. The listed data are the performance averages for Hydro's circuit breaker assets over the previous five-years for 138 kV and 230 kV circuit breakers in comparison to the national average of 138 kV and 230 kV circuit breakers. The comparison uses the performance data from the latest CEA five year average data collected between 2008 through 2012.

Table 1 shows Hydro has experienced 30 forced outages due to problems with its circuit breakers over the last five years.

Table 1: Circuit Breaker Performance (All Types)

	Number of Outages	Frequency (Per a) [1]	Unavailability (%) [2]
NLH 230 kV Circuit Breakers (2008-2012)	20	0.0536	0.0311
CEA 230 kV Circuit Breakers (2008-2012)	1352	0.1447	0.4678
NLH 138 kV Circuit Breakers (2008-2012)	10	0.0495	0.00096
CEA 138 kV Circuit Breakers (2007-2011)	1705	0.1060	0.4607

[1] Frequency (Per a) is the number of failures per year

[2] Unavailability is the percent of time per year the unit is unavailable

3.2.2 Legislative or Regulatory Requirements

The use of PCB material in oil circuit breaker bushings has presented an environmental issue that has led to the development of a plan for its removal and safe disposal. Prior to the mid 1980s the manufacturers of bushings used insulating oil that contained PCBs of varying concentration. The latest federal PCB Regulations (SOR/2008-273) provided an end of use date for different concentrations of PCBs. Subsection 16(1) states that the end of use for equipment containing PCBs in a concentration of 500 mg/kg or more was December 31, 2009; and for equipment containing PCBs in a concentration of at least 50 mg/kg but less than 500 mg/kg is December 31, 2025. The regulations also gave utilities an option to apply for an extension until 2014 to have all sealed equipment containing PCBs greater than 500 mg/kg removed. Hydro, like other Canadian Electricity Association (CEA) members, has a significant amount of sealed equipment with unknown levels of PCBs. As a result, Hydro applied for an extension in 2010 and this was granted until December 31, 2014.

However, due to the large volume of sealed equipment with unknown PCB levels, CEA members including Hydro pursued a regulatory amendment to allow the use of bushings and instrument transformers with PCB concentrations of 500 mg/kg and greater until December 2025. In April 2014 the amended PCB Regulations were released in the Canada Gazette and the new regulations come into force on January 1, 2015. This allows Hydro to continue with its current plan to have oil circuit breaker bushings removed by 2025.

3.2.3 Industry Experience

Many utilities in North America are in a similar position as Hydro with infrastructure that is nearing the end of its serviceable life. Hydro has developed a plan to find the most economic and reliable solution to refurbish and replace these aging circuit breakers.

3.2.4 Vendor Recommendations

ABB, the OEM for the air blast circuit breakers, has indicated that a refurbishment of these types of circuit breaker will extend the service life for approximately 15 years. This will

allow air blast breakers to have an anticipated useful service life of at least 50 years. As result of this, Hydro originally planned to refurbish the remaining air blast circuit breakers and schedule their replacement 10 to 15 years after this refurbishment to obtain a service life of 50 years. However due to concerns with air blast circuit breakers in the last two years, Hydro plans to replace all air blast circuit breaker by 2020.

The majority of the vendors for 138 kV and 230 kV SF_6 circuit breakers suggest that 40 years is a suitable end of service life period provided a refurbishment is completed near the mid-life of the circuit breaker.

3.2.5 Maintenance or Support Arrangements

For air blast circuit breaker refurbishments, Hydro is using a common supplier for the procurement of all refurbishment parts associated with the DCF type and DCVF type air blast circuit breakers and Hydro operations is completing the refurbishment on these circuit breakers. In 2014 Hydro operations were also supported with assistance from ABB for the refurbishment work on DCF and DCVF type breakers.

With respect to SF_6 refurbishments, Hydro is using ABB to assist with the refurbishment of the ABB 230 kV ELF (air-operated type) SF_6 circuit breakers and Siemens Canada Ltd. to direct the work associated with the refurbishment of Siemens 230 kV 3AQ1 circuit breakers.

The plan is to also partner with the OEM, or a current manufacturer who has the intellectual property, on refurbishments associated with DLF air blast circuit breakers and other SF_6 circuit breakers at the 138 kV and 230 kV voltage levels.

Hydro also plans to commence a partnership agreement to engage a contractor for the supply and installation of circuit breaker replacements starting in 2015

3.2.6 Maintenance History

For air blast circuit breakers, Hydro has experienced problems with air leaks and valves sticking, resulting in increased maintenance costs and circuit breaker unavailability. Such problems have mainly been a result of deteriorating seals and O-rings. The problems experienced by Hydro are common in the utility industry and owners of these types of air blast circuit breakers have addressed the problems through similar upgrading programs.

The two main problems experienced with SF_6 circuit breakers have been leaking SF_6 gas and operating mechanisms that malfunction. The operating mechanism is a mechanical device that is spring charged and engages the circuit breaker's contacts. If an operating mechanism malfunctions, the operation of the circuit breaker is unavailable.
Some examples of SF_6 circuit breaker replacements due to maintenance conditions include:

- Breaker B3L50 at Bottom Brook was replaced in 2010 due to gas leaks that were reoccurring and could not be repaired;
- Breaker L51T2 at Howley was replaced in 2009 due to severe corrosion of the air receiver associated with the SF_6 circuit breaker that is air operated;
- Breakers B1T1 and B1L57 at St. Anthony were replaced in 2011 and 2012 due to gas leaks that were reoccurring and could not be repaired; and
- Breaker B1L22 at the Springdale Terminal Station was replaced in 2013 due to internal damage.

With OCBs, the main problems experienced have been high contact resistance and poor oil condition. Both of these factors are considered in prioritizing a circuit breaker for replacement.

The five-year maintenance history for all circuit breakers is shown in Table 2.

Table 2: Five-Year Circuit Breaker Maintenance History

Year	Preventive Maintenance ($000)	Corrective Maintenance ($000)	Total Maintenance ($000)
2013	81.5	344.4	425.9
2012	72.5	196.6	269.1
2011	61.8	160.3	222.1
2010	50.3	64.5	114.8
2009	15.0	46.0	61.0

3.2.7 Historical Information

Table 3 provides a recent history of the circuit breaker replacement and upgrade work.

Table 3: Historical Information

Year	Capital Budget ($000)	Actual Expenditures ($000)	Units	Cost per Unit ($000)	Comments
2013	2,785	2,421	16	151	Four replacements, purchased one breaker (not installed), installed platforms for six breakers, five overhauls, purchased materials for one overhaul
2012	1,677	1,288	10	129	Three replacements, purchased one breaker (not installed), three overhauls, purchased materials for three overhauls
2011	334	297	11	27	Five overhauls, purchased materials for six overhauls
2011	631	646	1	646	Replacement of one 230 kV breaker (Sunnyside)
2011	780	757	2	379	Replacement of two 69 kV breakers (St. Anthony)
2010	342	501	6	83.5	Four overhauls, replacement of one 138 kV breaker (Bottom Brook), replaced one phase of B1B11 in Holyrood
2009	422	364	22	17	Five overhauls, purchased materials for four overhauls, upgraded 13 breakers with pressure relief devices

3.2.8 Anticipated Useful Life

Hydro depreciates a circuit breaker over a 55 year period. For the replacement of SF_6 circuit breakers, 40 years will be the trigger point. Until the system events in January 2013 and 2014, air blast circuit breakers were typically replaced 10 to 15 years after refurbishment and after the circuit breaker had been in service for 50 years. However, the new accelerated plan, which focuses on maintaining reliability, will now replace some air blast breakers prior to the above criteria to eliminate the risk of air blast circuit breaker failures.

Hydro also has been legislated to meet PCB Regulation (SOR/2008-273) that has set target limits for equipment that contains PCBs. There is a high probability that PCBs are contained within oil circuit breaker bushings.

The failure and lack of availability for circuit breakers is anticipated if the plan to refurbish and replace this equipment is not continued.

3.3 Forecast Customer Growth

Customer load growth does not affect this project.

3.4 Development of Alternatives

The purpose of this project is to maintain a fleet of 66 kV, 138 kV and 230 kV circuit breakers that are reliable, cost effective, and are more environmental friendly. The three possible alternatives to achieve this goal are:

1. Replacement of all circuit breakers at the age of 40 years;
2. Refurbishment of failed circuit breakers as they occur; or
3. Replacement and refurbishment of circuit breakers in a planned strategic approach to balance financial and human resources while minimizing outages.

3.5 Evaluation of Alternatives

1. Replacement of all circuit breakers at the age of 40 years: This alternative would require approximately 60 circuit breakers to be replaced immediately which will result in significant cost and system outages that are not feasible. As a result this alternative will not be pursued.
2. Refurbish failed circuit breakers as they occur: This is a run-to-failure approach and this philosophy is not prudent to maintain system reliability. With a planned approach the refurbishment and replacement of circuit breakers can be scheduled at an appropriate period for completion. Hydro does not plan to pursue the run-to-failure alternative.
3. Replacement and refurbishment of circuit breakers in a planned strategic approach. This is the preferred alternative as it would balance the financial costs, human resources requirements and system outages.

In reviewing Alternative 3 further, the options to consider for air blast circuit breakers are refurbishment versus replacement. The refurbishment cost for a 230 kV air blast breaker is approximately one quarter the cost of its replacement (with the latter estimated at $770,000). An outage period for a refurbishment would be one week versus up to five weeks for a replacement. Prior to the power system issues experienced in January of 2013 and 2014, Hydro has seen acceptable reliability from air blast circuit breakers particularly those with a high frequency of operations, such as generating unit breakers. However, due to the problems experienced with air blast circuit breakers in the past two years, the alternative being pursued is to replace all air blast circuit breakers by 2020 and as a result overhauls will not continue beyond 2015.

In considering the options for the SF_6 breakers, it is noted that the refurbishment cost of a 230 kV SF_6 circuit breaker is one seventh the cost of replacement (and one third the cost of replacing a 138 kV circuit breaker). The system outage requirement for a refurbishment is typically one week versus a four to five week outage for a replacement. The refurbishment

entails the restoration of seals and wearing parts in the operating mechanism to achieve anticipated service life of 40 years.

The refurbishment of some types of circuit breakers does not meet any criterion that is cost effective, for instance, the cost to refurbish 66 kV SF_6 circuit breakers. Therefore, Hydro has not listed this circuit breaker for refurbishment in this proposal. Due to PCB regulations the oil circuit breaker at all voltage levels will be replaced versus being refurbished.

As a result, Hydro will pursue Alternative 3 using a two tiered approach involving both refurbishments and replacements. This approach will help minimize system outages and provide for a more balanced financial and human resource approach to circuit breaker upgrades.

4 CONCLUSION

Hydro plans to use a combination of refurbishments and replacements for air blast, SF_6 and oil circuit breakers. The plan will see all existing in-service air blast circuit breakers replaced by 2020, all existing in-service 138 kV and 230 kV SF_6 circuit breakers refurbished at mid-life and replaced at or near the 40 year lifecycle period and all oil circuit breakers being replaced by 2023.

For air blast circuit breakers, due to all replacements being planned to be completed by 2020, no refurbishments are scheduled beyond 2015. A listing of all planned refurbishments and replacements are outlined in Appendices D and E.

For SF_6 circuit breakers, there will be three to five refurbishments completed annually. The replacement of SF_6 circuit breakers is not scheduled to begin until 2019 unless a circuit breaker's condition warrants an earlier replacement.

The supply and installation for the replacements of the scheduled 2015 and 2016 circuit breakers is included in this proposal to facilitate the commencement of a partnership agreement to complete the supply and installation of circuit breakers.

For oil circuit breakers, there are three scheduled replacements annually that started in 2012 with the last OCB being planned for replacement in 2023.

This proposal is seeking approval for the next two years of this multi-year plan to refurbish and replace circuit breakers. Table 4 summarizes the budget for this work.

4.1 Budget Estimate

Table 4: Project Budget Estimate

Project Cost:*($ x1,000)*	**2015**	**2016**	**Beyond**	**Total**
Material Supply	1,577.5	1,222.5	0.0	2,800.0
Labour	1,638.8	1,557.1	0.0	3,195.9
Consultant	6.0	8.4	0.0	14.4
Contract Work	2,455.6	990.8	0.0	3,446.4
Other Direct Costs	148.0	169.7	0.0	317.7
Interest and Escalation	363.2	970.4	0.0	1,333.6
Contingency	0.0	1,954.9	0.0	1,954.9
TOTAL	**6,189.1**	**6,873.8**	**0.0**	**13,062.9**

4.2 Project Schedule

Table 5: Project Schedule

Activity		**Start Date**	**End Date**
Planning	Initial Planning	January 2015	March 2015
Design	Equipment Ordering Tendering	April 2015	June 2015
Procurement	Equipment Delivery	September 2015	November 2015
Construction 2015	Equipment Installations (Overhauls)	September 2015 (April 2015)	October 2015 (October 2015)
Commissioning 2015	Installations in service	November 2015	December 2015
Construction 2016	Equipment Installations	June 2016	October 2016
Commissioning 2016	Installations in service	August 2016	November 2016
Closeout	Project Completion/Close Out	December 2016	December 2016

APPENDIX A

Air Blast Circuit Breakers Refurbishment/Replacement Plan

Table A1 – Air Blast Circuit Breakers Refurbishment/ Replacement Plan

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
HRD TS	B2B11	Brown Boveri	Air Blast	DLF 245 nc2	1974	230	40	-	2014	40	Required Replacement by Sept 2016 for LCP. Moved from 2015 to 2014.
HRD TS	B1B11	Brown Boveri	Air Blast	DLF 245 nc2	1974	230	40	-	2014	40	Required Replacement by Sept 2016 for LCP.
HRD TS	B1L17	Brown Boveri	Air Blast	DLF 245 nc2	1973	230	41	2014	2014	41	Required Replacement by Sept 2016 for LCP. Bkr failed on Jan 5, 2014 and was o/h. Planned to be replaced in 2014 and O/H parts will be moved to B2L42.
SSD TS	B2T1	Brown Boveri	Air Blast	DCF 170 mc4	1969	138	45	-	2014	45	Changed from 2011 to 2012 to 2014. Cancelled O/H and will be replaced due to T1 Fire in 2014. Changed replacement from 2015 to 2014.
SSD TS	B1L03	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2002	2014	48	Change replacement from 2015 to 2014.
HWD TS	B1L01	Brown Boveri	Air Blast	DLF 245 nc2	1972	230	42	NA	2015	43	Replace to eliminate Air System. Purchase in 2013 and install in 2014. Changed From 2014 to 2015 to swap with SSD B1L03.
BDE TS1	B1T2	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	1999	2015	49	Changed from 2015 to 2014 - moved to 2105 due to delivery schedule.
BDE TS1	B2T4	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2000	2015	47	Changed from 2016 to 2014 - moved to 2015 due to delivery schedule.
OPD TS	B1L18	Brown Boveri	Air Blast	DCVF 245 mc6	1969	230	45	2008	2015	46	Changed in 2014 to coordinate with transformer Upgrade/Tie Breaker Design - will be installed in 2015.
HRD TS	B2L42	Brown Boveri	Air Blast	DLF 245 nc2	1973	230	41	2014	2015	42	Required Replacement by Sept 2016 for LCP. Change replacement from 2014 to 2015 due to unit outage schedule. Will place o/h parts from B1L17 on B2L42 for 2014/2015 winter.
BDE TS1	B2T3	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2000	2015	49	Moved to 2016 due to surge tank work for Units 3 and 4 in 2016. Moved from 2016 to 2015 due to AMEC Review.
HRD TS	B3L18	Brown Boveri	Air Blast	DLF 245 nc2	1978	230	36	-	2015	37	Required Replacement by Sept 2016 for LCP - moved to 2015 from 2016 to advance unit breaker replacement.
HRD TS	B3B13	Brown Boveri	Air Blast	DLF 245 nc2	1978	230	36	-	2015	37	Required Replacement by Sept 2016 for LCP. Moved from 2016 to 2015 to complete Unit 3 bkrs.
SSD TS	B1L02	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2003	2015	49	Moved from 2016 to 2015 due to AMEC Review.
OPD TS	B1L36	Brown Boveri	Air Blast	DCVF 245 mc6	1969	230	45	2008	2015	46	Moved from 2016 to 2015 to replace BDE B2T3 in plan.
BDE TS1	B1B2	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2004	2015	49	Moved from 2017 to 2015 due to AMEC Review.
SSD TS	L06L07	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2014	2015	47	Moved O/H From 2013 to 2014. Changed replacement from 2015 to 2019. Move replacement from 2019 to 2015 due to AMEC Review.

