

ONTARIO ENERGY BOARD

IN THE MATTER OF the *Ontario Energy Board Act 1998*,
Schedule B to the *Energy Competition Act*, 1998, S.O. 1998, c.15;

AND IN THE MATTER OF an application by Ontario Power
Generation Inc. pursuant to section 78.1 of the *Ontario Energy
Board Act, 1998* for an Order or Orders determining payment
amounts for the output of certain generation facilities.

**CROSS-EXAMINATION COMPENDIUM OF THE
SCHOOL ENERGY COALITION
(Panel 1A)**

Jay Shepherd P.C.
2200 Yonge Street, Suite 1302
Toronto, ON M4S 2C6

Jay Shepherd
Mark Rubenstein
Tel: 416-483-3300
Fax: 416-483-3305

Counsel for the School Energy Coalition



Unit 2 Schedule: Segment 1

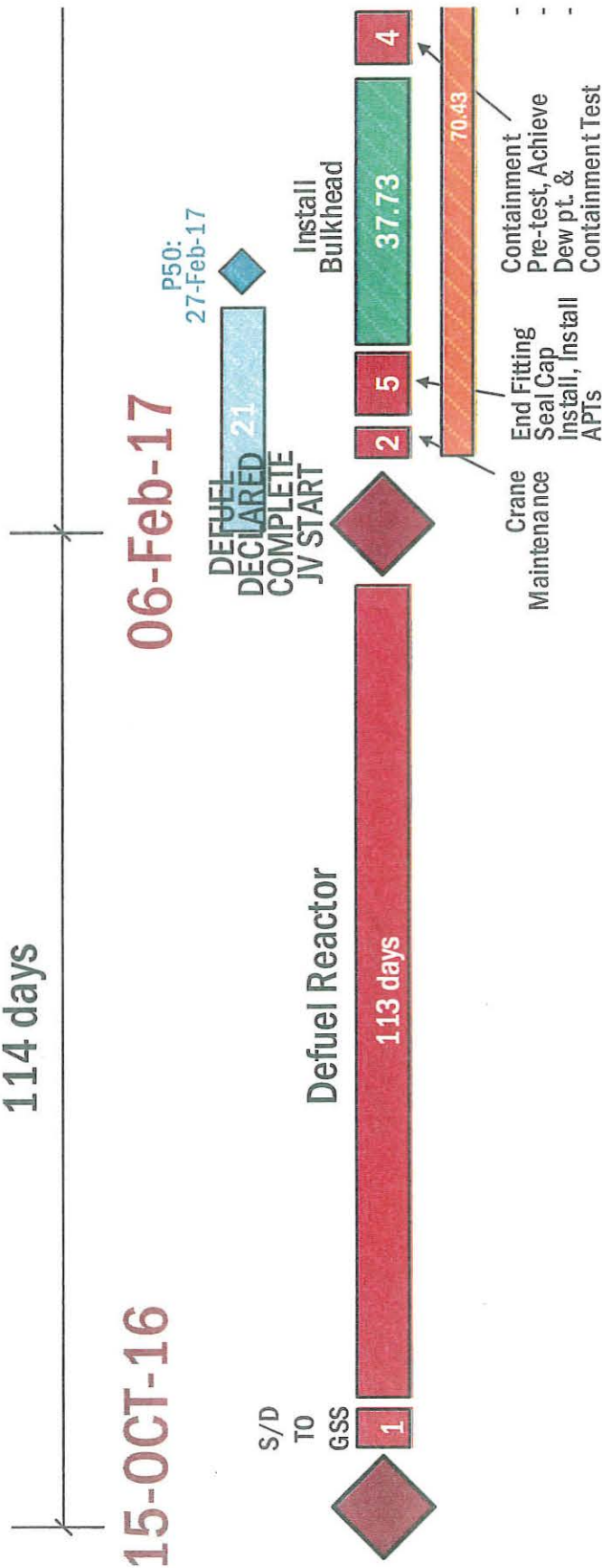
Segment 1: 163 days

113 days to Defuel

49 days to achieve Containment Isolation (bulkhead install) and containment test

Defuel

114 days



1 11. Approval to continue existing deferral and variance accounts, including interest, as
2 proposed in Ex. H1-1-1.

3
4 12. Approval of a hydroelectric payment rider to recover the approved balances of the
5 hydroelectric deferral and variance accounts (except the Pension & OPEB Cash
6 Versus Accrual Differential Deferral Account) at a rate of \$1.44/MWh applied to the
7 output from the hydroelectric facilities, beginning January 1, 2017 and terminating
8 December 31, 2018.

9
10 13. Approval of a nuclear payment rider to recover the approved balances of the nuclear
11 deferral and variance accounts (except the Pension & OPEB Cash Versus Accrual
12 Differential Deferral Account) at a rate of \$2.85/MWh applied to the output from the
13 nuclear facilities, beginning January 1, 2017 and terminating December 31, 2018.

14
15 14. Approval to establish the following deferral and variance accounts as described in Ex.
16 H1-1-1:

- 17 i. Darlington Refurbishment Rate Smoothing Deferral Account;
18 ii. Mid-term Nuclear Production Variance Account;
19 iii. Nuclear ROE Variance Account; and
20 iv. Hydroelectric Capital Structure Variance Account.

21
22 **Project Approvals**

23
24 15. OPG seeks the following approvals for the Darlington Refurbishment Program:

- 25 i. In-service additions to rate base of: (i) \$350.4M in the 2016 Bridge Year; and
26 (ii) for the 2017-2021 period, \$8.5M in 2017, \$8.9M in 2018, \$4,809.2M in
27 2020, and \$0.4M in 2021 on a forecast basis. These amounts reflect the
28 addition to rate base of \$4,800.2M related to Unit 2 in-service addition in
29 2020 and 2021, as well as \$377.2M related to Unit Refurbishment Early In-
30 Service Projects, Safety Improvement Opportunities, and Facilities &
31 Infrastructure Projects. If actual additions to rate base are different from

1 forecast amounts, the cost impact of the difference will be recorded in the
2 Capacity Refurbishment Variance Account ("CRVA") and any amounts
3 greater than the forecast amounts added to rate base will be subject to a
4 prudence review in a future proceeding; and

- 5 ii. OM&A expenditures of \$41.5M in 2017, \$13.8M in 2018, \$3.5M in 2019,
6 \$48.4M in 2020, and \$19.7M in 2021 (Ex. F2-7-1).
7

8 **Interim Payment Amounts**
9

- 10 16. An order from the OEB declaring OPG's current payment amounts for regulated
11 hydroelectric and nuclear facilities interim as of January 1, 2017, if the order or orders
12 approving the payment amounts are not implemented by January 1, 2017.

Chart 1

Simplified Breakdown of Total DRP Release Quality Estimate²

Program Component	RQE Total Cost (Billion \$)	RQE Total Cost (%)
Major Work Bundles	5.54	43
Safety Improvement Opportunities	0.20	2
Facilities & Infrastructure Projects	0.64	5
OPG Functional Support	2.23	17
Early Release Funds	0.11	1
Contingency	1.71	13
Interest & Escalation	2.37	19
Total Cost Estimate	12.8	100

Major Work Bundles are logical groupings of work scope, each consisting of a number of individual projects, defined by OPG for purposes of effectively contracting work to outside contractors and assigning project management accountabilities. The work to be undertaken through the major work bundles consists of the replacement and rehabilitation of components, inspections and the completion of upgrades directly related to unit refurbishment. The major work bundles are (1) Retube and Feeder Replacement (“RFR”), (2) Turbines, Generators and Auxiliaries (“Turbine Generator”), (3) Fuel Handling and Defueling, (4) Steam Generators, and (5) Balance of Plant.

Safety Improvement Opportunities (“SIO”) are initiatives which OPG committed to in the Environmental Assessment (“EA”) for the DRP, primarily to address beyond-design basis or four-unit events. The need for this work was established through the EA, which was filed with the Canadian Nuclear Safety Commission (“CNSC”). To meet required in-service dates, OPG commenced execution of SIO work early in the Definition Phase of the Program. The SIO are useful to OPG’s current and future nuclear operations independent of whether the DRP is completed.

² The vast majority of these amounts are capital, but included in these amounts are some amounts (e.g. removal costs) that are expensed as OM&A. OM&A costs associated with the DRP are set out in Ex. F2-7-1.

Chart 4

Breakdown of the 2020 \$4.8B in service additions (\$M)

Bundle / Category	2020 I/S	%
Retube & Feeder Replacement	1,834.8	38%
Turbine Generator	258.6	5%
Fuel Handling / Defueling	132.6	3%
Steam Generator	56.3	1%
Balance of Plant	480.9	10%
Subtotal Bundles ¹	2,763.2	58%
Project Execution	165.4	3%
Contract Management	31.0	1%
Engineering	163.6	3%
Managed Systems Oversight	31.6	1%
Planning & Controls	133.3	3%
Nuclear Safety	70.2	1%
Program Fees & Other Support	163.8	3%
Supply Chain	55.2	1%
Work Control	36.1	1%
Operations & Maintenance	336.9	7%
Subtotal Functions	1,187.1	25%
Early Release 3	144.9	3%
Early Release 4	10.5	0%
Subtotal Early Release Funds ²	155.4	3%
Subtotal Before Contingency	4,105.7	86%
Contingency	694.1	14%
Grand Total	4,799.8	100%

Notes:

(1) U2 in-service additions include minor close-out activities up to August 2020.

(2) There is an additional \$0.4M in-service addition in 2021.

Footnotes:

¹ Escalation and interest are included in the bundle/category in-service amounts.

² Early release funds are costs that were associated with the preliminary planning phase of the Definition Phase. During preliminary planning, the DRP program structure was not yet in place and this early work was not associated with major work bundles or OPG functional support.



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FOR APPROVAL by the Board of Directors

August 12, 2016

DARLINGTON REFURBISHMENT - UNIT 2 EXECUTION

DECISION REQUIRED

The purpose of this memo is to provide a summary of the Darlington Refurbishment Program (DRP) Unit 2 cost and schedule estimates and key risks, and request approval for:

- Commencement of Unit 2 refurbishment in October 2016;
- The Unit 2 budget and schedule; and
- Release of additional funds in the amount of \$2,876 Million, which includes \$635 Million of contingency to execute the Unit 2 refurbishment.

ISSUE

In November 2015, OPG's Board of Directors approved the Release Quality Estimate (RQE), representing the overall 4-unit high confidence budget, schedule and release strategy to refurbish the four Darlington units.

Since that time, as management continued with the detailed planning and preparations for execution of the Unit 2 refurbishment, management has further developed the Unit 2 cost estimate and schedule and performed an updated risk analyses. Consistent with the approved funding strategy, Management is now requesting Board approval to proceed with the refurbishment of Unit 2 starting in October 2016 and to release the required funding to complete the refurbishment of Unit 2.

ANALYSIS

The current Unit 2 Execution Estimate (U2EE) is an update to RQE, which takes into consideration additional planning and work executed over the past 8 months, and incorporates the following:

- Revised estimates for scope that has progressed from a Class V or IV estimate to a Class III and II.
- Updated base cost estimates to reflect the development of comprehensive execution work packages and an enhanced understanding of the cost to perform the work, which is a direct outcome of estimate development and actual field work.
- Updated risk profile, and resultant contingency required for residual risks.
- Assessment of the actual costs to date and the estimate-to-complete (ETC) for all work packages.
- Review of the cash flow, including interest and escalation requirements, against the current schedule.

All of these items have been compiled into the current U2EE, as well as a review of the 4-unit overall cost estimate. The following sections summarize this analysis.

1. Management is adequately prepared and ready to proceed with the execution of Unit 2.

Management has provided an update on the status of the DRP to the Darlington Refurbishment Committee (DRC) at its August 11, 2016 meeting. In the report, Management indicates that the DRP remains on track to commence the execution and refurbishment of Unit 2 in October 2016.

Management is executing all pre-requisite projects in order to be ready to commence the refurbishment of Unit 2. Some of these projects are currently behind schedule; however, all critical projects required to enable the start of refurbishment are expected to be complete prior to their need date.

Management is focused on applying lessons learned from the Ready to Execute (RTE) test period, where processes for managing in-plant execution of work were tested and refined, to increase the productivity and schedule compliance of all work being performed in the field. Although many of the pre-requisite projects are not required for the start of refurbishment, management remains focused on the delivery of these projects as quickly as reasonably feasible while managing safety, quality, and cost.

2. Unit 2 scope has been clearly specified, engineering is complete, and comprehensive work plans are in place.

Since RQE, there have been no major scope changes to the DRP.

Detailed design engineering is substantially complete for all field work to be executed during Unit 2.

Management has focused on the completion of Phase 1 Comprehensive Work Packages (CWPs) that describe the details of the work to be executed in the field. The CWPs for all the project bundles are now essentially complete with a few minor exceptions. Completion of the CWPs took an additional month beyond what was planned due primarily to station interfaces for the Re-tube & Feeder Replacement (RFR) project not being fully understood by the vendor; however, they have been completed with quality, and provide the necessary information to complete field execution of all project work.

3. Regulatory certainty has been achieved.

The Integrated Implementation Plan (IIP) identifies the regulatory scope required to be completed during the refurbishment period, including work being done by the station.

The 51 Integrated Implementation Plan (IIP) tasks that have been committed to the Canadian Nuclear Safety Commission (CNSC) for completion in 2016 are on track. To date, 17 items are complete and field work for an additional 10 is complete with document closeout underway.

OPG has received all remaining regulatory approvals from the CNSC required to support the start of Unit 2 refurbishment. No additional approvals are required to commence refurbishment of Unit 2.

OPG has committed in the IIP to have the 3rd Emergency Power Generator (EPG) and Containment Filtered Venting System (CFVS) in-service prior to the start of the Unit 2 refurbishment, and continues to demonstrate to the CNSC that completion of these projects is a high priority. The CNSC is being kept informed of the project complexities, including commissioning and site integration of the 3rd EPG, and is aware of the potential risk to the in-service date. In the event that the IIP commitment cannot be achieved, the IIP Change Control Process will be initiated.

The regulatory hold-points for returning the units to service, after refurbishment, have been agreed to with the CNSC. Development of a decision and escalation protocol with the CNSC, to ensure scope and schedule commitments are effectively managed, is being considered.

4. The Unit 2 high confidence schedule duration, consistent with RQE, remains at 40 months; the 4-unit schedule remains at 112 months.

The Unit 2 high confidence schedule duration of 40 months remains consistent with RQE.

The only significant change to the high confidence 4-unit schedule since RQE was the de-lapping of Unit 3 from Unit 2, to be consistent with the Province's Long Term Energy Plan (LTEP) requirement to complete Unit 2 prior to commencing any subsequent units.

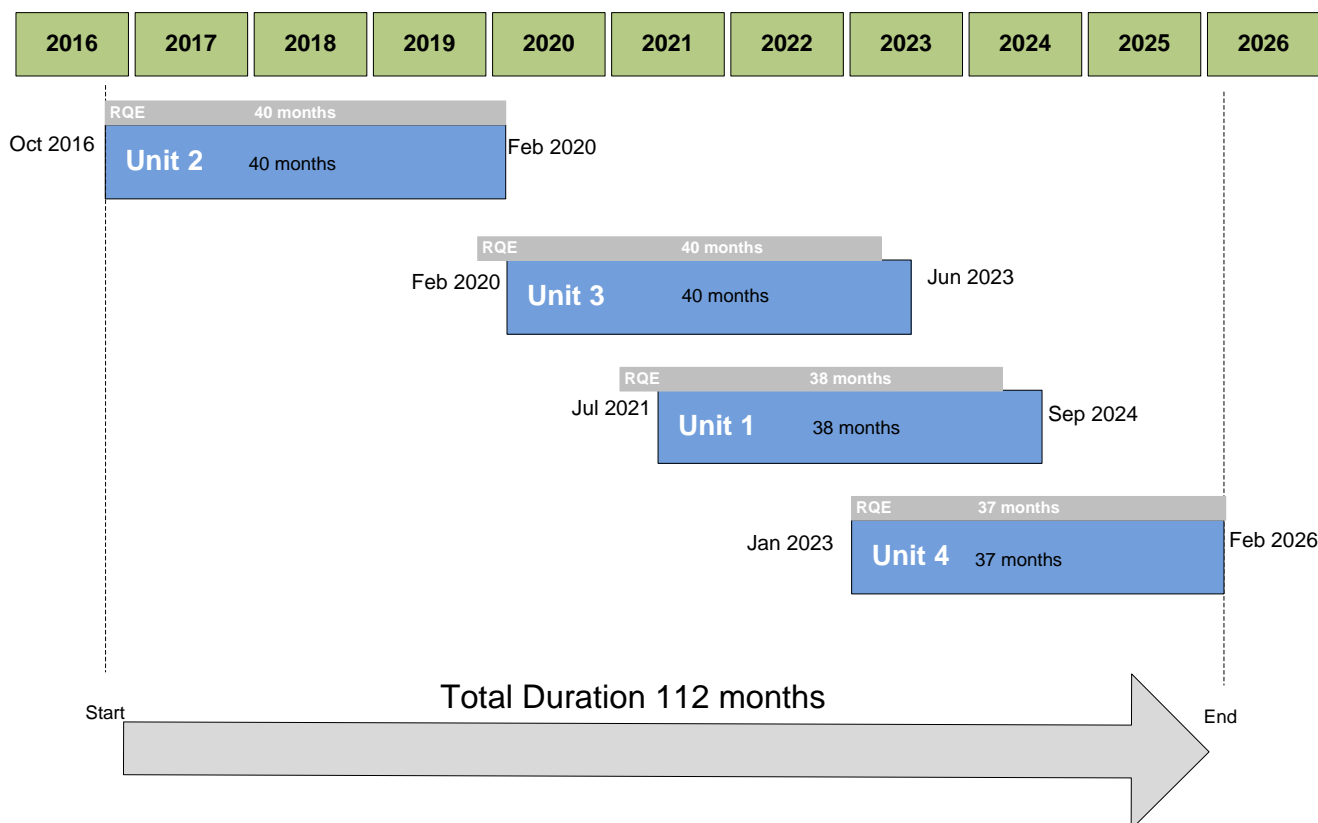
The overall 4-unit high confidence schedule duration remains at 112 months per Table 1 below:

Table 1: Comparison of 4-Unit High Confidence Schedule (RQE vs. U2EE)

Unit	High Confidence at RQE			High Confidence (U2EE)			Variance From RQE
	Start	Finish	Duration (Months)	Start	Finish	Duration (Months)	
Unit 2	15-Oct-16	15-Feb-20	40	15-Oct-16	15-Feb-20	40	0
Unit 3	15-Dec-19	15-Apr-23	40	15-Feb-20	15-June-23	40	0
Unit 1	15-Apr-21	15-Jun-24	38	15-Jul-21	15-Sep-24	38	0
Unit 4	15-Jan-23	15-Feb-26	37	15-Jan-23	15-Feb-26	37	0
4 Units	15-Oct-16	15-Feb-26	112	15-Oct-16	15-Feb-26	112	

The U2EE High Confidence schedule and comparison to RQE as noted above in Table 2, is illustrated in the following Figure A:

Figure A: Refurbishment 4-Unit High Confidence Project Schedule



High Confidence durations are shown above. Unit 2 project performance will however get managed against an aggressive planned outage duration (working schedule) of 35 months. Since RQE, detailed schedules have been further developed, and have resulted in a minor 10 day increase for activities within the removal and installation series. A copy of the Level 1 schedule is included as Appendix 1.

The planned outage duration is based on a detailed evaluation of the schedule risks for each segment of the critical path, including discrete technical risks such as a Primary Heat Transport pump motor failure during defueling and requirements for Primary Heat Transport system flush and Hot Conditioning on unit startup. Management is, and will continue to, look for opportunities to reduce schedule durations.

The high confidence schedule is the basis for the Release Quality Estimate, which is the program level control budget and this schedule is the schedule from which project success will be assessed. Management will report on the performance of the DRP to the DRC on a quarterly basis, against both the Unit 2 working schedule and the high confidence schedule, with clear indications of project status and contingency utilization.

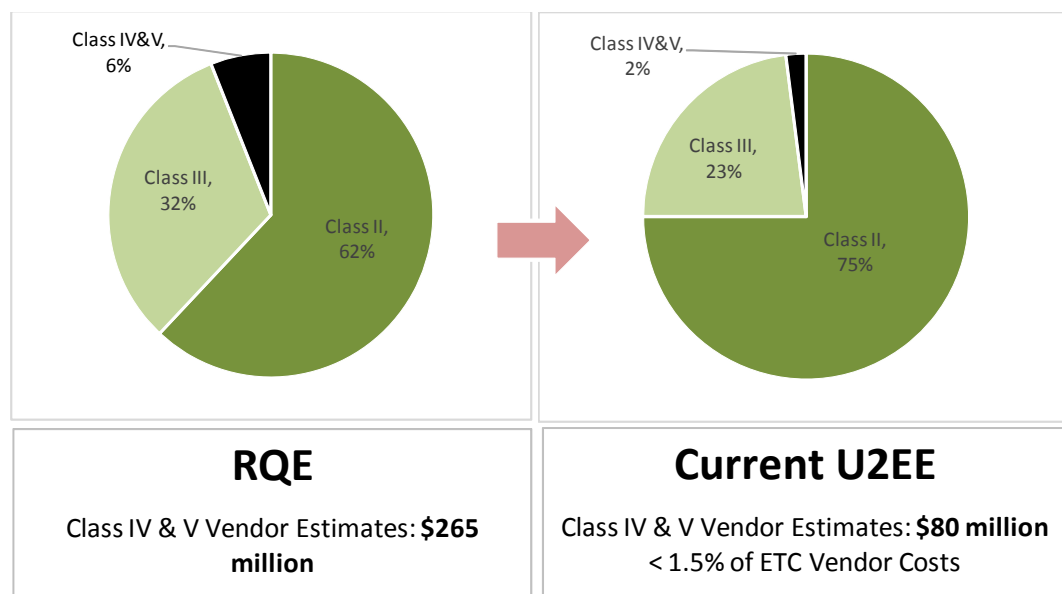
Final detailed schedule reviews are now underway in order to ensure all potential interferences between vendors are eliminated and labour resources are effectively balanced. The final baseline Unit 2 working schedule will be issued in mid September. This schedule will contain over 75,000 tasks for OPG and the vendors.

5. A detailed review of Unit 2 execution phase risks and contingencies is now complete.

Management has finalized its review of schedule and cost risks. Since the RQE analysis in October, a reduction in cost estimating uncertainty contingency requirements has been observed, which reflects the progression of project estimates and the integration of lessons learned from the Ready to Execute test period.

As shown in Figure B, the percentage of project costs where the estimate is at Class III or better has increased since RQE from 94% to 98%. For those projects not yet at Class III, adequate contingency has been carried to reflect the remaining uncertainty with these projects.

Figure B: Estimate Classification Summary



(1) Figures above represent 4-Unit estimates. Actions are already underway to finalize these estimates to Class III or II prior to work release and execution.

The contingency analysis summarized in Table 2 was derived through a detailed analysis and modeling of the current risk profile across the entire program. The assessed contingency is based on the residual risks contained within the DRP and excludes the \$61 Million of contingency allocated since RQE. In addition to the continuous monitoring of contingency draw-downs, a thorough assessment of the risk profile and impact on contingency will be performed quarterly.

