EB-2013-0321

ONTARIO ENERGY BOARD

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

AND IN THE MATTER OF an Application Ontario Power Generation Inc. for an order or orders approving payment amounts for prescribed generating facilities commencing January 1, 2014.

SCHOOL ENERGY COALITION CROSS-EXAMINATION COMPENDIUM (Niagara Tunnel Project Panel)

Jay Shepherd P.C.
2300 Yonge Street, Suite 806
Toronto, Ontario M4P 1E4

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

Counsel to the School Energy Coalition

ONTARIOPOWER GENERATION

BUSINESS CASE SUMMARY

Niagara Tunnel Project (EXEC0007)
July 28, 2005 (Confidential)

FULL RELEASE FOR NIAGARA TUNNEL PROJECT (EXEC0007)

1. RECOMMENDATION:

Approve the release of $963 M for design and construction of the Niagara Tunnel Project (the "Project"), bringing the total Project cost estimate to $985 M, including $22.5 M previously approved. Based on the recommended design / build proposal, the new tunnel will be in-service by June 2010, will increase the diversion capacity of the Sir Adam Beck Niagara GS complex by 500 m^3/s and facilitate a 1.6 TWh increase in average annual energy output. The cost contingency and schedule contingency included ($112 M and 8 months respectively) are each based on a confidence level of 90%. This Project compares favourably with other renewable electricity supply options and is aligned with directions provided to OPG by the Province. Project approval is contingent upon financing, satisfactory to OPG, being provided by the Province.

Total Investment Cost: $985 M (including $22.5 M previously approved)

Year	To 2004	2005	2006	2007	2008	2009	2010	Totals
Project Capital	4	69	194	215	228	209	66	985
2005 Business Plan	5	65	170	160	180	140	15	735
Variance	-1	4	24	55	48	69	51	250

Type of Investment: Strategic Projects (OAR - Section 1.3)

Release Type: Full

Funding: The Niagara Tunnel Project is in the approved Business Plan as presented above, contingent on financing being provided by the Province.

Investment Financial Measures: The increased energy output resulting from the Project will receive a regulated rate as part of OPG's regulated hydroelectric assets. An equivalent Power Purchase Agreement (PPA) Price estimated for the incremental energy output is 6.7 ¢/kWh (2011$) and compares favourably with the approximately 8.0 ¢/kWh (2011$) PPA rate offered under the recent RFP for renewable energy development. Other project financial metrics and sensitivities are presented in the Financial Analysis section of this BCS.

2. SIGNATURES

Submitted by:

Emad Elsayed Aug 8/05
Emad Elsayed — Date
Vice President
Niagara Tunnel Project

Reviewed By:

Jim Burpee — Date
Senior VP
Energy Markets

Approved By:

Aug 9/05
Donn Hanbidge — Date
Chief Financial Officer (Acting)

Approved By:

Jim Hankinson — Date
President and CEO

3. BACKGROUND & ISSUES

Background

- The Sir Adam Beck (SAB) hydroelectric complex at Niagara consists of two generating stations (SAB1 and SAB2), and a pumping / generating station (SAB PGS). SAB1 and SAB2 have a total generating capacity of 1,960 MW. SAB PGS has a capacity of 174 MW and is generally utilized to pump / store water during off-peak periods for use during periods of peak electricity demand. The SAB complex currently produces average annual energy output of approximately 12 TWh.

- The Niagara Tunnel development is a unique, site-specific opportunity for OPG to produce additional, low-cost, renewable and environmentally sustainable energy for its customers, enhancing the existing Sir Adam Beck – Niagara hydroelectric facilities in the efficient use of Niagara River flow available to Canada for power generation with a resultant 14% increase in average annual energy output.

- The Canadian streamflow share of the Niagara River has been calculated as ranging from about 600 to 3000 m^3/s, averages about 2000 m^3/s and exceeds the capacity of the existing SAB diversion facilities (canal and two tunnels) about 65% of the time.

- Feasibility studies for expansion of Ontario Hydro's hydroelectric facilities at Niagara commenced in 1982. Definition phase engineering and environmental assessment work started in 1988 and was suspended in 1993. The Environmental Assessment (EA) was submitted in March 1991 and approval was obtained on October 14, 1998.

- The Environmental Assessment (EA) approval was for the Niagara River Hydroelectric Development consisting of two new tunnels, an underground powerhouse and transmission improvements in the Niagara Peninsula. The EA approval provided Ontario Hydro with the flexibility to undertake the development in phases. A plan to proceed with only one tunnel was initiated in 1998, and tenders were called for detailed design and construction, but work was suspended in 1999 due to uncertain market conditions and imminent corporate reorganization. Expenditures in 1998/99 totalled $2.5 M and are included in the estimated total project cost. Earlier definition phase expenditures of $57 M on the Niagara River Hydroelectric Development were written off by Ontario Hydro.

- In November 2002, the Province announced that it had directed OPG to proceed with a new water diversion tunnel at Niagara and subsequently indicated a strong desire to have the project completed in the shortest possible timeframe.

- The timing for completion of the new tunnel is also linked to the required rehabilitation of the 83-year old SAB1 canal, which delivers over one third of the water used at the SAB complex. The canal rehabilitation work is expected to start in 2011 and will require taking the canal out of service for approximately 8-12 months. Having the new tunnel in place will avoid an energy generation loss of 2.7 to 4.0 TWh caused by the canal outage (depending on available Niagara River flow and outage duration).

- On June 24, 2004, the OPG Board of Directors approved a preliminary release of $10 M to conduct a Request For Proposal process and to carry out such preconstruction activities as OPG deems necessary. Commitments for this work, to the end of June 2005, total $8.7 M.

- Provisions of an agreement between the Niagara Parks Commission (NPC) and OPG, dated February 18, 2005 (which agreement forms part of the larger Niagara Exchange transaction concerning the long term disposition of water rights on the Niagara River), committed OPG to undertake remedial work at the retired Ontario Power and Toronto Power generating stations as part of reversion of these stations to the NPC and secured the agreement of the NPC that until 2056 it would grant water rights to no party other than OPG. An associated $10 M settlement with

Fortis Ontario, approved by the OPG Board on February 8, 2005, secured an irrevocable assignment of the water associated with Rankine GS. These costs are included in the release estimate for the Project.

- Under Ontario Regulation 53/05, effective April 1, 2005, the Project will become part of OPG's regulated hydroelectric assets and OPG will be given a fair opportunity to recover prudently incurred costs through the regulated rates.

- OPG has been in discussions with the Province regarding financing for the project. However, formal agreement including cabinet approval is still pending.

Project Execution Strategy

- A Design / Build contracting approach was selected for the Niagara Tunnel Project to minimize Project duration, to capture contractor experience and innovations, to appropriately allocate project risks and to provide as much price certainty as practical for design and construction of the Project.

- The Design / Build Contract transfers most tunnel design and construction risks to the contractor and includes bonuses for exceeding the Guaranteed Flow Amount[1] (tunnel flow capacity) and for early Substantial Completion[2] (In-Service Date), and liquidated damages for failure to achieve the Guaranteed Flow Amount and late Substantial Completion.

- The proposal process followed to determine the preferred Design / Build Contractor for this undertaking included:
  - prequalification following receipt of seven responses to an international invitation for expressions of interest
  - an invitation to four contractor consortia to submit proposals
  - submission of proposals by three contractor consortia
  - proposal evaluation and negotiation
  - contract award based on the best value considering evaluation criteria that included the design and construction approach, cost, risk profile, tunnel flow capacity, schedule, project team, health and safety management, environmental management and quality management.

Regulatory Approvals & Third Party Agreements

- Conditions of the EA Approval have been addressed to the extent possible without contractor input regarding means and methods to be employed during construction.

- The Community Impact Agreement, signed with the host communities on December 23, 1993 addresses predicted impacts on tourism, roads, domestic water supply, and sewage treatment during construction of the Project and includes provisions for engagement of local contractors, suppliers and labour and for local road improvements.

- The Project incorporates work and associated costs required under terms of the agreement between the Niagara Parks Commission and OPG as described above.

Project Management

[1] Guaranteed Flow Amount means the tunnel flow capacity guaranteed by the contractor at the reference hydraulic head and the reference elevation of energy grade line defined in the Design / Build Agreement.

[2] Substantial Completion means work has progressed to the point where the tunnel facility is ready for use and is sufficiently complete to be used for it's intended purpose.

- A strong team has been assembled for management and execution of the Niagara Tunnel Project and includes:
  - The OPG Project Director empowered to ensure effective integration of internal and external resources and timely communications between the project team and other stakeholders
  - Other OPG personnel representing Niagara Plant Group, Water Resources, Law Division, Supply Chain, Corporate Finance, Real Estate, Health & Safety and Risk Management
  - Hatch Mott MacDonald (HMM), an Ontario-based consultant with considerable experience in tunnel design and construction, has been engaged as Owner's Representative and holds primary responsibility for project management, design review and construction oversight with Acres International providing assistance in the areas of geotechnical and hydraulic engineering and third party liaison
  - Torys has been engaged as external legal counsel and has been part of the core project team providing advice on contractual, procedural fairness, environmental, real estate and regulatory matters
  - Strabag AG (a large Austrian construction group, supported by ILF Beratende Ingenieure of Austria, Morrison Hershfield of Toronto, and Dufferin Construction of Oakville), the selected Design / Build Contractor, has extensive international experience in tunnelling and heavy civil underground works.
  - Expert consultants and contractors are engaged, as required, to provide support in areas such as project risk assessment, financial modeling, teambuilding, field investigations, surveying, etc.

- Decision authority for this Project remains with OPG and delegation will be in accordance with OPG's Organization Authority Register (OAR).

- A Project Execution Plan, currently focussed on pre-construction efforts, has been developed and issued to provide the framework for management of the Niagara Tunnel Project, and will be reviewed and revised as necessary during project execution.

- The favourable score of 115, achieved on the Construction Industry Institute's Project Definition Rating Index (PDRI) in April 2005, indicates a high likelihood that completed project planning will result in a successful project (less than 200 = within budget and schedule).

- OPG, with the assistance of URS (a specialist consultant), completed a comprehensive risk assessment (qualitative and quantitative) for design and construction of the Niagara Tunnel Project based on "The Joint Code of Practice for Risk Management of Tunnel Works in the UK", and the recommendations have been incorporated into the project including maintenance of the Risk Register by the Owner's Representative. The quantitative risk assessment provided the basis for establishing the required cost contingency and schedule contingency.

4. ALTERNATIVES AND ECONOMIC ANALYSIS

Investment Cost and Project Funding Assumptions:

- Key assumptions are documented in the Niagara Tunnel Project Model Support Documentation binder.
- The Project is estimated to cost $985 M, including the previously released funding.
- The Project will receive a 10-year "holiday" for Gross Revenue Charge (GRC) payments.
- The Project will be funded through financing arranged with the Province.

Base Case – Do Nothing (Not Recommended)

- The Do Nothing option would forego the opportunity for OPG to significantly increase average annual energy output from the Sir Adam Beck generating stations and underutilization of Niagara River water available to Canada for power generation would continue. In addition, OPG commitments, under the Niagara Exchange Agreement, for remedial work at the retired Ontario Power and Toronto Power generating stations would continue to be required as part of the reversion of these stations to the Niagara Parks Commission. A write-off of about $37 M would be required to cover expenditures committed to date ($22.5 M) and remaining costs associated with the reversion of the Ontario Power and Toronto Power generating stations.

Alternative 1 – Design & Construct a Diversion Tunnel (Preferred Alternative)

- Design, construct and commission a new diversion tunnel to convey 500 m^3/s from the upper Niagara River to the Sir Adam Beck GS complex at Queenston using a design / build contracting approach developed to minimize the risk to OPG, optimize the additional diversion capacity, and achieve price and schedule certainty. The total cost for the Project is estimated at $985 M.

- **Appendix A** provides a more detailed breakdown of costs for the Project.

Financial Analysis

- While the Niagara Tunnel is expected to be part of OPG's regulated hydroelectric assets and receive a regulated rate reflecting cost recovery and a return on capital, it is appropriate to consider several financial metrics, as follows, to ensure that this is an economic investment relative to other generation options:

  - Levelized Unit Energy Cost (LUEC) represents the price required to cover all forecast costs, including a return on capital over the service life, escalates over time at the rate of inflation, and it permits a consistent cost comparison between generation options with different service lives and cost flow characteristics.
  - Equivalent Power Purchase Agreement (PPA) Price represents the price required if one were to bid the project into the renewable RFP. It is similar to LUEC except only 15% of the PPA escalates at the Consumer Price Index.
  - Revenue Requirement is a measure that represents the annual accounting cost of this project including an allowed return on capital employed. Revenue Requirement generally declines over time as the rate base is depreciated.
  - These metrics are equivalent in present value terms over the life of the asset and reflect full recovery of costs including a return on the investment.

Financial Analysis	Base Case	Alt.1
Initial or Remaining Costs (M$)	14	963
NPV (current year PV M$)	n/a	n/a
Impact on Economic Value (current year PV M$)		n/a
for Value Enhancing projects include:		
IRR (%)		n/a
Discounted Payback Period (years)		n/a
LUEC (¢/kWh in 2005$)		4.8
Equivalent PPA Price (¢/kWh in 2011$)		6.7
Revenue Requirement (¢/kWh in 2011$)		5.8
Revenue Requirement for OPG Baseload Hydroelectric (¢/kWh in 2011$) - Includes 10% Return on Equity	3.8	3.9

- The estimated equivalent PPA Price of 6.7 ¢/kWh (2011$) is approximately 84% of the estimated average PPA Price of 8.0 ¢/kWh (2011$) for the successful proponents in response to the Province's recent RFP for renewable electricity supply alternatives.

- Completion of the Project will result in a significant increase in average annual energy output from the Sir Adam Beck GS complex with only a marginal increase in the estimated regulated rate for OPG's hydroelectric assets.

- Key assumptions used in the financial analysis are listed in **Appendix B.**

Financial Sensitivity Analysis

- Financial sensitivity analysis of the Project is summarized below and indicates economic results that compare favourably with other future electrical energy supply options in Ontario, including recent submissions for renewable generation options.

Sensitivity Analysis [Jun-2010 In-Service Date]	Incremental Energy TWh	LUEC ¢/kWh in 2005$	Equivalent PPA Price ¢/kWh in 2011$	Revenue Requirement ¢/kWh in 2011$
Preferred Alternative	1.6	4.8	6.7	5.8
Water Availability				
Lower quartile for first 5 years of service	0.7[1]	5.4	8.1	n/a
Upper quartile for first 5 years of service	2.4[1]	4.2	5.5	n/a
Overall reduction of 5% in Niagara River Flow[2]	1.2	6.4	9.3	n/a
Higher Cost (+10%)	1.6	5.2	7.4	6.3
Shorter Service Life (30 year Life)	1.6	5.8	7.6	7.1
Elimination of 10 year Gross Revenue Charge Holiday	1.6	5.8	8.5	9.1
Other Renewable Supply			8.0	

(1) Calculated for the first 5 years of service only
(2) Annual flows assumed to be reduced by 5% each year, compared to historical flows for the life of the tunnel

- Overall, the project economics compare favourably against other renewable options. The sensitivity results indicate that the calculated equivalent PPA Price will continue to be competitive even under a range of pessimistic assumptions for water availability, project cost and service life.

5. THE PROPOSAL

- Enter into a fixed-price Design / Build Contract with Strabag AG to design, construct and commission a new diversion tunnel to convey approximately 500 m^3/s of water from the upper Niagara River to the Sir Adam Beck GS complex at Queenston. The concrete-lined tunnel will be approximately 10 km long and have an average internal diameter of 12.6 m. Flow will exceed the increased diversion capacity only about 15% of the time compared to the current 65%, and resultant incremental average annual energy output from the Sir Adam Beck generating stations is estimated at 1.6 TWh (14%). The project includes a new intake and associated modifications to the existing International Niagara Control Works, an outlet incorporating the emergency closure gate near the existing PGS reservoir, and removal of the PGS canal dewatering structure. The new tunnel will be in-service by June 2010 based on Project approval by the OPG Board in July 2005 and award of the Design / Build Contract by September 1, 2005.

- Extend the contract with Hatch Mott MacDonald, supported by Acres International, as Owner's Representative for project management, design review, geotechnical and hydraulic engineering, third party liaison and construction oversight.

- Execute remedial work required at the retired Ontario Power and Toronto Power generating stations related to the reversion of these stations to the Niagara Parks Commission (NPC) to secure agreement that the NPC will grant water rights to no party other than OPG.

