TESTIMONY OF
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CHAIRMAN,
PEGASUS GLOBAL HOLDINGS, INC.
ON BEHALF OF
ONTARIO POWER GENERATION INC.
IN RESPECT TO THE DARLINGTON REFURBISHMENT PROGRAM
BEFORE THE
ONTARIO ENERGY BOARD

2020

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LIST OF ACRONYMS & ABBREVIATIONS

AACE International ..... AACE

Balance of Plant ..... BOP

Board of Directors ..... Board

Calandria Tube ..... CT

Chartered Institute of Arbitrators ..... CIArb

Comprehensive Work Package ..... CWP

Construction Industry Institute CII

Cost Performance Index ..... CPI

Darlington Refurbishment Committee ..... DRC

Darlington Refurbishment Program ..... DRP, or "Program"

Darlington Unit 3 Improvements Project D3IP

End Fitting/Pressure Tube ..... EF/PT

Earned Value Management ..... EVM

First in a While ..... FIAW

First of a Kind ..... FOAK

Government Accountability Office ..... GAO

Integrated Gasification Combined Cycle ..... IGCC

National Association of Corporate Directors ..... NACD

National Building Specification Organization ..... NBS

Ontario Energy Board ..... OEB

Ontario Power Generation Inc. ..... OPG

Original Equipment Manufacturer ..... OEM

Pegasus Global Holdings, Inc. ..... Pegasus-Global

Pressure Tube ..... PT

Program Assurance Group ..... PAG

Program Management Oversight Board.....PMOB

Program Management Office.....PMO

Program Management Team.....PMT

Project Management Body of Knowledge..... PMBOK

Project Management Institute.....PMI

Project Management Professional .....PMP

Project Planning and Controls.....PP&C

Refurbishment Construction Review Board ..... RCRB

Release Quality Estimate ..... RQE

Remaining Units ..... Units 3, 1, and 4

Retube and Feeder Replacement .....RFR

Royal Institute of Chartered Surveyors..... RICS

Schedule Performance Indicator.....SPI

Senior Vice President.....SVP

Subject Matter Expert.....SME

Turbine Generator ..... TG

Unit 2 Execution Estimate.....U2EE

Unit 3 Execution Estimate.....U3EE

Vault Vapor Recovery System..... VVRS

Vice President.....VP

Work Breakdown Structure.....WBS

I. EXECUTIVE SUMMARY

Sections I of my testimony begins with a summary of my overall conclusions from this assessment. It is followed by **Section II**, an introduction of my background, qualifications, and experience relevant to the engagement, the purpose and summary of my testimony that identifies the scope of the assessment, and lastly provides a summary of my prior Unit 2 assessment. **Section III** examines the policies and procedures utilized by Ontario Power Generation, Inc (OPG) on the Darlington Refurbishment Program (DRP or Program), including how such policies and procedures evolved from the Unit 2 assessment. **Section IV and V** detail the specific planning efforts undertaken by OPG and the resulting output, including contract management approaches and current cost estimates and schedules, as OPG prepares to execute Unit 3 and continues planning on Units 1 and 4. These findings and conclusions are summarized below, with the complete testimony in the corresponding sections as they appear in my testimony:

SUMMARY OF SECTION III POLICIES AND PROCEDURES

- I conducted an evaluation of the following OPG policies and procedures for the execution of the Remaining Units (Units 3, 1, and 4): Estimating and Cost Management; Schedule Management; Risk Management; Scope/Change Management; Reporting Management; and Lessons Learned Management.

  These functions represent the core of program management and, as such, are most integral to the overall success of the Program. Additionally, these were the same functions reviewed during the Unit 2 assessment (with the exception of lessons learned, which is new for this assessment).
- OPG's policies and procedures have evolved based on review cycles and continuous improvement efforts that are typical within utilities executing a portfolio of large and complex capital programs and projects and are reflective of observed performance.

- As noted during the Unit 2 assessment regarding OPG's policies and procedures, I found that the set of policies and procedures used to govern the execution of the Program often matched or exceeded industry standards and practice in their thoroughness and are appropriate for a Program of this size and complexity. The current set of OPG's policies and procedures that govern the Program remains in alignment with the individual policies and procedures that comprise the full set, remains robust, and continues to match or exceed what is prescribed by industry standards.

SUMMARY OF SECTION IV UNITS 3, 1, AND 4 PLANNING

- OPG's oversight remains effectively consistent with the oversight in place for the Unit 2 execution, with some changes made to reflect the current status of the Program while remaining very robust and continuing to include multiple points of internal and external oversight. Reporting on the program status remains largely unchanged from what was implemented on Unit 2, with a Nuclear Refurbishment website/database utilized that automatically produces reports on key metrics (e.g. earned value management, milestone reports, risk management status reports, etc.). There are no major changes to the program progress metrics, but based on Unit 2 lessons learned, there are improvements to how the metrics are implemented with reporting, refined to ensure the appropriate information is available to management to inform decision-making. For example, adjusting task completion rates to show earned value, grouping, and consolidating of reports into a package where information can be viewed together. OPG is also working with vendors to improve alignment between vendor and OPG reporting so that schedules and information are timely, relevant with consistent information.
- The OPG team leading the Unit 3 execution has direct experience on Unit 2. OPG is also supported by a strong training and retention program to ensure it continues to have well-qualified personnel and the adequate number of resources to maintain program success.

Succession planning at OPG, and specifically within the DRP includes robust processes supported by regular reviews and meetings to ensure the needed talent is trained and prepared to support ongoing efforts. This includes succession planning for vendors, like CanAtom, who have established their own succession planning efforts to support successful execution of the full Program.

- The majority of work across the four units in the DRP is the same scope, however, there are specific scope differences that exist, including notably the Turbine Generator controls upgrade (for Units 3, 1, and 4) and Generator Stator rewind (for Units 3 and 4) that were not performed during the Unit 2 execution. Refurbishment support facilities (e.g. shop & work areas, washrooms, radiation protection facility, etc.) that were part of the Unit 2 scope will continue to be used across the Remaining Units and will not have to be reconstructed. Other items within the Unit 2 scope that are not repeated include one-time defuel engineering. I find that OPG has appropriately considered these unit to unit scope differences in its planning for the Remaining Units and in preparing for execution of Unit 3.
- OPG always intended that it would capture lessons learned from the execution of Unit 2 that would be incorporated into the planning of the Remaining Units. I find that OPG's lessons learned process goes beyond industry standards by utilizing a robust lessons learned program that ensures effective capture, documentation, evaluation, incorporation, and verification of lessons learned. Success has been demonstrated through the incorporation of several lessons learned into the execution planning, estimate, and schedule for Unit 3, and will continue to be utilized. Lessons learned have been appropriately considered in the planning for the Remaining Units, including incorporation into the schedules and cost estimates.
- Further, I found that OPG's strategic improvements, which are comprised of broader efforts such as the hybrid schedule and tooling improvements program that go beyond

typical lessons learned, allow for unit-over-unit improvements in the Program's execution.

- Unit-over-unit scope changes and unit-over-unit efficiency improvements have been accounted for in the planning for execution of the Remaining Units, including within the cost estimates and schedules. Based on these findings, I would expect OPG to realize these unit-over-unit improvements.
- OPG has taken positive steps in best aligning its contract management for the execution of the Remaining Units based on positive results of the Unit 2 engineering "One Team" approach that enhanced the existing collaboration management and through reviewing and revising its contractual incentive/disincentive mechanisms. The progress made should provide OPG with additional confidence that the turbine generator (TG) work can be accomplished within the planned budget and schedule. Further, the amendment to the retube and feeder replacement (RFR) contract has an appropriate alignment to the contract management strategy through revisions to the incentive and disincentive mechanisms, which should derive improved performance in the Remaining Units based on a structured goal alignment between OPG and the contractor.

SUMMARY OF SECTION V CURRENT COST AND SCHEDULE ESTIMATES

- I find that both the development of cost and schedule estimates for Unit 3 (as well as Units 1 and 4) have benefited from the gate review process utilized by OPG that ensure:
    - checks are performed at specific key milestones, usually tied to a funding release,
    - lessons learned are incorporated,
    - assumptions are challenged, and
    - risks are assessed, reviewed, and quantified.

- Both the schedule and cost estimates, including contingency development, continue to follow industry standard practices similar to what was observed in the Unit 2 planning efforts.
- OPG has effective processes that are rooted in industry standard practices for reviewing and updating the cost and schedule estimates of the Remaining Units to account for actual experience, lessons learned, strategic improvements, and other factors. The updated cost and schedule estimates provide a greater assurance to OPG on the status of the overall Program.
- The contingency process remains in alignment with industry standards. The steps taken by OPG during its recent contingency assessment provide confidence that Unit 3 can be completed within its schedule and estimate.
- The remaining Program contingency is based on thorough reviews and analyses of Units 1 and 4 to account for various future risks and opportunities. The OPG reviews confirm current contingency allotment is sufficient and remains within the bounds of the $12.8 billion Program estimate and should provide OPG with the increased confidence that the Program can be completed within this budget.
- The Unit 3 schedule was refined based on the actual Unit 2 experience and incorporation of lessons learned and other strategic improvements undertaken by OPG. One example of many of the strategic improvements is the use of a hybrid shift schedule, which improves OPG's ability not only to retain staff, but also benefits from expected improvements in productivity and the opportunity of having "implied float" on the non-working days.
- The cost and schedule estimates were also subjected to an independent review, in alignment with industry standards. The independent review confirmed that an appropriate and robust process was utilized in their development.

II. INTRODUCTION

A. NAME AND QUALIFICATIONS

Q. Please state your name, business address and qualifications.

A. My name is Dr. Patricia D. Galloway. My business address is 1750 Emerick Road, Cle Elum, Washington 98922. I am the Chairman of Pegasus Global Holdings, Inc. (Pegasus-Global), a management consulting firm that provides services to the energy and infrastructure industries globally, specifically focusing on megaprojects and megaprograms. My qualifications and experience are contained in my curriculum vita (C.V.) attached as **Exhibit No. PG-1**. In summary, I received a doctorate in Infrastructure Systems (Civil) Engineering from Kochi University of Technology in Kochi, Japan in 2005, a Master's in Business Administration from the New York Institute of Technology in 1984, and a Bachelor of Civil Engineering from Purdue University in 1978. I have over 42 years of experience in the construction and utility industries. I have performed extensive work on behalf of both public and private sector clients, on a wide range of complex, global engagements involving the construction, engineering, and procurement of megaprojects and megaprograms. I have an extensive background in engineering, construction, and project management, including project controls and scheduling. I have been involved with pre-design, engineering, procurement, construction, and commissioning work for large complex projects like the DRP. This work includes significant experience in management decision making, governance evaluations, estimate review and evaluation, contract risk reviews, contract strategy, bidding and bid solicitation for such projects, procurement, design change review, constructability reviews, project controls, schedule resource loading and activity evaluation, cost control, progress reporting, quality assurance and control, startup and operations, commissioning, testing and maintenance. I have worked on engineering and construction projects in over 60 countries. I am a licensed Professional Engineer currently in 15 U.S. States, Manitoba, Canada, and Australia. I am a certified Project Management Professional (PMP) by the Project Management Institute (PMI) and a Certified Quantity Surveyor in the fields of Project

1 Management and Risk Management by the Royal Institute of Chartered Surveyors (RICS). I hold
2 a Certificate in Dispute Resolution from Pepperdine Law School (Straus Institute), a Diploma in
3 International Arbitration from Jesus College, Oxford (through the Chartered Institute of
4 Arbitrators (CIArb)) , and am a Leadership Fellow from the National Association of Corporate
5 Directors (NACD) and have also served and continue to serve on several corporate boards for
6 both for-profit (public and private) corporations and non-profit corporations. I also served on the
7 National Science Board, appointed by President Bush and Senate confirmed, from 2006-2012,
8 having served as its Vice Chair from 2008-2010.
9
10 **Q. Are you the same Dr. Galloway that provided testimony to the Ontario Energy Board**
11 **(OEB) in 2016?**
12 A. Yes.
13
14 **Q. Are there any significant changes in your qualifications, role and/or responsibilities since**
15 **you filed that testimony?**
16 A. Yes. At the time I filed the 2016 testimony, I served as President and CEO of Pegasus-Global. I
17 now serve as Chairman of the Board and Mr. Michael Chilton now serves as President and CEO.
18 In addition, I now serve on both the Granite Construction Board of Directors and the Stantec
19 Board of Directors. As of May 2020, I retired from the American Arbitration Association Board
20 of Directors as I reached its 10-year term limit. In addition, in 2018, I started Galloway
21 Arbitration, received my Chartered Arbitrator Certificate from the CIArb and now serve as an
22 International Arbitrator.
23
24 **B. PURPOSE AND SUMMARY OF TESTIMONY**
25 **Q. What is the purpose of your testimony?**

1 A. Pegasus-Global was engaged by Torys LLP to provide an independent and objective assessment
2 of OPG's project management approach and preparedness with respect to the planned
3 refurbishment of Units 3, 1, and 4 of the Darlington Nuclear Generation Station, including: (i)
4 whether the planning for Units 3, 1, and 4 has appropriately considered unit-over-unit scope
5 differences and incorporated lessons learned from the execution of Unit 2 refurbishment to
6 demonstrate unit-over-unit improvement, and (ii) whether Pegasus-Global's prior assessment
7 with respect to OPG's plan and approach to the execution of Unit 2 refurbishment continues to be
8 applicable for Units 3, 1, and 4, all subject to the understanding that the planning of the Unit 3
9 refurbishment is more advanced relative to that of Units 1 and 4 and that the assessment with
10 respect to Units 1 and 4 will be undertaken subject to the availability of information.
11
12 **C. SUMMARY OF PRIOR ASSESSMENT (TESTIMONY)**
13 **Q. Can you summarize your prior Unit 2 testimony regarding megaprograms and industry**
14 **standards?**
15 A. Yes, the following reflects my findings of my 2016 filed testimony:
16 • The DRP is considered a megaprogram by every measure generally used within the
17 industry.
18 • OPG treated the DRP as a First-of-a-Kind (FOAK) program, which was appropriate
19 in my opinion.
20 • The content and scope of OPG's program and project management plans for Unit 2
21 were consistent with industry best practices and other megaprojects and
22 megaprograms I have reviewed, including for example, Southern Company's Vogtle
23 nuclear project and London's Crossrail 1 Program.
24 • OPG's policies and procedures were exemplary in their thoroughness and alignment
25 with other individual OPG policies and procedures and industry best practices.

- OPG's estimating process and basis of estimate aligned with industry best practices, with appropriate adaptations to account for the uniqueness of the Program.
- It was typical for megaprograms, such as the DRP, to be managed on a planned duration that is less time than reflected in the high-confidence schedule.
- OPG had the plans and processes in place to effectively develop, manage, and control the schedule in full alignment with industry standards and best practices.
- OPG's cost and schedule contingency development aligned with industry standards through identifying risks, estimating the probability of occurrence and impact, considering risk responses, addressing cost and schedule dependency, assessing overall outcomes through Monte Carlo simulations, and estimating and evaluating contingency.
- While I found there was no specific confidence level considered as a best practice, I found that using a P90 confidence level provided OPG with a high probability of completing the Program within the $12.8B estimate and was in accordance with the robust risk analyses that were performed.
- OPG's risk management processes were typical of what I would expect to find in a megaprogram such as the DRP and utilized the fundamental steps of: planning; identification; assessment; treatment; and, monitoring and control.
- The types of reports that OPG anticipated in 2016 to be used are what I would expect to see on a megaprogram such as the DRP.
- The DRP development was at a point in its execution where I would expect an owner to be in a megaprogram at that stage of execution at the time of my 2016 testimony.

