City of Whitehorse
(CW)

TOPIC: **Yukon Energy 2016 Resource Plan (Resource Plan)**

REFERENCE: Resource Plan, page 1, lines 7-11, YEC Application, page 8

PREAMBLE: In the Resource Plan, YEC states:

> A key component of the 2016 Resource Plan (the Plan) is a recommended Action Plan for meeting customer electricity demands. **The document does not seek approval for specific future projects**. While the Plan identifies resources of interest, the development of future resources will be managed through YEC's stagegate process for project development and approval, and will require engagement with First Nations and stakeholders, as well as regulatory reviews and permitting. (Emphasis added)

On page 8 of its Application, YEC states:

> Yukon Energy has provided as Volume 2 of its filed material the final 2016 Resource Plan. The 2016 Resource Plan addresses Yukon Energy's requirements for the next five years, as well as for the longer term planning horizon, and describes the extensive consultation undertaken during the preparation of this plan. Yukon Energy is not seeking specific approvals for the plan. The 2016 Resource Plan is provided for information of the Board and stakeholders and to provide context for capital expenditures and ongoing planning costs included in the test year forecasts.

CW requires information to understand the use of the Resource Plan.

QUESTION:

a) Please fully explain how the resource plan was used to create the GRA forecasts. Were projects in the resource plan specifically included in the GRA?

b) In the response to (b) above, please provide a cross reference between any projects in the GRA, and projects in the resource plan.

ANSWER:

(a) and **(b)**

The 2016 Resource Plan was used in YEC's GRA Application to provide context for the GRA capital expenditures and ongoing planning costs included in the test year forecasts.

Sales and generation forecasts in the GRA were prepared separately from the 2016 Resource Plan, based on the information and analysis as reviewed in Tab 2 of the Application and the required focus on 2017 and 2018 versus the 20-year planning period relevant to the Resource Plan. The relevant 2016 Resource Plan forecasts for sales, generation, winter peak capacity, and single contingency dependable capacity shortfalls are referenced in the Application.

Capital and deferred cost projects referenced in the 2016 Resource Plan for possible future development are noted where relevant throughout Tab 5 of YEC's Application. Examples for major projects (over $1 million spending) include: LNG Third Engine, Battery Project, Thermal Plant Project, Stewart Keno City Transmission Project, DSM, Marsh Lake (Southern Lakes) Storage Enhancement Project, Mayo Lake Storage Enhancement Project. Many of these projects remain in WIP at the end of 2018 and therefore do not affect test year revenue requirements or rates.

TOPIC: **Yukon Energy 2016 Resource Plan (Resource Plan)**

REFERENCE: Resource Plan, page 1, lines 2-6

PREAMBLE: On page 1 of the Resource Plan, YEC states:

> Yukon Energy Corporation (YEC) prepares an update to its 20-Year Resource Plan every five years. The following document is an update of the 2006 and 2011 Plans. The purpose of this plan is to provide recommendations as to how to cost-effectively meet the electricity needs of the Yukon Energy's customers over the next 20 years. Consistent with the values of these customers, environmental protection and low cost were key drivers in shaping the recommendations of this plan.

CW requires information to assess the accuracy of Resource Plans in forecasting needs.

QUESTION:

a) Please provide copies of 2006 and 2011 plans.

b) Please provide tables of annual sales forecasts for the 20 year period for each of the plans.

c) Please provide actual annual sales for each year from 2006-2016.

d) Please provide a table of peak load forecasts for the 20 year period for each of the plans.

e) Please provide the actual peak load for each year from 2006-2016.

f) Please provide a comparison of the proposed projects in each of the plans to the actual projects completed in the 2006-2016 time period. In the response, please explain variances between proposed and actual projects.

g) Please confirm that YEC facility planning is based on this resource plan. If not confirm please fully explain.

ANSWER:

(a)

Yukon Energy's 2006 Resource Plan is available from the YUB website for the proceeding re: Yukon Energy Corporation 20-Year Resource Plan at the link below.

http://yukonutilitiesboard.yk.ca/pdf/YEC%2020-Year%20Resource%20Plan/152_resource20yearplan.pdf

Yukon Energy's 2011 Resource Plan Overview dated July 2012 was filed as Attachment 1 to YECL-YEC-1-18(a), and is available on the YUB website at the link below.

http://yukonutilitiesboard.yk.ca/proceedings/yec-2012-general-rate-application/

A subsequent update to this forecast that was filed with the Board in November 2012 as Exhibit B-20 is provided as CW-YEC-1-2(a) Attachment 1.

(b) and **(d)**

Please see Table 1 below for a summary of the earlier Resource Plan Base Case generation and peak load forecasts.

The 2011 Resource Plan forecasts are from the July and November 2012 forecasts as filed with the Board during the 2012/13 GRA. The November version reflected non-industrial GRA load forecasts for 2012 and 2013 and DSM based on the ICF Marbek January 2012 report; it also included Minto, Alexco and Whitehorse Copper tailings loads.

The 2006 Resource Plan addressed the WAF and MD grids separately as these were not yet connected, and focused on the WAF grid. The Base Case assumed WAF non-industrial load growth at 1.85% per year over 2004 loads with no industrial load. Table 1 below provides an approximation of the energy forecast for the combined grids based on this assumed annual load growth, and the peak load for the WAF grid based on the 1.85% annual growth rate assumption.

Table 1: Summary of 2006 and 2011 Resource Plan Forecasts

Forecast Years	Base Case with DSM - Total Load (GW.h)			Base Case with DSM - Total Peak Load (MW)		
	2006 RP - 1.85%yr Case	2011 RP - July 2012 Version	2011 RP - Nov 2012 Version	2006 RP - 1.85%yr Case - WAF only	2011 RP - July 2012 Version	2011 RP - Nov 2012 Version
2006	302.0			57.4		
2007	307.6			58.5		
2008	313.3			59.5		
2009	319.1			60.6		
2010	325.0			61.8		
2011	331.0			62.9		
2012	337.1	416	406	64.1	80	78
2013	343.3	430	412	65.3	81	79
2014	349.7	443	437	66.5	83	82
2015	356.2	449	449	67.7	84	84
2016	362.8	455	461	68.9	85	88
2017	369.5	454	469	70.2	85	89
2018	376.3	460	474	71.5	86	90
2019	383.3	462	471	72.8	88	91
2020	390.4	441	469	74.2	89	92
2021	397.6	409	456	75.6	81	88
2022	404.9	416	464	77.0	83	90
2023	412.4	422	434	78.4	84	86
2024	420.1	429	443	79.8	85	88
2025	427.8	437	453	81.3	87	90
2026		444	463		88	92
2027		452	475		90	94
2028		459	486		91	97
2029		467	498		93	99
2030		475	510		94	101

(c)

Actual annual sales (including secondary sales) from 2006-2016 are as follows:

Year	Sales (GWh)
2006	302.0
2007	307.7
2008	315.7
2009	345.6
2010	351.5
2011	368.7
2012	392.1
2013	388.5
2014	373.9
2015	380.7
2016	386.0

(e)

Actual peak load for each year from 2006-2016 is as follows:

Year	Hourly Avg. Peak Generation [MW]
2006	65.0
2007	63.1
2008	67.5
2009	69.0
2010	72.6
2011	76.3
2012	82.2
2013	82.7
2014	76.5
2015	82.1
2016	88.1

(f)

Near term proposed projects (i.e., within the first five years of each plan) in the earlier Resource Plans are reviewed below:

1. **2006 Resource Plan:**

    a. **Proposed** - The initial plan proposed four projects (Aishihik 3rd Turbine, Carmacks-Stewart Transmission Project (CSTP), Mirrlees Life Extension (at Whitehorse), and Marsh Lake Fall-Winter Storage); the plan was subsequently revised to remove the Marsh Lake Fall-Winter Storage and to add Mirrlees life extension at Faro.[1]

    b. **Actual** – The Aishihik 3rd Turbine was developed, along with the CSTP in two stages; two Mirrlees units received life extension work; the Marsh Lake storage project continues to be examined (now referenced as Southern Lakes Storage Enhancement).

2. **2011 Resource Plan:**

    a. **Proposed** – The plan proposed the following (in addition to proposing cost-effective DSM) in the "recommended plans" section of the Overview:
        i. LNG transition option to establish LNG generating capability in Whitehorse prior to 2015, as a transition option able to meet current forecast loads with the least cost option available for near-term implementation.
        ii. Near term hydro enhancements related to planning for the Marsh Lake Storage hydro enhancement project, and to reach a final determination on the Gladstone Diversion project.
        iii. Other activities related to completing Ferry Hill wind monitoring, continuing planning studies for priority longer-term greenfield hydro

[1] The Yukon Utility Board's Report and Recommendations regarding the 2006 Resource Plan, Section 6.6, noted as follows regarding the Marsh Lake storage project "The Board is of the view that this project is not likely to be completed in the near term, given the argument by YEC regarding local opposition to the project. However, the Board sees some viability to this project in terms of either displacing diesel generation or delaying future capacity additions. Therefore, the Board recommends that this project be retained in the Plan but be removed as a near-term project. YEC should update the status of this project when it files its next resource plan. The timing for YEC's next resource plan is discussed in Section 13.

development opportunities, and studies for other potential future options (including geothermal, grid extensions, wood biomass, solar, and pipeline/natural gas).

b. **Actual** – The LNG Project was developed, planning continued on the Marsh Lake Storage project, and a final determination was reached on not pursuing the Gladstone Diversion project. Planning studies continued to review in the latest Resource Plan updates on a range of other potential longer-term resource options.

(g)

YEC generation and transmission planning utilizes the available resource plans to assess priorities and options, with updates on these plans carried out every five years. As noted in each resource plan, YEC's final decisions on any specific resource project involve additional stages of assessment and planning by management and YEC's Board of Directors.

B20

YUKON ENERGY

YUKON UTILITIES BOARD
EXHIBIT B-20
DAY | ENTERED BY YEC | DATE Nov 14/12

YUKON ENERGY CORPORATION

OVERVIEW OF 20-YEAR RESOURCE PLAN: 2011-2030

UPDATED APPENDIX A

November 2012

APPENDIX A: UPDATED NEAR-TERM GRID LOAD SCENARIOS

The 2011 Resource Plan grid load scenarios are updated on an ongoing basis. As at November 2012, four load scenarios are currently applicable for Yukon Energy grid generation and capacity planning (see Table A-1):

1. Load scenarios without connection of major new mines:

   a. **Base Case:**[1]

      i. GRA non-industrial forecast loads for 2012 and 2013[2];

      ii. Non-industrial growth at 2.26%/year[3] for 2014 and 2015, at 2.45%/year[4] for 2016-2020 inclusive, at 2.82%/year for 2021-2025 inclusive, at 3.13%/year for 2026 and thereafter;

      iii. DSM/SSE assumed at 32% of annual load growth based on Yukon Electricity Conservation and Demand Management Potential Review (CPR) report prepared by ICF Marbek (January 2012);

      iv. Minto generation load (includes grid losses) at 32.3 GW.h/2012, 28.3 GW.h/2013, 38.0 GW.h/2014 and at 39.1 GW.h/year for 2015-2022 (no load thereafter)[5];

      v. Alexco generation load (includes grid losses) for 2012 and 2013 are at the same level as in 2012/13 GRA (14.2 GW.h/2012 and 15.8 GW.h/2013)[6], at 20.9 GW.h/2014 and step-by-step increasing to approximately 33 GW.h in 2016, and decreasing to approximately 22 GW.h/year level by 2020 (no load thereafter); and

      vi. Whitehorse Copper Tailings (WHCT) generation load (includes grid losses) at 9.3 GW.h/yr 2014-2018 (as compared to 5.2 GW.h/yr in 2013, as per 2012/13 GRA) and 4.1 GW.h in 2019 (no load thereafter).

[1] The Base Case loads have been updated from the June 2012 Update for years after 2013 to reflect current information on industrial loads and non-industrial load growth rates and DSM/SSE projections based on the ICF Marbeck January 2012 CPR report. GRA forecasts for 2012 and 2013 are retained for this update, except for adjustments to reflect the major reductions in forecast Minto mine loads.

[2] YEC's current 2012 BP forecasts indicate loads in 2012 (9 month actual) and 2013 that exceed GRA forecasts (including losses, the 2012 BP is 7.0 GWh higher than GRA forecast and the 2013 BP is 8.0 GW.h higher than GRA forecast [includes impact from delay in Fish Lake hydro plant in-service]). Non-industrial Resource Plan forecasts have not been adjusted at this time to reflect the current 2012 BP adjustments.

[3] 2011 Resource Plan forecast annual growth rate for non-industrial load.

[4] The annual growth rates for 2016-2020, 2021-2025 and 2026-2030 are from Marbek's final CPR report.

[5] Minto generation load reflects major reductions as provided by Minto in fall 2012 that materially changed forecasts previously provided in fall 2011.

[6] Alexco generation load after 2013 reflects updated forecasts as recently provided by Alexco. (The 2012 and 2013 GRA forecasts are retained - Alexco's recent updates suggest a small generation load reduction in 2012 (0.6 GWh) and a small generation load increase in 2013 (1.3 GW.h).

b. **Base Case with Brewery Creek:** Base Case with the added connection, starting July 2014, of Brewery Creek mine with generation load (including grid losses) assumed of 9.6 GW.h/yr in 2014, 19.0 GW.h/yr for years 2015-2017, and 29.0 GW.h/yr thereafter until the end of 2023[7].

2. Load scenarios with connection of major new mines:

   a. **Scenario A:** Base Case with Brewery Creek and Victoria Gold mine, starting April 2015 with generation load (including grid losses) of 124.7 GW.h/yr for 2015-2018 (2015 at 103.4 GW.h, assuming April start of operations), 143.3 GW.h/yr for 2019-2020, 145.1 GW.h/yr for 2021 and 152.3 GW.h/yr for 2022-2024 (no load thereafter)[8].

   b. **Scenario B:** Base Case with Brewery Creek, Victoria Gold and Carmacks Copper mine, starting January 1, 2016 with generation load (including grid losses) of 54.4 GW.h/yr that continues until the end of 2022 and 27.2 GW.h/yr for 2023 (no load thereafter)[9].

[7] Negotiation of a PPA with Brewery Creek has not yet commenced.

[8] PPA negotiations are ongoing with Victoria Gold (an earlier LOI set out principles for connection to the grid). It is assumed that Victoria Gold will pay all costs required for grid connection, plus upgrade of the Mayo-Keno line. The timing for connection of this mine remains uncertain (but will not be earlier than the Q2 2015 assumed in Scenario A).

[9] Carmacks Copper has recently re-started its regulatory review processes, with an announced filing of a revised application planned this year with YESAB, followed shortly thereafter with revised filing with the YWB. PPA discussions occurred in the past – Carmacks Copper will be required to pay all costs required for grid connection plus a contribution to CSTP capital costs. The timing for connection of this mine remains uncertain, but could potentially occur by Q1 2016.

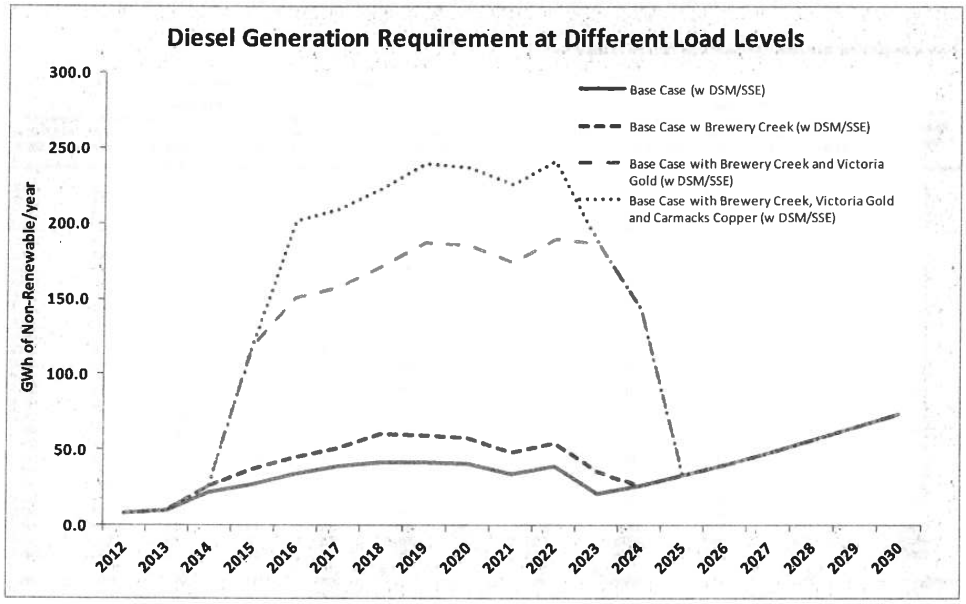
Table A-1: Updated Grid Load Scenarios

Forecast Years	Base Case (w DSM/SSE)			Base Case w Brewery Creek (w DSM/SSE)			Base Case with Brewery Creek and Victoria Gold (w DSM/SSE)			Base Case with Brewery Creek, Victoria Gold and Carmacks Copper (w DSM/SSE)		
	Non-industrial Load (GW.h)	Industrial Load (GW.h)	Total Generation (GW.h)	Non-industrial Load (GW.h)	Industrial Load (GW.h)	Total Generation (GW.h)	Non-industrial Load (GW.h)	Industrial Load (GW.h)	Total Generation (GW.h)	Non-industrial Load (GW.h)	Industrial Load (GW.h)	Total Generation (GW.h)
2012	359.0	46.5	405.5	359.0	46.5	405.5	359.0	46.5	405.5	359.0	46.5	405.5
2013	362.6	49.3	411.9	362.6	49.3	411.9	362.6	49.3	411.9	362.6	49.3	411.9
2014	368.3	68.3	436.6	368.3	77.9	446.2	368.3	77.9	446.2	368.3	77.9	446.2
2015	374.1	74.5	448.6	374.1	93.5	467.7	374.1	196.9	571.0	374.1	196.9	571.0
2016	380.6	80.4	461.0	380.6	99.4	480.0	380.6	224.2	604.7	380.6	278.5	659.1
2017	387.2	81.5	468.8	387.2	100.6	487.8	387.2	225.3	612.5	387.2	279.6	666.9
2018	394.0	79.5	473.6	394.0	108.6	502.6	394.0	233.3	627.3	394.0	287.6	681.7
2019	401.0	70.2	471.1	401.0	99.2	500.2	401.0	242.6	643.6	401.0	297.0	697.9
2020	408.1	60.9	469.0	408.1	89.9	498.0	408.1	233.3	641.4	408.1	287.7	695.8
2021	416.5	39.1	455.6	416.5	68.2	484.7	416.5	213.3	629.8	416.5	267.6	684.1
2022	425.2	39.1	464.3	425.2	68.2	493.3	425.2	220.5	645.6	425.2	274.8	700.0
2023	434.1		434.1	434.1	29.0	463.1	434.1	181.3	615.4	434.1	208.5	642.6
2024	443.2		443.2	443.2		443.2	443.2	152.3	595.5	443.2	152.3	595.5
2025	452.6		452.6	452.6		452.6	452.6		452.6	452.6		452.6
2026	463.4		463.4	463.4		463.4	463.4		463.4	463.4		463.4
2027	474.5		474.5	474.5		474.5	474.5		474.5	474.5		474.5
2028	485.9		485.9	485.9		485.9	485.9		485.9	485.9		485.9
2029	497.7		497.7	497.7		497.7	497.7		497.7	497.7		497.7
2030	509.8		509.8	509.8		509.8	509.8		509.8	509.8		509.8

Note: The 2012/2013 forecasts for this update retain the 2012/2013 GRA forecasts, except for the updated reduction to the Minto mine load. YEC 2012 BP updates indicate higher non-industrial generation loads (including grid losses) in 2012 (+7.0 GW.h) and in 2013 (+8.0 GW.h) compared to the 2012/2013 GRA forecasts.

September 22, 2017
Page 4 of 8
Yukon Energy Corporation
2017 – 2018 General Rate Application
CW-YEC-1-2 Attachment 1

Figure A-1: Diesel Generation Requirements at Different Forecast Loads: 2012-2030



Diesel Energy Requirement (GWh)	2012	2015	2020	2025	2030
Base Case	8.1	26.6	40.8	32.8	74.0
Base Case with Brewery Creek	8.1	37.3	57.8	32.8	74.0
Base Case with Brewery Creek and Victoria Gold	8.1	117.6	184.8	32.8	74.0
Base Case with Brewery Creek, Victoria Gold and Carmacks Copper	8.1	117.6	236.9	32.8	74.0

Figure A-1 and table provide the forecast diesel generation requirement during the 20-year planning period for each of the load scenarios.

1. The numbers are based on updated load for 2012-2030.
2. Diesel requirement numbers are long-term average diesel.
3. Model run with Aishihik 10-year rolling average rule, Mayo Lake assumed in-service by 2015.

Diesel generation forecasts for each load scenario reflect long-term average hydro generation, i.e., the average hydro generation over 28 recorded water year conditions at the assumed load, as estimated by the power benefits model used by YEC for grid generation planning. Table A-2 and the Figure A-2 below it provide a detailed review of potential diesel generation variability for the year 2015 under each load scenario for each of the 28 water years (the figure shows the annual load duration curve for diesel for each load scenario).

Table A-2: Forecast Diesel Generation Variability (GW.h) Depending on Water Year Conditions - Load Scenarios for 2016 and 28 Water Years of Record

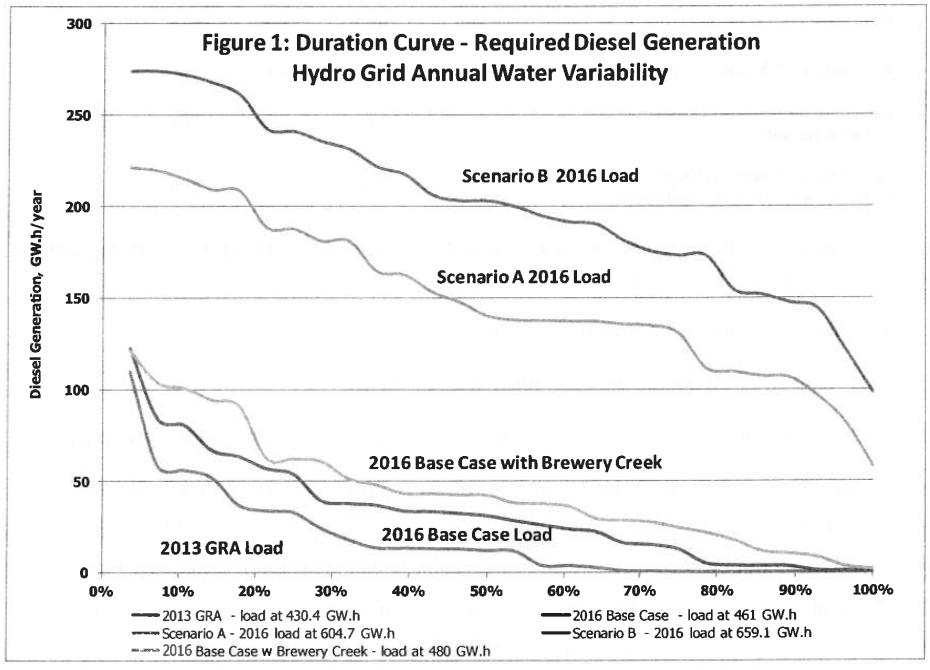
Average Annual Diesel Generation (Averaged Load Years for 28 Water Years)

Water Year	2016 Base Case - load at 461 GW.h	2016 Base Case w Brewery Creek load at 480 GW.h	Average diesel generation required (GW.h) Scenario A - 2016 load at 604.7 GW.h	Scenario B - 2016 load at 659.1 GW.h
1981	3.9	10.3	137.8	203.1
1982	26.2	48.0	147.7	194.7
1983	28.5	38.2	135.0	191.5
1984	37.9	62.1	188.5	242.1
1985	33.5	43.3	162.7	217.4
1986	37.0	43.2	135.7	181.3
1987	12.9	24.6	137.5	199.9
1988	15.3	27.6	111.7	147.6
1989	3.6	8.4	109.7	175.5
1990	5.2	17.8	138.1	190.1
1991	3.4	11.7	107.4	144.2
1992	1.0	1.9	58.2	98.5
1993	1.2	3.6	96.6	154.4
1994	0.9	21.8	209.1	267.4
1995	56.9	94.1	219.5	273.8
1996	80.5	103.6	221.3	271.7
1997	84.3	100.5	181.1	231.2
1998	63.4	90.8	214.9	273.8
1999	122.5	121.1	208.4	260.7
2000	66.9	62.6	137.3	173.1
2001	33.8	28.6	82.3	121.8
2002	39.6	36.1	140.2	203.2
2003	31.1	51.3	187.6	240.9
2004	53.8	60.7	181.2	235.5
2005	23.9	42.2	153.4	206.3
2006	22.4	37.7	164.7	221.7
2007	32.4	42.5	130.8	173.3
2008	16.3	29.5	106.6	151.9
Average	33.5	45.1	150.2	201.7

Distribution of Annual Water Year Loads (Figure 1)

	% of Years not less than	2013 GRA - load at 430.4 GW.h	2016 Base Case - load at 461 GW.h	2016 Base Case w Brewery Creek - load at 480 GW.h	Scenario A - 2016 load at 604.7 GW.h	Scenario B - 2016 load at 659.1 GW.h
1	4%	109.9	122.5	121.1	221.3	273.8
2	7%	58.5	84.3	103.6	219.5	273.8
3	11%	55.9	80.5	100.5	214.9	271.7
4	14%	51.8	66.9	94.1	209.1	267.4
5	18%	36.8	63.4	90.8	208.4	260.7
6	21%	33.6	56.9	62.6	188.5	242.1
7	25%	32.8	53.8	62.1	187.6	240.9
8	29%	24.3	39.6	60.7	181.2	235.5
9	32%	18.0	37.9	51.3	181.1	231.2
10	36%	13.5	37.0	48.0	164.7	221.7
11	39%	13.3	33.8	43.3	162.7	217.4
12	43%	12.9	33.5	43.2	153.4	206.3
13	46%	12.8	32.4	42.5	147.7	203.2
14	50%	12.0	31.1	42.2	140.2	203.1
15	54%	11.6	28.5	38.2	138.1	199.9
16	57%	3.8	26.2	37.7	137.8	194.7
17	61%	3.7	23.9	36.1	137.5	191.5
18	64%	2.6	22.4	29.5	137.3	190.1
19	68%	0.9	16.3	28.6	135.7	181.3
20	71%	0.6	15.3	27.6	135.0	175.5
21	75%	0.3	12.9	24.6	130.8	173.3
22	79%	0.1	5.2	21.8	111.7	173.1
23	82%	0.1	3.9	17.8	109.7	154.4
24	86%	0.0	3.6	11.7	107.4	151.9
25	89%	0.0	3.4	10.3	106.6	147.6
26	93%	0.0	1.2	8.4	96.6	144.2
27	96%	0.0	1.0	3.6	82.3	121.8
28	100%	0.0	0.9	1.9	58.2	98.5
		18.2	33.5	45.1	150.2	201.7

Figure A-2: Duration Curve – Required Diesel Generation Hydro Grid Annual Water Variability



Projected annual grid capacity MW surplus (shortfall) under each load scenario is provided in Table A-3, assuming existing plant and planned diesel unit retirements and applying YEC's approved N-1 and LOLE capacity planning criteria. These shortfalls assume that L172 is re-enforced (with by twinning or by provision for the 35 kV system to be able to by-pass this line between Takhini and McIntyre substations).