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
BDE TS1	B3T6	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2001	2016	50	Changed from 2014 to 2015. Moved from 2015 to 2016 due to AMEC Review.
BDE TS1	B3T5	Brown Boveri	Air Blast	DCVF 245 mc6	1969	230	45	2000	2016	47	Moved to 2015 from 2017. Moved to 2016 due to AMEC Review.
HRD TS	B12L42	Brown Boveri	Air Blast	DLF 245 nc2	1978	230	36	-	2016	38	Required Replacement by Sept 2016 for LCP. Moved from 2014 to 2015. Moved from 2015 to 2016 to complete unit breakers on Unit 3.
HRD TS	B12L17	Brown Boveri	Air Blast	DLF 245 nc2	1973	230	41	-	2016	43	Required Replacement by Sept 2016 for LCP - moved to 2016 from 2015 to advance B3L18.
BDE TS1	B1T1	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2002	2016	50	Changed from 2014 to 2016.
SSD TS	L02L07	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2002	2016	50	
BDE TS1	B4B5	Brown Boveri	Air Blast	DCVF 245 mc6	1964	230	50	2003	2016	52	Required Replacement by Sept 2016 for LCP.
BBK TS	B1L11	Brown Boveri	Air Blast	DLF 245 nc2	1971	230	43	-	2016	45	Planned Replacement by Emera for NL/NS Link.
BBK TS	B1L09	Brown Boveri	Air Blast	DLF 245 nc2	1971	230	43	-	2016	45	Planned Replacement by Emera for NL/NS Link.
BBK TS	L09L33	Brown Boveri	Air Blast	DLF 245 nc2	1973	230	41	-	2016	43	Planned Replacement by Emera for NL/NS Link.
BBK TS	L11L33	Brown Boveri	Air Blast	DLF 245 nc2	1978	230	36	-	2016	38	Planned Replacement by Emera for NL/NS Link.
HRD TS	B12B15	Brown Boveri	Air Blast	DLF 245 nc2	1978	230	36	-	2016	38	Required Replacement by Sept 2016 for LCP.
MDR TS	B5L11	Brown Boveri	Air Blast	DCVF 245 mc6	1967	230	47	2006	2017	50	
BDE TS1	B6B10	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2005	2017	49	Changed replacement from 2018 to 2017.
BDE TS1	B2B3	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2006	2017	49	Changed replacement from 2018 to 2017.
MDR TS	B1L28	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2007	2017	51	Changed replacement from 2019 to 2017.
BDE TS1	B3B4	Brown Boveri	Air Blast	DCVF 245 mc6	1972	230	42	2005	2017	45	Changed replacement from 2025 to 2017.
WAV TS	B1L37	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2005	2018	50	Changed replacement from 2018 to 2017. Moved from 2017 to 2018 due to AMEC Review.
BDE TS1	B5B6	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2007	2018	50	Changed replacement from 2020 to 2017. Moved from 2017 to 2018 due to AMEC Review.
WAV TS	B1L17	Brown Boveri	Air Blast	DCVF 245 mc6	1969	230	45	2009	2018	49	Changed replacement from 2022 to 2017. Moved from 2017 to 2018 due to AMEC Review.
STB TS	B2L04	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2011	2018	52	Changed replacement from 2020 to 2018.
STB TS	L05L31	Brown Boveri	Air Blast	DCF 245 mc6	1969	230	45	2008	2018	49	Changed replacement from 2021 to 2018.
SSD TS	B3T4	Brown Boveri	Air Blast	DCF 170 mc4	1966	138	48	2012	2018	52	Changed replacement from 2022 to 2018.

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
STB TS	B3L130	Brown Boveri	Air Blast	DCF 170 mc4	1968	138	46	2012	2018	50	Changed replacement from 2022 to 2018.
STB TS	B3T2	Brown Boveri	Air Blast	DCF 170 mc4	1969	138	45	2012	2018	49	Changed replacement from 2023 to 2018.
BDE TS1	B1B10	Brown Boveri	Air Blast	DCVF 245 mc6	1975	230	39	2014	2018	43	Move from 2015 to 2016. Cancelled O/H in 2016 and advanced replacement to 2018.
SSD TS	B2L12	Brown Boveri	Air Blast	DCF 170 mc4	1966	138	48	2014	2018	52	Changed from 2013 to 2014. Changed replacement from 2023 to 2020. Moved from 2020 to 2018 after AMEC Review.
SSD TS	L19L100	Brown Boveri	Air Blast	DCF 170 mc4	1966	138	48	2014	2018	52	Changed from 2013 to 2014. Changed replacement from 2023 to 2020. Moved from 2020 to 2018 after AMEC Review.
WAV TS	B1L08	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2010	2019	51	Changed replacement from 2020 to 2018. Move from 2018 to 2019 after AMEC Review.
STB TS	B1L31	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2008	2019	53	
STB TS	L05L35	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2009	2019	53	
STB TS	B1L32	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2009	2019	51	Changed replacement from 2021 to 2019.
WAV TS	L03L17	Brown Boveri	Air Blast	DCVF 245 mc6	1969	230	45	2009	2019	50	Changed replacement from 2022 to 2019.
SSD TS	L109T4	Brown Boveri	Air Blast	DCF 170 mc4	1968	138	46	2015	2019	51	Changed From 2014 to 2015. Changed replacement from 2023 to 2019.
STB TS	B1L35	Brown Boveri	Air Blast	DCF 245 mc6	1966	230	48	2010	2019	53	Moved from 2020 to 2019 after AMEC Review.
SSD TS	L100L109	Brown Boveri	Air Blast	DCF 170 mc4	1968	138	46	2014	2019	51	Changed From 2014 to 2015. Changed replacement from 2024 to 2020. Changed O/H from 2015 to 2014 due to condition. Moved from 2020 to 2019 after AMEC Review.
BUC TS	L05L33	Brown Boveri	Air Blast	DLF 245 nc2	1973	230	41	2013	2019	46	Moved to 2013 due to Jan 11 events and breaker failure. Changed replacement from 2025 to 2021.Moved from 2021 to 2019 after AMEC Review.
BUC TS	B1L05	Brown Boveri	Air Blast	DLF 245 nc2	1973	230	41	2014	2019	46	Changed replacement from 2027 to 2021. Moved from 2021 to 2019 after AMEC Review.
WAV TS	L01L03	Brown Boveri	Air Blast	DCVF 245 mc6	1969	230	45	2014	2020	51	Moved O/H From 2013 to 2014. Change to replacement to 2019 from 2024 to advance replacements. Moved from 2019 to 2020 after AMEC Review.
STB TS	B3L133	Brown Boveri	Air Blast	DCF 170 mc4	1969	138	45	2015	2020	51	Changed From 2014 to 2015. Changed replacement from 2024 to 2020.
STB TS	B3T1	Brown Boveri	Air Blast	DCF 170 mc4	1969	138	45	2015	2020	51	Move from 2015 to 2016. Advanced O/H to 2015 and changed replacement from 2025 to 2020.
STB TS	B3L22	Brown Boveri	Air Blast	DCF 170 mc4	1967	138	47	2014	2020	53	Changed from 2013 to 2014. Moved from 2021 to 2020 after AMEC Review.

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
BUC TS	L28L32	Brown Boveri	Air Blast	DLF 245 nc2	1972	230	42	2014	2020	48	O/H moved from 2013 to 2014. Changed replacement from 2026 to 2021. Moved from 2021 to 2020.
BUC TS	B1L28	Brown Boveri	Air Blast	DLF 245 nc2	1975	230	39	2014	2020	45	Changed from 2016 to 2014. Changed replacement from 2028 to 2021. Moved from 2021 to 2020.
WAV TS	B1B3	Brown Boveri	Air Blast	DLF 245 nc4	1977	230	37	2015	2020	43	Changed to 2014 from 2017. Changed replacement from 2031 to 2021. Overhaul moved to 2015. Moved from 2021 to 2020 due to AMEC Review.
STB TS	B3L10	Brown Boveri	Air Blast	DLF 145 nc2	1977	138	37	2015	2020	43	Changed to from 2017 to 2015. Changed replacement from 2031 to 2021. Moved from 2021 to 2020 after AMEC Review.

APPENDIX B

SF_6 Circuit Breaker Refurbishment/Replacement Plan

Table B1 – SF_6 Circuit Breakers Refurbishment/ Replacement Plan

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
BDE TS2	B9L34	Brown Boveri	SF6	ELF 245 n2s	1981	230	33	2004	2020	39	
HWD TS	B2L42	Brown Boveri	SF6	ELF 245 n2s	1981	230	33	2005	2020	39	
WAV TS	L01L37	Siemens	SF6	3AQ1	1990	230	24	2005	2030	40	
BUCTS	L32L33	Brown Boveri	SF6	ELF 245 n2s	1980	230	34	2006	2020	40	
HRD TS	B12L18	Brown Boveri	SF6	ELF 245 n2s	1981	230	33	2006	2021	40	
USLTS	L34T1	Brown Boveri	SF6	ELF 245 nc2s	1981	230	33	2006	2021	40	
HRD TS	B12T10	Siemens	SF6	3AQ1	1990	230	24	2006	2031	41	
HRD TS	B13B15	Brown Boveri	SF6	ELF 245 n2s	1981	230	33	2007	2021	40	
BDE TS2	B11L06	Siemens	SF6	3AQ1	1990	230	24	2007	2030	40	
BDE TS2	B10B11	Siemens	SF6	3AQ1	1990	230	24	2009	2030	40	
CAT TS	L47T1	Mitsubishi Electric Corp.	SF6	200-SFMT-40A	1984	230	30	2010	2024	40	
CAT TS	L47T2	Mitsubishi Electric Corp.	SF6	200-SFMT-40A	1984	230	30	2010	2024	40	
STB TS	L04L32	Siemens	SF6	3AQ1	1990	230	24	2011	2031	41	
HWD TS	B1B2	Sprecher Energie	SF6	BHG 114	1993	230	21	2011	2034	41	
BDE TS2	B9B10	Siemens	SF6	3AQ1	1990	230	24	2011	2030	40	
BDE TS2	L06L34	Siemens	SF6	3AQ1	1990	230	24	2011	2031	41	
DLK TS	B1L39	Brown Boveri	SF6	ELF 145 nls	1980	138	34	2013	2021	41	Parts purchased in 2011, ABB could not install.
DLK TS	B1L45	Brown Boveri	SF6	ELF 145 nls	1980	138	34	2013	2022	42	Parts purchased in 2012, ABB could not install.
HLY TS	B1L24	Brown Boveri	SF6	ELF 145 nls	1980	138	34	2013	2022	42	Parts purchased in 2012, ABB could not install.
HLY TS	B1L43	Brown Boveri	SF6	ELF 145 nls	1980	138	34	2013	2022	42	Parts purchased in 2012, ABB could not install.
HLY TS	B1L45	Brown Boveri	SF6	ELF 145 nls	1980	138	34	2014	2023	43	Moved back to 2014 from 2013.
MDR TS	B1L48	Sprecher & Schuh	SF6	HGF 114/1A	1983	230	31	2014	2024	41	
DLK TS	L39T2	Sprecher & Schuh	SF6	HGF 112/1C	1983	138	31	2015	2023	40	Moved From 2013 to 2014. Moved from 2014 to 2015.
DLK TS	B3L47	Sprecher & Schuh	SF6	HGF 114/1A	1983	230	31	2015	2024	41	Moved from 2014 to 2015.
IRV TS	B1L363	Brown Boveri	SF6	ELF 145 nls	1980	138	34	2015	2023	43	Moved overhaul from 2013 to 2014. and then to 2015.

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
DLK TS	L45T2	Sprecher & Schuh	SF6	HGF 112/1C	1983	138	31	2015	2024	41	Moved from 2014 to 2015.
DLK TS	B3L48	Sprecher & Schuh	SF6	HGF 114/1A	1983	230	31	2015	2025	42	
SVL TS	B1L09	S & C Electric	Circuit Switcher	Mark III	1983	230	31	2015	2025	42	
WAV TS	B1T1	S & C Electric	Circuit Switcher	Mark III	1983	230	31	2015	2025	42	
HLY TS	B1T2	Siemens	SF6	3 AR 1	1982	138	32	2016	2025	43	Move from 2015 to 2016.
IRV TS	B1L24	ASEA	SF6	HPL145/20C1	1992	138	22	2016	2032	40	
IRV TS	B1L23	ASEA	SF6	HPL145/20C1	1992	138	22	2016	2032	40	
WAV TS	B1T2	S & C Electric	Circuit Switcher	Mark III	1983	230	31	2016	2026	43	
BBK TS	L14L50	S & C	Circuit Switcher	Model 2030	1989	138	25	2016	2029	40	
BHL TS	B1L59	ASEA Brown Boveri Inc.	SF6	HPL 145/20Cl	1990	138	24	2017	2029	39	
SSD TS	B3L19	Asea Brown Boveri	SF6	HPL 145/20C1	1990	138	24	2017	2029	39	
BCV TS	B1L56	AEG	SF6	DT145-F1	1995	138	19	2017	2035	40	Move from 2017 to 2018.
BWT TS	L60T1	S & C	Circuit Switcher	Model 2030	1989	138	25	2017	2029	40	
BCV TS	B1R1	AEG	SF6	DT145-F1	1995	138	19	2018	2035	40	
PBN TS	B1L41	AEG	SF6	DT145-F1	1995	138	19	2018	2035	40	Change from 2019 to 2018.
PPT TS	B1L41	AEG	SF6	DT145-F1	1995	138	19	2018	2035	40	Change from 2019 to 2018.
PPT TS	L41R1	AEG	SF6	DT145-F1	1995	138	19	2018	2035	40	Change from 2020 to 2019. Changed O/H from 2019 to 2018.
PPT TS	L41R2	AEG	SF6	DT145-F1	1995	138	19	2018	2035	40	Change from 2020 to 2019. Changed O/H from 2019 to 2018.
PPT TS	B1L44	AEG	SF6	DT145-F1	1995	138	19	2019	2036	41	
CBC TS	B1B2	GEC Alsthom	SF6	HGF 114/1A	1997	230	17	2019	2037	40	Change from 2021 to 2019.
USL TS	L34L63	Alstom	SF6	HGF 1014IPO	2002	230	12	2022	2042	40	
SOK TS	L22T1	Siemens	SF6	CPV2-145-25-1	2003	138	11	2023	2043	40	
SPL TS	B1L22	Hyosung	SF6	HCSP-144B	2010	138	4	2030	2050	40	Replaced a 138 kV KSO in 2013 due to bkr failure as a result of Jan 11, 2013 events. Breaker taken from inventory.
CBCTS	B1C1	Areva T&D Inc.	SF6	DT1-245 F3	2010	230	4	2030	2050	40	
CBCTS	B1C2	Areva T&D Inc.	SF6	DT1-245 F3	2010	230	4	2030	2050	40	
CBCTS	B2C3	Areva T&D Inc.	SF6	DT1-245 F3	2010	230	4	2030	2050	40	
CBCTS	B2C4	Areva T&D Inc.	SF6	DT1-245 F3	2010	230	4	2030	2050	40	
BBKTS	B3L50	Areva	SF6	DT1-145-FK	2010	138	4	2030	2050	40	