Q. Can you summarize your key findings of your Unit 2 assessment 2016 testimony?

A. Yes. My key findings of my 2016 testimony regarding the planning and approval for Unit 2's execution was as follows:

- OPG's decision to substantially complete Unit 2 before starting Unit 3 would allow for an effective implementation of lessons learned for Unit 2.
- OPG used a strong matrix organization comprised of full-time project managers with considerable authority and full-time functional support staff, which I considered appropriate.
- OPG sought to find the most qualified individuals in the industry to manage the Program and I found that the individuals assigned to the Program were qualified and competent.
- OPG had efficient oversight in place, including senior and executive management and a Board of Directors (Board) with a focus on important process/progress issues; participation in strategic decisions; and, active in issue resolution.
- OPG had policies and procedures in place to effectively monitor and capture actual costs and evaluate performance against the physical work completed, similar to or beyond what I had observed on other megaprograms.
- OPG appropriately took into account lessons learned from other refurbishment projects, other nuclear projects, and other megaprojects and megaprograms.
- Performance and progress would be measured through Earned Value Management (EVM) techniques, which was typical within the construction industry.

D. SUMMARY OF CURRENT ASSESSMENT

Q. Can you summarize the findings of your current assessment?

A. Yes, based on the review of OPG's governance, policies and procedures, and project controls which have evolved and been enhanced since they were developed for Unit 2 for use for the

Program, and interviews conducted with OPG personnel, I found that OPG has reasonably and prudently prepared for its execution of Unit 3 of the DRP and continues to prepare and plan for the execution of the Units 1 and 4. This planning and preparedness for the execution of the Remaining Units is where I would expect it to be at this stage of the Program, which puts OPG in a position to successfully execute the full Program. My summary findings include:

- OPG's approach for executing the Program is consistent with the approach typically used on other megaprograms and in several areas exceed what I have seen on other megaprograms of similar magnitude, scale and complexity, including specifically the areas of risk management, cost estimating, and lessons learned, among others.
- Similar to my findings for Unit 2, I conclude that OPG management, executive management, and the Board: (i) have efficient oversight processes in place; (ii) have focused on important process/progress issues; (iii) are participating fully in strategic decisions; (iv) are active in issue resolution; and (v) are informed and engaged in the planning and pre-execution phases.
- The unit-over-unit scope changes and unit-over-unit expected efficiency improvements have been appropriately accounted for in the planning for execution of the Remaining Units, including within the cost estimates and schedules. Based on these findings, I would expect OPG to realize these unit-over-unit improvements.

III. POLICIES AND PROCEDURES

A. OVERALL FINDINGS

Q. Did you conduct an examination of OPG's policies and procedures as part of your current review?

A. Yes. I conducted an evaluation of the following OPG policies and procedures for the execution of the Remaining Units:

- Estimating and Cost Management
- Schedule Management
- Risk Management
- Scope/Change Management
- Reporting Management
- Lessons Learned Management

These functions represent the core of program management and, as such, are most integral to the overall success of the Program. Additionally, these were the same functions reviewed during the Unit 2 assessment (with the exception of lessons learned, which is new for this assessment).

Q. What are your overall findings of OPG's current policies and procedures?

A. As noted during the Unit 2 assessment regarding OPG's policies and procedures, I continue to find that the set of policies and procedures used to govern the execution of the Program are in alignment with and often match or exceed industry standards and practices.

All of the functional policies and procedures (e.g. cost, schedule, risk, etc.) are implemented by OPG under the direction of the Project Management Standard.[1] This OPG standard defines the elements required for project management, introduces the scalability concept to align application of these elements to the size and complexity of the project, describes the key project management processes to be adhered to as based on industry standards and best practices and outlines the organizational roles and responsibilities. The primary changes from the prior Project Management Standard that was reviewed during the Unit 2 assessment are the addition of a nuclear regulatory requirements matrix as a new appendix and revisions made to align this standard with the current project management processes (i.e. introducing scalability, sub-dividing project controls into cost, schedule, earned value, etc. and providing additional detail on these project management aspects).

One of the primary changes to the suite of OPG's policies and procedures since the time of the Unit 2 assessment is an OPG strategic initiative ("Project Excellence") to establish an enterprise-wide project delivery model with a common and scalable approach (based on project cost and complexity), an enterprise projects organization, and alignment of the project portfolio with the enterprise strategic objectives.[2] This Project Excellence initiative utilized experience gained through the planning and execution of Unit 2 and industry best practices to establish enterprise-wide policies, tools, and procedures (previously each business unit was responsible for its own set of standards). For the DRP, the influences of this initiative were predominantly seen in the "Nuclear Project" suite of procedures (cost management, schedule management, risk management, change management, etc.) that were updated to support use beyond the DRP (i.e. introducing the scalable approach to project management requirements), while still maintaining alignment with applicable industry standards.

Q. Can you summarize how OPG's "Nuclear Project" suite of policies and procedures evolved from the time the Unit 2 assessment was conducted?

A. Yes. OPG's policies and procedures have evolved based on review cycles and continuous improvement efforts that are typical within utilities executing a portfolio of large and complex capital programs and projects and are reflective of observed performance. The primary changes from the policies and procedures in place at the time of the Unit 2 assessment are the result of a consolidation of existing nuclear project management processes. This consolidation and evolution were part of the Project Excellence initiative discussed above, and as such, one of the more notable enhancements was the incorporation of the scalable project delivery method into these procedures defining the applicable requirements based on the cost and complexity of the individual project.

1 **B. ESTIMATING AND COST MANAGEMENT**

2 **Q. What estimating and cost management procedures did you review?**

3 A. I reviewed the *Project Estimating* (Rev 001)[3] and *Project Cost Management* (Rev 001)[4]
4 procedures that provide the structure for estimating project costs and monitoring and controlling
5 project costs in the Program.

6

7 **Q. What were your overall findings on OPG's estimating and cost management procedures?**

8 A. I found that both the *Project Estimating* and *Project Cost Management* procedures continue to
9 demonstrate alignment with industry standards (including both referencing industry standards
10 such as those from AACE International (AACE) that define the estimate classification system and
11 PMI's Project Management Body of Knowledge (PMBOK)). *Project Estimating* specifically
12 incorporates the estimate classification system prescribed by AACE into the procedure to support
13 the development of estimates that align with industry standards. *Project Cost Management*
14 outlines the processes, tools, roles, and responsibilities to plan, estimate, budget, and control costs
15 to enable completion within the approved budget. The procedure also provides various metrics
16 (i.e. Cost Performance Index (CPI)) for monitoring and analyzing work performance information
17 compared to the cost baseline.

18

19 **C. SCHEDULE MANAGEMENT**

20 **Q. What schedule management procedures did you review?**

21 A. I reviewed the *Project Scheduling Guide* (Rev 002)[5] and *Project Schedule Management* (Rev
22 001)[6] procedures. These documents provide guidance on schedule development, maintenance,
23 and control within Primavera P6 (*Project Scheduling Guide*) and the general schedule planning
24 and development and monitoring, analysis, reporting, and mitigation practices used in schedule
25 management (*Project Schedule Management*).

26

Q. What were your overall findings on OPG's schedule management procedures?

A. The *Project Schedule Management* procedure focuses on planning schedule management (e.g. methodology, required level of accuracy, units of measurement, rule of performance measurement, etc.), requirements for schedule development (e.g. milestones, resource-loading, alignment with the Work Breakdown Structure (WBS), etc.), and controlling the schedule (e.g. monitoring practices and requirements, performance reporting, etc.).

The *Project Scheduling Guide* walks users through how to develop, baseline, and update schedules within the Primavera P6 software program. It also provides instruction on analyzing the schedule, including critical path assessment, baseline comparisons, float analysis, and schedule performance (i.e. calculating Schedule Performance Index (SPI) and earned value metrics).

I found that both the Project Scheduling Guide and Project Schedule Management procedures align with industry standards such as the PMBOK, and AACE's *Schedule Development*, *Schedule Levels of Detail*, *Schedule Design*, *Original Baseline Schedule Review*, *Statusing the CPM Schedule*, and *Schedule Update Review* recommended practices. The incorporation of these industry standards into the procedures allows OPG to have a basis to ensure its planning, development, and monitoring of the Program's schedules are rooted in industry best practices.

D. RISK MANAGEMENT

Q. What risk management procedures did you review?

A. I reviewed the *Project Risk Management* (Rev 001)[7] procedure, which establishes processes for: planning risk management, identifying risks, performing qualitative and quantitative risk analyses, planning and implementing risk responses, and monitoring risks (which mirrors the risk management processes outlined in the PMBOK).

Q. What were your overall findings on OPG's risk management procedures?

A. I found that the *Project Risk Management* procedure aligns with industry standards, in particular the PMBOK, which as noted above, incorporates the same risk management processes detailed in the PMBOK. This alignment ensures that the risk management processes established and utilized by OPG on the Program encompass the industry standard practices that support robust risk management.

E. SCOPE/CHANGE MANAGEMENT

Q. What scope/change management procedures did you review?

A. I reviewed the *Project Integrated Change Control* (Rev 001)[8] procedure, which provides the processes for ensuring any changes to project scope, cost, and/or schedule are controlled and documented, as well as analyzed for potential impacts. I also reviewed the *Project Scope Management* (Rev 002)[9] procedure, which provides the processes for planning, defining, validating, and controlling scope.

Q. What were your overall findings on OPG's scope/change management procedures?

A. I found that the *Project Integrated Change Control* procedure aligns with industry standards, such as those prescribed in the PMBOK for integrated change control that discuss reviewing, approving, and managing changes, as the procedure establishes the processes for planning change control (i.e. developing a change control plan that is included within the project management plan and details the change approval thresholds in place for the project); controlling change (i.e. identifying the change, initiating the change, reviewing the change, approving or rejecting the change, and applying the change); and monitoring change (i.e. reviewing project performance against the approved change to confirm the change is achieving its intended benefits).

Similarly, the *Project Scope Management* also follows the scope management processes outlined in the PMBOK, such as planning, defining, validating, and controlling scope with establishing

processes for planning scope management (i.e. creating a scope management plan that documents how the scope will be defined, validated, and controlled); collecting requirements (i.e. determining, documenting, and managing stakeholder needs and requirements to meet objectives); defining scope (i.e. selecting final project requirements, detailed description of the project/product); creating a WBS (i.e. subdividing the deliverables and project work into smaller, more manageable components); validating scope (i.e. formalizing acceptance of the completed project deliverables); and controlling scope (i.e. monitoring the status of the project and scope and managing changes to the baseline). As with other procedures, by aligning the procedures with industry standards, OPG has ensured it has encompassed the breadth of activities that support strong scope and change management.

F. REPORTING/COMMUNICATIONS/STAKEHOLDER MANAGEMENT

Q. What reporting management procedures did you review?

A. I reviewed the *Project Communication and Stakeholder Management* (Rev 000)[10] procedure, which provides the processes related to project communications (planning, managing, and monitoring) and project stakeholder management (identifying stakeholders and planning, managing, and monitoring stakeholder engagement). These processes parallel those prescribed within the PMBOK for project communications management and project stakeholder management. I also reviewed the *Darlington Refurbishment Communications Program Management Plan* (Rev 004),[11] which provides overall direction for communications/information management on the Program such that information is communicated to those who need the information in a manner that ensures the information is current, correct and timely. Further, I reviewed the *Darlington Refurbishment Project Planning and Controls Program Management Plan* (Rev 004)[12], which defines the strategies and processes associated with the provision of the Project Planning and Controls (PP&C) function for the DRP and provides guidance to reporting

and data infrastructure in place on the Program consistent with recommended practices from PMI, the Construction Industry Institute (CII), and AACE.

Q. What were your overall findings on OPG's reporting, communication, and stakeholder management procedures?

A. I found the procedures provide direction on reporting, communication, and stakeholder management and remain effective tools that are aligned with industry standards and best practices. This is key to ensuring that accurate, appropriate, and timely information is collected and distributed to the necessary individuals monitoring the Program. Vital to this effectiveness is the integrated database (detailed within the *Darlington Refurbishment Project Planning and Controls Management Plan*) that OPG maintains for all Program metrics and reporting data, ensuring that data fidelity is maintained. Additionally, a Nuclear Refurbishment Reporting Website is maintained and utilized across OPG as a repository for approved reports, including automated reports generated for the Program (e.g. earned value performance reports, milestone reports, risk management status reports, etc.).[13] It also provides the list of reports generated for the Program stakeholders including Board update reports, monthly program status reports for senior management, and an annual report for the OEB, among other reports.

G. LESSONS LEARNED

Q. What lessons learned procedures did you review?

A. I reviewed the *Nuclear Refurbishment Lessons Learned* (Rev 001)[14] procedure, which was initially issued after my Unit 2 assessment was performed and thus was not reviewed previously. This document serves as a guide that details the lessons learned process OPG has implemented on the Program.

Q. What were your overall findings on OPG's lessons learned procedure?

A. The lessons learned procedure establishes a process that uses a three-phased approach: identification and documentation; evaluation and incorporation; and verification, which I found to be consistent with lesson learned practices used in other large and complex programs.[15]

- Identification & Documentation: lessons learned are identified on an ongoing basis by OPG employees and its vendor partners. Post-Window lessons learned meetings are mandatory and provide a significant source of tactical lessons learned for scope that is planned to be repeated on future refurbishment units and/or maintenance scope in planned outages. For the TG and RFR, which are much larger projects than the other scopes of work in the Program, the lessons learned meetings are held after major component completion and post-comprehensive work package completion, respectively. Programmatic lessons learned meetings/workshops are also conducted as requested by employee/vendor or from the lessons learned program team and cover a wider range of topics (e.g. trending issues, critical hold points, program risks, etc.). Additionally, strategic improvements are identified through interviews with OPG personnel and vendors following each Program segment that may provide value added or enhancing alternative strategies (e.g. organizational changes, contract or execution strategies, etc.) that may not otherwise be captured through the tactical lessons learned process. Lessons learned identified through these processes are generally collected within the a risk management software platform utilized by OPG, which serves as a single repository for documentation of all OPG's Program lessons learned (contractors and vendors, however, maintain their own lessons learned systems, e.g. CanAtom collects lessons learned internally, typically related to modifications and safety issues, etc., which are reviewed and shared with OPG). Additionally, a monthly lessons learned status report is issued to the Refurbishment Management Team that provides a summary of lessons learned collected, meetings held, and other related information.

- Evaluation & Incorporation: A Lessons Learned Tracking File is utilized that allows for review of the lessons learned and sorting by discrete data points. Project/functional managers then conduct an initial screening of lessons from the tracking file to determine the validity (i.e. ensuring it has value, is still applicable, etc.). Lessons learned are then evaluated and assigned a tiered ranking (0-3; with 0 representing strategic improvements identified by the Executive Team; and 1-3 representing the tactical lessons learned having thresholds based on impact/scope, with 1 being more significant, i.e. savings >$5M or outside of approved scope, 2 being moderate, i.e. savings >$500K or non-critical path savings of >5 days, and 3 being the lowest level, i.e. within scope/budget, and no critical path impacts, etc.) to ensure the more significant lessons learned receive the appropriate amount of attention and effort. The tiered rankings also establish the requirements for implementation of the lessons learned, such as Tier 1 and 2 requiring a formal action tracking via the risk management software platform. The gated process used by OPG for funding and approval of projects ensures that lessons learned have been evaluated and appropriately incorporated into the planning by requiring their incorporation prior to release of execution funding (Gate 3).
- Verification: as part of the post-window lessons learned meetings, the Program Management Team (PMT) will evaluate if lessons learned from prior efforts were effective in resolving the issue or providing the benefits as intended.