The following are noted regarding assumed diesel unit retirements, using projected shortfalls under the Base Case to demonstrate the impact of assumed retirements:

- 2015 Base Case shortfall of 3.8 MW: reflects following 8 MW of diesel unit retirements:
    - Mirrlees WD#1 and WD#2 retired in 2014/2015 (2011 Resource Plan rating of 3.50 and 4.5 MW=8 MW total).
    - Replacing one of these units with at least the same capacity would totally resolve the 2015 shortfall.
- 2020 Base Case shortfall of 16.9 MW: reflects following 13.11 MW of diesel unit retirements:
    - The above Mirrlees retirements (8 MW) plus.
    - Dawson retirement of 3 units (total 2.56 MW retired in 2017, 2018 and 2020).
    - Mayo retirement of 2 units (total 1.7 MW in 2019).
    - Faro retirement of 1 unit (0.85 MW in 2019).
- 2025 Base Case shortfall of 41.2 MW: reflects following 28.61 MW of diesel unit retirements:
    - The above 13.11 MW retired by 2020 plus.
    - Whitehorse retirement of 4 units (total 11.5 MW - last Mirrlees (4.5 MW) and 3 EMDs).
    - Faro Mirrlees unit (4.0 MW in 2021).
- 2030 Base Case shortfall of 58.4 MW: reflects following 34.41 MW of diesel unit retirements:
    - The above 28.61 MW retired by 2025 plus.
    - Whitehorse CAT (3.0 MW in 2026).
    - Faro CAT (2.8 MW in 2027).

Table A-3: Grid Capacity Planning - Forecast MW Surplus (Shortfall) by Load Scenario: 2012-2030

Forecast Years	Base Case (w DSM/SSE)			Base Case w Brewery Creek (w DSM/SSE)			Base Case with Brewery Creek and Victoria Gold (w DSM/SSE)			Base Case with Brewery Creek, Victoria Gold and Carmacks Copper (w DSM/SSE)		
	Peak MW	N-1 Surplus (shortfall) (MW)	LOLE Surplus (shortfall) (MW)	Peak MW	N-1 Surplus (shortfall) (MW)	LOLE Surplus (shortfall) (MW)	Peak MW	N-1 Surplus (shortfall) (MW)	LOLE Surplus (shortfall) (MW)	Peak MW	N-1 Surplus (shortfall) (MW)	LOLE Surplus (shortfall) (MW)
2012	77.8	7.2	7.2	77.8	7.2	7.2	77.8	7.2	7.2	77.8	7.2	7.2
2013	78.6	6.5	6.5	78.6	6.5	6.5	78.6	6.5	6.5	78.6	6.5	6.5
2014	81.9	1.8	1.8	84.4	1.8	1.8	84.4	1.8	1.8	84.4	1.8	1.8
2015	84.2	-3.8	-3.8	86.7	-3.8	-3.8	95.1	-3.8	-11.6	95.1	-3.8	-11.6
2016	87.9	-5.1	-5.1	90.4	-5.1	-6.9	98.8	-5.1	-15.3	106.1	-5.1	-22.6
2017	89.2	-7.3	-7.3	91.7	-7.3	-9.1	100.1	-7.3	-17.5	107.4	-7.3	-24.8
2018	90.0	-9.4	-9.4	92.5	-9.4	-10.6	100.9	-9.4	-19.0	108.2	-9.4	-26.3
2019	90.6	-13.4	-13.4	93.1	-13.4	-13.8	101.5	-13.4	-22.2	108.7	-13.4	-29.5
2020	92.0	-16.9	-16.9	94.5	-16.9	-17.3	102.9	-16.9	-25.7	110.2	-16.9	-33.0
2021	88.4	-27.0	-27.0	90.9	-27.0	-27.0	99.3	-27.0	-30.6	106.5	-27.0	-37.8
2022	90.1	-28.8	-28.8	92.6	-28.8	-28.8	101.0	-28.8	-32.3	108.3	-28.8	-39.6
2023	86.2	-30.5	-30.5	88.7	-30.5	-30.5	97.1	-30.5	-30.5	104.4	-30.5	-35.7
2024	88.0	-32.3	-32.3	88.0	-32.3	-32.3	96.4	-32.3	-32.3	96.4	-32.3	-32.3
2025	89.9	-41.2	-41.2	89.9	-41.2	-41.2	89.9	-41.2	-41.2	89.9	-41.2	-41.2
2026	92.0	-46.3	-46.3	92.0	-46.3	-46.3	92.0	-46.3	-46.3	92.0	-46.3	-46.3
2027	94.2	-51.3	-51.3	94.2	-51.3	-51.3	94.2	-51.3	-51.3	94.2	-51.3	-51.3
2028	96.5	-53.6	-53.6	96.5	-53.6	-53.6	96.5	-53.6	-53.6	96.5	-53.6	-53.6
2029	98.8	-56.0	-56.0	98.8	-56.0	-56.0	98.8	-56.0	-56.0	98.8	-56.0	-56.0
2030	101.3	-58.4	-58.4	101.3	-58.4	-58.4	101.3	-58.4	-58.4	101.3	-58.4	-58.4

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TOPIC: **Yukon Energy 2016 Resource Plan (Resource Plan)**

REFERENCE: Resource Plan, page 7-3 lines 42-43 and 7-4, lines 1-5

PREAMBLE: On pages 7-3 and 7-4 of the Resource Plan, YEC states:

- Technological uncertainties, either due to policy changes (such as the introducing more stringent local building codes), or as-yet unanticipated developments in technology such as what has already occurred with LED lighting. The resulting risk is increased rates caused by reduced load and, consequently, reduced sales; and

- Uncertainties over distributed electrical generation technologies such as solar panels, which could lead to the risk of lower electricity demand to be serviced by YEC, or a significant change in the annual pattern of demand. The resulting risk is increased rates caused by reduced load and, consequently, reduced sales.

CW requires information to assess the risks of Resource Plans in forecasting needs.

QUESTION:

a) Given that this is a 20 year plan, please fully discuss how the cost of any stranded assets that may arise will be treated if there is a disruptive technology change. Will customers be expected to bear the cost of stranded assets? Will the shareholders bear these costs, which ultimately makes taxpayers responsible for them? Please fully explain.

ANSWER:

(a)

The issue of stranded electricity utility asset risks related to major disruptive technology change is an emerging issue in many jurisdictions.

Focusing on Yukon, reducing risk was recognized to be an essential goal in the development of the 2016 Resource Plan. YEC believes that it has successfully struck the appropriate balance in the resulting Action Plan, in terms of meeting future customer demands, while mitigating future risks – the risk of stranded assets identified as being critical.

The 2016 Resource Plan incorporates the need for flexibility to deal with risks such as major and sudden changes in loads, and the possible inability to develop a preferred resource proposed in the Action Plan. The Action Plan is resilient and robust under various potential load scenarios and regulatory, financial and development outcomes. A portfolio of relatively small, scalable and modular assets, as proposed in the Action Plan presents a lower risk than a single large asset, in terms of regulatory approvals, financing, fuel diversity and resourcing. To further reduce risks, the resource plan is revisited and adjusted every five years to reflect changes, including that of possible disruptive technology changes.

Risks are inherent in developing resources to meet future customer needs. These risks include stranded assets, but also include the risk of unserved future customer demands, in the event of load growth outstripping forecasts, or an inability to develop resources as planned. The consequence of unsatisfied customer demand includes significant safety issues, particularly during the winter, constrained economic activity due to lessened electricity reliability, and the potential necessity to incur ultimately even higher costs, due to the need to expedite new electricity supplies.

With respect to who would bear the costs of possible stranded costs, utility industry history indicates that, typically, ratepayers would bear these, as this group is the most direct beneficiary of a reliable source of electricity. Nevertheless, the allocation of the costs is based on social values expressed through social policies and/or the regulatory framework at the time of decision making. As a consequence, the utility, ratepayers, or taxpayers, or any combination of those three could potentially bear the costs.

TOPIC: **Yukon Energy 2016 Resource Plan (Resource Plan) – Electricity and Peak Demand Forecast**

REFERENCE: Resource Plan page ix (PDF page 11), lines 2-4

PREAMBLE: At lines 2-4, YEC states

> Energy and peak demand forecasts are a critical input into YECs planning processes. The energy and peak demand forecast developed for this Resource Plan presents YEC's predicted electricity needs over the 20 year (2016 to 2035) planning period.

YEC then refers to a two stage approach, the first stage being an economic forecast for the Yukon, and the second stage, being a statistically adjusted end-use (SAE) model. As energy and peak demand forecasts are "critical inputs", the CW requires information to assess the forecasts.

QUESTION:

a) Please provide a copy of the detailed economic and demographic model described at lines 12-13 of page ix. In the response please include all assumptions, the basis for the assumptions, and all tables in Excel format. In the response, please also include an explanation of how each formula was developed, and how it is relevant or appropriate.

b) Please provide a copy of the SAE model referred to at line 15 of page ix. In the response, please include explicit reference to the inputs from the economic model provided in response to (a) above. Also, in the response, please include all assumptions, the basis for the assumptions, and all tables in Excel format. In the response, please also include an explanation of how each formula was developed, and how it is relevant or appropriate

c) Please provide any and all analysis that demonstrates that the results of the models provided in response to (a) and (b) above are statistically valid. In the

response please discuss and explain any and all statistical tests done on the models.

d) Please fully explain how the sales and demand forecasts developed for the Resource Plan are used in the actual GRA. In the response please provide a reconciliation between the sales and demand forecasts in the Resource Plan to the sales and demand forecasts in the GRA.

ANSWER:

(a)

The Yukon Macroeconomic Model (MEM) used to complete the econometric scenarios was developed and is maintained by the Centre for Spatial Economics (C4SE). Given the proprietary nature of the model, the details of the MEM cannot be publically released.

A detailed description of the model and the analyzed economic scenarios as part of the 2016 Resource Plan are presented in Appendix 4.2 of the 2016 Resource Plan. Links to the 2016 Resource Plan Appendices are provided in YUB-YEC-1-83(e). This document is also publicly available at the link below.

http://resourceplan.yukonenergy.ca/media/site_documents/Appendix_4.2_-_Yukon_Macroeconomic_Model.pdf

(b)

Itron Inc. developed the Statistically Adjusted End-use (SAE) model for the Yukon using their proprietary statistical modeling application MetrixND, Given the proprietary nature of the forecasting methodology and modeling application, the details of the SAE model cannot be publically released.

A detailed account of the econometric model results used in the SAE model, assumptions, forecasting methodology, model validation and results is included Appendix 4.3 of the 2016 Resource Plan. Links to the 2016 Resource Plan Appendices are provided in YUB-YEC-1-83(e). This document is also publicly available at the link below.

http://resourceplan.yukonenergy.ca/media/site_documents/Appendix_4.3_Long_Term_Load_and_Demand_Forecast_2016-2035.pdf

(c)

Please refer to Appendix 4.2 of the 2016 Resource Plan for a description of the Yukon MEM and Appendix 4.3 of the 2016 Resource Plan for a description of the SAE model. Links to the 2016 Resource Plan Appendices are provided in YUB-YEC-1-83(e). These documents are also publicly available at the links below. Historic data related to load and customers were used to calibrate and verify the SAE model, while a number of historical economic and demographic variables are used as inputs to the MEM to ensure its validity.

http://resourceplan.yukonenergy.ca/media/site_documents/Appendix_4.2_-_Yukon_Macroeconomic_Model.pdf

http://resourceplan.yukonenergy.ca/media/site_documents/Appendix_4.3_Long_Term_Load_and_Demand_Forecast_2016-2035.pdf

(d)

The sales and demand forecasts from the Resource Plan inform the GRA forecasts but not directly. Fundamentally, the two documents have a very different time resolution; as a long term planning method, the Resource Plan forecasts rely on high level long term trends in global factors (e.g. GDP, territorial population, end user behaviour, etc). In contrast, the GRA forecasts are much shorter term and therefore, there is more granularity of data to support the forecast; that is, for a 12-24 month forecast, YEC is able to access customer and community specific information on growth and incorporate that into the forecast. This level of information is not generally available for a 20 year forecast, thus the Resource Plan uses the higher level trend information.

While it is not feasible to conduct a specific variance analysis of the differences in the forecast, it is worth noting that the trends for loads are similar:

	2016	**2017**	**2018**
GRA	412,812	420,398	382,966
Resource Plan	414,300	417,800	377,000

Note that 2018 loads are for non-industrial customer classes only; the Resource Plan assumed no industrial customers on the system in 2018; the GRA was prepared at a later date after Capstone mining confirmed their Minto operation would continue to require service in 2018.

TOPIC: **Yukon Energy 2016 Resource Plan (Resource Plan) – Electricity and Peak Demand Forecast**

REFERENCE: Resource Plan page ix (PDF page 11), lines 21-27 and Chapter 4 (page 4-6, PDF 104) of the Resource Plan

PREAMBLE: At lines 21-27, YEC discusses a number of scenarios it considered, and discusses "sensitivity scenarios layered on government spending and economic activity".

CW requires information to assess the scenarios.

QUESTION:

a) Please provide a detailed summary of each of the 10 sensitivities discussed, including key assumptions, key variables, and the impact on the sales demand forecast.

b) Please provide a probability assessment of the likelihood of each of the 14 scenarios and 10 sensitivities of actually occurring. In the response, please provide the basis for each probability.

ANSWER:

(a)

The Yukon Macroeconomic Model (MEM) used to complete the econometric scenarios was developed and maintained by the Centre for Spatial Economics (C4SE). Given the proprietary nature of the model, the details of the MEM cannot be publicly released.

A detailed description of the model and the various economic scenarios assessed as part of the 2016 Resource Plan is presented in Appendix 4.2. This document is publicly available at the link below. Links to the 2016 Resource Plan Appendices are provided in YUB-YEC-1-83(e).

http://resourceplan.yukonenergy.ca/media/site_documents/Appendix_4.2_-_Yukon_Macroeconomic_Model.pdf

(b)

Itron Inc. developed the Statistically Adjusted End-use (SAE) model for the Yukon using their proprietary statistical modeling application MetrixND. Given the proprietary nature of the forecasting methodology and modeling application, the details of the SAE model cannot be publicly released.

A detailed account of the econometric model results used in the SAE model, assumptions, forecasting methodology, model validation and results is included Appendix 4.3 of the 2016 Resource Plan. This document is publicly available at the link below. Links to the 2016 Resource Plan Appendices are provided in YUB-YEC-1-83(e). Additional information is not available on the probabilities of the scenarios. Please also see the response to CW-YEC-1-7.

http://resourceplan.yukonenergy.ca/media/site_documents/Appendix_4.3_Long_Term_Load_and_Demand_Forecast_2016-2035.pdf

TOPIC: **Yukon Energy 2016 Resource Plan (Resource Plan) – Electricity and Peak Demand Forecast**

REFERENCE: Resource Plan page 4-8 (PDF page 106), lines 11-15.

PREAMBLE: At lines 11-15, YEC discusses calibration of the SAE model.

QUESTION:

a) Please provide the results of the calibration and verification process.

ANSWER:

(a)

Descriptive statistics showing the model performance for commercial (average energy use per customer, and customer models), residential (average energy use per customer, and customer models) and peak models are included in Appendix 4.3 of the 2016 Resource Plan. This document is publicly available at the link below. Links to the 2016 Resource Plan Appendices are provided in YUB-YEC-1-83(e).

http://resourceplan.yukonenergy.ca/media/site_documents/Appendix_4.3_Long_Term_Load_and_Demand_Forecast_2016-2035.pdf

TOPIC: **Yukon Energy 2016 Resource Plan (Resource Plan) – Electricity and Peak Demand Forecast**

REFERENCE: Resource Plan page ix (PDF page 11), lines 28-35

PREAMBLE: At lines 28-35, YEC states "five main industrial activity scenarios were brought forward as the base scenarios throughout the rest of the Plan."

CW requires information to assess the impact of these scenarios.

QUESTION:

a) Please provide a probability assessment of the likelihood of each of the five main industrial activity scenarios actually occurring. In the response, please provide the basis for each probability.

ANSWER:

(a)

Given the complexity and the quantity of internal and external variables affecting the territorial economy, YEC does not believe a quantitative probability assessment would bring further insight on the conclusions of the 2016 Resource Plan.

In completing the 2016 Resource Plan, YEC performed a portfolio analysis and obtained a solution for the five main industrial activity scenarios, as reported in the short term and long term action plans (2016 Resource Plan, Chapter 9, PDF pages 380-386). The results indicated that ten resource options were common to all main industrial activity scenarios. Deviations between portfolios were only observed in 2022 going forward. The update of the load forecast, planned for 2018, will inform YEC on which load scenario is unfolding while affording sufficient time to develop new resource options to meet the future loads and peak demand.

YEC adopted a prudent scenario based approach to define the five main industrial activity scenarios used for the econometric and subsequently the load and peak demand forecast using the Statistically Adjusted End-use model. These scenarios are intended to cover a

wide range of potential economic outcomes, allowing YEC to quantify the impacts on loads and peak demand. To define the scenarios, YEC received advice from multiple business and institutional leaders, members of its technical advisory committee and from the Yukon Minerals Advisory Board.

A detailed description of the methodology used and of the scenarios is provided in the Economic Scenarios section of Appendix 4.2 (pages 3-4) at link below. Links to the 2016 Resource Plan Appendices are provided in YUB-YEC-1-83(e).

http://resourceplan.yukonenergy.ca/media/site_documents/Appendix_4.2_-_Yukon_Macroeconomic_Model.pdf

TOPIC: **Yukon Energy 2016 Resource Plan (Resource Plan) – Portfolio Analysis**

REFERENCE: Resource Plan page xviii (PDF page 20), lines 21-32

PREAMBLE: YEC has used a portfolio analysis to assess options to assess scenarios.

QUESTION:

a) Please confirm that YEC uses the least cost alternative over the lifecycle of each asset. If not confirmed, please fully explain.

b) Please fully explain why a discount rate of 3.38% is appropriate. In the response, please fully discuss the impact of a higher discount rate on the results of the model.

c) Please fully discuss YEC's understanding of the appropriate discount rate from a customer perspective, i.e. what is the appropriate cost of capital for customers. In the response, please fully explain all research that YEC has done to understand what an appropriate customer discount rate would be.

ANSWER:

(a)

Please refer to Portfolio Analysis Methodology (Section 8.1) of the Portfolio Analysis chapter (Chapter 8) of the 2016 Resource Plan for details on the methodology used to recommend the assets presented in Short Term Action Plan (Sections 9.2) and Long Term Action Plan (Section 9.3) of the Action Plan chapter (Chapter 9) of the 2016 Resource Plan.

(b)

The discount rate equates to YEC's weighted average cost of capital as approved by the YUB at the last GRA applied at the 60:40 capital structure approved by the YUB and adjusted for inflation to achieve the real rate (i.e., last approved WACC = 5.45%; adjusted for 2% inflation, this equates to 3.38%). This approach ensures that a utility project will

meet or exceed the utility's requirement to pay debtors and earn a return sufficient to ensure the financial integrity of the utility including providing for sufficient resources for reinvestment. In general terms, the higher the discount rate, the lower the project present value calculated.

(c)

YEC deemed that inclusion of the customer discount rate (cost of capital) into the 2016 Resource Plan would not bring any value to the overall analysis, since the cost of capital is related to asset development. At this point in time, customers are not involved in developing assets that are a part of the YEC integrated grid. YEC could not predict the penetration of future technologies that would introduce customers as significant developers of grid integrated assets. YEC will monitor development of related technologies and, if warranted, introduce the customer discount rate into the next resource plan(s).

TOPIC: **Yukon Energy 2016 Resource Plan (Resource Plan) – Transmission Considerations**

REFERENCE: Resource Plan page 2-7 (PDF page 56), Section 2.6 and Section 5.2.12.

PREAMBLE: YEC discusses how it is an "Islanded grid". CW requires information to assess transmission options.

QUESTION:

a) Please fully explain all analysis that YEC has undertaken to connect the Yukon to the British Columbia Grid. In the response, please fully explain the length of transmission line needed, and the costs of the transmission line.

b) Please compare the costs of constructing a transmission line to the costs of the proposed projects. In the response, please consider the potential of incremental revenue from the sales of surplus power.

ANSWER:

(a)

Yukon Energy has referenced the following three recent Yukon-specific studies that will be provided on request:

1. Yukon - BC Interconnection Costing. Submitted by BBA Engineering Ltd. Document No.: 5954010_001RPT, Rev 0 Date: April 8, 2011.
2. Next Generation Hydro: Yukon Next Generation Hydro and Transmission Viability Study: Jurisdictional Transmission Line Technical Logistics Analysis. Submitted by: Midgard Consulting Incorporated. Date: July 6, 2015.
3. Next Generation Hydro: Yukon – Transmission Market Benefits Assessment. Submitted By: Midgard Consulting Incorporated. Date: July 24, 2015.

The interconnections to neighbouring jurisdictions studied involved hundreds of kilometers of transmission lines in very remote and challenging terrain. The costs would reach up to

$1.7bn. The details on the length, cost and technical attributes of the transmission lines are presented in the response to CW-YEC-09 (b) and the referenced documents.

(b)

In developing the 2016 Resource Plan, Yukon Energy's efforts were focused on recommending a plan and actions for serving its customers with reliable, cost-effective electricity generated in an environmentally and socially responsible manner. A critical outcome of this work was that YEC's primary current and future need is additional dependable capacity, driven by customer demands on cold winter days. The Action Plan arising from the 2016 Resource Plan was not driven by export potential. The interconnections to neighbouring jurisdictions studied each involved hundreds of kilometers of transmission lines in very remote and challenging terrain. Apart from the resulting physical reliability issues, depending on neighbouring jurisdictions for critical power supply would introduce new legal, regulatory and political risks.

With respect to the costs and potential benefits of building and operating transmission assets to neighbouring jurisdictions (Alaska and British Columbia), the following is a summary of the conclusions of these studies.

Connecting to British Columbia would involve a 287kV transmission line from Whitehorse (Takhini substation) to Iskut in British Columbia. The line would be 763 km in length, with an estimated capital cost of $1.71 billion. The line would have a potential export capacity range of 64-127 MW. This range is due to the (variable) state of both generation output and domestic demands on the BC Hydro grid, particularly in the vicinity of the BC Hydro Northwest Transmission Line. The export constraints on this line would be greatest during the spring freshet, due to the high level of generation output of regional BC-based (run of river) hydroelectric generation. Unfortunately, this period coincides with peak generation output in the Yukon.

The following statement summarizes the economic evaluation of the export potential:

> "Midgard does not see a plausible scenario, given the assumptions employed in the analysis, where exporting electricity from the Yukon to either British Columbia or Fairbanks, Alaska makes economic sense."

To provide a fulsome response, the following quotation from the Midgard report economic assessment is also included regarding the import potential of a Yukon-BC transmission line:

> "Importing electricity into the Yukon is similarly unattractive… Midgard cannot see a plausible scenario, given the assumptions, where Yukon profitably imports electricity. Moreover, the import scenario requires that the Yukon be willing to accept that it will be dependent on an external jurisdiction for critical winter energy supply which raises reliability issues."

TOPIC: **Yukon Energy 2016 Resource Plan (Resource Plan) – Capacity Deficits**

REFERENCE: Resource Plan page 4-54 (PDF page 152)

PREAMBLE: YEC provides a table that shows dependable capacity deficits in every year.

QUESTION:

a) Please confirm that industrial activity is the major driver in changes in requirements, and for the construction of assets proposed in the resource plan. If not confirmed, please fully explain.

b) Please fully explain how the costs of new assets will be allocated between wholesale customers, YEC retail customers, and industrial customers. In particular, please confirm that any surplus capacity generated by new assets will be only allocated to industrial load, and not to wholesale load.

ANSWER:

(a)

Industrial activity is one of the drivers of the territorial economy but it isn't the only driver affecting the construction of new assets. Industrial activity is specifically not a driver for construction of assets to address the dependable capacity deficits referenced in the preamble to this question.

Several resource options defined in the short term action plan are capacity based and intended to bridge the current dependable capacity shortfall under the Single Contingency (N-1) criterion. This criterion excludes industrial loads and construction of new assets for this purpose cannot be attributed to industrial activity.

Econometric model results have shown that a new industrial load, whether connected to the Yukon Integrated System or not, will affect other industries of the Yukon economy and ultimately, contribute to the increase in sales and peak demand. Results for other scenarios have indicated that a growth in the Tourism sector could also have a material

effect on loads and peak demand (See 2016 Resource Plan, Section 4.1.5.5.2 Commercial Energy Forecast Risks and Uncertainties, PDF page 124).

Industrial loads connected to the grid are the main driver affecting material changes in forecast energy requirements and related opportunities to potentially develop new renewable energy resources.

(b)

Costs of new resources will be allocated to customer classes in a Cost of Service Study (COSS) using normal utility COSS principles and in accordance with OIC directions to the YUB, and would require a specific YUB proceeding with consolidated YEC-AEY revenue requirement for the Yukon. The preparation of a COSS is not part of the scope of this GRA, therefore it cannot be confirmed today that surplus capacity provided by new assets will be only allocated to industrial load, and not to wholesale or other loads. Under the current forecasts, the capacity shortfall to be addressed by new assets is attributed entirely to non-industrial winter peak load requirements on the grid.

Prior to YUB review of a COSS and related YUB changes to rates, changes to rates are assumed to continue to require across-the-board rate rider adjustments with the same percentage rate changes for each customer class.

TOPIC: **System Sales – Wholesale sales**

REFERENCE: YEC Application, Section 2.2.1

PREAMBLE: In section 2.2.1 of its application, YEC discusses its wholesale forecast

QUESTION:

a) Please provide the latest approved GRA forecast from AEY.

b) At lines 6-7, on page 2-4 of its Application, YEC indicates that each year, AEY provides YEC with a forecast power purchase estimate. Please provide the latest forecast for 2017, and if available, 2018.

c) Please fully explain the discussions and communications between YEC and AEY regarding forecast sales and potential changes in sales levels.

d) On page 2-5 of its Application, at line 7, YEC discusses a multi-variable regression of wholesale sales. Please provide the regression analysis in excel format with formulae and links intact.

e) On lines 1-6 of page 2-5, YEC describes the increases in wholesale sales in 2015 and 2016 as slight increases over the prior year. Please provide an explanation as to why the 2015 and 2016 wholesale sales “increase slightly” over the prior year.

f) On lines 3-7 of page 2-6, YEC discusses the AEY forecast grid firm load and AEY forecast Fish Lake hydro generation. Please provide copies of both forecasts for 2017 and 2018.

g) Please provide the monthly wholesale sales for each of 2013, 2014, 2015, and 2016, as well as for 2017 year to date.

h) Please provide the actual and normal heating degree days by month for Whitehorse each of 2013, 2014, 2015, and 2016. In the response please indicate the determination of normal heating degree days.

i) Please provide the forecast heating degree days by month for Whitehorse for 2017 and 2018.

ANSWER:

(a)

As per Schedule 3.1 of AEY's compliance filing, AEY's 2017 firm power purchases forecast is 314.2 GWh.[1]

Please also see response to YUB-YEC-1-3 regarding the difference between YEC's GRA and the AEY Compliance Filing as approved by Board Order 2017-03.

