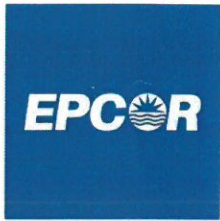


APPENDIX E DFO DISTRIBUTION DEFICIENCY REPORT



EPCOR Distribution & Transmission Inc. (EDTI)

Garneau Area Upgrades

Distribution Deficiency Report ¹

R3.2

September 19, 2018

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APEGA Permit to Practice P07061



¹ Distribution Deficiency Report (DDR) revised for Needs Identification Document (NID) filing of West Edmonton Transmission Upgrade Project.

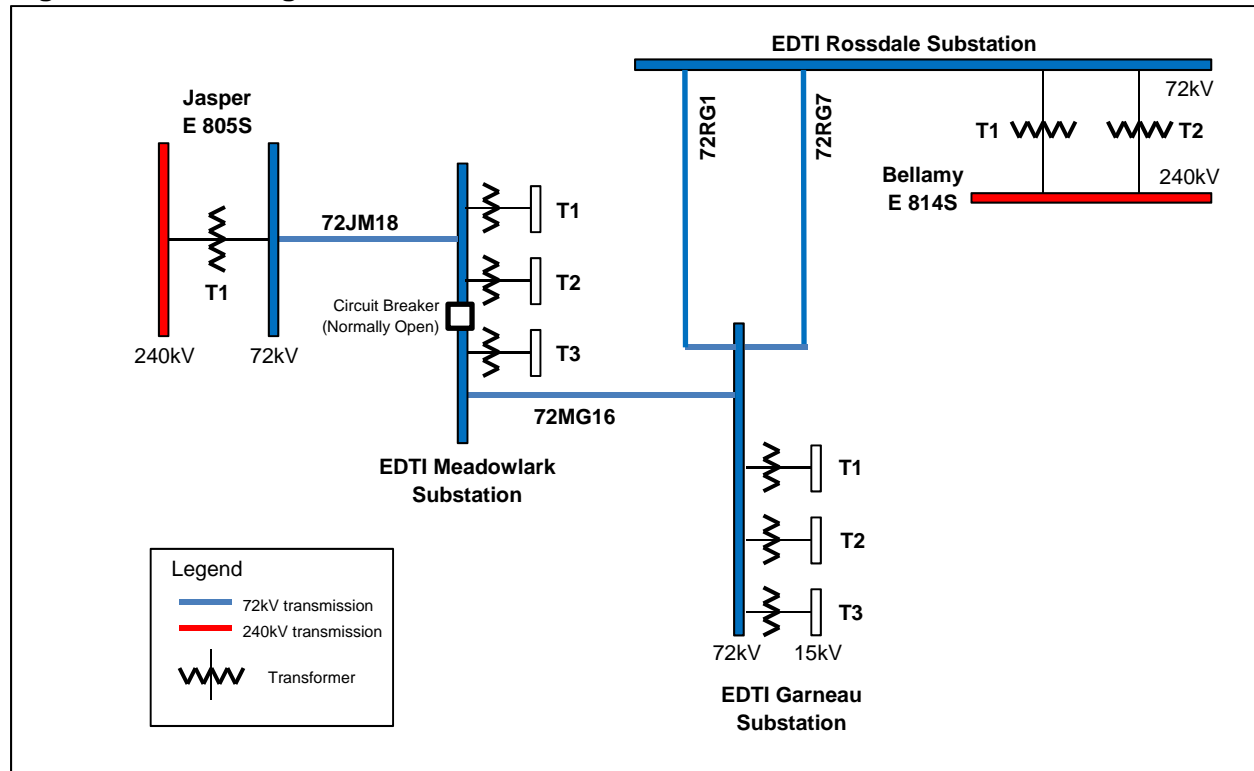
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1. Deficiency

Capacity limits of transmission equipment supplying EDTI Garneau and Meadowlark substations are presently exceeded under N-1 contingencies explained below. Refer to Figure 1-1 in understanding the EDTI transmission system supplying Garneau and Meadowlark substations.

Figure 1-1. Existing Garneau and Meadowlark Area Transmission



1. Garneau substation is normally supplied (under N-0 conditions) by two existing 72 kV underground transmission cables, 72RG1 and 72RG7. Both cables run between existing EDTI Garneau and Rosssdale substations. Presently, each cable will exceed its capacity limit if the other cable is forced out of service (an N-1 contingency).
 - The summer capacity limit of 72RG1 is 60 MVA.
 - The summer capacity limit of 72RG7 is 80 MVA

The actual 2017 summer peak load at the Garneau Point of Delivery (POD) was 81.6 MVA (on the Garneau substation 14.4 kV bus). The corresponding actual load on the Garneau 72 kV bus was 91.3 MVA (POD load and transformer losses). This 91.3 MVA load exceeds the capacity limit of 72RG1 (60 MVA) when 72RG7 is forced out of service, and exceeds the capacity limit of 72RG7 (80 MVA) when 72RG1 is forced out of service. By 2040, the Garneau POD load (on the substation 14.4 kV bus) is forecast to reach 100.5 MVA, and the corresponding load on the Garneau 72 kV bus to reach

115.2 MVA.

2. The existing Garneau substation firm transformer capacity is presently exceeded in an N-1 contingency.

The firm transformer capacity at Garneau is 80 MVA. In 2017 summer, the actual Garneau POD peak of 81.6 MVA resulted in 1.6 MVA load at risk if a forced transformer outage (an N-1 condition) had occurred. By 2022, the Garneau POD load is forecast to reach 85.3 MVA and results in 5.3 MVA load at risk. By 2040, Garneau POD load is forecast to reach 100.5 MVA and results in 20.5 MVA load at risk. EDTI's existing distribution system lacks the capacity to resolve this ongoing issue purely by distribution load transfers using existing distribution feeders.

3. Meadowlark substation transformers T1 and T2 are normally supplied (under N-0 conditions) from 72kV Jasper-Meadowlark cable 72JM18 (which has a summer capacity limit of 60 MVA). 72JM18 is, in turn, fed from EDTI's Jasper (E805S) 240/72kV transformer T1.

Presently, 72RG1 will overload following the N-1 contingency of a forced outage to either Jasper T1 or 72JM18. By 2020, 72MG16 and 72RG7 are also forecast to overload under the same contingencies. This is explained in more detail as follows.

In the event of a forced outage to either Jasper T1 or 72JM18, Meadowlark T1 and T2 transformers can only be restored by 72kV switching. Distribution switching to restore Meadowlark T1 and T2 loads from other PODs is not possible due to the magnitude of loads involved. Restoration by 72kV switching is accomplished by closing a normally open breaker on the Meadowlark 72kV bus. This transfers Meadowlark T1 and T2 to 72kV Meadowlark-Garneau cable 72MG16, which is itself supplied upstream from 72RG1 and 72RG7. Under this N-1 contingency, 72RG1 and 72RG7 supply both the Garneau and Meadowlark PODs.

The sum of the individual capacities of 72RG1 and 72RG7 is 140 MVA (60 MVA + 80 MVA). However, 72RG1 and 72RG7 operate in parallel (i.e., the cables are electrically connected to each other at both the Rossdale and Garneau ends). As a result, power flow from Rossdale to Garneau is split between the two cables with approximately 46% of the flow on 72RG1 and 54% on 72RG7 as dictated by the electrical impedance of each cable (and verified by power flows recorded by SCADA). Consequently, the total power that can be transmitted from Rossdale to Garneau without exceeding the rating of 72RG1 is 130.4 MVA (i.e., 46% of 130.4 MVA is 60 MVA).

In 2017, the non-coincident total of Garneau and Meadowlark 72kV summer peak loads was 141.2 MVA (the coincident total was 130.2 MVA). Again, for the contingency of a forced outage to either Jasper T1 or 72JM18, Meadowlark T1 and T2 load can only be restored by 72kV switching to 72RG1 and 72RG7 through 72MG16. If this contingency had occurred in 2017, the load on 72RG1 would have been 65.0 MVA (46% of 141.2

MVA). 72RG1 would have been overloaded by 5.0 MVA.

