Q. Please provide the specific reasons for Hydro's decision to reduce the ratings of the Holyrood units, including all associated studies and reports. In the response provide the "analysis and recommendations from Hydro's Asset Management team" relating to Holyrood de-rates, as noted on page 18, line 19 of the Energy Supply Risk Assessment Report, the analysis referred to in the response to PUB-NLH-009, lines 7 to 9 in the Replacement of the Lower Reheater Boiler Tubes Application and any reports or analysis from the AMEC NSS completed in 2016 as also referred to in the response to PUB-NLH-009. Also include any of the external reports or analysis including the results of any tests of failed boiler tubes in the last five years.

A. The electricity generation capability of Holyrood Thermal Generating Station is required until the integration of Muskrat Falls. For that period of time, Hydro's objective for the operation of Holyrood is to safely and reliably generate electricity for customers at the least cost.

To meet that objective, Hydro works to maintain competent personnel to operate the station; executes preventive maintenance procedures as required; completes appropriate condition and risk assessments; implements corrective actions; and invests in justified capital upgrades.

Modifying operating procedures to reduce ratings of the individual Holyrood generating units may be an outcome of asset condition and risk assessments but it will not be established until Hydro has completed thorough analysis involving external experts as required. At this time and as noted in the responses to PUB-NLH-001 and PUB-NLH-009 (the references in this response to PUB-NLH-001 and PUB-NLH-009 are from the Replacement of the Lower Reheater Boiler Tubes on

Units 1 & 2 at HTGS application), Hydro continues the work to finalize the ratings applicable to Unit 1, Unit 2 and Unit 3 once the lower reheater tubing projects are completed and the AMEC report is finalized.

When Hydro started work on the energy supply analysis, preliminary discussion amongst Asset Management personnel raised the possibility of derates after the completion of the lower reheater tubing projects, and further assessment and analysis was required. As a derate was possible, lower Holyrood generation capabilities were incorporated in the analysis to ensure a conservative approach to the analysis. To allow the energy supply risk analysis to proceed, an initial qualitative assessment by plant personnel was provided.

	U1	U2	U3
Normal Operation (MVA)	150	150	140
Short term emergency operation (MVA)	160	160	150

Later, Hydro personnel provided ratings (draft ratings) based on quantitative analysis of the measured thickness of various boiler tubing types using worst case thickness and location (for pressure and temperature). On April 8, this was forwarded to AMEC NSS for review and input. The draft ratings were:

	U1	U2	U3
Normal Operation (MVA)	140	140	130
Short term emergency operation (MVA)	150	150	140

The development of the draft ratings is discussed later in this response.

In order to continue developing the Energy Supply Risk Assessment (ESRA), the work continued with the more moderate preliminary ratings. When the ratings analysis and review were completed, the finalized ratings would be incorporated in the ESRA Report. The initial AMEC NSS review was scheduled to be completed April 21 but was rescheduled to July 31 as technical interactions with AMEC NSS took longer than expected and it was required to have Babcock and Wilcox (B&W), the boiler Original Equipment Manufacturer (OEM), complete computer modelling to provide additional information for completion of the analysis. Due to this delay, the ESRA Report was filed on May 27, 2016 with preliminary ratings for normal operation of Units 1 through 3, respectively, as 150, 150, 140 and for emergency operation as 160, 160, 150.

Once the Asset Management and AMEC NSS analysis and review is completed, Hydro will update the ESRA Report and update the Board through the Phase Two Inquiry.

The ratings provided in the response to PUB-NLH-001 are the quantitative draft ratings referenced above and use worst case thickness, pressure and temperature parameters. As noted earlier, as well as in Hydro's responses to PUB-NLH-001 and PUB-NLH-009, these ratings were considered initial and subject to further review and analysis. The following information is provided to outline the development of those ratings.

