Greater Ottawa

REGIONAL INFRASTRUCTURE PLAN

December 18, 2020

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Prepared and supported by:

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DISCLAIMER

This Regional Infrastructure Plan ("RIP") report was prepared for the purpose of developing an electricity infrastructure plan to address all near and mid-term needs identified in previous planning phases and any additional needs identified based on new and/or updated information provided by the RIP Study Team.

The preferred solution(s) that have been identified in this report may be re-evaluated based on the findings of further analysis. The load forecast and results reported in this RIP report are based on the information provided and assumptions made by the participants of the RIP Study Team.

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EXECUTIVE SUMMARY

THIS REGIONAL INFRASTRUCTURE PLAN ("RIP") WAS PREPARED BY HYDRO ONE WITH SUPPORT FROM THE RIP STUDY TEAM IN ACCORDANCE WITH THE ONTARIO TRANSMISSION SYSTEM CODE REQUIREMENTS. IT IDENTIFIES INVESTMENTS IN TRANSMISSION FACILITIES, DISTRIBUTION FACILITIES, OR BOTH, THAT SHOULD BE DEVELOPED AND IMPLEMENTED TO MEET THE ELECTRICITY INFRASTRUCTURE NEEDS WITHIN THE GREATER OTTAWA REGION.

The participants of the RIP Study Team included members from the following organizations:

- Hydro Ottawa Limited
- Hydro Hawkesbury Inc.
- Hydro One Networks Inc. (Distribution)
- Independent Electricity System Operator
- Hydro One Networks Inc. (Transmission)

This RIP provides a consolidated summary of the needs and recommended plans for both the Ottawa Area Sub-Region and Outer Ottawa Area Sub-Region that make up the Greater Ottawa Region over the next ten years.

The RIP is the final phase of the second cycle regional planning process of Greater Ottawa Region, which follows the completion of the Ottawa Sub-Region's Integrated Regional Resource Plan ("IRRP") in March 2020, the Greater Ottawa Region Scoping Assessment ("SA") in September 2018 and the Greater Ottawa Area Region's Needs Assessment ("NA") in June 2018.

The major infrastructure investments recommended by the Study Team, based on right sizing of equipment considering needs over the next ten years , are provided in the Table 1-1 below along with their planned in-service date.

Table 1-1. Recommended Plans in Greater Ottawa over the Next 10 Years.

No	Need	Recommended action plan	Expected I/S
1	Lincoln Heights TS: End of life of transformers T1/T2.	Replace end of life equipment.	2023
2	Longueuil TS: End of life of transformers T3/T4.	Replace end of life equipment.	2024
3	Riverdale TS: End of life of 115 kV breakers.	Replace end of life equipment.	2024
4	Transformation Capacity in South East Ottawa.	Hydro Ottawa to proceed with building transformer station.	2025
5	Albion TS: End of life of transformers T1/T2 and circuit breakers.	Replace end of life equipment.	2026
6	Russell TS: End of life of transformers T1/T2.	Replace end of life equipment.	2026
7	Overbrook TS: Station capacity.	Determine limitation of LV cables.	2021
		Upgrade cables or implement load transfers.	2026
8	Hawkesbury MTS: Capacity upgrade.	Hydro Hawkesbury to proceed with upgrade.	2026
9	Bilberry Creek TS: End of life of transformers T1/T2 and LV circuit breakers. Addition of two new LV circuit breakers for Hydro Ottawa.*	Install two new LV circuit breakers.	2024
		Replace end of life equipment.	2028
10	Merivale TS: Autotransformation capacity and end of life of T22, 230 kV breakers, 115 kV breakers.	Replace T22.**	2025
		Review recommendations of Ottawa 115 kV System Supply and Gatineau Corridor EOL studies to develop plan for Merivale TS.	2028

NOTES:

* Addition of two new breakers can be expedited following a formal request from Hydro Ottawa.

** Replacement of T22 with like for like transformer planned for completion by 2025. Inputs from the Gatineau Corridor EOL study and Ottawa 115 kV study may impact the timing of the replacement.

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1. INTRODUCTION

THIS REPORT PRESENTS THE REGIONAL INFRASTRUCTURE PLAN ("RIP") TO ADDRESS THE ELECTRICITY NEEDS OF THE GREATER OTTAWA REGION.

The report was prepared by Hydro One Networks Inc. ("Hydro One") on behalf of the Study Team that consists Hydro One, Hydro One Inc. (Distribution), Hydro Hawkesbury Inc. ("Hydro Hawkesbury"), Hydro Ottawa Limited ("Hydro Ottawa") and the Independent Electricity System Operator ("IESO") in accordance with the Regional Planning process established by the Ontario Energy Board ("OEB") in 2013.

The Greater Ottawa Region covers the municipalities bordering the Ottawa River from Arnprior in the West to Hawkesbury in the East and North of County Road 43 (Highway 43). At the center of this region is the City of Ottawa. Electrical supply to the Region is provided from fifty-two 230 kV and 115 kV step-down transformer stations. The boundaries of the Region are shown in Figure 1-1 below. The outer regions are referred to as the East and West Outer Ottawa sub-regions. The central region comprising of City of Ottawa is referred to as the Ottawa sub-region.

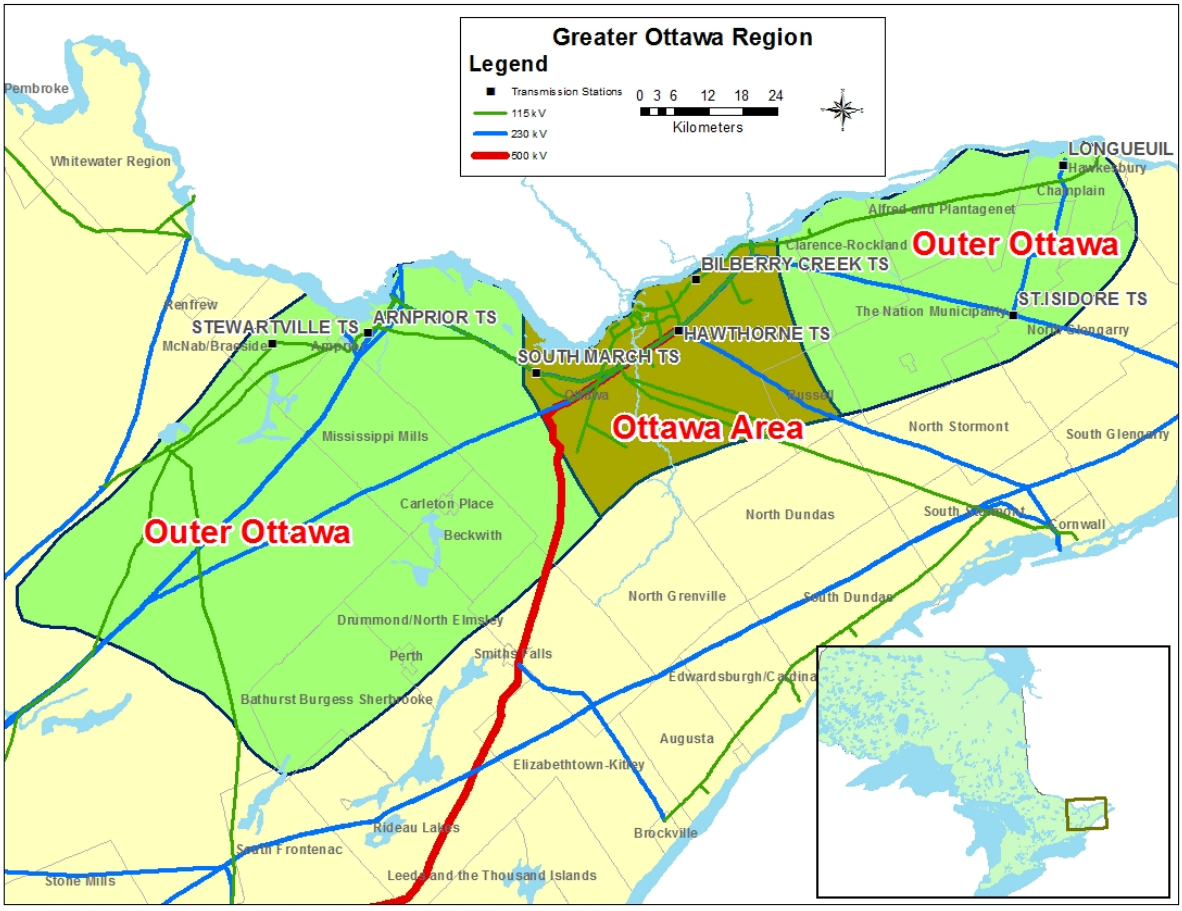

Figure 1-1 Greater Ottawa Region

1.1 Objectives and Scope

This RIP report examines the needs in the Greater Ottawa Region. Its objectives are to:

- Provide a comprehensive summary of needs and wires plans to address the needs;
- Identify any new needs that may have emerged since previous planning phases e.g., Needs Assessment ("NA"), Scoping Assessment ("SA"), and/or Integrated Regional Resource Plan ("IRRP");
- Assess and develop a wires plan to address these needs; and
- Identify investments in transmission and distribution facilities or both that should be developed and implemented on a coordinated basis to meet the electricity infrastructure needs within the region.

The RIP reviewed factors such as the load forecast, major high voltage sustainment issues emerging over the near, mid- and long-term horizon, transmission and distribution system capability along with any updates to local plans, conservation and demand management ("CDM") forecasts, renewable and non-renewable generation development, and other electricity system and local drivers that may impact the need and alternatives under consideration.

The scope of this RIP is as follows:

- A consolidated report of the needs and relevant plans to address near and medium-term needs identified in previous planning phases (Needs Assessment, Scoping Assessment, Local Plan or Integrated Regional Resource Plan).
- Identification of any new needs and wires plans to address these needs based on new and/or updated information.
- Develop a plan to address any longer term needs identified by the Study Team.

1.2 Structure

The rest of the report is organized as follows:

- Section 2 provides an overview of the regional planning process.
- Section 3 describes the regional characteristics.
- Section 4 describes the transmission work completed over the last ten years.
- Section 5 describes the load forecast and study assumptions used in this assessment.
- Section 6 describes the adequacy of the transmission facilities in the region over the study period.
- Section 7 discusses the needs and provides the alternatives and preferred solutions.
- Section 8 provides the conclusion and next steps.

2. REGIONAL PLANNING PROCESS

2.1 Overview

Planning for the electricity system in Ontario is done at three levels: bulk system planning, regional system planning, and distribution system planning. These levels differ in the facilities that are considered and the scope of impact on the electricity system. Planning at the bulk system level typically looks at issues that impact the system on a provincial level, while planning at the regional and distribution levels looks at issues on a more regional or localized level.

Regional planning looks at supply and reliability issues at a regional or local area level. Therefore, it largely considers the 115 kV and 230 kV portions of the power system that supply various parts of the province.

2.2 Regional Planning Process

A structured regional planning process was established by the Ontario Energy Board ("OEB") in 2013 through amendments to the Transmission System Code ("TSC") and Distribution System Code ("DSC"). The process consists of four phases: the Needs Assessment [1] ("NA"), the Scoping Assessment ("SA"), the Integrated Regional Resource Plan ("IRRP"), and the Regional Infrastructure Plan ("RIP").

The regional planning process begins with the NA phase, which is led by the transmitter to determine if there are regional needs. The NA phase identifies the needs and the Study Team determines whether further regional coordination is necessary to address them. If no further regional coordination is required, further planning is undertaken by the transmitter and the impacted local distribution company ("LDC") or customer and develops a Local Plan ("LP") to address them.

In situations where identified needs require coordination at the regional or sub-regional levels, the IESO initiates the SA phase. During this phase, the IESO, in collaboration with the transmitter and impacted LDCs, reviews the information collected as part of the NA phase, along with additional information on potential non-wires alternatives, and makes a decision on the most appropriate regional planning approach. The approach is either a RIP, which is led by the transmitter, or an IRRP, which is led by the IESO. If more than one sub-region was identified in the NA phase, it is possible that a different approach could be taken for different sub-regions.

The IRRP phase will generally assess infrastructure (wires) versus resource (CDM and Distributed Generation) options at a higher or more macro level, but sufficient to permit a comparison of options. If the IRRP phase identifies that infrastructure options may be most appropriate to meet a need, the RIP phase will conduct detailed planning to identify and assess the specific wires alternatives and recommend a preferred wires solution. Similarly, resource options that the IRRP identifies as best suited to meet a need are then further planned in greater detail by the IESO. The IRRP phase also includes IESO led stakeholder

[1] Also referred to as Needs Screening

engagement with municipalities, Indigenous communities, business sectors and other interested stakeholders in the region.

The RIP phase is the fourth and final phase of the regional planning process and involves: discussion of previously identified needs and plans; identification of any new needs that may have emerged since the start of the planning cycle; and development of a wires plan to address the needs where a wires solution would be the best overall approach. This phase is led and coordinated by the transmitter and the deliverable is a comprehensive report of a wires plan for the region. Once completed, this report is also referenced in transmitter's rate filing submissions and as part of LDC rate applications with a planning status letter provided by the transmitter.

To efficiently manage the regional planning process, Hydro One has been undertaking wires planning activities in collaboration with the IESO and/or LDCs for the region as part of and/or in parallel with:

- Planning activities that were already underway in the region prior to the new regional planning process taking effect;
- The NA, SA, and LP phases of regional planning;
- Participating in and conducting wires planning as part of the IRRP for the region or sub-region;
- Working and planning for connection capacity requirements with the LDCs and transmission connected customers.

Figure 2-1 illustrates the various phases of the regional planning process (NA, SA, IRRP, and RIP) and their respective phase trigger, lead, and outcome.