By 2020, the Garneau and Meadowlark non-coincident 72kV summer peak is forecast to reach 157.1 MVA. Following outages of either Jasper T1 or 72JM18:

- The contingency load on 72RG1 would be 72.3 MVA (46% of 157.1 MVA). This overloads 72RG1 by 12.3 MVA.
- The contingency load on 72RG7 would be 84.8 MVA (54% of 157.1 MVA). This overloads 72RG7 by 4.8 MVA
- The contingency load on 72MG16 would be 63.7 MVA (all Meadowlark substation). This overloads 72MG16 by 3.7 MVA.

By 2040, the Garneau and Meadowlark non-coincident 72kV summer peak is forecast to reach 181.6 MVA. Following outages of either T1 transformer at Jasper substation or 72JM18:

- The contingency load on 72RG1 would be 83.5 MVA (46% of 181.6 MVA). This overloads 72RG1 by 23.5 MVA.
- The contingency load on 72RG7 would be 98.1 MVA (54% of 181.6 MVA). This overloads 72RG7 by 18.1 MVA
- The contingency load on 72MG16 would be 66.4 MVA (all Meadowlark substation). This overloads 72MG16 by 6.4 MVA

4. Meadowlark substation transformer T3 is normally supplied (under N-0 conditions) from 72 kV cable Meadowlark-Garneau 72MG16. 72MG16 is, in turn, fed from 72RG1 and 72RG7 operating in parallel. By 2020, 72JM18 is forecast to overload following the N-1 contingency of a forced outage to 72MG16. This is explained in more detail as follows.

In the event of a forced outage to 72MG16, Meadowlark T3 transformer can only be restored by 72kV switching. Distribution switching to restore Meadowlark T3 load from other PODs is not possible due to the magnitude of loads involved. Restoration by 72kV switching is accomplished by closing a normally open breaker on the Meadowlark 72kV bus. This transfers Meadowlark T3 to 72kV Jasper-Meadowlark cable 72JM18. Under this N-1 contingency, 72JM18 supplies all of Meadowlark POD.

By 2020, the Meadowlark substation 72kV summer peak is forecast to reach 63.7 MVA. Following an outage of 72MG16, the contingency load on 72JM18 would also be 63.7 MVA (all Meadowlark substation). This overloads 72JM18 by 3.7 MVA.

By 2040, the Meadowlark substation 72kV summer peak is forecast to reach 66.4 MVA. Following an outage of 72MG16, the contingency load on 72JM18 would also be 66.4 MVA (all Meadowlark substation). This overloads 72JM18 by 6.4 MVA.

Under sections 105 and 127 of the Electric Utilities Act, EDTI, as the owner of an electric distribution system, is obligated to operate and maintain its system in a safe and reliable manner and to provide and maintain service that is safe, adequate and proper. To help EDTI as a Distribution Facility Owner (DFO) meet this obligation, EDTI adheres to the following POD Loading Policy:

EDTI DFO defines a POD's firm capacity as the maximum load that the POD can supply without overloading any transmission equipment under an N-1 contingency. N-1 contingencies include, but are not limited to, the loss of a single transmission line supply to a POD or the loss of a single transformer at a POD. All PODs should operate at or below their firm capacity.

Based on this policy, EDTI considers it a requirement to serve full Garneau and Meadowlark POD load under N-1 conditions. Consequently, EDTI is requesting a transmission development to eliminate the above transmission equipment capacity limits being exceeded in N-1 contingencies under *both* existing and forecast load. EDTI DFO notes that the drivers for the transmission development requested in this DDR (Garneau Area Upgrades) are unrelated to the drivers for AESO Connection Project P1659 Strathcona Substation Connection Enhancement (NID filed on June 11, 2018 with the Alberta Utilities Commission).

Note, EDTI is also requesting a Demand Transmission Service (DTS) contract capacity increase at its Garneau POD from 52.1 MW to 73.0 MW. No DTS contract capacity increase is requested for Meadowlark POD. Table 1 below summarizes existing and requested DTS contract capacities and actual 2017 summer peaks for Garneau and Meadowlark PODs.

Table 1. Garneau and Meadowlark POD Contract Capacities and 2017 Summer Peaks

	Garneau POD	Meadowlark POD
Existing DTS Contract Capacity [MW]	52.1	62.0
Requested DTS Contract Capacity [MW]	73.0	62.0 (no change)
Actual 2017 SP [MW]	75.4	47.4

2. Existing System

This section describes in detail the EDTI transmission system supplying Garneau and Meadowlark substations in Figure 1-1 above in Section 1. EDTI's Garneau substation is normally supplied by two 72 kV transmission cables from Rosedale, 72RG1 and 72RG7. Garneau substation supplies the University of Alberta (U of A) Main Campus load from 6 dedicated 14.4 kV distribution feeders (G2, G3, G5, G7, G9 and G10). The U of A also has two

distribution generators at its Main Campus that are normally synchronized to EDTI's 14.4 kV distribution system via feeders G5, G7, G9 and G10. EDTI has no control of generators connected to its distribution system and cannot guarantee generation during peak loading conditions. As such, for the purposes of planning its distribution and transmission systems, EDTI forecasts with the assumption that distributed generators will not be available. Historical load presented in Table 3-1 includes load supplied by U of A distributed generation (U of A's Behind-the-Fence load). The Garneau substation also supplies residential and commercial load in neighborhoods near the substation on 2 distribution feeders (G1 and G12).

72RG1 and 72RG7 also supply a portion of EDTI's Meadowlark substation (Transformer T3) through 72MG16 under N-0 conditions. However, in the event of an outage to either 72RG1 or 72RG7, 72MG16 is opened (at the Meadowlark end), and the entire Meadowlark substation is supplied by 72JM18.

The normal 72 kV supply to Meadowlark transformers T1 and T2 is from EDTI's Jasper (E805S) 240/72kV transformer T1, and 72kV Jasper-Meadowlark cable 72JM18. In the event of a forced outage to either 72JM18 or Jasper transformer T1, the normally open breaker on the Meadowlark 72kV bus is closed. In this contingency, 72MG16 will supply all Meadowlark load, and 72RG1 and 72RG7 will supply both Garneau and Meadowlark station loads.

2.1 EDTI DISTRIBUTION PLANNING CRITERIA - POD LOADING POLICY

The deficiencies identified in this DDR relate solely to the POD Loading Policy of EDTI's Distribution Planning Criteria. EDTI's POD Loading Policy is as follows:

The Firm Capacity of a POD is an important parameter that EDTI DFO considers for distribution planning purposes. EDTI DFO defines a POD's firm capacity as the maximum load that the POD can supply without overloading any transmission equipment under an N-1 contingency. N-1 contingencies include, but are not limited to, the loss of a single transmission line supply to a POD or the loss of a single transformer at a POD. All PODs should operate at or below their firm capacity.

It should be noted that none of the deficiencies in this DDR are a result of any contingencies arising on the EDTI distribution system.

2.2 Existing System POD Firm Capacities and Transmission System N-1 Overloads

Table 2-1 below provides an overview of existing POD substation firm capacities for the Garneau, Meadowlark and Rosedale substations and actual station peaks in 2017 (including load supplied by U of A distributed generation). As indicated in Table 2-1:

- The Garneau 72 kV bus load is exceeding the N-1 60 MVA transmission capacity of the system.

- The Garneau 14.4 kV POD load in summer is exceeding the N-1 80 MVA transformer capacity of the substation.
- The Meadowlark 72 kV bus load is exceeding the N-1 transmission capacity of the system, which is the 130.4 MVA transmission capacity of 72RG1 and 72RG7 in parallel, less the Garneau substation 72 kV load.