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
VBNTS	B1T1	Areva T&D Inc.	SF6	DT1-245 F3	2011	230	3	2031	2051	40	
VBNTS	B1T2	Areva T&D Inc.	SF6	DT1-245 F3	2011	230	3	2031	2051	40	
SSD TS	L03L06	Areva T&D Inc.	SF6	DT1-245 F3	2012	230	2	2032	2052	40	Replaced in 2012.
BBK TS	B2L14	Areva T&D Inc.	SF6	DT1-145	2012	138	2	2032	2052	40	Replaced in 2012.
MFATS3	B1T1	Alsthom	SF6	DT1- 145	2012	138	2	2032	2052	40	Added new in 2013 for construction power.
MFATS3	B1L1302	Alsthom	SF6	DT1- 145	2012	138	2	2032	2052	40	Added new in 2013 for construction power.
HWD TS	B1L36	Areva T&D Inc.	SF6	DT1-245 F3	2013	230	1	2033	2053	40	Replaced a 230 kV DLF in 2013.
BDE TS2	B13L20	Alsthom	SF6	DT1- 72.5	2013	66	1	2033	2053	40	Replaced a 66 kV FKP OCB in 2013.
HRD TS	B7L38	Alsthom	SF6	DT1- 72.5	2013	66	1	2033	2053	40	Replaced a 66 kV KSO OCB in 2013.
OPD TS	B5C1	Brown Boveri	SF6	ELF 72.5 n1rsv	1979	69	35	NA	2019	40	
DLKTS	B2L25	Westinghouse	SF6	690SP2500	1982	69	32	NA	2022	40	
STA TS	B1L61	Westinghouse	SF6	690SP2500	1983	69	31	NA	2023	40	
RWC TS	B1L57	Siemens	SF6	SP 72.5-23	1988	69	26	NA	2028	40	
HWD TS	B8B9	Siemens	SF6	SP 72.5-23-3	1992	69	22	NA	2032	40	
DLK TS	B2L26	Siemens	SF6	SPS-72.5-23-1	1996	66	18	NA	2036	40	
HRD TS	B7T5	AEG	SF6	DT1-72F1	1996	69	18	NA	2037	41	
HRD TS	B6T10	AEG	SF6	DT1-72F1	1996	69	18	NA	2037	41	
STA TS	B1C1	AEG	SF6	DT1-72F1	1996	69	18	NA	2037	41	
STA TS	B1C2	AEG	SF6	DT1-72F1	1996	69	18	NA	2037	41	
BUC TS	B2T1	GEC Alsthom	SF6	DT1-72.5 F1	1997	69	17	NA	2038	41	
BUC TS	B2L80	GEC Alsthom Canada	SF6	DT1-72F1	1997	69	17	NA	2038	41	
MDR TS	B4T1	GEC Alsthom/ Cogenel AEG	SF6	DT1 72.5 F1	1997	69	17	NA	2038	41	
STA TS	B1C3	AEG	SF6	DT1-72F1	1996	69	18	NA	2038	42	
PBN TS	B2T1	GEC Alsthom Canada	SF6	DT1-72F1	1997	69	17	NA	2039	42	
PBN TS	B2L21	GEC Alsthom	SF6	DT1-72.5 F1	1998	69	16	NA	2039	41	
RBK TS	L53T1	GEC-Alstom	SF6	DT1-72.5-1M	1998	69	16	NA	2039	41	
HWD TS	B8C2	Siemens	SF6	FA220	1999	69	15	NA	2040	41	
HWD TS	B8T4	Siemens	SF6	SPS2	1999	69	15	NA	2040	41	
OPD TS	B2C2	Siemens	SF6	FA220	1999	69	15	NA	2040	41	

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
OPD TS	B2T1	Alstom AEG	SF6	DT1-72.5 F1	2000	69	14	NA	2040	40	
CBF TS	252T	Alstom	SF6	DT1-72F1	2001	69	13	NA	2041	40	
PBN TS	B2L62	Alstom AEG	SF6	DT1-72.5 F1	2000	69	14	NA	2041	41	
HWD TS	B7T2	Alstrom	SF6	DT1-72.5 F1	2004	69	10	NA	2044	40	
HWD TS	B7C1	Areva	SF6	DT1-72.5 F1	2007	69	7	NA	2047	40	
HLY TS	L51T2	Areva	SF6	DT1-72.5 F1 FK	2009	69	5	NA	2049	40	
STA TS	B1T1	Alsthom	SF6	DT1-72.5 F1	2011	69	3	NA	2051	40	
HBY TS	B1L21	Alsthom	SF6	DT1-72.5 F1	2011	66	3	NA	2051	40	
DLS TS	B1L15	Areva T&D Inc.	SF6	DT1-72.5	2012	69	2	NA	2052	40	Replaced in 2012.
MDR TS	B2T2	Areva T&D Inc.	SF6	DT1-72.5	2012	69	2	NA	2052	40	Replaced in 2012.
STA TS	B1L57	Areva T&D Inc.	SF6	DT1-72.5	2012	69	2	NA	2052	40	Replaced in 2012.
BUC TS	B2L64	Areva T&D Inc.	SF6	DT-72.5 F1	2005	69	9	NA	2045	40	

APPENDIX C

Oil Circuit Breaker Replacement Plan

Table C1 – Oil Circuit Breakers Refurbishment/ Replacement Plan

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
CHD TS	B1L27	CGE	Oil	KSO-69-1500	1970	66	44	NA	2014	44	Leaking bushings. Moved from 2015 to 2013. Moved from 2013 to 2014 to late delivery of breaker.
SPL TS	B1L23	CGE	Oil	KSO-138-1500	1967	138	47	NA	2015	48	Being purchased in 2014 and installed in 2015.
BHL TS	L27T1	CGE	Oil	KSO-69-1500	1967	66	47	NA	2015	48	Being purchased in 2014 and installed in 2015.
CBF TS	152T	CGE	Oil	KSO-69-1500	1966	66	48	NA	2015	49	High Contact Resistance- Moved from 2013 to 2015. Move from 2015 to 2014 in exchange for L400T2. Ordered in 2014 and will be installed in 2015.
BBK TS	L400T2	CGE	Oil	KSO-69-1500	1967	66	47	NA	2015	48	High Contact Resistance. Moved from 2014 to 2015 in exchange for CBFCS 152T.
WAV TS	B2T1	CGE	Oil	KSO-69-1500	1967	66	47	NA	2015	48	Changed from 2014 to 2013 with BBK L400T2, changed from 2013 to 2015 with SPL B1L22.
BHL TS	L26L27	CGE	Oil	KSO	1968	66	46	NA	2015	47	
DHR TS	B1L27	CGE	Oil	KSO-69-1500	1970	66	44	NA	2016	46	
HWD TS	B7B8	CGE	Oil	FKP	1971	66	43	NA	2016	45	Required Replacement by Sept 2016 for LCP.
HWD TS	B7T1	CGE	Oil	FKP	1972	66	42	NA	2016	44	Required Replacement by Sept 2016 for LCP.
HWD TS	B7T5	CGE	Oil	FKP	1976	66	38	NA	2016	40	Required Replacement by Sept 2016 for LCP.
HVY TS	13-1	CGE	Oil	KSO-138-2500	1976	138	38	NA	2017	41	
HRD TS	B7L2	CGE	Oil	KSO-69-1500	1969	66	45	NA	2017	48	
WAV TS	B2T2	CGE	Oil	FKP	1973	66	41	NA	2017	44	
WAV TS	B4L64	CGE	Oil	KSO	1977	138	37	NA	2018	41	
SVL TS	B2L405	CGE	Oil	FKP	1975	66	39	NA	2018	43	
SVL TS	L405T4	CGE	Oil	FKP	1975	66	39	NA	2018	43	
HRD TS	B8L39	CGE	Oil	KSO-138-5000	1978	138	36	NA	2019	41	
BDE TS2	B13T11	CGE	Oil	FKP	1976	66	38	NA	2019	43	
MDR TS	B3T3	CGE	Oil	FKP	1975	66	39	NA	2019	44	
SVL TS	B2T3	CGE	Oil	FKP	1975	66	39	NA	2020	45	
WDL TS	B1L29	CGE	Oil	FKP	1976	66	38	NA	2020	44	

DLK TS	B2T1	CGE	Oil	FKP	1980	66	34	NA	2021	41	
OPD TS	B5T3	CGE	Oil	FKP	1977	66	37	NA	2021	44	
OPD TS	B2B5	CGE	Oil	FKP	1977	66	37	NA	2021	44	
HWD TS	B8T3	ASEA	Min. Oil	HLC 72.5/2000	1986	66	28	NA	2022	36	
HRD TS	B6L3	CGE	Oil	FKP	1978	66	36	NA	2022	44	
OPD TS	B2T2	ASEA	Min. Oil	HLC 72.5/2000	1986	66	28	NA	2023	37	

APPENDIX D

Summary Refurbishment Plan by Year

Table D1 – All Types of Circuit Breakers Refurbishment/ Replacement Plan

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
BDE TS1	B1T2	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	1999	2015	49	Changed from 2015 to 2014 - moved to 2105 due to delivery schedule.
BDE TS1	B2T4	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2000	2015	47	Changed from 2016 to 2014 - moved to 2015 due to delivery schedule.
BDE TS1	B2T3	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2000	2015	49	Moved to 2016 due surge tank work for units 3 and 4 in 2016. Moved from 2016 to 2015 due to AMEC Review.
BDE TS1	B3T5	Brown Boveri	Air Blast	DCVF 245 mc6	1969	230	45	2000	2016	47	Moved to 2015 from 2017. Moved to 2016 due to AMEC Review.
BDE TS1	B3T6	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2001	2016	50	Changed from 2014 to 2015. Moved from 2015 to 2016 due to AMEC Review.
SSD TS	B1L03	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2002	2014	48	Change replacement from 2015 to 2014.
BDE TS1	B1T1	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2002	2016	50	Changed from 2014 to 2016.
SSD TS	L02L07	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2002	2016	50	
BDE TS1	B4B5	Brown Boveri	Air Blast	DCVF 245 mc6	1964	230	50	2003	2016	52	Required Replacement by Sept 2016 for LCP.
SSD TS	B1L02	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2003	2015	49	Moved from 2016 to 2015 due to AMEC Review.
BDE TS1	B1B2	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2004	2015	49	Moved from 2017 to 2015 due to AMEC Review.
BDE TS2	B9L34	Brown Boveri	SF6	ELF 245 n2s	1981	230	33	2004	2020	39	
BDE TS1	B6B10	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2005	2017	49	Changed replacement from 2018 to 2017.
WAV TS	B1L37	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2005	2018	50	Changed replacement from 2018 to 2017. Moved from 2017 to 2018 due to AMEC Review.
BDE TS1	B3B4	Brown Boveri	Air Blast	DCVF 245 mc6	1972	230	42	2005	2017	45	Changed replacement from 2025 to 2017.
HWD TS	B2L42	Brown Boveri	SF6	ELF 245 n2s	1981	230	33	2005	2020	39	
WAV TS	L01L37	Siemens	SF6	3AQ1	1990	230	24	2005	2030	40	
MDR TS	B5L11	Brown Boveri	Air Blast	DCVF 245 mc6	1967	230	47	2006	2017	50	
BDE TS1	B2B3	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2006	2017	49	Changed replacement from 2018 to 2017.
BUCTS	L32L33	Brown Boveri	SF6	ELF 245 n2s	1980	230	34	2006	2020	40	
HRD TS	B12L18	Brown Boveri	SF6	ELF 245 n2s	1981	230	33	2006	2021	40	
USLTS	L34T1	Brown Boveri	SF6	ELF 245 nc2s	1981	230	33	2006	2021	40	
HRD TS	B12T10	Siemens	SF6	3AQ1	1990	230	24	2006	2031	41	
MDR TS	B1L28	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2007	2017	51	Changed replacement from 2019 to 2017.

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
BDE TS1	B5B6	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2007	2018	50	Changed replacement from 2020 to 2017. Moved from 2017 to 2018 due to AMEC Review.
HRD TS	B13B15	Brown Boveri	SF6	ELF 245 n2s	1981	230	33	2007	2021	40	
BDE TS2	B11L06	Siemens	SF6	3AQ1	1990	230	24	2007	2030	40	
OPD TS	B1L18	Brown Boveri	Air Blast	DCVF 245 mc6	1969	230	45	2008	2015	46	Changed in 2014 to coordinate with transformer Upgrade/Tie Breaker Design - will be installed in 2014, placed in service in 2015.
OPD TS	B1L36	Brown Boveri	Air Blast	DCVF 245 mc6	1969	230	45	2008	2015	46	Moved from 2016 to 2015 to replace BDE B2T3 in plan.
STB TS	B1L31	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2008	2019	53	
STB TS	L05L31	Brown Boveri	Air Blast	DCF 245 mc6	1969	230	45	2008	2018	49	Changed replacement from 2021 to 2018.
STB TS	L05L35	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2009	2019	53	
STB TS	B1L32	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2009	2019	51	Changed replacement from 2021 to 2019.
WAV TS	L03L17	Brown Boveri	Air Blast	DCVF 245 mc6	1969	230	45	2009	2019	50	Changed replacement from 2022 to 2019.
WAV TS	B1L17	Brown Boveri	Air Blast	DCVF 245 mc6	1969	230	45	2009	2018	49	Changed replacement from 2022 to 2017. Moved from 2017 to 2018 due to AMEC Review.
BDE TS2	B10B11	Siemens	SF6	3AQ1	1990	230	24	2009	2030	40	
STB TS	B1L35	Brown Boveri	Air Blast	DCF 245 mc6	1966	230	48	2010	2019	53	Moved from 2020 to 2019 after AMEC Review.
WAV TS	B1L08	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2010	2019	51	Changed replacement from 2020 to 2018. Move from 2018 to 2019 after AMEC Review.
CAT TS	L47T1	Mitsubishi Electric Corp.	SF6	200-SFMT-40A	1984	230	30	2010	2024	40	
CAT TS	L47T2	Mitsubishi Electric Corp.	SF6	200-SFMT-40A	1984	230	30	2010	2024	40	
STB TS	B2L04	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2011	2018	52	Changed replacement from 2020 to 2018.
STB TS	L04L32	Siemens	SF6	3AQ1	1990	230	24	2011	2031	41	
HWD TS	B1B2	Sprecher Energie	SF6	BHG 114	1993	230	21	2011	2034	41	
BDE TS2	B9B10	Siemens	SF6	3AQ1	1990	230	24	2011	2030	40	
BDE TS2	L06L34	Siemens	SF6	3AQ1	1990	230	24	2011	2031	41	
SSD TS	B3T4	Brown Boveri	Air Blast	DCF 170 mc4	1966	138	48	2012	2018	52	Changed replacement from 2022 to 2018.
STB TS	B3L130	Brown Boveri	Air Blast	DCF 170 mc4	1968	138	46	2012	2018	50	Changed replacement from 2022 to 2018.
STB TS	B3T2	Brown Boveri	Air Blast	DCF 170 mc4	1969	138	45	2012	2018	49	Changed replacement from 2023 to 2018.
BUC TS	L05L33	Brown Boveri	Air Blast	DLF 245 nc2	1973	230	41	2013	2019	46	Moved to 2013 due to Jan 11 events and breaker failure. Changed replacement from 2025 to 2021.Moved from 2021 to 2019 after AMEC Review.

