EB-2020-0290

OPG 2022-26 RATES

SEC CROSS-EXAMINATION MATERIALS

Evolution of Business Cases

($ millions)

Category	*May-13*	*Mar-15*	*Jan-18*	*Increase*	*Percent*
OPG Project Management	1.4	6.7	12.4	11.0	
OPG Engineering (incl. Design)	4.6	7.4	16.3	11.7	
OPG Procured Materials	0.0	1.4	10.3	10.3	
OPG TRF	0.0	0.0	3.0	3.0	
OPG Other	2.8	18.6	22.6	19.8	
Subtotal	8.8	34.1	64.6	55.8	634.1%
Design Contracts	0.0	7.1	14.3	14.3	
Construction Contracts	0.0	40.8	44.4	44.4	
EPC Contracts	77.8	244.9	331.6	253.8	
Consultants	0.0	0.1	0.2	0.2	
Other Contracts/Costs	0.7	0.1	0.1	-0.6	
Interest	7.5	20.1	43.3	35.8	
Subtotal	86.0	313.1	433.9	347.9	404.5%
Contingency/Mgmt. Reserve	15.2	33.9	11.5	-3.7	
Total	110.0	381.1	510.0	400.0	363.7%

Source: Ex. D2-2-10, Attach 2p (p. 17) and Attach 2q (p.16)

production forecast. The OEB's mid-term review findings are set out in section 9 of this Decision.

While OEB staff and LPMA have proposed a higher production forecast for Pickering in the test period based on their analysis of historical and forecast Pickering production, the OEB approves OPG's proposal. The OEB accepts that the lower Pickering production forecast in the test period is largely related to the 7.5 TWh of production losses related to PEO,[10] and the planned 2021 vacuum building outage. The OEB notes that OPG's Pickering production forecast proposal is based on 5% FLR, which is challenging given the prior period FLR averaged 8.5%.[11]

The Pickering test period production forecast assumes that the PEO technical assessments will determine fitness for service beyond 2020, and that system planning and other regulatory considerations will be in place for operation in 2021. The OEB's findings on PEO are in section 5.7 of this Decision.

The OEB is not convinced that OAPPA's proposal, supported by LPMA, to replace Darlington PHT pump motors only during planned outages has fully considered all the risks. The consequences of pump motor failures are significant and result in an automatic reactor trip.[12] PHT pump motor failures resulted in production losses of 1 TWh in 2015 and 0.4 TWh in 2016.[13] The OEB approves OPG's proposal for Darlington production forecast and notes that the forecast is based on a 1% FLR for 2017 to 2019 versus 2.9% in the prior period. FLR will be higher as DRP progresses and refurbished units are returned to service beginning in 2020.

5.2 Nuclear Operations Capital and Rate Base

Background

The nuclear operations project portfolio includes OM&A projects and capital projects. The former are discussed in section 5.6 of this Decision. The historical and forecast nuclear operations capital expenditures, excluding DRP, are summarized in the following table:

[10] Reply Argument page 96.
[11] Exh E2-1-1 page 9.
[12] Reply Argument page 103.
[13] Tr Vol 13 pages 24-25.

Table 8: Nuclear Operations Capital Expenditures

$million	2010 Actual	2011 Actual	2012 Actual	2013 Actual	2014 Actual	2015 Actual	2016 Budget	2017 Plan	2018 Plan	2019 Plan	2020 Plan	2021 Plan
Capital Project Portfolio	157.0	135.3	145.9	191.0	269.8	292.5	322.0	253.0	238.0	248.0	259.0	180.0
Pickering 2/3 Isolation	5.9											
Darlington New Fuel										15.3		
Minor Fixed Assets	15.4	12.9	15.5	10.2	22.9	22.3	31.0	26.0	20.0	19.1	19.5	19.3
Total	178.3	148.2	161.4	201.2	292.7	314.8	353.0	279.0	258.0	282.4	278.5	199.3
Five Year Average		2011-2015 Average: $223.7 million						2017-2021 Average: $259.4 million				

Source: Exh D2-1-2 Table 2, EB-2013-0321 and EB-2016-0152

The increase in capital expenditures starting in 2014 is largely related to DRP projects that were reclassified to the nuclear operations portfolio as these projects were determined to support the daily operations of the entire station. In total, $329 million of DRP projects were reclassified. The portfolio budget is administered by the Asset Investment Steering Committee (AISC). OPG states that the AISC review and Business Case Summary approval processes enhance OPG's ability to complete projects within budget and on schedule.

The historical and forecast nuclear operations in-service additions are summarized in the following table:[14]

Table 9: Nuclear Operations In-service Additions

$million	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Forecast	191.5	175.5	187.6	180.7	158.3	141.7	497.0	389.0	315.2	239.3	300.4	215.6
Actual	249.0	103.2	131.9	212.6	148.6	204.1	292.0					
Variance	57.5	-72.3	-55.7	31.9	-9.7	62.4	-205.0					
Updated - J21.1							292.0	479.0	354.7	385.4	244.7	181.6
Five Year Average		2011-2015 Actual Average: $160.1 million						2017-2021 (Updated) Average: $329.1 million				

Source: Exh D2-1-3 Table 4, EB-2013-0321 and EB-2016-0152, Undertaking J21.1

The historical and proposed nuclear rate base are summarized in the following table. The proposed rate base has been revised by the second impact statement, Exh N2-1-1, which excluded the in-service amount related to the DRP Heavy Water Storage and Drum Handling Facility Project (D2O project). DRP in-service additions are discussed in section 5.3. Asset retirement costs are discussed in section 5.13:

[14] There are support services capital projects entering rate base as well. For the test period, these additions range from $5 million to $18 million per year. The in-service additions with respect to DRP are discussed in section 5.3.

Table 10: Nuclear Rate Base

$million	2010 Actual	2011 Actual	2012 Actual	2013 Actual	2014 Actual	2015 Actual	2016 Budget	2017 Plan	2018 Plan	2019 Plan	2020 Plan	2021 Plan
Net Plant (Excl DRP)	1,586.7	1,575.5	1,495.9	1,473.4	1,457.5	1,414.8	1,597.8	1,780.5	1,861.0	1,848.6	1,813.9	1,848.4
Net Plant (DRP)				60.2	121.2	192.6	419.1	611.9	601.5	586.7	4,699.1	5,154.5
Asset Retirement Cost	1,517.6	1,490.0	1,851.1	1,470.2	1,389.4	1,308.7	825.7	524.0	446.7	369.5	292.2	249.6
Total Nuclear Net Plant	3,104.3	3,065.5	3,347.0	3,003.8	2,968.1	2,916.1	2,842.6	2,916.4	2,909.2	2,804.8	6,805.2	7,252.5
Cash Working Capital	14.3	25.9	32.0	32.0	9.3	11.0	11.0	11.0	11.0	11.0	11.0	11.0
Fuel Inventory	335.0	345.4	340.7	330.6	316.1	301.4	280.3	251.9	242.2	224.2	210.7	208.6
Materials and Supplies	441.8	421.9	413.3	413.5	420.8	426.7	438.7	448.7	444.5	436.3	427.0	415.0
Total Rate Base	3,895.4	3,858.7	4,133.0	3,779.9	3,714.3	3,655.2	3,572.6	3,628.0	3,606.9	3,476.3	7,453.9	7,887.1

Source: Exh B1-1-1 Table 2, Exh B3-1-1 Table 1 (EB-2013-0321 and EB-2016-0152), J21.1

Submissions of the Parties

Some intervenors questioned the pattern of nuclear operations capital spending and the proposed significant capital program in the test period. AMPCO observed that 2017-2021 capital expenditures are 20% higher than the period 2010-2015, and further observed that in-service additions as a percentage of capital expenditures was increasing. In reply, OPG provided reasons for the increasing capital expenditures, including the reclassification of DRP projects. The pattern of in-service additions as a percentage of capital expenditures is not smooth and reflects the multiple year duration of nuclear projects.

OEB staff and several intervenors submitted that the test period in-service additions should be adjusted to reflect the actual 2016 capital additions and historical overstatement of in-service additions, which totaled $(190.9) million in the period 2010 to 2016. OEB staff submitted that the in-service amounts should be reduced by $27.3 million in each year of the test period. OPG argued that the submissions of most of the parties ignored the $70.3 million of 2016 in-service capital that was placed into service in early 2017. Considering the combined effect of in-service additions and depreciation, OPG argued that updating for 2016 actuals and using its updated forecast of 2017-2021 in-service additions[15] results in a $60 million increase in revenue requirement because the project mix includes more Pickering projects which have higher depreciation rates. In OPG's view, the parties' argument regarding the historical overstatement hinges on the large 2016 variance (i.e. a single data point).

The Projects and Modifications (P&M) organization is responsible for nuclear operations capital projects. The effectiveness of P&M was reviewed in interrogatories, cross-examination and submissions. SEC analyzed nuclear capital projects that have gone into service between 2014 and 2016 and argued that the projects are 11.7% above the cost set out in the first execution business case, and that for projects larger than $20

[15] Undertaking J21.1.

million, the variance is 41.8%. Analysis of actual completion vs. scheduled completion for projects larger than $5 million, indicated average delays of 17 months.

OEB staff and several intervenors submitted that P&M performance has been weak and that this performance has been documented in reports prepared by Burns and McDonnell and Modus Strategic Solutions (Modus) for the Nuclear Oversight Committee of OPG's Board of Directors. Several parties referred to the 2nd Quarter 2014 Report wherein Modus cited P&M management failure for campus plan projects (projects related to DRP that also support ongoing operation of Darlington). The 2nd Quarter 2014 Report noted that P&M management failures were most evident with respect to the D2O Project[16] and the Auxiliary Heating System (AHS) project. AMPCO argued that OPG should undertake an audit of its P&M project controls in time for the mid-term review and provide a status report at that time.

The parties submitted that there should be rate base disallowances based on poorly developed estimates, flawed contractor selection and weak day to day risk management. The parties proposed reductions to in-service amounts ranging from $14.4 million to $53.1 million for the AHS project and reductions ranging from $7 million to $14.9 million for the Operations Support Building project. OPG argued that its application should stand, noting that increases are related to flawed initial estimates and that the final costs are the true costs of these projects.

Findings

Capital and Rate Base

This application is a five-year Custom IR. Accordingly, the opening rate base for 2017 should be based on the best information available. Undertaking J14.1 confirms that the 2016 nuclear operations in-service additions were significantly lower, i.e. $205 million lower, than planned. Undertaking J14.1 also notes that $70.3 million of the nuclear operations in-service additions originally planned for 2016 had been placed in-service by the first quarter of 2017. OPG has provided a revision to in-service amounts and rate base in Undertaking J21.1. That revision reflects the update for actual 2016 in-service amounts and changes in timing of in-service amounts in the test period underpinned by the 2017-2019 Business Plan. Some of the intervenors have submitted that the 2016 in-service additions should be revised, but that the test period in-service additions should

[16] In Exh N2-1-1 filed on February 22, 2017, OPG updated its application to remove the in-service amounts related to the D2O project due to project uncertainty. The revenue requirement impact will be recorded in the Capacity Refurbishment Variance Account once the project is in service.

remain as originally filed. The OEB finds that the Undertaking J21.1 forecast represents the appropriate starting point for the OEB's consideration. The forecast is updated to reflect OPG's best available information for the entire period from 2016 to 2021. The proposal of the intervenors to update only 2016 would not account for the cascading effects of additions in the test period. The OEB's finding on this matter applies to nuclear operations capital and support services capital.

The scope of capital expenditure on nuclear operations has expanded to include reclassified projects from DRP, replacement of obsolete equipment and additional Canadian Nuclear Safety Commission regulatory requirements, for example, related to Fukushima. As shown in Table 8, capital expenditures have increased in the bridge and test period. SEC submitted that the planned level of nuclear operations capital spending is much higher than historical levels. However OPG argued that the average 2017-2021 capital expenditures ($259.4 million) are in line with the historical period average 2013-2015 capital expenditures ($269.6 million).[17] The OEB observes, however, that a review of a five-year historical period average from 2011-2015 ($223.7 million) supports the SEC submission.

Based on the variance between 2010 to 2016 forecast and actual in-service additions, OEB staff submitted that in-service additions should be reduced by $27.3 million for each year of the test period (the total seven-year variance offset by the 2017 additions previously forecast for 2016). SEC submitted that a 12.5% reduction (the total seven-year variance as a percentage of the total additions) was appropriate. AMPCO argued that in-service additions should be reduced by 15% annually based on the in-service variance and AMPCO's review of variances for projects of different sizes and schedule delays. AMPCO suggested that a lumpy pattern of in-service capital additions and positive and negative variances would not be unexpected. The OEB concurs with OPG that the 2010-2016 seven-year variance of $(190.9) million is largely driven by the 2016 variance of $(205.0) million.

The forecast and actual in-service additions for 2016 are significantly higher than the period 2010 to 2015 and the forecast for the test period, both as filed and as revised, is higher than historical. The five-year 2010-2015 average actual in-service additions is $160.1 million while the five-year 2017-2021 average revised in-service additions is $329.1 million. OPG was not able to achieve the forecast 2016 nuclear operations in-service additions, and it is uncertain whether OPG will have the resources to execute a nuclear operations capital program with higher capital expenditures and a much higher level of in-service additions. The elevated capital expenditures and in-service additions

[17] Reply Argument page 33.

are concurrent with DRP which could further divert resources from the ambitious nuclear operations capital program, also contributing to delayed in-service additions.

The OEB finds that some reduction to the in-service capital additions is required. The OEB finds that the reductions proposed by SEC and AMPCO are too aggressive. Instead, the OEB finds that a 10% reduction each year (2017-2021) to the non-DRP nuclear operations and support services in-service capital additions is appropriate (using the updated forecast from Undertaking J21.1 as the starting point). The OEB notes that a similar reduction was ordered by the OEB in the last OEB decision on payment amounts with respect to OPG's hydroelectric in-service additions.[18]

The OEB's findings on nuclear Custom IR and productivity are in section 8.2. In accordance with those findings, the OEB orders OPG to apply a 0.6% stretch factor to the revenue requirement associated with the nuclear operations and support services in-service capital additions in each year from 2017 to 2021. The revenue requirement reductions related to the application of the stretch factor shall be applied in the typical manner whereby the reductions in each year persist going forward (during the entire 2017-2021 period). The OEB finds that the application of a stretch factor to the nuclear operations and support services in-service capital additions is appropriate. The OEB expects that OPG will achieve productivity improvements with respect to the delivery of its nuclear operations capital program during the 2017-2021 term and those productivity savings should be passed on to ratepayers.

Projects & Modifications Performance

The effectiveness of the P&M organization has been criticized by some intervenors. The evidence relied on by the intervenors included the 2nd Quarter 2014 Report to the Nuclear Oversight Committee of OPG's Board of Directors, prepared by Burns and McDonnell and Modus Strategic Solutions (Modus report), as well as OPG internal audit reports. SEC has completed an analysis of cost and schedule for historical projects and submitted that, "The Board can expect projects to continue to be over-budget and behind schedule. This means OPG will either overspend compared to its budget or, more likely, do fewer projects. Neither scenario is good for ratepayers."[19] OPG replied that the Operations Support Building project and the AHS project are the main contributors to the variances, and that OPG is close to budget otherwise. OPG stated that factors such as limited outage windows affect project scheduling.

[18] EB-2013-0321, Decision with Reasons, page 21.
[19] SEC Submission page 58.

AMPCO reviewed iterations of business case summaries and submitted that the number of superseding business cases indicated poor P&M performance. AMPCO also submitted that P&M has delayed implementing lessons learned and that project management practices such as the gated process were mentioned in the previous cost of service proceeding. Energy Probe questioned why it has taken OPG so long to overhaul its procedures for the P&M group. OPG maintains that it has been responsive to the Modus report and that subsequent reports have acknowledged OPG efforts to improve P&M.

As in all cases, it is the utility's responsibility to file an application that supports its proposals. It is not clear to the OEB that P&M project management processes and outcomes exhibit continuous improvement. There is a large volume of evidence – filed with the application, with interrogatory responses and in undertakings. There was extensive examination regarding estimates, classes of estimates, process controls, independent reviews and internal audits. OEB staff and the intervenors have argued that there are some P&M deficiencies. OPG argues that that the intervenors do not fully understand the reasons for schedule delays or the business case summary process,[20] and did not refer to the positive findings of internal OPG audit reports subsequent to the Modus report. The OEB finds that there is room for improvement in P&M performance and the findings on stretch factor implement this finding. The OEB also finds that disallowances related to two projects, the Operations Support Building (OSB) and the AHS, are appropriate, as discussed below.

AMPCO submitted that OPG should undertake an audit of its P&M project controls and file a status report at the mid-term review. OPG argued that this amounts to micromanaging. The OEB is not convinced that project controls are as robust as they could be. Robust project controls are a critical component of good planning and execution of capital projects that allow projects to be completed on time and on budget. Therefore, the OEB directs OPG to file an independent audit of its nuclear P&M organization including adherence to best practices, measures and reporting regarding cost and schedule performance, and implementation of lessons learned. The audit report will be filed with OPG's next cost-based application.

Auxiliary Heating System and Operations Support Building

OEB staff, AMPCO, CME, Energy Probe, LPMA, SEC and VECC have all proposed disallowances with respect to AHS and OSB rate base additions. These projects were classified as DRP projects in the previous EB-2013-0321 proceeding, but have since been reclassified. However, P&M managed the AHS and OSB projects when they were

[20] Reply Argument page 38.

considered DRP projects. The parties have suggested a range of disallowances referring to the range of estimates and forecasts filed in this proceeding[21] and the Modus report. The AHS project was specifically reviewed in the Modus report.

OPG submitted that the majority of the variances relate to initial estimation concerns and scope additions, and that the OEB should accept the OPG proposal as filed. Had the work been properly estimated and the full scope of work been known initially, OPG submitted that the original cost would be close to the current cost.

The estimates and forecasts for the AHS are:

- EB-2013-0321 as filed – $36.3 million (last EB-2013-0321 update $75.3 million)
- First execution business case – $45.6 million
- Forecast/proposed final cost – $107.1 million ($98.7 million in-service amount)

Clearly the original forecast has grown substantially from what was filed in the EB-2013-0321 proceeding.

The OEB does not accept OPG's position. The current cost is not the same as the prudently incurred cost. It is not obvious whether the best alternative was selected or whether costs for the alternative selected were contained. The Modus report states that, "P&M gave only token consideration to determining which contractor had a better approach for executing the work. P&M chose the 'low bidder' even though the other contractor's qualifications and project approach were viewed more favorably."[22] CME submitted that the evidence demonstrates that OPG's management of the AHS fell short of what ratepayers should expect: "OPG's argument that ratepayers are receiving value for the scope of work which was ultimately involved in completing the AHS project fails to take into account the lost opportunity to pursue alternative and less costly options for achieving the same outcome."[23] In response to cross-examination by SEC, OPG agreed that poor baseline information can lead to cost increases and schedule delays.

The parties have proposed disallowances that range from 100% of the variance between the first execution business case and the proposed in-service addition to 50% of the variance. The OEB has considered the submissions of the parties as well as the

[21] JT2.16.
[22] Exh L-4.3-Staff-72 Attachment 4.
[23] CME Submission page 25.

Supplemental Report prepared by Modus.[24] That report comments on the D2O and AHS projects, and states that the causes of cost overruns "root from mistakes made by management." The report also states that "many of the cost variances appear to be scope based, i.e. OPG is getting more value albeit for a higher cost." On the basis of these two considerations, mismanagement and increased scope, the OEB disallows 50% of the variance between the first execution business case and the proposed in-service addition on a permanent basis. The OEB estimates the reduction resulting from its finding to equal about $27 million. However, in the draft payment order, OPG should provide the detailed calculation showing the OEB ordered reduction related to the AHS based on 50% of the variance between the in-service amount set out in the first execution business case and the current proposed in-service amount.

The OEB is prepared to accept that there may be some merit to OPG's argument that there was an increase in scope. However, the OEB is not prepared to accept that the entire increase in cost is due to an increase in scope. The evidence shows that there were other options available to OPG when selecting a contractor that may not have been adequately explored. In addition, the Modus report speaks to issues with management of the project. The OEB cannot determine on an exact basis how much of the increased cost is due to additional scope and how much is due to project management issues. Therefore the OEB has considered both factors and has determined it will allow 50% of the increased cost on account of increased scope and disallow 50% of the increased cost to account for poor management.

The estimates and forecasts for the OSB are:

- EB-2013-0321 as filed – $29.7 million (last EB-2013-0321 update $45.1 million)
- First execution business case – $47.8 million
- Forecast/proposed final cost – $62.7 million ($60.6 million in-service amount)

Clearly the original forecast has grown substantially from what was filed in the EB-2013-0321 proceeding.

The submissions of OEB staff and the intervenors on the OSB are similar to their submissions on the AHS. The OEB finds that final costs for a building refurbishment that are double those initially filed in EB-2013-0321 are not reasonable. A senior OPG executive made a notation that "This is poor performance" on the Project Over-Variance Approval form seeking an increase from $53 million to $62 million for the

[24] Undertaking J15.3 Attachment 1 page 3.

OSB.[25] The notation on the Variance Approval form does not speak to the entire increase in cost of the OSB, but it does indicate that there was a performance issue on this project as well. Because the OEB cannot determine the exact amount of increased cost due to performance issues, the OEB has exercised its judgment and disallows 50% of the variance between the first execution business case and the proposed in-service addition on a permanent basis. The OEB calculates the reduction resulting from its finding to equal about $6 million. However, in the draft payment order, OPG should provide a detailed calculation showing the OEB-ordered reduction related to the OSB based on 50% of the variance between the in-service amount set out in the first execution business case and the current proposed in-service amount.

The methodology proposed by OPG to calculate rate base is accepted. However, the OEB's findings with respect to nuclear operations capital will impact the rate base amount. The OEB's findings for establishing the nuclear operations and support services rate base and capital additions shall be implemented as follows. The starting point for the rate base amounts and in-service capital additions for the 2017-2021 period is the updated forecast provided by OPG in Undertaking J21.1. The permanent disallowances associated with the AHS and OSB should first be removed from the amounts set out in the updated forecast. The 10% reduction should then be applied to the in-service capital additions net of the permanent disallowances. Finally, the stretch factor should be applied to the revenue requirement associated with the reduced nuclear operations and support services in-service capital additions resulting from the OEB-ordered disallowances.

For future proceedings, the OEB directs OPG to file, at a minimum, the costs for each major capital project based on the first execution business case and the final proposed amount for which OPG is seeking approval. The information provided should be sufficiently detailed as to adequately highlight both the total cost and the related in-service amount.

Operation of CRVA and Nuclear Operations Capital Projects

The Capacity Refurbishment Variance Account (CRVA) was established pursuant to section 6(2)4 of O. Reg. 53/05 to record the variance between certain actual capital and non-capital costs incurred and those costs underpinning payment amounts. The costs eligible for the CRVA are related to projects that increase the output of, refurbish or add operating capacity to a regulated generating facility.

[25] Exh D2-1-3 Attachment 1 Tab 1.

OEB staff raised a double counting concern in its submission.[26] If OPG placed less nuclear operations capital in service than approved, and if OPG places more CRVA eligible capital in service than approved, OPG would notionally recover the revenue requirement twice. OEB staff proposed that any nuclear operations in-service addition "credits" offset any CRVA "debits". CCC explored this matter in cross-examination.[27] CCC compared OPG's hydroelectric proposal with respect to the operation of the CRVA with OPG's proposed status quo operation for the nuclear sub-account of the CRVA. While the nuclear revenue requirement is based on annual capital plans for five years instead of mechanistic updates, CCC submitted that the remedy proposed by OEB staff should be implemented.

OPG has proposed that the operation of the nuclear sub-account of the CRVA continue as it has operated since the account was established. OPG argued that OEB staff and CCC's comparisons are wrong as different regulatory frameworks have been applied for the hydroelectric and nuclear businesses.[28] The OEB does not agree with OEB staff's and CCC's proposal. The potential outcome of the proposal is that prudently incurred CRVA eligible costs will be disallowed for recovery. OPG is entitled to recover prudently incurred CRVA-eligible costs as per the regulation. The OEB finds that the operation of the nuclear sub-account of the CRVA will continue as proposed by OPG.

Nuclear Projects Subject to CRVA

Under issue 4.1, OPG requested that section 6(2)4 of O. Reg. 53/05, and the associated CRVA treatment, apply to: (a) the capital and non-capital costs of the DRP; (b) the capital and non-capital costs of the Darlington Spacer Retrieval Tooling project; (c) the non-capital costs for the PEO project (including the Fuel Channel Life Assurance project); (d) the non-capital Fuel Channel Life Extension project (including ongoing costs); and (e) the Fuel Channel Life Management project.[29]

OEB staff submitted that the DRP and the other nuclear projects discussed above, as set out at OPG's updated response to an OEB staff interrogatory, meet the requirements of section 6(2)4 of O. Reg. 53/05 and therefore CRVA treatment applies.

The OEB finds that the projects for which OPG requested section 6(2)4 of O. Reg. 53/05 apply are appropriate. The OEB notes that no parties disagreed with OPG's request.

[26] OEB staff submission page 62.
[27] Tr Vol 20 page 82.
[28] Reply Argument page 207.
[29] Exh L-4.1-Staff-24 pages 1-2.

Capitalization of Darlington Unit 2 New Fuel

OPG proposes to capitalize half of the cost of new fuel for Darlington Unit 2 in 2019 when the fuel is loaded into the reactor, to be depreciated after the unit is in service over the life of the station. AMPCO submitted that it is not OPG's past practice to capitalize new fuel and that OPG's evidence to support the capitalization is weak. OPG replied that AMPCO mischaracterized the interrogatory response regarding new fuel.[30] There is no past OPG practice as Darlington Unit 2 is the first instance of a full new fuel load since OPG's inception. However, the practice is consistent with USGAAP and was applied by the former Ontario Hydro. The OEB accepts the new fuel capitalization proposal as it is consistent with accounting guidance and past practice.

Projects for Future Review

Undertaking J7.3 is an internal OPG audit, "Project Controls Audit – Project & Modifications Group," March 9, 2016. The report reviewed 13 projects and identified deficiencies related to cost and schedule baseline information. OEB staff observed that the Darlington Class II Uninterruptable Power Supply Replacement and the Fukushima Phase 1 Beyond Design Day Event Project are not near completion. OEB staff submitted that the in-service amounts may include costs that were imprudently incurred and that the OEB should identify these two projects as requiring further review at the cost rebasing when these projects are complete. OPG argued that this advance identification is unwarranted and unnecessary as the OEB has the ability to assess any cost variances at rebasing. The OEB finds that processes in place are sufficient and that advance identification is not necessary.

Draft Payment Amounts Order

The OEB requires OPG to incorporate the OEB's findings on nuclear operations and support services rate base and in-service additions in the determination of revenue requirement. The filing will be consistent with the LPMA submission with respect to the filing of fixed asset continuity schedules and changes in depreciation, to which OPG agreed. OPG shall file detailed fixed asset continuity schedules for each year that reflect the changes ordered by the OEB as well as the details of changes in the depreciation expense as part of the draft payment amounts order.

[30] Exh L-6.3-Staff-111.

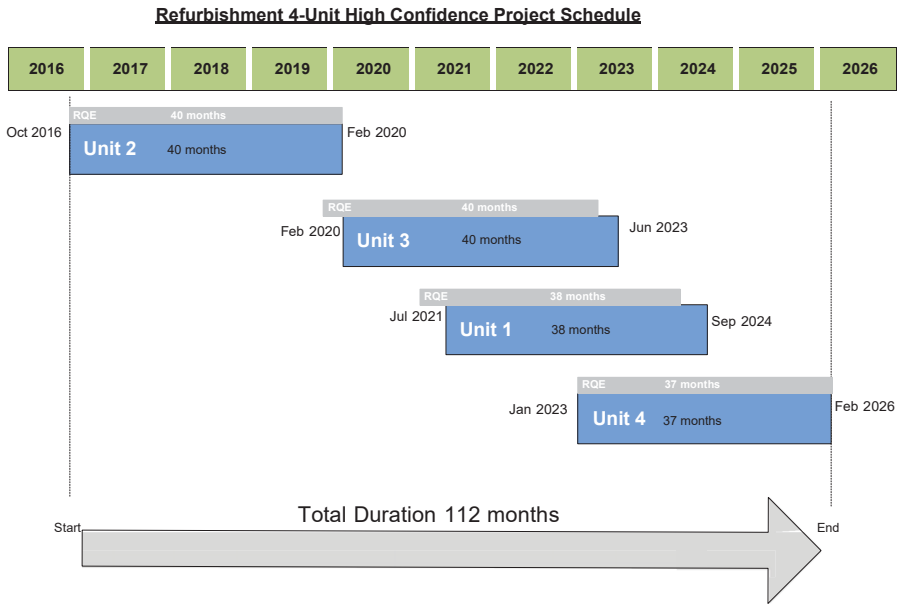
5.3 Darlington Refurbishment Program

5.3.1 DRP Planning and Costs

Background

The Darlington Refurbishment Program (DRP) is a $12.8 billion "megaprogram" to refurbish all four units at the Darlington nuclear station with a view to extending the life of the station until approximately 2055. OPG calls it a "destiny project" on which the company's future, and indeed the future of the Canadian nuclear industry, depend.

The first unit to be refurbished, Unit 2, was disconnected from the power grid (breaker open) in October 2016, and is forecast to come back online in February 2020. As the schedule below shows, the last of the units is expected to be completed in 2026.[31]



After ten years of planning, OPG's board of directors approved a Release Quality Estimate (RQE), setting out the detailed budget and schedule for the entire four-unit program, in November 2015. The RQE breaks down the $12.8 billion total cost as follows:

[31] Exh L-4.3-Staff-55 Attachment 1.

Table 11: Release Quality Estimate

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**

The RQE is said to represent a "P90" confidence level. As OPG explains in its Argument in Chief, "A P90 estimate means there is a 90% chance that the actual project cost will not exceed the estimated amount." This confidence level was determined through statistical modeling of risks identified by OPG.

By the time of the hearing, about $2.9 billion of the $12.8 billion had already been spent.

In this application, OPG is seeking approval for rate base additions of $4.8 billion of in-service amounts associated with the Unit 2 refurbishment (including contingency, interest and escalation), along with $377 million in in-service amounts for other DRP-related facilities that will enter into service during the test period. No costs for the refurbishment of the other three units are requested in this proceeding, as they will not complete their refurbishments during the test period.

For the reasons that follow, the OEB approves the additions to rate base as proposed by OPG.

Regulatory Framework

The OEB's jurisdiction in respect of the DRP is limited by O. Reg. 53/05. The regulation states in paragraph 6(2)12 that "the Board shall accept the need for the Darlington Refurbishment Project in light of the Plan of the Ministry of Energy known as the 2013 Long-Term Energy Plan and the related policy of the Minister endorsing the need for nuclear refurbishment." The question of whether the DRP makes economic sense or is otherwise justified as a matter of electricity system planning was therefore out of scope in this proceeding.

The 2013 Long-Term Energy Plan, to which the regulation refers, states that "The government is committed to nuclear power," and that "Refurbished nuclear is the most cost-effective generation available to Ontario for meeting base load requirements." The Government of Ontario reiterated its support for the DRP in January 2016, after the RQE was finalized.

The regulation also stipulates in paragraph 6(2)4 that the OEB must allow OPG to recover DRP-related costs so long as they are prudent: "The Board shall ensure that Ontario Power Generation Inc. recovers capital and non-capital costs and firm financial commitments incurred in respect of the Darlington Refurbishment Project … including, but not limited to, assessment costs and pre-engineering costs and commitments… if the Board is satisfied that the costs were prudently incurred and that the financial commitments were prudently made."

This requirement is reflected in OPG's Capacity Refurbishment Variance Account (CRVA), which the OEB has approved in every payments amount case since it was given jurisdiction over payment amounts.[32] Under the CRVA, if OPG were to go over budget on the DRP, a balance would build up in the CRVA, and the OEB would review the prudence of the overruns before approving the disposition of the balance. The CRVA is symmetrical: if the program went under budget, the excess amounts collected through payment amounts would be returned to ratepayers in a future proceeding.

Matters related to the safety, security and environmental impacts of the Darlington station and the DRP are regulated by the Canadian Nuclear Safety Commission (CNSC). The CNSC reviewed OPG's environmental assessment of the DRP and determined in March 2013 that the program would not result in significant adverse environmental effects given the proposed mitigation measures. In December 2015, the CNSC renewed the operating licence for Darlington until November 30, 2025 and found that OPG is qualified to undertake the DRP.

Planning, Contracting and Oversight

Much of the evidence in this proceeding related to the extensive planning efforts that OPG has undertaken to prepare for the execution of the DRP. OPG explained that there are three phases to the DRP: Initiation, Definition and Execution. The exploratory Initiation Phase began in 2007 and was completed at the end of 2009 when OPG's board of directors agreed to proceed with the DRP. The Definition Phase culminated in the RQE, which was approved by the board of directors in November 2015, and endorsed by the Minister of Energy shortly thereafter. OPG explained that the Definition Phase included an extensive effort to define the scope of the program. The RQE incorporates a high-confidence (P90) budget and schedule.[33]

[32] In the first payment amounts decision, EB-2007-0905 (November 3, 2008), the OEB wrote: "In light of the obligation imposed on the Board by Section 6(2)4, the Board accepts that a variance account is required for the period beginning April 1, 2008 and authorizes OPG to establish the capacity refurbishment variance account."
[33] Tr Vol 1 page 32.

During the Definition Phase, OPG also sought to identify and incorporate “lessons learned” from other nuclear projects and other megaprojects. This included a thorough review of why prior refurbishments of CANDU nuclear power plants have experienced challenges, namely the refurbishments at Bruce Power, Point Lepreau (New Brunswick) and Wolsong (South Korea). OPG also built a full-scale reactor mock-up in order to test tools and train staff – something that had not been done for the earlier CANDU refurbishments. OPG awarded the major DRP contracts, and worked with the contractors to complete the detailed engineering for the program. In total, OPG spent $2.2 billion during the Definition Phase.

OPG is using a “multi-prime contractor model” where there is more than one prime contractor and OPG has a separate contract with each of them. As the owner and integrator between contractors, OPG has overall project management responsibility and design authority, with the assistance of external technical and project management experts. The benefits of this model are said to be that OPG retains control over the project, including deliverables, costs and schedules. OPG’s functional support costs for DRP are forecast to be $2.2 billion.

OPG explained that it used different contracting strategies for each of the five major work bundles (retube and feeder replacement [RFR], turbine generator, steam generator, defueling and fuel handling, and balance of plant), which it says balanced the need and ability of OPG to transfer risk to its contractors against the benefit of achieving a lower price. By far the largest contract by value is the $3.4 billion contract for the RFR. The RFR contract is based on the Engineering, Procurement and Construction model and combines fixed pricing for known or highly definable tasks with target pricing for work that is less definable. If the actual cost of the work ends up being more or less than the estimate, the difference (outside a neutral band) would be shared by OPG and the contractor, through a system of incentives and penalties. The major DRP contracts were filed with OPG’s application (with some redactions approved by the OEB for the versions placed on the public record).

OPG provided an assessment of its contracting strategies prepared by Concentric Energy Advisors (which was initially filed in the EB-2013-0321 case). Concentric concluded that the commercial strategies employed by OPG were appropriate and met the regulatory standard of prudence. In July 2016 Concentric provided an update report on the RFR contract and stated that the terms of the finalized contract, including the target price and the allocation of risk, are prudent.

OPG also filed an expert report by Dr. Patricia Galloway of Pegasus Global Holdings Inc., an expert in megaprojects, on the degree to which OPG’s plan and approach to the execution of the DRP was consistent with the way other projects of comparable size and

complexity have been carried out. Dr. Galloway states in her report that, "Based on the review of OPG's governance, policies and procedures, and project controls developed and in use for the Program, and interviews conducted with OPG personnel, I found that OPG has reasonably and prudently prepared for its execution of the DRP."[34] Other key findings by Dr. Galloway include:

- "OPG sought to find the most qualified individuals in the industry to manage the Program and the individuals that were assigned to manage the Program are qualified and competent"[35]
- "OPG's oversight process is thorough, complete and consistent with what I would expect from a reasonable and prudent utility company embarking on this type of megaprogram"[36]
- "In reviewing OPG's policies and procedures, both from an organizational and program-specific standpoint, I found they are exemplary in their thoroughness and alignment with other individual policies and procedures providing OPG with a comprehensive tool from which it can properly execute the Program"[37]
- "I found the methodologies employed by OPG to develop the RQE estimate to be *world-class*"[38]

OEB staff also engaged an independent expert in megaproject planning and risk management: Kenneth M. Roberts, the chair of the construction law group at the US law firm, Schiff Hardin, LLP. Mr. Roberts agreed with Dr. Galloway that OPG's planning was thorough and in accordance with industry standards. Asked to summarize his conclusions at the oral hearing, Mr. Roberts answered:

> Specifically, my opinions included the following: That the DRP risk and OPG risk assessment are in fact consistent with industry standard practices used by utilities and large capital construction projects of similar size and complexity; that OPG's planned project control system for the DRP to manage costs and schedule are consistent with industry standard practices used by utilities in large capital construction projects of similar size and complexity; that OPG's program and project management staffing plans and the written management policies and procedures for the DRP are consistent with industry standards used by utilities in large capital projects; that OPG's contracting strategy, contract terms, and contractual risk allocation between OPG and the contractors for the DRP are consistent with industry standards for [risk] shifting on projects of this size and complexity.[39]

[34] Exh D2-2-11 Attachment 2, page 8.
[35] Exh D2-2-11 Attachment 2, page 40.
[36] Exh D2-2-11 Attachment 2, page 40.
[37] Exh D2-2-11 Attachment 2, page 43.
[38] Exh D2-2-11 Attachment 2, page 51 [emphasis in original].
[39] Tr Vol 7 pages 13-14. The transcript erroneously refers to "rate shifting" in the last sentence.

He cautioned, however, that no amount of planning can ensure the smooth execution of a megaproject: “All megaprojects experience some form of cost and/or schedule issues, which may include but [are] not limited to commercial challenges, changes, unexpected and high-impact events and/or delays. It's not a question of whether these types of events will occur. It’s a matter of how OPG handles and responds to these issues when they arise.”[40]

The DRP is now in the third and final phase: the Execution Phase. There are multiple layers of oversight, including but not limited to: a special DRP committee of the board of directors, which has engaged its own external expert; OPG’s internal audit group; and the Refurbishment Construction Review Board, which is made up of external individuals with expertise in megaprojects and nuclear power and which reports to OPG’s CEO and the Chief Nuclear Officer. OPG’s shareholder, the Province of Ontario, also has an oversight role, through the Ministry of Energy, which has retained outside experts through Infrastructure Ontario to provide oversight and report back on findings.

The President and CEO of OPG, Jeff Lyash, appeared before the OEB twice in this proceeding – first at the presentation day on September 1, 2016 and then on the first two days of the oral hearing on February 27 and 28, 2017 – to speak to the importance of the DRP to the company and the company’s efforts to ensure it is executed successfully. He explained:

> What incentive does OPG have to come in under budget? I think there is a layered set of incentives that we have, beginning with the fact that we're an Ontario business corporation, so, as part of that, we have an obligation, a fiduciary obligation, to run the company in a certain manner, and as part of that, our long-term objective is to satisfy our customers so that we're rewarded with net income and return on equity. Successfully completing this project on or under budget, on or under schedule, we believe substantially increases the company's potential to be successful in the long run.
>
> The second incentive I point out to you is that, in regard to Darlington, we’re a regulated generating company, and part of the compact for being a regulated generating company is to deliver value to the customer. And that’s at the heart of the value proposition for a regulated utility. It is for OPG. And so delivering projects ahead of schedule and under budget in a way that lowers the customer's price is part of our core objectives.
>
> The third element, I think, that provides us an incentive is that our shareholder in this case, unlike most other companies, are the citizens of Ontario. And so they, through the provincial government, own the company. And so, in defining what shareholder value we're delivering, ahead of schedule, under budget, and lowest customer price is what our

[40] Tr Vol 7 page 15.