The outcome of Management's contingency analysis yielded that, at a high confidence, the estimate should include \$2,006 Million of contingency for the DRP, including \$677 Million for Unit 2.

There is no significant change to the anticipated contingency calculated at RQE. For clarity, RQE consisted of \$1,706 Million of contingency in 2015 dollars, plus \$300 Million of inflation and interest,

which totals \$2,006 Million. Contingency on Unit 3 has increased due to a shift of risks from Unit 2 to Unit 3 related to the Turbine Controls installation on Unit 3.

Below, in Table 3, is a breakdown of the \$2,006 Million of contingency, by unit and contingency type.

Table 2: 4-Unit Contingency Summary

Unit	RQE (\$M)	Current U2EE (\$M)	Changes since RQE (\$M)
Campus Plan Program Total, *plus \$41mil of add'l contingency included with projects	32	18	-14
Unit 2 Total	690	677	-13
Unit 3 Total	516	557	41
Unit 1 Total	419	409	-10
Unit 4 Total	350	345	-5
4-Unit Contingency (\$M)	2,006	2,006	0

Table 3: 4-Unit Contingency Summary by Type

Level	Contingency Type	Updated 4-Unit Contingency (\$M)	Facility and SIO Projects (\$M)	U2 (\$M)	U3 (\$M)	U1 (\$M)	U4 (\$M)
PROJECT	Project Discrete Risks - Specific to Bundles	658	18	216	177	135	112
	Project Level Estimating Uncertainty - Project Bundles and Resources	192	-	67	54	38	33
	Critical Path Schedule Contingency - for the Working Schedule Duration	438	-	149	122	91	76
	Critical Path Schedule Contingency - to High Confidence Duration	192	-	66	55	38	33
PROGRAM	Program Discrete Risks - Functional Risks	458	-	153	129	95	81
	Program Level Estimating Uncertainty - Functional Resources	68	-	26	20	12	10
	Total Contingency \$M	2,006	18	677	557	409	345

The contingency of \$2,006 Million represents 23% of the Execution Phase Estimate-to-Complete cost of \$8,300 Million, or 32% of the external vendors' estimate of \$6,000 Million. With 98% of vendor cost estimates well defined at Class III or better, Management believes that the contingency amount is sufficient.

6. OPG's oversight requirement has been assessed and is deemed to be appropriately sized.

Since RQE, OPG's role as the General Contractor performing integration and oversight of safety, quality, schedule, cost and risk, with consideration of current field experience, has been evaluated.

Lessons learned from the pre-requisite projects have been evaluated and OPG has added resources in each of the following areas:

- Field construction support and oversight;
- Quality surveillance;
- Work control;
- Source surveillance and vendor procurement; and
- Contract and claims management.

Management is further evaluating its organization and looking for further opportunities to streamline processes and reduce oversight staff. Also, OPG's investment in vendor training, including supervisor training, is expected to improve performance and in time should have a positive impact on resources.

Due to the under spend in OPG labour of approximately \$40 Million to date, management believes that these increases can be managed and will not impact the Unit 2 estimate. However, Management is also carrying \$77 Million of contingency (per Unit) for risks and an uncertainty associated with higher owner's costs, which management believes is sufficient.

Management has put in place processes required to plan and forecast staff demands and will closely monitor all labour demands and variances during execution of the DRP to mitigate any further cost growth related to OPG's oversight.

The overall histograms of OPG and vendor resources are shown in Appendix 5A and 5B.

7. The Unit 2 high confidence cost estimate is \$3.4 Billion including contingency, consistent with the estimate provided at RQE.

The high confidence cost estimate to execute Unit 2, including contingency is \$3.4 Billion and is \$24 Million higher than presented at RQE due several vendor changes, increase in OPG staffing, but offset by lower anticipated contingency needs.

Furthermore, the in-service amount of \$4.8 Billion reported at RQE has been maintained.

Appendix 3 provides a project bundle level analysis of the current cost estimate and as compared to RQE.

8. The overall budget remains within the \$12.8 Billion set at RQE.

As shown in Appendix 2, the overall 4-Unit high confidence cost estimate remains at \$12.8 Billion.

Table 4: Refurbishment Current Estimate Compared to Prior Estimates

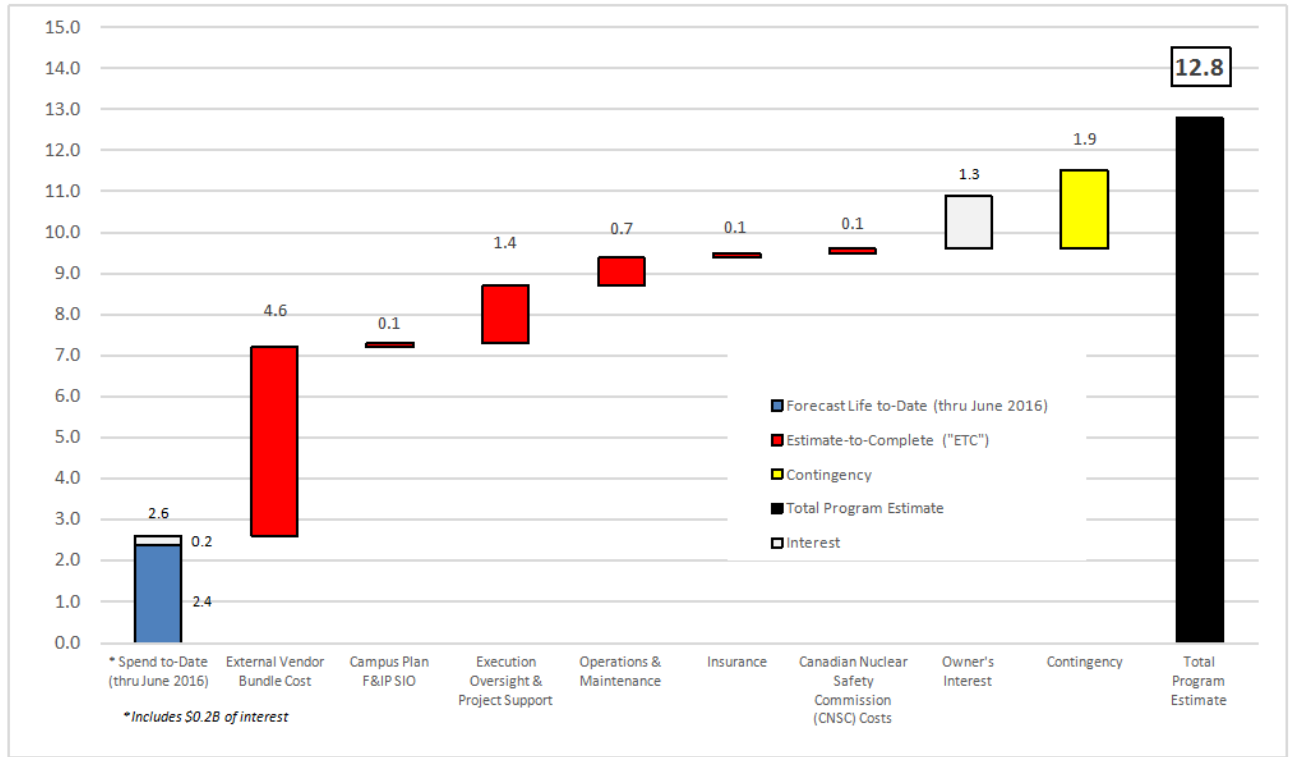
2009 Estimate	2015 RQE High Confidence Estimate	Current High Confidence Estimate
\$14.0 Billion ^(1,2)	\$12.8 Billion ⁽²⁾	\$12.8 Billion⁽²⁾

(1) The 2009 estimate was reported as \$10 Billion in \$2009, excluding interest and inflation. When interest and inflation is included, the estimate was \$14 Billion.

(2) Estimate includes interest and inflation. Inflation is estimated at 2% and interest is estimated using 5% to 2021 and 6% thereafter.

Figure C below provides a summary of the cost elements that build up to the high confidence 4-unit cost estimate. Each cost element now includes allocated inflation.

Figure C: 4-Unit Cost Estimate Build-up



Appendix 2A and 2B provides a more detailed breakdown of the overall cost.

9. Funding is requested in the amount of \$2.9 Billion to complete Unit 2 refurbishment.

The cumulative release at RQE was \$3,228 Million including \$723 Million for Unit 2 activities. The current high confidence cost estimate for the Unit 2 refurbishment, including \$677 Million of contingency, is \$3,417 Million. Management is requesting incremental funding of \$2,876 Million to complete the refurbishment of Unit 2 as well as the Facility & Infrastructure, Safety Improvement, and other in-plant pre-requisite projects, for a total cumulative release of \$6,104 Million. Details of the release amount are included in Appendix 6.

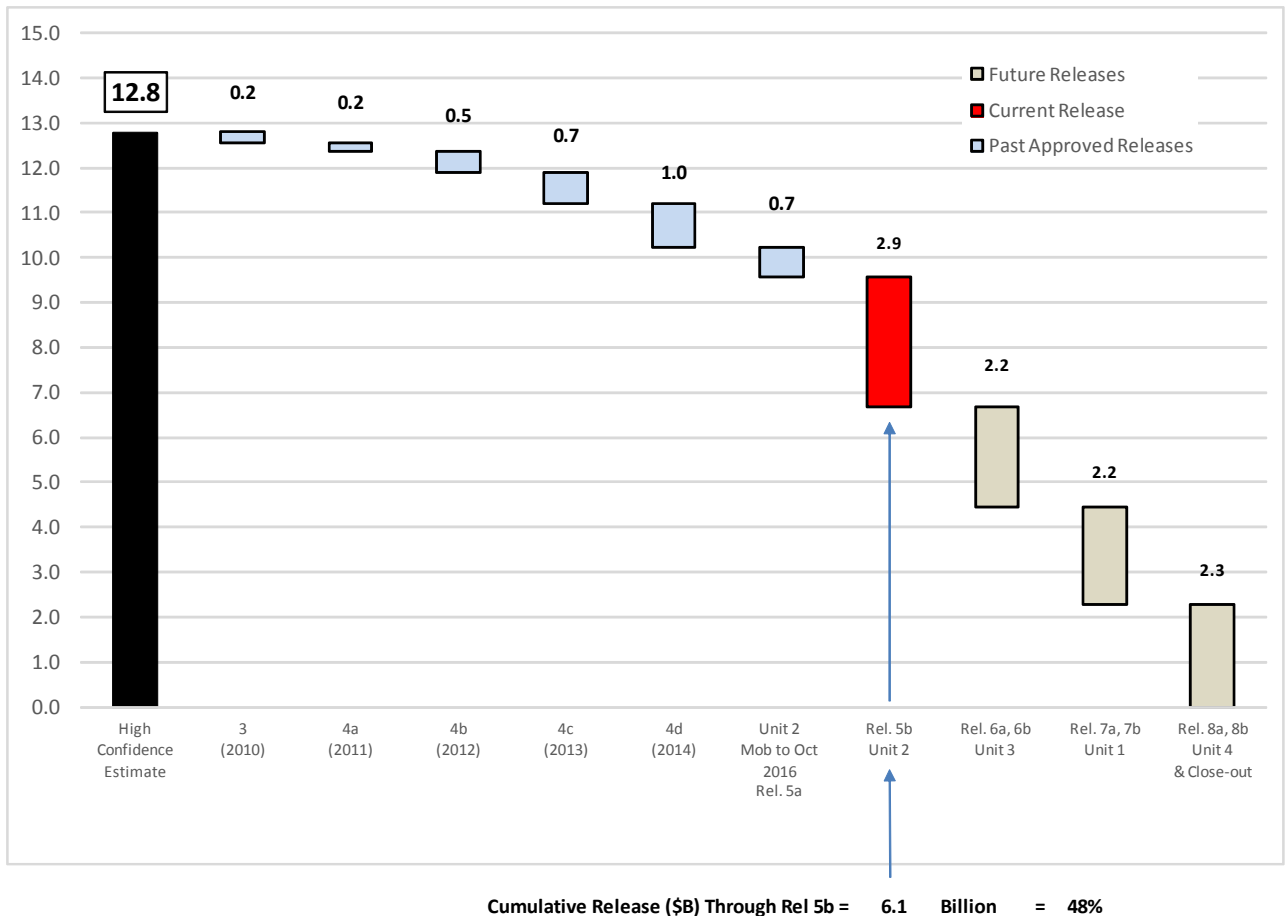
Table 5: Program Funding Releases

Previous Approved Funding Cumulative through Release 5a (at RQE)	Current Funding Request, Release 5b for U2 Execution	Cumulative Funding through end of Unit 2
3,228	2,876	6,104
Values in \$Million		

Release 5a funding, approved by the Board in November 2015, included approximately \$102 Million for a portion of subsequent unit planning, primarily for long lead materials for the Turbine Generator Control system, which will be installed initially on Unit 3, and the Re-tube and Feeder Replacement project.

Figure D below provides a summary of the cumulative releases to the DRP to date.

Figure D: Program Funding Releases



In 2017, Management will request additional funding to commence preliminary planning for subsequent unit refurbishments. This will include funding to complete engineering and to initiate long lead procurement for Unit 3. A dedicated team will be put in place to lead the Unit 3 planning effort.

10. The LUEC of refurbishing and continuing to operate the Darlington units for a further 30 years remains at 8.1 ¢/kWh (2015\$).

There is no anticipated change to the economic assessment, and the LUEC of refurbishing and continuing to operate the Darlington station for a further 30 years remains at 8.1 ¢/kWh (2015\$).

The DRP continues to contribute 3.3 ¢/kWh (\$2015) to the LUEC estimate, and the post-refurbishment operations and support costs necessary to run the plant, including fuel, continue to contribute 4.8 ¢/kWh (\$2015) to the total LUEC.

11. Management will commence reporting to the DRC on the status of the Unit 2 Execution Phase in November 2016.

The Unit 2 refurbishment baseline working schedule will be issued in mid September. At that time, Management will make any needed adjustments to the Unit 2 cost flows and control budget, which will then be used for performance monitoring and reporting.

RECOMMENDATION / RESOLUTION

Management is requesting that the Board of Directors approve the following items related to the DRP:

- Approval to commence Unit 2 refurbishment in October 2016;
- Approval of the Unit 2 high confidence cost estimate (\$3.417 Billion) and high confidence schedule (40 months); and
- Approval of a release of funds in the amount of \$2,876 Million, which includes \$635 Million of contingency to execute the Unit 2 refurbishment.

Recommended by:

**Approved for submission to
the Board of Directors by:**

Dietmar Reiner
Senior Vice President, Nuclear Projects

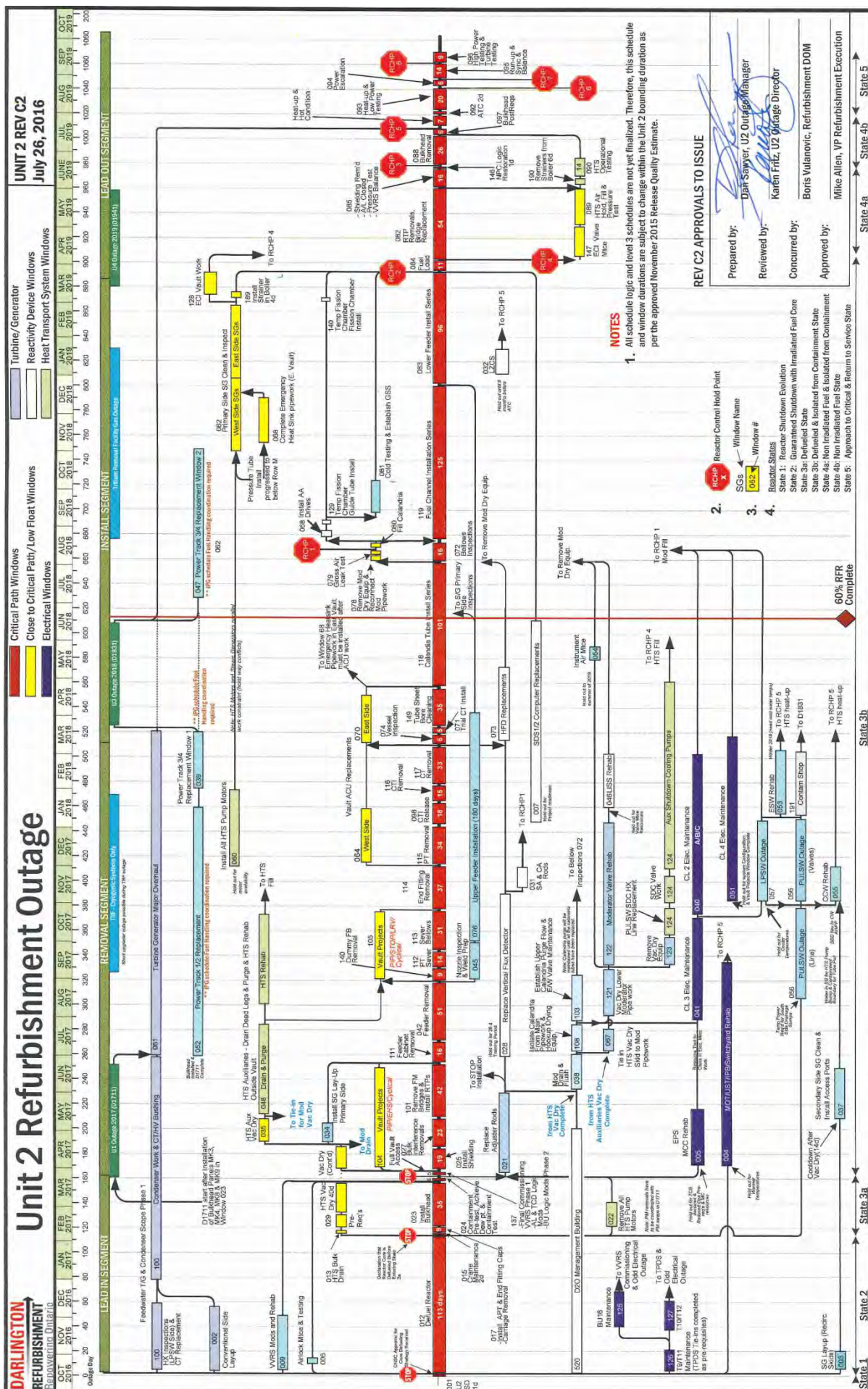
Jeff Lyash
President and CEO

This Board memo was reviewed and approved for submission to the Board of Directors by the
Darlington Refurbishment Committee at their meeting of August 11, 2016.

APPENDICES

1. Unit 2 Level 1 Schedule
2. DRP 4-Unit Cost Estimate Summary including Variance Analysis to RQE
3. Unit 2 Cost Estimate Summary including Variance Analysis to RQE
4. Unit 2 Key Discrete Risk Summary
5. Resource Histograms
6. Funding Release Calculation

DARLINGTON
REFURBISHMENT



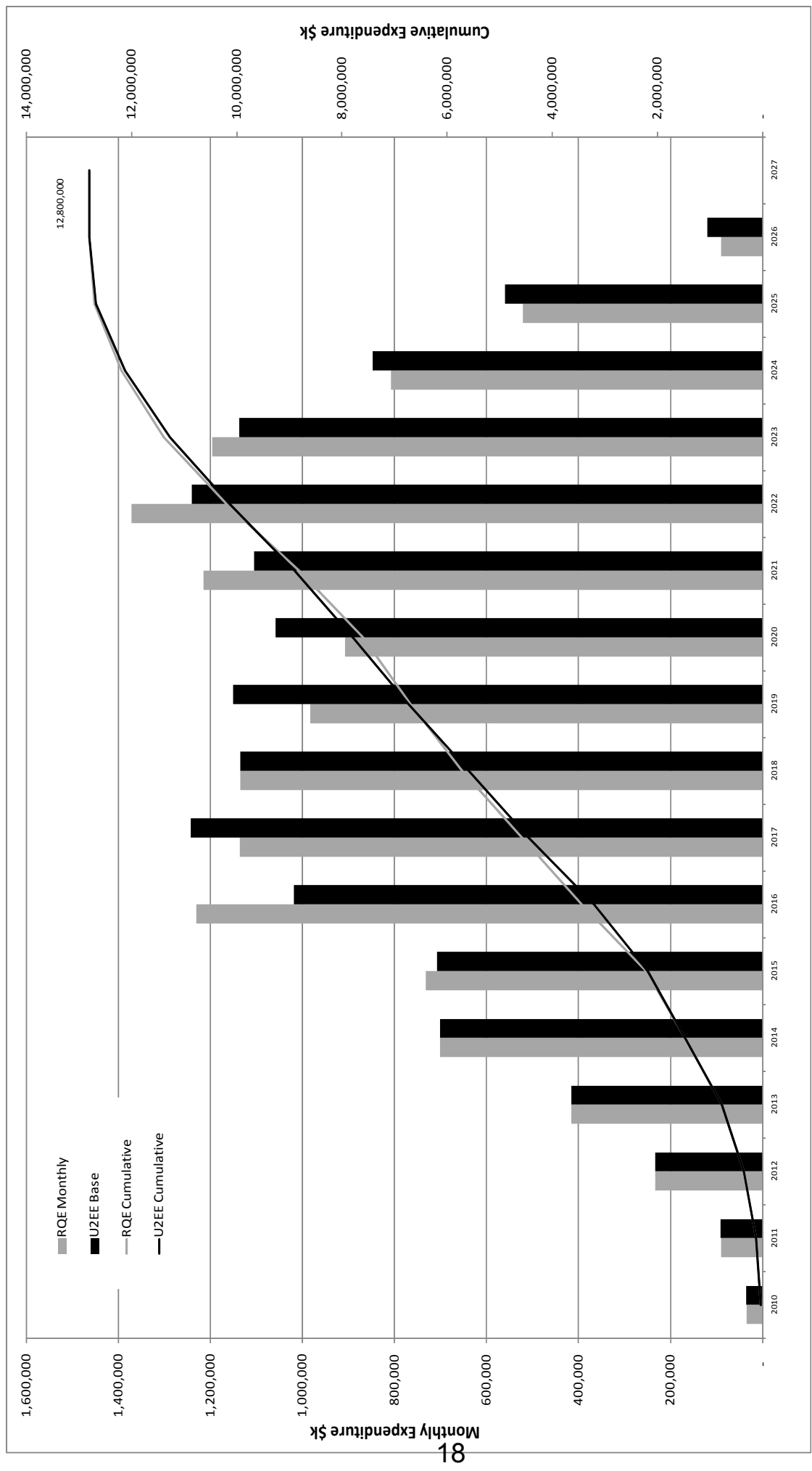
APPENDIX 2A: 4-UNIT COST SUMMARY

#	Division	RQE	Current U2EE	Variance from RQE	%
1	NR - Retubing & Feeder Replacement	4,489,335	4,494,607	5,273	0%
2	NR - Turbine Generator	862,083	865,336	3,253	0%
3	NR - Balance of Plant	570,780	587,350	16,569	3%
4	NR - Fuel Handling	186,563	166,363	(20,200)	-11%
5	NR - Defueling	50,798	54,917	4,119	8%
6	NR - Steam Generator	161,509	163,275	1,765	1%
7	NR - Specialized Projects	134,837	135,862	1,025	1%
8	NR - Shutdown, Layout and Services	232,311	197,877	(34,434)	-15%
9	NR - Unit Islanding	167,378	172,288	4,910	3%
10	NR - Waste Disposal	38,518	38,518	0	0%
11	NR - Refurbishment Support Facilities	98,114	82,901	(15,213)	-16%
12	SubTotal Bundle Projects	6,992,227	6,959,296	(32,932)	0%
13	NR - F&IP + SIO Projects	932,792	958,738	25,946	3%
14	SubTotal Campus Plan Projects	932,792	958,738	25,946	3%
15	OPG Functions + Ops & Maintenance	2,868,663	2,875,193	6,531	0%
16	SubTotal Functions	2,868,663	2,875,193	6,531	0%
17	Contingency	2,006,318	2,006,773	455	-
18	SubTotal Contingency	2,006,318	2,006,773	455	0%
19	Nuclear Refurbishment Program	12,800,000	12,800,000	(0)	0%

