ONTARIO POWER GENERATION

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OPG-FORM-0076-R005*

Type 3 Business Case Summary

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

Executive Summary and Recommendations

Project Information			
Project #:	BK182777, BK182199	**Document #:**	NF20-PLAN-08707.021-0019
Project Title:	G5 Overhaul – Capital , Non-Std		
Class:	☒ OM&A ☒ Capital ☐ Capital Spare ☐ MFA ☐ CMFA ☐ Provision ☐ Others:	**Investment Type:**	Sustaining
Phase:	Execution	**Release:**	Full
Facility:	SAB1 (NF20)	**Target In-Service or Completion Date:**	2020-07-29

Project Overview

We recommend the release of $32,175 k, including $5,008 k of contingency. The estimated total project is $ 36,993 k, including $ 5,488 k of contingency. The quality of estimate for this release is Class 2, and for the total project is Class 2.

This release will fund the unit refurbishment of the penstocks, turbine, generator and auxiliary mechanical and electrical systems to facilitate the business needs.

This project is included in the latest Life Cycle Plan (R-NF20-01556-0002) and will be managed within the Niagara Operations Capital Budget Envelope.

The business needs of this project are:

1. Ensure availability, reliability, and continued operation of SAB1 G5 for the next 25-30 years.
2. Enhance the capacity of the generating asset by 2 MW of clean power and maximize utilization of available water resources.

Summary of Preferred Alternative:

Alternative 2 Major Overhaul and Upgrade to a higher capacity as defined in the DPC is the preferred alternative as it more completely addresses the need for sustaining long-term reliable operation and enhancing the capacity of the generating asset.

Project procurement of long lead components identified in the PBCS release is in progress to help meet the scheduled execution phase planned for Q2 2019. The OEM will purchase long lead equipment not included in the PBCS.

The OEMs will be engaged to engineer, procure components, construct and provide Owner's Representation to address the condition of the unit. The OEM will be responsible for the BTU portion of the work, which is approximately 50% of the overall project SOW. The OEM will also have to execute the work in alignment with the schedule constraints imposed by the G1/G2 Project.

History of BCS releases and project cost estimates:

The total project cost is estimated at **$36,993 k**, including **$5,488 k** of contingency, compared to **$24,276 k**, including **$3,528 k** of contingency in the previous PBCS release. The variance is an incorrect assumption on the G10 OEM actuals and in part to a refinement of the estimate: the EBCS is based on proposal pricing from the OEM.

History of scope and schedule changes:

The outage plan is scheduled for May, 2019 to Jul, 2020. There is no change in scope or schedule from the PBCS which was approved August 30, 2018.

Key Assumptions and Risks:

The BK182198 G1/G2 Frequency Conversion Project schedule has been confirmed. Proceeding with the G5 Major Overhaul and Upgrade in advance of BK182198 is the preferred, supported alternative. It is discussed in the body of the EBCS under Part B – Description of the Preferred Alternative.

There is a risk of delays and higher costs due to increased coordination required for the 50/50 labour assignment (added complexity - see Part B). A cost allowance has been included in the project estimate. Daily coordination meetings will be held which will include participants from other projects (e.g. G1/G2).

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

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Type 3 Business Case Summary

Project #: BK182777, BK182199
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release
Document #: NF20-PLAN-08707.021-0019

Project Cash Flows, NPV, and OAR Approval Amount									
k$	LTD	2018	2019	2020	2021	2022	2023	Future	Total
Currently Released		791	4,327						5,118
Requested Now:	-	-237	23,179	8,933					31,875
Future Required	-								
Total Project Cost		554	27,506	8,933					36,993
Ongoing Costs	-								
Grand Total		554	27,506	8,933					36,993

Estimate Class:	Class 2	**Estimate at Completion:**	36,993
NPV:	$136 M	**OAR Approval Amount:**	36,993
Additional Information on Project Cash Flows (optional):			

Approvals			
	Signature	**Comments**	**Date**
The recommended alternative, including the identified ongoing costs, if any, represents the best option to meet the validated business need.			
Recommended by (Project Sponsor): Jessica Polak, VP Operations, Niagara Operations			11/23/18
I concur with the business decision as documented in this BCS.			
Finance Approval: Norma Siroski Director Controllership, RG per OPG-STD-0076	Finance Controller Niagara	(DOA for Norma)	11/23/18
I confirm that this project, including the identified ongoing costs, if any, will address the business need, is of sufficient priority to proceed, and provides value for money.			
Approved by: Mike Martelli President, RG per OAR 1.1			26 Nov 18

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Type 3 Business Case Summary

Project #: BK182777, BK182199
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release

Document #: NF20-PLAN-08707.021-0019

Business Case Summary

Part A: Business Need

The business needs of this project are:

1. Ensure availability, reliability, and continued operation of SAB1 G5 for the next 25-30 years.
2. Enhance the capacity of the generating asset. An opportunity exists to cost effectively increase production of G5 and maximize utilization of available water resources by replacing and upgrading the runner. The recommended alternative upgrades the current rating of the unit to the following capabilities:

	Turbine Rating	Generator Mechanical Limit
Pre-Overhaul Ratings	53.1 MW	73 MW
Post-Overhaul Ratings	**55.1 MW**	73 MW
Improvement	+2.0 MW	-

Background

Sir Adam Beck 1 (SAB1) G5 was placed in-service in 1923 as a 25 Hz unit rated for 45 MVA. It underwent frequency conversion to 60 Hz in 1985 as part of the runner upgrade program. SAB1 G5 has not had a major overhaul since 1985. Hydroelectric units of this type normally require overhauls on a 25-30 year cycle to maintain reliable operation. As a unit approaches end of life, it faces higher potential for production losses due to degraded reliability.

G5 has now passed the 25-30 year window (2010-2015) and since 2012 has had a restricted operating window in order to mitigate the effects of high generator rotor vibration. This approach has been used to manage the deterioration of the unit beyond its 30-year major overhaul schedule, due to a heavy overhaul program, which began in 2007. For the period from 2007-2018, a primary focus for Niagara Operations has been to overhaul and upgrade SAB1 units as they reached or exceeded the 25-30 year mark in their overhaul cycle. Over this period, G7 was converted to 60 Hz and upgraded (2009), while G9 (2010), G3 (2013) and G10 (2017) underwent major overhauls and runner replacements.

The 2015 SAB1 G5 Condition Assessment (R-NF20-01550—0011) included major water-to-wire electrical, mechanical and civil equipment/ structures related to G5, and assessment of an upgrade alternative. Feasibility was assessed for the following alternatives:

1. Do Nothing (Maintain Status Quo) – not feasible
2. Upgrade to a Higher Capacity provides 25-30 yr reliable operation with incremental capacity of 2 MW
3. Major Overhaul provides 25-30 yr reliable operation - no incremental capacity
4. Minor Overhaul provides 7-10 yr reliable operation with the need for a planned outage at the end of this period and no incremental capacity

There is a risk of failure of the generator due to high mechanical vibration on the rotor assembly, including the generator and turbine shafts. The OEM (Andritz) has asserted that a loose rim would contribute to vibration on the rotor. Their report recommends shrinking the rim to eliminate the vibration and minimize eccentricity. This project will implement the proposed remedy to move towards restoration of the unit's full, unrestricted operating window.

The recommended alternative proposed in the Definition Phase Charter (DPC NF20-PLAN-00121.2-0003) was Alternative 4, to perform a Minor Overhaul during the outage in 2019 and then perform the remainder of the overhaul scope during a planned outage after the BK182198 G1/G2 Frequency Conversion Project. At the time the recommendation was endorsed, there was uncertainty regarding whether the G5 Major Overhaul could be completed without affecting the BK182198 project. Given the risk of delaying the BK182198 project, a decision was made to proceed with the conservative schedule alternative which would only execute the Minor Overhaul scope as the leading alternative. Subsequently, the schedule details for BK182198 have been confirmed, logistics have been assessed, and further input from Production has concluded that proceeding with the Major Overhaul and upgrade in advance of BK182198 is the preferred, supported alternative.

The total required funding for this project is broken down in the following table.

k$	LTD	2018	2019	2020	2021	Future	Total
BK182199 Non-Std	0	0	2,202	0	0	0	2,202
BK182777 Cap	0	554	25,303	8,933	0	0	34,790
Total Project Cost	0	554	27,506	8,933	0	0	36,993

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

Type 3 Business Case Summary

Project #: BK182777, BK182199 Document #: NF20-PLAN-08707.021-0019
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release

Part A: Business Need

Part B: Preferred Alternative: Major Overhaul and Upgrade to a Higher Capacity (25-30 year reliable operation)

Description of Preferred Alternative

Alternative 2, Major Overhaul and Upgrade to a Higher Capacity, from the DPC is the preferred alternative as it most completely addresses the business needs for sustaining long-term reliable operation and enhances the capacity of the generating asset.

Advantages:

- Addresses generator vibration issues
- Reliable operation restored for the next 25 to 30 years
- Capacity is enhanced ~2 MW with positive Net Present Value (NPV) associated with upgrading the runner

Disadvantages:

- None

The project will execute a complete refurbishment of the unit. High level scope as follows:

- New upgraded turbine runner, wicket gates, draft tube extension, headcover, bottom ring, turbo-venting in the draft tube and surface air coolers
- Refurbish servomotors, turbine guide and thrust bearing
- Clean/re-wedge generator stator, refurbish generator windings (dry-ice blast cleaning), clean/shrink generator rotor, refurbish field poles
- New MOT, static exciter, bus work, and switches
- Perform further investigation and probable repair on the scrollcase, draft tube, moody cone and penstock (including completion of a load carrying capacity analysis)

The outage for the overhaul is planned for May, 2019 to Jul, 2020.

Procurement of long lead components identified in the PBCS release is in-progress to help meet the scheduled execution phase planned for Q2 2019. The items funded by the partial release include:

(1) A contract with American Hydro for purchase of new Francis Runner w cowl/skirt, new Nose Cone, Turbo-Vent Assembly, Turbine Shaft Refurb, Runner Shaft Assembly, Draft Tube Cone (Extension). The contract is being negotiated with American Hydro.

(2) An execution support contract from Andritz for Generator Rotor Rim Shrink oversight and special tooling. Negotiations are in progress.

(3) Protections and Controls (P&C) panel fabrications by OPG. The panels have been designed and material purchase is in progress.

Long lead equipment not purchased as part of the PBCS, will be purchased by the OEM from approved vendors. For the more detailed scope for the entire project see project Scope of Work (NF20-PLAN-00121.2-0008).

The project's labour determination was endorsed on April 24, 2018. The split of the work was approximately 50% PWU to 50% BTU. A 50/50 split in the labour determination means that OPG will need to assume the role of Owner-Constructor and will require more internal resources and coordination to manage the workgroups. In the recent past, overhauls having labour determinations with such a high proportion of PWU were overflowed to BTU. Niagara Ops Production and Plant Engineering Service (PES) have committed manpower to fulfill the resource requirements. Due to the high degree of coordination in this scenario, the Project Execution Plan (PEP) (NF20- PLAN-00121.1-0006) incorporates changes in Niagara Operations organizational structure, resource strategies and clear responsibilities for ensuring this coordination. Given the lessons learned from previous projects which have been entirely BTU, it is believed that this strategy will reduce risk associated with schedule as we leverage skills and knowledge better from both unions, OPG and the OEM. Strategies have been built into the plan to account for coordination effort requirements, such as detailed schedule monitoring, schedule flexibility options (e.g. double shifts, if required) and ensuring adequate OPG schedule contingency.

A Functional Specification has been developed for an EPC contract to an OEM to engineer, procure components, and construct the BTU portion of the work. The OEM will also provide Owner's Representative Services. Delivery of long lead material is scheduled to arrive after disassembly has begun but before the material is required for install in order to advance the outage start. Refer to the Contracting Strategy, report NF20-REP-00600-0003, for further details.

Type 3 Business Case Summary

Project #: BK182777, BK182199 Document #: NF20-PLAN-08707.021-0019
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release

Part B: Preferred Alternative: Major Overhaul and Upgrade to a Higher Capacity (25-30 year reliable operation)

Description of Preferred Alternative

G5 Major Overhaul project normalized score was 240 which is a good score. The next steps required are defining schedule sequencing, resourcing, P&C panel completion, risk analysis, commissioning and training plan.

A Constructability, Operability, Maintainability, Environment and Safety (COMES) review was completed September 28, 2018. Major actions identified include:

1. Complete the Engineering floor loading assessment
2. Complete the detailed schedule
3. Tailrace isolation remedy required
4. Both ends of the powerhouse will have concurrent construction projects in execution which impacts safety routes. The contractors Site Specific Safety Plan and OPGs Safe work plan will include mitigation measures.
5. Install ethernet fibre trunk for the SAB1 station prior to G5 overhaul (a new base project)

A follow-up to the COMES review will be conducted in March 2019 to focus on COMES aspects of the detailed designs from the contractors.

A Class EA Amendment for G5 will not be required. Execution of the G5 Major Overhaul must precede the G1/G2 Frequency Conversion Project in order to be exempt from this requirement.

Deliverables:	Associated Milestones (if any):	Target Date:
Partial Release of Funds for procurement of long lead components and remaining definition phase deliverables.	PBCS Approved	Aug 30, 2018 Completed
Gate 3 Review for EBCS	RG PGR Committee meeting	Nov 23, 2018
Execution funds released	EBCS Approved	Dec 7, 2018
Select an OEM for EPC and be Owner's Rep.	Issue PO and LNTP	Dec 18, 2018
Outage start		May 6, 2019
Planned unit in service	REIS approved	Jul 29, 2020
Project Closure Report	PCR approved	Jul 29, 2021
Post Implementation Review Complete	PIR approved	Jul 29, 2022

Part C: Other Alternatives

For the detailed Scope of each alternative and evaluation information see Appendix A in the DPC.

Alternative 1: Base Case – Status Quo (No Project)

G5 would run in the short term without significant rehabilitation or overhaul work but would eventually run to fail. This alternative does not address the potential failure of the generator due to rotor vibration and turbine runner due to vibration-induced cavitation.

This alternative is not recommended because failure of the unit would result in an unplanned outage and reduce OPG's ability to reliably supply renewable power to the grid.

Alternative 3: Major Overhaul (25-30 yr reliable operation)

This alternative has the same scope of work as the preferred alternative except that the runner would be refurbished rather than replaced. Reliability is restored for 25-30 years but there is no increase in capacity.

This alternative has a lower project cost than the preferred alternative but is not recommended because the runner upgrade alternative has the highest NPV.