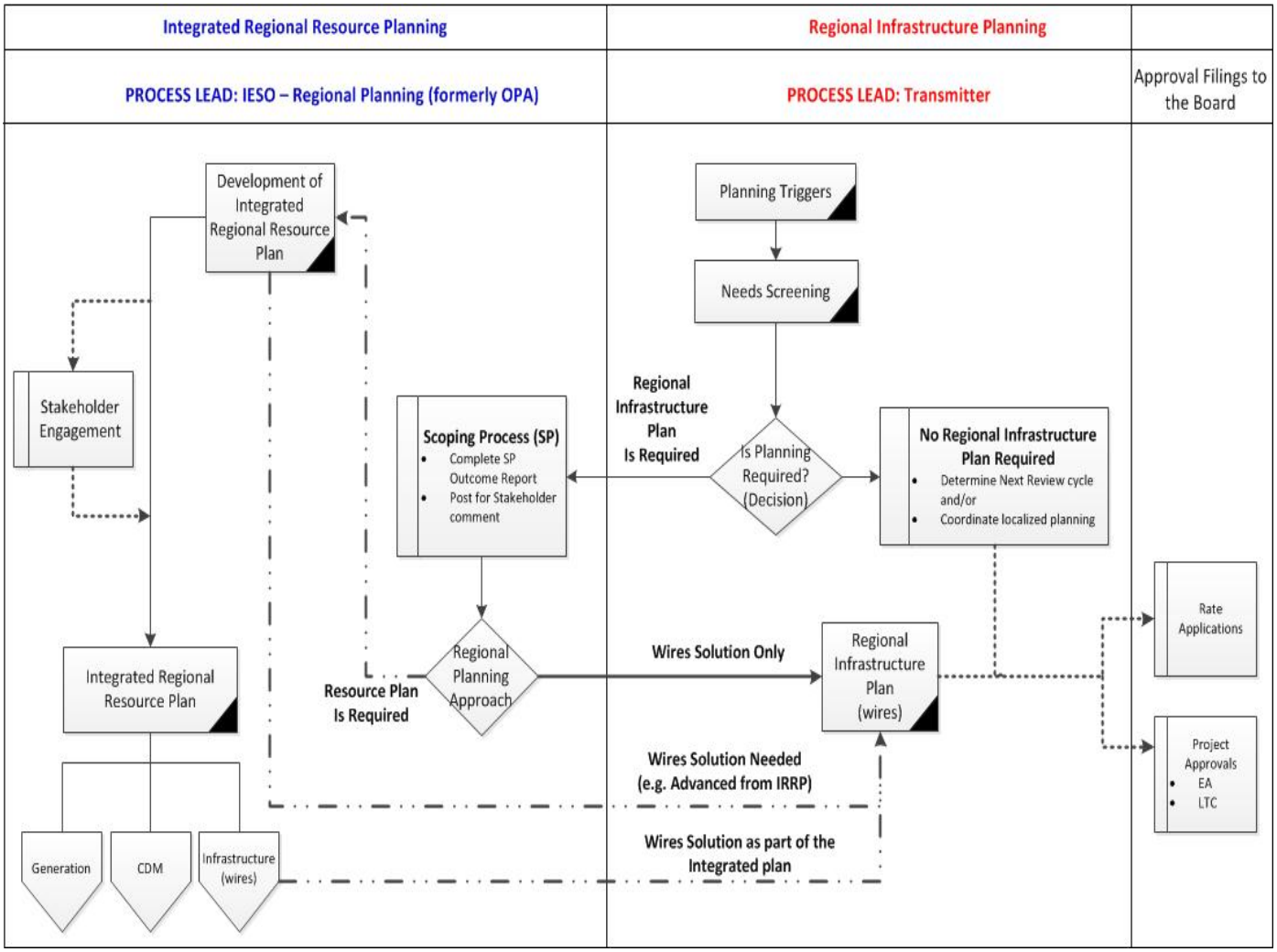

Figure 2-1 Regional Planning Process Flowchart

2.3 RIP Methodology

The RIP phase consists of a four step process (see Figure 2-2) as follows:

1. Data Gathering: The first step of the process is the review of planning assessment data collected in the previous stages of the regional planning process. Hydro One collects this information and reviews it with the Working Group to reconfirm or update the information as required. The data collected includes:
   - Peak demand forecast at the transformer stations. This includes the effect of any distributed generation or conservation and demand management programs. The load forecasts from the NA and IRRP were reviewed before the start of the RIP against the actual historical peak loading observed in 2018 and 2019. The working group chose to readjust the load forecast for some stations and incorporate updated CDM values for all stations.
   - Existing area network and capabilities including any bulk system power flow assumptions.

- Other data and assumptions as applicable such as asset conditions; load transfer capabilities, and previously committed transmission and distribution system plans.

2. Technical Assessment: The second step is a technical assessment to review the adequacy of the regional system including any previously identified needs. Depending upon the changes to load forecast or other relevant information, regional technical assessment may or may not be required or be limited to specific issue only. Additional near and mid-term needs may be identified in this phase.
3. Alternative Development: The third step is the development of wires options to address the needs and to come up with a preferred alternative based on an assessment of technical considerations, feasibility, environmental impact and costs.
4. Implementation Plan: The fourth and last step is the development of the implementation plan for the preferred alternative.

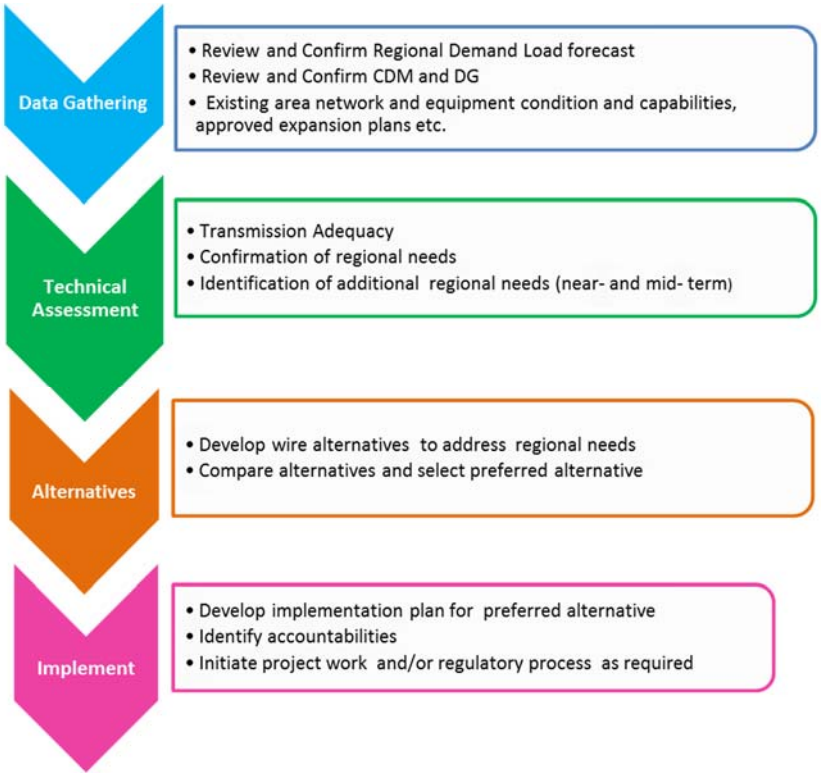

Figure 2-2 RIP Methodology

3. REGIONAL CHARACTERISTICS

THE GREATER OTTAWA REGION COVERS THE MUNICIPALITIES BORDERING THE OTTAWA RIVER FROM ARNPRIOR IN THE WEST TO HAWKESBURY IN THE EAST AND NORTH OF HIGHWAY 43. AT THE CENTER OF THIS REGION IS THE CITY OF OTTAWA (SEE FIGURE 3-1). ELECTRICAL SUPPLY TO THE REGION IS PROVIDED FROM FIFTY-TWO 230 KV AND 115 KV STEP-DOWN TRANSFORMER STATIONS.

Bulk electrical supply to the Greater Ottawa Region is provided through the 500/230 kV Hawthorne TS and a network of 230 kV and 115 kV transmission lines and step-down transformation facilities. The area has been divided into two sub-regions as shown in Figure 1-1 and described below:

- The Ottawa Sub-Region comprises primarily the City of Ottawa. It is supplied by two 230/115 kV autotransformer stations (Hawthorne TS and Merivale TS), eight 230 kV and thirty-three 115 kV transformer stations stepping down to a lower voltage. Local generation in the area consists of the 70 MW Ottawa Health Science Non-Utility Generator ("NUG") located near the downtown area and connected to the 115 kV network. The Ottawa Sub-Region is shown in Figure 3-1 below.

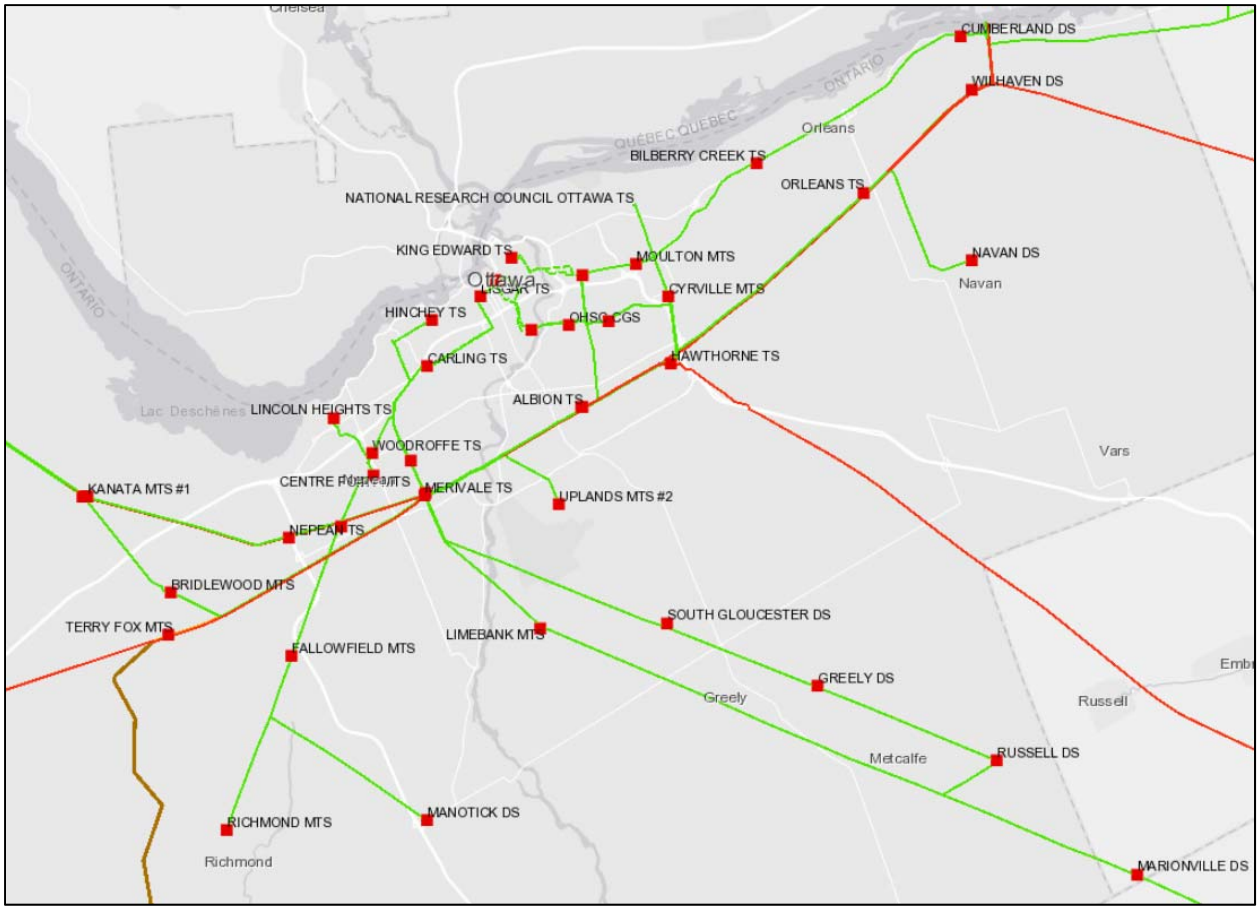

Figure 3-1 Ottawa Sub-Region

Hydro Ottawa is the main LDC that serves the electricity demand for the City of Ottawa. Hydro One Distribution supplies load in the outlying areas of the sub-region. Both Hydro Ottawa and Hydro One Distribution receive power at the step-down transformer stations and distribute it to the end users, i.e. industrial, commercial and residential customers.

- The Outer Ottawa Sub-Region covers the remaining area of the Greater Ottawa Region. The eastern area (shown in Figure 3-2) is served by three 230 and five 115 kV step-down transformer stations. Hydro One Distribution and Hydro Hawkesbury are the LDCs in the area that distribute power from the stations to the end use customers. It also includes a large industrial customer, Ivaco Rolling Mills, in L'Orignal, Ontario.