(1) All figures now include inflation & interest (RQE reported base costs in 2015, with inflation & interest "below-the-line")

APPENDIX 2B: 4-UNIT COST FLOW – U2EE vs. RQE

To be updated by September 30th, post issue of REV0 Level 1 Schedule (Sept 15th), upon which time final interest will be re-calculated



RQE	RQE Monthly	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	Total
	RQE Cumulative	35	125	358	774	1,475	2,207	3,438	4,574	5,709	6,692	7,599	8,814	10,186	11,382	12,189	12,710	12,800	-	12,800
	U2EE Total	36	91	233	416	701	707	1,018	1,243	1,135	1,151	1,059	1,105	1,240	1,137	848	560	120	-	12,800
	U2EE Cumulative	36	127	360	776	1,476	2,184	3,202	4,445	5,580	6,731	7,790	8,895	10,135	11,272	12,120	12,680	12,800	12,800	12,800

APPENDIX 3: UNIT 2 COST SUMMARY

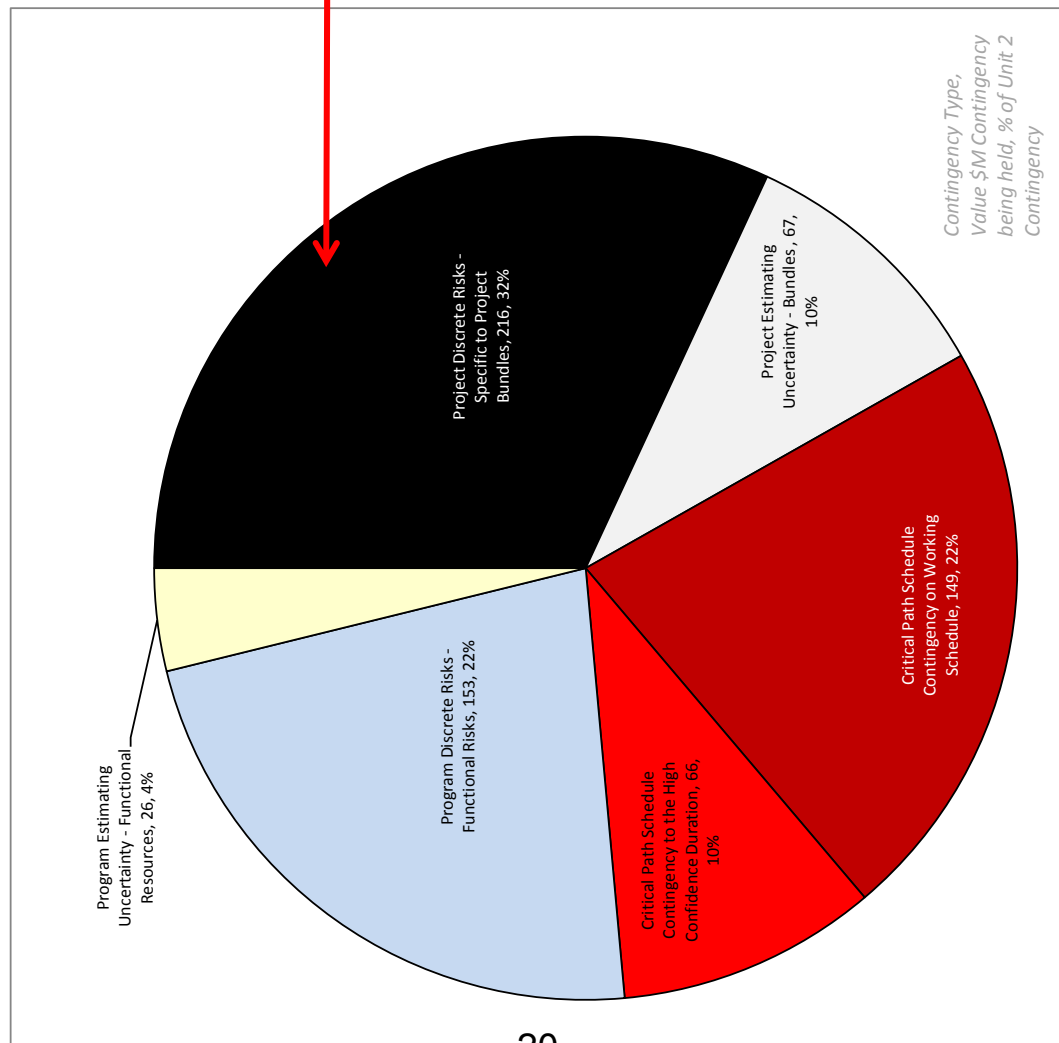
#	Division	RQE	Current U2EE	Variance from RQE	%
1	NR - Retubing & Feeder Replacement	1,143,965	1,148,041	4,077	0%
2	NR - Turbine Generator	226,164	228,012	1,849	1%
3	NR - Balance of Plant	165,731	186,299	20,568	12%
4	NR - Fuel Handling	21,498	16,448	(5,050)	-23%
5	NR - Defueling	31,544	35,978	4,434	14%
6	NR - Steam Generator	53,313	54,537	1,224	2%
7	NR - Specialized Projects	85,593	86,656	1,063	1%
8	NR - Shutdown, Layup and Services	83,371	76,354	(7,017)	-8%
9	NR - Unit Islanding	57,731	61,058	3,327	6%
10	NR - Waste Disposal	7,713	7,713	0	0%
11	NR - Refurbishment Support Facilities	35,478	36,382	904	3%
12	SubTotal Bundle Projects	1,912,101	1,937,479	25,378	1%
13	NR - F&IP + SIO Projects				
14	SubTotal Campus Plan Projects				
15	OPG Functions + Ops & Maintenance	791,583	802,114	10,532	1%
16	SubTotal Functions	791,583	802,114	10,532	1%
17	Contingency	689,530	677,452	(12,078)	-2%
18	SubTotal Contingency	689,530	677,452	(12,078)	-2%
19	Nuclear Refurbishment Program	3,393,213	3,417,045	23,832	1%

- (1) All figures now include inflation & interest (RQE reported base costs in 2015, with inflation & interest "below-the-line")
- (2) Campus Plan F&IP + SIO Projects (Unit F and Unit S) excluded from "Unit 2", but are included in the overall Release 5b funding request.
- (3) Estimate to Complete (ETC) costs for Unit 0 (Common Work) and Unit D (Definition Phase Work) are excluded from the above, but are included in the overall Release 5b funding request.

APPENDIX 4: UNIT 2 KEY RISK & CONTINGENCY SUMMARY

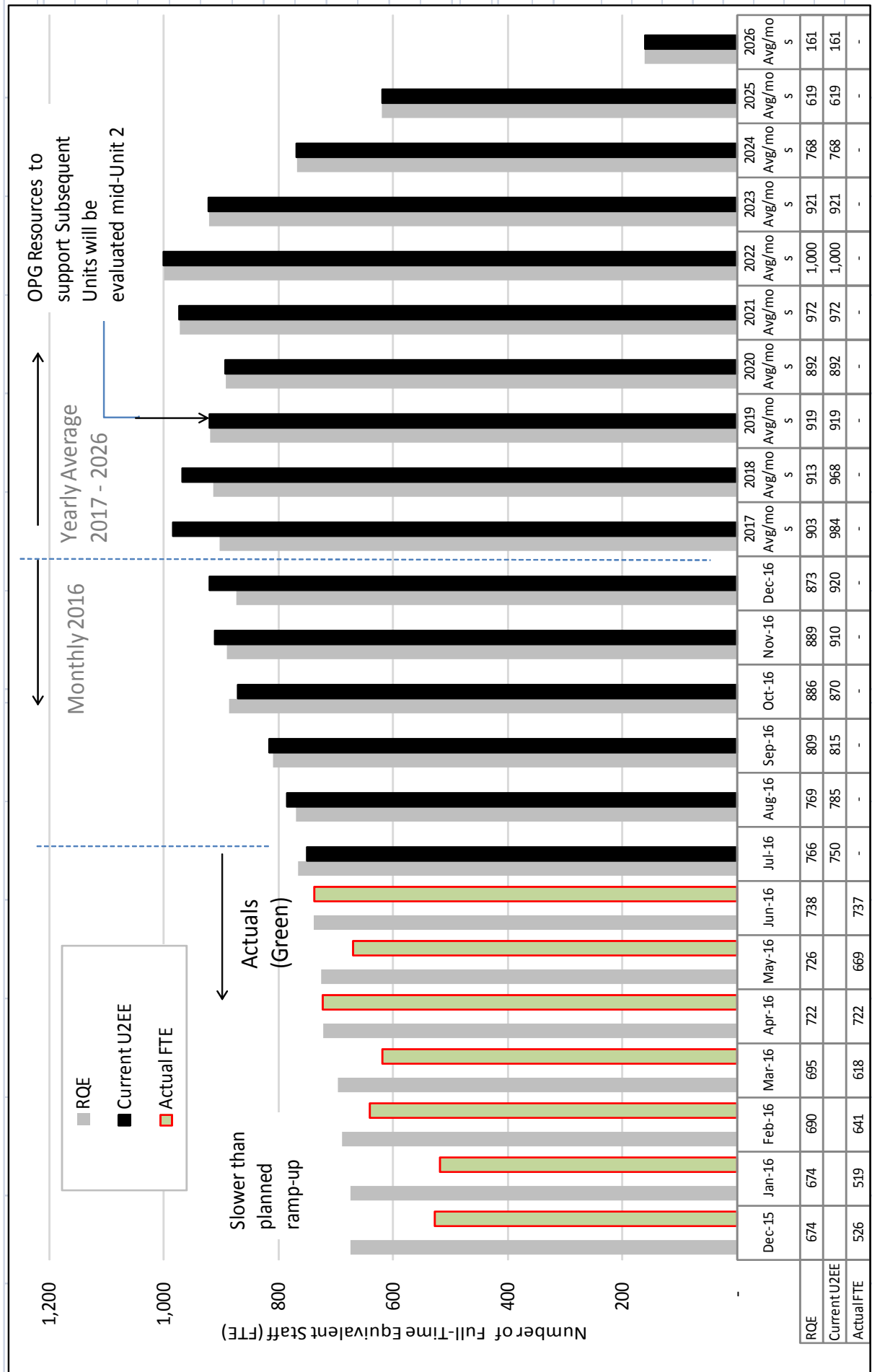
Unit 2 Discrete Top Risks by \$ Value

Bucket	Bundle / Functional	ID	Description	U2EE Unit 2 \$k
Discrete Risks	Retube and Feeder	13325	Concealed Conditions [Window 167,168]	20,565
Discrete Risks	Refurbishment Execution	683	Refurb Construction - Poor EPC Vendor performance may require additional oversight during all phases	18,381
Discrete Risks	Refurbishment Execution	783	Refurb Construction - Estimated Cost of General Services contract may be underestimated	17,190
Discrete Risks	Refurbishment Execution	TBD	Trough Management	16,487
Discrete Risks	Program Support	751	Foreign Exchange	16,006
Discrete Risks	Balance of Plant	13663	Additional BoP Resource Risk due to lack of Vendor EPC Experience	12,225
Discrete Risks	Turbine Generator	11250	TG Discovery work scope caused by inspections with impact on long lead items or major repairs	8,063
Discrete Risks	Retube and Feeder	13329	Claims from Retube and Feeder Replacement (RFR) Vendor Not already Covered in the Contract	6,594
Discrete Risks	Balance of Plant	14413	73750 Phase 2 cost escalation (Windows 122, 124, 029, 057)	6,579
Discrete Risks	Operations and Maintenance	708	Materials budget for emergent broke-fix maintenance during Shutdown, Layup and Runup	6,141
Discrete Risks	Operations and Maintenance	564	Large Potential Worker Doses due to Inadequate Internal (Alpha etc.) Hazard Characterization	6,045
Discrete Risks	Refurbishment Execution	717	Refurb Construction - Estimated Cost of RPPE Laundry may be underestimated	5,847
Discrete Risks	Retube and Feeder	13917	Insufficient Tool Quantities or Spares for RFR Execution - all causes [Potential Window 160-188]	5,619
Discrete Risks	Retube and Feeder	13860	Owner Specified Material (OSM) pricing from Unit-to-Unit Procurement [No Window Related]	4,956
Discrete Risks	Shutdown and Layup - Services	13619	SDUJ Pre-requisite projects delays [No Window Related]	4,874
Discrete Risks	Shutdown and Layup - Services	14318	Quality issues [No Window Related]	4,495
Discrete Risks	Retube and Feeder	14115	Feeder fabrication schedule delay as a result of flow element (1690) weldability challenges.	3,773
Discrete Risks	Operations and Maintenance	839	Valve Program Vendor Contract not Secured	3,690
Discrete Risks	Balance of Plant	13263	73639 - PHT & Auxiliaries - PHT & Aux - PHT Pumps Will Require Repairs	3,461

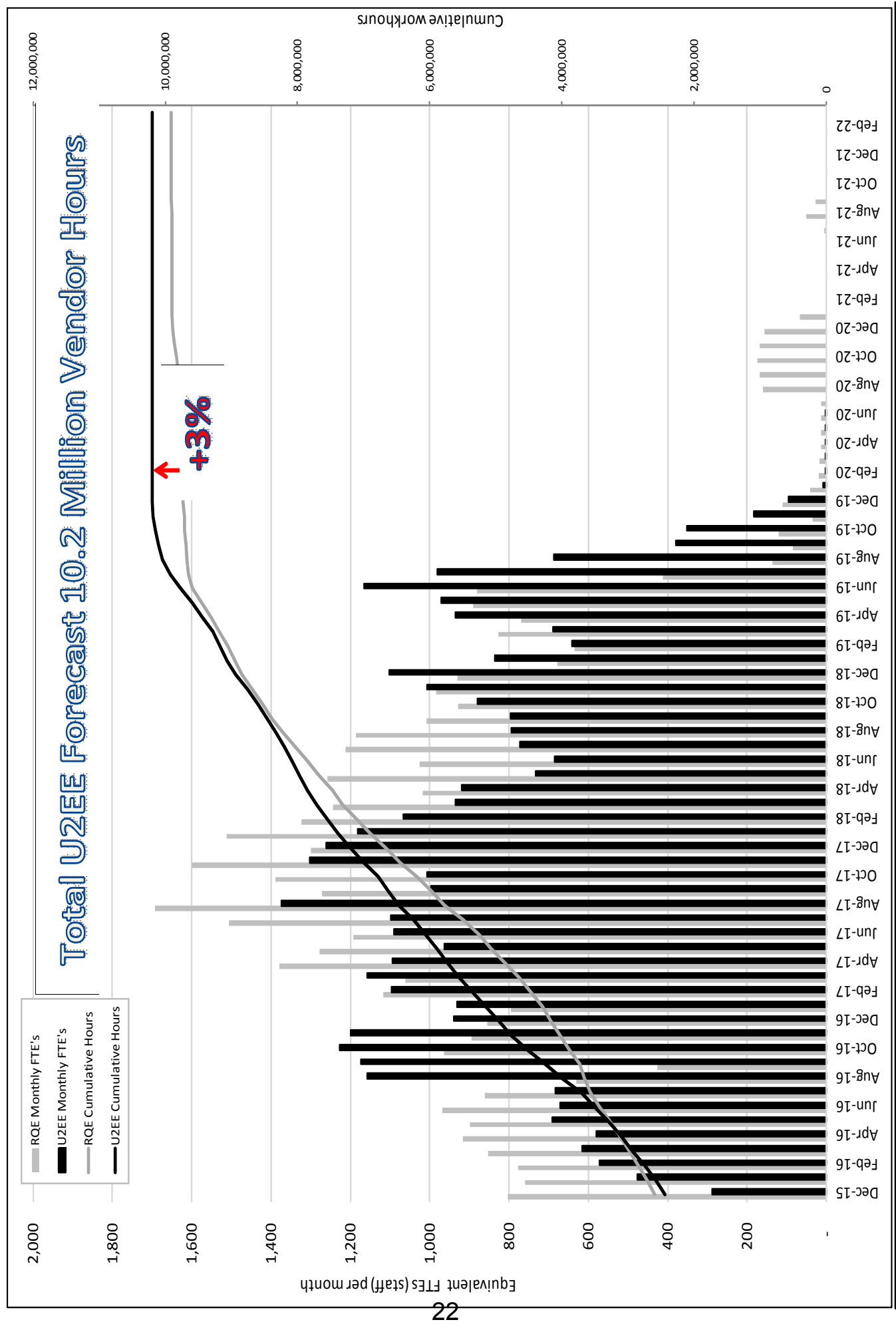


APPENDIX 5A: RESOURCE ANALYSIS – OPG RESOURCES: U2EE vs. RQE

The following chart includes OPG Project Management, Oversight and Functional Support, plus Operations & Maintenance



APPENDIX 5B: RESOURCE ANALYSIS – VENDOR RESOURCES: U2EE vs. RQE (UNIT 2)



APPENDIX 6: FUNDING RELEASE CALCULATION

<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	<i>e=c+d</i>	<i>f</i>	<i>g=e+f</i>
#		Cumulative Release 4	Approved Release 5a (at RQE)	Cumulative Release 5a	Current Request	Cumulative Release 5b (Unit 2)
1	Unit 0 (Common)	128,000	230,701	358,701	631	359,332
2	Unit D (Definition)	1,014,997	97,062	1,112,059	139,155	1,251,214
3	Unit 2	371,382	360,995	732,377	2,007,216	2,739,593
4	Subtotal thru U2	1,514,379	688,758	2,203,137	2,147,002	4,350,139
4	Unit F (F&IP projects)	693,547	186,983	880,530	94,293	974,823
5	Unit S (SIO Projects)					
6	Subtotal Campus Plan	693,547	186,983	880,530	94,293	974,823
7	Unit 3	0	45,805	45,805	0	45,805
8	Unit 1	0	50,730	50,730	0	50,730
9	Unit 4	0	5,465	5,465	0	5,465
10	Subtotal Other Units	0	102,000	102,000	0	102,000
10	Contingency U2	0	42,699	42,699	634,753	677,452
12	Subtotal Other	0	42,699	42,699	634,753	677,452
12	Total DNP	2,207,926	1,020,440	3,228,366	2,876,047	6,104,413

^

Requested 5b

2,876,047

October 1, 2015

Darlington Refurbishment Program:
Execution Phase Readiness and Business Case Summary

REASON FOR REPORT

The purpose of this report is to provide the following:

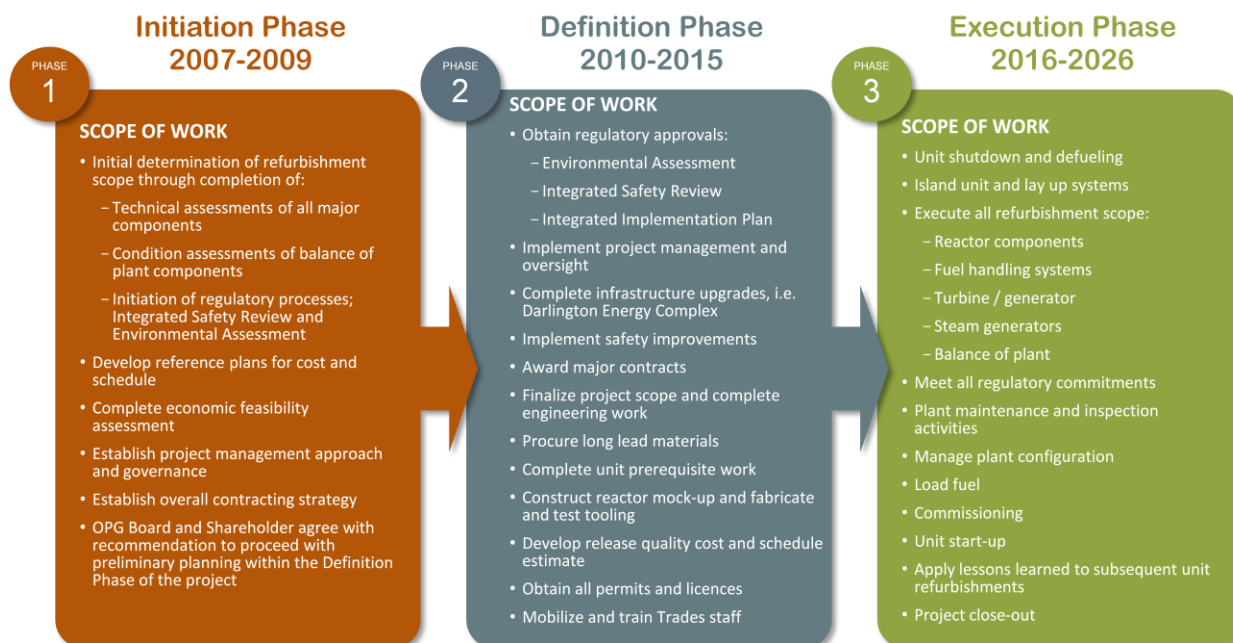
- An update on the status of the Darlington Refurbishment Program (“DRP”) Definition Phase activities,
- An overview of the cost and schedule estimate for the execution phase to be presented in November with a recommendation on final contingencies and management reserve, and
- A summary of the business case including key OPG benefits and the expected energy cost from the refurbished Darlington station.

HIGHLIGHTS

Definition Phase Update

In 2009, the DRP identified three phases of project development as shown in Figure 1. The Initiation Phase, completed in 2009, concluded with the approval of a “Feasibility Business Case” allowing Management to proceed to the Definition Phase. In the past five years, the DRP has completed its planning deliverables including completion of the Canadian Nuclear Safety Commission’s (CNSC) regulatory requirements related to the refurbishment and life extension of a nuclear plant, as identified in regulatory document RD-360. Management is now ready to proceed to the Execution Phase and have developed the overall 4-unit scope, cost, and schedule estimate including preparation of an execution phase business case, as outlined in this document.

Figure 1: Darlington Refurbishment Phases of Project Development



Execution Phase Cost Estimate

OPG is nearing completion of the development of its Execution Phase cost estimate. Estimates have been received from all vendors and have been integrated into the overall cost estimate and a detailed risk register has been developed. A preliminary cost and schedule contingency analysis has also been performed; however, further reviews are underway and the estimate will be finalized by October 15th in advance of the November Board meeting. Management believes that the base project estimate and contingency amounts provided within this document are bounding and that any further refinement will reduce the overall project estimate, before Management Reserve is applied.