Type 3 Business Case Summary

Project #: BK182777, BK182199
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release
Document #: NF20-PLAN-08707.021-0019

Alternative 4: Minor Overhaul (5-10 yr reliable operation)

This alternative would perform the following scope only:

- The generator rotor floating rim is changed to shrunk design removing the vibration issue
- MOT and exciter are replaced.

This alternative is not recommended because the unit would likely require a subsequent unplanned outage within 5 to 10 years. This decreases the financial attractiveness of this alternative.

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

k$	LTD	2018	2019	2020	2021	2022	2023	Future	Total
Currently Released		791	4,327						5,118
Requested Now:	-	-237	23,179	8,933					31,875
Future Required	-								
Total Project Cost		554	27,506	8,933					36,993
Ongoing Costs	-								
Grand Total		554	27,506	8,933					36,993

Estimate Class:	Class 2	**Estimate at Completion:**	36,993
NPV:	$136 M	**OAR Approval Amount:**	36,993

Additional Information on Project Cash Flows (optional):

Part E: Financial Evaluation

M$	Alt2 – Major OH & Upgrade	Alt1 – Status Quo	Alt3 – Major OH Only	Alt4 - Minor OH
Project Cost	37.6	2.3	31.0	14.5
NPV	136	119	130	119

Summary of Financial Model Key Assumptions or Key Findings:

Assumptions

- Evaluated over a 25 year span
- All ongoing OM&A costs (i.e. standard operating expenses) are equivalent for each alternative
- Utilized Base System Economic Values (SEV)
- Capacity Credit not used
- Major Overhaul will be taken for each alternative in 25 years (2043)
- Alt 1 Status Quo: Vibration issue requires an outage for Major OH in 2023 (5 years). Operating restrictions are maintained. An unplanned outage would be required circa Oct 2023 to Oct 2024, which coincides with PNGS shutdown.
- Preferred Alternative – Alt 2 Major OH & Upgrade: 2 MW increase in capacity achieved with the runner upgrade. Planned outage May 2019 to Jul 2020
- Alt 3 Major OH only: Planned outage May 2019 to Jul 2020
- Alt 4 Minor OH: Planned outage May 2019 to Oct 2019 with another outage within 5 years
- The project will be completed in time to minimize the schedule impacts on BK182198 (G1/G2)

Part F: Qualitative Factors

- G5 is one of four units that provide station service power. Reliability of this unit is important to the stability of the station service system.
- Experience gained from G5 will be applied to the SAB2 overhaul program in alignment with the Strategic Imperative for Project Excellence.

Type 3 Business Case Summary

Project #: BK182777, BK182199 Document #: NF20-PLAN-08707.021-0019
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release

Part F: Qualitative Factors

- P&C panel design and fabrication was removed from the scope for the main contractor and is being performed by OPG. There should be fewer delays due to vendor integration issues. Installation of the OPG design will be proven out on G5 and can then be applied to the G1, G2 project.

Part G: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
			Probability	Impact
Cost	An increase to project costs would cause the overall expenditures to exceed the release amount for the project.	This release is based on bids received through the RFP process. Contingency (5% of the entire project) has been included for discovery work. Allowance for variability in material costs is 10% of total material cost. Allowance for variability in labour costs is 15% of total labour cost. The contract change management process will be used. The budget will be continuously monitored and controlled by the PL and CSA.	Low	Medium
Scope	There is a risk that the Moody Cone is not present.	Existence of the Moody cone was proved out Oct 26, 2018. This risk has been eliminated.	~~Low~~	~~Medium~~
Schedule	There is a risk that design completion and integration will take longer than anticipated delaying schedule.	OPG has assumed control of design and fabrication for PLC and Protection panels. PES will drive the control integration. They will provide work packages for PLC/ Software support for PWU. Electrical and Mechanical detailed engineering designs and work packages will be provided by the OEM. Integration of the whole system will require collaboration between the OEM and the OPG project team. Commissioning and integration will be led by OPG. OPG's contractor will be given advanced notice of this expectation (risk) and ensure a plan is in place by the contractor to mitigate. OPG will incorporate schedule variance of this type into OPG schedule float.	Low	Medium
Schedule	There is a risk that the increased coordination required for the 50/50 labour assignment will cause delays and or higher costs (Added complexity).	Leverage lessons learned from other projects – reviewed schedules for SAB1 G9 headcover, Des Joachims and Whitedog G3. OPG has included 2 months of schedule float to manage delays which includes the added coordination effort. Hold daily coordination meetings to manage logistical issues. These meetings will include participants from other projects (e.g. G1/G2). WOs will be added to AS7 for each of the scheduled tasks. OPG will mitigate delays due to schedule coordination by emphasis on schedule controls and OPG schedule float.	Low	Medium

Type 3 Business Case Summary

Project #: BK182777, BK182199 Document #: NF20-PLAN-08707.021-0019
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release

Part G: Risk Assessment

Risk Class	Description of Risk	Risk Management Strategy	Post-Mitigation	
			Probability	Impact
Technical	There is a risk that the generator rotor rim shrink is not the root cause of the generator vibration. The risk of vibration is that when the unit starts up there will be a bearing wipe. The unit has been operating for 4 years avoiding starts/stops.	Vibration measurements in 2013/2014 and 2017 indicate that the condition is stable. Air gap readings over the full load range will be taken when the unit shuts down to confirm whether the vibration continues to be stable. The project will eliminate the most probable, largest contributor to vibration. If the vibration root cause has not been eliminated, Production will re-implement the restricted operating window. PES will continue root cause analysis to determine the source of vibration.	Low	High
Technical/ Schedule	There is a risk that the unit cannot be isolated due to inability to install tailrace stoplogs.	PES assessed the condition Oct 26, 2018. Divers removed obstructing concrete at the sill. The steel gains were in good condition. New stoplogs will be ordered under a separate project. Lead time requires expediting the new project approval. ETA Apr 2019.	Low	High
Technical	There is a risk of station outage if there is a single-line station service contingency due to G9 & G10 shutdown(s) for Hydro One E-bus upgrade.	A temporary diesel generator will be provided when necessary. PES is investigating an alternate station service supply from SAB2 or the feasibility of islanding.	Low	High
Technical	Lessons learned from recent projects have indicated the potential for configuration management issues impacting turnover of final as-built drawing and documentation package from the contractor(s).	The PEP documents the strategy for documentation expectations, exchange, delivery and tracking. The contracts for QA/QC support include scope requesting the contractor(s) provide pricing estimates for documentation control.	Low	Medium

Additional Risk Analysis:

Refer to the Risk Register in the PEP for further risk assessment information.

Type 3 Business Case Summary

Project #: BK182777, BK182199 Document #: NF20-PLAN-08707.021-0019
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release

Part H: Post Implementation Review (PIR) Plan

Type of PIR Report	Target In-Service or Completion Date	Target PIR Completion Date
Simplified PIR	2020-07-29	2022-07-29

Measurable Parameter	Current Baseline	Target Result	How will it be measured?	Who will measure it? (person/group)
MCR (MW)	53.1	55.1	Unit Metering	SAB1 Production
Apparent Power (MVA)	55	63	Unit Metering	SAB1 Production
Runner Efficiency at best efficiency point.	Pre-overhaul Gibson Test (best) or G4's 1986 results.	[redacted]	Post-overhaul Gibson Test	Tech Support Eng. With RG P&T
Operating Restrictions	Rough zone >40% Must run >80% Shutdown on high gen runout alarm	Operating Window consistent with other SAB1 Units. Range 85% to 100% of maximum flow.	Visual Inspection	NiOps Operations and SAB1 Production

Part I: Definitions and Acronyms

AS7 – Asset Suite 7
BP – Business Plan
BTU – Building Trades Union
CAP – Capital
COMES – Constructability, Operability, Maintainability, Environment and Safety review
CSA – Cost and Schedule Analyst
DPC – Definition Phase Charter
EA – Environmental Assessment
EBCS – Execution Business Case Summary
ETA – Estimated Time of Arrival
Hz – Hertz
ITP – Inspection and Test Plan
LNTP – Limited Notice to Proceed
LTD – Life to Date
MCR – Maximum Continuous Rating
MOT – Main Output Transformer
MVA – Mega Volt Amp
MW – Mega Watt
NA, N/A – Not Applicable
Non-Std – Non Standard
NPV – Net Present Value
OAR – Organization Authority Register
OEM – Original Equipment Manufacturer
OH - Overhaul
OPG – Ontario Power Generation
OM&A – Operations, Maintenance and Administration
PBCS – Partial Business Case Summary
PCR – Project Closure Report
PDRI – Project Definition Rating Index
PEP – Project Execution Plan
PES – Plant Engineering Services (OPG Engineering)
PIR – Post Implementation Review
PO – Purchase Order
QA/QC – Quality Assurance/ Quality Control
REIS – Report of Equipment In-service
RFP – Request for Proposals
RG - Renewable Generation
SAB1 – Sir Adam Beck Generating Station 1
SAC – Surface Air Cooler
SEV – System Economic Values
SIA – System Impact Assessment
SoE – Summary of Estimate
TWh – Terra Watt hours
VP – Vice President
WOs – Work Orders

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Type 3 Business Case Summary

Project #: BK182777, BK182199 Document #: NF20-PLAN-08707.021-0019
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release

For Internal Project Cost Control

Type 3 Business Case Summary

Project #: BK182777, BK182199
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release

Document #: NF20-PLAN-08707.021-0019

Appendix A: Summary of Estimate (EBCS – Full Project – Non-Std + Capital)								
Project Number:	BK182199 + BK182777							
Project Title:	G5 Major Overhaul – Non-Std + Capital Scope							
k$	**LTD**	**2018**	**2019**	**2020**	**2021**	**Future**	**Total**	**% of Project Total**
OPG Project Management		99	216	151			466	1.3
OPG Engineering (including Design)		125	285	219			629	1.7
Procured Materials		96	143	10			249	0.7
OPG Other (PWU)		20	746	1,271			2,037	5.5
Design Contract(s)								
Construction Contract(s)		214	4,279	200			4,693	12.7
EPC Contract(s)			16,462	4,970			21,432	57.9
Consultants								
Other Contracts/Costs			65				65	0.2
Interest		1	317	815			1,132	3.1
Removal Costs			802				802	2.2
Subtotal		554	23,315	7,635			31,504	85.2
Contingency			4,191	1,297			5,488	14.8
Total Capital		554	27,506	8,933			36,993	100.0

Notes			
Project Start Date	Sep-18-2018	**Total Definition cost** (excludes unspent contingency for Nuclear)	343
Target In-Service (or AFS) Date	Jul-29-2020	**Contingency included in this BCS** (Nuclear only)	N/A
Target Completion Date	Jul-29-2021	**Total contingency released plus contingency in this BCS** (Nuclear only)	N/A
Escalation Rate	NA	**Total released plus this BCS without contingency** (Nuclear only)	N/A
Interest Rate	4.40%	**Total released plus this BCS with contingency** (Nuclear only)	N/A
Removal Costs	802	**Estimate at Completion** (includes only spent contingency for Nuclear)	36,993

Prepared by:	Approved by:
M. Sokol 26-NOV-2018	K Prince FOR KEN PRINCE NOV 26, 2018
Michele Sokol Project Leader Date	Ken Prince Section Manager - Projects Date

Type 3 Business Case Summary

Project #: BK182777, BK182199
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release
Document #: NF20-PLAN-08707.021-0019

Appendix A: Summary of Estimate (EBCS – Full Project Capital)								
Project Number:	BK182777							
Project Title:	G5 Major Overhaul – Capital Scope							
k$	**LTD**	**2018**	**2019**	**2020**	**2021**	**Future**	**Total**	**% of Project Total**
OPG Project Management		99	194	151			444	1.3
OPG Engineering (including Design)		125	234	219			578	1.7
Procured Materials		96	43	10			149	0.4
OPG Other (PWU)		20	664	1,271			1,955	5.6
Design Contract(s)								
Construction Contract(s)		214	4,179	200			4,593	13.2
EPC Contract(s)			14,914	4,970			19,884	57.2
Consultants								
Other Contracts/Costs			65				65	0.2
Interest		1	317	815			1,132	3.3
Removal Costs			802				802	2.3
Subtotal		554	21,412	7,635			29,602	85.1
Contingency			3,891	1,297			5,188	14.9
Total Capital		554	25,303	8,933			34,790	100.0

Notes			
Project Start Date	Sep-18-2018	**Total Definition cost** (excludes unspent contingency for Nuclear)	343
Target In-Service (or AFS) Date	Jul-29-2020	**Contingency included in this BCS** (Nuclear only)	N/A
Target Completion Date	Jul-29-2021	**Total contingency released plus contingency in this BCS** (Nuclear only)	N/A
Escalation Rate	NA	**Total released plus this BCS without contingency** (Nuclear only)	N/A
Interest Rate	4.40%	**Total released plus this BCS with contingency** (Nuclear only)	N/A
Removal Costs	802	**Estimate at Completion** (includes only spent contingency for Nuclear)	34,790

Prepared by:	Approved by:
M. Sokol 26-NOV-2018	FOR KEN PRINCE NOV 26, 2018
Michele Sokol Project Leader Date	Ken Prince Section Manager - Projects Date

Type 3 Business Case Summary

Project #: BK182777, BK182199
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release
Document #: NF20-PLAN-08707.021-0019

Appendix A: Summary of Estimate (EBCS – Full Project Non-Std)								
Project Number:	BK182199							
Project Title:	G5 Major Overhaul							
k$	**LTD**	**2018**	**2019**	**2020**	**2021**	**Future**	**Total**	**% of Project Total**
OPG Project Management			22				22	1.0
OPG Engineering (including Design)			51				51	2.3
Procured Materials			100				100	4.5
OPG Other			82				82	3.7
Design Contract(s)								
Construction Contract(s)			100				100	4.5
EPC Contract(s)			1,548				1548	70.3
Consultants								
Other Contracts/Costs								
Subtotal			1,902				1902	86.4
Contingency			300				300	13.6
Total Non-Std			2,202				2202	100.0

Notes			
Project Start Date	Sep-18-2018	**Total Definition cost** (excludes unspent contingency for Nuclear)	0
Target In-Service (or AFS) Date	Jul-29-2020	**Contingency included in this BCS** (Nuclear only)	N/A
Target Completion Date	Jul-29-2021	**Total contingency released plus contingency in this BCS** (Nuclear only)	N/A
Escalation Rate	NA	**Total released plus this BCS without contingency** (Nuclear only)	N/A
Interest Rate	4.40%	**Total released plus this BCS with contingency** (Nuclear only)	N/A
Removal Costs	NA	**Estimate at Completion** (includes only spent contingency for Nuclear)	2,202