At Holyrood, a tube inspection program monitors the thickness of boiler tubing, relative to the original thickness. This information was used in the internal analysis to determine the draft unit ratings. As well as tubing thickness, there are additional factors, the extent of which are unknown, that can impact the ability of a boiler tube to withstand the operating conditions. These factors include: anomalies in the tube material, tubes not measured that may be further degraded than the known conditions, and boiler transient conditions where temperatures and pressures may be temporarily elevated or cause additional stress on tubes through rapid changes. Derating the units' electrical load capability thereby lowers steam pressure in boiler tubing. Lower steam pressure would mitigate the risk of a tube failure as it reduces the stress in boiler tubing.

The internal analysis involved reviewing the boiler tube thickness measurement data since 2010 and determining a worst case measured tube thickness for each boiler section i.e. waterwalls, reheater, superheater and economizer. Using a formula from the ASME Boiler and Pressure Vessel Code and the reduced thickness for each section, an internal tube pressure was determined that approximately maintained the original design margin allowances that were provided when the boiler tubing was new. For each section calculation, the consequential load reduction was estimated to accommodate all of the determined steam pressures. The load reduction estimates were obtained from operational data and personnel experience. These estimates were considered to be the emergency limits, with a 10 MW reduction to arrive at a conservative normal operating limit.

The Load Calculator document attached as Attachment 1 shows the analysis that has been completed for the three units. The rationale document attached as Attachment 2 explains the analysis and includes an example calculation to explain how the Load Calculator spreadsheet works. This analysis was completed internally to arrive at the draft de-rate values for further internal discussion and planning.

In doing these calculations it was recognized that the original calculated thickness data were not available for Unit 3. Often, tubing actually used in the manufacturing of a boiler is thicker than calculated in the design. To determine an initial derate for Unit 3, it was assumed that the original thickness was the same as the calculated thickness. Once Unit 3 calculated thickness information could be obtained, Unit 3 calculations would be redone. B&W was hired to provide the calculated thickness information and their results were received on July 7, 2016. Some confirming thickness measurements will be taken during the planned annual outage of Unit 3.

AMEC NSS have been provided with the draft ratings and the B&W calculations and are now working to complete the analysis by July 31, 2016. However, if AMEC requires thickness measurements to be confirmed on either of Unit 1 or Unit 2 to complete their work, this could move the availability of final results to September. Confirming measurements can be obtained only during Unit 1 and Unit 2 outages which are scheduled for this summer and early autumn. As such, AMEC NSS has not yet completed its 2016 work[1]. It is expected that AMEC may make recommendations for some remedial work to improve the reliability and alleviate potential derating based on its review. Hydro would need to review this possibility in terms of timing, material availability and cost to determine if it can be down in 2016 or at a later date. Once Hydro has reviewed and accepted AMEC's work, the report and any associated analysis will be provided to the Board.

In addition to the reheater tube failures in January and February of 2016, there has been one tube failure in the past five years. This occurred in the primary (low temperature) superheater of Unit 2 in 2014.

[1] A draft report was received during final review of this RFI response; however, the details were not available for this response.