I found that the lessons learned process, as detailed in the *Nuclear Refurbishment Lessons Learned* procedure, is a robust guide for effectively identifying, evaluating, incorporating, and verifying lessons learned on the Program. Industry standards, such as the PMBOK or AACE's *Project Planning* recommended practice,[16] recognize the importance of lessons learned, but generally limit their discussion to maintaining a lessons learned register. Thus, I found OPG's lessons learned process goes beyond industry standards by establishing a process that ensures effective capture, documentation, evaluation, and incorporation and verification of lessons

learned. Further, I found that OPG's strategic improvements such as the hybrid schedule, allow for step improvements in the Program based on my review of Unit 2's planned execution that should see unit-over-unit improvements.

IV. UNITS 3, 1, AND 4 PLANNING

A. OVERALL FINDINGS

Q. How did you evaluate OPG's planning for execution of Units 3, 1, and 4?

A. I began my evaluation by examining the policies and procedures implemented by OPG to provide governance and structure to OPG's management of the Program. As discussed above, given that the prior Unit 2 assessment also featured a review of policies and procedures, this evaluation focused on the evolution of those policies and procedures, assessing that evolution and reviewing the policies and procedures and their evolution against industry standards to ensure the policies and procedures in place for the Remaining Units remain effective tools to plan and manage the Program.

I then looked at the key lessons learned and other strategic improvements identified and implemented by OPG from the Unit 2 experience to understand the basis for these elements (i.e. what circumstances led them to be identified and how they can improve the future performance in the Program). Corresponding with those efforts, a review of the unit-over-unit scope differences was also performed to appreciate how these differences may influence the planning and execution of these units. Included in this examination was a review of risk assessments performed by OPG and how those risks influenced the cost and schedule estimates, particularly in regard to the actual Unit 2 experience and any FOAK/first-in-a-while (FIAW) work on the Remaining Units.

Understanding these elements, I then examined the current cost and schedule estimates, including planned unit-over-unit improvements, for the Remaining Units to reach a determination that this experience and these factors were appropriately accounted for in planning the execution of Unit 3 and in the initial planning for Units 1 and 4.

Another aspect of this overall evaluation focused on the organization within OPG that is leading the planning and execution of these Remaining Units, including the training and succession planning initiatives established by OPG to ensure that the appropriate type and amount of skilled resources remain available to OPG. These evaluations were supported through interviews conducted with OPG personnel to further explore the planning and preparation for Units 3, 1, and 4.

Q. What are your overall findings on OPG's planning for execution of Units 3, 1 and 4?

A. I found that OPG's oversight remains effectively consistent with the oversight in place for the Unit 2 execution, with some changes made to reflect the current status of the Program while remaining very robust and continuing to include multiple points of internal and external oversight. The OPG team leading the Unit 3 execution has direct experience on Unit 2. OPG is also supported by a strong training and retention program to ensure it continues to have well-qualified personnel and the adequate number of resources to maintain program success. Succession planning at OPG, and specifically within the DRP includes robust processes supported by regular reviews and meetings to ensure the needed talent is trained and prepared to support ongoing efforts. This includes succession planning for vendors, like CanAtom, who have established their own succession planning efforts to support successful execution of the full Program.

I also found that the unit-over-unit scope changes and unit-over-unit expected efficiency improvements have been appropriately accounted for in the planning for execution of the Remaining Units, including within the cost estimates and schedules and based on these findings, I would expect OPG to realize these unit-over-unit improvements.

I further found that OPG has a robust lessons learned program that operates as intended following an identification/evaluation/verification process that has demonstrated its success through the incorporation of several lessons learned and will continue to be utilized. Lessons learned have

been appropriately considered in the planning for the Remaining Units, including incorporation into the schedules and cost estimates.

B. PROGRAM OVERSIGHT AND ORGANIZATION

Q. Has OPG's oversight of the Program changed since the Unit 2 assessment?

A. I found that the oversight groups that monitored the planning and execution of Unit 2 were reassessed by OPG for the necessary oversight on the Remaining Units. The result of the reassessment was that slight refinements have been implemented as would be expected during the normal course of review that reflects the current status of the Program. For example:

- I found the Program Assurance Group (PAG) historically performed surveillances across OPG's projects, including the DRP. However, within the DRP, the Nuclear Oversight group also performs surveillances. Thus, OPG reasonably determined that consolidating these dual oversight functions could streamline the DRP oversight. Based on that determination, OPG made the decision to maintain DRP surveillances within the Nuclear Oversight group, as that group has additional expertise that is applicable to the Program while still maintaining the independence required in the oversight role which I found to be prudent to avoid duplication of efforts.[17]
- Burns & McDonnell/Modus were contracted to perform independent updates on Unit 2 execution that were reported to the Darlington Refurbishment Committee (DRC) of the OPG Board.[18] This group was also requested by the DRC to perform an evaluation of the process used by OPG in developing the control budget and schedule for Unit 3, which was completed in November 2019. Because the Unit 3, 1, and 4 scopes are largely duplicative of Unit 2, the Board made the decision that the type of oversight performed by Burns & McDonnell/Modus was no longer needed. Therefore, at the end of 2019, the contract with Burns & McDonnell/Modus was mutually agreed to expire and the Board

moved the role of the Refurbishment Construction Review Board (RCRB) to the role of Independent Oversight. OPG will continue to utilize other oversight groups (e.g. Internal Audit) as appropriate.[19]

- Should there be a specific need for additional oversight on the Program in specific areas, multiple external agencies are available to provide such services in the areas of their expertise and experience based on the request of the Program or OPG Executive Management.
- The RCRB is comprised of a team of experts with significant hands-on experience managing and overseeing large-scale nuclear projects and/or operations. During the execution of the Unit 2 refurbishment, the RCRP conducted multiple site visits per year and prepared reports as independent oversight to DRP Management. In its new role as independent oversight to the DRC of the OPG Board, the RCRB will continue to conduct independent assessments approximately three-four times a year reporting to the DRC of the OPG Board on its observations and any recommendations or opportunities identified. The RCRB will primarily observe and report on aspects of the Program related to safety, cost, schedule, and quality. Its assessments are also intended to discuss project performance, and identify risks, and opportunities that the project may not perceive. I found the decision to appoint the RCRB to the role of Independent Oversight to the DRC of the OPG Board to be reasonable and prudent.[20]

Additionally, the 2020-2021 Integrated Assurance Plan that outlines the assurance activities, identified key areas for oversight currently planned or underway for Unit 3, including:[21]

- The TG controls upgrade – representing FOAK scope for Unit 3 and included a readiness audit conducted by Internal Audit;
- Resourcing and management of Unit overlap – focusing on Units 3 and 1 overlap to identify and mitigate risks of simultaneous refurbishment on multiple units;

- Implementation of Covid-19 protocols – protocols implemented in March 2020 in response to the Covid-19 pandemic will be the focus of internal self-assessments and oversight from the Nuclear Oversight Group and Internal Audit to ensure the continued safety of the workers while maintaining the program work; and,
- Incorporation of lessons learned and key performance metrics – early tracking of project performance on Unit 3 will be key to confirm the Unit 2 lessons learned have been successfully incorporated and are achieving the expected results.

These plans are subject to change as project risks evolve, which is reflected through continual assessment of the assurance plans and activities.

Q. Is it industry practice or prudent for the oversight of a megaproject or megaprogram to be adjusted as the program matures?

A. Yes. At a high-level, one example of changing requirements of oversight is the difference between the planning and execution phases of a megaprogram. The planning phase generally requires a fairly robust level of oversight to ensure the processes, procedures, resources, assumptions, and other factors have been identified, assessed, improved (if needed), and are ready for execution. Early in the execution phase, the oversight typically remains fairly robust to ensure the execution is carried out as intended. As the megaproject or megaprogram reaches a more mature stage of development, such as following the completion of the first unit within the DRP, the level of oversight may be adjusted based on the experience gained and the higher confidence realized from the execution to date. Likewise, if specific issues are encountered during execution, it similarly may require different expertise within the oversight group to ensure the issues are adequately addressed.

As an example, when Duke Energy initially embarked on its Ash Removal Program, it retained an independent Program Management Oversight Board (PMOB) which I personally chaired. As the Program matured and the policies and procedures and execution processes were developed,

implemented, and assessed by the PMOB, the need for such a large formal oversight group was no longer necessary as it accomplished its intended scope.

Q. Have there been changes to the reporting on the Program implemented since execution of Unit 2 began?

A. Reporting on the Program remains largely unchanged from what was implemented on Unit 2, with a Nuclear Refurbishment website/database utilized that allows the generation of reports on key metrics (e.g. earned value management, milestone reports, risk management status reports, etc.).[22] There are no major changes to the program progress metrics, but based on Unit 2 lessons learned, there are enhancements to how the metrics are implemented with reporting to ensure the appropriate information is available to management to inform decision-making. For example, standardized reporting across all Refurbishment bundles/projects and consistent earned value methodologies were established to facilitate accountability for performance and support timely decision-making.[23] OPG also worked with vendors to improve alignment between vendor and OPG reporting schedule, which enhances the decision-making process by ensuring timely, relevant, and consistent information continues to be available.[24]

Q. In your opinion, does OPG still have effective oversight in place as it continues executing the Program?

A. Yes, similar to my findings for Unit 2, I conclude that OPG senior management, executive management, and the Board: (i) have efficient oversight processes in place; (ii) are focused on important process/progress issues; (iii) are participating fully in strategic decisions; (iv) are active in issue resolution and are informed and engaged in the planning and pre-execution phases, and (v) based on these findings should see unit-over-unit improvements. I also conclude that 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.

Q. Does OPG continue to possess the necessary level of experience and expertise to successfully execute a megaprogram the size and complexity of the Darlington Refurbishment Program?

A. Yes, as I found in my Unit 2 assessment, OPG had extensive experience managing nuclear construction projects, including intimate involvement with the engineering and project management aspects of those projects. During the current assessment, interviews of 18 individuals involved in the DRP in different capacities were conducted, from the Senior Vice President (SVP) of Nuclear Refurbishment to the Director of Project Controls to the Director of Nuclear Refurbishment Training. I find that OPG continues to have well-qualified individuals with appropriate experience and expertise in place to execute the Program.

Q. Have there been any changes to the Program organization since your Unit 2 assessment?

A. Yes, as of September 2020, OPG implemented a realignment across its entire organization, including the DRP.[25] This realignment is intended to better integrate OPG to improve collaboration, innovation, and enterprise talent development. While this realignment brings about a number of changes to the overall OPG organization, for the purposes of the DRP, the changes are primarily seen in the newly established Enterprise Projects organization. The Enterprise Projects organization is led by the Chief Projects Officer and includes leadership roles for the SVP, Nuclear Refurbishment, the VP, Enterprise Project Management Office, the VP, Nuclear Projects, the Director, Renewable Generation Projects, and the VP, Project Assurance & Commercial Management.[26] The SVP, Nuclear Refurbishment is further supported by the SVP, U3 Refurb Execution, the VP, U1/U4 Planning, and the VP, Support U1/U3/U4.[27] Dietmar Reiner, who was SVP, Nuclear Projects at the time of my Unit 2 assessment, is now serving as SVP, Refurbishment Transition until March 2021, at which point Mr. Reiner is expected to transition to an advisory role that will help OPG to maintain a clear and strategic understanding of large project execution.[28]

I found that these changes to the Program organization, while relatively immaterial in nature were reasonable and appropriate based upon the status of the Program, OPG's succession planning and talent development efforts, and reflect alignment with other OPG strategic initiatives such as the Project Excellence initiative.

Q. What steps has OPG taken to ensure it maintains the necessary resources for the duration of the Program?

A. I found that OPG has taken the following steps to ensure it maintains the necessary resources for the duration of the Program:

- Functional support from internal groups within OPG for the execution of Units 3, 1, and 4 have been assessed by OPG to ensure the appropriate resources are available (and have been included in the corresponding estimates). The assessment includes reviewing the Unit 2 forecasts/actuals and updating the assumptions for the forecasts for the future units accordingly.[29]
- By utilizing a hybrid shift schedule, an idea originated by CanAtom, OPG has been able to reduce the required resources (two crews vs. four crews on Unit 2), which also reduces the required supervisory/management oversight in addition to mitigating some of the risk associated with craft availability.[30] By instituting a hybrid schedule, I conclude that OPG and its vendors will likely increase their ability to retain resources and improve productivity given the reduction of fatigue and burnout from moving to the hybrid shift schedule.
- Units 3, 1, and 4 will feature a project-centric model that utilizes a dedicated organization and resources for each of the Lead In (Removal Series), Lead Out (Installation Series), and Feeder series for each subsequent unit.[31] The teams performing the work will also be grouped by specific area and transition from unit-to-unit in that area, rather than transitioning to new work types/series as was done during the bulk of Unit 2, which I

conclude should enhance the expertise and proficiency of the teams performing the work and increase retention of those same teams with the expectation of long-term employment over the Program duration. In addition, this model is expected to improve execution during the overlapping refurbishment outages planned for the Remaining Units because it will avoid the necessity to complete the same work simultaneously on overlapping units.

- OPG actively monitors the organizational structure for the DRP to ensure that the right number and type of resources are available to support the execution of the Program.[32] Through this active monitoring I found that OPG has identified enhancements based on the observed experience to date, such as the hybrid shift schedule and the project-centric model for each series, that are designed to increase the effectiveness and employee/craft retention in executing Units 3, 1, and 4.[33]

Q. Does OPG's approach to its oversight and its program organization remain reasonable and appropriate?

A. Yes. OPG's oversight remains very robust and provides the appropriate accountability to manage this large and complex Program. By leveraging internal and external expertise and having clear and structured communications, the information gleaned from this oversight is conveyed to the appropriate individuals that utilize the information in continuing to plan, manage, and execute the Program.

Similarly, based on my Unit 2 assessment, I found that the program organization is comprised of many individuals that have direct experience on Unit 2, which will serve as a benefit to OPG in carrying out the Remaining Units. I further found that the program organization also benefits from a robust succession planning and training initiatives led by OPG to provide assurance that the appropriate expertise remains within the organization to facilitate successful execution of the Program.

1 **C. CONTRACT MANAGEMENT**

2 **Q. Please explain "contract management" and specifically how it differs from "commercial**
3 **management."**

4 A. Within OPG, contract management concerns the processes and actions that support the parties of
5 a contract (e.g. owner and subcontractor) in meeting the objectives and requirements as defined
6 within the contract.[34] These contract management efforts support the commercial management
7 efforts by OPG, which include development of the contract strategies for the major work
8 packages, vendor selection and contract negotiation, and contract closeout, including resolution of
9 claims.[35]

10

11 **Q. How would you define the contract management style being implemented for Unit 3?**

12 A. I found that OPG continues to practice a collaboration management style.

13

14 **Q. What is collaboration management?**

15 A. Collaboration management is defined as a collection of various management techniques used to
16 bring a sense of unity and teamwork among managers, supervisors, and the employees within
17 organizations. By actively working together as a team, complex projects can be accomplished
18 within a given timeframe. Per the UK's National Building Specification Organization (NBS),
19 "*Collaboration construction contracts maybe described as providing a mechanism for*
20 *organizations involved in a construction project to work together-to proactively and jointly*
21 *manage project risks-in order to achieve the common goal of effective project execution. This*
22 *includes encouraging innovation and continuous improvement during the course of a project or*
23 *series of projects."*[36]

24 The concept behind a collaborative management style is to allow managers to combine their
25 strengths with the strengths of their team making it possible to overcome any individual team
26 member weakness thus enhancing the efficiency and productivity.