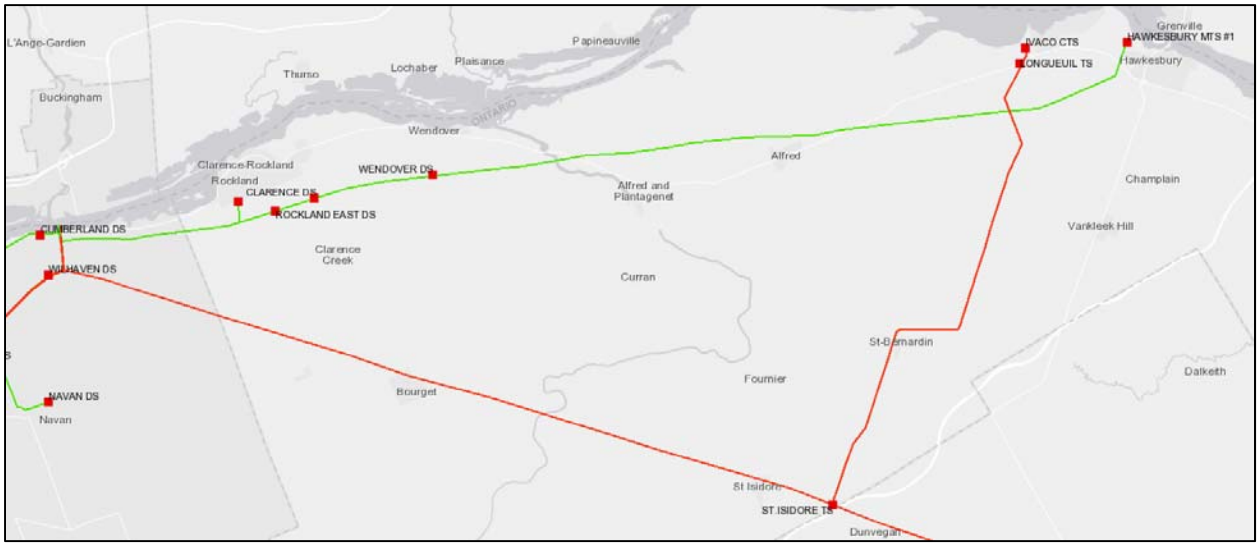

Figure 3-2 Outer Ottawa Sub-Region, Eastern Area

The western area of the Outer Ottawa Sub-Region is served by one 230 kV and two 115 kV step-down transformer stations. Hydro One Distribution is the LDC that supplies end use customers for these stations. The area includes the following generating stations: Barrett Chute GS, Chats Falls GS and Stewartville GS with a peak generation capacity of about 450 MW.

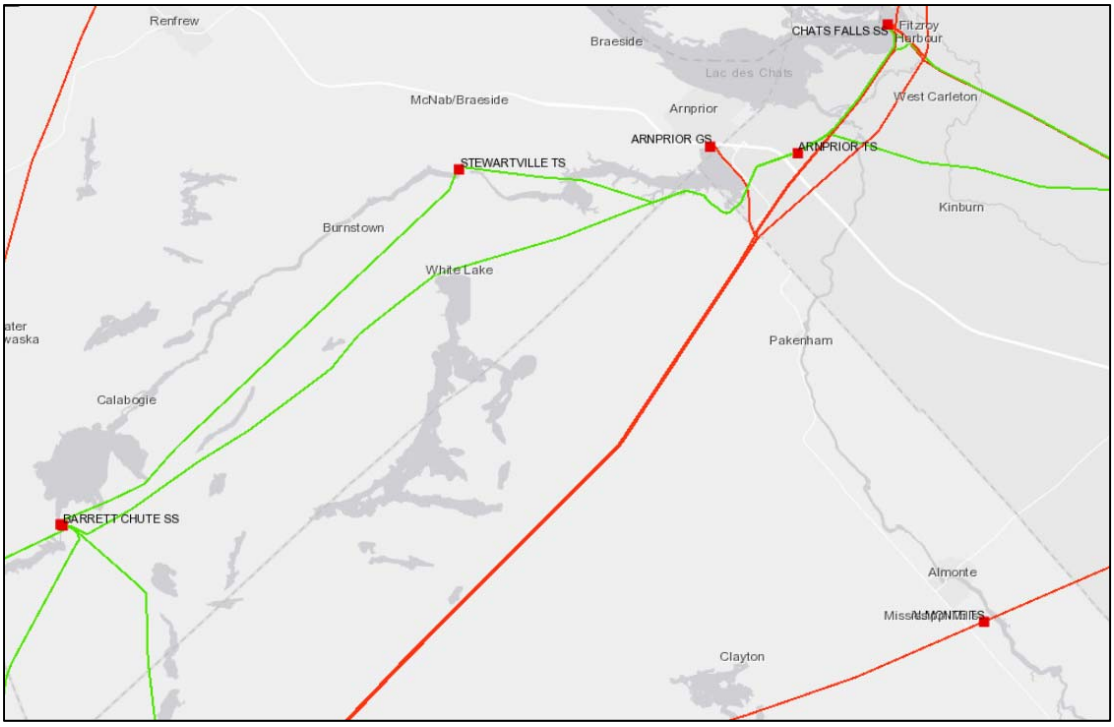

Figure 3-3 Outer Ottawa, Western Area

An electrical single line diagram for the Greater Ottawa Region facilities is shown in Figure 3-4.

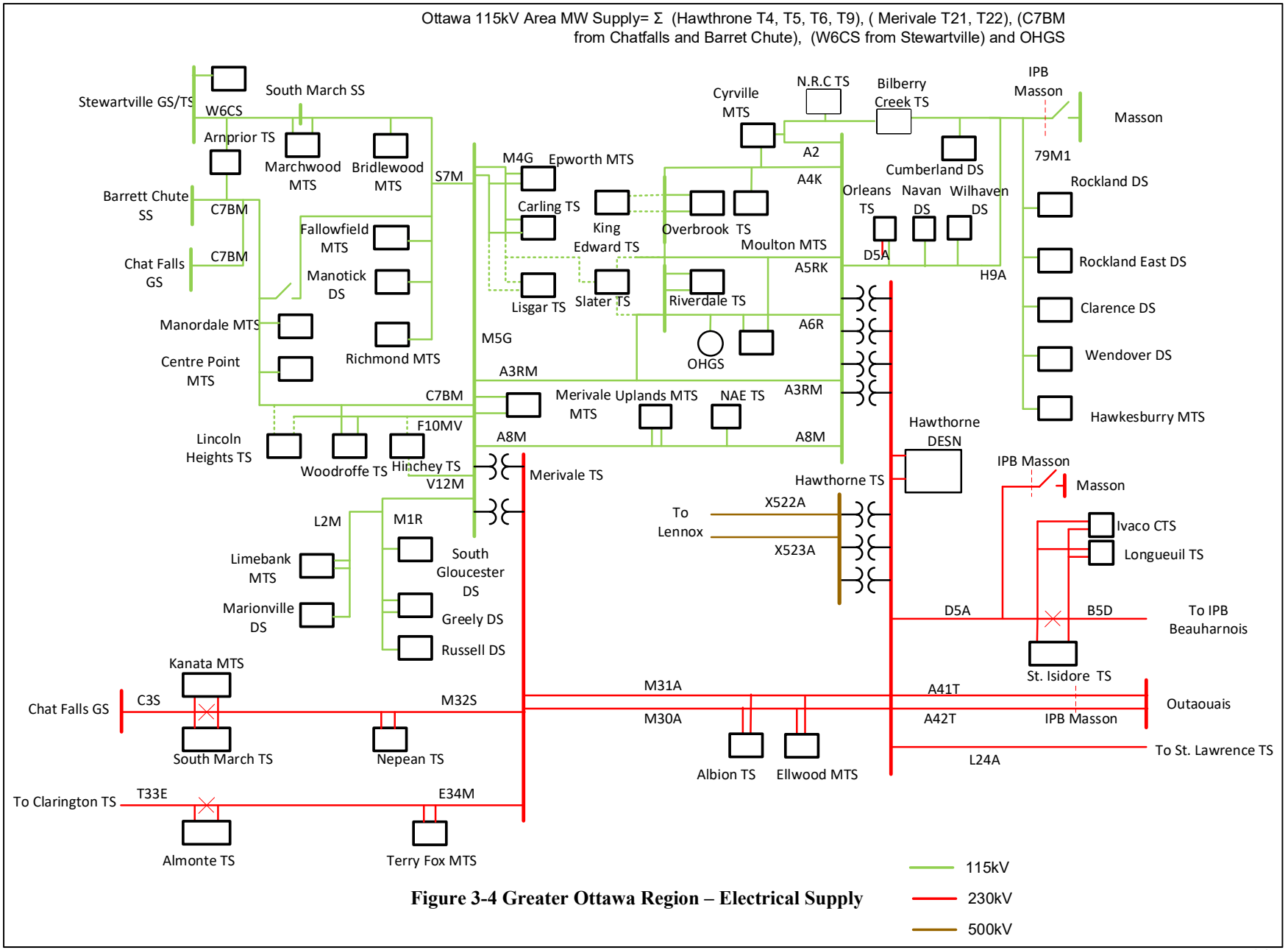

Figure 3-4 Greater Ottawa Region – Electrical Supply

4. TRANSMISSION FACILITIES/PROJECTS COMPLETED AND/OR UNDERWAY OVER THE LAST TEN YEARS

OVER THE LAST TEN YEARS, A NUMBER OF TRANSMISSION PROJECTS HAVE BEEN PLANNED AND UNDERTAKEN BY HYDRO ONE AIMED TO MAINTAIN THE RELIABILITY AND ADEQUACY OF ELECTRICITY SUPPLY TO THE GREATER OTTAWA REGION.

A summary and description of the major projects completed over the last 10 years is provided below:

- Connect Ellwood MTS (2012) – connected new Hydro Ottawa owned Ellwood MTS to 230 kV circuits M30A and M31A.
- Connect Terry Fox MTS (2013) – connected new Hydro Ottawa owned Terry Fox MTS to 230 kV circuit E34M (formerly M29C).
- Hawthorne TS 115 kV switchyard Upgrade (2014) – replaced 115 kV breakers with inadequate short circuit capability with new breakers of higher short circuit capability. This work improved system reliability by allowing 115kV switchyards to be operated with bus tie closed. This work also facilitated incorporation of DG in the Ottawa area.
- Build new Orleans TS (2015) – built a new step-down transformer station in East Ottawa supplied from 230 kV circuit D5A and 115 kV circuit H9A. This station provides additional load meeting capability to meet Hydro One Distribution and Hydro Ottawa requirements. It provides improved reliability for Hydro One Distribution customers in the Orleans-Cumberland area.
- Hinchey TS (2015) – Connected idle winding of transformers T1/T2 to new Hydro Ottawa metalclad switchgear to provide additional load meeting capability at the station.
- Add 230 kV inline breaker on 230 kV circuit M29C at Almonte TS (2015) – added breaker to improve reliability of supply for Almonte TS and Terry Fox MTS and split line M29C into E34M and E29C (now T33E).
- Overbrook TS (2017): Replaced 45/60/75 MVA, 115/13.8 kV step down transformers with new 60/80/100 MVA, 115/13.8 kV – replaced end-of-life transformers with higher capacity units to provide additional load meeting capability at the station due to anticipated load growth.
- Hawthorne TS (2019): Replaced 50/67/83 MVA, 230/44 kV step down transformers with new 75/100/125 MVA, 230/44 kV units – replaced end-of-life transformers with higher capacity units to provide additional load meeting capability at the station due to anticipated load growth.

- Change supply to Overbrook TS (2019) – Reduced the loading on A4K by modifying the supply to Overbrook TS by connecting transformer T1 to A6R instead of A4K. This was accomplished by rebuilding the line section of A5RK from Riverdale JCT to Overbrook TS as a double circuit 115 kV line and tapping A6R at Riverdale JCT.

- Connection of Crysler CGS wind farm (2020) – connection of 100 MW wind farm to 230 kV circuit L24A.

The following projects are currently underway:

- Hawthorne TS: Replace 225 MVA, 230/115 kV autotransformers T5 and T6 with new 250 MVA, 230/115 kV autotransformers (2021) to provide additional 230/115 kV transformation capacity – autotransformer T6 has been replaced and T5 replacement is expected to be completed in 2021.

- King Edward TS (2021): Replace 45/60/75 MVA, 115/13.8 kV step down transformer T3 with a new 60/80/100 MVA, 115/13.8 kV unit – the existing transformer is being replaced with a new higher capacity unit to match the existing rating of T4 and to provide additional load meeting capability at the station.

- Cambrian MTS and South Nepean Transmission reinforcement (2022) – Connection of a new Hydro Ottawa owned station in the south Nepean area. The station will normally be supplied by 230 kV circuit E34M with alternate supply from 115 kV circuit S7M. To connect this project, the section of S7M (single circuit 115 kV line) from Hunt Club road (STR673JCT) to Manotick JCT, and from Manotick JCT to Cambrian Road will be rebuilt as a double circuit 230 kV line. At STR673JCT, the new double circuit will connect to both S7M (to continue the supply to the area stations) and to E34M to supply the new Cambrian MTS. The two circuits will be extended for about 1.3km along Cambrian road to supply the new MTS.

- Slater TS (2023): Replace 45/75 MVA, 115/13.8 kV step down transformers T2 and T3 with new 60/80/100 MVA, 115/13.8 kV units – the existing transformers are being replaced with new units with higher rated capacity to match the rating of T1 and to provide additional load meeting capability at the station.

- Rebuilding Arnprior TS (2023) – A station rebuild at Arnprior TS is underway with replacement of existing 25/33/42 MVA step down transformers with new 25/33/42 MVA units and building of a new 44 kV switchyard to supply the station load.

- M30A/M31A circuit upgrade (2023) – reconductor 230 kV circuits M30A and M31A between Hawthorne TS and Merivale TS with twin-bundled conductors to increase the circuit ratings. The existing 1843.2kcmil conductors will be replaced with a twin-bundled 1443kcmil conductors. This work is expected to increase the interface limit from 648 MW to 1080 MW.

5. FORECAST AND OTHER STUDY ASSUMPTIONS

5.1 Load Forecast

The electricity demand in the Greater Ottawa Region is anticipated to grow at an average rate of 2.0% between 2020 and 2025, 1.0% between 2026 and 2030 and 0.7% for the remainder of the study period.

Figure 5-1 shows the Greater Ottawa Region's net extreme summer peak coincident load forecast developed during the Outer Ottawa NA and Ottawa IRRP processes and updated in the RIP phase. The updated forecast also takes into account the most recent conservation programs and distributed generation resources assumptions. This forecast was used to determine any transmission system needs in the region. The forecast shows that the Region peak summer load increases from 2149 MW in 2020 to 2502 MW in 2030 and 2620 MW in 2037. The RIP load forecasts for the individual stations in the Greater Ottawa Region is given in Appendix D.