> shareholder demands, and they exercise that through the Minister of Energy, and he has made that very clear.
>
> Another significant element here is that this is a destiny project for the company, and it is, frankly, a destiny project for the nuclear industry, and we're all very clear that meeting or exceeding expectations has tremendous value for the company and the industry in the long-term. This is also tied directly to management compensation, delivering not only the project but reliable and cost-effective operation of the units post-refurbishment.
>
> And then lastly – and I would ask Mr. Reiner to comment on this – we have built incentives down through the project management team and the contracts that we've structured.[41]

At the time the oral hearing began, at the end of February 2017, OPG advised that it was "tracking slightly under budget at this point in time, as of end of January, about $59 million".[42]

OEB staff submitted that OPG has planned effectively and that an appropriate framework has been implemented for DRP, but concurred with Mr. Roberts about execution phase risk. SEC's submission is similar:

> OPG appears to have tried their best to put in place project controls, a risk management framework, and a schedule that will ensure completion on time and on budget. All of this is a very positive sign. But it is only that. In no way does good planning guarantee successful execution.[43]

Proposed Additions to Rate Base

In this application, OPG asks the OEB to approve in-service additions to rate base for Unit 2 (the only unit planned to be completed in the test period) of $4,800.2 million in 2020 and 2021. In addition, OPG seeks approval for in-service additions of $377.2 million for other DRP-related projects, known as "campus plan projects", comprising the "early in-service projects", the facilities and infrastructure (F&I) projects, and the safety improvement opportunities (SIO) projects.[44]

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[41] Tr Vol 1 pages 37-38. March 2017 status reports were filed with Undertaking JT2.10
[42] Tr Vol 1page 16.
[43] SEC Submission page 42
[44] The early in-service projects are projects that will be placed in service before the refurbishment of Unit 2 is completed because they provide immediate benefit to the Darlington station even before Unit 2 is returned to service. The F&I projects are certain projects that OPG says are necessary to enable execution of the DRP, but which would be useful to the station even if the DRP were not completed. The SIO projects are initiatives that OPG committed to completed in the environmental assessment for the DRP that was approved by the CNSC, and would be useful to the station even if the DRP were not completed.

OPG is seeking approval of in-service additions to rate base associated with the DRP as set out in the following table:

Table 12
Bridge Year and Test Period In-Service Amounts ($ million)

	2016	2017	2018	2019	2020	2021	Total	Ex Campus Plan	Campus Plan
1 Original	350.4	374.4	8.9	0	4,809.2	0.4	5,543.3	4,800.2	743.1
2 Update		(365.9)		0			(365.9)		(365.9)
3 Net	350.4	8.5	8.9	0	4,809.2	0.4	5,177.4	4,800.2	377.2

Sources:

1. Original Request: Exh D2-2-1 page 6.
2. Update for removal of the Heavy Water Facility project (D2O project): Exh D2-2-10 Table 2 and Exh N2-1-1.
3. Net: Confirmed Tr Vol 1 pages 23 and 24 and Exh N2-1-1.

In an update to its original application,[45] OPG removed the Heavy Water Facility project (the D2O project), which will store large volumes of heavy water, but which has experienced delays and cost overruns. OPG testified that, despite these difficulties, the completion of the D2O project did not threaten the overall Unit 2 schedule and budget. Although some other DRP-related projects, including the Third Emergency Power Generator project, have also encountered delays or overruns, OPG did not seek to update the associated in-service amounts (and the timing of those amounts) as originally filed.

The Unit 2 in-service amounts are broken down as follows:[46]

[45] Exh N2-1-1.
[46] Exh D2-2-1 Figure 1.

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Black & McDonald

October 21, 2014

Mr. Riyaz Habib, Project Director
Projects and Modifications
Ontario Power Generation
1908 Colonel Sam Drive, 011-226,
Oshawa, ON
L1H 8P7

Dear Riyaz,

Re: Extended Services Master Agreement (the "ES MSA")
Re: Termination of D20 Project Purchase Order No. 217807 (the "D2O Purchase Order")

As promised in our Letter dated October 17, 2014 in response to your letters dated October 16, 2014, in which you purport to terminate the D2O Purchase Order, pursuant to section 9.1 of the ES MSA, effective immediately, the following is a more thorough response to the allegations contained in your letter of October 16, 2014.

B&M Is Not in Breach of the ES MSA

B&M has been diligently working in good faith since the issuance of the D20 Purchase Order. In spite of the adversity B&M has faced as a result of OPG's breaches of its obligations under the ES MSA and D2O Purchase Order, including acknowledged organizational challenges within OPG, and also unexpected site conditions and other factors. B&M has met and exceeded its standard of care under Section 3.1(c) of the ES MSA, and denies the vague and unsubstantiated allegations referenced in your letter.

In addition, your letter seeks to attribute exclusive responsibility to B&M for project conditions which developed over a period of time. These project conditions have been acknowledged by the third party consultants retained by OPG, Burns & McDonnell/ Modus Strategic Solutions in their report to the Nuclear Oversight Committee of the OPG Board of Directions dated June 26, 2014 (the "Modus Report"),which was also given in evidence before the Ontario Energy Board.

By way of example, in your letter, you seek to attribute full responsibility for the increase in the project's budget to B&M. However, your own third-party consultants found in their Report (at page 16) that "[it] is important to note that we believe that the majority of the cost increases with D2O Storage and AHS are due to maturation of these projects' scope definition, scope management, unforeseen subsurface conditions or flawed estimates. In other words, the increased budgets are simply reflective of the true project costs had they been estimated properly at the outset." [emphasis added]

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Direct Factors Influencing Cost Increases and Schedule Extensions

The increases in cost of the D2O Purchase Order and related schedule extensions are largely attributable to the following list of factors impacting scope or B&M's ability to move forward with the project, which have been provided by way of example, but are by no means an exhaustive list:

(a) Significant scope growth and project disruption arising from contaminated soil and water necessitating mitigation and monitoring measures. B&M was instructed by the OPG Project & Modifications Group ("P&M") not to provide for the presence of tritium on-site in its original bid.

(b) Scope growth from the original proposed annex to the existing building (3 walls and a roof) becoming a standalone building with the new requirement of a piping / services bridge.

(c) Schedule delays arising from Engineering approvals and decision making such as the methodology of the LPSW relocation and delays in the comment and disposition review cycle for items acknowledged by OPG senior management as items of preference.

(d) Scope increase arising from unknown soil and water conditions adding complexity to the shoring requirements over the proposed bid and common industry practice which had significant impacts on cost, schedule and risk.

(e) Scope increase introduced by Tritium Recovery Facility stakeholders during the acceptance review of the design which multiplied the piping and valve complexity and increased scope of office facilities.

(f) Delays and inefficiency arising from site space allocation for laydown areas, trailers and construction area boundaries not finalized with OPG Operations and OPG Security until late in the project.

(g) Slow response time for issuing PCA's, CTP's, PO revisions and ONCORE setups by OPG PMO, OPG Supply Chain and OPG Finance which impacted Contractor's response time to subcontractors and their subcontractors and created significant additional PMT effort and cost.

(h) Delays and costs arising from the months required to obtain OPG approval for a Graded Approach to procurement and construction activities. This first impacted the scope and schedule for the concrete reinforcing bar in the pad for the helium tank relocation.

(i) Additional PMT cost and distraction as well as schedule delays arising from B&M project team resources being consumed in responding to an ongoing series of OPG requests for new schedule scenarios, new design strategies and schedule compression requests, which effort detracts from advancing the Work itself.

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The above listed generally arise from a failure of OPG to manage its internal stakeholders to take actions promptly as per 4.1(a),(b) & (c) of the ES MSA in providing approvals, information and decisions required by B&M to advance the project. Instead, B&M was generally left to deal with the site stakeholders without any authority or control over them.

Indirect Factors Influencing Cost Increases and Schedule Extensions

(a) The project award was delayed by OPG's Supply Chain process but there was pressure to maintain schedule milestones, resulting in compressed mobilization, engineering and planning for the TRF outage and the project in general.

(b) OPG has failed to fulfill its implied reciprocal obligation to facilitate the project as a buyer of engineering, procurement and construction services for this "first of a kind" project of its magnitude and complexity inside the nuclear protected area in over 20 years. Instead, OPG's approach was to make the Contractor responsible for everything without fulfilling OPG's necessary role.

(c) OPG project management on the project had never managed a construction project of this magnitude and it became apparent that they had little to no influence with the other OPG stakeholders to remove obstacles, secure access or obtain approvals to facilitate the B&M project team to proceed on time and within budget;

(d) OPG required that this construction project be performed under the modern Engineering Change Control process, which was designed to manage sustaining capital changes in a maintenance environment in an operating nuclear facility, and not what is essentially a brownfield construction site. This was also acknowledged in the Modus Report;

(e) Addition of subsequent projects impacted Sally Port congestion and transit time further impacting cost, schedule and productivity. B&M included qualifications and concerns in its bid regarding the capacity of the Sally Port if project activity was to increase in the protected area.

(f) B&M endured an uncooperative labour relations environment, including but not limited to:

    (i) OPG's engineers, who are members of a collective bargaining unit (*i.e.* the Society of Energy Professionals) and who previously would have been responsible for the design, have held up the acceptance of B&M's engineering deliverables with excessive, trivial and preferential comments that had no impact on the functionality or quality of the design.

    (ii) Stakeholder disengagement by many members of other bargaining units, such as the Power Workers Union, who are gatekeepers to many of the barriers to B&M performing its work.

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(g) The Modus Report confirms at page 17 that OPG's own P&M Group failed to appropriately budget the D2O project internally, based upon a realistic scope of work and the proper classification of the estimate, and if it had done so, the perceived "budget overrun" would not have occurred:

> Based on these practices, the budgets initially approved by the Board for D2O Storage ($108M) and AHS ($45.7M) were not sufficient for the planned scope of work. Moreover, had P&M appropriately classified these two project's cost estimates at a Class 5 (-50% to +100%) maturity level, it is very likely that these projects could have entirely avoided an overrun. [emphasis added]

Despite the uncertainty posed by the increases in scope as well as the indirect obstacles and factors, B&M has worked diligently to develop the budget and schedules through all of the changes in Project scope and functionality. As a result of the factors outlined above, the estimate of $287 million outlined in B&M's October 7, 2014 letter remains a valid target price, assuming that there are no further scope changes.

Deemed Termination for Convenience

For the foregoing reasons, B&M expressly denies that it has breached its obligations under either the ES MSA or the D2O Purchase Order, including, but not limited to its obligation to exercise a standard of care normally exercised by professional contractors having specialized knowledge and expertise in performing work or a similar nature, scope and complexity to the Work and to implement all Prudent Practices.

Furthermore, even if a breach had occurred under the D2O Purchase Order, which B&M explicitly denies, ES MSA Section 9.1(l) and the post-amble of Section 9.1 provide that it is a precondition to an Event of Default arising that OPG has served a Notice of Default specifying the breach, and that the 7-day cure period provided therein has expired. Neither of those preconditions has been met, since OPG has not previously served a Notice of Default under the D2O Purchase Order, nor provided B&M with the requisite cure period.

As such, B&M cannot be terminated for default. Section 9.5 of the ES MSA provides that "if, at any time after OPG ... exercises its rights under Sections 9.3 or 9.4, it is determined for any reason that an Event of Default had not occurred or that the Event of Default was otherwise excusable, the rights and obligations of the Parties will be the same as if the termination of this Agreement by OPG had occurred under Section 10.2".

In light of the foregoing, and in light of OPG's stated intention to immediately terminate the D2O Purchase Order, B&M interprets this termination as being pursuant to the Termination for Convenience provisions of Section 10.2 of the ES MSA.

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Path Forward

Notwithstanding that B&M vehemently denies that an Event of Default has arisen and that B&M intends to vigorously defend any such accusation, B&M remains available to work with OPG in transitioning the D2O Project.

To that end B&M firmly believes that OPG and B&M should meet in the next day or two to engage in good faith discussions regarding a D2O transition plan and all other outstanding items related to D2O. It is our hope that this meeting will clearly appoint decision making representatives from each of B&M and OPG, set a list of action items requiring resolution, and set fixed dates for achieving such resolution.

B&M of course remains committed to carrying out its obligations on all other purchase orders under the ES MSA and will do so without compromising performance, including with respect to safety and HU.

Sincerely,

J. Bruce McDonald
President and Chief Executive Officer

cc: Dietmar Reiner, OPG, SVP, Nuclear Projects
Scott Martin, OPG, SVP, Business and Administrative Services
Chris Ginther, OPG, SVP and General Counsel and Chief Ethics Officer
Art Rob, OPG, VP, Project and Modifications
Stephun Cliver, OPG, Chief Supply Officer
Phil Reinert, OPG, VP, Supply Services, OPG Projects
Keith Backus, Black & McDonald

Report to Nuclear Oversight Committee

2nd Quarter 2014

Darlington Nuclear Refurbishment Project

Burns & McDonnell
Modus Strategic Solutions

May 13, 2014

I. Executive Summary

Burns & McDonnell Canada Ltd. and Modus Strategic Solutions Canada Company ("BMcD/Modus") provide the following Quarterly Report to the Nuclear Oversight Committee of the OPG Board of Directors ("NOC") regarding the status of the Darlington Nuclear Generating Station's Refurbishment Project ("Project" or "DR Project") as of April 30, 2014. The DR Project continues to advance toward its major goal of producing a Release Quality Estimate ("RQE") for final Board of Directors and Shareholder approval by October 15, 2015.

BMcD/Modus has continued to stress the importance for OPG to embrace its role as the integrator of the work and to actively manage the multiple contractors. To this end, the DR Team has made a significant shift in engineering strategy and will now directly manage and supervise the engineering service providers, rather than continuing the previous "hands-off" oversight approach. This is a bold but necessary move and one that is endorsed by BMcD/Modus. If OPG manages this transition well, we would expect a significant increase in engineering efficiency.

Pursuant to the Project's Assurance Plan approved by the Audit & Finance Committee, BMcD/Modus has prepared independent reports documenting the DR Team's status as well as further recommendations for improvement. This quarter we have issued Assurance Reports based upon our detailed review of: 1) DR Project Schedule Process and Development; 2) the 2013-2014 Business Plan as it relates to the latest project estimate (the "4c Estimate") and 3) Scope Status and Process. Upcoming reports will focus on our review of the Campus Plan cost and schedule overruns, 4d Cost Estimate vetting and RQE preparation. These full reports will be available for the NOC's review. In addition to our regular, everyday contact with the Project Team, we will continue to meet periodically with the Refurbishment Project Executive Team ("RPET") to discuss our reports to NOC and our Assurance Reports in order to clarify any recommendations and engage in discussion of appropriate actions. We are also coordinating our efforts with Internal Audit so that we meet our assurance commitments in an efficient and effective manner.

Much of our focus in this quarter's report was on evaluating the performance of the pre-requisite Facilities and Infrastructure projects ("F&I" or "Campus Plan Projects"). The Campus Plan Projects remain a significant risk to the Refurbishment Project, and provides important lessons learned for the DR Project.

The following is a brief summary of the DR Project's most significant developments over the last quarter:

- **Campus Plan Performance Project Risk:** Many of the Campus Plan Projects are forecasted to complete significantly beyond the approved budgets and schedules. In fact, schedule adherence is so poor that the Campus Plan work poses multiple threats to the start of Refurbishment. Over the last quarter, BMcD/Modus has engaged in a thorough review of several key Campus Plan projects in an attempt to identify trends and understand the causes of these cost and schedule overruns. Our findings show that the predominant cause was OPG's Projects & Modifications ("P&M") organization, who is managing this work for the DR Project, incorrectly applied an "oversight" project management approach for its EPC contracting strategy, leading to a series of cascading management failures and contractor performance issues, including misunderstandings of scope, uncontrolled scope creep, poor quality cost estimates, unrealistic and incorrect schedules and an inability to manage known risks, additional costs and delays. For multiple reasons described herein, P&M was completely overwhelmed in trying to manage Campus Plan Projects – in particular, the two largest of these projects, the D2O Storage Facility and Auxiliary Heat Steam Plant ("AHS") which were the "pilot" projects for this new contracting model.

  Simultaneous to our review, the P&M team's new leadership has taken aggressive action to correct as many of the major issues as possible. In acknowledgement of many of our recommendations and as a result of its own findings, P&M, the performing Extended Services Master Service Agreement ("ESMSA") contractors and the DR Team are developing more realistic project schedules for each scope of work that will account for need dates, available resources and optimal work flow. Senior management has committed to a full reforecast of the cost of each of the Campus Plan Projects, starting with the two most notable problem projects, the D2O Storage Facility

and AHS. P&M's and the DR Team's senior leadership instructed their managers to actively manage the work henceforth through increased collaboration with the contractors. In particular, OPG's engineering team will be taking on a much more active role in directly managing the remaining engineering work. While these measures are much more likely to be successful, the damage to a certain extent cannot be fully mitigated, as the affected Campus Plan Projects will cost more, finish later and pose a much greater threat to Refurbishment than management initially realized; this is in large part due to the unrealistic nature of P&M's initial project budgets and the way in which scope crept into these projects after these initial budgets were approved. We recommend that OPG look at the impact of these Campus Plan Projects on the Definition Phase budget as soon as possible. Moreover, P&M can only hope to recover these Campus Plan Projects if it receives support from OPG's corporate functions, from whom P&M will require fast action and some needed modifications to processes. Our team has been engaged in closely monitoring the recovery plan and will continue to report on P&M's progress. Our observations and recommendations with respect to the Campus Plan performance to date are summarized in this report and will be the subject of an Assurance Report we intend to issue at the conclusion of the 2nd Quarter.

- **RQE Preparation**: RQE development remains essentially on schedule, though the development of the 4d Cost Estimate will be a good test of the DR Team's preparation. Senior management has introduced two new controls to the Project to aid in this endeavor: 1) an Options Review Board chaired by the Senior VP of Refurbishment that is vetting the maturing plans for each scope of work, and 2) a Readiness Schedule and related process which will hold the project managers accountable for meeting interim preparation milestones. These are good measures that will provide additional confidence for RQE. In addition, all of the major Project Bundles except for the Steam Generator Project will be going through Gate 3 prior to the fall of 2015, which should provide the DR Team with an opportunity to re-examine these sub-projects' business cases including scope alternatives, status, methods of delivery, cost estimates, schedules and risks. Strengthening the gate process as we have recommended will provide further levels of vetting for the work planning and should streamline the DR Team's approach to the 4d Cost Estimate.

- **Retube & Feeder Replacement Project Risks**: The RFR project remains the DR Project's most notable ongoing risk, with respect to the Execution Phase as it represents the majority of the work on the Critical Path. SNC/Aecon's performance trends during the Definition Phase needs to be taken into account in the vetting of its Class 3 Estimate[1] (an estimate with an expected accuracy range of between -10% on the low side and +30% on the high side after the application of contingency) and OPG's confidence level for the Execution Phase. Through March 31, 2014, the contract is underspent by $9 M against plan, though this gap is closing. Additionally, SNC/Aecon's cumulative schedule performance index ("SPI") has improved to 0.94. As noted in our last report, SNC/Aecon's original plan to complete tooling delivery by June 2014 will not be met, and aspects of its recovery plan dates are being challenged by further supplier delays. SNC/Aecon has committed to recover these dates and is reassigning work to different suppliers, though the impacts of these delays could be felt in the tool performance guarantee period. OPG's RFR team is closely monitoring these events and holding SNC/Aecon accountable.

  With respect to the Class 3 Estimate preparation, SNC/Aecon met its internal goal of March 15, 2014 to produce construction work packages ("CWP's") and has progressed with its other key deliverables, including the detailed Level 4 schedule. However, the compressed time frame during which SNC/Aecon produced all of these estimate components has put the onus on OPG to review, comment and rationalize SNC/Aecon's estimate by June 15, 2014, which will take considerable effort and coordination. Ultimately, SNC/Aecon must provide OPG with comfort that the Class 3 Estimate meets its committed level of accuracy. Equally important is how the Class 3

[1] Estimate accuracy is classified per the Association for the Advancement of Cost Engineering International (AACEi) standards Class 1 through 5. Class 1 is the most accurate.

Estimate forms the platform from which the Class 2 Estimate (with an expected accuracy range of -5% to +20%) will be developed for RQE. As discussed below, there are some commercial opportunities OPG must weigh that could impact the cost estimate as well. Given its high importance to the overall project, BMcD/Modus sees OPG arriving at an appropriate comfort level with the Class 3 Estimate as essential to tightening the project's cost estimate, and we would recommend the team take any reasonable time and action needed to reach that level of comfort.

- **Commercial Risks:** The Project Team has taken our recommendation to review commercial incentives and disincentives in the Project's major contracts in light of some changed planning basis and assumptions—including the Shareholder's mandates set forth in the LTEP, the unlapping strategy and the evidence to date of contractor performance. The DR Team took an action to develop a negotiation strategy with SNC/Aecon that will take into account the impact on their work caused by the unlapping Unit 2, prioritization of Unit 2 performance, potential for economies of scale with the Turbine Generator work and other key considerations. Regarding the ESMSA, senior management is instituting a number of changes to managing and executing the EPC model that has proven to be ineffective at driving performance, cost and schedule compliance and reducing OPG's risk. [redacted], and OPG theoretically has both the expertise and the essential knowledge needed to more effectively manage this work. Going-forward, it is OPG's intention to take a much stronger role in managing and directing the engineering portion of the work. In doing so, it will be important to for OPG to understand and communicate the impact of the shifting of risk for this added responsibility as well as any impact to warranties provided by the contractors. The success of this new strategy will depend on OPG's ability to attract and retain talent and OPG's ability to drive change down through its organization to implement a new project management philosophy.

Other ongoing challenges to the DR Project include the development of the DR Team for the Execution Phase, further refinement of the Risk Management Program and Fuel Handling work. Attachment "A" provides an update regarding the DR Project's risks.

II. Summary of Campus Plan Root Cause

A. Overview

The Campus Plan Projects consist of 26 separate scopes of "pre-requisite" work that are needed to support the DR Project or the station's operations during construction. These projects are being managed by OPG's P&M organization. Prior to this Campus Plan work, P&M executed capital projects for the stations, with annual budgets of approximately $300M. With the advent of the DGNS Refurbishment Project, senior management sought to use P&M to develop and oversee all of the Campus Plan Projects, allowing the DR Team to focus on planning for the DR Execution Phase. The inclusion of the Campus Plan Projects caused P&M's portfolio to increase by four to five times, and the scale and technical complexity of this work was unprecedented for this organization. At the same time, OPG was under pressure to decrease its staff in line with the Shareholder's requests. As with many utilities in the US, OPG who had once had a very large construction unit that built the current stations and Bruce, and as recently as Pickering A Unit 1 RTS Project in the mid-2000's had considerable in-house construction, planning, procurement and engineering resources, was shrinking even further and the capability for managing and directing large capital projects was sacrificed.

From 2010 until July 2013, P&M was led by its former VP [redacted]. [redacted] ultimately succeeded [redacted] in January 2014. P&M's governance, including most of its business and management processes, were separately developed and maintained from those used by the Refurbishment Project. Also, P&M negotiated and utilized the Extended Service Master Services Agreement ("ESMSA") contract and the two "ESMSA Contractor" consortiums led by Black & McDonald and ES Fox. The ESMSA contract is actually a mix of multiple standard form agreements that could be used in combination depending on the circumstances – e.g. there are separate forms for engineering, procurement and construction that could be combined into an "EPC" contract. The business deals with the ESMSA Contractors were

the result of a competitive process which resulted in the contractors agreeing to some unique provisions that are used for all contracted work with these vendors. As an example, when used as an EPC, the contractors who lead these consortia are required to bid engineering work on a fixed-price basis with no profit for themselves. The construction work is all cost reimbursable target price, and the performance incentives include up to a 50% reduction of profit, though this and some other disincentives built into the contract have proven thus far to be much less effective in practice than concept at driving the contractors' behavior and performance.

The impetus for having P&M execute the Campus Plan work was that through the Definition Phase of Refurbishment, the DR Team was not assembled as an execution organization, but a planning one. P&M was an existing service resource with some experience in managing the ESMSA contractors. P&M's work on the Campus Plan Projects is funded by Refurbishment and it must report its progress to Refurbishment, though these business units are otherwise autonomous. Until recently, other than these approvals and the fact that both organizations use the ESMSA Contractors, there was very little else in common between Refurbishment and P&M, including the project management procedures utilized for their respective projects. P&M's project management procedures were not developed to manage multi-year projects of the size and scope of some of the Campus Plan Projects. Over the last several months, P&M has begun to manage the Campus Plan projects in accordance with the project management procedures developed for the DR Project in an attempt to implement industry-standard risk, cost and schedule controls. Additionally, the new VP has implemented a series of organizational and strategic initiatives with the goal of improving performance.

As of April 2, 2014, the Campus Plan Projects are estimated to cost in aggregate approximately $660M (an increase of $111.5 Million over the Board of Directors approved 2014 Business Case release for this work) and the work varies widely in size and complexity. The performance of the work is largely split between the two ESMSA contractors, Black & McDonald and ES Fox. Deadlines for completion of these Projects vary based on the project's and stations' needs; AHS is scheduled to be complete prior to the DNGS Vacuum Building Outage ("VBO") in mid-April 2015, while all the remaining work is scheduled to be completed one year later, in April 2016, to allow enough time for commissioning prior to the October 2016 Refurbishment Project's breaker open milestone. Many of these Campus Plan Projects involve the construction of commercial buildings that are made more complex because of their location on or adjacent to the nuclear island, which impacts their associated design requirements for such things as nuclear safety, security, and seismic requirements. Additionally, these are brownfield projects on a site where soil quality issues and underground interferences are the norm and coordination with the operation of DNGS must be managed.

Over the last quarter, BMcD/Modus has engaged in a number of activities related to the Campus Plan Projects. In this regard, we have:

- Reviewed the reasons for significant cost variances in five of the largest Campus Plan and Prerequisite Projects: D20 Storage Facility; Auxiliary Heat System Building ("AHS"); Water & Sewer; RFR Island Annex Building ("RFRISA"); and Retube Waste Processing Building ("RWPB"). Our goal was to determine the root cause of the Campus Plan Projects' variances so that past mistakes will not be repeated. We chose to examine the RWPB, which is being built by SNC/Aecon and managed by the DR Team, for a real-time direct comparison with the ESMSA-managed projects.
- Reviewed the Campus Plan Projects' schedules prepared by the vendors to identify any major gaps. This review led our team to make a series of recommendations to the P&M and DR Teams, and our subsequent monitoring of progress of the vendors' ongoing redevelopment of their detailed schedules for each of the major projects.
- Examined the risk management process within the P&M organization, including its ability to properly identify, avoid, mitigate and monetize risk.
- Reviewed the design and scoping process and identified the causes for the extreme inaccuracy of the vendors' engineering cost and schedule estimates.

- Reviewed the management structure and capabilities of the P&M team that started this work down the current path. We have also spent time with P&M's new VP and members of P&M's restructured leadership team to convey our findings and recommendations and gauge the effectiveness of P&M's current initiatives to improve performance and mitigate these earlier management failures.

As noted, these Campus Plan Projects have been plagued by myriad problems that have resulted in significant schedule and cost variances. Our findings show that the predominant cause of these overruns was P&M's original strategy to use a project "oversight" management model for the EPC contracting strategy utilized by OPG that was inappropriate in application and lead to a series of cascading management failures and contractor performance issues. The oversight management model employed a disengaged, "hands-off" approach by the P&M organization which caused the fledgling P&M organization to: (1) wrongly assume that the contractors understood the scope on the basis of performance specifications that outlined scope initial requirements; (2) utilize inexperienced project managers; (3) allow Operations & Maintenance and other OPG stakeholders to initiate scope changes to these projects long after the conceptual design period ended; (4) to accept the poor schedules and cost estimates by the contractors without appropriate vetting and challenge, and which were not updated to incorporate the impact of scope changes on a timely basis; and (5) to inaccurately or untimely report the projects' progress, risks and cost and schedule overruns to the DR Team and senior management.

B. OPG Contractor Management and Contractor Performance

1. Summary

Based on the information we have reviewed, it is apparent that P&M put excessive faith in the ESMSA Contractors' ability to perform this work and an over-reliance on the perceived ability of the EPC contracting model to shift project risk to the contractor and alleviate the need for active project management. As a result, OPG chose to provide oversight of the contractor's work at arms-length. In a recent self-assessment related to the D2O Storage Project's delays, the P&M Project team ("P&M Team") noted that at the onset of the Project, P&M believed "the EPC Process" would mitigate known risks via "project efficiency gains due to the expertise and autonomy of the contractor."[2] This exemplified OPG management's initial hands-off approach to project management that P&M piloted under which the contractor was given autonomy to develop its own scope requirements without process monitoring. As noted in P&M's self-assessment, this model resulted in "unclear expectations, re-work, frustration."[3] P&M's error was misunderstanding the essential nature of the ESMSA contracts, which are not fixed-price EPC contracts that shift all risk and responsibility for performance to the contractors (nor were they ever meant to be). The majority of the Campus Plan Project's execution cost is being performed on a cost-reimbursable target price, where contractors have only a portion of their fee at risk in the event that the target price is exceeded. In our experience, the nature of this work (refurbishment and construction of new facilities on an operating nuclear site) and the fact that the contract is cost reimbursable, require the owner to engage in active management of the contractors and coordinate interfaces. This means providing very specific instructions to lock down scope at the project's conceptual design phase and holding the contractors accountable on a daily basis to meet expected cost and schedule.

- Moreover, it is apparent that the P&M Team did not have the necessary experience, training or internal management direction to properly manage this work. Attachment B is a matrix that provides a summary of our observations regarding the five major ongoing F&I Projects. This matrix shows, among other things, that in the management of the work, P&M:
- Routinely accepted poor quality schedules and cost estimates without adequate vetting;

[2] SCR Number D-2013-19100, January 22, 2014.
[3] Id.

- Mischaracterized the nature of these estimates by assuming anything provided by a contractor was at a very high level of maturity (Class 3/2) when such estimates were based on conceptual (at best) engineering, meaning these estimates could not have been better than Class 5 (-50% to +100%) in nature;
- Failed to establish accountability standards for the contractors;
- Failed to identify or mitigate known risks;
- Did not effectively react to problems when they materialized and accurately and timely report the extent of cost overruns, schedule delays and scope increases to senior management;
- The P&M Team did not seek to lock down the scope at start of this work and allowed the "customer" – Operations and Maintenance – to make significant changes to the design that were not properly understood, quantified or captured in subsequent reports to senior management; and
- The ESMSA contractors contributed to the problem by not transparently reporting or timely identifying how these projects were evolving and failing to provide any reliable metrics—cost, schedule or otherwise – that informed OPG of these brewing problems.

2. Indicative Projects - D2O Storage and Auxiliary Heat

In our analysis, BMcD/Modus examined five separate projects in detail, and each exhibited some or all of the management issues to some extent. Attachment C is a brief summary of each of these projects' cost overruns.

The management failures we observed were most evident and acute with the D2O Storage and AHS projects. These projects were the "pilot" EPC projects for the ESMSA contractors—[redacted]In both cases, P&M sought the Board's full funding approval at a point when very little design was done, only to have to later seek additional funds from the Board once design had matured.

a. The Flawed Bidding/Estimating Process

P&M's management failures can be seen throughout the planning and execution phase of the project. Notable from OPG's initial negotiation and acceptance of bids for this work is P&M's mischaracterization of the vendors' estimates in the approved Business Case Summaries ("BCS"). In August 2011, OPG produced a BCS for D2O Storage that estimated its cost at $210.6M, [redacted]. At the project's next gate in June 2012, the estimated cost had dropped from $210M to $108M. However, BMcD/Modus could not find any attempt by P&M to rationalize or otherwise explain how the cost estimate for this building was cut virtually in half from one approval gate to the next. Moreover, the estimate for design and construction was $52.2M, which P&M characterized as a "Class 2 Estimate" despite the fact that at the time of the estimate, Black & McDonald had little experience with this type of construction and had performed no engineering or scope definition. Thus, this estimate was more likely a Class 5 Estimate. In retrospect, it is likely that the initial $210M estimate was more accurate; however, it is certainly clear that the approved $108M estimate should not have had any greater accuracy attributed to it, since it was not based on a significantly greater level of project maturity. Likewise, the AHS BCS was termed a "Class 3" Estimate, though it was similarly immature.

This estimate classification drove P&M to vastly underestimate the amount of contingency associated with each package. There is no evidence that P&M engaged in the type of vetting of the estimates that we would expect on projects of these size and importance. From interviews with the current P&M staff and the contractors, it appears that these initial BCS estimates were poorly characterized as part of a deliberate management strategy directed by the former VP of P&M. P&M's managers told us that the contractors were challenged to reduce their bid prices and remove all contingencies for unknowns, despite the extreme immaturity of project definition underlying their respective bids. As

an example, for the D20 Storage project, Black & McDonald was told to remove from its contract price any contingency for unforeseen soil conditions, even though there was a high likelihood that there would be contaminated soil issues. Moreover, P&M clearly overvalued price as a consideration in the contractor selection process, especially in light of the fact that the work was going to be performed on a cost-reimbursable basis and the bid prices were not binding.

P&M gave only token consideration to determining which contractor had a better approach for executing the work. P&M chose the "low bidder" even though the other contractor's qualifications and project approach were viewed more favorably. Thus, P&M created the conditions for a perfect storm of cost and schedule overruns. Because the work is largely based on a cost-reimbursable target price with no caps on size, P&M's artificial beating down the contractors' prices in the bid phase was a Pyrrhic victory: P&M's actions did not reduce cost and only served to deprive senior management of realistic cost projections for this work. The budgets for these and other F&I projects were nothing more than paper barriers that were easily surmounted as the design work continued to generate more complex (and expensive) work.

b. Lack of an Integrated Schedule

Until April 2014, the P&M project teams for D20 and AHS were working without a reliable, integrated Level 3 Schedule. Many on the project and throughout the OPG organization were given a false impression that the Campus Plan Projects, and D20 in particular, had a year of float, and so on-going delays had no impact on the Project. The delays to D2O Storage's schedule were not forecasted by the project team and were simply reported after the fact. By this point, the schedule had already slipped so that engineering was on its way to an 18-month projected overrun of an original 11-month schedule. However, without a resource-loaded, level 3 schedule, it was impossible to assess the status of the project, let alone calculate with any accuracy any remaining float.

One of the strategic initiatives was implemented by the new P&M VP was to improve the projects' schedules. This endeavor allowed the project team to see that D20 Storage was actually projected to be completed on April 26, 2016, more than a year after the original April 15, 2015 deadline. Furthermore, once known risks are factored in, it is likely that the D20 project can only achieve this revised date if some of the schedule durations are accelerated—at an additional cost. Even then, these efforts will not improve completion of the schedule by much, but will increase the probability that the April 2016 date can be met. However, none of this would be known if efforts had not been made to improve the schedule.

c. Risk Management

Based on our observations, it appears that all P&M's identification of risks is a "check-the-box" activity due the fact that having a list of risks is a prerequisite to obtaining a funding release. P&M does not actively manage its on-going risks as a part of an effective risk management program. As an example, the risk sections of the D20 and AHS BCSs consist of lists of potential risks and some evaluation of their nature, but it is not apparent that these risks in any way influenced the calculation of these projects' contingency, nor are there any regular reviews or updates of these risks until required to do so in order to pass a gate and obtain a funding release. Once a project obtains full funding for execution, very little, if any, attention is paid to day-to-day risk management, including the ongoing identification of new risks and opportunities as well as the formalized implementation of risk mitigation strategies. Additionally, there is no structured or defined risk program management oversight (such as the NR Risk Oversight Committee).

A recent self-assessment performed by the NR Management Systems Oversight group (SA RF13-000855 dated January 20, 2014) identified perceptions (opinions) of several P&M managers that included the following: "[D]evelopment and use of a Risk Register is seen as purely administrative and not adding value to the Project Managers." This suggests a lack of understanding of the value of a risk management program or lack of acceptance, which can be addressed by effective training and indoctrination. However, risk management training is virtually non-existent in the P&M organization in distinct contrast to several years ago when quarterly workshops were regularly conducted.

d. The Gate Process and Failure to Report Cost and Schedule Increases to Senior Management

BMcD/Modus next explored the relative effectiveness of the gate process for this work, and found that while the process in concept is a good one, it suffers from problems in execution. The BCS documents for D2O Storage and AHS were inconsistent in presentation of key information on cost, risk and scope. As these projects progressed, P&M's management failed to provide visibility to OPG management of the extent or nature of project cost increases. Most notably, P&M failed to update its project reports during the design phase to reflect cost increases due to scope changes in the projects.

AHS provides a critical example. On November 12, 2012, P&M presented its Gate 3A package for approval and full funding release (except for a small portion of costs to be approved in 2014). The P&M Team's gate presentation characterized the AHS cost estimate as a Class 3 estimate in the amount of $45.6 M. P&M included [redacted] of contingency in the $45.6M estimate, of which [redacted] was identified as having a 100% chance of occurrence. P&M expressed an "85% confidence level" in this cost estimate and assessed there were [redacted] days of schedule contingency in the estimate—despite the fact that the full scope of the project was not known at that time because detailed engineering had not started. The option of building a new AHS was preferred over seven alternatives, based primarily on the projected cost. At the time of this gate, the project had spent $1.46M.

Between this gate and January 2014, ES Fox engaged in the design of the AHS, scope changes caused the cost to increase from the initial $45.6M estimate to $79.9M. This cost increase is largely attributable to two causes: (1) remediation of contaminated soil that as of the time of bid was known by both OPG and the contractor to be of poor quality; and, (2) prescriptive design requirements that served to make a stock steam boiler design follow nuclear Engineering Change Control ("ECC") processes, which caused an increase in the size, complexity and nature of the work. Moreover, these design requirements and the overall length of the design phase, coupled with the soil issues, has frittered away virtually every day of float.

The fact this project had so substantially changed from the original BCS was not accurately or timely reported to management. The failure of the gate process was that the Gate Review Board members did not provide adequate oversight in ensuring that the AHS project team had a reliable estimate, schedule, and well-defined scope prior to approving the gate and recommending a funding release. As of January 2014, P&M had already expended nearly $20M, or more than half the approved budget excluding contingency, even though the design was not complete and no construction had begun. However, during this entire time, P&M's estimate at completion ("EAC") in all of the DR Project's and Campus Plan reports ***never varied*** from the approved BCS amount. Moreover, the DR Project's Program Status Report for March 2014 showed the AHS at 49% spent with a CPI of 1.10 and an SPI of 1.0, clearly not an accurate representation of the Project's status. Part of this failure was based upon some of the P&M project managers' mistaken belief that the reported EAC amounts should not be changed until additional funds had been approved for the projects. This lack of accurate reporting has deprived senior management and the Board the option of revisiting the original BCS analysis in order to determine if building a new AHS facility continues to be the preferred option—and if not, change course. This is particularly true in light of the fact that as of November 2012, three of the competing options to building AHS were priced at less than $50 M.

D2O Storage provides a very similar example at a much higher overall cost. The cost variance progression from D2O Storage began with an original approved BCS of $110M, based upon estimated contractor costs of approximately $77.8 Million. The ES Fox team and design solution were both preferred but Black & McDonald was chosen entirely because its price was $30M less even before P&M further drove Black & McDonald's estimate down.

D2O Storage's engineering effort was originally scheduled for 11 months, and was supposed to be completed by July 2013. However, even today, engineering is not complete and is projecting to extend to a total duration of 29 months. The P&M team provided sporadic updates to the design milestones as they continued to be missed but failed to convey the potential consequence. In August 2013, P&M reported that CNO Milestone 73472M0015, "D2O Modifications –

Detailed Design Complete" was expected to miss its planned completion date of August 21, 2013 **by four months** though stated, "there is no impact to the critical path."[4] As of this same meeting, an action was recorded to "confirm the timing for integration" of the D2O Storage schedule into the master C&C Schedule, the follow-up to which indicated that the schedule would not be available for integration because "it falls short of our requirements for several parameters."

In September 2013, P&M reported in the Program Status Report that:

> Due to the change in design for the connection of the new tanks to the existing, significant additional design work is required. This change of design was required to address water hammer issues with the initial plans which could not be resolved without a significant change in design. A new underground tunnel connecting the two buildings will now be utilized to connect the two buildings.[5]

However, this "significant" design change was not highlighted as a major risk item in P&M's reporting, and P&M maintained the same EAC for D2O Storage despite having this information in hand. P&M also maintained that there was no impact to the critical path, even though P&M again admitted that the vendor had yet to produce a detailed schedule, which begs the question how could one arrive at such a conclusion regarding float without a reliable schedule.