Q. What benefits does collaboration management have on a megaproject?

A. Megaprojects by their very nature are comprised of multiple, layered projects within an overall framework. By actively involving all project members in the planning and control processes, fostering systems, processes and communication, teams can be more productive and avert problems and issues. Management is considered an integral part of the project work for all team members.

Roles and responsibilities are clearly defined, with interfaces between the subprojects established that promote the transparent flow of information. Project members plan their work scopes and assume direct responsibility for coordination with other sub-projects.

The success of the improved efficiencies experienced during the "One Team" approach for Unit 2 engineering has led OPG to seek to expand the team integration to the TG and RFR projects.[37] OPG's One Team principles are based on an approach that does not take away vendor roles and responsibilities or change any rights and obligations of OPG or its vendors from what is provided in the individual agreements between those parties.[38] What the One Team approach offers is: an increase in collaboration, optimization of processes, removal of organizational silos, streamlining redundant functions/positions, increasing transparency, and ensures the best qualified personnel are deployed in the appropriate roles on a prioritized basis.[39] All this supports an overarching objective of the One Team approach to improve performance in safety, quality, cost, and schedule; the four pillars of success in the Program.[40]

As the Balance of Plant (BOP) work is less complex than that of the TG and RFR work, OPG consciously made the decision not to use the One Team approach on BOP work. Further, engineering replication for the Remaining Units has been moved inside OPG and some scopes of work have been reassigned with OPG to align work more closely to existing organizational strengths.[41]

I find these changes to be reasonable and that these changes should see positive affects to overall performance on the Program, including cost and schedule.

Q. Is it industry practice to enhance contract management strategies based on execution experience?

A. Yes. There are five common objectives to every megaproject (safety, scope, cost, schedule, and quality). They can be achieved by establishing reasonable span of control, testing the implementation of policies and procedures at the project level, and instituting a continuous improvement loop using lessons learned. By using collaborative management systems, tools and approach, the project teams are an active, learning, problem solving organization that adapts to changes in conditions, seeking solutions and averting problems before they happen. Enhancing contract management as experience is gained on actual execution of the work and implementation of the contracts should be expected as a standard contract management practice and is a key component of collaboration management. As explained by McKinsey & Company, *"Collaborative contracting is also geared toward building better relationships, but it lies within the fold of traditional contracting. In encourages more cooperative relationships along a project's contracting life cycle…by offering incentives for various cooperative practices and behaviors. And it achieves this collaboration without completely overhauling the way the contractual relationships work."*[42]

Q. What were your overall findings on OPG's contract management?

A. I found that OPG has taken proactive steps in best aligning its contract management for the execution of the Remaining Units based on positive results of the Unit 2 engineering "One Team" approach that enhanced the collaboration management on the Program. The progress made should provide OPG with additional confidence that the TG and RFR work can be accomplished within the planned budget and schedule.[43] Further, the amendment to the RFR contract has an

appropriate adjustment to the contract management strategy through the introduction of additional collaborative principles and enhancements to the incentive and disincentive mechanics which should drive improved performance in the Remaining Units.

Q. What were the enhancements made to the incentive and disincentive mechanism of the RFR contract?

A. Through the return to service of Unit 2 in June 2020, OPG and CanAtom worked to resolve outstanding commercial issues related to Unit 2 and apply their Unit 2 experience to planning for the Remaining Units. As part of their resolution, , the parties agreed to enhance the incentive and disincentive structure to put the parties in a position to execute the Remaining Units more efficiently based on the experience and lessons learned from Unit 2.[44] These incentives/disincentives are directly tied to the cost and schedule performance of the contractor, which benefits both parties by aligning the goals and objectives of the parties towards successful execution and completion of the Remaining Units. For example, a new schedule incentive is tied to the more aggressive working schedule (previously the schedule incentive was only tied to longer execution durations) where the contractor receives an incentive up to $25 million for achieving completion per the working schedule. OPG benefits from this approach as if the working schedule is achieved, it will have unused schedule contingency (greater than the incentive amount) that it can apply to this incentive. Similarly, the cost targets in this agreement are structured to better align goals such that the contractor has the opportunity to share in the cost savings should the work be completed under a set threshold, and likewise penalties are in place should the costs exceed set thresholds. The cost and schedule thresholds under the new incentive/disincentive regimen were developed such that there is no neutral band between the incentives being obtained and the disincentives being realized, thus putting OPG in a stronger position where it either realizes the improved contractor performance or it recovers additional costs from the contractor should the incentive thresholds not be met.

Q. Is it reasonable and appropriate to revise contractual incentives/disincentives during the execution of a megaprogram?

A. Yes, in my experience adjusting the contractual incentives and/or disincentives to reflect the actual execution experience is an appropriate method of ensuring the contractual mechanisms in place support the successful execution of the megaprogram, particularly given the complexity and unknown issues that are frequently encountered on these programs. As the authors of "Five Rules for Managing Large, Complex Projects" noted, *"Complexity usually increases with project scale, and complexity can give rise to uncertainty and an inability to foresee the difficulties, changing conditions, and unanticipated opportunities that will be encountered…we argue that one way to manage the uncertainties is to innovate throughout the course of the project."* The authors further stated that, *"The client creates incentives encouraging contractors working on the project to reveal problems, recover costs, achieve agreed-upon profit margins, exploit innovative possibilities, and build solutions."*[45] Thus, not only is adjusting contractual incentives/disincentives a reasonable mechanism to managing the Program, it can provide benefits to both parties and help ensure successful completion of the Program.

D. UNIT-OVER-UNIT SCOPE CHANGES

Q. What are the changes in scope from Unit 2 to Unit 3?

A. The majority of work across the four units in the DRP is the same scope, however, there are specific scope differences that exist, including notably the TG controls upgrade (for Units 3, 1, and 4) and the Generator Stator in-situ rewind (for Units 3 and 4) that were not performed during the Unit 2 execution. Likewise, refurbishment support facilities (e.g. shop & work areas, washrooms, radiation protection facility, etc.) that were part of the Unit 2 scope will continue to be used across the Remaining Units, but expectedly will not have to be reconstructed. Other items within the Unit 2 scope that are not repeated include one-time defuel engineering.[46]

One of the changes from the Unit 2 execution will be the strategic improvement that will implement new tooling not used on Unit 2. Collectively these new tooling improvements are referred to as "Darlington Unit 3 Improvements Project" (D3IP) and have been incorporated as an additional scope item for Unit 3.[47] While it will continue to be utilized in Units 1 and 4, the costs are captured within the Unit 3 estimate and are expected to be more than offset by productivity and schedule improvements.[48]

Q. Were there any notable scope changes for any vendors/contractors from Unit 2 to Units 3, 1 and 4?

A. Yes. With respect to the TG – the initial plan was to replace the Unit 3 stator with a new stator and subsequently rewind the removed Unit 3 stator for installation in Unit 4.[49] The Unit 4 stator would then be rewound and used as the Station spare.[50] OPG evaluated the alternative of an in-situ rewind on the turbine floor for Unit 3 and Unit 4, based on GE's proposal for this work and its multiple experiences globally in performing similar work.[51] Rewinding the generator in-situ will not require the TG Project to fully disassemble the generator or lifting and rigging of the stator. Completing the stator re-wind in-situ removes the stator lifting and rigging risk, a significant risk reduction. In this scenario, the new purchased stator will become the Station spare. OPG accordingly, concluded this scope change in addition to reducing risk, should result in both a cost and schedule savings.[52] Since GE is the Original Equipment Manufacturer (OEM) on the mechanical equipment (GE bought out Alstom) and it is the same turbine set as is utilized in US plants where GE performs the same work regularly, I found that OPG's decision to be reasonable based on the GE proposed time/cost savings that supported this decision (can be completed in approximately two months vs. approximately seven months as originally planned).[53] Similarly, a change in execution strategy was implemented for the TG shaft line inspection and maintenance scope and Unit 1 rotor pull and inspection.[54] Like the stator change in execution strategy, this scope was originally awarded to CanAtom, but OPG determined that by awarding

the TG shaft line inspection and maintenance scope to GE that cost and schedule savings could be realized, as well as having the benefit of the OEM executing the work.[55] Additionally, GE confirmed with OPG it intends to use the majority of the same resources, including all key personnel and tooling and test equipment, that it used at Bruce Power for these scopes of work, which benefits OPG as these resources already performed an audit an accounting of all tools to ensure the performance, functionality, and certification/calibration is up to date.[56] I found this decision to be reasonable and prudent as this change in strategy is expected to result in savings across Units 3, 1, and 4 and reduce the duration of the shaft line work from 250 days to 54 days.[57] I further found that as CanAtom will retain all the modifications in the TG controls upgrades, CanAtom will be well positioned to successfully complete this work in accordance with the planned budget and schedule as CanAtom will be able to focus its work strictly on the modifications.[58]

Q. How have these scope changes been accounted for in the planning for execution of Unit 3 including the cost and schedule estimates?

A. The differences in scope between Unit 2 and Unit 3 have been specifically identified and reviewed by OPG and are reflected in the current cost and schedule estimates for Unit 3, including detailed comparisons of how the scope differences have driven variances to the cost and schedule estimates.

A prime example of how the scope changes have influenced the planning and affected the cost and schedule estimates is through the D3IP tooling improvements, which are discussed in greater detail in the lessons learned discussion below. These D3IP tooling improvements have a total estimated cost of $65 million, which has been included in the Unit 3 cost estimate and is further expected to have a net-zero cost from the efficiencies the investments support.[59] The benefits from these tooling improvements have similarly been captured in the respective Units 3, 1, and 4 schedules where approximately 60 days savings for each unit's critical path are anticipated.[60]

Q. Are there notable scope changes for Units 1 and 4 as well?

A. As noted above, the majority of the scope remains consistent across each of the Units, however, there are some minor differences going forward on Units 1 and 4. For Unit 1, it, like Unit 2 does not include a stator replacement that are part of the Unit 3 and 4 scopes.[61] Additionally, the tooling investments that represent new scope for Unit 3 will continue to be utilized for Units 1 and 4, but do not require additional investment for these subsequent units.[62] Lastly, there are certain program closeout activities that are associated solely with Unit 4, given that it is the last unit to be executed in the Program.

In summary, I find that OPG has accounted for unit-over-unit scope changes and unit-over-unit efficiency improvements in the planning for the Remaining Units and the preparation to execute Unit 3, including incorporation into the cost and schedule estimates.

E. UNIT 2 LESSONS LEARNED

Q. Please summarize the lessons learned gained from the Unit 2 execution.

A. In summary, I find that:

- In total, more than 4,000 lessons learned have been captured on the Program to date.[63] As explained in the policies and procedures discussion, OPG captures by tiers – with Tier 0 representing strategic improvements at the enterprise level; Tier 1 including FOAK/FIAW approaches, and/or significant cost/schedule savings; Tier 2 exceeding the current control budget, and/or moderate cost/schedule savings; and Tier 3 being within current scope/budget and no critical path impacts. While OPG has begun to incorporate or will incorporate open lessons learned into the Unit 3 execution plan, the majority have been in the lower tiers (Tier 2/Tier 3) based on OPG's tiered system to categorizing lessons learned, as would be expected from the lessons learned process naturally identifying a significantly higher volume of smaller/tactical lessons learned than large

over-arching or strategic improvements.[64] I find this process to be reasonable and in accordance with industry best practice.

- While many lessons learned were identified from the Unit 2 experience, OPG continuously seeks lessons learned from outside the organization as well (Bruce Power, Southern Company's Vogtle Units 3 & 4, other industry sources).
- OPG conducts post-window lessons learned meetings as a mandatory milestone following completion of a window.[65] These post-window lessons learned meetings include relevant vendor partners and other groups (e.g. operations, maintenance, system engineering, etc.) that participate in a review of the performance during execution of the window, including review of field changes, station condition reports, key risks, and cost/schedule performance in addition to identification of lessons learned.[66] For key execution windows, OPG conducts a "milestone completion report" that is intended to provide senior leadership at OPG with a high-level summary of these key execution windows, including identification of key successes and lessons learned.[67] I find this to be an effective process that should allow for continuous enhancements to better assure the efficiencies identified will be obtained.

Q. Can you provide examples of some of the more notable lessons learned?

A. Yes. The following represent the more significant lessons learned and strategic improvements that should result in cost and/or schedule savings and improve the confidence in the Program being successfully completed:

- The D3IP tooling improvements are one of the more significant categories of strategic improvements implemented by OPG. Smaller D3IP projects were deployed during execution of Unit 2 and resulted in at least 15 days of activities being eliminated or removed from the critical path and have already paid for their initial cost.[68] Additional key projects from the D3IP initiative being incorporated into the execution of Units 3, 1,

and 4 include modified installation worktables, bellow cut tool improvements, and tooling to support the combined removal of the pressure tube and calandria tube.[69] Some of these additional D3IP tooling improvements could have been available for execution during Unit 2, but because they are FOAK tools, OPG opted to reduce the risk associated with using them on the first unit of the DRP, while also reducing the risk for Units 3, 1, and 4, as the standard tooling sets remain available for use if needed. Collectively, these tooling improvements have a cost of $65 million included in the Unit 3 costs and are expected to provide an improvement of 60 critical path days per unit if successful, which would result in a net zero cost for their implementation.[70] The detailed aspects of the new tooling improvements are as follows:[71]

- Modified Installation Worktables:
  - Supports two times the tools.
  - Expected to save 26 critical path days per unit.
  - Similar tables built for Bruce Power in same shop, so low fabrication risks (not FOAK).
- Bellow Cut Tool:
  - Improvement resulted from collaboration with Bruce Power.
  - Results in faster cutter drive, faster z-drive, and an expected 4 days per unit total improvement.
  - Manufacturing on schedule, first tools shipping April 2020, with first execution planned for March 2021.
- Pressure Tube (PT)/Calandria Tube (CT) Combined Removal:
  - Expected to save 30 critical path days per unit.
  - Design complete, proof-of-principle tests complete, manufacturing in process.

1 ○ Business case approved for use on Units 1 and 4, but currently on track
2 and planning for deployment on Unit 3 (July 2021) and has been
3 incorporated into the current Unit 3 schedule.

4 • Lessons learned incorporated into the planning for the Remaining Units specific to the
5 feeder series which should increase the efficiency of the work to be performed and move
6 work off the critical path that experienced challenges during Unit 2's execution
7 including:[72]

8 ▪ While feeders were identified as a long-lead item, Unit 2 experienced delays in
9 receipt of the new feeders due to fabrication backlogs; as a result, all Unit 3
10 feeders were planned with extra procurement durations and will be received at
11 the Station at least 12 months prior to the installation window.

12 ▪ Unit 2 execution involved training boilermakers in use of machine orbital
13 welding technology; Remaining Units will utilize specialty welders with deep
14 experience to improve productivity and reduce weld-failure rates.

15 ▪ Unit 2 deployed a complex reactor-face scaffold approach to open up eight
16 quadrants for simultaneous work-face access; Unit 3 will deploy a simpler,
17 streamlined scaffold approach to reduce congestion, speed transitions from work-
18 face to work-face and leverage a smaller, more highly skilled workforce.

19 ▪ Unit 2 removed both inlet and outlet feeder stubs requiring welding new feeders
20 to header nozzles; Unit 3 will leave inlet stubs in place reducing welding risk and
21 complexity.

22 ▪ Unit 2 experienced lower feeder delays due to pushes to upper & middle feeder
23 schedules that became critical path activities; Unit 3 reflected this experience in
24 the current schedule and also benefits from the use of dedicated resources that
25 will perform this work for each subsequent unit.