Table 2-1. Overview of Existing Substation Capacities

Substation	Garneau	Meadowlark	Rossdale
Peak Station Recorded Historical Load in 2017	81.6 MVA (summer) at 14.4 kV 91.3 MVA (summer) at 72 kV 67.0 MVA (winter) at 14.4 kV 73.4 MVA (winter) at 72 kV	48.7 MVA (summer) at 14.4 kV 49.9 MVA (summer) at 72 kV 56.4 MVA (winter) at 14.4 kV 58.5 MVA (winter) at 72 kV	136.3 MVA (summer) at 14.4 kV 116.4 MVA (winter) at 14.4 kV (Rossdale 72kV load \cong 14.4kV load)
Transformer Capacity Installed (N-0)	T1: 72/14.4 kV, 30/40 MVA T2: 72/14.4 kV, 30/40 MVA T3: 72/14.4 kV, 30/40 MVA	T1: 72/14.4 kV, 30/40 MVA T2: 72/14.4 kV, 30/40 MVA T3: 72/14.4 kV, 30/40 MVA	T1: 72/14.4 kV, 50/66.7/75 MVA T2: 72/14.4 kV, 50/66.7/75 MVA T3: 72/14.4 kV, 50/66.7/75 MVA T4: 72/14.4 kV, 50/66.7 MVA
Firm (N-1) Transformer Capacity	80 MVA	80 MVA	217 MVA
Firm (N-1) Transformer Capacity <u>Less</u> Peak Station 14.4kV Load	1.6 MVA (summer) shortfall 13.0 MVA (winter)	31.3 MVA (summer) 23.6 MVA (winter)	80.7 MVA (summer) 100.6 MVA (winter)
72kV Transmission Capacity (N-0)	130.4 MVA (summer) 141.3 MVA (winter) from 72RG1 // 72RG7 capacity 72RG1 rating <u>exceeded</u> when 72RG1 and 72RG7 are paralleled, and total load exceeds 130.4 MVA (summer) or 141.3 MVA (winter). See Note 1.	Capacity from 72JM18: 60 MVA (summer) 65 MVA (winter) <u>AND LESSER OF i) and ii):</u> i) 72RG1 // 72RG7 capacity – Garneau 72kV load: 39.1 MVA (summer) 67.9 MVA (winter) (i.e., 130.4 – 91.3 = 39.1 MVA in summer, 141.3 – 73.4 = 67.9 MVA in winter; see Note 1). ii) capacity from 72MG16 60 MVA (summer) 65 MVA (winter)	not applicable (not typically supplied by 72kV transmission circuits)
Firm (N-1) 72kV Transmission Capacity	<u>72RG7 outage:</u> Remaining capacity from 72RG1: 60 MVA (summer) 65 MVA (winter) <u><i>EDTI will switch all Meadowlark POD load to 72JM18 supply.</i></u>	<u>72JM18 outage or Jasper T1 outage:</u> 39.1 MVA (summer) from 72RG1 // 72RG7 capacity – Garneau 72kV load 65 MVA (winter) from capacity of 72MG16	not applicable (not typically supplied by 72kV transmission circuits)
Firm (N-1) 72kV Transmission Capacity <u>Less</u> 2017 Peak Station 72kV Load	<u>72RG7 outage:</u> 60 – 91.3 = 31.3 MVA (summer) shortfall 65 – 73.4 = 8.4 MVA (winter) shortfall	<u>72JM18 outage or Jasper T1 outage:</u> 39.1 – 49.9 = -10.8 MVA (summer). 46% of 10.8 = 5.0 MVA overload on 72RG1 (summer shortfall) . See Note 1. 65.0 – 58.5 = 6.5 MVA (winter).	not applicable (not typically supplied by 72kV transmission circuits)
Existing Switchgear Cells For New Distribution Feeders	3	1	2

(1) 72RG1 rating is 60 MVA (summer) / 65 MVA (winter). 72RG7 rating is 80 MVA (summer) / 90 MVA (winter). However, when 72RG1 and 72RG7 paralleled (//), 72RG1 carries ~46% of total load (determined by cable impedances). Consequently, the total power that can be transmitted from Rossdale to Garneau without 72RG1 exceeding its ratings is 130.4 MVA in summer and 141.3 MVA in winter.

3. Load Forecast

3.1 Load Forecasting Methodology

EDTI uses a hybrid and multilayered load forecasting methodology that combines economic theory, statistical techniques and end-use methods to forecast electricity peak demands at the system level, POD levels and distribution circuit levels. EDTI has determined that load demand in the Edmonton area is highly sensitive to weather conditions. Furthermore, EDTI found that 98% of growth in non-weather sensitive load during the period from 2011 to 2017 can be explained by only three parameters that include gross domestic product (GDP), population growth and housing starts. EDTI's load forecasting methodology can be summarized as follows:

- Weather normalization – As electricity peak demands in the Edmonton region are sensitive to weather conditions, EDTI's historical peak load demands -both summer and winter- are separated into two components (weather sensitive load and non-weather sensitive load) using the Jackknife analysis. Non-weather sensitive peak demands have higher correlation with load growth factors in the city of Edmonton and they allow for more accurate regression models. Based on the past seventeen years of daily temperature during system peak, EDTI has determined the 10th, 50th and 90th percentile temperature, which are provided in the table below. EDTI produces a 10th, 50th and 90th percentile forecast at the system level, POD levels and distribution circuit levels.

	Summer	Winter
10 th percentile	28.3°C	-16.4°C
50 th percentile	30.7°C	-26.3°C
90 th percentile	34.0°C	-32.8°C

- System level load forecasting – Multiple linear regression analysis is deployed to model the system level coincident load based on historical hourly system loading data, historical and forecasted GDP for the Edmonton area, historical and forecasted housing starts, historical and forecasted population growth.
- POD level coincident and non-coincident peaks – EDTI categorizes each POD as residential, mixed/commercial, or industrial depending on the POD's load profile. Residential PODs are the most sensitive to weather conditions whereas industrial PODs are the least sensitive. Depending on the type of the POD, weather sensitivity is adjusted and different predictors are used for the regression analysis. In addition, an area study is performed for each POD to set the upper limit of load growth and historical growth is examined to validate the regression model. Lastly, any anticipated load

transfers and special loads are included. Coincident peaks are computed from the POD non-coincident peaks using coincidence factors derived from historical data.

- Circuit level coincident and non-coincident peaks – The POD level non-coincidental peaks are allocated to each circuit and adjusted based on responsibility factors (circuit's loading at the time of the POD's peak divided by the circuit's peak demand) to calculate both coincidental and non-coincidental circuit peak demands. The size of vacant lands, customers' applications for load connection and special loads are also considered to refine the forecast.
- The winter/summer power factor recorded at each of the PODs in 2017 is used as the winter/summer forecast for years 2018 to 2040. While apparent power [MVA] is forecasted using the methodology described above, active power [MW] is a calculated value that assumes the 2017 power factor.

3.2 Existing System Load Forecast

Table 3-1 below provides non-coincident summer historical and forecast peak loads (90th percentile) for the Garneau, Meadowlark and Rossdale substations. Note the aggregate summer peak of Garneau, Meadowlark and Rossdale PODs is substantially higher than the winter peak. In addition, summer transmission equipment ratings and corresponding POD firm capacities are lower than winter ratings and capacities. Consequently, deficiencies identified in the summer actual and forecast tables in this DDR will be worst case. For this reason, winter load forecasts are not considered in this DDR.

Note in summer of 2010, EDTI temporarily transferred approximately 11 MVA of Garneau summer peak load to Rossdale using existing distribution circuit ties. In May 2011, this transfer was made permanent to reduce the potential overload on 72RG1 under an N-1 contingency (72RG7 out of service). No new distribution construction was required for these transfers.