P&M first reported a variance to the D2O Storage budget in October 2013, which coincided with months of mitigating adverse soil conditions and failing to meet the schedule for tie-ins for the TRF outage. Black & McDonald presented a high-level cost estimate that showed approximately $49M of increases in foundation work and engineering in October 2013, though this estimate was characterized as a work in progress. This estimate was increased by $5M in December 2013. P&M finally updated the D2O Storage EAC in the January 2014 DR Program Status Report from $95M to $122.7M, though simultaneously, P&M issued a report to the Nuclear Executive Committee ("NEC") showing a forecasted EAC of $152M. Thus, P&M's first reporting to senior management and other OPG stakeholders of any impact of the design changes that had been brewing for nearly two years was inconsistent at best.

In January 2014, Bill Robinson required Black & McDonald to update its costs. Black & McDonald committed to an estimate of $94M (compared to its original contract of $67M), which with OPG's costs was ranged by P&M at a total of $150-170M, including OPG contingency and financing costs. After coming on board, P&M's new VP required Black & McDonald to prepare a bottoms-up, high confidence schedule and budget based on the high level of engineering completion. Black & McDonald's output has trickled in. [redacted] Black & McDonald has broken down the cost increases into several categories, including: additional scope ($85.4M), changed assumptions ($14M), soil remediation ($17.3 M), delays to the schedule resulting in acceleration ($9.8 M) and inclusion of items that were either missed or misestimated in the original estimate ($31 M). Black & McDonald characterized this estimate as a Class 4 even though: (1) the design is 80% complete; and (2) Black & McDonald had just provided a Level 3 schedule for the remaining work which they claimed was comprehensive. Based on these two data points alone, Black & McDonald should be able to produce at least a Class 2 estimate at this time. [redacted].

Moreover, throughout 2011-13, P&M did not require Black & McDonald to timely update costs and provide visibility to the cost of these design changes as they were occurring; thus, as with AHS, P&M's management allowed the contractors

[4] DN Refurbishment Program Status Report Meeting, August 21, 2013
[5] DN Refurbishment Program Status Report Meeting, September 18, 2013

to run up the tab and incorporate a flood of OPG stakeholder generated late design changes without adequate checks and balances or understanding of the magnitude of these changes.

As a direct consequence of P&M's failure to report these cost and schedule variances, senior management was deprived of the ability to:

- Stop the design changes that led to these increases;
- Stop the project entirely and resort to one of the other evaluated options;
- Identify and characterize the cost increases that are not related to Refurbishment and subject these changes to the same value-enhancing criteria as the remainder of the DR Project's work; and
- Mitigate the impact of the schedule delays and overruns.

Thus, the consequences to OPG are two projects that may cause external stakeholders to question OPG's management prudence.

e. Vendor Performance Issues

[redacted]

[redacted]

3. Current Schedule Status

P&M's effort to recover these projects began with finally getting the vendors to develop resource loaded, integrated Level 3 schedules, with focus on developing template schedules for D2O Storage and AHS. These schedules are portraying the following significant challenges:

- The AHS project is currently projecting about 3 months behind schedule which will delay the VBO outage. The schedule is currently being impacted by late design, with some twenty outstanding design changes that ES Fox needs to process. This late design could impact the schedule to September 2014 and beyond and frustrate both procurement and construction, which have essentially no float. Based on our review of this schedule, attempts to accelerate the work to recover this time could be ineffective. Instead, BMcD/Modus recommends P&M, in concert with the Station, look to: (1) eliminate these multiple design changes; and (2) rationalize and potentially reduce the time needed to commission the AHS. If these upfront and follow-on tasks can be reduced in duration, the project will regain some much needed time for construction.

- D2O Storage is more complicated. The combination of underground utilities and poor soil conditions, design changes, engineering delays and contractor performance has pushed D2O Storage to a projected completion of April 15, 2016, which has no float to OPG's need date. In analyzing the current status of the work, we have determined that: (1) while engineering has driven significant delays to date, accelerating its final completion will not result in improvement to the overall completion date; (2) the current March 2015 completion date for concrete and foundation work, including drilling and setting caissons, needs to be improved by as much as possible and ideally to complete prior to the onset of winter conditions in 2014; (3) the current duration for building on top of the completed foundations, including structural steel erection, building enclosure and mechanical piping, is a scant 5 ½ months and needs to be substantially improved. Based on this status, we recommend OPG examine: (1) value engineer the foundations and structural design, with the goal to eliminate as much of the building's complexity as possible – the office space and associated concrete structure may be over-designed based on non-Refurbishment requirements added during the attenuated design phase; (2) value engineer the building's piping design, which similarly increased due to ASIC and Station needs; (3) accelerate the caisson drilling so that rebar and foundation work can recover essential lost time.

OPG should also examine other options in light of the overruns on these projects, as less permanent solutions that were narrowly rejected in the upfront BCS may now prove to be more economical solutions. At a minimum, we recommend OPG examine and parse the costs associated with non-Refurbishment scope that was added by OPG's other stakeholders and consider capitalizing those costs separately from Refurbishment for purposes of future rate recovery. In any event, whichever course OPG choses with these buildings, it is imperative that it act quickly and definitively.

4. Corrective Actions by P&M Team

OPG senior management has taken definitive action to turn around the Campus Plan work, including bringing in new leadership for P&M and fostering greater integration between the P&M Campus Plan and DR Project work. The visibility of the issues P&M has encountered will help the BOP, Islanding and Services projects work more effectively with the ESMSA contractors.

P&M's and the DR Team's senior leadership are fostering a more collaborative and cooperative effort between OPG and the contractors, known as the "Collaborative Approach." Essential parts of this Collaborative Approach include:

- For the remaining Campus Plan Projects and BOP work, the OPG teams and the vendors working "shoulder-to-shoulder" to develop project scope basis and corresponding cost estimates. The ESMSA vendors have agreed to perform the work on an open-book, split cost basis. Relieving the ESMSA of the secondary compete bidding

process through direct assignment of the work should expedite the process, though the funding for this phase of the collaboration has been slow to arrive.

- OPG's Refurbishment Engineering and Design Authority directly managing and supervising the engineering work to reduce scope creep, unnecessary management and supervision costs and delays due to churn. This will include co-locating OPG engineering resources at the vendor's shops to answer questions and involve themselves in the development of the detailed design work and institute regular Steering Committee meetings with project leadership to remove performance barriers.
- Continuing integration of all of the Campus Plan pre-requisite work into a single integrated schedule so that the ESMSA's can properly plan and resource load the work and OPG can manage the contractors' work load and performance.
- Complete the work allocation to each of the ESMSA vendors so that they can properly plan their work. The DR Team has attempted to allocate the work evenly, though it may become necessary to shift work based on performance and resource availability. This becomes a more complex issue with the BOP work scope also needing attention in the coming months.
- Provide additional and focused project management support from OPG to clear barriers to engineering and execution work.
- Engage in constructive high-level dialogue with the ESMSA's senior management on a regular basis. P&M has established weekly meetings with each contractor that senior management attends to deal with any barriers and discuss status of the key projects. OPG has also established a monthly ESMSA Summit that allows for OPG to air and discuss issues with senior management of both contractors together. These meetings have had an immediate and measureable impact on both OPG's and the ESMSA's performance.

These changes will not fully recover the work in progress – in particular D2O Storage and AHS – but should provide some needed relief and better approaches for the remaining Campus Plan Projects.

For P&M, the recent changes in its senior leadership as well as the increased integration with the DR Team are taking root and providing visible benefits. P&M's VP is working through the multiple issues caused by the "hands-off" project management approach. The P&M staff has begun to accept the changes and is becoming motivated to correct its past problems, though the need for continual guidance and mentoring is evident. P&M will need corporate support to execute a full turn-around as discussed below. The DR Team's engineering organization is poised to take on active management of the ESMSA's engineering shops, which is diametrically opposite to how these projects were initially conceived. P&M's problems are now visible, as is the recovery the new team is trying to make, and the DR Team must recognize that P&M needs its support or the Refurbishment of Unit 2 is very much at risk.

5. Lessons Learned and Recommendations

Based on our root cause findings, BMcD/Modus's recommendations to OPG are somewhat different for P&M, which is in full recovery mode, versus Refurbishment, which has time (though not much) to incorporate lessons learned from the Campus Plan Projects into its program. For P&M, our recommendations focus on speeding the pace of the recovery, while for the DR Team, these Campus Plan Projects need to be a vivid reminder of what can happen if and when contractors are not actively managed. Ultimately, there are two major questions for the DR Project as a whole: (1) Can P&M succeed in completing the Campus Plan Projects on-time and within reasonable (though much higher than originally considered) cost parameters; and (2) whether the same issues we found related to the mismanagement of the Campus Plan Projects are a threat to the DR Project's BOP work and if so, to take strong and decisive action for eliminating the threat.

Regarding the Campus Plan Projects, we believe these can be turned around to support the VBO and breaker open, though at a higher cost that will require greater management focus than ever anticipated. Moreover, to facilitate this recovery, OPG will likely have to make some accommodations to its normal course of business:

- **Hiring practices will require increased flexibility** – P&M's ranks are filled with inexperienced personnel who need guidance. OPG needs to recognize that the P&M organization urgently needs qualified people to fill significant management positions in project management, project controls and field supervision that are open at this time. Moreover, because P&M is a business unit with an expected expiration date, it makes for a difficult sell to OPG employees. In our experience, business units such as P&M would not be subjected to the same rules as the company-at-large for the hiring of temporary or transitory employees. Moreover, companies usually provide incentives for employees to work in transitional project environments because it forms a valuable learning experience. Such moves are needed and, in our view, completely justifiable in light of industry best practices. It is likely that Refurbishment will need similar changes to allow the development of its Execution Phase team.

- **Operations & Maintenance's and other OPG stakeholders' ability to change project scope must be contained** – As noted, the processes in place for the Campus Plan Projects allowed Operations & Maintenance and various other OPG stakeholders to make scope and resultant design changes that caused significant increases to the Campus Plan Projects after the conclusion of the conceptual design phase. These changes have crept into cost estimates over time. The appropriate time to add scope to projects is the conceptual design phase, subject to the approval of the authorized stakeholders, not after the project has been approved and passed through multiple gates including approval at the Board of Directors level. The process needs change to eliminate the consideration of major post-award design changes that increase project costs or extend project schedules.

- **Scope of work for Campus Plan and DR Projects needs frequent re-examination -** As a general principle, management prudence requires that scope and objectives be periodically examined in light of current circumstances. Where OPG has information that shows projects trending above approved budgets and beyond schedule milestones, it is prudent to examine both the cause of the overruns and any reasonable alternatives that can be justified based on a renewed net present value calculation. Thus, we recommend that OPG senior management take a second look at the scope and question its value, including re-examining (as necessary) alternative ways to accomplish the originally intended scope of work.

  Similarly, where the root cause of the overruns appears to be the insertion of nuclear processes where such are not typically applicable or necessary (i.e. for commercial buildings), OPG senior management should take action to rescale and change the scope of such projects. This may require OPG's senior management to the CNSC to allow changes to its regulatory commitments if such commitments are so costly as to make them unreasonable.

  Finally, as noted, if there are reasonable and prudent costs for non-Refurbishment related enhancements that are being spent by Refurbishment, OPG should consider capitalizing such costs separately from the DR Project. As an example, many of the value enhancing changes to D2O Storage were apparently made to handle and process water for non-Refurbishment purposes. These costs may ultimately have been prudently incurred but are likely in the wrong cost bucket for purposes of cost recovery.

- **Supply Chain and Finance need to streamline controls to accommodate changes** – The potential for the Campus Plan and BOP projects to rationalize the scope, develop more realistic cost estimates and schedules and model risk depends on the success of the collaborative process. Initiating this process will require some changes in the Supply Chain and Finance processes to allow for timely award of the work and prompt payment to the ESMSA contractors during the concept development phase. The benefit of this collaboration should be seen as projects reach their subsequent gates, they should be in much better shape with better defined and controlled scope, more accurate cost estimates and more achievable schedule goals. The ESMSA vendors will need appropriate funding to meet these goals. Finance has already moved forward with some measures that will enhance the cash flowing of the contractors' work. Additionally, the Supply Chain procedures with respect to change orders or contract amendments are cumbersome, time consuming, and reduce the project teams' accountability for managing costs. We would expect the project team to have the ability to negotiate and approve change orders directly with the contractor with appropriate controls.

- **Risk Management needs immediate attention** – Risk management was not taken seriously in the P&M organization, thus many of the problems that have emerged were hidden below the surface. P&M needs a different approach which the DR risk management team is helping to facilitate: (1) the P&M team needs to monetize risks for future gates on a deterministic basis; (2) risks need to be managed on a day-to-day basis as a part of project management; (3) a better understanding of the ESMSA Contractors' risk management programs is needed; (4) formalized risk training is needed within the P&M organization. Most importantly, there needs to be a culture shift towards recognizing risk management as an important aspect of maintaining cost and schedule. This culture shift can only be driven from the top of the organization. Refurbishment has made many strides in improving the risk management program and their improvements should form OPEX for P&M.
- **Security and site access changes are urgently required** – The current time needed to in-process workers and management personnel alike is frustrating the OPG project teams and the ESMSA contractors. The reported average time it takes for clearance is upward of 6 weeks, and the contractors' cost per employee for the screening process is estimated at $8,000 to $10,000 per person. Moreover, there are security issues preventing or complicating the contractors' use of essential project-based systems - the P6 Schedule and the Electronic Document Management System (EDMS) are notable examples. BMcD/Modus certainly sees the need for maintaining the company's security, though in our experience with other nuclear utilities there are readymade solutions for these issues that OPG has been slow to adopt. These issues will cause continued risk to the DR Project if not fixed.
- **Contractor performance** – OPG needs to reconsider the scope of the work given to the ESMSA vendors on the Campus Plan and Refurbishment Projects in light of their current performance. OPG should examine the possibility of assigning Refurbishment BOP scope to other contractors performing on the DR Project where this makes economic and strategic sense.
- **Project estimating needs significant improvement** – As discussed throughout this report, BMcD/Modus has significant concerns that need to be addressed with the performance of project estimating by both the contractors and P&M's team. BMcD/Modus recommends that P&M should make changes, and Refurbishment should examine and potentially refine its processes for the following:
    - Check estimates be developed in the same format as estimates provided by vendors – the templates should be developed by OPG and provided to vendors prior to bid, and any submitted bid not utilizing the approved template is noncompliant;
    - All estimates need to be fully vetted and understood, regardless of whether the quoted price is more or less than the expected cost. Drivers of variances (both positive and negative) between bid and check estimates need to be investigated and understood by the Project Teams;
    - Contractors need to be trained in the method of estimating that OPG finds acceptable. The current process SNC/Aecon is using for developing its estimate includes upfront vetting by OPG of the contractor's specific processes and ongoing, real-time review of estimating product in a collaborative manner. These are principles that can be easily applied to the rest of the DR Project's work;
    - Estimates and project metrics/reports must incorporate accurate past, current and forecast cost information. The team needs to receive appropriately detailed contractor cost reports which, coupled with a resource loaded schedule, will enable them to properly status and forecast contractor performance;
    - P&M needs to standardize an EAC process so that all project teams follow the same basic procedures on a consistent basis. A seminar or workshop should be considered so that project team members are taught the fundamentals for preparing a reliable EAC; and

- OPG needs to examine staffing and resources. Currently, there is only one dedicated cost estimator for all of P&M's work. The DR Team has already taken action to increase staffing levels and add experienced personnel, and P&M needs to do the same.

- **Project Reporting must be accurate, timely and convey information critical to senior management for decision-making** – As noted, the reports P&M provided to senior management on the Campus Plan projects were inaccurate and not updated in a timely manner to enable prudent decision-making. Our examination of P&M's reporting shows a general desire to produce large volumes of surface-level reports that are completely inadequate for managing the work, all the while P&M ignored such critical metrics as an accurate Estimate at Completion (EAC) and detailed schedule of work. Any tendency to "turn everything green" when such is not the case must be resisted - prudent management of complex projects requires full transparency and visibility of anything that is not going well so it can be addressed and fixed. P&M and the DR Team need to increase the focus on accurate, concise reporting with an emphasis on forecasting.

- **P&M needs to break down the silos**—All of the Campus Plan Projects are being performed by two contractors. However all of the Campus Plan work has been managed as 26 separate projects. All of the project management functions—i.e. schedule, cost and risk need to be managed through an integrated approach so that resources and management focus can be applied appropriately. We recommend that P&M look at its organizational structure to optimize the ability of its project managers to have more direct accountability. This may require more and different resources.

- **Campus Plan Projects will require a full rebaseline of cost and schedule** – Irrespective of when these projects' next gates occur, each of the Campus Plan Projects and, likely, each of the P&M non-Refurbishment projects at DNGS and Pickering, will require a full, bottoms-up rebaseline of costs and schedules. With the examples cited herein, BMcD/Modus cannot ascribe any confidence to any project estimate that was developed by P&M's former regime. Bill Robinson has made this commitment and appropriate focus will need to be applied. P&M needs to perform this reforecast on an urgent basis.

With respect to the Refurbishment portion of the DR Project, BMcD/Modus's monitoring of the BOP work to date shows that OPG has spent considerable time and effort in a robust scope definition process that addresses most of the external OPG stakeholder-driven scope issues in a manner that is consistent with the DR Project's charter. The DR Team has embedded in the organization a Director of Maintenance and a team to work our operational concerns and has an independent Design Authority. Moreover, as stated, the DR Team had already acted to safeguard against some of the problems seen in the early Campus Plan Project, notably; (1) the DR Project's institution more thorough scope definition to contractors via the MDPs the engineering team developed was a direct consequence of the OPEX from D2O Storage from over a year ago; (2) it is also apparent to us that while the DR Team had started down the same management path as P&M, it was able to put on the brakes and change course at a much earlier stage. Nonetheless, in light of our review of the Campus Plan Projects, we recommend that the DR Team perform a detailed self-assessment that considers the ways in which the Campus Plan Projects management failures might apply to Refurbishment.

III. RQE Preparation

With this report, BMcD/Modus will begin a dedicated section for assessing the status of the DR Team's activities that specifically lead to the development of the RQE budget and associated schedule for the October 15, 2015 deadline. With respect to RQE planning, the DR Team has started its specific planning efforts, though soon there needs to be a greater focus on the specific deliverables, the timing of their preparation and a thorough understanding of how the many components will be compiled into a comprehensive estimate. Project Controls has named a manager for this effort and an activity schedule is being developed for incorporation into the Project's plan.

The most imminent upcoming RQE-related tasks relate to the development of the 4d Release Cost Estimate for the 2015 Business Plan ("4d Cost Estimate") that will be prepared for the Board's approval at the November 2014 meeting. The 4d Cost Estimate effort should also provide a template for many of the activities needed for RQE. In this section, we will

also report on the maturity of the DR Project's development of the project's integrated schedule, which is an important component to providing a reliable RQE.

A. 4d Cost Estimate

In our Initial Project Assessment, we recommended that OPG consider the 4d Cost Estimate as a "dry run" for RQE. This recommendation has been embraced by senior management. As part of our 4th Quarter 2013 Report, BMcD/Modus provided the DR Team with specific recommendations on the development of its cost estimates and lessons learned from last year's 4c Cost Estimate, which we refresh here with some additional observations:

- **Organization of the 4d Cost Estimate**: The DR Team is getting organized for the 4d Cost Estimate effort, which will be considerable. Project Controls has begun with the predecessor work the projects will need to develop their various estimates and is in the process of developing a schedule for these activities. Based on last year's approach to the 4c Cost Estimate, we see more activity occurring at a similar stage though we are still concerned that the development of 4d Cost Estimate will run into summer, during which time very little can be finalized due to the critical individuals taking vacation.
- **Projectizing Costs**: The DR Team is moving toward "projectizing" the functional costs, i.e. attempting to bucket as much of the cost of the functional work as a distinct part of the sub-projects' cost. This is an appropriate methodology and should provide a more accurate cost picture, though the DR Team needs to develop some clear guidelines for how this will be accomplished. Also, since this will mean functional cost centers from the 4c Cost Estimate will be distributed differently, the DR Team should provide traceability between the two phases of the estimate.
- **Bottoms-up Approach**: Given the increase in project maturity since the 4c Cost Estimate, a bottoms-up approach to many elements of the 4d Cost Estimate is appropriate. To the extent that projects have recently passed through a gate, the associated gate documentation should reflect this approach. However, a gate review should not be viewed by the DR Team as an opportunity to reset the clock and the budget on projects that are in trouble. The DR Team should review its processes for rebaselining at gates so that projects that are projecting to over-spend or run late are not given proverbial "get out of jail free" passes.
- **Re-examine Scope and Commitments**: As the Definition Phase has unfolded, it has become apparent that the cost estimates for many scopes of work have greatly exceeded the 4c Cost Estimate. In particular, F&I projects have changed in scope, execution strategy and cost, and many of the BOP projects are showing similar signs, such that the increases in cost would likely run at or above any alternative. The recently initiated Options Review Board (discussed below) has the potential to be a good control to catch projects with wide variances at an earlier stage. As noted above, BMcD/Modus believes that the periodic reexamination of principles on a project as an essential ingredient to prudent management. Thus, we recommend that OPG re-analyze any scope item with a wide cost variance over its 4c Cost Estimate budget allowance by re-reviewing the requirements and any alternatives, including canceling the scope entirely, on the basis of the least-cost alternative at this time. Had this methodology been followed with the F&I Projects, it is now apparent that OPG would have considered different alternatives for a number of projects. OPG should also review such alternatives when a regulatory commitment is at the root of a significant cost increase, as once the extent of the cost increases are fully known, it is possible the regulator would entertain alternatives as well.
- **Increase Efficacy of Project Estimating**: As discussed in the Campus Plan section of our report, BMcD/Modus is concerned that OPG's ability to develop check estimates is challenged by resources and work volume. To the extent that OPG's check estimates are intended to be a control mechanism, these estimates need to be executed with the same information and level of rigor that the contractors/project teams are developing. From our observations to date, the current method used for check estimates at Class 4/5 level: (1) includes the use of too many factors and factored values for check estimates at the Class 3/2 level; (2) suffer from a general lack of transparency of the root sources of information; (3) utilize non-standardized estimating templates despite OPG's investment in the US Cost estimating platform. As the DR Project moves to the next phase of maturity, so

should the estimating work. We have also observed that the check estimates have gaps and errors that should not occur if the estimates had been performed by qualified, experienced individuals. Moreover, it is becoming evident that estimating is becoming a choke point to the point of causing notable delays in the procurement schedule, and its importance will only increase as time goes on. Thus, we have recommended that OPG examine its vendor's (Faithful & Gould) resources, experience level and ability to support the increase in both the volume and efficacy of the estimates it is preparing. In addition, we recommend OPG utilize the collaborative estimating/vetting approach that it has initiated with the ESMSA vendors and with SNC/Aecon for each of the DR Project's other scopes of work. The DR Team is already acting on these recommendations.

Considering the increased focus on the DR Project from its external stakeholders, it is very likely the development of 4d Cost Estimate will receive significant scrutiny. Therefore, the DR Team needs to organize its efforts, develop appropriate expectations for the deliverables and intensify its efforts as soon as possible.

B. Schedule

A high-confidence RQE depends on a reliable integrated schedule. In our past reports, BMcD/Modus has identified several concerns and observations with respect to the development of the DR Project Schedule and the Project Schedule Management Program. Over the last few months, the DR Team has made significant strides in addressing many of the issues we have raised. While much work remains to be done, the DR Team has moved forward with a significant number of initiatives calculated to improve both the DR Schedule and the Schedule Management Program, including:

- The DR Team now sees itself as a project management team and is putting programs in place to properly manage its contractors;
- The DR Team has abandoned earlier questionable scheduling methods in favor of developing a fully integrated Level 3 resource loaded schedule that automatically rolls-up to form a Level 2 depiction of the work;
- P&M is becoming the "beta" group for testing the basic standards for managing the Level 3 with the Campus Plan Projects;
- OPG has developed standards for required resource loading of the Level 3 schedules by OPG and the contractors; and
- Detailed schedules for sub-projects that are not let are represented by placeholder activities to be replaced once a contractor is in place.

While these changes are positive, we have made additional observations that should be addressed by OPG in order to improve the reliability of the integrated project schedule, including:

- Development of an improved set of metrics for monitoring the schedule is imperative. As part of the effort to improve the Level 3 integrated scheduling process, a set of metrics needs to be established to categorically monitor improvements made by the Project Teams and their respective contractors.

- Currently, the DR Team is making manual adjustments the cash flows in Proliance, rather than having it be an automated function tying the cost estimates to the P6 dates for cash flow analysis. Ultimately, work hours in cost estimates and schedules must balance and the Work Breakdown Structure ("WBS") should be the binding mechanism. The DR Team is planning on automating this process though it will remain prone to error until that time.

- OPG needs to speed contractors' access to the scheduling network. The OPG and the contractors need to all work from the same network (preferably OPG's or an third party network) in order to operate in a common environment. However, OPG is not granting the contractors network access in a timely manner. Improvements in time and better standards for control of the databases need to be established.

IV. Major Projects – Summary of Key Risks

A. Retube & Feeder Replacement

1. Work Status – Tooling, Definition and Mock-up

Through March 31, 2014, the RFR contract is underspent by $9 M against plan, though this gap is closing. Additionally, SNC/Aecon's SPI during this time period has improved to 0.94. Although SNC/Aecon remains behind schedule in the Definition and Tooling phases of its work, the mock-up reached substantial completion in March and is ready to receive, test and integrate tooling.

The tooling recovery plan that was initiated at the end of 2013, however, is currently challenged to achieve its August 2014 target. Tooling engineering is now critical path and the tooling design complete milestone for June 15, 2014 will likely be missed while the follow-on milestones for prototypes complete and qualification complete are in jeopardy as well. Continued problems with SNC/Aecon vendors and sub-vendors are driving many of these delays. In particular, the RT platforms being fabricated by Rolls Royce have continued to slip and are now projected to complete 2-4 weeks later than the recovery plan completion dates of June 30 and July 15, 2014. Meanwhile, SNC/Aecon's supplier ATS is suffering from late delivery of parts from its sub-vendors, delaying assembly on its shop floor. SNC/Aecon has made repeated projections for delivery of these tools that have been further impacted by late deliveries, quality issues, and process missteps. SNC/Aecon has resorted to additional mitigation plans and is making reasonable attempts to recover the time lost. The OPG team continues to monitor SNC/Aecon's progress and is holding them accountable to meet the deadlines. The impact of SNC/Aecon's slippages will be felt in the development of the Class 2 estimate. To mitigate this potential delay, OPG's project team is requiring SNC/Aecon develop a clear plan for monitoring tool testing and productivity in the mock-up to ensure this process moves smoothly and that all the required information is captured and incorporated into the estimate.

In addition, the JV is trending over-budget for the target price portion of its Definition Phase work, which includes engineering, schedule and estimate development, and construction management planning. The fact the JV is projecting to complete this phase of the work 15-25% above its target needs to be considered in establishing the confidence level of the JVs Class 3/2 estimates for the Execution Phase. However, OPG's team plans to dispute any charges advanced by SNC/Aecon for the Definition Phase that were caused by SNC/Aecon's own actions.

Finally, the Definition phase shows signs of slow progress with an SPI at 0.91 as of the February 2014 SNC/Aecon Progress Report. Engineering and procurement dates are slipping, showing similarities with the tooling effort described above. These activities will require close monitoring as the Definition phase moves toward the Class 2 estimate over the next year.

2. Class 3 Estimate and Level 4 Schedule

In our 1Q 2014 report, BMcD/Modus expressed serious concerns with the ability of SNC/Aecon to provide Construction Work Packages (CWPs) and variance reports by March 15, 2014 to support the Class 3 estimate. As of February 10, 2014, SNC/Aecon was only 32% complete in preparing its "Stage 1" CWPs and variance reports. Over the next month, SNC/Aecon significantly increased its production in order to meet this date and, in the process, compressed delivery, creating a large bow-wave of work for OPG to review.

Since our 1Q 2014 report, OPG's estimating group has struggled to keep up with SNC/Aecon's pace and its review and analysis of the variance reports, estimates, and mini-reports that will ultimately comprise the Class 3 estimate is proceeding slowly. BMcD/Modus's concern is that the sheer volume of reports provided by SNC/Aecon, essentially all at once, will result in errors or that OPG will be challenged to make sense of the data. Ultimately, SNC/Aecon should be tasked with providing an explanation of how the products satisfy the requirements of a Class 3 estimate. Per the Class 3 Estimate Plan, SNC/Aecon's commitment for this Class 3 Estimate should include:

- Completed CWPs formulated for DNGS;
- Variance reports showing differences between the OPEX driven Class 4 estimate and the current estimate;
- A Level 4 execution schedule;
- Detailed reports characterizing how SNC/Aecon prepared the estimate; and
- A well-defined risk register.

All of these SNC/Aecon products will require time for OPG to review and in this case it is our opinion that it is better to provide an extension of time than rush the review of such important material in order to meet a previously set deadline.

Concurrent with the development of the Class 3 estimate, SNC/Aecon is developing its Level 4 execution schedule. The first draft of this schedule was delivered on April 15, 2014 and ongoing review sessions are being held to refine it. First impressions of the schedule were that SNC/Aecon had not brought the best possible schedule for Unit 2 forward. It appeared that SNC/Aecon presented a comfortable, achievable schedule rather than an aggressive benchmark. This created a longer schedule than what would be considered a "target" schedule. In addition, several examples of incorrect logic and misalignment with OPG's level 1 schedule were identified. OPG is continuing to review and recommend changes prior to the delivery of the Schedule mini-report for the Class 3 estimate on April 30, 2014.

Looking forward from Class 3, it is important for OPG and SNC/Aecon to align around the plan and start preparing for the Class 2 estimate. As we have noted in prior reports, after SNC/Aecon completed the Class 4 estimate, there was a long period with no activity that only served to compress the preparation time for the Class 3 estimate, and that compression is at the root of the current need to rush through its approvals. As the Class 3 report is being developed, the team should endeavor to complete the Class 2 estimate plan so that any opportunities or progression points are identified early. In addition, the tool testing and productivity plan should be incorporated with the Class 2 estimate plan so that results are properly incorporated into the schedule and estimate. SNC/Aecon and OPG need to maintain focus on the finished product and what it means to be Class 2 RQE ready.

3. RWPB Building

The RWPB is being performed under many of the same conditions as the Campus Plan Projects as a pre-requisite to Refurbishment but by SNC/Aecon, the contractor performing the RFR retube work, rather than the ESMSA contractors. RWPB is facing very some familiar issues to those described above for D2O and AHS. The start of work is currently being impacted by the soil that was excavated from D2O Storage. There is a possibility the soil is contaminated, which has resulted in additional testing. In addition, the building has or will encounter plant operation coordination, and seismic issues have delayed foundation design and pushed out engineering. As of this report, engineering design complete is showing 43 days of negative float and installation/commissioning is showing an October 24, 2016 completion date. Although this schedule is immature and based on very preliminary engineering, the original plan was completion in June 2016 allowing three months before breaker open. It is vital for SNC/Aecon to utilize the lessons that are being learned from the F&I work in order to keep this building within a reasonable cost and schedule envelope. In addition, if there are cost increases, the Options Review Board should test the decisions being made with regard to building design in light of the fact that it is a temporary building that will be housing heavily contaminated materials. Further, the building should avoid any element of gold plating or permanent design.

4. RFR Commercial Risks

We recommended in our last report that the DR Team review some major provisions of the RFR contract in order to ensure that it will drive the proper behavior from SNC/Aecon in order to achieve success on the first unit and that OPG will be able to establish that it adequately and prudently considered the principles set forth in the government's Long Term Energy Plan ("LTEP")—primarily success on the first unit and ensuring appropriate risk shifting. This included re-visiting: (1) the performance incentives for unit-over-unit improvement as an incentive to the contractor to meet an aggressive schedule for the first unit; (2) whether the cost and schedule incentives/disincentives would drive the right contractor behavior; (3) the treatment and monetization of identified risks; and (4) whether to negotiate a guaranteed maximum price ("GMAX") once engineering is complete. In addition, OPG and SNC/Aecon will need to incorporate the

maturing Turbine Generator work into the estimate where economies of scale in project management and other areas are identified. To date, DR senior management has acknowledged that this is an important exercise that must be done with some sense of urgency. However, this sentiment has not been communicated to those individuals tasked with performing the review, who appear not to understand its purpose and are reluctant to even consider the need to modify any portion of the contract.

B. Balance of Plant and Other Projects

The BOP work should be the direct beneficiary of any lessons learned from the Campus Plan/F&I work. The majority of the BOP work will be performed by the ESMSA contractors based on direct assignment of the work packages. This methodology should readily lend itself to a cooperative, interactive process between OPG and the vendors that should, in theory, eliminate many of the issues we have observed with the F&I work.

With the awards of the containment isolation and Turbine Generator performance work to SNC/Aecon, OPG should consider the benefits of SNC/Aecon treating its overall scope of work as one contract. There are certain economies of scale that can be achieved – plus benefits associated with workforce assignment flexibility and dose management. The DR Team would also benefit from consolidating all of the work in the vault into a single subproject to better manage the critical path and subcritical path interferences.

V. Functional Groups Update

A. Engineering

1. Revised Plan for ESMSA Engineering

Amongst other conclusions, the BMcD/Modus Initial Project Assessment (August 13, 2013) recommended improvements to engineering metrics and a close look at the turn-around times for the review, comment and approval cycles. The need for “active management” of the engineering work along with a greater focus on front-end planning was introduced in the BMcD/Modus 4Q 2013 report and expanded upon in our 1Q 2014 report. We continue to stress the importance for OPG to shift their role and perspective from the culture of ‘observation at a distance’ to a much more proactive engagement and active management of the engineering service providers. We also continue to stress the importance of thorough front-end planning.

Since our last report the DR Team’s Senior Leadership has recognized a number of deficiencies with the ESMSA design process, including:

- The quality of planning and scheduling is insufficient. There are no integrated resource loaded schedules. Schedule adherence is very poor - the execution of most of the ESMSA project engineering (e.g. D2O Storage Building, Shield Tank Overpressure Protection, Auxiliary Heating Steam, and Containment Filtered Venting System) is consistently behind plan.
- Cost estimates for the detailed engineering phase are significantly higher than anticipated, particularly given OPG’s development of detailed Modification Design Packages (MDP’s) that were intended to provide the vendors with specific and prescriptive requirements.
- The actual costs to date are significantly above the original budgets (planned value) for all ESMSA projects. A significant portion of these increases are driven by engineering.
- ESMSA quality programs are not aligned with OPG’s quality program. The result is multiple review and comment cycles which add significant cost and time.
- OPG’s intent to shift risk to the ESMSA partnerships was misplaced. The risk associated with the execution of nuclear engineering work is limited by the application of detailed regulatory and OPG standards and procedures. The execution of nuclear engineering work needs to be under the direct control of the OPG Design Authority.

- Single-point responsibility for coordination of the engineering, procurement and construction elements of these projects through these ESMSA partnerships has not been realized, leading to inefficiency, confusion and rework. Moreover, significant OPG intervention has been required to achieve the results obtained to date.

The results of these deficiencies have become clearly apparent: an inability to predict engineering performance, significant churn, poor cost performance and frustration at all levels of the collective organization. These deficiencies have driven Senior Leadership to make changes to the remaining engineering effort for the ESMSA work. These changes include:

- Shifting to a culture of 'active management' of the engineering work;
- Utilizing a collaborative front-end planning methodology for the remaining work;
- OPG taking a leadership role in developing and monitoring the engineering schedules;
- For work in progress, OPG will increase monitoring and provide ready answers through embedded staff within the engineering vendor organizations; and
- For work that has not started, OPG will provide management and direction of the engineering work.

This is a bold but necessary move and one that is endorsed by BMcD/Modus. We will continue to monitor the progress made under this revised plan and provide additional recommendations for streamlining the design process as necessary.

2. Scope Definition

Overall, as mentioned in the BMcD/Modus Assurance Report on Scope, we believe that the DR Team has taken a balanced approach to the development of the DR Project scope. The initial scope identification effort incorporated scope beyond that of refurbishment and life extension, potentially increasing the budget and project complexity. However, to balance this out, the DR Team has continuously monitored and repeatedly tested the included scope through scope reviews and de-scoping exercises. Additionally, the team has monitored scope definition through the gate review process and Health of Scope (HOS) metrics. Through this extended process we believe that the DR Team has struck an important balance between overly limiting scope (and risking scope growth during execution) and being overly-inclusive (and risking excessive project budgets).

The resultant Darlington Scope Requests (DSR's) drive engineering. Through April 24, 2014, Engineering had completed 142 MDP's. While this met OPG's goal, the number of MDP's continues to rise and is now at 161 (as compared to 139 in our last report) with 19 known packages remaining. This is particularly important considering the new path OPG has chosen to take for ESMSA engineering.

However, whereas scope definition may be sound, the development of solutions is not. As the revised plan for ESMSA engineering takes root, the DR Team also needs to examine the assumptions and engineered solutions. The DR Team's Senior Leadership initiated a new control, a monthly Options Review Board ("ORB"), the intent of which is to re-review the approaches the project teams are taking and see if the means and methods in the plan are appropriate, cost effective and still required. At the first ORB, the BOP, Shutdown/Lay-up and Services projects identified initial plans for six different scopes that needed to be reconsidered. These different subprojects suffered from many of the same problems evident with the Campus Plan Projects discussed above, thought these problems are being exposed, escalated and resolved. The ORB found:

- OPG's design requirements can cause confusion, misalignment and very expensive solutions that defy common sense. As an example, based on the guidance from the original MDP, the dehumidification of the turbine deck would have cost upwards of ten times more than OPG has spent in the past performing the same work on laid-up fossil units.

- The performance specifications in some packages provided the vendors with limited guidance, and in such cases, vendors will usually take the most conservative route.
- OPG often relied on the vendors to suggest more creative solutions to their issues when OPG's team knew the best course to take all along. This was evident with the polar crane package inside the plant. OPG left it to the vendors to discern what was needed. The vendors decided to replace all of the cranes, even though OPG's team determined only refurbishment, not replacement, was required. OPG often relied on the vendors to suggest a more creative solution to their issues when OPG's team knew the best course to take all along. This was evident with the crane package for the polar cranes inside the plant. OPG left it to the vendors to discern what was needed, from which the vendors decided to replace all of the cranes, even though the needed scope determined by OPG's team was refurbishment, not replacement.

This initial ORB was a success and will be followed by further, similar reviews of planned solutions. From this and the lessons learned from the F&I work, BMcD/Modus recommends that OPG consider the aforementioned controls on scope, including: (1) reviewing the necessity of performing the work; (2) revisiting prior options; (3) refreshing the view of net present value; (4) questioning whether scopes of work that are driven by regulatory requirements and have experienced significant cost overruns are still cost effective.

In addition, the DR Team is instituting a Unit Scope Review Board that will examine each subproject's readiness at key intervals in the manner employed by the station for outage preparedness. This team will be led by the DR Team's senior management and will test whether a given project has key deliverables in place at required quality levels as it advances toward execution. We believe these tests are part of prudent management and necessary to meet the intent of the Minister of Energy's Long Term Energy Plan ("LTEP").

B. Project Controls

The DR Project's reports (namely the Program Management Report) needs attention. This report is difficult to read, contains multiple formats changes, and has, in the case of the Campus Plan Projects, erroneous and outdated information that is included without verification. The Campus Plan Projects' reporting discussed above provides a vivid example of how reports that lack accuracy and transparency mislead and deprive senior management the opportunity to make key decisions. The DR Team's Project Controls team is bringing needed QA/QC reviews and personnel to test and monitor this and other key reports' information. The tendency by the DR Team is to provide too much data in these reports so that important information is often obscured and lost in the "noise." Furthermore, metrics and reporting are supposed to provide an accurate snapshot of the status of a project. The current Project Reports need work to achieve these goals. . Project Controls is endeavoring to improve its reporting suite that both informs and allows for management focus. The team is working currently on revised versions of the "quad charts" that provide metrics and description of the projects' current focus areas. The DR Team has also agreed to abandon the quarterly produced "report card" which was ineffective at communicating the Project's status. This metric was a jumble of key performance indicators, dates, milestones, etc. and only serves to confuse rather than provide useful information.