- Fuel channel installation is the most complex work series in the refurbishment effort. Unit 2 lost 58 days versus the base plan, predominantly associated with coordination of materials and tools, human performance, End Fitting/Pressure Tube (EF/PT) alignment, and bellows welding. Unit 3, has reviewed the lessons learned thus improving the efficiencies of work execution by:[73]
  - Implementing better planning and coordination for organizing tools on the platform, including in training.
  - Upgrading the PT alignment tool so that it remains calibrated, is easier to use, and delivers reliable results; and
  - Improved welding process and increased number of welding machines on site.
- Training improvements that will gain not only "A team" capability, but also increase field efficiency including:[74]
  - Training as a crew – same crew, including support functions, will continue working together as one team across the Program.
  - Improvements in simulating the plant environment – augmented facilities, rubber areas mimicked, training in plastics/respirators as work requires it.
  - Training for proficiency, not qualification – training to cycle time, performance targets established and tracked with pass/fail criteria in place; and
  - Training with Comprehensive Work Packages (CWPs) and tooling that will be used in the field – CWPs developed earlier to ensure materials are properly developed.
- The strategic improvement to change to a hybrid shift schedule should result in both cost and schedule savings, as well as support improved productivity, reduced resource demand and resource retention,[75] as I will discuss later with respect to the Unit 3 Schedule.

- OPG's Radiation Protection Initiative that greatly enhances working rights and responsibilities for vendor partners with respect to making radiation protection related decisions and demonstrates OPG's commitment to worker safety including:[76]
  - "Rapid Access Program" introduced to allow supervisors to electronically identify radiation protection demands to the task level of detail. Expected benefits are improved demand predictability and resource alignment and reduced waiting times for workers entering radiation work areas; and
  - Enhanced working rights/responsibilities for vendor partners – provides opportunity for work to be performed in low level radioactive work areas without the need for resources from the Radiation Protection Team.

Q. Have any of the lessons learned already been demonstrated as effective on Unit 3?

A. Yes. I found that the Unit 3 vault vapor recovery system (VVRS), which is a component of the prerequisite work for each of the units, benefited directly from discrete Unit 2 lessons learned on engineering, construction, and commissioning of the VVRS. Two examples of these discrete lessons learned include:[77]

- On Unit 2, late delivery of materials (24" valves) contributed to delays in engineering in the planning phase and late identified changes to material specs. For Unit 3, delivery of the 24" valves were expedited, and material requirements were imbedded in the Refurbishment Milestone governance for procurement requirements for long lead materials, thus ensuring avoidance of unnecessary delays.
- On Unit 2, during the installation, a valve and drain line were plugged with desiccant that caused schedule delays. For Unit 3, action was taken to schedule prerequisite tasks for Station Maintenance to clean the drain lines in advance resulting in no delays experienced on Unit 3.

In large part due to the lessons learned implemented on the Unit 3 VVRS work, this revised scope was completed with an approximate 50% reduction to the cost and schedule compared to Unit 2.[78]

In OPG's Unit 3 VVRS post-execution effectiveness review, additional lessons learned were identified (e.g. reducing/consolidating temporary field change requests, incorrect wiring of the limit switches on the 24" containment valves, etc.) that were incorporated into the planning and execution for Unit 1 and Unit 4.[79]

Q. Has OPG implemented other improvements to improve performance and efficiency on the Program?

A. Yes. OPG has introduced a Lean/Kaizen program to seek additional improvements in the work processes and execution, which I find should result in both a cost and schedule savings. Current efforts include CWP review improvements, bulkhead installation process improvements as follows:[80]

- CWP review process improvement – expected to reduce content/volume by 50%; combined work processes to streamline CWP preparation, review, and approval;
- Bulkhead Installation process improvement – improved workflow/integration, leading to high confidence in completing work in the schedule duration; and
- Will continue to use across other applications in the future (e.g. retube tooling platform installation, documentation process, onboarding, feeders).

Q. Do the lessons learned captured on the Program support unit-over-unit productivity improvements?

A. Yes, by the very nature of lessons learned, they have an overall objective to improve future performance by means such as identifying more efficient practices, avoiding issues encountered,

ensuring resource and material availability. Beyond lessons learned, the "experience curve" or "learning curve" theory provides that *"as more and more units of a technology are produced, managers gain experience with the production process and may learn how to improve it, e.g. by increasing work specialisation or by reducing waste. Workers may become more efficient in their respective tasks as they continuously repeat their individual production steps."*[81] Thus, based on my experience and industry best practices, repeated work from unit-to-unit is expected to result in efficiency gains not only from lessons learned, but from the natural repetition of work.

I conclude that OPG has positioned itself to realize these productivity improvements and efficiencies by implementing a robust lessons learned program and undertaking other strategic improvements such as the training improvements discussed above.

Q. Have the lessons learned been incorporated into Unit 3 planning including the cost and schedule estimates?

A. Yes. OPG has appropriately captured lessons learned from the execution of Unit 2 that were incorporated into the planning of the Remaining Units. I find that the robust lessons learned program implemented by OPG improves the planning efforts of future units and should result in significant efficiencies that will lead to cost and schedule savings as well as reducing risks and enhancing available labor skills, labor retention, and work safety.

V. CURRENT COST AND SCHEDULE ESTIMATES

A. OVERALL FINDINGS

Q. What are your overall findings with regard to the development of the Unit 3 cost and schedule estimates?

A. I find that both the development of cost and schedule estimates for Unit 3 (as well as Units 1 and 4) have benefited from the gate review process utilized by OPG that ensures:

- checks are performed at specific key milestones, usually tied to a funding release,

- lessons learned are incorporated,
- assumptions are challenged, and
- risks are assessed, reviewed, and quantified.

Both the schedule and cost estimates, including contingency development, continued to follow industry standard practices similar to what was observed in the Unit 2 planning efforts.

Further I conclude that:

- As detailed in the November 2015 Board material, OPG established a funding release strategy for executing the Program that explained *"Management will request a release funds* [sic] *in advance of each unit's execution period to complete unit specific planning and mobilization activities including the preparation of a unit 'check' estimate to confirm that the cost and schedule is bounded by the execution phase business case…"*[82]
- OPG has effective processes that are rooted in industry standard practices for reviewing and updating the cost and schedule estimates of the Remaining Units. The processes account for actual experience, lessons learned, strategic improvements, and other factors that result in updated cost and schedule estimates and thus, provide a greater assurance to OPG on the status of the overall Program.
- The contingency process remains in alignment with industry standards and the steps taken by OPG during its recent contingency assessment provide confidence that Unit 3 can be completed within its schedule and estimate.
- The Unit 3 schedule was refined based on the actual Unit 2 experience and incorporation of lessons learned and other strategic improvements undertaken by OPG. By using a hybrid shift schedule, OPG improves its ability not only to retain staff, but also benefits from expected improvements in productivity and the opportunity of having "implied float" on the non-working days, which can serve to recover lost time if needed based on a cost/benefit analysis of the then-current Program status.[83]

- The cost and schedule estimates were also subjected to an independent review, in alignment with industry standards.[84] The independent review confirmed that an appropriate and robust process was utilized in their development.[85]

Q. How did the Covid-19 pandemic affect OPG's planning for the Remaining Units?

A. Following the pandemic declaration by the Provincial Government of Ontario on March 17, 2020, OPG made the decision to focus on completion of return-to-service work on Unit 2, suspend all pre-requisite work for the Remaining Units inside the station protected area, and implement new measures to promote safety of OPG's employees, vendor partners, and the public in alignment with mandates and guidelines from the Provincial Government of Ontario. As more was learned about the pandemic, OPG made the decision on May 5, 2020 to delay the start of the Unit 3 outage approximately four months to September 3, 2020. After evaluating how this delay to Unit 3 would impact the overlap of the Remaining Units, OPG determined it was appropriate to also delay Unit 1 and Unit 4 by the same four-month duration. This allows the overlap between units to remain as previously planned and maintains an end date for the Program before the end of 2026.[86] I found this to be an appropriate decision that balances the plan to execute the Program with the impacts and uncertainties present due to the Covid-19 pandemic.

Q. Are there cost impacts associated with the delay in execution of the Remaining Units associated with the Covid-19 pandemic?

A. OPG has evaluated the impacts associated with the four-month delay to the Remaining Units and determined an expected impact of $150 million. Because of the uncertainty surrounding the pandemic, OPG is monitoring and tracking expenditures related to the pandemic separately from the general Program expenditures and will continue to assess opportunities to mitigate the impacts.[87]

Q. Is it reasonable for OPG to be tracking the costs associated with the Covid-19 pandemic separately from the Program and not have included a contingency for such an event within the $12.8B Program estimate?

A. Yes. I find the Covid-19 pandemic to be a Black Swan event or an unknown unknown for which could not have reasonably been foreseen and as a Black Swan event, would not be included in Program contingency as such an event cannot be reasonably estimated. I find the process and methodology for how OPG is tracking the costs separately from the $12.8B Program estimate to be reasonable and typical for how such unforeseen unknown unknowns are treated.

Q. What are your overall opinions of the current Unit 3 cost estimate?

A. The current cost estimate for Unit 3 is $2.559 billion (originally including $257 million of contingency, since drawn down to $240 million) based on a P90 confidence factor.[88] I evaluated the estimate and I find that the estimate has incorporated lessons learned from the Unit 2 execution, including strategies and initiatives implemented by OPG to improve performance, and represents a Class 2 estimate. Some of the increase in the base estimate (and reduction in contingency) was attributed to the actual upper and lower feeder work on Unit 2, which was over-budget and schedule.[89] The lessons learned discussed earlier have been incorporated to eliminate and/or minimize those risks on the Remaining Units.[90]

Q. What is your overall opinion regarding the cost estimate development for Units 1 and 4?

A. I find the Units 1 and 4 cost estimates have similarly been updated based on the risks and opportunities identified from the Unit 2 experience and the further refinement of the Unit 3 estimate (such as including savings from the capital investment in tooling improvements and the change to hybrid shifts). Additionally, the last two units are anticipated to further benefit from the additional experience and lessons learned gained on Unit 3, including the strategic improvements relating to training and transitioning that are expected to further improve unit-over-unit

1 productivity. Other savings from Unit 3 to future units include: modification packages issued by
2 engineering that will be applied to the other Remaining Units, reduced PMT or shared resources
3 attributable to overlapping units, and tooling procured for Unit 3 that can largely be
4 repaired/reused on Units 1 and 4.[91]
5 The current cost estimate for Unit 1 is $1.954 billion (including $233 million of contingency) and
6 the current cost estimate for Unit 4 is $2.106 billion (including $207 million of contingency),[92]
7 each of which will continue to be refined and updated through the gated process utilized by OPG
8 as additional lessons learned are identified and incorporated and as each unit moves closer to
9 execution.
10
11 **B. COST ESTIMATES**
12 **Q. How has the Unit 3 estimate changed since the RQE?**
13 A. At the Release Quality Estimate (RQE), the Unit 3 cost estimate was $2.408 billion (including
14 $524 million of contingency);[93] in November 2019, OPG's Board approved the full release of
15 Unit 3 funding based on a then current Unit 3 cost estimate is $2.559 billion (including $257
16 million of contingency).[94] Since that time, OPG has continued with detailed planning and
17 preparations for the Unit 3 execution, including responding to the emergence of the Covid-19
18 pandemic. In August 2020, OPG's Board reaffirmed the current Unit 3 cost estimate of $2.559
19 billion (with contingency reduced to $240 million through drawdowns on contingency since
20 November 2019), and revisited the risks and opportunities to confirm the remaining amount is
21 sufficient to address unknown risks in Unit 3.[95] The primary changes from the Unit 3 estimate as
22 of the RQE to the current Unit 3 cost estimate are:[96]
23 • Incorporation of lessons learned and strategic improvements;
24 • Capital investment in tooling improvements;
25 • Transfer to Unit 3 of pressure tubes, end fittings, and GE controls purchased on Unit 2;

- Delay of breaker open to September 2020 and a revised working schedule of 1,096 days; and
- Unit-over-unit productivity improvements and observed experience on Unit 2. More specifically, some of the increase in the base estimate (and reduction in contingency) was attributed to the actual upper and lower feeder work on Unit 2.

Q. Is it typical for a Program to have updated estimates through its execution?

A. Yes, it is industry standard practice to not only have recurring current forecast updates, but also to perform updated estimates as the Program advances. As PMI notes, *"Program cost estimating is performed throughout the course of the program. Many organizations use a tiered funding process with a series of go/no-go decisions at each major stage of the program."*[97] This "tiered funding process" described by PMI is the same process used by OPG through its gate review process, including updated cost estimates at the gate review points.

Q. What assumptions were incorporated into the Unit 3 cost estimate that did not form assumptions in the Unit 2 cost estimate?

A. Other than different assumptions that relate to the difference in scope between the two units, the primary change to cost estimate assumptions on Unit 3 from Unit 2 is the incorporation of actual Unit 2 experience – lessons learned, observed productivity, scope changes for certain vendors (e.g. GE and CanAtom discussed previously), and other strategic improvements implemented.[98]

Q. Are any of those assumptions also being applied to Units 1 and 4?

A. Yes. As with the differences from Unit 2 to Unit 3, the current estimates for Units 1 and 4 also reflect the changes in scope and benefits expected from the execution experience gained from Units 2 and 3. For example, the Unit 1 current estimate shows approximately $0.3 billion in lower costs from Unit 3, which are attributed to:[99] modification packages issued by engineering that will

be applied to Units 1 and 4; reduced PMT or shared resources attributed to overlapping units; and tooling procured during Unit 3 will largely be repaired and re-used on Units 1 and 4. In addition, further productivity improvements are expected due to the lessons learned and utilizing specialized crews that transition between units (which also reduces training costs).

Q. What class of estimate is the Unit 3 current cost estimate considered?

A. I found that OPG considers the Unit 3 cost estimate to be a Class 2 estimate, which I concur as the estimate class is supported by the maturity of the Program, with Unit 3 design engineering over 90% complete and the comprehensive work packages over 50% complete.[100] I find this aligns with the AACE estimate classification system, which stipulates that a Class 2 cost estimate has a maturity level of project definition deliverables of 30% to 75%.[101]

Q. What is the expected accuracy range of a Class 2 cost estimate?

A. Per AACE, the cost estimate classification system for the process industries[102] establishes that a Class 2 estimate has an expected accuracy range of -5% to -15% and +5% to +20%.[103]

Q. What was the status of the Unit 1 and 4 estimates as of the RQE and how have those estimates since changed?

A. As of the RQE, the Unit 1estimate was $2.138 billion and the Unit 4 estimate was $2.208 billion, both including contingency and interest.[104]

Both the Unit 1 and Unit 4 cost estimates have been updated in conjunction with the updates to the Unit 3 estimate, such as the Unit 3 Execution Estimate (U3EE) and the updated estimate approved in November 2019.[105] With the final U3EE approved in August 2020, there was no change from the updated estimate approved in November 2019 with the current Unit 1 estimate at $1.954 billion and the current Unit 4 estimate at $2.106 billion.[106] From the RQE, the Unit 1 and Unit 4 estimates have experienced modest reductions to each estimate attributed to reduced PMT

or shared resources attributable to the overlapping units, re-using tooling procured for Unit 3, and productivity improvements anticipated from the lessons learned, D3IP investments, and other similar improvements to enhance performance.[107]

Q. What are the next steps for the Units 1 and 4 cost estimates?

A. As with the Unit 3 estimate, the cost estimates for Units 1 and 4 will undergo detailed reviews and assessments as they get closer to their execution dates following the gated process that OPG has utilized for Units 2 and 3.