(b)

Prior to the Board's final decision on the AEY GRA, AEY provided YEC with a forecast of 300.3 GWh for 2017 and 303.0 GWh for 2018 for firm power purchases. YEC has not received any updates from AEY after its Compliance Filing.

(c)

Senior management of AEY and YEC participated in both conference calls and email communications. Prior to filing of YEC's Application, no discussions occurred on this matter after the AEY Compliance Filing.

(d)

Please note the model description included in the Application (Page 2-5, Lines 7-14) was developed to further understand the basis of the AEY forecast of 300.3 GWh for 2017 and 303 GWh for 2018 as indicated in response to (b) above. The table included in CW-YEC-1-11 Attachment 1 presents the input variables and the multi-variate regression coefficients used to support the wholesales forecast of 309 GWh and 309.5 GWh for the 2017 and 2018 test years, as included in Table 2.1 of the Application. The regression uses the past six years of monthly sales data with the impact of Fish Lake hydro generation.

[1] Schedule 3.1 of AEY's May 26, 2017 Compliance Filing.
http://yukonutilitiesboard.yk.ca/pdf/YECL_GRA_2016-2017/2017-05-26_AEY_2016-2017_GRA_Compliance_Filing.pdf

The model calibration yields a coefficient of determination (R^2) of 96.3%, indicating a very strong correlation between the input variables and the monthly sales data.

(e)

See response to YUB-YEC-1-59.

(f)

AEY provided YEC with the following forecasts prior to the Board's decision on its GRA (the 2017 forecasts were consistent with AEY's GRA as filed[2]):

- Forecast AEY grid load of 318.3 GWh for 2017 and 322.9 GWh for 2018, including secondary sales and sales supplied by AEY's Fish Lake Hydro.
- Forecast AEY Fish Lake Hydro generation of 8.5 GWh for 2017 and 8.4 GWh for 2018.
- Forecast AEY standby diesel generation of 0.04 GW.h in 2017 and 2018.
- Forecast secondary power purchases of 9.4 GW.h in 2017 and 11.5 GW.h in 2018.
- Forecast firm power purchases of 300.3 GW.h in 2017 and 303.0 GW.h in 2018.

(g)

Monthly firm wholesale sales for each of 2013-2016 and 2017 to July are provided in Table 1 below.

[2] Please see Schedule 3.1 of AEY's 2016-17 GRA original filing.
http://yukonutilitiesboard.yk.ca/pdf/YECL_GRA_2016-2017/2016-05-09_AEY_2016-2017_GRA_-_Phase_I.pdf

Table 1: Monthly Wholesale sales, GW.h

Month	2013	2014	2015	2016	2017
JAN	32.6	29.7	31.2	29.4	36.9
FEB	26.5	30.0	29.9	29.3	30.5
MAR	26.6	28.5	28.0	26.5	33.5
APR	27.8	23.0	22.8	21.6	22.8
MAY	22.6	20.0	19.4	21.8	23.7
JUN	18.5	20.0	20.4	19.6	20.4
JUL	21.8	19.8	19.3	19.6	20.4
AUG	19.6	18.2	19.9	19.7	
SEP	22.0	22.5	21.3	21.8	
OCT	24.7	24.7	24.0	27.5	
NOV	28.6	25.2	29.2	29.1	
DEC	36.6	33.7	32.7	35.4	

(h)

Monthly Heating Degree-Days (below 13 ^{o}C) for the 2012-2016 period are provided in Table 2 below.

Table 2: Monthly Heating Degree Days

Month	Year					Normal (5-yr Avg.)
	2012	2013	2014	2015	2016	
JAN	958.1	797.0	576.3	760.5	655.5	749.5
FEB	547.2	525.4	841.3	698.6	525.4	627.6
MAR	592.6	696.1	681.5	498.2	441.2	581.9
APR	299.3	489.9	344.6	298.7	233.7	333.2
MAY	197.6	156.7	114.3	78.4	105.4	130.5
JUN	63.7	28.2	63.9	28.4	23.4	41.5
JUL	29.0	7.1	8.3	8.8	3.9	11.4
AUG	29.4	22.0	29.8	60.7	20.7	32.5
SEP	142.7	121.0	164.3	188.4	151.3	153.5
OCT	484.5	309.6	360.7	315.9	451.2	384.4
NOV	819.6	706.5	610.2	602.3	541.3	656.0
DEC	1041.8	965.3	677.3	773.5	895.4	870.7

(i)

Forecast heating days in 2017 and 2018 equal the Normal as shown in (h).

TOPIC: **System Sales – Major Industrial sales**

REFERENCE: YEC Application, Section 2.2.2

PREAMBLE: In section 2.2.2 of its application, YEC discusses its Industrial Sales forecast

QUESTION:

a) Please fully provide a copy of all communication between the Minto Mine and YEC related to forecast 2017 and 2018 load.

b) In Table 2.1 the 2016 Industrial load was 41,169 MWh compared to 2015 actual of 37,186 MWh. Please fully explain the reason for the increase.

c) In Table 2.1, 2017 forecast Industrial load decreases from 41,169 MWh in 2016 to 38,219 MWh in 2017. Please fully explain the decrease of 2,950 MWh (7.2%)

d) On page 2-8 of its Application, YEC discusses two potential sources of load, Eagle Gold and Alexco Mine. Please provide an update as to the status of these projects.

ANSWER:

(a)

For the purpose of establishing the 2017/18 GRA forecast, YEC received a forecast range of possible sales from the on-site analyst. YEC senior management contacted the Minto General Manager and determined that the mine expected to achieve similar power purchases as recent years. The parties agreed that a three year average was an appropriate proxy for test year sales.

(b)

There was an equipment failure at the mine site that affected revenue metering between October 2015 and March 2016. The correction was posted to 2016, which resulted in 2,776.68 MWh of 2015 sales being recorded in 2016. See table below for adjustment for

this correction. The residual variance is not material (<4%) and therefore no specific reason is noted for the variance

(in MWh)

Year	Recorded	Adjustment	Actual
2015	37,186	2,777	39,963
2016	41,169	- 2,777	38,392
		Actual Difference	**- 1,570**

(c)

Adjusting for the metering issue noted in (b) results in the following:

(in MWh)

Year	Recorded	Adjustment	Actual
2016	41,169	- 2,777	38,392
2017	38,219		38,219
		Actual Difference	**- 173**

The corrected variance is less than 0.5%; no specific explanation is available for this difference.

(d)

With respect to Eagle Gold, please see response to John Maissan-YEC-1-5. Alexco Resource has publicly stated a desire to resume industrial mining activities by late 2018; however, to date, YEC has received no official notification.

TOPIC: **System Sales – Yukon Energy Firm Retail Sales**

REFERENCE: YEC Application, Section 2.2.3 and Table 2.1

PREAMBLE: In section 2.2.3 of its application, YEC discusses its firm retail sales forecast.

QUESTION:

a) For Residential and General Service, please provide the working papers in support of the calculation of customer forecasts. Please provide the response in Excel format with formulae and links intact.

b) For Residential, there is an increase in customers of 27 in 2015 and 22 in 2016. Please fully explain why there is only a forecast of 14 and 12 new customers in 2017 and 2018 respectively.

c) For General Service, there is an increase in customers of 5 in 2014, 6 in 2015 and 8 in 2016. Please fully explain why there is only a forecast of 1 and 0 new customers in 2017 and 2018 respectively

d) For Residential and General Service, please provide the working papers in support of the calculation of use per customer forecasts. Please provide the response in Excel format with formulae and links intact.

ANSWER:

(a)

Please see CW-YEC-1-13 Attachment 1.

(b)

The general approach is to use the average of historical actual customers, not growth in customers. Each community is looked at individually based on information available at the time of the preparation of the forecast. In certain situations, the general approach is then

adjusted based on the information available that may cause a difference in the forecast (for example, a significant housing or commercial development).

(c)

The general approach is to use the average of historical actual customers, not growth in customers. Each community is looked at individually based on information available at the time of the preparation of the forecast. In certain situations, the general approach is then adjusted based on the information available that may cause a difference in the forecast.

(d)

Please see CW-YEC-1-13 Attachment 1.

TOPIC: **System Sales – Yukon Energy Secondary Sales**

REFERENCE: YEC Application, Section 2.2.4 and Table 2.1

PREAMBLE: In section 2.2.4 of its application, YEC discusses its secondary sales forecast.

QUESTION:

a) Please provide the calculation of the four year average for the Canada Games Centre. In the response, please provide monthly data.

b) Please provide the calculation of the three year average for the Yukon Hospital. In the response, please provide monthly data.

c) Please fully explain why 2011, 2012, 2013, and 2014 data was not used for the Yukon Hospital. Please provide monthly load data for the Yukon Hospital for each of 2011, 2012, 2013, and 2014.

d) Please provide actual to date, as of the end of August, 2017, sales for each of the Canada Games Centre, the Yukon Hospital, and the Yukon College.

e) In Table 2-1, the cents per KWh for secondary sales declines from 7.7 cents in 2016 to 5.6 cents in 2017 and 2018. Please fully explain why the rate declines. In the response please provide the actual price to the end of August, 2017, and an explanation of why the 7.7 cent amount is not appropriate for 2017 and 2018 forecasts.

ANSWER:

(a)

Details (kW.h) for Canada Games Centre are shown in Table 1 below. YEC uses an average, as well as professional judgement in determining forecasts for these customers.

Table 1: Canada Games Centre Sales: 2013-2016 (kWh)

Month	2013	2014	2015	2016	Average
January	398,400	448,200	472,200	382,200	425,250
February	366,000	372,600	359,400	400,200	374,550
March	408,000	360,600	364,200	456,600	397,350
April	391,200	418,200	438,000	386,400	408,450
May	355,800	405,000	329,400	264,600	338,700
June	250,800	261,600	204,600	265,800	245,700
July	154,800	228,000	196,800	208,800	197,100
August	141,600	159,600	171,000	186,600	164,700
September	78,600	184,200	143,400		135,400
October	271,800	298,200	148,200		239,400
November	301,800	337,200	306,000		315,000
December	441,600	394,200	390,600		408,800
Total	**3,560,400**	**3,867,600**	**3,523,800**	**2,551,200**	**3,650,400**

(b)

Details (kW.h) for Yukon Hospital are below - please note that while Section 2.2.4 of the Application notes that the forecast was based on an average of 2009, 2010 and 2015, the four years of data noted in Table 2 below were actually used. YEC uses an average as well as professional judgement in determining forecasts for these customers.

Table 2: Yukon Hospital Sales: 2008-2010, 2015 (kWh)

	2008	2009	2010	2015	Average
January	435,000	366,000	303,000	21,000	281,250
February	201,000	252,000	417,000	297,000	291,750
March	672,000	114,000	522,000	540,000	462,000
April	822,000	237,000	456,000	399,000	478,500
May	495,000	342,000	537,000	336,000	427,500
June	474,000	360,000	501,000	339,000	418,500
July	411,000	228,000	453,000	318,000	352,500
August	525,000	81,000	393,000	363,000	340,500
September	579,000	315,000	93,000	60,000	261,750
October	480,000	606,000		126,000	404,000
November	-	591,000		384,000	487,500
December	-	360,000			360,000
Total	**5,094,000**	**3,852,000**	**3,675,000**	**3,183,000**	**3,951,000**

(c)

Yukon Hospital did not purchase power under the secondary sales rate schedule during those years.

(d)

August data is not available as of the date of preparation. Actual 2017 secondary sales for each of the three customers to July 31, 2017 is below:

	KWh
Canada Games Centre	1,636,800
Yukon Hospital	1,365,000
Yukon College	1,800,000

(e)

Pursuant to Rate Schedule 32 Secondary Energy (as approved in Board Order 2005-12), the Secondary Energy rate is adjusted on a quarterly basis. Each quarter it is adjusted based on published Yukon Territorial Government – Bureau of Statistics biweekly prices for Furnace Oil in Whitehorse. At the time of filing the GRA, 5.6 cents was the calculated rate in effect. The 2017 Q4 rate has just been finalized and it remains at 5.6 cents.

TOPIC: **System Sales – Losses**

REFERENCE: YEC Application, Table 2.2

PREAMBLE: In Table 2.2 of its application, YEC calculates losses.

QUESTION:

a) Please confirm that the entire YEC system is fully integrated. If not confirmed, please provide a loss calculation for each portion or segment of the system.

ANSWER:

(a)

Confirmed.

TOPIC: **Fuel and Purchased Power**

REFERENCE: YEC Application, Section 3.2 and Table 3.2

PREAMBLE: In section 3.2 of its Application, YEC discusses Fuel and Purchased Power

QUESTION:

a) For each year in Table 3.2, please provide the working papers that convert thermal generation to Fuel costs for each type of thermal generation. In the response, include the heat rate, losses and prices of fuel that are used to convert generation to amounts of fuel and then to costs.

b) Please fully explain why 2014 actual fuel costs decrease from 2013 actual costs. In the response include a price and quantity variance analysis that demonstrates the impact of changing prices, and changing thermal requirements.

c) Please fully explain why 2015 actual fuel costs increase from 2014. In the response include a price and quantity variance analysis that demonstrates the impact of changing prices, and changing thermal requirements.

d) Please fully explain why 2016 actual fuel costs decrease from 2015. In the response include a price and quantity variance analysis that demonstrates the impact of changing prices, and changing thermal requirements.

e) Please fully explain the difference between “Existing” and “Proposed” for 2017 and 2018. In the response, please fully explain why YEC cannot apply the “Existing” forecast for proposed rates.

ANSWER:

(a)

The rate applicable to fuel expense in a non-test year is that rate as approved by the YUB at the most recent GRA. The rate for diesel applicable to the years 2013-2016 is $0.2872

(see Tab 3 of the 2012/13 GRA for the determination of this rate). The calculation of fuel expense based on volumes is shown in CW-YEC-1-16 Attachment 1.

(b) through **(d)**

As shown in CW-YEC-1-16 Attachment 1, fuel costs are primarily determined by the DCF Transfer Cost, which is calculated from LTA Expected Thermal Generation based on Actual grid load. The variances in DCF Transfer Costs (and actual fuel costs) from 2013 to 2016 are a direct result of variances in grid load.

(e)

For the explanation of the difference between "Existing" and "Proposed", see YUB-YEC-1-1(b).

The "Existing" for Table 3.2 uses fuel prices and YECSIM assessments as approved in the last GRA.

The "Proposed" in Table 3.2 uses proposed updates to the data used in the calculation, including the following:

- Expected Fish Lake load;
- Expected wind generation;
- LTA thermal as per updated DCF Term Sheet;
- Inclusion of LNG as a thermal source;
- LTA Diesel/LNG allocation as proposes;
- Diesel prices updated for this GRA;
- LNG prices updated for this GRA.

TOPIC: **Non Fuel Operating and Maintenance Expenses**

REFERENCE: YEC Application, Section 3.3 and Tables 3.3 - 3.4

PREAMBLE: In Table 3.3, YEC provides total Labour, and in Table 3.4, YEC provides staffing. The following table, taken from YEC data provides the cost per employee.

	2013 GRA compliance	Actual 2013	Actual 2014	Actual 2015	Actual 2016	Forecast Proposed 2017	Forecast Proposed 2018
Labour - From Table 3.3	$ 9,348	$ 10,604	$ 11,172	$ 11,068	$ 11,739	11,770	11,823
Staff - From Table 3.4	92.00	92.95	92.90	93.19	93.31	93.70	93.70
Cost per Employee	$ 101,605.47	$ 114,084.65	$ 120,264.03	$ 118,761.42	$ 125,810.33	$ 125,609.61	$ 126,176.66

QUESTION:

a) Please fully explain why the cost per employee declines in 2015 compared to 2014.

b) Please fully explain why this decline does not continue into 2016, and the test period forecasts.

ANSWER:

(a) and **(b)**

The calculation is not an accurate presentation of cost per employee because it ignores the labour cost charged to balance sheet accounts (e.g. capital projects, RFID, etc). Table 3.3 only captures labour costs charged to the income statement (O&M and Administration expense). Section 3.3 explains the factors impacting labour. Please also see YUB-YEC-1-7 for further explanation of the impact of the capital/maintenance allocation and its impacts.

TOPIC: **Non Fuel Operating and Maintenance Expenses**

REFERENCE: YEC Application, Section 3.3 page 3-6

PREAMBLE: At lines 12-14, YEC discusses Labour Rates including such things as base pay, benefit costs annual increments (performance increments, cost of living adjustments), etc.

QUESTION:

(a) Please provide a detailed analysis that separates base pay from incentive pay for each year in Table 3.3. Please ensure that the total equals total Labour.

(b) Please provide the YEC incentive pay policy, and a complete analysis of the targets, thresholds and metrics used to determine incentive pay.

(c) Please provide a detailed analysis of YEC benefits for each year in Table 3.3, with a complete explanation of all changes in benefits, with the cost of each change clearly identified. In the analysis, please explain where employee benefits are reported.

(d) Please provide the annual cost of living increases awarded for each year in Table 3.3, on an actual basis, and forecast for the test period. Please provide the percentages for each bargaining unit, as well as out of scope staff.

(e) Please provide the actual 2017 wage increase for each bargaining unit as well as out of scope staff.

(f) Please provide all analysis and research YEC has conducted to demonstrate that its wages and salaries are prudent, including, but not limited to salary surveys, Statistics Canada benchmarks of average weekly earnings and inflation, or any other research YEC has conducted.

ANSWER:

(a)

Incentive pay is only available to the President through the employment contract. Labour in table 3.3 includes $36,000 estimate of this pay item in each of 2017 and 2018.

(b)

YEC does not have an incentive pay policy. The Presidents employment contract has provision for incentive pay based on goals established by the Board of Directors.

(c)

Employee benefits are reported in Labour costs. As employee benefits apply to YEC as a whole (including capital labour), analysis is not specific to only non-fuel operating and maintenance expense labour.

Below is a table summarizing the total cost of benefits:

Table 1: Cost of Benefits

Cost of Benefits

	2013	2014	2015	2016	2017 Forecast	2018 Forecast
Northern	$1,028,306	$1,017,448	$1,037,274	$1,053,587	$1,061,226	$1,074,109
Benefits	$890,769	$838,602	$721,293	$863,237	$922,407	$926,392
VTA	$237,983	$226,502	$250,431	$255,750	$262,150	$259,600
Pension/RRSP	$967,746	$1,408,649	$1,280,374	$1,330,008	$1,493,515	$1,280,734
Leave	$1,224,330	$1,285,501	$1,239,757	$1,332,104	$1,370,350	$1,386,152
Stat	$413,148	$430,265	$446,818	$450,374	$454,565	$466,555
Totals	$4,762,282	$5,206,966	$4,975,947	$5,285,060	$5,564,212	$5,393,543

	2013	2014	2015	2016	2017 Forecast	2018 Forecast
Wage Increase	2.25%	2.00%	2.00%	1.75%		

	2013	2014	2015	2016	2017 Forecast	2018 Forecast
FTE Count	93.16	93.11	93.4	94.1	93.91	93.91

	2013	2014	2015	2016	2017 Forecast	2018 Forecast
Vacancy Rate	4.4	0.57	1.85	1.6	2	2

YEC has a general provision for forecast negotiated wages. The specific rate included cannot be provided at this time as this would compromise YEC's negotiations with the unions as part of the collective bargaining process. However, YEC can confirm that rates used in lieu of the actual wages increase were developed consistent with awards granted in arbitration in the last two collective agreement settlements.

The main factors driving the cost of benefits are wage increases, FTE counts and vacancy rates.

- **Northern Allowances:** This is impacted by yearly wage increases, increase/decreases to FTE Count, and the vacancy rate.

- **Benefits (Location Allowance, Vac. Pay for Casual, EI, CPP, AD&D Ins., Life Ins., Dental and Health):** This is impacted by yearly wage increases, increases/decreases to the FTE Count, and vacancy rate. A decrease in premiums for life insurance, dental and health was negotiated with YEC's insurance provider for 2015. In 2016/2017 (forecast) those benefits were re-negotiated which resulted in an increase in costs.

- **Vacation Travel Allowances**: This is impacted by Increase/decreases to FTE Count, the vacancy rate and the number of dependants a new or former employee claims/or has claimed in the past will impact the cost this benefit. As well, new employees are not able to claim the benefit for the first year of their employment.

- **Pension/RRSP:** This is impacted by yearly wage increases, increase/decreases to FTE count, and vacancy rate. The define benefit pension plan is a large cost driver; factors such as changes in market values (2013/2014), changes in accounting standards (move IFRS in 2015), as well as employees retirements from the pension plan have affected the pension costs over the years.

- **Leave**: Yearly wage increases, increases/decreases to FTE count and the vacancy rate impact leave costs. Employees get increases to vacation entitlements the longer they are with the company and the average employee tenure has increased in recent years. Offsetting this, YEC has a number employees that have/are forecasted retire and are being replaced by new employees that are only allocated the minimum amount of vacation time each year.

- **Stat:** This is impacted by yearly wage increases, increases/decreases to FTE count and the vacancy rate. There will be an increase to costs due to the addition of Aboriginal Day in 2018.

(d)

Out of scope staff received the same percentages as each bargaining unit.

(e)

No wage increase has been granted to staff for cost of living as collective bargaining arrangements have not been concluded to date for 2017.

(f)

As part of collective bargaining, YEC conducts local market surveys of wage increases of like organizations. In each of the last two union agreements, staff were awarded cost of living increments at or near that awarded Yukon Government in its most recent settlement.

TOPIC: **Non Fuel Operating and Maintenance Expenses**

REFERENCE: YEC Application, Section 3.3 page 3-6

PREAMBLE: At lines 15-23, YEC discusses Capital/Maintenance Allocation.

QUESTION:

a) Please provide the detailed working papers in support of the Capital/Maintenance allocation for each year in Table 3.3.

b) Please fully explain why the forecast ratio of 18:82 is appropriate, given the history, and forecast capital program.

c) Please provide the YEC Capitalization policy that is currently in place, and the one that was in place immediately prior to the current one, with any changes clearly marked and explained.

ANSWER:

(a)

The Capital/Maintenance allocation calculation is provided in the Table 1 below:

Table 1: Capital/Maintenance Allocation

	2013 Actual	2014 Actual	2015 Actual	2016 Actual	2017 Forecast	2018 Forecast
Non-Capital	$10,604,235	$11,172,035	11,067,742	$11,738,919	$11,770,210	$11,823,345
Capital	$2,246,695	$2,344,331	$2,776,884	$2,248,19	$2,544,854	2,581,609
	$12,850,930	$13,516,366	$13,844,626	$13,987,115	$14,315,064	$14,404,953
Capital	17%	17%	20%	16%	18%	18%
Non-Capital	83%	83%	80%	84%	82%	82%

(b)

Please see response to YUB-YEC-1-7.

(c)

Please see CW-YEC-1-19 Attachment 1 for the current capitalization practice with tracked changes to show the previous version.

YUKON ENERGY	Finance Accounting Practice FX-Appendix	DEPARTMENT:	INQUIRIES TO:	TOPIC:
		All	Finance	~~Fixed Asset~~Property, Plant and Equipment Definitions
		ISSUED:	REVIEW DATE:	APPROVED BY:
		January 1, 2014~~05~~	January 1, 2017~~08~~	Chief Financial Offici~~e~~r

1.0 Purpose

To provide detailed definitions for various ~~fixed asset~~Property, Plant and Equipment (PP&E) terminologies.

2.0 Definitions

1~~8~~. ***Property, plant and equipment*** are identifiable tangible assets that meet all of the following criteria:

a) are held for use in the production or supply of electrical services, for administrative purposes, or for the development, construction, maintenance or repair of other property, plant and equipment;
b) have been acquired, constructed or developed with the intention of being used on a continuing basis for longer than one year;
c) are not intended for sale in the ordinary course of business (i.e. goods purchased for resale),
d) have a cost greater than $1,000.

~~1. *Fixed Assets* are assets of a permanent or lasting nature whose useful service life is expected to extend over several years. Examples include land, buildings, equipment and furniture.~~

2. ***Acquisition Costs***

a) The cost of an item of property, plant and equipment includes the purchase price and other acquisition costs such as options costs when an option is exercised, brokers' commissions, installation costs, site preparation costs, freight, brokerage and duty charges, transportation insurance costs, ~~training costs~~, acceptance and commissioning costs.

~~***b)*** The cost of an item of property, plant and equipment includes direct construction or development costs (such as material and labour), and Engineering, Services & General (ES&G) attributable to the construction or development activity.~~

~~***c)***~~***b)*** The cost of an item of property, plant and equipment that is acquired, constructed, or developed over time includes carrying costs directly attributable to the acquisition, construction, or development activity such as interest costs. For a~~n item of~~ rate-regulated ~~property plant and equipment~~ asset, the cost includes the directly attributable AFUDC allowed by the Yukon Utilities Board (YUB) (see 10.)

3. ***Units of Property*** represent the main units of equipment or property contained within each ~~Fixed Asset~~PP&E category. A unit of property is defined as that which is independently operational, readily separable ~~from the Fixed Asset~~ and useful in its own right. Examples include dam, turbine, wood pole structures, conductors, transformers, regulators, circuit breakers, diesel engines and hydro generators.
(refer to GP Users Manual for Property, Plant and Equipment for additional information)

4. ***Components of Units*** represent the associated parts or items making up units of property. Components must be in service to be considered for capitalization. Examples include transformer bushings, voltage regulator bushings, fuel pumps, cross arms, guys or insulators.

5. ***Betterment*** is an upgrade and/or enhancement that extends the life of a capital asset or increases its functionality or service potential without replacement of a complete unit. Betterment relates to such additions to the asset that increase its useful life, results in reliability and/or quality improvements, increase in previously assessed physical output or service capacity, reduces operating costs by a substantial and quantifiable amount over a period of at least three years or reduces financial liability, environmental or safety risks. Overhaul and maintenance of machinery and equipment are not betterment expenditures.

6. ***Maintenance costs*** incurred to maintain the service potential of an item of property, plant or equipment are repairs and must be expensed.

   Note: If a cost has the attributes of both a repair and betterment, the portion considered ~~being~~ a betterment should be capitalized.

7. ***Overhauls*** are routinely conducted on diesel, wind and hydro production units. Major overhauls extend the useful life of the unit and minor overhauls maintain the efficient and effective operations of the unit. Costs associated with major overhauls are capitalized and depreciated, while costs associated with minor overhauls are expensed in the period in which they are incurred. (refer to FX-002 Overhauls for additional information)

~~8. ***Property, plant and equipment*** are identifiable tangible assets that meet all of the following criteria:~~

   e) ~~are held for use in the production or supply of electrical services, for administrative purposes, or for the development, construction, maintenance or repair of other property, plant and equipment;~~
   f) ~~have been acquired, constructed or developed with the intention of being used on a continuing basis for longer than one year;~~

g) ~~are not intended for sale in the ordinary course of business (i.e. goods purchased for resale),~~
h) ~~have a cost greater than $1,000.~~

~~9. ***Engineering Services and General (ES&G)*** is overhead that is applied to capital and feasibility projects. It is intended to recover costs that are not charged directly to capital projects such as supervision, preliminary engineering and support, as well as administration and financial services. (Refer to Finance and Administration Policy FX-003 for complete details on application of ES&G).~~

10. ***Allowance for Funds Used During Construction (AFUDC)*** is imputed interest that is applied to capital projects during construction. It is intended to cover the cost of financing a capital project during the period of construction ~~that carry over a fiscal year-end, which result in additions to Property, Plant and Equipment~~. AFUDC ceases when an item of property, plant and equipment is substantially complete and ready for productive use. Determining when an asset, or a portion thereof, is substantially complete and ready for productive use requires consideration of the circumstances and operating functions.
(refer to FX-004 AFUDC for additional information)

11. ***Asset retirements*** – when assets reach the end of their useful life they are retired from service.