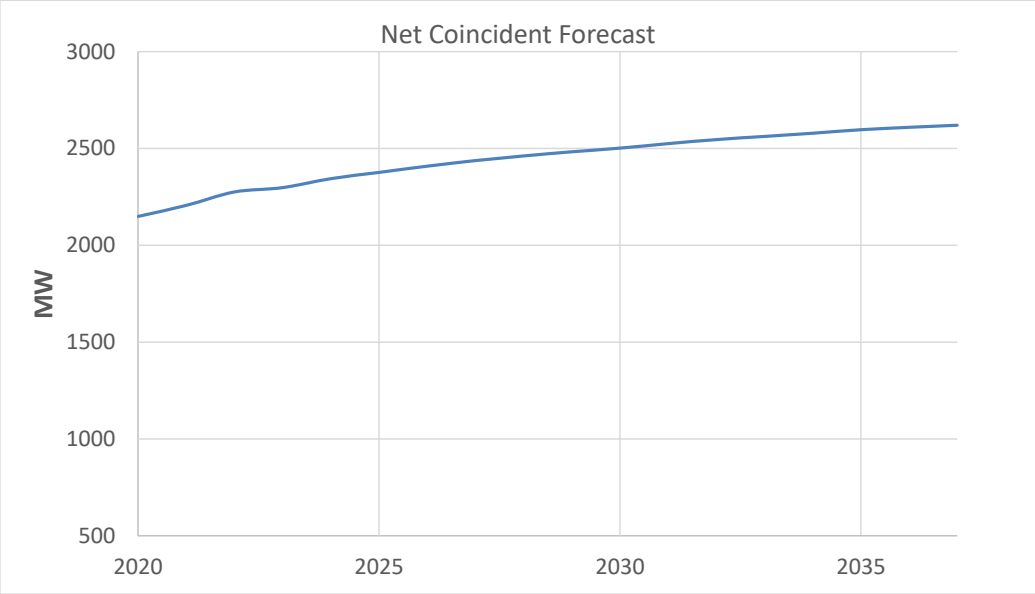

Figure 5-1 Greater Ottawa Region Summer Net Extreme Weather Forecast

5.2 Other Study Assumptions

The following other assumptions are made in this report.

- The study period for the RIP adequacy assessment is 2020-2037.
- All planned facilities for which work has been initiated and are listed in Section 4 are assumed to be in-service.
- Summer is the critical period with respect to line and transformer loadings. The assessment is based therefore based on summer peak loads.

- Station capacity adequacy is assessed by comparing the load forecast with the station's normal planning supply capacity, assuming a 90% lagging power factor for all stations at the point of connection to the transmission grid. Normal planning supply capacity for transformer stations in this region is determined by the summer 10-Day Limited Time Rating (LTR).
- Output of generating stations in the area is based on 98% dependable generation availability for transmission connected run of river hydro-electric stations as per Ontario Resource Transmission Assessment Criteria (ORTAC) criteria.
- Adequacy assessment is conducted as per ORTAC.

6. ADEQUACY OF EXISTING FACILITIES

THIS SECTION REVIEWS THE ADEQUACY OF THE EXISTING TRANSMISSION AND TRANSFORMER STATION FACILITIES SUPPLYING THE GREATER OTTAWA REGION OVER THE PLANNING PERIOD (UP TO 2037). ALL PROJECTS CURRENTLY UNDERWAY ARE ASSUMED IN-SERVICE.

Within the current regional planning cycle two regional assessments have been conducted for the Greater Ottawa Region. The findings of these studies are inputs to this Regional Infrastructure Plan. These studies are:

- 2018 Outer Ottawa Sub-region Needs Assessment ("NA") Report
- 2020 Ottawa Sub-region Integrated Regional Resource Plan ("IRRP") and Appendices

This section provides a review of the adequacy of the transmission lines and stations in the Greater Ottawa region including both the Outer Ottawa and City of Ottawa sub-regions. The adequacy is assessed using the latest regional load forecast provided in Appendix D and assumes all projects currently underway (described in section 4) are in-service. Sections 6.1 to 6.5 present the results of this review. End of life equipment needs were identified in previous phases of this regional planning cycle and are also addressed in Section 7 of this RIP report.

6.1 500 kV and 230 kV Transmission Facilities

All 500 kV and 230 kV transmission circuits in the Greater Ottawa Region are classified as part of the Bulk Electricity System ("BES"). They connect the Region to the rest of Ontario's transmission system and to the Hydro Quebec transmission system. A number of these circuits also serve local area stations within the region and the power flow on them depends on the bulk system transfers as well as local area loads. These circuits are as follows (refer to Figure 3-4):

1. Hawthorne TS to Merivale TS 230 kV transmission circuits M30A/M31A – supply Albion TS and Ellwood TS.
2. Hawthorne TS to Cornwall 230 kV transmission circuits D5A/B5D/B31L/L24A – supply Orleans TS, St. Isidore TS and Longueuil TS. Also connects to Hydro Quebec at Beauharnois Station and to Lievre Power at Masson GS.
3. Merivale TS to Chats Falls 230 kV transmission circuits M32S/C3S – supply Nepean TS, South March TS and Kanata MTS
4. Merivale TS x Cherrywood TS 230 kV transmission circuits E29C/E34M (M29C) – supply Terry Fox MTS and Almonte TS.

Circuits M30A/M31A were identified for reinforcement and the IESO provided a hand off letter to Hydro One to proceed with the upgrades in 2019. The upgrades to the circuits is expected to be completed in 2023. With the M30A/M31A reinforcement in-service in 2023, the circuits will be adequate over the study period.

Based on the revised load forecast for the RIP and the study assumptions stated in Section 5.2, all other 230 kV circuits are expected to be adequate over the study period.

6.2 230/115 kV Transformation Facilities

Almost sixty percent of the Region load is supplied from the 115 kV transmission system. The primary source of 115 kV supply is from 230/115 kV autotransformers at Hawthorne TS and Merivale TS. Additional support is provided from 115 kV generation at Barrett Chute GS, Stewartville GS, part of Chats Falls GS, and the Ottawa Health Science NUG and the Ottawa River generation at Chaudière. Support from DG and CDM was considered as part of the load forecast.

Table 6-1 summarizes the results of the adequacy studies and identifies the need dates for reinforcement of the 230/115 kV autotransformer facilities at Hawthorne TS and Merivale TS. Assuming no change in the system configuration the Limited Time Rating ("LTR") of the Merivale autotransformers, T21 and T22, are exceeded in 2020. The continuous rating of the Merivale autotransformers are exceeded by 2024/25 for T21 and T22 respectively.

The need dates are sensitive to the availability and dispatch of hydraulic generation from Barrett Chute GS, Stewartville GS and Chats Falls GS and are based on 98% dependable generation availability as per ORTAC criteria. This corresponds to about 31 MW of available generation. A higher level of generator output and dispatch from these stations would defer the need dates. Voltage support is provided by some generating units used as synchronous condensers at Stewartville GS and Barrett Chute GS.

Replacement of autotransformer T6 at Hawthorne TS was completed in 2017 and T5 is undergoing replacement with a projected in-service date in Q2 2021. The need dates assume that the Hawthorne TS 225 MVA, 230/115 kV autotransformer T6 have been replaced with new 250 MVA unit.

Table 6-1 Adequacy of 230/115 kV Autotransformer Facilities

Overloaded Facilities	2020 MVA Loading	MVA Load Meeting Capability	Limiting Contingency	Need Date
Merivale TS 230/115 kV autotransformer T21	353	347[1]	T22	2020
Merivale TS 230/115 kV autotransformer T22	347	315[1]	T21	2020
Merivale TS 230/115 kV autotransformer T21	255	250	[2]	2024
Merivale TS 230/115 kV autotransformer T22	252	250	[2]	2025

[1] Limited time rating exceeded.

[2] Continuous rating exceeded with all elements in service based on existing system configuration

6.3 115 kV Transmission Facilities

The Greater Ottawa Region 115 kV transmission facilities can be divided in five main sections: Please see Figure 3-4 for the single line diagram.

1. Hawthorne 115 kV Center – has four circuits A3RM, A4K, A5RK and A6R. Circuit A4K approaches but does not exceed its LTR upon the loss of A6R in the long term horizon. This will be re-assessed in the next Regional Planning cycle. All circuits are adequate for the study period.
2. Hawthorne 115 kV East – has two circuits A2 and H9A/79M1. These are expected to be adequate over the study period.
3. Merivale 115 kV Center – has two circuits M4G and M5G. These are expected to be adequate over the study period.
4. Merivale 115 kV West – has five circuits C7BM, F10MV, S7M, V12M and W6CS. These are expected to be adequate over the study period. In the long term, C7BM was observed to approach its LTE limit for the loss of F10MV. Similarly S7M section from STR654 JCT to Bridlewood JCT also approaches its LTE for the loss of C7BM. It should be noted that Kanata area growth will likely result in a new 230 kV station which may impact the loading of the stations supplied by S7M. No violations were observed in the study period. The loading on these circuits will be re-evaluated in the next regional planning cycle.
5. Merivale 115 kV South – has two circuits L2M and M1R. Circuit L2M exceeds its continuous rating in the medium term. The need and recommendation are discussed in Section 7.4 and the area is shown in Figure 7-3.

The loading on the limiting sections is summarized in Table 6-2.

Table 6-2 Adequacy of 115 kV Circuits

Corridor	Section	Overloaded Circuit	Rating (A)	Contingency	2020 Loading (A)	Need Date
1. Merivale to Chesterville TS	Merivale x Limebank JCT	L2M	480	continuous loading	390	2028

6.4 Step-Down Transformation Facilities

There are a total of fifty-two step-down transmission connected transformer stations in the Greater Ottawa Region. The stations have been grouped based on the geographical area and supply configuration. The station loading in each area and the associated station capacity and need date for relief is provided in Table 6-3 below. However considerations such as feasibility of load transfers will also impact the transformation capacity need within a region. As shown, areas requiring additional transformation capacity are the Center 230/44 kV area, and the South 115 kV. Table 6-4 shows station loads for all areas which are adequate over the 2020-2037 study period. Details of the areas and associated stations are given in Appendix D.

Table 6-3 Adequacy of Step-Down Transformer Stations - Areas Requiring Relief

Area/Supply	Capacity (MW)	2020 Loading (MW)	Need Date
Center 230/44 kV	143	115	2026
South 115	189	137	2029

Table 6-4 Adequacy of Step-Down Transformer Stations – Areas Adequate

Area/Supply	Capacity (MW)	2020 Loading (MW)	2037 Loading (MW)
East 115 kV	358	178	257
West 115 kV	453	346	398
Center 115 kV	574	487	559
South West 115 kV	98	67	65
Center 230/13.8 kV	134	96	97
West 230 kV	474	356	440
Outer East 115 kV	55	45	53
Outer West 115 kV	97	71	71
Outer East 230 kV	301	163	186
Outer West 230 kV	104	43	44

6.5 Load Restoration

Load restoration describes the electricity system's ability to restore power to a customer affected by a transmission outage within specified time frames. Both transmission and distribution (transfers) measures are considered when evaluating restoration capability. The load restoration criteria is defined in ORTAC and summarized in Figure 6-1.

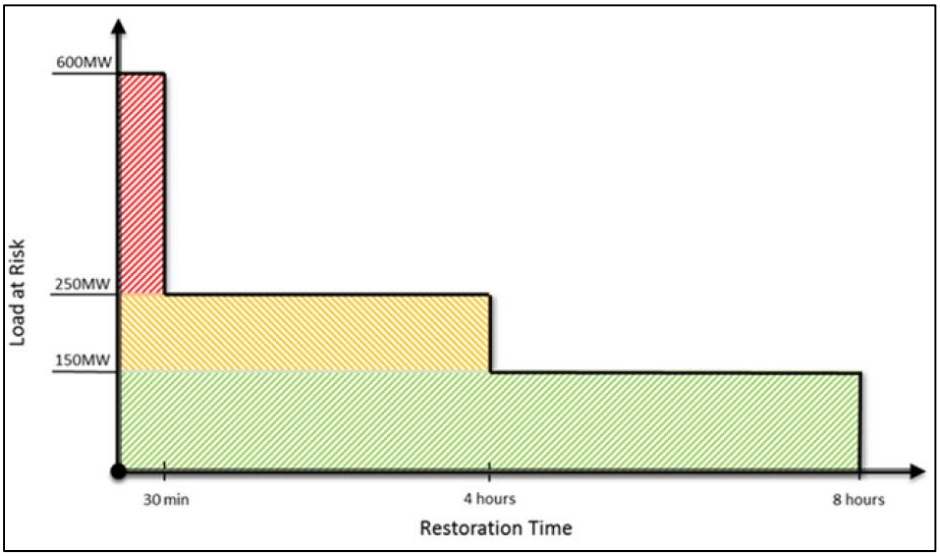

Figure 6-1. Illustration of ORTAC restoration criteria.

6.5.1 Load Restoration for M4G/M5G

Load restoration was assessed for 115 kV double circuit line M4G/M5G supplying stations Nepean Epworth MTS, Carling TS, and Lisgar TS in downtown Ottawa. Circuit M4G also supplies Slater TS, however this station is not considered in this analysis as this station is also fed from two different circuits. In case of a loss of both M4G and M5G, up to 165 MW can be lost. As per ORTAC, 15 MW have to be restored in 4 hours, and the remaining load in 8 hours. Hydro One expects that at least one of the overhead line can be restored in 4 hours for outages not caused by force majeure. The Study Team recommends that no further action is required at this time.