Table 3-1 EXISTING SYSTEM HISTORICAL AND PROJECTED SUMMER PEAK LOADS (Red = 72 kV Station load exceeds N-1 72kV transmission capacity. Orange = Garneau 14.4 kV POD load exceeds station N-1 transformer capacity)

Table with columns: Actual (2010-2017), Forecast (2018-2040). Rows include various transmission capacity and load metrics for N-1, Garneau, Rosedale, and Meadowlark areas.

Notes:

- 1) Distribution circuit summer peaks in this table are non-coincident with POD peaks.
2) In June 2010, Garneau G4 and G11 loads (5.4 MVA and 5.0 MVA) were temporarily transferred to Rosedale circuits R23 and R24 (2010-06-14 to 2010-11-20). This is reflected in Rosedale and Garneau summer peaks.
3) In May 2011, Garneau G4 and G11 loads were permanently transferred to Rosedale circuits R23 and R24.
4) New R19 feeder to new downtown Arena complex in service June 2016. New Rosedale 15 kV bus section (see AUC Proceeding 23165, EDTI 2018-2019 TFO Tariff Application). Planned in service date: 2019 Q4. R11, R12, R21, R22, R31, R32, R41, R42 will be transferred to new bus section (feeders R51 to R58).
5) N-1 Transmission Capacity at Meadowlark is lesser of: i) 60 MVA capacity of 72JM18 or 72MG16; or ii) 130.4 MVA parallel capacity of 72RG1 and 72RG7 less Garneau 72kV load
6) In July 2015, Meadowlark M26 circuit temporarily supplied Jasper J72 circuit load.
7) In 2020: Jasper J72 circuit load will be transferred to Meadowlark M37 circuit; Jasper J82 circuit load will be transferred to Meadowlark M26 circuit.

4. Alternatives Analysis

The following alternatives were considered to mitigate the deficiencies identified in section 1.0:

Alternative 1: Distribution Load Shifting

Alternative 2: 72 kV Transmission Development and New Transformer

Alternative 3: 72 kV Transmission Development and Replace 2 Transformers

Alternative 4: Hybrid 72 kV Transmission and Distribution Development

4.1 Alternative 1: Distribution Load Shifting

4.1.1 Description

EDTI investigated distribution load transfers from the Garneau service area to Rossdale substation. The Rossdale substation is the nearest POD to Garneau, and has sufficient spare N-1 transformer capacity to accept the required load transfers from Garneau. Load would be shifted off Garneau to reduce its peak demand below its 60 MVA (N-1) transmission capacity limit.

Load transfers from Garneau to Rossdale would be accomplished using newly constructed 14.4 kV distribution feeders. These load transfers will occur over a period of several years, as follows:

2020 – transfer Garneau G2 and G3 feeder load (initially 14.2 MVA and 10.4 MVA) to new Rossdale feeders R39 and R49. This load is U of A Main Campus load.

2020 – transfer Garneau G1 feeder load (initially 6.5 MVA) to new Rossdale feeder R11

2026 – transfer Garneau G12 feeder load (initially 5.9 MVA) to new Rossdale feeder R42.

4.1.2 Load Forecast

The impact of the Distribution Load Shifting Alternative on Garneau, Rossdale, and Meadowlark station loading is presented below in Table 4.1.2-1.

4.2 Alternative 2: 72 kV Transmission Development and New Transformer

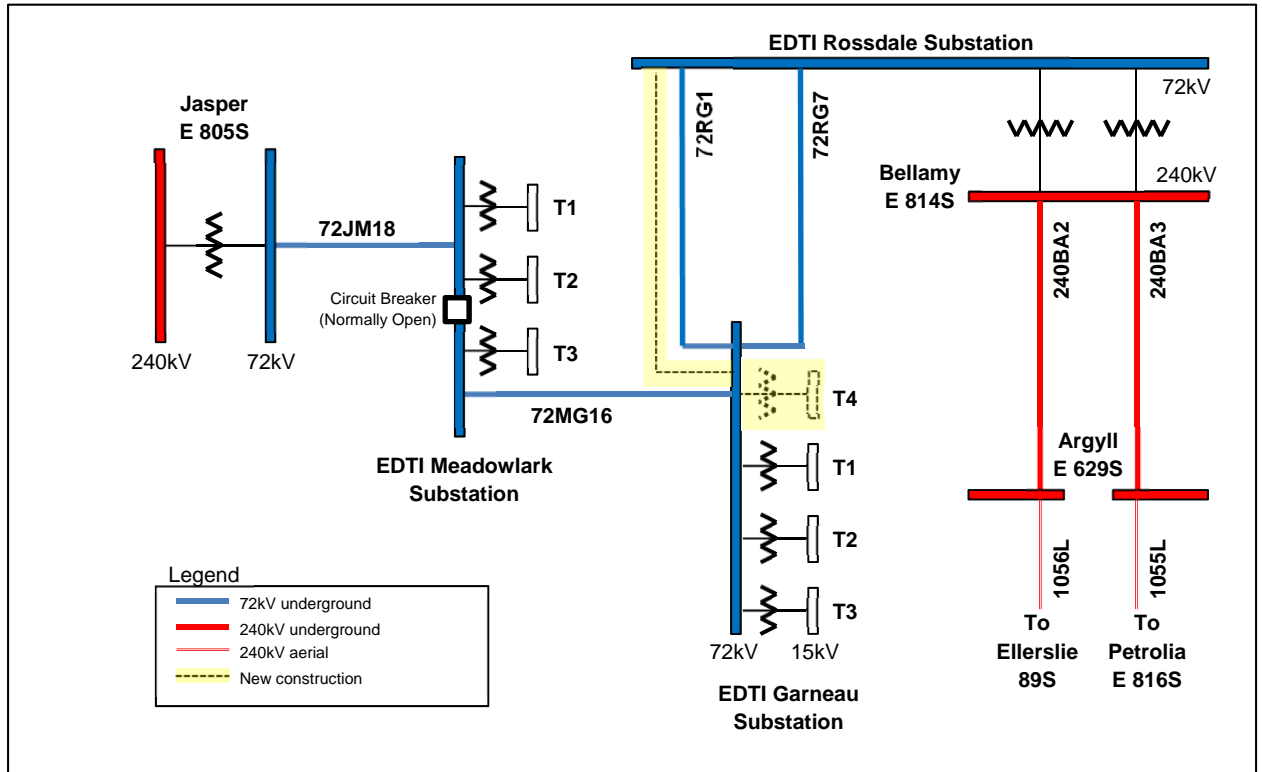
4.2.1 Description

This alternative involves the following:

- Installation of a new 72kV circuit between Rosssdale and Garneau to address the shortfall of firm (N-1) 72kV capacity at Garneau. The minimum capacity of this circuit to mitigate the forecast shortfall at Garneau by 2040 is estimated at 55.2 MVA, which is the Garneau 72kV load forecast of 115.2 MVA in 2040, less the existing 60 MVA firm 72kV capacity. Power flow studies will confirm the actual minimum capacity requirement for the new circuit. New circuit capacity above the estimated minimum 55.2 MVA would have the benefit of meeting load growth beyond 2040, and better matching proposed Garneau N-1 transformer capacity under this alternative.
- Addition of a new 30/40 MVA transformer at Garneau to address the shortfall of firm (N-1) transformer capacity at Garneau.
- New 15kV switchgear line up at Garneau, along with an expansion of the existing building and substation switchyard.
- Two new 72kV SF6 circuit breaker bays along with associated disconnects and control equipment at Garneau.
- One new 72kV outdoor circuit breaker bay along with associated disconnects and control equipment at Rosssdale.

Note Alternative 2 is a purely transmission development with no distribution component.

Figure 4.2.1-1: Alternative 2 - 72 kV Transmission Development and New Transformer



4.2.2 Load Forecast

The impact of the Alternative 2 on Garneau and Meadowlark station loading is presented below in Table 4.2.2-1. This alternative does not impact Rosedale POD loading.