12. ***Salvage*** - is any recovery associated with the retirement of an asset from service including any proceeds received from the sale of the retired asset.

13. ***Net Salvage*** – is proceeds received from salvage less any costs incurred to remove or dismantle assets retired from service.

14. ***Disposals*** – assets are said to be disposed of when they are sold, destroyed, lost, abandoned, or expropriated. Disposals require the approval of the Chief Financial Officer.

TOPIC: **Non Fuel Operating and Maintenance Expenses**

REFERENCE: YEC Application, Section 3.3 page 3-6

PREAMBLE: On page 3-6, YEC discusses the drivers for Labour. CW requires information about non-labour cost drivers.

QUESTION:

a) Please provide all assumptions used in the derivation of non-labour forecasts. In the response please include forecasts of Whitehorse inflation, CPI, GDP, and any other assumptions that influence costs in Whitehorse.

ANSWER:

(a)

Please see the response to YUB-YEC-1-29.

There was no general overall escalation. Some of the specific assumptions are as follows:

- Whitehorse property taxes were based on the City of Whitehorse forecast increases of 1.7% and 2.3% in 2018;
- Phone costs were based on contracted amounts;
- Donations were based on YEC's donation policy;
- All risk insurance was based on 2016 premiums;
- Software fees were based on increases of between 0% and 2%;
- Auto insurance was based on a rate increase of 2%, adjusted for changes in the forecast of vehicles; and
- Liability insurance was based on 2016 premiums.

TOPIC: **Non Fuel Operating and Maintenance Expenses**

REFERENCE: YEC Application, Section 3.3 page 3-9 and 3-10

PREAMBLE: On pages page 3-9 and 3-10 YEC discusses transmission costs.

QUESTION:

a) Transmission Brushing decreases from $1.161 million in 2014 to $1.069 million 2015 and to $1.034 million in 2016, then increases to $1.182 million in 2017. Please fully explain why total Transmission brushing decreases between 2014 and 2016.

b) In the response to (a) above, please fully explain why the decreases experienced between 2014 and 2016 cannot be maintained into 2017 and 2018. In the response please fully explain what causes the increases in detail and do not just refer to implementation of the YEC vegetation management policy.

ANSWER:

(a) and **(b)**

Fluctuations in transmission brushing costs result from the different site specific characteristics (i.e., size of area, terrain difficulties, access issues, density and composition of brush, etc.) and variations in contractor unit rates resulting from annual competitive processes (e.g., volume of participants, level of activity in other jurisdictions). YEC continues to apply the recommendations of the YUB-mandated brushing study with respect to designation of areas requiring attention.

TOPIC: **Non Fuel Operating and Maintenance Expenses**

REFERENCE: YEC Application, Section 3.3 page 3-11

PREAMBLE: On pages page 3-11 YEC discusses distribution costs.

QUESTION:

a) Please fully explain why YEC only spent $39,000 on distribution brushing in 2016.

b) Distribution Brushing decreases from $0.262 million in 2014 to $0.160 million in 2015 and to $0.039 million in 2016, then increases to $0.304 million in 2017. Please fully explain why total Distribution brushing decreases between 2014 and 2016.

c) In the response to (b) above, please fully explain why the decreases experienced between 2014 and 2016 cannot be maintained into 2017 and 2018. In the response please fully explain what causes the increases in detail and do not just refer to implementation of the YEC vegetation management policy.

ANSWER:

(a), (b) and **(c)**

Fluctuations in distribution brushing costs result from the different site specific characteristics (i.e. size of area, terrain difficulties, access issues, density and composition of brush, etc.) and variations in contractor unit rates resulting from annual competitive processes (e.g. volume of participants, level of activity in other jurisdictions).

Distribution brushing is more cyclical than transmission brushing due to the smaller scale. There were no significant lines required to be brushed in 2016. Distribution brushing costs are expected to be higher in 2017 and 2018 due to the cyclical nature of the distribution brushing requirements.

TOPIC: **Non Fuel Operating and Maintenance Expenses**

REFERENCE: YEC Application, Section 3.3 page 3-11 and 3-12

PREAMBLE: On pages 3-11 and 3-12 YEC discusses general operating and maintenance costs.

QUESTION:

a) Please fully explain why Transportation, Maintenance of Company Owned Property, and SCADA Communication decrease between 2015 and 2016.

b) Please fully explain why the costs for Transportation, Maintenance of Company Owned Property, and SCADA Communication are forecast to increase in 2017, and why the decreases experienced in 2016 do not continue into 2017.

ANSWER:

(a)

Explanations of differences are discussed below.

($000's)	Actual 2015	Actual 2016	Change	Reasons for differences
Transportation	$ 505	$ 459	$ (46)	Decrease in fuel costs resulting from lower mileage
Maintenance of Company Owned Properties	$ 673	$ 501	$ (172)	2015 was abnormally high due to extensive company-wide crane repairs/maintenance
SCADA Communication	203	197	$ (6)	External consulting budget was not required

(b)

See YUB-YEC-1-10 for an explanation regarding differences in Transportation and Maintenance of Company Owned Properties costs. See below for SCADA communication costs.

($000's)	**Actual 2016**	**Forecast 2017 and 2018**	**Change**	**Reasons for differences**
SCADA Communication	$197	$202	$5	Expect to use external consulting budget

TOPIC: **Non Fuel Operating and Maintenance Expenses**

REFERENCE: YEC Application, Section 3.3 page 3-12 through 3-14

PREAMBLE: On pages page 3-12 through 3-14 YEC discusses Administration costs. In total, administration increases by $600,000 (7.1%) yet the explanations focus on where the increases are, not why the costs increase.

QUESTION:

a) Please provide a detailed explanation of why each of the cost items included in Administration change from year to year, between the 2013 and 2016 actual costs.

b) Please provide a detailed explanation of why each of the cost items is forecast to change in 2017 from the 2016 actual results.

c) Please provide a detailed explanation of why each of the cost items is forecast to change in 2018 from the 2017 forecast.

ANSWER:

(a)

Administration costs have increased by $0.430 million (5%) from 2013 to 2016 primarily due to Labour which increased $0.482 million over this period. Labour and other increases between 2013 and 2016 are discussed below:

- Labour ($0.482 million)
  - Annual wage increments as per the collective bargaining agreement
  - Changes in benefits (see CW-YEC-1-18)
  - Changes to the capital/maintenance allocation (see CW-YEC-1-19)
- General ($0.023 million)
  - Engineering services external consulting for vibration monitoring
- Information Systems ($0.095 million)
  - Costs have increased in external consulting, license fees and data circuits all resulting from increased importance of technology

- Safety ($0.008 million)
  - Nothing significant
- Recruitment ($0.107)
  - 2013 was an abnormally low year
  - Vacancy rate was abnormally high (see YUB-YEC-1-2)
- Board of Directors ($0.010)
  - Nothing significant
- Contracting ($0.001)
  - Nothing significant

(b)

Changes in costs from 2016 actual to 2017 forecast are below.

	Actual 2016	**Proposed 2017**	**Change**	**Reasons for differences**
Labour	$ 5,783	$ 5,961	$ 178	See YUB-YEC-1-11
Resource Planning	14	48	$ 34	Additional maintenance for water flow monitoring
Communications	129	130	$ 1	Nothing significant
Customer Accounting	208	224	$ 16	See YUB-YEC-1-11
Environmental Mgmt	166	278	$ 112	See YUB-YEC-1-11
General	613	705	$ 92	See YUB-YEC-1-11
Information Systems	576	631	$ 55	See YUB-YEC-1-11
Fish Hatchery	157	168	$ 11	Expected increase in professional fees
Safety	172	171	$ (1)	Nothing significant
Training	143	175	$ 32	See YUB-YEC-1-11
Recruitment	231	244	$ 13	See YUB-YEC-1-11
Board of Directors	160	182	$ 22	See YUB-YEC-1-11
Union	0	95	$ 95	See YUB-YEC-1-11
Regulatory Affairs	99	33	$ (66)	See YUB-YEC-1-11
Material Management	41	38	$ (4)	Nothing significant
Contracting	14	12	$ (2)	Nothing significant
Professional Development	3	15	$ 12	See YUB-YEC-1-11
Total Administration	$ 8,509	$ 9,110		

(c)

Changes in costs from 2017 to 2018 forecast are below.

	Proposed 2017	Proposed 2018	Change	Reasons for differences
Labour	$ 5,961	$ 5,911	$ (50)	See YUB-YEC-1-11
Resource Planning	48	48	$ -	Nothing significant
Communications	130	130	$ -	Nothing significant
Customer Accounting	224	225	$ 1	Nothing significant
Environmental Mgmt	278	238	$ (40)	See YUB-YEC-1-11
General	705	662	$ (43)	See YUB-YEC-1-11
Information Systems	631	645	$ 14	See YUB-YEC-1-11
Fish Hatchery	168	168	$ -	Nothing significant
Safety	171	182	$ 12	Nothing significant
Training	175	175	$ -	Nothing significant
Recruitment	244	229	$ (15)	See YUB-YEC-1-11
Board of Directors	182	182	$ -	Nothing significant
Union	95	20	$ (75)	See YUB-YEC-1-11
Regulatory Affairs	33	33	$ -	Nothing significant
Material Management	38	37	$ (0)	Nothing significant
Contracting	12	12	$ -	Nothing significant
Professional Development	15	15	$ -	Nothing significant
Total Administration	$ 9,110	$ 8,912		

TOPIC: **Non Fuel Operating and Maintenance Expenses**

REFERENCE: YEC Application, Section 3.3 page 3-14 and 3-15

PREAMBLE: On pages 3-14 and 3-15 YEC discusses its insurance and RFID

QUESTION:

a) Please fully explain all changes in the YEC insurance coverages, including changes in limits, deductibles, or any other changes in the coverage.

b) In Table 3.11, YEC provides a 10 year history of RFID annual charges. Please provide a detailed analysis of the items included in each year. Please update the table to include 2016 actual data.

ANSWER:

(a)

With respect to annual property insurance, premiums are based on the replacement cost of insured assets. As YEC expands and updates its property portfolio, there is upward pressure on the overall premium (annual premium rate stated in premium dollars/$1000 of insured assets is not subject to material changes year over year). During the 2017 property & equipment renewal, YEC reduced the deductible on mechanical breakdown from $250,000 to $100,000 without an increase in premium rate. There was no change in the liability program as YEC is in the second year of a 3-year agreement.

(b)

Please see table below.

($000's)	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Takhini Substation Break-In	15	-	-	-	-	-	-	-	-	-	-
Kulan Break In	32	-	-	-	-	-	-	-	-	-	-
L171 Lightning Arrestor Failure	11	-	-	-	-	-	-	-	-	-	-
L171 Insulator Failure	35	-	-	-	-	-	-	-	-	-	-
Whitehorse Hydrant Leak	36	-	-	-	-	-	-	-	-	-	-
Unit 63 Vehicle Theft	2	-	-	-	-	-	-	-	-	-	-
WH1 Hub and Blade Overhaul	302	-	-	-	-	-	-	-	-	-	-
Aishihik Cable Repair	200	-	-	-	-	-	-	-	-	-	-
L174 Broken Pole	-	39	-	-	-	-	-	-	-	-	-
Water Damage at MLCS	-	17	-	-	-	-	-	-	-	-	-
Kulan Warehouse Water Damage	-	7	-	-	-	-	-	-	-	-	-
L172 Insulator Failure	-	-	40	-	-	-	-	-	-	-	-
Rock Creek Crossing	-	-	11	-	-	-	-	-	-	-	-
Polaris Ranger & Trailer Rplcm	-	-	9	-	-	-	-	-	-	-	-
Outage Damages- Oct.2008	-	-	41	-	-	-	-	-	-	-	-
Whitehorse Hydrant Leak	-	-	-	16	-	-	-	-	-	-	-
Outage Damages- Oct.2008	-	-	-	2	-	-	-	-	-	-	-
Aishihik Sub Cable Failure	-	-	-	24	-	-	-	-	-	-	-
Premature VFD Failure	-	-	-	27	-	-	-	-	-	-	-
Lost Tool Kit	-	-	-	2	-	-	-	-	-	-	-
Aishihik Service Building Crane Cable Replacement	-	-	-	60	-	-	-	-	-	-	-
Aishihik Pole Fire	-	-	-	24	-	-	-	-	-	-	-
Vehicle Rollover Deductible	-	-	-	5	-	-	-	-	-	-	-
WH4 Rotor Crack Repair	-	-	-	-	315	-	-	-	-	-	-
MH1 Slip Ring Repair	-	-	-	-	74	-	-	-	-	-	-
Aishihik Station Transformer	-	-	-	-	27	-	-	-	-	-	-
Mayo Customer Damage	-	-	-	-	-	6	-	-	-	-	-
Trail Blazer	-	-	-	-	-	3	-	-	-	-	-
S150 Cable & PT Repairs	-	-	-	-	-	10	-	-	-	-	-
Repair WD6 Premature Failure	-	-	-	-	-	271	-	-	-	-	-
WH4 Rotor Crack Repair	-	-	-	-	-	12	-	-	-	-	-
Lewes Cont.Structure-Gate Fire	-	-	-	-	-	-	150	-	-	-	-
Frazil Ice Blockage-P125 Intake	-	-	-	-	-	-	53	-	-	-	-
Aishihik Forest Fire 2013	-	-	-	-	-	-	-	25	-	-	-
L170 Carmacks Forest Fire 2013	-	-	-	-	-	-	-	343	-	-	-
L171 Lighting Response 2013	-	-	-	-	-	-	-	35	-	-	-
Whitehorse Ice Blockage 2014	-	-	-	-	-	-	-	-	196	-	-
L177 Dempster Corner Fire 2015	-	-	-	-	-	-	-	-	-	116	-
L170 L173 and Faro Fire Outage	-	-	-	-	-	-	-	-	-	20	-
Mayo River Crossing Emergency	-	-	-	-	-	-	-	-	-	57	-
Whitehorse Spillway Gearbox	-	-	-	-	-	-	-	-	-	-	352
L177 Structure Damaged	-	-	-	-	-	-	-	-	-	-	90
WH4 Rotor Crack Repair	-	-	-	-	-	-	-	-	-	-	253
LNG Tank Leak Tests and repair	-	-	-	-	-	-	-	-	-	-	192
Aishihik Transformer Failure	-	-	-	-	-	-	-	-	-	-	49
L178 Snow Shed Emergency Repair	-	-	-	-	-	-	-	-	-	-	82
Total	**633**	**63**	**101**	**159**	**415**	**302**	**204**	**404**	**196**	**193**	**1,018**

TOPIC: **Rate Base, Depreciation and Amortization**

REFERENCE: YEC Application, Section 3.4

PREAMBLE: YEC Application, Section 3.4

QUESTION:

a) Please confirm that YEC is using the exact same depreciation and amortization rates as approved in 2013. If not confirmed, please fully explain and provide a detailed analysis of each change in depreciation or amortization rates, along with an explanation of the reason for the change.

b) If (a) above is not confirmed, please provide a depreciation study in support of any changed depreciation or amortization rate.

c) Please provide a detailed working paper, in excel format, that applies the depreciation rates used by YEC to plant and contribution balances to arrive at total depreciation and amortization.

ANSWER:

(a) and **(b)**

Please see response to YUB-YEC-1-18.

(c)

Please see response to YUB-YEC-1-17

TOPIC: **Return on Rate Base**

REFERENCE: YEC Application Section 3.5

PREAMBLE: In section 3.5.1, YEC discusses cost of debt.

QUESTION:

a) Please fully explain if the debt secured through the Yukon Development Corporation is funded by the Yukon Development Corporation (or the Yukon Government) or borrowed in the market by the Yukon Development Corporation and then provided to YEC.

b) If, in response to (a) above, the financing is borrowed in the market, please fully explain whether the debt secured through the Yukon Development Corporation includes any mark up or premium that is retained by the Yukon Development Corporation, or if the cost of debt is mirrored down to YEC at cost. If there is a premium retained by the Yukon Development Corporation, please provide a detailed analysis of the amount and rate of the premium.

ANSWER:

(a) and **(b)**

The interest rate assigned to debt from the parent is market-based. At the time of debt commitment, YEC requests a market rate for long term debt from a Canadian Chartered Bank (TD Commercial). This is the rate that is used. YEC is not privy to YDC`s decision making on how it sources it`s capital and that process is not relevant to this proceeding.

TOPIC: **Return on Rate Base**

REFERENCE: YEC Application Section 3.5 and Section 8

PREAMBLE: In section 3.5.2, YEC discusses Return on Common Equity. In Section 8, YEC provides more detail about its requested ROE.

QUESTION:

a) On page 8-1, lines 12-14, YEC states it faced "considerably higher risk levels than ATCO Electric Yukon (AEY)". Please provide a detailed analysis of the risks faced by each of AEY and YEC. In the response, please provide copies of any and all outside research or expert reports that YEC relied on to reach its conclusion.

b) In Table 8.1 and 8.2, YEC includes three comparators, Fortis BC Inc, PNG West and PNG NE.
   a. Please fully explain why YEC only considered three comparators.
   b. Please explain why YEC did not include AltaGas Utilities Inc. (AUI) as a comparator. Please provide similar data as in Tables 8.1 and 8.2 for AUI.
   c. Please provide a complete list of other Canadian utilities that have revenues of less than $100 million.

ANSWER:

(a)

It has been long accepted by the Board (in its orders), Yukon Energy, and AEY (and experts retained by AEY) that Yukon Energy faces higher risk levels than AEY. Specifically, this was noted by AEY's expert Kathy McShane in the 2008/2009 GRA[1] (whose evidence on fair return was also relied on by AEY in the 2013-15 GRA), and accepted by the Board in Order 2009-2 as follows[2]:

[1] YECL 2008/09 GRA. Transcript Volume 2, page 206 lines 4-7 Ms. McShane acknowledges that relative to YECL, YEC has more risk. This was cited by intervenors in argument at the time and also by cited in Order 2009-2.
[2] Order 2009-2, page 29.

Should a risk premium be applied?

In Appendix A to Board Order 2005-12, the Board accepted YEC's recommendation of a risk premium of 52 basis points and noted that it was greater than the risk premium for FortisBC and less than the risk premium for Pacific Northern Gas. YEC argued that it was more risky than FortisBC since FortisBC had inter-tie connections with other utilities allowing more purchase power options and affording greater flexibility to its generation. The evidence in the Foster Report, although related to capital structure, also suggested a risk premium for YECL. The Board accepts that when using the BCUC generic cost of capital, a risk premium is required for Yukon utilities.

What risk premium should be applied to YECL?

In its reply argument, YECL suggested a risk premium of 52 basis points, the same as YEC. However, the Board notes that YECL acknowledges that relative to YECL, YEC has more risk[3]. The Board considered Appendix A of Board Order 2005-12 in finding that without the same inter-tie connections as FortisBC, YECL is more risky than FortisBC. As a result, the Board finds it reasonable to place the risk premium for YECL at the midpoint of the risk premiums between YEC and FortisBC — at 46 basis points. Therefore YECL is directed to use an ROE for 2008 of 9.08%. For 2009, YECL will use a risk premium of 46 basis points above the BCUC 2009 benchmark ROE.

The following is specifically noted in this regard:

- AEY is predominantly a distribution utility (with its own generation sources supplying only 9% of its requirements); in contrast Yukon Energy has generation, transmission and distribution functions and its own generation sources supply 100% of its requirement).

- AEY has a retail customer base of about 17,600 retail customers across Yukon (and has no industrial customers); Yukon Energy's load is dominated by one wholesale customer (AEY) and an industrial customer (Minto mine) with other potential industrial connections in the near future (Alexco and Victoria Gold).

[3] Transcript Volume 2, October 8, 2008. Page 206 lines 4-7 inclusive.

(b)

Please see the response provided in YUB-YEC-1-53 regarding the rationale for using Fortis BC Electric and PNG-West as comparable utilities for determining the Yukon Energy risk premium above the low risk utility ROE.

As noted in that response, the Board has repeatedly noted that the BCUC model for determining ROE is most appropriate for Yukon; FortisBC Electric and PNG West are each BC-based utilities that have a BCUC approved risk premium over and above the BCUC-approved benchmark ROE of 8.75%.

Based on the above, other utilities outside of BC, and utilities that do not have a BCUC approved risk premium, are not useful comparators for the purpose of YEC's Application.

TOPIC: **Vegetation Management Policy**

REFERENCE: YEC Application, Appendix 3.1

PREAMBLE: In Appendix 3.1, YEC provides its vegetation management policy, dated May 2017.

QUESTION:

a) Please provide the date of any prior vegetation management policy. If a prior policy exists, please provide a copy of the policy with all changes clearly identified.

b) Please fully explain the process for developing this version of the vegetation management policy. In the response, please provide copies of all other such policies from other utilities that YEC examined or considered in the preparation of this policy.

ANSWER:

(a)

No prior policy exists.

(b)

The policy was drafted by internal YEC staff with collaboration and input from the operations, environment, health & safety, and engineering departments. In addition, the policy reflects a review of brushing practices which was reviewed in the 2012/13 application. While YEC did some cursory reviews of other utility brushing approaches, these reviews were not used in any substantive way in the YEC policy development.

TOPIC: **Reserve for Injuries and Damages (RFID) Policy**

REFERENCE: YEC Application, Appendix 3.2

PREAMBLE: In Appendix 3.2, YEC provides its RFID, dated March 2012.

QUESTION:

a) Please confirm that this is the latest policy. If not confirmed, please provide the latest policy, with any changes from this policy clearly marked.

b) The review date is February 2015. Please fully explain what review took place in February 2015, and the results of the review.

ANSWER:

(a)

Confirmed

(b)

The February 2015 review date represents the standard 3-year review cycle for YEC policies. Please see YUB-YEC-1-20 for a description of updates to the policy.

TOPIC: **Rates**

REFERENCE: YEC Application, Tab 4

PREAMBLE: In Tab 4, YEC discusses rates.

QUESTION:

a) Please confirm that YEC has not included any Phase II rate adjustments in this application, and that this is solely a Phase I application. If not confirmed, please provide a detailed Cost of Service study in support of new rates.

b) Please confirm that YEC is not proposing any changes to its Terms and Conditions of service. If not confirmed, please provide a revised copy of its Terms and Conditions of Service, with all changes clearly marked.

c) Please advise when YEC expects to file its next Phase II application and/or Cost of Service Study and explain its understanding of any government directions or government-imposed constraints that impact YEC's answer.

ANSWER:

(a)

Confirmed.

(b)

Confirmed.

(c)

Please see response to UCG-YEC-1-2. Current OIC direction effectively provides that material rate design changes that would result in rebalancing of rates between different customer classes cannot be undertaken until mid-2019 at the earliest.

TOPIC: **Capital Projects**

REFERENCE: YEC Application, Section 5.2.1.1

PREAMBLE: In Section 5.2.1.1, YEC discusses a legal dispute with a contractor.

QUESTION:

a) At lines 23, 24 and 25 of page 5-6, YEC mentions costs of $2.715 million, $2.574 million, and $2.117 million. At line 9 of page 5-7, YEC identifies the amount in dispute as $1.623 million and legal fee of $0.962 million. Please provide a detailed analysis of the cost in question. In the response, please itemize the total costs in dispute and the related legal fees separately.

b) Please fully explain how the costs and legal fees have been treated in YEC's accounts, and for rate making purposes.

c) At lines 27-28 YEC mentions a final settlement and an appeal. Please provide the Court docket number of any proceedings leading to any decision that is under appeal, the citation to the decision and the court action number of any appeal from that decision.

ANSWER:

(a) and **(b)**

Please see the response provided to YUB-YEC-1-61.

(c)

The court action number of the proceedings that led to the decision that is under appeal was Yukon Supreme Court No. 11-A0114. The citation to the decision that is under appeal is North America Construction (1993) Ltd. v. Yukon Energy Corporation, 2016 YKSC 33. The court action number of the appeal is Yukon Court of Appeal No. 16-YU787.

TOPIC: **Capital Projects**

REFERENCE: YEC Application page 6-6

PREAMBLE: At page 6-6, YEC responds to a board direction to include business cases for all projects greater than $1 million. In the response, YEC indicates that Business Cases are provided in Tab 5. In a review of Tab 5, sections 5.2.1 and 5.3.1, there is a description of each major project.

QUESTION:

a) Please confirm that the documentation in sections 5.2.1 and 5.3.1 are what YEC asserts are its business cases. If not confirmed, please provide references to where YEC has provided business cases.

b) Please fully explain what internal documentation YEC provides to management for approval and sign off of capital projects.

ANSWER:

(a)

Confirmed.

(b)

Capital project initiation begins with a Project Identification Document (PID). Any staff member can initiate a PID based on their observation of an issue. After pre-screening by the Director Engineering Services, including review of a priority ranking, the project goes to a cross-functional review committee for a funding decision. Once funding is granted, a project manager (PM) is assigned who creates an Authorization for Expenditure (AFE). A completed AFE is required before the PM is assigned a project code in the financial system (i.e., an AFE must be complete before any spending can occur). The AFE is signed by the Director Engineering Services, CFO and, for large dollar projects, the President. Once the project is started, any significant changes to scope, schedule or budget require completion of a Project Change Request to explain the change. Project Change Request approvals are similar to the AFE.

TOPIC: **Capital Projects**

REFERENCE: YEC Application, page 5.4-2, PDF page 257, Schedule 5.2

PREAMBLE: Under "Development of Asset Management Program", YEC states:

> Currently there is no asset management methodology or plan for managing critical hydro and transmission assets at YEC. This results in ad hoc repairs and replacement projects that are costly and unplanned. An asset management program will consist of documented plans to systematically assess major asset groups (Hydro, Substations, T&D) and manage the planning of investments to meet overall corporate goals. This project will develop the asset management program and involves defining program goals and scope, a gap analysis of current state and desired future state, development of strategies for assessing and managing the different asset groups, and the creation of an implementation plan for the program.

On lines 2-8 of page 55 (PDF page 176), YEC indicates that it has focussed on projects required to address sustaining capital requirements.

In Appendices 5.3 and 5.4, YEC provides a summary or each project between $100,000 and $1 million.

CW requires information to assess YEC's current approach to asset replacement.

QUESTION:

a) Please fully explain the current YEC method to decide which assets should be replaced. In the response, please provide a detailed explanation of how, under YEC's current approach, customers can be assured that costs are prudent, and YEC has undertaken the least cost alternative.

b) Please fully discuss and explain YEC's asset monitoring processes and procedures. In the response, please provide the results of any inspections, testing or other processes that have driven the YEC capital plan for this GRA.

c) Other than for the major projects on schedule 5.2, please provide an analysis that demonstrates that the forecast project and costs are required to sustain capital and assets. In the response, please fully explain the impact of delaying the costs outside the test period. In effect, please explain why the costs are required now.

d) For L170 Line Access (PDF page 249), YEC indicates that it lacks the necessary permitting and the asset may not have been constructed to an acceptable standard.
   i. Please fully explain when the L170 line was built and who built it.
   ii. Please fully explain why customers should pay for costs to correct an asset that was not constructed to an acceptable standard, and lacks the proper permitting.
   iii. Please provide a list of all YEC assets that are not constructed to an acceptable standard, or lack proper permitting.

e) On PDF page 283, YEC discusses Mayo Transient Trailer unit.
   i. Please provide an analysis of the number of nights that the proposed unit will be used.
   ii. Please provide the actual nights that local accommodation were used for each of 2013-2016.
   iii. Please provide the cost of local accommodation for each of 2013-2016.
   iv. Please provide the forecast annual operating costs for the Trailer unit.