6.5.2 Load Restoration for C3S/M32S

M32S is a 230 kV circuit connecting Merivale TS to South March TS, and 230 kV circuit C3S connecting Chats Falls SS to South March TS. The two circuits are connected through an in-line breaker A1A2 at South March TS. Stations South March TS and Kanata MTS are supplied by both C3S and M32S. Nepean TS is only fed from circuit M32S. Load restoration was assessed for A1A2 breaker fail. The breaker fail condition can lead to no supply to all three stations. The loss of the two circuits results in approximately 300 MW of load loss. As per ORTAC, 50 MW have to be restored in 30 minutes, 150 MW restored in 4 hours and the entire load in 8 hours. Nepean TS can be restored by opening circuit switcher M32S-1 within 30 minutes. The breaker A1A2 disconnect switches at South March TS can be opened within 30 minutes to restore load

stations from either C3S or M32S. All load can be restored within 4 hours. The Study Team recommends that no further action is required at this time.

6.5.3 Load Restoration for S7M

Circuit S7M and W6CS are tie via an in-line breaker L6L7 at South March SS. A L6L7 breaker failure results in no supply to Fallowfield MTS, Richmond MTS, Manotick DS, Bridlewood MTS, and Marchwood MTS. The amount of load loss is about 152 MW by the end of the study period. As per ORTAC, all load above 150 MW must be restored in 4 hours and all load restored in 8 hours. All load can be restored by opening breaker L6L7 disconnect switches at South March SS within 4 hours. The Study Team recommends that no further action is required at this time.

6.5.4 Load Restoration for D5A/B5D

Circuits D5A and B5D supply Longueuil TS, St Isidore TS, and Ivaco CTS. The worst contingency for the area can result in approximately 187 MW of load loss. Hydro One prepared a Local Planning report during the previous cycle of Regional Planning. The report considered the loss of up to 174 MW of load for the same contingency. Hydro One has reviewed the report and determined that the conclusions of the report are still applicable to the new load forecast. The report shows that all load can be restored in at least 4 hours, meeting ORTAC restoration criteria. The Study Team recommends that no further action is required at this time.

7. REGIONAL PLANS

This section discusses electrical infrastructure needs in Greater Ottawa Region, and presents wires alternatives and preferred wires solution for addressing these needs. Table 7-1 lists needs previously identified in the IRRP for the Ottawa Sub-Region [1] and the NA for the Outer Ottawa Sub-Region [2] as well as the adequacy assessment carried out as part of this RIP report.

Table 7-1: Identified Near and Mid-Term Needs in Greater Ottawa Region

Need Type	Section	Station/Circuit/Area	Timing
Area Capacity	7.1	South East Ottawa	Near Term
	7.2	Kanata-Stittsville Area	Near Term
Station Capacity	7.3.1	Orleans TS	Near Term
	7.3.2	Hawthorne TS	Medium Term
	7.3.3	Overbrook TS	Medium Term
Development & Sustainment	7.4	Transmission circuit L2M supply capacity	Medium Term
	7.5	Merivale TS: Autotransformation capacity and end of life of T22, 230 kV breakers, 115 kV breakers	Medium Term
	7.6	Bilberry Creek TS: End of life of transformers T1/T2 and LV circuit breakers and addition of two new LV circuit breakers for Hydro Ottawa	Near/Medium Term
Voltage Regulation	7.7	Circuit 79M1	NA
	7.8	Circuit E34M	NA
Station Capacity/ Sustainment	7.9	Hawkesbury MTS	Medium Term
Sustainment	7.10	Lincoln Heights TS: End of life of transformers T1/T2	Near Term
	7.11	Longueuil TS: End of life of transformers T3/T4	Near Term
	7.12	Riverdale TS: End of life of 115 kV breakers	Medium Term
	7.13	Albion TS: End of life of transformers T1/T2 and circuit breakers	Medium Term
	7.14	Russell TS: End of life of transformers T1/T2	Medium Term

7.1 Transformation Capacity in South East Ottawa

7.1.1 Description

There is significant load growth expected on the 27.6 kV distribution system in the south eastern part of Ottawa. The anticipated load will be connected to Uplands MTS, Limebank MTS and Leitrim MS (supplied through 44 kV feeders from Hawthorne TS). The stations are shown in Figure 7-1. Based on the RIP load forecast and existing station capacity, the loading at Limebank MTS, Uplands MTS and Leitrim MS would exceed its respective station capacity in in the first year of the load forecast as shown in Table 7.2.

In preparation for the load growth, Hydro Ottawa has initiated projects to increase transformation capacity at Uplands MTS and Limebank MTS. The existing 33 MVA transformer at Uplands MTS is being replaced by two new 50 MVA units. The transformer unit removed from Uplands MTS will be added as a fourth unit at Limebank MTS. Both projects are expected to complete in 2021. The transformation capacity at Leitrim MS is limited by the supply capacity of the 44 kV M2 feeder out of Hawthorne TS. Even after increasing capacity at Limebank MTS and Uplands MTS there is need for additional transformation capacity in the region.

Table 7-2 Transformation Capacity in South East Area before upgrades or new station

Station	LTR (MW)	2020	2022	2025	2030	2037
Limebank MTS	59.4(1)	61.2	70.3	63.2	83.6	103.9
Uplands MTS	29.7(2)	32.2	39.9	56.3	59.0	61.8
Leitrim MS (from Hawthorne TS)	22.5	30.4	34.5	32.0	43.3	56.0

(1) (2) Current LTR at Limebank & Uplands MTS before upgrades

Figure 7-1 South East area. Approximate location of the proposed station on L24A shown.

7.1.2 Alternatives and Recommendation

The following alternatives were previously considered to address the capacity need:

1. **Alternative 1 – Maintain Status Quo:** This alternative is rejected as it does not address the need for greater transformation capacity in the region.
2. **Alternative 2 – New DESN at Hawthorne TS:** This alternative proposes to put a new DESN station at Hawthorne TS. Due to the high volume of lines and feeders, the station feeder egress is very congested. Feeder runs are also expected to be longer due to geographic location of the load. Due to the reasons provided, this alternative was considered, but rejected by the Study Team.
3. **Alternative 3 – New station on circuit L24A:** This alternative proposes to construct a new Hydro Ottawa owned transformer station approximately 9 km south of Hawthorne TS. This is an ideal location to supply the new load, minimizing feeder runs out of the station. This alternative also gives Hydro Ottawa the opportunity to further interconnect their distribution network in the area and allow for greater supply diversity to new loads. Revised loading for the stations in the area has been provided in Table 7-3 after the addition of the new station on circuit L24A. The capability of circuit L24A has been assessed and determined adequate to supply the new station load forecast under study assumptions stated in section 5.2.

Table 7-3 Transformation Capacity in South East Area – After upgrades and new L24A Station

Station	LTR (MW)	2020	2022	2025(1)	2030	2037
Limebank MTS	89.1(2)	61.2	70.3	65.3	89.1	94.1
Uplands MTS	54.0(3)	32.2	39.9	45.9	49.1	52.2
Leitrim MS (from Hawthorne TS)	22.5	30.4	34.5	4.9	10.9	16.3
New L24A Station	TBD	0	0	40.1	46.5	52.8

(1) Expected in-service year for new station on circuit L24A

(2) (3) LTR after transformer upgrades to Limebank & Uplands MTS

Considering the above alternatives, the study team recommends that Hydro Ottawa proceed with Alternative 3 – new station on circuit L24A. This reaffirms the recommendation made in the IRRP phase. The new station is expected to be in-service by 2025. Until the new station is built, Hydro Ottawa will manage any overloads by transferring loads between stations, as an interim solution. In addition, Hydro One Distribution's Greely DS can also supply approximately 10 MVA of Hydro Ottawa's load until the new station is built.

7.2 Kanata-Stittsville Transformation Capacity

7.2.1 Description

Situated in the outskirts of the city, the Kanata-Stittsville area is a growing part of the Ottawa region. The area is supplied by multiple stations including South March TS, Bridlewood MTS, Kanata MTS,

Marchwood MTS and Terry Fox MTS. Further increase in demand is anticipated in the area over the near and mid-term planning horizon. The new load is expected to connect to Hydro Ottawa's 27.6 kV distribution system supplied by stations Terry Fox MTS, Marchwood MTS and Kanata MTS, please refer to Figure 7-2.

The combined capacity of the three stations is exceeded in the first year of the forecast by 25 MW. This is slightly lower than the forecasted overload seen in the IRRP report. The overload gradually increases to 45 MW towards the end of the study period. Table 7-4 below shows the loading of the stations over the study period.

Table 7-4 Adequacy of Step-Down Transformer Stations – Kanata-Stittsville Area

Station	LTR (MW)	2020	2021	2025	2030	2037
Marchwood MTS	29.7	57.8	58.5	60.1	60.2	60.2
Kanata MTS	48.8	67.2	70.3	68.0	68.7	69.0
Terry Fox MTS	81	60.1	61.2	65.5	72.9	76.0
Grand Total	**160**	**185**	**190**	**194**	**202**	**205**

Figure 7-2. Kanata-Stittsville Area.

7.2.2 Alternatives and Recommendations

This near-term need can be managed via load transfers between stations until a permanent solution is implemented.

A potential solution identified in the IRRP report is to supply the overload in the area with a new station connected to the 230 kV network. Consistent with the IRRP review of the existing system capacity, the RIP

reaffirms the adequacy of the system to supply the new 230 kV station to alleviate the overloaded stations. The ongoing Gatineau Corridor EOL study for the supply into Ottawa region may recommend changes to the 230 kV system that might impact the supply to the new station. The Study Team recommends Hydro One and Hydro Ottawa to develop a wires plan in Q3 2021 to address this need based on the recommendation stemming from the Gatineau Corridor EOL study currently underway.

7.3 Station Capacity

7.3.1 Description

Based on the RIP load forecast, several transformer stations are expected to reach their transformation capacity limits. The Study Team has reviewed the transformation capacity and load transfer capability of each area and concluded that in most cases, the capacity is sufficient to address the load growth in the near to medium term.

A few stations were identified where the load growth in the near term was high and would need further review. These stations are discussed below.

7.3.2 Recommended Plan and Current Status

7.3.2.1 Hawthorne TS

The DESN station at Hawthorne TS starts to overload in 2026 by approximately 2 MW and reaches 32 MW by the end of the study period. This overload is attributed to the significant load growth experienced on Leitrim MS fed through a 44 kV feeder out of Hawthorne TS.

As discussed in section 7.1.1, the recommended plan for a new station on circuit L24A will relieve the stations in the south area of any overloads, including Hawthorne TS. Please refer to Table 7-3 to see how the load is being transferred out of Hawthorne TS. As an interim measure the overloading at Hawthorne TS will be managed by load transfers out of the station. Once the new station on L24A is in service it will alleviate the overloading experienced at Hawthorne TS.

7.3.2.2 Overbrook TS

Overbrook TS is 115/13.8 kV transformer station in east of the Ottawa downtown core. Over the past few years, the station's load was fairly stable. However over the next five years, load growth is forecasted to reach and surpass the station's transformation capacity.

A review of the station's LTR indicate that the 13.8 kV cables from the transformers to the 13.8 kV switchgear are limiting the transformation capacity of the station. The Study Team recommends that Hydro One to review the capacity of the 13.8 kV cables to determine the cause of the limitation in 2021. The findings will be discussed between Hydro One and Hydro Ottawa to determine next steps, which could include LV cable upgrades or implementation of new feeder ties to transfer load out of the station. The plan should be implemented by 2026 when station is expected to reach its capacity.

7.3.2.4 Orleans TS

Orleans TS is a transformer station that was placed in service in 2015 that supplies Hydro One Distribution and Hydro Ottawa. The station's load has grown significantly over the past 5 years due to load transfers and load growth in the area. Based on the forecast, the station's transformation capacity is expected to reach its limit in the near term, and the load is expected to continue to grow. An overload of approximately 15 MW is expected within the next 10 years.

Other stations in the area, including Bilberry Creek TS, have sufficient transformation capacity to address the overload seen at Orleans TS. Hydro One Distribution has confirmed that transfer capability is available to nearby stations Bilberry Creek TS, Wilhaven DS, and Navan DS. To accommodate Hydro Ottawa load transfers, two new feeder breakers may be required at Bilberry Creek TS by 2024. Please see Section 7.6 for further details on the Bilberry Creek TS plan.

The Study Team recommends to manage any overload at Orleans TS by load transfers to neighboring stations. This need will be re-evaluated in the next cycle.

7.4 115 kV Transmission Circuit L2M Supply Capacity

L2M is a 115 kV circuit supplying two stations in southern Ottawa from Merivale TS: Limebank MTS and Marionville DS. The circuit extend to St Lawrence TS 115 kV network via a normally opened point at Chesterville TS (fed from St Lawrence TS). Stations transfers between the Merivale L2M network and the St Lawrence L2M network is possible for operating measures. Limebank MTS and Marionville DS are normally radially supplied by L2M from Merivale TS. The circuit is thermally limited to approximately 86 MW. Circuit L2M and its connected stations is shown in Figure 7-3.

Figure 7-3. Limebank MTS and Marionville DS connection to L2M.

Based on the study results, the 7.8km line section between Merivale TS and Limebank MTS is expected to reach its thermal capacity limit in the medium term by 2029. The Study Team has reviewed the following alternatives to address the loading limitation.

7.4.1 Alternatives

The following alternatives were considered to address the capacity need:

1. **Alternative 1 - Increase the thermal rating of L2M**

The rating of circuit L2M between Merivale TS and Limebank MTS is currently limited due to clearance concerns. This option looks at increasing the thermal capacity of L2M by addressing the conductor sag issue. Hydro One has reviewed the work necessary to remove the limitation and has determine that approximately 3.2km of the line section would have to be rebuilt in addition to modification to some existing towers and insulators where no rebuild is required. This work would remove the clearance limitation and would allow the circuit capacity to be increased to approximately 106 MW.

Based on the load forecast, this option would defer the capacity need to the long term, however this option may not be sufficient to meet demand in the final years of the load forecast.

2. **Alternative 2 – Circuit Rebuild**

This alternative would look at rebuilding the 7.8km of circuit L2M between Merivale TS and Limebank MTS to increase the circuit's thermal rating. Two options were considered.