Unit 1													
Area of Boiler	Year	Lowest Recorded UT Measurement (inches)	Ordered (Original) Thickness (inches)	ASME Minimum Thickness (inches)	Lowest UT Measurement Below ASME MWT?	If Lowest UT Measurement Below ASME, Average UT Reading from Year	Percent Remaining from Original	Design Pressure (psig)	Recommended New Pressure Based on ASME (psi)	Recommended New Pressure Based on ASME (kPa)	Plant Maximum Operating Pressure (psi)	Recommended Pressure Less Than Operating Pressure?	Reduce Pressure?
Water Wall Tubes at Buners	2014	0.204	0.200	0.191	No		102%	2205			1875		
Economizer, 8th Floor, Below Feet	2015	0.202	0.200	0.190	No		101%	2255			2084		
Boiler Floor Tubes	2015	0.174	0.200	0.191	Yes	0.198	87%	2205	2043	14086	1875	No	No
Primary Superheater, 10th Floor, Below Feet	2013	0.206	0.180	0.174	No		114%	2205			1875		
Primary Superheater, 9th Floor, Overhead	2015	0.190	0.180	0.176	No		106%	2205			1875		
Primary Superheater, 9th Floor, Below Feet	2012	0.183	0.165	0.161	No		111%	2205			1875		
Primary Superheater, 8th Floor (Bend)	2015	0.153	0.165	0.161	Yes	0.161	93%	2205	2080	14342	1875	No	No
Primary Superheater, 8th Floor (Tube)	2015	0.173	0.165	0.161	No		105%	2205			1875		
Secondary Superheater, 7th Floor, Overhead	2013	0.192	0.165	0.165	No		116%	2205			1875		
Secondary Superheater, 7th Floor, Below Feet	**2013**	**0.215**	**0.260**	**0.258**	**Yes**	**0.257**	**83%**	**2205**	**1789**	**12335**	**1875**	**Yes**	**162 mws**
Secondary Superheater, 8th Floor, Below Feet	2015	0.197	0.240	0.209	Yes	0.218	82%	2205	2059	14197	1875	No	No
Secondary Superheater, 6th Floor (Overhead from Scaffold)	2010	0.193	0.238	0.203	Yes	0.239	81%	2205	2074	14300	1875	No	No
Reheater, 8th Floor, Overhead	**2016**	**0.061**	**0.148**	**0.106**	**Yes**		**41%**	**617**	**319**	**2200**	**545**	**No***	**No***
Reheater, 9th Floor, Below Feet (North Bend)	2010	0.140	0.148	0.127	No		95%	617			545		
Reheater, 9th Floor, Below Feet (South Bend)	2010	0.182	0.148	0.127	No		123%	617			545		
Reheater, 9th Floor, Below Feet (South Section of Tube)	2013	0.214	0.203	0.192	No		105%	617			545		
Reheater, 9th Floor, Below Feet (North Section of Tube)	2013	0.154	0.148	0.127	No		104%	617			545		
Reheater, 9th Floor, Overhead	2014	0.165	0.148	0.135	No		111%	617			545		
Reheater, 10th Floor, Below Feet	2013	0.137	0.134	0.072	No		102%	617			545		
Water Wall Knee Region	2014	0.211	0.200	0.191	No		106%	2205			1875		
Economizer, 5th Floor, Overhead (Bend)	**2010**	**0.143**	**0.200**	**0.190**	**Yes**	**0.157**	**72%**	**2255**	**1629**	**11232**	**2084**	**Yes**	**138 mws**
Economizer, 5th Floor, Overhead (Tube)	2010	0.183	0.200	0.190	Yes	0.210	92%	2255	2166	14935	2084	No	No