Q. Has OPG appropriately considered the experience from Unit 2 in updating the Units 3, 1 and 4 cost estimates?

A. Yes. As I discuss in detail elsewhere in this testimony, the Unit 2 experience has been a key component in updating the Units 3, 1, and 4 estimates. This is a standard industry practice, as noted by the U.S. Government Accountability Office (GAO), *"Accurate cost estimates are rooted in historical data. These data provide insight into actual costs of similar programs, including any cost growth from the original baseline estimate. Historical data can be used to challenge optimistic assumptions and bring more realism to the estimate. Thus, collecting valid and useful historical data is a key step in developing a sound cost estimate."*[108]

Similarly, for example, once detailed design and regulatory approvals were completed, updates to the Vogtle program estimate were developed. Also, once Crossrail One was completed, experience obtained in execution of the first Crossrail Program was obtained, this information formed the update to the next Crossrail Program.

Q. Please provide examples of how the Unit 2 experience has influenced the current cost estimates.

A. During the updating of the Unit 3 estimate, part of the review process implemented by OPG included confirming that the cost elements that comprise the estimate were reflective of the actual Unit 2 experience, including lessons learned and other strategic improvements that stemmed from the Unit 2 experience. Specific examples of how the Unit 2 experience has influenced the current Unit 3 estimate include the following changes from the Unit 3 RQE estimate:[109]

- RFR increased $55 million from direct field labor productivity observed on Unit 2;
- Major Systems increased $16 million from direct field labor productivity observed on Unit 2; and
- OPG functions (project management, operations, and maintenance support) increased by $30 million based on a bottoms up assessment, reductions of headcount from Unit 2, and increases in Radiation Protection support services; and
- Lower body tubing had an initial plan for Unit 2 to perform the work off the critical path. It was later determined this was not possible, so it has been built into the Units 3, 1, and 4 schedules, resulting in slightly longer PMT carrying costs in the current estimates due to the longer duration established in the working schedule.

These increases were largely offset by changes to contingency (funds shifting from being held in contingency to the base estimate), which are discussed in more detail below.

Q. Do the additional or revised assumptions provide a greater level of confidence that the cost estimates for Units 3, 1 and 4 can be achieved?

A. Yes. As would be expected during the continued refinement of cost estimates, actual experience including lessons learned, new strategic improvements, risk management activities, and observed productivity figures result in less uncertainty associated with the cost estimate. The overall 4-unit estimate remains at $12.8 billion, which I still find to be achievable based on the Unit 2

execution, and lessons learned and strategic improvements that have been incorporated into Unit 3 execution and planning for Units 1 and 4.

Q. Has the process to update the Units 3, 1, and 4 estimates followed industry standard practices?

A. Yes. As noted by the GAO in its *Cost Estimating and Assessment Guide*, *"Regardless of whether changes to the program result from a major contract modification or other factors, the cost estimate should be regularly updated to reflect all changes. The estimate should also be kept current as the program passes through new phases or milestones."*[110] The GAO identified several key activities related to updating the cost estimate, a list of these activities alongside actions taken by OPG is provided in the following table.

GAO Cost Estimating and Assessment Guide[111]	OPG's Actions [using the RFR bundle as an example][112]
"documenting all changes that affect the overall program estimate so that differences from past estimates can be tracked"	Compares current estimate against prior estimates, noting the changes to assumptions (e.g. delay of U3 breaker open).
"updating the estimate as requirements change, or at major milestones, and reconciling the program budget"	This estimate was prepared at the Gate 3A checkpoint to support full funding of the U3 RFR execution phase.
"updating estimates with EVM estimates at completion (EACs) and independent EACs, if applicable"	The estimate was based on Unit 2 experience (material price, labor costs, etc.) and reviewed to challenge underlying productivity assumptions and costs, comparisons of key labor ratios, shift structures & crew makeup, and included an estimate from CanAtom.
"updating the estimate with actual costs as they become available during the program's life cycle"	The current estimate developed using actual Unit 2 experience.
"recording reasons for variances so that the estimate's accuracy can be tracked"	Variances between the current actuals to the Gate 2A plan are identified and noted.
"recording actual costs and other pertinent technical information such as source lines of code sizing, effort, schedule, risk items, and the like so they can be used for estimating future programs"	Each critical path activity was reviewed for logic, uncertainty, and risk, additionally discrete risks were reviewed – the output was consolidated and aggregated into a combined RFR risk register that was modeled in a Monte Carlo simulation.
"assessing and recording lessons learned as the program progresses to inform the next version of the estimate"	Lessons learned (e.g. bulkhead execution and fuel channel install) were captured in addition to OPG's strategic improvements (e.g. hybrid

GAO Cost Estimating and Assessment Guide[111]	OPG's Actions [using the RFR bundle as an example][112]
	shift approach, D3IP tooling improvements, etc.).

1

2 **C. CONTINGENCY**

3 **Q. Has the amount of contingency changed since the RQE?**

4 A. Yes, as would be expected through the process of updating the estimate to reflect the additional
5 definition and experience gained. At the RQE, contingency on the full $12.8 billion program was
6 approximately $2.0 billion, split between bundle/project level, schedule contingencies, and
7 program level contingency.[113] For Unit 3, its contingency was set at $557 million as of the Unit 2
8 Execution Estimate (U2EE).[114] Since that time, and per OPG's procedures, contingency has been
9 reassessed, which culminated in a reduction of contingency to $257 million when the Unit 3
10 estimate was updated and the Board approved full funding for execution in November 2019.[115]
11 The reduction largely reflects the observed direct field labor productivity and lessons learned that
12 are now included in the base estimate, additionally from the Board approval in November 2019 to
13 the final execution estimate approved in August 2020 (which did not change the estimate),
14 contingency was reduced to $240 million after approximately $17 million in drawdowns.[116] The
15 contingency amounts for Units 1 and 4 were similarly reduced based on the better definition of
16 scope and risk, including the observed experience on the Program to date.[117]

17

18 **Q. Is the amount of contingency still based on a P90 confidence level and do you find the**
19 **amount of contingency to be reasonable?**

20 A. Yes. I find the contingency assessment to have been robust and in accordance with industry best
21 practices and consistent with how the Unit 2 contingency was developed, including maintaining
22 the same confidence level which is appropriate when executing a program. Contingency for Unit
23 3 was fully reassessed with a revised Monte Carlo analysis.[118] As a result, the U3EE included

1 contingency of $257 million, representing 11% of the base estimate or 17% of the amount of base
2 estimate that is risk-exposed (i.e. removing actuals and fixed cost items from the base estimate)
3 and is within the expected range for a Class 1/2 estimate.[119] At the start of the Program, there
4 were several unknowns that were reflected in the Unit 2 contingency and for which that
5 contingency amount was utilized to cover such unknowns when (and if) they became realized
6 during execution. As Unit 3 was being planned, aspects that were initially unknown for Unit 2
7 was now reflected as known work and as such, the estimate for those scopes of work adjusted to
8 reflect these known aspects in the actual base cost estimate, thereby reducing the amount of
9 contingency for unknowns for Unit 3 from the contingency amount estimated for Unit 2.[120]
10
11 **Q. How was the contingency assessed for Unit 3?**
12 A. The updated contingency assessment for Unit 3 included the following:[121]
13 • Unit 2 risks were reviewed and reassessed, based on lessons learned and operating
14 experience, and new risks were identified and created in the risk management software
15 platform. The resulting list was reviewed and challenged in multiple sessions to align,
16 address gaps, and remove duplication. The risks were then further refined and given
17 quantitative values for probability, cost, and schedule impacts with 3-point estimates used
18 as inputs to the risk model.
19 • Risks that can impact the critical path were linked to specific windows to determine
20 schedule risk uncertainty in addition to schedule uncertainty and were used as inputs to
21 the risk model.
22 • FOAK/FIAW meetings were also created for specific scope on Unit 3 to review,
23 evaluate, and challenge project work and processes to ensure sufficient planning and
24 management of risk. The FOAK risk has been reduced on Unit 3, albeit the TG control
25 scope was not part of Unit 2 and the approach to be undertaken by GE has not been

previously tested by OPG. However, as GE has significant experience in this area, I find, based on the information I have reviewed, that this risk should be relatively minimal. This process follows industry standards such as those prescribed by AACE, which note that expert judgment, predetermined guidelines (with varying degrees of judgment and empiricism used), and similar analysis (primarily expert judgment incorporated in a simulation) are all appropriate methods used to estimate contingency. More specifically, AACE prescribes that *"…the best approach is sometimes to use two or more methods to estimate risk cost/time."*[122] The following table shows how OPG applied this hybrid-type approach of industry standard contingency development practices.

AACE Recommended Practice[123]	**OPG's Contingency Development Process**[124]
Expert Judgement: *"This method is largely self-explanatory. The term 'expert' explicitly means that the judgement must have a strong basis in experience and be backed up by competency in risk management and analysis. The results of all methods are improved to the extent that expertise and good judgment is brought to bear (i.e. most methods are to some extent hybrid combinations employing expert judgment). However, this method is highly subject to imposing iatrogenic risk when the judgment is inconsistent or biased. Bias can be minimized by obtaining the consensus of multiple experts or an experienced team, provided there is varied, independent opinion (i.e., avoid 'group-think')."*	*"The project team may engage the estimating subject matter experts* [SMEs] *in supporting the determination of the cost impact of a risk, and the evaluation of the cost uncertainty range compared to the project plan and estimate."*
Predetermined Guidelines: *"This method may be as simple as providing a single contingency of float value (e.g., percentage of base cost or duration) for use on all estimates or schedules of a certain type to complex tables or scoring mechanisms that employ elements of parametric modeling. A common approach is to establish a table of contingency values and ranges for each of AACE's estimate or schedule classes with alternate values and ranges provided for common risks such as the use of new technology."*	*"The project manager and PMO* [Program Management Office] *risk management SME should jointly conduct the risk contingency adequacy review (project levels A/B/C). The project should use Association for the Advancement of Cost Engineering (AACE) standards as the guideline to evaluate contingency adequacy range per estimate classification."*

AACE Recommended Practice[123]	OPG's Contingency Development Process[124]
Simulation Analysis: *"This method combines expert judgment with an analytical model that is then used in a simulation routine to provide probabilistic output."*	*"Performed by the PMO risk management SME based on project team schedule, cost and risk input. Contingency estimate for the project is calculated based on three contributors – discrete risks (known unknowns), cost uncertainty and schedule uncertainty. ...* *The project team should populate the Monte Carlo input file with support from the PMO risk management SME."*
Parametric Modeling: *"A parametric model is generally an algorithm that is derived from multi-variable regression analysis of quantified risk drivers versus cost growth or schedule slip outcomes for historical projects."*	*"Quantitative risk analysis takes into account probabilistic or project-wide effects, such as correlation between risks, interdependency, and feedback loops, thereby indicating the degree of overall risk faced by the project.* *The results of quantitative analysis should be used to focus the development of appropriate responses, particularly the calculation of required contingency."*

Q. What were the main drivers to the change in contingency for Unit 3?

A. The Unit 3 contingency was established at the November 2019 U3EE at $257 million, which was reduced from $557 million as of the U2EE and $305 million as of the March 2019 U3EE, and is comprised of four primary categories, each of which was adjusted through the updated contingency analyses and include the following:[125]

- Discrete Risks: OPG reviewed the Unit 2 risks for relevancy to Unit 3 and utilized lessons learned and operating experience to reassess old risks and identify new risks. These risks were then compiled and discussed in challenge sessions to ensure alignment, gaps were addressed, and duplicates removed. The risks were then further refined and given quantitative values for probability, cost, and schedule impacts with 3-point estimates used as inputs to the contingency model.

- Cost Uncertainty: Costs estimates provided by the project teams and estimating groups were based on actual Unit 2 experience and lessons learned with a range based on estimate classification in alignment with AACE standards, culminating in 3-point estimates that were used as inputs to the contingency model.

- Schedule Contingency: Based on the planned schedule durations for Unit 3, review meetings were held to determine 3-point durations for the critical path schedule that were rooted in actual experience on Unit 2 and lessons learned and then used as inputs to the contingency model.

- Interest & Escalation on Contingency: Reflective of the adjustments made to the other primary categories of contingency.

While each fully updated contingency analysis performed will result in changes to virtually every detailed item that comprises the full contingency, the primary changes in the Unit 3 contingency are reflective of the observed direct field labor productivity and lessons learned from the Unit 2 experience that have been incorporated into the base estimate (i.e. shifted from being held in contingency to part of the base estimate based on the Unit 2 experience). Following approval of the U3EE in November 2019, OPG has drawn approximately $17 million from the Unit 3 contingency and OPG's Board reaffirmed that the remaining balance of $240 million is appropriate for the execution of Unit 3.[126] I find that the process utilized by OPG to update its contingency, including accounting for actual experience, and undertaking various reviews and challenges, is appropriate and aligns with industry standards. The result is a high-confidence view of the potential risks and associated impacts, providing OPG with the information needed to appropriately manage and control such risks within the overall Unit 3 estimate.

Q. Do these drivers also apply to Units 1 and 4?

A. Yes. Current contingency estimates for Units 1 and 4 have been similarly updated as they were for Unit 3, however, as the risk profiles for Units 1 and 4 have not been finalized, the risk analysis was more robust for Unit 3 at this time. As a result of the updated analysis, the contingency for Units 1 and 4 has similarly been reduced (with a corresponding increase to the base cost) based largely on the direct field labor productivity and lessons learned from the Unit 2 experience.[127] As Units 1 and 4 move close to execution, OPG will continue to monitor, review, and reassess the contingency as appropriate based on the continued experience and lessons learned gained. As discussed above, I found OPG's process of updating the contingency estimate at key program milestones and utilizing current experience to be aligned with industry standard practices and supports having more current and accurate information as these future units get closer to execution.

Q. In your view, is there an appropriate amount of contingency in the estimates for Units 3, 1 and 4?

A. Yes. The contingency process remains in alignment with industry standards and based on the now known scope of work having been performed in Unit 2 and the steps taken by OPG during its recent contingency assessment that reflect updated productivity assumptions, lessons learned, strategic improvements, and other factors, I find that it provides confidence that Unit 3 can be completed within its schedule and estimate.

Q. How has contingency been allocated on the overall Program?

A. OPG has assessed the contingency per unit based on the known and unknown scope and risks for each unit. Should there be any remaining contingency from Unit 3, the remaining contingency would be reallocated between Units 1 and 4 based on the then-current risk profiles of those units. As noted by the AACE, contingency is "[a]*n amount added to an estimate to allow for items,*

conditions, or events for which the state, occurrence, or effect is uncertain and that experience shows will likely result, in aggregate, in additional costs…and is expected to be expended."[128]

Q. Do you consider the remaining contingency to be an appropriate amount for executing the remainder of the Program?

A. Yes. The current contingency is based on thorough reviews and analyses undertaken by OPG. In the recent update to the Unit 3 contingency, OPG extended the analyses to the current Units 1 and 4 estimates to account for various future risks and opportunities, which confirmed that the current contingency allotment is sufficient and remains within the bounds of the $12.8 billion Program estimate.[129] As Units 1 and 4 move closer to execution, an execution estimate will similarly be prepared for each Unit that will include updated risk and contingency analyses based on the status of the Program at that time and any additional lessons learned from the Unit 3 execution.[130] I find OPG's process for updating contingency appropriate and in alignment with industry standards, including the resulting shift of certain funds from contingency to the base cost estimate that reflected actual experience to date. This should provide OPG with increased confidence that the Program can be completed within the $12.8 billion Program estimate. In the August 2020 U3EE reaffirmation, OPG also revisited the risk and opportunities profile for Units 1 and 4 to confirm the 4-unit contingency allotment is sufficient and within the $12.8 billion Program commitment.[131]

Q. Is the approximate $150 million in Covid-19 related costs covered by the contingency funds?

A. No. As I discussed earlier, as the contingency funds were established based on a robust analysis of the Program's risk profile. The Covid-19 pandemic is considered a "Black Swan" type event, meaning a true unforeseen event outside what was contemplated and as such it is not reflected in

the contingency.[132] As I also discussed earlier, OPG is tracking these Covid-19 related expenditures separately and will continue to evaluate opportunities to mitigate the impact.[133]

D. SCHEDULE

Q. What is your overall conclusion related to the development of the Baseline Schedule for Unit 3 and the high-level development for Units 1 and 4?