- **Alt 2a:** This option would rebuild the existing 7.8km as a single circuit 115 kV line. It would address the thermal rating constraint currently on the circuit and would be adequate to supply the forecasted load of Marionville DS and Limebank MTS. However with this option, Limebank MTS and Marionville DS would remain on a single circuit supply.
- **Alt 2b:** This option would rebuild the existing 7.8km as a double circuit 115 kV line. Similar to Alternative 2a, this option would address the thermal rating issue. This option would also help improve the reliability of supply to Limebank MTS by providing a second supply to the station.

3. **Alternative 3 – Load Transfer**

This option looks at transferring load from Limebank MTS to Cambrian MTS, a new station planned to be in service in Q1 2022. Hydro Ottawa has confirmed that load can be transferred from Limebank MTS to Cambrian MTS to help mitigate the L2M loading concern. With these transfers, the need date for addressing L2M thermal constraint can be deferred into the long term. The cost of feeder transfers is expected to be minimal to Hydro Ottawa.

7.4.1 Recommendation

The Study Team recommends to monitor the load at Limebank MTS and implement load transfers out of the station when L2M reaches its thermal capacity. With the ongoing Gatineau Corridor EOL study, network changes could occur which would alleviate the thermal capacity need of L2M. This need will be re-evaluated in the next Regional Planning cycle when the Gatineau Corridor EOL study results are known.

7.5 Merivale TS

Merivale TS is a major 230/115 kV transformer station in the area that supplies load stations in west Ottawa. The station houses a 230 kV GIS switchgear with six SF6 breakers, two 230/115 kV auto-transformers T21 and T22 and a 115 kV switchyard with four oil circuit breakers and twelve SF6 circuit breakers.

7.5.1 Sustainment Need

The existing 230 kV breakers have been in-service from 1977 and are approaching end of life. The existing auto-transformer T22 has been in-service since 1978 and is approaching end of life. The 115 kV oil circuit breakers came to service between 1973-1976 and have been identified for replacement.

Based on the EOL timing, the replacement of autotransformer T22 is required by 2027. However, T22 replacement will be expedited during execution of the project at Merivale TS to help with the 230/115 kV transformation need described in the next section.

7.5.2 230/115 kV Transformation Capacity Need

As discussed in Section 6.2, about 60% of the Greater Ottawa load is supplied from the 115 kV network. The autotransformers at Merivale TS and Hawthorne TS supply the majority of this load with support from generating stations located west of Merivale TS, on the Madawaska and Ottawa rivers. At Merivale TS, the LTR of autotransformer T22 is rated at 315 MVA and T21 is rated at 347 MVA. As the load is growing on the 115 kV network, the autotransformers are approaching both their continuous and LTR ratings.

Based on the forecast and the generation assumptions described in Section 5.2, the station 230/115 kV transformation capacity is exceeded under the loss of an autotransformer in the first year of the forecast. In addition, the study results show that both autotransformers will reach their continuous loading limits of 250 MVA over the next five years. Please see results shown in Table 6-1 in Section 6.2.

In order to address the autotransformer loading concerns, additional 230/115 kV transformation capacity or load transfers from the 115 kV to the 230 kV system is required. The replacement of T22 discussed above will not be sufficient to address the autotransformer overload.

A joint planning study by Hydro One and IESO is currently underway for the Ottawa 115 kV System Supply, which will develop and review alternatives to resolve the autotransformation need at Merivale TS. Some of the alternatives that are being considered are discussed below.

1. Alternative 1 - Addition of one new autotransformer at Merivale TS

This alternative considers the addition of one new autotransformer at Merivale TS. This option requires modification to both the 230 kV and 115 kV switchyard.

The 230 kV SF6 switchgear is housed in a GIS building. There are no positions available on the existing diameters to connect a new autotransformer. To connect the new autotransformer to the 230 kV yard would

therefore require expansion to provide a new breaker position. The 115kV yard is air insulated and no breaker position is available to connect a new autotransformer.

The configuration changes at Merivale TS, including the expansion required are shown in Figure 7-4 below. Please note: the yard configuration is shown as an example only to illustrate the expansion; if this option is selected, Hydro One will develop the 230 kV and 115 kV layouts configuration. Some circuit relocations may also need to be considered as shown in the figure below.

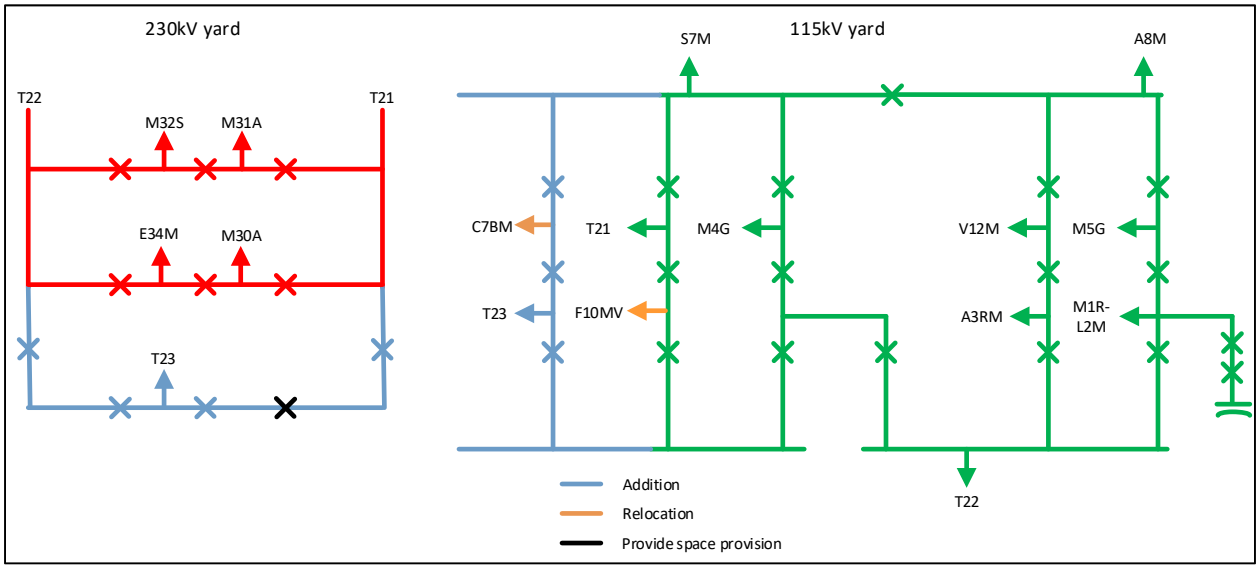

Figure 7-4. Merivale TS switchyard configuration with the addition of a third autotransformer.

2. Alternative 2 - Addition of two new autotransformers at Merivale TS

This alternative considers the installation of two new autotransformers at Merivale. To avoid having the 230 kV yard expansion discussed in the previous section, this option would share the 230 kV connection between two autotransformers. However, this option would require further work on the 115 kV yard compared with the previous alternative, as two new diameters would be required since the 115 kV terminations cannot be shared due to high load currents. This configuration would result in the loss of two autotransformers if the 230 kV breakers supplying the autotransformers open. However, two autotransformers will still remain in service to supply the load, similar to the Alternative 1.

The configuration changes at Merivale TS are shown in Figure 7-5 below. Note: the yard configuration is shown as an example only to show the expansion required. If this option is selected, Hydro One will develop the 230 kV and 115 kV layouts configuration.

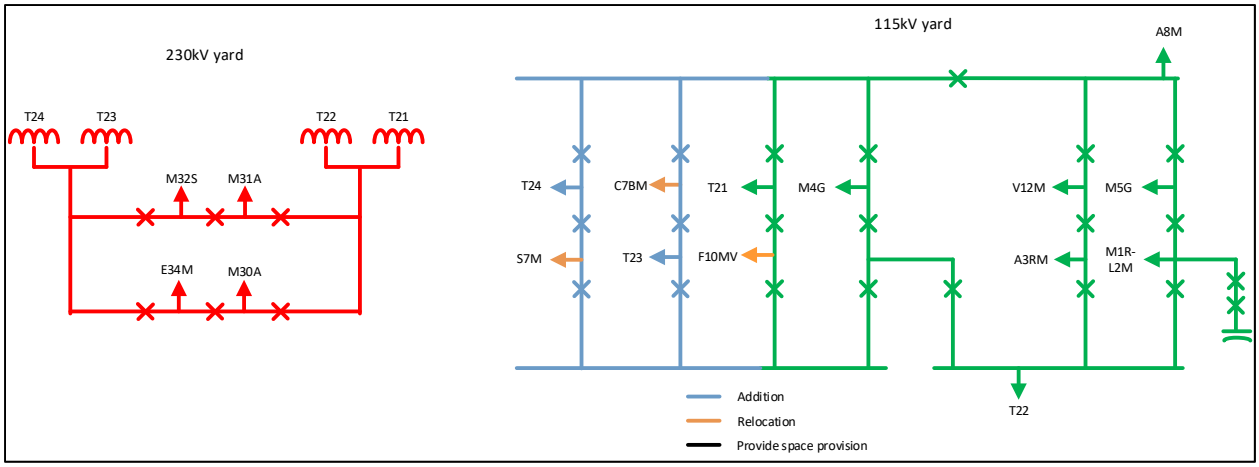

Figure 7-5. Merivale TS switchyard configuration with the addition of two new autotransformers.

7.5.3 Recommendation

The Gatineau Corridor EOL and Ottawa 115 kV System Supply studies could change the configuration at Merivale TS. The outcome of these studies is required to develop a plan to address the 230/115 kV transformation capacity and sustainment needs at the station. Both reports will be complete by Q2 2021.

The replacement for autotransformer T22 with a like for like unit (in situ) can be completed by 2025. The on-going studies can impact this timing based on their recommendations and necessary approvals including SIA.

The study team recommends Hydro One to monitor the health of all aging assets at the station and develop a plan to address both sustainment and development needs following completion of the aforementioned studies.

7.6 Bilberry Creek TS: Station refurbishment

Bilberry Creek TS is a transformer station located in the east end of Ottawa. The station is supplied by two 115 kV circuits A2 and H9A from Hawthorne TS. The station supplies electricity to Hydro Ottawa and Hydro One Distribution customers.

The two 50/67/83.3 MVA transformers T1 and T2 are 44 years old, and approaching the end of life. Five LV oil circuit breakers owned by Hydro One were installed in 1976 and are approaching end of life. Two feeder breakers at the station are owned by Hydro Ottawa. The Hydro One owned oil breakers are in need of replacement in the medium term planning horizon.

7.6.1 Alternatives and Recommendations

The following alternatives were considered to address Bilberry Creek TS end-of-life assets need:

1. **Alternative 1 - Maintain Status Quo**: This alternative was considered and rejected as it does not address the need to replace the assets identified in the previous section resulting in increased maintenance expenses and deteriorating supply reliability to load customer.
2. **Alternative 2 – Station Refurbishment:** Under this alternative the existing transformers at the station are replaced with new standard 50/67/83.3 MVA units. The existing breakers will be replaced with new SF6 breakers with similar rating. This alternative would address the end-of-life assets need and would maintain reliable supply to customers.

In addition to the sustainment need, the IRRP recommended the addition of two new feeder breakers for Hydro Ottawa's load transfers and possible growth in the area.

The current station transformation capacity is 85 MW. The expected forecast for Bilberry Creek is shown in the Table 7-5 after the addition of the new breakers. The forecast includes planned transfers from both Hydro Ottawa and Hydro One Distribution. The station is expected to reach about 65 MW by 2028 and will remain at that level for the remainder of the study period. The station is expected to be within its loading limit for the duration of the study period based on the RIP forecast.

Table 7-5 Bilberry Creek TS forecast including HOL/H1DX transfers

	2024	2025	2026	2027	2028	2029	2033	2037
Net load (MW)	62.1	62.3	63.6	64.8	65.0	65.2	65.9	65.9

The Study Team recommends Hydro One to continue with Alternative 2 for the replacement of assets at Bilberry Creek TS. The plan cost is currently estimated to be approximately $25-30 million. Additionally, Hydro One expects the two new feeders can be installed by 2024 subject to an early confirmation from Hydro Ottawa. Hydro Ottawa and Hydro One will work together to develop a plan for the new breakers in 2021.

7.7 Voltage Regulation on 115 kV Circuit 79M1

7.7.1 Description and Current Status

The 115 kV circuit 79M1 supplies Rockland DS, Rockland East DS, Clarence DS, Wendover DS, and Hawkesbury MTS as shown in Figure 7-6. The circuit is supplied from Hawthorne TS via circuit H9A. Total distance to the end station Hawkesbury MTS is approximately 80km. As a result of this long distance and circuit loading, lower voltage can be expected at the end of the line. The previous Greater Ottawa planning report identified that the voltage at Hawkesbury MTS will approach ORTAC limits under peak load and contingency conditions by 2023. The recommendation of the previous RIP report was to continue to monitor the situation.