Figure 3 provides a summary of the cost build-up for the Execution Phase of the project. Of the \$12.8 Billion estimate, \$2.3 Billion has been spent in the Definition Phase and the Execution Phase estimate is \$10.5 Billion. In addition to external vendor bundle costs to execute the major scopes of work, the project is carrying costs for vendor oversight, operations and maintenance and general project support. The project estimate also includes an estimate for CNSC fees and insurance.

OPG is responsible for providing the insurance coverage under an Owner Controlled Insurance Program, where the project owner places the construction insurance program rather than the contractor. This allows OPG to leverage the insurers on the corporate program for optimal terms and conditions. The Insurance estimate includes Course of Construction-Property, Wrap-Up Liability, Marine Cargo and Advance Loss of Profit, Nuclear Energy Physical Damage-Property, and Delayed Start-up insurance.

Figure 3: Execution Phase Cost Estimate Build-up

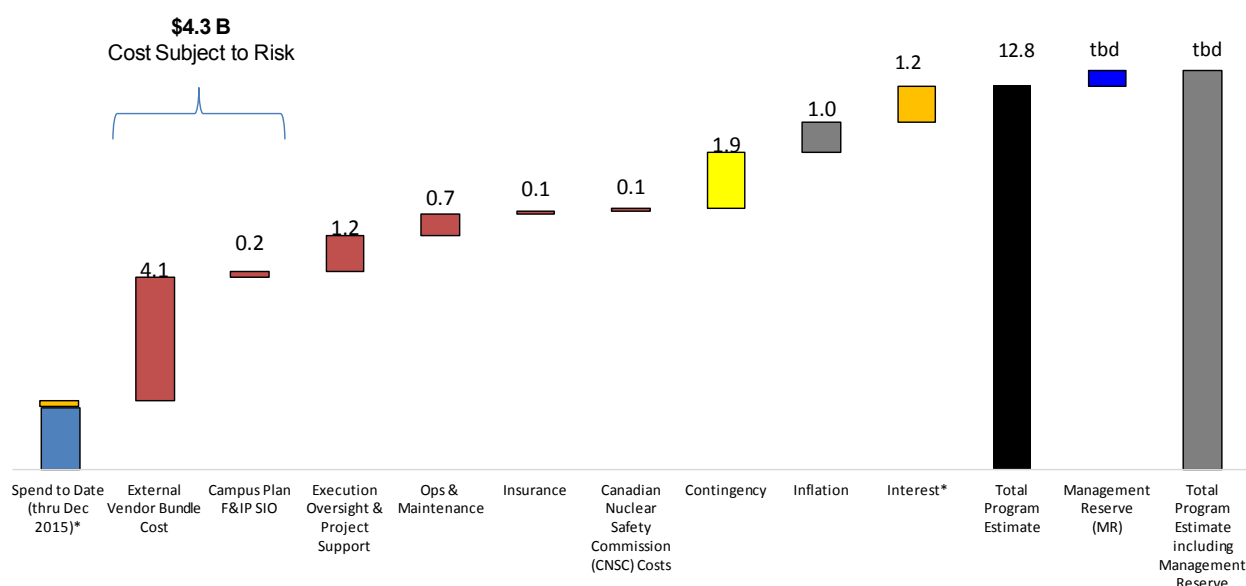
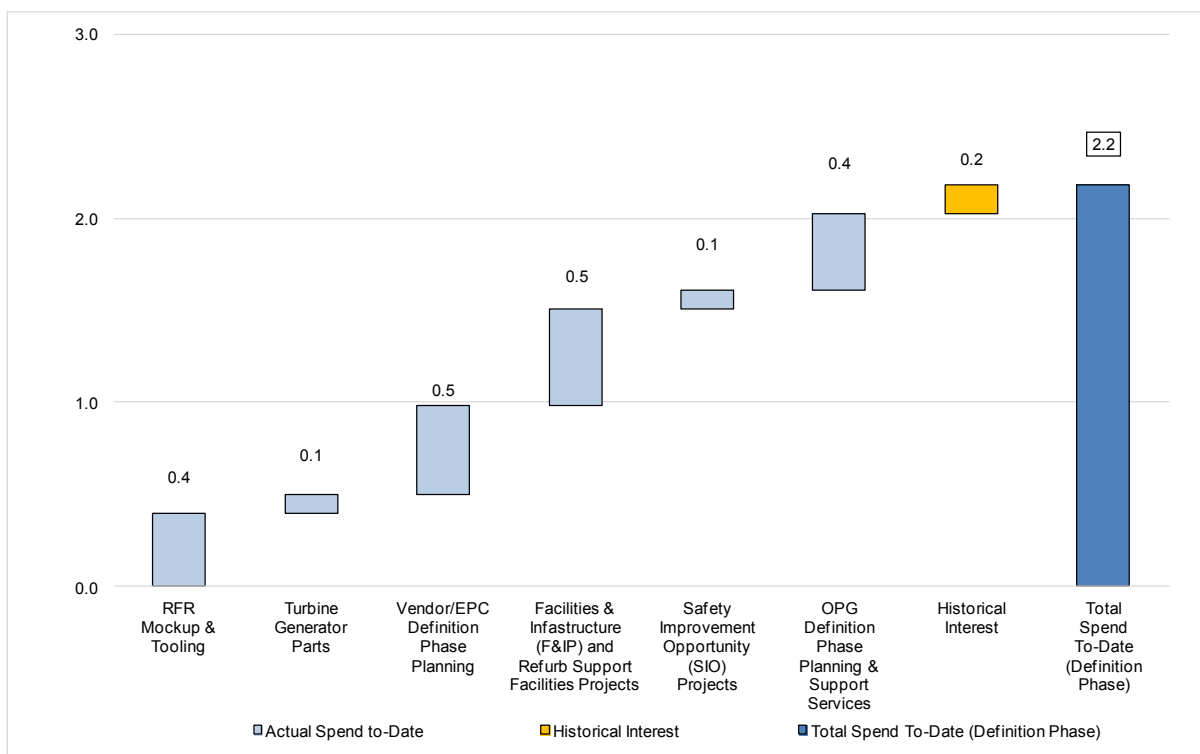


Figure 4 provides a breakout of external vendor bundle costs for EPC activities including those incurred in the Definition Phase and those to be incurred in the Execution Phase.

Figure 1
Summary of Life to Date Definition Phase Spending to December 31, 2015 (B\$)



The primary outputs of the Definition Phase was: (i) complete planning, including scoping, engineering, cost estimating, and scheduling, (ii) complete pre-requisite activities to enable the refurbishment including facilities, tooling, and a full scale reactor mock-up, and (iii) to obtain approval from OPG's Board of Directors as well as from the Province of the four-unit cost and schedule budget, or RQE, for the DRP. Obtaining RQE signified that detailed planning was complete and set in place a Program level scope, cost and schedule baseline for the four-unit DRP. In addition, RQE approval established the basis for release of Execution Phase funding for the Unit 2 refurbishment. OPG successfully met the following key Definition Phase milestones in order to obtain RQE approval:

- *Scope Definition:* Developed a detailed definition of scope, including clarification of what work is required to be done during the refurbishment outage versus the work occurring outside the refurbishment outage, and established the regulatory scope

Table 1
OM&A - Darlington Refurbishment (\$M)

Line No.	Description	2013 Actual	2014 Actual	2015 Actual	2016 Budget	2017 Plan	2018 Plan	2019 Plan	2020 Plan	2021 Plan
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
1	Darlington Refurbishment - Unit Refurbishment ¹	4.6	4.3	1.4	1.0	41.5	13.8	3.5	48.4	19.7
2	Facilities and Infrastructure Projects ²	1.7	2.0	0.1	0.3	0.0	0.0	0.0	0.0	0.0
3	Safety Improvement Opportunities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	Total Darlington Refurbishment OM&A	6.3	6.3	1.6	1.3	41.5	13.8	3.5	48.4	19.7

Notes:

1

The Unit Refurbishment 2016-2021 amounts include removal costs of existing structures or facilities, and L&ILW variable expense.

2

The F&IP 2013-2021 numbers include removal costs of existing structures or facilities prior to construction or modification.

Pre-requisite Projects Summary

No	Project Description	Contractor	Need Date	Current Forecast Date	
				2016	2017
1	Darlington Energy Complex	McKay Cocker	In-Service		
2	Operations Support Building Refurbishment	B&M	In-Service		
3	Re-tube & Feeder Replacement Island Support Annex	ES-FOX	In-Service		
4	Refurbishment Project Office	ES-FOX	In-Service		
5	Vehicle Screening Facility	ES-FOX	In-Service		
6	Holt Road Interchange Improvements	MTO	In-Service		
7	Electrical Power Distribution	B&M	In-Service		
8	Auxiliary Heating System	ES-FOX	Note 1	May	
9	Water and Sewer	B&M	In-Service		
10	Heavy Water Storage & Drum Handling Facility	SLN-AECON	Feb 2017 (Unit 2)	Sept (Unit 2)	May (Full)
11	Re-tube Waste Processing Building	SLN-AECON	Jul 2017	Dec	
12	3 rd Emergency Power Generator	ES-FOX	Oct 2016	Sept	
13	Containment Filtered Venting System	ES-FOX	Oct 2016	May	
14	Power House Steam Venting System	B&M	In-Service		
15	Shield Tank Overpressure Protection	B&M	Note 2	Apr (Unit 4) Oct (Unit 3)	Feb (Unit 1)
16	Emergency Service Water	ES-FOX	In-Service		
17	Re-tube Waste Storage Building (Note 3)	ES-FOX	Jul 2017		Jun
18	Used Fuel Dry Storage Building (Note 3)	ES-FOX	In-Service		

Notes: (1) Project is not required for Refurbishment. (2) Project will be installed on Units 1, 3 and 4 during planned Unit outages and on Unit 2 during Refurbishment. (3) Project is Provision funded.

Chart 1

Reconciliation of F&IP Project List to EB-2013-0321 Ex. D2-2-1, Tables 3 and 4

Project	Project Number	EB-2013-0321	EB-2016-0152	Total Project Cost based on approved project BCS (\$M)
Projects >\$20M				
Heavy Water Storage and Drum Handling Facility	31555	DRP	DRP	381.1
Water & Sewer Project	73802	DRP	DRP	57.7
Darlington Energy Complex	73803	DRP	DRP	105.4
Retube Feeder Replacement Island Support Annex	73810	DRP	DRP	40.7
Refurbishment Project Office	73815	DRP	DRP	99.9
Darlington Operations Support Building Refurbishment	25619	DRP	Nuclear Operations Portfolio	62.7
Darlington Auxiliary Heating System	34000	DRP	Nuclear Operations Portfolio	99.5
Electrical Power Distribution System	73821	DRP	DRP	20.8
Projects \$5M - \$20M				
GM Facility Interim Office Leasehold Improvements	73806/ 73814	DRP	DRP	9.3

In addition to the projects in the table above, the following projects were reclassified as Nuclear Operations Portfolio projects:

- Emergency Service Water Pipe and Component Replacement (Project 73397, Ex. D2-1-3, Table 2d)
- Primary Heat Transport Pump Motor Replacements (Project 73566/ 80144, Ex. D2-1-3, Table 1)
- Primary Heat Transport Pump Motor Overhaul (Project 73566/ 80144, Ex. D2-1-3, Table 1)

UNDERTAKING JT1.16

Undertaking

TO PROVIDE THE BREAKDOWN BETWEEN CAPITAL AND OM&A AMOUNTS

Response

The following table represents the details that make up the \$327 million Capital and \$533 million OM&A as per Ex. L-4.3-2 AMPCO-105.

OM&A and Capital Costs Details Underlying AMPCO 105 (\$M)	Total
Unit Maintenance / Operations (Online / Outage)	398
Contracted Maintenance Programs (T/G, BOP)	81
Engineering Systems Surveillance Activities	28
Operator Training Program	25
Total OM&A	533
Darlington Operations Support Building Refurbishment	63
Darlington Auxiliary Heating System	99
Emergency Service Water Pipe and Component Replacement	7
Primary Heat Transport Pump Motor Replacements & Overhaul	130
Highway 401 & Holt Road Interchange	29
Total Capital	327

Note: Numbers may not add due to rounding.

Project #34000 Darlington Auxiliary Heating System:

The auxiliary heating system (“AHS”) project involves the replacement of the life expired original station construction era boiler house at the Darlington site. Auxiliary heating is required as backup in order to protect station systems in the event that there is a power outage and loss of electricity and heating in the power plant on cold days. The project was undertaken to address a long standing CNSC concern regarding the adequacy and reliability of the backup heating available in the event of a four unit outage during the winter. The new AHS facility would provide a source of reliable back-up steam to the Darlington Nuclear Generating Station main heating steam in the event of a four unit shutdown, thereby mitigating potential major equipment damage due to freezing. The AHS project was reclassified to the Nuclear Operations Project Portfolio in 2015, as discussed in Ex. D2-1-10.

During EB-2013-0321, OPG updated the forecasted total project cost of the AHS project to \$85.1M as set out in an execution release BCS. OPG also provided a forecast in-service amount of \$75.3M in 2015.

The expected final forecast project completion cost, including the demolition of the construction boilerhouse slated for October 2016, has increased by \$14.4M to \$99.5M, as set out in the full release BCS included in Attachment 1, Tab 11 to this exhibit. This increase is for additional funding to complete the construction of the AHS and commissioning, demolition of the construction boilerhouse and close out. The in-service amount is \$94.2M in 2016. The increase is a result of several factors with the most significant being higher than anticipated engineering-procurement-construction contract costs resulting from the following:

- Approved project change authorizations due to design and construction scope changes (+\$3.9M)
- Under-estimation of vendor engineering, construction and commissioning support (+\$5.8M)
- Under-estimated fabrication and installation sub-contractor costs (+\$4.3M)
- Increased labour costs, e.g., lengthened schedule for completion (+\$2.7M)
- Increased internal project management and support costs (\$1.7M)
- Increased material costs (+\$1.0M)

- Increased interest due to the longer construction schedule (+\$0.3M)

These cost increases were offset by reduced project contingency (-\$5.3M).

Project #25619 Darlington Operations Support Building Refurbishment: The operations support building ("OSB") (also reclassified from the DRP per Ex. D2-1-10) houses various technical services (e.g., site security, site information technology, telephone network hubs) essential to the business operations of Darlington pre- and post-refurbishment. The OSB was constructed in 1982, with a third floor added in 1988. An assessment by an external engineering firm found that many of the existing building systems are or would life expire by 2015 and concluded that the preferred alternative was refurbishment of the building.

During EB-2013-0321, OPG provided an updated forecast in-service amount of \$45.1M in 2015. This was based on a forecast total project cost of the OSB refurbishment project of \$47.7M (including contingency) as set out in the partial release BCS included in Attachment 1, Tab 1 to this exhibit.

The forecast project completion cost of the OSB is now \$62.7M, which consists of a full release for execution of \$53.0M with a superceding release for an additional \$9.7M. This increase is primarily due to increased engineering, procurement and construction ("EPC") contract costs (+\$8.8M) arising from under-estimation of effort to complete contract scope, including scope additions for electrical distribution equipment upgrades, additional telephone and information technology cable and hardware, upgrades to fire separation barriers and other minor changes.

In-service amounts are \$55.1M in 2015 and \$3.6M 2016.

Project #25609, Security Physical Barrier System: A supplemental release of \$67.2M for an additional \$17.7M over the full release of \$49.5M was primarily due to:

- Settlement of a claim by a subcontractor to the EPC vendor (+\$7.0M)
- Higher costs to complete portions of the project (+\$1.1M)

CCC Interrogatory #24

Issue Number: 5.1

Issue: Is the proposed nuclear production forecast appropriate?

Interrogatory

Reference:

Reference: Ex. E2/T1/S1

Please list in table form all of the planned outages that are included in the test period forecast, the duration of each planned outage, the lost production resulting from each planned outage and the dollar value of each planned outage based on the proposed nuclear payment amount that would result if OPG is able to cancel the planned outage.

Response

Please see Table 1 attached.

Year		Outage	Unit Affected	Description	Outage Duration (days)	Forecast Production (TWh) Impact Due to Outage	Revenue Impact of Outage (\$M)
2017	Pickering	P1711	Unit 1	Planned Outage	204.9	2.6	168.0
		P1742	Unit 4	Mid-Cycle Outage	43.0	0.5	35.2
		P1751	Unit 5	Planned Outage	160.7	2.0	132.0
		P1761	Unit 6	Planned Outage	133.0	1.7	109.2
		Total			541.6	6.8	444.4
	Darlington	D1711	Unit 1	Planned Outage	108.4	2.3	152.9
		DNRU2	Unit 2	Refurbishment Outage	365.0	7.8	514.8
		D1731-PD	Unit 3	Planned Derate	2.5	0.1	3.5
		D1732	Unit 3	PHT Pump Motor Outage	20.0	0.4	28.2
		D1741-PD	Unit 4	Planned Derate	2.5	0.1	3.5
		D1742	Unit 4	PHT Pump Motor Outage	20.0	0.4	28.2
	Total			518.4	11.1	731.2	
	Total 2017				1,060.0	17.9	1,175.6
2018	Pickering	P1812	Unit 1	Mid-Cycle Outage	43.0	0.5	39.1
		P1841	Unit 4	Planned Outage	144.1	1.8	131.2
		P1871	Unit 7	Planned Outage	193.5	2.4	176.4
		P1881	Unit 8	Planned Outage	150.2	1.9	136.9
	Total			530.8	6.6	483.6	
	Darlington	D1811	Unit 1	PHT Pump Motor Outage	20.0	0.4	31.3
		DNRU2	Unit 2	Refurbishment Outage	365.0	7.8	571.4
		D1831	Unit 3	Planned Outage	103.3	2.2	161.7
		D1841	Unit 4	PHT Pump Motor Outage	20.0	0.4	31.3
	Total			508.3	10.9	795.8	
	Total 2018				1,039.1	17.5	1,279.4
2019	Pickering	P1911	Unit 1	Planned Outage	128.5	1.6	129.8
		P1942	Unit 4	Mid-Cycle Outage	43.0	0.5	43.4
		P1951	Unit 5	Planned Outage	165.6	2.1	167.6
		P1961	Unit 6	Planned Outage	180.1	2.2	182.3
	Total			517.2	6.5	523.1	
	Darlington	D1911	Unit 1	PHT Pump Motor Outage	20.0	0.4	34.8
		D1912-PD	Unit 1	Planned Derate	2.5	0.1	4.3
		DNRU2	Unit 2	Refurbishment Outage	365.0	7.8	634.3
		P1931-PD	Unit 3	Planned Derate	2.5	0.1	4.3
		D1941	Unit 4	Planned Outage	99.1	2.1	172.2
	Total			489.1	10.5	850.0	
Total 2019				1,006.3	16.9	1,373.1	
2020	Pickering	P2012	Unit 1	Mid-Cycle Outage	43.0	0.5	48.2
		P2041	Unit 4	Planned Outage	164.5	2.0	184.4
		P2071	Unit 7	Planned Outage	102.5	1.3	115.1
		P2081	Unit 8	Planned Outage	188.9	2.4	212.2
	Total			498.9	6.2	560.0	
	Darlington	D2011	Unit 1	Planned Outage	108.2	2.3	208.7
		DNRU2	Unit 2	Refurbishment Outage	45.0	1.0	86.8
		D2022-PD	Unit 2	Planned Derate	2.5	0.1	4.8
		D2021	Unit 2	Post Refurb Mini Outage	55.0	1.2	106.1
		DNRU3	Unit 3	Refurbishment Outage	321.0	6.9	619.2
		D2042-PD	Unit 4	Planned Derate	2.5	0.1	4.8
		D2041	Unit 4	PHT Pump Motor Outage	20.0	0.4	38.6
	Total			554.2	8.6	773.6	
Total 2020				1,053.1	14.8	1,333.5	
2021	Pickering	P2111	Unit 1	Planned Outage	150.5	1.9	187.3
		P2141	Unit 4	Vacuum Building Outage	30.0	0.4	37.3
		P2151	Unit 5	Planned Outage	179.7	2.2	224.1
		P2161	Unit 6	Planned Outage	112.6	1.4	140.4
		P2162	Unit 6	Vacuum Building Outage	30.0	0.4	37.4
		P2171	Unit 7	Vacuum Building Outage	30.0	0.4	37.4
		P2181	Unit 8	Vacuum Building Outage	30.0	0.4	37.4
		Total			562.8	7.0	701.3
	Darlington	DNRU1	Unit 1	Refurbishment Outage	200.0	4.3	428.3
		D2121	Unit 2	Post Refurb Mini Outage	31.2	0.7	66.8
		D2122-PD	Unit 2	Planned Derate	2.5	0.1	5.4
		DNRU3	Unit 3	Refurbishment Outage	365.0	7.8	781.6
		D2142-PD	Unit 4	Planned Derate	2.5	0.1	5.4
		D2141	Unit 4	PHT Pump Motor Outage	20.0	0.4	42.8
	Total			621.2	13.3	1,330.2	
	Total 2021				1,184.0	20.3	2,031.5

UNDERTAKING JT1.2

Undertaking

TO ADVISE WHAT OPG IS OVERSEEING WITHIN THE PROJECT AND TO BREAK DOWN COSTS ASSOCIATED WITH UNIT 2

Response

OPG has interpreted the question to provide oversight costs consistent with the categories listed D2-2-8 Chart 3 for both the total RQE as well as Unit 2.

Oversight costs have been defined to include those costs associated with performing oversight of vendors who are executing work in the field. This includes direct oversight of project teams as performed for each project bundle, as well as indirect oversight of project execution which includes construction, safety, and quality oversight. Contract Management performing commercial oversight, Managed Systems Oversight performing assurance activities, Planning and Controls which performs project controls including estimating, cost management, change management, and reporting, and Work Control performing scheduling and day-to-day work management are also included in oversight.

The costs which have been excluded are not considered oversight, but are instead providing support to the executing organizations. For example:

- Operations and Maintenance functional costs are considered as support costs as these costs predominantly relate to the “custodian” role, controlling authority, as well as radiation protection services.
- Engineering costs are predominantly to support design and return-to-service activities.

DRP OPG Oversight costs represent costs across the entire program (2010 – 2026), whereas Unit 2 OPG Oversight costs are related to Unit 2 including during the definition phase (2010 – 2020).