4.3 Alternative 3: 72 kV Transmission Development and Replace 2 Transformers

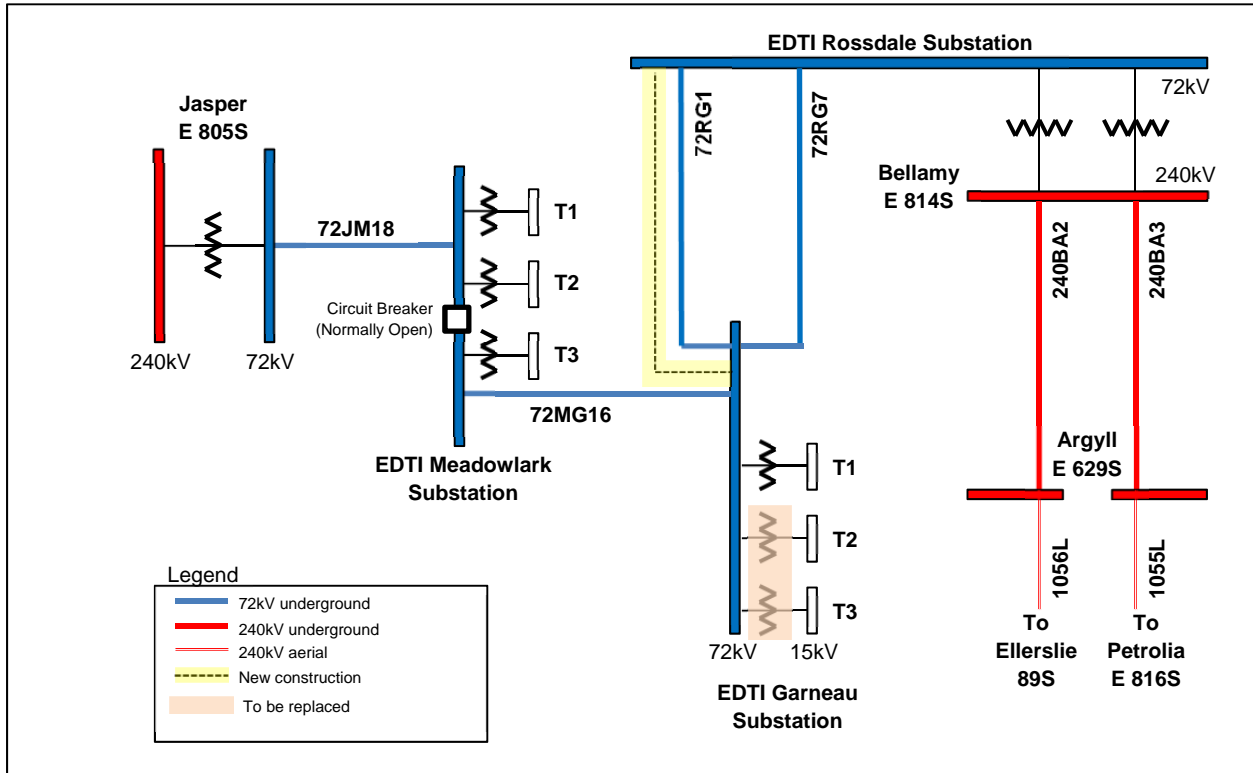
4.3.1 Description

This alternative involves the following:

- Installation of a new 72kV circuit between Rossdale and Garneau to address the shortfall of firm (N-1) 72kV capacity at Garneau. The minimum capacity of this circuit to mitigate the forecast shortfall at Garneau by 2040 is estimated at 49.1 MVA, which is the Garneau 72kV load forecast of 109.1 MVA in 2040, less the existing 60 MVA firm 72kV capacity. Power flow studies will confirm the actual minimum capacity requirement for the new circuit. New circuit capacity above the estimated minimum 49.1 MVA would have the benefit of meeting load growth beyond 2040, and better matching proposed Garneau N-1 transformer capacity under this alternative.
- Replace the existing two (2) Garneau 30/40 MVA transformers with new 50/60MVA rated transformers. (Transformer capability would limit Garneau to 100MVA).
- Installation of one new 72kV SF6 circuit breaker bay along with associated disconnects and control equipment at Garneau.
- Installation of one new 72kV outdoor circuit breaker bay along with associated disconnects and control equipment at Rossdale.

Note Alternative 3 is a purely transmission development with no distribution component.

Figure 4.3.1-1: Alternative 3 - 72 kV Transmission Development and Replace 2 Transformers



4.3.2 Load Forecast

The impact of the Alternative 3 on Garneau and Meadowlark station loading is presented below in Table 4.3.2-1. This alternative does not impact Rosedale POD loading.

4.4 Alternative 4: 72 kV Hybrid Transmission & Distribution Development

4.4.1 Description

This alternative involves both transmission and distribution developments to attempt to mitigate the deficiencies identified in section 1.0. EDTI would transfer load from the Garneau service area to Rosssdale substation and maintain Garneau's load below the station's existing 80 MVA firm (N-1) transformer capacity.

Load transfers from Garneau to Rosssdale would be accomplished using newly constructed 14.4kV distribution feeders. The load transfers would occur over a period of several years, as follows:

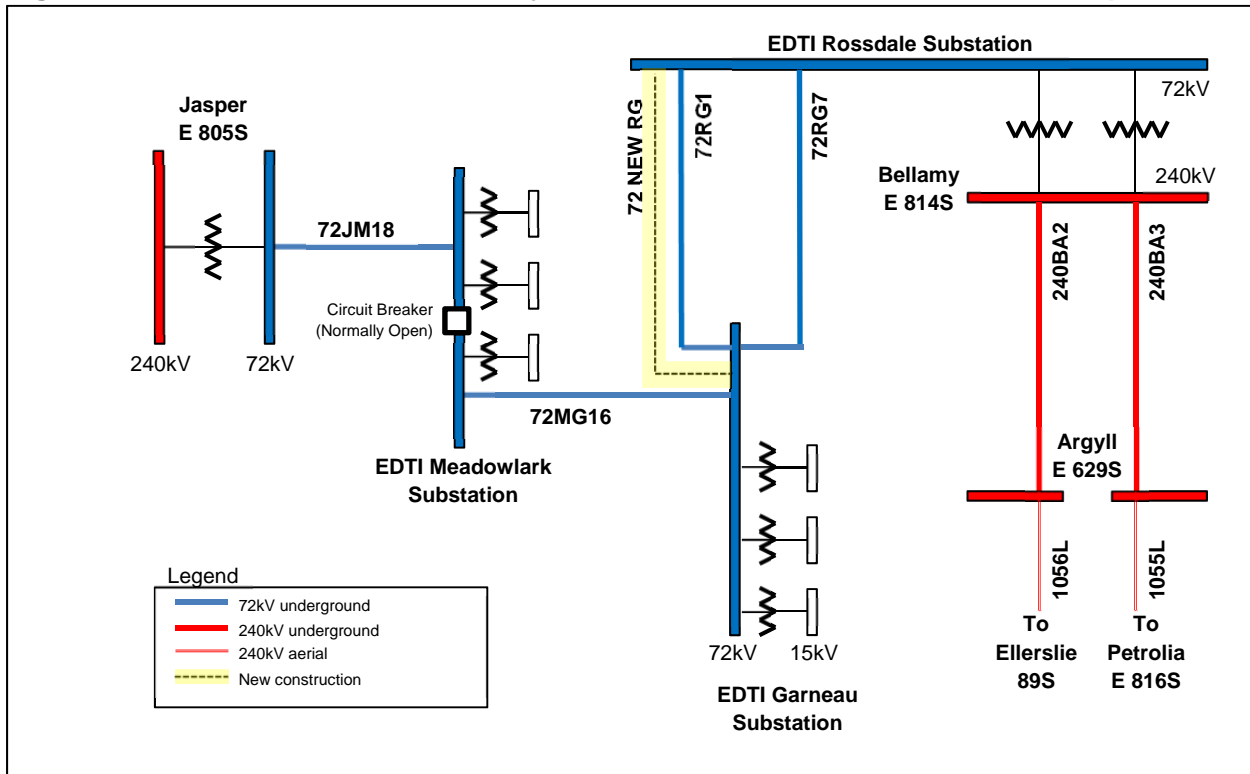
2020 – transfer Garneau G1 feeder load (initially 6.5 MVA) to new Rosssdale feeder R39.