* - Pending replacement of reheater tubing in 2016

Area of Boiler	Year	Lowest Recorded UT Measurement (inches)	Ordered (Original) Thickness (inches)	ASME Minimum Thickness (inches)	Lowest UT Measurement Below ASME MWT?	If Lowest UT Measurement Below ASME, Average UT Reading from Year	Percent Remaining from Original	Design Pressure (psig)	Recommended New Pressure Based on ASME (psi)	Recommended New Pressure Based on ASME (kPa)	Plant Maximum Operating Pressure (psi)	Recommended Pressure Less Than Operating Pressure?	Reduce Pressure?
Unit 2													
Water Wall Tubes at Buners	2012	0.171	0.200	0.191	Yes	0.220	86%	2205	1946	13418	1875	No	No
Economizer, 8th Floor, Below Feet	2010	0.209	0.200	0.190	No		105%	2255			2084		
Boiler Floor Tubes	2015	0.177	0.200	0.191	Yes	0.177	89%	2205	2025	13962	1875	No	No
Primary Superheater, 10th Floor, Below Feet (Bend)	2015	0.163	0.180	0.174	Yes	0.220	91%	2205	2052	14149	1875	No	No
Primary Superheater, 10th Floor, Below Feet (Tube)	2015	0.188	0.180	0.174	No		104%	2205			1875		
Primary Superheater, 9th Floor, Overhead	2014	0.191	0.180	0.176	No		106%	2205			1875		
Primary Superheater, 9th Floor, Below Feet	2011	0.182	0.165	0.161	No		110%	2205			1875		
Primary Superheater, 8th Floor (Bend)	**2011**	**0.125**	**0.165**	**0.161**	**Yes**	**0.138**	**76%**	**2205**	**1757**	**12115**	**1875**	**Yes**	**160 mws**
Primary Superheater, 8th Floor (Tube)	2014	0.179	0.165	0.161	No		108%	2205			1875		
Secondary Superheater, 7th Floor, Overhead	2010	0.192	0.165	0.165	No		116%	2205			1875		
Secondary Superheater, 7th Floor, Below Feet	**2015**	**0.220**	**0.260**	**0.258**	**Yes**	**0.266**	**85%**	**2205**	**1815**	**12514**	**1875**	**Yes**	**145 mws**
Secondary Superheater, 8th Floor, Below Feet	2014	0.192	0.240	0.209	Yes	0.220	80%	2205	2047	14114	1875	No	No
Secondary Superheater, 6th Floor (Overhead from Scaffold)	2012	0.213	0.238	0.203	No		89%	2205			1875		
Reheater, 8th Floor, Overhead	**2016**	**0.050**	**0.148**	**0.106**	**Yes**		**34%**	**617**	**248**	**1710**	**545**	**No***	**No***
Reheater, 9th Floor, Below Feet (North Bend)	2010	0.206	0.203	0.192	No		101%	617			545		
Reheater, 9th Floor, Below Feet (South Bend)	2010	0.202	0.203	0.192	No		100%	617			545		
Reheater, 9th Floor, Below Feet (South Section of Tube)	2015	0.225	0.203	0.192	No		111%	617			545		
Reheater, 9th Floor, Below Feet (North Section of Tube)	2014	0.170	0.148	0.127	No		115%	617			545		
Reheater, 9th Floor, Overhead	2012	0.169	0.148	0.135	No		114%	617			545		
Reheater, 10th Floor, Below Feet	2012	0.133	0.134	0.072	No		99%	2205			545		
Water Wall Knee Region	2014	0.216	0.200	0.191	No		108%	2255			545		
Water Wall Upper Rear Tubes	**2014**	**0.150**	**0.200**	**0.191**	**Yes**	**0.159**	**75%**	**2205**	**1673**	**11535**	**1875**	**Yes**	**140 mws**
Economizer, 5th Floor, Overhead (Bend)	**2011**	**0.155**	**0.200**	**0.190**	**Yes**	**0.168**	**78%**	**2255**	**1788**	**12328**	**2084**	**Yes**	**150 mws**
Economizer, 5th Floor, Overhead (Tube)	2011	0.188	0.200	0.190	Yes	0.211	94%	2255	2234	15403	2084	No	No