33 D2-2-8 Chart 3 - DRP RQE Breakdown (\$M)

34

#	Bundle / Category	DRP OPG Oversight	U2 OPG Oversight
1	Retube & Feeder Replacement	167	106
2	Turbine Generators	41	22
3	Balance of Plant	183	98
4	Fuel Handling/Defueling	49	32
5	Steam Generators	13	6
6	Subtotal Major Work Bundles	452	264
7	Facility and Infrastructure Projects	-	-
8	Safety Improvement Opportunities	-	-
9	Subtotal F&IP / SIO	-	-
10	Project Execution	180	88
11	Contract Management	52	25
12	Engineering	-	-
13	Managed Systems Oversight	41	25
14	Planning & Controls	95	65
15	Nuclear Safety	-	-
16	Program Fees & Other Support	-	-
17	Supply Chain	-	-
18	Work Control	80	30
19	Ops & Mtce	-	-
20	Early Release 3	-	-
21	Early Release 4	-	-
22	Subtotal OPG Functions	447	233
23	Contingency	-	-
24	Subtotal before Escalation	899	497
25	Interest	-	-
26	Escalation	-	-
27	Subtotal Interest & Escalation	-	-
28	Total Oversight	899	497

35

**OPG ACTIONS TAKEN/PLANNED IN ALIGNMENT
WITH LTEP PRINCIPLES**

2013 LTEP – Nuclear Refurbishment Principles	OPG Actions Taken/Planned in Alignment with LTEP Principles
Minimize commercial risk on the part of ratepayers and government	<ul style="list-style-type: none"> • Locked down project scope well in advance of starting construction; • Fully developed engineering and planning of the work so that it is 100 per cent complete prior to the start of construction; • Built a full-scale mock-up of the Darlington reactor and vault and used them to fully test the tools and determine tooling durations in order to build a reliable schedule. All workers will be trained using the tools in the mock-up prior to working in the plant; • In phases, developed a Release Quality Estimate that incorporates a high-confidence budget and schedule for the work; • "Unlapped" Unit 2 from subsequent units so that the focus can be on planning and construction of a single unit to ensure its success while documenting lessons learned from the first unit and applying them to work processes on subsequent units; • Utilizing target price contracts for the execution phase that are based on developing cooperation, transparency, and risk sharing with key vendors; • Utilizing fixed price contracts for certain execution phase scope that is well defined and where risk transfer to a third party is appropriate; • Negotiated various off-ramps and stages into contracts; and • Established a robust risk management process to directly identify and administer commercial risks.
Mitigate reliability risks by developing contingency plans that include alternative supply options if contract and other objectives are at risk of non-fulfillment	<ul style="list-style-type: none"> • Decision to "unlap" Unit 2 from the other unit refurbishments, which predated the LTEP, was intended to mitigate performance risk and allow the DRP team to focus on refurbishing the first unit prior to commencing subsequent units. If the first unit is not successful, off-ramps are in place; the second unit refurbishment will not commence until the first unit is successfully returned to service. • Risk assessment and appropriate contingency and mitigation plans for each execution work package have been developed. • OPG's investment in the reactor mock-up is being used to perform full integration and commission testing of tools needed for refurbishment; lessons are being learned on the mock-up,

	<p>not on the unit. The results of the mock-up testing have been incorporated into the tooling performance guarantee, which sets the target schedule and price, with the RFR vendor.</p>
<p>Entrench appropriate and realistic off-ramps and scoping</p>	<ul style="list-style-type: none"> • OPG has engaged in a deliberate process with numerous off-ramps for the definition phase including Board of Directors oversight and annual releases of funds. • Each contract has off-ramp provisions allowing OPG to terminate, with or without cause; OPG would be accountable to reimburse contractors only for any reasonably incurred costs. • Scope review process in place to minimize scope of work performed in refurbishment period to address things that must be done to extend life or that can only be done in drained/defueled state. • OPG has fully examined the scope of the Unit 2 refurbishment project and optimized the work based on OPG's regulatory commitments and/or analysis of the best time to perform the work.
<p>Require OPG to hold its contractors accountable to the nuclear refurbishment schedule and price</p>	<ul style="list-style-type: none"> • OPG, in implementing all of its contracts, is highly focused on achieving value for money; there are incentives and disincentives related to achieving the cost and schedule set out in the contracts. • Contracts with major contractors have been developed and vetted utilizing a deliberate, staged and gated process with requirements for budget, schedule, scope, and risk identification at each gate. • Contracts have specific negotiated incentives and disincentives that are calculated toward promoting the contractor's (and OPG's) responsible management of the work. • OPG is implementing a detailed, integrated Level 3 schedule that will encompass all of the contractors' and OPG's work, as well as a rolled-up Level 2 Control and Coordination Schedule that is used as a higher level interfacing tool. • OPG has implemented cost control systems that are geared toward holding contractors accountable. These systems include earned value and budget controls, as well as validation of progressive project plans, through a gated process. • OPG performs analysis of all pricing and checks estimates for contractors' work. • OPG's senior management have established separate regular steering committees with each of the major contractors' executives which provide senior level leadership with a forum to discuss progress, potential and real issues impacting performance and commercial issues.
<p>Make site, project management,</p>	<ul style="list-style-type: none"> • RQE fully considered all of the factors listed in advance of execution of the work.

<p>regulatory requirements and supply chain considerations, and cost and risk containment, the primary factors in developing the implementation plan</p>	<ul style="list-style-type: none"> • Taking lessons from Pickering A, the DRP team completed the identification of all regulatory requirements well in advance of final design and construction. • OPG has completed the design and proving of the RFR tools. • Procurement of all long lead materials commenced well in advance of the start of the first unit refurbishment with all deliverable dates confirmed to be well in advance of the need dates. Mitigation plans are in place for any material that is not on hand well in advance of the need date. • OPG has implemented, in accordance with Project Management Institute standards and Association for Advancement of Cost Engineering best practices, project controls and risk management programs, as well as a continuous improvement focus, to refine these tools as the outage nears. • OPG has retained external oversight and engaged other corporate functions in providing input and assurance that the DRP team is meeting its commitments.
<p>Take smaller initial steps to ensure there is opportunity to incorporate lessons learned from refurbishment including collaboration by operators.</p>	<ul style="list-style-type: none"> • To fully incorporate lessons learned from the refurbishment of the first unit (Unit 2), the start of refurbishment work on the second unit (Unit 3) has been delayed until the completion of the first unit. While Unit 2 is underway, lessons learned will be captured and incorporated into Unit 3 planning. • OPG has filled key positions in its project management team with individuals having direct experience with prior CANDU refurbishments. • OPG has contracted with SNC/Aecon, whose subsidiary CANDU Energy (formerly AECL) has been associated with each of the prior refurbishments. • OPG and its contractors have studied lessons learned and operating experience from prior projects and incorporated those into the DRP. • OPG routinely collaborates with other CANDU operators directly and through the CANDU Owner's Group. OPG established a Memorandum of Understanding with Bruce Power to support collaboration.

CCC Interrogatory #17

Issue Number: 4.1

Issue: Do the costs associated with the nuclear projects that are subject to section 6(2)4 of O. Reg. 53/05 and proposed for recovery meet the requirements of that section?

Interrogatory

Reference:

Reference: Ex. A1/T3/S1/p. 3

Does OPG have the discretion to stop the DRP in its entirety or at any stage of its completion? If so, under what conditions might OPG consider exercising that discretion? Does OPG have the discretion to change the scope or timing of the DRP at any stage? If so, under what conditions might OPG consider exercising that discretion?

Response

OPG's plan is to complete the refurbishment of all four units at Darlington and the project planning, project infrastructure and contracts have been put in place to achieve this goal. The Ministry of Energy has endorsed OPG's plan to refurbish all four units.

OPG does not have full discretion to stop the DRP in its entirety at any stage or to change the scope and timing of the DRP at any stage without consulting its Board of Directors and the Ministry of Energy.

OPG will continually exercise due diligence throughout the DRP to ensure that the economic and strategic benefits of continuing with the DRP remain robust. Given the strategic importance of the DRP to the Province of Ontario, OPG's Board of Directors, the Province of Ontario, the IESO and other stakeholders will exercise a continuing high degree of oversight (see Ex. D2-2-9, p. 8 for a description internal to OPG as well as external oversight). Because of the multi-unit nature of the DRP among other factors, OPG would expect the strategic and economic benefits of the DRP to be reconfirmed at least as frequently as after the completion of each unit's refurbishment, i.e., that there continues to be a strong business case to proceed with the remaining units. Please see also L-4.3-1 Staff-44.

Schedule Performance Index, CPI and variance metrics are all past-performance oriented. For the DRP, OPG also uses forecasts at the Program and project levels against approved life cycle estimates in order to proactively assess future success and take early corrective action where required. A key metric used for this purpose is *Forecast or Estimate at Completion*, which is determined by adding the Actual Cost and the Estimate to Complete (Estimate at Completion = Actual Cost + Estimate to Complete). For the example, the Estimate at Completion would be \$2,500 + \$800 based on the forecast provided, for a total of \$3,300. Note that the forecast can be determined through a variety of methods, including simply by using the original planned value, or actual unit cost to determine the forecast. The *Variance at Completion* is equal to the Budget at Completion less the Estimate at Completion, which in the example is calculated as \$4,000 - \$3,300, or \$700.

7.0 REPORTING

An integral part of successful project management is reliable and accurate performance information. Reporting provides this performance information through the collection, collation and presentation of data and information. The key objectives of reporting are to:

- ensure information is being communicated to the right stakeholders such that the appropriate decisions can be made, actions taken, or awareness generated;
- communicate the status of the program including any trends, variance from plan, and how the potential variance is being addressed or corrected; and
- ensure information is reliable, accurate and transparent.

OPG plans to issue annual status reports to the public for the duration of the Program through its website. This reporting will include a range of measures, including construction completion, cost performance, schedule performance and safety performance. Chart 1 illustrates the measures that will be provided in the public domain for the duration of the DRP.

Chart 1

Public Reporting on the DRP

Category	Measure
Progress	<ul style="list-style-type: none"> • Key Achievements • % Complete
Safety	<ul style="list-style-type: none"> • All Injury Rate
Quality	<ul style="list-style-type: none"> • Quality Compliance (metrics to be determined)
Cost	<ul style="list-style-type: none"> • Cost Performance Index • Life-to-date cost • Forecast to Complete • Estimate at Complete
Schedule	<ul style="list-style-type: none"> • Schedule Performance Index • Status of Key Milestones • Critical Path Progress • Forecasted Completion Dates

8.0 OVERSIGHT

OPG has developed and implemented an assurance plan that is comprised of several layers of oversight, including from Program staff, external contractors, Program leadership, enterprise leadership and external advisors. The plan ensures appropriate oversight during the execution readiness and Execution Phase of the Program, with a focus on key risk areas. Specifically, oversight will help to ensure that the DRP meets safety, quality, cost and schedule expectations, that issues are identified and resolved expeditiously, and that transparent and accurate information flows up to the Board of Directors.

OPG's oversight and assurance processes are supported by transparent, timely and accurate information flows to support decision making at appropriate levels within the organization. Key aspects of OPG's DRP oversight include:

- *project-specific oversight processes and practices* based on risk management, operating experience, contract requirements, scope of work and reviews of contractor performance by each of the Project Management Teams, as well as by the Project Execution Support Function (see: section 3.2.1 of Ex. D2-2-2);
- *oversight of the Executing Organization* (see Ex. D2-2-2, Figure 1) by the DRP leadership team and by Program functions, including the:

- *Managed Systems Oversight Function*, which provides programmatic oversight based on risks and themes emerging from operational experience, project oversight data, and Program and project risks (see section 3.2.6 of Ex. D2-2-2). Through the Program Assurance Group, the Managed Systems Oversight Function conducts surveillances across the projects focused on identifying emerging problems and opportunities in time to address them, including: process improvement, lessons learned and providing coaching and assistance to the project team and contractors as part of an effective risk management culture; and
- *Planning and Controls Function*, which ensures cost and schedule compliance including forecasting, change management, and milestone adherence, effective risk management, and complete and accurate metric and progress reports.
- *OPG's Internal Audit group*, which provides oversight in a broad range of areas such as scheduling, cost estimates, contractor procurement, quality assurance, cost management, contractor time keeping and EPC contracts. OPG's Internal Audit group has functional independence from management. The Internal Audit group publishes the results of audits in a report and requires management actions be assigned, and tracked to completion. The results of all audits are presented to OPG's Chief Executive Officer and the OPG Board of Directors;
- the *Refurbishment Construction Review Board* ("RCRB"), which supports Program level oversight by the Chief Nuclear Officer and the Chief Executive Officer. The RCRB provides independent assessments of DRP progress, estimates and schedules for early intervention and correction of any shortfalls in execution. The RCRB is comprised of approximately six external members with expertise in nuclear plant operations, mega-projects and relevant regulatory requirements, typically with support from one internal OPG member. It meets quarterly and reports directly to OPG's Chief Executive Officer and its Chief Nuclear Officer. The RCRB will also provide the OPG Board of Directors with an annual report on the scope and execution of the DRP; and

- 1 • the *Darlington Refurbishment Committee of OPG's Board of Directors*, which
2 supports Program level oversight by OPG's Board of Directors. During the Definition
3 Phase, OPG's Board of Directors engaged BMcD/Modus to provide oversight
4 support. A copy of the final quarterly oversight report from BMcD/Modus to OPG's
5 Board of Directors in respect of the Definition Phase is provided in Attachment 2.
6 OPG's Board of Directors has recently re-engaged BMcD with Modus as
7 subcontractors, to provide independent oversight services during the Execution
8 Phase. BMcD will validate the accuracy and transparency of reports from the DRP to
9 the Darlington Refurbishment Committee and validate that DRP assurance processes
10 at the Program level are healthy, robust, and reviewing the right areas.

UNDERTAKING JT1.18

Undertaking

TO PROVIDE THE OPG POSITION ON MONTHLY AND QUARTERLY REPORTING OF THOSE FIGURES

Response

The context for this undertaking is shown in the Technical Conference transcript of November 14, 2016, p. 96, line 23 through to p. 100, line 13 and with reference to OPG's responses to Ex. L-4.3-7 ED-006 and Ex. L-4.3-7 ED-009 with respect to Unit 2 costs and public reporting on the Darlington Refurbishment Program (DRP) respectively.

OPG has considered the request and will issue public reporting on the status of the DRP and specifically on Unit 2 safety, quality, cost performance and schedule performance on a quarterly basis shortly after the issuance of its quarterly Management Discussion and Analysis (MD&A) and external financial reports.

OPG will also issue frequent updates on the status of the project on OPG's website, with the current plan being monthly.

In addition, as discussed in Ex. L-10.4-1 Staff-223, OPG proposes to report annually to the OEB on the DRP performance measures set out in Ex. D2-2-9, pp. 9-10, in conjunction with the reporting on the hydroelectric and nuclear performance measures set out in Ex. A1-3-2, pp. 41-42.



December 2016 Project Performance Update

Key Performance Indicators (KPIs) are an important part of OPG's strategy to ensure project commitments are met, to evaluate performance against plan and to guide decision-making regarding any necessary course adjustments.

OPG's December 2016 KPIs indicate that the organization brought to a close a very productive year for Darlington Refurbishment. After moving from the planning to execution phase with a successful Unit 2 breaker-open and a strong start by the defuelling team, the project gained positive momentum coming into 2017.

SAFETY

- OPG and its vendor partners have been actively communicating the importance of safe work practices in the field. Subsequently, safety performance improved from the month prior.

QUALITY

- The project did not experience any significant quality events.

SCHEDULE

- As a result of defuelling's strong performance, the project was ahead of schedule by 26 days (leading to this work program's early completion date in January).
- The team continued advancing non-critical work, such as Re-tube and Feeder Replacement and Balance of Plant work, aiming to take advantage of time gains.

COST

- As at the end of December, the project was \$43 million under budget — mostly due to the difference between when work was scheduled for completion and when it was actually completed.
- The forecast to complete Unit 2 refurbishment remains within the approved budget.

See the [December 2016 KPI infographic](#) for an overview of project performance, and visit www.opg.com/darlingtonrefurb for regular updates about Darlington Refurbishment.

NUCLEAR REFURBISHMENT

KEY PERFORMANCE INDICATORS FOR **DECEMBER**



SAFETY PERFORMANCE

SLIGHT IMPROVEMENT
IN DECEMBER BUT NINE
MEDICALLY TREATED
INJURIES IN 2016.

OF DAYS
WORKED
SINCE LAST
LOST TIME
INCIDENT

2,556
**DAYS
WORKED
SAFELY**

OVER 2.8 MILLION
HOURS WORKED SAFELY



QUALITY OF WORK

OVERALL, PERFORMANCE
IS GOOD AND REMAINS
STABLE. CORRECTIVE
ACTIONS HAVE BEEN
IMPLEMENTED.

0

**QUALITY
EVENT-FREE
DAY RESET**



IMPACT IDENTIFIED AND CORRECTIVE
ACTIONS IMPLEMENTED.



SCHEDULE PERFORMANCE

CRITICAL PATH FOR
UNIT 2 IS AHEAD OF
SCHEDULE. SOME
NON-CRITICAL WORK
REMAINS BEHIND PLAN.

UNIT 2 CRITICAL PATH SCHEDULE



UNIT 2 ALL WORK SCHEDULE



COST PERFORMANCE

DARLINGTON REFURBISHMENT REMAINS
WITHIN BUDGET OF \$12.8B.

UNIT 2 COSTS ARE \$43M BELOW PLAN DUE
TO SCHEDULE DELAYS. TIGHT COST CONTROL
CONTINUES TO BE A FOCUS.

STATUS



STATUS



■ Excellent □ Good ■ Moderate ■ Poor

GEC Interrogatory #13

Issue Number: 4.5

Issue: Are the proposed test period in-service additions for the Darlington Refurbishment Program appropriate?

Interrogatory

Reference:

If not already filed, please provide copies of all of the quarterly oversight reports from Burns & McDonnell Canada and Modus Strategic Solutions Canada since 2014.

Response

Please see Ex. L-4.3-1 Staff-72, part a.

Please see also the first Burns & McDonnell Canada/Modus Strategic Solutions Canada report for the Execution Phase attached.

Executive Summary

OPG Management's August 11, 2016 report to the DRC affirms the DR Project remains within the overall RQE control budget of \$12.8 billion and that the Project's overall P90 schedule duration has not changed. Based on our review, the Independent External Oversight Team (EO Team) found OPG Management's report to the DRC adequately reflects and is generally focused on the DR Project's current key status points and risks. The process OPG used for developing the Execution Phase schedule has followed accepted industry practices and once complete should provide a good baseline for the Project. We have also reviewed recent output from OPG's assurance programs and find them to be effective.

OPG has accomplished most of its planned readiness activities and, at this time, there are no known imminent threats to Unit 2 breaker open; however, there are issues that require attention that could have a significant downstream impact on the Project if they are not addressed:

- Schedule performance and adherence is an ongoing concern;
- While the technical tools are now in place, cost and schedule trending and forecasting are not mature;
- Aspects of key vendors' readiness for execution are a concern; and
- The Risk Management Program has not been fully embraced as an essential day-to-day management tool.

Evaluation of DR Project Status

The EO Team has identified the following key status points that should be considered for purposes of evaluating the DR Project's health as a whole and for the Board of Directors' approval of management's Unit 2 budget and schedule.

Key DR Project Status Indicators	
Schedule Performance	OPG identified the DR Project's current SPI of 0.91 which equates to being approximately 9-10% behind the Project's P50 schedule (though should not impact the P90 range). The impacts of these delays include late finalization of the Unit 2 Execution Phase schedule, procurement and field preparation that will need to be recovered or mitigated prior to field need dates. The vendors' ability to meet their procurement schedules is a concern. OPG has increased visibility and management attention to resolving outstanding vendor and internal issues.
Cost Performance	<p>Based on all of the available information, the overall Project control budget of \$12.8 Billion has been maintained, though the EO Team identifies three caveats:</p> <ul style="list-style-type: none"> ❖ The final Unit 2 Execution Phase schedule will be completed in mid-September. Until that schedule is completed, issues can materialize that could impact the final Unit 2 budget. OPG Management has reserved the possibility of making changes to the Unit 2 budget until the schedule is closed-out. ❖ Since RQE, \$61M of contingency has been drawn and allocated, which translates to a rate of approximately \$10 Million/month. While we believe this is largely due to finalizing and updating the Unit 2 cost estimate, this velocity of change would be a concern if it continues past the locking-down of the Unit 2 budget. ❖ Risk and contingency calculations for Unit 2 may change as a result of recent additions to the DR Project's risk register. For example, within the last month, certain technical risks have materialized that could have significantly impacted the Project's critical path. While these issues

	were resolved without additions to the base schedule. This underscores the potential for discovery of changes while a project undertakes a detailed baseline schedule review.
Vendor Performance	
Risk Management	Since RQE, OPG has identified a number of new program and project risks. Many of these new risks appear to have been added without benefit of the rigor established during RQE and required Management attention. Key technical risks were identified or revised during the Execution Phase schedule preparation, which are under consideration for Unit 2 contingency calculations.
Safety and Quality	OPG's assurance activities have included identifying adverse safety or quality trends and have been adequate to date.

Project and Program Assurance

The EO Team believes the activities performed by the Project and Program assurance teams have been appropriate and their findings have positively influenced behaviors. The DR Team's Performance Assurance Group (PAG), Enterprise Risk Management and OPG Internal Audit have developed and are executing robust plans for assurance activities. The DR Project's quality and safety trends are being reviewed, tracked and monitored and the Project Team has identified and pursued course corrections.

Effectiveness of OPG Project Team

OPG's Project leadership is displaying its commitment to identifying issues and increasing accountability across all work groups. The OPG Execution Team has revised processes based on the Readiness to Execute and its own OPEX that, on paper, should be effective but must be proven. Ensuring that the vendor and OPG commitments are kept and lines of authority are maintained will be a key contributor to success for the Project.

Strategic Considerations

Based on our independent review of the current DR Project's status, the EO Team offers the following analysis of certain forward-looking risks and strategic considerations as the Project advances to Unit 2's Execution Phase. As a part of our analysis, the EO Team has reviewed and assessed OPG's assurance activities to identify any potential gaps. The risks described below have the potential to challenge the DR Project's ability to maintain the P90 schedule and/or cost.

Risk Area	EO Team Observations
Cost and Change Management	<p>OPG's Internal Audit verified that the DR Team has put into place the tools needed to maintain and analyze cost trends; it is now the Project Team's responsibility to properly use these tools. The Project Team has not been utilizing a consistent process for forecasting the impacts caused by deviations from the plan to overall cost and schedule of any particular project. Moreover, critical information needed from the vendors to prepare accurate forecasts has been suspect or missing.</p> <p>As an example, the DR Team has identified mitigation plans for the late finishing F&IP Projects (D2O Storage Facility, EPG3, CFVS and STOP). Analyzing the full impact of these delays requires the vendors</p>

to provide accurate information and for OPG to validate that information for its cost and schedule forecasts. The current documented status of these projects suggests a high likelihood that OPG will need further draws against contingency due to extended costs and/or recovery of delays, though the vendors' information (or lack thereof) makes accurate analysis of the extent of delays more difficult.

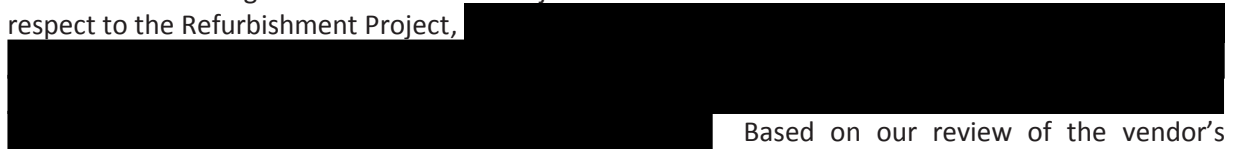
Without robust forecasting, projects have limited ability to estimate the impact of current progress on future completion and, thus, no basis for timely or effective corrective action. On a large and complex project like Refurbishment, this could have a significant impact on the cost and schedule. Going forward, improving the accuracy of cost and schedule forecasts will depend upon the Project Team's use of the available tools, verification of the work in the field and ensuring it is receiving timely and accurate data from the vendors.