2024 – transfer Garneau G12 feeder load (initially 5.9 MVA) to new Rosssdale feeder R49.

2030 – transfer Garneau G2 feeder load (initially 15.9 MVA) to new Rosssdale high capacity feeder R11.

This alternative also involves the following transmission developments:

- Installation of a new 72 kV circuit between Rosssdale and Garneau. With Garneau's load maintained below 80 MVA by distribution load shifting, the minimum capacity of the new 72 kV circuit to mitigate the N-1 transmission shortfall is estimated at 29 MVA, which is equal to the Garneau 72kV load of 89 MVA (when 14.4 kV load is 80 MVA), less the existing 60 MVA firm 72kV capacity. New circuit capacity above the estimated minimum 29 MVA would have the benefit of meeting load growth beyond 2040.
- Installation of one new 72kV SF6 circuit breaker bay along with associated disconnects and control equipment at Garneau.
- Installation of one new 72kV outdoor circuit breaker bay along with associated disconnects and control equipment at Rosssdale

Figure 4.4.1-1: Alternative 4 - 72 kV Hybrid Transmission & Distribution DevelopmentDetails of Distribution Development:

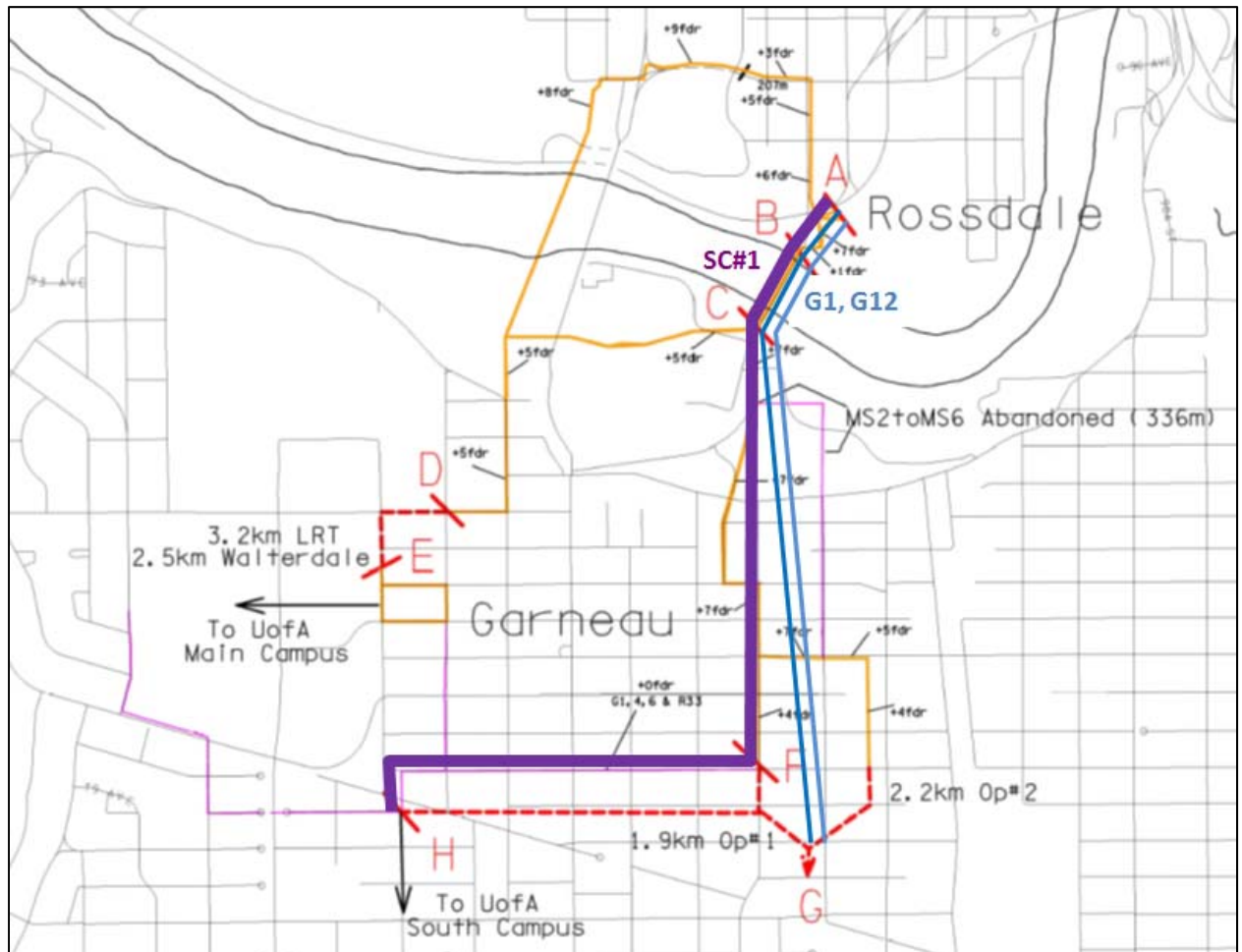
At Rosssdale, there is forecast to be sufficient spare 15kV switchgear space and capacity to handle all these distribution load transfers. Presently, there is existing switchgear space for new R39 and R49 feeders. Space for R11 feeder in 2030 feeder is contingent upon completion of EDTI's capital maintenance project Rosssdale Medium Voltage Switchgear Addition (filed with AUC in Proceeding 23165, EDTI 2018-2019 TFO Tariff Application).

The existing distribution feeder duct line system will need to be expanded to address these additional feeders from Rosssdale. The duct line expansion will run in existing EDTI roadway allowances except for a river crossing necessary in the Rosssdale area.

Rosssdale and Garneau are separated by the North Saskatchewan River and as such a duct line across the river would be required. Providing feeders across the river requires the use of limited crossings afforded by City of Edmonton bridges. Key to this is the proposal to use 10 ducts on the new Walterdale Bridge that was completed 2017 Q3. Existing facilities on the old Walterdale Bridge consist of 4 feeder cables and 5 communication cables. The City has agreed to allow 12 ducts to be installed on the new bridge for the exclusive use of EDTI. The 12 new ducts in the new Walterdale Bridge would be utilized as follows:

- 4 ducts for 4 existing Rosssdale feeders.
- 2 ducts for 5 communication cables.
- 2 ducts for the transfer of two 7.5 MVA capacity distribution feeders (G1 and G12) to Rosssdale
- 2 ducts for one high capacity feeder (R11) from Rosssdale to U of A Main Campus. The high capacity feeder would be comprised of paralleled runs of 750 MCM copper cables; hence 2 ducts are required for this feeder.
- 2 spare ducts for future or emergency use.

Figure 4.4.1-2 New Distribution Construction For Hybrid Alternative



G1 circuit transfer to R39 Rosssdale (2020)

- Construct new 12-way ductline constructed from Rosssdale to north side of new Walterdale Bridge (A to B). Install new 750 MCM Cu feeder cable from Rosssdale sub to new Walterdale bridge (A to B)
- Install new 750 MCM Cu feeder cable across new Walterdale bridge (B to C)
- Install new 750 MCM Cu feeder cable in existing ductline from south side of new Walterdale Bridge to G1 lateral (C to G).

G12 circuit transfer to R49 Rosssdale (2024)

- Construct new 12-way ductline constructed from Rosssdale to north side of new Walterdale Bridge (A to B). Install new 750 MCM Cu feeder cable from Rosssdale sub to new Walterdale bridge (A to B)

- Install new 750 MCM Cu feeder cable across new Walterdale bridge (B to C)
- Install new 750 MCM Cu feeder cable in existing ductline from south side of new Walterdale Bridge to G1 lateral (C to G).