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
DLK TS	B1L39	Brown Boveri	SF6	ELF 145 nls	1980	138	34	2013	2021	41	Parts purchased in 2011, ABB could not install.
DLK TS	B1L45	Brown Boveri	SF6	ELF 145 nls	1980	138	34	2013	2022	42	Parts purchased in 2012, ABB could not install.
HLY TS	B1L24	Brown Boveri	SF6	ELF 145 nls	1980	138	34	2013	2022	42	Parts purchased in 2012, ABB could not install.
HLY TS	B1L43	Brown Boveri	SF6	ELF 145 nls	1980	138	34	2013	2022	42	Parts purchased in 2012, ABB could not install.
SSD TS	L06L07	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2014	2015	47	Moved O/H From 2013 to 2014. Changed replacement from 2015 to 2019. Move replacement from 2019 to 2015 due to AMEC Review.
WAV TS	L01L03	Brown Boveri	Air Blast	DCVF 245 mc6	1969	230	45	2014	2020	51	Moved O/H From 2013 to 2014. Change replacement to 2019 from 2024 to advance replacements. Moved from 2019 to 2020 after AMEC Review.
BUC TS	L28L32	Brown Boveri	Air Blast	DLF 245 nc2	1972	230	42	2014	2020	48	O/H moved from 2013 to 2014. Changed replacement from 2026 to 2021. Moved from 2021 to 2020.
BUC TS	B1L05	Brown Boveri	Air Blast	DLF 245 nc2	1973	230	41	2014	2019	46	Changed replacement from 2027 to 2021. Moved from 2021 to 2019 after AMEC Review.
BUC TS	B1L28	Brown Boveri	Air Blast	DLF 245 nc2	1975	230	39	2014	2020	45	Changed from 2016 to 2014. Changed replacement from 2028 to 2021. Moved from 2021 to 2020.
HRD TS	B1L17	Brown Boveri	Air Blast	DLF 245 nc2	1973	230	41	2014	2014	41	Required Replacement by Sept 2016 for LCP. Bkr failed on Jan 5, 2014 and was o/h. Planned to be replaced in 2014 and O/H parts will be moved to B2L42.
BDE TS1	B1B10	Brown Boveri	Air Blast	DCVF 245 mc6	1975	230	39	2014	2018	43	Move from 2015 to 2016. Cancelled O/H in 2016 and advanced replacement to 2018.
HRD TS	B2L42	Brown Boveri	Air Blast	DLF 245 nc2	1973	230	41	2014	2015	42	Required Replacement by Sept 2016 for LCP. Change replacement from 2014 to 2015 due to unit outage schedule. Will place o/h p[arts from B1L17 on B2L42 for 2014/2015 winter.
STB TS	B3L22	Brown Boveri	Air Blast	DCF 170 mc4	1967	138	47	2014	2020	53	Changed from 2013 to 2014. Moved from 2021 to 2020 after AMEC Review.
SSD TS	B2L12	Brown Boveri	Air Blast	DCF 170 mc4	1966	138	48	2014	2018	52	Changed from 2013 to 2014. Changed replacement from 2023 to 2020. Moved from 2020 to 2018 after AMEC Review
SSD TS	L19L100	Brown Boveri	Air Blast	DCF 170 mc4	1966	138	48	2014	2018	52	Changed from 2013 to 2014. Changed replacement from 2023 to 2020. Moved from 2020 to 2018 after AMEC Review.
SSD TS	L100L109	Brown Boveri	Air Blast	DCF 170 mc4	1968	138	46	2014	2019	51	Changed From 2014 to 2015. Changed replacement from 2024 to 2020. Changed O/H from 2015 to 2014 due to condition. Moved from 2020 to 2019 after AMEC Review.

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
MDR TS	B1L48	Sprecher & Schuh	SF6	HGF 114/1A	1983	230	31	2014	2024	41	
HLY TS	B1L45	Brown Boveri	SF6	ELF 145 nls	1980	138	34	2014	2023	43	Moved back to 2014 from 2013.
WAV TS	B1B3	Brown Boveri	Air Blast	DLF 245 nc4	1977	230	37	2015	2020	43	Changed to 2014 from 2017. Changed replacement from 2031 to 2021. Overhaul moved to 2015. Moved from 2021 to 2020 due to AMEC Review.
SSD TS	L109T4	Brown Boveri	Air Blast	DCF 170 mc4	1968	138	46	2015	2019	51	Changed From 2014 to 2015. Changed replacement from 2023 to 2019.
STB TS	B3L133	Brown Boveri	Air Blast	DCF 170 mc4	1969	138	45	2015	2020	51	Changed From 2014 to 2015. Changed replacement from 2024 to 2020.
STB TS	B3L10	Brown Boveri	Air Blast	DLF 145 nc2	1977	138	37	2015	2020	43	Changed to from 2017 to 2015. Changed replacement from 2031 to 2021. Moved from 2021 to 2020 after AMEC Review.
STB TS	B3T1	Brown Boveri	Air Blast	DCF 170 mc4	1969	138	45	2015	2020	51	Move from 2015 to 2016. Advanced O/H to 2015 and changed replacement from 2025 to 2020.
SVL TS	B1L09	S & C Electric	Circuit Switcher	Mark III	1983	230	31	2015	2025	42	
WAV TS	B1T1	S & C Electric	Circuit Switcher	Mark III	1983	230	31	2015	2025	42	
DLK TS	B3L47	Sprecher & Schuh	SF6	HGF 114/1A	1983	230	31	2015	2024	41	Moved from 2014 to 2015.
DLK TS	B3L48	Sprecher & Schuh	SF6	HGF 114/1A	1983	230	31	2015	2025	42	
DLK TS	L39T2	Sprecher & Schuh	SF6	HGF 112/1C	1983	138	31	2015	2023	40	Moved From 2013 to 2014. Moved from 2014 to 2015.
IRV TS	B1L363	Brown Boveri	SF6	ELF 145 nls	1980	138	34	2015	2023	43	Moved overhaul from 2013 to 2014 and then to 2015.
DLK TS	L45T2	Sprecher & Schuh	SF6	HGF 112/1C	1983	138	31	2015	2024	41	Moved from 2014 to 2015.
WAV TS	B1T2	S & C Electric	Circuit Switcher	Mark III	1983	230	31	2016	2026	43	
BBK TS	L14L50	S & C	Circuit Switcher	Model 2030	1989	138	25	2016	2029	40	
HLY TS	B1T2	Siemens	SF6	3 AR 1	1982	138	32	2016	2025	43	Move from 2015 to 2016.
IRV TS	B1L24	ASEA	SF6	HPL145/20C1	1992	138	22	2016	2032	40	
IRV TS	B1L23	ASEA	SF6	HPL145/20C1	1992	138	22	2016	2032	40	
BWT TS	L60T1	S & C	Circuit Switcher	Model 2030	1989	138	25	2017	2029	40	

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
BHL TS	B1L59	ASEA Brown Boveri Inc.	SF6	HPL 145/20Cl	1990	138	24	2017	2029	39	
SSD TS	B3L19	Asea Brown Boveri	SF6	HPL 145/20C1	1990	138	24	2017	2029	39	
BCV TS	B1L56	AEG	SF6	DT145-F1	1995	138	19	2017	2035	40	Move from 2017 to 2018.
BCV TS	B1R1	AEG	SF6	DT145-F1	1995	138	19	2018	2035	40	
PBN TS	B1L41	AEG	SF6	DT145-F1	1995	138	19	2018	2035	40	Change from 2019 to 2018.
PPT TS	B1L41	AEG	SF6	DT145-F1	1995	138	19	2018	2035	40	Change from 2019 to 2018.
PPT TS	L41R1	AEG	SF6	DT145-F1	1995	138	19	2018	2035	40	Change from 2020 to 2019. Changed from 2019 to 2018.
PPT TS	L41R2	AEG	SF6	DT145-F1	1995	138	19	2018	2035	40	Change from 2020 to 2019. Changed O/H from 2019 to 2018.
PPT TS	B1L44	AEG	SF6	DT145-F1	1995	138	19	2019	2036	41	
CBC TS	B1B2	GEC Alsthom	SF6	HGF 114/1A	1997	230	17	2019	2037	40	Change from 2021 to 2019.
USL TS	L34L63	Alstom	SF6	HGF 1014IPO	2002	230	12	2022	2042	40	
SOK TS	L22T1	Siemens	SF6	CPV2-145-25-1	2003	138	11	2023	2043	40	
CBCTS	B1C1	Areva T&D Inc.	SF6	DT1-245 F3	2010	230	4	2030	2050	40	
CBCTS	B1C2	Areva T&D Inc.	SF6	DT1-245 F3	2010	230	4	2030	2050	40	
CBCTS	B2C3	Areva T&D Inc.	SF6	DT1-245 F3	2010	230	4	2030	2050	40	
CBCTS	B2C4	Areva T&D Inc.	SF6	DT1-245 F3	2010	230	4	2030	2050	40	
BBKTS	B3L50	Areva	SF6	DT1-145-FK	2010	138	4	2030	2050	40	
SPL TS	B1L22	Hyosung	SF6	HCSP-144B	2010	138	4	2030	2050	40	Replaced a 138 kV KSO in 2013 due to bkr failure as a result of Jan 11, 2013 events. Breaker taken from inventory.
VBNTS	B1T1	Areva T&D Inc.	SF6	DT1-245 F3	2011	230	3	2031	2051	40	
VBNTS	B1T2	Areva T&D Inc.	SF6	DT1-245 F3	2011	230	3	2031	2051	40	
SSD TS	L03L06	Areva T&D Inc.	SF6	DT1-245 F3	2012	230	2	2032	2052	40	Replaced in 2012.
BBK TS	B2L14	Areva T&D Inc.	SF6	DT1-145	2012	138	2	2032	2052	40	Replaced in 2012.
MFATS3	B1T1	Alsthom	SF6	DT1- 145	2012	138	2	2032	2052	40	Added new in 2013 for construction power.
MFATS3	B1L1302	Alsthom	SF6	DT1- 145	2012	138	2	2032	2052	40	Added new in 2013 for construction power.
HWD TS	B1L36	Areva T&D Inc.	SF6	DT1-245 F3	2013	230	1	2033	2053	40	Replaced a 230 kV DLF in 2013.
BDE TS2	B13L20	Alsthom	SF6	DT1- 72.5	2013	66	1	2033	2053	40	Replaced a 66 kV FKP OCB in 2013.
HRD TS	B7L38	Alsthom	SF6	DT1- 72.5	2013	66	1	2033	2053	40	Replaced a 66 kV KSO OCB in 2013.

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
HRD TS	B2B11	Brown Boveri	Air Blast	DLF 245 nc2	1974	230	40	-	2014	40	Required Replacement by Sept 2016 for LCP.
HRD TS	B12L42	Brown Boveri	Air Blast	DLF 245 nc2	1978	230	36	-	2016	38	Required Replacement by Sept 2016 for LCP. Moved from 2014 to 2015. Moved from 2015 to 2016 to complete unit breakers on Unit 3.
BBK TS	B1L11	Brown Boveri	Air Blast	DLF 245 nc2	1971	230	43	-	2016	45	Planned Replacement by Emera for NL/NS Link.
BBK TS	B1L09	Brown Boveri	Air Blast	DLF 245 nc2	1971	230	43	-	2016	45	Planned Replacement by Emera for NL/NS Link.
BBK TS	L09L33	Brown Boveri	Air Blast	DLF 245 nc2	1973	230	41	-	2016	43	Planned Replacement by Emera for NL/NS Link.
BBK TS	L11L33	Brown Boveri	Air Blast	DLF 245 nc2	1978	230	36	-	2016	38	Planned Replacement by Emera for NL/NS Link.
HRD TS	B1B11	Brown Boveri	Air Blast	DLF 245 nc2	1974	230	40	-	2015	41	Required Replacement by Sept 2016 for LCP.
HRD TS	B12L17	Brown Boveri	Air Blast	DLF 245 nc2	1973	230	41	-	2016	43	Required Replacement by Sept 2016 for LCP - moved to 2016 from 2015 to advance B3L18.
HRD TS	B3L18	Brown Boveri	Air Blast	DLF 245 nc2	1978	230	36	-	2015	37	Required Replacement by Sept 2016 for LCP - moved to 2015 from 2016 to advance unit breaker replacement.
HRD TS	B12B15	Brown Boveri	Air Blast	DLF 245 nc2	1978	230	36	-	2016	38	Required Replacement by Sept 2016 for LCP.
HRD TS	B3B13	Brown Boveri	Air Blast	DLF 245 nc2	1978	230	36	-	2015	37	Required Replacement by Sept 2016 for LCP. Moved from 2016 to 2015 to complete Unit 3 bkrs.
SSD TS	B2T1	Brown Boveri	Air Blast	DCF 170 mc4	1969	138	45	-	2014	45	Changed from 2011 to 2012 to 2014. Cancelled O/H and will be replaced due to T1 Fire in 2014. Changed replacement from 2015 to 2014.
HWD TS	B1L01	Brown Boveri	Air Blast	DLF 245 nc2	1972	230	42	NA	2015	43	Replace to eliminate Air System. Purchase in 2013 and install in 2014. Changed from 2014 to 2015 to swap with SSD B1L03.
HWD TS	B8T3	ASEA	Min. Oil	HLC 72.5/2000	1986	66	28	NA	2022	36	
OPD TS	B2T2	ASEA	Min. Oil	HLC 72.5/2000	1986	66	28	NA	2023	37	
SPL TS	B1L23	CGE	Oil	KSO-138-1500	1967	138	47	NA	2015	48	Being purchased in 2014 and installed in 2015.
HVY TS	13-1	CGE	Oil	KSO-138-2500	1976	138	38	NA	2017	41	
WAV TS	B4L64	CGE	Oil	KSO	1977	138	37	NA	2018	41	
HRD TS	B8L39	CGE	Oil	KSO-138-5000	1978	138	36	NA	2019	41	
CHD TS	B1L27	CGE	Oil	KSO-69-1500	1970	66	44	NA	2014	44	Leaking bushings. Moved from 2015 to 2013. Moved from 2013 to 2014 to late delivery of breaker.
BHL TS	L27T1	CGE	Oil	KSO-69-1500	1967	66	47	NA	2015	48	Being purchased in 2014 and installed in 2015.
CBF TS	152T	CGE	Oil	KSO-69-1500	1966	66	48	NA	2015	49	High Contact Resistance- Moved from 2013 to 2015. Move from 2015 to 2014 in exchange for L400T2. Ordered in 2014 and will be installed in 2015.