Moreover, the DR Team's methodology for measuring earned value needs to be stress tested. The DR Project's schedule is now matured to include resource loading to allow OPG to test work hour productivity factors from information contained in the P6 schedule. As the schedule further matures, we will be providing additional focus to the coincidental development of earned value and productivity factors.

C. Supply Chain

Our observations of the P&M organization and the Campus Plan Projects have raised some concerns regarding the interface between Supply Chain and the project management team. In particular, the current procedures require that Supply Chain negotiate all change orders (also called contract amendments) on behalf of OPG. This appears to be a cumbersome process with a number of built-in walls that only cause for multiple review stages of the same information.

This process has the potential to cause delays to both the Campus Plan and DR Projects, but more importantly, it disconnects scope, schedule and cost accountability from the project team. We will be further examining these processes as the project progresses, including an upcoming Assessment of the DR Project's Change Management process.

VI. Other Project Risks

A. Project Team Development

As previously noted, Enterprise Risk Management carries the retention of key personnel as the biggest program risk to the DR Project, and we would agree that it is certainly among the DR Project's biggest challenges. The most urgent challenge in this regard is to ensure that the Project has sufficient skilled resources to manage and monitor all of the work that must precede Refurbishment, including supporting the F&I, ASIC and VBO work, while maintaining the pace of the Refurbishment's key developmental activities. In our view, the best way to address this challenge is to continue to ramp up the front end planning effort so that all the work that must be performed is known and identified by schedule window and priority. Once the total needs of the organization are better defined, OPG can address resource needs in a more comprehensive manner. BMcD/Modus also sees monitoring resources in the schedule via fully resource loaded, level 3 schedules and tracking work hours productivity factor indices as essential ingredients in understanding the resource needs for each work group, trade specialty and the like. Senior Leadership of Refurbishment and P&M have coordinated a monthly ESMSA Summit at which resource needs will be discussed in greater detail going forward.

As the DR Team focuses more on developing its team for the Execution Phase, OPG will need to obtain individuals with different skills and experience than it may have currently in-house. OPG's current hiring, banding, salary constraints and onerous, time-consuming onboarding procedures serve as a barrier to finding the necessary experienced and qualified personnel. BMcD/Modus recommends that the DR Team closely look at the optimal Execution Phase organization design so that it can properly cost-out the Execution Team in the 4d Cost Estimate and prepare to deal with the barriers to securing suitably experienced management and staff .

B. Program Management Plan Development

In our last report, BMcD/Modus identified some shortcomings with DR Team's Program Management Plan ("PgMP"). The DR Project's Senior Leadership has moved forward with our recommendations to progress the PgMP. Senior Leadership also led the first of what will likely be a series of meetings with key Project Team members to foster alignment of the functional groups into a "projectized" team in which the individual sub-projects will capture the majority of the cost and coordinate the activities in a more focused manner. This initiative exposed for Senior Leadership that it must go farther to communicate roles and responsibilities within this matrix organizational model.

As we noted in our last report, the PgMP is the key unifying document set for project execution; in our experience, it would be tantamount to the project bible that a new employee would use to understand his or her roles and responsibilities. In addition, with the 4d Cost Estimate beckoning, the project teams will need to know the breadth of their matrixed organization and related cost centers to properly allocate the different elements of the estimate. The Project's need for a solid PgMP is further heightened by Senior Leadership's attempts to evolve the organization for the Execution Phase.

In summary, BMcD/Modus recommends that the DR Team simplify the approach it is taking to develop the PgMP so that it is unifying document and increase collaboration across the team. We believe the current efforts of the Engineering team to provide its portion of the plan could establish a model for the other functions and projects to follow.

MODUS Strategic Solutions CANADA

Attachment A – 1Q 2014 Risk Perspective

Burns & McDonnell CANADA

Area	Observations	High / Medium / Low	Current Status / Mitigation
RFR	**SNC/Aecon Performance**: Largest Program risk due to overall risk to the DR Project and OPEX.		► Tooling recovery progressing; next tooling milestones will be missed but impacts are limited and mitigating actions are in progress ► Tooling and procurement recovery plan in place, some slippage continues ► RWPB and Definition Phase Engineering showing signs of slow progress
	Class 3 Estimate: Progression to RQE requires SNC/Aecon's Class 3 Estimate to be thoroughly vetted		► Completing thorough OPG review by May 15, 2014 will be challenging ► Ultimate goal of delivery by August 2014 is acceptable ► Monetizing contingency remains a risk
	Schedule Development: Level 4 schedule under development; requires challenge to total duration		► First draft of the Level 4 schedule lacked creativity and boldness ► Continued review required from OPG project team to push SNC/Aecon for a more aggressive but achievable schedule
	RWPB Delays: Facing similar problems that have plagued Campus Plan projects		► Contaminated soil, interferences, and seismic issues delaying engineering ► Minimize design aspects of gold plating or permanence ► Utilize/implement lessons learned from Campus Plan work
	RFR Commercial Risks: Contract provisions currently in place may not drive desired performance		► Negotiation of the Execution Phase target price should revisit incentives and disincentives/focus on success of the first unit
Campus Plan	**ESMSA Performance**: D20 Storage and AHS work is behind schedule and over budget		► Vendor performance/unforeseen issues remain significant risks ► Similar trends are being observed with several other F&I projects; budgeting process is being investigated ► Bids for remaining work are significantly higher then budgets ► Re-evaluation of business case required in light of new estimates
	Engineering and Planning: D20 provides key lessons learned for remaining Campus Plan and BOP		► Engineering is co-locating with ESMSA vendors and taking more active role in directing and managing the work ► Clarification of RFPs and process ongoing ► Modifications to planning and scheduling underway
BOP	**ESMSA Performance**: Concern over ESMSA contractors' performance and ability to execute BOP work		► Allocation of work underway; some issues with cost/scope estimates ► Risk of ESMSA Performance will continue until improvements on performance issues in Campus Plan are observed

MODUS Strategic Solutions CANADA

Attachment A – 1Q 2014 Risk Perspective

Burns & McDonnell CANADA

Area	Observations	High / Medium / Low	Current Status / Mitigation
Engineering	**Scope Review**: New Options Review Board has increased scrutiny of design decisions		► Options Review Board has been effective in challenging scope decisions
	Planning of Engineering Work: Engineering work was not well understood and is poorly planned		► OPG engineering is taking more active role in directing and managing the work at the engineering studios ► "Bottoms-up" estimating process initiated for engineering activities ► Increased focus placed on engineering planning for the design phase; new progress tracking mechanisms in place
Project Controls	**Continued Schedule Development**: Schedule approach was unproven; integration at appropriate level at risk		► Project Team is moving toward industry-wide recommended practices for scheduling ► Substantial work remains to populate detailed level 3 schedule
	Progress Towards RQE: The plan for developing RQE is being developed.		► RQE development remains essentially on schedule, but will be heavily reliant on the quality of the various inputs. ► The DR Team has assigned a manager for the planning and development of the multiple pieces that must come together for RQE.
	Risk Management Program: Risk registers require scrubbing; monitoring tools are cumbersome		► DR Team is cleaning up the risk register and improving reporting ► Risk Group is taking a more active role in managing the Risk Program ► Risk training is being conducted but more is required

Project Matrix
Campus Plan
Observations/Findings

REF.	OBSERVATIONS	PROJECTS				
		Water & Sewer	D20 Storage	Aux Htg Sys	RFR Annex	* RFR Waste Storage
1	Lack of scope definition.	√	√	√	√	
2	Insufficient effort and time in creating engineering requirements.	√	√	√	√	
3	Initial Project was deferred and then reactivated over a period of years (> 5yrs).	√	√	√		
4	3rd Party Estimates - Mixed results w/F+G being significantly over or under vendor quote.	√	√	√		
5	Change in contracting strategy with Vendor from a E-PC to EPC.	√	√	√		
6	Basis of Estimates do not conform to AACE Recommended Practices.	√	√	√	√	√
7	Project Team has failed to characterize the changes/progression to the estimates from gate to gate.	√	√	√	√	
8	Mischaracterized Estimate Classification - OPG is accepting vendor quote as a "Class 2" or "Class 3 estimate when such quote does not meet the threshold for a Class 2 or 3.	√	√	√	√	√
9	Contingency calculated at ~21% - not clear how contingency and risk assessment are linked, if at all.	√	√	√	√	
10	Risk shifting - Project Team does not fully understand the nature of target price work.	√	√	√	√	√
11	The process of bid evaluation scoring and metrics used varies among Project Teams.	√	√	√	√	√
12	The process of comparing bids and 3rd party estimates varies among Project Teams.	√	√	√	√	
13	Significant differences between Vendor Quotations (from 50% to > 100%).	√	√	√	√	
14	Vendor quotes and 3rd Party Estimates (Faithful + Gould) are not aligned for ease of comparison to facilitate a comprehensive review of differences.	√	√	√	√	
15	The contractor selection process compelled the contract to be awarded to the lowest bidder over other qualifying considerations.	√	√	√	√	
16	Risks materialized greater than expected during execution, i.e. underground utilities.	√	√	√	√	
17	Senior Management is reluctant to increase contingency on the front end despite selecting the lowest bidder.		√	√		
18	Project Manager is young and appears inexperienced to manage size of project.		√	√	√	
19	Project Team has difficulty in obtaining reliable cost and schedule data from contractor resulting in OPG's inability to effectively forecast costs to complete.	√	√	√	√	√
20	Contractor performance issues have increased costs	√		√	√	
21	OPG performance issue has increased costs, or has the potential to increase costs					√
22	Scope growth beyond what was anticipated for the project.		√	√	√	
*	*Project is in its early stages.*					

Attachment C – Summary of Cost Variances to Date for Campus Plan Projects
BMcD/Modus 2Q 2014 Report to NOC
May 13, 2014

In accordance with recommended industry practices, construction project costs should be periodically evaluated and updated in order to develop reliable estimate at completion ("EAC") forecasts. Planning for cost forecasting establishes the timing of forecasts, how forecasts are communicated or reported, methodologies and systems/tools to be used, and specific roles and responsibilities for forecasting. EACs should be prepared and issued on an established schedule that is appropriate for the pace of work on the project.

The development cycle of an EAC typically follows a set process with standard guidelines for the project team to follow. For instance, one step would be to review and rigorously vet contractor cost reports to understand the development of costs versus current budget, planned and actual productivity. Based on our review of five (5) Campus Plan Projects, it does not appear that Facilities and Infrastructure ("F&I") used a set process or guidelines to govern EAC development. When we interviewed the project teams, we discovered that each team was following its own EAC process, indicating that there was neither visibility to cost increases nor internal cost control.

To understand the impact to the project costs and EAC process, we compared the current EAC to the last approved BCS to identify the magnitude of cost increases. The following chart illustrates the cost increases on the projects[1]:

Overall Cost Variances between the Latest BCS and the Current EAC on F&I Projects

Project	Board-Approved Costs	Current EAC	Variance	% Increase
D2O Storage & Drum Handling	$ 110,015	$ 314,383	$ 204,368	186%
Auxiliary Heating System	$ 45,607	$ 85,102	$ 39,495	87%
RFR Island Support Annex	$ 32,504	$ 40,738	$ 8,234	25%
Water and Sewer	$ 45,703	$ 57,712	$ 12,009	26%

We then analyzed the project documents to identify the categories of costs behind the increases identified on each of the projects as described below. We also interviewed the project teams to understand their EAC process.

D2O Storage & Drum Handling

Our analysis of the RFR Island Support Annex estimates yielded the following summary highlights:

- On this project, nearly every cost category of work has increased considerably ranging up to +537% above approved gate funds, with the exception of Phase I engineering design and award long lead procurement which was contracted on a fixed price basis.
- Engineering work is 82% complete overall versus a planned completion of 100%; 48 of 84 ECs have been issued in Passport. Engineering is forecasting that all ECs will be completed by early November 2014.

[1] The chart contains only 4 projects because Retube Waste Storage is not included; this project has not progressed beyond the definition phase.

Summary of D20 Cost Variances between the Latest BCS and the Current EAC

Cost Category	BCS/Gate 3b	Current EAC (4/22/14)	Variance	% Increase
[redacted]				
TOTAL	$ 110,015	$ 314,384	$ 204,369	186%

Summary of D20 Storage Building Cost Variances

Cost Element	Variance ($K)	% Increase
Underestimate of Effort	$ 30,978	19%
Design Scope Growth	$ 46,466	29%
Underestimate PM Plant Materials	$ 33,654	21%
Client Requested Changes	$ 5,273	3%
Schedule Extension & Acceleration	$ 9,852	6%
Environmental Requirements	$ 17,439	11%
Pipe Chase	$ 4,326	3%
EPSCA	$ 1,569	1%
Building Relocation	$ 9,726	6%
Total	$ 159,283	100%

A brief explanation of the significant changes, as reported by B&M in its updated cost estimate, is provided below:

- *Underestimate of Effort* – This cost element represents the underestimated effort required to execute the project based on the original scope of work. The staffing levels required to manage the work, generate CWPs/ ITPs and integrate the project plans into the OPG work management system were much greater than the original budgets allowed.
- *Design Scope Growth* – Represents the increased construction cost of the project from the original concept. The design engineering was a fixed price. Bidding took place on preliminary design requirements and a conceptual design report with many assumptions that were later invalidated. The absence of the MDR at the time of bidding meant that it was impractical to estimate the project beyond an AACE Class 5 quality level.
- *Underestimate of Permanent Plant Materials*
    - 367% increase in the quantity of process and service piping from 3,000M of piping to >14,000M.
    - 340% increase in the quantity of valves from 250 valves to ~1,100 valves.
    - 40 % increase to the electrical load list including additional equipment such as a UPS and Diesel generator that were not previously in the design requirements.
- *Environmental Requirements* – The project was awarded on the basis that the soil and ground water were free of contamination, an assumption that proved incorrect. Soil testing revealed the presence of tritium above acceptable levels, requiring special soil storage and operational requirements to manage the water runoff.
- *Building Relocation* – The original design concept had a new building with a "shared wall" in contact with the existing west wall of the TRF Building. However, the new foundations for the D20 interfered with the existing foundations necessitating a seven (7) meter relocation of the building to mitigate the conflict. This meant that the building now required four (4) architecturally completed sides rather than the original 3-sided finishes. More significantly, the scant pile (caisson) foundation shoring system became significantly more complex.
- *Schedule Acceleration and Extension required for:*
    - Premium time expended to recover lost time on the critical path and meet outage requirements.
    - Premium time planned critical work and make-up days for inclement weather

Auxiliary Heating System

Our analysis of the Auxiliary Heating System estimates yielded the following summary highlights:

- The current EAC was provided by the contractor just after the 4c estimate effort was complete. The contractor's EAC was provided in a high-level letter and spreadsheet form, which the project team did not dive into or vet.
- On this project, nearly every category of cost has increased significantly. The overall project, including interest and contingency is projecting an overrun of 87%.
- As of the March 2014 Program Status Report, the project is reporting 60% complete ($24M earned on a BAC of $40M).

Summary of Aux Heating Cost Variances between the Latest BCS and the Current EAC

Cost Category	BCS/Gate 3	Current EAC	Variance	% Increase
[redacted]				
TOTAL	$ 45,607	$ 85,103	$ 39,496	87%

The primary cost driver behind the $9.5M increase in engineering costs include $5M of additional Phase III engineering $3M for items that were simply underestimated. For example, HSL underestimated the cost of working in accordance with OPG's review processes; OPG's design review and approval processes are more time consuming than HSL anticipated. The team explained that OPGs EC process is very time consuming as compared with a commercial process. In addition, lack of detail and definition of scope at the beginning impacted the quality of the estimates and bids, including F+G's estimates.

RFR Island Support Annex

Our analysis of the RFR Island Support Annex estimates yielded the following summary highlights:

- For the current EAC, the team relied on high level cost data provided by the contractor which the team did not vet. This information was used at Gate 3B in February 2014.
- The RFR Annex Project is currently projecting a project cost of $40M, or $8M over its 4c estimate of $32M at the last project gate, for an overall increase of 25%.
- As of March 2014, the project is reporting 20% complete ($7M earned of a BAC of $33M).
- The EPC portion accounts for 91% of the overrun, with engineering comprising half of the overrun, procurement and construction 40%, and OPG costs, contingency and interest making up the balance of the overrun. See the table below for additional details.

Summary of RFR Island Support Annex Variances between the Latest BCS and the Current EAC

Cost Category	4C Estimate	Current EAC	Variance	% Increase
Project Costs	$ 23,265	$ 31,280	$ 8,015	34%
Interest	$ 1,973	$ 1,966	$ (7)	0%
Contingency	$ 7,266	$ 7,492	$ 226	3%
Total Project Cost	$ 32,504	$ 40,738	$ 8,234	25%

The following table briefly explains and summarizes the cost increases by $ and % of the RFR Annex Project is shown as follows:

Cost Category	Variance	% Increase
Engineering		
[redacted]		
Total Project Cost Increase	$ 8,234	25%

This project team has done a better job of trying to allocate the cost increases between scope increases and contractor underestimates as shown above.

- The main driver of cost overruns on the current EAC is contractor cost, specifically engineering. The primary issue is that the engineer, HSL, is unfamiliar with OPG's internal processes for design review and approval. The project team feels that Engineering is approximately 80% complete though there are no metrics to confirm; 16 of 22 design packages are complete.
- Communication direction between OPG and HSL has been an issue driving up the engineering costs; OPG's and HSL's processes are not aligned. HSL bid the job assuming that it would be a typical "commercial" level job, i.e. would not require extensive owner review and signoff. Instead, OPG's review and approval process has required much more level of effort from HSL than originally bid.
- In other instances, HSL has over anticipated OPG expectations and burned hours performing unnecessary engineering that could have been mitigated by better communications (e.g. the replacing and redesigning pole supporting security camera. OPG expected to simply mount the camera on an existing pole while HSL anticipating camera vibration issues engineered a new pole replacement).
- The ESMSA contract process has caused more engineering cost by shifting more risk and liability to the engineer. The work is subject to more stringent codes and is performed by different trades which HSL did not anticipate. That also drives up the engineering cost. The work is subject to more stringent codes and is performed by different trades which HSL did not anticipate. As a result, cost overruns for engineering alone equate to an additional $100 per square foot in building costs.

Water and Sewer

As of December 2013 the project was reporting 81% complete ($36.9M earned on a BAC of $45.7M). The Water and Sewer Project is currently projecting a cost increase of $8.3M on a budget of $54.0M or an increase of $18% as shown below:

Cost Category	BCS/Gate 3	Current EAC	Variance	% Increase
OPG Project Management	$ 3,237	$ 3,764	$ 527	16%
OPG Engineering	$ 705	$ 688	$ (17)	-2%
OPG Other	$ 983	$ 2,298	$ 1,315	134%
[redacted]				
Total	$ 45,703	$ 57,712	$ 12,009	26%

- The major driver of this cost increase is in the cost of the construction contracts, due to contractor underestimating the value of change requests, additional change requests not identified or anticipated and increased contractor indirect costs due to schedule delays.

- On a pure percentage basis, the major driver is the OPG other costs which have proved to be higher due to underestimate of the level of effort needed from OPG's Operations Manager, Operations, Project Oversight and Field Support and Drawing Office.
- The EAC for this BCS was based on actual invoiced additional changes as well as internal OPG estimates of the cost of anticipated contract changes.
- Another increase in overall cost of these projects has been due to the nature of the underground work – unforeseen conditions, soil conditions, and undocumented actual conditions.
- Compared to the other projects, water and sewer is well underway. Phase I is 100% complete; phase II is 100% complete on engineering and 75% construction; phase III is scheduled to complete by November 2014 and construction is scheduled to complete by June 2015. However, the work is demolition of the old water treatment plant and is less complicated than the other earlier scopes.

UNDERTAKING J7.3

Undertaking

To provide a copy of the report ARC 2016 Q1: Project Controls - Projects & Modifications ("P&M") Group, if possible before Panel 3A appears.

Response

The Project Controls Audit – Projects & Modifications Group Internal Audit report is filed as Attachment 1. In addition, consistent with OPG's response to L-4.3-1 Staff-072, please see Attachment 2 for a summary of the findings and the associated status of the management action plans.

ONTARIO POWER GENERATION

Internal Audit

Project Controls Audit - Project & Modifications Group

March 9, 2016

Report Rating: **Requires Improvement**

Distribution:

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Table of Contents

1.0 EXECUTIVE SUMMARY

1.1 Summary of Internal Audit Findings

Report Rating: **Requires Improvement**

No.	Finding	Risk Type	Risk Rating[1]		
			High	Moderate	Low
1	Project estimates are not at a sufficient level of accuracy prior to the execution phase.	Financial	x		
2	Cost and Schedule Control Baselines ("CSCB's") are not keeping pace with approved project changes.	Operational		x	
3	A Gating Process for AISC Portfolio Projects has not been formally implemented.	Operational		x	
4	Governance and Procedures specific to AISC projects require improvement.	Operational			x
Total			**1**	**2**	**1**

1.2 Background

The Projects and Modifications ("P&M") Group, part of the Nuclear Projects Organization, is responsible for the management and execution of Operations, Maintenance and Administration ("OM&A") and Capital Projects supporting the Darlington and Pickering Nuclear Generating Stations and Western Waste Facility. The P&M Group has a total project portfolio of $1.1B over the three year period from 2015 through to 2017. The projects that the Asset Investment Steering Committee ("AISC") manages total $833M, with the remaining portfolio related to projects supporting the Darlington Nuclear Refurbishment ("DNR") Project. DNR Projects are executed using the Nuclear Project's Project Management framework which has different requirements than is currently used on the AISC projects, which follows Finance governance. To address these differences, a "Project Excellence" initiative is now in place and includes the development of a common set of standards for all projects across Nuclear. This initiative had just started at the time of the audit.

The AISC is a committee that meets to review, prioritize and provide budgets for sustaining projects for OPG's Nuclear Generating Stations. The committee works in conjunction with business line sponsors to prioritize and recommend projects for approval in accordance with business objectives.

Given the high value of P&M's AISC project portfolio and the critical role these projects play in OPG's on-going nuclear operations, this audit was performed as part of Internal Audit's ("IA's") cyclical audit program.

[1] Please refer to Appendix D for risk rating definitions

1.3 Audit Objective & Scope

The objective of this audit was to assess the design and operational effectiveness of project management controls implemented by the P&M Group to support timely completion of the current portfolio of AISC projects in a manner that achieves project goals.

The scope of the audit included a review of processes and testing, on a sample basis, to determine whether:

A. Governance & Procedures

1. Policies and procedures for project control processes have been established and reflect current practices;
2. Roles and responsibilities for project control processes have been clearly defined.

B. Planning

1. Each project has a valid Business Case Summary ("BCS") which has been approved by the ASIC;
2. A Project Charter and Project Management Plan ("PMP") has been developed, approved, and communicated;
3. The project scope has been clearly defined, with the input of key stakeholders and approved;
4. An appropriate Work Breakdown Structure ("WBS") has been developed which identifies all work to be performed by the project and its deliverables;
5. A schedule has been created that considers resource requirements;
6. The schedule is structured in accordance with the project's WBS, built upon the logical division of work by cost accounts, work packages;
7. The schedule integrates and identifies interdependencies between activities, including critical path as appropriate;
8. Costs are planned, structured, controlled and reported based on the project's WBS, Cost Accounts, and Work Packages;
9. Risks are formally identified with mitigation plans and managed with periodic reviews and updates throughout the project; and
10. Contingency amounts are assigned, formally tracked and appropriately approved when released.

C. Execution

1. Schedule monitoring and control has been established on the project;
2. Schedules are updated on a timely basis and accurately reflect the current status of all deliverables, activities, interdependences and timelines across the project;
3. Performance Metrics have been adopted on the project and are reported to management (e.g. Schedule Performance Index, Cost Performance Index, etc.);
4. The project has a material procurement schedule or tracking sheet representing the receipt of materials, equipment and prefabricated items;
5. Scope, cost, schedule, and contingency changes are managed and approved through a change management process;
6. Forecasts are generated and reviewed for expected variances to plan;
7. Completion of work packages is validated including quality requirements;
8. Projects are executed in accordance with OPG's quality requirements; and
9. Projects are assessed for completeness of scope, cost, schedule and quality objectives, and approved by project sponsors prior to close-out.

D. Reporting

1. Costs are accurately coded to projects to allow for proper tracking;
2. Cost, quality and schedule performance is accurately measured and reported to management on a timely basis. Variances and mitigation efforts to recover on these variances are explained and reported in a complete fashion;
3. Post-implementation reviews are performed to validate that completed projects have met their objectives and to gather lessons learned for future projects; and
4. System access to reporting systems are controlled and monitored.

The scope of the audit included an evaluation of thirteen projects (see Appendix A) from P&M's AISC Portfolio up to the end of September, 2015. Projects were selected based on size, facility, and phase to ensure a cross-section of the population.

1.4 Conclusion

Positive Observations

- The P&M Group is in the process of implementing several changes to their project management framework to align with the revised Nuclear Projects governance, including adopting more up-front planning activities prior to execution; and

- The P&M group's project management team were found to be highly knowledgeable concerning project management principles and how to deploy them on their projects.

Key Findings and Recommendations

The audit has noted the following key findings:

- Project scope definition and estimate accuracy is sometimes insufficient for the start of a project's execution phase. This has caused significant variances to project estimates on several AISC projects. The P&M group should ensure, through implementation of its new gating process, that an AACE[2] Class 3 or better estimate for the project is developed, approved and established as a baseline prior to the start of execution phases. The amount of contingency should reflect risks, including the confidence in and the class of estimate;

- Cost and Schedule Control Baselines ("CSCB's") are not keeping pace with approved changes in Business Case Summaries ("BCS's") and Project Change Request Authorization Forms ("PCRAF's"). The P&M Group should evaluate resource requirements and work with its vendors to ensure proper CSCB's are deployed prior to starting work. In addition, a review of the project change management processes should be undertaken as considerable amount of time is required to get approval for changes;

- The plan to change to the Gated Process for AISC Portfolio Projects to facilitate oversight, phased approval and release of project funds has not been fully implemented. The Nuclear Projects group should work with the AISC Chair in the implementation of a gating process for AISC projects, clearly defining the requirements for each gate; and

[2] Association for the Advancement of Cost Engineering ("AACE").

- There are gaps in governance and procedures. For example a Terms of Reference ("TOR") document for AISC should be finalized and reporting for cost and schedule performance should be standardized.

The findings noted in the report have been reviewed with management who has committed to specific action plans to address them. Please refer to Section 2.0 for details of the above findings along with the potential causes, impacts, recommendations and management action plans.

Opportunities for improvement

The P&M group should look at:

- Expanding its use of Earned Value ("EV") techniques such that cost and schedule variances are explained formally by work package, and Cost Performance Index ("CPI") values take on a greater role in cost and forecast management. At present, use of EV techniques have not been fully implemented for AISC projects, although the plan is to implement EV techniques going forward on all new 2016 projects;

- Improving the Contingency Management process utilized in AISC projects such that specific contingency is established and tracked on a per-risk basis. Contingency Tracking Logs should be used to monitor the allocation of contingency on an on-going basis. The confidence level associated with the class of estimate at the various release phases should be considered in contingency development. Management should also review the assignment and ownership of contingency for monitoring and releases; and

- Improving housekeeping efforts on Risk Registers such that risks and risk action items are closed in a timely manner.

2.0 DETAILED AUDIT FINDINGS

1. Project estimates are not at a sufficient level of accuracy prior to the execution phase.	**High**

As per OPG's BCS requirements and the Association for the Advancement of Cost Engineering ("AACE") standards, cost estimates should be developed to at least a Class 3 estimate prior to execution (see Appendix B). For certain projects, a Class 2 estimate may be used as a "check estimate" once construction work packages are complete and just prior to the start of field execution to confirm accuracy of the Class 3 estimate submitted as part of the Execution Phase BCS. In order to come to a more precise estimate, detailed engineering must be substantially complete to determine material and labour requirements.

It was noted that of the six projects sampled in the execution phase, all six projects did not have an Estimate at Completion ("EAC") for the project established at either a Class 3 or Class 2 level and they were still performing detail engineering work while in their execution phase. In some cases, the true EAC value for the entire project is not identified until the project is in the advanced stages of execution when a significant portion of the execution costs have already been incurred. (Refer to Appendix A for sample projects reviewed in the execution phase).

Potential Causes & Impact

Potential Cause:

- The current AISC process, which utilizes Finance Governance, does not mandate the establishment of at least an AACE Class 3 estimate prior to the start of execution governance allows for execution to be released with different class of estimates;
- Business Case Summary documents and governance does not require clearly identifying the class of estimate and the range for the potential costs for the current release and the total project;
- Contingency assigned does not always fully address potential variances associated with the class of estimate;
- Lack of a formal gating process and clear definition of gate requirements; and
- Station requirements for "fast tracking" of projects to address emergent issues.

Impacts:

- Growth in project estimate-at-completion values through the execution phase of the project;
- Insufficient budget assignments when entire cost of project is not defined prior to execution, potentially resulting in deferrals or cancellations of other downstream projects; and
- The decision process to proceed with projects may be based on inaccurate cost/benefit analysis when releases are sought with incomplete cost information.

Recommendations	Management Action Plan	Owner & Target Completion Date
Management should ensure sufficient detailed engineering is completed in the definition phase to yield at least an AACE 3 estimate prior to start of execution and factor in potential variability associated with the class of estimate when establishing contingency in the various phases of the project. The BCS's and reporting of EAC for Definition Phase should provide the approving authorities with the understanding of the ranges of estimate for the release and the total project.	As part of the Nuclear Projects "Project Excellence" initiative, an estimating Centre of Excellence ("COE") is now in place within the Planning and Project Controls group; all 2016 AISC Project New Starts greater than $5 Million will require estimate review by the COE, consistent with the Gated process (See Finding 3). Gated process will also provide increased oversight in the release phase of projects and cost and estimate accuracy and contingency management.	Gary Rose VP Planning and Controls April 30, 2016

2. Cost and Schedule Control Baselines ("CSCB's") are not keeping pace with approved project changes.	**Moderate**

Cost and Schedule Control Baselines ("CSCB's") are the primary control for measuring cost and schedule performance on a project. When setup correctly (i.e. Built upon reliable project estimates and front-end planning), they provide an indication of which work packages on a project are ahead or behind on cost and schedule performance, the magnitude of these variances and their net impact on the overall project.

CSCB's on three out of 13 projects sampled were found not to be keeping pace with cost and schedule baseline changes being requested and approved in Business Case Summaries ("BCS's") and Project Change Request Authorization Forms ("PCRAF's"). The reliability of contractor data has contributed to this issue. This lack of accurate and timely data has contributed to Cost Performance Index ("CPI") measurements being skewed at work package levels.

In addition to the above, two of the projects were found to be without CSCB's entirely. The P&M group has indicated that they are in the process of implementing project planning and control protocols with their Engineer-Procure-Construct ("EPC") vendors to ensure vendor schedules are received at the start of projects and that CSCB's are created, beginning with new project starts for 2016.

Potential Causes & Impact

Potential Causes:

- Less than adequate front-end planning due to a substantially larger work program executed in short time frame;
- Contractors are not providing accurate cost and schedule information as required by the contract. Therefore, cost and schedule are being updated through PCRAFs and BCS' by OPG Cost and Schedule Analysts ("CSA's") who are challenged to keep up with increasing changes;
    - CSA resources are constrained due to competing priorities associated with processing numerous BCS and contingency releases;
- Some station priority projects are fast-tracked with reduced front-end planning that may result in increased changes later in the project; and
- Difficulty incorporating vendor schedules within CSCB's due to the significant volume of scope changes.

Impact:

A CSCB is the primary control mechanism used to manage and control cost and schedule performance on a project. The absence of a current and realistic CSCB may result in potential cost increases and schedule delays.

Recommendations	Management Action Plan	Owner & Target Completion Date
Management should: • Review workloads of CSAs and evaluate resource requirements; • Work with contractors to ensure proper CSCB's are deployed prior to starting work; and • Review the current BCSs and PCRAF approval processes to reduce time for approvals.	P&M is reviewing the Project Controls work processes executed by CSAs in planning and controlling projects and the amount of project work which will be executed by P&M through the Business Plan period. This information will help in determining the resource gap with CSAs. Once the gap has been determined, an appropriate resourcing strategy will be implemented. This review will include the review of BCSs and PCRAF approval processes to determine opportunities to reduce time of approval.	Jamie Lawrie Director, Project Controls September 30, 2016

3. A Gating Process for AISC Portfolio Projects has not been formally implemented.	**Moderate**

A gating process is meant to define a clear list of requirements, deliverables, and expectations a project should follow in order to be granted approval to proceed to its next phase within the typical five phases of a project's life cycle.[3] In addition to the above, a robust gating process also requires that a project be defined and associated work scope be estimated to specified levels of accuracy.

Although the AISC acts as a de facto Gate Review Board for AISC projects, the gating process outlined in the Nuclear Projects governance (N-STD-AS-0028) and Project Management Manual (N-MAN-00120-10001-GRB) has not been fully implemented for AISC projects. At present, the primary control used for gate approval between phases in the AISC project life cycle is the BCS process. While this is an important requirement, the BCS process does not constitute a complete list of all the deliverables required at each gate approval, nor formalize the challenge process that should take place regarding the approval of each deliverable. Management has indicated that they are in the process of formalizing a gating process for AISC projects in Q1 2016.

Potential Causes & Impacts

Potential Cause:
The new Nuclear Projects governance and procedures are high-level principle-based documents which do not specifically address AISC requirements.

Impact:
Potential for cost increases and schedule delays due to insufficient independent oversight and control of project activities and objectives.

Recommendations	**Management Action Plan**	**Owner & Target Completion Date**
Management should: • Complete its plans to develop and deploy a formal gating process for P&M use on AISC projects; • Ensure gate review documentation packages are created and maintained as a key part of the gate-approval process; and • Ensure that formal gate reviews and approvals are performed and that required stakeholders such as Finance are involved in the gate review and challenge process.	The Nuclear Projects Gated process will become the standard approach for P&M AISC projects beginning with 2016 Project New Starts. This change has been approved by the SVP/CNE and VP, P&M and an initiative is underway to align and implement the Gated process. Finance will be involved in the gate review process. Implementation requires the following actions: 1. Establish a common Gated process for all Nuclear Projects. 2. Through a Change Management Plan, prepare and issue desktop guides for Project Life Cycle to AISC Members and Project Managers. 3. Preparation and Issuance of AISC Terms of Reference to AISC Members and Project Managers.	Actions #1 and #2: Gary Rose VP Planning and Controls April 30, 2016 Action #3: Steve Woods SVP & CNE April 30, 2016

[3] The five standard phases in a project life-cycle are Identification, Initiation, Definition, Execution and Closeout.

4. Governance and Procedures specific to AISC projects require improvement.	**Low**

There are three key gaps identified in governance and procedures that should be addressed:

1. A formal Terms of Reference ("TOR") document does not exist to govern the role, accountabilities, and operation of the AISC;

2. Although Nuclear Projects Governance should apply to AISC funded projects, this principal is not adequately documented as AISC projects follow existing Finance governance. To reduce this confusion, some AISC specific processes should be defined including:
   - The scope and change management process involving PCRAF's should be substituted with the current process in Nuclear projects called CCF;
   - The gating process, including the requirements and deliverables for each gate; and
   - The process for establishing and integrating vendor schedules, establishing forecast inputs, work breakdown structure requirements, etc.

3. Requirements for month-end performance reports and record keeping are undefined. Each project manager runs their project using a different set of month-end reports and reports are not formally stored by project in a central directory for future reference.

Potential Causes & Impact

Potential Cause:
The new Nuclear Projects governance and procedures are high-level principle-based documents which do not specifically address AISC requirements.

Impacts:
- Potential for confusion amongst project team members on how to handle AISC specific requirements versus other DNR requirements; and
- Potential for cost increases and schedule delays due to ineffective planning and control of project activities and objectives.

Recommendations	**Management Action Plan**	**Owner & Target Completion Date**
Management should: 1. Formalize a Terms of Reference document for the AISC; 2. Formalize requirements specific to AISC Project Management; leveraging Nuclear Project's governance where possible; and 3. Standardize the reporting for AISC projects and store these in a centralized repository for future reference. i.e. Book of Record.	Recommendations 1 and 2: Action plan for Finding 3 will include issuance of AISC Terms of Reference and a desktop guide to assist projects under AISC authority in the use of Nuclear Projects Governance, specifically the gated process. Recommendations 3 and 4: Nuclear Projects is in the process of developing standardized reports using Ecosys. Phase 1 implementation will be in Nuclear Refurbishment and Phase 2 will be in P&M.	Recommendations 3 and 4: Gary Rose VP Planning and Controls December 31, 2016

APPENDIX A – LIST OF PROJECTS REVIEWED

Item	Project No.	Project Description	Project Area	Current Project Phase	Current EAC (CDN$M)
1	31412	DN Class II UPS Replacement	Darlington	Execution	55.099
2	31422	DN Pressurizer Heaters & Controllers Replacement Project	Darlington	Execution	14.511
3	31426	DN F/H Inverter Replacement	Darlington	Execution	14.386
4	31508	DN Fukushima Phase 1 Beyond Design Basis Event (BDBE) Emergency Mitigation Equipment (EME)	Darlington	Execution	58.391
5	31710	DN Shutdown Cooling Heat Exchanger Replacement	Darlington	Execution	56.085
6	80058	NWM Western Waste Management Facility Groundwater Monitoring Network	NWM	Execution	4.710
7	33623	DN Installation of partial discharge monitors	Darlington	Close-out	7.147
8	40682	PB MOT8 Foundation Settlement	Pickering	Close-out	3.844
9	60144	IC-18's/IC-HX's	NWM	Close-out	9.730
10	40990	PN Bay Module Loader PLC Replacement	Pickering	Definition	1.200
11	41027	PN Fukushima Phase 2 Beyond Design Basis Event (BDBE) Emergency Mitigation Equipment (EME)	Pickering	Definition	46.302
12	38419	DN Capping of D2O Collection Lines	Darlington	Definition	8.398
13	31516	DN Station Lighting Retrofit	Darlington	Deferred	11.379

Legend:

EAC= Estimate-At-Complete based upon latest Business Case Summary ("BCS").

APPENDIX B – AACE AND BCS CLASSIFICATIONS FOR ESTIMATES

Estimate Class

Estimate Class is a cost estimate classification system developed by the Association for the Advancement of Cost Engineering International (AACE) which defines the estimate "quality" based on the input information used and the project's stage of development. AACE uses five estimate classes with Class 5 being the least accurate, and Class 1 being the most accurate. Below is a table that is included in the instructions for Cost Estimates in the BCS template.

Estimate Class	**Class 5**	**Class 4**	**Class 3**	**Class 2**	**Class 1**
Project Phase	**Identification**	**Initiation**	**Definition**	**Execution**	**Execution**
Level of Project Definition (%)	0% to 2	1 to 15	10 to 40	30 to 75	65 to 100
Expected Accuracy Range (%)	-50 to +100	-30 to +50	-20 to +30	-15 to +20	-10 to +15

APPENDIX C – PROJECTS WITH BASELINE DISCREPANCIES

Item	Project No.	Project Description	Latest EAC (CDN$M)	Latest Target In-Service Date	CSCB Out-of-Date	CSCB Does Not Exist	Summary of Discrepancy
1	31412	DN Class II UPS Replacement	55.099M	2023-Q4	x		Vendor Schedule has not been integrated into Baseline Schedule.
2	31422	DN Pressurizer Heaters & Controllers Replacement Project	14.511M	2020-03-20	x		The current Performance Measurement Baseline (PMB) does not yet include baseline changes required by PCRAF No.'s 3 and 4 dated 15Apr2015 and 22Oct2015, respectively.
3	31508	DN Fukushima Phase 1 Beyond Design Basis Event (BDBE) Emergency Mitigation Equipment (EME)	58.391	2017-12-23	x		No Vendor Schedule. Vendor Schedule has not been integrated into Baseline Schedule.
4	40990	PN Bay Module Loader PLC Replacement	1.2M	TBD BCS under Revision		x	Integrated Cost & Schedule Control Baseline not yet established in P6 and Proliance.
5	80058	NWM Western Waste Management Facility Groundwater Monitoring Network	4.710M	2016-09-30		x	Integrated Cost & Schedule Control Baseline not yet established in P6 and Proliance.
				Totals:	**3**	**2**	

Legend:
BCS= Business Case Summary
CSCB= Cost and Schedule Control Baseline
EAC= Estimate-At-Complete
P6= OPG's Scheduling Software System.
Proliance= OPG's Cost Management Software
TBD= To be Determined

Notes:
Latest EAC and Target In-Service Date based upon latest Business Case Summary inputs.