* - Pending replacement of reheater tubing in 2016

Area of Boiler	Year	Lowest Recorded UT Measurement (inches)	Ordered (Original) Thickness (inches)	ASME Minimum Thickness (inches)	Lowest UT Measurement Below ASME MWT?	If Lowest UT Measurement Below ASME, Average UT Reading from Year	Percent Remaining from Original	Design Pressure (psig)	Recommended New Pressure Based on ASME (psi)	Recommended New Pressure Based on ASME (kPa)	Plant Maximum Operating Pressure (psi)	Recommended Pressure Less Than Operating Pressure?	Reduce Pressure?
Unit 3													
Boiler Roof Tubes (Boiler Side)	2015	0.188	0.240				78%	2200	**1659**	**11439**	**2050**	**Yes**	**130**
Water Wall Knee Region	2011	0.213	0.210				101%	2200			2050		
Boiler Floor Tubes	2015	0.110	0.210				52%	2200	**892**	**6150**	**2050**	**Yes**	**No***
Water Wall at Buners (Elevation 1)	2015	0.169	0.210				80%	2200	**1468**	**10122**	**2050**	**Yes**	**90 mws**
Water Wall at Buners (Elevation 2)	2015	0.199	0.210				95%	2200	**1772**	**12218**	**2050**	**Yes**	**130 mws**
Water Wall at Buners (Elevation 3)	2015	0.191	0.210				91%	2200	**1690**	**11653**	**2050**	**Yes**	**100 mws**
Economizer Tubes, 6th Floor, Lower Tube Wall (South Bend)	2013	0.153	0.203				75%	2200	**1588**	**10949**	**2070**	**Yes**	**90 mws**
Economizer Tubes, 6th Floor, Lower Tube Wall (North Bend)	2011	0.155	0.203				76%	2200	**1612**	**11115**	**2070**	**Yes**	**90 mws**
Economizer Tubes, 6th Floor, Lower Tube Wall (Tube)	2011	0.189	0.203				93%	2200	**2026**	**13969**	**2070**	**Yes**	**150 mws**
Economizer Tubes, 8th Floor, Lower (Under Sootblower)	2015	0.178	0.203				88%	2200	**1891**	**13038**	**2070**	**Yes**	**140mws**
Economizer Tubes, 8th Floor, Lower (North Bend)	2015	0.218	0.203				107%	2200			2070		
Economizer Tubes, 8th Floor, Lower (North Bend)	2015	0.186	0.203				92%	2200	**1989**	**13714**	**2070**	**Yes**	**145 mws**
Economizer Tubes, 8th Floor, Upper (South Bend)	2011	0.171	0.203				84%	2200	**1805**	**12445**	**2070**	**Yes**	**135 mws**
Economizer Tubes, 8th Floor, Upper (Tube)	2011	0.178	0.203				88%	2200	**1805**	**12445**	**2070**	**Yes**	**135 mws**
Economizer Tubes, 8th Floor, Upper (North Bend)	2012	0.178	0.203				88%	2200	**1891**	**13038**	**2070**	**Yes**	**140 mws**
Low Temperature Superheater, 8th Floor, Overhead (Bend)	2010	0.180	0.203				89%	2150	**1872**	**12907**	**1910**	**Yes**	**145 mws**
Low Temperature Superheater, 8th Floor, Overhead (Tube)	2015	0.194	0.203				96%	2150	2041	14073	1910	No	No
Low Temperature Superheater, 9th Floor, Below Feet (Bend)	2011	0.179	0.203				88%	2150	**1860**	**12825**	**1910**	**Yes**	**145 mws**
Low Temperature Superheater, 9th Floor, Below Feet (Tube)	2011	0.216	0.203				106%	2150			1910		
Low Temperature Superheater, 9th Floor, Overhead (Bend)	2010	0.170	0.203				84%	2150	**1753**	**12087**	**1910**	**Yes**	**138 mws**
Low Temperature Superheater, 9th Floor, Overhead (Tube)	2013	0.210	0.203				103%	2150			1910		
Low Temperature Superheater, 10th Floor, Below Feet (Boiler Side) (Bend)	2013	0.374	0.394				95%	2150	2018	13914	1910	No	No
Low Temperature Superheater, 10th Floor, Below Feet (Boiler Side) (Tube)	2013	0.430	0.394				109%	2150			1910		
Low Temperature Superheater, 10th Floor, Below Feet (Economizer Side) (Bend)	2010	0.310	0.338				92%	2150	1940	13376	1910	No	No