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
BBK TS	L400T2	CGE	Oil	KSO-69-1500	1967	66	47	NA	2015	48	High Contact Resistance. Moved from 2014 to 2015 in exchange for CBFCS 152T.
WAV TS	B2T1	CGE	Oil	KSO-69-1500	1967	66	47	NA	2015	48	Changed from 2014 to 2013 with BBK L400T2, changed from 2013 to 2015 with SPL B1L22.
BHL TS	L26L27	CGE	Oil	KSO	1968	66	46	NA	2015	47	
DHR TS	B1L27	CGE	Oil	KSO-69-1500	1970	66	44	NA	2016	46	
HWD TS	B7B8	CGE	Oil	FKP	1971	66	43	NA	2016	45	Required Replacement by Sept 2016 for LCP.
HWD TS	B7T1	CGE	Oil	FKP	1972	66	42	NA	2016	44	Required Replacement by Sept 2016 for LCP.
HWD TS	B7T5	CGE	Oil	FKP	1976	66	38	NA	2016	40	Required Replacement by Sept 2016 for LCP.
HRD TS	B7L2	CGE	Oil	KSO-69-1500	1969	66	45	NA	2017	48	
WAV TS	B2T2	CGE	Oil	FKP	1973	66	41	NA	2017	44	
SVL TS	B2L405	CGE	Oil	FKP	1975	66	39	NA	2018	43	
SVL TS	L405T4	CGE	Oil	FKP	1975	66	39	NA	2018	43	
BDE TS2	B13T11	CGE	Oil	FKP	1976	66	38	NA	2019	43	
MDR TS	B3T3	CGE	Oil	FKP	1975	66	39	NA	2019	44	
SVL TS	B2T3	CGE	Oil	FKP	1975	66	39	NA	2020	45	
WDL TS	B1L29	CGE	Oil	FKP	1976	66	38	NA	2020	44	
DLK TS	B2T1	CGE	Oil	FKP	1980	66	34	NA	2021	41	
OPD TS	B5T3	CGE	Oil	FKP	1977	66	37	NA	2021	44	
OPD TS	B2B5	CGE	Oil	FKP	1977	66	37	NA	2021	44	
HRD TS	B6L3	CGE	Oil	FKP	1978	66	36	NA	2022	44	
OPD TS	B5C1	Brown Boveri	SF6	ELF 72.5 n1rsv	1979	69	35	NA	2019	40	
DLKTS	B2L25	Westinghouse	SF6	690SP2500	1982	69	32	NA	2022	40	
STA TS	B1L61	Westinghouse	SF6	690SP2500	1983	69	31	NA	2023	40	
RWC TS	B1L57	Siemens	SF6	SP 72.5-23	1988	69	26	NA	2028	40	
HWD TS	B8B9	Siemens	SF6	SP 72.5-23-3	1992	69	22	NA	2032	40	
HRD TS	B7T5	AEG	SF6	DT1-72F1	1996	69	18	NA	2037	41	
HRD TS	B6T10	AEG	SF6	DT1-72F1	1996	69	18	NA	2037	41	
STA TS	B1C1	AEG	SF6	DT1-72F1	1996	69	18	NA	2037	41	

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
STA TS	B1C2	AEG	SF6	DT1-72F1	1996	69	18	NA	2037	41	
BUC TS	B2T1	GEC Alsthom	SF6	DT1-72.5 F1	1997	69	17	NA	2038	41	
BUC TS	B2L80	GEC Alsthom Canada	SF6	DT1-72F1	1997	69	17	NA	2038	41	
MDR TS	B4T1	GEC Alsthom/ Cogenel AEG	SF6	DT1 72.5 F1	1997	69	17	NA	2038	41	
STA TS	B1C3	AEG	SF6	DT1-72F1	1996	69	18	NA	2038	42	
PBN TS	B2T1	GEC Alsthom Canada	SF6	DT1-72F1	1997	69	17	NA	2039	42	
PBN TS	B2L21	GEC Alsthom	SF6	DT1-72.5 F1	1998	69	16	NA	2039	41	
RBK TS	L53T1	GEC-Alstom	SF6	DT1-72.5-1M	1998	69	16	NA	2039	41	
HWD TS	B8C2	Siemens	SF6	FA220	1999	69	15	NA	2040	41	
HWD TS	B8T4	Siemens	SF6	SPS2	1999	69	15	NA	2040	41	
OPD TS	B2C2	Siemens	SF6	FA220	1999	69	15	NA	2040	41	
OPD TS	B2T1	Alstom AEG	SF6	DT1-72.5 F1	2000	69	14	NA	2040	40	
CBF TS	252T	Alstom	SF6	DT1-72F1	2001	69	13	NA	2041	40	
PBN TS	B2L62	Alstom AEG	SF6	DT1-72.5 F1	2000	69	14	NA	2041	41	
HWD TS	B7T2	Alstrom	SF6	DT1-72.5 F1	2004	69	10	NA	2044	40	
HWD TS	B7C1	Areva	SF6	DT1-72.5 F1	2007	69	7	NA	2047	40	
HLY TS	L51T2	Areva	SF6	DT1-72.5 F1 FK	2009	69	5	NA	2049	40	
STA TS	B1T1	Alsthom	SF6	DT1-72.5 F1	2011	69	3	NA	2051	40	
DLS TS	B1L15	Areva T&D Inc.	SF6	DT1-72.5	2012	69	2	NA	2052	40	Replaced in 2012.
MDR TS	B2T2	Areva T&D Inc.	SF6	DT1-72.5	2012	69	2	NA	2052	40	Replaced in 2012.
STA TS	B1L57	Areva T&D Inc.	SF6	DT1-72.5	2012	69	2	NA	2052	40	Replaced in 2012.
DLK TS	B2L26	Siemens	SF6	SPS-72.5-23-1	1996	66	18	NA	2036	40	
HBY TS	B1L21	Alsthom	SF6	DT1-72.5 F1	2011	66	3	NA	2051	40	
BUC TS	B2L64	Areva T&D Inc.	SF6	DT-72.5 F1	2005	69	9	NA	2045	40	

APPENDIX E

Summary Replacement Plan by Year

Table E1 – All Circuit Breakers Summary Replacement Plan by Year

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
SSD TS	B2T1	Brown Boveri	Air Blast	DCF 170 mc4	1969	138	45	-	2014	45	Changed from 2011 to 2012 to 2014. Cancelled O/H and will be replaced due to T1 Fire in 2014. Changed replacement from 2015 to 2014.
SSD TS	B1L03	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2002	2014	48	Change replacement from 2015 to 2014.
HRD TS	B2B11	Brown Boveri	Air Blast	DLF 245 nc2	1974	230	40	-	2014	40	Required Replacement by Sept 2016 for LCP.
HRD TS	B1B11	Brown Boveri	Air Blast	DLF 245 nc2	1974	230	40	-	2014	40	Required Replacement by Sept 2016 for LCP. Moved from 2014 to 2015.
HRD TS	B1L17	Brown Boveri	Air Blast	DLF 245 nc2	1973	230	41	2014	2014	41	Required Replacement by Sept 2016 for LCP. Bkr failed on Jan 5, 2014 and was o/h. Planned to be replaced in 2014 and O/H parts will be moved to B2L42.
CHD TS	B1L27	CGE	Oil	KSO-69-1500	1970	66	44	NA	2014	44	Leaking bushings. Moved from 2015 to 2013. Moved from 2013 to 2014 to late delivery of breaker.
OPD TS	B1L18	Brown Boveri	Air Blast	DCVF 245 mc6	1969	230	45	2008	2015	46	Changed in 2014 to coordinate with transformer Upgrade/Tie Breaker Design - will be installed in 2014, placed in service in 2015.
BDE TS1	B1T2	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	1999	2015	49	Changed from 2015 to 2014 - moved to 2105 due to delivery schedule.
BDE TS1	B2T4	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2000	2015	47	Changed from 2016 to 2014 - moved to 2015 due to delivery schedule.
OPD TS	B1L36	Brown Boveri	Air Blast	DCVF 245 mc6	1969	230	45	2008	2015	46	Moved from 2016 to 2015 to replace BDE B2T3 in plan.
BDE TS1	B2T3	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2000	2015	49	Moved to 2016 due surge tank work for units 3 and 4 in 2016. Moved from 2016 to 2015 due to AMEC review.
SSD TS	B1L02	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2003	2015	49	Moved from 2016 to 2015 due to AMEC Review.
BDE TS1	B1B2	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2004	2015	49	Moved from 2017 to 2015 due to AMEC Review.

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
SSD TS	L06L07	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2014	2015	47	Moved O/H From 2013 to 2014. Changed replacement from 2015 to 2019. Move replacement from 2019 to 2015 due to AMEC Review.
HWD TS	B1L01	Brown Boveri	Air Blast	DLF 245 nc2	1972	230	42	NA	2015	43	Replace to eliminate Air System. Purchase in 2013 and install in 2014. Changed From 2014 to 2015 to swap with SSD B1L03.
HRD TS	B2L42	Brown Boveri	Air Blast	DLF 245 nc2	1973	230	41	2014	2015	42	Required Replacement by Sept 2016 for LCP. Change replacement from 2014 to 2015 due to unit outage schedule. Will place o/h p[arts from B1L17 on B2L42 for 2014/2015 winter.
HRD TS	B3L18	Brown Boveri	Air Blast	DLF 245 nc2	1978	230	36	-	2015	37	Required Replacement by Sept 2016 for LCP - moved to 2015 from 2016 to advance unit breaker replacement.
HRD TS	B3B13	Brown Boveri	Air Blast	DLF 245 nc2	1978	230	36	-	2015	37	Required Replacement by Sept 2016 for LCP. Moved from 2016 to 2015 to complete Unit 3 bkrs.
BHL TS	L26L27	CGE	Oil	KSO	1968	66	46	NA	2015	47	Purchased in 2014 and installed in 2015.
SPL TS	B1L23	CGE	Oil	KSO-138-1500	1967	138	47	NA	2015	48	Being purchased in 2014 and installed in 2015.
BHL TS	L27T1	CGE	Oil	KSO-69-1500	1967	66	47	NA	2015	48	Being purchased in 2014 and installed in 2015.
CBF TS	152T	CGE	Oil	KSO-69-1500	1966	66	48	NA	2015	49	High Contact Resistance- Moved from 2013 to 2015. Move from 2015 to 2014 in exchange for L400T2. Ordered in 2014 and will be installed in 2015.
BBK TS	L400T2	CGE	Oil	KSO-69-1500	1967	66	47	NA	2015	48	High Contact Resistance. Moved from 2014 to 2015 in exchange for CBFCS 152T.
WAV TS	B2T1	CGE	Oil	KSO-69-1500	1967	66	47	NA	2015	48	Changed from 2014 to 2013 with BBK L400T2, changed from 2013 to 2015 with SPL B1L22.
BDE TS1	B3T6	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2001	2016	50	Changed from 2014 to 2015. Moved from 2015 to 2016 due to AMEC Review.
BDE TS1	B3T5	Brown Boveri	Air Blast	DCVF 245 mc6	1969	230	45	2000	2016	47	Moved to 2015 from 2017. Moved to 2016 due to AMEC Review.
BDE TS1	B1T1	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2002	2016	50	Changed from 2014 to 2016.
SSD TS	L02L07	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2002	2016	50	

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
BDE TS1	B4B5	Brown Boveri	Air Blast	DCVF 245 mc6	1964	230	50	2003	2016	52	Required Replacement by Sept 2016 for LCP.
HRD TS	B12L42	Brown Boveri	Air Blast	DLF 245 nc2	1978	230	36	-	2016	38	Required Replacement by Sept 2016 for LCP. Moved from 2014 to 2015. Moved from 2015 to 2016 to complete unit breakers on Unit 3.
HRD TS	B12L17	Brown Boveri	Air Blast	DLF 245 nc2	1973	230	41	-	2016	43	Required Replacement by Sept 2016 for LCP - moved to 2016 from 2015 to advance B3L18.
BBK TS	B1L11	Brown Boveri	Air Blast	DLF 245 nc2	1971	230	43	-	2016	45	Planned Replacement by Emera for NL/NS Link.
BBK TS	B1L09	Brown Boveri	Air Blast	DLF 245 nc2	1971	230	43	-	2016	45	Planned Replacement by Emera for NL/NS Link.
BBK TS	L09L33	Brown Boveri	Air Blast	DLF 245 nc2	1973	230	41	-	2016	43	Planned Replacement by Emera for NL/NS Link.
BBK TS	L11L33	Brown Boveri	Air Blast	DLF 245 nc2	1978	230	36	-	2016	38	Planned Replacement by Emera for NL/NS Link.
HRD TS	B12B15	Brown Boveri	Air Blast	DLF 245 nc2	1978	230	36	-	2016	38	Required Replacement by Sept 2016 for LCP.
HWD TS	B7B8	CGE	Oil	FKP	1971	66	43	NA	2016	45	Required Replacement by Sept 2016 for LCP.
HWD TS	B7T1	CGE	Oil	FKP	1972	66	42	NA	2016	44	Required Replacement by Sept 2016 for LCP.
HWD TS	B7T5	CGE	Oil	FKP	1976	66	38	NA	2016	40	Required Replacement by Sept 2016 for LCP.
DHR TS	B1L27	CGE	Oil	KSO-69-1500	1970	66	44	NA	2016	46	
MDR TS	B5L11	Brown Boveri	Air Blast	DCVF 245 mc6	1967	230	47	2006	2017	50	
BDE TS1	B6B10	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2005	2017	49	Changed replacement from 2018 to 2017.
BDE TS1	B2B3	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2006	2017	49	Changed replacement from 2018 to 2017.
MDR TS	B1L28	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2007	2017	51	Changed replacement from 2019 to 2017.
BDE TS1	B3B4	Brown Boveri	Air Blast	DCVF 245 mc6	1972	230	42	2005	2017	45	Changed replacement from 2025 to 2017.
WAV TS	B2T2	CGE	Oil	FKP	1973	66	41	NA	2017	44	
HVY TS	13-1	CGE	Oil	KSO-138-2500	1976	138	38	NA	2017	41	
HRD TS	B7L2	CGE	Oil	KSO-69-1500	1969	66	45	NA	2017	48	
SSD TS	B3T4	Brown Boveri	Air Blast	DCF 170 mc4	1966	138	48	2012	2018	52	Changed replacement from 2022 to 2018.
STB TS	B3L130	Brown Boveri	Air Blast	DCF 170 mc4	1968	138	46	2012	2018	50	Changed replacement from 2022 to 2018.
STB TS	B3T2	Brown Boveri	Air Blast	DCF 170 mc4	1969	138	45	2012	2018	49	Changed replacement from 2023 to 2018.
SSD TS	B2L12	Brown Boveri	Air Blast	DCF 170 mc4	1966	138	48	2014	2018	52	Changed from 2013 to 2014. Changed replacement from 2023 to 2020. Moved from 2020 to 2018 after AMEC Review.
SSD TS	L19L100	Brown Boveri	Air Blast	DCF 170 mc4	1966	138	48	2014	2018	52	Changed from 2013 to 2014. Changed replacement from 2023 to 2020. Moved from 2020 to 2018 after AMEC Review.