APPENDIX D – RISK RATING DEFINITIONS FOR AUDIT FINDINGS

Ratings are derived through professional judgement by the audit team and discussion with management. The ratings for individual control findings are outlined below.

Rating	Definition
High Risk	The finding presents a risk that could potentially have severe/major impact on financial sustainability (≥$5M), operational excellence, project excellence, safety, environment and reliability, reputation, regulatory relationship, or compliance with laws and regulations.
Moderate Risk	The finding presents a risk that could potentially have a moderate impact on financial sustainability ($500K to <$5M), operational excellence, project excellence, safety, environment and reliability, reputation, regulatory relationship, or compliance with laws and regulations. If not remediated, this risk could escalate to high risk.
Low Risk	The finding could potentially have a minor impact on financial sustainability (<$500K), operational excellence, project excellence, safety, environment and reliability, reputation, regulatory relationship, or compliance with laws and regulations. Recurring "low risk" findings may be elevated to medium risk status.

OVERALL REPORT RATING SCALE

An overall report rating has been assigned as an indication of the overall design, existence and effectiveness of the components of the internal control structure that was subject to the internal audit. The internal audit rating should be considered in conjunction with the definitions noted above.

- *Effective:* control and risk management practices provide reasonable assurance that business process objectives will be achieved and may include minor improvements and/or opportunities for improvement.
- *Generally Effective*: control and risk management practices require more than minor but less than significant improvements to provide reasonable assurance that business process objectives will be achieved.
- *Requires Improvement*: control and risk management practices require significant improvements in high risk and/or core areas to provide reasonable assurance that business process objectives will be achieved.
- *Not Effective:* control and risk management practices are not designed and/or are not operating effectively.

#	Finding	Management Action	Management Action Status as of March 10, 2017	Risk Rating
1	**Project estimates are not at a sufficient level of accuracy prior to the execution phase.** As per OPG's BCS requirements and the Association for the Advancement of Cost Engineering ("AACE") standards, cost estimates should be developed to at least a Class 3 estimate prior to execution (see Appendix B). For certain projects, a Class 2 estimate may be used as a "check estimate" once construction work packages are complete and just prior to the start of field execution to confirm accuracy of the Class 3 estimate submitted as part of the Execution Phase BCS. In order to come to a more precise estimate, detailed engineering must be substantially complete to determine material and labour requirements. It was noted that of the six projects sampled in the execution phase, all six projects did not have an Estimate at Completion ("EAC") for the project established at either a Class 3 or Class 2 level and they were still performing detail engineering work while in their execution phase. In some cases, the true EAC value for the entire project is not identified until the project is in the advanced stages of execution when a significant portion of the execution costs have already been incurred. (Refer to Appendix A for sample projects reviewed in the execution phase).	As part of the Nuclear Projects "Project Excellence" initiative, an estimating Centre of Excellence ("COE") is now in place within the Planning and Project Controls group; all 2016 AISC Project New Starts greater than $5 Million will require estimate review by the COE, consistent with the Gated process (See Finding 3). Gated process will also provide increased oversight in the release phase of projects and cost and estimate accuracy and contingency management.	Management completed the following to close the finding: **Closed – April 28, 2016** • Issued a series of Estimate "checking" requirements into the gated process on April 28, 2016. They include "Plan" documents for how to review Gate Packages with respect to estimates as well as a series of checklist forms which must be approved as part of gate reviews. Including requirements for approvals by centre-led Estimating Manager and solidifying the Centre of Excellence concept for estimating. **Closed – April 19, 2016** • Evidence provided showing Centre of Excellence (COE) for Estimating is in place. Gated process, when issued, will require all projects to follow Gated Process which will require a review of all estimates > $5Million by the Estimating COE. Initial focus will be on all 2016 New Starts and any projects that	High

#	Finding	Management Action	Management Action Status as of March 10, 2017	Risk Rating
			require a Business Case to be presented to the Board. Later in 2016, the process will be expanded to all projects.	
2	**Cost and Schedule Control Baselines ("CSCB's") are not keeping pace with approved project changes.** Cost and Schedule Control Baselines ("CSCB's") are the primary control for measuring cost and schedule performance on a project. When setup correctly (i.e. Built upon reliable project estimates and front-end planning), they provide an indication of which work packages on a project are ahead or behind on cost and schedule performance, the magnitude of these variances and their net impact on the overall project. CSCB's on three out of 13 projects sampled were found not to be keeping pace with cost and schedule baseline changes being requested and approved in Business Case Summaries ("BCS's") and Project Change Request Authorization Forms ("PCRAF's"). The reliability of contractor data has contributed to this issue. This lack of accurate and timely data has contributed to Cost Performance Index ("CPI") measurements being skewed at work package levels. In addition to the above, two of the projects were found to be without CSCB's entirely. The P&M group has indicated that they are in the process of implementing project planning and control protocols with their Engineer-Procure-Construct ("EPC") vendors to ensure vendor schedules are received at the start of projects and that CSCB's are created, beginning with new	P&M is reviewing the Project Controls work processes executed by CSAs in planning and controlling projects and the amount of project work which will be executed by P&M through the Business Plan period. This information will help in determining the resource gap with CSAs. Once the gap has been determined, an appropriate resourcing strategy will be implemented. This review will include the review of BCSs and PCRAF approval processes to determine opportunities to reduce time of approval.	Management completed the following to close the finding: **Closed – September 23, 2016** Implemented the Cost and Schedule Baselines Action Plan (Dated September 22, 2016) to review the Project controls work processes executed by CSAs (const Schedule Analysis) in planning and controlling projects and the amount of project work which will be executed by P&M through the Business Plan period. This information will be issued to assess the resource gap with CSAs. Once the gap has been assessed a resourcing strategy will be implemented. The review also included the BCS and PCRAF approval process to determine opportunities to reduce time of approval which relates to approvals for implementing Cost and Schedule baselines and approved changes	Moderate

#	Finding	Management Action	Management Action Status as of March 10, 2017	Risk Rating
	project starts for 2016.		to baselines. The review was conducted in three areas: a) P&M Work Program based on the business plan b) Simplify it - by reviewing the PCRAF and BCS processes to identify low or no valve activities which can reduce the work burden on the CSA and project team. c) Gated Process Review for Readiness to process	
3	**A Gating Process for AISC Portfolio Projects has not been formally implemented.** A gating process is meant to define a clear list of requirements, deliverables, and expectations a project should follow in order to be granted approval to proceed to its next phase within the typical five phases of a project's life cycle. In addition to the above, a robust gating process also requires that a project be defined and associated work scope be estimated to specified levels of accuracy. Although the AISC acts as a de facto Gate Review Board for AISC projects, the gating process outlined in the Nuclear Projects governance (N-STD-AS-0028) and Project Management Manual (N-MAN-00120-10001-GRB) has not been fully implemented for AISC projects. At present, the primary control used for gate approval between phases in the AISC project life cycle is the BCS process. While this is an important	The Nuclear Projects Gated process will become the standard approach for P&M AISC projects beginning with 2016 Project New Starts. This change has been approved by the SVP/CNE and VP, P&M and an initiative is underway to align and implement the Gated process. Finance will be involved in the gate review process. Implementation requires the following actions: 1. Establish a common Gated process for all Nuclear Projects. 2. Through a Change Management Plan, prepare and issue desktop guides for Project Life Cycle to AISC	Management completed the following to close the finding: **Closed – April 19, 2016** 1. Management has developed a common Gated process for Nuclear Projects. An update to N-STD-AS-0028 reflecting the new common Gated process will was issued on April 28. 2. N-MAN-00120-10001-GRB and the associated forms/check sheets have been updated and issued on April 29 in governance. A change management presentation summarizing the changes was	Moderate

#	Finding	Management Action	Management Action Status as of March 10, 2017	Risk Rating
	requirement, the BCS process does not constitute a complete list of all the deliverables required at each gate approval, nor formalize the challenge process that should take place regarding the approval of each deliverable. Management has indicated that they are in the process of formalizing a gating process for AISC projects in Q1 2016.	Members and Project Managers. 3. Preparation and Issuance of AISC Terms of Reference to AISC Members and Project Managers.	developed and presented at an AISC meeting in Q2 2016. **Closed – April 26, 2016** 3. AISC Terms of Reference guideline – N-GUID-00120-10016– Dated April 19, 2016.	
4	**Governance and Procedures specific to AISC projects require improvement.** There are three key gaps identified in governance and procedures that should be addressed: 1. A formal Terms of Reference ("TOR") document does not exist to govern the role, accountabilities, and operation of the AISC; 2. Although Nuclear Projects Governance should apply to AISC funded projects, this principal is not adequately documented as AISC projects follow existing Finance governance. To reduce this confusion, some AISC specific processes should be defined including: a. The scope and change management process involving PCRAF's should be substituted with the current process in Nuclear projects called CCF; b. The gating process, including the requirements and deliverables for each gate; and c. The process for establishing and integrating vendor schedules, establishing forecast inputs,	Recommendations 1 and 2: Action plan for Finding 3 will include issuance of AISC Terms of Reference and a desktop guide to assist projects under AISC authority in the use of Nuclear Projects Governance, specifically the gated process**.** Recommendations 3: Nuclear Projects is in the process of developing standardized reports using Ecosys. Phase 1 implementation will be in Nuclear Refurbishment and Phase 2 will be in P&M.	Management completed the following to close the finding: **Closed – April 26, 2016** • Recommendations 1 and 2 of Finding No. 4 were closed under Finding No.3. Project Controls provided AISC Terms of Reference and revised Nuclear Gating Process on the associated due date. • Recommendation 3: Rollout to P&M for P&M projects in Ecosys was scheduled to be completed by Dec 2016, whereas rollout for AISC projects in Ecosys was to be completed in Q1 2017. IA accepted evidence consisting of 28 active P&M project reports available in Ecosys as of Dec 13,	Low

#	Finding	Management Action	Management Action Status as of March 10, 2017	Risk Rating
	work breakdown structure requirements, etc. 3. Requirements for month-end performance reports and record keeping are undefined. Each project manager runs their project using a different set of month-end reports and reports are not formally stored by project in a central directory for future reference.		2016 (evidence: list and samples), together with evidence that AISC projects in Ecosys were to be rolled out in Q1 2017 and were tracked via RMO action #6602. P&M reports were considered a standardized template for both P&M and AISC projects. Thus "Standardize reporting for AISC projects" is done. IA Confirmed that all of P&M data are loaded. It consists of P&M's non NR projects and totals over 100 projects. • Supplementary evidence provided showing that gated process has been implemented. P&M provided the list of AISC 2016 "New Starts" projects indicating that respective Gate Packages has been filed.	

Table C-4 Conversion of US Currency Values to Canadian Currency Values

Year	USD	FX	ESC	CAD
2012	100	1.03	1.16	119.48
2013	100	1.10	1.18	129.80
2014	100	1.10	1.17	128.70
2015	100	1.28	1.17	149.76
2016	100	1.32	1.09	143.88
2017	100	1.30	1.06	137.80
2018	100	1.30	1.01	131.30
2019	100	1.32	1.00	132.00

Labour Cost Adjustments

Actual average hourly rates for OPG contractors were higher than the labour rates embedded in RSMeans for the Toronto metropolitan area. To determine how much higher, we computed the ratio of actual OPG contractor wage rates for various trades (*e.g.*, electrician journeyman, structural steel foreman, and plumber) to RSMeans wage rates for the same trades at comparable seniority levels. We obtained the OPG contractor rates from a Canadian government source and factored in 2 hours' worth of overtime pay daily to account for the contractor's 10-hour day. We found that the contractor's average labour rate was, on average, 1.46 times higher than the RSMeans presumed labour cost. In other words, if RSMeans reported a CAD50 per hour wage rate, the commensurate actual wage rate CAD73 per hour.

We then adjusted for differences between labour productivity on the D2O Storage Project with the premised 66% labour productivity in the RSMeans database. We derived our estimate for the OPG contractor productivity from data in two "wrench time" studies that were commissioned by OPG, but consistent with our own first-hand experience with construction projects inside the protected area of a nuclear facility. The studies estimated productivity rates for various activities performed in the projects. We combined the findings of those studies and computed an average productivity rate of 39%, which is in our opinion a reasonable and appropriate measure of expected productivity for this project.

The ratio of 66% to 39% is 1.7. We multiplied this 1.7 factor by the wage adjustment factor of 1.46 to compute a combined factor of 2.5.

The RSMeans database does not contain data that are applicable for procuring or installing materials required to meet nuclear quality standards. Thus, for those items in the BOQ requiring nuclear quality assurance requirements, we supplemented the RSMeans data with additional crew members (welders and quality assurance specialists) and adjusted for specialized material and labour costs based on cost factors in the EMWG guidelines. These guidelines present specific cost factors for nuclear class commodities, piping, and the associated labour required to place or install those commodities, piping, and components. These commodities comprised nuclear class form work, embedded metal, reinforcing steel bars, steel, piping, etc. In addition, the Guidelines provided costs for installation of non-nuclear-grade materials, for comparison purposes. We used this information to develop adjustment factors to reflect additional costs associated with procurement and installation of nuclear-grade materials.

C.2.a. Added Crew Members

For the installations required to meet nuclear safety standards, we added a welder and quality assurance member to the identified RSMeans crew. To calculate the associated labour cost, we used the basic pricing method RSMeans uses. We estimated the hourly rate and multiplied that rate by the number of hours we expected the crew member would work.

As an illustration of our approach for computing this added cost, we offer this example. Assume the requirement is to install 200 meters of pipe and, because of nuclear safety standards, the installation requires welded (rather than mechanical) joints and fixtures. These requirements would not exist in a common construction project.

Further assume that the RSMeans crew, based on common construction requirements, comprises three workers and that, after reviewing OPG union rates, we determined that an average welder's wage is $75 per hour. The cost of an additional welder would be calculated as shown below:

- Starting crew and initial crew cost
  - Crew size = 3
  - Average wage = $75 per hour
  - Installation time = 40
  - Crew cost = Crew size x Average wage x Installation time = 3 * $75 * 40 = $9,000

- Add an additional welder at $75 per hour
  - Welder factor = 1 + (1/Crew size) = 1 +1/3
  - New crew cost = Welder factor * Crew cost = $9,000 * (1 + 1/3) = $12,000
  - Cost of additional welder = $12,000 - $9,000 = $3,000

C.2.b. Revised Material Costs

Some of the items listed in the BOQ specified Nuclear Class 3 (NC-3) or Nuclear Class 6 (NC-6) classification as identified by the Canadian Nuclear Safety Commission's quality assurance requirements. These requirements divide mechanical components into several classes.

We present below the EMWG-calculated relative cost relationships between costs for nuclear-related items and costs for non-nuclear items for ten categories of commodities (Table C-5).[54] The last column is the factor we used to adjust the base RSMeans cost data. For example, for concrete placed below-grade (for the nuclear dike), we estimated the cost of placing concrete using the RSMeans cost data and then added the product of that cost multiplied by the factor 0.5); thus, if the cost of placing a specified volume of concrete for a portion of the nuclear dike was CAD100 based on RSMeans cost data, we would have added another CAD50 (100 x 0.5) to estimate an adjusted cost of CAD150.

Table C-5: Cost Differentials betw. Nuclear and Nonnuclear Materials

Commodity	Unit	Nuclear	Non-nuclear	Ratio	Factor
Formwork	m^2	31.23	29.14	1.07	0.07
Embedded metal	kg	13.06	7.87	1.66	0.66
Rebar	m^2	1278.50	821.92	1.56	0.56
Concrete	m^3	208.93	139.20	1.50	0.50
Structural steel	Mt	4446.70	2008.07	2.21	1.21
Misc. steel	MT	10269.48	2008.07	5.11	4.11
50 mm SS weld pipe	m	369.04	278.63	1.32	0.32
100 mm SS spooled pipe	m	1549.97	926.29	1.67	0.67
300 mm SS spooled pipe	m	9305.24	8936.30	1.04	0.04

The EMWG guidelines include factors for labour hours per unit quantity for the installation of nuclear-related materials and non-nuclear-related materials that are installed in or around nuclear-related materials compared to labour hours for placing and installing common construction commodities. We used those factors to compute factors based on RSMeans presumed labour hours.

Table C-6 depicts those factors in the column labelled *Nuclear unit hr*. The third column, labelled *RSMeans hrs,* depicts the associated RSMeans data for installing the same materials in common, non-nuclear construction. The fourth column depicts the ratio of the two installation times, and the fifth column depicts the adjustment factor we applied to the RSMeans data.

[54] Note that SS designates stainless steel, here and elsewhere in this report.

This example illustrates how we applied the adjustment factor for placing concrete below-grade for the nuclear dike. We started with the RSMeans-derived labour cost for conventional construction based on the time for placing a cubic meter of concrete (average wage rate per hour time 0.76 per cubic meter of concrete). We then added to that cost the product of the factor (12.1) times the cost to arrive at our estimated labour cost.

Table C-6: Differentials betw. Nuclear-Related Installation Hrs. and RSMeans-Presumed Installation Hrs.

Commodity	Nuclear unit hours	RSMeans hours	Nuclear ratio	Factor
Formwork - substructure	6.89	0.76	9.07	8.07
Formwork - superstructure	12.06	0.76	15.87	14.87
Rebar superstructure	36.03	15.32	2.35	1.35
Concrete -substructure	2.62	0.20	13.10	12.10
Concrete - superstructure	5.23	0.80	6.54	5.54
Steel	58.06	3.50	16.59	15.59
SS Pipe <50mm	34.02	0.92	36.98	35.98
SS Pipe >50mm	87.59	1.54	56.73	55.73

C.2.c. *Adjustments to Labour Costs to Account for Nuclear Grade Work*

We followed the same procedure for estimating labour costs for placing or installing materials requiring special treatment because they were placed or installed on or near nuclear-related materials.

Table C-7 depicts the adjustment factors for labour hours for installation of non-nuclear-related materials in or around nuclear-related materials.

Table C-7: Differentials betw. Non-Nuclear-Related Installation Hrs. and RSMeans-Presumed Installation Hrs.

Commodity	Nonnuclear unit hours	RSMeans hours	Non-nuclear ratio	Factor
Formwork – substructure	5.1	0.760	6.71	5.71
Formwork – superstructure	9.04	0.76	11.89	10.89
Rebar superstructure	27.22	15.32	1.78	0.78
Concrete – substructure	1.96	0.200	9.8	8.80
Concrete – Superstructure	3.92	0.800	4.9	3.90
Steel	13.06	3.50	3.73	2.73
SS Pipe <50mm	12.75	0.920	13.87	12.87
SS Pipe >50MM	33.01	1.544	21.38	20.38

C.2.d. *Assessment of Potential for Adjustment Factor Interaction*

We examined the potential for adjustment factor interaction between the EMWG system installation rate data and the productivity factors discussed in Section C.2 above.

In performing notional second checks of the estimates of direct labour for construction of nuclear-grade mechanical systems, we identified a potential interaction, or overlap, between an adjustment that was used to reflect general site productivity and labour adjustments implied by estimates for nuclear-grade mechanical equipment installation in the EMWG guide. We summarize our assessment of both of these factors below.

The “wrench time” study done by the University of Ontario Institute of Technology (“UOIT”) reviewed several DRP activities to identify major contributors to downtime, *i.e.*, time when craft personnel were not actively prosecuting

ONE
TEAM
ONE
GOAL

Filed: 2021-04-19, EB-2020-0290
Exhibit L-D2-02-SEC-104
Attachment 1, Page 1 of 24

D2O Storage Project Alternatives

FOAK/FIAW Options Review Board
Jun 19, 2017

Safety
Quality
Schedule
Cost

ONTARIO POWER GENERATION

Agenda

1. Project Summary – D20 Timeline of Events
2. Overview of what Plan "A" and Plan "B"
3. Quantities remaining
4. Estimates done to date summary slide
5. Early Contractor Involvement overview
6. SWOT analysis: Strengths, Weaknesses, Opportunities and Threats
7. Vendors Short Listed
8. Engineering , Procurement & QA/QC Overview
9. Schedule Overview
10. "Plan C"
11. Overview of the OPG PMT
12. Current Budget

Project Overview – D20 Timeline

D20 Timeline of events: Key dates:

October 2014 – Termination of Black and McDonald Contract
April 2015 – JV awarded LNTP
August 2016 – Final Award to JV for **$146M**
October 2016 – JV presented ECAC at **$187M**
January 2017 - JV presented updated ECAC at **$242M**
April 2017 – JV presented another updated ECAC at **$270M**
April 21st, 2017 – OPG Halted all works and started Transition

Plan "A" vs. Plan 'B"

- Plan "A"
  1. JV Re-estimate the ECAC in a fully transparent process & Incorporate OPG's comments from the estimate review
  2. Lock in final estimate in a Lumpsum commercial arrangement
  3. Reach an acceptable reduction to the Lumpsum for all outstanding commercial issues and OPG impacts due to the JV's mismanagement of the D20 Project
  4. Re-assign D20 Project to the JV

Plan "A" vs. Plan 'B"

- Plan "B"
  1. Establish Early Contractor Involvement Process
  2. Identify two Vendors, that
     - Capacity and ability to finish the work
     - Enthusiastic (working with OPG)
     - Willingness to accept risk or "skin in the game"
  3. Incorporate Vendors teams with in OPG
  4. At conclusion Vendors provide:
     - Level 2/1 Estimate (high confidence)
     - Level 4 Schedule (detailed)
     - Hard money proposal (Lumpsum, unit rate, PMT at risk)

Scope of Work: Quantities

Item Description	QTY (April 2017)	UoM
BLOCK WALLS	18,669	SF
PIPE & SUPPORTS	39,071	LF
CONTROL CABLE / CABLE TRAY W/ SUPPORTS	154,940	LF
CONDUIT W/ SUPPORTS	60,313	LF
TERMINATIONS, POWER & CONTROL	11,307	Ea

Current Estimates Completed

Row	Description	HB Estimate	F&G April 26, 2017	Adjusted consolidated estimate, to be managed by JV	Adjusted consolidated estimate, to be managed by OPG
1	**DIRECT LABOR**	$37,194,210	$81,515,330	$37,097,930	$37,097,930
2	***CIVIL***	*$5,668,603*	*$4,905,927*	*$4,260,000*	*$4,260,000*
3	***ELECTRICAL/I&C***	*$13,229,787*	*$28,079,049*	*$18,808,667*	*$18,808,667*
4	***MECHANICAL***	*$15,059,400*	*$36,791,713*	*$10,792,844*	*$10,792,844*
5	***SCAFFOLDING***	*$3,236,420*	*$11,738,641*	*$3,236,420*	*$3,236,420*
6	**SUPPORT LABOR & INDIRECTS**	$11,371,850	$8,151,533	$7,035,669	$7,035,669
7	**CONSTRUCTION EQUIPMENT**	$1,756,963	$245,243	$1,112,938	$1,112,938
8	**ENGINEERED EQUIPMENT/MATERIAL**	$8,101,632	$6,293,202	$6,293,202	$6,293,202
9	**PROJECT MANAGEMENT TEAM**	$24,190,375	$4,177,000	$19,500,000	$15,400,000
10	**DESIGN ENGINEERING**	$5,724,078	$11,400,000	$5,000,000	$4,900,000
11	**SUBCONTRACTOR**	$7,414,213	$6,195,471	$5,977,897	$5,977,897
	Subtotal	**$95,753,321**	**$117,977,779**	**$82,017,636**	**$77,817,636**

Current Estimates Completed

Row	Description	HB Estimate	F&G April 26, 2017	Adjusted consolidated estimate, to be managed by JV	Adjusted consolidated estimate, to be managed by OPG
12	PROFIT, MARKUP & OVERHEAD	included above	$4,426,213	$5,904,889	$4,907,662
14	EPSCA FEE	not included	$4,669,685	$1,892,752	$1,892,752
13	VENDOR CORE TEAM COST	not included	not included	not included	not included
	Subtotal	**$95,753,321**	**$127,073,677**	**$89,815,277**	**$84,618,049**
16	SLOW DOWN COST	$3,733,000	not included	not included	not included
	Subtotal	**$99,486,321**	**$127,073,677**	**$89,815,277**	**$84,618,049**
17	CONTINGENCY	$9,027,043	$11,943,818	$7,185,222	$6,769,444
	Subtotal	**$108,513,364**	**$139,017,495**	**$97,000,499**	**$91,387,493**
15	OPG - SUPPORT COST	$6,391,996	$6,391,996	$6,391,996	$5,113,597
18	DISCRETE RISKS	To be added	To be added	To be added	To be added
	Grand Total	**$114,905,360**	**$145,409,492**	**$103,392,495**	**$96,501,090**

Class 5	*Class 3 - overestimated*

Early Contractor Involvement

- Early Contractor Involvement (ECI) provides:
  - an efficient means of planning projects
  - cost-effectiveness
  - less adversarial structure
  - partnering relationship
  - increase transparency
  - reduced risk monetary allocation

Above all, Confidence:

1. Cost and Schedule Certainty confidence
2. Vendor confidence their understanding of the project


Plan "B" SWOT Analysis

SWOT: Strengths of Plan "B"

- Strengths
  - OPG / Vendor Planning Incorporation
  - Increased Flow of materials and information (as compared to normal RFP process)
  - Increased Vendor Confidence in scope (reduced Contract Price)
  - OPG PMT Integration
  - Vendor Skin in the game
  - Increased Cost and Schedule Certainly through Contract Model
  - Vendor to be in lock step with OPG manegment teams to understand OPG process and requirements

SWOT: Weaknesses of Plan "B"

- Weaknesses
  - New Vendors will take longer time to get familiar with OPG process
  - May encounter more interface issues with various groups
  - Rework or catch up from where JV has left potential
  - Change Procurement System and PO ownership
  - Re-establish relationship with sub-vendors (if applicable)
  - Project carrying costs; November start date

SWOT: Opportunities of Plan "B"

- Opportunities
  - Bring in fresh perspectives and management approaches, which will leads to efficiency gain and schedule recovery
  - OPG to optimize the Vendors PMT oversight levels
  - Potential over-all cost savings and reduced project cost
  - Increase OPG vendor roster bench
  - Customize and optimize OPG PMT requirements to complement Vendor setup

SWOT: Threats of Plan "B"

- Threats
  - Risk Contract price can be more than "Plan A"
  - New to OPG and Nuclear, steep learning curve in process and interface with OPG

FOAK/FIAW Considerations

	FOAK / FIAW Aspects	Score 0-3		
1	New design / innovation / software unique to project?	2		describe the specific aspects scored: examples: FOAK conversion to digital control for this system. FOAK for Vendor to perform <task> previously only done by station. FIAW - <equipment> has not been disassembled since original build.
2	New line of equipment, devices, materials?	1		
3	New installation method / tools or first time in 5/10/20 years?	3		
4	Work is new to performing group and oversight or both.	2		
5	Equipment/asset not maintained/ accessed for 10/20 years?	2		
6	Unprecedented scale of activity (>10x, >20x, >50x)	4		
			14	

Vendors

Potential Vendor Short list:

- The State Group *(interviewed)*
- Matrix NAC *(interviewed)*
- Lorneville *(interviewed)*
  - Sunny Corners *(interviewed)*
  - Kiewit Canada Corp.
- Bird Construction
- PCL Constructors Inc.
- Ledcor Group of Companies

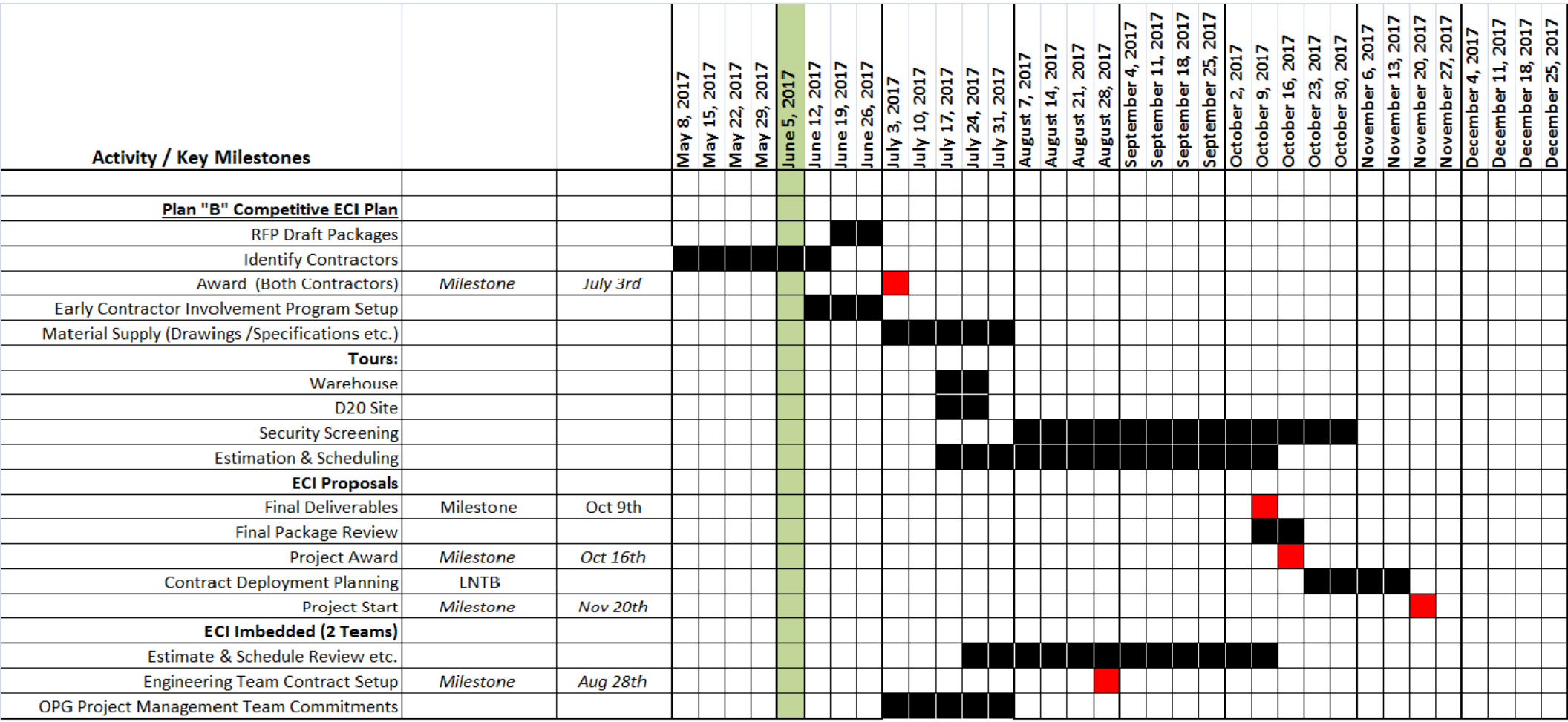
Engineering Strategy

Procurement Strategy

Field Quality Control Strategy

Schedule

Activity / Key Milestones		
Plan "B" Competitive ECI Plan		
RFP Draft Packages		
Identify Contractors		
Award (Both Contractors)	*Milestone*	*July 3rd*
Early Contractor Involvement Program Setup		
Material Supply (Drawings /Specifications etc.)		
Tours:		
Warehouse		
D20 Site		
Security Screening		
Estimation & Scheduling		
ECI Proposals		
Final Deliverables	Milestone	Oct 9th
Final Package Review		
Project Award	*Milestone*	*Oct 16th*
Contract Deployment Planning	LNTB	
Project Start	*Milestone*	*Nov 20th*
ECI Imbedded (2 Teams)		
Estimate & Schedule Review etc.		
Engineering Team Contract Setup	*Milestone*	*Aug 28th*
OPG Project Management Team Commitments		



Go/ No-Go Plan & Plan C

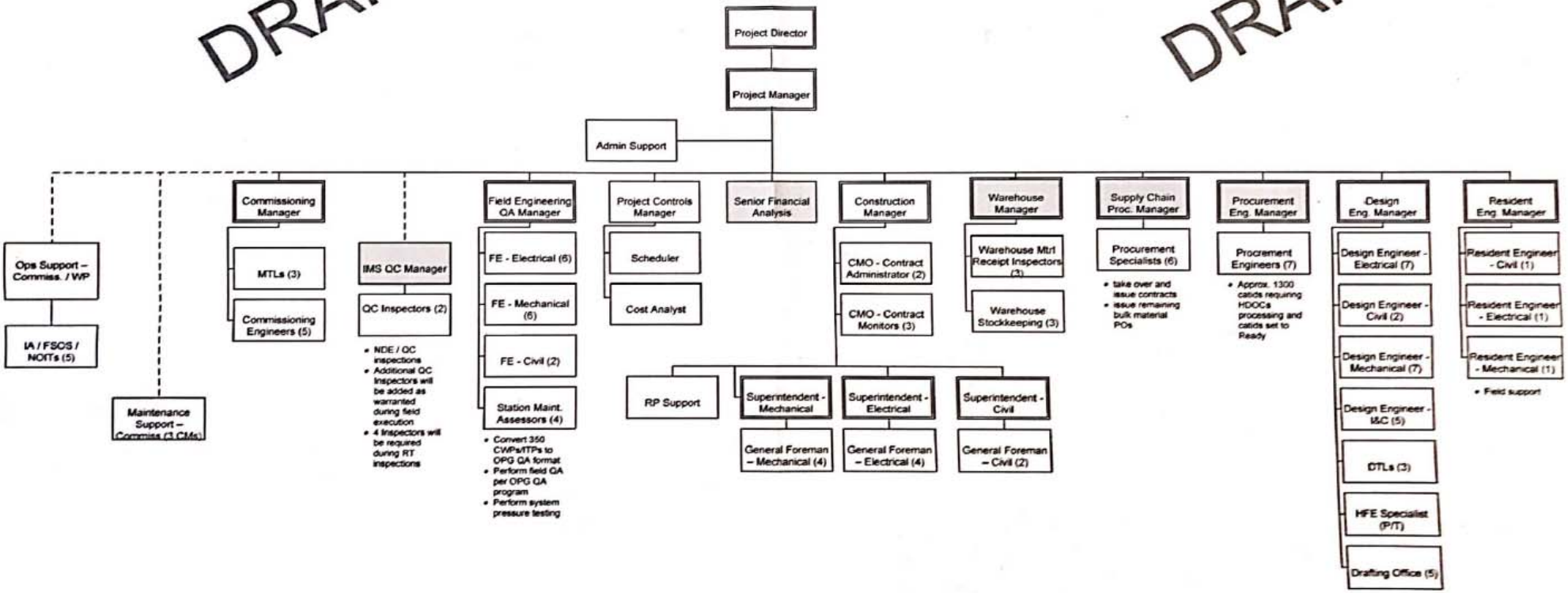
Filed: 2021-04-19, EB-2020-0290
Exhibit L-D2-02-SEC-104
Attachment 1, Page 22 of 24

D2O Storage Project – proposed project Org Chart if completing project under OPG QA Program

DRAFT

DRAFT

Base resources as required



Current Budget

Rev 01 Last Update: May 26, 2017

Deliverable /Services	May	June	July	Aug	Total	Remarks
Project PMT	$610,000	$610,000	$610,000	$610,000	$2,440,000	Estimated monthly funding to cover: - OPG Eng. Support - OPG Projects Team - OPG CMO/FE core team (Eric, Sue, Zane, Ted) - Aquatech - PGL - And support from TRF, DO, DCC group as required
Direct Hire (D/H) Elec/Laborers	$150,000	$150,000	$150,000	$150,000	$600,000	Includes 4 D/H BTUs (2 laborers, 2 Electricians per 8 hr shift, days, afternoons, part weekends) for dewatering/temp power monitoring, clean-up
Interest	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$4,000,000	
Project Controls	$50,000	$50,000	$50,000	$50,000	$200,000	2 CSAs + 1 PCM (40*2*$80+40*1*$115)/Week
OPG Costs Sub-Total	**$1,810,000**	**$1,810,000**	**$1,810,000**	**$1,810,000**	**$7,240,000**	
JV Transition Costs (Estimate)	**$690,000**	**$690,000**	**$690,000**	**$690,000**	**$2,760,000**	
Roofing installation		$250,000	$275,000	$75,000	$600,000	100% Flynn roofing contract & drains installation
HVAC installation		$75,000	$190,000	$185,000	$450,000	20% of remaining Cullition installation contract
Scaffolding support	$30,000	$75,000	$195,000	$195,000	$495,000	includes scaffold rental costs
Building civil works		$110,000	$290,000	$290,000	$690,000	masonry block installation, sealing precast walls, caisson removal, OE (12 BTU/Supervision)
Equipment Rentals		$20,000	$25,000	$25,000	$70,000	man lift, fork truck, skid steer with jackhammer
Construction Costs Sub-Total	**$30,000**	**$530,000**	**$975,000**	**$770,000**	**$2,305,000**	
Grand Total Estimate per Month	**$2,530,000**	**$3,030,000**	**$3,475,000**	**$3,270,000**	**$12,305,000**	
Grand Total Estimate Cumulative	**$2,530,000**	**$5,560,000**	**$9,035,000**	**$12,305,000**		**Requested Fund: $15,000,000**
Requested Fund per Month	$3,084,112	$3,693,620	$4,236,083	$3,986,184		
Requested Fund Cumulative	$3,084,112	$6,777,733	$11,013,816	$15,000,000		


Further Discussions

Chapter A – Tritiated Heavy Water Storage and Handling

A-1 SUMMARY

There are two main components of heavy water management at OPG:

- Heavy Water Recovery, Cleanup, Upgrading and Detritiation
- Heavy Water Storage and Handling

This study does not deal with improvements to heavy water recovery, cleanup, upgrading and detritiation. However, the recent poor reliability of the Darlington Tritium Removal Facility (TRF) has focused attention on the fact that the TRF is the main driver of heavy water management at OPG. It is an essential facility for all stakeholders as it is the only source of high isotopic, low Curie make up water for the PHT system and is essential to ensuring that the Stations meet their OP&P limits. The poor reliability of this aging facility has a large impact on storage, segregation and management of heavy water. As a result, the storage volumes recommended in this study are intended to compensate for the low reliability to a limited extent. Development of the TRF life cycle plan, aimed at improving the reliability of this facility is under way in a separate study.

The major issues with storage of tritiated water at Pickering and Darlington can be summarized as follows:

- Lack of adequate bulk storage for reactor grade and downgraded heavy water
- Inability to empty out, clean and dispose of surplus drums
- Inadequate storage space for drums and excessive space currently occupied by dirty drums
- Inability to ensure integrity of drums by pressure testing

The principal objective of this study is to develop an OPG Heavy Water Storage and Handling Strategy which can be implemented at the Stations to create significant improvements in the following areas:

- Virgin and Reactor Grade D_2O Storage – optimizing the storage requirements to support operational flexibility and meet operational needs by eliminating bottlenecks. These improvements should be designed to meet operational needs to the end of station life.
- Improving the ability to support outages requiring moderator or PHT system drains and better managing heavy water storage during extended outages of the Darlington TRF, thereby minimizing its impact
- Drum Management Program – i.e. reducing the backlog of drums at the Stations to a minimum manageable level by enabling cleaning, pressure testing and disposal of surplus empty drums combined with emptying and processing of drum contents,
- Reducing "dirty" D_2O storage at source thereby reducing the load on cleanup and D_2O storage.
- Improving the sites' ability to support external opportunities by more streamlined handling and storage of heavy water and containers received from external customers or by providing

more space for storage and handling of these drums. These commercial activities optimize the heavy water assets of OPG by providing low cost D_2O for loss make-up as well preserving the more valuable virgin D_2O inventories

The approach used in this study was to gather information from a wide number of stake holders, assess current D_2O storage practices and limitations at each station and thereby develop options and specific recommendations to remove bottlenecks or improve operations. The benefits that would result from implementation of the recommendations are clearly outlined together with an estimate of the major capital expenditures required for implementation of the recommendations.