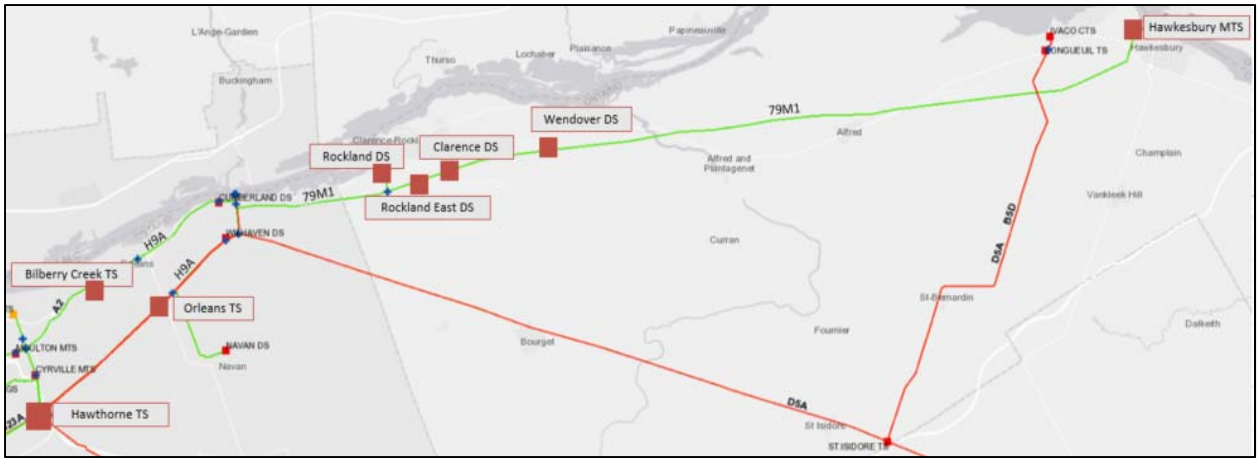

Figure 7-6. East Ottawa stations supplied by 115 kV circuits H9A and 79M1.

The voltage performance of circuits H9A/79M1 was reviewed as part of the RIP for this area. The worst contingency considered for the voltage on H9A/79M1 is the loss of 115 kV circuit A2, which results in all of Bilberry Creek TS load being supplied by H9A. This contingency increases the loading on circuit H9A and can cause lower voltages to be observed on the circuit.

Study results indicate that the voltage in the area and stations supplied by H9A/79M1 is within the limits of ORTAC for the near term. As mentioned in the Outer Ottawa Sub-Region NA report, Hydro One continues to monitor the loading in the area and voltage on the line. The Study Team recommends this need to be reassessed in the next regional planning cycle.

7.8 Voltage on E34M with Merivale End Open

7.8.1 Description

Circuits E34M (37.6km) and T33E (254.3km) tie Merivale TS to Clarington TS, through an in-line breaker at Almonte TS. If the circuit E34M (Almonte-Merivale) is open at the Merivale end, Terry Fox MTS, Almonte TS, and Cambrian MTS (once in service in 2022) will be supplied radially by Clarington TS. Clarington TS cannot supply the Ottawa stations with acceptable voltage levels when E34M is open at Merivale TS. This issue was identified in the previous regional planning cycle.

7.8.2 Recommended Plan and Current Status

Hydro Ottawa's new station, Cambrian MTS, will implement a scheme to remove the station load from circuit E34M and move it to its alternate supply S7M in the event of a line end open (LEO). A LEO at Merivale TS can results in load loss at Almonte TS and Terry Fox MTS. Terry Fox MTS is part of the Ottawa Area under voltage load rejection scheme ("UVLS"). This scheme is designed to shed the station load if the 230 kV supply voltage to the station drops below 204 kV when it is activated.

The combined load of both stations is less than 150 MW and can be restored within 8 hours as mandated by the ORTAC. As the load restoration criteria can be met, no further action is recommended by the Study Team.

7.9 Hawkesbury MTS: Capacity Upgrade

Hydro Hawkesbury is supplied from two transformer stations, Hawkesbury MTS and Longueuil TS. Currently Hawkesbury MTS has a 15 MVA transformers and a 7.5 MVA transformer to supply their load. Hydro Hawkesbury plans to replace their 7.5 MVA transformer with a new 15 MVA transformer.

The station capacity is limited to the rating of the smaller transformer. Hydro Hawkesbury plans to replace the 7.5 MVA transformer with a new 15 MVA transformer with a proposed in-service date in 2026. This upgrade will increase the station capacity and improve customer reliability such that if a transformer has to be taken out of service, the entire station load can be supplied without interruptions.

The Study Team recommends that Hydro Hawkesbury to proceed with the proposed upgrade.

7. 10 Lincoln Heights TS: End-of-Life Transformer T1/T2 Replacement

7.10.1 Description

Lincoln Heights TS is an indoor DESN station located in the city of Ottawa. The station houses two 45/60/75 MVA transformers with dual secondary windings. The station is supplied by two 115 kV circuits F10MV and C7BM. The station supplies electricity to Hydro Ottawa customers.

Transformers T1 and T2 are 40-45 years old and approaching end of life. There is limited load growth being experienced at the station over the course of the study period as seen in the RIP load forecast.

7.10.2 Alternatives and Recommendations

The following alternatives were considered to address Lincoln Heights TS end-of-life assets need:

1. **Alternative 1 - Maintain Status Quo**: This alternative was considered and rejected as it does not address the need to replace the assets identified in the previous section resulting in increased maintenance expenses and deteriorating supply reliability to load customer.
2. **Alternative 2 - Replace with similar type and size equipment as per current standard:** Under this alternative the existing transformers at Lincoln Heights TS are replaced with new standard 115/13.8 kV, 45/60/75 MVA units. This alternative would address the end-of-life assets need and would maintain reliable supply to customers.

The RIP Study Team recommends Hydro One continue with Alternative 2 for the refurbishment of Lincoln Heights TS. The cost is estimated to be approximately $22 million, and is expected to be in-service by late 2023.

7.11 Longueuil TS: End-of-Life Transformer T3/T4 & Component Replacement

7.11.1 Description

Longueuil TS is a DESN station located in the Outer Ottawa East region. The station is supplied by two 230 kV circuits D5A and B5D. The station supplies electricity to Hydro One Distribution customers.

The two 56/75/93 MVA transformers T3 and T4 are 55 years old and approaching end of life. The 10-day summer LTR of both transformers is 97 MVA. In additions, two 230 kV CVTs and two line traps are also approaching the end of their useful life.

7.11.2 Alternatives and Recommendations

The following alternatives were considered to address Longueuil TS end-of-life assets need:

1. **Alternative 1 - Maintain Status Quo**: This alternative was considered and rejected as it does not address the need to replace the assets identified in the previous section resulting in increased maintenance expenses and deteriorating supply reliability to load customer.
2. **Alternative 2 - Replace with similar size or higher rated equipment as per current standard:** Under this alternative the existing transformers at Longueuil TS are replaced with new standard 230/44 kV, 50/66.7/83.3 MVA units or with new 75/100/125 MVA units. Replacing transformers with higher rated units is expected to have minimal incremental cost. A final determination will be made between Hydro One and Hydro One Distribution based on anticipated load at the station. This alternative would address the end-of-life assets need and would maintain reliable supply to customers.

The Study Team recommends Hydro One to continue with Alternative 2 in consultation with Hydro One Distribution for the refurbishment of Longueuil TS. The project cost will be determined based on the size selected for the replacement transformers. The project is expected to in-service by late 2024.

7.12 Riverdale TS: 115 kV Breaker Replacement

7.12.1 Description

Riverdale TS is a transformer station located in the city of Ottawa supplied by three 115 kV circuits A3RM, A5RK and A6R. The station comprises of a 115 kV switchyard and a DESN with two transformers and a 13.8 kV metalclad switchgear suppling station load. The station supplies electricity Hydro Ottawa customers.

There are three 115 kV busses connected together by two oil circuit breakers A1A2 and A1A3. The circuit breakers have been in service since 1953 and were rebuilt in 1994/95. The 115 kV circuit breakers are nearing the end of life.

7.12.2 Alternatives and Recommendations

The following alternatives were considered to address Riverdale TS end-of-life assets need:

1. **Alternative 1 - Maintain Status Quo**: This alternative was considered and rejected as it does not address the need to replace the assets identified in the previous section resulting in increased maintenance expenses and deteriorating supply reliability to load customer.
2. **Alternative 2 - Replace with similar type and size equipment as per current standard:** Under this alternative the existing 115 kV oil circuit breakers will be replaced with SF6 circuit breakers of similar rating. This alternative would address the end-of-life assets need and would maintain reliable supply to customers.

The Study Team recommends Hydro One to continue with Alternative 2 for the replacement of circuit breakers at Riverdale TS. The plan cost is estimated to be approximately $6.5 million, and is expected to in-service by late 2024. In addition, Hydro One will look for opportunities to coordinate this project with Hydro Ottawa for their 13 kV switchgear replacement.

7.13 Albion TS: End-of-Life Transformer T1/T2 & Component Replacement

7.13.1 Description

Albion TS is a transformer station located in the city of Ottawa between Hawthorne TS and Merivale TS. The station is supplied by two 230 kV circuits M30A and M31A. The station supplies electricity to Hydro Ottawa customers.

The two 45/60/75 MVA dual secondary transformers T1 and T2 are 49 years old, and are at end of life. The 13.8 kV metalclad switchgear installed since 1971 contains six air circuit breakers and two SF6 capacitor bank breakers. The station also has four 13.8 kV conventional SF6 breakers. All circuit breakers require replacement in the near to medium term planning horizon.

7.13.2 Alternatives and Recommendations

The following alternatives were considered to address Albion TS end-of-life assets need:

1. **Alternative 1 - Maintain Status Quo**: This alternative was considered and rejected as it does not address the need to replace the assets identified in the previous section resulting in increased maintenance expenses and deteriorating supply reliability to load customer.
2. **Alternative 2 - Replace with similar type and size equipment as per current standard:** Under this alternative the existing transformers at Albion TS are replaced with new standard 60/80/100 MVA units. These are closest standard size units to the existing transformers. All existing Hydro One owned circuit breakers will be replaced with breakers of similar rating. This alternative would address the end-of-life assets need and would maintain reliable supply to customers.

The Study Team recommends Hydro One to continue with Alternative 2 for the replacement of assets at Albion TS. The plan cost is estimated to be approximately $40 million, and is expected to in-service by late 2026.

7.14 Russell TS: End-of-Life Transformer T1/T2 & Component Replacement

7.14.1 Description

Russell TS is a DESN transformer station located in the city of Ottawa. The station is supplied by two 115 kV circuits A5RK and A6R. The station supplies electricity to Hydro Ottawa customers.

The two 45/60/75 MVA dual secondary transformers T1 and T2 have been in service since 1975 and 1971 respectively. Both transformers are approaching end of life. The 13.8 kV air insulated metalclad switchgear at the station is jointly owned by Hydro One and Hydro Ottawa. The four LV bank breakers and two bus-tie breakers, owned by Hydro One, are approaching end of life in the medium term. Considering the multiple aging assets at the station this need requires addressing in the medium term planning horizon.

The revised load forecast for the RIP shows that loading at Russell TS marginally exceeds the LTR of the station. The replacement of the transformers will resolve any overload at the station for the duration of the study period.

7.14.2 Alternatives and Recommendations

The following alternatives were considered to address Russell TS end-of-life assets need:

1. **Alternative 1 - Maintain Status Quo**: This alternative was considered and rejected as it does not address the need to replace the assets identified in the previous section resulting in increased maintenance expenses and deteriorating supply reliability to load customer.
2. **Alternative 2 - Replace with similar or higher rated equipment as per current standard:** Under this alternative the existing transformers at Russell TS are replaced with new, standard 115/13.8/13.8 kV, 45/60/75 MVA units or with new 60/80/100 MVA units. Replacing transformers with higher rated units is expected to have minimal incremental cost and provide flexibility to Hydro Ottawa. A final determination will be made by Hydro Ottawa and Hydro One based on anticipated load at the station.
   The 13.8 kV metalclad circuit breakers will be replaced with SF6 breakers with similar rating under this alternative. This alternative would address the end-of-life assets need and would maintain reliable supply to customers.

The Study Team recommends Hydro One to proceed with Alternative 2 in consultation with Hydro Ottawa for the replacement of assets at Russell TS. The project cost will be determined based on the size selected for the replacement transformers. The project is expected to in-service by late 2026.

8. CONCLUSION AND NEXT STEPS

THIS REGIONAL INFRASTRUCTURE PLAN REPORT CONCLUDES THE REGIONAL PLANNING PROCESS FOR THE GREATER OTTAWA REGION.

This RIP report addresses near term and mid-term regional needs identified in the earlier phases of the Regional Planning process and during the RIP phase. The major infrastructure investments recommended by the Study Team in the near and mid-term planning horizon are provided in Table 8-1 below.

Investments to address the mid-term needs, for cases where there is time to make a decision, will be reviewed and finalized in the next regional planning cycle. These needs are summarized in Table 8-2.

Table 8-1. Recommended Plans in Greater Ottawa over the Next 10 Years.

No	Need	Recommended action plan	Expected I/S
1	Lincoln Heights TS: End of life of transformers T1/T2.	Replace end of life equipment.	2023
2	Longueuil TS: End of life of transformers T3/T4.	Replace end of life equipment.	2024
3	Riverdale TS: End of life of 115 kV breakers.	Replace end of life equipment.	2024
4	Transformation Capacity in South East Ottawa.	Hydro Ottawa to proceed with building transformer station.	2025
5	Albion TS: End of life of transformers T1/T2 and circuit breakers.	Replace end of life equipment.	2026
6	Russell TS: End of life of transformers T1/T2.	Replace end of life equipment.	2026
7	Overbrook TS: Station capacity.	Determine limitation of LV cables.	2021
		Upgrade cables or implement load transfers.	2026
8	Hawkesbury MTS: Capacity upgrade.	Hydro Hawkesbury to proceed with upgrade.	2026
9	Bilberry Creek TS: End of life of transformers T1/T2 and LV circuit breakers. Addition of two new LV circuit breakers for Hydro Ottawa.*	Install two new LV circuit breakers.	2024
		Replace end of life equipment.	2028
10	Merivale TS: Autotransformation capacity and end of life of T22, 230 kV breakers, 115 kV breakers.	Replace T22.**	2025
		Review recommendations of Ottawa 115 kV System Supply and Gatineau Corridor EOL studies to develop plan for Merivale TS.	2028

NOTES:

* Addition of two new breakers can be expedited following a formal request from Hydro Ottawa.

** Replacement of T22 with like for like transformer planned for completion by 2025. Inputs from the Gatineau Corridor EOL study and Ottawa 115 kV study may impact the timing of the replacement.