- The estimated project cost of $985 M includes a negotiated firm price for the tunnel Design / Build Contract, agreed payments under the Community Impact Agreement, engineering estimates for Niagara Exchange Agreement costs, Owner's Representative costs, and OPG direct costs, and an overall contingency of approximately 13% to address project risks, including risks not transferred to the Design / Build Contractor.

- Provided that the Design / Build contract is awarded by September 1, 2005, the Substantial Completion (In-Service) Date guaranteed by the recommended Design / Build Contractor is October 2009, however a schedule contingency of approximately 8 months is recommended to address potential schedule extension due to residual OPG risks primarily associated with differing subsurface conditions. This contingency brings the expected completion date to June 2010.

- The design / build contracting approach for a fixed-price proposal from qualified contractors will reduce the risk of construction cost and schedule over-runs, however, OPG has retained risks associated with differing subsurface conditions and included cost and schedule contingencies accordingly, as described above.

- The estimated project cost flow is as follows:

Project Cost Flow Estimate ($M) (including Contingency)	To 2004	2005	2006	2007	2008	2009	2010	Totals
OPG Project Management	0.1	0.7	0.8	0.8	0.8	0.7	0.5	4.4
Owner's Representative	0.5	2.7	5.2	6.2	6.0	3.4	1.4	25.4
Other Consultants	0.4	2.4	0.2	0.2	0.2	0.3	0.3	4.0
Environmental / Compensation		7.6	4.0	0.1	0.1	0.1	0.0	12.0
Tunnel Contract		30.5	158.3	180.3	179.5	138.9	36.2	723.6
Other Contracts / Costs	2.5	24.1	17.9	7.8	7.8	18.8	0.1	78.9
Interest		1.3	7.9	20.1	33.2	46.6	27.7	136.8
Total Project Capital	3.5	69.2	194.1	215.5	227.7	208.9	66.2	985.2
Costs Approved to Date	3.5	19.0						22.5

6. QUALITATIVE FACTORS

- Sustainable Energy Development
  - The new tunnel will enable increased generation at the Sir Adam Beck GS complex utilizing Niagara River flow available to Canada for power generation that exceeds the capability of the existing diversion system (canal and two tunnels), and reducing spill over Niagara Falls from approximately 65% to approximately 15% of the time.
  - Rehabilitation of Sir Adam Beck GS No.2, completed in April 2005, including overhaul or replacement of primary mechanical / electrical equipment, improving conversion efficiency, increasing discharge capacity by 11% and adding 194 MW (15%) of capacity increases the gap between the existing diversion capacity and generating station discharge capacity.
  - There is potential to upgrade units at Sir Adam Beck GS No.1 by 100 to 150 MW, including conversion of the 25 Hz units, and further optimize conversion efficiency of the additional water to be supplied by the Niagara Tunnel Project.
  - Completion of the Niagara Tunnel Project in advance of an 8 to 12 month outage required for rehabilitation of the Sir Adam Beck GS No.1 diversion canal will significantly reduce associated energy losses (2.7 to 4.0 TWh) and financial losses.

- Community, Government & Customer Relations
  - The Province, through the Ministry of Energy, has indicated a strong desire for the Niagara Tunnel Project to be completed in the shortest possible timeframe.
  - There is broad support for the project in the host communities.
  - There will be significant benefits to the local economy during the approximately 4-year construction period.

- Technical / Operational Considerations
  - The Niagara Tunnel design life is 90 years without the need for any planned maintenance.

- Health & Safety
  - Safety program / performance was a significant factor in contractor pre-qualification.
  - The Design / Build Contractor will be required to develop and implement comprehensive project site specific plans for construction safety and for public safety and security.

- Staff Relations
  - An agreement has been reached with The Society of Energy Professionals regarding "purchased services" required for the Niagara Tunnel Project.
  - Purchased Services Agreement discussions have been completed with the Power Workers Union.
  - In accordance with the Chestnut Park Accord Addendum, trades work has been assigned to the Building Trades Unions.
  - Electric Power Systems Construction Association (EPSCA) conditions apply to the performance of this work.

7. RISKS

- OPG, with the assistance of URS (a specialist consultant), conducted a comprehensive risk assessment (qualitative and quantitative) for design and construction of the Niagara Tunnel. Major project risks were identified through a series of workshops involving the project team and key stakeholders.
- A Risk Register and associated Risk Management Plan will be maintained throughout project execution to manage residual risks.
- Project risks, consequences, mitigation activities and residual risks are summarized in **Appendix C**.
- Based on risks identified and mitigation measures implemented, it has been determined that the contingency for OPG residual risks associated with the tunnel construction component of the Project, based on a 90% confidence level, is $96M (15%) and this provision has been included in the release estimate. The overall Project contingency included in the release estimate is $112M (13%).
- Based on risks identified and mitigation measures implemented, it has been determined that the schedule contingency required for OPG residual risks, based on a 90% confidence level, is approximately 8 months and this provision has been included in the estimated in-service date.
- The financial analysis completed for the recommended alternative is based on spending the entire cost and schedule contingency and is therefore considered to be conservative and robust.

8. POST IMPLEMENTATION REVIEW (PIR) PLAN

Type of PIR	Target Project In Service Date	Target PIR Completion Date
Comprehensive	June 2010	December 2010

Measurable Parameter	Current Baseline	Target Result	How will it be measured?	Who will measure it? (person/group)
Tunnel Capacity	500 m^3/s	500 m^3/s	Flow test using tracer transit time method.	Design / Build Contractor with oversight by an independent Chief of Test retained by OPG
In-Service Date	June 2010		Compared with contracted Substantial Completion Date and approved changes.	
Actual Cost	$985 M		Compared to the approved release.	

Responsibilities

- The OPG Project Director will be responsible for the execution of the Project, and will be responsible for the completion of the PIR.
- The PIR will be undertaken after Substantial Completion of the Project (within 3-6 months).

Project Execution Monitoring

- The OPG Project Director, with the assistance of the Owner's Representative, will monitor on an ongoing basis and summarize as part of the PIR:
  - Project costs to ensure there are no material variances,
  - Project schedule and Schedule Performance Index (SPI) to track progress and to ensure completion in accordance with the contract,
  - Compliance with legislation and project-specific permits and approvals including periodic audits and non-compliance reporting
  - Compliance with the Project Execution Plan including scope management, deliverables, program and resource management, execution, risk management and the handling of health and safety issues.

- Disruption to the local community is to be minimized and will be measured by the public reaction including the number of complaints received

- Oversight by the Major Projects Committee will include frequent updates and guidance provided to the project team at critical points of Project development.

Remedial Work at Ontario Power GS and Toronto Power GS

- Confirm the completion of remedial work required at the retired Ontario Power and Toronto Power generating stations and the subsequent reversion of these facilities to the Niagara Parks Commission.

Tunnel Flow Capacity Verification

- Verification will be completed using the tracer transit time method established by the International Electrotechnical Commission Publication 41 (IEC 41), with testing performed under the direction of a Chief of Test engaged by OPG, and witnessed by OPG and the contractor. This testing will be used to determine whether a bonus or liquidated damages apply relative to the contracted Guaranteed Flow Amount.

Project Financial Analysis

- Re-evaluate financial metrics and compare to Business Case Summary as applicable.

Lessons Learned

- Document over-all lessons learned for future improvement in other projects.
- Review effectiveness of the design and construction contract arrangements and how effectively they were implemented, including an assessment of any liquidated damages and bonuses paid.

ONTARIOPOWER GENERATION	**PROJECT** **Summary of Estimate**	Date	14-Jul-2005
		Project #	**EXEC0007**

Facility Name:		
Project Title:	**Niagara Tunnel Project**	

Estimated Cost in Million $

Year	2004	2005	2006	2007	2008	2009	2010	Totals	%
OPG Project Management	0.1	0.6	0.7	0.7	0.7	0.7	0.4	4.0	0.4
Consultants	0.9	5.0	4.9	5.9	5.6	3.4	1.5	27.2	2.8
Design & Construction		28.3	147.0	167.4	166.6	113.4	0.0	622.6	63.2
Other Contracts / Costs	2.5	29.2	19.0	7.2	7.2	17.1	0.0	82.3	8.4
Interest		1.3	7.9	20.1	33.2	46.7	27.7	136.9	13.9
Contingency		4.9	14.7	14.3	14.2	27.6	36.5	112.2	11.4
Totals	3.5	69.2	194.1	215.5	227.7	208.9	66.2	985.2	100.0

Notes:

1. Schedule — Start Date: June 2004; In-Service Date: June 2010
2. Interest and Escalation rates are based on current allocation rates provided by Corporate Finance
3. Includes Removal Costs of: **n/a**
4. Includes Definition Phase Costs of: **n/a**
5. Percentages above relate to the total cost.

Prepared by:	**Approved by:**
R.A. Everdell Project Support Manager	E.E. Elsayed Vice President – Niagara Tunnel Project

Appendix B:
Niagara Tunnel Financial Model – Assumptions

Following are the key assumptions used during the modeling of the Niagara Tunnel Project.

Project Cost Assumptions:
1. Design/Build contract costs of $724M which include $101M for contingency and GFA (Guaranteed Flow Amount) bonus allowance
2. Other cost of $124M which include $11M for contingency
3. Interest during Construction (IDC) of $137M

Financial Assumptions:
1. Debt Rate of 6%
2. Return on Equity (ROE) of 10%
3. Debt Ratio of 55%

Project Life Assumptions:
1. Substantial Completion Date provided by the proposed Design/Build contractor of Oct, 2009. To this date, to assure a 90% confidence for completion, an additional 36 weeks has been added to arrive at the in-service date of June 2010
2. The tunnel life is 90 years

Energy Production Assumptions:
1. The tunnel will contribute an additional ~1.6 TWh/yr to the production at the SAB facilities
2. The tunnel will "re-capture" ~1.1 TWh during the SAB1 canal outage in 2011
3. Water transfers to NYPA, consistent with historical conditions, were incorporated into the calculation of the incremental energy output.

Operating Cost Assumptions:
1. When energy production begins OPG will realize a 10 year holiday on Gross Revenue Charge (GRC)
2. Annual OM&A costs of ~$.1M

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Appendix C – Project Risk Profile

Description of Risk	Description of Consequence	Risk Before Mitigation	Mitigation Activity	Risk After Mitigation
Cost				
The contractor may encounter subsurface conditions that are more adverse than described in the Geotechnical Baseline Report (GBR)	Unexpected, adverse subsurface conditions could slow tunnel construction and require the contractor to undertake remedial / extra work resulting in legitimate claims for extra costs and / or schedule extension for differing subsurface conditions (DSC).	High	• The GBR is based on extensive field investigations carried out over a 10-year period and knowledge gained through construction of the existing SAB2 tunnels. • The 3-stage GBR process used facilitates contractor input and concurrence before construction begins. • Residual tunnel construction risk to OPG is addressed by a contingency allowance of $96 M in the project release estimate and a contingency allowance of 8 months in the scheduled in-service date, both based on a 90% confidence level. •	Medium
Insurance coverage is inadequate or unavailable because underground construction has developed a reputation for cost over-runs and a negative perception from insurers.	Establishing an Owner Controlled Insurance Program (OCIP) to mitigate insurable risks for OPG, the Owner's Representative, the contractor and affected third parties.	Medium	• Engagement of key underwriters through project presentations. • Following, in principle, the UK Code of Practice for Risk Management of Tunnel Works. • A conservative estimate for insurance costs is included in the release estimate.	Low
The design / build contractor may not complete the tunnel due to non-performance or default.	OPG would need to engage another contractor to complete the tunnel construction.	Medium	• Requirements in the design / build contract for the contractor to provide bonds and / or letters of credit as security for non-performance or default. • Requirements in the design / build contract for the contractor to provide a parental guarantee.	Low

Appendix C – Project Risk Profile

Description of Risk	Description of Consequence	Risk Before Mitigation	Mitigation Activity	Risk After Mitigation
Scope				
OPG triggers variations in the scope of work.	Significant scope changes initiated by OPG could add significant cost and extend the project schedule.	Low	• Credible potential changes are limited because of the configuration of project and contracting approach. • The change control process is documented in the PEP and includes a Change Control Board comprised of OPG and Owner's Representative senior managers.	Low
Schedule				
Inability to meet environmental approval conditions in a timely manner.	Schedule delays could result from late submissions, unforeseen requirements or inability to satisfy stakeholder requirements.	Medium	• Proactive engagement of regulatory authorities • Use of a tracking system containing a comprehensive list of required permits and approvals. • Regular meetings with Ministry of Environment staff to review status and address outstanding issues. • The release estimate includes provisions to address outstanding issues (Welland River).	Low
Delay in manufacturing and / or delivery of the tunnel boring machine (TBM).	Potential delays in TBM manufacturing, delivery or assembly will be on the critical path for this project and will affect the overall project schedule.	Medium	• Schedule set by the Design / Build Contractor. • Contract provisions including liquidated damages for project delays and performance bond for default. • OPG / Owner's Representative will monitor progress at the TBM manufacturer's facilities.	Low
Inadequacy of the TBM and support systems to achieve required excavation and lining productivity.	Poor performance of the TBM, including frequent breakdown, could delay the completion date, increase the project cost.	Medium	• Design / Build Contract includes liquidated damages for late Substantial Completion valued to include incremental OPG costs and lost energy production for a period of about 16 to 18 months.	Low

Appendix C – Project Risk Profile

Description of Risk	Description of Consequence	Risk Before Mitigation	Mitigation Activity	Risk After Mitigation
Resources				
OPG resources with knowledge and experience required for design and construction of a major tunnel are severely limited.	OPG resource limitations could have significant impacts on project quality, cost and schedule.	High	• OPG has engaged Hatch Mott MacDonald, an Ontario based consultant with considerable tunnel design and construction management experience, as Owner's Representative for this project. • The design/ build contracting approach, engaging internationally-experienced tunnelling experts, will provide the necessary engineering and construction expertise.	Low
There is potential for a shortage of skilled construction labour resources qualified for performance of major tunnel construction by TBM.	A shortage of required construction labour resources, primarily operating engineers and labourers, could result in higher costs for imported labour or schedule extension.	Low	• The workforce required is relatively small and the contractor is expected to fill key positions with experienced, regular staff, reducing the likelihood that construction labour resources will limit tunnel construction progress.	Low
Technical				
Queenston shale, the host rock formation for the majority of the tunnel, has swelling properties when exposed to fresh water.	Swelling of the Queenston shale surrounding the tunnel could over-stress the tunnel lining and cause damage that would interrupt flow through the tunnel and require expensive remedial work.	High	Because this kind of damage could take decades to develop, penalties, warranties or holdbacks are impractical. Instead this risk is being mitigated through conservative, mandatory engineering specifications for aspects of the tunnel design related to rock swelling.	Low

Appendix C – Project Risk Profile

Description of Risk	Description of Consequence	Risk Before Mitigation	Mitigation Activity	Risk After Mitigation
Design / Performance Criteria Not Met	The constructed tunnel may not meet design / performance criteria such as the guaranteed water flow capacity, accommodation of swelling of the host bedrock, particularly Queenston shale, or design for a 90-year service life.	High	• Mandatory design requirements established by OPG / Hatch Mott MacDonald. • Design Review by an experienced Technical Review Committee. • Design / Build Contract includes liquidated damages for failure to achieve the agreed diversion capacity (Guaranteed Flow Amount) valued to compensate OPG for the reduced energy production throughout the 90-year service life. • Performance / warranty bonds and / or letters of credit provided by the Design / Build Contractor.	Low
Environmental / Regulatory				
Delay in obtaining Regulatory Approvals and Permits	Delay in obtaining required permits, failure to identify required permits or legislative changes requiring new or revised permits have the potential to extend the project schedule.	Medium	• Regulatory risks are relatively low because Environmental Assessment approval was obtained in 1998 and it is expected that outstanding conditions of the approval will be resolved before tunnel construction commences.	Low
Inability of OPG to fully recover the project costs through the Regulated Rate	Adverse financial impact on OPG	Low	• Demonstrate prudence in managing project cost through a comprehensive cost control process • Project costs include a contingency allowance which corresponds to a 90% confidence level that the project will be completed within the estimated costs.	Low

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Appendix C – Project Risk Profile