For the portion of the study dealing with tritiated heavy water, there were 13 separate issues identified at Darlington and 18 issues identified at Pickering. These were grouped into various categories (e.g. bulk storage, drum handling, etc.).
A summary of the findings, options and recommendations of the study for Darlington and Pickering are presented below:

Bulk Storage

At Darlington, eight stainless steel tanks, with a total capacity of 747 m^3 are provided for storage; four tanks are for moderator heavy water and four tanks are for heat transport heavy water. In addition, two stainless steel weigh tanks, 10 m^3 and 30 m^3 are provided for heavy water make-up for the moderator and heat transport systems respectively. As a result of this study, a total of 750 m^3 of additional bulk storage is recommended at Darlington as follows:

Proposed Additional Bulk Storage at Darlington	
Purpose	**Capacity: m^3**
PHT Storage Tank	1x100
Upgrader Product Storage Tank	1x100
Moderator Drain Storage Tank	1x100
TRF External Feed	1x100
TRF External Product	1x100
Downgraded Dirty Tanks	2x25
Downgraded Clean Tanks	2x50
Downgraded D_2O from Emptied Drums	1x100

An alternate configuration of storage has been suggested at the recent review meeting by Darlington staff. This proposes the use of more, smaller tanks rather than large 100 m^3 tanks. This will allow easier segregation of different grades of water. The proposed alternate configuration is as follows:

Proposed Alternate Bulk Storage Configuration at Darlington	
Purpose	**Capacity: m^3**
PHT Storage Tanks	2x50
Upgrader Product Storage Tank	2x50
Moderator Drain Storage Tank	2x50
TRF External Feed	2x50
TRF External Product	1x100
Downgraded Dirty Tanks	2x50
Downgraded Clean Tanks	2x50
Downgraded D_2O from Emptied Drums	4x25

This alternate configuration requires almost double the number of tanks and a total capacity of 800 m^3. It will need more piping and valves as well as requiring a larger building. The cost of the new facility, therefore, is expected to be somewhat higher than shown below.

Proposed New Addition to Darlington HWMB Facility

A major recommendation of this study is to construct an addition to the Heavy Water Management Building (HWMB). The building will house facilities to improve drum handling as well as bulk storage. The original recommendation of the study was to construct and addition to the west of the HWMB. It was to have been an industrial structure with approximate floor area of 10m by 30m or greater, depending on confirmation of the space available. However, to accommodate the many more additional tanks in the alternate proposal, a new location with a bigger footprint is required. The design of the building will be such that ISO Container and drum unloading will be on the ground floor so that trucks can drive in for unloading. Also on this floor will be drum storage area and the drum cleaning and pressure testing facility. The drum cleaning and pressure testing facility will be common to Pickering and Darlington. The building will have a full basement which will contain all of the additional bulk storage tanks that have been proposed in this report. An order-of magnitude cost of the HWMB extension with the original proposal using 100 m^3 tanks has been estimated (±50%) as $ 10 million to $15 million. This includes the cost of tie-ins to existing systems in the reactors and in the HWMB.

The cost of the extension and additional facilities at Darlington can be roughly broken down as follows:

Equipment (Tanks, pumps, drum cleaning system, etc.)	$4,680,000
Engineering Design, Assembly, Administration, Accessories	$1,586,000
Sub-Total for Tanks, Drum Cleaning, Pressure Testing, Engineering, Assembly, Installation	**$6,266,000**
Cost of Building Extension	$1,100,000
Services, equipment within Building	$633,000
Engineering, etc.	$729,000
Sub-Total for Building and Services (including design, engineering, construction)	**$2,462,000**
Interfacing System Materials (piping, valves, etc.)	$460,000
Engineering	$360,000
Construction, installation	$905,000
Sub-Total for interfacing with existing systems	**$1,725,000**

The cost of the alternate configuration, with more tanks and bigger building is estimated to be about $ 5 million greater, i.e. a total of $15 to $20 million.

Currently, the total capacity for storing reactor grade water at Pickering consists of 11 stainless steel tanks with a total capacity of approximately 570 m^3. Two 150 m^3 tanks are used for Pickering B moderator water drains, Pickering A has dump tanks. As the station ages, there is a projected need to perform on average, one moderator drain per year. The Station cannot physically handle two drains concurrently. Storage of Moderator drains adversely affects the

station's maneuverability and the ability to perform on-line moderator D_2O swaps and hence eliminates or reduces the ability to send D_2O to the TRF.

At Pickering, installation of an additional two 150 m^3 storage tanks to accommodate moderator drains is recommended as a way of providing increased flexibility.

Existing downgraded D_2O storage capacity at Pickering consists of 7 x 6 m^3 D_2O recovery tanks (4 Low Curie (Ci), 3 High Ci) at the Ion Exchange Clean Up (IXCU) system. The tanks are used to collect downgraded Primary Heat Transport (PHT) and moderator water. Additional storage capacity is required to address the need for segregation of PHT and moderator recoveries and to prevent an accumulation of drums resulting from the insufficient capacity to process high Ci water throughput the Sulzer-B upgrader. This segregation is required to ensure that the upgrader can be used to produce low curie D_2O suitable for use as PHT make-up, in the event of an extended, unplanned shutdown of the TRF. The TRF is the only source of PHT make-up and is an aging facility that could be subjected to unplanned outages as a result of unforeseen component failures. It is recommended that two 25 m^3 D_2O Recovery Tanks be installed. An order-of magnitude cost of the additional bulk storage at Pickering and the tie-ins to systems has been estimated (±50%) as $ 5 million.

A cost for the installation and commissioning of the UV Oxidation has also estimated as $520,000. A gross breakdown of the estimates for Pickering is shown below:

Bulk Storage Tanks

Equipment	$1,900,000
Engineering, Installation, Commissioning	$1,100,000
Sub-Total	**$3,000,000**

Interfacing and Tie-ins

Equipment	$450,000
Engineering, Installation, Commissioning	$1,550,000
Sub-Total	**$2,000,000**

The additional storage will provide the following significant benefits to Station and to TRF operations:

- Improve flexibility of operation by satisfying the storage demands during normal operation but particularly, during outages requiring draining of various systems. During these outages, segregation requirements will be met without having to resort to moving heavy water off-site
- Preserve the segregation of high and low Curie D_2O and improve the isotopics for the Units
- Allow unit moderators to be drained completely when required, e.g. during a Station Containment Outage (SCO)
- Provide the benefits of lower tritium concentrations by enabling the drained moderator to be processed through the TRF in a once-through mode of operation
- Additional downgraded D_2O storage capacity will enable the segregation of PHT and moderator recoveries during an extended outage of the TRF. This segregation is required to

ensure that the upgrader can be used to produce low curie D_2O suitable for use as PHT make-up, in the event of an extended, unplanned shutdown of the TRF.

- Additional storage for clean D_2O product from the Clean-up System would enable more efficient use of the UV Oxidation system and better TOC removal. Otherwise, if clean product is recycled through the Clean-up System in order to meet TOC specifications, this product water ends up being stored in the same tank as the "off-spec" water being recycled, thus mixing clean and dirty water.

- The extra storage would result in more efficient utilization of the TRF capacity, as DND's use of the TRF would be reduced.

- This also has transportation advantages as the transportation trucks (TDO's) would be more efficiently utilized and their use would not be tied to TRF availability.

- Additional TRF product storage would also allow the TRF to keep operating if the TDO's were not available for a period of time.

- The additional storage would also be beneficial in supporting OPG's commercial efforts to secure additional external heavy water for upgrading and detritiation, hence optimizing the heavy water assets.

Drum Handling and Management

The unavailability of an existing ultra-violet (UV) oxidation system at Pickering is a major impediment both in reducing the backlog of heavy water filled drums as well as in meeting the upgrader's feed specifications for TOC. It is strongly recommended that an oxidation system be commissioned on an urgent basis. Aside from the ability to effectively destroy elevated levels of TOCs, the adequacy of the throughput capacity of a single oxidation system in meeting both the ongoing processing needs at Pickering as well as the need for expeditiously treating the back logged HW inventory, must be evaluated. If the back logged inventory cannot be treated on a timely basis using a single oxidation system, then the option of hiring an external contractor should be considered. Otherwise, the recovery of real estate currently used for storage of drums will be unacceptably slow.

The nominally empty drums at Pickering contain a heel of material at the bottom, and as such do not meet Western Waste Management Facility (WWMF's) current waste acceptance criteria which requires that the concentration of tritiated water vapor within a drum does not exceed 100 MPCa.

A number of options were considered for disposal of the empty drums at Pickering. The simplest and least cost option involves the use of available binders to immobilize the small volume of sludge still present in the drums. These binders may be employed without the need for mixing the drum contents. After solidification, the largely empty drum should be compacted for efficient storage at WWMF. This option is feasible only if a safety case can be made to demonstrate compliance with NWMD's waste acceptance criteria.

As at Darlington, drum handling at Pickering involves a significant amount of manual effort. Further, facilities for drum cleaning and pressure testing which are pre-requisites for the re-use of drums in transportation and storage, do not exist. Thus, a key to reducing the backlog of stored drums is to have access to a drum cleaning and pressure testing facility. Because of the unavailability of drum cleaning equipment, surplus drums cannot be cleaned and sent to the WWMF and thus the backlog of drums would continue to increase. The increasingly reduced real estate combined with the inadequate drum handling equipment currently being utilized will result in an increasingly unsafe environment.

The appointment of a "Drum Management Program Champion" at Pickering and Darlington is recommended. This individual would be responsible for all aspects of drum handling, storage, cleaning, and disposal.

While the above recommendations require investment, the costs can be offset by providing the following benefits:

- Increased safety (reduced handling, lower radiation dose)
- More efficiently run operation
- Ability to keep stations within OP&P limits (regulatory requirement)
- Environmental stewardship (less tritium emissions)
- Increased revenues

Similar constraints also apply to Darlington, and they must be addressed to improve the detritiation program so that the stations can efficiently operate within the limits.

1.2 Lack of Operational flexibility

At both Pickering and Darlington, the lack of storage capacities for proper segregation of different streams of D2O inventory impairs operation.

During normal operation, the present storage capacity does not provide adequate flexibility for operation to properly segregate different streams or grades of D2O for processing. This is being resolved by finding and using off-site storage, but this increases cost and creates extra workload for operation to handle & move these inventories around, such as,

- Downgraded D2O from PHT & Moderator drains
- Lithiated PHT D2O
- PHT system shrink & swell reserves
- PHT & Moderator grade D2O
- High & Low Currie D2O
- TRF grade D2O.

During a unit shutdown, or Station Containment Outage (SCO) in Darlington, or Vacuum Building Outage (VBO) in Pickering, complete moderator system drain may be required. This further reduces the current storage capacity, and drastically reduces the ability to segregate the different grades of D2O to support normal operation, or for PHT shrink and swell management. The problem is further exacerbated during extended outages where the capability to send tritiated water to TRF or receive TRF product to support normal operation could be significantly limited. Furthermore, as the plants age, the need to drain the moderator completely to facilitate maintenance increases. For example, Pickering now expects to perform one moderator drain a year on average.

Having adequate storage capacity to properly segregate various grades of D2O must be addressed to increase processing flexibility for normal operation, and during outages.

1.3 Tritium Removal Facility (TRF) Operation not Optimized

At TRF in Darlington, the lack of storage impairs efforts to optimize its usage and efficiency.

The reliability of the TRF and its performance when available, has been inconsistent over the last several years, reflecting the age and condition of the facility. Its current reliability is quite low, and it is not expected to improve with any certainty until a planned overhaul program (not part of the scope of this project) is completed 18 to 24 months from today.

The poor TRF performance last year and its continued poor reliability raise question on the feasibility of the current detritiation plan, which calls for high availability of the TRF operating at 60% capacity factor (rarely achieved in the past) over the next 5 years. In short, the current strategy is at high risk.

Whenever the TRF is available or in service, its optimum usage depends on steady feed from Darlington, Pickering, and occasionally from other third party sources. As there is no significant storage available on either side of the TRF process, other than a small buffer to help manage feed flow issues, the availability of make up feed water to TRF & its efficiency is dictated by TRF availability. On the other hand, both Darlington and Pickering rely primarily on the TRF for their PHT make-up water, the lack of storage capacity for TRF products reduces its capability to respond and supply the stations the required PHT make-up water to sustain normal operation.

Darlington is directly connected to the TRF, so it is able to use the TRF when TRF is up and running. For Pickering, the feed to TRF depends on operational or transport constraints. This occasionally leads to situations where the TRF is unable to receive new feeds, and has to operate at a fairly low efficiency level (cleaning already reasonably clean Darlington water) or shut down altogether for lack of feed. This is evident by at least one such incident this year (1 week shut down). At the same time, there are cases where OPG had to borrow (for a fee) low curie D2O water from AECL in order to meet operational needs to avoid the use of high cost virgin heavy water.

Additional storage capacity at both input and output ends of the TRF in Darlington is critical to improve its efficiency, operational flexibility, and reduces its dependency on the station's ability to provide the feed water. It also increases stations' operational flexibility by reducing their reliance on the availability of the TRF in service for their PHT make-up.

1.4 Lack of Drum Handling Facilities

Lack of drum handling facility causes safety concerns, reduces valuable station spaces, and constrains OPG to pursue other commercial opportunities.

The use of drums for permanent storage is currently not an option, it should only be used as a temporary and contingency measure. Large volume of drums in the station reduces valuable spaces, poses extra safety (tritium and conventional) hazards, and increases labor and efforts for the extra handling and movement of these drums.

A large volume of drums has been accumulated in both Pickering and Darlington mainly because there are no facilities to clean and test the emptied drums before disposal or re-use. The ability to reduce the currently large inventory of drums and gain back some of the valuable station spaces hinges on the ability to empty, clean and test these drums.

A drum must pass the required test before it can be reused for D2O shipment, and the lack of facilities to receive third party shipments (loading and unloading) properly further constraints the ability to handle third party water. This creates much stress on

operations when a contractual obligation to a third party must be fulfilled using drums. It also constraints OPG ability to pursue other commercial opportunities such as sale of heavy water and detritiation services to third parties.

Bruce Power (BP) plan to install D20 storage facilities will allow BP to perform high volume swaps to manage tritium levels. This will result in lower shipments of D20 to OPG and more capacity being available for other commercial processing. To optimize TRF detritiation services to third parties drum handling, testing and storage facilities are required. This will enable OPG to pursue other prospects that can offset BP revenue loss.

A facility to handle, clean, test and store drums is critical for the station to recover valuable space, reduce safety hazards and generate external revenue.

2.0 PROJECT OBJECTIVES (CRITICAL SUCCESS FACTORS)

2.1 Storage facilities

The proposal is to provide sufficient storage facilities at Pickering and Darlington to

- Allow large volume bulk swap of downgraded water for detritiation so that the units can be efficiently operated within the Administration limit and more importantly the OP&P limit;
- Improve operation flexibility to segregate different streams of D2O to support normal operation and outages;
- Allow the stations to reduce their reliance on the availability of TRF for continuous supply of nuclear grade D2O (both PHT and Moderator) for normal operation or as back up contingency.
- Allow the utilization of TRF to be optimized by reducing its reliance of the on-time delivery of tritiated D2O from the stations to the TRF.
- Provide flexibility in scheduling TRF operations and outages by having storage buffers at both ends of the TRF.
- Provide more TRF processing capability and opportunity for other commercial purposes (Bruce Power new units, New Brunswick Power, Hydro Quebec are potential customers) after the operation of TRF is optimized;
- Enhance the availability of low curie water inventory to meet emerging demands.

2.2 Drum Handling, Cleaning, and Testing Facility

The proposal is to build a Drum Handling, Cleaning, and Testing facility. This facility is the key for OPG to successfully manage its current inventory of drums, and to reduce

1.2.1 TRF and DN Operational Improvements D_2O Storage:

A number of deficiencies in OPG's tritium removal process constrain OPG from maximizing TRF utilization and minimizing airborne and waterborne tritium emissions.

- There is a disconnect between TRF availability and tritium removal demand due to insufficient feed and product storage capacity at the TRF, resulting in decreased tritium removal efficiency
- The TRF is extremely complex in design, has numerous single point equipment vulnerabilities, and an operating cycle which requires lengthy maintenance outages, resulting in inconsistent availability. TRF unavailability would be mitigated by additional feed and product storage capacity
- Weekly Bruce Power and PN D_2O shipments to/from the TRF are currently limited in volume and are only scheduled when the TRF is in service. Additional storage capacity would allow more flexible D_2O shipment scheduling.

A shortage of D_2O storage space at DN constrains operations' ability to address competing demands for D_2O inventory and storage for outages and process needs.

- Reactor grade D_2O storage problems become particularly acute when there is a 4 unit outage, a moderator drain, or an unplanned extended TRF outage.
- Current storage capacity does not provide adequate flexibility to segregate different streams or grades of high isotopic D_2O for processing. This is being resolved by off-site storage use, but this increases cost and creates extra work to handle and move inventories.
- The lack of sufficient storage for downgraded D_2O creates problems whenever there is a need to clean-up and upgrade D_2O contaminated with total organic compounds, or if there is a need for an extended SUP outage.

The required storage capacity for refurbishment shall be operational after the refurbishment to support station outages and the overall future D_2O management strategy.

1.2.2 Increased drum handling capability:

A large number of drums have been accumulated at both PN and DN, mainly because there are no facilities to handle (loading and unloading properly) clean and test the emptied drums before disposal or re-use. A drum must pass a required test before it can be reused for D_2O shipment. This uses valuable station space, creates stress on operations and increases safety and spill hazards. It also constrains OPG's ability to pursue other commercial opportunities such as sale of heavy water and detritiation services to third parties (the external revenue is estimated as being $ 9 million/year (Ref [11])).

1.2.3 Office space:

The current temporary state of TRF offices requires permanent replacements:

- Temporary trailers adjacent to the HWMB are used for TRF outage and internal work control meetings, roll-outs, field offices, permit preparation, etc. These trailers will be replaced by temporary code-compliant trailers as part of DN's Fire safety reviews to meet CSA N293-07 by the end of 2010, and need to be ultimately replaced by permanent offices per the station long term plan to eliminate temporary trailers.
- Current non-standard locations (e.g. transformer room, waste-handling areas, laundry room etc) for offices require permanent office space replacements

1.3 Long Term Decommissioning - D_2O Storage

At the time of producing this charter the future of other generating assets are not precisely defined. It is too early to assume a strategy for the fate of the D_2O from other nuclear assets' D_2O after shutdown. However it is important to ensure that major storage expenditures such as this project consider the potential impact of future storage requirements that may arise from corporate generation planning.

It is reasonable to ensure that provisions are made during the design phase of this project to grant flexibility in accommodating potential future expansions to the storage facility.

2.0 PROJECT OBJECTIVES (CRITICAL SUCCESS FACTORS)

The project must integrate current heavy water storage needs to maximize economies of scale in construction and in logistics for future operation and maintenance. Specific success factors for each of the contributing needs are as follows:

2.1 Refurbishment - D_2O Storage

- The project must be completed within the approved schedule and funding envelopes while meeting corporate safety, quality, sustainable energy and environmental targets, and the facility must be fully operational three months before the earliest potential start of refurbishment (i.e. AFS by July 2015)
- The new Heavy Water Storage Facility at DN must have a storage capability of 1700 m^3. This storage is for two units Moderator drain (700 m^3), HTS drain including auxiliaries (800 m^3), and downgraded D_2O generated during HTS Decontamination (200 m^3)
- All pressure boundary systems and components shall meet the requirement of CSA-N285.0-08
- The facility needs to meet the requirement of a Zone 3 area (contains systems and equipment that may be sources of radiation or contamination)

[3])

- At the time of producing this charter OPG is planning to proceed with the installation under the current license (i.e. without waiting for an EA), and has requested CNSC's concurrence. If inclusion in the Darlington refurbishment EA is necessary (projected to be approved in Q1/2013) then construction cannot be started before approval of the EA
- Consideration of the construction season, especially if relocation is needed for the existing underground services such as the H_2 line

4.2 Long Term Decommissioning - D_2O Storage

Any consideration for long term safe storage is not required until the refurbishment is completed. Consideration of location or connection shall be given when appropriate in the design phase of the project.

5.0 FUNDING/COST

Since parts of a combined project were previously identified separately as either refurbishment or sustaining capital, a final decision on funding source is required (e.g. dual stream or just refurbishment) from Refurbishment and Corporate Finance. In the interim, developmental funding will be available from Nuclear Refurbishment.

A combined implementation of the two projects (Refurbishment and Operational Improvements) is expected to save an average of 10% to 15% ($20M to $30M) versus the independent execution. With this saving, the estimated total cost is $210 million with a proposed cash flow as follows:

Cost [k$]	2010	2011	2012	2013	2014	2015	2016	Total
No Contingency	500	9,500	25,000	38,300	44,800	36,900	3,000	158,000
Including Contingency	700	11,500	33,600	50,800	60,900	49,300	3,800	210,600

This table of cost of the combined project supersedes previous estimates. Note that the scope of the previous project, 16-31555, will now be considered part of the scope of the larger combined project and, if approved, will be funded by Nuclear Refurbishment going forward. For identification and reference purposes the two separate project costs are presented below as previously reported including sources of the cost information.

5.1 Refurbishment - D_2O Storage

This component of the project has been identified in the Darlington Refurbishment preliminary cost estimate. The costs are considered Capital and will be funded from the Refurbishment Project Budget. The total cost of the building has been identified in

the above mentioned cost estimate as $147 million for a total capacity of 1500 m^3. Since then the needs were re-evaluated in more detail and the need has increased to 1700 m^3. As a result the cost was recalculated as being $165 million. For further details see Ref [2].

The estimated cash flows are distributed as follows:

Cost [k$]	2010	2011	2012	2013	2014	2015	2016	Total
No Contingency	600	6,800	17,200	27,000	34,400	34,400	2,500	122,900
Including Contingency	800	9,100	23,100	36,200	46,100	46,100	3,300	164,700

The cost estimate is a Conceptual Estimate (i.e. +60%, -40%) and includes contingency. The yearly cash flow is based on the Schedule in Section 4.1 of this charter.

5.2 Operational Improvement - D_2O Storage & Drum Handling

This component of the project was previously classified as Sustaining Capital in the preceding Project 16-3555.

It is understood that the current project estimate is preliminary, since the impact of integration with DN has not been considered. The cost and funding details of the project are to be determined as part of the development phase and will be adjusted as the scope is further defined.

The project was to be funded in the 2011-2015 Business Plan (Capital Projects Portfolio) for a total of about 77 M$ at Darlington. Past OPGN spending and preliminary future DN distribution of funds is as follows:

LTD DN Spending: 1.86 M$ of 3.6 M$ released

LTD PN Spending: 0.382 M$ of 2.506 M$ released

The DN distribution outlined below is based on the draft BCS prepared by Projects & Modifications for the Partial Release request for Project 16-31555, at the time of deferral of the project.

Cost (k$)	LTD	2010	2011	2012	2013	2014	2015	2016	Total
No Contingency	1,860	1000	3000	11,200	16,500	16,500	7,500	1,000	56,700
Including Contingency	1,860	1000	3000	15,200	21,500	23,100	9,900	1,000	74,700

ONTARIO POWER GENERATION

Records File Information:
Final Security Classification of the completed form is determined below
00120.3 - P For Nuclear
08707.021 - P For All Others

Type 3 Business Case Summary

Final Security Classification of the BCS: **OPG Confidential**

Business Case Summary

Part A: Business Need

Business Need:

The purpose of the project is to build a heavy water storage facility to meet the needs of Refurbishment, to increase operational storage at DNGS and to add a D2O drum handling, cleaning, testing and storage capability at Darlington to meet the combined needs of Darlington refurbishment, Tritium Removal Facility (TRF) and Darlington operational improvements.

In August 2010, a project charter was approved which included both the operational and refurbishment needs for additional heavy water storage capacity and drum handling, cleaning, testing and storage at Darlington. The project charter was subsequently revised in June 2011 to remove additional incremental storage capacity, above the minimum Refurbishment and TRF Operational needs, required for the long term heavy water storage needs of Pickering Nuclear Generating Station (PNGS). Any incremental storage required for Pickering decommissioning above the 2100 Mgs recommended in the preferred solution will be addressed separately when this need is confirmed and justified.

The first major driver to install additional D2O storage capacity is the refurbishment of Darlington. The first refurbishment outage is scheduled to begin October 2016. To meet refurbishment needs, the new D2O Storage Facility at Darlington, must be completed and fully operational six months before the earliest potential start of refurbishment. This gives the organization flexibility to advance the beginning of refurbishment if new information requires it.

The additional storage facility has to provide sufficient capacity at the Darlington site for the heavy water from two reactors. The storage required to meet this need is 1500 Mgs and in addition, the new facility will require 200 Mg to facilitate flushing and other support operations associated with the preparation of the Darlington units for refurbishment work. This 200 Mg storage need must be met through additional capacity as the existing Darlington operational storage is required to support the operations of the units that remain in service during Refurbishment. Therefore, the total additional storage capacity required to support the Refurbishment project is 1700 Mg.

The second major driver has three main components and is a consequence of a previously initiated Operational Improvement project, 16-31555, subsequently deferred to be merged with the refurbishment D20 project in order to reduce costs and improve value for money. The three main components of the secondary driver are as follows:

1. Additional 400 Mg of permanent storage required to improve utilization of the Darlington TRF and mitigate threats to the achievement of OPG detritiation objectives (before, during and after Darlington refurbishment) due to current storage constraints. The increased storage will address the TRF feed and product storage bottleneck that is a significant challenge to the efficiency of the overall tritium removal process. According to internal reports, eliminating this bottleneck is required to meet OPG's objectives to maintain the units within the Regulatory Operating Policies and Principles limits for tritium concentration in the moderator.
2. A new Drum Handling, Cleaning, Testing, and Storage Facility providing services to both Pickering and Darlington stations, will centralize drum storage, and provide a means of long term cleaning and disposal of the current inventory of drums. Incident reports indicate that the current large backlog of drums has caused radiological and conventional safety concerns, injuries, and significant operational burden due to storing drums throughout the Heavy Water Management Building. The facility will also provide the ability to support any refurbishment activities requiring drum cleaning/disposal, and expedite commercial shipments.
3. New consolidated office space for TRF staff. Construction of the new D2O Storage Facility will require demolition of existing permanent office trailers, and new replacement office space for these operations staff is required. As well, there are currently numerous staff located in nonstandard offices throughout the TRF/HWMB. In addition, Strat III and IV managers will be relocated to the central offices, improving communication, oversight, and time in the field. It is estimated that increased efficiencies associated with consolidating the TRF operations, maintenance, and management team will result in a productivity increase; manifested by increased TRF throughput. The office requirements are:

*Associated with OPG-STD-0076, Developing and Documenting Business Cases

(a) One (1) conference room
(b) One (1) field operator (stratum I/II) office
(c) One (1) supervising nuclear operator (stratum I/II) office
(d) One (1) field shift operating supervisor (stratum I/II) office
(e) One (1) section manager (stratum III) office
(f) One (1) manager (stratum IV) office
(g) Four (4) hotelling stations (stratum IV)

The increased operational storage (400 Mg) is a key element of the TRF Life Extension Strategy because it allows the existing facility to operate more efficiently and effectively and therefore maintain sufficiently large quantities of detritiated D2O to support the operating units. This support is required to maintain Darlington's operating units within the established regulatory limits for tritium.

The improvements to the TRF and Darlington operations are summarized below:

- Improve tritium removal capability within OPG by providing scheduling flexibility and reducing detritiation management dependency on TRF availability
- Improve utilization efficiency of available TRF capacity by providing storage for high Curie input feed, thereby maximizing tritium removal
- Improve operational flexibility and ability to segregate different D2O streams to support Darlington operation and outage scenarios, such as unit, station containment, and vacuum building outages
- Eliminate the backlog of D2O in drums that needs to be processed through the D2O Cleanup System
- Allows OPG to pursue new business opportunities for heavy water upgrading/detritiation and isotope sales
- Rectify long standing problem of unconsolidated and nonstandard work locations with new offices
- Supports life extension of the TRF until 2055, mitigating risk of a costly TRF refurbishment or new TRF construction

This investment is required to start immediately to ensure completion in advance of the proposed start of refurbishment to ensure refurbishment is not delayed by this pre-requisite.

ONTARIO POWER GENERATION

Records File Information:
Final Security Classification of the completed form is determined below
00120.3 - P For Nuclear
08707.021 - P For All Others

Type 3 Business Case Summary

Final Security Classification of the BCS: **OPG Confidential**

Business Case Summary

Part A: Business Need

Business Need:

The purpose of the project is to build a heavy water storage facility to meet the needs of Refurbishment, to increase operational storage at DNGS and to add a D2O drum handling, cleaning, testing and storage capability at Darlington to meet the combined needs of Darlington refurbishment, Tritium Removal Facility (TRF) and Darlington operational improvements.

In August 2010, a project charter was approved which included both the operational and refurbishment needs for additional heavy water storage capacity and drum handling, cleaning, testing and storage at Darlington. The project charter was subsequently revised in June 2011 to remove additional incremental storage capacity, above the minimum Refurbishment and TRF Operational needs, required for the long term heavy water storage needs of Pickering Nuclear Generating Station (PNGS). Any incremental storage required for Pickering decommissioning above the 2100 Mgs recommended in the preferred solution will be addressed separately when this need is confirmed and justified.

The first major driver to install additional D2O storage capacity is the refurbishment of Darlington. The first refurbishment outage is scheduled to begin October 2016. To meet refurbishment needs, the new D2O Storage Facility at Darlington, must be completed and fully operational six months before the earliest potential start of refurbishment. This gives the organization flexibility to advance the beginning of refurbishment if new information requires it.

The additional storage facility has to provide sufficient capacity at the Darlington site for the heavy water from two reactors. The storage required to meet this need is 1500 Mgs and in addition, the new facility will require 200 Mg to facilitate flushing and other support operations associated with the preparation of the Darlington units for refurbishment work. This 200 Mg storage need must be met through additional capacity as the existing Darlington operational storage is required to support the operations of the units that remain in service during Refurbishment. Therefore, the total additional storage capacity required to support the Refurbishment project is 1700 Mg.

The second major driver has three main components and is a consequence of a previously initiated Operational Improvement project, 16-31555, subsequently deferred to be merged with the refurbishment D20 project in order to reduce costs and improve value for money. The three main components of the secondary driver are as follows:

1. Additional 400 Mg of permanent storage required to improve utilization of the Darlington TRF and mitigate threats to the achievement of OPG detritiation objectives (before, during and after Darlington refurbishment) due to current storage constraints. The increased storage will address the TRF feed and product storage bottleneck that is a significant challenge to the efficiency of the overall tritium removal process. According to internal reports, eliminating this bottleneck is required to meet OPG's objectives to maintain the units within the Regulatory Operating Policies and Principles limits for tritium concentration in the moderator.
2. A new Drum Handling, Cleaning, Testing, and Storage Facility providing services to both Pickering and Darlington stations, will centralize drum storage, and provide a means of long term cleaning and disposal of the current inventory of drums. Incident reports indicate that the current large backlog of drums has caused radiological and conventional safety concerns, injuries, and significant operational burden due to storing drums throughout the Heavy Water Management Building. The facility will also provide the ability to support any refurbishment activities requiring drum cleaning/disposal, and expedite commercial shipments.
3. New consolidated office space for TRF staff. Construction of the new D2O Storage Facility will require demolition of existing permanent office trailers, and new replacement office space for these operations staff is required. As well, there are currently numerous staff located in nonstandard offices throughout the TRF/HWMB. In addition, Strat III and IV managers will be relocated to the central offices, improving communication, oversight, and time in the field. It is estimated that increased efficiencies associated with consolidating the TRF operations, maintenance, and management team will result in a productivity increase; manifested by increased TRF throughput. The office requirements are:

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(a) One (1) conference room
(b) One (1) field operator (stratum I/II) office
(c) One (1) supervising nuclear operator (stratum I/II) office
(d) One (1) field shift operating supervisor (stratum I/II) office
(e) One (1) section manager (stratum III) office
(f) One (1) manager (stratum IV) office
(g) Four (4) hotelling stations (stratum IV)

The increased operational storage (400 Mg) is a key element of the TRF Life Extension Strategy because it allows the existing facility to operate more efficiently and effectively and therefore maintain sufficiently large quantities of detritiated D2O to support the operating units. This support is required to maintain Darlington's operating units within the established regulatory limits for tritium.

The improvements to the TRF and Darlington operations are summarized below:

- Improve tritium removal capability within OPG by providing scheduling flexibility and reducing detritiation management dependency on TRF availability
- Improve utilization efficiency of available TRF capacity by providing storage for high Curie input feed, thereby maximizing tritium removal
- Improve operational flexibility and ability to segregate different D2O streams to support Darlington operation and outage scenarios, such as unit, station containment, and vacuum building outages
- Eliminate the backlog of D2O in drums that needs to be processed through the D2O Cleanup System
- Allows OPG to pursue new business opportunities for heavy water upgrading/detritiation and isotope sales
- Rectify long standing problem of unconsolidated and nonstandard work locations with new offices
- Supports life extension of the TRF until 2055, mitigating risk of a costly TRF refurbishment or new TRF construction

This investment is required to start immediately to ensure completion in advance of the proposed start of refurbishment to ensure refurbishment is not delayed by this pre-requisite.

Part B: Preferred Alternative

Description of Preferred Alternative: Build 2100 Mgs of D2O Storage and a Drum Handling Facilty

Construction of a new D2O storage and drum handling facility is recommended because it meets the needs of Darlington refurbishment D2O storage as well as Darlington Operations.

The four major components of this option are:

(a) 1700 Mg of storage for Refurbishment project
(b) 400 Mg storage for improved TRF operations
(c) Drum Handling, Cleaning and Testing Facility
(d) TRF Staff Offices for 9 staff, including 1 conference room

For refurbishment to be successful, the new facility must provide sufficient heavy water storage at the Darlington site for the heavy water from two units, a requirement of the Darlington refurbishment project. This option meets this requirement. In addition, by increasing the operational storage, this option would enable increased utilization of the Darlington TRF and mitigate threats to the achievement of OPG detritiation objectives (before, during and after Darlington refurbishment) due to current D2O storage constraints. Lastly, this option allows continuation of the current TRF/HWM Life Cycle Management plan to 2055, thus mitigating the risk of requiring a costly refurbishment of the existing TRF or construction of a new TRF facility.

The location of the new facility has soil contaminated with tritium from the 2009 Injection Water Storage Tank spill. The cost impact of tritium contamination has not fully been assessed for its impact to disposal costs. It is expected to have this risk fully quantified once data on the extent of contamination is received in July 2012 and the EPC vendor is engaged in detailed design to support analysis of any potential cost impacts. To mitigate this risk, $5,000k of specific contingency is currently allocated to address the tritium in soil and ground water risk. Of this $5,000k specific contingency, $750k is allocated to the Detailed Design Phase I, and the remaining $4,250k is allocated to Phase II for site preparation/excavation. The base excavation and disposal costs for non-contaminated soil and water are included in the requested funding.

The execution of this work will be divided into 3 Phases. In order to ensure the earliest possible start and to mitigate completion schedule risk, the phases overlap, in order to preserve the in-service date and mitigate any delays to the Refurbishment schedule. The contractual commitment of OPG under this release is to Phase I work only. The overall project schedule will be developed immediately following Phase I contract award. The work will be phased as below:

Phase I, June 2012 – July 2013

Detailed Design. This work will be executed under a Full Definition Release (this BCS).

Phase II, September 2012 – September 2013

Site Preparation and procurement of Long Lead materials. Site preparation includes activities such as demolition of existing truck dock and TRF trailers, relocation of existing buried services, and upon Environmental Assessment approval and completion of civil design packages, installation of caisson walls, and start of excavation in 2013, and miscellaneous civil substructure. The Environmental Assessment is expected to be completed by December 2012. This work will be executed under a Partial Execution Release.

Phase III September 2013 – April 2016

Completion of caisson wall installation and excavation, facility construction, tie-in to existing station services, commissioning, and close-out. This work will be executed under a Full Execution Release.

The project has negotiated performance target prices for an engineer, procure, and construct (EPC) contract to complete this work. A target price has been provided for Phase I, and a second target price has been provided to include both Phase II and Phase III. These target prices are the basis of the design and construction costs. The OPG costs are associated with the required nuclear oversight to mitigate schedule and quality risks to ensure timely completion of this critical path project for Darlington Refurbishment. A significant constraint on the project is that the project cannot start Phase II excavation and Phase III construction until the Darlington Refurbishment Environmental Assessment has been approved.

forecast to occur during the 2017 to 2021 period, and to revise the revenue requirement accordingly. The actual revenue requirement impact of the D2O Project will be recorded in the nuclear portion of the Capacity Refurbishment Variance Account ("CRVA") once the project enters into productive service. Such entries into the CRVA will continue to be recorded until the OEB-approved D2O Project in-service amount is reflected in the revenue requirement through a subsequent rate setting process. The OEB will have the opportunity to conduct a prudence review in respect of the D2O Project after it has been completed and placed into service. This approach is consistent with the OEB's Decision with Reasons in EB-2013-0321[1]. The prudence review of the D2O Project is expected to occur at the mid-term review in the first half of 2019. The in-service amount determined by the OEB as a result of that review will provide the basis for determining the revenue requirement impacts that will be recorded in the CRVA until the OEB approved unamortized in-service D2O Project amount is reflected in revenue requirements in a subsequent rate setting process.

3.0 ITEMS INCLUDED IN THE IMPACT STATEMENT

This section provides additional detail on the changes reflected in the revised revenue requirement requested for the IR period.

The impact on the nuclear revenue requirement from removing the projected in-service amounts for the D2O Project is $(40.4)M in 2017, $(36.9)M in 2018, $(36.4)M in 2019, $(40.9)M in 2020 and $(40.1)M in 2021, as shown in Chart 1 below.

[1] EB-2013-0321 Decision with Reasons, page 59.

ONTARIO POWER GENERATION

Records File Information:
Records SCI/USI Retention
- See Guidance Section

OPG-FORM-0076-R005*

Type 3 Business Case Summary

To be used for investments/projects meeting Type 3 criteria in OPG-STD-0076.

Executive Summary and Recommendations

Project Information			
Project #:	16-31555	**Document #:**	D-BCS-09701-10007
Project Title:	Heavy Water Storage and Drum Handling Facility		
Class:	☐ OM&A ☒ Capital ☐ Capital Spare ☐ MFA ☐ CMFA ☐ Provision ☐ Others:	**Investment Type:**	Value Enhancing
Phase:	Execution	**Release:**	Superseding
Facility:	Darlington	**Target In-Service or Completion Date:**	2017-05-01

Project Overview

We recommend the release of $270.9M, which includes $33.9M of contingency, to fund the completion of the Heavy Water Storage and Drum Handling Facility. This project is value enhancing and will introduce 2,100,000 litres of new heavy water storage capacity to support the Darlington Refurbishment Project (DRP) and ongoing operational improvements to the Tritium Removal Facility (TRF) at Darlington Nuclear. The total Class 2 estimated project cost for the 31,000 square foot facility is $381.1M, including contingency.

The purpose of the Heavy Water Storage and Drum Handling Facility is to provide heavy water storage and processing capability for OPG. Heavy water is a radioactive material with environmental consequences if it is not effectively managed. Without heavy water, CANDU nuclear generating stations such as Darlington cannot operate. Heavy water can no longer be produced.

The Heavy Water Storage and Drum Handling Facility is a first of a kind multifunctional building. The building structure, process equipment and control systems provide an integrated solution to two separate business needs. The facility will provide the storage capacity required to execute the DRP as well as integration with the existing Tritium Removal Facility (TRF) to allow for ongoing operational improvements. As stipulated by the Canadian Nuclear Safety Commission (CNSC) in October 2012, this facility is now designed with enhanced seismic protections and spill containment systems that can withstand an earthquake 1.5 times more severe than the original design basis. The facility is equipped with environmental protections including vapour recovery systems that ensure that no net increase in tritium emissions are introduced during the storage and handling of heavy water. By increasing the operational storage, the Heavy Water Management Life Cycle Management Plan can be met and the need to refurbish or build a new TRF is mitigated. These features allow the building to satisfy immediate business needs while also forming the underpinning of a long term solution to heavy water storage and treatment needs for the nuclear industry in Ontario.