Prepared by:	Approved by:
M. Sokol 26-NOV-2018 Michele Sokol Project Leader Date	FOR KEN PRINCE NOV 26, 2018 Ken Prince Section Manager - Projects Date

Type 3 Business Case Summary

Project #: BK182777, BK182199
Project Title: G5 Overhaul – Capital , Non-Std, Full Execution Release
Document #: NF20-PLAN-08707.021-0019

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

Comparison of Total Project Estimates

Phase	Release	Approval Date	Total Project Estimate in k$ (by year including contingency)						Future	Total Project Estimate
			2018	2019	2020	2021	2022	2023		
DBCS	300	05-03-2018	510	4,755			125	10,945	3,160	21,550
PBCS	4,818	08-27-2018	791	16,637	6,848					24,276
EBCS	32,175	TBD	554	27,506	8,933					36,993

Project Variance Analysis

k$	LTD	Total Project		Variance	Comments
		Last BCS	This BCS		
OPG Project Management		370	466	96	Refined RQE estimate
OPG Engineering (including Design)		275	629	354	P&C Panel design
OPG Procured Materials		3,884	249	-3,635	PBCS: Am. Hydro, EBCS: P&C Panels
OPG Other (PWU)		3,565	2,037	-1,528	Refined RQE estimate
Design Contract(s)		190		-190	Andritz Rim Shrink design
Construction Contract(s)		11,407	4,693	-6,714	PBCS: covers OEM contract, EBCS: covers Am. Hydro and QAQC
EPC Contract(s)			21,432	21,432	EBCS: covers OEM contract - thought G10 OEM sum included Am. Hydro runner purchase
Consultants		748		-748	QA/QC moved to Constr. Contracts for EBCS
Other Contracts/Costs			65	65	ABB breaker support added in EBCS
Interest		308	1,132	824	Refined RQE estimate
Removal Costs		718	802		Refined RQE estimate
Subtotal		21,465	31,505	10,040	**OEM purchased mat'ls increase of 26%** **OEM Labour/Profit/Overhead increase of 29%** **Note: G5 does not include as much scope as G10**
Contingency		3,529	5,488	1,959	14.8% contingency request for: • discovery and • first time that NiOps will execute 50/50 PWU/BTU labour determination
Total		24,994	36,993	11,999	

Appendix C: Financial Evaluation Assumptions

Key assumptions used in the financial model of the Project are (complete relevant assumptions only):

Project Cost (Expenditures prior to 2043 = 25 year)**:**

1. 2.3 M$ in 2019, unplanned outage: 36.0 M$ in 2024
2. 37.6 M$ in 2020
3. 31.0 M$ in 2020
4. 14.5 M$ in 2019, planned outage 41.7 M$ in 2029 (10 years is optimistic)

Financial (NPV):

1. 119 M$
2. 136 M$
3. 130 M$
4. 119 M$

Project Life:

1. 5 years (or sooner) before an unplanned outage
2. 25 years reliable operation with upgraded turbine
3. 25 years reliable operation with refurbished turbine
4. 10 years reliable operation with planned outage in 2028 - 2029

Energy Production (2019 to 2043)**:**

1. 8.911 TWh
2. 9.353 TWh
3. 9.201 TWh
4. 8.813 TWh

Operating & Other Cost (2019 to 2043)**:**

1. 92.7 M$
2. 96.8 M$
3. 95.7 M$
4. 92.4 M$

******Financial Evaluation (NPV) available upon request.

Appendix D: References

R-NF20-01556-0002 SAB1 Life Cycle Plan
R-NF20-01550—0011 SAB1 G5 Condition Assessment
NF20-REP-00121.2-0001 SAB1 G5 Major Overhaul Alternatives – Feasibility
NF20-PLAN-00121.2-0003 BK182199_BK182777 G5 Major Overhaul Definition Phase Charter
NF20-PLAN-00121.2-0008 Project Scope of Work
NF20-REP-00600-0003 Contracting Strategy
NF20-PLAN-08707.021-0006 Partial Business Case Summary
NF20-PLAN-00121.1-0006 Project Execution Plan

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Business Case Summary

Project #	BK182777, BK182199	**File #**	NF20-BCS-08707.021-0004
Project Title	G5 Major Overhaul – Capital, Non-Std		
Facility	SAB1 (NF20)	**Investment Classification**	Sustaining
Project Level (Scalability)	B	**Financial Classification**	☒ OM&A ☒ Capital ☐ Capital Spare ☐ MFA ☐ CMFA ☐ Provision ☐ Others: [if applicable]
Release: Gate and Project Phase	☐ Choose an item. G0☐: Initiation ☐ Choose an item. G1☐: Choose an item.		☐ Choose an item. G2☐: Definition ☒ Superseding G3C☒: Execution
Estimate Class (overall project)	Class 2	**Target Project Completion Date**	2022-09-20

Recommendation

We recommend a release of $4,569 K, including $500 K of contingency. This will bring the total released-to-date to $47,666 K.

The total project cost is now estimated at $47,666K, compared to $43,098 K in the previous released, including contingency.

This release is to fund the schedule extension both for additional Contractor support and OPG labour costs and materials to complete the project commissioning phase.

This Superseding BCS is requesting an in-service date change to 20-Sep-2021.

The project BK182199 (non-standard portion of the project), is not included in the approved 2021-26 Business Plan.
The project BK182777 (capital portion of the project), is included in the approved 2021-26 Business Plan.
The 2021 funding will be managed within the South Central Operations Capital budget and Non-Standard budgets.

Investment Cash Flows - OMA BK182199

$K	LTD	2021	2022	2023	2024	2025	2026	Future	Total
Previous releases	2,494	180							2,674
Current request	-	(194)							(194)
Total released to date	**2,494**	**(14)**	-	-	-	-	-	-	**2,480**
Future required	-								-
Total Project Cost	**2,494**	**(14)**	-	-	-	-	-	-	**2,480**
Ongoing Costs	-								
					Gate:	**G3**	**OAR Approval:**		$2,480 K

Investment Cash Flows - CAP BK182777

$K	LTD	2021	2022	2023	2024	2025	2026	Future	Total
Previous releases	29,970	10,453							40,423
Current request	(5)	4,769							4,764
Total released to date	**29,965**	**15,222**	-	-	-	-	-	-	**45,186**
Future required	-								-
Total Project Cost	**29,965**	**15,222**	-	-	-	-	-	-	**45,186**
Ongoing Costs	-								
					Gate:	**G3**	**OAR Approval:**		$45,186 K

Investment Cash Flows - Total OMA/CAP

$K	LTD	2021	2022	2023	2024	2025	2026	Future	Total
Previous releases	32,464	10,633							43,097
Current request	(5)	4,574							4,569
Total released to date	**32,459**	**15,208**	-	-	-	-	-	-	**47,666**
Future required	-								-
Total Project Cost	**32,459**	**15,208**	-	-	-	-	-	-	**47,666**
Ongoing Costs	-								
					Gate:	**G3**	**OAR Approval:**		$47,666 K

Project #: BK182777, BK182199
Project Title: G5 Major Overhaul – Capital, Non-Std
Document #: NF20-BCS-08707.021-0004

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Business Case Summary

Approvals	Signatures	Date
The recommendation, including the identified ongoing costs, if any, represents the best option to meet the validated business need.		
Recommended by: Project Sponsor Paul Seguin VP Regional Operations, Niagara		17 Sep. 2021
I concur with the business decision as documented in this BCS.		
Finance Approval: Alec Cheng VP Treasurer		Sep 19 2021
I confirm that this investment/project, including the identified ongoing costs, if any, will address the business need, is of sufficient priority to proceed, and provides value for money.		
Line Approval per OAR 1.1: Sean Granville Chief Operations Officer		17-Sep-21

EXECUTIVE SUMMARY – Project Overview

The original outage plan for G5 was scheduled for 6-May-2019 to 29-July-2020. In order to minimize the overlap between G1/G2 removals, the G5 outage was postponed and shortened to the period of 27-Jan-2020 to 6-May-2021.

The POVA requested and approved an outage change starting 29-Jan-2021 to 8-Jul-2021 and included additional funding for added scope to complete the project. We have since spent all funding from the POVA, and the scheduled in-service date has been pushed out due to an extended dry commissioning phase and equipment failure during wet commissioning.

The OMA project is coming in under budget by $166,405. The CAP project is requesting additional funding of $4,763,622. The total net additional funding request is $4,569,625.

This Superseding Business Case Summary (SBCS) is requesting additional funding to cover costs for:

1. OPG Labour costs for the extended commissioning schedule, late unknown scope, and hardware failure repairs of $1,934,149.77
2. Voith Hydro Inc – Total Ask $2,329,472.10 due to additional reassembly costs, site management, new scope and schedule changes.
3. Overall project Contingency of $500,000.00

Business Need

For Project Level B

The business needs of this project are:

1. Ensure availability, reliability, and continued operation of SAB1 G5 for the next 25-30 years.
2. Enhance the capacity of the generating asset by 2 MW of clean power and maximize utilization of available water resources.

	Turbine Rating	Generator Mechanical Limit
Pre-Overhaul Ratings	53.1 MW	73 MW
Post-Overhaul Ratings	**55.1 MW**	73 MW
Improvement	+2.0 MW	-

Background

Sir Adam Beck 1 (SAB1) G5 was placed in-service in 1923 as a 25 Hz unit rated for 45 MVA. It underwent frequency conversion to 60 Hz in 1985 as part of the runner upgrade program. SAB1 G5 has not had a major overhaul since 1985. Hydroelectric units of this type normally require overhauls on a 25-30 year cycle to maintain reliable operation. As a unit approaches end of life, it faces higher potential for production losses due to degraded reliability.

G5 has now passed the 25-30 year window (2010-2015) and since 2012 has had a restricted operating window in order to mitigate the effects of high generator rotor vibration. This approach has been used to manage the deterioration of the unit beyond its 30-year major overhaul schedule, due to a heavy overhaul program, which began in 2007. For the period from 2007-2018, a primary focus for Niagara Operations has been to overhaul and upgrade SAB1 units as they reached or exceeded the 25-30 year mark in their overhaul cycle. Over this period, G7 was converted to 60 Hz and upgraded (2009), while G9 (2010), G3 (2013) and G10 (2017) underwent major overhauls and runner replacements.

Project #: BK182777, BK182199
Project Title: G5 Major Overhaul – Capital, Non-Std
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Business Case Summary

Business Need — For Project Level B

The 2015 SAB1 G5 Condition Assessment (R-NF20-01550—0011) included major water-to-wire electrical, mechanical and civil equipment/ structures related to G5, and assessment of an upgrade alternative.

The total required funding for this project is broken down in the following table.

k$	LTD	2021	2022	2023	2024	Future	Total
BK182199 Non-Std	2,494	-14				0	2,480
BK182777 Cap	29,965	15,222				0	45,187
Total Project Cost	32,459	15,207				0	47,666

Deliverables:	**Associated Milestones (if any):**	**Actual Date** (DD-MMM-YYYY):
Previous releases: EBCS		
Gate 1 Review Change Request Authorization (CRA)	GR1	Jun 18, 2013
Project Manager Milestones	PMM	Jul 9, 2015
Gate 2 Business Case Summary Approved	GR2	May 4, 2018
Gate 2A Partial Business Case Summary Approved for procurement of long lead components and remaining definition phase deliverables.	GR2A	Aug 29, 2018
Gate 3 Execution Funds Approved signed by OAR		Nov 18, 2018
Gate 3 Review for Execution Business Case RG PGR Committee Meeting	GR3	Dec 12, 2018
EPC PO issued to Voith Hydro Inc.	EPC	May 29, 2019
Outage start / Start of Installation	SOI	Jan 27, 2020
Start of Work Suspension due to COVID-19	7 week on site work suspension; engineering continued off-site	Mar 26, 2020
Finish of Installation	FOI	Mar 19, 2021
Current release: POVA		
Gate 3B POVA Project Over Variance Authorization Approved	GR3B	Mar 22, 2021
Future release: SBCS		**Target Date** (DD-MMM-YYYY):
Gate 3C approval and BCS signed by OAR	GR3C	Aug 31, 2021
Available for Service	AFS	Sep 20, 2021
Report of Equipment In Service	REIS approved	Sep 30, 2021
Project Close Out Completed	PCO	Dec 31, 2021
Project Closure Report	PCR approved	Sep 30, 2022
Post Implementation Review Complete PIR approved	PIM	Sep 30, 2022

Key Risk Assessment — For Project Level A, B or C

Risk Class	Description of Risk	Response Type/ Actions/Final TCD	For Additional Review	Residual Ranking
Schedule	COVID-19 may further delay the project with increased cost and schedule delay.	Mitigate: • The work teams continue to off set shift start, breaks and finish times so that resources do not overlap in lunch/break rooms and entering and exiting the site at the same time.	No	Low

Key Risk Assessment			For Project Level A, B or C	
Risk Class	**Description of Risk**	**Response Type/ Actions/Final TCD**	**For Additional Review**	**Residual Ranking**
		• Full PPE warn and extra care taken at all times when congregated around display screens during commissioning. • OPG and the Contractor have identified additional support resources to step in to continue and complete the commissioning testing if required. **Final TCD: [17-Sep-2021]**		
Cost	During Commissioning, a component failure may force the unit out of service.	Mitigate: • The team have executed a number of wet commissioning tests already with no indication of further issues. **Final TCD: [17-Sep-2021]**	No	Low

Additional Risk Analysis — For Project Level A or B

COVID-19 Variant Concern: There are a large group of internal resources involved with the G5 Wet commissioning along with 3rd party resources. Voith have been limiting attendance to tailboard and commissioning face-to-face meetings sending 1 delegate at a time. OPG engineers are also being cautious and alternating on-site test witnessing.

The Commissioning Team are being cautious during the completion of the wet testing. Equipment failure has already occurred at the initial start of wet commissioning, and there is still a risk of equipment failure until the load rejection testing has completed and all data has been reviewed and analyzed.