Description of Risk	Description of Consequence	Risk Before Mitigation	Mitigation Activity	Risk After Mitigation
Health & Safety				
Serious Construction Accident	There are many safety hazards associated with tunnel construction that need to be identified and appropriately managed (steep grades, slips and falls, falling objects, water hazards, confined space, truck traffic, operating machinery, noise, dust, etc)	High	• Safety program / performance was a significant factor in contractor pre-qualification • Contractor required to develop and submit an acceptable comprehensive site specific safety plan prior to start of construction activities • Safety accountabilities clearly identified • Site safety monitoring by the Owner's Representative.	Low
Public Safety and Security	Risk of incidents, accidents and potentially fatalities to unauthorized persons entering the construction site and gaining access to areas and activities having High MRPH hazards.	High	• Contractor to implement an approved site-specific Security, Public Safety & Emergency Response Plan that is consistent with the Niagara Plant Group's managed system. • Site safety monitoring by the Owner's Representative.	Low
Fire in the tunnel during construction	Health & Safety of construction personnel (and visitors) could be endangered and there could be significant schedule and cost impacts depending on the extent of damage.	Medium	• Contractor to implement an Emergency Response Plan and provide adequate ventilation. • Contractor to provide back-up power supply, a dedicated water supply, and trained personnel to facilitate fire fighting in the tunnel during construction. • Project insurance will cover repair of damages.	Low

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Appendix C – Project Risk Profile

Description of Risk	Description of Consequence	Risk Before Mitigation	Mitigation Activity	Risk After Mitigation
Investment				
OPG has retained the hydrologic risk (uncertainty regarding Niagara River flow).	Incremental average annual energy output from the SAB complex could be less than 1.6 TWh resulting in a need to increase base load hydroelectric energy rates to recover project costs.	Medium	• Financial sensitivity analyses demonstrate that the Niagara Tunnel Project remains competitive with future renewable electricity supply options if less water is available throughout the expected service life. • Being part of OPG's regulated hydroelectric assets, the hydrologic risk is expected to be borne by electricity customers through the water variance account.	Low
A successful claim by others in Canada or the United States to use Niagara River water available for power generation that exceeds OPG's capacity.	OPG could lose rights to use some of the Niagara River water available for power generation.	Medium	• Under the terms of the Niagara Exchange Agreement, the Niagara Parks Commission provided covenants securing the assurance of NPC that it would grant water rights to no party other than OPG through 2056. • Complete the new tunnel so OPG has adequate facilities to utilize Canada's entitlement to water available for power generation to reduce the risk of a claim by others to unused water.	Low
The 1950 Niagara Diversion Treaty is now subject to renegotiation following a 1-year notice period.	The government in either Canada or the United States could pursue renegotiation of the 1950 Treaty to address issues raised by other stakeholders that could result in a reduction of flow available to OPG for power generation at the SAB complex.	Low	• No mitigation possible.	Low

Appendix C – Project Risk Profile

Description of Risk	Description of Consequence	Risk Before Mitigation	Mitigation Activity	Risk After Mitigation
Other				
Failure to adequately address public / community issues concerning the Project.	OPG's reputation could be damaged by negative public reaction to the Project.	Medium	• Implementation of the Community Impact Agreement (tourism, traffic, noise & dust, etc). • Regular public communications. • A Project website maintained with current information. • A Project hotline to receive public concerns / feedback, including timely response.	Low

NIAGARA DIVERSION

TUNNEL REPORT

Prepared for Ontario Power Generation

Roger C. Ilsley

9 September 2013

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NIAGARA DIVERSION TUNNEL PROJECT

1.0 Executive Summary

I was requested by Tory's to review all pertinent geotechnical investigations conducted and reports prepared for the design and construction of the 14.4 m excavated diameter, approximately 10.4 Km long (as designed vs. 10.2 Km as constructed), Niagara Diversion Tunnel.

I have done so and formed an opinion that these site investigations addressed the appropriate design and construction issues and that the studies undertaken were completed to professional standards and exceeded those standards in some cases.

I was also requested to review the design work undertaken by Strabag during their proposal preparation and subsequently during the work. I have done so and formed an opinion that the design work performed was conducted to an appropriate professional standard.

In addition, I was requested to form an opinion as to whether it was appropriate to refer the dispute between OPG and the contractor Strabag for a hearing conducted by the Dispute Review Board (DRB) and to form an opinion as to the way OPG conducted the hearing. I have done so and found that it was appropriate to take the dispute before the DRB and further that OPG conducted the hearing in a proper manner.

Finally, after review of the subsequent DRB recommendations coupled with my own evaluation of the circumstances, I formed the opinion that the decision to re-negotiate a revised contract with Strabag was appropriate and reasonable given the circumstances of the dispute and the status of the project.

2.0 Project Investigations Overview and Scope of Document Review

The design and construction of the Niagara Diversion Tunnel as part of the Niagara River Hydroelectric Development was the culmination of various geotechnical investigations and design efforts beginning in 1983.

2.1 Concept Phase Geotechnical Investigations

The main objectives were to provide the essential geotechnical data for conducting technical feasibility and economical comparison of various development alternatives being studied for increasing the generating capacity at the Sir Adam Beck (SAB) complex.

The investigations were initiated in 1983 and conducted successively in 1984, 1984/85, 1986 and 1988/89. The geotechnical data collected during this period were for various project arrangements considered at that time and were not solely for the project actually constructed. Refer pages 2-1 to 2-18 of the Geotechnical Data Report (GDR) for a comprehensive description of the various studies done. (GDR is discussed below at the end of section 2.2)

In addition geological and geotechnical data were acquired by OPG during the construction of the SAB Generating Station (GS) 2 in the 1950s.

The results of these investigations were summarized in Feasibility Report 87269 Rev.1 dated March 1989.

2.2 Definition Engineering Phases

In the fall of 1988 OPG advanced the project into the Definition Engineering Phase in which environmental assessment and preliminary engineering were carried out. Phase 1 was completed in 1990 and included various site investigations. [Refer to GDR pages 3-1 to 3-20 for a full description]. A final report [Report 91150] consisting of five volumes was issued in May 1991.

This was followed by Phase 2 consisting of an Exploratory Adit (Adit) excavated in the Queenston Formation (Queenston) to the elevation of the proposed tunnels and enlarged at the end to the approximate diameter of the proposed tunnels. This work was completed in 1992/93 [Refer GDR pages 4-1 to 4-44 for a full description] and a seven volume draft report [Report NAW130-P4D-10120-0005-00] issued to OPG in December 1993.

Additional laboratory testing was done from 1994 to 1996 on samples of core from the Adit and a final draft report [Report NAW130-P4D-10120-007-00] issued in February 1997.

The geological and design issues studied in these investigations are addressed in detail below in Section 3.0 as is the manner in which the work was completed.

The GDR was prepared for inclusion in the document package issued to the selected Design-Build teams for their use in the preparation of their proposals. The GDR consisted of 12 volumes and incorporated all of the pertinent data collected during the phases of the work described above. It included a bibliography listing all of the investigation reports. A Geotechnical Baseline Report (GBR) was also prepared and issued in the RFP as GBR A. The GBR is discussed further below in section 6.1

3.0 Site Investigations

The primary aim of site investigations for a rock tunnel is to characterize the rock mass conditions sufficiently so that the design approach and selected construction methods can address the indicated ground conditions. The appropriate approach was adopted for the Niagara Tunnel, which was to phase the investigations beginning with general studies for the Conceptual Phase that began to define rock mass properties, overall stratigraphy, in situ stress conditions, the groundwater regime and other geologic hazards such as the presence of gas. Based on these results and preliminary analyses, a second phase of investigation was done for the Definition Engineering Phase which included additional borings with field and laboratory testing that resolved data gaps and focused on acquiring data to address design issues. Additional phases were completed as necessary until an appropriate level of confidence was reached that the geotechnical related risk issues had been mitigated to an acceptable level.

3.1 Design Challenges

It was recognized from the beginning that the tunnel design and construction presented several design challenges; chiefly the high horizontal stress, the presence of the St. David’s Gorge, time dependent deformation of the rock mass and the presence of sulphates in the groundwater. The various site investigations were directed at recovering physical data and making qualitative geological assessments for preliminary analyses and so address these challenges. The related design and constructability issues are discussed below. The subsequent discussion will cover the actual investigations performed during the Concept and Definition Phases of the work.

3.1.1 Ground Characterization Along Alignment

The tunnel length of 10.4 km results in a natural variability in the rock mass characteristics of the rock formations to be excavated, including; rock mass strength, rock structure (presence and character of discontinuities such as bedding and joints), lithology (nature of the rock material such as siltstone, mudstone or shale) and the piezometric level of groundwater as well as its quality, in the formations to be excavated.

All of these characteristics needed to be quantified and the tunnel length characterized appropriately, with differences identified. The rock mass was generally known to vary from weak to moderately strong.

The depth of the tunnel was dictated by the necessity of passing beneath the glacial soil filled ancestral river channel some 800 m wide, named the St. David’s Gorge (Gorge). The location and character of the top of rock in the Gorge and in relation to the tunnel roof (crown) was therefore an issue.

3.1.2 High Horizontal Stresses

The presence of high horizontal stress had been recognized in the region and on previous OPG construction at the site. The identification of the stress magnitude and direction was an important objective due to the high stresses that develop around the excavation perimeter upon excavation and the resulting potential for overstress of the rock mass. The nature of the failure which would occur if the rock remained unsupported after excavation is termed the ‘rock mass behavior’. This relates to the type of initial support to be placed and the timing of placement of the support – the elapsed time of stable rock conditions is commonly referred to as the ‘stand-up time’ and is the window for erection of the initial tunnel support. Because the stand-up time is affected by the chosen construction method it is deemed to be a constructability issue as well as a design issue. The large size of the proposed tunnels would also be part of the concern regarding tunnel stability upon excavation.

3.1.3 Time Dependent Deformation

During the construction of the vertical shaft Wheel Pit of the Canadian Niagara and Toronto Power Plants, the 5.5 m wide and 50 m deep slots showed an inward movement of both walls. The total maximum inward movement of both walls over a 68 year period was approximately 7 cm. The data shows a general trend of decreasing rate of rock movement with time. These long term deformations were in the rock formations above the Queenston and it was known that the Queenston was prone to swelling, hence both of these mechanisms could potentially generate long term loading on the lining. The presence of saline and sulphate bearing groundwater with the resulting potential for corrosion effects on steel and sulphate attack on concrete, plus high operating pressures in the finished tunnel; all became issues bearing on the design of the tunnel lining. These factors and the requirement for a 90 year design life would define the design and eventual thickness of the concrete lining, in itself a very significant challenge.

3.2 Conceptual Phase Investigations

As described in general above, this phase occurred in the period from 1983 to 1989. During this period the investigations were broadly based so only the parts relating to the tunnel alignment will be discussed. A list of the activities is presented below:

- Geological mapping including joint measurements of rock outcrops;
- Drilling and core recovery of 5 boreholes, SD-1 to 5, coupled with seismic reflection surveys to determine the location of the top of rock in the Gorge;
- Drilling of 25 borings NF-1 to NF -26 (not NF-16) along potential tunnel alignments, surface and underground power house locations and around the PGS reservoir;
- Installation and monitoring of multi-level Westbay piezometers in 4 borings (NF-2 to NF-4 and NF-6);
- In-situ stress measurements by over-coring in boring NF-1 and by hydraulic fracturing in boreholes NF-3 and NF-4; and

- Laboratory testing on rock samples including physical and mechanical properties, compression and tensile strength tests; also tests on the time dependent deformation characteristics of core samples from the Queenston.

The results of these Conceptual Phase investigations were presented in Volume 11 of the GDR. A review of these investigative reports indicates that in general the following important activities (Sections 3.2.1, 3.2.2, 3.2.3, 3.2.4) were accomplished in regard to the three principal areas (described in Sections 3.1.1, 2, and 3 above) of design issues for the tunnel.

3.2.1 Drilling Along Tunnel Alignment

To quantify the natural variability of the rock mass along the alignment it was necessary to drill exploratory holes, conduct field tests, recover core for the purpose of identification of the lithology, to identify stratigraphic relations between different rock formations, to identify groundwater levels and groundwater quality and to provide core for various laboratory tests.

In 1983 four vertical boreholes (NF-2 to NF-5) were drilled south of the Gorge using wireline core recovery methods, each penetrating 30m into the Queenston. The core lithology was logged to define stratigraphic relations between formations; also Core Recovery (CR) and Rock Quality Designation (RQD) were recorded and the character of the discontinuities logged. Constant head permeability tests were carried out as the holes advanced. In situ permeability tests were done in borings NF-2 and NF-4 in 1984 in the various rock strata to be excavated by the tunnel. Also a series of Westbay multi-level piezometers were installed in boreholes NF-2 to NF-4. These were designed to allow groundwater samples to be taken at any of the ports located in the various strata for water quality (chemistry) testing.

3.2.2 Exploration in the St. David's Gorge Area

It was necessary to define the bottom of the glacial sediment filled gorge so that the tunnel could be optimally located in the most favorable rock conditions.

In 1983 a single borehole (SD-1) was drilled into Queenston bedrock sufficiently to define top of rock. In 1988/89 four vertical holes (SD-2 to SD-5) were drilled east of the alignment to the top of rock to define the deepest part of the Gorge. A Gravity Survey was also done to attempt to define the bedrock surface and gave indications of the deepest part of the Gorge. In addition a seismic reflection survey was completed but was ineffective as the energy source was too low.

A second seismic survey was done in 1988 which gave insufficient definition resulting in a third survey in 1989 using explosives as the energy source. Based on the seismic and borehole data an inferred bedrock surface plan was produced along with several profiles.

3.2.3 In Situ Stress Measurements

The identification of the stress magnitude and direction was an important objective due to the resulting high stresses that develop around the tunnel periphery during excavation.

In 1983 in situ stress measurements were made in Borehole NF-1 using overcoring methods, located at the SAB GS 1 access shaft. Although not on the tunnel alignment all in situ stress measurements were useful in an attempt to gain an overall picture of both magnitude and direction of the principal stresses; especially because of the inferred effects of the Niagara River Gorge and St. David's Gorge on these parameters. In 1983/84 hydro-fracturing stress measurements were made in boreholes NF-3 and NF-4. In 1988 a single piezometer was placed in the Queenston in boring SD-3.

3.2.4 Laboratory Testing of Rock Core Samples

In order to conduct appropriate analyses for the design, rock material parameters were provided from a comprehensive laboratory testing program of the rock core recovered from the boreholes.

In 1983 samples from the Whirlpool and Queenston Formations were tested. Values were measured for the following parameters; uniaxial compressive strength (UCS); static elastic modulus; Poisson's Ratio; compressive wave velocity, dynamic elastic modulus, water content; density; free swell rate and calcite content.

In 1984/85 core samples for the rock formations to be excavated from boreholes NF-2 to NF-5 were tested. Values were measured for the following parameters: UCS; tensile strength, Schimdt hammer hardness and free swell tests. Also core samples from various formations in borehole NF-7 were tested. Values were measured for the following parameters: anisotropic Poisson's Ratio and elastic modulus; UCS; free swell and semi-confined time dependent deformation of Queenston samples.

In 1986, seventeen core samples from the Queenston containing one or more clay seams were tested. Values were measured for the shear strength of the clay seams in both multi-stage direct shear and biaxial tests. Index testing consisting of grain size analysis and Atterberg Limits of the clay fillings were also done and mineralogical analyses of the clay. These results were used in the Wedge Analysis described below in Section 4.2.2.

In 1988/89 core samples from the Queenston were tested. Values were measured for the following parameters: anisotropic Poisson's Ratio; elastic modulus; UCS; tensile strength and free swell tests. A time dependent deformation test program on samples from the Queenston was also completed. The purpose of these tests was to evaluate the swell pressures that could be experienced by the finished lining system and so allow for them in the design.

The results of these laboratory test programs were incorporated in a data base of engineering and index parameters for the overall purpose of characterizing the rock formations present with respect to rock mass strength, modulus and swelling characteristics.

Initial stability analyses were performed using closed formed solutions with elastic properties and preliminary numerical modeling using finite element analysis using an early (1980) Hoek and Brown constitutive model with assumed rock mass factors based broadly on evaluations of Rock Mass Rating by Z.T. Bieniawski. These initial studies indicated that generally for the diameters considered, the Queenston rock would not be overstressed. It was recognized that UCS test values declined in proportion to the shale vs. siltstone content in the samples tested leading to a division of the Queenston into sub-units based on changes in lithology, particularly the proportion of siltstone versus mudstone and shale present. Also the UCS values of core box dried samples of Queenston were significantly stronger than saturated samples.