Area of Boiler	Year	Lowest Recorded UT Measurement (inches)	Ordered (Original) Thickness (inches)	ASME Minimum Thickness (inches)	Lowest UT Measurement Below ASME MWT?	If Lowest UT Measurement Below ASME, Average UT Reading from Year	Percent Remaining from Original	Design Pressure (psig)	Recommended New Pressure Based on ASME (psi)	Recommended New Pressure Based on ASME (kPa)	Plant Maximum Operating Pressure (psi)	Recommended Pressure Less Than Operating Pressure?	Reduce Pressure?
Low Temperature Superheater, 10th Floor, Below Feet (Economizer Side) (Tube)	2013	0.347	0.338				103%	2150			1910		
High Temperature Superheater, 8th Floor, Overhead (Bend)	2015	0.216	0.327				66%	2150	**1311**	**9039**	**1910**	**Yes**	**90 mws**
High Temperature Superheater, 8th Floor, Overhead (Tube)	2015	0.228	0.327				70%	2150	**1396**	**9625**	**1910**	**Yes**	**100 mws**
High Temperature Superheater, 8th Floor, Below Feet	2015	0.221	0.285				78%	2150	**1596**	**11004**	**1910**	**Yes**	**115 mws**
High Temperature Superheater, 8.5 Floor, Overhead (Bend)	2015	0.275	0.327				84%	2150	**1743**	**12018**	**1910**	**Yes**	**138 mws**
High Temperature Superheater, 8.5 Floor, Overhead (Tube)	2015	0.283	0.327				87%	2150	**1804**	**12439**	**1910**	**Yes**	**142 mws**
High Temperature Superheater, 8.5 Floor, Below Feet (Bend)	2015	0.279	0.285				98%	2150	2097	14459	1910	No	No
High Temperature Superheater, 8.5 Floor, Below Feet (Tube)	2015	0.275	0.285				96%	2150	2061	14211	1910	No	No
Reheater Tubes, 7th Floor, Top of Scaffold (Bend)	2013	0.113	0.148	0.131	Yes		76%	650	546	3765	542	No	No
Reheater Tubes, 7th Floor, Top of Scaffold (Tube)	2013	0.129	0.148	0.131	Yes		87%	650	637	4392	542	No	No
Reheater Tubes, 9th Floor, Overhead (Bend)	2011	0.126	0.180	0.159	Yes		70%	650	561	3868	542	No	No
Reheater Tubes, 9th Floor, Overhead (Tube)	2011	0.161	0.180	0.159	No		89%	650			542		
Reheater Tubes, 9th Floor, Below Feet	2015	0.169	0.180	0.0694	No		94%	650			542		

* - Pending replacement of boiler floor tubing in 2016

Holyrood Risk Assessment and Planning Analysis

Summary

In consideration of the risk assessment in relation to generation supply until the expected North American grid interconnection, recommended operating loads for Holyrood have been identified as shown in the Table below.

	U1	U2	U3
Normal Maximum Operating Load	140	140	130
Emergency Maximum Operating Load	150	150	140

The following has been assumed:

1. Current capital program will proceed as planned ;
2. The lower reheater sections will be replaced in 2016 in Unit 1 and 2 boilers;
3. The planned floor tube replacements will be completed in Unit 3 boiler this year;
4. Annual boiler maintenance and inspection will proceed as currently planned;
5. Level 2 Condition Assessment work will proceed through 2017, 2018 and 2019;
6. Tube sampling and assessments of tube deposits will continue to show that we do not need to perform boiler chemical cleaning. Consultants are recommending that this not be done unless the sampling shows a clear need to complete this work because of the inherent risk of causing boiler damage during a chemical clean.