Risk Management

Since RQE, the EO Team has seen a broad range of risks added by the Project Team to the risk register. The program and structure is well established and functional. Discrete risks have been clearly identified and represent significant aggregate exposure which must be addressed. However, the Project Team's focus should be aimed at building effective mitigation strategies that can be successfully tracked and executed. The EO Team acknowledges that the OPG assurance teams have identified a number of concerns regarding the Project Team's use of the risk program as a management tool. However, the fact this issue continues to come up is evidence that the Project Team has not fully embraced the Risk Management Program as an essential day-to-day working tool. In our opinion, risk management is just as important to project success as methods used to control cost and schedule.

Vendor Capability and Readiness

To date, the vendors have struggled performing the F&IP projects and in meeting some of their commitments during the Refurbishment Project's Definition Phase. This raises several concerns with respect to the Refurbishment Project,




Based on our review of the vendor's performance over time, we have made the following observations that could have a significant impact on cost and schedule:

- ❖ The OPG Project Team has a tendency to "help" the contractors resolve issues in a manner that imposes unanticipated demands on OPG staff. Care must be taken to ensure that the contractors do not unnecessarily rely on OPG and shift contractual responsibilities.
- ❖ OPG's ability to effectively manage the vendors and anticipate issues depends largely on the quality of the data the contractors provide to OPG. As an example, OPG has not consistently compelled the contractors to provide performance data for its second and third-tier contractors or contractor actual hours, also known as their "burn rates." Such data is critical for assessing the contractor's true performance, assessing productivity and finding troubled areas.
- ❖ OPG has allowed the contractors to re-sequence their projects, which is generally an indicator of either poor performance or poor baseline scheduling. Accountability suffers when a project loses sight of its original baseline. OPG needs to ensure that the contractors are meeting schedule commitments as the Project moves into the Execution Phase and hold them accountable when the schedule slips. Changing a baseline schedule also makes forecasting much more difficult.
- ❖ OPG has requested changes to the key vendors' project management teams which the vendors have honored. It will be important to monitor these changes for their effectiveness.

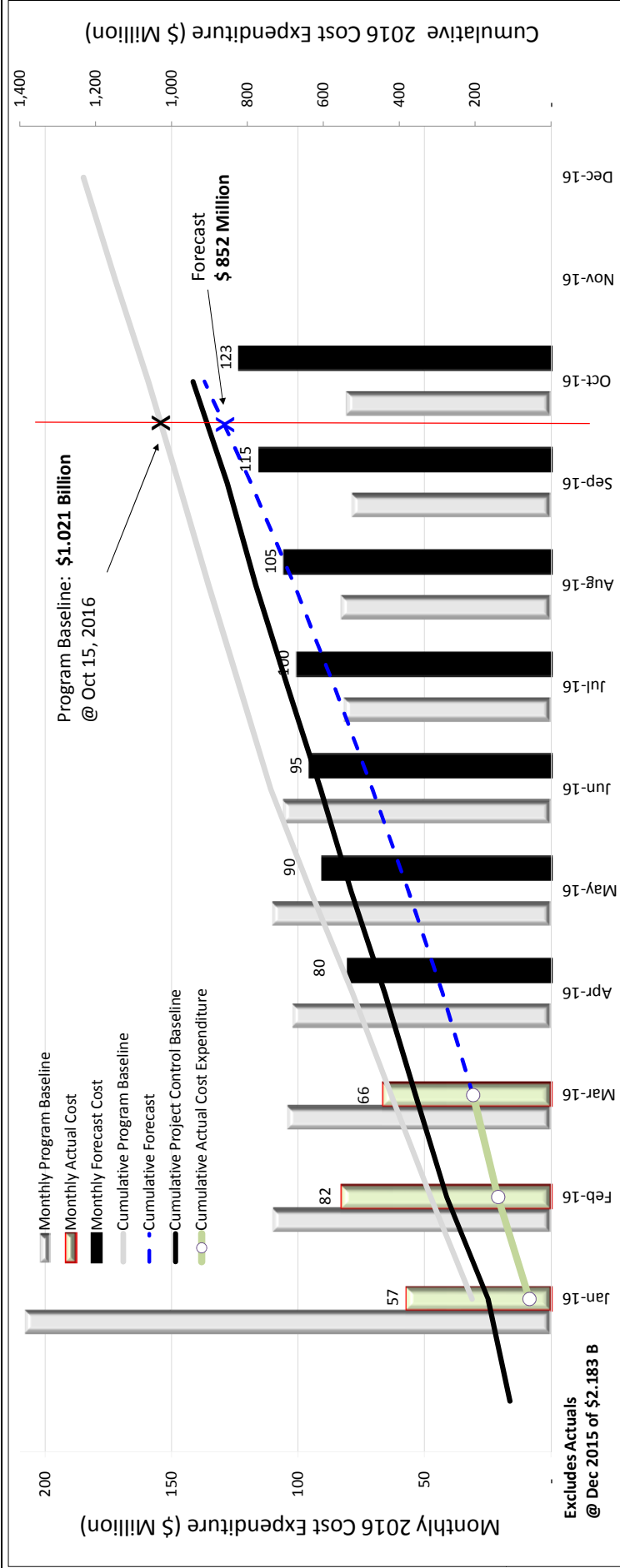
OPG's commercial management team is currently understaffed. OPG is in the process of finalizing an RFP process to retain an outside vendor to assist in this regard, to keep pace with the volume of potential commercial issues, which it anticipates will increase after breaker open.

SAFETY PERFORMANCE - YEAR TO DATE (YTD)					EXPLANATORY NOTES				
All Injury Rate (AIR)		Actual	Target	Status	Safety performance over the period has been positive with zero lost time injuries, and zero Level 1 Work Protection Events.				
Nuclear Refurbishment Program									
OPG and Vendor Refurbishment Staff		0.00	0.24	<div></div>	-				
BUNDLE SAFETY PERFORMANCE - YEAR TO DATE (YTD)									
Line	Bundles	All Injury Rate (AIR)	Accident Severity Rate (ASR)	Reportable Safety Incidents			Incidents		Hours Worked
		Actual	Actual	# Lost Time Injury	# Medical Injuries	# First Aid Injuries	# High MRPH	# Med. MRPH	# Level 1 Work Protection Events
1	Re-tube & Feeder Replacement								
2	Turbine Generator								
3	Fuel Handling & Defueling								
4	Steam Generator								
5	Balance of Plant & Refurb. Support Facilities								
6	Facilities & Infrastructure and Safety Improvement Opportunity Projects								
7	Nuclear Refurbishment Performance	0.00	0.00	0	0	1	1	0	0
VENDOR SAFETY PERFORMANCE - YEAR TO DATE (YTD)									
Line	Vendors	All Injury Rate (AIR)	Accident Severity Rate (ASR)	Reported Safety Incidents			Incidents		Hours Worked
		Actual	Actual	# Lost Time Injury	# Medical Injuries	# First Aid Injuries	# High MRPH	# Med. MRPH	# Level 1 Work Protection Events
1	SNC-Lavalin & Aecon								
2	ES Fox Ltd.								
3	BWXT								
4	GE-Alstom								
5	GE Hitachi Nuclear								
EXPLANATORY NOTES									
1) First Aid was administered when an contractor backed into a furniture partition which tipped over and struck the worker in the back. The contractor reported the incident but was not seriously injured and returned to normal duties. Partitions were subsequently moved until ready for installation and the contractor was coached on situational awareness.									
2) A high MRPH occurred on the Turbine Generator project when a temporary handrail installed on the turbine hall crane struck and damaged a section of lighting fixtures. The fixtures fell on top of the crane, and the light tubes fell approximately 19 meters to the turbine hall floor. No injuries resulted from this event. An investigation is underway to identify causal factors and actions to prevent recurrence.									

QUALITY PERFORMANCE - YEAR TO DATE (YTD)						EXPLANATORY NOTES			
Overall Quality Performance		# Program Event Free Day Resets	# Regulatory Non-Compliance Events	Status	Trend	The yellow status indicator is related to quality issues with [REDACTED]. An investigation is in progress, and Regulators are being kept informed and are satisfied with our oversight of the investigation. The extent of condition review will include documentation of Refurbishment projects, and vendors.			
Nuclear Refurbishment Program									
Significant Quality Events		0	0		-				
BUNDLE QUALITY PERFORMANCE - YEAR TO DATE (YTD)									
Line	Bundles	# Program Event Free Day Resets	# Regulatory Non-Compliance Events	# Program Event Free Day Resets	# Regulatory Non-Compliance Events	# NCAR Initiated in Period	# CAR Initiated in Period	Avg. # Field Initiated Changes	# ITP Non Compliance
1	Re-tube & Feeder Replacement								
2	Turbine Generator								
3	Fuel Handling & Defueling								
4	Steam Generator								
5	Balance of Plant & Refurb. Support Facilities								
6	Facilities & Infrastructure and Safety Improvement Opportunity Projects								
7	Nuclear Refurbishment Performance			0	0	1	-	0.99	1
VENDOR QUALITY PERFORMANCE - YEAR TO DATE (YTD)									
Line	Vendors	# Program Event Free Day Resets	# Regulatory Non-Compliance Events	# Program Event Free Day Resets	# Regulatory Non-Compliance Events	# NCAR Initiated in Period	# CAR Initiated in Period	Avg. # Field Initiated Changes	# ITP Non Compliance
1	SNC-Lavalin & Aecon								
2	ES Fox Ltd.								
3	BWXT								
4	GE-Alstom								
5	GE Hitachi Nuclear								
EXPLANATORY NOTES									
1) Reported NCAR under [REDACTED] Issue identified with performance of work done under [REDACTED] quality program, and corrective action and root cause analysis are underway.									
2) Reported NCAR under Campus Plan and vendor [REDACTED]: Repeat Finding on [REDACTED] that sub-supplier was not on Approved Supplier List. Action with vendor to correct.									
3) The average number of FICs to approved modification packages for Balance of Plant is slightly above the target of 1.5. Actions are in place to understand the root causes of the FICs to prevent recurrence.									
**NCAR = Non-conformance Corrective Action Request; CAR= Corrective Action Request; ITP = Inspection and Test Plan									

APPENDIX 3: FINANCIAL PERFORMANCE

Financial performance of the Unit 2 Mobilization release for the period until October 15, 2016 (Breaker Open)



Executive Summary & Discussion:

2016 Cost Expenditure Summary

	Life-to-Date Cost (\$M)	Variance from Plan (\$M)	%	Cost Expenditure	%
Program Baseline ^(a)	421	(216)	-51%	1,021	
Project Control Baseline ^(b)	357	(152)	-42%	852	-17%
Actual Cost Expenditure	205	-	-	(169)	

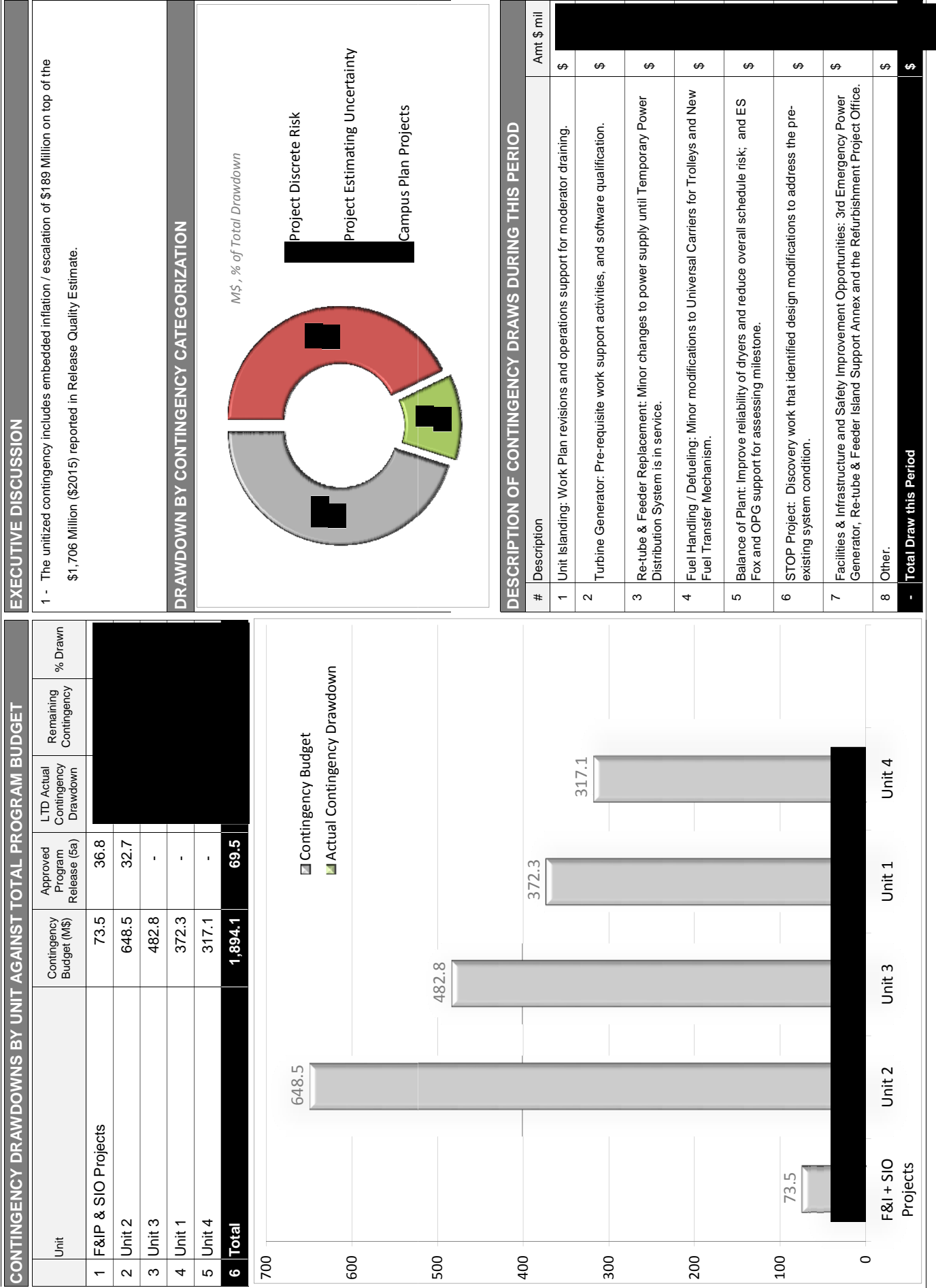
1 - Actual expenditures as of March 31 is \$216 Million below plan due to:

- Lower spend by the Re-tube & Feeder Replacement (\$96 Million) due to delays in work instruction development and assessment, and the procurement of reactor components. The project is expected to recover the majority of this delay by Q3 of 2016.
- Schedule delays in Facilities & Infrastructure and Safety Improvement Opportunities (\$63 Million), including the 3rd Emergency Power Generator and Heavy Water Storage Project. These projects have recovery plans in place through 2016 and into early 2017.
- Lower OPG resources (\$16 Million) due to delays in transferring of staff to the project and/or recruitment. Recruitment strategies are in place to ramp up to meet the planned staffing levels.

2 - Forecasted cost expenditures through Oct 15, 2016 is \$169 Million below plan mainly due to re-flowing of the work based on the latest schedules presented at Gate and as a result of the delays in completing the Heavy Water Storage Project as noted above. The life-cycle forecast for the overall program remains at \$12.8 Billion.

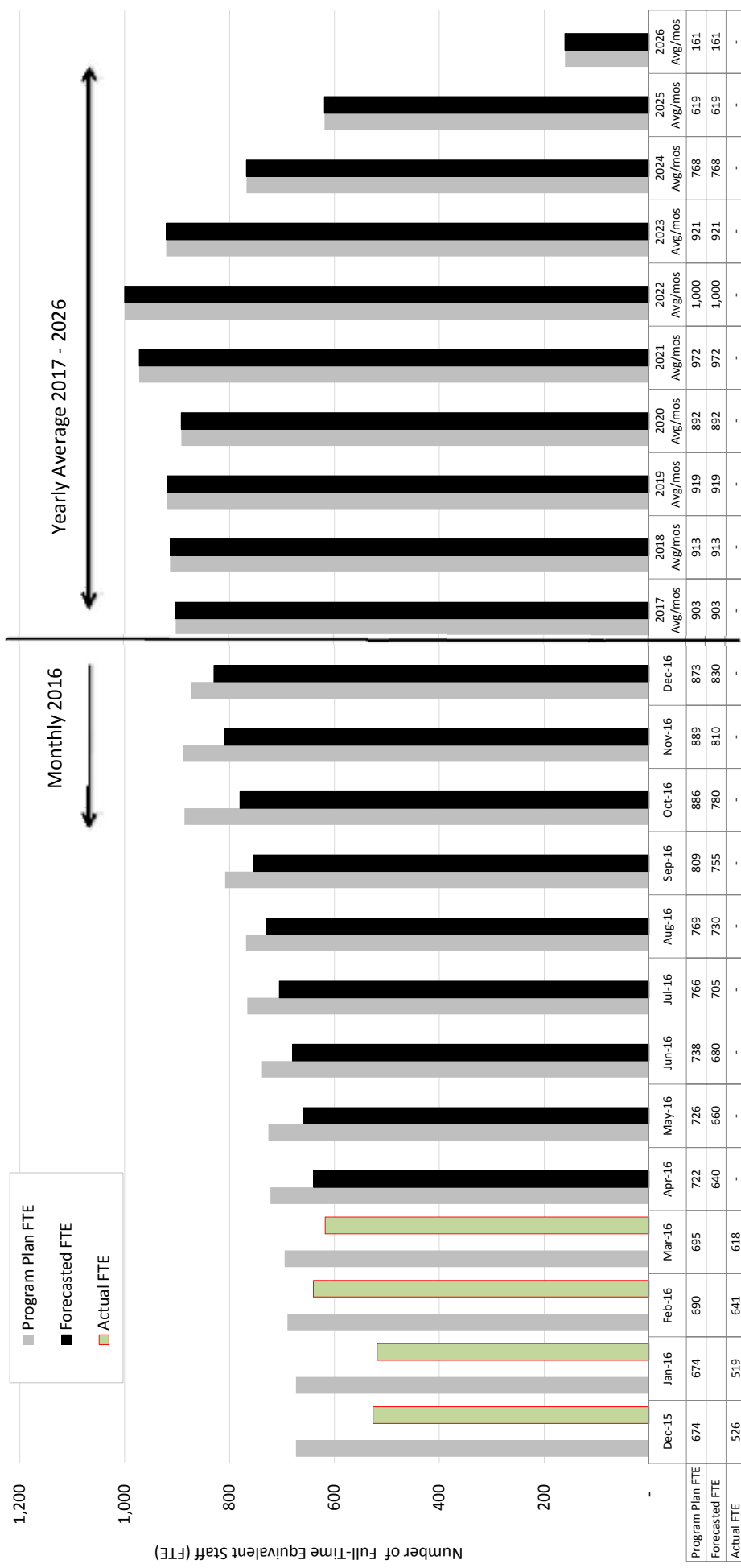
Notes:

- Program Baseline represents the amount of funds released to the project by the Board of Director's at the Release Quality Estimate (November 2015).
- Project Control Baseline represents the amount of funds released by the Program, to the individual projects, for executing their scope. It is the basis for which individual project performance, including SPI, CPI, etc. is measured.



APPENDIX 5: OPG PROJECT RESOURCES

Excluding Purchased Services / Contract Labour \$



Executive Discussion

- 1 - OPG Staffing includes Functions, Operations & Maintenance and Bundle Project Management/Oversight Teams and counts regular, augmented (agency), Electrical Power Systems Construction Association (EPSCA) and temporary staff.
- 2 - OPG actual staffing levels are 11% below RQE plan (618 vs. 695) due to slower than expected hiring and planned transfers of staff from Operations. In some cases, these shortfalls are being mitigated through purchased services contracts.
- 3 - A Nuclear Projects Staffing and Hiring Plan has been developed to ensure that resource requirements and strategies are identified, and that they effectively utilize resources for the project while considering staffing strategies relating to Pickering End of Commercial Operation. As of March 2016, over 100 regular and approximately 80 augmented positions are currently in various stages of the recruitment process, which will support the resource need for the start of Unit 2 Refurbishment. The resource identification process is being reviewed for optimization.

APPENDIX 6: FACILITIES & INFRASTRUCTURE AND SAFETY IMPROVEMENT PROJECTS
Cost and Schedule Performance

COST DETAIL (\$ MILLION)

Line	Project Title	Cumulative (Life-to-Date)					At Completion of Project				In-Service Date			
		a	b	c=b-a	d	e	f	g	h	i	k	m	n	o
		Plan (PV)	Actual (AC)	Variance	CPI	SPI	Budget at Completion (BAC)	Estimate at Completion (EAC)	Variance from BAC	Variance from Last Period	Need Date	Current Forecast	# Months Float	Variance from Last Period
1	Heavy Water Storage & Drum Handling Facility	253.2	217.9	(35.2)	1.03	0.80	356.3	381.1	24.8	0.0	Feb 2017 (PHT) May 2017 (Full)	Nov 2016 (PHT) May 2017 (Full)	0	0
2	3rd Emergency Power Generator	87.7	85.1	(2.6)	0.94	0.79	105.4	128.8	23.4	3.8	Oct 2016	Sep 2016	1	2 1
3	Containment Filtered Venting System	62.7	66.3	3.6	0.89	1.01	75.4	84.6	9.2	0.0	Oct 2016	Sep 2016	1	0
4	Shield Tank Over Pressure Protection	10.4	11.9	1.5	0.94	0.88	13.4	14.1	0.7	0.0	Mar 2017	Feb 2017	1	0
5	Balance of Pre-Requisite Projects In-Service	324.8	323.8	(1.0)	*	*	327.1	333.7	6.6	(0.5)	IN SERVICE			
6	Subtotal Campus Plan Before Contingency	738.7	705.0	(33.7)	0.95	0.84	877.6	942.3	64.7	3.3				

Portion of the Re-Tube & Feeder Replacement Bundle

9	Re-tube Waste Processing Building	65.9	52.4	(13.5)	5	Under Review	192.0	192.0	0	0	Jul 2017	Jun 2017	1	0
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Notes: * Indicates not applicable. The CPI and SPI calculations exclude project management costs and support tasks which are considered level of effort.