3.3 Definition Engineering Phase 1

Phase 1 site investigations related to the Diversion Tunnel were carried out in 1990 and included drilling boreholes with core recovery for laboratory testing, a geophysical program, and in-situ stress measurement.

Phase 2 consisted primarily of the excavation of an Exploratory Adit (Adit) located in the area of the power generation complex; also additional borings were completed as well as some additional long term swell tests.

The objectives of the program were as follows:

- Further definition of the bedrock surface location in the Gorge;
- Additional in-situ stress measurements, especially the Queenston;
- Further definition of the lateral and vertical variations in the Queenston along the tunnel alignment; and
- Investigation of potential for inflows of groundwater and methane gas.

The results of the Phase 1 investigations were presented in Report No. 91150 consisting of five volumes issued in May 1991. The results of the Adit related investigations were issued as Definition Engineering Phase 2 Geotechnical Investigations and Evaluation in seven volumes in December 1993 (Report NAW130-P4D-10120-0005-00).

A review of the investigative reports indicates that the rock characterization along the alignment, better definition of the bottom of the St. David's Gorge, measurement of the in-situ stresses, definition of the groundwater regime and groundwater quality analysis and measurement of rock material parameters, were accomplished in regard to the three principal areas (see section 3.1.1, 2, and 3 above) of design issues for the tunnel.

3.3.1 Drilling Along Tunnel Alignment

The following five vertical borings to the tunnel level were done in Phase 1: NF-4A, NF-28, NF-30, NF-32 and NF-33; also four borings at the Gorge of which SD-7 and SD-8 penetrated to the tunnel level and SD-5 and SD- 6 ended at the top of rock. In Phase 2 the following borings were done: existing borehole NF-31 was extended from el. 41 m to el. 10 m; NF-45 inclined at 53 degrees; NF-43 vertical boring; NF-39 inclined at 53 degrees at the Gorge.

Core recovery, RQD and the character of the discontinuities encountered, were recorded on the log for each borehole. The inclined borings were done to intersect sub-vertical to vertical joints. Also borehole photography with core orientation and permeability testing were done in NF-45, NF-39 and geophysical logging in NF-43 to further define the orientation, frequency and character of discontinuities. Permeability tests were done in borings NF-45 and NF-39 and ground water samples retrieved for water chemistry tests and piezometric heads in the various formations measured.

3.3.2 Exploration in the St David's Gorge Area

It was ascertained that within a zone of 15 to 25 m below the bedrock surface, the rock was slightly weathered with RQD values varying from 31 to 71 %. Bedding joints were frequent and some slickensides (surfaces of discontinuities with evidence of former movement and therefore of very low shear strength) were present. At depths greater than 30m below the bedrock surface, the RQD values improved significantly and were generally higher than 90% generally indicating that with increasing depth below the bedrock surface, rock conditions improved significantly.

3.3.3 In-Situ Stress Measurement

Hydro-fracture tests were done in borehole NF-31 (at a distance of 400 m from the Niagara River gorge) and NF-38 (powerhouse area) in order to locate the proposed Adit enlargement in an area where the in-situ stresses would be similar to those anticipated in the deep section of the diversion tunnels, as well as for the design of the underground powerhouse.

3.3.4 Laboratory Testing of Rock Core Samples

The testing for the Definition Engineering Phase 1 investigations was focused primarily on the Queenston along the diversion tunnels and at the underground powerhouse locations.

The laboratory test program consisted of the following components:

- Strength and deformation testing;
- Time dependent deformation testing-swell tests;
- Petrographic analyses of thin sections from the Lockport and Queenston Formations;
- Point Load Strength Index testing;
- Chemical analysis of groundwater samples from piezometer installations; and
- Testing for hydraulic fracturing tensile strength and biaxial testing for deformation modulus of samples from over-coring tests (for in situ stress measurement).

A summary of the tests completed was presented in Tables 3.5 and 3.6 in the GDR and described in more detail in Section 12.1.2 of the GDR.

The 1992/3 Definition Engineering Phase 2 laboratory testing program addressed the following key issues regarding the engineering properties of the Queenston:

- Uniaxial (UCS), triaxial and tensile strength of intact rock;
- Direct shear strength tests of the major (very persistent and clay filled showing signs of movement) bedding planes sampled in the Adit; and
- Time dependent swelling characteristics of the Queenston in confined and unconfined tests to ascertain potential load on the final lining of the tunnel.

The scope of the testing program was presented in Table 4.9 of the GDR. Particular emphasis was placed on the proper sealing and storage of the rock core, with early testing of the samples to preserve the in situ moisture content. The results of the program were described in more detail in Section 12.4.3 of the GDR.

Additional testing on the time dependent deformation characteristics of the Queenston was done from 1994 to 1996 to further define the pressures to limit swelling; to investigate the effects of increasing axial load (analogous to swelling pressure build up on the tunnel lining); to investigate anisotropy by providing results for horizontal cores and to determine the swelling characteristics with pore water of different saline concentrations. The results of the program were presented in Section 12.4.4 of the GDR.

3.4 Definition Engineering Phase 2 Exploratory Adit

The excavation of the Adit represents a level of exploration rarely achieved due to the cost and was therefore a significant commitment to achieving the objective of ascertaining the rock behavior in an excavation of comparable size to the planned tunnel.

The Adit, excavated in 1992/93 entirely within the Queenston, was located in the vicinity of the power generating complex in order to provide access to and to develop the powerhouse test area and to allow over-coring stress measurements. The objectives of the program were to:

- To record qualitative observations of rock mass behaviour and to measure rock mass behaviour with instrumentation;
- Conduct in situ stress measurements;
- Record geological data by mapping of the excavation, photography and coring of the exposed rock; and
- Conduct in situ testing.

3.4.1 Adit Enlargement

Stage 3B Excavation mainly comprised of widening the end of the Adit as part of a trial enlargement. The main objective was to evaluate the full face Tunnel Boring Machine (TBM) excavation method by observing and measuring the rock mass response around an opening similar in span to the final excavation dimension. The test program was as follows:

- Developed an opening 12m wide and 4m high with a circular arch of radius 6.8m to simulate the upper part of the diversion tunnel;
- Rock deformations and the extent of the overstressed zone were measured with rod extensometers and surface convergence points. Stress changes at the roof were also measured;
- The excavation was supported with dowels and mesh; and
- The last approximately 5m of the enlargement was left unsupported for 48 hours to assess stand-up time of the arch.

Stage 3C Excavation consisted of further deepening of the opening by benching downwards to a full height of 12m to further observe the effects on stability of the crown, invert and face. Additional extensometers were installed at the springline of the full depth excavation and in the end wall invert to monitor deformation.

A detailed description of the Stage 2 Exploratory Adit Investigation Program was provided in Section 4.3 of the GDR.

4.0 Site Investigation Results

The results of all the phased site investigations conducted for the Conceptual Phase and the Definition Engineering Phases 1 and 2 were presented in the GDR as follows:

- Section 6 Surface Geological Mapping;
- Section 7 Results of Surface Drilling: Logging and Downhole Testing;
- Section 8 Results of Underground and In Situ Testing;
- Section 9 Exploratory Excavations- Geotechnical Conditions and Observations;
- Section 10 Results of Adit Enlargement and Field Instrumentation and Testing;
- Section 11 Groundwater and Gas; and
- Section 12 Results of Laboratory Testing of Rock Samples.

The GDR was a comprehensive document which gathered all of the data from numerous studies for a variety of concepts of power generation with various configurations and included detailed studies for the diversion tunnels inlet and outlet works and for underground power stations.

In my review I have focused on the site investigations related to the diversion tunnels which remained within a defined corridor from the start of the studies. The number of borings was appropriate given the relative uniformity of the Queenston. I have reviewed a sufficient number of examples of laboratory and field test results to form an opinion that they were completed in an appropriate manner. I will discuss below how the objectives of the investigations were met, in that the necessary data was provided for the appropriate design analyses and for evaluation of the perceived constructability issues.

The issues listed below are broadly described above in section 3.1:

- 3.1.1 Ground Characterization Along the Alignment;

- 3.1.2 High Horizontal Stresses; and
- 3.1.3 Time Dependent Deformations.

4.1 Ground Characterization for Design Analyses Along the Alignment

In order to characterize the ground conditions, the rock mass characteristics were required including intact rock UCS and triaxial strength and elastic modulus; rock structure, including RQD, core recovery, frequency of discontinuities such as bedding planes and joints; the characterization of the discontinuities including type of filling, roughness and persistence; the shear strength of prominent bedding planes; groundwater levels and the presence of gas; the chemistry of the ground water and logging of the rock type (lithology). All of this data was incorporated on a geologic profile prepared for the approximately 10.4 km long, 14.4 m diameter tunnel (Refer Strabag ILF Drawing No. PD-0101002). In this manner the alignment was split up into sections with similar properties for the purposes of analysis and subsequent support design.

4.2 Rock Mass Strength for Design Analysis

Strabag's designer ILF conducted design analyses including elastic beam-spring models, wedge analysis and convergence-confinement methods. These analyses, completed by ILF as part of the Strabag design-build proposal, were incorporated in two reports titled "Outline Design Basis and Method Statements" and "Structural Analysis for the Diversion Tunnel", both dated April 2005. Figure 3.1 Flow Chart for the Geotechnical Design was presented in the "Outline of Design Basis" and shows the steps and inputs required to arrive at the type of support to be used, beginning with the geotechnical parameters provided in the GDR and derived from the GDR data. The geotechnical data used in the various analyses was based on data from Table 6.16 of the GBR for rock mass strength and deformation and GDR Volume 2 and Fig. 12.1 for major bedding plane shear strength parameters.

4.2.1 FEM Analysis

The 2D and 3D finite element modeling (FEM) conducted by ILF as part of the design, enabled analysis of rock overstress at the tunnel periphery during excavation. The method used a rock mass constitutive model (or rock mass failure criteria) derived by Hoek and Brown in 1980 and then successively improved by them with the last iteration issued in 2002. The model assumed isotropic conditions as evaluated by consideration of the block size formed in the mass by the discontinuities present. The inputs to the model were derived from the intact rock UCS and triaxial test data and a Geological Strength Index (GSI) that incorporated the rock structure. The model provided rock mass strength parameters for the numerical analysis. Also the Owner's Mandatory Requirements, chapter 8.3.4 of the Design Build Agreement (DBA) stipulated Hoek-Brown residual rock mass strength parameters 'mr = 1' and 'sr = 0.001'and a plastic shear strain in rock for peak to post-peak strength ranging from 0.5 to 2.0%.

The FEM modeling incorporated the measured existing high rock stress and could allow for the presence of the identified major bedding planes, as well as the delay in placing rock support sufficiently stiff to prevent further convergence and loosening of the rock mass. Direct shear tests on the major bedding planes provided the necessary shear strength parameters for this analysis.

Strabag's designer ILF conducted other analyses including elastic beam-spring models, wedge analysis and convergence-confinement methods for the purpose of initial and final support design which are described below.

4.2.2 Wedge Analysis

The wedge analysis identified kinematically feasible blocks that may slide or fall into the excavation. Logging of the discontinuities in the core and mapping of outcrops, coupled with evaluation of downhole photography, provided the characterization, orientation and frequency of joint sets and bedding present. Direct shear tests on discontinuities from recovered core provided the shear strength parameters for limit equilibrium analyses of the resulting blocks. This approach allowed appropriate initial support to be designed for a given set of geologic conditions in the Queenston and for the formations above.

4.2.3 Convergence-Confinement Method

The convergence-confinement method of analysis provides the interaction of ground behaviour, represented by a ground-reaction curve and tunnel support, represented by a support reaction curve. The available support pressure was evaluated from computations of the initial lining characteristics including rock reinforcement, shotcrete, and steel ribs. An essential input was the convergence measured during the excavation of the Exploratory Adit enlargement to the approximate planned tunnel diameter. The method was used for preliminary tunnel support design; short term time dependent load distribution of ground load to the initial support and long term time dependent load distribution of ground load to the final lining.

4.2.4 Beam-Spring Model

The Beam-Spring Model used linear elastic analyses to evaluate static loading of the tunnel lining from self weight, hydrostatic pressures, temperature, shrinkage and live loads from post lining grouting. The rock mass strength and deformation properties used were based on Table 6.16 from the GBR.

4.3 High Horizontal Stress

Extensive in situ testing was done to determine the stress regime along the alignment which enabled the tunnel to be divided into three parts and stress magnitudes and directions assigned to each. The results presented in the GDR and summarized in Table 6.14 of the GBR B covered the concept alignment in the RFP. Table 3.3 Stress Regimes for Design Purposes in “Outline Design Basis and Method Statements”, lists the in-situ stress conditions for different tunnel sections that were used in the proposal design.

4.4 Time Dependent Deformations

In their structural design analysis ILF analyzed swell pressure data using FEM and concluded that the area with swelling potential was small. This was mainly based on the advantages of the proposed dual shell lining system. In addition the existence of high horizontal stresses >5 MPa suppressed the swelling potential. This conclusion was based upon laboratory test results which reported that application of stress in one direction not only suppressed the swelling in that direction but reduced it in the orthogonal direction.

ILF concluded that the swelling potential was negligible due to the secondary stress state and the dual shell lining system.

ILF also considered in the final lining design the recognized long term deformation (which they termed rock squeeze behaviour) that had been observed and measured in previously constructed OPG underground facilities. The long term rock mass behaviour was considered by calculating a reduced stiffness modulus for the design life of 90 years using a creep rate based on the measured deformations.

4.5 Constructability Considerations

The presence of high horizontal stress had been recognized in the region and on previous OPG construction at the site. The identification of the stress magnitude and direction was an important objective due to the resulting high stresses which develop around the excavation perimeter upon excavation and to the potential for overstress of the rock mass. The nature of the failure which would occur if the rock remained unsupported after excavation is termed the 'rock mass behavior'.

This relates to the type of initial support to be placed and the timing of placement of the support – the elapsed time of stable rock conditions is commonly referred to as the 'stand-up time' and is the widow for erection of the initial tunnel support. Because the stand-up time is affected by the chosen construction method it is deemed to be a constructability issue as well as a design issue. The large size of the tunnel would also be part of the concern regarding tunnel stability upon excavation.

A review of the various design documents prepared by ILF and described above in 4.2 shows that these considerations were evaluated in detail by the contractor as described below. This in turn was made possible by the sufficiency and appropriateness of the geotechnical and geological data gathered in the site investigations described in Section 3 above and provided in the GDR and GBR for the contract.

4.5.1 Excavation and Support

As described by ILF in Section 3.5 of **"**Outline Design Basis and Method Statements" the requirements for excavation methods and support were based on the following factors:

- Worker safety;
- Structural stability of support system;
- Avoidance of rock mass loosening;
- Initial lining capacity; and
- Allowable deformations.

Section 3.5.4 Tunnel Support Application of the ILF report, describes the planned locations and type of support to be placed. These were carried through into the actual TBM configuration used and the detailed support designs provided.

5.0 Conclusions in Regard to the Scope and Quality of the Tunnel Site Investigations

It is my opinion that both the quality and standard of the site investigations met the generally recognized professional standards for work of a similar type and magnitude.

The natural variability of the 10.4 km alignment as manifested by variable lithology, high horizontal stresses in varying directions, rock strength anisotropy, adverse groundwater chemistry, methane gas potential, swelling pressures and long term deformation, provided significant challenges to OPG in providing the necessary and sufficient data to the Strabag design-build team for their use in the design and construction of the work. The geotechnical and geologic data gathered in the various site investigations as previously described, was sufficient and appropriate to meet these challenges. The field and laboratory testing provided appropriate data for the empirical and numerical analyses conducted. The excavation and instrumentation of the Exploratory Adit provided key data on the ground characterization and behavior. In conclusion, the appropriate and comprehensive designs and construction procedures developed by Strabag (summarized above) were based upon the geological and geotechnical data provided to them in the GDR and GBR.

6.0 OPG Decision to Bring the Dispute to the DRB for a Hearing

This section describes the background leading up to the decision to resolve a dispute on differing sub-surface (ground) conditions by taking it before the Dispute Review Board (DRB) for a hearing and the appropriateness of OPG actions in doing so.