G2 circuit (U of A Main Campus load) transfer to R11 Rosedale (2030)

- Construct new 12-way ductline constructed from Rosedale to north side of new Walterdale Bridge (A to B).
- Install new 2x 750 MCM Cu feeder cable from Rosedale sub to new Walterdale bridge (A to B)
- Install new 2x750 MCM Cu feeder cable across new Walterdale bridge (B to C)
- Install new 2x 750 MCM Cu feeder cable in existing ductline from south side of new Walterdale Bridge to intercept existing redundant feeder cables G4 and G6 (C to F)
- Splice new 2x 750 MCM Cu feeder cable to existing G4 and G6 feeder cable (near F)
- Existing 2x 750 MCM Cu feeder cables becomes part of feeder (F to H)

4.4.2 Load Forecast

The impact of the 72kV Hybrid Transmission and Distribution Alternative 4 on Garneau, Rosedale, and Meadowlark station loading is presented below in Table 4.4.2-1.

4.4.3 Cost Estimate

The distribution capital cost of the 72kV Hybrid Transmission and Distribution Alternative 4 is presented in Table 4.4.3-1 below. This alternative is estimated to a +/- 30% accuracy.

Table 4.4.3-1: Alternative 4 Distribution Costs and NPV (+/- 30%)

Item	Base cost \$ million	Year	NPV \$ million
Distribution work for G1 (to R39) transfer and new Walterdale Bridge ducts.	\$4.0	2020	\$3.6
New R39 feeder breaker	\$0.1	2020	\$0.1
Distribution work for G12 (to R49) transfer.	\$2.0	2024	\$1.6
New R49 feeder breaker	\$0.1	2024	\$0.1
Distribution work for G2 (to R11) transfer.	\$3.6	2030	\$2.5
Total Distribution cost	\$9.8		\$7.9

Inflation: 2.80%

Discount Rate: 6.40%

WACC: 7.00%

5. Technical Analysis of Alternatives

The following sections present the technical analysis for the alternatives considered in this Distribution Deficiency Report.

5.1 Alternative 1: Distribution Load Shifting

EDTI rejected Alternative 1 Distribution Load Shifting as technically unacceptable for the following reasons:

1. As indicated in Table 4.1.2-1, this alternative provides adequate N-1 72 kV transmission capacity to Garneau only up to 2033. After 2033, this alternative does not provide adequate N-1 72 kV transmission capacity to Garneau. The shortfall in N-1 capacity is forecast to be 0.2 MVA in 2034 and 2.1 MVA in 2040.

Also as indicated Table 4.1.2-1, this alternative does not provide adequate N-1 72 kV transmission capacity to Meadowlark in any year from 2020 to 2040. This is because overloads will occur on 72JM18 or 72MG16 under N-1 conditions. Alternative 1 was rejected by EDTI DFO as it does not adequately meet EDTI's distribution planning criteria (as found in Section 2.1).

2. Supplying the University of Alberta Main Campus from both Garneau and Rosssdale allows the U of A to parallel (i.e. simultaneously connected to) both Rosssdale and Garneau 14.4 kV feeders. When this happens, the following problems occur:
 - With Rosssdale 15kV busses closed (existing situation), short circuit levels at Rosssdale increase from 27 kA to 36 kA. Rosssdale 15 kV switchgear is only rated for 30kA. This is an intolerably unsafe condition.
 - Upon completion in 2019 of EDTI's capital maintenance project Rosssdale Medium Voltage Switchgear Addition (filed with AUC in Proceeding 23165, EDTI 2018-2019 TFO Tariff Application), short circuit levels at Rosssdale are intended to be reduced to a safe level of 11 kA. Under this alternative, the short circuit levels at Rosssdale have the potential to increase to approximately 20 kA. This would negate one of the key drivers for the capital maintenance project to reduce fault levels to 11 kA. This too would be intolerable.
 - Power flow studies indicate that, with the future Rosssdale split bus configuration, when U of A 15kV buses are simultaneously fed from both Rosssdale and Garneau feeders, Rosssdale 15kV feeders supply almost no load and Garneau 15kV feeders are overloaded. This would not be acceptable.
3. The large U of A load, their complex distribution system, and their large generating capabilities operating in conjunction with the Garneau Substation creates complex operations and a complicated operating environment of the overall system. This requires close coordination between the U of A and EDTI System Control centers. This operating environment will be made even more complex with two new feeders from Rosssdale.
4. Garneau load transfers to Rosssdale will limit the ability of Rosssdale POD to accommodate long term load growth in its own service area, which includes portions of downtown Edmonton. Alternative 1 would leave Rosssdale with only 27.0 MVA spare capacity by 2026, and 17.7 MVA by 2040.

Overall, the flexibility of Alternative 1 to adapt to load forecast variance is only acceptable if loads are lower than forecast. Conversely, if the load forecast at either Garneau or Rosssdale is more than forecasted, then this alternative does not have the flexibility to accommodate this sort of change.

5. Leaving the load capability at Garneau POD at 56 MVA (limited by the 72RG1 cable capacity) in effect strands 24 MVA of existing transformer capacity. The 56 MVA limit also leaves existing Garneau feeder breakers G1, G2, G3, G6 and G12 as stranded assets.
6. Long distribution feeders from Rossdale (2.5 and 3.2 km) to U of A will also be subject to increased security issues that would not be as prevalent with existing shorter lines (0.5 km) fed from the Garneau POD.
7. The load transferred from Garneau to Rossdale is well within the service area of the existing Garneau Substation. The new feeders from Rossdale serving U of A Main Campus load will pass the Garneau Substation.

5.2 Alternative 2: 72 kV Transmission Development and New Transformer

- This alternative provides adequate N-1 capacity to Garneau substation out to 2040.
- This alternative does not provide adequate N-1 72 kV transmission capacity to Meadowlark in any year from 2020 to 2040. This is because overloads will occur on 72JM18 or 72MG16 under N-1 conditions. For this reason, Alternative 2 was rejected by EDTI DFO as it does not adequately meet EDTI's distribution planning criteria (as found in Section 2.1).

5.3 Alternative 3: 72 kV Transmission Development and Replace 2 Transformers

- This alternative provides adequate N-1 72 kV transmission capacity to Garneau substation out to 2040.
- This alternative provides adequate N-1 transformer capacity at Garneau substation only up to 2038. After 2038, this alternative does not provide adequate N-1 transformer capacity. The shortfall in N-1 capacity is forecast to be 0.2 MVA in 2039 and 0.5 MVA in 2040
- This alternative does not provide adequate N-1 72 kV transmission capacity to Meadowlark in any year from 2020 to 2040. This is because overloads will occur on 72JM18 or 72MG16 under N-1 conditions. For this reason, Alternative 3 was rejected by EDTI DFO as it does not adequately meet EDTI's distribution planning criteria (as found in Section 2.1).

5.4 Alternative 4: Hybrid 72 kV Transmission and Distribution Development

- This alternative provides adequate N-1 capacity to Garneau substation out to 2040.
- This alternative does not provide adequate N-1 72 kV transmission capacity to Meadowlark in any year from 2020 to 2040. This is because overloads will occur on 72JM18 or 72MG16 under N-1 conditions. For this reason, Alternative 4 was rejected by EDTI DFO as it does not adequately meet EDTI's distribution planning criteria (as found in Section 2.1).

6. Conclusions/Recommendations

EDTI DFO rejects Alternative 1 Distribution Load Shifting as technically unacceptable for reasons noted in section 5.1, including not adequately meeting EDTI's distribution planning criteria (as found in Section 2.1).

EDTI believes alternatives 2, 3 and 4 will mitigate all shortfalls in firm (N-1) capacity identified for the Garneau POD. These alternatives mitigate overloads on 72RG1 and 72RG7 under N-1 contingencies. However, none of the alternatives mitigate the N-1 overloads on 72JM18 or 72MG16 supplying Meadowlark POD. For this reason, EDTI DFO also rejects Alternatives 2, 3 and 4 as they do not adequately meet EDTI's distribution planning criteria (as found in Section 2.1).