Problem Statement/Business Need:

This project addresses an integrated solution to address the following individual business needs:

1) There is a need to store heavy water to facilitate the refurbishment of Darlington Nuclear Generating Station (DNGS). To accommodate the DRP execution strategy for overlapping refurbishment outages 1,700,000L of storage capacity is required. An assessment of the existing storage capacity performed by a 3rd party vendor determined that there was not sufficient storage available to meet the refurbishment needs. In assessing similar refurbishment projects that had been completed, it was determined that additional storage facilities were either built or augmented to store heavy water (Bruce) or the existing storage capacity onsite was sufficient to store the heavy water (Pt. Lepreau).
2) There is a need to improve heavy water management in support of all OPG nuclear units. The improvements to operations and OPG Heavy Water management are summarized below:
   - Improve operational flexibility and ability to segregate different heavy water streams to support Darlington operation and outages.
   - Eliminate the backlog of heavy water drums that need to be processed.

   An Operational Improvement project for the existing TRF was launched in 2006 and was subsequently merged with the DRP heavy water storage project in order to align strategies and achieve efficiencies. This operational enhancement scope minimizes the risk of incurring capital costs to refurbish the existing TRF or build a new TRF

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Type 3 Business Case Summary

Project #: 16-31555 Document #: D-BCS-09701-10007
Project Title: Heavy Water Storage and Drum Handling Facility, Superseding Release

Project Overview

facility in 2035.

Summary of Preferred Alternative:

The preferred alternative is to construct a new 2,100,000 Litre heavy water storage and drum handling facility adjacent to the existing TRF. This option meets Darlington Refurbishment and heavy water management operational improvement requirements.

The new facility is designed to provide sufficient storage at the Darlington site for the heavy water from two units. This option will facilitate the Heavy Water Management Life Cycle Management plan to 2055 by increasing operational storage capacity.

The execution strategy for this alternative will focus on readying the facility to receive the heavy water from Unit 2 in support of the refurbishment outage schedule. This includes the implementation of a temporary modification (TMOD) to drain the unit in advance of the full in-service date of the facility to allow a partial in-service to be achieved. In this alternative, the remainder of the facility will be finalized in parallel with the execution of the Unit 2 refurbishment outage and placed fully in service prior to the Unit 3 refurbishment outage.

History of BCS Releases and Project Cost Estimates:

The initial project estimate was prepared based on conceptual design and preliminary design requirements. The estimate was not prepared in sufficient detail to reflect the final project scope and complexity. In addition to the initial underestimation, fundamental changes imposed on the project such as CNSC code revision for seismic requirements were not anticipated. During excavation activity, the realization of identified risks such as the remediation of contaminated groundwater and soil and relocation of unidentified buried services has introduced costs.

OPG removed the prime vendor from the project due to poor performance and the inability of OPG and the vendor to negotiate an agreeable commercial arrangement to complete the project. A new construction contractor has now been brought on board to execute the project. The majority of ground construction is complete and design is substantially complete. The project has been assessed for viable options to ensure the business need is met and the estimate to complete is a bounding high confidence estimate. The total project cost is now estimated at $381M ($347.1M base cost, plus $33.8M contingency), compared to $110M ($94.8M base cost, plus $15.1M contingency) in the previous release. The history of releases and project cost estimates are shown in the following table.

$k	Date	Release with Contingency	Cumulative Release	Total Cost with Contingency
Developmental Release	November 2006	3,600	3,600	36,383
Full Definition Release	June 2012	15,689	19,289	108,148
Partial Execution Release	August 2012	11,641	30,930	108,051
Full Execution Release	May 2013	79,085	110,015	110,015
Superseding Full Execution Release	Mar 2015	270,999	381,100	381,100

A detailed variance explanation is shown in Appendix B.

Background:

A purchase order was issued to a vendor in July 2012 to complete this work at a total cost of $65.7M, including Engineering, Procurement, and Construction (EPC). As a result of the evolution of design work and completion of engineering, field discoveries during site preparation, further definition of environmental and regulatory requirements, and underestimation by the EPC vendor, the cost and schedule to deliver this facility is substantially higher than originally anticipated.

Major contributors include:

- Soil contaminated with low concentrations of tritium in the footprint of the building. This low concentration of tritium was from a spill in 2009, and eliminated the option of disposing of this soil conventionally. While the concentrations are below regulatory limits, the soil has to be treated to address the tritium before it can be removed from the Darlington site. This has been a large contributor to added costs to the project, requiring the construction of a soil lay down pad to manage the tritiated soil and modified soil handling procedures to adhere to the environmental regulations. Additional water treatment equipment was also required to lower the ground water table and allow excavation during site preparation phase while meeting environmental discharge limits.
- The new structure was originally contemplated to be directly affixed to the existing Tritium Removal Facility but

Type 3 Business Case Summary

Project #: 16-31555 Document #: D-BCS-09701-10007
Project Title: Heavy Water Storage and Drum Handling Facility, Superseding Release

Project Overview

due to the technical complexity and risk of tying the seismic footings together the building had to be separated into a standalone structure. This has resulted in increased in construction costs. The building also had a number of structural changes (such as a second floor to accommodate the vapour recovery equipment that was required to satisfy the environmental assessment). These changes resulted in increased excavation, concrete, cladding, structural components, etc. With the relocation of the building, and to mitigate water hammer issues identified during the detailed design phase, a seismically qualified tunnel is required to route the piping between the TRF and the new facility. This tunnel installation affected numerous design packages and resulted in increased project costs.

- The permanent material requirements were under estimated due to evolution of the design. The total length of piping contained within the new facility was originally estimated to be approximately 3km. The actual design requires over 5km of piping (including all relocates, process and non-process piping) with an associated increase in supporting equipment (i.e. valve, controls, hangers, etc.). The large increase in the amount of piping is to allow for the independent filling and emptying of each tank, which provides operational benefits and flexibility.
- The field work for site preparations was completed at approximately three times the original budget. This was due in part to the higher than anticipated ground water elevation which required substantial temporary dewatering and excavating challenges. This work included the relocation of 12 services, including a 30" Low Pressure Service Water pipe, at a depth of 6 metres.

Key Risks:

Risks:

- There is a risk that the complexity of integrating a new construction vendor results in cost and schedule impacts due to interfacing issues between the multiple design, procurement, and construction vendors currently supporting the project.
- There is a risk that the use of an expedited construction strategy leads to quality issues/potential rework/turnover inefficiencies due to the complexity of the project.
- There is a risk that during execution it is determined that the contractor will be unable to meet the committed "tanks ready for U2 D2O" milestone, requiring the refurbishment organization to implement an alternate strategy so that the Unit 2 refurbishment schedule is not impacted.

Each of the above risks has been documented and risk mitigation strategies have been or are being implemented. Refer to Part G: Risk Assessment for full breakdown of risks and mitigation strategy.

Project Cash Flows, NPV, and OAR Approval Amount

M$	LTD	2015	2016	2017	2018	2019	2020	Future	Total
Currently Released	93.0	17.2	-	-	-	-	-	-	110.2
Requested Now	30.1	96.3	125.2	19.2	-	-	-	-	270.9
Future Required	-	-	-	-	-	-	-	-	
Total Project Cost	**123.1**	**113.5**	**125.2**	**19.2**	**0**	**0**	**0**	**0**	**381.1**
Ongoing Costs	-		1.5	0.8	0.8	0.8	0.8	3.5	8.2
Grand Total	**123.1**	**113.5**	**126.7**	**20.0**	**0.8**	**0.8**	**0.8**	**3.5**	**389.3**

Estimate Class:	Class 2	**Estimate at Completion:**	$381.1M
NPV:	$73M	**OAR Approval Amount:**	$389.1M

Type 3 Business Case Summary

Project #: 16-31555
Document #: D-BCS-09701-10007
Project Title: Heavy Water Storage and Drum Handling Facility, Superseding Release

Approvals			
	Signature	**Comments**	**Date**
The recommended alternative, including the identified ongoing costs, if any, represents the best option to meet the validated business need.			
Recommended by (Project Sponsor): Dietmar Reiner Senior Vice President Nuclear Projects			Mar. 3, 2015
I concur with the business decision as documented in this BCS.			
Finance Approval: Beth Summers Chief Financial Officer per OPG-STD-0076			MARCH 5, 2015
I confirm that this project, including the identified ongoing costs, if any, will address the business need, is of sufficient priority to proceed, and provides value for money.			
Approved by: Tom Mitchell President & CEO per OAR 1.1			March 6, 201-

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Records SCI/USI Retention
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OPG-FORM-0076-R005*

Type 3 Business Case Summary

Project #: 16-31555
Document #: D-BCS-09701-10007
Project Title: Heavy Water Storage and Drum Handling Facility, <Superseding> <Execution> Release

Business Case Summary

Part A: Business Need

This project addresses two distinct business needs:

Business Need 1: Darlington Refurbishment Project (DRP)

There is a need to store heavy water to facilitate the refurbishment of Darlington Nuclear. To accommodate the DRP execution strategy for overlapping refurbishment outages 1,700,000L of storage capacity is required. An assessment of the existing storage capacity determined that there was insufficient storage available to meet the refurbishment needs. In assessing similar refurbishment projects that had previously been completed, it was concluded that storage facilities were either built or augmented to store heavy water (Bruce) or the existing storage capacity onsite was sufficient to store the heavy water (Pt. Lepreau).

Individually, each unit requires 750,000L of storage for moderator and heat transport heavy water. However, the scope of this project assumes refurbishment will be executed with over-lapping shutdown units, requiring sufficient capacity to store two units worth of heavy water, equivalent to 1,500,000L. Additionally, refurbishment requires 200,000L of storage to facilitate flushing and other support operations associated with the preparation of the Darlington units for refurbishment work. This storage is for light water, and must be segregated from reactor grade heavy water. The 200,000L storage need must be met through additional capacity as the existing Darlington operational storage is required to support the operational requirements of OPG nuclear fleet.

The 1,500,000L of reactor grade storage created under this project will be available for the long term storage of heavy water from OPG Pickering units post Darlington Refurbishment. This presents a significant ancillary benefit to OPG and addresses a significant concern as Pickering Nuclear approaches its end of commercial operations.

Business Need 2: Heavy Water Management Capability

The second business need for this project is to improve heavy water management in support of all nuclear units in Ontario. This was identified in a previously approved operational Improvement project in 2007, which was deferred and merged with the refurbishment heavy water storage project in order to facilitate cost efficiencies. The two primary needs to support heavy water management are as described below:

1) Provision of an additional 400,000L of permanent storage required to improve utilization of the Darlington Tritium Removal Facility (TRF). This storage is specific to the needs of the TRF, as the heavy water stored in these tanks has a different composition than the heavy water that will be stored for the reactors during refurbishment. The increased storage will address the TRF feed and product storage bottleneck that impacts the efficiency of the tritium removal process. Improving the efficiency of the TRF will allow increased detritiation efforts to occur, and lower both tritium emissions and employee radiation exposure.
2) A new facility that will provide services to both Pickering and Darlington stations. This facility will centralize drum storage and provide a means of long term cleaning and disposal of the current inventory of drums. The current backlog of drums stored in the Heavy Water Management Building (HWMB) has caused radiological and conventional safety concerns and operational burdens that have required increased management and controls to mitigate. The facility will also provide the ability to support any refurbishment activities requiring drum cleaning/disposal, and the ability to expedite shipments.

Overall **1,700,000L** of storage is required for Business Need 1 and **400,000L** for Business Need 2, a total of **2,100,000L** of new storage capacity that shall be addressed by this project.

Part B: Preferred Alternative: Build the remainder of the Heavy Water Storage and Drum Handling Facility with construction sequenced to meet Refurbishment requirements first, with full in-service (to meet TRF Operational Improvement needs) to follow – with the full project expedited in an accelerated manner.

Description of Preferred Alternative

The preferred alternative is to finish construction of a new 2,100,000L heavy water storage and drum handling facility adjacent to the existing TRF with an accelerated execution strategy. This option meets Darlington Refurbishment and heavy water management operational improvement requirements.

This alternative is estimated to result in a total project cost of $381M to satisfy both DRP and operational improvements needs

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Type 3 Business Case Summary

Project #: 16-31555 Document #: D-BCS-09701-10007
Project Title: Heavy Water Storage and Drum Handling Facility, <Superseding> <Execution> Release

Part B: Preferred Alternative: Build the remainder of the Heavy Water Storage and Drum Handling Facility with construction sequenced to meet Refurbishment requirements first, with full in-service (to meet TRF Operational Improvement needs) to follow – with the full project expedited in an accelerated manner.

Description of Preferred Alternative

and exhibits the most positive NPV of all alternatives of $73M, as assessed against the operational improvement scope.

The major components of this alternative are as follows:

(a) **Facility:** The preferred alternative requires the design and construction of a multistory building, adjacent to the existing TRF within the protected area of the Darlington station. To prepare the site for the new facility, interferences with existing station systems (such as buried piping & electrical cable ducts, over ground structures such as bulk gases tanks, temporary trailers etc) were relocated using the engineering change control process while minimizing impact on safe plant operations.

(b) **Building:** The facility is designed to accommodate heavy water storage tanks to facilitate draining of 2 units in parallel (see details below) in the basement within a seismically qualified foundation/dyke which would be built on bedrock to prevent leakage of heavy water to the environment in the unlikely event of failure of all tanks. The facility must be seismically qualified to meet CNSC requirements. The basement would also contain a slightly negative pressure HVAC and filtering systems to minimize emissions to the atmosphere. A back-up heating system, supplied by a new system being installed by project 34000 Auxiliary Heating System, is required to ensure the heavy water does not drop below 10°C to mitigate the risk of tritium emissions by avoiding freezing and tank rupture.

A vapour recovery system consisting of dryers will be installed to remove tritiated vapour to minimize emissions to the environment and reduce radiological hazards to personnel. The building will be classified as radiological Zone 3, and contain appropriate radiation monitoring and handling systems (e.g. stack effluent monitors, personnel and materials monitors, etc.) to comply with radiological requirements.

(c) **Building Services**: The building electrical loads will be supplied by a new distribution network. A backup electrical power supply will also be provided to maintain critical loads in service at all times, including a back-up generator and battery backup for key systems. A new instrument air system will be installed to support the new facility's process systems as there is insufficient capacity in the existing system. Other support services, such as domestic water, active/inactive drains, and steam and condensate systems will also be tied in to the existing station systems.

(d) **Process and Tie-ins:** 25 tanks of various sizes, to contain the heavy water from Moderator, Heat Transport, Cleanup system, etc. are be designed and built to rigorous standards as required by applicable nuclear codes and standards. Support equipment such as piping, valves, pumps, instrumentation & controls required to be designed to the same standards is provided to monitor and operate the facility. Tie-ins to existing HWMB tanks and to the Darlington units and TRF facility for heavy water transfer capability will be provided. All this work will be coordinated and planned to ensure minimal impact on station operations.

(e) **Caissons and Excavation work:** To facilitate the excavation of the building footprint 14.5 metres below grade, a caisson wall consisting of 160 caissons were installed to provide shoring support. Due to the adjacent building and buried services inferring with the optimal number of tie-backs, internal bracing has been installed to compliment tie-backs in order to support the shoring walls. The internal bracing is specifically designed to allow the installation of the tanks prior to pouring the floor slab at grade.

(f) **Environmental Support Systems:** To manage the soil containing tritium above the level required for free release, a soil lay down pad was built to treat the soil with the goal of remediating and disposing as clean soil. A dewatering water treatment system was also designed to meet Ministry of Environment and Darlington site Certificate of Authorization requirements for discharging the water from construction projects due to excavation.

The execution of this work has been divided into 3 Phases:

Phase I, Detailed Design, June 2012 – May 2015 (In progress)

Due to design elaboration (vapour recovery system, instrument air/service air, building relocation, underground pipe tunnel connecting the new and existing facility), the detailed design portion of the work is still progressing with a completion date of June 2015 (compared to a milestone of July 2013 in the last BCS). The delay to detailed design increases schedule risk. The risk to the in service date is being mitigated by prioritizing release of design packages to match the construction schedule. The civil package for the seismic dyke has been completed, and the execution of the civil construction is underway with excavation being fully complete.

Phase II, Site Preparation, September 2012 – April 2014 (Complete)

This work was scheduled to be completed by September 2013 in the last release. This work was completed in March 2014, allowing caisson installation to be completed. This work included site preparation, construction planning, and procurement of long lead materials. Site preparation activities included demolition of TRF trailers, relocation of existing and buried services.

Type 3 Business Case Summary

Project #: 16-31555 Document #: D-BCS-09701-10007
Project Title: Heavy Water Storage and Drum Handling Facility, <Superseding> <Execution> Release

Part B: Preferred Alternative: Build the remainder of the Heavy Water Storage and Drum Handling Facility with construction sequenced to meet Refurbishment requirements first, with full in-service (to meet TRF Operational Improvement needs) to follow – with the full project expedited in an accelerated manner.

Description of Preferred Alternative

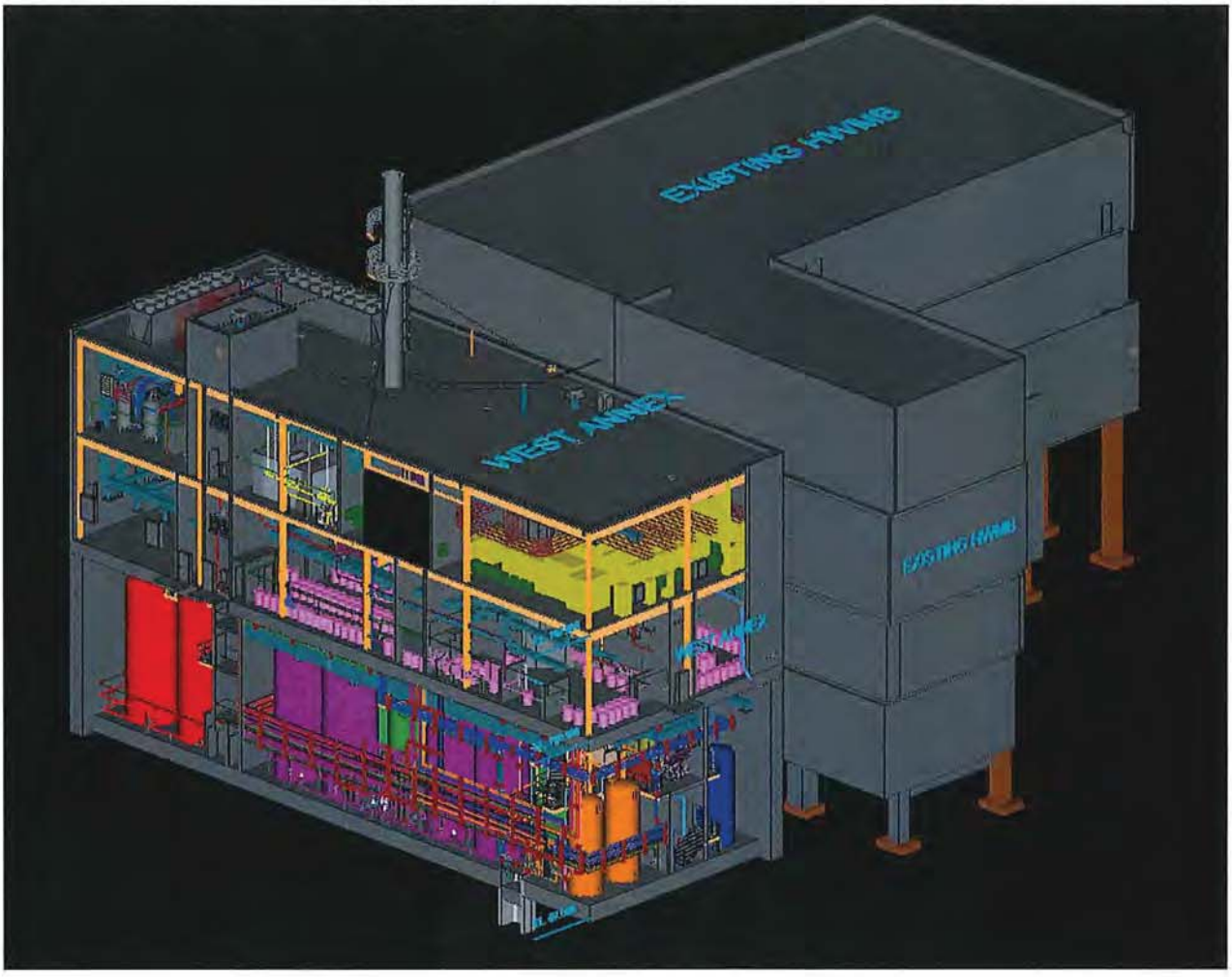
Long lead material purchase orders have been awarded as scheduled, including a purchase order for the 25 heavy water storage tanks, 12 process pumps, and 2 heat exchangers. Site preparation is substantially complete, and $14.6M of service relocations has been declared in-service.

Phase III, Full Execution, September 2013 – May 2017 (Released, Requires Superseding Release to complete)

This phase includes completion of the caisson work and excavation for TRF building connections, completion of construction planning, foundation pouring, installation of the tanks, construction of facility and supporting building and process systems, and tie-in to existing station.

Process piping, services and process controls will be included as will the updating of drawings, commissioning and training.

The following visuals are 3D renderings of the new Heavy Water Storage and Drum Handling Facility, adjacent to the Heavy Water Management Building (HWMB), also known as the Tritium Removal Facility (TRF). The first rendering shows the facility with civil installations, the second highlights the process and piping installations and the integration with the existing TRF.

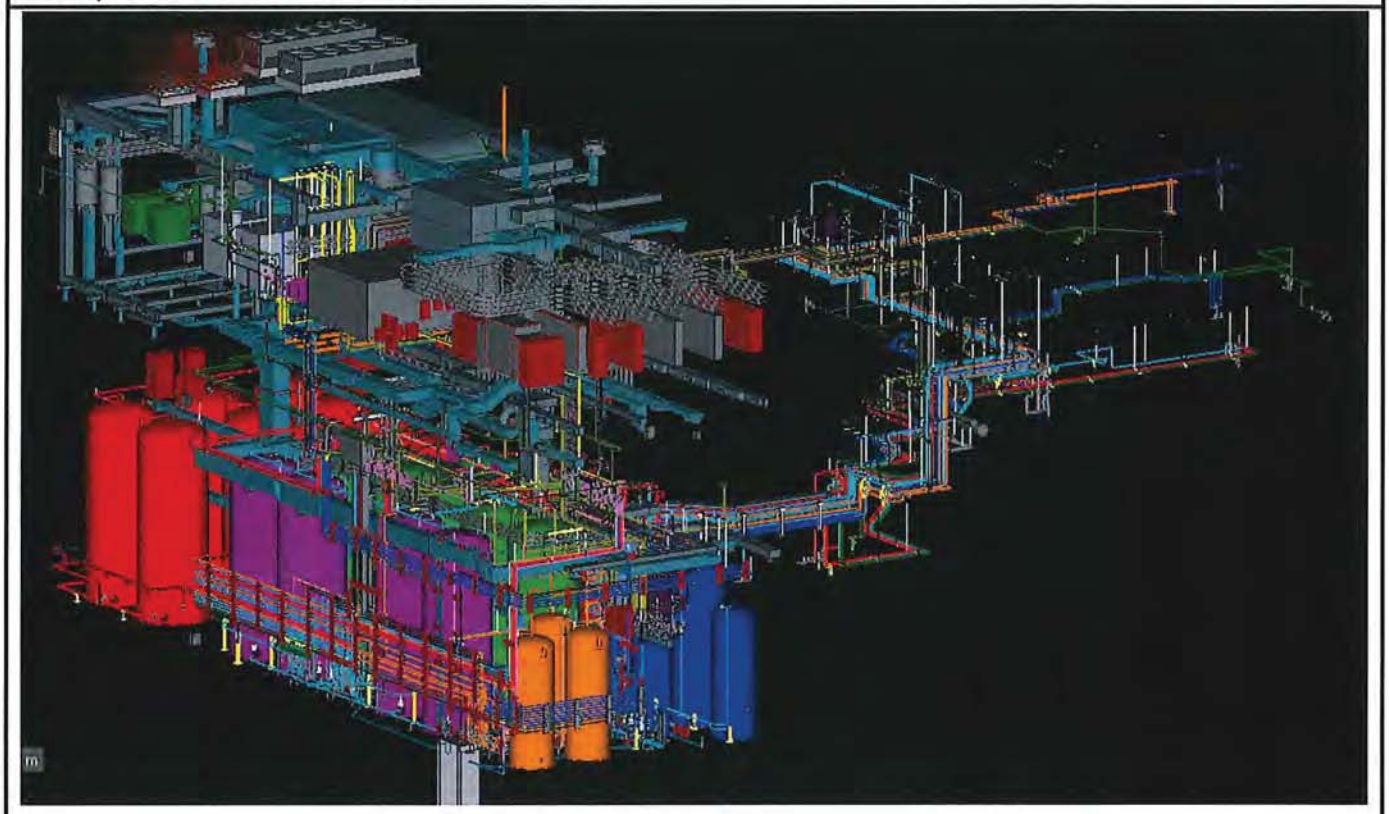


Type 3 Business Case Summary

Project #: 16-31555 Document #: D-BCS-09701-10007
Project Title: Heavy Water Storage and Drum Handling Facility, <Superseding> <Execution> Release

Part B: Preferred Alternative: Build the remainder of the Heavy Water Storage and Drum Handling Facility with construction sequenced to meet Refurbishment requirements first, with full in-service (to meet TRF Operational Improvement needs) to follow – with the full project expedited in an accelerated manner.

Description of Preferred Alternative



Deliverables:	Associated Milestones (if any):	Original 3b Target Date	Current Target Date:
Excavation Complete		New Milestone	24-DEC-2014
Detailed Design Complete	Design Documents Approved and Issued	15-JUL-2013	31-MAY-2015
Dyke Construction Complete – Ready for Tank Installation		New Milestone	22-DEC-2015
All Tanks Placed in Basement		New Milestone	21-APR-2016
Capable of receiving refurbishment water Unit 2		New Milestone	30-JUN-2016
Start of Commissioning		17-JUN-2015	12-DEC-2016
Building Shell Complete		New Milestone	03- JAN-2017
Construction Substantially Complete		New Milestone	10-MAR-2017
All Commissioning Complete, Final In-Service Declaration Complete	Available for Service	15-OCT-2015	01-MAY-2017
Project Close-out Complete	Project Close Out	15-APR-2016	01-NOV-2017

Part C: Other Alternatives

Summarize all viable alternatives considered, including pros and cons, and associated risks. Other alternatives may include different means to meet the same business need, and a reduced or increased scope of work, etc.

Type 3 Business Case Summary

Project #: 16-31555 Document #: D-BCS-09701-10007
Project Title: Heavy Water Storage and Drum Handling Facility, <Superseding> <Execution> Release

Alternative 2: Build the remainder of the Heavy Water Storage and Drum Handling Facility with construction sequenced to meet Refurbishment requirements first, with the balance of the facility (to meet TRF Operational Improvement needs) built in a non-accelerated manner:

The alternative is to finish construction of a new 2,100,000L heavy water storage and drum handling facility adjacent to the existing TRF. This option meets Darlington Refurbishment and the heavy water management operational improvement requirements.

The execution strategy for this alternative will focus on accelerated construction of the facility for refurbishment needs only, with a non-accelerated construction strategy then employed to complete the balance of the facility.

A summary cost and schedule analysis was performed in support of this alternative and it was determined that this approach would result in a protracted construction period with project resources deployed for a longer duration and increased interest expenditures. The additional costs that would be incurred do not outweigh the cost reductions that would be realized from reducing shift schedules.

This alternative is estimated to result in a total project cost of $391M to satisfy both DRP and operational improvements needs and exhibits a positive NPV of $63M assessed against the operational improvement scope.

Alternative 3: An alternate storage tank solution is implemented for Unit 2 heavy water storage to ensure that Unit 2 Refurbishment schedule is not compromised. The Heavy Water Storage and Drum Handling Facility will be finalized in parallel with the execution of the Unit 2 refurbishment outage and placed in service prior to the Unit 3 refurbishment outage.

The alternative is to finish construction of a new 2,100,000L heavy water storage and drum handling facility adjacent to the existing TRF. This option meets Darlington Refurbishment and the heavy water management operational improvement requirements.

The execution strategy for this alternative will focus on non-accelerated construction of the remainder of the facility, with the recognition that the facility will not be ready in time to support the Unit 2 Refurbishment outage, but will be ready to support the remaining refurbishment outages. In order to ensure the Unit 2 refurbishment schedule is not compromised OPG would be required to design, purchase, and implement an alternate tank storage solution that will hold Unit 2 heavy water during the Unit 2 refurbishment outage.

A summary cost and schedule analysis was performed in support of this alternative and it was determined that this approach, similar to Alternative 2, would result in a protracted construction period with project resources deployed for a longer duration and increased interest expenditures. The additional costs that would be incurred do not outweigh the cost reductions that would be realized from reducing shift schedules. The cost to implement a temporary storage solution does not reduce the requirements or the costs of the main facility and as such is an incremental expenditure that increases the overall cost.

This alternative is estimated to result in a total project cost of $433M to satisfy both DRP and operational improvements needs and exhibits a positive NPV of $67M assessed against the operational improvement scope.

Alternative 4: Suspend construction of Heavy Water Storage and Drum Handling Facility. Implement alternate storage tank solution that satisfies Nuclear Refurbishment needs for all four units. Implement a separate solution for the TRF operability enhancements at a later date.

The alternative considers decoupling the business needs into two separate solutions rather than a combined single solution, and suspending the construction of the existing Heavy Water Storage and Drum Handling Facility.

In order to meet refurbishment needs, OPG would be required to design, purchase, and implement an alternate tank storage solution that will span the life of the refurbishment project. This option to satisfy NR needs was proposed for analysis and was formally precluded due to operational and safety risks.

To support TRF operational improvement needs, approximately 400,000L of additional heavy water storage capacity is required. To satisfy this 26m x 12m storage building and eight 50,000L storage tanks and a drum testing facility will need to be built, as detailed in developmental business case summary November 2006. At the time this developmental BCS was prepared, the cost of this alternative was estimated at $37M (2007$), with no design started or contracts in place. As such, the developmental BCS cost estimate prepared in 2007 is not considered an accurate representation of the actual costs to complete the facility. The total costs to complete a standalone facility to satisfy the operability need is approximated at 75% of the total cost to finish the existing planned facility. A separate facility comparable to the planned D2O storage facility would still have to be built to satisfy refurbishment needs.

Overall, this alternative is not viable as the alternate tank plan while identified as suitable for temporary storage introduces operational and safety risks to DNGS when considered as a long term solution and as such this option was eliminated. Proceeding with a standalone operational improvements facility will not satisfy refurbishment needs.

Type 3 Business Case Summary

Project #: 16-31555 Document #: D-BCS-09701-10007
Project Title: Heavy Water Storage and Drum Handling Facility, <Superseding> <Execution> Release

Part D: Project Cash Flows, NPV, and OAR Approval Amount

M$	LTD	2015	2016	2017	2018	2019	2020	Future	Total
Currently Released	93.0	17.2	-	-	-	-	-	-	110.2
Requested Now	30.1	96.3	125.2	19.2	-	-	-	-	270.9
Future Required	-	-	-	-	-	-	-	-	
Total Project Cost	**93.0**	**143.7**	**125.2**	**19.2**	**0**	**0**	**0**	**0**	**381.1**
Ongoing Costs	-		1.5	0.8	0.8	0.8	0.8	3.5	8.2
Grand Total	**93.0**	**143.7**	**126.7**	**20.0**	**0.8**	**0.8**	**0.8**	**3.5**	**389.3**

Estimate Class:	Class 2	**Estimate at Completion:**	$381.1M
NPV:	$73M	**OAR Approval Amount:**	$389.3M

Part E: Financial Evaluation

Choose an item.	(Preferred) Alternative 1	Alternative 2	Alternative 3	Alternative 4
Project Cost	381M	391M	433M	N/A
NPV	73M	63M	67M	N/A
Other (e.g., IRR)	-	-	-	-

Summary of Financial Model Key Assumptions or Key Findings:

1. Project Costs shown are all in costs. NPVs are calculated based on go-forward costs.
2. NPV values are for the Heavy Water Management Operational Improvements scope of work (i.e. 400,000L and Drum Handling Facility). The NPV benefit for refurbishment scope of work is not calculated in this BCS as it enables the NPV benefit of the overall Darlington Refurbishment Project.
3. Key assumptions used to calculate the NPV include:
   a. Operational improvements result in more efficient utilization of the Darlington TRF and improved heavy water management (e.g. decreased impact from TRF outages, potential for 3rd party heavy water sales, dose savings at OPG stations)

Because of improved utilization of the existing TRF, operational improvements reduce the probability of needing to refurbish this facility, or construct a new TRF. Between 3 and 4 staff (depending on which alternative) are required to support operation of the new Heavy Water Storage and Drum Handling Facility.

Part F: Qualitative Factors

Qualitative factors associated with this project are as follows:

Ability to use this facility for long term storage of Pickering Nuclear Heavy Water

- The 1,500,000L of reactor grade storage created under this project will be available for the long term storage of heavy water from OPG Pickering units post Darlington Refurbishment.
- This presents a potentially significant ancillary benefit to OPG as Pickering Nuclear approaches its end of commercial operations.

Citizenship & Regulatory

- Reduce tritium emissions through improved efficiency for the detritiation of heavy water.
- Reduce risk of infringing on tritium emission regulatory limits

Customer Relations

- Increasing OPG's capability and flexibility to process heavy water will improve customer relations by providing flexibility in meeting contractual obligations with Bruce Power for detritiation services and provide the ability to increase detritiation services to third parties.

Type 3 Business Case Summary

Project #: 16-31555 Document #: D-BCS-09701-10007
Project Title: Heavy Water Storage and Drum Handling Facility, <Superseding> <Execution> Release

Part F: Qualitative Factors

Health and Safety

- Reduced tritium levels due to increased TRF efficiency will reduce worker dose
- Additional drum storage will improve housekeeping and reduce drum handling requirements, thereby reducing the related health and safety concerns
- Reduce operator work around and extra operation actions that are required to maneuver various grades of heavy water into unconventional storage arrangements

Part G: Risk Assessment

Risk	Description of Risk	Risk Management Strategy	Post-Mitigation	
			Probability	Impact
Quality Issues Resulting from Expedited Construction	The risk is that the use of an expedited construction strategy leads to quality issues/potential rework/turnover inefficiencies due to complexity and production pressure.	The vendors have confirmed the do-ability of the work within the proposal. OPG will implement heightened routine and strategic oversight activities to ensure cost, schedule, and quality objectives are being met.	High	Medium
Station Tie-in Impacts	The risk is that the constraints imposed by station requirements for tie-in of the D20 facility impacts the planned cost and schedule.	The design has been structured such that all station tie-ins have been included in separate engineering change packages, to ensure the impact is minimized.	Low	Low
Pipe Chase Construction Cost Estimate	The risk is that the actual construction costs to complete the pipe chase work exceed the current estimate, due to the construction estimate being prepared without the full design completed.	Risk will be monitored. The vendor was provided the available detail in the RFP, and contingency for estimating uncertainty has been applied. This risk is for fundamental intent change which is not anticipated.	Medium	Medium
Contractor cannot meet Schedule	The risk is that during execution it is determined that the contractor will be unable to meet the committed schedule for "tanks ready for U2 D2O", requiring an alternate strategy to ensure the U2 refurbishment schedule is not impacted.	Detailed contingency plans have been developed and are ready to initiate in the event field progress monitoring indicates that the schedule is slipping and the facility will not be ready. Monitor the field progress and initiate contingency plan if the risk triggers.	Medium	Medium
Transition to New Contractor	The risk is that the new contractor selected to execute the balance of D2O storage building encounters contractual or sub contractual issues working with the existing (or new) teams supporting the project, detrimentally impacting their ability to meet cost and schedule commitments.	The RFP clearly outlines roles and responsibilities and a joint OPG/vendor cutover plan is being developed as part of the base work. Contract Terms and Conditions further mitigate OPG's exposure. This risk will be monitored but is currently perceived low.	Medium	Low
Cost and Schedule Forecast Accuracy for Non M&E Contracts	The risk is that the forecasted costs to complete the civil and design scope are understated. This includes understanding and validation of subcontracting costs.	Risk is accepted and will be monitored because the Project management team has engaged with Ellis Don (for example) directly leading up to BCS preparation. Line by line schedule reviews have been performed to validate cost and schedule estimates leading up to business case preparation. Subcontracts are now in place. OPG increased oversight and monitoring of cost and schedule will be performed.	Low	Medium

Type 3 Business Case Summary

Project #: 16-31555 Document #: D-BCS-09701-10007
Project Title: Heavy Water Storage and Drum Handling Facility, <Superseding> <Execution> Release

Part G: Risk Assessment

Risk	Description of Risk	Risk Management Strategy	Post-Mitigation	
			Probability	Impact
Vendor Execution Under New Contractual Arrangement	The risk is that the vendor that is selected may not have executed a project under the existing commercial terms, which may introduce inefficiency or delays as a result of claims management or contract clarification issues.	This risk is accepted. The vendors doing work for the project have experience delivering projects to OPG. The contractual terms are not expected to present any significant risk.	Low	Low
"Tanks Ready for U2 water" Regulatory Risk	The risk is that regulatory approvals for contingency plans for D2O storage, if required, are not obtained in time to support U2 schedule.	The risk is accepted, as all the regulatory approval required to house D2O in the storage facility are on track. Risk is perceived to be low.	Low	High
OPG Acting as Integrator for the E and PC work	The risk is that, due to the new contracting/execution strategy, OPG incurs cost and schedule impacts stemming from integration/interface issues between the multiple design/procurement/ construction vendors.	This risk will be monitored. The current resource and execution strategy incorporates this contract strategy.	Medium	Medium
Field Changes Required	The risk is that the Revision 0 mechanical and electrical designs, as completed, are not fully constructible and require field changes or design revisions, resulting in additional cost and schedule impacts.	The collaborative front end planning process that involves OPG design oversight has been implemented throughout. The engineering change control process has been employed for all designs. This risk will be monitored as the project progresses.	Medium	Medium

Type 3 Business Case Summary

Project #: 16-31555 Document #: D-BCS-09701-10007
Project Title: Heavy Water Storage and Drum Handling Facility, <Superseding> <Execution> Release

Part H: Post Implementation Review (PIR) Plan

Type of PIR Report	Final Target In-Service or Completion Date	Target PIR Completion Date
Comprehensive PIR	01-MAY-2017	01-MAY-2018

Measurable Parameter	Current Baseline	Target Result	How will it be measured?	Who will measure it? (person/group)
Heavy water storage volume to meet needs of Refurbishment Project	No refurbishment storage	1,700,000L heavy water storage ready for Refurb project draining of Unit 2	Storage volume available in time for Refurb draining of Unit 2	VP Execution, Nuclear Refurbishment
Heavy water storage volume for TRF Operations	Insufficient storage to support optimal TRF operations	400,000L provided for improved TRF operation	Storage volume for operational improvements	SVP DNGS
Amount of Drum Handling, Cleaning and Testing Facility at DNGS	No capability to clean and test drums in-house	Ability to clean and test 100/drums per year	Amount of drum cleaning and testing.	SVP DNGS

Part I: Definitions and Acronyms

AACE – The Association for the Advancement of Cost Estimating
BCS – Business Case Summary
CDR – Conceptual Design Report
CFEP – Collaborative Front End Planning
CNSC – Canadian Nuclear Safety Commission
D_2O – Deuterium oxide, aka heavy water
DNGS – Darlington Nuclear Generating Station
ECC – Engineering Change Control
EPC – Engineer, Procure, Construct
ES-MSA – Engineering Services Master Services Agreement
HVAC – Heating, Ventilation, Air Conditioning
HWMB – Heavy Water Management Building
L - litres
LLM – Long Lead Materials
LPSW – Low Pressure Service Water
MOE – Ministry of Environment
OPG – Ontario Power Generation
OSS – Owner Support Services
PDRI – Project Definition Rating Index
PIR – Post Implementation Review
Pipe Chase – An underground pipe tunnel containing the transfer piping connecting the new and existing facility
PNGS – Pickering Nuclear Generating Station
PO – Purchase Order
QA – Quality Assurance
RFP – Request for Proposals
SVP – Senior Vice President
TRF – Tritium Removal Facility
TSSA – Technical Standards and Safety Authority
T&C – Terms and Conditions

Type 3 Business Case Summary

Project #: 16-31555 Document #: D-BCS-09701-10007
Project Title: Heavy Water Storage and Drum Handling Facility, <Superseding> <Execution> Release

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Type 3 Business Case Summary

Project #: 16-31555 Document #: D-BCS-09701-10007
Project Title: Heavy Water Storage and Drum Handling Facility, <Superseding> <Execution> Release

For Internal Project Cost Control

Internal Use Only

OPG-FORM-0076-R005

Type 3 Business Case Summary

Project #: 16-31555 Document #: D-BCS-09701-10007

Project Title: Heavy Water Storage and Drum Handling Facility, <Superseding> <Execution> Release

Appendix A: Summary of Estimate							
Project Number:	16-31555						
Project Title:	Heavy Water Storage and Drum Handling Facility						
M$	**LTD**	**2015**	**2016**	**2017**	**Future**	**Total**	**%**
OPG Project Management	2.7	1.5	1.6	0.9	-	6.7	2
OPG Engineering (including Design)	4.4	1.9	0.5	0.6	-	7.4	2
OPG Procured Materials	0.2	0.3	0.9	-	-	1.4	0
OPG (Other)	9.5	3.6	2.8	2.8	-	18.7	5
Design Contract(s)	1.9	5.2	-	-	-	7.1	2
Construction Contract(s)	7.0	33.8	-	-	-	40.8	11
EPC Contract(s)	92.5	48.1	94.0	10.3	-	244.9	64
Consultants	0.1	-	-	-	-	0.1	0
Other Contracts/Costs	0.02	0.03	0.03	-	-	0.1	0
Interest	4.8	7.5	6.7	1.0	-	20.0	5
Subtotal	**123.1**	**101.9**	**106.5**	**15.6**	**-**	**347.2**	**91**
Contingency	0	11.6	18.7	3.6	-	33.9	9
Total	**123.1**	**113.5**	**125.2**	**19.2**	**-**	**381.1**	**100**

Notes			
Project Start Date	2006-11-11	**Total Definition cost** (excludes unspent contingency for Nuclear)	$16.4M
Target In-Service (or AFS) Date	2017-05-01	**Contingency included in this BCS** (Nuclear only)	$33.9M
Target Completion Date	2017-10-01	**Total contingency released plus contingency in this BCS** (Nuclear only)	$33.9M
Escalation Rate	2.00%	**Total released plus this BCS without contingency** (Nuclear only)	$347.1M
Interest Rate	5.25%	**Total released plus this BCS with contingency** (Nuclear only)	$381.1M
Removal Costs	$650k included in (e.g., EPC Contracts)	**Estimate at Completion** (includes only spent contingency for Nuclear)	$381.1M

Prepared by:	**Approved by:**
Julian Read Section Manager, Darlington Projects Project Manager Date: Mar 2, 2015	Art Rob Vice President Projects and Modifications Date: MARCH 3/15

Type 3 Business Case Summary

Project #: 16-31555
Document #: D-BCS-09701-10007
Project Title: Heavy Water Storage and Drum Handling Facility, <Superseding> <Execution> Release

Appendix B: Comparison of Total Project Estimates and Project Variance Analysis

Comparison of Total Project Estimates

Phase	Release	Approval Date	Total Project Estimate in M$ (by year including contingency)						Future	Total Project Estimate
			2011	2012	2013	2014	2015	2016		
Definition	Partial	2006-10-22	35.8	0.6						36.4
Definition	Full	2012-06-14	3.0	10.8	38.4	41.3	14.6	31		108.1
Execution	Partial	2012-07-18	3.0	10.7	38.8	40.9	14.7			108.1
Execution	Full	2013-05-14	3.0	9.6	28.0	52.1	17.2			110.0
Execution	Superseding	2015-02-15	3.0	9.6	33.4	77.1	113.6	125.2	20.1	381.1

Project Variance Analysis

M$	LTD (Dec 2014)	Total Project		Variance	Comments
		Last BCS	This BCS		
OPG Project Management	2.7	1.4	6.7	5.3	See Comment (1) below
OPG Engineering (including Design)	4.4	4.6	7.4	2.8	See Comment (2) below
OPG Procured Materials	0.2	-	1.4	1.4	See Comment (3) below
OPG Other	9.5	2.8	18.6	15.8	See Comment (4) below
Design Contract(s)	1.9	-	7.1	7.1	See Comment (5) below
Construction Contract(s)	7.0	-	40.8	40.8	See Comment (6) below
EPC Contract(s)	92.5	77.8	244.9	167.1	See Comment (7) below
Consultants	0.1	-	0.07	0.1	See Comment (8) below
Other Contracts/Costs	0.02	0.7	0.08	-0.6	See Comment (9) below
Interest	4.8	7.5	20.1	12.6	See Comment (10) below
Subtotal	**123.1**	**94.8**	**347.1**	**252.3**	
Contingency	0.00	15.19	33.9	18.7	See Comment (11) below
Total	**123.1**	**110.0**	**381.1**	**270.9**	

Type 3 Business Case Summary

Project #: 16-31555 Document #: D-BCS-09701-10007
Project Title: Heavy Water Storage and Drum Handling Facility, <Superseding> <Execution> Release

Explanation of Variances above:

1. OPG Project Management – OPG Project Management costs have increased in alignment with the longer schedule to deliver the project as well as the increased amount of oversight required to actively manage the EPC vendor and support numerous initiatives which were not included at the onset of this project (i.e. Soil management, dewatering, etc.).