6.1 Design Build Agreement

The Design-Build Agreement (DBA) between OPG and Strabag included Section 11 Dispute Resolution, which described the establishment and operation of a DRB as an alternative method of dispute resolution in that it provided a means of resolving disputes without resorting to arbitration or litigation. This was part of a risk sharing initiative provided by OPG; other elements included the provision of a GDR and a jointly negotiated GBR C (as discussed below) in the contract and for the contractor to place in escrow at the time of bid, data pertinent to the development of the cost estimate for the work. The DBA also included Section 5 Changes in Work with sub-sections 5.5 Differing Subsurface Conditions and 5.7 Resolution of Claims.

To further assist the parties in the resolution of any issues arising from the encountered ground conditions, Section 5.5 Differing Subsurface Conditions was included in the DBA. In particular Section 5.5(c) which states: “Notwithstanding Sections 5.5(a) and 5.5(b) and in lieu of the procedures described in Sections 5.5(a) and 5.5(b), the following procedure shall apply in full satisfaction of any change to the Contract Price and Contract Schedule relating to rock support resulting from differing subsurface conditions (the “Rock Support Adjustment”):

> (1) on a continuous basis during the performance of the Work, the contractor will record the rock conditions (as defined in the GBR) encountered during the performance of the Work and measure the tunnel lengths thereof and OPG will review and verify such determinations. If the parties cannot agree, the positions of both parties shall be recorded. The resolution of any disagreements will be held in abeyance until the step described in section (4) below has been completed, unless the parties mutually agree that the issue is sufficiently material that the issue should be referred to dispute resolution in which event the matter be resolved in accordance with Section 11;
>
> …

(4) OPG shall promptly thereafter issue a one-time Project Change Directive setting out the net change to the Contract price and Contract Schedule determined by completing the Rock Support Table as set out in (3) above."

The referenced table was included in Section 8.1.3.7 of the GBR C as follows:

"Tunnel rock support will be designed to accommodate the Rock Conditions as given below. The in-situ Rock Conditions shall be determined based on the closest match to the Rock Characteristics within each Rock Condition defined below."

The table is presented on page 37 of GBR C.

By this means the parties intended to provide a way to avoid protracted disagreements in regard to the type and placement of appropriate support for the encountered conditions. Note that Section 3.3 No OPG Control of the Work of the DBA, expressly makes Strabag responsible for "the Contractor's means, methods, techniques, sequences or procedures respecting the work".

The interpretation of these clauses by the parties in relation to the referral of a dispute for Differing Site Conditions to the DRB for a hearing is discussed further in section 6.4 below.

6.2 GDR and GBR

The geological and geotechnical aspects of the project were fully developed to the 100% level for inclusion in the RFP issued to the pre-selected design-build teams. The twelve volumes of the GDR consisted of material excerpted and summarized from the numerous studies and reports completed from 1983 to 1997. Version A of the GBR, termed GBR A, was also included in the RFP. GBR A provided baselines which were an assessment by OPG of the various geological and geotechnical risks to be encountered on the project; these baselines were distilled to a quantification of the physical parameters governing a particular risk, coupled with assessments of parameters such as ground behaviour, based on professional judgment. Version B of the GBR termed GBR B was provided by Strabag in their proposal. Version C of the GBR, termed GBR C was prepared and negotiated by both parties and included in the DBA for the work.

In providing these documents in the contract, OPG shared the risk with Strabag in that any differences that could potentially occur in regard to the actually encountered ground conditions were limited in that if ground conditions encountered were more adverse, the baselines would provide the means for resolving the ensuing claims. If the parties could not negotiate a resolution of the claim then it could be brought before the DRB for a hearing and the issuance of recommendations as to resolution.
By sharing the risk in this manner, OPG benefitted in that the cost estimate for the work did not include contingencies for these risks which otherwise would be included.

6.3 Dispute Review Board

The DRB was formed at the start of the project and manned with recognized experts in the field of tunnel construction. The DRB visited the job on a regular basis and received documentation related to the progress of the work and the issues that arose during the course of the work. In this manner the DRB became familiar with the site staff and with the construction progress and the problems which arose in the course of the work. The contract required the DRB, if requested by either party, to hold a hearing on a particular dispute and to then issue non-binding recommendations.

6.4 DRB Hearing on Strabag Claim for a Differing Site Condition

Strabag filed a claim (PCN 017) for differing site conditions on 18/05/07, related to the ground conditions encountered at the Whirlpool/Queenston Formation contact, from chainage 0+806.5 to 0+839.7. The claim was filed under Section 5.5 (a) of the DBA, and was rejected by OPG on the basis that as it was a clearly a claim relating to rock support resulting from differing subsurface conditions, it must be resolved through the procedure as negotiated and agreed by the parties in Section 5.5 (c) and cannot fall within Section 5.5 (a). The procedure in Section 5.5 (c) is to apply "in full satisfaction of any change to the Contract Price and Contract Schedule relating to rock support resulting from differing subsurface conditions."

Subsequently after several exchanges on the issue Strabag filed Dispute Notice No. 001 under Section 5.7 (a) of the DBA on 05/11/07. OPG again responded on 12/11/07 to the effect that the dispute notice was premature because the claim in PCN 017 must be resolved through the procedure as negotiated and agreed by the parties in Section 5.5 (c) and cannot fall under Section 5.5 (a). However OPG indicated that the first issue to put before the DRB was if they had jurisdiction of the dispute.

Strabag responded on 14/11/07 as follows: “The “rock support adjustment” clause allows for contract price and schedule adjustments to be made relative to the variation in the distribution of the Encountered vs. Expected GBR denoted rock conditions. The PCN 017 encountered rock conditions are clearly not within those denoted rock conditions nor were they anticipated by the GBR and are subsequently a Differing Subsurface Condition. Contrary to OPG’s stated position (letter of 31 October 2007), it was not the intention nor would it be reasonable to expect that the Rock Condition 6 would become a “catch all” for any possible rock condition ever encountered in the tunnel that did not fit into the conditions 4Q or 5 whether anticipated in the GBR or not.”

OPG responded on 28/11/07 in a memo confirming an agreement, reached in the meeting of 27/11/07, the following: “If the parties are unable to achieve a mutually acceptable plan for tunnel realignment within the next 3 months, that also resolves PCN 017 and as many other open issues under the contract as possible, the threshold issue will be the first to go to the DRB as soon as possible after February 29, 2008.”

On 27/02/08 Strabag issued Dispute Notice No.002 as per Section 5.7(a) and Section 5.7(c) of the DBA regarding PCN 017 in which they noted that the parties had agreed that the dispute should be placed before the DRB for resolution under Section 11 of the DBA.

On 05/03/08 OPG responded as follows:

> “1.Strabag’s inability to achieve the agreed TBM advance rates and any “excessive” overbreak described in Strabag’s Proposal for Optimized Alignment and Revised Schedule are a direct consequence of the design, means and methods of construction eventually adopted by Strabag on this project. Pursuant to Section 5.4 of the DBA, Strabag accepted sole and exclusive responsibility and commercial risk for its choice of design, means and methods. Section 5.4 therefore precludes Strabag’s claim in its entirety. This is the preliminary issue for the DRB’s consideration under Section 11 of the DBA before any possibility of differing subsurface conditions under Section 5.5 of the DBA may be considered;

2. To the extent Strabag's claim is not fully disposed of under Section 5.4 of the DBA, Strabag's claim is a Rock Support Adjustment claim under Section 5.5(c) of the DBA and is premature. The parties agreed at the time of contact that the procedures set out in Section 5.5(c) were in full satisfaction and in lieu of any change to the Contract Price or Contract Schedule. Section 5.5(c) is mandatory.

Consequently no Section 5.7(a) "Dispute" is properly before the DRB at this time."

Eventually the parties agreed to hold a hearing starting on 23/06/08, on the differing site condition issue which had grown to include the following issues:

- Large Block Failures;
- Ground Conditions beneath St. David's Gorge;
- Insufficient Stand-up time;
- Excessive Overbreak; and
- Inadequate Table of Rock Conditions and Rock Characteristics.

6.5 Conclusions

In my opinion OPG's decision to go before the DRB with the issue was appropriate because of the following reasons. Section 5.5(c) (1) of the DBA provided that: "unless the parties mutually agree that the issue is **sufficiently material** that the issue should be referred to dispute resolution in which event the matter be resolved in accordance with Section 11." [Emphasis added]. It was eventually apparent that the ground conditions and support methods were severely impacting the work and would continue to do so as long as the tunnel excavation was in the Queenston Formation.

Given the merits of OPG's position a consideration of forcing Strabag to comply with the contract by invoking arbitration and bypassing the dispute resolution laid out in Section 11 of the DBA was a possibility. However, given the losses being sustained by Strabag at the time they would likely have stopped work and spent their project management efforts on the dispute thereby piling up additional substantive costs in addition to those being experienced. Also an adversarial relationship would inevitably have arisen between the parties, a further detriment to the completion of the work.

OPG may also have considered termination of Strabag's contract in order to cure the problems. This would have resulted in a long delay to allow preparation of new contract documents and procurement of a new contractor and afterwards a protracted litigation between the parties. All of which would have delayed the contract completion with concomitant revenue loss and the further unknowns of the re-bid amount and the litigation costs and outcomes.

I was on the DRB on a major tunneling project in Canada and have direct experience where such a course of action was adopted in that the differing site condition issue was not brought before the DRB and the contractor was terminated after stopping work for six months. This led to about a year delay in re-bidding and the new bid coming in at about 1.8 times the original bid with about 60 % of the work completed; plus litigation is ongoing 5 years afterwards.

I have formed the opinion after my extensive review of the circumstances pertaining to this dispute, that OPG's decision to bring it before the DRB was appropriate.

7.0 OPG Performance at the DRB Hearing

Section 11-Dispute Resolution of the DBA provides general guidelines as to the procedures to be adopted by the DRB when conducting a hearing and the preparation of their subsequent recommendations. It is also made clear that the DRB is in charge of the proceedings.

Following the provisions in Section 11, in preparation for the hearing, each party submitted Position Papers on the dispute to the DRB and each other, followed by Rebuttal Papers. All this was done on a mutually agreed timetable.

The hearing was convened by the DRB and conducted from 23/06/08 to 26/06/08. The DRB issued their recommendations dated 30/08/08.

Importantly the construction of the work continued throughout this period with the parties cooperating fully in its prosecution.

7.1 OPG Position and Rebuttal Papers

The principal arguments put forth by OPG are those bulleted in section 6.4 above and were prepared in the main by Hatch Mott McDonald staff (Owner Representative of

OPG) with retained experts and oversight from OPG. The experts were Dr. Dougal McCreath for rock mechanics and design issues, Dr. Ed Cording for design and constructability issues and Larry Snyder for TBM design related issues; all of whom are very experienced and experts in their fields as evidenced by the reports provided as part of the Position and Rebuttal Papers.

The Position Paper prepared by OPG was clear and comprehensive in its presentation of the issues; the history of development of the design and the construction history; the discussion related to the collaborative effort with Strabag in the preparation of the DBA and the GBR included in the contract. Similarly, the Rebuttal Paper further clarified OPG's position.

7.2 DRB Recommendations

The recommendations provided by the DRB on the five issues listed in section 6.4 are summarized below.

Large Block Failures: The DRB indicated that this condition was adequately forewarned in the GBR and no DSC was warranted.

St. David's Gorge: The DRB found that the Contractor was not entitled to make a claim of DSCs within the 800m width of the Gorge as stipulated in the GBR.

Insufficient Stand-Up Time: The DRB indicated that there was a serious misunderstanding between the parties with respect to the anticipated rock conditions and rock behaviour at the time the contract GBR Version C was being negotiated. Since both parties developed the GBR jointly, any misunderstanding was the shared responsibility of both Parties.

Excessive Overbreak: The large overbreak quantity encountered throughout much of the Queenston Formation mined at that time, had impacted the rate of advance of the TBM and it appeared that the total quantity of overbreak would exceed the GBR quantity by a significant amount. Although the DBA indicated that if DSCs are encountered, the resolution of such claims should be held in abeyance until tunnel excavation was complete, the DRB believed that the consequences of the misunderstandings that had led to both the large overbreak quantities and the related impacts had been so material that some form of resolution was needed.

Whether the GBR was defective or simply misleading, both Parties developed the GBR jointly and therefore both Parties must share in the consequences in resolving the issue.

Inadequate Table of Rock Conditions and Rock Characteristics: The DRB agreed that the Table of Rock Conditions and Rock Characteristics was inadequate to be used for the identification of DSCs and, further, that the inclusion of such terms as the “closest match” and “all other conditions” essentially rendered the concepts of DSCs meaningless and made the GBR defective. In this Design-Build contract, both parties jointly developed the GBR document and both parties should share the shortcomings of the resulting document.

8.0 OPG Decision to Renegotiate a Revised Contract with Strabag

In my opinion there was sufficient weight to Strabag’s positions, particularly regarding the issues relating to ground behaviour and the removal of loose rock, to engender acceptance of the DRB’s recommendations, at least in part. In addition the first three major issues were resolved in OPG’s favour. Taking into account the DRB recommendations and their delineation of the various joint areas of responsibility for the encountered conditions and the subsequent mitigating actions of the parties, in my opinion the decision of OPG to renegotiate a new contract with Strabag was appropriate. The alternatives of arbitration or termination discussed above in section 6.5, would have very likely led to protracted delays and unknown cost expansion in order to complete the project.

9.0 Summary and Conclusions

There were significant challenges to OPG in providing the necessary and sufficient data for the design and construction of the proposed 10.4 km Diversion Tunnel. The natural variability of the alignment was manifested by variable lithology, high horizontal stresses in varying directions, rock strength anisotropy, adverse groundwater chemistry, methane gas potential, rock swelling pressures and long term deformation of the rock mass. OPG conducted a series of phased site investigations from 1983 to 1997. The results of all the investigations conducted for the Conceptual Phase and the Definition

Engineering Phase 1 and Phase 2, were presented or referenced in the twelve volume GDR which was included in the proposal issued to the design-build teams as well as GBR Version A. It is my opinion that the site investigations addressed the appropriate design and construction issues and that the studies undertaken were professionally completed and met or exceeded in some cases, the professional standards for work of similar type and magnitude.

As part of the DBA, Strabag was required to conduct appropriate analyses for the initial support and final lining design; the final lining had a mandatory 90 year design life. Strabag's designer ILF conducted design analyses including Finite Element Modeling, Wedge Analysis, Convergence-Confinement Analysis, and Beam- Spring Model Analysis. Constructability issues were also evaluated in relation to the timing of placement of the initial support. I concluded that the geotechnical and geological data gathered from the various site investigations was sufficient and appropriate for ILF's comprehensive design analyses and further that the analyses were conducted to an appropriate professional standard.

In my opinion the decision to present the disputes to the DRB was appropriate because it was apparent that the ground conditions and support methods were severely impacting the work. I believe that bypassing the DRB process and proceeding to arbitration or terminating Strabag would have resulted in long delays with protracted litigation. All of which would have delayed the contract completion with related revenue loss and the further unknowns of the re-bid amount and the litigation costs and outcomes. I also formed the opinion that OPG's conduct of the hearing was appropriate.

Finally, after review of the subsequent DRB recommendations coupled with my own evaluation of the circumstances, I formed the opinion that the decision to re-negotiate a revised contract with Strabag was appropriate and reasonable given the circumstances of the disputes and the status of the project.

GLOSSARY

Anisotropic: The material properties are different in different directions.

Atterberg Limits: Laboratory tests measuring the moisture content of a clay soil at its consistency (resistance to deformation) limits, termed the liquid and plastic limits.

Closed Formed Solution: A calculation method which assumes that the rock is a homogenous, isotropic, linearly elastic material.

Core Recovery: The length of actual core recovered during core drilling of a measured interval, referred to as a core run, expressed as a percentage of the core run length, which is typically 3m. It is an indirect measure of core loss which is indicative of general rock quality.

Dynamic Elastic Modulus of Elasticity: The Modulus of Elasticity derived from the measured sonic velocity of sound waves propagated in the rock sample.

Free Swell Test: Test for determining the swelling strain developed in an unconfined rock sample submersed in water as described in the International Society of Rock Mechanics Suggested Test Methods 1979.

Geotechnical Baseline Report (GBR): A report that is part of the contract documents, the purpose of which is to mitigate contingencies in the bid amount and to prevent litigation by promoting dispute resolution in a timely way at the site level. The report incorporates values of the rock's physical parameters as measured during the site investigations, ground characterization and an assessment of rock behavior, which are termed baselines. Generally speaking if the presented baselines are found to be materially different during the work then the resulting Differing Site Condition forms the basis for a contract modification.