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
STB TS	L05L31	Brown Boveri	Air Blast	DCF 245 mc6	1969	230	45	2008	2018	49	Changed replacement from 2021 to 2018.
WAV TS	B1L37	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2005	2018	50	Changed replacement from 2018 to 2017. Moved from 2017 to 2018 due to AMEC Review.
BDE TS1	B5B6	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2007	2018	50	Changed replacement from 2020 to 2017. Moved from 2017 to 2018 due to AMEC Review.
WAV TS	B1L17	Brown Boveri	Air Blast	DCVF 245 mc6	1969	230	45	2009	2018	49	Changed replacement from 2022 to 2017. Moved from 2017 to 2018 due to AMEC Review.
STB TS	B2L04	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2011	2018	52	Changed replacement from 2020 to 2018.
BDE TS1	B1B10	Brown Boveri	Air Blast	DCVF 245 mc6	1975	230	39	2014	2018	43	Move from 2015 to 2016. Cancelled O/H in 2016 and advanced replacement to 2018.
SVL TS	L405T4	CGE	Oil	FKP	1975	66	39	NA	2018	43	
WAV TS	B4L64	CGE	Oil	KSO	1977	138	37	NA	2018	41	
SSD TS	L109T4	Brown Boveri	Air Blast	DCF 170 mc4	1968	138	46	2015	2019	51	Changed From 2014 to 2015. Changed replacement from 2023 to 2019.
SSD TS	L100L109	Brown Boveri	Air Blast	DCF 170 mc4	1968	138	46	2014	2019	51	Changed From 2014 to 2015. Changed replacement from 2024 to 2020. Changed O/H from 2015 to 2014 due to condition. Moved from 2020 to 2019 after AMEC Review.
STB TS	B1L35	Brown Boveri	Air Blast	DCF 245 mc6	1966	230	48	2010	2019	53	Moved from 2020 to 2019 after AMEC Review.
WAV TS	B1L08	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2010	2019	51	Changed replacement from 2020 to 2018. Move from 2018 to 2019 after AMEC Review.
STB TS	B1L31	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2008	2019	53	
STB TS	L05L35	Brown Boveri	Air Blast	DCVF 245 mc6	1966	230	48	2009	2019	53	
STB TS	B1L32	Brown Boveri	Air Blast	DCVF 245 mc6	1968	230	46	2009	2019	51	Changed replacement from 2021 to 2019.
WAV TS	L03L17	Brown Boveri	Air Blast	DCVF 245 mc6	1969	230	45	2009	2019	50	Changed replacement from 2022 to 2019.
BUC TS	L05L33	Brown Boveri	Air Blast	DLF 245 nc2	1973	230	41	2013	2019	46	Moved to 2013 due to Jan 11 events and breaker failure. Changed replacement from 2025 to 2021.Moved from 2021 to 2019 after AMEC Review.
BUC TS	B1L05	Brown Boveri	Air Blast	DLF 245 nc2	1973	230	41	2014	2019	46	Changed replacement from 2027 to 2021. Moved from 2021 to 2019 after AMEC Review.
OPD TS	B5C1	Brown Boveri	SF6	ELF 72.5 n1rsv	1979	69	35	NA	2019	40	

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
BDE TS2	B13T11	CGE	Oil	FKP	1976	66	38	NA	2019	43	
MDR TS	B3T3	CGE	Oil	FKP	1975	66	39	NA	2019	44	
HRD TS	B8L39	CGE	Oil	KSO-138-5000	1978	138	36	NA	2019	41	
STB TS	B3L133	Brown Boveri	Air Blast	DCF 170 mc4	1969	138	45	2015	2020	51	Changed From 2014 to 2015. Changed replacement from 2024 to 2020.
STB TS	B3T1	Brown Boveri	Air Blast	DCF 170 mc4	1969	138	45	2015	2020	51	Move from 2015 to 2016. Advanced O/H to 2015 and changed replacement from 2025 to 2020.
STB TS	B3L22	Brown Boveri	Air Blast	DCF 170 mc4	1967	138	47	2014	2020	53	Changed from 2013 to 2014. Moved from 2021 to 2020 after AMEC Review.
WAV TS	L01L03	Brown Boveri	Air Blast	DCVF 245 mc6	1969	230	45	2014	2020	51	Moved O/H From 2013 to 2014. Change to replacement to 2019 from 2024 to advance replacements. Moved from 2019 to 2020 after AMEC Review.
STB TS	B3L10	Brown Boveri	Air Blast	DLF 145 nc2	1977	138	37	2015	2020	43	Changed to from 2017 to 2015. Changed replacement from 2031 to 2021. Moved from 2021 to 2020 after AMEC Review.
BUC TS	L28L32	Brown Boveri	Air Blast	DLF 245 nc2	1972	230	42	2014	2020	48	O/H moved from 2013 to 2014. Changed replacement from 2026 to 2021. Moved from 2021 to 2020.
BUC TS	B1L28	Brown Boveri	Air Blast	DLF 245 nc2	1975	230	39	2014	2020	45	Changed from 2016 to 2014. Changed replacement from 2028 to 2021. Moved from 2021 to 2020.
WAV TS	B1B3	Brown Boveri	Air Blast	DLF 245 nc4	1977	230	37	2015	2020	43	Changed to 2014 from 2017. Changed replacement from 2031 to 2021. Overhaul moved to 2015. Moved from 2021 to 2020 due to AMEC Review.
BDE TS2	B9L34	Brown Boveri	SF6	ELF 245 n2s	1981	230	33	2004	2020	39	
HWD TS	B2L42	Brown Boveri	SF6	ELF 245 n2s	1981	230	33	2005	2020	39	
BUCTS	L32L33	Brown Boveri	SF6	ELF 245 n2s	1980	230	34	2006	2020	40	
SVL TS	B2T3	CGE	Oil	FKP	1975	66	39	NA	2020	45	
WDL TS	B1L29	CGE	Oil	FKP	1976	66	38	NA	2020	44	
DLK TS	B1L39	Brown Boveri	SF6	ELF 145 nls	1980	138	34	2013	2021	41	Parts purchased in 2011, ABB could not install.

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
HRD TS	B12L18	Brown Boveri	SF6	ELF 245 n2s	1981	230	33	2006	2021	40	
HRD TS	B13B15	Brown Boveri	SF6	ELF 245 n2s	1981	230	33	2007	2021	40	
USLTS	L34T1	Brown Boveri	SF6	ELF 245 nc2s	1981	230	33	2006	2021	40	
DLK TS	B2T1	CGE	Oil	FKP	1980	66	34	NA	2021	41	
OPD TS	B5T3	CGE	Oil	FKP	1977	66	37	NA	2021	44	
OPD TS	B2B5	CGE	Oil	FKP	1977	66	37	NA	2021	44	
DLKTS	B2L25	Westinghouse	SF6	690SP2500	1982	69	32	NA	2022	40	
DLK TS	B1L45	Brown Boveri	SF6	ELF 145 nls	1980	138	34	2013	2022	42	Parts purchased in 2012, ABB could not install.
HLY TS	B1L24	Brown Boveri	SF6	ELF 145 nls	1980	138	34	2013	2022	42	Parts purchased in 2012, ABB could not install.
HLY TS	B1L43	Brown Boveri	SF6	ELF 145 nls	1980	138	34	2013	2022	42	Parts purchased in 2012, ABB could not install.
HRD TS	B6L3	CGE	Oil	FKP	1978	66	36	NA	2022	44	
HWD TS	B8T3	ASEA	Min. Oil	HLC 72.5/2000	1986	66	28	NA	2022	36	
STA TS	B1L61	Westinghouse	SF6	690SP2500	1983	69	31	NA	2023	40	
HLY TS	B1L45	Brown Boveri	SF6	ELF 145 nls	1980	138	34	2014	2023	43	Moved back to 2014 from 2013.
IRV TS	B1L363	Brown Boveri	SF6	ELF 145 nls	1980	138	34	2015	2023	43	Moved overhaul from 2013 to 2014 and then to 2015.
DLK TS	L39T2	Sprecher & Schuh	SF6	HGF 112/1C	1983	138	31	2015	2023	40	Moved From 2013 to 2014. Moved from 2014 to 2015.
OPD TS	B2T2	ASEA	Min. Oil	HLC 72.5/2000	1986	66	28	NA	2023	37	
CAT TS	L47T1	Mitsubishi Electric Corp.	SF6	200-SFMT-40A	1984	230	30	2010	2024	40	
CAT TS	L47T2	Mitsubishi Electric Corp.	SF6	200-SFMT-40A	1984	230	30	2010	2024	40	
DLK TS	L45T2	Sprecher & Schuh	SF6	HGF 112/1C	1983	138	31	2015	2024	41	Moved from 2014 to 2015.
DLK TS	B3L47	Sprecher & Schuh	SF6	HGF 114/1A	1983	230	31	2015	2024	41	Moved from 2014 to 2015.
MDR TS	B1L48	Sprecher & Schuh	SF6	HGF 114/1A	1983	230	31	2014	2024	41	
HLY TS	B1T2	Siemens	SF6	3 AR 1	1982	138	32	2016	2025	43	Move from 2015 to 2016.
DLK TS	B3L48	Sprecher & Schuh	SF6	HGF 114/1A	1983	230	31	2015	2025	42	
SVL TS	B1L09	S & C Electric	Circuit Switcher	Mark III	1983	230	31	2015	2025	42	
WAV TS	B1T1	S & C Electric	Circuit Switcher	Mark III	1983	230	31	2015	2025	42	

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
WAV TS	B1T2	S & C Electric	Circuit Switcher	Mark III	1983	230	31	2016	2026	43	
RWC TS	B1L57	Siemens	SF6	SP 72.5-23	1988	69	26	NA	2028	40	
SSD TS	B3L19	Asea Brown Boveri	SF6	HPL 145/20C1	1990	138	24	2017	2029	39	
BHL TS	B1L59	ASEA Brown Boveri Inc.	SF6	HPL 145/20Cl	1990	138	24	2017	2029	39	
BBK TS	L14L50	S & C	Circuit Switcher	Model 2030	1989	138	25	2016	2029	40	
BWT TS	L60T1	S & C	Circuit Switcher	Model 2030	1989	138	25	2017	2029	40	
WAV TS	L01L37	Siemens	SF6	3AQ1	1990	230	24	2005	2030	40	
BDE TS2	B9B10	Siemens	SF6	3AQ1	1990	230	24	2011	2030	40	
BDE TS2	B11L06	Siemens	SF6	3AQ1	1990	230	24	2007	2030	40	
BDE TS2	B10B11	Siemens	SF6	3AQ1	1990	230	24	2009	2030	40	
HRD TS	B12T10	Siemens	SF6	3AQ1	1990	230	24	2006	2031	41	
STB TS	L04L32	Siemens	SF6	3AQ1	1990	230	24	2011	2031	41	
BDE TS2	L06L34	Siemens	SF6	3AQ1	1990	230	24	2011	2031	41	
IRV TS	B1L24	ASEA	SF6	HPL145/20C1	1992	138	22	2016	2032	40	
IRV TS	B1L23	ASEA	SF6	HPL145/20C1	1992	138	22	2016	2032	40	
HWD TS	B8B9	Siemens	SF6	SP 72.5-23-3	1992	69	22	NA	2032	40	
HWD TS	B1B2	Sprecher Energie	SF6	BHG 114	1993	230	21	2011	2034	41	
BCV TS	B1L56	AEG	SF6	DT145-F1	1995	138	19	2017	2035	40	Move from 2017 to 2018.
BCV TS	B1R1	AEG	SF6	DT145-F1	1995	138	19	2018	2035	40	
PBN TS	B1L41	AEG	SF6	DT145-F1	1995	138	19	2018	2035	40	Change from 2019 to 2018.
PPT TS	B1L41	AEG	SF6	DT145-F1	1995	138	19	2018	2035	40	Change from 2019 to 2018.
PPT TS	L41R1	AEG	SF6	DT145-F1	1995	138	19	2018	2035	40	Change from 2020 to 2019. Changed from 2019 to 2018.
PPT TS	L41R2	AEG	SF6	DT145-F1	1995	138	19	2018	2035	40	Change from 2020 to 2019. Changed O/H from 2019 to 2018.
PPT TS	B1L44	AEG	SF6	DT145-F1	1995	138	19	2019	2036	41	
DLK TS	B2L26	Siemens	SF6	SPS-72.5-23-1	1996	66	18	NA	2036	40	

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
HRD TS	B7T5	AEG	SF6	DT1-72F1	1996	69	18	NA	2037	41	
HRD TS	B6T10	AEG	SF6	DT1-72F1	1996	69	18	NA	2037	41	
STA TS	B1C1	AEG	SF6	DT1-72F1	1996	69	18	NA	2037	41	
STA TS	B1C2	AEG	SF6	DT1-72F1	1996	69	18	NA	2037	41	
MDR TS	B4T1	GEC Alsthom/ Cogenel AEG	SF6	DT1 72.5 F1	1997	69	17	NA	2038	41	
BUC TS	B2T1	GEC Alsthom	SF6	DT1-72.5 F1	1997	69	17	NA	2038	41	
BUC TS	B2L80	GEC Alsthom Canada	SF6	DT1-72F1	1997	69	17	NA	2038	41	
STA TS	B1C3	AEG	SF6	DT1-72F1	1996	69	18	NA	2038	42	
PBN TS	B2L21	GEC Alsthom	SF6	DT1-72.5 F1	1998	69	16	NA	2039	41	
RBK TS	L53T1	GEC-Alstom	SF6	DT1-72.5-1M	1998	69	16	NA	2039	41	
PBN TS	B2T1	GEC Alsthom Canada	SF6	DT1-72F1	1997	69	17	NA	2039	42	
CBC TS	B1B2	GEC Alsthom	SF6	HGF 114/1A	1997	230	17	2019	2037	40	Change from 2021 to 2019.
OPD TS	B2T1	Alstom AEG	SF6	DT1-72.5 F1	2000	69	14	NA	2040	40	
HWD TS	B8C2	Siemens	SF6	FA220	1999	69	15	NA	2040	41	
OPD TS	B2C2	Siemens	SF6	FA220	1999	69	15	NA	2040	41	
HWD TS	B8T4	Siemens	SF6	SPS2	1999	69	15	NA	2040	41	
PBN TS	B2L62	Alstom AEG	SF6	DT1-72.5 F1	2000	69	14	NA	2041	41	
CBF TS	252T	Alstom	SF6	DT1-72F1	2001	69	13	NA	2041	40	
USL TS	L34L63	Alstom	SF6	HGF 1014IPO	2002	230	12	2022	2042	40	
SOK TS	L22T1	Siemens	SF6	CPV2-145-25-1	2003	138	11	2023	2043	40	
HWD TS	B7T2	Alstrom	SF6	DT1-72.5 F1	2004	69	10	NA	2044	40	
BUC TS	B2L64	Areva T&D Inc.	SF6	DT-72.5 F1	2005	69	9	NA	2045	40	
HWD TS	B7C1	Areva	SF6	DT1-72.5 F1	2007	69	7	NA	2047	40	
HLY TS	L51T2	Areva	SF6	DT1-72.5 F1 FK	2009	69	5	NA	2049	40	
BBKTS	B3L50	Areva	SF6	DT1-145-FK	2010	138	4	2030	2050	40	
CBCTS	B1C1	Areva T&D Inc.	SF6	DT1-245 F3	2010	230	4	2030	2050	40	
CBCTS	B1C2	Areva T&D Inc.	SF6	DT1-245 F3	2010	230	4	2030	2050	40	
CBCTS	B2C3	Areva T&D Inc.	SF6	DT1-245 F3	2010	230	4	2030	2050	40	
CBCTS	B2C4	Areva T&D Inc.	SF6	DT1-245 F3	2010	230	4	2030	2050	40	