A. I find that the Unit 3, 1, and 4 schedules have high-confidence durations that are unchanged, although the start dates have been adjusted based on the delays to Unit 2 and later based on the response to the Covid-19 pandemic. The Units 1 and 4 schedules will continue to be developed based on the experience realized through the execution of Unit 3 and go through the same gate review process utilized by OPG in preparing for execution of Unit 2 and Unit 3.

For Unit 3, the schedule was built from review of the CWPs up that reflected the level of effort needed to perform the work, based on actual Unit 2 experience with consideration of lessons learned and other initiatives like the tooling improvements.[134] The Unit 3 working schedule duration was 1,099 days as approved in November 2019 (which equates to approximately 930 critical path working days, allowing "implied float"), based on a P50 confidence factor and utilizing assumptions from the lessons learned and other initiatives, such as the hybrid shift schedule and the combined PT/CT removal, and actual Unit 2 experience/productivity.[135] Since that time, OPG identified additional opportunities to increase the efficiency of the return-to-service deliverables based on the Unit 2 experience, which resulted in a 3-day reduction in the working schedule that is now 1,096 days,[136] while the high confidence (public commitment) schedule remains at 1,216 days, unchanged from what was approved in November 2019.[137] The extra time afforded by the high confidence schedule provides additional assurance that Unit 3 can be completed on time. This aligns with industry standard practices, such as those prescribed by the GAO, which notes, *"...management should not adhere solely to a target float value...Large amounts of float may be justified, given an activity's place in the flow of work."*[138]

I find the Unit 3 schedule development, in which OPG appropriately analyzed the actual Unit 2 performance, adjusting the durations to reflect this experience, is reasonable and appropriate.

Q. What additional and revised assumptions were used in the development of the Baseline Schedule for Unit 3 from those used on the Unit 2 schedule?

A. The primary change in assumptions on the schedule is the incorporation of a hybrid shift schedule for Unit 3. In incorporating this hybrid shift approach into the schedule, OPG evaluated each critical path series to determine an optimal execution strategy based on a 24/5, 24/6, or 24/7 shift schedule.[139] As I discussed above, this hybrid shift schedule also supports a reduction in crew size (utilizing two crews instead of four), which also reduces the overall size of the PMT organization as a result in addition to supporting improved resource retention by reducing burnout on long duration series.[140]

In my experience evaluating megaprojects, it is a common practice to adjust the shifts to optimize the work. For example, the Kemper Integrated Gasification Combined Cycle (IGCC) Project utilized double shifts and weekend work as necessary to mitigate or recover the impact of unexpected issues that were encountered during the execution.

Q. Are any of the assumptions based on Unit 2 lessons learned?

A. In developing the Unit 3 schedule, OPG undertook a detailed evaluation of schedule risks, tooling and work production rates, transition times between series, and incorporation of lessons learned from Unit 2.[141] This resulted in a reduction to the critical path duration based primarily on lessons learned, strategic improvements, and the expected efficiencies to be gained including:[142]

- Exclusion of one-time events – technical issues resolved (e.g. bellows cutting tool not working as effectively as intended, lifting and rigging issues, etc.);
- Investments in new tooling (e.g. PT/CT removal in parallel); and

- Productivity and ramp up rate improvements – improved training, teams focused on specific series (e.g. removal, installation) rather than full scope to improve expertise and efficiency.

Q. Do any of the revised or additional assumptions provide a greater level of confidence that the schedule for Unit 3 can be achieved?

A. Yes. I find that all the schedule refinements to be reasonable and should not only result in greater confidence that the schedule can be achieved, but that these identified refinements are expected to also result in cost savings that have been incorporated into the current cost estimate. As additional refinements continue to be identified throughout the execution of the DRP, they too will be evaluated and incorporated as appropriate.[143]

Q. Are any of these assumptions also being applied to Units 1 and 4?

A. While only high-level schedules have been developed for Units 1 and 4 at this time, they have similarly been adjusted based on the revised assumptions utilized for Unit 3. Most notably, these subsequent unit start dates have been planned to align series windows such that dedicated execution teams can transition from one unit to the next during overlapping refurbishment for their specific scopes of work, which enables improved proficiency and productivity, and as a result, improved durations.[144]

Q. Do any of the revised or additional assumptions similarly provide a greater level of confidence for Units 1 and 4 and thus overall Program completion?

A. As with the cost estimate, having the benefit of actual Unit 2 (and later Unit 3) experience from which to add another evaluation point in developing these subsequent unit schedules will increase the confidence of having an accurate schedule that supports timely overall Program completion.

Q. Have OPG's schedule updating processes followed industry standard practices?

A. Yes. It is industry standard practice to update the schedule based on observed performance and other new information. For OPG, high-level schedules for each Unit were established at the onset of the Program, as each unit gets closer to execution, that unit's baseline schedule is updated. This aligns with what the GAO recommends, which explains, *"...as periods of summary and intermediate-level planning packages are planned in greater detail, the baseline is updated to reflect that detail."*[145] The GAO also provides four characteristics of a reliable schedule – comprehensive, well-constructed, credible, and controlled – which are detailed below in comparison to OPG's schedule development actions.

GAO Schedule Assessment Guide[146]	OPG's Actions [using the RFR bundle as an example][147]
"A comprehensive schedule includes all activities...necessary to accomplish a program's objectives as defined in the program's WBS."	Schedule review conducted to ensure the entire project scope and life cycle are included with sufficient detail to reflect the project's execution plan.
"A schedule is well-constructed if all its activities are logically sequenced with the most straightforward logic possible."	Specific review performed to ensure activities are tied in sequence logic.
"A schedule is credible if it is horizontally traceable – that is, it reflects the order of events necessary to achieve aggregated products or outcomes. It is also vertically traceable: activities in varying levels of the schedule map to one another and key dates presented to management in periodic briefings are in sync with the schedule."	"Acumen Fuse" analysis performed to analyze the health of the schedule. A schedule quality control check was also performed, including a review of the Level 1, 2, and 3 schedules to ensure each is aligned and coded per OPG's requirements.
"...a schedule is controlled if trained schedulers update it regularly using actual progress and logic – based on information provided by activity owners – to realistically forecast dates for program activities."	Milestone dates were compared against the Gate 2A schedule, with key changes identified (e.g. change in breaker open date from October 2019, utilization of a hybrid shift schedule, etc.). A review against the actual Unit 2 critical path was also performed to ensure the Unit 3 schedule had taken that experience into account.

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[137] Darlington Refurbishment Program November 2019 DRC – Post U3EE Update, November 11, 2019; Darlington Refurbishment – Revised Unit 3 Execution Board Memo, November 14, 2019; Ontario Power Generation, Darlington Refurbishment – Final Unit 3 Execution Estimate, August 13, 2020
[138] U.S. Government Accountability Office, Schedule Assessment Guide, Doc. No. GAO-16-89G, p. 95, December 2015
[139] Darlington Refurbishment Program November 2019 DRC – Post U3EE Update, November 11, 2019; Darlington Refurbishment – Revised Unit 3 Execution Board Memo, November 14, 2019
[140] Ontario Power Generation, Decision Record and Analysis Summary Form, "24x7 Schedule vs. Hybrid Schedule Assessment for U3, U1, U4 Critical Path, DRAS ID 975, November 15, 2019
[141] Darlington Refurbishment Program November 2019 DRC – Post U3EE Update, November 11, 2019
[142] Darlington Refurbishment Program November 2019 DRC – Post U3EE Update, November 11, 2019
[143] Darlington Refurbishment – Revised Unit 3 Execution Board Memo, November 14, 2019
[144] Darlington Refurbishment – Revised Unit 3 Execution Board Memo, November 14, 2019
[145] U.S. Government Accountability Office, Schedule Assessment Guide, Doc. No. GAO-16-89G, p. 136, December 2015
[146] U.S. Government Accountability Office, Schedule Assessment Guide, Doc. No. GAO-16-89G, p. 148, December 2015
[147] Ontario Power Generation, RFR Gate 3A Progression Form, December 2019; Ontario Power Generation U3 RFR GRB Gate 3A presentation, December 2, 2019

Exhibit No. PG-1

Pegasus-Global Holdings, Inc.

DR. PATRICIA D. GALLOWAY

Chairman

AREAS OF EXPERTISE

- Arbitrator
- Change Management
- Claims Prevention
- Contract Administration
- Corporate Governance
- Cumulative Impact
- Damages
- Disruption / Productivity
- Industry Best Practices
- International Contracting
- Mediator
- Megaproject Oversight
- Program / Project Management
- Project Controls
- Prudence / Performance Audits
- Risk Assessment
- Risk Management
- Scheduling / Delay
- Standard of Care

PROFESSIONAL EXPERIENCE

2008 – PRESENT
CHAIRMAN, PEGASUS-GLOBAL HOLDINGS, INC.
GENERAL: Dr. Galloway has been an international Engineer/Construction Consultant traveling and working in over 100 countries for over 40 years concentrating primarily on megaproject construction. She has also served as an arbitrator since 1987. Dr. Galloway has consulted on matters covering the entire project delivery process in the energy and infrastructure industries, working on behalf of private and public-sector clients globally. She also served as a member of the U.S. National Science Board, appointed by U.S. President Bush with Senate confirmation for a six-year term, serving on its executive committee and as its Vice Chair for two of those years and received an honorary Doctor of Science from the South Dakota School of Mines.

Dr. Galloway's experience includes: strategic advice to boards and senior management concerning governance, management structures and performance, contracting strategies, contract development and risk reviews, contract administration; risk management including corporate-wide enterprise risk management programs, project risk identification, assessment and analysis, trend evaluations and risk reduction plans; auditing including performance, prudence, and management audits; Integrity Generally Accepted Processes & Practices Analysis™ of policies and procedures and benchmarking; and Alternative Dispute Resolution (ADR) services including claims avoidance, non-testifying expert consulting including Testing Expert Evidence,® litigation strategy, assistance in legal counsel and arbitrator selection, and serving as an arbitrator and mediator.

Dr. Galloway has extensive global experience having worked on some of the world's largest projects including: over 30 nuclear power plant projects; Ontario Power's Darlington Nuclear Refurbishment Program; Duke Energy's Coal Ash Basin Closure Program; Kemper County IGCC plant; Edwardsport IGCC plant; Vogtle Nuclear Units 1,2,3,4; Kuala Lumpur International Airport; Sakhalin Island, Russia, Oil and Natural Gas Pipeline Project; Cadereyta Refinery Project, Mexico; HBJ Pipeline Project, India; Murrin Murrin nickel-cobalt mine, Western Australia; the Tsing Ma Bridge, Hong Kong; Australia LNG Project; Panama Canal; Seattle Sound Transit Light Rail Program; London's Crossrail Project; Citylink Project, Melbourne, Australia; Venice Lagoon Floodgate Project, Italy; Xiaolangdi Dam, China; and, City of Winnipeg, Canada, Capital Improvement Program.

She serves as an advisor to both owner and contractor clients including board audit and compliance committees and has served as a member of various Independent Review Panels (IRP), including advisor to the New York Thruway Authority for the approximately $4 billion New Tappan Zee Bridge, her appointment by both the Governors of Washington and Oregon to the IRP for the Columbia River Crossing Project, and by the Washington Legislature and Governor as Chair of the Expert Review Panel for the $3.5 billion Alaskan Way Viaduct Replacement Program.

Dr. Galloway is often retained as a keynote speaker regarding arbitration, mediation, leadership, women in engineering, and risk management. She has served as a guest lecturer at multiple universities including: Manhattanville College, the University of Melbourne; UCLA; New York Institute of Technology (NYIT); Central Washington University (CWU); University of Wisconsin; Harbin University of Technology in Harbin, China; the University of Bologna, Italy; the Old Master's Program at Purdue University; University of British Columbia and the West Virginia's University Center for Women's Studies Programs.

ENERGY:

- Substantial experience working with Merchant Utilities, Regulated Public Utilities, Public Service Commissions, FERC, Independent Power Producers, Wind and Solar Developers, and major oil and gas companies
- Multiple types of energy projects including oil and gas (refineries, LNG, steam-flood, pipelines, offshore platforms), alternative and renewable energy (wind power, solar power, geo-thermal, biomass, hydro power, nuclear power), transmission and distribution, storm hardening and resilience, electric base-load generation (over 67 power plants [nuclear, combined cycle, coal, IGCC and hydro] involving construction, outages and decommissioning)
- Extensive experience in evaluating and assessing construction claims, including issues of delay, productivity, standard of care, terminations and fraud; auditing and assessment of prudent decision-making, corporate policies and procedures and/or processes; contract risk reviews; advising re: transmission support agreements; power purchase agreements/cost-sharing agreements including curtailment issues; coal asset and production leases; decommissioning; and coal-ash removal/cleanup
- Independent Monitor regarding new capital megaprojects
- Arbitrator

TRANSPORTATION/HEAVY INFRASTRUCTURE:

- Extensive experience with multiple types of transportation projects including airports, bridges, highways, mass transit (both light and heavy rail), canals, and ports. Heavy infrastructure projects include mining (coal, iron-ore, gold, and cobalt/nickel), process plants, and tunnels
- Substantial experience in analyzing and assessing claims: contract issues (FIDIC, ENAA, EJCDC, AGC, AIA, Standard Forms and Agreement), Contract Delivery Issues (Design-Build, EPC, P3, Progressive Design-Build, Design-Bid-Build), breach of contract, contract interpretation, contract termination, schedule delay/acceleration, cumulative impact, standard of care, productivity/disruption, accounting and financial issues, fees, lost profits, errors and omissions, construction defects, construction failures, engineering issues, delay damages, quantum meruit, consequential damages, subsurface utility engineering, and fraud
- Independent Review Panels for megaproject execution
- Advisor for Program and Project Management, Program and Project Execution Plans, and Governance
- Extensive experience with Dispute Review Boards, Mediation, Settlement Negotiations and Arbitration

1978 – PRESENT

INDUSTRY ACTIVITY

Dr. Galloway is an internationally recognized leader in the engineering and construction arena. In 2004, she served as the first woman President of the American Society of Civil Engineers (ASCE). She has been recognized by her peers and is a Fellow of the College of Commercial Arbitrators (CCA), becoming the first non-lawyer to be elected to the College; a Fellow and a Chartered Arbitrator of the UK Chartered Institute of Arbitrators; a member of the Distinguished Academy of Neutrals; the National Academy of Construction; the Pan American Academy of Engineering; and the position of Fellow in several professional organizations.

Dr. Galloway's achievements have been highlighted by: TED with her TEDx talk on "Are Engineers Human?"; on Sky News Australia TV; ADR Perspectives; PM Network; Time magazine; CNN Lou Dobbs; Discovery Channel; Engineering News Record; and Federal Technology Watch. She was also a blog writer for Engineering News Record discussing current trends, challenges, and hot topics in the construction industry.