Financial Evaluation — For Project Level A, B (with multiple feasible alternatives) or Value-Enhancing

$M	Alt2 – Major OH & Upgrade	Alt1 – Status Quo	Alt3 – Major OH Only	Alt4 – Minor OHH
Project Cost	47,666	2.3	31.0	14.5
NPV	136	119	130	119

Analysis of Financial Evaluation – Key Assumptions and Key Results:

- Evaluated over a 25 year span
- All on-going OM&A costs (i.e. standard operating expenses) are equivalent for each alternative
- Utilized Base System Economic Values (SEV)
- Capacity Credit not used
- Major Overhaul will be taken for each alternative in 25 years (2043)
- Alt1 Status Quo: Vibration issue requires an outage for Major OH in 2023 (5 years). Operating restrictions are maintained. An unplanned outage would be required circa Oct 2023 to Oct 2024, which coincides with PNGS shutdown.
- Preferred Alternative – Alt2 Major OH & Upgrade: 2MW increase in capacity achieved with the runner upgrade. Planned outage May 2019 to July 2020. Since revised to 29-Jan-2020 to 17-Sep-2021.
- Alt3 Major OH only: Planned outage May 2019 to Jul 2020
- Alt4 Minor OH: Planned outage May 2019 to Oct 2019 with another outage within 5 years
- The project will be completed in time to minimize the schedule impacts on BK182198 (G1/G2)

Refer to original EBCS

- The team is confident that the in-service date will be mid September
- The OPG Engineering Lead has confirmed through commissioning testing to-date, that the unit has achieved an additional 2MW output.

Qualitative Factors

- G5 is one of four units that provide station service power. Reliability of this unit is important to the stability of the station service system.
- Experience gained from G5 will be applied to the SAB2 overhaul program in alignment with the Strategic Imperative for Project Excellence.
- P&C panel design and fabrication was removed from the scope for the main contractor and is being performed by OPG. There should be fewer delays due to vendor integration issues. Installation of the OPG design will be proven out on G5 and can then be applied to the G1, G2 project.

Post Implementation Review (PIR) Plan (refer to OPG-PROC-0056)

Type of PIR Report	Simplified/Standard PIR	**PIR Completion Date**	2022-09-30

☐ Detailed PIR KPIs will be provided in future BCS(s) when Execution Phase BCS release is requested.

PIR KPIs	Current Baseline	Target Result	How to measure?	Who will measure?
MCR (MW)	53.1	55.1	Unit Metering	SAB1 Production
Apparent Power (MVA)	55	63	Unit Metering	SAB1 Production
Runner Efficiency at best efficiency point.	Pre-overhaul Gibson Test (best) or G4's 1986 results.	[redacted]	Post-overhaul Gibson Test	Tech Support Eng. With RG P&T
Operating Restrictions	Rough zone >40% Must run >80% Shutdown on high gen runout alarm	Operating Window consistent with other SAB1 Units. Range 85% to 100% of maximum flow.	Visual Inspection	NIA Operations and SAB1 Production

Definitions and Acronyms

AS7 – Asset Suite 7
BP – Business Plan
BTU – Building Trades Union
CAP – Capital
COMES – Constructability, Operability, Maintainability, Environment and Safety review
CSA – Cost and Schedule Analyst
DPC – Definition Phase Charter
EA – Environmental Assessment
EBCS – Execution Business Case Summary
ETA – Estimated Time of Arrival
Hz – Hertz
ITP – Inspection and Test Plan
LNTP – Limited Notice to Proceed
LTD – Life to Date
MCR – Maximum Continuous Rating
MOT – Main Output Transformer
MVA – Mega Volt Amp
MW – Mega Watt
NA, N/A – Not Applicable
Non-Std – Non Standard
NPV – Net Present Value
OAR – Organization Authority Register
OEM – Original Equipment Manufacturer
OH - Overhaul
OPG – Ontario Power Generation
OM&A – Operations, Maintenance and Administration
PBCS – Partial Business Case Summary
PCR – Project Closure Report
PDRI – Project Definition Rating Index
PEP – Project Execution Plan
PES – Plant Engineering Services (OPG Engineering)
PIR – Post Implementation Review
PO – Purchase Order
QA/QC – Quality Assurance/ Quality Control
REIS – Report of Equipment In-service
RFP – Request for Proposals
RG - Renewable Generation
SAB1 – Sir Adam Beck Generating Station 1
SAC – Surface Air Cooler
SEV – System Economic Values
SIA – System Impact Assessment
SoE – Summary of Estimate
TWh – Terra Watt hours
VP – Vice President
WOs – Work Orders

Project #: BK182777, BK182199
Project Title: G5 Major Overhaul – Capital, Non-Std
Document #: NF20-BCS-08707.021-0004

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Business Case Summary

APPENDICES

Appendix A1: Summary of Estimate - Released to date										
Project Number:	BK182777 / BK182199									
Project Title:	G5 Major Overhaul CAP / OMA									
$K	**LTD**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**Future**	**Total**	**%**
Project Mgmt	5,499	4,019							9,518	20%
Inspection									-	0%
Engineering	1,008	719							1,727	4%
Procurement	653	209							861	2%
Construction	24,483	6,193							30,677	64%
Commissioning	212	2,670							2,883	6%
Closeout									-	0%
Turnover (Doc. & Training)	39	43							82	0%
Subtotal	31,893	13,854	-	-	-	-	-	-	45,747	96%
Outside WBS	-	-							-	0%
Contingency	0	500							500	1%
Subtotal w/ Contingency	31,893	14,354	-	-	-	-	-	-	46,247	97%
Interest	565	853							1,419	3%
Other									-	0%
Total	**32,459**	**15,208**	-	-	-	-	-	-	**47,666**	**100%**
Removal Costs (incl. above)	1,054	7							1,061	2%

Appendix A2: Summary of Estimate – Notes			
Escalation Rate	1.7%	**Interest Rate (going-forward)**	3.45%

Appendix A3: Summary of Estimate – In-Service Estimates				
$K	Only applicable to capital projects. In-Service amount shall include interest but exclude removal costs.			
Project #	**Date (YYYY-MM-DD)**	**Description**	**Amount**	**%**
BK182777	2021-09-17	G5 Major Overhaul	46,605	100%
				0%
Total			46,605	100%

Prepared by:	Reviewed and Endorsed by:
Michele Sokol 15-Sep-2021 Michele Sokol Project Leader, Maintenance Projects Date	Ray DeJonge 15 Sept 2021 Ray DeJonge Work Centre Manager, Maintenance Projects Date

Project #: BK182777, BK182199
Project Title: G5 Major Overhaul – Capital, Non-Std
Document #: NF20-BCS-08707.021-0004

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Business Case Summary

$K	LTD	2018	2019	2020	2021	2022	2023	Future	Total
G3A -EBCS	-	554	27,506	8,933					36,993
G3B -POVA				32,464	10,633				43,097
G3C -SBCS				32,459	15,208				47,666

Total Project Estimate Variance Explanation (delete if not required)

This Superseding Business Case Summary (SBCS) is requesting additional funding to cover costs for:

1. OPG Labour costs for the extended commissioning schedule, late unknown scope, and hardware failure repairs of $1,934,149.77
    - An increased number of OPG Engineers supporting IESO/COVER/SIA for electrical design changes, programming and testing, with additional field OPG labour estimated $120,000.00
    - Labour for hardware failure: engineering support, disassembly, removal, replacement, reassembly estimated $320,000
    - Higher than forecast labour commissioning schedule estimated $1,094,149.77 (May 6 - Sep 13)
    - Interest to cover schedule extension estimated $280,000
    - Allowance for schedule extensions of $60,000/week; assuming a 2 week schedule extension Sept. 13-27, 2021 $120,000
2. Voith Hydro Inc – Total $2,329,472.10 for prior outstanding costs not known at the time of the POVA. These costs cover site management, schedule changes, new scope and contingency.
    a) Reassembly costs from March, April, May 2021 (General T&M) of $1,382,714.23
        - Site & Office Management hours and expenses
        - New Scope based on original completion forecast of December 2020 in the field with the following vendors: The State Group, Tower Scaffolding Services, Acklands, Altra Construction Rentals, Bickles and Newman Bros.
    b) Project Change Directives for Site Management, Site Running Costs and Project Office Management caused by Schedule changes of $710,522.86
        - PCD-013 Original Fixed Commissioning Cost from the Voith proposal is based on 2 month scheduled duration. Due to circumstances outside of Voith's control, the Commissioning Schedule was extended to a 3 month duration. Total cost impact: $392,728.57
            - Original May 6, 2021 moved to July 8,2021
            - Actual (at the time of PCD-013): May 3, 2021 to August 14, 2021
        - PCD-014 Generator Shroud Seal failure occurred on June 29, 2021 and was resolved on August 3, 2021. This incident forced Voith Hydro to focus support personnel on the recovery effort and postponed the commissioning activities by one (1) additional month. As of August 12, 2021, the in-service date is pushed to September 13, 2021.Total cost impact: $317,794.29
    c) Project Change Directives (PCD-013 & 014) for new scope and replacement materials total cost estimates of $152,827.90
        - Additional Demobilization Cost $36,592.89
        - GeoArc/GKM training $2,864.40
        - Governor Spare Parts $16,889.43
        - Penstock Stress Analysis $36,538.00
        - Air Gap Sensor Extension Cable $4,046.40
        - Spare High Pressure Lift Pump/motor Assembly & Gear $3,231.63
        - Spare Strainers $12,715.14
        - Replacement Air Gap Sensors $32,430.10
        - Replacement GP03 material (estimate) $933.36
        - Replacement Shroud Rubber Seal $6,371.40
        - Replacement Shroud Rivets, washer, etc. (estimate) $215.15
    d) Allowance for schedule extension estimate $60,000/per week. 2 weeks schedule extension Sept. 13-27, 2021 $120,000.00
3. Overall project Contingency of $500,000.00

ONTARIO POWER GENERATION

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Business Case Summary

Project #	AGU83610	**Controlled Doc #**	P27-BCS-08707-0815775 R0
Project Title	Surge Tank Replacement		
Facility	Aguasabon GS (P27)	**Investment Classification**	Sustaining
Project Level (Scalability)	B	**Financial Classification**	☐ OM&A ☒ Capital ☐ Capital Spare ☐ MFA ☐ CMFA ☐ Provision ☐ Others: [if applicable]
Release: Gate and Project Phase	☐ Choose an item. G0☐: Initiation ☐ Choose an item. G1☐: Choose an item.		☐ Choose an item. G2☐: Definition ☒ Full G3☒: Execution
Estimate Class (overall project)	Class 2	**Target Project Completion Date**	June 2021

Recommendation

To date we have a partial planning/execution release of $6,319K.

We recommend an additional execution release of $18,904K.

This will bring the full release to $25,223K.

The estimated total project cost is $25,223K, including $1,921K of contingency.

This execution BCS will fund the full replacement of the Aguasabon Surge Tank. The scope will include: final engineering, mobilization, site upgrades (tree removal, pad construction, road upgrades), material supply, shop fabrication, shipping, demolition, supervision, safety, labour, equipment, installation, commissioning, training, de-mobilization and a final turnover package. All work is to comply with the RFP specifications.

There is approximately $15M increase in the project forecast compared to the business plan. During business planning and during the project planning phase, Hatch developed a project estimate derived from past previous similar project information. This estimate was submitted in the latest business plan. Upon OPG conducting an open competition RFP process for this project, costs submitted with proposals came in significantly higher than anticipated. Of the 3 proposals received, OPG selected the proposal with the lowest cost.

Investment Cash Flows

$K	LTD	2020	2021	2022	2023	2024	Future	Total
Previous releases	781	5,538						6,319
Current request	-	18,868	36					18,904
Total released to date	**781**	**24,406**	**36**	**-**	**-**	**-**	**-**	**25,223**
Future required	-							-
Total Project Cost	**781**	**24,406**	**36**	**-**	**-**	**-**	**-**	**25,223**
Ongoing Costs	-							
				Gate:	**G3**	**OAR Approval:**		$25,223 K

Project #: AGU83610
Project Title: Surge Tank Replacement
Document #: P27-BCS-08707-0815775 R0

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Business Case Summary

Approvals	Signatures	Date
The recommendation, including the identified ongoing costs, if any, represents the best option to meet the validated business need.		
Recommended by: Project Sponsor Paul Giardetti Regional Vice President - Northwest Operations	Routed in Smart Form for approval (ID#00495198)	
I concur with the business decision as documented in this BCS.		
Finance Approval: Martin Rupnik Acting Director RG Controllership	Routed in Smart Form for approval (ID#00495198)	
I confirm that this investment/project, including the identified ongoing costs, if any, will address the business need, is of sufficient priority to proceed, and provides value for money.		
Line Approval per OAR 1.1: John Hefford COO (acting) - RG	Routed in Smart Form for approval (ID#00495198)	

EXECUTIVE SUMMARY – Project Overview

The surge tank is 72 years old and is approaching the end of its rated asset life of 75 years. The surge tank is vital to the water conveyance system that serves as a regulator of water flow and pressure to protect the two (2) hydroelectric units and associated water conveyance system. Upon discovery of significant leakage on the lower bowl of the surge tank in 2015, an engineering condition assessment of the surge tank was completed. The assessment concluded the surge tank was in poor condition and should be replaced. See report P27-REP-29800-0001 – Surge Tank Condition Assessment dated June 21, 2018.

Based on the recommendation from the condition assessment and to ensure reliability of the station and public safety, the path forward is to replace the surge tank. This requires detailed engineering design, demolition, material procurement, shop fabrication, installation, and commissioning.

The previous partial execution release was to fund the tank and pedestal final engineering, partial mobilization, site upgrades, road upgrades, material procurement and shop fabrication.

This release will fund the mobilization, demolition, material supply, fabrication, labour, equipment, de-mobilization, commissioning and turnover package for the new surge tank.

OPG Plant Engineering Services and Northwest Production Support group consulted with Nova Scotia Power, which operates 12 similar surge tanks. Nova Scotia Power is also pursuing tank replacement over tank refurbishment for similar age structures.

Business Need

The surge tank is in poor condition and a replacement surge tank is vital for safe and reliable plant operation. The tank was observed to be leaking again in 2019, after significant repairs in 2015. Tank replacement mitigates significant risks to generating assets, public safety, employee safety and the environment.

Preferred Alternative:	New Surge Tank

Description of Preferred Alternative

This alternative address's replacing the existing 72-year-old structure with a new modern design, incorporating new materials, equipment and maintenance strategies with a service life of 75 years.

OPG conducted a condition assessment of the existing tank which provided a detailed summary of the current condition of the tank. All of the tank steel components inspected required some variation of repairs ranging from moderate to significant tank wall thicknesses loss (up to 67%) due to corrosion. The existing tank is in poor condition.

Project #: AGU83610
Project Title: Surge Tank Replacement
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Business Case Summary

Preferred Alternative:	New Surge Tank

Description of Preferred Alternative

OPG completed a Risk-Benefit Analysis on the replacement vs. rehabilitation option, see report P27-REP-29800-0002 R000 Aguasabon Surge Tank Risk Benefit Analysis of Asset Investment Alternatives dated July 07, 2018. The analysis considered the relative cost advantage (cost saving) gained from choosing one alternative vs. the other. The evaluation criteria used were safety risk, schedule risk, modification risk, and reliability risk.