2. OPG Engineering (including Design) – OPG Engineering support has increased due to the schedule extension for design (extension from July 2013 completion to September 2015 target completion). As well, $600k of contingency was allocated to the Darlington Computer Group within OPG to complete the computer software design work for this project upon finalisation of delineation between EPC scope and OPG scope for computer software.

3. OPG Procured Materials – In the EPC contract, it is the responsibility of the vendors to procure materials for the project. On occasion, materials from OPG stores are used when lead times do not match project schedule, or field issues arise, and material is required to keep the field progressing. As well, OPG is now providing all welding consumables, and allowance has been carried for those provisions. The last BCS did not carry any budget for materials from OPG stores.

4. OPG Other – This significant increase is related to the additional OPG support required to actively support the vendors, such as security personnel to escort trucks to increase productivity at work face, additional OPG staff to support new procedure reviews, updates, etc., includes additional funds for OPG commissioning staff underestimated in the previous BCS, and additional oversight on the field progression.

5. Design Contract(s) – As a result of the EPC vendor contract termination, OPG now is carrying design contract costs directly for completion of the "Revision 0" design, which is a completed design excluding material supplier information. The new general contractor will assume the design and incorporate design changes and material supplier information into the design, which is carried as the new EPC contract.

6. Construction Contract(s) – In order to manage the transition following termination of the former EPC vendor, two Construction Only contracts were awarded. One construction contract for construction support services awarded to support OPG meet its obligations as General Contractor during civil substructure construction and one contract to complete the mechanical and electrical installations as part of the civil substructure. Lastly, following former vendor termination, a civil contractor was retained to complete the substructure work to maintain the schedule as a new General Contractor (EPC vendor) was procured.

7. EPC Contract(s) – The original contracted target price for the contract was $65.7M, subsequently updated with OPG requested scope changes in the last BCS for a total EPC contract of $77.8M. The EPC contract has increased significantly from the original $65.7M target price (see Change Summary below).

The new price includes the former General Contractor accrued costs and the new EPC contract to be awarded as General Contractor to complete the remaining work scope following substructure completion. This item includes material procurement costs related to the tanks/pumps taken over from the former EPC contractor.

During implementation of the Execution Full Release, $14.5M of the $15.1M contingency was released to increase completion of the former EPC contract. $14.5M contingency was allocated to the original EPC contractor to do the following:

- Low pressure service line Relocate and Tie-in
- Asbestos discovery and removal
- Trailer Rentals for Contractor Support On-site
- Contaminated Soil Storage including construction and operation of soil laydown areas
- Completion of additional shoring requirements utilizing night and weekend shifts

For further detail refer to Change Summary on page A-4.

8. Consultants – This project did not include costs for any consulting contracts in the last BCS. Due to the cost increases experienced on the project, a third party estimating company was brought on board to validate the EPC estimates developed by the previous vendor.

9. Other Contracts/Costs – Other contracts include re-categorization of legacy contract costs for technical evaluation, on-going temporary trailer rental for rental trailer related to project support, and previous value engineering costs. This section also covers the independent contracts with the design agency, civil construction firm and mechanical and miscellaneous support contracts after the termination of the EPC vendor.

10. Interest – Increased due to the increase in capital expenditures and schedule.

Type 3 Business Case Summary

Project #: 16-31555 Document #: D-BCS-09701-10007
Project Title: Heavy Water Storage and Drum Handling Facility, <Superseding> <Execution> Release

Change Summary

The original preliminary estimate, prior to detailed design of $65.7M for the EPC Contract was proposed by the EPC vendor based on a conceptual report and preliminary design requirements that were provided with the request for proposal. As the engineering design evolved and progressed towards completion, it has been identified that the original concept for the project would not meet the requirements of the design, and original assumptions were invalidated. The final design is considerably more complex and expensive to construct because of the following main categories:

A. The relocation of the building 7 metres to the west

B. Increased materials quantities of piping and valves and equipment

C. Requirement to have process piping run in a pipe chase/tunnel buried 7 metres below grade

D. Design scope growth required to meet the design requirements

E. OPG Requested Scope Changes

F. Environmental Requirements

G. Under estimate of effort

A. The relocation of the building 7 metres to the west

The original design concept had the new D2O Storage Building located immediately adjacent to the existing TRF. The new building would have a 'shared wall' in contact with the existing west wall of the TRF.

As design progressed, it was determined that it was not feasible to arrange the new foundations for the D2O Storage Building in a way that would not interfere with the foundations of the existing TRF. It was necessary to move the building 7 metres to the west to avoid the foundation interference.

The building relocate meant that the building now required 4 architecturally completed sides – rather than the original 3-sided finishes. More significantly, the secant pile (caisson) shoring system became significantly more complex, including the addition of a modified tieback system and cross braces, as well as installation of struts.

B. Increased materials quantities of piping and valves and equipment

The cost of permanent plant material is significantly higher than the original estimate for the project. The increase driven primarily by:

- Increase in the quantity of process & services piping that was identified as design was completed and full requirements were determined and designed for
- The HVAC / Chiller system is larger than originally estimated by the former EPC vendor due to additional loads of Instrument air/service air, vapour recovery system (which includes items such as heat exchanger, condensers, evaporative coolers, etc)
- Former vendor under estimate of equipment has significantly contributed to increase costs

C. Requirement to have process piping run in a pipe tunnel

The interconnecting process piping was originally conceived to be routed from the existing TRF into the new D2O Storage Building via an overhead, above ground, pipe corridor. The water hammer analysis that was done on this piping configuration indicated that a severe water hammer would occur during the start-up of the transfer pumps, eliminating this option.

A number of solutions were considered. Ultimately, engineering concluded that the most cost effective option was to route the interconnecting piping into the new building via a buried pipe chase at a low enough level to eliminate the water hammer issue. This increased the cost due to:

- Engineering rework to modify the transfer piping (and related civil design packages)
- Increased construction costs to:
  - Construct a concrete pipe chase 7 metres below grade
  - Relocate buried piping along the pipe chase route
  - Penetrate the existing TRF basement – a 1.3 metre thick concrete wall.

D. Design scope growth required to meet design requirements

Type 3 Business Case Summary

Design Scope Growth represents a cost element that reflects the increased construction cost (direct labour) of the project from the original concept. While design scope growth also increases the cost of materials, the materials cost has been discussed previously. The design engineering was a fixed price scope.

Under the contract, the vendor prepared the detailed system level Design Requirements, per the OPG Engineering Change Control process. The RFP and original performance fee price was based on the preliminary design requirements and a conceptual design report. As design was progressed, many assumptions were invalidated, increasing the construction effort to build as designed.

E. Scope Changes

- The Darlington Refurbishment Environmental Assessment committed no net increase of tritium emissions on site as a result of refurbishment activities. This meant that a D2O Vapour Recovery system incorporating a Dryer would need to be added to the scope to accommodate short and long term heavy water to be stored at the Darlington site.
- The original project requirement identified existing plant instrument air/service system for the new D2O Storage project was high risk of not having sufficient capacity. The vendor bid in this area was based on the conceptual design requirements which planned for connection to the existing station. During design, it was discovered that the existing plant could not expand the air load list for the new building. It has now been determined the vendor estimate did not have any allowance for tie-in to this high risk capacity system, and in cost reimbursable contract the overall costs have increased. Furthermore, the additional equipment required that the building be enlarged to provide the equipment room on the second floor.
- Temporary construction trailers were required to be provided to support the field oversight of the work at the Darlington site.
- A maintenance procedure to pump out the box drain was completed to mitigate tritium in the ground water risk.

F. Environmental Requirements

Soil and water testing during the construction phase of the project revealed the presence of tritium above the free release limits of the Darlington license. The consequences of this were that special soil storage areas (C13 and F1) needed to be constructed to manage the soil and ground water to support required excavation activities for the project. The F1 stockpile site has the operational requirements to manage the water runoff and turn the soil on an on□going basis. The environmental requirements increased the cost of the dewatering system by impacting the supplied equipment and discharge point.

G. Under Estimate of Effort

This cost element represents the areas of the project where the effort required to execute the project was under estimated based on the original scope of work. The staffing levels required managing the work and integrating the project plans into, especially as the first large ES-MSA, EPC, and Refurbishment project were much greater than the original budgets for these positions. Additionally, the effort to generate the Construction work packages and inspection test plans were also higher. The staffing plan and organization charts were updated to provide adequate staff to manage the work.

As well, effort to relocate the LPSW line was entirely missing from the original vendor proposal. As a result, a consent to proceed for $1.9M was signed, and this work ended up be completed for significantly higher costs (~$10M) due to increased complexity of shoring and significant overtime expended to mitigate schedule delay to TRF outage T1301.

Type 3 Business Case Summary

Project #: 16-31555 Document #: D-BCS-09701-10007
Project Title: Heavy Water Storage and Drum Handling Facility, <Superseding> <Execution> Release

Appendix C: Financial Evaluation Assumptions

Key assumptions used in the financial model of the Project are.

General:

The NPV calculations include the Heavy Water Management Operational Improvements portion of the integrated Heavy Water Management Facility. The going forward costs and benefits are included in the calculation.

Project Cost:

For each alternative, a portion of the Integrated Heavy Water Management Facility capital cost, 28%, was allocated to the Heavy Water Management Operational Improvements scope for financial evaluation.

Financial:

1. 2% escalation
2. 7% discount rate

Project Life:

For the Heavy Water Operational Improvements scope of the facility (tanks and drum cleaning facility), the in service date assumed was May 2017 (for the preferred alternative) and May 2019 (for alternatives 2 and 3). The Heavy Water Operational improvements portion of the integrated facility is assumed to operate until station end of life (2055) for all alternatives considered.

Operating Cost:

For the integrated Heavy Water Management Facility, the following incremental staff requirements were assumed: Operator – 1.5 FTE, Control Maintainer – 1 FTE, Mechanical Maintainer – 1 FTE, Engineer – 1 FTE, Civil Maintainer – 0.5 FTE. For the Heavy Water Management Operational Improvements portion of the facility, one incremental operator was included in the financial evaluation for all three alternatives considered.

Other:

Benefits for Operational Improvements Management

1. Minimizes risk of capital cost of refurbishing TRF or building a new TRF facility in 2035. Assume cost of $532M (2012$) and 30% probability
2. Reduces impact of unplanned TRF outages on OPG ability to manage heavy water inventories. Assume 50% probability of saving $7.2M/yr (2012$) during operation of the facility.
3. Improves ability to achieve incremental third party heavy water sales. Assume 50% probability of $3.1M/yr (2012$) of facility operation until 2043.
4. OPG achieves dose savings during outages. Assume $450k/year (2012$) during facility operation.
5. Reduces risk of need to detritiate primary heat transport heavy water after storage in moderator S&I tanks during a Vacuum Building Outage/Station Containment Outage. Assume one occurrence eliminated saving $3.6M (2012$) and modeled as $600k (2012$) every 6 years during facility operation.
6. Elimination of Kinectrics Drum Handling Contract. Assume saving of $30k/yr (2012$) during facility operation.
7. Avoids risk of downgrading reactor grade heavy water during acute recovery events or SUP outage. Assume savings of $0.9M (2012$) over 40 years, or $22k/yr during facility operation.

Note: For alternatives 2 and 3, these benefits were started in May 2019 when the heavy water Operational Improvements portion of the integrated facility is assumed to be placed in service.

Appendix D: References

N/A

Type 3 Business Case Summary

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Type 3 Business Case Summary

Project #: 16-31555
Project Title: Heavy Water Storage and Drum Handling Facility (HWSF), Superseding Execution Release

Document #: D-BCS-09701-10007 R01

Project Overview

An Operational Improvement project for the existing TRF was launched in 2006 and was subsequently merged with the DRP heavy water storage project in order to align strategies and achieve efficiencies. This operational enhancement scope minimizes the risk of incurring capital costs to refurbish the existing TRF or build a new TRF facility in 2035.

Summary of Preferred Alternative:

The preferred alternative is to construct a new 2,100,000 Litre heavy water storage and drum handling facility adjacent to the existing TRF. This option meets Darlington Refurbishment and heavy water management operational improvement requirements and meets the required codes and standard for this type of a facility. Detailed analysis of the alternatives considered is documented in the previous Full Release BCS ref D-BCS-097001-10007 R00 and not repeated in this superseding Business Case Summary ("BCS").

The new facility is designed to provide sufficient storage at the Darlington site for the heavy water from two units and will facilitate the Heavy Water Management Life Cycle Management plan to 2055 by increasing operational storage capacity.

The execution strategy for this alternative will focus on readying the facility to receive the heavy water from the Darlington Units when there are two units in a refurbishment state. Water from Unit 2 is being stored using existing fleet capacity. The current schedule will result in the facility being placed in service prior to the Unit 3 refurbishment outage.

History of BCS releases and project cost estimates:

The initial project estimate was prepared based on conceptual design and preliminary design requirements. The estimate was not prepared in sufficient detail to reflect the final project scope and complexity. In addition other unforeseen circumstances such as discovery work during excavation activities and fundamental changes imposed on the project, such as CNSC code revision for seismic requirements, were not anticipated and led to changes to project scope, schedule, and cost.

OPG removed the prime vendor from the project due to poor performance and its inability to negotiate an agreeable commercial arrangement to complete the project. A new construction contractor was retained to complete the project.

In March 2015, a revised "superseding" BCS was issued and approved for the project. The total project cost at that time was estimated at $381.1M ($347.2M base cost, plus $33.9M contingency) based on information from the original vendor. The majority of the cost increases were due to maturation of project scope and reflected the true project cost.

Following the approval of that business case, OPG engaged a new vendor. The new vendor recommended changes to the existing design based on what it said were code deficiencies in the original design. It assured OPG that the changes would have no cost or schedule impact. OPG approved the changes on that basis.

In fact, the changes resulted in significant cost and schedule impacts. After OPG refused to pay for the cost increases, it negotiated revisions to the agreement with the vendor to convert it to a guaranteed maximum price agreement.

At this point, 85% of the civil work, 20% of the electrical work, and 50% of the mechanical work have been completed. A limited Notice to Proceed has been issued in order to safe state the building.
The current estimate of $498.5 Million is based on the cost to complete the project under the guaranteed maximum price agreement.

The history of releases and project cost estimates are shown in the following table:

$k	Date	Release with Contingency	Cumulative Release	Total Cost with Contingency
Developmental Release	November 2006	3,600	3,600	36,383
Full Definition Release	June 2012	15,689	19,289	108,148
Partial Execution Release	August 2012	11,641	30,930	108,051
Full Execution Release	May 2013	79,085	110,015	110,015

Type 3 Business Case Summary

Project #: 16-31555 Document #: D-BCS-09701-10007 R01

Project Title: Heavy Water Storage and Drum Handling Facility (HWSF), Superseding Execution Release

Project Overview

Superseding Full Execution Release	March 2015	271,085	381,100	381,100
Superseding Full Execution Release (THIS BCS)	January 2018	117,400	498,500	498,500

A detailed variance explanation is provided in Appendix B.

Background:

OPG issued it's initial Execution Phase Business Cases in August 2012 and May 2013. Subsequent to these releases, the cost to complete increased as the design evolved, additional engineering was required, field discoveries were made during site preparation, further definition of environmental and regulatory requirements occurred, and flaws in the original EPC vendor's estimate were discovered. As a result, by the time that OPG terminated the agreement with the original vendor, the cost and schedule to deliver the facility was substantially higher than originally anticipated.

Major cost contributors at this stage of the project include:

- Soil contaminated with low concentrations of tritium in the footprint of the building. This low concentration of tritium was from a spill in 2009, and eliminated the option of disposing of this soil conventionally. While the concentrations are below regulatory limits, the soil has to be treated to address the tritium before it can be removed from the Darlington site. This has been a large contributor to added costs to the project, requiring the construction of a soil lay down pad to manage the tritiated soil and modified soil handling procedures to adhere to the environmental regulations. Additional water treatment equipment was also required to lower the ground water table and allow excavation during site preparation phase while meeting environmental discharge limits.
- The new structure was originally contemplated to be directly affixed to the existing Tritium Removal Facility but due to the technical complexity and risk of tying the seismic footings together the building had to be separated into a standalone structure. This has resulted in increased in construction costs. The building also had a number of structural changes (such as a second floor to accommodate the vapour recovery equipment that was required to satisfy the environmental assessment). These changes resulted in increased excavation, concrete, cladding, structural components, etc. With the relocation of the building, and to mitigate water hammer issues identified during the detailed design phase, a seismically qualified tunnel is required to route the piping between the TRF and the new facility. This tunnel installation affected numerous design packages and resulted in increased project costs.
- The permanent material requirements were under estimated due to evolution of the design. The total length of piping contained within the new facility was originally estimated to be approximately 3km. The actual design requires over 5km of piping (including all relocates, process and non-process piping) with an associated increase in supporting equipment (i.e. valve, controls, hangers, etc.). The large increase in the amount of piping is to allow for the independent filling and emptying of each tank, which provides operational benefits and flexibility.
- The field work for site preparations was completed at approximately three times the original budget. This was due in part to the higher than anticipated ground water elevation which required substantial temporary dewatering and excavating challenges. This work included the relocation of 12 services, including a 30" Low Pressure Service Water pipe, at a depth of 6 metres.

Key Assumptions and Risks:

The risk profile of the cost and schedule to complete this project has now been substantially reduced as a result of the stage of the project (design substantially complete and construction well underway) and the conversion of the contract to a Guaranteed Maximum Price arrangement.

Refer to Part G: Risk Assessment for full breakdown of any remaining risks and mitigation strategy.

related to OPG's management of the overall project, correct?

MR. REINER: Yes, there were challenges encountered in the management of the project.

MR. STEPHENSON: Right. And I want to focus on the second of those two in some of my questions here as distinct from the scoping issues.

One of the management challenges that you had to deal with was in your selection and oversight of your primary contractors, correct?

MR. REINER: That is something that needed to be tackled; that is correct. With respect to issues related to that, I would need to see the specific questions you have. But definitely one of the tasks that management needed to execute was selection of contractors and to oversee contractor performance.

MR. STEPHENSON: Right. And one of the benefits that we have now is that we are able to exercise some hindsight about some of these issues, and I appreciate that you didn't have that benefit at the front end, but we now know that you wound up having some significant issues with respect to your initial contract with Black & MacDonald that led to their termination ultimately, correct?

MR. REINER: Yes, that is correct, and that's laid out in the evidence.

MR. STEPHENSON: Okay. Now, my question is this: Have you now had the opportunity to reflect upon the process by which you ultimately selected Black & MacDonald

at the outset as the prime contractor?

MR. REINER: That is an area that we have reflected on, but I would say that we would not necessarily change anything in that regard. Black & MacDonald was a qualified contractor, fully capable and qualified under OPG's quality program to execute projects of this nature, of the nature of the D2O storage facility. It was a process that was executed through our supply-chain procurement process that established a set of criteria for selection, and all of that was followed.

So to the extent that there are lessons learned related to those activities, yes, we would have looked at those and incorporated those into our processes, but we would not necessarily have changed anything as a result.

MR. STEPHENSON: Okay. And then we do know that there comes a point in time where Black & MacDonald engagement is terminated, and so a question also arises whether that was a prudent decision, bearing in mind you -- I assume you understood that the termination of that engagement would necessarily involve some delay and some cost.

And are you satisfied that that was a prudent decision?

MR. REINER: I am satisfied that that was a very prudent decision. It became apparent that Black & MacDonald was not going to be able to provide the certainty that OPG was looking for with respect to schedule for completing the project and final cost for completing the project, and ultimately those were -- those issues were at

5.2.2 Groundwater Control

Provided the excavations do not extent below the observed groundwater level (i.e. 2.5 m below existing grade), no major groundwater dewatering is anticipated. Seepage from perched water in the fill or surface water run-off should be anticipated during construction. It should be possible to control and drain the seepage water using conventional construction dewatering techniques, i.e. pumping from sumps.

For excavations extended to below 2.5 m depth, it is anticipated that significant water seepage will be encountered within the granular and rock fill layers. It is therefore recommended that the groundwater be lowered by a vacuum well point dewatering system prior to excavation. The well points should be installed down to below the granular and/or rock fill layer. Within the native clayey silt till, clayey silt and silt, the permeability of these soils are relatively impervious, and groundwater seepage may be controlled and drained using conventional construction dewatering techniques, i.e. pumping from sumps. For flow rate calculation purposes, the coefficient of hydraulic conductivity for the granular/rock fill, silt and clayey silt till/clayey silt are about $1x10^{-2}$, $1x10^{-5}$ and $1x10^{-6}$ cm/sec, respectively.

Dewatering should be carried out by a special contractor familiar with the site and groundwater conditions using their own equipment and expertise.

5.2.3 Excavation and Shoring

No special problems are envisaged in constructing the shallow foundation for the proposed structure. The bulk excavation is expected to be carried out within the granular fill material. Excavation should be relatively straightforward and must be carried out in accordance with the latest Occupational Health and Safety Act. In this regard, the compacted fill is considered to be a Type 2 soil.

For guidance, side slopes of 1 vertical to 1 horizontal may be used for the shallow temporary excavation anticipated subject to geotechnical inspection. Where loose soil is encountered at shallow depths or within zones of persistent seepage, it may be necessary to locally flatten the side slopes.

Deeper excavations should be adequately sloped. Shoring will be required where there is a space restriction. For calculations of the triangular lateral earth pressure acting on the shoring system, the following values may be used:

Unit weight of soils	$\gamma = 20.5$ kN/m^3
Coefficient of active earth pressure	$K_a = 0.33$
Coefficient of passive earth pressure	$K_p = 3.0$
Surcharge loads (i.e. equipment or fill stockpiles)	$q = 10$ kPa

The shoring system should be designed by a qualified structural engineer and executed by specialist contractors with experience in projects of similar magnitude.

UNDERTAKING JT1.12

Undertaking

TO FILL IN BLANKS IN CHART IN KT1.1 ON A BEST EFFORTS BASIS, AND TO INCLUDE OTHER MATERIAL ESTIMATES IN THE EVIDENCE OR KNOWN TO OPG.

Response

Please see Chart 1 below. OPG prepared this chart at SEC's request. OPG does not agree that the items that SEC included represent valid estimates of the project's anticipated costs at various points in time. In particular, the estimate derived from Ex. D2-2-10, p. 66 "Chart 3 – B&M's Growing Estimates of EPC Project Costs" represent unverified estimates of future costs put forth by B&M that were never accepted by OPG and were included in OPG's evidence for the sole purpose of demonstrating B&M's inability to provide a stable estimate of project costs in the months leading to the termination of the B&M contract. As OPG states in Ex. D2-2-10, at p. 65 "As shown in the chart below, B&M's EPC contract cost estimate increased substantially month after month. The information provided with these estimates was not sufficient to allow OPG to verify the basis for the forecast increases."

Additionally, the estimates in Chart 1 are not directly comparable to one another as some of the lines requested by SEC are estimates for portions of the project only. As OPG has explained in Ex. L-D2-02-SEC-094, the approved estimates of the D2O Storage Project's total cost at various points in time are those contained in OPG's BCS.

Chart 1: Estimates related to the D2O Storage Project

	D2O Storage Project Cost Estimates						
	Date of Estimate	Total Estimated Cost ($M)	Entity that Provided the Estimate	General Contractor	Total Cost Expended on the Project At Date of Estimate ($M)	Notes	Evidence Reference
Faithful & Gould Construction Costs Estimate	Early 2012	$ 64.60	Faithful & Gould (OPG)	N/A	$ 3.40	Estimate of overnight cost for construction only based on the project information available at the time. OPG did not complete a contemporaneous estimate of the total project cost	D2-2-10, p.43
2012 Full Release Definition BCS	Jun-12	$ 108.00	OPG Project Team	B&M	$ 3.48	Estimate to complete the D2O Storage Project based on then current information	D2-2-10, Attachment 2m
2012 Partial Release Execution BCS	Aug-12	$ 108.00	OPG Project Team	B&M	$ 4.59	Estimate to complete the D2O Storage Project based on then current information	D2-2-10, Attachment 2n
2013 Full Release Execution BCS	May-13	$ 110.02	OPG Project Team	B&M	$ 15.16	Estimate to complete the D2O Storage Project based on then current information	D2-2-10, Attachment 2o
B&M EPC Estimate	Jan-14	$ 123.50	B&M	B&M	$ 56.53	EPC only estimates demonstrating B&Ms ongoing challenge to produce a stable cost estimate. OPG did not complete contemporaneous estimates of total project cost	D2-2-10, p.66, Chart 3
B&M EPC Estimate	Feb-14	$ 133.10	B&M	B&M	$ 60.84		
B&M EPC Estimate	Apr-14	$ 224.90	B&M	B&M	$ 74.62		
B&M EPC Estimate	May-14	$ 253.70	B&M	B&M	$ 85.71		
B&M EPC Estimate	Jul-14	$ 282.10	B&M	B&M	$ 100.96		
2014 Faithful & Gould Estimate	Jul-14	$ 345.00	Faithful & Gould/OPG/B&M	B&M	$ 100.96	Estimate to complete the D2O Storage Project including forecast and incurred costs	D2-2-10, p.66
B&M EPC Estimate	Sep-14	$ 286.60	B&M	B&M	$ 109.55	See comment above regarding B&M EPC estimates	D2-2-10, p.66, Chart 3
2015 Superseding Release Execution BCS	Mar-15	$ 381.00	OPG Project Team	OPG	$ 142.60	Estimate to complete the D2O Storage Project based on then current information	D2-2-10, Attachment 2p
CanAtom Estimate of Costs to Complete	Aug-16	$ 146.00	CanAtom	CanAtom	$ 163.09	Estimates of costs to complete the D2O Storage Project. OPG did not prepare a contemporaneous estimates of the total project cost	L-D2-02-SEC-104 Attachment 1
CanAtom Estimate of Costs to Complete	Oct-16	$ 187.00	CanAtom	CanAtom	$ 309.39		
CanAtom Estimate of Costs to Complete	Jan-17	$ 242.00	CanAtom	CanAtom	$ 353.52		
High Bridge Estimate to Complete	Mar-17	$ 108.50	High Bridge (CanAtom)	CanAtom	$ 373.01	Estimate of the cost to complete the remaining project scope over approximately 18 months. OPG did not prepare a contemporaneous estimate of the total project cost	D2-2-10, p.93
CanAtom Estimate of Costs to Complete	Apr-17	$ 270.00	CanAtom	CanAtom	$ 380.50	See comment above regarding CanAtom estimates to complete	L-D2-02-SEC-104 Attachment 1
2018 Superseding Release Execution BCS	Dec-17	$ 510.00	OPG Project Team	CanAtom	$ 399.21	Estimate to complete the D2O Storage Project and actual D2O Storage Project final cost	D2-2-10, Attachment 2q

See Ex. D2-2-9, Table 5 for the D2O Storage Project capital project listing including in-service additions for the years 2016-2020.

The $160M placed in service in 2016 represents the costs of the seismic dike, five PHT storage tanks and the piping and equipment necessary to allow them to receive heavy water if required. These were declared useful once the seismic dike was complete, piping was installed to create a flow path to fill the PHT tanks with Unit 2 PHT heavy water, and the tanks were capable of storing heavy water. The $320.9M placed in service in 2019 represents the cost of the major process systems, process support systems and building support systems shown in Figure 1, above. The $13.8M being placed in service in 2020 represents the cost of the remaining equipment installed to complete the project, including radiation and tritium monitors, and system controls, and commissioning costs.

OPG requests that the remaining $494.7M be approved for inclusion in rate base based on the dates the various components were placed in service as discussed above. The revenue requirement impacts of these investments once in service have been recorded in the CRVA established under section 6(2) 4 of O. Reg. 53/05 and will continue to be recorded in the CRVA until the effective date for the payment amounts that include this project in the rate base.[10] OPG has proposed that deferral and variance account balances up to year-end 2019 be dispositioned as part of this application, which includes all unrecovered revenue requirement amounts from 2019 and earlier related to the D2O Storage Project, as discussed in Ex. H1-1-1.[11]

2.4 D2O Storage Project Business Case Summaries

The BCS for the project are discussed in Section 13 below and included as Attachments 2k – 2q. The D2O Storage Project was a first-of-a-kind project and the first major DRP project to be

[10] The revenue requirement approved in EB-2016-0152 included the tax impact of capital cost allowance ("CCA") deductions for forecasted capital expenditures on the D2O Storage Project as part of the CCA for the overall DRP expenditures, as set out in EB-2016-0152, Ex. F4-2-1, Table 3b, Note 3. The impact of the CCA for the D2O Storage Project expenditures was not removed from OPG's proposed revenue requirement in EB-2016-0152 Ex. N2-1-1.
[11] OPG has not sought recovery of any DRP-related CRVA balances, including those related to the D2O Storage Project, since the December 31, 2015 balances were last dispositioned in the EB-2016-0152 proceeding.

interrogatory in front of them, this is with respect to B&M's performance around the spring of 2014.

My question -- what I was trying to understand and ask about was the increased cost aspect of that sentence, and try to quantify how much costs had increased by. And I didn't get an answer to that specific question and I'm asking that again now if I can get that answer, or if I can't, why not.

MR. REINER: We can take a look, we can have a look. You're after -- I want to understand specifically what you're after -- what the cost increase was that was attributable to relocation of that specific interference?

MR. BUONAGURO: No. I think the sentence, at least to me, it speaks for itself. It says "the failure to meet the schedule for delivery of design documents", so that's a failure on B&M's part, "and the delay in completing the LPSW relocation", so presumably another failure on behalf of B&M, "has increased costs." I am trying to know what those costs were.

MR. REINER: So we have to -- one of the issues related to B&M's early work on this project is in relation to a baseline cost estimate which we had extreme difficulty getting to with Black & McDonald, and you will see in the evidence and in the interrogatory answers that that theme comes through.

So in order to answer that question, it means -- to answer it precisely with a quantification, you need good baseline estimates to compare to.

Intuitively, we know it increased cost because it added time and time means more effort, more cost. So I don't know that we are able to give you -- because I don't believe it exists -- that we are able to give you a quantification of that relative to a cost estimate, because that was a big part of the problem with Black & McDonald which ultimately resulted in changing course with contractors. We couldn't get a baseline cost estimate or schedule that they would commit to.

MR. BUONAGURO: Okay.

MR. REINER: On the basis of that, it would be impossible to quantify this.

MR. BUONAGURO: Okay. I'm going to move on to the next interrogatory on my cite list, which was Exhibit D2-02-CCC-36. And if you go down to the answer, in this question -- the evidence I cite in the interrogatory, you were at the point where you were negotiating a potential new contract with B&M with a target price that had a cap on it, if I can call it that. And they didn't want to do that, fair enough, and that's clear in the answer.

I was trying to find out what that target price was or would have been, and you said you didn't get to that point where you actually agreed on a target price. But you did provide, presumably to be helpful, that B&M's final estimate of the cost to complete the EPC contract was 286.6 million, was shown in Exhibit D2-2-10-66. I want to put that in context.

And I did read the correspondence between B&M and OPG

"A", if a design is chosen which excavates to bedrock (approx 87-m El). Dewatering and disposing / treating tritiated groundwater for the duration of the foundation construction would likely be cost and schedule prohibitive. This risk is what is driving OPG to consider Site "C". If not for this risk, the preferred option from all stakeholders would be Site "A". The OPG Project team, with OPG Environmental Compliance Department, has developed a strategy to investigate and characterize the extent of tritium contamination at Site "A", with the aim to develop a remediation plan, if necessary. The full investigation (Environmental Site Assessment Phase II) is expected to conclude in April 2013, however by April 2012, initial groundwater samples and Geotechnical Evaluation for Site "A" will be complete. An interim groundwater report will also be made available.

The Proponents should assume, for the purposes of this RFP, that there are no tritium concerns with Site "A".

2.6 Expected Tritium Levels in Process

For guidance, the new facility is expected to receive water with the following tritium levels. The proponent is required to verify all values in their proposals and design.

From NK38-OPP-03600, the concentration of tritium in the Darlington moderator shall be no higher than 15.0 Ci/kg, and the concentration of tritium in the Darlington heat transport system shall be no higher than 1.2 Ci/kg. Also, the tritium concentration of feed water at the inlet of the TRF feed treatment process shall not exceed 34 Ci/kg. Currently, this includes moderator water from external customers.

The current D2O downgraded heavy water transfer system, SCI 38500, contains water not exceeding 10.0 Ci/kg in tritium concentration as per CSA N285-95 and TRANS-TS-03459-TR18-0008. Connected to this system is the D2O cleanup system, SCI 38410, which may also contain tritiated water at levels up to 10 Ci/kg.

From NK30-OPP-03600 and NA44-OPP-03600, the tritium concentration in the Pickering moderator system shall not exceed 25.0 Ci/kg, and the tritium concentration in the Pickering heat transport system shall not exceed 2.5 Ci/kg.

AMPCO Interrogatory #107

Interrogatory

Reference: Ex D2 T2 S10 P44

OPG also began soil and water testing at the D2O Storage Project site to test for the presence of tritium on the proposed site of the D2O Storage Project. OPG had done sampling following a 2009 spill at the Injection Water Storage Tank, which indicated elevated tritium levels in the soil and groundwater in the area north of the site.

Please discuss how the presence of tritium in the site's soil and the water contributed to any cost overruns, schedule delays and scope changes on the project and quantify the impact.

Response

The presence of tritium did not contribute to cost overruns as the costs of addressing potential tritium contamination were not included in the original EPC contract. As explained in Ex. L-D2-02-Staff-155 a), OPG instructed respondents to the D2O Storage Project work request not to assume any costs to address tritium, so as to make their bids comparable. Thus, B&M's original proposal and OPG's original BCS contemplated that any incremental costs due to tritium would be addressed through the use of contingency once the extent of the tritium was known.

Testing revealed low levels of tritium in the soil, which required drying, aeration and monitoring. OPG developed the F1 soil laydown area to accept the soil and bedrock excavated from the D2O Storage Project. As described in Ex. D2-2-10, pp. 53-54, the soil was held to dry, turned for aeration, monitored and ultimately disposed of on Darlington lands. The cost associated with the development, construction, monitoring and restoration of the F1 area were approximately $14M and there was no delay associated with the development and execution of this additional scope. OPG notes that absent the presence of tritium, it still would have incurred costs to transport and dispose of the extensive quantity of soil and bedrock excavated from the D2O Storage Project site.