ANSWER:

(a) and **(b)**

Please see YUB-YEC-1-86 for an explanation of current method of asset evaluation. With respect to the request for "any inspections, testing or other processes", the request is overly broad. YEC constantly monitors, measures and inspects asset condition and performance. This could be internal or external reporting that may result in a formal assessment report or could be internal communication only. YEC has provided examples of assessment reports in the following interrogatory responses:

- CW-YEC-1-40 – Insulator and cross arms.
- John Maissan-YEC-1-37 – Building condition assessments.
- UCG-YEC-1-16 – Communication needs assessment.
- YUB-YEC-1-63 – Aishihik Hydro Assessment (RE: electrical & control upgrades).

(c)

Appendix 5.3 provides the rationale for the projects referenced.

(d)

(i), (ii) and **(iii)**

The requirement for this project is unrelated to the original construction of the transmission line. Past practice whereby the regulator allowed for ad hoc access to the power line right of way has been deemed unacceptable now and thus YEC is being directed to change its approach.

(e)

(i)

Based on the average of prior years and the future work planned for the Mayo area, the trailer is expected to be used 250 room-nights per year

(ii) and **(iii)**

Please see Table 1 below.

Table 1: Local Accommodation (2013-2016)

Year	Nights	Cost
2013	267	$ 30,324
2014	265	$ 30,251
2015	214	$ 24,118
2016	130	$ 14,280

(iv)

Please see response to YUB-YEC-1-87(f).

TOPIC: **Capital Projects**

REFERENCE: YEC Application, Section 5.2.1.2

PREAMBLE: In Section 5.2.1.2, YEC discusses the Aishihik Elevator Shaft Structural Steel Rehabilitation project.

QUESTION:

a) Please provide the detailed initial estimate or budget for the project.

b) Please explain any variances between the initial estimate and the actuals/latest forecast.

c) Please provide the status of the project.

ANSWER:

(a), (b) and **(c)**

Please see YUB-YEC-1-62

TOPIC: **Capital Projects**

REFERENCE: YEC Application, Section 5.2.1.3

PREAMBLE: In Section 5.2.1.3, YEC discusses the Aishihik Electrical and Control Upgrades project.

QUESTION:

a) In line 15 of page 5-8, YEC mentions end of life. Please provide all analysis conducted by YEC that demonstrates end of life. In the response, please confirm and discuss whether YEC determines end of life based on condition or age.

ANSWER:

(a)

Please see the response to YUB-YEC-1-63.

YEC typically determines end of life based on asset condition. Depending on specific operating conditions and environment, an asset may have a longer or shorter life than suggested by the manufacturer.

TOPIC: **Capital Projects**

REFERENCE: YEC Application, Section 5.2.1.4

PREAMBLE: In Section 5.2.1.4, YEC discusses Communications Upgrades projects.

QUESTION:

a) On lines 3-8 of page 5-12, YEC discusses the benefits of the projects. Please fully explain each benefit, and any cost savings that result.

b) Please fully explain all research done by YEC that demonstrate that the purported benefits are wanted or needed by customers.

ANSWER:

(a)

Increase performance: The current communications links to certain sites are barely large enough to carry essential information. The increase in performance will enable YEC to transfer more information allowing better analysis and decision making. Being able to see grid statistics in real time as opposed to when someone is on site reading meters allows significantly more proactive behaviors thereby extending the life of the assets. A major benefit of this increased performance is the ability of remote troubleshooting, saving staff substantial travel time.

Improved reliability: Having multiple paths to get data from site to site creates redundancy that will result in fewer outages and less travel to remote sites for troubleshooting. Having two links provides the ability to work on one link remotely with no downtime, something that would have previously taken two people (one on each end) combined with travel to the remote site. This currently occurs multiple times a year per site. This project will also allow for a full backup location for system control, so that a loss of the Whitehorse office does not result in a full loss of SCADA control of the grid.

(b)

YEC has not performed any specific research to determine the wants or needs of customers regarding internal operational communication infrastructure, however the Resource Plan Values Survey reported that 71% of respondents indicated they would support a rate increase due to efforts to reduce power outages in their area.

TOPIC: **Capital Projects**

REFERENCE: YEC Application, Section 5.2.1.5

PREAMBLE: In Section 5.2.1.5, YEC discusses the Hydro Unit #WH4 Overhaul project.

QUESTION:

a) In lines 3-6 of page 5-15 YEC discusses a 10 year Major Overhaul. Please fully explain the basis for a 10 year major overhaul, including discussion of practises by other utilities, and industry standards.

b) Please fully explain whether all assets are subject to a 10 year major overhaul. If all assets are not subject to a 10 year major overhaul, please fully explain why not, and which assets are subject to a 10 year major overhaul.

ANSWER:

(a)

Given the nature of the isolated Yukon grid, the reliability of generation assets is critical to dependable service to customers. As a result, YEC aims to perform a major overhaul on hydro units every 10 years. A major overhaul also provides YEC with an opportunity to inspect certain components that are otherwise inaccessible, offering key insights into asset health and the ability to remedy minor problems before they result in an in-service failure. Other utilities will have differing maintenance timeframes based on the nature of their assets and operating conditions which may allow for major overhauls to occur on a much less frequent basis.

(b)

YEC Hydro units are the only assets subject to 10 year major overhauls, although the 10 year timeframe could be modified depending on the actual usage of a specific unit. Diesel generators are maintained on an hour-based schedule and other assets are typically maintained based on manufacturer recommendations.

TOPIC: **Capital Projects**

REFERENCE: YEC Application, Section 5.2.1.7

PREAMBLE: In Section 5.2.1.7, YEC discusses the T&D – Breaker Replacements project.

QUESTION:

a) In line 18 of page 5-18, YEC mentions end of life. Please provide all analysis conducted by YEC that demonstrates end of life. In the response, please confirm and discuss whether YEC determines end of life based on condition or age.

ANSWER:

(a)

YEC Condition Assessment: Based on the OEM assessment these assets are in medium to poor condition and are demonstrating material reliability and performance declines from their historical condition. There is a low level of confidence that the equipment will perform well under normal operating conditions. Restricted operation and/or non-routine maintenance is necessary. YEC typically determines end of life based on condition. ABB no longer supplies parts for the operating mechanisms coupled to the breakers and for the poles there are limited spares available at this time.

YEC Consequence Assessment: Reliability – Prudent system design has allowed for minor reliability impact (brief localized loss of service) due to the failure of a single breaker, however, the failure of multiple units simultaneously would result in rolling blackouts or local outage for longer than 48 hours. There are no longer ASEA parts available for these breakers and so damaged components could result in lengthy downtime.

Based on the above condition and consequence assessment the risk to YEC is deemed unacceptable.

TOPIC: **Capital Projects**

REFERENCE: YEC Application, Section 5.2.1.8

PREAMBLE: In Section 5.2.1.8, YEC discusses the T&D - Line Replacement project.

QUESTION:

a) On lines 16 and 17 of page 5-19, YEC discusses two events that it purports drive the need for an external assessment of the line (Line 18). Please provide the external assessment.

b) Please provide all documents provided to the entity conducting the assessment, and all instructions given to the entity.

ANSWER:

(a)

Please see CW-YEC-1-40 Attachment 1.

(b)

The entity was given drawings of the transmission line structures, a sample is attached. See CW-YEC-1-40 Attachment 2. They were instructed to determine the cause of the failed component and determine the condition of test components removed from service before failure.

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POWERTECH LABS INC.

FAILURE ANALYSIS AND CONDITION ASSESSMENT TESTS ON SUSPENSION INSULATORS FROM YUKON ENERGY 138 KV TRANSMISSION LINE

PROJECT NO. PL-01281

ABSTRACT: Yukon Energy sent seventy-eight insulators that had been removed from a failed wood pole 138 kV transmission structure (it burned) to Powertech for determination of the root cause of the fire and to assess the condition of all insulators removed from the same structure. A series of test were carried out on the insulators. Twenty percent of the individual insulators had a failure load below the rated value on a combined mechanical and electrical test.

The root cause of fire was most likely due to excessive leakage current which triggered a pole top file. If the condition of these insulators is typical of the insulators in this transmission line it is recommended that all insulators that are marked with “Made in England 1968” or “Buller’s England 1968” be replaced. Any live line work done on these transmission lines should take into account there is a significant risk that there are punctured insulators and there may be insulators with low mechanical strength in the insulator strings being work on.

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1 SUMMARY

Yukon Energy sent nine strings of insulators to Powertech (three suspension and three dead-end horizontal strings with three jumper strings - 78 insulators). They had been removed from a failed wood pole 138 kV transmission structure (it burned). Powertech was requested to determine the root cause the fire incident and to assess the condition of all insulators removed from the same structure. A series of test were carried out on the insulators.

The megger tests found one failed insulator. Visual inspection found that the insulator strings had some electrical and environmental damage. Pollution level tests (ESDD) found the pollution level on the insulators was very low. Five percent of the insulators failed an RIV (radio-influence voltage) test. Two of the insulators punctured on the AC flashover test and one of the insulators was cracked. Corrosion assessment of the insulators found them to be in good shape from a corrosion perspective. Twenty percent of the individual insulators had a combined mechanical and electrical failure load below the rated value.

The root cause of fire was most likely due to excessive leakage current which triggered a pole top file. No parts of the wood structure were available for examination therefore it is not possible to definitively conclude that the fire was due to high leakage current, however, based on the poor condition of the insulators and the absence of lightening or switching activity in the this is the most likely cause of the failure.

These insulators were all removed from on structure so it is not possible to determine if the insulator condition is typical of the insulators on this transmission line. However, if this is typical it is recommended that all insulators marked “Made in England 1968” or “Buller’s England 1968” be replaced. They are all at high risk of failing either electrically and mechanically. Given that there were three similar failures in 2015 there is a high probability of further failures. It is recommended that a replacement program be implemented as soon as possible. If live line work is to be done on these transmission lines the work procedures should take into consideration that there may be punctured (shorted) insulators and/or insulators with lower than rated mechanical strength on the structure being worked on.

2 REQUEST

Yukon Energy requested Powertech to determine the root cause of an pole fire incident on its 138 kV transmission line and to assess the condition of all insulators removed from the same structure.

The following information was provided on the incident:

- Failure occurred on Oct. 8 2015 around 19:00
- Failed structure was str.1248 on L-178
- The insulators are brown porcelain made in England in 1968
- It was raining when the string failed
- There is sign of flashover on the glass
- There had been a trip on L-178 two weeks earlier but it was caused by a tree on C phase
- We replaced all the glass on str. 1248 and one other string also should signs of tracking
- There have been three similar failures this year all of them have been on three pole double dead ends. I believe it may be cause by the lack of bonding and the close proximity of the dead end to the uninsulated guy.

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- There is no known history of maintenance on this structure.

Appendix II shows pictures taken at the failure site.

Nine strings of insulators (three suspension and three dead-end horizontal strings with three jumper strings) were removed from the failed wood pole structure and sent to Powertech. The insulators received were only identified by the phase they came from. The individual insulators were not identified as to which insulator string they came from or by their position in the insulator string.

3 TEST STANDARD

The tests were performed in accordance with CAN/CSA-C411.1, “AC Suspension Insulators” and IEEE Std. 4, “IEEE Standard Techniques for High-Voltage Testing”.

4 TESTS PERFORMED

The following tests were performed on the insulators:

- Megger all insulators at 1 kV
- Visual examination on all insulators
- An ESDD (pollution level) measurement on six insulators from three strings of insulators
- Radio influence voltage (RIV) test on all insulators
- Dry AC flashover test on all insulators
- Assessment of any corrosion on the insulators
- Combined mechanical and electrical test on all insulators

5 INSULATOR IDENTIFICATION

The insulator strings were identified as follows:

Identification on Glaze: Type 1: Made in England 1968
Type 2: Buller’s England 1968

The insulator strings were removed from structure 1248, L-178 (based on the marking on the insulator crates):

Insulator type: ANSI Class 52-3 (based on the insulator dimensions and rating on the insulators)

The insulators from each string were identified as follows:

1. Structure 1248, L-178 (Road phase).

PT Identification	Name on the Glaze	PT Identification	Name on the Glaze
1273-1A	England	1273-14A	England

1273-2A	England	1273-15A	England
1273-3A	England	1273-16A	England
1273-4A	England	1273-17A	England
1273-5A	England	1273-18A	England
1273-6A	England	1273-19A	England
1273-7A	England	1273-20A	England
1273-8A	England	1273-21A	England
1273-9A	England	1273-22A	England
1273-10A	England	1273-23A	England
1273-11A	England	1273-24A	England
1273-12A	England	1273-25A	England
1273-13A	England	1273-26A	England

2. Structure 1248, L-178 (Centre phase).

PT Identification	Name on the Glaze	PT Identification	Name on the Glaze
1273-1B	England	1273-14B	England
1273-2B	England	1273-15B	England
1273-3B	England	1273-16B	England
1273-4B	England	1273-17B	England
1273-5B	England	1273-18B	England
1273-6B	England	1273-19B	England
1273-7B	Buller’s	1273-20B	England
1273-8B	Buller’s	1273-21B	England
1273-9B	Buller’s	1273-22B	England
1273-10B	Buller’s	1273-23B	England
1273-11B	Buller’s	1273-24B	England
1273-12B	Buller’s	1273-25B	England
1273-13B	England	1273-26B	England

3. Structure 1248, L-178 (Bush phase)

PT Identification	Name on the Glaze	PT Identification	Name on the Glaze
1273-1C	England	1273-14C	England
1273-2C	England	1273-15C	England
1273-3C	England	1273-16C	England
1273-4C	England	1273-17C	England
1273-5C	England	1273-18C	England
1273-6C	Buller’s	1273-19C	England
1273-7C	England	1273-20C	England
1273-8C	England	1273-21C	England
1273-9C	England	1273-22C	England
1273-10C	England	1273-23C	England
1273-11C	Buller’s	1273-24C	England
1273-12C	Buller’s	1273-25C	Buller’s
1273-13C	England	1273-26C	Buller’s

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6 TEST DATE

The tests were performed during the period of 13 April 2016 to 31 May 2016.

7 TEST RESULTS

7.1 *Megger Test*

7.1.1 Acceptance Criterion

This test was done to determine if any of the insulators "as received" were punctured. The insulators pass the test, if the insulator is not shorted or it does not have a low resistance value at 1000 VDC.

7.1.2 Test Procedure

A voltage of 1000 VDC was applied between each insulators cap and pin and the insulator resistance value was recorded.

7.1.3 Test Results

Structure 1248, L-178 (Road phase)

Insulator No.	Megger Reading	Insulator No.	Megger Reading
1273-1A	>20 GΩ	1273-14A	>20 GΩ
1273-2A	>20 GΩ	1273-15A	>20 GΩ
1273-3A	>20 GΩ	1273-16A	>20 GΩ
1273-4A	>20 GΩ	1273-17A	>20 GΩ
1273-5A	>20 GΩ	1273-18A	>20 GΩ
1273-6A	>20 GΩ	1273-19A	>20 GΩ
1273-7A	>20 GΩ	1273-20A	>20 GΩ
1273-8A	>20 GΩ	1273-21A	>20 GΩ
1273-9A	>20 GΩ	1273-22A	>20 GΩ
1273-10A	>20 GΩ	1273-23A	>20 GΩ
1273-11A	>20 GΩ	1273-24A	>20 GΩ
1273-12A	>20 GΩ	1273-25A	>20 GΩ
1273-13A	>20 GΩ	1273-26A	>20 GΩ

Note: None of the Road phase insulators failed the megger test.

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Structure 1248, L-178 (Centre phase)

Insulator No.	Megger Reading	Insulator No.	Megger Reading
1273-1B	>20 GΩ	1273-14B	>20 GΩ
1273-2B	>20 GΩ	1273-15B	>20 GΩ
1273-3B	>20 GΩ	1273-16B	>20 GΩ
1273-4B	>20 GΩ	1273-17B	>20 GΩ
1273-5B	>20 GΩ	1273-18B	>20 GΩ
1273-6B	>20 GΩ	1273-19B	>20 GΩ
1273-7B	>20 GΩ	1273-20B	>20 GΩ
1273-8B	>20 GΩ	1273-21B	>20 GΩ
1273-9B	>20 GΩ	1273-22B	>20 GΩ
1273-10B	>20 GΩ	1273-23B	>20 GΩ
1273-11B	>20 GΩ	1273-24B	>20 GΩ
1273-12B	>20 GΩ	1273-25B	>20 GΩ
1273-13B	>20 GΩ	1273-26B	>20 GΩ

Note: None of the Centre phase insulators failed the megger test.

Structure 1248, L-178 (Bush phase)

Insulator No.	Megger Reading	Insulator No.	Megger Reading
1273-1C	>20 GΩ	1273-14C	>20 GΩ
1273-2C	>20 GΩ	1273-15C	>20 GΩ
1273-3C	>20 GΩ	1273-16C	0.2 MΩ
1273-4C	>20 GΩ	1273-17C	>20 GΩ
1273-5C	>20 GΩ	1273-18C	>20 GΩ
1273-6C	>20 GΩ	1273-19C	>20 GΩ
1273-7C	>20 GΩ	1273-20C	>20 GΩ
1273-8C	>20 GΩ	1273-21C	>20 GΩ
1273-9C	>20 GΩ	1273-22C	>20 GΩ
1273-10C	>20 GΩ	1273-23C	>20 GΩ
1273-11C	>20 GΩ	1273-24C	>20 GΩ
1273-12C	>20 GΩ	1273-25C	>20 GΩ
1273-13C	>20 GΩ	1273-26C	>20 GΩ

Note: Insulator 1273-16C of the Bush phase failed the megger test.

7.2 *Visual Examination*

7.2.1 Examination Results

The visual examination looks for any abnormalities or damage in all parts of the insulators i.e. the cap, the porcelain shell the pin and the cement. This examination is used to make an overall visual assessment of the insulator condition.

Structure 1248, L-178 (Road phase)

Insulator No.	Visual Examination Results
1273-1A	15000 lb, No rust on cap, the mould was a little rougher than other insulators. There is a round mould bump on top. The code “HF 8326” was moulded onto the cap. There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base. The portion of the cap under the lip is not as recessed as other brands. There is a brass coloured sheen in this area; there is a light line of material run off from the cap on the porcelain surface under the lip. There is also a fine line running from the point on the cap to the edge. The porcelain retains its lustre. Some points where the glaze is missing, the surface of the glaze is covered with extremely tiny pits. Light dust covers the surface, common to all. The sheds underneath have a light dust layer. The 3rd skirt in has a portion missing, probably done in disassembly of the strings or shipping. There are some manufacturer defects, such as runny glaze that appears darker and raised. Some tiny points of missed glaze. There is no rust on the pin. The grout looks O.K.
1273-2A	15000 lb, No rust on cap, the mould was a little rougher than other insulators. There is a round mould bump on top. The code “HF 8326” was moulded onto the cap. There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base. There is brass colour sheen in this area. There is a deposit on the porcelain in this area about 3” long under the cap. The deposit fans out towards the edge. There are 2 flashover marks etched into the porcelain beside this deposit, they converge on a point at the edge. The rest of the porcelain looks good with very tiny pits on the surface. Underneath the point where the tracking occurs there is a similar etching going from shed to shed then along the surface to the pin. There is no damage on the pin. The rest of the porcelain retains its lustre. There are bits of grit glazed into the surface and a lot of pits without glaze. The grout has a single crack otherwise O.K.
1273-3A	15000 lb, No rust on cap, there is a slight brass colour on one side. There is a long triangular stain coming up from the cap bottom; it has a white powder along its perimeter. This area has a concrete deposit on the porcelain for about 5 cm. The top porcelain looks O.K. it still holds its lustre with the same roughened tiny pits on the surface. The porcelain underneath has a hardened dust deposited on its surface on one side about 20%. The three inner sheds have a layer of light brown dirt in the troughs. There are some manufacturer defects like flattened shed, raised surface, tiny points of missed glaze. The pin is O.K. but off centre. Grout looks good.
1273-4A	15000 lb, No rust on cap. The code “HF 8326” was moulded onto the cap. There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base, the mould line is raised, the mould plug is raised and rough. There are tiny deposits beneath the cap on the porcelain around most of the circumference. There is a fine layer of dust on the surface, there is tiny pitting on the surface, and there are tiny points where there is no glaze. Underneath the surface has hardened dust that can be removed by wiping with force. The sheds on one side have about 20% of hardened dust in the troughs. The inner shed beside the grout it is baked on. The pin is O.K. with some slag on the surface from manufacture. The grout looks O.K.

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Insulator No.	Visual Examination Results
1273-5A	15000 lb, this insulator looks rougher than others, the cap looks rough and the galvanizing is not smooth. There is a rust ring on top outside of the socket possibly from wear as there is some shine on the surface on the other side of the socket. There is little bit of deposit under the cap. The top part of the porcelain still has its lustre but is roughened. The outside edge has had some abrasion as it looks scuffed and lustreless, this could have occurred during shipping. The porcelain underneath has a hardened dust deposited on its surface on one side about 20% There are some manufacturer defects like irregular surfaces on shed and missed glaze. The pin stem looks O.K. but the ball is blackened, there is tinge of rust possibly from arcing. The grout looks O.K.
1273-6A	15000 lb, the cap looks O.K. the socket is blackened, there are some wear patterns on the pin surface. There is one dot of rust on the surface of the cap. The top porcelain looks O.K. but with some tiny pits. Underneath the porcelain there is a light layer of dirt, except around the pin where there is some hardened dust and possibly concrete from the grout. The glaze has some grit in it, the pin looks O.K., and the grout surface is slightly eroded.
1273-7A	15000 lb, No rust on cap, the cap looks O.K. There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base. There is a fine deposit under cap from dust, the cap itself and cement. There is some light dust on the top porcelain. Underneath the porcelain there is some dense dust. There are some manufacturer defects, some tiny points of missed glaze, same with the top porcelain. The pin is O.K. The grout looks O.K.
1273-8A	15000 lb, No rust on cap. There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base. There is a 1cm deposit underneath the porcelain; quite thick and cement coloured, it extends and fades as it approaches the porcelain edge in a streaky pattern. There is some electrical etching on this portion. There are tiny points on whole porcelain surface. There is a light layer of dust underneath the porcelain. There are some manufacturer defects, such as runny glaze that appears darker and raised. Some tiny points of missed glaze The pin is O.K. The grout has a 3mm weathered hole against pin.
1273-9A	15000 lb, No rust on cap, the cap looks O.K. There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base. There is a 2cm concrete colour deposit under this portion and it is fairly thick near the cap then fades towards the edge. There is highly dense dust on the top porcelain. Underneath the porcelain there is some light dust slightly heavier on one side, otherwise it looks good. There are some manufacturer defects, such as some tiny points of missed glaze. The pin is O.K. The grout has one crack and a tiny hole against the porcelain.
1273-10A	15000 lb, No rust on cap. There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base, there is a slight brass discolour at this area, the other side of the porcelain has two points that might be slight arc damage, there is a faint line from the cap t the edge that coincides with the two points. There is a slight layer of dust on the top porcelain. The cap has a point of stain with deposit underneath that extends and fades to the edge. Slightly roughened surface, there is a light dust layer

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Insulator No.	Visual Examination Results
	underneath. There are some bits in glaze and pin point glaze flaws. There is a round deposit on porcelain near grout. The pin is O.K. The grout looks O.K.
1273-11A	15000 lb, No rust on cap. There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base, at the bottom edge of this area it is darker and rougher, the stain comes to point in within this darker area but light at the point. There is a 4cm deposit on the porcelain underneath the cap that extends the full width but fades around the porcelain edge. There is a thin line etched into this deposit edge. There is light dust on the top porcelain covered with tiny points of glaze. Underneath there is some light dust layered, with some particles in glaze and pin point missed glaze. The pin is O.K. The grout looks O.K.
1273-12A	15000 lb, No rust on cap. There is some cement on the cap. There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base. There is a large bloom in galvanizing near the socket opening. There is a stain on the cap under the pattern on the porcelain, it extends and fades towards the edge. There is some light dust on the surface underneath. There are some points of exposed glaze, with a couple of bits glazed into the surface. There is a bump beside the inner ring that has some electrical erosion. The pin is O.K. The grout has some cracks
1273-13A	15000 lb, there is a tiny area of rust neat the cotter pin. There is uneven moulding coming off of the cap base to the middle of the cap, at the top of this there is a wear mark, it is hard to tell if it is electrical or mechanical. There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base. There is a point on the cap with fingers spreading out to the top and cotter pin hole. There is a bright tinge at this area. There is some deposit on the porcelain surface in this area. There is a very faint deposit extending towards the porcelain edge. The top porcelain has lustre and covered with tiny pits. There is some grit glazed into the porcelain. Some accumulation of dirt in one area of skirts underneath heaviest in inner skirt, the rest is fairly clean and retains lustre, some missing points of glaze and glazed over bumps. The pin is O.K. There are a couple of superficial cracks on the grout surface.
1273-14A	15000 lb, No rust on cap. The original moulding is not smooth. There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base. There is a light deposit on the porcelain under the point about 3cm wide extending and fading towards the porcelain edge. The top porcelain has lustre with tiny pits on the surface, also there are some points with missed glaze, and Some accumulation of dirt in one area of skirts underneath heaviest in inner skirt, the rest is fairly clean and retains lustre. There is a number of glazed bumps on the surface of skirts and one point of missed glaze.
1273-15A	15000 lb, No rust on cap There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base. There is a deposit about 5cm under the cap that won't scrape off, it is dark at the cap and lightens as it reaches the cap edge. There are tiny pits on the porcelain surface with some missed glaze parts. Underneath there are a number of points of missing glaze. Irregularities on skirt edges from the moulding.