The analysis revealed the below findings:

1. The risk associated with the tank replacement is considerably less than that of the tank rehabilitation.
2. The tank rehabilitation alternative is not a viable option in terms of its benefit to risk balance.
3. The tank replacement option has a favorable benefit to risk ratio.

The report concludes the tank replacement option is the best value for OPG and the rate payer.

The advantages of this option are:

- A well defined project scope will allow the contractors to understand the tasks required to complete the work efficiently.
- Cost overruns will be minimized as clear definition and scope reduces this risk.
- Development of an accurate schedule can be accomplished as the project management plan, scope of work, specifications, material supply, fabrication and construction strategy will be well defined. The contractors past experiences installing tanks of similar size and complexity also play a key factor into producing an accurate schedule.
- The outage duration will be minimized as an accurate schedule, project management plan and construction strategy can be developed with a new tank.
- The new surge tank will provide safe and reliable operation for another 75 years.
- Current plant and public safety risks will be significantly decreased or eliminated.
- Damage to public assets, Hydro One and OPG infrastructure downstream of tank, in case of a failure, will be eliminated.
- Asbestos and lead paint work will be limited, only during demolition (two week window). All hazardous substances associated with this structure will be removed from site.
- Working at heights will be minimized as the pedestal and tank are built on the ground and tank is jacked into place.
- Maintenance costs will be reduced and reliability of the station will be restored.

The disadvantages of this option are:

- Highest initial capital cost

Deliverables:	Associated Milestones (if any):	Target Start Date:
Previous releases:		
$1,319K (Definition BCS)	Detailed estimate, scope development, RFP review, preparation of long lead external contracts	Complete
$5,000K (Partial Execution BCS)	Limited Notice to Proceed (LNTP) Issued	Complete
	Tank material procurement	Complete
	Partial mobilization, site upgrades, road upgrades	Complete
	Tank and pedestal final engineering	January, 2020
Current release:		
$18,904K (Full Execution BCS)	Final PO issued	February, 2020
	Shop fabrication	March, 2020
	Mobilization	April, 2020
	Site execution	July, 2020
	Commissioning	October, 2020
	In service	October, 2020
	De-mobilization	November, 2020

Project #: AGU83610
Project Title: Surge Tank Replacement
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Business Case Summary

Deliverables:	Associated Milestones (if any):	Target Start Date:
	Turn Documentation	December, 2020
	Project close out	November 2021

Alternative 2:	Base Case – No Project

This alternative does not address the poor condition of the tank. Issues identified in the Tank Condition Assessment report would be discounted. Under this option, there is an eventual risk of a major tank failure. This is not a preferred alternative.

The Aguasabon generating station requires the surge tank to operate. Not replacing or refurbishing the surge tank increases the risk of failure. A tank failure could result in damage to OPG, Hydro One and public assets and will have a significant impact on OPG's ability to produce electricity from this station.

The advantages of this option are:

- Only continued routine maintenance is required.
- Asbestos and lead paint are not disturbed.
- Lowest initial cost.

The disadvantages of this option are:

- Surge tank continues to deteriorate.
- Maintenance cost overruns are plausible as future repairs are not defined. In 2015 OPG spent $1,791K to repair leaks in the tank and the tank is now leaking again only 4 years later.
- Plant reliability will be diminished as repairs will not be scheduled.
- The tank service life of 75 years will soon be surpassed.
- Public safety risks will continue to increase as tank ages.
- Failure could occur at any time, causing damage to public assets, Hydro One and OPG infrastructure downstream of the tank.

Alternative 3:	Tank Refurbishment

This alternative addresses rehabilitating the tank in-situ. Rehabilitation of the 72 year old tank would involve: erecting scaffold around the riser and tank, asbestos removal, lead paint removal, sandblasting the inside and outside of the tank, complete 100% visual and NDE testing, engineering design repairs as they are identified, tank rehabilitation, and closeout. This is not a preferred alternative.

It is unclear at this time what the increased life expectancy of the tank would be after the refurbishment. Initial estimate is it would extend the life 10-20 years.

The potential for safety incidents, scope creep, schedule extensions, and quality of repair are high risk due to the height, age, condition of the tank and poor working conditions.

OPG's internal Risk-Benefit Analysis on the replacement and rehabilitation options recommends not to pursue this option.

The advantages of this option are:

- Lower initial cost compared to tank replacement.

The disadvantages of this option are:

- No clear scope of repair. Unknown scope due to discovery work will lead to inefficient repair work.
- Cost overruns will be unavoidable due to discovery work. The contract will most likely be a time and material contract due to lack of scope.
- The schedule and outage time will be unknown due to lack of scope, unreliable schedule and undefined construction strategy.
- The service life of a refurbished surge tank is uncertain. Initial assumption is 10-20 years, at which time a new surge tank will have to be installed.

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Alternative 3:	**Tank Refurbishment**

- Reliability and future maintenance costs will be unknown.
- Plant and public safety risks may still be an issue due to the nature of the repairs.
- Asbestos and lead paint exposure will be increased due to the intense abatement requirements.
- Working at heights will be maximized, as the refurbishment will be in-situ. This is a safety concern.

Alternative 4:	**Tank Elimination**

Hatch Engineering assessed this option in a hydraulic transient analysis and it is not technically feasible to eliminate the tank. The maximum penstock pressure peak when eliminating the surge tank reached approximately 277 psi, well above allowable pressure peak of 170 psi. As such, the elimination of the surge tank was deemed not technically possible. This alternative was discarded, and no further investigation was required.

Key Risk Assessment — For Project Level A, B or C

Risk Class	Description of Risk	Response Type/ Actions/Final TCD	For Additional Review	Residual Ranking
Cost	There is a risk that project costs could be impacted by the risk classes listed below.	Accept: Contractor's final price submission was used to determine the release amount. Contingency is also included to mitigate impact. Scope and schedule well defined.	No	Low
Scope	There is a risk of scope increase due to discovery work (i.e. ground conditions, condition of riser)	Accept: Scope is well defined and based on RFP specifications. Contingency is included to mitigate impact. Replacement of tank in its entirety reduces potential scope creep.	No	Low
Schedule	There is a risk of schedule delays due to vendor delivery delays, discovery work, equipment breakdowns and weather delays	Accept: Vendor has installed numerous tanks of this size and type in the past. Comprehensive schedule agreed to by relevant stakeholders prior to outage. Good communication through-out project and appropriate level of oversight by OPG is required.	No	Medium
Quality	There is a risk that installed or rehabilitated equipment will not meet expected performance or reliability standards.	Accept: Sufficient knowledge and experience in engineering, execution and associated contractors. Contractor and Owners Engineer have experience with similar tanks and lessons learned mitigate the risk significantly. Full time on-site Owners Engineer to monitor and report on quality and specification compliance.	No	Low

Financial Evaluation

$M	Tank Replacement	Base Case (No Project)	Delay work	Tank Refurbishment	Tank Elimination
Project Cost	25.223	-	-	14.160	-
NPV	-21.143	-	-	-25.347	-
Other: (e.g., IRR)	-	-	-	-	-

Analysis of Financial Evaluation – Key Assumptions and Key Results: Refer to Appendix A4

Project #: AGU83610
Project Title: Surge Tank Replacement
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Business Case Summary

Financial Evaluation

- Assumed refurbishment option would take 3 months longer to execute than a tank replacement due to inability to fully define scope ahead of time. This results in 3 months of incremental revenue losses.
- Refurbishment estimate based/scaled from minor repair project executed in 2015 which cost $1.8M. Repairs were ineffective as the tank has shown signs of leakage again in 2019.
- Tank refurbishment would extend life of tank by 10-20 years, with a full tank replacement required in 2035.
- Refurbishment option would result in a $10K increase in maintenance costs annually, to maintain remote heating system at top of tank.

Qualitative Factors

For Project Level A or B

- Tank replacement eliminates health and safety risks for both construction and maintenance.
- Tank replacement increases station reliability due to reduced chance of leaks or tank failure.
- Tank replacement reduces public and staff safety risks and improves OPG's social license compared to a tank refurbishment.
- Defined scope and schedule for tank replacement.
- Defined tank performance and reliability for another 75 years.
- Less exposure to hazardous substances with tank replacement.

Post Implementation Review (PIR) Plan (refer to OPG-PROC-0056)

Type of PIR Report	Simplified/Standard PIR	PIR Completion Date	Q4-2021

☐ Detailed PIR KPIs will be provided in future BCS(s) when Execution Phase BCS release is requested.

PIR KPIs	Current Baseline	Target Result	How to measure?	Who will measure?
Leaks	Leaky tank	No leaks	Visual	Contractor and OPG
Unit and Water Conveyance Protection	Adequate	Operates as per specification	Unit load rejections	OPG
De-icing system	Functions as intended. Difficult to maintain.	Operates as per specification and ease of maintenance.	Visual and monitor temperature	Contractor and OPG

Project #: AGU83610
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Business Case Summary

APPENDICES

Appendix A1: Summary of Estimate - Total Project Cost										
Project Number:	**AGU83610**									
Project Title:	**Surge Tank Replacement**									
$K	**LTD**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**Future**	**Total**	**%**
Project Mgmt	23	192	13						228	1%
Inspection		790	10						800	3%
Engineering	507	179	12						698	3%
Procurement	42	5							47	0%
Construction	200	20,691							20,891	83%
Commissioning (PWU)		77							77	0%
Closeout									-	0%
Subtotal	772	21,934	36	-	-	-	-	-	22,742	90%
Outside WBS									-	0%
Contingency		1,921							1,921	8%
Subtotal w/ Contingency	772	23,855	36	-	-	-	-	-	24,662	98%
Interest	9	552							561	2%
Other									-	0%
Total	**781**	**24,407**	**36**	**-**	**-**	**-**	**-**	**-**	**25,223**	**100%**
Removal Costs (incl. above)		1,453							1,453	6%

Appendix A3: Summary of Estimate – In-Service Estimates				
$K	Only applicable to capital projects. In-Service amount shall include interest but exclude removal costs.			
Project #	**Date (YYYY-MM-DD)**	**Description**	**Amount**	**%**
AGU83610	12/21/2020	Surge tank in service estimate [total cost (25,223k) minus removal cost (1,453k)] = 23,770k	23,770	100%
Total			23,770	100%

Prepared by:	Reviewed and Endorsed by:
	Routed in Smart Form for approval (ID#00495198)
Sean Lacey FOR Kris Chartrand	Darryl Flank
Project Leader – NWO Date: February 5, 2020	Section Manager – NWO Date: February 5, 2020

References For Project Level A or B

1. Report P27-REP-29800-0001 R000 - Surge Tank Condition Assessment dated June 21, 2018.
2. Report P27-REP-29800-0002 R000 - Aguasabon Surge Tank Risk Benefit Analysis of Asset Investment Alternatives dated July 07, 2018.
3. Financial evaluation

Appendix A4: Financial Evaluation

Surge Tank Replacement Estimate

AGU83610-SURGE TANK REPLACEMENT

Project Class	Choose Classification		
Project Number	AGU83610	**Estimate Class**	2:-15% to +20%
Project Name	SURGE TANK REPLACEMENT		
Project Leader	K. CHARTRAND	**Forecast Update Date:**	2/5/2020
CAPL or NSTD	CAPL	**Earned Value Date:**	2/5/2020
Start Year	2018		

FINANCIAL SUMMARY	Prev	2019	2020	2021	2022	2023	2024	FUTURE	TOTAL
Regular Labour Total	$ 16,712	$ 114,901	$ 334,764	$ 20,795	$ -	$ -	$ -	$ -	$ 487,172
Overtime Labour Total	$ 3,480	$ 18,963	$ 41,244	$ -	$ -	$ -	$ -	$ -	$ 63,687
SAVH	$ 3,844	$ 26,427	$ 76,996	$ 4,783	$ -	$ -	$ -	$ -	$ 112,050
Material Total	$ -	$ 11,020	$ -	$ -	$ -	$ -	$ -	$ -	$ 11,020
Services Total	$ 25,000	$ 549,917	$ 21,465,601	$ 10,000	$ -	$ -	$ -	$ -	$ 22,050,518
Other	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Contingency	$ -	$ -	$ 1,920,814	$ -	$ -	$ -	$ -	$ -	$ 1,920,814
Interest	$ 112	$ 10,360	$ 567,263	$ -	$ -	$ -	$ -	$ -	$ 577,736
Sub-Total	$ 49,148	$ 731,588	$ 24,406,682	$ 35,578	$ -	$ -	$ -	$ -	$ 25,222,997
Removals	$ -	$ -	$ (1,453,300)	$ -	$ -	$ -	$ -	$ -	$ (1,453,300)
Total	**$ 49,148**	**$ 731,588**	$ 22,953,382	$ 35,578	$ -	$ -	$ -	$ -	$ 23,769,697
Total calculated	$ 49,148	$ 731,588	$ 22,953,382	$ 35,578	$ -	$ -	$ -	$ -	$ 23,769,697

Surge Tank Refurbishment Estimate

AGU83610-Surge Tank Refurbishment

Project Class	B		
Project Number	AGU83610	**Estimate Class**	5:-50% to +100%
Project Name	Surge Tank Refurbishment		
Project Leader	KC	**Forecast Update Date:**	1/28/2020
CAPL or NSTD	CAPL	**Earned Value Date:**	
Start Year	2020		

FINANCIAL SUMMARY	Prev	2020	2021	2022	2023	2024	2025	2026	FUTURE	TOTAL
Regular Labour Total	$ -	$ 151,035	$ 47,190	$ -	$ -	$ -	$ -	$ -	$ -	$ 198,226
Overtime Labour Total	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
SAVH	$ -	$ 34,738	$ 10,854	$ -	$ -	$ -	$ -	$ -	$ -	$ 45,592
Material Total	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Services Total	$ -	$ 6,085,000	$ 3,115,000	$ -	$ -	$ -	$ -	$ -	$ -	$ 9,200,000
Other	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Contingency	$ -	$ 3,000,000	$ 1,500,000	$ -	$ -	$ -	$ -	$ -	$ -	$ 4,500,000
Interest	$ -	$ 121,762	$ 94,316	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 216,077
Sub-Total	$ -	$ 9,392,535	$ 4,767,360	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 14,159,895
Removals	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total	**$ -**	$ 9,392,535	$ 4,767,360	$ 0	$ 0	$ 0	$ 0	$ 0	**$ 0**	$ 14,159,895
Total calculated	$ -	$ 9,392,535	$ 4,767,360	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 14,159,895