Based on recent operating experience and qualitative assessments, the boilers are considered the biggest risk to reliable power generation. Calculations have been completed to determine recommended unit loading based on the boiler condition as discussed below. These calculations involved determining the required pressure reduction of each tube section to maintain the original ASME (American Society of Mechanical Engineers) design margin based on the as measured tube thickness. Hydro has reviewed the pressure reductions and calculated load reduction that would be required to achieve the pressures. This is the same approach that was taken earlier in 2016 to determine the maximum load for the boiler reheaters based on the actual measured tube thickness. Also, as was done for the reheater this year, an additional margin of a 10 MW reduction was applied to arrive at a normal maximum operating load. Based on this analysis, the recommended normal maximum operating load for Units 1 and 2 is 140 MW and for Unit 3 is 130 MW. The recommended emergency maximum operating load for Unit 1 and 2 would be 150 MW and for Unit 3 would be 140 MW. The rationale is detailed in the sections below. An example calculation is provided at the end of this document to illustrate the process followed.

Holyrood Risk Assessment and Planning Analysis

In general, by reducing the temperature, pressure and flow in the boilers and piping, through limiting load, the susceptibility to damage and deterioration is reduced and reliability is increased.

Along with the load reductions, it is recommended that load cycling and the number of stops and starts be limited where possible.

Stage 1 Rationale (Unit 1 and Unit 2)

The ASME Code is followed when designing a boiler. This Code provides rules for calculating the required thickness of a tube based on variables such as the tube material, operating temperature and operating pressure. The Code calculated thickness values include a design margin so that the resulting thickness calculated is significantly more than the thickness at which the tube would be expected to fail under the design conditions. When tubes thin below the calculated thickness during operation, this margin is reduced and the likelihood of failure increases.

For stage 1 the original calculated tube thickness values are available from the Original Equipment Manufacturer (OEM). With this information it was possible to determine the required pressure reduction of each tube section to maintain the original ASME design margin based on the as measured tube thickness. Hydro reviewed the pressure reductions and determined a load reduction that would be required to achieve the calculated pressures.

The attached spreadsheet contains the calculations. For each tube section, measured thickness data from 2010 to present was reviewed and the lowest measurements were used in the calculation. Tube sections requiring a pressure reduction are shaded brown.

For Unit 1, the load is limited to an average of 150 MW based on the 5th floor economizer readings taken in 2010, and the 7th floor secondary superheater thickness measurement taken in 2013. A further reduction of 10 MW is applied to arrive at the normal maximum operating load of 140 MW.

For Unit 2, the load is limited to an average of 150 MW based on the thickness of the upper rear waterwall tubes as measured in 2014, by the 5th floor economizer tubes (2011), by the 7th floor superheater tubes (2015), and by the 8th floor primary superheater (2011). A further reduction of 10 MW is applied to arrive at the normal maximum operating load of 140 MW.

140 MW is a reliable and efficient operating load for other reasons. For example, at this load the unit can be operated with one (of two) condensate polisher and one (of two) extraction pump.

Operating procedures will be updated to ensure the pressures are kept to a minimum in the boiler under the load restrictions. Also, the possibility of having to change safety valve settings would have to be considered.

Stage 2 Rationale (Unit 3)

For stage 2 the original calculated tube thickness values are not available from the OEM. This information can be obtained but the boiler manufacturer would have to run computer models at a cost of approximately $30,000 and the work would take about one month to complete.

In the absence of this information, the attached spreadsheet was completed using a very conservative assumption that the original calculated thickness is the same as the ordered tube thickness. These values were then used to determine the operating pressure for the thinned tubes that would maintain the same design margin as the original tube material thickness. In the same manner as for stage 1, Operations determined the load reduction required to achieve the new pressure limit.

As can be seen in the final column of the spreadsheet, the analysis shows that for the majority of tube sections, the margins would be maintained at 140 MW. Additional measurements and focused repairs or replacements of waterwall tubes in the burner regions will be planned. In sections of the 6th floor economizer bends and the 8th floor superheater tubes, further work, beyond a load reduction to 140 MW is required to restore the original design margins. To assist in this, the calculated design thickness should be obtained from the OEM. Detailed thickness measurements will be made during the 2016 maintenance outage to verify the condition. This will allow for detailed planning of strategies to ensure full design margin for these tube sections.