Geotechnical Data Report (GDR): The GDR incorporates all of the geotechnical and geotechnical data gathered for the project and/or refers to documents containing such data.

In-Situ Stress Measurement: The existing stresses in the rock mass are measured by hydro-fracture field tests in which water is injected into a discrete section of a borehole isolated by packers, at a pressure sufficient to induce a vertical fracture in the rock. From the data collected, the magnitude and direction of the principal field stresses in the rock mass are estimated.

Isotropic: The material properties are the same in all directions.

Limit Equilibrium Analysis: Analytical method which compares the induced shear stresses on a given set of discontinuities forming a block, to the shear strength of the discontinuities for the purpose of ascertaining the stability of the block in the tunnel crown.

Lithology: The nature of the rock material such as siltstone, mudstone, shale, sandstone.

Numerical Modeling: Calculation methods for numerical stress analysis using computer models such as the Finite Element Method.

Over-Coring Method of In-Situ Stress Measurement: Another method of measuring in –situ stresses in the rock mass, in which a series of strain gauges attached to a plug are inserted in a core hole and the hole over-cored; during this process the induced strains are measured. From this data, the magnitude and direction of the principal field stresses are calculated.

Permeability Testing: A field test conducted in a borehole in which the rate of water injected into a discrete interval isolated by packers under a given pressure is measured; from this data the rock permeability or hydraulic conductivity is calculated.

Petrographic Analysis: Examination of very thin sections of rock under a polarizing light microscope which enables the identification of the minerals present.

Point Load Strength Index Testing: A measure of rock strength using a testing device consisting of two opposing pointed platens actuated by a hydraulic ram. The load at failure and the distance between the platen points at the start of the test is measured. The Point Load Strength Index is calculated by dividing the load at failure by the square of the initial distance between the points of the platens and expressed in Mpa. It can be normalized to the equivalent distance for a 50 mm diameter core. The test is principally conducted axially or diametrically on core samples but can be used on lumps of rock.

Rock Mass Behaviour: The performance of the rock mass after it is excavated; the term is usually applied to the unsupported condition.

Rock Mass Rating (RMR): An empirical, quantitative measure of a rock mass as initially proposed by Z.T. Bieniawski in 1976 and subsequently revised.

Rock Quality Designation (RQD): The total length of core pieces greater than 10 cm expressed as a percentage of the core run length, generally of 300 cm.

Rock Structure: General term referring to the presence of discontinuities in the rock mass such as bedding planes, joints, faults.

Poisson's Ratio: The ratio of the axial and radial strains as measured during the Uniaxial Compressive Strength Test.

Seismic Reflection Survey: A field test in which an array of geophones are used to record reflected seismic waves emanating from a surface of interest as a result of an energy input on the ground surface.

Stand-up Time: The elapsed time of stable rock conditions is referred to as the stand-up time and is the window for erection of the initial tunnel support.

Modulus of Elasticity: A measure of the rock stiffness expressed as the ratio of the axial stress and the axial strain, as measured in the Uniaxial Compressive Strength test.

Stratigraphy: Describes the spatial relationships between the various rock formations identified by core logging from boreholes spaced along the alignment.

Triaxial Strength Test: A compressive strength test conducted on a specially prepared rock sample placed in a cell which is capable of applying a radial pressure to the sample to simulate in-situ stress. An axial load is applied to the sample through end platens.

Tunnel Crown: Roof of tunnel.

Tunnel Invert: Floor of tunnel.

Tunnel Springline: The location on the tunnel wall which is intersected by a horizontal plane through the center of the tunnel.

Uniaxial Compressive Strength: A compressive strength test of a properly prepared rock core sample conducted by applying an axial load to each end of sample through the platens of the testing machine. The axial load and axial deformation are recorded in real time until failure occurs. The uniaxial compressive strength is calculated by dividing the load at failure by the initial cross sectional area of the sample expressed as Mpa. The axial deformation is used to calculate the Modulus of Elasticity. Radial deformation can also be recorded if the Poisson's Ratio is required.

Westbury Piezometer: Instrument located in a borehole which enables recording of water levels and recovery of water samples at selected elevations within the borehole.

Wireline Core Recovery: A drilling method in which the core is recovered from the borehole by a wireline for each core run without removing the drill string and core barrel.

DISPUTE REVIEW BOARD REPORT
Niagara Tunnel Project

Dispute Review Board Dispute No. 1

Differing Subsurface Conditions in Queenston Formation

Hearing Dates: June 23 through 26, 2008 **Report Date: August 30, 2008**

The Dispute Review Board (DRB) met with the Parties and their experts in Niagara Falls, Ontario to hear the Strabag Inc. (Contractor) dispute with Ontario Power Generation (Owner) regarding alleged differing subsurface conditions (DSC) encountered in the Queenston Formation (QF) portion of the tunnel between Stations 0+806 and approximately 2+200. In preparation for the hearing the DRB reviewed the Parties' position papers, reference documents and rebuttal papers, including expert reports and rebuttals to them. The hearing was closed on June 26,2008 following completion of testimony by the Parties and their experts, including their responses to questions from the Board. The Parties provided additional material as requested by the DRB.

1 SUMMARY OF DISPUTE

The following paragraphs summarize the Board's understanding of the Parties positions relative to the pertinent issues in dispute before the DRB and this hearing.

1.1 Large Block Failures

1.1.1 Contractor's Position

Large block failures within the Queenston Formation (QF) that occurred at cutterhead Sta. 0+815 and 0+839 were bounded by the overlying lithological contact with the Whirlpool Formation and natural discontinuities oriented sub parallel and sub perpendicular to the tunnel axis. These failures were structurally controlled, gravity failures with no evidence of any stress-related effects and were not anticipated based on the conditions described in the Geotechnical Baseline Report (GBR). The GBR reference to up to 3 m of slabbing implies progressive failure in layers and not sudden large block failure and these conditions constitute a DSC.

1.1.2 Owner's Position

The Owner maintains that block failure is not due to a geotechnical subsurface condition but a result of inadequate rock support. Further, that although some limited reduction of regional in situ stress field was expected in the QF immediately below the stiffer Whirlpool Sandstone, the stress reduction would not be of a magnitude that would promote block failures in the crown. Rather, the Contractor's failure to install closely spaced steel sets within or immediately behind the shield of the TBM, as agreed to in the Design Build Agreement (DBA) led to the large block failures and no DSC was encountered.

1.2 St. Davids Gorge

1.2.1 Contractor's Position

Clause 5.5e of the DBA states: "No request by the Contractor for relief for differing subsurface conditions will be allowed in respect of Work under the St. David's Gorge to the extent that the width of the gorge is within the width defined in the GBR." This clause was added by the Owner to reduce its risk exposure if rock conditions worsened as a direct result of the Contractor's raising the vertical alignment of the tunnel some 50 m. The Contractor maintains that it's acceptance of this clause relied on the GBR description of rock conditions under the Gorge (Article 4.4.4.4 of the GBR) as being "generally fresh and of excellent quality" at depths greater than "15 m to 25 m below the bottom of the gorge". Clause 5.5(e) of the DBA is not a waiver of entitlement to any DSC within the limits of the Gorge and Strabag's anticipated risk was limited to a potential narrow feature filled with sediment and water that may have gone undetected at the higher tunnel alignment by borehole investigations conducted prior to bidding. This risk was mitigated by additional vertical and horizontal boreholes drilled by Strabag and it is indisputable that the "excellent" rock conditions described in the GBR do not exist. As such, Strabag contends it is entitled to relief from the more adverse excavation conditions resulting from such DSCs encountered in the Gorge area.

1.2.2 Owner's Position

The Owner maintains that raising the tunnel alignment had real and potential benefits to the Contractor in the form of reduced grades and total length of tunnel and possible bonus payment from increased water delivery. Further, that the proposed raising of the tunnel could put the tunnel crown within roughly 15 m of the bottom of the Gorge. Clause 5.5e was added to the DBA because it moved the tunnel from more competent to less competent rock and the Owner wanted no part of this risk, and Strabag agreed that the Owner would have no part of this risk. Strabag cannot claim for DSCs under the St. Davids Gorge as such claims are expressly prohibited by the Agreement.

1.3 Insufficient Stand-Up Time

1.3.1 Contractor's Position

Stand-up time provides a time frame within which support must be installed and the Contractor maintains that, as defined by Bieniawski (1976 and referenced in the GBR), the stand-up times relative to RMR values of the rock (as provided in the GBR) and the tunnel span would imply sufficient stand-up time to allow installation of initial support throughout most of the QF. The Contractor maintains that 10 singular events were included in its proposal when the stand-up time would not be sufficient to allow installation of the intended regular support. The Contractor also maintains that it advised the Owner prior to award that, with an "open" TBM, standard rock support could only be placed in the L1 area, a distance of about 4-7 m from the face. The Contractor contends that the stand-up times interpreted from Bieniawski's relationships with RMR values (referenced in the GBR) together with the operational constraints of the TBM are in conflict with the actual stand-up time encountered during tunneling in the QF and that this condition was not anticipated from the information presented in the GBR and thus constitutes a DSC.

1.3.2 Owner's Position

The Owner maintains that the stand-up time relationships with RMR values, as developed by Bieniawski, are for ground conditions not subjected to high in situ stresses and therefore are not applicable to this situation. Further, the Owner maintains that stress induced failure in the QF, where tangential stresses are a high proportion of the rock's unconfined compressive strength, will occur at or immediately behind the cutterhead and, if not controlled by the TBM roof shield and immediate rock support, will continue into the rock mass and result in excessive overbreak. The Owner maintains that the Contractor agreed to install full and immediate support and closely spaced steel sets over ~75% of the QF to mitigate this. Therefore, if the Contractor recognized the need for full and immediate support, stand-up time could not have been expected. The Owner maintains that stress-induced failure has been the primary failure mechanism within the QF, exactly as indicated in the GBR, and therefore no DSC was encountered.

1.4 Excessive Overbreak

1.4.1 Contractor's Position

The Contractor maintains that the QF did not behave as a "generally massive" rock, as indicated in the GBR, and therefore, that the originally agreed on support method using steel sets could not be practically installed in a manner that would limit loosening of the remaining rock to the degree deemed necessary by its Designer. Also, "the principal reason for using steel sets were indications in the GBR of a high stress environment and significant potential for swelling and squeezing in the QF, with invert heave and sidewall distress". Further, the final liner approach with a prestressed unreinforced cast-in-place liner and a water tight membrane was a key factor in the selection of this Contractor. Considering the extraordinary 90-year service life specified in the Owner's Mandatory Requirements, combined with practical limitations on the ability to grout any remaining voids, the Contractor had to change its support means and methods to reliably and practically limit the amount of loosened rock left in place. Also, the reduced squeeze, sidewall spalling and invert heave actually encountered made the use of steel sets less important. The change in means and methods was driven by the DSCs, not vice versa, and the resulting excessive overbreak (several times greater than the average amount per meter that was anticipated) is, in itself, sufficiently material to entitle the Contractor to immediate relief under the contract provisions for DSCs.

1.4.2 Owner's Position

The Owner maintains that the features originally provided on the TBM should have been sufficient to provide the necessary rock support until steel sets could be placed immediately behind the TBM shield and expanded behind the fingers. The Contractor removed the equipment on the TBM that was needed to install steel sets before reaching the QF and, hence, never attempted to install steel sets in the QF as stipulated in the GBR, let alone document an unacceptable degree of loosening of the remaining rock as required by Section 5.7(b) of the DBA. The Owner maintains that if the steel sets were properly installed, including the intermediate bolts, the resulting loosening of the rock could have been limited to levels that met the design requirements. Further, the conditions encountered were as defined in the GBR and it was the Contractor's decision to change its means and methods that caused the excessive overbreak. The DBA specifically states that the Contractor will not be entitled to make any claim for the impacts resulting from a change or deficiency in the designs, means and methods that causes a difference in the behaviour of the geotechnical subsurface conditions.

1.5 Inadequate Table of Rock Conditions and Rock Characteristics

1.5.1 Contractor's Position

The Contractor maintains that the rock mass behaviour encountered during tunneling in the QF is materially different and is not adequately described by the Table of Rock Conditions and Rock Characteristics included in the GBR. Further, the Contractor maintains that the table is not only insufficient and inadequate to define the actual conditions encountered; it is also inconsistent with the Rock Support Requirements stipulated in the GBR (Article 8.1.3.) and with standard practice. As a consequence it was necessary to develop two new rock support types (4R and 4S) for rock conditions and characteristics not included in the Table. This necessitated significant modifications to the TBM backup equipment and, in turn, modifications to the means and methods for supporting the tunnel. Thus, the Contractor maintains that this Table presented in the GBR does not accurately describe the in-situ conditions encountered during tunneling and thus constitutes a DSC.

1.5.2 Owner's Position

The Owner maintains that, as stated in the GBR, the in-situ rock condition is to be determined based on the "closest match" to the Rock Characteristics within each Rock Condition defined. Further, the Table must be read in conjunction with the remainder of the GBR and it deals with stress-induced failure as the predominant failure mechanism within the QF. Based on the characteristics in the Table, essentially all of the rock within the claimed length of tunnel has been classified by the Owner as Type 5. Should the Contractor's contention result in an agreement that greater support is required than Type 4Q or 5 can provide, then the rock would be classified as a Type 6 condition. The price and schedule would be adjusted accordingly following the completion of the tunnel excavation with no DSC required.

2 BACKGROUND

2.1 General

Strabag Inc., an Austrian contractor, and the Owner entered into a Design-Build Agreement (DBA) to construct the Niagara Tunnel Project, a 10,400 m long, 14.4 m excavated diameter tunnel to convey water from the Niagara River upstream of Niagara Falls to the existing canal system that feeds the Sir Adam Beck hydroelectric plants at Queenston, Ontario. The original Contract Price was $623M. This Work will add significant power generation to the existing facilities and prompt completion is critical, as is the continuous operation of the tunnel over a 90-year service life. The tunnel functions as an inverted siphon and, consequently, unwatering of the tunnel must be done by pumps rather than by gravity drainage. This would result in significant interruption of service (on the order of 3 weeks) just to unwater the tunnel. The contract includes a significant bonus for early completion and significant liquidated damages for late completion, both of which are limited to 20% of the Contract Price (~$125M).

The tunnel is being excavated with a main beam tunnel-boring machine (TBM). At the time of the hearing the TBM had excavated approximately 2,200 m of tunnel, of which roughly 1,400 m is within the QF, with an additional 5,500 m (~80% of the tunnel in the QF) remaining to be excavated.

2.2 Chronology

Proposal documents submitted to tenderers	12-22-04
Proposals received from tenderers	5-13-05
Contract awarded to Strabag Inc. and signed	8-18-05
Noticed to Proceed	9-1-05
First DRB meeting	2-7-06
Start tunnel excavation	9-1-06
Large fallout at start of QF	5-16-07
Notice of DSC from Contractor to the Owner	5-23-07
Excavation of St Davids Gorge portion of tunnel	11-07 through 5-08 (approx dates)
Dispute Request from Contractor to DRB	3-5-08
Original Substantial Completion Date	10-9-09

2.3 Pertinent DBA Provisions

Section 2.1 (a) states "The Contractor will ensure that all Work is performed in accordance with and complies with the Owner's Mandatory Requirements, the Contractor's Proposal Documents, Final Submittals, Applicable Law and the other terms of this Agreement."

Section 2.13 (a) states "... The Contractor will be solely responsible for the means, methods, ... used to perform the Work, ..."

Section 3.3 states "... The Contractor acknowledges exclusive control over and commercial responsibility for any and all means, methods, ... to complete the Work for the Contract Price and in accordance with the Contract Schedule."

Section 5.4 states "The Geotechnical Baseline Report (GBR) shall serve as the only basis for determining ... differing geotechnical subsurface conditions." The GBR has been developed jointly by the Owner's team and the Contractor and, as such, describes anticipated behaviors and conditions that are dependent on the Contractor's selected designs, means, methods ... anticipated or implied at the date of this Agreement. ...The Parties acknowledge that such means, methods, ... are the sole responsibility of the Contractor, and the Contractor is free to make changes at any time. To the degree that any difference in the behavior of the geotechnical subsurface conditions is attributable to a change or deficiency in the designs, means, methods ... then the Contractor will not be entitled to make any claim for the impacts resulting therefrom."