Project #: AGU83610
Project Title: Surge Tank Replacement
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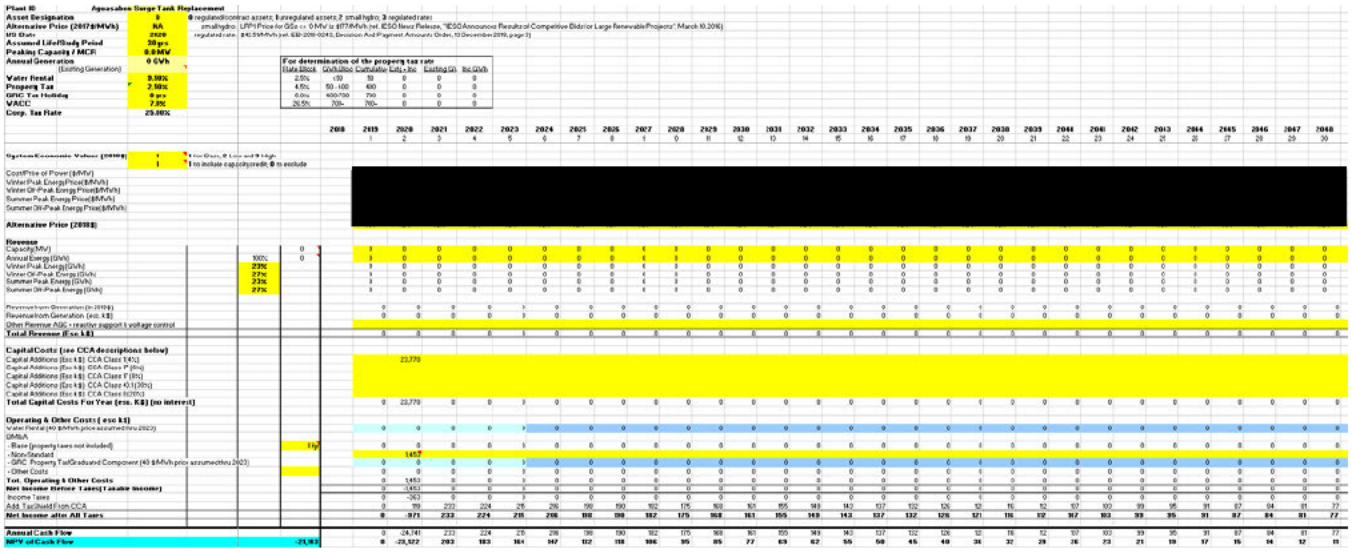
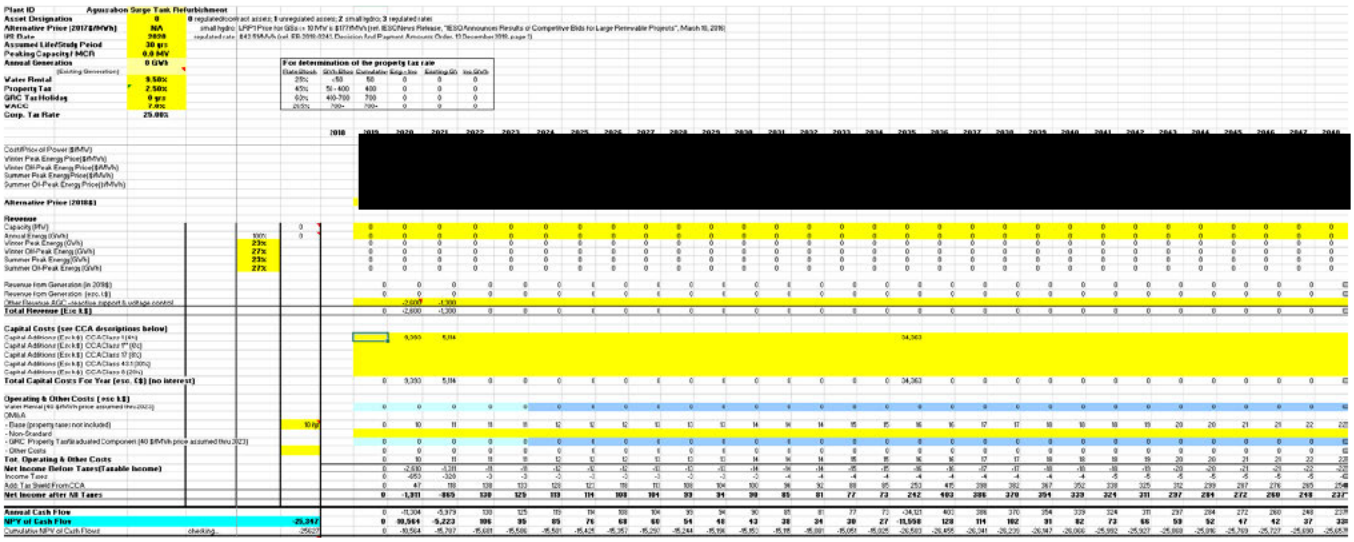
Business Case Summary

Net Present Value Calculation – Replacement



Net Present Value Calculation – Refurbishment



ONTARIO POWER GENERATION

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Business Case Summary

Project #	BK1 84185	**Controlled Doc #**	NF20-PLAN-08707.021-0032
Project Title	SAB1 – G1/G2 Replacement		
Facility	Sir Adam Beck I G.S.	**Investment Classification**	Value Enhancing
Project Level (Scalability)	A	**Financial Classification**	☐ OM&A ☒ Capital ☐ Capital Spare ☐ MFA ☐ CMFA ☐ Provision ☐ Others: [if applicable]
Release: Gate and Project Phase	☐ Choose an item. G0☐: Initiation ☐ Choose an item. G1☐: Choose an item.		☐ Choose an item. G2☐: Definition ☒ Full G3☐: Execution
Estimate Class (overall project)	Class 2	**Target Project Completion Date**	2022-12-31

Recommendation

We recommend the release of $87.7M, including $6M of contingency. A previous Development Phase BCS released $32.0M including $2.2 M of contingency, bringing the full project release to $119.7M, including $8.2M of contingency.

This release is to fund the procurement and installation of two new generating units (G1 & G2) at Sir Adam Beck I GS (SAB1), specifically:

- Installation of new generator, exciter, transformer, buswork, breakers, switches and protection & control systems for each unit.
- Replacement of all turbine components between the remaining embedded concrete draft tube and scrollcase.
  - New turbine, turbine shaft, headcover, stay vanes, discharge ring, turbine bearing, draft tube extension, wicket gates, gate arms, links and control ring and governor system for each unit.
- Refurbishment of the three G2 Headgates (refurbishment of G1 headgates was done in FEED phase to facilitate inspections of the penstocks).

The proposed units will have a nameplate of 56.4 MW each, for a total of 112.8 MW of new generation at SABI.

Investment Cash Flows

$K	LTD	2019	2020	2021	2022	2023	2024	Future	Total
Previous releases (Cap)		24,832	327						25,158
Previous releases (OM&A)		3,865							3,865
Current request (Cap)	-	(3,329)	45,815	40,611	7,498				90,595
Current request (OM&A)	-	90							90
Total released to date	**-**	**25,457**	**46,141**	**40,611**	**7,498**	**-**	**-**	**-**	**119,708**
Future required	-								-
Total Project Cost	**-**	**25,457**	**46,141**	**40,611**	**7,498**	**-**	**-**	**-**	**119,708**
Ongoing Costs	-								
					Gate:	**G3**	**OAR Approval:**		$119,708 K

Approvals	Signatures	Date
The recommendation, including the identified ongoing costs, if any, represents the best option to meet the validated business need.		
Recommended by: Project Sponsor Michael Martelli President, Renewable Generation		22 October 2019
I concur with the business decision as documented in this BCS.		
Finance Approval: John Mauti Chief Finance Officer & SVP Finance		22/10/19
I confirm that this investment/project, including the identified ongoing costs, if any, will address the business need, is of sufficient priority to proceed, and provides value for money.		
Line Approval per OAR 1.1: Ken Hartwick President & Chief Executive Officer		Oct 23/19

Project #: BK1 84185
Project Title: SAB1 – G1/G2 Replacement
Document #: NF20-PLAN-08707.021-0032

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Business Case Summary

EXECUTIVE SUMMARY – Project Overview

Business Need:

Execution of this project will increase the capacity of the SAB1 generating station's supply of clean, renewable, cost effective generation in accordance with the mandate of OPG and consistent with the 2017 Long Term Energy Plan. This is an opportunity to replace the G1 and G2 units and increase the peaking capacity of renewable energy in the Province prior to the closure of the Pickering Nuclear GS and the upcoming Sir Adam Beck2 GS overhauls. It will leverage existing facilities and infrastructure at the Beck Complex to provide increased operational flexibility at a lower cost alternative to constructing greenfield generation (i.e. new combined cycle thermal station).

Summary of Preferred Alternative:

- Removal of existing 25 Hz G1 and G2 units and all associated equipment.
- Installation of new generator, exciter, transformer and protection & control systems for each unit.
- Replacement of turbine components between the remaining embedded concrete draft tube and scrollcase (new turbine, turbine shaft, headcover, stay vanes, discharge ring, turbine bearing, draft tube extension, wicket gates, gate arms, links and control ring) and governor system for each unit.
- Procurement and site installation of headworks and tailrace stoplogs for isolation during G1/G2 construction.
- Refurbishment of G1 and G2 Headgates.
- Inspection and repairs of remaining embedded components (penstocks, scrollcase & draft tubes).
- Replacement of electrical and control components on the SAB1 Powerhouse cranes.

The project will be funded as Capital, with the exception of G1 and G2 removals, which will be funded as OM&A.

Current Project Status:

The project is currently in Definition phase. Detailed engineering design is 75% complete, and the existing G1/G2 units and associated equipment have been removed from SAB1. The penstock, scrollcase and draft tube inspections have been completed. Approximately $3.8M in long lead procurement has been authorized and was included in the $32.0M Definition phase release. The Target Price for execution phase was negotiated in Q1 2019 and based on additional information through Definition phase and discovery work on embedded components, is expected to increase by $13.8M. Overall project cost estimate is $119.7M.

Key Risks:

The project is completely replacing the G1 and G2 units but is relying on 100 year old embedded components. Specifically, penstocks, scroll cases and draft tubes. These components have been thoroughly examined during the Definition phase (after removal of the old G1/G2 units) and issues have been identified with the penstocks and scrollcase flanges. Repair estimates have been received and have been included as an allowance in the project estimate. The residual risk of discovery work is low.

SAB1 has limited workspace, and many planned and in-flight projects. The G1/G2 Project coordinates weekly integration meetings at the management level, as well as trades level, including contractors to minimize disruptions and interference between projects. Integration with other projects will continue to be a risk to the project in execution phase, but it will be mitigated in the same fashion.

The project is also dependant on the Hydro One (HONI) switchyard replacement project. This project is currently replacing the end of life switchyard (E-bus), which is fully within the generating station building envelope, as well as increasing ampacity on the circuits for the additional G1/G2 generation. Key milestones from the HONI project schedule have been incorporated into the overall G1/G2 schedule for integration and interface management.

Business Need

For Project Level A or B

Execution of this project will increase the capacity of the SAB1 generating station's supply of clean, renewable, cost effective generation in accordance with the mandate of OPG and consistent with the 2017 Long Term Energy Plan. Replacing SAB1 G1/G2 will increase the peaking capacity of renewable energy in the Province prior to the closure of the Pickering Nuclear GS and the upcoming SAB2 GS overhauls. The Project leverages existing facilities and infrastructure at the Beck Complex to provide increased operational flexibility at a lower cost alternative to constructing greenfield generation (i.e. new combined cycle thermal station). Outside of peaking, G1/G2 will also be able to use additional water which will be available at the SAB Complex during the 31 planned overhauls at SAB1, SAB2 and PGS between 2023 and 2041.

The energy and capacity at the SAB complex were modeled with and without G1/G2 and the Pump Generating Station (PGS) diffuser flaps available, using 100 years of historical rivers flows. The models also took into account winter and summer (tourist) flows diverted from the Niagara River to the Complex for generation (diversion flows).

G1/G2 peaking capacity can be utilized when diversion flows are above 1,600 cms (occurs approximately 50% of time during peak summer hours). In contrast, PGS Diffuser Flaps peaking capacity is available when diversion flows are less than 1,600 cms. When diversion flows are lower, the PGS diffuser flaps (currently being re-instated) will provide an additional 180 cms of flow to G1 & G2. The combination of replacing G1/G2 units and re-instating the PGS diffuser flaps (4

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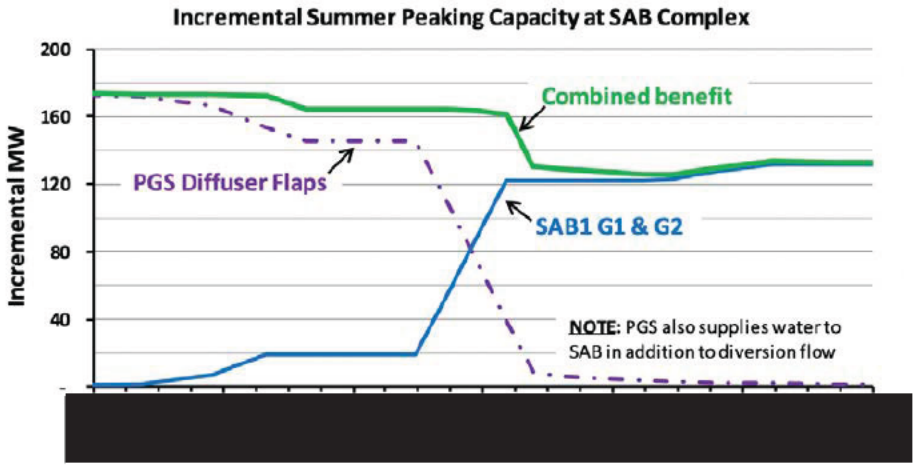
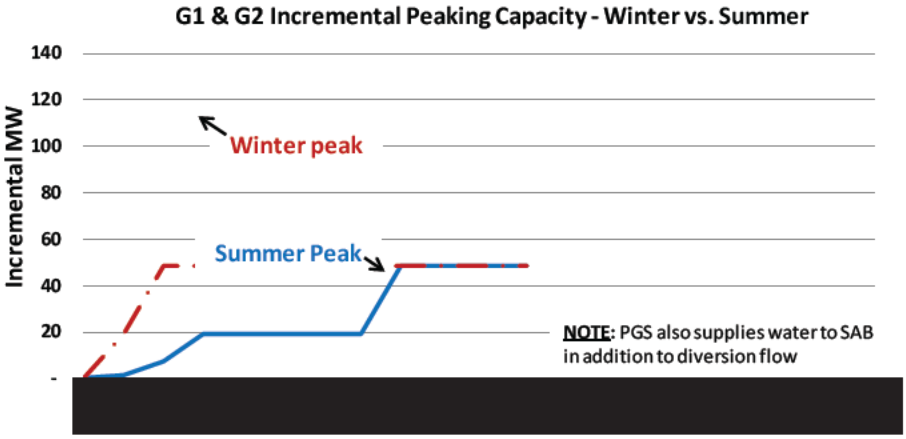
Business Case Summary

Business Need	For Project Level A or B

of 6 completed to-date) provides at least 125 MW of peaking capacity under all anticipated flow conditions. Based on the past 100 years of available summer diversion flows, G1/G2 will provide an average of 76 MW of peaking generation.