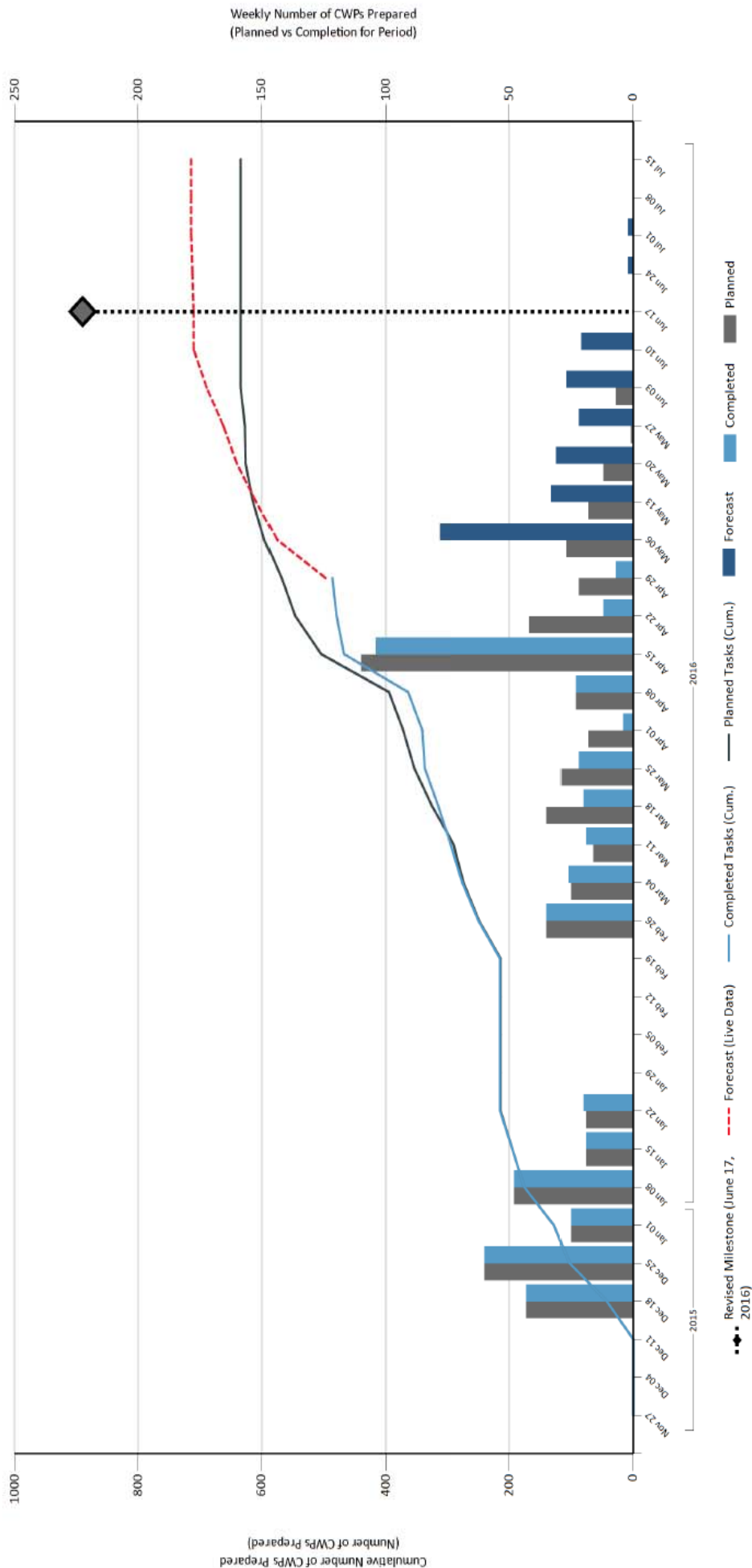
Executive Discussion

- The final in-service date for the facility has been maintained since the previous report. The schedule performance has been impacted due to delays in material pre-fabrication and construction pre-requisite activities such as Comprehensive Work Package development. At OPG's request, the vendor has put a new project manager and additional resources in place. Construction activities have been re-sequenced to recover schedule and maintain the planned in-service dates. Contingency plans to mitigate potential impacts of a delayed in-service on the Unit 2 refurbishment execution schedule are being developed
- The current in-service date for the 3rd Emergency Power Generator has been delayed to September 30 due to construction delays, potential material delivery issues and potential delays in commissioning. The delays in construction are due to 1) [REDACTED] and 2) issues with obtaining quick resolution of engineering issues in the field. [REDACTED] OPG is also recruiting field engineers with a strong construction background.
- The forecast to complete is expected to increase as a result of the design changes required to rectify the pre-existing system condition. The installation of the STOP modification is on track to be completed during the current Unit 4 outage, while remaining installations on Unit 1 and Unit 3 are on track to support the need date of March for Unit 2 Bulkhead in-service milestone.
- Included in the Balance of Pre-Requisite Projects In-Service is the Refurbishment Project Office and Re-tube & Feeder Replacement Island Support Annex. Variance memos for both have been updated to align with the most current estimate-at-complete costs and have been approved by the CEO. The final estimate-to-complete cost was included in the previous report and has not increased. Minor savings have been noted in the closeout of in-service projects, resulting in \$0.5 Million of reductions over the period.
- The contract amendment for the Re-tube Waste Processing Building has been finalised, and is in alignment with the Release Quality Estimate. The project cost and schedule will be aligned with the amendment, and the revised cost and schedule performance index will be included in the next report.
- Based on the Estimate at Complete, there is currently [REDACTED] of anticipated contingency use. To date, [REDACTED] has been released to the projects for use. Additional details are contained within Appendix 4 Contingency Management.

APPENDIX 7: COMPREHENSIVE WORK PACKAGE COMPLETION

Planned and forecast completion of Comprehensive Work packages to support Work Package Assessment Milestone (June 17, 2016)

COMPREHENSIVE WORK PACKAGE COMPLETION FOR UNIT 2 REFURBISHMENT



Executive Discussion




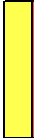

- 1 - Vendor completion of comprehensive work packages is behind plan largely due to delays within the Re-tube & Feeder Replacement project. Vendor is delayed due to a general lack of working experience and understanding of the integration requirements when performing work in an operating nuclear station. As an interim measure, OPG has provided the vendor with skilled resources to train vendor staff and accelerate completion of the work packages.
- 2 - An OPG team is in place to expedite Comprehensive Work Package reviews as the documents become available. An increase in completions over the next 2 weeks is expected.
- 3 - The total number of Comprehensive Work Packages has increased from the original plan as a result of increased clarity on the work. All Comprehensive Work Plans are expected to be complete prior to the June 17 target.

APPENDIX 8: VENDOR PERFORMANCE

Vendor Performance within the Core Nuclear Refurbishment Projects










VENDOR PERFORMANCE INDICATORS

Vendor Name & Key Scope		Safety	Quality	Cost	Schedule	Relationship	Explanatory Notes
Line							
1	SNC-Lavalin & Aecon Fuel Channel and Feeder Tube Replacement, Turbine Generators Execution						
2	ES Fox Ltd. Balance of Plant, Fuel Handling						
3	BWXT Steam Generators, Balance of Plant						
4	GE-Alstom Turbine Generators Parts and Technical						
5	GE Hitachi Nuclear Defueling						

KEY MILESTONES & STATUS				
Line	Milestone	Baseline	Forecast	Explanatory Notes
1	Regulatory Final Approvals Requested	COMPLETE	COMPLETE	
2	Re-tube & Feeder Replacement Island Support Annex	COMPLETE	COMPLETE	
3	All Level 3 Schedules Quality Acceptance Complete	COMPLETE	COMPLETE	
4	Field Constructability Reviews Complete	COMPLETE	COMPLETE	
5	 Work Package Assessing Complete	15-Apr-16	17-Jun-16	
6	 Draft Unit 2 Integrated Schedule Issued	31-May-16	17-Jun-16	
7	 Unit 2 Integrated Schedule Complete	15-Jul-16	25-Aug-16	
8	Construction Readiness Lookaheads Complete (Seg. 1)	15-Jul-16	15-Jul-16	
9	Refurbishment Construction Review Board	*New*	5-Jun-16	Tentative date to be finalised.
10	Regulatory Final Approvals In Place	15-Jul-16	15-Jul-16	
11	Outage Execution Metrics Prepared	15-Jul-16	15-Jul-16	
12	Unit 2 Execution Estimate Complete [Presentation to DRC]	11-Aug-16	11-Aug-16	
13	Refurbishment Construction Review Board	*New*	15-Aug-16	Tentative date to be finalised.
14	Fuel Handling Ready to Defuel	30-Sep-16	30-Sep-16	
15	Unit 2 Readiness Review [Presentation to DRC]	30-Sep-16	30-Sep-16	
16	Refurbishment Construction Review Board meeting with DRC	*New*	30-Sep-16	Tentative date to be finalised.
17	Unit 2 Breaker Open	15-Oct-16	15-Oct-16	
Legend		 Completion forecast within 1 month of baseline.  Completion forecast as late greater than 1 month of baseline.		

APPENDIX 10: KEY PROGRAM RISKS

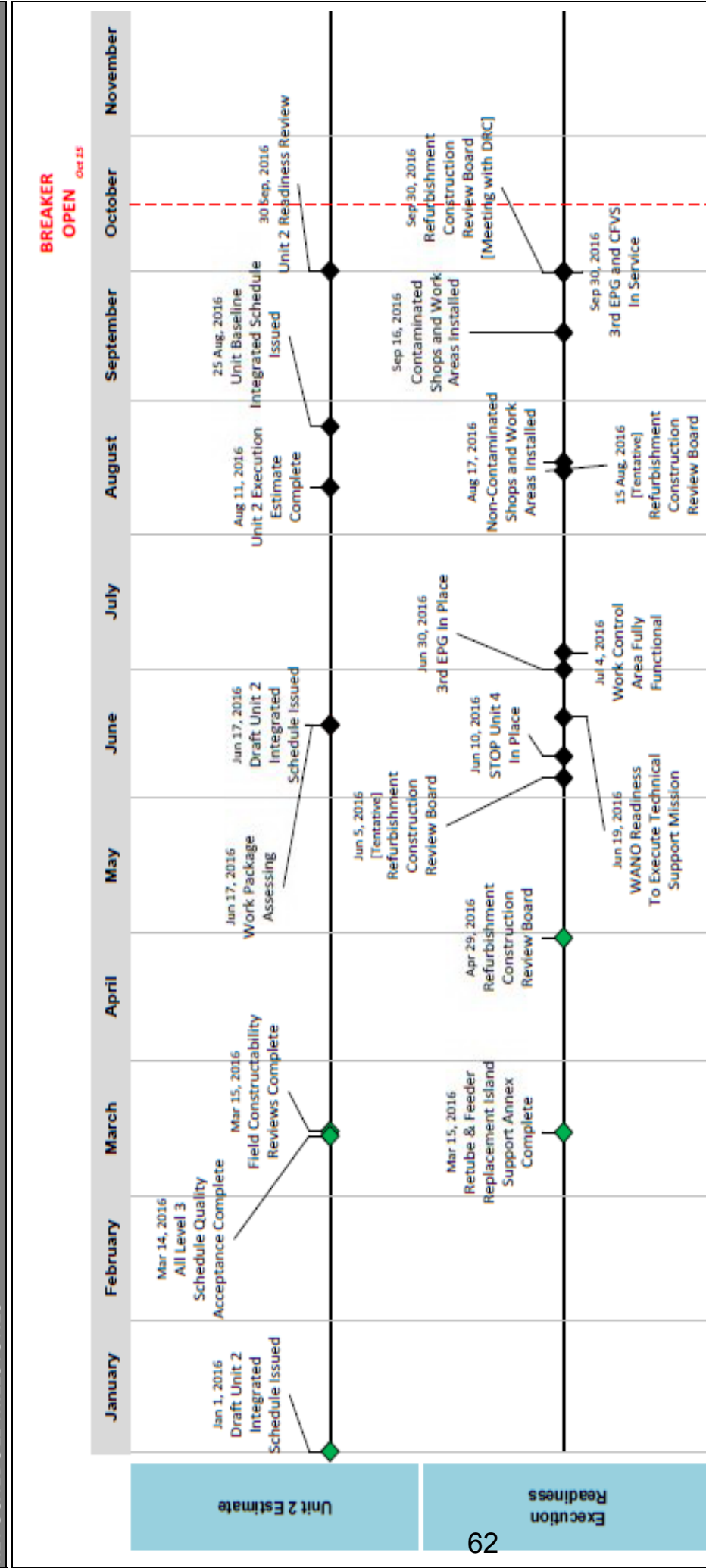
Risks Being Actively Managed by the Program

KEY PROGRAM RISKS AND MITIGATION STATUS				
Line	Status	Risk Description	Mitigation Plan	
1		Vendor Performance Poor vendor performance will negatively impact safety, quality, cost and/or schedule.	A Readiness to Execute oversight plan has been issued. This will support the detailed readiness assessment challenge process leading to the readiness milestone in June 2016. Plans to improve collaborative activities with the vendors for Engineering, Procurement and Construction have been developed. It includes active management and assisting vendors in removing barriers to work. A Nuclear Construction Supervisor Academy is operational, and is integral in improving vendor supervisory performance. The integrated field readiness walk downs at T-6 months and T-3 months with refurbishment and vendor teams will also promote better vendor performance overall in the field portion of the work.	
2		Availability/Retention of Staff Key project personnel with the required skill set will not be in place for the full refurbishment program resulting in impacts on performance.	Nuclear Projects People & Culture completed all but two actions from its comprehensive Mitigation Plan that addressed the risk in four key areas: 1. Strategic Direction; 2. Succession Plans/Process Improvements; 3. Building Project Depth/Emerging Talent; 4. PPR Health & Development Planning. The focus has been on establishing a strategic resourcing framework for the project under the RQE approved budget with the right organizational design and ensuring the right leadership pipeline is in place for future Unit Refurbishments (Units 3, 1, 4). Phase 2 of the Nuclear Fleet Bench Strength Improvement Plan in progress.	
61 3		Availability of Skilled Craft Resources/Supervision Key skilled craft resources may not be available when required for the Execution Phase.	OPG is participating in labour market information studies to gain insights into labour market issues, including the identification of skilled craft resource needs using tactics that include both short and long term approaches. The current plans and tactics are being evaluated to ensure integration with the Nuclear fleet to minimize the risks in all support areas. Provisions in trades union agreements also provide for resourcing flexibility.	
4		First of A Kind/First in A While Work and Processes A lack of recognition of FOAK/FAIW work and processes during design and execution planning results in installations that do not meet requirements causing rework/delay or degraded production post Refurbishment.	A thorough and in-depth review was completed with Engineering, Project Teams and various execution and functional groups in Nuclear Refurbishment and Projects & Modifications organizations to flag FOAK/FAIW risks. A defined set of screening criteria align with WANO 2015 SOER report was developed and utilized. Specific mitigation actions are defined for FOAK/FAIW risks, and In-depth challenge/review of risks impact/events along with robust tracking of the mitigation actions are in progress.	
No change over period  Improvement  Decline			HIGH RISK    LOW RISK	

APPENDIX 11: KEY DELIVERABLES FOR NEXT PERIOD

Significant Milestones Leading to October 15, 2016 (Breaker Open)

KEY SCHEDULE MILESTONES



APPENDIX 12: PHOTO CATALOGUE

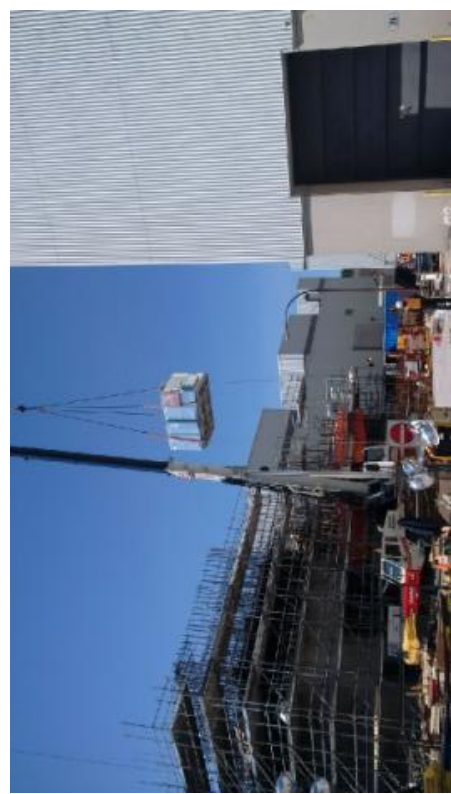
PROJECT

Heavy Water Storage &
Drum Handling Facility



Installation of a temporary roof

3rd Emergency Power
Generator

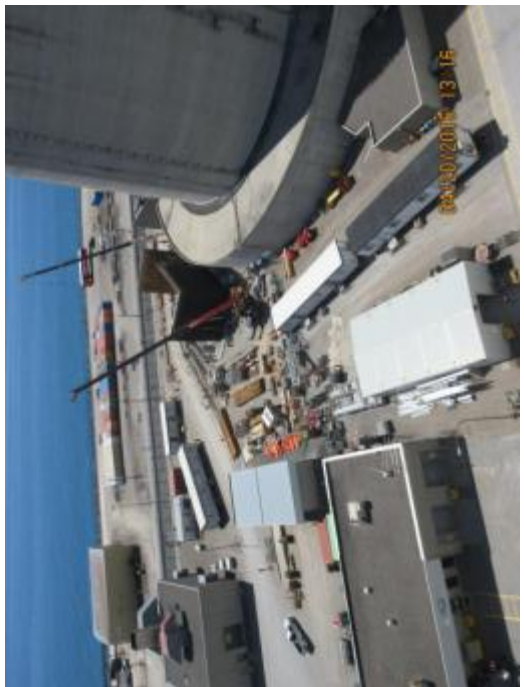


Concrete pours and rebar construction

APPENDIX 12: PHOTO CATALOGUE

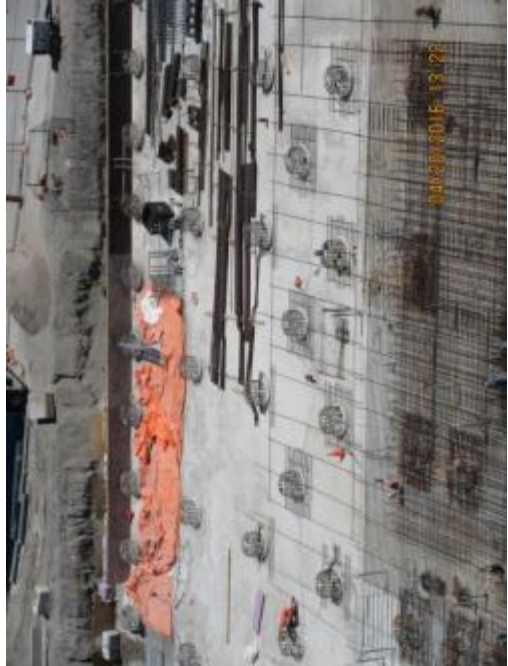
PROJECT

**Containment Filtered
Vented System**



Filter enclosure

**Re-tube Waste
Processing Building**



Pilecap construction



Darlington Nuclear Refurbishment Program

APPENDIX 12: PHOTO CATALOGUE

PROJECT

Re-tube & Feeder Replacement
Island Support Annex



Building completion

Refurbishment Project Office



Building completion



APPENDIX 12: PHOTO CATALOGUE

PROJECT

**Re-tube Waste
Storage Building**
(non-Refurbishment funded)



Erection of structural steel




**Used Fuel Dry
Storage Building**
(non-Refurbishment funded)



Construction complete

APPENDIX 13: METRICS LEGEND




DARLINGTON REFURBISHMENT PROGRAM PERFORMANCE DASHBOARD

METRIC/DESCRIPTION	TARGET				↑	↓
COST PERFORMANCE INDEX (CPI) = Earned Value / Actual Costs Ratio that measures the financial effectiveness.	1.00	0.95-1.05 Within 5% of the target.	≥1.06 0.90-0.94 Between 5% and 10% off target OR greater than 10% off target in positive direction.	≤0.89 Greater than 10% off target in negative direction.		
ALL INJURY RATE (AIR) (# Safety Events/200k hrs worked) - Year-to-Date Safety events are categorized as the number of fatalities, lost-time injuries, medical treatment injuries and other injuries/illnesses. The safety statistics include both OPG and contractor performance year-to-date (i.e. reset in January).	0.24	AIR ≤0.24 AND WP Events = 0	AIR 0.25-0.27 OR WP Event = 1	AIR >0.27 OR WP Event ≥2		
# LEVEL 1 WORK PROTECTION EVENTS Count of the number of Level 1 Work Protection Events on DRP over the quarter.	0	AIR is at or below target AND zero Work Protection Events in the quarter.	AIR is above target within 10% OR 1 Work Protection Event occurred in the quarter.	AIR is above target > 10% OR ≥2 high Work Protection Event occurred in the quarter.		
# EVENT FREE DAY RESETS (EFDR) # of Darlington Site Event Free Day Resets that occurred within the quarter as a direct result of work being performed within the Darlington Refurbishment Program. The criteria are aligned to the nuclear industry standards and applied consistently across the sites to allow performance comparisons and benchmarking.	0	BOTH at ZERO Cumulative No. events for the quarter is 1. OR management assessment on low level trending.	EFDR + REG. = 1	EFDR + REG. ≥ 2		
# REGULATORY NON-COMPLIANCE Count of the number of number of regulatory non-compliance events related to quality that have occurred within the quarter.	0					

Managements assessment on the current performance trend.
↑ Performance is IMPROVING;
– Performance is being maintained;
↓ Performance is DECLINING.




FINANCIAL SUMMARY

CURRENT APPROVED RELEASE refers to the total budget of the last release approved by the Board of Directors. The last release was approved by the Board in November 2015, and was to complete the Mobilization Phase.
MOBILIZATION PHASE refers to the work completed Dec 31, 2015 (end of Definition Phase) to October 15, 2016 (Unit 2 Breaker Open).
TOTAL PROGRAM refers to the refurbishment of all 4-units.

METRIC/DESCRIPTION				↑	↓
LIFE-TO-DATE COST (M\$)					
ACTUAL Total Program costs incurred to date against the Approved Release.					
PLAN Planned Program costs to date for the Approved Release.					
VARIANCE Variance of Actual to Plan. (\$) indicates underspent vs. plan.					
AT COMPLETION OF MOBILIZATION PHASE					
FORECAST Forecast of total Program costs at the end of Mobilization phase.					
PLAN Planned Program costs at the end of Mobilization phase as per the Approved Release.					
VARIANCE Variance of Forecast to Plan. (\$) indicates underspent vs. plan.					

Managements assessment on the current performance trend.
↑ Performance is IMPROVING;
– Performance is being maintained;
↓ Performance is DECLINING.

PROJECT PERFORMANCE INDICATORS AND TRENDS

METRIC/DESCRIPTION				↑	↓
UNIT 2 EXECUTION PROJECTS PRE-REQUISITE PROJECTS					
Managements assessment of current performance and risk to Unit 2 Refurbishment Execution.					
Managements assessment on the current performance trend.					

Refurbishment Construction Review Board Review July 18 - 22, 2016

Confidential (Commercially sensitive issues are discussed in this document)

Background:

The Refurbishment Construction Review Board (RCRB) conducted a review of the Darlington Refurbishment project from July 18 through July 22, 2016. This report is based on document reviews during the preparation for the review, interviews with Refurbishment personnel, and plant walk-downs during four days of the onsite visit.

The RCRB provides a report of its activities to the President Nuclear and Chief Nuclear Officer, which includes both observations and recommendations to improve performance.

The RCRB team consisted of the following members:

External members:

Ken Ellis
Drew Feters
Britt McKinney
Mike Rencheck
Ike Zeringue

Internal member:

Paul Pasquet

The RCRB would like to recognize the excellent support provided by Jennifer Vulcanovic, Irena Doslo, and Graem Meteer; their preparation and hard work enabled the RCRB to productively conduct this review.