LOCATION	NLH ID	MFG	TYPE	MODEL	YEAR BUILT	OPER VOLT (kV)	CURRENT AGE	OVERHAUL YEAR	REPLACEMENT YEAR	AGE AT REPLACEMENT	COMMENTS
SPL TS	B1L22	Hyosung	SF6	HCSP-144B	2010	138	4	2030	2050	40	Replaced a 138 kV KSO in 2013 due to bkr failure as a result of Jan 11, 2013 events. Breaker taken from inventory.
VBNTS	B1T1	Areva T&D Inc.	SF6	DT1-245 F3	2011	230	3	2031	2051	40	
VBNTS	B1T2	Areva T&D Inc.	SF6	DT1-245 F3	2011	230	3	2031	2051	40	
HBY TS	B1L21	Alsthom	SF6	DT1-72.5 F1	2011	66	3	NA	2051	40	
STA TS	B1T1	Alsthom	SF6	DT1-72.5 F1	2011	69	3	NA	2051	40	
MFATS3	B1T1	Alsthom	SF6	DT1- 145	2012	138	2	2032	2052	40	Added new in 2013 for construction power.
MFATS3	B1L1302	Alsthom	SF6	DT1- 145	2012	138	2	2032	2052	40	Added new in 2013 for construction power.
BBK TS	B2L14	Areva T&D Inc.	SF6	DT1-145	2012	138	2	2032	2052	40	Replaced in 2012.
SSD TS	L03L06	Areva T&D Inc.	SF6	DT1-245 F3	2012	230	2	2032	2052	40	Replaced in 2012.
DLS TS	B1L15	Areva T&D Inc.	SF6	DT1-72.5	2012	69	2	NA	2052	40	Replaced in 2012.
MDR TS	B2T2	Areva T&D Inc.	SF6	DT1-72.5	2012	69	2	NA	2052	40	Replaced in 2012.
STA TS	B1L57	Areva T&D Inc.	SF6	DT1-72.5	2012	69	2	NA	2052	40	Replaced in 2012.
BDE TS2	B13L20	Alsthom	SF6	DT1- 72.5	2013	66	1	2033	2053	40	Replaced a 66 kV FKP OCB in 2013.
HRD TS	B7L38	Alsthom	SF6	DT1- 72.5	2013	66	1	2033	2053	40	Replaced a 66 kV KSO OCB in 2013.
HWD TS	B1L36	Areva T&D Inc.	SF6	DT1-245 F3	2013	230	1	2033	2053	40	Replaced a 230 kV DLF in 2013.

APPENDIX F

Accelerated Air Blast Circuit Breaker Replacement Program

NEWFOUNDLAND AND LABRADOR HYDRO

Accelerated Air Blast Circuit Breaker Replacement Program

July *30*, 2014

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1) Executive Summary

Newfoundland and Labrador Hydro (Hydro) has an on-going program to replace circuit breakers at the end of the asset's useful life. This includes replacing all 63 air blast circuit breakers with SF6 circuit breakers by 2031. Although historically the performance of air blast circuit breakers has been reasonable, Hydro has experienced two significant outage incidents in the last two years in which the failure of air blast circuit breakers was a significant contributing factor. As a consequence Hydro now plans to initiate a program to carry out the replacement on an accelerated schedule. This document provides a strategic plan for accomplishing this.

The accelerated air blast circuit breaker replacement program is designed to be implemented in two three-year phases with the first installation of breakers in 2015. A partnership arrangement would be established between Hydro and an external contractor for each phase for the supply and installation of breakers. Breakers purchased under the current replacement program would be installed in 2014 but beginning in 2015 the existing program would be merged into the accelerated program.

The overall program scheduled to be completed by 2020 provides a significant reduction in the time required to replace all air blast circuit breakers while maintaining safety, ensuring reliability and maximizing the use of available resources.

2) Introduction

Hydro plans to initiate a program to replace all air blast circuit breakers on an accelerated schedule. There are a total of 63 air blast circuit breakers on the Hydro system. Although historically the performance of these breakers has been reasonable, Hydro has experienced two significant outage incidents in the last two years in which the failure of air blast circuit breakers was a significant contributing factor.

During the next few years there are a number of activities already in progress which will result in the replacement of a number of these breakers. The activities include the LCP program at Holyrood, Bay D'Espoir and Hardwoods, the NL/NS link at Bottom Brook, breaker replacement associated with the transformer repairs at Sunnyside and the program currently underway to replace breakers at end-of-life. The accelerated replacement program will be carried out in addition to these other programs but must consider the overall impact of all activities on the system and resources. Close coordination with these other programs is required.

3) Background

In July 2012 Hydro submitted an *Upgrade Circuit Breaker* plan to the Board of Commissioners of Public Utilities (PUB) as part of its 2013 capital plan. The plan contained two components. One was to refurbish and replace aging air blast and SF6 circuit breakers to ensure system reliability. The other was to comply with legislation to remove PCB contaminated bushings on oil circuit breakers by replacing the oil circuit breakers with new SF6 circuit breakers.

No changes are anticipated for either the oil circuit breaker replacement program or the SF6 refurbishment and replacement program

The July 2012 plan for air blast circuit breakers had been to overhaul these breakers at about 40 years of service and replace them at the useful end of the asset life between 50 and 55 years of service. Replacement breakers would be SF6 type breakers and the replacement program would be completed by 2031. This meant that four to five overhauls would be completed per year and about three replacements per year. The report indicated that the experience in Newfoundland and from other utilities was that overhauls were effective in maintaining the reliability of air blast circuit breakers and extending their lifecycle.

In January 2013 and January 2014 Hydro experienced major system outages. In both incidents air blast circuit breakers failed to operate properly. During the PUB investigation into the January 2014 power outages its consultant, the Liberty Consulting Group, made a number of recommendations regarding air blast circuit breakers. These recommendations included exercising breakers, catching up on overdue maintenance, reducing the preventive maintenance cycle from 6 years to 4 years and periodically operating breakers from protection. Furthermore, the PUB in its May 15th Interim Report has requested that Hydro file a report on August 1st on the acceleration of the replacement of air blast circuit breakers.

This Accelerated Air Blast Breaker Replacement program has been independently developed for Hydro to address the recent experience with the decreased reliability of air blast circuit breakers and the recommendations of the Liberty Consulting Group. Factors considered in the development of the program include the criticality of the circuit breaker to system reliability, the age of the breaker and time since its last overhaul, the optimal use of resources through selection of the number work sites and avoiding delays in removal of air systems. Data for the development of the program was obtained from Hydro's Breaker 20 Year Plan dated Mar 26, 2014 and revisions to it up to July 3, 2014.

4) Program Goal and Scope

The overall program goal is to replace all air blast circuit breakers on an accelerated schedule in order to eliminate reliability issues associated with failure of air blast circuit breakers. This requires a balanced approach that replaces the breakers on a timely basis but maintains reliability of the power system during the work required to replace them. A six (6) year project schedule has been chosen that would begin in 2015. A partnership arrangement would be established between Hydro and an external contractor. Initially, Hydro would prepare and issue tender documents, evaluate bids and award the contract. The external contractor would supply and install the breakers. During the contract execution, Hydro would disconnect existing breaker, review and approve drawings including protection and control, provide outage coordination and on-site supervision, and oversee commissioning.

The scope of the contract would include:

- Removal of existing breaker and foundation
- Construction of a new foundation for the circuit breaker structure
- Supply and installation of new breaker
- Installation of new protection equipment and control cables
- Commissioning of new breaker

The accelerated air blast circuit breaker replacement program is designed to be implemented in two three-year phases. For each phase, a multi-year contract (3 years) will be issued for supply and installation of breakers. The contract will contain specific numbers of breakers to be supplied and installed each year. The contract should also contain an option to supply and install additional breakers on an incremental basis by year that allows for flexibility to adapt to changing system conditions. By breaking the contract into two phases Hydro can ensure a competitive and competent supplier is used throughout while still benefitting from the economies resulting from large orders and dealing with one (either through a successful re-bid or a contract extension) or two suppliers.

5) Schedule

Due to the time required to procure circuit breakers it is not practical to implement an accelerated breaker replacement plan in the field prior to 2015. In 2014 the procurement process would be put in place that incorporates and replaces the existing Upgrade Circuit Breaker project to have the necessary breakers and services available in 2015. Current activities will ensure that a number of air blast circuit breakers get replaced in 2014. This also enables time to properly analyze the requirements, prepare a plan and put in place a contract for the accelerated replacement of circuit breakers beginning in 2015.

The plan requires that a tender be prepared and issued in the fall of 2014 for the first phase of the program to secure a contractor for the years 2015-2017. Breakers required for installation in 2015 need to be delivered in the spring of 2015. Installation would then take place during the construction season of April – October. Subsequent years 2016 and 2017 would follow a similar schedule. Preparation for Phase 2 would take place during the summer/fall of 2017. At that time either the existing contract could be extended for an additional 3 years or a new contract awarded in time to continue the replacement program without interruption.

It is important that a thorough review of the specific breakers to be replaced be conducted on an annual basis. This review should include all affected departments including system operations (ECC), regional operations and maintenance, engineering, plant operations as required and protection and control. The first review should take place in the fall to finalize the list for the following year. A preliminary schedule and resource requirements should be looked at. With this if there are resource issues then there is still time to address them. Three months prior to the beginning of the construction season the outage schedule needs to be finalized. During the construction season final scheduling and approval of outages would be done in accordance with Hydro procedures.

6) Risk

The accelerated air blast circuit breaker replacement program contains significant but manageable risks. During the years 2015 and 2016 there are 12 air blast circuit breakers being replaced each year. This is in addition to oil circuit breaker replacements (5 and 4 respectively), overhauls and preventive maintenance. This represents a significant risk to schedule and resource availability. However, in both 2015 and 2016 there are other breaker replacement programs already active such as LCP that would mitigate the risk somewhat. Coordination of the work by Hydro and the contractor / partner is critical to the success of this program.

7) General

The overall plan for accelerated circuit breaker replacement needs to meet the following criteria:

- ***Safety*** of personnel and equipment must be a priority at all times. Hence any plan that incorporates external resources needs to ensure that all safety requirements of Hydro are met or exceeded.
- ***Reliability*** of power system is continuously maintained. Although the outages incurred to install new breakers will impact the ability of the power system to respond to disturbances the overall plan should not create undue risks. It is imperative that the plan be coordinated with system operations.
- The replacement of the circuit breakers should consider ***effective use of resources*** including technical capabilities and capacity of available labour, equipment and materials as well as be ***economic***.
- ***Timely***. Accelerating the replacement of circuit breakers will reduce the potential for further outages caused by failures of air blast circuit breakers.

A number of factors were used to select and prioritize the breaker replacements. These included the criticality of the breaker to system reliability, the age of the breaker and time since its last overhaul, optimizing use of resources through selection of the number work sites and avoiding delays in removal of air systems. Locations where the breakers were critical to system reliability or where breakers with known problems existed were given the highest priority. For continuity and efficient use of resources, the number of work locations was constrained and once a Terminal Station was started replacements continued at that location until completed. This also ensured that the air systems could be removed on a timely basis. Coordination with other on-going breaker replacement programs was an important consideration due to the impact on both resources and reliability of the system. The age and the time of the last overhaul were used to guide the replacement when other more critical factors had been satisfied.

During **Phase 1** of the accelerated program from 2015 – 2017 a total of 18 air blast circuit breakers will be replaced. These are in addition to those being done under other programs currently in progress. By the end of 2017 a total of 34 breakers (all 230 kV) at 7 locations will have been replaced. This will also enable the associated air systems at 5 of these locations to be de-commissioned. At Sunnyside, the portion of the air system used to supply the 230 kV breakers can also be de-commissioned. The air systems which are an integral component required for the reliable operation of air blast circuit breakers require a significant amount of maintenance

In the years 2014 – 2016 other programs are in place that will result in replacement of air blast circuit breakers. The LCP program will result in ten (10) 230 kV breaker replacements at Holyrood and Bay D'Espoir. Two breakers (1 – 230 kV, 1 – 138 kV) are scheduled to be replaced in 2014 at Sunnyside in conjunction with the transformer T1 replacement. The NL/NS link requires that all four (4) 230 kV breakers at Bottom Brook be replaced in 2016.These are to be replaced by Emera and at this time are treated separately from the accelerated breaker program. In addition, the Upgrade Circuit Breakers project has air blast circuit breakers scheduled for replacement in 2015 and 2016 but these breakers have been included in the accelerated program beginning in 2015. For efficiency, consideration should also be given to incorporating the Emera work within the accelerated program.

During **Phase 2** of the accelerated program from 2018 – 2020 the remaining 29 air blast circuit breakers will be replaced (18 – 230 kV, 11 – 138 kV) at five locations. The air systems at these locations will also be de-commissioned. All 138 kV breaker replacements are scheduled to occur during Phase 2 because the 138 kV system is less critical to the overall reliability of the

electrical grid and resultant outages tend to be more localized. Moreover, from a project perspective the initial procurement need not address 138 kV breakers.

The following table provides a summary of the complete air blast breaker replacement programs. A more detailed description of the replacement program by location is included in Section 9 and Appendix 1 contains a complete list of all breakers to be replaced.

Air Blast Circuit Breaker Replacement

		Phase 1			Phase 2			
Description	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Total**
Accelerated Program		9	4	5	11	10	8	47
LCP	3	3	4					10
NL/NS Link			4					4
Other	2							2
Total	5	12	12	5	11	10	8	63

8) Circuit Breaker Planned Maintenance and Overhauls

On June 2, 2014 Hydro filed a report with the PUB on work required on air blast circuit breakers. In it Hydro identified that 40 breaker Preventive Maintenance (PMs) were due to be completed by the end of 2015. The schedule would be to complete 23 in 2014 (14 planned, nine overdue) and 17 in 2015 (eight planned, nine overdue). In 2016 and beyond the PMs would return to nine or ten per year and decrease over time.

The PM program for air blast circuit breakers has not been reviewed as part of this study. It is anticipated, however, that all overdue work will still be completed by the end of 2015 and the number of scheduled PMs for air blast circuit breakers should decrease rapidly between 2016 and 2019 with no PMs required in 2020. Although the PM program for air blast breakers will decrease and then end by 2019, the PM program for SF6 breakers will correspondingly increase as new SF6 breakers are added.

Hydro also had plans for overhauls of existing breakers at about 40 years. The current plan is to complete overhauls in 2014 and 2015. Beyond 2015 the circuit breaker replacement program would eliminate the need for overhauls of air blast circuit breakers.

This overhaul program for air blast breaker was briefly reviewed to determine if any opportunities existed for eliminating some overhauls by advancing the schedule for breaker replacement. It was noted that Hydro had advanced a couple of breakers, one at Bay D'Espoir (B1B10) and another at Sunnyside (L100L109). Given the aggressive schedule for breaker replacement and the desire to replace the most critical breakers first, no further opportunities were identified. Moreover, completion of the overhauls in 2014 and 2015 will be beneficial to the accelerated breaker replacement program by providing some added flexibility in the scheduling of breakers in the latter years of the program.

Air blast circuit breakers that have been scheduled for an overhaul have been identified in the detailed description of the breaker replacement program by location contained in Section 9.