System Economic Values (SEVs) were used to value incremental energy and summer peaking capacity. Results show that G1/G2 in combination with the use of PGS Diffuser Flaps has a $144M net present value (NPV) over 75 operating years. See graphs below for the model output of the anticipated incremental summer peaking capacity at SAB complex.





[redacted]

[redacted]

Preferred Alternative:	**Convert G1 & G2 to 60 Hz 56.4 MW Units**	For Project Level A, B or C

Description of Preferred Alternative

The Preferred Alternative meets the business needs with the most effective MW output and provides reduced project risk and on-going maintenance costs. Restoring G1 and G2 to service will make use of existing assets and infrastructure at the Beck Complex and provide a source of low-cost green energy while increasing operational flexibility of the electricity system.

The preferred alternative includes the following scope:

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Preferred Alternative:	**Convert G1 & G2 to 60 Hz 56.4 MW Units**	For Project Level A, B or C

Description of Preferred Alternative

- Removal of existing 25 Hz units G1 and G2 and associated equipment.
- Installation of new generator, exciter, transformer and protections and control systems for each unit.
- Replacement of the turbine components between the remaining embedded concrete draft tube and scrollcase (new turbine, turbine shaft, headcover, stay vanes, discharge ring, turbine bearing, draft tube extension, wicket gates, gate arms, links and control ring) and governor system for each unit.
- Procurement of forebay and tailrace stop logs to provide isolation during the project, they will become station spares at the end of the project.
- Refurbishment of the six G1 & G2 headgates (3 per unit).
- Inspection and repairs of remaining embedded components (penstocks, scrollcase & draft tubes).
- Replacement of electrical and control components on the SAB1 Powerhouse cranes.

Contracting and Procurement Strategies were developed with the key objectives of controlling cost and schedule growth, sharing risks/opportunities with the Contractor and ensuring the Contractor will meet the Project deliverables within the project deadlines. The project consists of two phases:

Phase 1 (Previous Release):

- Phase 1 consists of the front-end engineering design (FEED), procurement of long lead time items, dismantling of the old units, and technical assessment of the water conveyance structures and existing concrete foundation of the stator to help mitigate the risk of discovery work during execution (Phase 2). The work started in December 2018 (with a Limited Notice to Proceed to the successful proponent) and will be substantially completed by March 2020.
- A fixed price or "lump sum" strategy was chosen mainly due to the well-defined project deliverables on the dismantling and design scope. The engineering design is considered core work for the Contractor.

Phase 2 (This Release):

- Phase 2 will consist of the fabrication and installation of new G1 & G2 units. The work is scheduled to start in July 2020, with in-service dates for G2 in Q4 2021 and G1 in Q1 2022.
- A blend of target and fixed price was selected for Phase 2, as it best meets the key objectives of controlling procurement costs of major equipment which has minimal risks under fixed price. Project scope with more substantial risk can be subjected to additional planning under a target price model. During execution, the Contractor will be incentivized to find cost effective project delivery methods and disincentivized to allow excessive cost grown. This approach has been used with success on many projects of similar size, scope and complexity across OPG.
- The installation of G1/G2 is expected to proceed as "Owner Only", similar to the unit dismantling and removal work done in Phase 1.

A Project Management Plan (PMP) has been completed for the project and a Testing and Commissioning Plan will be completed by December 2019.

Regulatory Approvals

An Ontario Waterpower Association Class Environmental Assessment was completed for the project in February 2018. It was required due to the planned capacity upgrades exceeding the "grandfathered" capacity of the SAB1 GS.

Cultural Heritage Research and Cultural Heritage Recommendation Reports were completed in July 2018 for the SAB1 GS. Units 1 and 2 were listed as having Provincial heritage attributes due to the fact they were listed in the 1992 Federal heritage designation. A Strategic Conservation Plan (SCP) for SAB1 GS was initiated, and a Heritage Impact Analysis (HIA) was completed in March 2019 for the removal of the original G1 & G2 units. The HIA was accepted by Ministry of Tourism, Culture and Sport (MTCS).

Both a System Impact Assessment (SIA) and a Connection Impact Assessment (CIA) were completed in October 2015 for G1/G2. The SIA allows the IESO to assess the impacts of the new connection to the IESO Controlled Grid (ICG) and identify fault limits. The SIA was also needed for Hydro One to complete a CIA to incorporate SAB1 G1/G2 return to service into their projects. OPG signed a Connection Cost Recovery Agreement (CCRA) with Hydro One in May 2018 for $7.5 M. The CCRA released funding for Hydro One to perform ampacity upgrades attributed to G1 and G2 in the switchyard (E bus) and to connect G1 and G2 to the transmission grid.

Constraints:

- The SAB1 Powerhouse is only set up to manage one major overhaul at a time; coordination will be required with Production for the use of the overhead crane during execution and for laydown areas.
- Niagara Parkway is classified as a controlled access highway and requires a "Heavy or Oversized Load" permit when transporting heavy or oversized loads. Load restrictions may apply during spring seasons.

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Preferred Alternative:	**Convert G1 & G2 to 60 Hz 56.4 MW Units**	For Project Level A, B or C

Description of Preferred Alternative

- Entrance road to SAB1 (Glen Access Road) off Niagara Parkway has limitation on size and length of trucks due to space constraints.
- Coordination is required with Hydro One to ensure the required 115 kV "E" Bus upgrades are completed by Q1 2021 to avoid the critical path and allow for G1/G2 to be connected to the system.

Key assumptions and risks include:

- This project, combined with the PGS diffuser flaps project currently in execution, will provide the grid with 125 MW of reliable peaking capacity under all anticipated flow conditions.
- Major water conveyance and control structures (penstocks, scroll cases, draft tubes, headgates) will not require full replacements. $9M in allowances ($1M for penstock repairs and $8M for scroll case flange repair/replacement) has been included in the overall project estimates based on the results of the Definition phase engineering assessment of these components and budgetary estimates from suppliers for repairs.

Deliverables:	**Associated Milestones (if any):**	**Target Date:**
Previous Releases (for Phase 1):		
Runner and Turbine Development and Model Testing	Start Runner Design and Modelling Test Engineering design for runner (CFD) complete Runner modelling and testing complete	Complete Complete Complete
Early procurement of runner ($1.4 M)	Start procurement of runner	Complete
Procurement of headworks and tailrace sectional service gates to provide isolation during the project	Delivery of tailrace sectional gates Delivery of headworks sectional gates	Complete Complete
Dismantling and removal of existing 25 Hz Units 1 & 2	Completion of G2 removal Completion of G1 removal	Complete Complete
Inspection and refurbishment of G1 intake headgate	G1 intake gate refurbishment complete	Complete
Contractor submission of revised Target Cost (for Phase 2)	Contractor submission of revised Target Cost	Oct. 31, 2019
FEED Phase (Detailed Engineering) complete	Substantial completion - Phase 1 (FEED) milestone	Mar. 17, 2020
Current release (for Phase 2):		
SAB1 North and South Powerhouse Crane electrical and controls replacement	Powerhouse Crane electrical upgrades complete	Jul 31, 2020
Hydro One switchyard (E-Bus in the SAB1 GS) connection and ampacity upgrades for Units 1 and 2	G2 connection complete G1 connection complete	Oct. 31,2020 Apr. 30, 2021
Installation of new generator, exciter, transformer, buswork, breakers, switches, and protections and control systems for Unit 1 and Unit 2 Start of Installation	Contractor mobilization for Phase 2 Unit G2 Available for Service (AFS) Unit G1 Available for Service (AFS)	Jul. 6, 2020 Oct. 28, 2021 Mar. 7, 2022
Project Close out	Close out completed	Dec. 31, 2022

Alternative 2:	**Base Case – Cancel Project**	For Project Level A, B or Value-Enhancing

Not recommended. This alternative would close down the project.

Pros:

- None.

Cons:

- The alternative would require a write off of costs incurred to date.
- Does not improve peaking capacity in the Province.
- Cancelling the project would not align with water availability as a result of 31 planned overhauls at SAB1, SAB2 and PGS between 2023 and 2041. Beginning in 2022, OPG plans to refurbish one generating unit at SAB2 each year for 16 years. If the 25 Hz generators are converted to 60 Hz in that time, they will make up for the lost generation as the other generators are taken offline to be refurbished. This would reduce the overall production of hydroelectric power from the Niagara hydro stations during this overhaul period.

Alternative 3:	**Delay Work for Preferred Alternative (Replacing G1/ G2) until Pickering Closure 2025**

Not recommended. This alternative would delay the project with a re-start date of 2025. In-service would be delayed until 2028. This option used a Rate of Inflation Increase Calculation of 2%/Yr (The Bank of Canada inflation-control target range is 1 to 3 %).

Pros:

- The short-term costs of replacing the units could be deferred by delaying the work. Depending on the provincial demand for electricity in the early 2020s, the delayed approach may better align with the needs of the grid. The NPV for this alternative is lower than the recommended alternative ($53 M vs $62M), and this alternative would forgo the operating flexibility described below.

Cons:

- Delaying the work would not align with water availability as a result of planned overhauls at SAB1 and SAB2. From 2021/22 (proposed in-service in recommended alternative) to the proposed 2028 in-service date in this scenario, 8 overalls are planned at the SAB complex. Excess water not being used at SAB2, would be used by G1/G2 in the recommended alternative.

Alternative 4:	**Convert only one unit (G2) to 60 Hz 56.4 MW (MCR)**

Not recommended. This alternative would convert only Unit G2.

Pros:

- This approach would replace one generator unit and its associated components. OPG would deliver added value by proceeding with at least one unit.

Cons:

- This approach has a lower NPV ($36M vs $62M) versus replacing both units due to lose of economies of scale, and lower overall peaking capacity. Engineering, project management and many other base costs remain the same regardless if one or two units are replaced.
- Proceeding with only one unit prevents OPG from maximizing the hydroelectric power production from the SAB Complex during the overhaul period of 2022 to 2041.

Key Risk Assessment — For Project Level A, B or C

Risk Class	Description of Risk	Response Type/ Actions/Final TCD	For Additional Review	Residual Ranking
Cost	Increase in project cost during Execution	Mitigate: • Contracting strategy uses Target Cost model with locked in labour and equipment rates, as well as disincentives for cost overruns • Auditing of submitted invoices • Water conveyance structures and unit foundations inspected during Phase 1	No	Low

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Key Risk Assessment			For Project Level A, B or C	
Risk Class	**Description of Risk**	**Response Type/ Actions/Final TCD**	**For Additional Review**	**Residual Ranking**
Schedule	Interference or delays from other projects (e.g. G5 overhaul, Hydro One) in the station and conflicts arising from shared space or resource equipment	Mitigate: • Project Site Manager to monitor potential impacts and provide coordination between work groups • Craning operations require transfer of control between work groups • Offsite storage of unit components. Will be local but arrive at site "just in time"	No	Medium
Quality	Upon final commissioning, the results yield less than acceptable vibrations due to hydraulic imbalances (e.g. roping or cavitation) or a large operational "rough zone" and must be corrected	Mitigate: • Detailed model testing was performed • Air emission allowance in specs • Operational zone clearly specified	No	Low
Schedule	Hydro One infrastructure not completed in time to allow G1 and G2 to connect to the system resulting in commissioning/operating delays	Mitigate: • CCRA signed with Hydro One with connections milestones 6 months ahead of when required for testing • OPG SPOC to monitor	No	Low
Quality	After model testing, contractual performance targets are not met during Gibson testing	Mitigate: • LDs, cost disincentive for not meeting the performance requirement.	No	Low
Industrial Safety	Injury to OPG or Contractor staff	Transfer: • Replacement of Units 1 and 2 will be "Owner-Only" where the Contractor shall perform all Work and shall fulfill the role of "Constructor" in accordance with the Ontario Occupational Health and Safety Act (OHSA) and its regulations. OPG will act as "Owner" as per the OHSA. • Standard construction risks, which are to be managed by following OHSA regulations	No	Low

Additional Risk Analysis — For Project Level A or B

The project is recommending using the P90 results from the Monte Carlo analysis for calculating the project contingency. ($5.9M in cost risk and $2.3M in schedule risks. $8.2M in total).

The project identified 10 discrete risks that were significant in nature. Three of those risks are related to the 100 year old embedded components (penstocks, scroll cases and draft tubes) that the project is planning to re-use. As part of the Definition phase, the penstocks and draft tubes were both inspected and will require minor repairs. However, based on detailed inspections, the scrollcase flanges will require significant repairs or replacement. These 3 risks were removed from the Monte Carlo Analysis and based on budgetary quotes, an allowance of $12M has been held in the project estimates ($3M allowance for Penstock repairs and $8M allowance for scrollcase flange replacements).

As a result of the Monte Carlo Analysis, $8,169K will be held in contingency for schedule delays, unknown unknowns and other discrete risks.

We are confident the remaining contingency is sufficient given the old G1/G2 units are fully removed, there are no remaining sub surface risks and engineering design is 75% complete.

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Business Case Summary

Financial Evaluation		For Project Level A, B (with multiple feasible alternatives) or Value-Enhancing		
$M	Preferred Alternative Convert G1 & G2 to 60 Hz 56.4 MW Units	Base Case (Cancel Project)	Alternative 3 Delay Preferred Alternative to 2026 Start	Alternative 4 Convert ONLY G2 to 60 Hz 56.4 MW Unit
Project Cost	119.7	0	134.7	74.8
NPV (based on 76MW G1/G2 peaking only)	62	0	53	36

Analysis of Financial Evaluation – Key Assumptions and Key Results:

Economic analysis performed by OPG Finance Investment Planning. Key findings include:

- All alternatives (except cancellation) have positive NPV, with the Preferred Alternative being the most economic.
- Peaking capacity value is the most critical component of NPV.