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Insulator No.	Visual Examination Results
	Lustre O.K. The pin is O.K. The grout looks O.K.
1273-16A	15000 lb, No rust on cap. There are some bits of concrete on it. There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base, it has a slight brass colour. There are deposits on porcelain underneath. There is a streak pattern with electrical lines etched in it that extend almost all the way to the porcelain edge. The porcelain has lustre, a point of no glaze and tiny pits. There is high dust accumulation underneath the porcelain, some bits in glaze.
1273-17A	15000 lb, No rust on cap. There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base, slight brass colour, There are deposits on porcelain underneath, it extends across porcelain surface to the edge fanning out and fading. The porcelain retains its lustre. Some points where the glaze is missing, the surface of the glaze is covered with extremely tiny pits, there is slight arc damage on the edge. There is a tiny bit of dust underneath. There is arc damage corresponding to the bit on the edge, it extends right to the pin.
1273-18A	15000 lb, No rust on cap There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base, and the base of the cap is much darker. There is a deposit on porcelain underneath about 4cm, the deposit extends and fades to the edge, to the left of this deposit there is a thin arc damage line that extends to the edge then underneath to the pin. The porcelain retains its lustre. Some points where the glaze is missing, the surface of the glaze is covered with extremely tiny pits.
1273-19A	15000 lb, No rust on cap, but rough mould on seams. There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base. There are some circular marks below socket opening that look like arc damage. There is a light deposit on porcelain under extending and fading towards the porcelain edge. There is a faint layer of dust on the surface. The porcelain retains its lustre. Some points where the glaze is missing, the surface of the glaze is covered with extremely tiny pits. The porcelain underneath looks O.K. There are bits of grout in the glaze, some missing glaze points. The pin is O.K. with a tinge of rust on the bell. The grout looks O.K.
1273-20A	15000 lb, No rust on cap. There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base. Outside the cap opening there is a large circle of shiny galvanizing with possible electrical lines going through it, the pattern comes to a point on the cap bottom. There is a deposit underneath on the porcelain about 3cm that extends to the porcelain edge fading as it approaches. There appears to be electrical lines etched into this part of the surface. The porcelain retains its lustre. Some points where the glaze is missing, the surface of the glaze is covered with extremely tiny pits. There is light dust on the top and bottom of the shell. There are a number of points missing glaze underneath. There is some grit on the porcelain. The pin is O.K. The grout looks O.K.
1273-21A	15000 lb, No rust on cap. There is no noticeable pattern on the cap as the previous insulators did, but there is a large circle underneath the cap opening. There is no real deposit under the cap on the porcelain. There are very faint fingers that extend from the edge of the cap to the edge of the porcelain. There is not much lustre

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Insulator No.	Visual Examination Results
	underneath; there is a light deposit underneath that is easily scrapped off. There is dirt about 15% on one area of the inner sheds. There are some particles in the glaze. The pin is O.K. The grout looks O.K.
1273-22A	15000 lb, there is a slight tinge of rust on the very top of the cap otherwise the cap is O.K. Porcelain has lustre overall. There are tiny pits on the surface. Underneath the lustre is somewhat lost. There is baked on deposit that can be scrapped off. There is some dirt on the inner rings, one portion about 20%. There is some grout in the glaze with a tiny bit of rust on the pin top.
1273-23A	15000 lb, No rust on cap, there is some discoloration on the bottom edge; the galvanizing has a bloom shape near the opening at the bottom. The top porcelain looks O.K. There is a circular mark on the surface that can't be scratched off. There are a lot of tiny pits on the surface. Underneath the surface has little lustre as there is a film attached to the surface that is wiped off with some force. The two inner skirts on one side have dirt in the recess. There is a mould imperfection, bumps on the skirts and the inner ring. There is some grout in the glaze. The pin is O.K. The grout looks O.K.
1273-24A	15000 lb, There is a tinge of rust at the top and bottom edge. There is a small rust spot just outside the cap opening. There are some rough spots from the galvanizing, also a small chunk of concrete stuck on the surface beside the cap opening. There is also a galvanized bloom beneath the opening, the top porcelain has its lustre but with a lot of tiny pits. There is a circular mark on the surface that can't be scratched off. Underneath there is a thin film on the surface that can be rubbed off with some force. The two inner skirts on one side have dirt in the recess. There are some manufacturer defects, such as moulding flaws, grit in glaze and some tiny points of missed glaze. The pin is O.K. The grout looks O.K.
1273-25A	15000 lb, the cap has very light rust on the opening at the top. There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base. The porcelain surface underneath this point has a deposit running about 4cm under the cap; the deposit extends to the porcelain edge; narrowing and fading. There are electrical streamers from the cap etched into the surface. The surface is pitted, but it retains its lustre. The underneath retains its lustre. There is dirt between sheds on one side. There are a number of pin points of missing glaze. The pin is O.K. There are some cracks on the grout.
1273-26A	15000 lb, the cap has slight rust on the top edge of the opening. There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base. Under this point there is a deposit about 3cm wide. It narrows and fades as it reaches the edge of the porcelain. There is some tracking in the deposit, beside this deposit there are 2 spots on the shell possibly from electrical erosions, it appears in one of the spots as if the glaze has lifted off. There are a lot of pits on the surface, and a few spots where the glaze was missed and one large spot without glaze. There are a number of depressions on the surface in this area. Underneath is fairly clean, the lustre is retained. There are some pin points of missing glaze. The pin is O.K. The grout has a couple of cracks.

The results relate only to the items tested
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Structure 1248, L-178 (Centre phase)

Insulator No.	Visual Examination Results
1273-1B	15000 lb, Cap rust free. There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base. There is a deposit on the porcelain under the point about 3cm long, it extends halfway to the edge and then fades out. There is some electrical environmental activity on the deposit bot it is not etched in the surface. The surface is pitted but it retains its lustre. Underneath, the porcelain is covered in light dust. There is some grit in the glaze and exposed points of glaze. There are a few moulding flaws. There are some spots of rust at the bottom of the pin ball, otherwise O.K. There is a single crack in the grout.
1273-2B	15000 lb, Cap rust free. There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base. There is a slight brass colour on this pattern. There is a deposit on the porcelain under the point about 1cm long, it extends halfway to the edge and then fades out. There is some electrical environmental activity on the deposit and around it. There are some fine lines etched into the surface to the edge. The surface is pitted but it retains its lustre. Underneath, the porcelain is covered in light dust. There are a number of fine bits in the glaze. The pin looks O.K. The grout looks O.K.
1273-3B	15000 lb, Cap rust free. There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base. There is a deposit on the porcelain under the point about 1cm long, it extends halfway to the edge and then fades out. The surface is pitted but it retains its lustre. Underneath, the porcelain is covered in light dust, but it retains its lustre. There are some bits in glaze and some missed glaze points. The pin looks O.K. The grout looks O.K.
1273-4B	15000 lb, Cap rust free. There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base. There is a bloom circle of galvanizing under the cap opening. There is a deposit on the porcelain under the point about 3cm long, it extends halfway to the edge and then fades out. There is some electrical environmental activity on the deposit bot it is not etched in the surface. The surface is pitted but it retains its lustre. Underneath the porcelain retains good lustre. There are bits of grit in the porcelain. The pin looks O.K. The grout looks O.K.
1273-5B	15000 lb, there is a tiny bit of rust on the top of the cap. Uneven area during original manufactured concrete on surface. There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base. There is a bloom circle of galvanizing under the cap opening. There is a deposit on the porcelain under the point about 4cm long, it extends halfway to the edge and then fades out. There is some electrical environmental activity on the deposit bot it is not etched in the surface. Some missed glaze points, but still has its lustre. Underneath the porcelain retains its lustre. There are some missed glaze points and some grit in the glaze. The pin looks O.K. The grout looks O.K.
1273-6B	15000 lb, Cap rust free. There is a light stain caused by electrical activity coming

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Insulator No.	Visual Examination Results
	from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base. There is a brass hue to this portion. There is a deposit on the porcelain under the point about 1cm long, it extends halfway to the edge and then fades out, there are some electrical streamers in it, a few are etched in and extend to the edge of the porcelain. The deposit fades 1/3 away from the cap. There are some points of missing glaze. There are a couple of circular blemishes permanently on the surface. Underneath the lustre is O.K. There are bits in the glaze and points of missing glaze. The pin looks O.K. The grout has a couple of cracks.
1273-7B	10000 lb, there are light rust marks on some areas of the cap. There is a light stain caused by electrical activity coming from the socket to the cap base, it appears as lines at the top and converges to a point on the cap base. This brand of insulator has a smoother edge on the cap. There is a deposit on the porcelain under the point about 1cm long, it extends halfway to the edge and then fades out. There are some points of missed glaze. The porcelain underneath is in good shape, and it retains its lustre. The pin is O.K. The grout is O.K. but is deep down inside the insulator.
1273-8B	10000 lb, the cap is O.K. There is a light stain caused by electrical activity coming from the socket to the cap base. There is a deposit on the porcelain under the point about, it extends halfway to the edge and then fades out. There is some grit in the glaze, underneath there is good lustre, and a number of points of missed glaze. There is a halo around some areas on sheds where they are bunched points. The glaze around the pin hole has some manufacturer flaws, grit, concrete and thinner glaze. The pin is O.K. but there is erosion on the grout at the glaze interface.
1273-9B	10000 lb, the cap is O.K. There is a light stain caused by electrical activity coming from the socket to the cap base. There is a deposit on the porcelain under the point about 2cm long, it extends halfway to the edge and then fades out. There is electrical activity marks etched into the deposit, the porcelain retains its lustre, and there are some tiny points of missed glaze. The porcelain underneath retains its lustre, but there are a lot of missed glaze points especially in the area nearest to the pin. There are a couple of halos on the shed edges. There are some manufacturer defects in the porcelain around the pin.
1273-10B	10000 lb, the cap is O.K. There is white material in the socket. There is a light stain caused by electrical activity coming from the socket to the cap base. There is a deposit on the porcelain under the point about 1cm long, it extends 1/3 to the edge and then fades out. The porcelain lustre is good; there is a dense dirt layer above and below. There is a good lustre underneath; there is grit in the glaze as well as points of missed glaze or thin glaze. The pin and grout look O.K. There are a couple of halos on the shed edges; they can't be rubbed off, possible flashover marks.
1273-11B	10000 lb, the cap is O.K. There is a light stain caused by electrical activity coming from the socket to the cap base. There is a deposit on the porcelain under the point about 1cm long, it extends halfway to the edge and then fades out. There is electrical activity marks etched into the deposit. The porcelain underneath retains its lustre, but there are a lot of missed glaze points. Underneath the edge where the deposit sits on the top of the shell, there are a couple of metallic looking halos on the shed edges, possibly flashover marks. The pin and grout are O.K.
1273-12B	10000 lb, the cap is O.K. There is a light stain caused by electrical activity coming from the socket to the cap base. There is a deposit on the porcelain, it extends halfway to the edge and then fades out. There is electrical activity marks etched into

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Insulator No.	Visual Examination Results
	the deposit. The porcelain underneath retains its lustre, but there are a lot of missed glaze points. Underneath lustre is good, there are some points of glaze missing, and some manufacturer defects. There is a chunk of porcelain missing from one of the sheds, possibly cracked off during disassembly. The outside shed has a halo spot over from activity on the top shell. The pin and grout are O.K.
1273-13B	15000 lb, the cap has some rust on one side near the opening at the base of the opening and a pin cotter pattern in the opening. There is no patter on the cap like the other insulators did. The top porcelain is O.K. There is pitting on the surface. Underneath there is some dirt on one side between 2 skirts. There is some deposit reducing the porcelain's lustre it can be wiped off with force. There are some bits in the glaze and some points of missed glaze. The pin and grout are O.K.
1273-14B	15000 lb, there is no rust on the cap. There is a circular galvanized bloom below the opening. There is a light stain caused by electrical activity coming from the socket to the cap base. There is a deposit on the porcelain, it extends halfway to the edge and then fades out. The porcelain still has its lustre, there are some concrete deposits under the cap on the porcelain, and there is a lot of pitting. Underneath there is some dirt in between 2 sheds. There is some deposit reducing the porcelain's lustre it can be wiped off with force. There are some bits in the glaze, and some points of missing glaze. The pin and grout are O.K.
1273-15B	15000 lb, there is a tinge of rust on the top. There is one spot of rust at the bottom on mould seam. There is a galvanized bloom under the opening and below at the cap base. The porcelain has some pitting but it retains its lustre. Underneath there is some dirt on one side on the inner 2 skirts. There is some deposit on the surface mostly on the inner area and it reduces the lustre. There are pin points of missed glaze, some bits in the glaze. The pin is O.K. The grout is O.K. Except one area at the pin base where there is a space between the grout and the pin, possibly during manufacture.
1273-16B	15000 lb, there is no rust on the cap. There is a galvanized bloom under the opening and below at the cap base. There is a light stain caused by electrical activity coming from the socket to the cap base. The top porcelain is O.K. There is some pitting and grit in the glaze. There are circular halos on the surface that can't be scrapped off. Underneath there is some dirt on the inner 2 skirts. There is deposit on most of the surface, as well as some mould flaws. The pin and grout look O.K.
1273-17B	15000 lb, there is slight rust on the cap. There is a galvanized bloom under the opening and below at the cap base. There is a light stain caused by electrical activity coming from the socket to the cap base. The top porcelain is O.K. There is some pitting and grit in the glaze. There are circular halos on the surface that can't be scrapped off. Underneath there is some dirt on the inner 2 skirts. There is deposit on most of the surface, as well as some mould flaws. The pin O.K. but not centred, grout looks O.K.
1273-18B	15000 lb, there is a tinge of rust on the cap. There is no pattern on the cap like the previous insulators. The porcelain retains its lustre. There are tiny pits on the porcelain and some bits of missed glaze. There are a few bumps on the surface. There is a deposit underneath on most of the surface. There is some dirt on the 2 inner sheds on one side. The surface on the inner ring is irregular. There are some electric lines at this spot. There is some dirt in the glaze and some missed points of glaze. The pin is O.K. and the grout has uneven surface.

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Insulator No.	Visual Examination Results
1273-19B	15000 lb, the cap is O.K. There is a light stain caused by electrical activity coming from the socket to the cap base which is different from the others; the lines are finer and numerous and converge on a round spot in the middle of the cap. There is a circular bloom on the other side of the cap. The porcelain lustre is O.K. at the top and bottom. There is very little dirt underneath. There are some manufacturer flaws. The pin is O.K. but not centred, the grout has no cracks but there is a hole.
1273-20B	15000 lb, the cap is O.K. There is a large stain caused by electrical activity coming from the socket to the cap base which is different from the others. Below the point there is a very light deposit about 3cm that extends and fades to the porcelain edge. There is electrical activity etched in the surface. There is some lustre on the top porcelain, with small points of missing glaze, there are some grits in the glaze and manufacturer flaws near the centre porcelain near the pin. The pin and grout look O.K.
1273-21B	15000 lb, the cap is rust free. There is a light stain caused by electrical activity coming from the socket to the cap base. There is a deposit on the porcelain under the point about 4cm wide, it extends halfway to the edge and then fades out, there is some electrical activity etched on the surface of the deposit, but it can be wiped off with the deposit. There are some pits in the porcelain. Underneath the porcelain retains its lustre, there are some bits in the glaze and a few points of missing glaze. The pin and the grout look O.K
1273-22B	15000 lb, there is a tinge of rust on the cap opening. There is a light stain caused by electrical activity coming from the socket to the cap base. Underneath the point there is a 3cm deposit, extending and fading towards the edge of the porcelain. There is some electrical activity that etched into the deposit. There are several pits on the porcelain surface. Underneath is fairly clean, there are some missing points of glaze and tiny debris in the glaze. The inner small shed near the pin and grout is deformed in shape and has a concentrated amount of small pits. The pin looks O.K. The grout looks O.K.
1273-23B	15000 lb, the cap is rust free. There is a light stain caused by electrical activity coming from the socket to the cap base. There is a fine deposit on the porcelain under the cap that fades across the porcelain. Underneath there is good lustre, the porcelain has some pits, there are some points of missed glaze and grit in the glaze. The pin looks O.K. The grout has a single crack.
1273-24B	15000 lb, the cap is rust free. There is some concrete on the top of the cap. There is a light stain caused by electrical activity coming from the socket to the cap base, the imprint is quite defined. Underneath the cap there is a deposit about 2cm wide that extends and fades towards the porcelain edge, electrical activity etched into the surface. The top porcelain surface is pitted. Underneath lustre is good, but there is some light dirt. There is some missed glazed and there is grit in the glaze. The pin looks O.K. The grout looks O.K.
1273-25B	15000 lb, there is a tinge of rust on the cap socket. There is not a pattern on the cap like other insulators. There is a weld spot on the centre of the cap on the cotter pit side. In front of it, on the porcelain there is a shiny metallic deposit with flashover marks etched into it. There is a small point of missed glaze on top of the porcelain. Underneath lustre is lost due to deposits, they can be wiped off with force. There are some flaws during manufacturing and point of missed glaze. The pin is O.K. The grout is O.K.

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Insulator No.	Visual Examination Results
1273-26B	15000 lb, The cap is rust free. There is not a pattern on the cap like other insulators. The top porcelain has a darkened chip on the surface. Lustre is O.K. but with some pits on the surface and points of missed glaze. Underneath the inner sheds have baked dirt and a deposit on most of the bottom porcelain. The pattern of dirt around the porcelain suggests heavy electrical activity. There are some pitting and flaws on the surface. There is a bit of rust on the pin top and at pin base/grout interface, also on the pin stem. The grout has a rust colour and one crack.

Structure 1248, L-178 (Bush phase)

Insulator No.	Visual Examination Results
1273-1C	15000 lb, There is a slight tinge of rust at the top of the cap. There is a light stain caused by electrical activity coming from the socket to the cap base. There is no deposit below this point but there is more pitting and a rougher surface on the side. Underneath there is a layer of dirt on one side, and a fine dust cover the rest. Underneath this layer there is a deposit that can be scraped off, it is most noticeable in the centre porcelain near the pin. The deposit has a heavy electrical pattern on its surface. There is some grit in the glaze and a few points of missing glaze. There is a tiny bit of rust on the pin head and the stem/grout interface. The grout is O.K but it has a rust tinge.
1273-2C	15000 lb, There is a slight tinge of rust at the top of the cap. There is a light stain caused by electrical activity coming from the socket to the cap base. There is a small deposit under the cap about 3cm wide that extends 1cm towards the edge of the porcelain. There is a small bloom on the porcelain to the side of the deposit that can't be rubbed off. Underneath the porcelain retains its lustre. There are a number of manufacturer flaws. There are also tiny points of missed glaze. The pin is O.K. The grout is O.K.
1273-3C	15000 lb, the cap is rust free. There is a slight discoloration at the top of the cap. There is some concrete from manufacturing on the cap. There is a light stain caused by electrical activity coming from the socket to the cap base. There is a deposit below the stain underneath the cap about 3cm that extends and narrow to the edge of the porcelain edge. There is a metallic sheen on the deposit next to the cap. There is some electrical activity on the surface of the deposit. The top porcelain has pitting and missed glaze points. Underneath lustre is good, there are some manufacturer flaws. Outside the shed there is a thin line about 1.5cm of missing glaze. The pin is O.K. The grout has a single crack.
1273-4C	15000 lb, there is some rust on the top of the cap and a dark rust pattern alongside near the opening. The galvanizing is rough near the cotter pin and opening. There is a light stain caused by electrical activity coming from the socket to the cap base. The metal is a brass colour. There is some concrete from manufacturing at the bottom of the cap. There is a deposit about 2cm on the porcelain underneath the cap, it extends and fades towards the porcelain edge. Lustre on top porcelain is O.K. There is some pitting. Underneath the lustre is good. There is a small chip on the second shed from the pin. There are some bits in the glaze. The pin is O.K. The grout is O.K.
1273-5C	10000 lb, There is a small amount of rust at the top of the cap. Lustre is good .

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Insulator No.	Visual Examination Results
	There are some points of missing glaze. Underneath there is dirt in between two rings on one side. There is a light deposit on the rest of the bottom porcelain. There are a number of tiny points of missed glaze. There is a "W" stamp in the middle near the pin. There is some electrical activity etched into this area. The pin is set deep in the insulator, and the grout is about 1.5cm down.
1273-6C	10000 lb, there is a small amount of rust at the top of the cap. Lustre is good . There are some points of missing glaze. Underneath there is dirt in between two rings on one side. There is a light deposit on the rest of the bottom porcelain. There are a number of tiny points of missed glaze. There is a "W" stamp in the middle near the pin. There is some electrical activity etched into this area. The pin is O.K. The grout is O.K.
1273-7C	15000 lb, there is no rust on the cap. There is a light stain caused by electrical activity coming from the socket to the cap base. There is some discoloration where the stain pattern is. Underneath the cap there is a deposit on the porcelain about 3cm wide that extends and fades towards the edge. There is some electrical activity on the surface of the deposit; one line is faintly etched in the surface. The top porcelain has tiny pits, there are a couple of points of missed glaze. Underneath lustre is good, there are some manufacturer flaws on the inner ring closest to the pin, it also has a number of concentrated pits.
1273-8C	15000 lb, there is no rust on the cap. There is a light stain caused by electrical activity coming from the socket to the cap base. There is a deposit underneath the cap on the porcelain about 4cm wide that extends and fades towards the edge. There is some electrical activity on the deposit with a couple of lines slightly etched in the porcelain surface. There are tiny pits on the surface of the porcelain. Underneath there is good lustre, there are some pin points of missing glaze and a bit of grit in the glaze. The pin is O.K. The grout has a single crack.
1273-9C	15000 lb, there is no rust on the cap. There is a light stain caused by electrical activity coming from the socket to the cap base. There is a deposit underneath the cap below the stain patter about 4cm wide that narrows and fades towards the porcelain edge. There is some electrical activity etched in the deposit. The porcelain has some points of missed glaze. There are some manufacture flaws like bumps and flat spots on the sheds. The pin is O.K. The grout is O.K.
1273-10C	15000 lb, there is a slight tinge of rust on the top of the cap. There are bits of concrete on the surface. There is a light stain caused by electrical activity coming from the socket to the cap base. There is a deposit on the porcelain at this point below the cap about 3cm wide that extends and fades towards the porcelain edge. There is some electrical activity etched into the deposit. The top porcelain has some grit in the glaze. The surface is pitted. There are a couple of points of missed glaze. Underneath the porcelain still has good lustre. There are several pin points of missed glaze, uneven surfaces. The centre ring around the pin has little lustre. The pin is O.K. The grout is O.K.
1273-11C	10000 lb, There is some rust on the side at the seam. There is no stain on the cap as the other insulators did. The porcelain has good lustre with some points of missed glaze. Most of the porcelain has some dirt on it. There is some grit in the glaze. The pin is O.K. The grout is O.K.
1273-12C	10000lb, there is no rust on the cap. There is no stain on the cap as other insulators did. The top porcelain has good lustre. There are several pin points of missed glaze,

Insulator No.	Visual Examination Results
	and there is some grit in the glaze. Underneath there is some dirt on the two inner rings. There are deposits on most of the bottom porcelain reducing its lustre. There are a number of points missing glaze. The pin is O.K. The grout is roughened but O.K.
1273-13C	15000 lb, there is a tinge of rust on the cap. There is a light stain caused by electrical activity coming from the socket to the cap base. The cap is discoloured at the stain. There is a 3cm wide deposit on the porcelain underneath the cap that extends and fades towards the porcelain edge. There is electrical activity etched in the deposit, with a metallic sheen to it. There are some pits on the surface. Underneath the lustre is good, but there are tiny bits of concrete on the surface, tiny bits of missing glaze, and a few missed glaze points. The pin is O.K. The grout is O.K.
1273-14C	15000 lb, There are a couple of tiny rust spots on top of the cap. There is a light stain caused by electrical activity coming from the socket to the cap base. There is a deposit about 3cm that extends and fades towards the porcelain edge. The top porcelain is pitted and there are tiny points of missed glaze. There is a single piece of grout in the glaze. Underneath the glaze is good, but there are bits of missed glaze. There are some manufacture flaws, flattened surface on the sheds, runny glaze. The pin is O.K. The grout has a single crack.
1273-15C	15000 lb, There is no rust on the cap. There is a light stain caused by electrical activity coming from the socket to the cap base. There is a deposit about 2cm that extends and fades towards the porcelain edge. There is some electrical activity etched into the deposit. The top porcelain is pitted and there are tiny points of missed glaze. Underneath the lustre is good. There are bits of missed glaze. The pin is O.K. The grout has a crack with a hole in it.
1273-16C	15000 lb, There is no rust on the cap. This sample is marked “punctured 0.2MΩ”. There is a light stain caused by electrical activity coming from the socket to the cap base. There is a deposit about 1cm that extends and fades towards the porcelain edge. There is some electrical activity etched into the deposit. The top porcelain is pitted and there are tiny points of missed glaze. There is a single bloom on the porcelain. Underneath the lustre is good, but there are some bits in the glaze. There are some manufacture flaws like flattened porcelain on the sheds. The pin is O.K. The grout is O.K.
1273-17C	15000 lb, There is a tiny bit of rust on the top. There is a light stain caused by electrical activity coming from the socket to the cap base. There is a deposit about 3cm that extends and fades towards the porcelain edge. There is some electrical activity etched into the deposit. There is a circular bloom near the edge. There are bits of missed glaze. Underneath the lustre is good There are bits of missed glaze. The centre porcelain around pin has glaze erosion. The pin is O.K. The grout is O.K.
1273-18C	15000 lb, there is a tinge of rust on the cap. There is a galvanizing bloom near the opening. There is no stain pattern like other insulators did. The porcelain is pitted. Underneath the lustre is hidden by deposit on most of the surface it can be rubbed off with force. There is some dirt on one side of the inner rings. There is some grit in the glaze and a few pin points of missed glaze. The pin is O.K. The grout is O.K.
1273-19C	15000 lb, there is no rust on the cap. There is a light stain caused by electrical activity coming from the socket to the cap base. There is a deposit about 3cm that extends and fades towards the porcelain edge. The porcelain is pitted. There are

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Insulator No.	Visual Examination Results
	bits of missed glaze. There is a bloom on the surface. Underneath the lustre is good. There are bits of missed glaze. The pin is O.K. The grout is O.K.
1273-20C	15000 lb, there is no rust on the cap, but does have 4 arc damage points. One below the cotter pin and three in line under the side of opening. There are a couple of light arc marks in line on the porcelain. The surface under the cap is rough and has a tiny bit of porcelain damage. There is a faint pattern on the cotter pin side that includes the one arc point on the cap. There is a small deposit that extends and fades towards the porcelain edge. The top porcelain is pitted and there are tiny points of missed glaze. There is no arc damage underneath. There are some manufacture flaws. The pin is O.K. The grout is O.K.
1273-21C	15000 lb, there is no rust on the cap. There is a light stain caused by electrical activity coming from the socket to the cap base. There is a deposit about 3cm that extends and fades towards the porcelain edge. There is some electrical activity etched into the deposit. The top porcelain is pitted and there are tiny points of missed glaze. The lustre is less than others. Underneath the lustre is good. There is some arc damage on the edge of the outer shed. There are some manufacture flaws. The pin is O.K. The grout is O.K.
1273-22C	15000 lb, there is a tinge of rust on the cap. There is some concrete on the surface. There is a light stain caused by electrical activity coming from the socket to the cap base. There is a deposit about 2cm that extends and fades towards the porcelain edge. There is some electrical activity etched into the deposit. The lustre is good but there are pits and points of missed glaze. Underneath there is arc damage in a small area on the 3 outer sheds. The 2nd shed is discoloured, showing high temperature damage. The rest of the area looks good with lustre. There are bits of missed glaze. The pin is O.K. The grout is uneven with a hole at the base of the pin.
1273-23C	15000 lb, there is no rust on the cap, but some discoloration on one side. There is a light stain caused by electrical activity coming from the socket to the cap base. There are a couple of arc marks around the cotter pin area and one near opening. There is a deposit about 3cm that extends and fades towards the porcelain edge. There is some electrical activity etched into the deposit. The top porcelain is pitted and there are tiny points of missed glaze. Underneath the lustre is good There are bits of missed glaze. The pin is O.K. The grout is O.K.
1273-24C	15000 lb, there is no rust on the cap. There is a light stain caused by electrical activity coming from the socket to the cap base. The cap is discoloured at the stain patter. There is a deposit about 3cm that extends and fades towards the porcelain edge. There is some electrical activity etched into the deposit. The top porcelain is pitted and there are tiny points of missed glaze. There are some manufacture flaws underneath, runny glaze, irregular bumps on sheds, bits in glaze. The pin is O.K. The grout is O.K.
1273-25C	10000 lb, there is a tinge of rust on the cap. There is no stain pattern like other insulators did. The top porcelain has good lustre. There are bits of missed glaze. There is a metallic stain on the surface, not sure if it is from a tool or arc damage, it can't be scrapped off. Underneath is quite dirty; there is an electrical pattern in the dirt. There is some missed glaze on the inner shed by the pin. There are pin points of missing glaze. The pin is O.K. but off centre. The grout is O.K.