1981 – 2008

CEO and PRINCIPAL, THE NIELSEN WURSTER GROUP, INC.

Prior to joining Pegasus-Global, Dr. Galloway was the Chief Executive Officer and Principal of The Nielsen Wurster Group Inc. (Nielsen-Wurster), an international management consulting firm which specialized in management consulting, risk management and dispute resolution. She served as both a consulting and testifying witness in numerous arbitration forums regarding projects throughout the world: refineries, offshore platforms, oil depots, LNG facilities, petrochemical plants, gas pipelines and compression modules, power plants (wind, nuclear, fossil fuel, gas-fired, combined-cycle, hydroelectric, waste-to-energy, transmission), hotels, casinos, stadiums, commercial offices, hospitals, universities, civic and convention centers, parking garages, process plants, wastewater treatment plants, landfills, airports, highways, bridges, tunnels, mass transit, railroads, port facilities, dams, bulk pharmaceutical plants, manufacturing and other projects.

Her executive roles prior to becoming Chief Executive Officer included President and Chief Financial Officer. She was also the Chief Executive of Nielsen-Wurster Asia Pacific, a Nielsen-Wurster subsidiary corporation, which was located in Melbourne, Australia. In addition, Dr. Galloway served as President of another Nielsen-Wurster subsidiary Nielsen-Wurster ESB, a joint venture with the Electricity Supply Board of Ireland that specialized in power plant maintenance software.

1978 – 1981

CH2M Hill

Before joining Nielsen-Wurster, Dr. Galloway was employed by CH2M Hill assigned to the $1.6 billion Milwaukee Water Pollution Abatement Program (MWPAP). Her responsibilities at CH2M Hill on the MWPAP involved project controls including estimating and CPM scheduling; inspection; and assistance to the Program Director. In her last role at the MWPAP as the Master Program Scheduler, her responsibilities included the preparation and updating of the Program Master Schedule, coordination of all project schedules, involvement with cost engineering functions, preparation of all program / project schedule progress reports for public and client presentations and monitoring compliance with court orders imposed on the Program. Other activities at the MWPAP included authoring a scheduling manual; preparation of bid documents, on-site tunnel inspection, and coordination of a project manager's training series.

REGISTRATIONS / CERTIFICATIONS

- Chartered Arbitrator, Chartered Institute of Arbitrators (CIArb)
- Board Leadership Fellow, National Association of Corporate Directors (NACD)

- Certificate in Dispute Resolution, Pepperdine Law School at Straus Institute
- Diploma in International Commercial Arbitration, Jesus College, Oxford, CIArb
- Certificate of Director Education, NACD
- Professional Engineer in the following U.S. and global locations:
  - Arizona, No. 16978
  - Colorado, No. 28566
  - Florida, No. 44498
  - Georgia, No. 031939
  - Kansas, No. 19495
  - Kentucky, No. 17690
  - Mississippi, No. 25328
  - New Hampshire, No. 12184
  - Ohio, No. 72520
  - New Jersey, No. GE-29321
  - New York, No. 060684-1
  - Pennsylvania, No. PE-046146-R
  - Washington, No. 28262
  - Wisconsin, No. 21786-006
  - Wyoming, No. PE-4974
  - Canada, Province of Manitoba No. 15061
  - Australia, Institution of Engineers Australia, CPEng No. 1194740

- International Registry of Professional Engineers in the discipline of Civil Engineering, Construction Management by the United States Council for International Engineering Practice, No. 131
- Certified Examiner, National Council of Examiners for Engineering and Surveying, No. 12046
- Certified Project Management Professional, No. 0012-84
- Professional Member of the Royal Institution of Chartered Surveyors, Faculties of Project Management and Risk Management

ARBITRATION EXPERIENCE

Dr. Galloway is a member of the Academy of Distinguished Neutrals, a Fellow and Chartered Arbitrator of the CIArb and a Fellow of the CCA where she was a past co-chair of its construction committee. She served as a member of the American Arbitration Association's (AAA) Board of Directors for its 10-year term from 2009-2020 and also served as past chair of the AAA's National Construction Dispute Resolution Committee. Her ADR panel memberships include:

- AAA: Mega Projects, Large Complex Cases, Construction, Energy, and Commercial Panels (Member of AAA Board of Directors and Past Chair of its National Construction Dispute Resolution Committee)
- The International Center for Dispute Resolution (ICDR) Panel of Arbitrators including its International Energy Arbitrators List
- CIArb Panel of Arbitrators
- London Court of International Arbitration (LCIA) North America Users Council
- International Council for Commercial Arbitration
- International Institute for Conflict Prevention & Resolution (CPR) Energy, Construction and Cross Border Panels
- The United States Council for International Business Chamber of Commerce Panel (ICC)

She has served as a sole arbitrator, chair and member of three-member panels arbitrating a large number of disputes involving commercial, construction and energy issues of private and governmental facilities in the energy, process and building industries. She also serves as a Dispute Board member including as Chair under various DB rules including ICC. Dr. Galloway has experience with numerous arbitration forums including ICC, UNCITRAL, Singapore International Arbitration Center, and the LCIA, with disputes ranging from $1 million to $6 billion.

BOARDS AND DIRECTORSHIPS

Publicly Traded Boards

- Stantec, (TSE: STN: NYSE: STN), Member of the Corporate Governance & Compensation and Health, Safety, Security, Environment & Sustainability Committees, May 2020 - Present
- Granite Construction, Inc. (NYSE:GVA), Chair of Nominating and Governance Committee and Member of Executive and Audit Committees, 2017 – Present

Privately Held Boards

- Pegasus-Global Holdings, Inc., Chairman, 2000 – Present

Former Publicly Traded and For-Profit Boards

- SCANA Corporation, Chair of Special Litigation Committee, 2018 – January 2019
- Bergmann and Associates, 2012 – 2016
  - Governance Committee (2015-16)
  - Future Leaders Development Committee (2013-16)

Former Government Boards

- National Science Board, 2006 – 2012
  - Vice Chair (2008-10)
  - Executive Committee (2010-11)
  - Sustainable Energy Task Force Committee (2007-09)
  - Audit & Oversight and Polar Research Committees (2006-12)
  - Committee on Strategy & Budget (2006-12)
  - International Task Force Committee (2006-08)

Current Non-Profit Boards

- American Arbitration Association, 2009 – 2020
  - Executive Committee (2014-16)
- Life Support Board of Trustees (Philanthropic Organization), 2010 – Present

Former Non-Profit Boards

- CWU Foundation Board of Trustees, 2012 – 2018
  - Treasurer (2013-15)
- Pacific Science Center, 2012 – 2017
  - Development Committee (2013-17)
  - Co-chair CEO Search Committee (2014-15)
  - Co-chair of the Festival of Fountains (2014)
  - Chair of the Foundations of Science Breakfast (2015) and Co-chair (2014)
  - Finance and Audit Committee (2012)
  - Science & Education Advisory Committee (2012-15)
- Pan American Academy of Engineering, 2006 – 2011

Former Advisory Boards

- University of North Carolina Charlotte National Ash Management Advisory Board, 2015 – 2018
- Duke Energy's Coal Ash Basin Closure Program Management Oversight Board, Chair, 2015 – 2017
- Seattle Chamber of Commerce Community Development Roundtable, 2013 – 2014
- Discovery Channel, Science Channel Board of Advisors, 2009 – 2012
- Roebling Global Technical School, 2012 – 2015
- Independent Expert Review Panel for Alaskan Way Viaduct Replacement Project, Chair, 2011 – 2015
- SR520 Strategic & Technical Advisory Panel, 2011 – 2014

- NYIT Engineering Dean's Advisory Council, 2011 – 2016
- Eastern Washington Governor's Business Advisory Council, 2007 – 2012
- IRP for Columbia River Crossing Bridge Project, 2010
- Construction Industry Institute Advisory Board, Co-chair, 2006 – 2010
- Construction Superconference Advisory Board, 2007 – 2010
- ASCE Industry Leadership Council, 2008 – 2010
- University of Nebraska, Charles W. Durham School of Architectural Engineering and Construction Academic Review Team, 2009
- Extraordinary Women in Engineering Project, 2004 – 2009

Editorial Boards

- ASCE Journal of Legal Affairs and Dispute Resolution in Engineering and Practice Board, 2009 – 2020

AWARDS AND HONORS

- Albert Nelson Marquis Lifetime Achievement Award, Marquis Who's Who as a Leader in the Engineering Industry, 2019
- 2019 Women's Inc. – One of the Most Influential Corporate Directors, 2019
- Chartered Arbitrator - CIArb, 2018
- Leadership Fellow - NACD, 2017
- Academy of Distinguished Neutrals, 2017
- Fellow - CCA, 2014
- Outstanding Director - AAA, May 2014
- The Center for Computer-Assisted Legal Instruction Excellence for the Future Award in Arbitration and Advocacy - Pepperdine Law School, March 2013
- Profiles in Leadership - NYIT, 2013
- Honorary Doctor of Science - South Dakota School of Mines, December 2011
- Women's Enews.org, 21 Leaders for 21st Century Honoree for "Architect of Spaces for Women in Engineering and Science", May 2011
- ASCE *Journal of Legal Affairs and Dispute Resolution in Engineering and Practice* Best Scholarly Feature, Case Study Paper Award for "Design Build/EPC Contractor's Heightened Risk – Changes in a Changing World", July 2010
- National Association of Professional Executive Women "Woman of the Year" in Prudence Audit Consultation, 2008
- G. Brooks Ernest Award, Cleveland (Ohio) Chapter of ASCE, 2007
- Engineering Excellence and Leadership Award, George Mason University, 2007
- CSI Michelangelo Award Panel of Judges, 2006-2007
- Pan American Academy of Engineering, 2006
- Sigma Kappa Colby Award, 2006
- "Who's Who in America," Edition 68, 2005-Present
- Key Women in Energy-Global Awards, Energy Leaders Council, 2005
- National Academy of Construction, 2005
- "Who's Who of American Women," 2004-Present (listed since 1983)
- "Who's Who in the World," 2004-Present
- "Who's Who in Science and Engineering," 2002-Present
- YWCA Tribute to Women Honoree, 2004
- Society of Women Engineers' Upward Mobility Award, 2003
- Kentucky Governor's Award - Kentucky Colonel, 2004

- Lafayette High School Hall of Fame, Inducted 2001
- National Academy of Engineering: Celebration of Women, 2000
- Professional Leadership Award, National Professional Women in Construction, 1995
- Purdue University Distinguished Engineering Alumni Award, 1991
- Mercer County Engineer of the Year Award, 1990
- White House Fellowship Regional Finalist, 1990
- Glamour Magazine's "Ten Outstanding Young Working Women for 1988," February 1988
- Somerset County's Outstanding Women in Business and Industry, October 1987
- "Who's Who in America's Emerging Leaders," 1987-Present
- Engineering News Record, "Top Women in Construction," October 1986
- "Distinguished New Engineer," Society of Women Engineers, 1980

EDUCATION AND COURSES

- Diploma in International Commercial Arbitration, Jesus College, Oxford, CIArb, 2015
- Certificate in Dispute Resolution, Pepperdine Law School at Straus Institute, Malibu, CA, 2014
- PhD in Infrastructure Systems Civil Engineering, Kochi University of Technology, Kochi, Japan, 2005
- MBA – Magna cum Laude, NYIT, New York, NY, 1984
- BS in Civil Engineering, Majors in Structures and Construction Management, Purdue University, West Lafayette, IN, 1978

INDUSTRY / ACADEMIC RESEARCH

- Co-chair and member of research team, *CII Guide to Reimbursable Contracting, Implementation Resource 260-2,* Construction Industry Institute (CII), The University of Texas at Austin, 2011
- Co-chair and member of research team, *CII Construction Industry Institute Reimbursable Contracts, Research Summary 260-1,* CII, The University of Texas at Austin, 2008 – 2010
- National Research Council Committee for Advancing the Productivity and Competitiveness of the U.S. Construction Industry Workshop, 2008 – 2009

AUTHORED BOOKS / FORWARDS / CHAPTERS

- "International Construction Arbitration From an Arbitrator's Perspective", Chapter 13, *Dealing with Delay and Disruption,* Thompson Reuters, First Edition, 2020
- *Managing Gigaprojects-Advice from Those Who've Been There, Done That,* co-authored with the late Dr. Kris R. Nielsen and Jack L. Dignum, ASCE Press, Reston, VA, 2013
- "Interview: Patricia Galloway," *Connecting Students to STEM Careers, Social Networking Strategies,* Camille Cole, International Society for Technology in Education, 2011
- Foreword to Lunsden, Reese, *The View from Here, Optimize Your Engineering Career from the Start*, Illumina Publishing, 2011
- *Engineering in Government and Public Policy*, Section 4.5.3, UNESCO Report, Engineering: Issues, Challenges and Opportunities for Development, United Nations, UNESCO Publishing, Paris, France, 2010
- Galloway's 21st Century Engineer: An Essay Review, Robert Calfee, Stanford University, Thomas Stipanowich, University of California, Riverside, CA, Vol. 12, No. 14, 08 October 2009
- Foreword to Kusayanagi, S.; Niraula, R.; and Hirota, Y., *Principles and Practice of International Construction Project Management*, Tokyo, Japan, 2009
- Foreword to Williams, F. Mary and Emerson, Carolyn J., *Becoming Leaders*, ASCE Press, Reston, VA, 2008

- *The 21st Century Engineer: A Proposal for Engineering Education Reform*, ASCE Press, Reston, VA, 2007
- Foreword to Hatch, Sybil E., *Changing our World: True Stories of Women Engineers*, ASCE Press, Reston, VA, 2006
- *Anticipating Problems: Project Risk Assessment and Project Risk Management*, co-authored with K. Nielsen, Chapter 6, Collaboration Management, New Project and Partnering Techniques, edited by H. Shaughnessy, John Wiley & Sons 1994

MEMBERSHIPS

- American Bar Association, 2013 – Present
  - Forum Committee on the Construction Industry
  - Dispute Avoidance & Resolution Committee
  - International Construction Committee
  - Section of International Law
- American Nuclear Society
- American Society of Civil Engineers, Fellow
  - President, 2004-05
  - National President, 2003-04
  - National President-Elect, 2002-03
  - International Director of the Board, 1992-95
- Association for the Advancement of Cost Engineering International, Fellow
  - Chair of National Committee – Women in Project Controls, 2004-05
  - Member of National Planning and Scheduling Committee, 2003-11
  - Member of Executive Director Search Committee, 2009-10
- Association for International Arbitration
- Chartered Institute of Arbitrators
- College of Commercial Arbitrators: Construction, International and Energy Committees
- Construction Institute
- Dispute Review Board Foundation
- Institute of Civil Engineers, United Kingdom, Fellow
- Institute of Engineers, Australia, Fellow
- International Bar Association
  - Member of International Construction Projects Committee
- Inter-Pacific Bar Association
- National Academy of Construction
- National Association of Corporate Directors
- National Council of Examiners for Engineering and Surveying
- Order of the Engineer
- Pan American Academy of Engineers

TECHNICAL PAPERS AND PRESENTATIONS

Dr. Galloway is a prolific writer and world-renowned speaker having authored over 130 papers, approximately 30 peer reviewed journal articles and nearly 200 public speaking (including over 45 keynote addresses) engagements regarding leadership, corporate governance, ethics and professionalism, communication, risk management, dispute resolution, contract administration, program and project management, project controls, women in engineering and other topics.