Qualitative Factors For Project Level A or B

- The project will increase available renewable energy to the Ontario grid, reducing the environmental impact of meeting Ontario's electricity demand.
- The project will leverage existing facilities and infrastructure at the Beck Complex to provide increased operational flexibility and a lower cost alternative to constructing greenfield generation.
- Complete replacement of the old units instead of retrofitting components provides increased unit reliability, easier integration with existing embedded components with less risk of design not working with existing equipment, and higher efficiencies with new technology.
- Outside of peaking capacity, G1/G2 will also be able to use additional water which will be available at the SAB Complex during the 31 planned overhauls at SAB1, SAB2 and PGS between 2023 and 2041.

Post Implementation Review (PIR) Plan (refer to OPG-PROC-0056)

Type of PIR Report	Comprehensive PIR	**PIR Completion Date**	Dec. 2022

PIR KPIs	Current Baseline	Target Result	How to measure?	Who will measure?
Unit Vibration and hydraulic stability	Industry Standards	Listed in detail in the technical specification and EPC with penalties to vendor for non-performance	Vibration testing during testing/commissioning	Machine Dynamics & Component Integrity (MDCI)
Turbine Power @ 91.0m net head	57,500 kW (per EPC)	57,500 kW	Performance testing during commissioning after in-service.	Engineering Technical Services - Performance & Testing Group (ETS P&T)
Transformer Losses	Per EPC – 192kW	192kW	Performance testing during commissioning after in-service.	Engineering Technical Services - Performance & Testing Group (ETS P&T)
Hydraulic Performance	57,500 kW at 68 m3/s. (per constraint in Tech Spec, and guaranteed output in EPC)	57,500 kW at 68 m3/s.	Gibson Test to be performed 6 – 1 year)	Specialized team including US Army Corps of Engineers and OPG Engineering

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Business Case Summary

APPENDICES

Appendix A1: Summary of Estimate - Total Project Cost										
Project Number:	**BK184185**									
Project Title:	**SAB1 G1 G2 Replacement Project**									
$K	**LTD**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**Future**	**Total**	**%**
Project Mgmt		2,299	4,855	4,569	2,209				13,932	12%
Inspection		301							301	0%
Engineering		5,196	2,866	2,594	766				11,422	10%
Procurement		5,131	12,784	13,586	-				31,502	26%
Construction		10,881	18,440	10,935	512				40,768	34%
Commissioning									-	0%
Closeout									-	0%
Contractor Fee		244	3,004	3,144	1,008				7,400	6%
Subtotal	-	24,052	41,950	34,828	4,496	-	-	-	105,326	88%
Outside WBS									-	0%
Contingency		1,000	2,390	2,390	2,390				8,170	7%
Subtotal w/ Contingency	-	25,052	44,340	37,218	6,886	-	-	-	113,496	95%
Interest		406	1,801	3,393	613				6,212	5%
Other									-	0%
Total	**-**	**25,457**	**46,141**	**40,611**	**7,498**	**-**	**-**	**-**	**119,708**	**100%**
Removal Costs (incl. above)		3,955							3,955	3%

Appendix A2: Summary of Estimate – Notes			
Escalation Rate	2%	**Interest Rate (going-forward)**	4.4%

Project #	Date (YYYY-MM-DD)	Description	Amount	%
BK184185	10/28/2021	Unit 2 in Service	56,855	49%
BK184185	3/7/2022	Unit 1 in Service	56,855	49%
BK184185	12/31/2022	Close-out	2,045	2%
Total			115,754	100%

Prepared by:		Reviewed and Endorsed by:	
Dave Bonell	11OCT19	Michael Martelli	October 22, 2019
RG - PMO	Date	President Renewable Generation	Date
Project Manager		Project Sponsor	

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APPENDICES (Continued)

Appendix C: Financial Evaluation Assumptions For Project Level A, B (with multiple feasible alternatives) or Value-Enhancing

Key assumptions used in the financial model of the project are:

Project Capital Costs:

(1) Estimate for construction based on competitive bids and historical records for similar work

(2) Contingency is 11.34% or $8.170 M for the remaining project estimate (minus allowances, contingency and interest) of $72.7M.

Financial/Economic:

(1) Corporate Tax Rate: 25%

(2) CCA Rate: 8% - assumes that full CCA benefit can be claimed in any given year

(3) After-tax WACC: 7% - estimate for OPG's long-term Weighted Average Capital Cost (WACC)

(4) Annual Escalation (CPI): 2%

Project Life:

(1) Unit G2 In-service by Oct. 2021

(2) Unit G1 In-Service by Feb. 2022

(3) Forecast length: 75 years

Energy Production:

(1) Station output modelled with linear cms to MW curves; different slopes used up to an efficiency point and up to max capacity

(2) Diffuser flaps rehabilitated on all 6 Pump Generation Station (PGS) units, increases output by 30 cms/unit and 4 MW/unit

(3) Station specifications assume G1 & G2 converted to 56.4 MW units, and assume all existing PGS, SAB1 and SAB2 units are operating

Operations, Maintenance & Administration (OM&A) Expenses and Sustaining Capital:

(1) Annual fixed OM&A: 0.15 $M/Unit ($2018)

(2) GRC: 14.4 $/MWh

(3) Major Overhaul Costs: 30 $M/Unit ($2018)

(4) Major Overhaul Frequency: 25 years – units are out of service for the full year during major overhaul

Station Outages:

(1) PGS unit outages: 365 day outage every 15 years – station outage schedule provided by Plant Operations, PGS unit outage more frequent due to pumping and generating functions

(2) SAB1 unit outages: 365 day outage every 25 years

(3) SAB2 unit outages: 365 day outage every 25 years

ONTARIO POWER GENERATION

Records File Information:
For all projects, file in accordance with local project management governance
For capital projects, send a copy to Shared Financial Services/Asset Accounting
For PIRs,refer to OPG-MAN-00120-0010; Retention: P

Internal Use Only

FIN-FORM-PA-005-R006*

Project Closure Report

This Project Closure Report (PCR) form is used for documenting relevant project closure information and approving the project closure decision in accordance with FIN-PROC-0030.

Part 1: Project Account Closure – Complete for all projects	
Is PIR required? Yes	**Records Document Number** (required only when PIR is not required)
Project Executing Organization Renewable Generation Projects	**Date** 9 November 2023
Project Number COR80581	**Site / Location Name** QC10 - Ranney Falls
Project Title Ranney Falls G3	
Project and Asset (if any) Description Ranney Falls - New G3 10 MW unit generation station to replace end-of-life existing G3 0.8MW unit.	
Company Code / Business Area (Controller) 9822	**Asset Class (Controller)** See list
Super Asset Number (Controller) 08717	**Super Asset Description (Controller)** RANNEY FALLS G3

Part 2: Final In-Service Transfer – Complete for CAPITAL projects
Final In-Service Transfer Credit Account (Controller) See journal

Part 3: Project Cost and Schedule Variance – Complete for all projects

When the Cost variance is not within the acceptable range as per OPG Estimate Manual, OPG-MAN-00120-0012, cost variance root cause should be captured e.g., inflation, scope creep, performance issues, etc.).

	(1) Original Approved Estimate	(2) Current Approved Estimate	(3) Final / Actuals	(4) Variance (= 3 – 2)
Cost ($K)	$77,300,147	$77,300,147	$74,497,193	$2,802,954
Schedule (In-service date)	2019-12-31	2022-06-27	2023-10-30	130 weeks behind schedule

*Associated with FIN-PROC-0030, Property, Plant and Equipment

Project Closure Report

Deliverables (Completed? Intended Functionality Achieved? Target vs. Actual?)

Deliverables were successfully achieved. Although there were extensive schedule delays, the overall cost remained within budget.

BCS - Approved 14 March 2017

- Recommended the release of $71.2M, including $7.4M of contingency. This approval brought the total released for the Project to $77.3M, including definition phase of $6.1M plus execution phase of $71.2M.

This release was to fund the construction, testing and turnover to Operations of the new 10MW G3 single unit generating station, transmission connection with Hydro One, Owner's Engineer and other OPG direct costs and interest during construction, specifically:

- Replacement of the existing G3 unit (0.8 MW), which reached end-of-life in June 2014, with a 10 MW Andritz EcoBulb by using the excess water running through existing OPG and Parks Canada water control infrastructure on the Trent River
- Installation of a new spillway integrated with the new G3 powerhouse providing asset protection at the Ranney Falls Generating Station (GS) site and enhanced public safety in Campbellford.

The project also provided the following qualitative benefits:

- Consultation and capacity building with area Indigenous communities resulting in contracting and construction employment opportunities.
- Enhancement of OPG's long-term relationship with Parks Canada and the Trent Hills Municipality.
- Satisfied the Province's Long Term Energy Plan (LTEP) objective of providing cost-effective and green ways of leveraging provincial hydroelectric assets while avoiding the need for new near-term procurement in Southern and Central Ontario.

Schedule

The G3 powerhouse civil construction phase, gates and balance of plant equipment were placed in service in May 2019 according to schedule. Spillway gate automation of the two existing powerhouse units took place on April 2019. Unit 3 turbine generator was placed in service Jun 2022.

The water-to-wire (W2W) phase of the project suffered major delay due [redacted]

[redacted]

- [redacted]
- [redacted]
- [redacted]

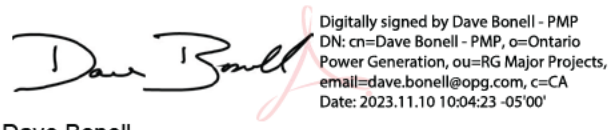
References or attached pages for:

- Listing in chronological order of all corresponding BCSs and of variance approvals – date and approval authority; and what approved – cost, schedule, and deliverables
- If PIR is required (based on last BCS), then lessons learned report is NOT required.
- If PIR is NOT required, lessons learned report should be attached (export from ePMX or automated lessons learned report exported from reporting website is acceptable).
- Discussion and analysis – cost, schedule, deliverables, and key lessons learned

References:

- HDEV0024-BCS Ranney Falls GS G3 Project Definition Phase Hydro Development - Commission The End of Life 0.8MW Unit - Developmental Business Case - Dec. 15, 2011.
- QC10-22260-0001 - Ranney Falls GS - G3 Project - Execution Phase Business Case Summary (BCS) - COR80581 - March 14, 2017.

Project Closure Report

Part 4: PCR Approval Signatures – Complete for all projects	
Project Manager: The project is declared closed. I confirm that all remaining materials (if applicable) of the project are appropriately dispositioned as spare parts to accepting business areas or are declared surplus. No costs shall be charged to this project at this point forward. **Controller for Project Organization (if applicable, i.e., the BU/Function has a Project Organization Controller):** I confirm the information documented in this PCR is correct.	
PCR Submitted by: Project Manager  Digitally signed by Dave Bonell - PMP DN: cn=Dave Bonell - PMP, o=Ontario Power Generation, ou=RG Major Projects, email=dave.bonell@opg.com, c=CA Date: 2023.11.10 10:04:23 -05'00' Dave Bonell Senior Manager Project, RG Major Projects, **Date** Nov 10, 2023	**PCR Reviewed by: Controller for Project Executing Organization** (if applicable)  Joel Pereira Finance Controller,Project Control, Major RG and Nuclear Projects **Date** Nov 10, 2023
Station / Plant Group / Function Controller: I confirm the information documented in this PCR is correct. **Asset Owner:** I authorize the decision to declare project closure for this project.	
PCR Reviewed by: Controller for Sponsoring Organization  John Sim Director Controllership, Business Support Central **Date** Nov 14, 2023	**PCR Approved by: Asset Owner or Sponsoring Organization Authority**  John Hefford VP Regional Operations , Western Region **Date** Nov 16, 2023

Part 5: PIR Signature – Required only when PIR is not required		
	Signature	**Date**
I have reviewed and accept the project results in this report.		
Reviewed by: Project Sponsor N/A		

Part 6: Distribution – Required only when PIR is not required

Distribution:

When PIR is not required, the Project Sponsor shall ensure distribution (cc) to the following personnel if they have not already signed off above:

- Finance Approver in the BCS: Name, Title, Department, BU/Function
- Line Approver in the BCS: Name, Title, Department, BU/Function
- Other key stakeholders:
  Name, Title, Department, BU/Function

Project Closure Report

Part 7: PCR Checklist – Complete for all projects by Project CSA or Project Manager	
Checklist Item	**Checkbox**
MyTime – Correction to default labour account distribution: Indicate if PCR relates to a Project where Default Labour was posted via MyTime – YES – NO If **YES,** Shared Services A&R to take action to correct the accounting in ZZFI_CC table in SAP Note - Work Events will be automatically end dated upon Projects closure in AS9 master data.	☒ ☐
All PO/WO/MRs/CRs have been closed, including: • Request sent to AS9 buyer to close PO/COs after closing related MRs/CRs Complete • Request sent to Planner to close any AS9 Work Order Tasks Complete • Request sent to ONCORE to close all tasks and associated PO's Not Required	☒ ☒ ☒
All Accruals have been cleared. Complete	☒
Any purchases through purchasing cards (VISA) or Ariba Web Catalogue have been reconciled in Concur or shipped by Ariba Vendor. Complete	☒
All default Business Expense or VISA default accounts have been changed. Complete	☒
All spare parts have been set up in AS9, including: • Inventory by Cat ID with ROP/TMAX values Not required • Capital Spares are set up in the appropriate Asset Class and account Complete	☒ ☒
All obsolete or surplus inventory or components have been identified and Surplus Declarations routed to ensure that all retired assets have been properly removed from the fixed asset ledger and inventory accounts. Not Required	☒
The Super Asset Class, the Company Code, Super Asset Numbers agree with previous REIS. Complete	☒
The Final Actual Costs and Current Approved Estimate agree with FRA and/or SAP. Complete	☒
If PIR is not Required, it was defined in the approved BCS. PIR Required	☒
If the Actuals are greater than the Approved amount, the overspend has been approved in accordance with the appropriate OAR Element specified in the BCS standard (OPG-STD-0076, Developing and Documenting Business Cases), with an approved OPG-FORM-0077, Project Over-Variance Approval or a Superseding BCS. Actuals are less than the approved amount	☒
A copy of the FRA and/or SAP Report is attached. Complete	☒

Project CSA / Project Manager (Sign-Off): I confirmed the completion of all the checklist items.		
Project CSA or Project Manager Kenneth Welsh Cost and Schdule Analyst, EPMO, Major Projects/HALO	**Signature**	**Date** 9 November 2023