Section 5.5 (b) states that to be a DSC, the subsurface conditions:

(1) Must "... differ materially from the GBR;"
(2) "the material difference in the conditions is not attributable to a change or deficiency in the Contractor's designs, means, methods, sequences, timing and/or level of workmanship;"
(3) Must "... directly and materially impact performance of the Work; and"
(4) "such impact has the effect of materially increasing or decreasing the cost or time of performing the Work."

Section 5.5 (c) (1) states "...the Contractor will record the rock conditions (as defined in the GBR) encountered in the performance of the Work and measure the tunnel lengths thereof and OPG will review and verify such determinations. If the parties cannot agree, the positions of both parties shall be recorded. The resolution of any disagreements will be held in abeyance ..., unless the parties mutually agree that the issue is sufficiently material that the issue should be referred to dispute resolution in which event the matter be resolved in accordance with Section 11;..."

Section 5.5 (e) states "No request by the Contractor for relief for differing subsurface conditions will be allowed in respect of Work under the St. Davids Gorge to the extent that the width of the gorge is within the width defined in the GBR."

2.4 Contract

2.4.1 Design Build

Tunnels in North America have traditionally been constructed using Design-Bid-Build contracts, in which the Contractor has no involvement in preparing the contract documents, including the GBR. All bidders tender to the identical contract provisions, GBR conditions and design.

Design-Build (DB) contracting is becoming a more frequently used form of contract on large, challenging construction projects primarily to reduce the pre-bid time spent on design efforts and equipment procurement, thereby facilitating earlier completion. DB is used on this Project and four main parties are involved: the Owner, the Owner's Representative (OR), the Contractor, and the Designer, ILF Consulting Engineers, of Austria, who is retained by the Contractor. The three contractors that proposed for this Work and their designers prepared preliminary designs, design basis and methods statements, specifications, drawings and payment provisions in general accordance with the Owner's bidding requirements, mandatory requirements and conceptual design. However, after evaluating the conceptual tunnel design, Strabag proposed a different lining design that required a different type of TBM. This was accepted by the Owner and is being used to construct the tunnel.

On this contract the Owner's team prepared an initial GBR, called a GBR-A. Each proposal included a GBR-B, in which the tenderers supplemented and revised GBR-A, to be consistent with the bidder's proposed design approach and planned means and methods of construction. The GBR-C was negotiated with the selected tenderer and became the contractually binding GBR.

The Contractor is responsible for design and construction of the Work. The Owner is responsible for more adverse subsurface conditions than are represented in the GBR. The Owner **and** the Contractor are **jointly** responsible for preparation of the GBR.

2.4.2 Contractor's Proposal

The Contractor proposed a prestressed tunnel lining method, and listed nine hydroelectric tunnels where the method had been used between 1963 and 1988. This lining approach was judged by the Owner's team to be significantly superior, for the unique requirements of the Niagara project, to the methods proposed by the other two tenderers, each of which involved a fully-shielded TBM with a single pass, pre-cast segmental lining. The price and duration of the Strabag proposal, as negotiated, were acceptable. Therefore the Owner contracted with this Contractor to do the Work.

As the DRB understands it, Strabag was not the low bidder and acknowledged in their proposal that using a shielded TBM with a pre-cast segmental liner would make construction easier. However, Strabag considered a segmental liner too unreliable, under the unique site conditions, to meet the required service life of 90-years without unwatering the tunnel for repairs.

In the Contractor's proposed lining method a waterproofing membrane is placed between the initial lining and a cast-in-place, unreinforced final concrete lining. After the concrete cures, interface grout is injected under high pressures between the initial lining and the waterproofing membrane to prestress the final concrete lining. This is intended to ensure that the tunnel will not leak during operation at 14 bar internal water pressure. This is particularly important on this project since the QF swells on long-term contact with fresh water and leakage could cause the lining to fail, and consequently to require the tunnel to be unwatered for repairs. The inside surface of the initial shotcrete lining must be of a relatively uniform diameter since the membrane is prefabricated to fit the initial lining. According to the design, no loose rock can remain outside the initial lining as this could cause unacceptable deformations to occur during interface grouting that could cause the membrane to fail or possibly result in the inability to develop the planned prestress.

2.4.3 Negotiations

DB contracts require the Parties to jointly negotiate and prepare the contract according to the owner's requirements and the proposer's design, means and methods. Typically during DB negotiations the parties concentrate on getting the contract signed and the work started, often without adequate attention to details of the design, specifications, and payment provisions. It is not uncommon therefore that, after award of DB contracts, problems arise from provisions in the negotiated contract that were either not clearly written, were overlooked, or reflect misunderstandings during negotiations and final drafting of the contract. Subsequently the parties are often able to negotiate acceptable solutions to these problems.

This DBA involves a final lining method for a high-pressure water tunnel that, to the DRB's knowledge, has not been used in North America. Also, this project is using the largest diameter hard rock TBM ever built. These unique features, combined with the other unusual conditions mentioned elsewhere in this report made negotiations a monumental effort, characterized by the OR as "fast-tracked and extensive" over "a long, hot summer". In hindsight, all of these factors contributed to a contract that had a number of problems, particularly in the GBR and resulting DSC dispute resolution.

2.5 Construction

2.5.1 Planned Means and Methods

The Contractor chose a main beam TBM with a roof shield with 3 m long trailing fingers. The total distance from the face of the tunnel to the end of the fingers was originally 7 m. As with typical main beam TBMs, muck buckets are on the periphery of the cutterhead. There are grille bars on the periphery between the buckets that prevent large rocks from jamming or plugging the buckets. The TBM also has radial openings in the cutterhead faceplate through which muck also enters the muck buckets. The TBM and trailing equipment are configured to complete placing the initial support immediately behind the fingers, in the L1 area, and to complete the initial lining in the L2 area. There is a separate platform for low pressure cavity grouting at the far end of the trailing equipment, some 100 m behind the TBM face. The Contractor states in his proposal that the primary function the planned cavity grouting was to reduce inflows into the tunnel during construction.

Generally, two types of initial lining within the QF were listed in the GBR:

- Rock bolts holding steel channels that were pre-bent to the excavation radius and then further deformed as they were secured to the irregular contours of the excavated rock surface over 120 degrees of the crown (or more if required). This was followed by a full-circle of 130 mm thick shotcrete added in the L2 area to complete the initial lining. Type 4Q support was assumed in the GBR to comprise 27% of the tunnel length in the QF.

- Full circle steel sets, pre-bent to the excavation radius, expanded against a relatively uniform excavated rock surface (i.e.not further deformed), with a row of rock bolts and anchor plates in the crown on each side of each set, followed by full-circle shotcrete added in the L2 area to complete the initial lining. These sets are Type 5 or 6 support, depending on the size and spacing of the steel set and the thickness of shotcrete. Type 5 consisted of 150 mm steel sets with 160 mm of shotcrete while Type 6 consisted of 200 mm steel sets with 260 mm of shotcrete. Types 5 & 6 comprised a total of 73% of the tunnel length in the QF, as assumed in the GBR.

The steel channels were to be on 0.9 m centers and the full circle steel sets on 1.8 m and 1.2 m centers. Wire mesh was used as reinforcing for the shotcrete and for safety to support the rock between the bolts, channels and sets. Shotcrete was placed some 25m behind in the L2 area to complete the full-circle initial lining, providing full support.

The initial lining design drawings included in the proposal clearly state: "loose rock to be removed". Loose rock contained by the wire mesh was to be removed through openings in the mesh or by cutting the mesh. The extent of loose rock removal was not delineated as "all", or otherwise defined.

It appears that the Contractor may have realized that there was a misunderstanding with respect to the anticipated QF rock conditions, either through discussions with the Owner's personnel on site or through more detailed analysis before starting to drive tunnel. This is illustrated by the Contractor's drawing NAW 130-DOV-29230-0033 Rev. 00 issued in June of 2006, less than 3 months prior to the start of tunneling, that indicates it's intention to install rock support Type 4Q throughout approximately 90% of the tunnel length within the QF (Ref. Doc. No. S10 in the Contractor's Position Paper).

2.5.2 Actual Means and Methods

The Contractor discontinued using full circle steel sets after the first 175 m of tunnel (a total of 123 sets were installed). The fingers were shortened from 3 m to 1.9 m soon thereafter, to allow better access to place steel channels held with rock bolts. Parts of the steel set erector were also removed prior to reaching the QF and all parts were finally removed after the block failure at Sta 0+806, in September 2007, and were never reinstalled.

There were many reasons to not install steel sets. The lack of sidewall spalling, invert heave, and short term squeezing and swelling negated the need for immediate support of the full perimeter of the tunnel. In addition, loosening in the crown gave the Contractor concern over the use of steel sets while still meeting the design requirements to remove loose rock. In the Designer's judgment, loose rock had to be removed and this was impractical as well as quite unsafe with steel sets. Further, removal of loose rock over the sets was highly undesirable as it slowed the tunnel advance rate and thus contributed to further loosening of the rock in the crown, as well as posing safety issues.

To support most of the QF, steel channels were deformed to the irregular rock surface as rock bolts were installed over 90 to110 degrees of the crown. Channels were installed on about 1 m centers, as required by rock conditions. A 70 mm preliminary layer of shotcrete was added to the crown in the L1 area, to complete the initial support. The full-circle of minimum 130 mm thick shotcrete was placed from the L2 area to complete the initial lining. This is referred to as Type 4R support.

In particularly bad areas of overbreak, spiling was used to pre-support rock over and ahead of the TBM. This consists of 2 in. diameter, heavy-wall pipes, 9 m long, placed in 90 mm holes drilled over the TBM cutter head. Spiles generally cover some 90 degrees of the tunnel crown, are spaced on less than 1 m centers and look up at 10 to 15 degrees. The spile pipes could not be grouted in the holes, as the rock was too open and fractured to contain the grout. Steel channels, rock bolts and shotcrete, as above, supported the spiles. A preliminary layer of shotcrete in the crown was added in the L1 area to complete the initial support. A full-circle of minimum 130 mm thick shotcrete was added in the L2 area to complete the initial lining. This is referred to as Type 4S support.

In both Types 4R and 4S additional shotcrete was placed as needed in the L2 area to fill out the initial lining to the uniform diameter required for the membrane.

The design (1921/PR-00-3001 / Rev 1, page 5) stated that a condition of no voids behind the lining was to be "achieved by contact grouting, interface grouting and cavity grouting where required." Cavity grouting at low pressure is frequently done with Type 4S from the far end of the trailing equipment after the initial lining is complete, but cannot be expected to fill all voids with certainty. Interface grouting at high pressure will be done after placement of the final cast-in-place lining and contact grouting. Interface grouting is to be done through tubing placed between the initial lining and the membrane and, therefore, cannot be expected to fill voids outside the initial lining with any degree of certainty. A condition of no voids in the rock is best achieved by removal of all loosened rock before rock support is installed to the intact rock surface. According to the Contractor, in order to have confidence in the prestressing of the final lining there is no practical and safe solution other than to remove all loose rock that forms in the QF and support the remaining rock with Type 4R or 4S initial support. Because the Contractor cannot delay his mining operations to see if the rock will fall under gravity, the Contractor bars down what it believes to be loose rock before pushing steel channels tight against the rock surface and then installing rock bolts to hold the channel and remaining rock in place.

3 DISCUSSION and FINDINGS

3.1 Large Block Failures

The DRB believes this was adequately forewarned in the GBR and no DSC is warranted. Some examples from the GBR are as follows:

- 6.3.2: "… the RMR values are slightly lower than average below the Whirlpool/Queenston contact primarily due to a slightly higher joint frequency."
- 6.3.3: ".information from the Generation area to provide a further assessment of the QF near the contact with the overlying Whirlpool" states "… the RMR value

is relatively low within the first 10 m below the Whirlpool/Queenston contact and gradually increases with depth …".

- 8.1.2.3 "The weathered zone below the contact with the Whirlpool Formation … represents a weaker zone."
- 8.1.3.4 "… support must be full and immediate for a 25 m length before and after the intersection, at the tunnel crown, of a major lithological boundary."

In addition, ten days before the first large block fell, the OR sent the Contractor an RFI asking when the Contractor would start installing full circle rock support, noting that the GBR stipulated this.

Based on the information presented in the GBR, the strength and Young's modulus of the Whirlpool is on the order of 4 to 5 times greater than the underlying QF causing the Whirlpool to carry more of the horizontal stresses with less deformation. This will create a stress shadow effect (reduction in horizontal stress) within the upper portion of the QF that should have been anticipated, and it appears that the Designer did anticipate this. Further, if the Contractor's impression of the QF was that it was "generally massive", the potential for such large block failures beneath a much stronger formation in a high horizontal stress environment would seem likely.

3.2 St. Davids Gorge

The Contractor's Proposal included raising the Owner's conceptual design low-point of the tunnel's vertical alignment some 50 m. The Owner was concerned about the added risk of encountering less competent rock at this higher elevation, as well as the added risk of intersecting the buried channel itself. However, the Owner approved raising the vertical alignment on the condition that no DSCs could be claimed for the 800m long section of tunnel under St. Davids Gorge. The Contractor recognized that raising the tunnel this amount increased the risk of difficult ground conditions but agreed to the Owner's condition and the following provision was added to DBA Section 5.5(e): "No request by the Contractor for relief of DSCs will be allowed in respect of Work under the St. Davids Gorge …".

Even though the GBR states that the QF becomes "generally fresh and of excellent quality" at depths of 15 to 25 m below the bottom of the Gorge, the DRB believes the amount of overbreak encountered at this location is likely to have been influenced by more adverse conditions associated with raising the tunnel this much closer to the bottom of St. Davids Gorge. Further, even though the tunnel did not intersect St. Davids Gorge, boring explorations are not reliable in defining the exact depth of a buried channel such as this and it is uncertain how close the tunnel may have come to the bottom of the Gorge.

Consequently, the Board finds that the Contractor is not entitled to make a claim of DSCs within the 800 m width of St. Davids Gorge stipulated in the GBR.

3.3 Changes or Deficiencies in the Means and Methods

The OR claims that the initial support means and methods were changed. The Contractor acknowledges that changes in the means and methods were made to facilitate the changes in support types as noted in the prior section of this report. However, the Contractor maintains that these changes were driven by the DSCs that were encountered and not vice versa.

According to the OR and their experts, steel sets could be installed when using a hard rock TBM and the rock supported sequentially and simultaneously in three places:

- First, close behind the cutter head, supported with the roof shield,
- Then, at the back of the roof shield, supported with the fingers, which are firmly supported by partially expanded steel sets (with wire mesh),
- Then finally, past the fingers, supported with the steel sets (and mesh) fully expanded into final position as soon as possible after each set emerges from under the fingers as the TBM moves ahead.

The Owner's team agrees that the rock over the steel set supports would be fractured and could dilate slightly, but maintains that the remaining rock would not fail and become loose. They believe that subsequent low pressure cavity grouting and high pressure interface grouting would provide sufficient filling of voids to obtain tight embedment for the final lining.

The DRB believes that this support method would be adequate on tunnel projects with less stringent final lining design criteria.

However, this TBM cannot prevent loss of rock from outside the excavated surface in the crown over the cutter head, at the grille bars/buckets. QF rock in this area can relax, crack, break apart and fall past the grille bars and into the muck buckets. Further, rock cannot be completely supported for the width of the steel set spacing at the end of the fingers. QF rock in this area can also relax, fracture, break apart and would have to be left in place or removed by hand from outside the wire mesh. In the Board's opinion, this relaxation, fracturing and breaking apart in the QF cannot be prevented with steel sets and wire mesh. This condition will also leave an irregular rock surface and steel sets (unlike steel channels) cannot be further deformed to expand tightly against the contours of an irregular rock surface.

In addition, the combination of a very large tunnel diameter, high horizontal overstress in the QF shale, serious grouting limitations and a prestressed final lining design with a waterproof membrane make it questionable whether a condition of no voids behind the lining could be achieved with adequate certainty using steel sets. Ultimately this is a judgment call and since the Contractor is assigned the risk, he and his Designer's judgment must prevail.