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Insulator No.	Visual Examination Results
1273-26C	10000 lb, there is no rust on the cap. There is no stain pattern like other insulators did. The lustre is good but there is some grit in the glaze and there are bits of missed glaze. Underneath is quite dirty. There is some missed glaze. The lustre is hidden by the dirt and surface deposits can be wiped with force. The pin and grout are O.K.

7.2.2 Main findings in the visual inspections:

Visual inspection shows these insulator strings had some electrical and environmental damage. The inspections found evidence on all of the insulator strings of some electrical activities such as: flashover and electrical discharge. This electrical activity indicates that all of these insulators have been subjected to higher than normal leakage current. Many of the insulators in all the strings have cracks in the grout; however, there was no significant loss of grout observed. The cracks are typical of old insulators and are not an immediate concern unless accompanied by loss of grout.

Figures 1 to 3 shows examples of electrical damage:



Figure 1 – Stain from the cap that extends and fades towards the porcelain edge.

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Figure 2 - Electrical activity etched in the stain,



Figure 3 – Arcing damage

7.3 *ESDD Measurement*

7.3.1 Test Description:

The ESDD test (Equivalent Salt Deposit Density-IEEE Std. 4) is a measure of the pollution level on the insulators. The pollutant on the upper and the lower surfaces of the insulators was washed off separately and the ESDD was determined for each surface.

Two insulators from each of the three different insulator sets were tested.

7.3.2 Test Results:

Insulator Sample No.	ESDD (mg/cm^2)
1273-20A Top	0.014925
1273-20A Bot	0.007788
1273-6A Top	0.014433
1273-6A Bot	0.017628
1273-11B Top	0.019195
1273-11B Bot	0.009725
1273-17B Top	0.014343
1273-17B Bot	0.013867
1273-25C Top	0.015205
1273-25C Bot	0.01653
1273-8C Top	0.014817
1273-8C Bot	0.007517

According to the information from IEC Standard 815, the ESDD level on an insulator below 0.03 mg/cm^2 is generally considered to be very light pollution level. The results from the ESDD measurement on these insulators show that the pollution level was lower than a "very light pollution level" on all the insulators tested.

7.4 *Radio Interference Test*

7.4.1 Acceptance Criterion

According to the CSA standard each of five tested insulators shall meet the requirements for maximum radio interference voltage (RIV). If one insulator fails an additional five insulators are to be tested. In this investigation all 78 insulators were tested in order to give an overall picture of the condition of the insulators on the 138 kV transmission line.

Rating: < 50 µV @ 1 MHz, using an applied test voltage of 10 kV rms.

A high RIV reading indicates that there is partial discharge activity on the insulators which means that there is some damage to the insulator. This test is normally done as type test but no insulator in service should exhibit high RIV (partial discharge) levels. The high RIV level

can be caused by external problems with the insulators (such as glaze damage) or to internal problems (such as cracks).

7.4.2 Atmospheric Test Conditions

Test date:	May 2, 2016	May 3, 2016
Barometric pressure:	752.2 mmHg	758.1 mmHg
Temperature, dry-bulb:	21.2 °C	22.2 °C
Relative humidity:	34.0 %	44.0 %

Background RIV = <1.0 µV @ 1 MHz at an applied test voltage of 10 kV rms

7.4.3 Test Results

Note: In the following tables all insulators that had an RIV above 50 µV electrical or mechanical failure below the rating of 15 kip are highlighted in red.

Structure 1248, L-178 (Road phase)

Insulator No.	Name on the Glaze	Radio-influence voltage (µV)	Insulator No.	Name on the Glaze	Radio-influence voltage (µV)
1273-1A	England	0.75	1273-14A	England	94.5
1273-2A	England	0.56	1273-15A	England	0.67
1273-3A	England	3.67	1273-16A	England	2.62
1273-4A	England	2.25	1273-17A	England	0.67
1273-5A	England	0.75	1273-18A	England	0.56
1273-6A	England	2.62	1273-19A	England	0.41
1273-7A	England	2.43	1273-20A	England	0.71
1273-8A	England	0.56	1273-21A	England	0.75
1273-9A	England	0.56	1273-22A	England	94.1
1273-10A	England	0.93	1273-23A	England	0.63
1273-11A	England	0.45	1273-24A	England	1.12
1273-12A	England	1.12	1273-25A	England	0.75
1273-13A	England	0.56	1273-26A	England	0.75

Structure 1248, L-178 (Centre phase)

Insulator No.	Name on the Glaze	Radio-influence voltage (µV)	Insulator No.	Name on the Glaze	Radio-influence voltage (µV)
1273-1B	England	1.50	1273-14B	England	1.50
1273-2B	England	1.68	1273-15B	England	52.5
1273-3B	England	0.93	1273-16B	England	0.56
1273-4B	England	1.12	1273-17B	England	2.62
1273-5B	England	2.43	1273-18B	England	1.50
1273-6B	England	2.25	1273-19B	England	9.37

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1273-7B	Buller's	0.67	1273-20B	England	2.06
1273-8B	Buller's	0.93	1273-21B	England	1.31
1273-9B	Buller's	9.37	1273-22B	England	2.06
1273-10B	Buller's	2.06	1273-23B	England	0.75
1273-11B	Buller's	52.5	1273-24B	England	1.12
1273-12B	Buller's	0.56	1273-25B	England	2.06
1273-13B	England	45.0	1273-26B	England	0.56

Structure 1248, L-178 (Bush phase)

Insulator No.	Name on the Glaze	Radio-influence voltage (µV)	Insulator No.	Name on the Glaze	Radio-influence voltage (µV)
1273-1C	England	0.75	1273-14C	England	0.48
1273-2C	England	0.75	1273-15C	England	1.87
1273-3C	England	0.56	1273-16C	England	Punctured-not tested
1273-4C	England	0.75	1273-17C	England	2.25
1273-5C	England	0.56	1273-18C	England	0.56
1273-6C	Buller's	1.12	1273-19C	England	0.75
1273-7C	England	0.56	1273-20C	England	1.12
1273-8C	England	0.56	1273-21C	England	56.2
1273-9C	England	1.50	1273-22C	England	2.25
1273-10C	England	0.75	1273-23C	England	1.68
1273-11C	Buller's	6.00	1273-24C	England	1.68
1273-12C	Buller's	9.37	1273-25C	Buller's	2.25
1273-13C	England	1.50	1273-26C	Buller's	0.93

7.4.4 Summary of RIV test results:

The radio-interference voltage of all the insulators was measured.

The overall failure rate of the insulators was 6% (5 out of 78). These insulators failed the radio-interference voltage test.

7.5 *Dry Power-Frequency Voltage Flashover Test*

7.5.1 Acceptance Criterion

The insulators pass the test, if the average dry flashover voltage of three tested insulators is equal to or exceeds 95% of the rated dry flashover value of 80 kV (corrected to standard atmospheric conditions) and no insulators are punctured. For evaluation purpose all the insulators were tested and they were evaluated on the basis of the complete string.

7.5.2 Test Procedure

The applied voltage to the insulator was initially increased to approximately 75% of its flashover value. Then it was increased gradually with a rate of rise of about 2% of the estimated flashover voltage (80 kV) per second until the flashover voltage was reached. Five flashover values were obtained per insulator.

7.5.3 Atmospheric Test Conditions

Date of test:	2 May 2016	3 May 2016
Barometric pressure:	757.2 mmHg	758.1 mmHg
Temperature dry-bulb:	21.2 °C	22.2 °C
Relative humidity:	39.2 %	44.0 %

Note: Test results are corrected to standard atmospheric conditions, as specified by the test standards, so that the evaluation of the results is based on the same atmospheric conditions.

7.5.4 Test Results

Note: In the following tables all insulators that had an RIV above 50 µV electrical or mechanical failure below the rating of 15 kip are highlighted in red.

Structure 1248, L-178 (Road phase)

Insulator No.	Flashover Voltage (kV)	Flashover Voltage (kV)	Flashover Voltage (kV)	Flashover Voltage (kV)	Flashover Voltage (kV)	Average Flashover Voltage (kV)	
1273-1A	80.48	77.84	77.68	76.64	76.78	76.41	
1273-2A	76.24	76.00	76.32	74.24	78.24	76.20	
1273-3A	76.44	76.16	76.48	76.00	76.96	76.41	
1273-4A	74.64	77.84	75.20	77.20	76.88	76.35	
1273-5A	74.64	75.12	74.16	76.00	77.44	75.47	
1273-6A	79.20	77.76	74.12	77.60	77.04	77.14	
1273-7A	76.80	76.80	76.80	75.20	75.20	76.16	
1273-8A	76.00	76.00	76.00	75.20	73.60	75.36	
1273-9A	76.00	76.80	76.80	76.00	77.60	76.64	
1273-10A	73.60	73.60	74.40	76.00	76.80	74.88	
1273-11A	75.76	74.72	73.20	74.16	73.60	74.28	
1273-12A	80.40	78.16	77.60	76.64	76.56	77.87	
1273-13A	75.84	76.64	79.76	78.16	77.88	77.65	
1273-14A	78.40	77.40	78.40	79.28	79.12	75.52	
1273-15A	77.40	76.60	75.60	76.08	77.12	76.56	
1273-16A	77.60	78.20	78.00	75.40	78.16	77.47	
1273-17A	75.80	79.80	77.00	75.60	77.50	77.14	
1273-18A	75.20	75.20	77.60	76.80	76.00	76.16	
1273-19A	77.28	80.48	79.68	77.04	77.92	78.48	
1273-20A	75.04	76.72	77.44	78.00	80.32	77.50	
1273-21A	77.76	75.68	74.16	75.70	76.16	75.89	
1273-22A	22.32	20.80	20.80	22.96	20.00	21.37	
1273-23A	77.70	75.40	74.64	76.60	74.30	75.74	

Not Corrected 74.2

Corrected to standard atmospheric conditions 75.0

Insulator No.	Flashover Voltage (kV)	Flashover Voltage (kV)	Flashover Voltage (kV)	Flashover Voltage (kV)	Flashover Voltage (kV)	Average Flashover Voltage (kV)	
1273-24A	75.50	75.40	75.10	74.90	75.04	75.18	
1273-25A	74.40	75.20	74.40	73.60	76.00	74.72	
1273-26A	77.60	76.80	79.20	74.40	76.80	76.96	

Structure 1248, L-178 (Centre phase)

Insulator No.	Flashover Voltage (kV)	Flashover Voltage (kV)	Flashover Voltage (kV)	Flashover Voltage (kV)	Flashover Voltage (kV)	Average Flashover Voltage (kV)	
1273-1B	73.92	75.52	76.16	76.96	78.08	76.12	Not Corrected 74.8 Corrected to standard atmospheric conditions 75.6
1273-2B	74.56	78.00	76.16	76.64	77.76	76.62	
1273-3B	77.60	75.36	77.68	75.28	77.60	76.70	
1273-4B	77.28	77.12	81.84	78.80	77.84	78.57	
1273-5B	75.68	76.80	77.36	79.36	75.44	76.92	
1273-6B	75.12	77.92	76.80	75.28	77.60	76.40	
1273-7B	70.16	72.40	71.76	73.92	72.72	72.19	
1273-8B	71.20	71.68	72.00	73.60	71.84	72.06	
1273-9B	72.24	71.76	71.76	72.96	71.44	72.03	
1273-10B	72.80	72.64	72.32	74.16	72.96	72.97	
1273-11B	73.52	73.44	72.08	73.60	72.96	73.12	
1273-12B	73.36	73.36	71.12	74.08	73.84	73.15	
1273-13B	76.56	76.08	74.88	75.84	74.48	75.56	
1273-14B	76.80	76.64	76.16	77.16	76.24	76.60	
1273-15B	78.24	76.56	76.48	76.00	77.60	76.96	
1273-16B	75.92	76.08	76.08	76.24	77.44	76.35	
1273-17B	72.32	74.96	74.64	73.44	74.64	74.00	
1273-18B	76.96	76.40	75.84	76.48	76.48	76.38	
1273-19B	75.76	73.10	73.68	74.08	74.00	74.12	
1273-20B	77.60	76.64	76.24	75.28	78.00	76.75	
1273-21B	77.68	76.48	75.84	73.60	76.80	76.08	
1273-22B	75.36	74.16	75.36	73.68	74.96	74.70	
1273-23B	75.68	75.92	74.56	76.00	74.40	75.31	
1273-24B	77.28	78.88	76.08	75.92	78.16	77.26	
1273-25B	75.60	76.64	76.24	77.20	80.3	77.20	
1273-26B	75.44	73.44	75.60	77.20	punctured	60.33	

Structure 1248, L-178 (Bush phase)

Insulator No.	Flashover Voltage (kV)	Flashover Voltage (kV)	Flashover Voltage (kV)	Flashover Voltage (kV)	Flashover Voltage (kV)	Average FLO Voltage (kV)	
1273-1C	78.32	79.36	77.28	77.92	76.48	77.87	Not Corrected 71.7 Corrected to standard atmospheric
1273-2C	74.32	73.52	76.08	72.56	74.56	74.20	
1273-3C	76.80	74.80	74.40	74.96	75.44	75.28	
1273-4C	71.52	73.12	73.52	74.96	73.84	73.39	
1273-5C	70.72	78.12	69.76	69.28	67.76	69.12	
1273-6C	73.36	72.08	72.56	72.56	71.04	72.32	
1273-7C	77.28	75.92	76.48	76.48	74.40	76.11	
1273-8C	74.16	75.08	76.00	74.80	75.36	75.08	

The results relate only to the items tested
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1273-9C	77.84	75.76	78.80	77.12	78.40	77.58	conditions
1273-10C	72.40	76.08	76.0	76.96	73.12	74.91	72.4
1273-11C	69.68	67.28	72.88	68.48	70.48	69.76	
1273-12C	71.36	68.88	71.36	71.68	74.32	71.52	
1273-13C	76.80	80.24	79.68	75.84	76.88	77.88	
1273-14C	73.68	74.80	72.16	74.80	74.80	74.04	
1273-15C	73.28	73.12	78.48	76.80	78.16	75.96	
1273-16C	punctured						
1273-17C	75.20	77.84	78.16	80.16	75.84	77.40	
1273-18C	76.08	77.20	75.84	74.28	77.12	76.10	
1273-19C	77.68	78.80	78.24	74.96	77.12	77.36	
1273-20C	75.60	75.76	75.36	75.52	76.56	75.75	
1273-21C	74.40	74.72	74.40	72.00	75.60	74.22	
1273-22C	75.60	78.80	73.36	76.48	73.92	75.63	
1273-23C	79.52	75.20	75.76	74.72	75.84	76.20	
1273-24C	75.60	72.00	74.24	72.96	75.52	74.06	
1273-25C	70.64	69.94	71.28	72.32	73.52	71.54	
1273-26C	71.92	69.84	71.76	71.28	69.52	70.86	

Overall the insulators fail the requirements of CAN/CSA-C411.1-M89, Clause 5.3: "Dry power frequency voltage tests". The corrected average flashover voltage was <76 kV (95% x 80 kV). There were two insulator punctures and one cracked insulator (very low flashover voltage of 21 kV).

7.6 *Assessment of Corrosion*

7.6.1 Condition Assessment of Insulators

The condition of the galvanized fittings and grouted interfaces were assessed with respect to corrosion attack. The samples were subjected to the following examinations:

- Visual Examination of Galvanized Fittings and Grouted Interfaces
- Energy Dispersive X-ray Spectroscopy
- Coating Thickness Measurements

7.6.2 Visual Examination

All sample sets showed varying degrees of similar features, with the following observations noted:

- The galvanized cap and pin of the insulators are in excellent condition. The majority of samples do not exhibit any corrosion product on the surface. Several samples were noted having a white crystalline corrosion product present on the cap; typical of minor corrosion attack of a galvanized coating. However, the amount of corrosion product was minor and the presence of the zinc corrosion products is actually beneficial, as they are adherent and fairly insoluble; acting as a passive layer to slow the effective corrosion rate as time progresses and the corrosion product builds. The typical surface condition of the galvanized caps is seen in Figures 4 and 5.

- Several samples sets showed dust like debris primarily on the bottom side of the sheds, seen in Figure 6

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- The grout condition on the underside of the insulators is also in good condition, with no cracking, shrinkage or porosity noted in the grout. Similarly no features of cement growth phenomena which can lead to cracking in the shells was noted. Examples of the grout condition is seen in Figure 4



Figure 4: Overall Condition of In-Service Insulators. No apparent corrosion attack of the galvanized coating is noted in the majority of samples.

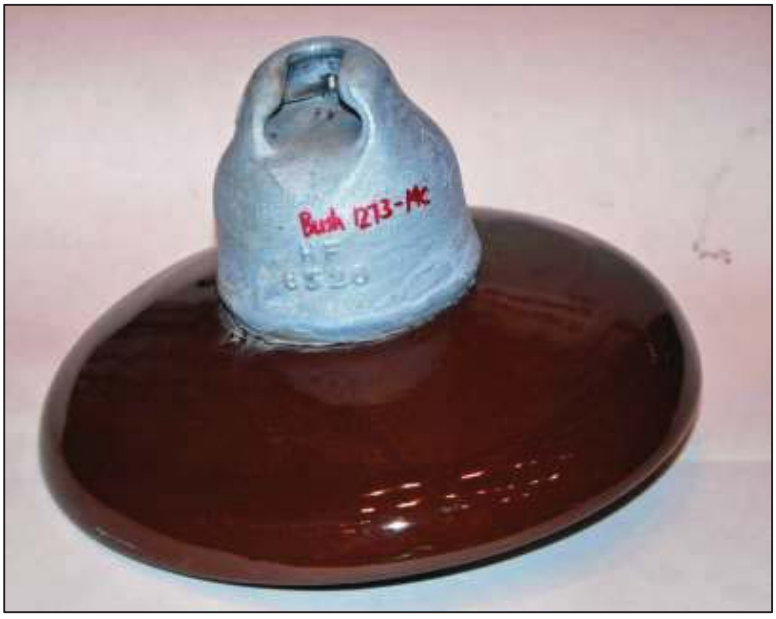


Figure 5: Example of insulator containing a small amount white crystalline deposit on cap of

insulator.



Figure 6: Debris present on underside of insulator sheds. Also note good condition of grout



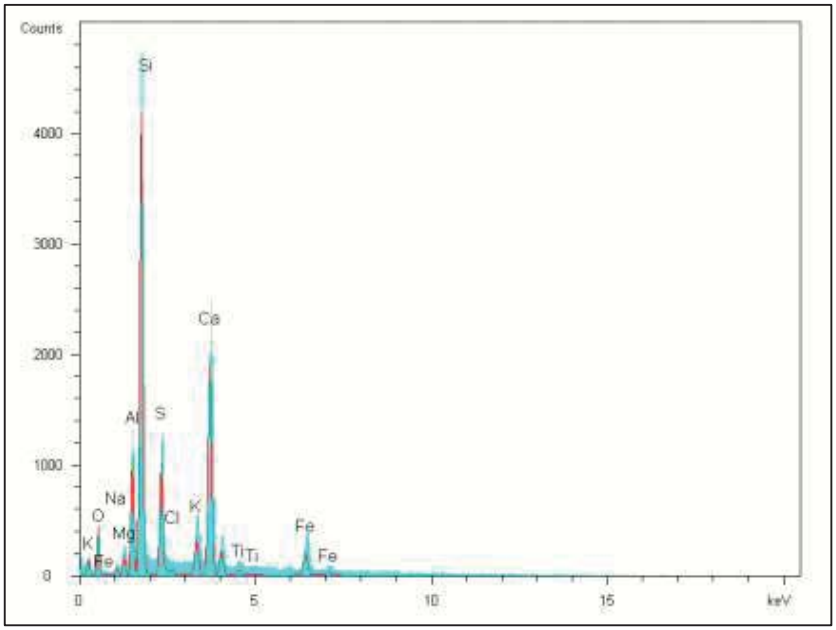
Figure 7: Typical condition of underside of insulator, with no dust like debris on underside

7.6.3 Energy Dispersive X-ray Spectroscopy

The general dust like debris on the underside of several sheds noted in the assessment was sampled from the insulators. The collected material was then placed in a Hitachi SU1510 Scanning Electron Microscope and analyzed by Energy Dispersive X-ray Spectroscopy (EDS) to determine the elemental composition.

A representative EDS spectrums obtained from the analyses is seen in Figure 5.

The dust debris on the underside of the sheds consisted primarily of silicon (Si), calcium (Ca), aluminum (Al), and sulphur (S), as expected for general dust contamination (Figure 7). Minor concentrations of potassium (K), iron (Fe), magnesium (Mg) and sodium (Na) were also noted in the spectrum, elements that are also commonly attributed to general dust contamination. While sulphur can act as a corrosion accelerant, this typically occurs in environments where there is continuous wet / dry cycling. The presence of sulphur in the debris on the sheds of the insulators is clearly not causing corrosion, as the galvanized components are in excellent condition.



7.6.4 Coating Thickness Measurements

The coating thickness of the cap and pin of selected insulators was measured using a PosiTector 6000 coating thickness gage. At each test location, the surface of the area tested was cleaned of any surface debris. Three reading were performed in each area, and the average value reported. The results of the coating thickness measurements are seen summarized in Table 1.
There was minor variation in the coating thickness between samples, however all samples tested show a significant remaining coating thickness, with the current values consistent with a newly hot dip galvanized product

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Table 1: Coating Thickness Measurements

Sample ID	Coating Thickness Readings Cap (mils)			Avg. Coating Thickness Cap (mils)	Coating Thickness Readings Pin (mils)			Avg. Coating Thickness Pin (mils)
1273-3A	5.4	6.3	6.7	**6.1**	4.6	5.0	5.4	**5.0**
1273-20A	6.0	5.9	6.4	**6.1**	6.0	5.2	5.8	**5.7**
1273-13B	5.8	5.2	6.0	**5.7**	6.4	6.4	6.0	**6.3**
1273-25B	7.2	6.4	6.6	**6.7**	6.3	5.9	6.1	**6.1**
1273-9C	5.6	5.8	5.4	**5.6**	5.6	6.5	6.1	**6.1**
1273-14C	6.1	5.4	6.4	**6.0**	4.9	5.4	5.3	**5.2**

7.7 *Electro-mechanical Failing Load Test*

7.7.1 Test Procedure

Each insulator was tested individually. The insulator was subjected to a mechanical load with the load initially increased rapidly and smoothly from zero to approximately 11.3 kip (75 % of the specified electromechanical failing load). It was then increased at a rate between 35% to 100% of the rating per minute until the failing load was reached. Simultaneously, a 60 Hz voltage of 60 kV was applied to the tested insulator - an internal electrical discharge would indicate that a mechanical failure of the insulating part (porcelain shell) has occurred prior to the mechanical failure. An electrical failure causes the circuit breaker on the high voltage to trip. The load at which this occurs is recorded while the mechanical load increase is continued at the same rate till the mechanical failing load is reached. The electrical (E) and mechanical (M) failure loads were both recorded.

7.7.2 Acceptance Criteria

The insulators pass the test if the tested units (normally ten insulators. in this case the complete set of 26 insulators was evaluated) comply with the electro-mechanical failing load test requirements of CAN/CSA-C411.1-M89, Clause 6.6 as follows:

(a) $X \geq R + 3S$

where X = mean value of the lowest (electrical or mechanical) individual failing load test
R = specified failing load (rating) of 15 kN
S = standard deviation of sample test units provided by the formula

$$S = \sqrt{\frac{(X_1 - \overline{X})^2 + (X_2 - \overline{X})^2 + \cdots (X_N - \overline{X})^2}{N - 1}}$$

where

N = number of units tested

(b) each value measured should be equal to or greater than the rating of 15 kip ($X_i \geq R$)

where

X_i = each individual failing load value measured
i = 1, 2, 3, … N

7.7.3 Test Results

Note: In the following tables all insulators that had an electrical or mechanical failure below the rating of 15 kip are highlighted in red.