Table 8-2: List of Mid-Term Needs to be Reviewed in Next Regional Planning Cycle

No	Facilities
1	Orleans TS – Transformation capacity
2	Circuit 79M1 – voltage regulation
3	Circuit L2M – thermal rating

9. REFERENCES

[1]. Independent Electricity System Operator, "Ottawa Area Integrated Regional Resource Plan", 28 April 2015.
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[3]. Hydro One, "Local Planning Report - B5D-D5A Load Restoration", 22 September 2015.
https://www.hydroone.com/abouthydroone/CorporateInformation/regionalplans/greaterottawa/Documents/Local%20Planning%20Report%20-%20B5D-D5A%20Load%20Restoration.pdf

[4]. Hydro One, "Needs Assessment Report, Greater Ottawa Region", 15 June 2018.
https://www.hydroone.com/abouthydroone/CorporateInformation/regionalplans/greaterottawa/Documents/Greater%20Ottawa%20Needs%20Assessment%202018.pdf

[5]. Independent Electricity System Operator, "Ottawa Sub-Region: Integrated Regional Resource Plan", 4 March 2020
http://www.ieso.ca/-/media/Files/IESO/Document-Library/engage/ottawa/Ottawa-Sub-Region-IRRP-20200304.pdf?la=en.

APPENDIX A: STATIONS IN THE GREATER OTTAWA REGION

No.	Station	Voltage (kV)	Supply Circuits
1	Albion TS	230	M30A, M31A
2	Almonte TS	230	E34M, T33E
3	Arnprior TS	115	W6CS, C7BM
4	Bilberry Creek TS	115	A2, H9A
5	Bridlewood MTS	115	S7M
6	Carling TS	115	M4G, M5G
7	Centrepoint MTS	115	C7BM
8	Clarence DS	115	79M1
9	Cumberland DS	115	H9A
10	Cyrville MTS	115	A2, A4K
11	Ellwood TS	230	M30A, M31A
12	Epworth MTS	115	M4G, M5G
13	Fallowfield DS	115	S7M
14	Greely DS	115	M1R
15	Hawkesbury MTS	115	79M1
16	Hawthorne TS	230	-
18	Ivaco CTS	230	D5A
19	Kanata MTS	230	C3S, M32S
20	King Edward TS	115	A4K, A5RK
21	Limebank MTS	115	L2M
22	Lincoln Heights TS	115	C7BM, F10MV
23	Lisgar TS	115	M4G, M5G
24	Longueuil TS	115	B5D, D5A
25	Manordale MTS	115	C7BM
26	Manotick DS	115	S7M
27	Marchwood MTS	115	S7M, W6CS
28	Marionville DS	115	L2M
29	Merivale MTS	115	-
30	Moulton MTS	115	A4RK
31	Nation Research TS	115	A2
32	National Aeronautical CTS	115	A8M
33	Navan DS	115	H9A
34	Nepean TS	115	M32S
35	Orleans TS	230 & 115	D5A, H9A
36	Overbrook TS	115	A5RK, A6R
38	Riverdale TS	115	A3RM, A5RK
39	Rockland DS	115	79M1
40	Rockland East DS	115	79M1

41	Russell DS	115	M1R
42	Russell TS	115	A5RK, A6R
43	Slater TS	115	A3RM, A5RK, M4G
44	South Gloucester DS	115	M1R
45	South March TS	230	C3S, M32S
46	Cambrian MTS	230 & 115	E34M, S7M
47	St. Isidore TS	230	B5D, D5A
48	Stewartville TS	115	W3B, W6CS
49	Terry Fox MTS	230	E34M
50	Uplands MTS	115	A8M
51	Wendover DS	115	79M1
52	Wilhaven DS	115	H9A
53	Woodroffe TS	115	C7BM, F10MV

APPENDIX B: TRANSMISSION LINES IN THE GREATER OTTAWA REGION

Location	Circuit Designations	Voltage (kV)
Hawthorne TS – Merivale TS	M30A, M31A	230
Hawthorne TS – St Isidore TS	D5A	230
Merivale TS – Almonte TS	E34M (formerly M29C)	230
Merivale TS – South March TS	M32S	230
South March SS – Chats Falls SS	C3S	230
Hawthorne TS – Bilberry Creek TS	A2	115
Hawthorne TS - Merivale TS	A3RM, A8M	115
Hawthorne TS – Overbrook TS	A4K, A5RK	115
Hawthorne TS – Riverdale TS	A6R	115
Hawthorne TS – Hawkesbury MTS	H9A/79M1	115
Merivale TS – Chats Falls TS	C7BM	115
Merivale TS – Hinchey TS	F10MV, V12M	115
Merivale TS – Lisgar TS	M4G, M5G	115
Merivale TS – South March SS	S7M	115
Stewartville TS – South March SS	W6CS	115
Stewartville TS – Barrett Chute TS	W3B	115

APPENDIX C: DISTRIBUTORS IN THE GREATER OTTAWA REGION

Distributor Name	Station Name	Connection Type
Hydro 2000	Longueuil TS	Dx
Hydro Hawkesbury	Hawkesbury MTS	Tx
	Longueil TS	Dx
Hydro One	Almonte TS	Tx
	Arnprior TS	Tx
	Bilberry Creek TS	Tx
	Clarence DS	Tx
	Cumberland DS	Tx
	Greely DS	Tx
	Hawthorne TS	Tx
	Longueil TS	Tx
	Manotick DS	Tx
	Marionville DS	Tx
	Navan DS	Tx
	Orleans TS	Tx
	Rockland DS	Tx
	Rockland East DS	Tx
	Russell DS	Tx
	South Gloucester DS	Tx
	St Isidore TS	Tx
	Stewartville TS	Tx
	Wilhaven DS	Tx
Hydro Ottawa	Albion TS	Tx
	Almonte TS	Dx
	Bilberry Creek TS	Tx
	Bridlewood MTS	Tx
	Cambrian MTS	Tx
	Carling TS	Tx
	Centrepoint MTS	Tx
	Cyrville MTS	Tx
	Ellwood MTS	Tx
	Nepean Epworth MTS	Tx
	Fallowfield DS	Tx
	Hawthorne TS	Tx
	Hinchey TS	Tx
	Kanata MTS	Tx

	King Edward TS	Tx
Hydro Ottawa	Limebank MTS	Tx
	Lincoln Heights TS	Tx
	Lisgar TS	Tx
	Manordale MTS	Tx
	Marchwood MTS	Tx
	Moulton MTS	Tx
	Merivale MTS	Tx
	Nepean TS	Tx
	Orleans TS	Tx
	Overbrook TS	Tx
	Richmond MTS	Tx
	Riverdale TS	Tx
	Russell TS	Tx
	Slater TS	Tx
	South Gloucester DS	Dx
	South March TS	Dx, Tx
	St Isidore TS	Dx
	Terry Fox MTS	Tx
	Upland MTS	Tx
	Woodroffe TS	Tx
Ottawa River Power Corporation	Almonte TS	Dx
Renfrew Hydro	Stewartville TS	Dx

APPENDIX D: AREA STATIONS LOAD FORECAST

Table D-1. Greater Ottawa Net Coincident Load Forecast (extreme weather, low CDM)

Area & Station	LTR (MW)	Near and Medium Term Forecast (MW)										Long-Term Forecast (MW)		
		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2035	2037
Center 115 kV														
King Edward TS	82	88	88	88	87	87	87	88	88	89	89	90	90	90
Lisgar TS	75	55	55	60	60	61	61	61	64	64	65	65	68	69
Overbrook TS	95	75	76	78	83	87	93	100	104	108	110	112	123	127
Riverdale TS	106	85	87	88	88	88	88	89	89	90	90	91	96	97
Russell TS	70	76	76	75	74	74	73	73	73	73	73	73	73	73
Slater TS	146	108	107	106	104	104	103	103	102	102	102	102	103	103
Center 230 kV														
Albion TS	89	52	52	51	51	50	50	50	50	50	50	50	51	51
Ellwood MTS	45	44	45	46	46	45	45	45	45	45	45	45	45	45
Hawthorne TS	143	115	122	140	141	141	142	144	147	151	157	159	171	175
East 115 kV														
Bilberry Creek TS	85	40	51	54	59	59	58	58	58	58	58	58	58	58
Cumberland DS	7	6	6	6	6	6	6	6	6	6	6	6	6	6
Cyrville MTS	45	28	33	36	39	43	44	46	47	48	49	50	55	57
Moulton MTS	30	29	31	32	34	34	34	33	33	33	33	33	33	33
Nation Research TS	25	9	9	9	9	9	9	9	9	9	9	9	9	9
Navan DS	14	4	4	4	4	4	4	4	4	4	4	4	4	5
Orleans TS	117	52	56	60	61	61	62	64	65	66	66	67	69	69
Wilhaven DS	35	3	3	3	3	3	3	3	3	3	4	3	4	4
East 230 kV														
Orleans TS	117	52	56	60	61	61	62	64	65	66	66	67	69	69
South 115 kV														
Greely DS	21	24	29	29	29	29	29	29	30	30	30	30	31	32
Limebank MTS	89	63	65	71	64	67	63	66	70	75	79	84	99	104
Marionville DS	14	13	13	13	13	13	13	13	13	13	13	13	14	14
NRC Uplands CTS	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Russell DS	7	4	4	4	4	4	4	4	4	4	4	4	4	4
South Gloucester DS	7	5	5	5	5	5	5	5	5	5	5	5	5	5
Uplands MTS	54	29	31	37	42	47	56	57	57	58	59	59	61	62

	LTR	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2035	2037
South West 115 kV														
Fallowfield DS	23	49	51	21	24	24	25	26	27	27	29	30	32	32
Manotick DS	8	8	9	10	11	12	12	12	12	12	12	12	12	12
Richmond DS	68	10	13	16	18	20	20	21	21	21	21	21	21	21
West 115 kV														
Bridlewood MTS	23	18	19	19	20	20	20	23	26	27	27	27	27	27
Carling TS	95	75	76	76	74	79	79	78	78	79	79	79	79	79
Centrepoint MTS	13	16	16	16	16	16	16	16	16	15	15	15	15	15
Epworth MTS	13	18	18	18	17	17	17	17	17	17	17	17	17	17
Hinchey TS	86	55	40	41	42	45	48	49	51	52	54	56	63	65
Lincoln Heights TS	72	44	46	46	45	45	54	54	54	54	54	53	53	53
Manordale MTS	9	10	10	10	10	10	9	9	9	9	9	9	9	9
Marchwood MTS	30	58	58	59	59	60	60	61	60	60	60	60	60	60
Merivale MTS	23	20	20	20	20	20	20	20	21	21	21	21	22	22
Woodroffe TS	91	32	33	33	34	50	50	50	49	49	49	49	49	49
West 230 kV														
Kanata MTS	49	67	70	70	69	68	68	68	69	69	69	69	69	69
Nepean TS	145	142	145	123	122	121	121	120	120	120	120	120	120	120
South March TS	110	87	87	96	95	93	93	94	93	92	90	90	93	93
Cambrian MTS	90	0	0	40	44	47	50	54	58	61	64	67	81	81
Terry Fox MTS	81	60	61	62	63	64	66	67	68	70	71	73	76	76
Outer East 115 kV														
Clarence DS	3	3	5	5	5	5	5	5	5	5	5	5	5	5
Hawkesbury MTS	18	13	14	14	13	13	13	13	13	13	13	13	13	13
Rockland DS	13	8	8	8	8	8	8	8	8	8	8	8	8	8
Rockland East DS	8	12	12	13	14	14	15	15	15	15	15	15	15	15
Wendover DS	14	10	12	12	13	13	13	13	13	13	13	13	13	13
Outer East 230 kV														
Ivaco CTS	100	81	82	83	84	85	86	87	87	87	87	87	87	87
Longueuil TS	87	42	45	47	48	48	49	49	49	49	49	49	49	49
St. Isidore TS	114	40	40	50	50	50	50	50	50	50	50	50	50	50
Outer West 115 kV														
Arnprior TS	46	44	45	45	45	45	45	45	46	46	46	46	46	46
Stewartville TS	50	26	26	25	25	25	25	25	25	25	25	25	25	25
Outer West 230 kV														
Almonte TS	104	43	43	44	45	46	46	45	45	44	44	44	44	44

APPENDIX E: LIST OF ACRONYMS

Acronym	Description
A	Ampere
BES	Bulk Electric System
BPS	Bulk Power System
CDM	Conservation and Demand Management
CIA	Customer Impact Assessment
CGS	Customer Generating Station
CTS	Customer Transformer Station
DESN	Dual Element Spot Network
DG	Distributed Generation
DSC	Distribution System Code
GS	Generating Station
GTA	Greater Toronto Area
HV	High Voltage
IESO	Independent Electricity System Operator
IRRP	Integrated Regional Resource Plan
kV	Kilovolt
LDC	Local Distribution Company
LP	Local Plan
LTE	Long Term Emergency
LTR	Limited Time Rating
LV	Low Voltage
MTS	Municipal Transformer Station
MW	Megawatt
MVA	Mega Volt-Ampere
MVAR	Mega Volt-Ampere Reactive
NA	Needs Assessment
NERC	North American Electric Reliability Corporation
NGS	Nuclear Generating Station
NPCC	Northeast Power Coordinating Council Inc.
NUG	Non-Utility Generator
OEB	Ontario Energy Board
OPA	Ontario Power Authority
ORTAC	Ontario Resource and Transmission Assessment Criteria
PF	Power Factor
PPWG	Planning Process Working Group
RIP	Regional Infrastructure Plan
ROW	Right-of-Way
SA	Scoping Assessment
SIA	System Impact Assessment
SPS	Special Protection Scheme
SS	Switching Station
TS	Transformer Station
TSC	Transmission System Code
UFLS	Under Frequency Load Shedding
ULTC	Under Load Tap Changer
UVLS	Under Voltage Load Rejection Scheme