Appendix 1 also includes the date of the last overhaul for all breakers in the replacement program.

It is recommended that Hydro retain some breakers and/or breaker parts from those recently removed from service to be used as spares until the completion of the breaker replacement program. The inventory kept should be comparable to what is used for a breaker overhaul since maintenance personnel are familiar with the overhaul procedure.

9) Breaker Replacement Program by Location

There are currently 63 air blast circuit breakers at 10 locations still in service. A plan for each site follows. Programs that are already in place such as the LCP program are included to provide a complete picture of the activity level by year and location. Consideration has been given to reliability, efficient use of resources, and a balancing of the effort by year. A specific breaker replacement schedule is included. However, there is flexibility in the overall schedule that would allow for some swapping of breaker replacements while still achieving the same overall results.

a) Holyrood

Holyrood contains nine (9) 230 kV air blast circuit breakers. All of these breakers will be replaced between 2014 and 2016 as part of the LCP program. This program will be operated separately from the accelerated program but the numbers will be tracked. No changes to this program are anticipated.

Breaker replacement schedule[1]:
2014 – B2B11, B1B11, B1L17[2]
2015 – B2L42[3], B3L18, B3B13
2016 – B12L42, B12L17, B12B15

Notes
1. All breakers replaced as part of the LCP program.
2. Breaker failed in Jan 2014
3. Breaker scheduled for overhaul in 2014

b) Bay D'Espoir

Bay D'Espoir Terminal Station contains thirteen (13) 230 kV air blast circuit breakers. This generating station is critical to the reliability of the integrated island electrical system. During phase 1 eleven (11) of the breakers will be replaced.

There are 6 generator unit breakers that need to be replaced. These breakers are operated frequently as the hydro units are brought on and off line. The concern with these breakers is not with failure to having them exercised but rather with wear and tear due to the number of operations. Hydro has identified these breakers as the most critical to the system driven by the fact they are generator breakers without an alternate route to get power to the grid. Due to on-going work at other locations such as Sunnyside, Holyrood and Oxen Pond and the challenge of attempting to schedule outages for all generator breakers in one year, these breakers have

been scheduled to be replaced in 2015 and 2016. This will also mitigate risks associated with having the hydro plant available for energy, peak demand and reserve.

From a risk perspective, if a generator breaker fails before it is replaced then the consequence is the loss of that generator until it can be repaired or replaced. For a hydro unit the risk is primarily loss of capacity and/or reserve in times when total supply is limited such as during peak load conditions. To mitigate this it is recommended that a plan be developed to rapidly deal with the failure of one of these breakers. This could include keeping a spare breaker or key parts set aside specifically for these locations. It is also recommended that a PM be performed in 2015 on the three breakers that are not scheduled for replacement until 2016.

The remaining seven breakers are part of the ring bus. The outage required to remove any one breaker will not impact the output of the plant or the delivery of energy to the system via the connecting transmission lines. However, the system will be at risk and tripping of any of the transmission lines at Bay D'Espoir may result in the loss of additional transmission lines or unit generation. Each outage will need to be carefully planned and the generation levels at Bay D'Espoir may need to be adjusted to ensure the overall system reliability is maintained. Given the complications and risks associated with replacing these breakers, the number of breakers scheduled in any one year has been limited to three. The result is that the outages for these breakers are spread over the four years to minimize system related reliability risks. One of the breakers B4B5 will be replaced in 2016 as part of the LCP program.

From a risk perspective, if a ring breaker fails before it is replaced then the consequence is that other breakers will operate to isolate the failed breaker. The most common failure mode occurs when a breaker is commanded to operate such as for a fault but fails to do so. The impact on the system is less predictable because of the numerous potential configurations and load levels but could be severe.

The air system will be de-commissioned in 2018 at the end of the breaker replacements.

Breaker replacement schedule:
2015 – B1T2, B2T3, B2T4, B1B2
2016 – B1T1, B3T5, B3T6, B4B5[1]
2017 – B3B4, B6B10, B2B3
2018 – B5B6, B1B10[2]

Notes:
1. Breaker to be replaced as part of LCP program
2. Breaker scheduled for overhaul in 2014. Advanced from 2016.

c) Sunnyside

Sunnyside Terminal Station contains four (4) 230 kV and six (6) 138 kV air blast circuit breakers. Sunnyside occupies a critical location in the Newfoundland electrical grid connecting the large generation supply of Bay D'Espoir to the major load area of the Avalon peninsula. Therefore, maintaining the integrity of the 230 kV ring bus at Sunnyside is crucial to the reliability of the grid. In the major outage of January 2014, tie transformer T1 failed and the 230 kV air blast circuit breaker B1L03 failed to operate. Work will be carried out in 2014 to replace

the tie transformer, 138 kV breaker B2T1 which was damaged during the transformer fire and breaker B1L03.

During Phase 1 the remaining 230 kV breakers are scheduled to be replaced over a two year period. This will ensure that this critical location will be upgraded with new equipment by the end of 2016.

During Phase 2, the remaining air blast circuit breakers, all at 138 kV, will be replaced.

Breaker replacement schedule:
2014 – B1L03[1], B2T1[2]
2015 – B1L02, L06L07[3]
2016 – L02L07
2017
2018 – B3T4, B2L12[3], L19L100[3]
2019 – L109T4[4], L100L109[5]

Notes

1. Breaker failed to operate Jan 2014. New breaker purchased for Hardwoods moved to Sunnyside
2. Breaker damaged during transformer fire.
3. Breaker scheduled for overhaul in 2014
4. Breaker scheduled for overhaul in 2015
5. Breaker scheduled for overhaul in 2014. Advanced to 2014 due to condition assessment.

d) Hardwoods

One (1) 230 kV air blast circuit breaker remains in service at Hardwoods Terminal Station. Early replacement will allow for the air system to be de-commissioned. It was scheduled for replacement in 2014 but has been swapped with a breaker at Sunnyside. It has been re-scheduled to 2015.

Breaker replacement schedule:
2015 – B1L01[1]

Notes:

1. Purchased in 2013, scheduled for installation in 2014 but moved to Sunnyside.

e) Oxen Pond

Oxen Pond Terminal Station contains two (2) 230 kV air blast circuit breakers. To coordinate with transformer upgrade / tie breaker design one breaker will be installed in 2014 and placed in service in 2015. The other breaker will be scheduled for 2016 to complete the station and enable the air system to be de-commissioned.

Breaker replacement schedule:
2014/15 – B1L18[1]
2015 – B1L36

Notes:

1. Breaker to be installed in 2014 but commissioned in 2015. Therefore it is not included in accelerated replacement program.

f) Bottom Brook

All four (4) 230 kV breakers at Bottom Brook Terminal Station are air blast circuit breakers. These breakers are scheduled for replacement by Emera in 2016 for the NL/NS link. The breakers are configured in a ring bus arrangement and Bottom Brook supplies the southwestern part of NL. The removal from service of each breaker will need to be carefully planned. Although treated separately, the replacement of breakers at Bottom Brook will need to be coordinated with the accelerated breaker replacement program. Hydro should explore the possibility of managing this work under the accelerated program. When complete the air system can be de-commissioned.

Breaker replacement schedule[1]:
2016 – B1B11, B1L09, L09L33, L11L33

Notes:

1. All breakers to be replaced by Emera as part of NL/NS link

g) Massey Drive

Massey Drive Terminal Station contains two (2) 230 kV air blast circuit breakers. They are scheduled for replacement in 2017. This schedule needs to be reviewed prior to initiating the work to replace the breakers at Bottom Brook. If transmission line TL211 can be removed from service then one breaker at Massey Drive and two at Bottom brook can be replaced simultaneously under the same outage.

Breaker replacement schedule:
2017 – B1L28, B5L11

h) Stony Brook

Stony Brook Terminal station contains six (6) 230 kV air blast breakers and six (6) 138 kV air blast breakers. The replacement program is included in Phase 2. Four breakers are scheduled per year with a mixture of 230 kV and 138 kV breakers each year. Most of the 138 kV breakers will require a line or transformer outage for the duration of the replacement work. Work on this station has been delayed until Phase 2 because all 230 kV breakers have been overhauled since 2008 and should be reliable. Some of the 138 kV breakers are scheduled for an overhaul in the next couple of years. Due to the large number of breakers to be replaced and the requirement for outages for the 138 kV work, the scheduling of this work will require extra discussion and be carefully planned to ensure reliability and to minimize outage times. The air system can be de-commissioned in 2020.

Breaker replacement schedule:
2018 – B2L04, L05L31, B3L130, B3T2
2019 – B1L31, L05L35, B1L32, B1L35
2020 – B3L22[1], B3L133[2], B3T1[2], B3L10[2]

Notes:

1. Breaker scheduled for overhaul in 2014
2. Breaker scheduled for overhaul in 2015

i) Western Avalon

Western Avalon contains six (6) 230 kV air blast circuit breakers. These are all scheduled for replacement in Phase 2.The primary reason is that all six breakers will have been overhauled between 2005 and 2014. Two breakers per year are scheduled for replacement. This assumes that all breakers continue to perform well regardless of model. If issues arise with a particular model (e.g. B1L03 is an older model type DCVF), then adjustments may need to be made in the schedule. This can be done during the annual review process.

Breaker replacement schedule:
2018 – B1L17, B1L37
2019 – B1L08, L03L17
2020 – L01L03[1], B1B3[2]

Notes:

1. Breaker scheduled for overhaul in 2014
2. Breaker scheduled for overhaul in 2015

j) Buchans

Buchans Terminal station contains four (4) 230 kV breakers. These breakers are scheduled for replacement over a two year period in 2019 – 2020 at the end of Phase 2. With overhauls recently completed or scheduled for the current year the reliability of the station should be good. Hence, the installation of replacement breakers can be delayed. The breakers are configured in a ring bus configuration that enables the removal of one breaker at a time without causing any outages. The air system can be de-commissioned in 2020.

Breaker replacement schedule:
2019 – L05L33, B1L05[1]
2020 – L28L32[1], B1L28[1]

Notes:

1. Breaker scheduled for overhaul in 2014

10) Conclusions and Recommendations

This report provides a plan for the implementation of an accelerated air blast circuit breaker program. During the current year, 2014, previously scheduled work to replace breakers, undertake breaker overhauls and perform preventive maintenance will occur. In addition preparation work for the accelerated program should begin in 2014 with tender preparation, selection of a partner/contractor and ordering the first set of breakers. Installation of the air blast circuit breakers would then take place over a 6-year period between 2015 and 2020. At the end

of 2020 all 63 air blast circuit breakers that were on the Hydro system at the beginning of 2014 would be replaced.

This report includes a discussion of the many factors affecting the replacement of the air blast circuit breakers and provides a summary by year and location of each breaker to be replaced. Some of the key recommendations contained in the report are repeated below.

R1. Implement the accelerated air blast circuit breaker replacement program in two phases. The actual implementation may be done through separate contracts or a single contract with extension. This will minimize spares as well as ensure efficiencies in the implementation.

R2. Coordinate the accelerated air blast circuit breaker replacement programs with other breaker replacement programs including LCP and NL/NS link.

R3. Review the plan annually to ensure the specific breakers selected are the most appropriate for replacement and to address any scheduling and resource issues.

R4. Maintain a set of spares from recently replaced breakers to have available in case of premature failure of a still-in-service air blast circuit breaker.

Appendix 1

Accelerated Air Blast Breaker Replacement Program

Location	NLH ID	Year Built	Oper Volt (kV)	Overhaul Year	Replacement Year	Age at Replacement	Criticality
HRD TS	B1B11	1974	230	-	2014	40	B
HRD TS	B1L17	1973	230	2014	2014	41	B
HRD TS	B2B11	1974	230	-	2014	40	B
SSD TS	B1L03	1966	230	2002	2014	48	B
SSD TS	B2T1	1969	138	-	2014	45	C
BDE TS1	B1B2	1966	230	2004	2015	49	B
BDE TS1	B1T2	1966	230	1999	2015	49	A
BDE TS1	B2T3	1966	230	2000	2015	49	A
BDE TS1	B2T4	1968	230	2000	2015	47	A
HRD TS	B2L42	1973	230	2014	2015	42	B
HRD TS	B3B13	1978	230	-	2015	37	B
HRD TS	B3L18	1978	230	-	2015	37	B
HWD TS	B1L01	1972	230	NA	2015	43	B
OPD TS	B1L18	1969	230	2008	2015	46	B
OPD TS	B1L36	1969	230	2008	2015	46	B
SSD TS	B1L02	1966	230	2003	2015	49	B
SSD TS	L06L07	1968	230	2014	2015	47	B
BBK TS	B1L09	1971	230	-	2016	45	C
BBK TS	B1L11	1971	230	-	2016	45	C

BBK TS	L09L33	1973	230	-	2016	43	C
BBK TS	L11L33	1978	230	-	2016	38	C
BDE TS1	B1T1	1966	230	2002	2016	50	A
BDE TS1	B3T5	1969	230	2000	2016	47	A
BDE TS1	B3T6	1966	230	2001	2016	50	A
BDE TS1	B4B5	1964	230	2003	2016	52	B
HRD TS	B12B15	1978	230	-	2016	38	B
HRD TS	B12L17	1973	230	-	2016	43	B
HRD TS	B12L42	1978	230	-	2016	38	B
SSD TS	L02L07	1966	230	2002	2016	50	B
BDE TS1	B2B3	1968	230	2006	2017	49	B
BDE TS1	B3B4	1972	230	2005	2017	45	B
BDE TS1	B6B10	1968	230	2005	2017	49	B
MDR TS	B1L28	1966	230	2007	2017	51	C
MDR TS	B5L11	1967	230	2006	2017	50	C
BDE TS1	B1B10	1975	230	2014	2018	43	B
BDE TS1	B5B6	1968	230	2007	2018	50	B
SSD TS	B2L12	1966	138	2014	2018	52	D
SSD TS	B3T4	1966	138	2012	2018	52	C
SSD TS	L19L100	1966	138	2014	2018	52	D
STB TS	B2L04	1966	230	2011	2018	52	C
STB TS	B3L130	1968	138	2012	2018	50	D
STB TS	B3T2	1969	138	2012	2018	49	C
STB TS	L05L31	1969	230	2008	2018	49	C

WAV TS	B1L17	1969	230	2009	2018	49	B
WAV TS	B1L37	1968	230	2005	2018	50	B
BUC TS	B1L05	1973	230	2014	2019	46	C
BUC TS	L05L33	1973	230	2013	2019	46	C
SSD TS	L100L109	1968	138	2014	2019	51	D
SSD TS	L109T4	1968	138	2015	2019	51	C
STB TS	B1L31	1966	230	2008	2019	53	C
STB TS	B1L32	1968	230	2009	2019	51	C
STB TS	B1L35	1966	230	2010	2019	53	C
STB TS	L05L35	1966	230	2009	2019	53	C
WAV TS	B1L08	1968	230	2010	2019	51	B
WAV TS	L03L17	1969	230	2009	2019	50	B
BUC TS	B1L28	1975	230	2014	2020	45	C
BUC TS	L28L32	1972	230	2014	2020	48	C
STB TS	B3L10	1977	138	2015	2020	43	D
STB TS	B3L133	1969	138	2015	2020	51	D
STB TS	B3L22	1967	138	2014	2020	53	D
STB TS	B3T1	1969	138	2015	2020	51	C
WAV TS	B1B3	1977	230	2015	2020	43	B
WAV TS	L01L03	1969	230	2014	2020	51	B