Structure 1248, L-178 (Road phase)

Insulator Sample No.	Failure load (kip) (Electrical)	Failure load (kip) (Mechanical)	Mechanical Failure mode	Initial Failure Mode (M or E)	Acceptance parameters		
					X (kip)	S (kip)	X + 3 x S (kip)
1273-1A	14	19	Pin stretch and pullout	E			
1273-2A	21	21	Pin pullout	E			
1273-3A	18	18	Pin pullout	M			
1273-4A	20	21	Pin pullout	Both			
1273-5A	18	19	Pin stretch and pullout	E			
1273-6A	21	21	Pin pullout	Both			
1273-7A	21	21	Cap pullout, pin loose	Both			
1273-8A	17	22	Pin pullout	E			
1273-9A	13	19	Pin pullout	E			
1273-10A	21	21	Pin pullout	E	Electrical 16.2	Electrical 5.2	Electrical 15 + 3x5.2 = 30.7
1273-11A	20	20	Pin pullout	M			
1273-12A	17	17	Pin pullout	M			
1273-13A	14	19	Cap pullout, pin loose	E			16.2<30.7
1273-14A	14	19	Pin pullout	E	Mechanical 20.2	Mechanical 1.4	Mechanical 19.3
1273-15A	13	19	Pin stretch and pullout	E			20.2>19.3
1273-16A	23	23	Cap pull out	Both			
1273-17A	17	19	Pin pullout	E			
1273-18A	20	20	Pin pullout	M			
1273-19A	15	20	Cap pullout, pin loose	E			
1273-20A	5	23	Pin pullout	E			
1273-21A	17	20	Pin stretch and pullout	E			
1273-22A	0	21	Porcelain already cracked	E			
1273-23A	20	20	Pin pullout	E			
1273-24A	19	20	Pin stretch and pullout	E			

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Insulator Sample No.	Failure load (kip) (Electrical)	Failure load (kip) (Mechanical)	Mechanical Failure mode	Initial Failure Mode (M or E)	Acceptance parameters		
					X (kip)	S (kip)	X + 3 x S (kip)
1273-25A	12	22	Pin stretch and pullout	E			
1273-26A	11	20	Pin pullout	E			

Road phase individual insulators summary:

Insulators Tested	Electrical Failures (<15 kip)	Mechanical Failures (<15 kip)	Total Failures (<15 kip)
26	8 (30 %)	0 (0 %)	8 (30 %)

Structure 1248, L-178 (Centre phase)

Insulator Sample No.	Failure load (kip) (Electrical)	Failure load (kip) (Mechanical)	Mechanical Failure mode	Initial Failure Mode (M or E)	Acceptance parameters		
					X (kip)	S (kip)	X + 3 x S (kip)
1273-1B	18	22	Pin stretch and pullout	E			
1273-2B	15	18	Pin pullout	E			
1273-3B	14	16	Pin stretch and pullout	E			
1273-4B	16	16	Pin stretch and pullout	M			
1273-5B	20	20	Pin stretch and pullout	M			
1273-6B	18	21	Cap pullout	E			
1273-7B (10 kip)	17	17	Cap pullout, pin loose	E	Electrical 18.0	Electrical 3.1	Electrical 15 + 3x3.1 = 24.3
1273-8B (10 kip)	11	16	Cap pullout	E			18.0<24.3
1273-9B (10 kip)	20	20	Cap pullout	Both			
1273-10B (10 kip)	23	23	Cap pullout, pin loose	Both	Mechanical 19.3	Mechanical 2.5	Mechanical 15 + 3x2.5 = 22.5
1273-11B (10 kip)	14	15	Cap pullout	E			19.3<22.5
1273-12B (10 kip)	14	18	Cap pullout	E			
1273-13B	19	23	Cap pullout, pin loose	E			
1273-14B	19	19	Cap pullout Pin pullout	Both			
1273-15B	23	23	Pin stretch and pullout	M			
1273-16B	20	20	Pin stretch and pullout	M			

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Insulator Sample No.	Failure load (kip) (Electrical)	Failure load (kip) (Mechanical)	Mechanical Failure mode	Initial Failure Mode (M or E)	Acceptance parameters		
					X (kip)	S (kip)	X + 3 x S (kip)
1273-17B	21	22	Pin stretch and pullout	E			
1273-18B	20	20	Pin stretch and pullout	M			
1273-19B	19	19	Pin stretch and pullout	M			
1273-20B	15	21	Pin stretch and pullout	E			
1273-21B	20	20	Pin stretch and pullout	M			
1273-22B	21	15	Pin stretch and pullout	E			
1273-23B	17	17	Pin stretch and pullout	M			
1273-24B	14	21	Cap pullout Pin stretch and pullout	E			
1273-25B	21	21	Cap pullout	Both			
1273-26B	20	20	Cap pullout	M			

Center phase individual insulators summary:

Insulators Tested	Electrical Failures (<15 kip)	Mechanical Failures (<15 kip)	Total Failures (<15 kip)
26	5 (19 %)	0 (0 %)	5 (30 %)

Structure 1248, L-178 (Bush phase)

Insulator Sample No.	Failure load (kip) (Electrical)	Failure load (kip) (Mechanical)	Mechanical Failure mode	Initial Failure Mode (M or E)	Acceptance parameters		
					X (kip)	S (kip)	X + 3 x S (kip)
1273-1C	19	19	Pin stretch and pullout	M	Electrical 18.6	Electrical 2.7	Electrical 15 + 3x2.7 = 23.1
1273-2C	15	20	Pin stretch and pullout	E			
1273-3C	19	19	Pin stretch and pullout	M			18.6<23.1
1273-4C	12	22	Pin stretch and pullout	E	Mechanical 19.3	Mechanical 2.0	Mechanical 15 + 3x2.0 = 21.0
1273-5C (10 kip)	21	21	Cap pullout Porcelain cracked	Both			18.6<21.0
1273-6C (10 kip)	22	22	Porcelain fell off	M			
1273-7C	20	20	Pin stretch and pullout	M			

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Insulator Sample No.	Failure load (kip) (Electrical)	Failure load (kip) (Mechanical)	Mechanical Failure mode	Initial Failure Mode (M or E)	Acceptance parameters		
					X (kip)	S (kip)	X + 3 x S (kip)
1273-8C	20	20	Pin stretch and pullout	M			
1273-9C	20	20	Pin stretch and pullout	M			
1273-10C (10 kip)	19	19	Pin stretch and pullout	M			
1273-11C	14	17	Cap pullout	E			
1273-12C (10 kip)	23	23	Porcelain fell off	M			
1273-13C (10 kip)	21	15	Cap pullout	E			
1273-14C	20	20	Pin stretch and pullout	E			
1273-15C	19	20	Pin stretch and pullout	E			
1273-16C	21	21	Cap pullout	M			
1273-17C	20	18	Cap pullout	E			
1273-18C	19	18	Pin stretch and pullout	E			
1273-19C	21	21	Pin stretch and pullout Cap pullout	E			
1273-20C	15	19	Pin stretch and pullout	E			
1273-21C	14	20	Pin stretch and pullout	E			
1273-22C	16	16	Pin pullout	M			
1273-23C	19	16	Pin stretch and pullout	E			
1273-24C	18	19	Pin stretch and pullout	E			
1273-25C (10 kip)	17	17	Cap pullout	Both			
1273-26C (10 kip)	20	20	Cap pullout	Both			

Bush phase individual insulators summary:

Insulators Tested	Electrical Failures (<15 kip)	Mechanical Failures (<15 kip)	Total Failures (<15 kip)
26	3 (12 %)	0 (0 %)	3 (12 %)

The tested insulators did not comply with the acceptance criterion, which requires that $X_i \geq R$ and $X + 3S$ and that the average electrical or mechanical failure exceed the rating of 15 kip. A large percentage (21%) of the individual insulators had an electrical failure load below the rated value. The mechanical failure load in all cases were at or above the rated load, however, the centre and bush phases did not meet the requirement that $X \geq R + 3S$.

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7.7.4 M&E Test Result Summary

The three sets of insulators failed to meet the requirements of CAN/CSA-C411.1Clause 6.6.1: "Electro-mechanical failing load test" based on the rating of 15 kip (.

The Electro-mechanical failing load test results show serious concern for the electrical and mechanical strength of these insulators.

8 DISCUSSION AND CONCLUSIONS

The megger test found one failed insulator on the Structure 1248, L-178 (Road phase). The visual inspection found that the insulator strings had some electrical and environmental damage. The inspections found evidence on all of the insulator sets of electrical activities such as flashovers and electrical discharge. The ESDD evaluation of the insulators found the pollution level on the insulators was very low. Five of the 78 (6%) insulators failed the RIV test. Two of the insulators were found to be punctured on the AC flashover test and one of the insulators was cracked. Each of the three sets of insulators had a punctured or cracked insulator. The corrosion assessment of the insulators found them to be in good shape from a corrosion perspective. All three sets of insulators failed the combined mechanical and electrical test. They did not comply with the acceptance criterion, which requires that $Xi \geq R$ and $X + 3S$ and that the average electrical or mechanical failure exceed the rating of 15 kip. A large percentage (21%) of the individual insulators had an electrical failure load that was below the rated value. The mechanical failure load in all cases was at or above the rated load, however, the center phase and bush phase insulators did not meet the requirement that $X \geq R + 3S$. The failure rate was evenly distributed between the two insulator types.

These insulators were manufactured in 1968. The condition of the glaze has deteriorated over time due electrical activity and the porcelain on some of the insulators has punctured. The porcelain does slowly degrade over time due to the electric field. The rate of this degradation slow but the higher the electric field and the temperature the faster the degradation will be. Insulators can also puncture due to steep front transient voltages that the transmission line is expose to from lightning. Insulators manufactured today are required to pass a steep front impulse test. Insulators manufactured in 1968 did not have to pass this test and based on testing experience it very unlikely these insulators would have passed a steep front when they were manufactured.

Fires on wood structures can be caused be insulator string flashovers or by excessive leakage current into the structure. Flashovers can be due to transient conditions (such as lightning strikes or switching transients) or due to loss of insulation strength. Excessive leakage current flowing into the wood can also occur due to moist/fog weather conditions combined with polluted insulation combined, poor insulator quality or a combination of these conditions. In this case there is no evidence of polluted insulation. The insulators are, however, in poor electrical condition. The pole top fire occurred on bush phase. This phase of the line had one punctured insulator which would have resulted in an increase in leakage current due to the higher electrical stress on the remaining intact insulators. This structure did not have any bonding. There was no reported lightning or switching activity at the time of the failure. It was raining at the time of the failure.

None of the wood structure was available for examination. Based on the condition of the insulators, the lack of pollution on the insulators and information provided that there were no lighting and switching activity at the time of the failure the most probable cause of the pole top fire is excessive leakage current which initiated the fire. In dry weather the wood structure dries out and then under

the wet humid conditions the leakage current increases. The current flows through from the insulators into the wood. If the wood is dry enough and the current is high enough the wood will be ignited and a fire will start. It is not possible to definitively conclude that the fire was due to high leakage current, however, based on the available information about the event the poor electrical condition of the insulators as determined in the test program this is the most likely cause of the failure.

In general to reduce the risk of pole top fires on wood structures excessive current must be prevented from entering the wood structure or the current density where it enters the pole must be decreased. There are a number of methods that can be used to achieve these objectives.

1. Increase the number of insulators in the string to reduce the leakage current.
2. Increase the surface area of the metal at the area that the current enters the pole. This will reduce the current density. This has been found to be effective in some line designs were the washers used were too small.
3. Bond all metal parts on the pole together and connect them to a local ground so the current does not flow into the pole. This is the most reliable solution. However this method will reduce the lightning and switching transient insulation withstand level for the structure as it will no longer have the added insulation of the wood components.
4. In this particular transmission line replacing faulty insulators with new insulators that meet the specification will also reduce the risk of a pole top fire.

It is recommended that all 1968 vintage insulators from these manufacturers be replaced. They are all at high risk of failing either electrically and mechanically. Given that there were three similar failures reported in 2015 there is a high probability of further failures. It is recommended that a replacement program be implemented with the priority being given to structures that have more than one insulator string per phase. The greater the number of insulator strings on the same structure the higher the leakage current would be.

The information we have is that this transmission line has not had a long term history of having problems with pole top fires, this is a recent issue. This is consistent with the problem being due to deterioration of the insulators. Replacing the insulators will restore the structures to their original electrical condition. At present the horizontal suspension strings have nine insulators and the vertical suspension strings have eight insulators. Increasing all strings to nine insulators would provide an increase safety margin.

The insulators evaluated in this project were all removed from on structure. The recommendation to replace all 1968 vintage insulators is based on the assumption that the results are typical of all the insulators of this type on this transmission line. This could be confirmed by removing and evaluating additional insulators from this transmission line. For such a program we would recommend that insulators from 0.5 % (based on recommendation for quality conformance testing of ANSI C29.2B, “Wet Process Porcelain and Toughened Glass-Transmission Suspension Type”) of the structures be evaluated.

Any live line work done on these transmission lines should take into account there is a significant risk that there are punctured insulators and there may be insulators with low mechanical strength in the insulator strings being worked on.

The results relate only to the items tested
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APPENDIX I - TEST EQUIPMENT SPECIFICATIONS

1. Resonant Test Set (used for AC flashover and RIV tests)	Manufacturer:	American High Voltage Test Systems
	Rating:	800 kV_{rms}
2. Voltage Divider (used for AC flashover and RIV tests)	Manufacturer:	Haefely
	Type:	capacitive
	Rating:	800 kV_{rms}, 1000 pF
	Ratio:	8000:1
	Accuracy:	± 1%
3. Tensile Testing Machine (used for M&E tests)	Manufacturer:	Tinius Olsen
	Model:	400 Super L
	Capacity:	400,000 lbs
	Ser. No.:	162665
4. Test Transformer (used for M&E tests)	Manufacturer:	CGE
	Serial No:	742245
	Rating:	138 kV_{rms}, 60 Hz, 8 kVA
5. Voltage Divider (used for M&E tests)	Manufacturer:	Plastic Capacitor/BC Hydro
	Type:	capacitive (150 pF)
	Rating:	100 kV_{rms}, 60 Hz
	Ratio:	1000:1
	Accuracy:	± 1%
4. Megohm Meter (used for megger tests)	Manufacturer:	Norma
	PTL No:	10433

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APPENDIX II - SITE PICTURES



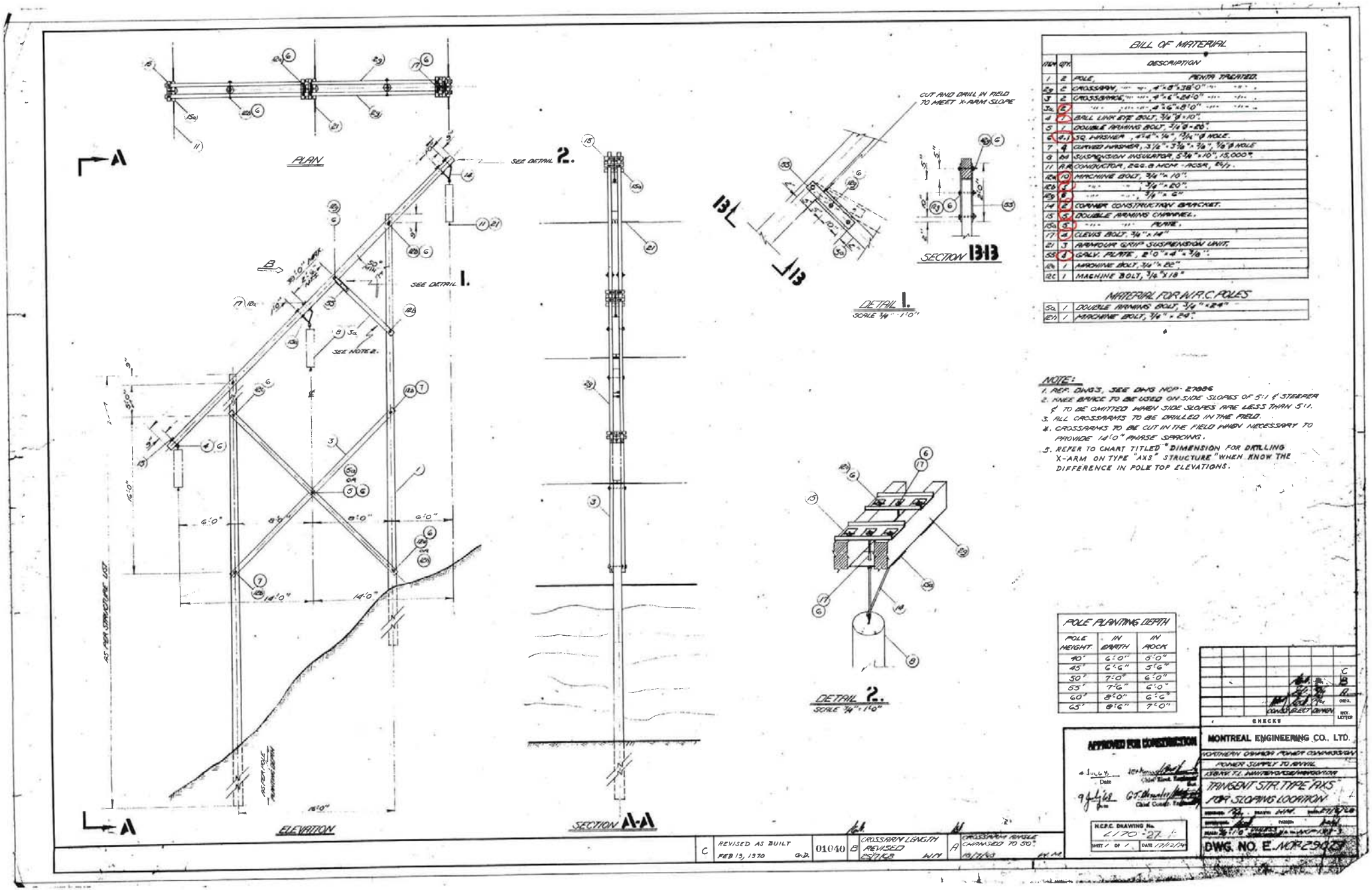
Figure A1



Figure A2



Figure A3



BILL OF MATERIAL

ITEM	QTY.	DESCRIPTION
1	2	POLE, PENTA TREATED.
2a	2	CROSSARM, " " 4"×8"×38'0" " "
3	2	CROSSBRACE, " " 4"×6"×24'0" " "
3a	2	" " " " 4"×6"×8'0" " "
4	1	BALL LINK EYE BOLT, 7/8"ø×10".
5	1	DOUBLE ARMING BOLT, 7/8"ø-20".
6	4	SQ. WASHER, 4"×4"×1/4"×13/16"ø HOLE.
7	4	CURVED WASHER, 3 1/2"×3 3/8"×3/8", 7/8"ø HOLE
8	24	SUSPENSION INSULATOR, 5 3/4"×10", 15,000#
11	A.R.	CONDUCTOR, 266.8 MCM - ACSR, 84/3.
12a	10	MACHINE BOLT, 3/4"×10".
12b	1	" " 3/4"×20".
12c	8	" " 3/4"×2".
14	2	CORNER CONSTRUCTION BRACKET.
15	3	DOUBLE ARMING CHANNEL.
15a	3	" " PLATE.
17	14	CLEVIS BOLT, 3/4"×14"
21	3	ARMOUR GRIP SUSPENSION UNIT.
33	1	GALV. PLATE, 2'0"×4"×3/8".
42b	1	MACHINE BOLT, 3/4"×22"
12c	1	MACHINE BOLT, 3/4"×18"

MATERIAL FOR N.R.C. POLES

2a	1	DOUBLE ARMING BOLT, 3/4"×24"
42b	1	MACHINE BOLT, 3/4"×24".

NOTE:
1. REF. DWG 3, SEE DWG NOR-27886
2. KNEE BRACE TO BE USED ON SIDE SLOPES OF 5:1 & STEEPER & TO BE OMITTED WHEN SIDE SLOPES ARE LESS THAN 5:1.
3. ALL CROSSARMS TO BE DRILLED IN THE FIELD.
4. CROSSARMS TO BE CUT IN THE FIELD WHEN NECESSARY TO PROVIDE 14'0" PHASE SPACING.
5. REFER TO CHART TITLED "DIMENSION FOR DRILLING X-ARM ON TYPE "AXS" STRUCTURE" WHEN KNOW THE DIFFERENCE IN POLE TOP ELEVATIONS.

POLE PLANTING DEPTH

POLE HEIGHT	IN EARTH	IN ROCK
40'	6'0"	5'0"
45'	6'6"	5'6"
50'	7'0"	6'0"
55'	7'6"	6'0"
60'	8'0"	6'6"
65'	8'6"	7'0"

REV. LETTER	CONST. SHEET OMISSION	CHECKS
C		
B		
A	ORIG.	

APPROVED FOR CONSTRUCTION
4 July 68 Date — Chief Electrical Engineer
9 July 68 Date — G.T. Chamberlain, Chief Consulting Engineer

MONTREAL ENGINEERING CO., LTD.
NORTHERN ONTARIO POWER COMMISSION
POWER SUPPLY TO ARVIDA
ESTATE TI, MAINTENANCE AND OPERATION
TRANSIT STR. TYPE AXS FOR SLOPING LOCATION
SCALE 3/4"=1'0" DRAWN HNP PASSED
DWG. NO. E-NOR-29078

N.C.P.C. DRAWING No. L/70-27
SHEET 1 OF 1 DATE 11/12/68

C	REVISED AS BUILT FEB 13, 1970 G.D.	01040	B	CROSSARM LENGTH REVISED OFFICE WIY	A	CROSSARM ANGLE CHANGED TO 30° 10/7/68	

TOPIC: **Capital Projects**

REFERENCE: YEC Application, Section 5.2.1.12

PREAMBLE: In Section 5.2.1.12, YEC discusses the LNG Third Engine project.

QUESTION:

a) YEC indicates that the project is driven by the 2016 Resource Plan. Please fully explain all alternatives examined to defer the project to 2019, or avoid the project entirely.

ANSWER:

(a)

The 2016 Resource Plan identified a dependable capacity shortfall for the Yukon Integrated System under the single contingency (N-1) capacity reliability criterion that approximates 6 MW in 2017, increasing to about 13 MW by 2020 and 23 to 24 MW by 2021.[1] Yukon Energy is required to provide sufficient dependable winter capacity to meet the single contingency capacity reliability criterion. There is no acceptable "do nothing" option given the need to maintain reliable service, and permanent solutions are needed to address an ongoing and growing dependable capacity shortfall. There is no basis to defer introduction of a cost effective resource to address the dependable capacity shortfall.

The LNG Third Engine project as outlined at Section 5.2.1.12 of YEC's Application is the first new resource identified for in-service in early 2019 to address a portion (4.4 MW) of the dependable capacity gap. Regulatory reviews have already been concluded for this project. Section 5.2.1.12 notes additional option review conducted in late 2016. In summary, this project is a cost effective addition to dependable capacity, and is also able to be in-service sooner than other options identified.

Please refer to Portfolio Analysis (Chapter 8) and Action Plan (Chapter 9) of the 2016 Resource Plan for details on the methodology and alternatives examined that led to the

[1] The 2017/18 GRA Application Tab 2 includes a forecast dependable capacity shortfall on this same basis at 5.6 MW in 2017 and 6.9 MW in 2018. The 2021 shortfall assumes retirement of two Mirrlees units (8.5 MW) located in Whitehorse and Faro in the summer of 2021.

recommendation of the LNG Third Engine as a part of the Short Term Action Plan (Section 9.2) of the Action Plan chapter (Chapter 9) of the 2016 Resource Plan.

TOPIC: **Capital Projects**

REFERENCE: YEC Application Section 5.3

PREAMBLE: On page 5-31, YEC discusses a number of projects that are under way, with costs in WIP, including Sustaining Capital ($2.899 million), Capacity Planning Requirements ($13.067 million) and potential future Generation and Transmission requirements ($9.845 million), which in total amount to $25.811 million.

QUESTION:

a) Please fully explain what approvals, if any, YEC is seeking in this GRA, regarding deferred costs.

b) Regarding the Capacity Planning Requirements projects, YEC indicates that the projects are driven by the 2016 Resource Plan. Please fully explain all alternatives examined to defer each project to 2019, or avoid each project entirely

c) Please provide the status of each Capacity Planning Requirement Project.

d) Regarding the Thermal Plant (Section 5.3.1.4), please fully discuss and explain all renewable energy options considered in the evaluation of this project.

ANSWER:

(a)

YEC is seeking approval to transfer to rate base deferred costs of about $14.130 million in 2017 as illustrated in Table 5.7 and about $3.122 million in 2018[1] as illustrated in Table 5.8.

In Order 2013-01, [paragraph 398] following the review of YEC's 2012/13 GRA, the Yukon Utilities Board directed YEC that for project expenditures incurred in the 2012 and 2013

[1] 2018 excluding forecast 2017/18 GRA cost at $0.817 million which will be part of the hearing reserve account.

test years and beyond, that expenditures be held in WIP until such time the costs are brought before the Board. The amount for 2017 at $14.130 million includes $13.017 million deferred costs held in WIP by end 2016 and $1.113 million additional expenditures forecast to occur in 2017 for new and existing projects held in WIP.

The 2018 proposed transfer to rate base includes new projects started in the 2017 and 2018 test years [except for two projects: Mt Sumanik Wind Feasibility Study and Moon Lake Hydro Project started in 2014 and 2015 years respectively].

The transfer to rate base also includes large projects which are discussed in Section 5.3 of YEC's Application.

By end of 2017 test year, the deferred costs remaining in WIP are forecast to be $15.349 million [excluding 2017/18 GRA cost] and by end of 2018 $29.858 million. Major projects that remain in WIP are as follows:

- Stewart Keno Transmission Project that has incurred approximately $2.807 million of rate base costs which are fully offset by contributions;
- Marsh Lake Storage with about $8.156 million incurred cost by end of 2018,;
- Battery project with about $8.856 million incurred cost by end of 2018;
- Thermal plant project with about $4.211 million incurred cost by end of 2018;
- Mayo Lake Hydro Enhancement Project with about $3.356 million incurred cost by end of 2018;
- Aishihik Relicensing project with about $2.899 million incurred cost by end of 2018.

(b)

The 2016 Resource Plan identified a dependable capacity shortfall for the Yukon Integrated System under its single contingency (N-1) capacity reliability criterion that approximates 6 MW in 2017, increasing to about 13 MW by 2020 and 23 to 24 MW by 2021.[2] Yukon Energy is required to provide sufficient dependable winter capacity to meet the single contingency capacity reliability criterion. There is no acceptable "do nothing" option given the need to maintain reliable service, and permanent solutions are needed to

[2] The 2017/18 GRA Application Tab 2 includes a forecast dependable capacity shortfall on this same basis at 5.6 MW in 2017 and 6.9 MW in 2018. The 2021 shortfall assumes retirement of two Mirrlees units (8.5 MW) located in Whitehorse and Faro in the summer of 2021.

address an ongoing and growing dependable capacity shortfall. Temporary options such as mobile thermal plants are not considered due to the lead time that is deemed too long to provide reliable power in winter months. Consequently, there is no basis to defer introduction of a cost effective resource to address the dependable capacity shortfall.

The LNG Third Engine project as outlined at Section 5.2.1.12 of YEC's Application is the first new resource identified for in-service in early 2019 to address a portion (4.4 MW) of the dependable capacity gap. The two Capacity Planning Requirement projects identified in Section 5.3 (i.e., Battery Project and the Thermal Plant Project) are the other projects identified in the Application specifically to address the dependable capacity gap.

As reviewed in Sections 5.3.1.3 and 5.3.1.4 of YEC's GRA Application, earliest completion of these two Capacity Planning Requirement projects is the end of 2019 (Battery Project) and the end of 2020 (Thermal Plant Project). Each project's costs are forecast to be incurred in WIP by the end of 2018, and not yet included in rate base in this GRA. Sections 5.3.1.3 and 5.3.1.4 review ongoing work requirements for each project before construction can commence, including steps to define options (alternatives relating to each project are noted in the Application), Stagegate 3 project reviews in late 2017/ early 2018, and project proposal submissions to YESAB. There is no apparent basis to defer the project, or avoid it all together.

Please also refer to Portfolio Analysis (Chapter 8) and Action Plan (Chapter 9) of the 2016 Resource Plan for details on the methodology and alternatives examined that led to the recommendations presented in the Short Term Action Plan (Section 9.2) and Long Term Action Plan (Section 9.3) of the Action Plan chapter (Chapter 9) of the 2016 Resource Plan.

Please see also response to CW-YEC-1-8(a) and CW-YEC-1-41(a).

(c)

Please see Table 1 provided below (includes reference to recently completed projects and major capital projects reviewed in Section 5.2.1 of YEC's Application, as well as major deferred cost projects reviewed in Section 5.3.1 of YEC's Application).

Table 1: Capacity Planning Requirement Projects

Project	Status
Whistle Bend Supply / Takhini Upgrade	Complete
LNG Plant	Complete
LNG Third Engine	Completion of RFQ for supply, installation, and commissioning of engine; Class 3 cost estimate for entire project
Battery	Initial planning
Thermal	Initial planning

(d)

The 2016 Resource Plan reviewed a wide range of renewable energy options, including various small hydro and pumped storage hydro options, various scales and sites for wind options, solar PV options, and biomass options. Based on the range of load forecast scenarios considered, fossil fuel thermal expansion options (with the potential inclusion of the Battery Project) were found to be the least costly options able to address the existing and growing dependable capacity planning shortfall as soon as practical. In the event that sufficient additional mine loads are connected to the grid, the 2016 Resource Plan also identified a small hydro option that could potentially provide 8 MW of dependable capacity by 2023 and defer the need for further thermal generation capacity development (i.e., another 10 MW of thermal plant capacity development, beyond the Thermal Plant Project identified in YEC's Application).

Please see the Portfolio Analysis (Chapter 8) and Action Plan (Chapter 9) of the 2016 Resource Plan for details on the methodology and alternatives examined that led to the recommendations presented in the Short Term Action Plan (Section 9.2) and Long Term Action Plan (Section 9.3) of the Action Plan chapter (Chapter 9) of the 2016 Resource Plan.