As a consequence of none of the alternatives discussed above being able to meet all identified needs, EDTI requests that the AESO participate in developing an appropriate transmission solution to serve the load requirements for the Garneau and Meadowlark POD distribution service areas.

As per Table 3-1 above, the Garneau POD has been loaded beyond its rated capacity and at risk since at least 2010. EDTI has received requests from the AESO's real time operations group to reduce the load on the Garneau POD. Therefore, EDTI requests the development at the earliest possible opportunity to eliminate existing transmission overloads and resulting POD loads at risk.

**ADDENDUM: AESO Proposed Development and Poundmaker Substation 5 Year
Peak Load History**

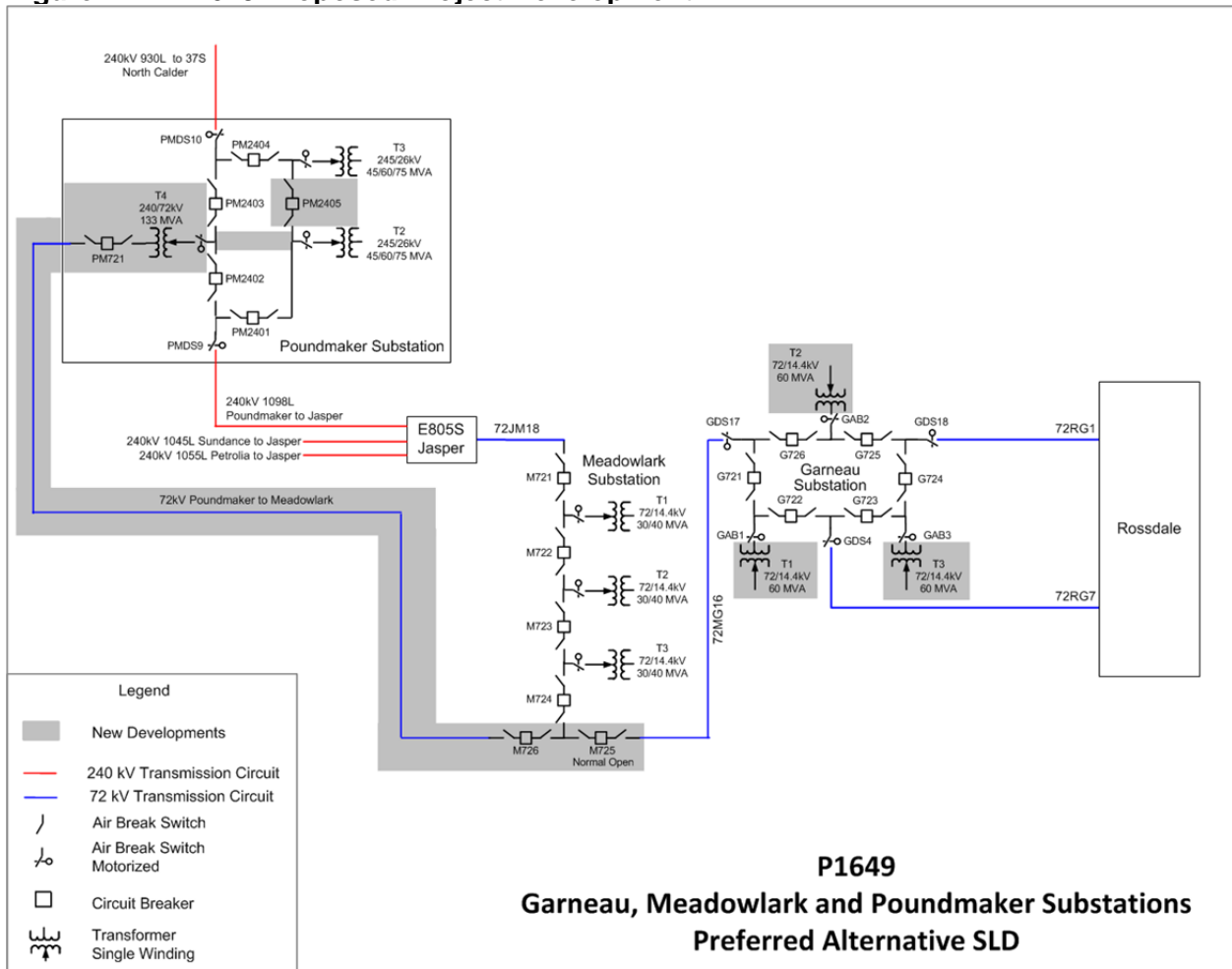
P1649 Proposed Transmission Development and Poundmaker POD 5 Year Peak Load History

To address the need presented in this DDR, AESO has proposed the transmission development in Connection Proposal P1649 – West Edmonton Transmission Upgrade Project. This development is illustrated in Figure A-1 below and is comprised of the following:

- Building a new 72kV circuit between Poundmaker and Meadowlark substations with a minimum capacity of 125 MVA.
- Addition of one (1) 240kV/72kV LTC transformer at Poundmaker with a minimum rating of 133 MVA
- Replace the three (3) existing 30/40 MVA transformers with three (3) LTC transformers, with a minimum rating of 60 MVA.
- Implement a Remedial Action Scheme (RAS) that reconfigures the 72kV system without any loss of load following an N 1 forced outage to any of the following transmission elements: 72RG1, 72RG7, 1098L, new Poundmaker 240/72kV transformer T4, or new Poundmaker-Meadowlark 72 kV circuit.

Note that both alternatives (Alternative 2-A and Alternative 2-B) analyzed in Connection Proposal P1649 – West Edmonton Transmission Upgrade Project are purely transmission developments with no distribution components or costs associated to distribution system development.

Figure A-1. P1649 Proposed Project Development



This proposed transmission development addresses the EDTI deficiencies identified in this DDR. The impact of the proposed development on Garneau and Meadowlark station loading is presented below in Table A-1. Note this alternative does not impact Rosedale POD loading.

As this proposed transmission development involves equipment additions at EDTI Poundmaker substation, a 5 year history of Poundmaker substation loads are presented in Tables A-2 and A-3 below.

Table A-2: Poundmaker POD 5 Year Peak Load History - Winter

Winter	Actual				
	2013	2014	2015	2016	2017
N-1 Transformer Capacity MVA	89.0	89.0	89.0	89.0	89.0
Poundmaker POD MVA	36.8	37.2	40.8	44.4	50.0
Poundmaker POD MW	36.4	36.8	40.6	44.3	49.7
Poundmaker POD pf	0.990	0.991	0.997	0.998	0.993
21PM MVA	11.1	12.4	13.6	8.3	7.5
22PM MVA	8.0	8.5	8.8	10.0	14.1
23PM MVA	-	-	-	-	-
31PM MVA	11.5	10.5	11.5	9.8	11.2
32PM MVA	8.5	8.5	8.5	9.0	8.8
33PM MVA	-	-	-	11.5	11.6

Table A-3: Poundmaker POD 5 Year Peak Load History - Summer

Summer	Actual				
	2013	2014	2015	2016	2017
N-1 Transformer Capacity MVA	75.0	75.0	75.0	75.0	75.0
Poundmaker POD MVA	34.7	35.2	38.1	39.0	44.2
Poundmaker POD MW	32.3	34.7	37.3	38.1	43.2
Poundmaker POD pf	0.930	0.985	0.978	0.978	0.977
21PM MVA	10.1	11.3	12.2	7.2	6.9
22PM MVA	8.9	8.9	9.3	9.1	14.5
23PM MVA	-	-	-	-	-
31PM MVA	8.4	9.5	11.0	7.9	10.8
32PM MVA	7.5	7.6	8.1	7.5	7.4
33PM MVA	-	-	-	9.2	10.0