The RCRB has made a limited number of key recommendations which the project needs to address with priority. The recommendations have been flagged and although no “formal” action plans are being requested, the RCRB will expect a briefing during the next visit to ensure progress is being made.

Executive Summary:

It is clear to the RCRB that progress has been made getting “ready to execute” the refurbishment project at Darlington Station. The team is impressed with the collaboration and level of preparations associated with the Fuel Handling readiness for defueling, turbine generator work, and the Re-tube Feeder Replacement (RFR) project. Likewise, other support aspects such as the project “material staging” facility is world class and is one of the best organized and laid out facilities that the RCRB has seen.

Key Issues and recommendations:

There are a number of issues that require prompt attention by the refurbishment leadership team given there is less than 3 months to breaker open on the unit entering its refurbishment outage.

1. Currently, the execution of the pre-requisite refurbishment work is behind schedule and a “bow wave” of activities is starting to occur. Only 21 of 67 prerequisite work windows are complete or on schedule, the remainder are delayed.

A work completion rate of approximately 150 tasks per week is currently being completed. A rate of 2 to 3 times that will be needed to complete the prerequisite work prior to the shutdown of the unit. In addition, execution of some of the planned work is progressing more slowly than expected due to the complexity of the work, late discovery, or late identification of issues (e.g. Shutdown Cooling HX replacements).

Portions of this work is key to the start of the project and has completion dates that are ‘just in time’ for their use. The current schedule for a number of the prerequisite activities have little float. For example:

- The construction of the waste processing building, which is required to receive re-tube waste has little float.
- The sequence of Shutdown Cooling HX replacement, Primary Heat Transport System heavy water transfer header maintenance, and the unbudgeted outage to address the STOP modification short-falls will require good co-ordination and has little schedule float.

Recommendation #1

The RCRB recommends that action is taken to both understand why the desired task/work off rate is not being achieved and take the required actions to ensure this work is completed as scheduled.

It was noted during the review week that no routine “T+1” type meeting is held to both identify and rectify schedule challenges and hold staff accountable for achieving the schedule. Carrying out schedule reviews may partially rectify this issue.

2. The level of readiness to execute the project is most advanced in the ‘lead-in segment’ (but decreases with subsequent segments), for example;
 - The level of preparation, teamwork, and ownership for the reactor defueling appears to be good.
 - The level of preparation for the installation of the ‘bulkhead’ appears adequate.
 - The RFR component of the ‘removal segment’ (removal of reactor components such as pressure tubes etc) appears to be well planned. The use of the mock-up is a valuable tool, and is being used to practice and to perform tool testing.

Work activities such as the Heat Transport Pump motor movement (currently a requirement exists to stop work in the reactor vault while hoisting motors) and the currently planned radiography in the reactor vault could still impact the critical path schedule, and have not been resolved. (Note, this is not an all inclusive list).

3. Project preparation, planning, and scheduling is incomplete in part due to the processes and infrastructure to close-out the construction work, complete the necessary documentation reviews, and then plan and execute the commissioning and “return to service” activities are not well advanced. Scheduling the return of plant systems should govern how the construction work is sequenced. Failure to follow this pattern will result in having to revise the schedule and add to the required resources to complete the schedule. ***The RCRB considers this crucial to the success of the project.***

Once the unit is shut down and defueling is commenced, the RCRB is concerned about the organization’s ability to manage the challenges of execution while completing return to service planning. Key resources such as availability of certified staff with project experience will be at a premium. In addition, with all the issues that the management team currently has to manage (for example the need to develop mitigation plans for potentially late campus plan projects), then add the inevitable discovery issues with a shutdown unit in the execution phase. It is critical for the success of the project that these issues are resolved in a timely manner.

Recommendation #2

- a) It is the RCRB experience that some form of “close out group” needs to be created to ensure that the close out of construction work is done correctly and timely (with quality and ensuring that gaps do not exist which demonstrate the work was completed as specified). There is considerable project related OPEX to support the formation of this group or function. Currently within the “Projects and Modifications” group, elements of this function currently exist and could be modelled.

- b) As discussed above, a return to service group needs to expeditiously complete both the conceptual and detailed planning associated with returning of layed up / operating and modification systems and components to service. This activity needs to be monitored and tracked by the Refurbishment management team.
4. During the RCRB review a number of reports with associated metrics were reviewed. In a number of cases it was difficult to determine how these metrics rolled up to the refurbishment score card.

Recommendation #3

While the project does have a large number of metrics, they do not consistently provide an accurate, integrated picture of project health. The metrics identify individual project performance but do not adequately portray the integrated project execution and status. A “pyramidal system” of metrics and performance indicators is needed to effectively manage a project of this complexity. There are a sufficient number of metrics generated; they need to be strategically applied to allow management to focus on the problem areas. The RCRB recommends on a priority basis, the following changes be made to the existing metric set:

- Where qualitative measures of readiness are used, Management needs to ensure a challenge process exists to ensure the rating chosen reflects the true level of readiness.
 - As was discussed during the on site visit, individual departments need to produce “score cards” supported by metrics which roll up to an “overall refurbishment” score card.
5. Currently, the project is being managed from the ‘online’ operational perspective. It is being viewed as a ‘very large planned outage’ using traditional outage processes. From experience on past refurbishment projects, the RCRB views this as a significant challenge to efficiently use those processes to manage the project, given the scale of work being planned and executed.

The “operational model” for this project needs to change, and be based on: eliminating unnecessary reviews and approvals, streamlining of processes to support work execution, and only requiring operational involvement where value is added. In addition, except for OP&P revisions, there have been few requests for relief on reactor safety constraints (e.g. SLOD, Single Line of Defence) from Refurbishment staff.

There are a number of interface issues between the site and the project that needs to be resolved, and are well behind when they should have been decided. These are adversely affecting the organization’s ability to obtain clarity on standards and expectations associated with execution of the project.

Recommendation # 4

One of the fundamental premises of a strong culture is to ensure that written expectations exist; staff need to understand the expectations and then follow them. In addition, with the reactor defueled and the unit separated from containment there exists a once in the life of the operating unit an opportunity to streamline the work processes so only those that truly add value (be it from a safety / quality / schedule or cost perspective) are in effect. In order to achieve these two basic principles a team needs to be struck utilizing personnel with external project experience to do the following:

- Review the expectations associated with the execution of work (be it approvals to go to work / approvals to modify work instructions / modify designs packages / expectations for how work is carried out etc)
 - Identify the value added components (and eliminate the non value added components)
 - Look to minimize the operational constraints and constraints posed by operations personnel
 - Obtain craft and vender input as to what constraints appear not to be adding value
 - Ensure that constraints that may be relaxed are taken into account in the return to service process
 - Produce a refurbishment document set for staff to follow defining the expectations for doing work and when they apply (which phase or segment in the project they apply). In addition transition plans need to be in place to move between project work segments (as referenced in the level 1 project plan) or between states as referenced in the Operating policies and principles.
6. There is a cultural tolerance for acceptance of work delays. This tolerance for work delays is being enabled by the leadership team. There is a lack of understanding for what it means to be an ‘accountable organization.’ Example:
- Project pre-requisite milestones have moved multiple times
 - Currently no T+1 nor “schedule adherence” accountability meetings exist.

Recommendation # 5

As discussed in this report both in this section and in the observations section, the level of accountability and understanding of what accountability means must be improved on the project. This includes a common understanding by both OPG staff and the contract partners of what it means to be an accountable organization. The RCRB is not suggesting that a management style be implemented that is not consistent with the culture of OPG. OPG does have stated norms and expectations when it comes to accountability and has examples where people and organizations

do demonstrate the required behaviours. The leadership team needs to ensure what is expected is clearly understood, then modeled by the leadership team and subsequently re-enforced and coached.

For a project with multiple contractors, a number of different types of contacts and a large number of interface points between OPG and its Vendors, it is very important that all people involved are truly ready to execute their work. Failure to have a high level of readiness including having the processes whereby work is executed and closed out, can put the project at risk.

It is the view of the RCRB that unless the appropriate amount of progress is made resolving these 5 recommendations, a significant impact to the project schedule and cost will occur.

Observations

During the course of the review week, a large number of observations and interviews were carried out. Outlined below are a number of insights.

1. Refurbishment Work Processes:

The refurbishment project is currently being planned, controlled and scheduled as a “large planned outage.” This is not recommended by the RCRB. If OPG determines that it is to be performed as a large ‘normal plant process’ outage, then the current refurbishment schedule is at risk. Change processes (for CWP/ work plans/ ITPs/ field changes, etc.) need to be streamlined. The RCRB recommends that the process is flow-charted, and the non-value-added steps removed. In addition, the process expectations must be clearly communicated.

- An example of the inefficiencies noted above was found regarding the use of the OPG guidance document associated with making field changes. The relocation of an EQ label on a junction box using the contractor engineering vendors to process this change was estimated to cost upwards of \$10K. This document serves as a guide for when field changes are to be used and are clearly inappropriate.
- The vendor/OPG work flow is not aligned to common goal or methodology. (For example, it was unclear if work reports were to be used on the project).
- Managing of field changes, CWP/ work plans is not fully vetted and tested for efficiency.
- TSSA involvement must be clearly identified and co-ordinated. Indications are that it has not been fully considered and needs further development.
- The Expedited Material Acquisition process needs to be streamlined. Only associated “value-added” activities should be mandated.
- The vendors openly state the current processes are placing stress on their ability to complete work. These remarks have not been dealt with appropriately (or dispositioned) by OPG.
- Engineering will have 10 resident engineers with design authority. The JV are being directed to utilize this concept as well. This is seen as positive by the RCRB.

2. A fully staffed commissioning group must be put in place:

- Operations clarity regarding Return to Service (RTS) is still outstanding, and lacks a clear direction (RTS philosophy is not decided). Construction work must be sequenced based on the methodology of the RTS. Currently, there is effectively no RTS group (staffing of this group does not appear to be a priority). There is a small effort being done informally via spreadsheets, which is not part of the Work Control Process. Integration of equipment and systems that will be in 'layup' conditions have not been considered as part of the RTS thought process, but need to be integrated. 'Layup' equipment is being viewed as 'normal outage restoration.' The use of 'partial' versus 'fully compete' system or equipment turnover is not decided.
- The philosophy of "What does the end state of the project look like" still needs to be documented. RTS activities are not scheduled yet.
- Communication to the Operation staff on how decisions will be made, or what priorities or philosophies the staff needs to follow and is substantially behind.
- Metrics are not developed around the key commissioning/RTS activities.

3. Culture: Sense of urgency & accountability:

- The station needs to articulate and enforce what success looks like associated with accountability. Very simply: do what you say you are going to do, when you say you are going to do it, and do it with the requisite quality. The leadership team lacks the "discipline" to re-enforce the needed attributes associated with accountability.
- Management behaviour when Schedule expectations are missed is weak. The prevailing 'discussion' at a meeting is focused on when the new target completion date is, but little to no discussion as to why was it missed, why was there no previous warnings or requests for assistance, why there was not a previous recovery plan to ensure the target completion date would not be missed, what is the cumulative impact of the delay on both the project and colleagues, what follow-up is needed, who needs to rally around mitigating the negative impact of the delay, who has overall ownership or corrective action.
- Any 'enforcement' that does occur is driven by meetings (not process), and the lessons learned appear to be forgotten going forward.
- "Accordion" was a word used to describe the current scheduled activities. There is a perception that there is still the four month 'defueling window' to plan and execute work before "real" outage starts. Thus there appears to be a perceived 'four-month float' in the work, and conversely little importance (or belief) placed on schedule discipline.

- Further examples of being comfortable (tolerance, willingness to use up schedule float):
 - i. EPG3 – work completion is very tight, but there is also a very complicated testing sequence. This project is at risk of not meeting the date committed to CNSC.
 - ii. D₂O storage building – looking at November for piping fully installed. The fully complete date is currently scheduled for April 2017. This date has slipped, substantially. The RTS need by date is also April 2017. If completed as scheduled, it will have zero margin.
- In short, both the management team and the contract partners need to make it very uncomfortable for those who do not deliver on their commitments, and offer support wherever they can to get the commitments back on track. That will be the commencement of a true team.

4. Organizational interface:

Both the project and the station have aggressive work programs, performance targets and objectives to achieve. In some cases, these objectives may result in competing priorities that need to be managed. During interviews it was apparent that in some cases, issues may not ‘bubble-up’ to the right level and the right decision maker. This is needed in order to set the proper priorities. As a consequence, issues may be lingering at a lower management level in the organization for longer periods of time than they should be. An organization with an execution mindset can’t allow these types of issues to languish.

Three different types of organization models can be used for the refurbishment project being executed at Darlington:

1. There is a senior leader on the DN site who is accountable for all day-to-day and long-term activity going on at the site.
2. The project is essentially self-contained and antonymous, and does not rely on the other organizations for services etc.
3. The project organization reports to a higher level in the organization.

Currently, a hybrid organization exists which relies on a significant level of alignment, interaction, mutual support, and teamwork. The current approach is not yet mature, and may be difficult to sustain going forward. Clearly, 100% autonomy is not possible. The RCRB is suggesting that a review of how the project is interfacing with the plant, as well as what should be the role of Operations, needs to be periodically reviewed.

5. Resourcing:

The project has created a group to support line managers in completing and initiating the hiring process (be it augmented or regular staffing) which reduces the workload on the line managers. This is seen as a positive by the Project Managers and by the RCRB. Metrics associated with the hiring and security clearance process exist, and are reviewed at senior oversight forums. Very recently a list of priority positions (on the order of approximately 130 positions) required to support project execution has been identified and is currently being addressed (of the 250 total positions needed). The project may wish to further prioritise the 130 to ensure the most critical resources are secured first. Once the hiring is completed, the line organization will need to assimilate and train these individuals.

The resourcing plans and their performance will continue to be a focus area for the RCRB. At this point plans appear to be in place, but results need to be demonstrated.

6. [REDACTED]

Overall, [REDACTED] performance has not been consistent. This contractor will need to be closely monitored and additional support maybe required. [REDACTED]

[REDACTED] This has resulted in additional interfaces to be managed, as well as quality challenges, on some projects. Listed below are a number of observations associated with the Vendor:

- [REDACTED] currently is not stocking commodities in their warehouse to timely resolve installation problems.
- At the T-2 schedule meeting a number of [REDACTED] jobs were pushed out due to lack of resources.

7. Project Meetings:

Time management within the project organization (this applies to OPG staff and the requirements OPG places on its Vendors) needs to transition to an 'execution focus.' Once the breaker opens, the need to be concise, ensure adequate time is spent overseeing field activities, and being able to strategically look ahead, will be very important. In addition, it appears that repetitive meetings are being used to make decisions.

It appears there is an excessive number of meetings, many of which are attended by people who may not be adding a lot of value.

- As an example, during the "Change control meeting," there were 20 plus people involved in the decision making associated with relatively small amounts of money and no

schedule impact. A review by the appropriate person with a single sign-off would be sufficient.

- Management needs to utilize the “delegation of work” work model where there is efficient use of managers’ time (minimize non-value-added meetings). The project now needs to be focused on the Critical Path and Overall Schedule, as opposed to which meetings to attend.
- There were over 50 people in the PCC meeting. This may be too large a group with too little value for most of them. Other methods of communication and information sharing could be used.
- The RCRB believes it would prove very beneficial if the organization rationalised and reduced both the multitude of regular meetings, and their attendees, thereby facilitating more time for the management team to focus on execution activities.

8. Plant Walk-downs and general observations:

- Maintenance staffing looks insufficient, or has ‘just-in-time’ transfer dates. The RCRB did not have time to focus on this issue to understand how the OPG maintenance work component of the outage is being managed, but the number of maintenance personnel assigned to the project (~ 50) looks low based on our experience.
- Housekeeping in the plant has improved.
- The designated walkway has not yet been painted which “corrals” contractors entering and walking through the building, and directs flow through protected areas. The RCRB understands the floor pathway painting is scheduled shortly.
- Hand and Foot monitor for interzonal monitoring was broken (again), with no redundant instrumentation installed or contact information given. During the project this type of infrastructure support short fall can be a significant issue for trades getting to work.
- Several aspects of islanding have progressed such as defining boundary points, and CBTs for different stakeholders has been developed. Islanding needs to take into account the return to service aspects of the project to support construction completion and testing. . It took the RCRB numerous meetings to try to get to understand to overall picture, and it is fair to say the RCRB still does not fully understand it, nor do a multitude of station staff. Failure to properly communicate this to affected parties would be yet another issue and challenge for the Management team and is crucial to the success of the project.
- The location of additional service air compressors have been marked in the four units, but installation has not yet started. Regarding Unit 2, concrete pedestals have been poured but that is the extent of the installation. Given the time frame from now to

breaker open, the installation of the Unit 2 additional service air compressors appears to be behind

9. Valves:

- This is a ‘critical activity’ for the project. The RCRB were unable to review the full scope of this work with all the owners but did not get a view that the potential impact was understood, nor was there clarity in how the scope is being managed. Project OPEX is that the valve program is the “Achilles heel” of most refurbishments and needs considerable oversight. The RCRB did not observe this.
- The timelines for procurement of some valves under BOP scope will be close to the ‘need-by date’ for the work in the field. The project may want to consider looking at some forms of incentives to encourage contractors to perform at higher levels.

10. Good team dynamic in TG project:

The preparation to execute the turbine generator work appears to be progressing well.

- Personnel are comfortable with each other and the required work is being completed. Vertical slice meeting – good teamwork, not defensive, supporting each other, meeting the schedule. The vertical slice schedule reviews are viewed as a positive activity, and are effective at uncovering important issues that need to be addressed.
- All project parts have arrived on time (including contingency parts). Preparatory work started (crane work) is being executed as scheduled and they are meeting their commitments.

11. RFR team dynamic:

- The RCRB see progress in the level of readiness of the RFR project. The JV project team appears to be working well together with the OPG project, and the right behaviours are being exhibited. The JV team depends on other organizations for support (e.g. airlock repair) and its ability to minimize impacts on their critical path work will depend on the responsiveness of those organizations. The previously discussed interface and accountability issues can adversely impact critical path schedule if not resolved. The RCRB will continue to monitor the progress being made.

12. Material Staging:

- The project “material staging” facility was toured, and found to be world class and one of the best organized and best laid out facilities that the RCRB has seen. In addition, the facility is being run and owned by a dedicated individual.

AMPCO Interrogatory #30

Issue Number: 4.3

Issue: Are the proposed nuclear capital expenditures and/or financial commitments for the Darlington Refurbishment Program reasonable?

Interrogatory

Reference:

Ref: D2-2-1 Page 3, Chart 1 & D2-2-8 Page 7, Chart 3

Preamble: OPG provides a cost breakdown of the total Darlington Refurbishment Program (DRP) Release Quality Estimate (RQE) showing the Program components.

- a) Please confirm that the RQE provides the baseline cost estimate for each major program component that OPG will compare all future costs to until 2026.
- b) Please add a column to Chart 1 to reflect the component costs approved by OPG's Board of Directors in November 2013.
- c) Based on OPG's review of other nuclear refurbishment projects and other megaprojects please compare OPG's Contingency of 16.4% of the RQE (excluding interest & escalation) to the Contingency % of these other projects.
- d) Based on OPG's review of other nuclear refurbishment projects megaprojects, please compare OPG's Functional Costs of 21.3% of the RQE (excluding interest & escalation) to the % of Functional Costs of these other projects.
- e) Please provide the original and current (revised) Safety Improvement Opportunities and Facilities & Infrastructure Projects budgets and show the % of costs for each that have been reclassified to date.

Response

- a) OPG will compare future costs to the baseline established by the RQE on a total program basis. As indicated at Ex. D2-2-8 p. 8, while actual costs may ultimately be different than forecast for individual major program components, OPG's success on refurbishing and returning Unit 2 to service and the Program as a whole, should be measured at the total envelope level.
- b) In November 2013, OPG's Board of Directors did not approve any costs equivalent to the costs shown in Ex. D2-2-1 p. 3. The Board of Directors' approval was limited to a release of \$680M to continue the Definition Phase of the Darlington Refurbishment Program (DRP) and complete planned 2014 deliverables. The life cycle estimate prepared in

Witness Panel: Darlington Refurbishment Program

November 2013 in support of the release was a preliminary estimate and is not directly comparable to the RQE, as the scope of work was yet to be finalized. However, an approximation of the comparison is identified below:

Chart 1

	Ex. D-2-2-1 p.3 Chart 1		Nov. 2013 Total Cost Est (Release 4C)		
Program Component	RQE Total Cost (\$2015B)⁽¹⁾	RQE Total Cost (%)	Total Cost Estimate Converted to 2015\$⁽¹⁾	Total Cost (%)	Total Cost Estimate (2013\$)⁽²⁾
Major Work Bundles	5.54	43	4.35	38	4.18
Safety Improvement Opportunities	0.20	2	0.11	1	0.11
Facilities & Infrastructure Projects	0.64	5	0.57	5	0.55
OPG Functional Support	2.23	17	2.16	19	2.08
Early Release Funds	0.11	1	0.12	1	0.12
Contingency	1.71	13	2.16	19	2.08
Interest & Escalation(\$B) ⁽³⁾	2.37	19	1.97	17	2.20
Total Cost Estimate (\$B) ⁽³⁾	12.8	100	11.32	100	11.32

(1) All numbers are in 2015\$ except for Interest and Escalation and the Total Cost Estimate

(2) All numbers are in 2013\$ except for Interest and Escalation and the Total Cost Estimate

(3) Interest and Escalation and the Total Cost Estimate are in nominal dollars, i.e. a sum of the dollars of the year in which they are expended

c) OPG does not have enough detailed information on the costs estimates developed for such projects and the percentage of contingency in those estimates to do the comparison requested.

d) Please see Ex. L 4.3-1 Staff-45, part c).

e) The requested information for Facilities & Infrastructure Projects is shown in the following chart:

1

Chart 2

Project Title	Total Project Cost (M\$)		% of costs Reclassified
	Original Full Release	EB-2016-0152	
Darlington OSB Refurbishment	53.0	62.7	100
DN Auxiliary Heating System	99.5	99.5	100
D2O Storage Facility	110.0	381.1	0
Water & Sewer Project	40.6	57.7	0
Darlington Energy Complex	105.4	105.4	0
R&FR Island Support Annex	40.7	40.7	0
Refurbishment Project Office	99.9	99.9	0
Electrical Power Distribution System	16.9	20.8	0
GM Office Facility	9.3	9.3	0
Vehicle Screening Facility	3.0	6.6	0

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The requested information for the Safety Improvement Opportunities (SIO) projects is shown in the following chart. No SIO projects have been reclassified.

Chart 3

Project Title	Total Project Cost (M\$)		% of costs Reclassified
	Original Release	EB-2016-0152	
Third Emergency Power Generator	88.2	120.4	0
Containment Filtered Venting System	80.6	80.3	0
Powerhouse Steam Venting System	5.6	5.6	0
Shield Tank Overpressure Protection	13.5	13.5	0
Emergency Service Water Buried Services	7.9	14.6	0

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Note: The original release amounts for the SIO projects are based on the first approved Gate Progression Form or Change Control Form for Execution Phase.

Witness Panel: Darlington Refurbishment Program