Holyrood Risk Assessment and Planning Analysis

Example Calculation

The below example calculation illustrates the process followed. The sample is for Unit 2 Secondary Superheater located on the 7th floor below feet.

Area of Boiler	Year	Lowest Recorded UT Measurement (inches)	Ordered (Original) Thickness (inches)	ASME Minimum Thickness (inches)	Lowest UT Measurement Below ASME MWT?	If Lowest UT Measurement Below ASME, Average UT Reading from Year	Percent Remaining from Original	Design Pressure (psig)	Recommended New Pressure Based on ASME (psi)	Recommended New Pressure Based on ASME (kPa)	Plant Maximum Operating Pressure (psi)	Recommended Pressure Less Than Operating Pressure?	Reduce Pressure?
Secondary Superheater, 7th Floor, Below Feet	**2015**	**0.220**	**0.260**	**0.258**	**Yes**	**0.266**	**85%**	**2205**	**1815**	**12514**	**1875**	**Yes**	**145 mws**

In the spreadsheet, the 3rd column contains the lowest recorded thickness for the section of the boiler between the years of 2010 and 2015. The year column refers to the year it was recorded. The original thickness is the tube thickness that was supplied by the boiler manufacturer, as can be found on boiler drawings. The ASME minimum thickness is the thickness calculated by the ASME Code based on pressure, temperature and tube material. This calculation includes a design margin or factor of safety such that the tubes are significantly thicker than the need to be to This has been provided by the boiler OEM upon request. In this case the calculated thickness was 0.258”, which is only slightly less than the original ordered thickness of 0.260”. Note that for most of Unit 3, the calculated thickness has not been obtained. Instead it was conservatively assumed to be equal to the ordered thickness per the drawings.

The next column is a test to identify sections where the lowest measured thickness is less than the calculated thickness. If it is not there is no further consideration required. If it is, then the next column provides an average of all the thickness readings in the section for the year in question. In this case the average thickness is actually higher than the calculated thickness and this indicates that the area of concern is relatively small. The next column shows the percent thickness remaining from the calculated thickness , based on the lowest measurement.

The design pressure is the pressure that was used in the design calculations for the boiler tube section. This comes from boiler drawings. The recommended new pressure is the calculated pressure that provides the same design margin as the original calculated tube thickness operating at the design pressure. In this case the design pressure was 2205 psig and the calculated pressure (based on 0.220” thickness) was 1597 psig. This pressure is also expressed in kPa in the next column.

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The next column shows the plant maximum operating pressure. This is the pressure that the tube section would normally be operating at for full load conditions. The calculated pressure is then compared to the maximum operating pressure of the boiler. If the calculated pressure is less than the operating pressure then a reduction in operating pressure to the calculated value would be required to maintain the original design margin. If it is not, no further consideration is required.

Finally, for sections where a reduction in the operating pressure is required, Operations performed an analysis to determine what load could be maintained at this reduced pressure per the following rationale.

The boiler combustion controls system controls the firing rate to maintain a constant pressure of 12900 kPa at the throttle. The pressure is sensed by a pressure transmitter at the turbine stop valve. The pressure in the steam drum can exceed the pressure at the turbine by up to 1550 kPa at full load (with 90-100 % valve opening) this is because there is a pressure drop pf 850 kPa in the superheaters and approximately 700 kPa in the main steam pipe at maximum flow conditions.

In the above case, the 12514 kPa becomes the main steam pressure and the pressure drop up to the first stage of the turbine is approximately up to 1550 kPa, depending on load.

12514-1550= 10964 kPa	(this is the new pressure at the throttle)
12900- 10964= 1936	(this is the change in throttle pressure)
1936/12900= 0.15	(this is the percent reduction in throttle pressure)
170mwsx 15% = 25.5 MW	(this is the expected loss of load)
170-25.5= 144.5 MW	(this is the determined new load)

round off to 145 MW.