The Contractor is using Type 4 supports in accordance with the provisions of Note 11 on the drawing of Types 3 and 4 Initial Support (NAW130-DOV-29230-0019, rev 05) dated February 28, 2007 states: "In case of significant overbreak, the position of rock dowels and mesh shall follow the contours of the rock surface." All of the drawings issued with the proposal, however, show only bolts through steel channels for Type 4 support whereas only bolts with anchor plates (no steel channels) are shown for Types 5 and 6 supports. Types 2 and 3 support drawings in the proposal, for rock formations above the QF, show both bolts with anchor plates and bolts through steel channels. Based on the Board's experience, bolts with anchor plates and wire mesh are only effective in fairly massive rock, whereas less massive rock requires the bolts to be installed through steel channels or pans to effectively support the ground. All of these drawings before tunneling began, including NAW 130-DOV-29230-0033 Rev 00 discussed in Section 2.5.1, and the subtle differences in bolt support methods shown on these drawings, leads the Board to believe that the Contractor, through further evaluation, had revised its understanding of the subsurface conditions in the QF following signing of the DBA, but prior to actually encountering the ground in the tunnel.

Although this might be construed to mean that no DSC has been encountered (i.e. the Contractor had correctly anticipated the ground conditions prior to encountering the ground within the tunnel), the DBA clearly states that the identification of a DSC shall be based on the information contained in the GBR. If the GBR is ambiguous or imprecise in its description of the subsurface conditions such that the Contractor reasonably misunderstood those conditions at the time the DBA was signed, then a DSC would exist. In this regard, one of the main differences in Rock Characteristics between Rock Condition 4 and Rock Conditions 5 & 6 as presented in the GBR is the inclusion of "rock pressure generally exceeding rock mass strength" for Types 5 & 6, but not for Type 4. Nonetheless, over 25% of the tunnel length in the QF is identified in the GBR as Rock Condition 4Q. This is inconsistent with the conditions actually encountered in the QF where stress induced fracturing has been encountered throughout, as evidenced by its classification as Type 5 by the Owner.

The addition of shotcrete in the L1 area to the Type 4 support described above is called Type 4R support. In the Board's opinion, this addition of shotcrete does not constitute a change in means and methods that would justify invoking the provision of DBA Section 5.5(b)(2) regarding "...a change or deficiency in the Contractor's designs, means, methods...".

Type 4S is a new support method necessitated, based on subsurface conditions actually encountered, by the QF overbreaking higher than the Contractor anticipated from the descriptions provided in the GBR. Types 4R and 4S are required by the design note: "loose rock to be removed".

The DRB believes that loose rock formed faster than the Contractor anticipated, largely due to the stress induced fracturing, and the Board is also of the opinion that full circle steel sets are unnecessary and impractical to use to support only the crown (i.e. no significant sidewall spalling or invert heave). In the Board's opinion, rock bolts and steel channels, following removal of loose rock, are the optimum initial support in the QF in this tunnel under the actual ground conditions encountered and the final lining requirements, although this will probably result in greater overbreak quantities than indicated in the GBR.

3.4 Insufficient Stand-Up Time

The Contractor testified that RMR values stated in the GBR led it to believe the QF would not fail so fast that adequate initial support could not be installed within the L1 and L2 areas. Although GBR 6.3 states that RMR values were used to assess rock mass strengths in the concept design, it neglected to point out that the RMR method of rock mass classification was not applicable as an indicator of stand-up time in rock subject to stress-induced failure, such as the QF. Even for rock not subjected to a high horizontal stress, the reported RMR values, when compared to Bieniawski graphs showing opening spans, should have raised serious concerns over stand up times when installing initial support

However, the configuration of the selected TBM suggests to the DRB that the Contractor did not expect that rock in the crown in the QF (over 80% of the tunnel) would fail almost immediately due to overstress. If immediate overstress failures had been anticipated, the DRB believes the TBM would have been designed so all passages for muck to enter the cutterhead would have been radial openings in the cutterhead faceplate without peripheral buckets. With the TBM used on this project, there is an unsupported distance of 1.2 m over the cutterhead with the peripheral buckets comprising some 0.6 m of this distance. The rock can relax, fracture, break apart and fall into theses buckets before it can be supported by the TBM roof shield. Even with stress induced fractures, such a condition may not have been anticipated if the rock was believed to be "generally massive".

In the DRB's opinion, the Contractor's original plan to use steel ribs as a regular means of initial support in the QF suggests that it anticipated the rock to be "generally massive" with reasonably good stand up time throughout much of the QF formation. Under such a scenario, the need for full circle steel ribs to resist sidewall spalling and invert heave would make sense, while feeling that stress induced fracturing in a "generally massive" rock would not produce serious crown stability problems or loosening of crown rock to a degree that would raise concern over performance of the final liner under high interface grouting pressures.

It appears to the Board that there was a serious misunderstanding between the Parties with respect to the anticipated rock conditions and rock behavior at the time the contract GBR was being negotiated. Since both Parties developed the GBR jointly, any misunderstanding is the shared responsibility of both Parties.

3.5 Geotechnical Baseline Report

It is noteworthy that Appendix 5.4 – Geotechnical Baseline Report states in item 1.4 that "the GBR will be used during the execution of the Contract for comparison of the *assumed subsurface conditions with actual subsurface conditions* as encountered during construction." The wording contained in this Appendix 5.4 is consistent with the usual concept of a GBR on a Design-Bid-Build project.

Section 5.4 of the DBA, however, states the GBR "describes *anticipated behaviors and conditions that are dependent on the Contractor's selected designs, means, methods….anticipated or implied* at the date of this Agreement." The wording in the DBA expands and complicates the GBR concept and purpose by (1) changing "*assumed*" to "*anticipated*" or "*implied*" and (2) by including "*behaviors and conditions that are dependent on the Contractor's selected designs, means, methods…*" , both of which require a mutual understanding between the Parties. The DRB assumes the objective of these modifications is to avoid DSCs based on subsurface conditions set by one party to the contract. This may seem achievable, especially when the GBR is "jointly developed" by the Owner and Contractor. However, neither Party is likely to anticipate all of the conditions and behaviours that will be encountered and would influence the performance of the Work, let alone have a clear mutual understanding of those conditions and behaviours. In the Board's opinion, the wording in the DBA makes the application of the GBR concept much more complex and increases the likelihood of misunderstandings.

The GBR concept was originally developed and generally used as a risk allocation tool. It should be noted that rock behavior is generally dependant on both the ground conditions (Owner's responsibility) and the means and methods (Contractor's responsibility) and, therefore, identification of a DSC based on behavior makes allocation of the risk inherent in the work extremely difficult, if not impossible.

The Owner's conceptual design assumed that a precast segment lining would be used. Thus, at the time the GBR-A was prepared, the Owner's team anticipated that a precast, gasketed segmental liner would be used, erected within a fully shielded TBM. Under such conditions, the rock surrounding the excavation is never exposed; the rock is allowed to slab, loose rock is not removed, and continuous support is provided by the shield, segments and annular backfill. Consequently, greater emphasis in the GBR-A may have been placed on anticipated problems with squeezing and swelling rock over the long term, with lesser emphasis placed on the immediate support problems associated with main beam TBM excavation in the QF under high horizontal overstress. This would be misleading to a Contractor contemplating the use of a main beam TBM.

The Contractor and Designer could have also been misled by statements within the GBR that were incorrectly or imprecisely drafted according to guidelines in "Geotechnical Baseline Reports for Construction", ASCE, 2007, Section 6.4, page 27. Specific quotes from the GBR that illustrate this point include:

- 8.1.2.2: "...As a result, there is a *potential* for thin rock wedges to develop at any bedding plane." To the optimistic contractor bidding for the work, *potential* is likely to be interpreted as seldom likely to occur.

- 8.1.2.3 "The Queenston Formation is *generally* massive." Without defining the extent more quantitatively, this could, in the Board's opinion, lead to a reasonable interpretation of massive rock. Other descriptions in the GBR warn of less massive conditions that "must be accounted for", but these could be interpreted as local conditions.

- 8.1.2.3: "significant slabbing *can* occur in the crown" which could also be interpreted that slabbing might not occur; when in actuality it occurred throughout the QF.

- 8.1.3.2: "initial support must be installed within or *immediately behind* the shield". This can be interpreted that installation of initial support could be delayed to immediately behind the shield.

Consideration of such statements may have led the Contractor to propose Rock Condition 4Q in the QF that does not include *slabbing* as one of the rock characteristics, while actual conditions show *slabbing* should have been expected throughout the horizontally overstressed QF.

Other statements in the GBR that describe conditions that may have influenced the Contractor or his Designer, but never developed or were more severe than expected include:

- 8.1.2.5 "*Slabbing* and plucking of rock blocks *around* and above the TBM shield..." was apparently written for a TBM using a full circle shield and erecting pre-cast concrete segments. A main beam TBM roof shield does not have an "*around*" portion and no substantial *slabbing* of rock blocks *around* the TBM shield can occur.

- 8.1.2.6 "Stress induced spalling will occur at the sidewalls...within ½ hour of excavation", when in actuality it has not occurred in the sidewalls within the QF to any measurable degree, even after days of the sidewalls standing unsupported.

- 8.1.2.6 "Invert heave is *expected*.", when actually invert heave does not appear to have been a problem, although some fracturing of the invert has been reported.

- 8.1.3.2 "… initial support must be installed … immediately … and must provide full coverage to the rock surface." Initial support cannot be installed immediately when using a main beam TBM. This apparently is also written for a TBM with a full circle shield.

The statement that stress induced spalling *will* occur at the sidewalls within ½ hour of excavation, in addition to the statement that invert heave is expected, could have led the Contractor to accept steel sets as the predominant support method within the QF, considering this to be the only method to effectively support both the sidewall spalling and invert heave.

There are also potentially misleading portions in Section 7.4.1.2 of the GBR "Observed Performance of the Trial Enlargement", such as:

- (a) "numerous incidences of …sidewall spalling developed." Sidewall spalling in the Trial Enlargement probably occurred because it was excavated in four levels. Sidewall spalling would not be expected in a circular tunnel, excavated with a TBM in rock expected to fail due to high horizontal overstress. Sidewall spalling has not occurred in the QF; although some joint controlled and gripper induced fallout has occurred.

- (b) "The depth of crown slabbing (up to 0.5 m) was controlled by the presence of the overlying bedding plane." The fact that rock bolts were promptly installed to support the rock above the bedding plane may have limited the depth of crown slabbing and the degree of loosening of the crown rock. In addition, testimony noted that crown-slabbing observations were minimized because the roadheader operator over-excavated the crown to remove slabbing as it formed. Crown slabbing in the QF to Sta. 2+200 has varied from <0.5 m to 3 m in depth and is expected to continue.

- (c) "…slabbing of rock in the invert, up to 1.4 m in depth, was noted … when the invert was excavated to a horizontal … profile." The wide flat invert was most prone to invert heave in the high horizontal overstress environment; whereas the circular invert of a TBM tunnel might show only minor invert cracking under the same subsurface conditions. Only fracturing and minor slabbing of rock in the invert has occurred.

The Board considers that the Contractor's design, means and methods for support were changed based on the subsurface conditions encountered (4R & 4S) and as a result of serious misunderstandings as to the rock characteristics and behaviour within the QF.

The DRB believes that during preparation of the GBR, the Owner, the OR, the Contractor and the Designer did not realize these misunderstandings. Further, the DRB believes that these misunderstandings led to misinterpretations that resulted in the current dispute over the subsurface conditions that were anticipated in the QF and delineated in the GBR. Since both Parties worked together to develop the GBR, the consequences of the resulting misunderstandings should be shared between the Parties.

As noted previously, the DBA states "the GBR shall serve as the only basis for determining changes in or differing geotechnical subsurface conditions". However, the GBR states under Rock Support Requirements (Section 8.1.3.7) that "the in-situ Rock Condition shall be determined based on the **closest match** to the Rock Characteristics within each Rock Condition defined below" (in the Rock

Conditions and Rock Characteristics Table). With this provision, there is no possibility of a DSC because no matter how different the actual conditions may be from the assumed or anticipated conditions described in the GBR, there will always be a "closest match".

Similarly, the Type 6 Rock Condition defines the Rock Characteristics as, among other things, "all other conditions requiring greater support than under Conditions 4Q and 5". Again, use of the provision "**all other conditions**" eliminates the possibility of a DSC since this wording would cover all other possibilities not assumed or anticipated in the GBR.

Therefore, the Board concludes that the language used in the GBR may have been misleading to one or both Parties. More importantly, the provisions "closest match" and "all other conditions" used in the GBR would make the DSC clause in the contract essentially meaningless, contrary to the intent of both Parties and contrary to case law disallowing exculpatory language.

Since both Parties jointly developed the GBR, any misunderstanding or inappropriate wording should, in the Board's opinion, be the shared responsibility of both Parties.

3.6 Excessive Overbreak

During hearing testimony, the Contractor explained that it anticipated only ~15,000 m^3 of overbreak using its anticipated means and methods in the QF (27% steel channels bolted against the rock surface in the crown of the QF and 73% steel sets for immediate support within the QF, followed by shotcrete installed over the entire perimeter to resist long term loads associated with swelling and further squeeze). The OR, on the other hand, indicated that it had estimated ~ 45,000 m^3 of total overbreak (3 times as much as the Contractor) even though the OR maintains it anticipated full round steel sets on closely spaced centers and installed under or immediately behind the TBM shield (retaining any loose rock behind the wire mesh) throughout most of the QF portion of the tunnel excavation. This is the exact opposite of what the Board would have expected for the two support methods and when the DRB queried the Parties for an explanation of this apparent inconsistency, there was no logical explanation forthcoming. Nonetheless, the GBR set the total overbreak quantity at 30,000 m^3, the average of the two estimates. This leads the DRB to believe there was a serious misunderstanding between the Parties with respect to overbreak.

As discussed in the foregoing sections of this report, the Board considers that the large overbreak quantities in the QF are the result of the means and methods being employed by the Contractor. Normally steel set support retains the loose rock and would lead to less overbreak. The Board, however, also considers that the support methods being used are appropriate for the ground being encountered, considering the type of TBM being used, the Designer's concern over possible voids left outside the initial liner, and the potential impact of such voids on the construction and long term performance of the final liner.

The Owner's Mandatory Requirements require that the Contractor design and construct a final liner that will perform without significant repair for an extraordinarily long 90-year service life and the Board understands this was an important factor in the Owner's award of the contract to Strabag. The Contractor's design requires that no voids remain outside the initial liner and the Designer stated on its rock support drawings contained in the Contractor's proposal: "loose rock to be removed". The decision as to what means and methods satisfactorily ensure that no voids remain outside the initial liner must lie with the Contractor.

Based on the GBR provisions "closest match" and "all other conditions requiring greater support" that would invalidate the concept of a DSC, as discussed previously, the DRB would conclude that the GBR is defective. In addition to being defective, the DRB concludes that the GBR was misleading based on imprecise terms used in the document and the exclusion of "rock pressure generally exceeding rock mass strength" in the rock characteristics for rock condition 4Q in the QF. In combination, these led the Contractor to a reasonable but incorrect interpretation of anticipated subsurface conditions within the QF at the time the DBA was signed. Thus the DRB concludes that, were it not for the defective GBR, a DSC with respect to excessive overbreak would exist.

Whether the GBR was defective or simply misleading, both Parties developed the GBR jointly and therefore both Parties must share in the consequences in resolving the issue.

Further, the large overbreak quantity encountered throughout much of the QF mined to date has impacted the rate of advance of the TBM and it appears that the total quantity of overbreak will exceed the GBR quantity by a significant amount. Although the DBA indicates that if DSCs are encountered, the resolution of such claims should be held in abeyance until tunnel excavation is complete, the DRB believes that the consequences of the misunderstandings that have led to both the large overbreak quantities and the related impacts have been so material that some form of resolution is needed at this time in the best interests of the project.

3.7 Inadequate Table of Rock Conditions and Rock Characteristics

The Table of Rock Conditions and Rock Characteristics included on page 37 of Appendix 5.4 – Geotechnical Baseline Report is the Table referred to in Section 8.1.3 of the GBR that states, "The in situ Rock Condition shall be determined based on the closest match to the Rock Characteristics within each Rock Condition defined below." Some of the Rock Characteristics referred to in this Table are rock behaviors that are dependent on both the subsurface conditions and the means and methods for supporting the rock. As the DRB understands it, this Table was developed jointly by both Parties in an effort to identify the type of support that was anticipated over estimated lengths of the bored tunnel. Further, the Rock Condition on this Table is, in fact, the specific rock support type (4Q, 5 or 6 in the QF) that was anticipated for the "closest match" to the Rock Characteristics given. Type 6 includes a "catch all" phrase of "all other conditions requiring greater support than under Conditions 4Q and 5" that would imply that all DSCs would be included under Rock Condition 6.

Review of the Table indicates several unworkable Rock Characteristics. For instance, each of the Rock Conditions in the QF referred to "continuous overbreak due to any of: sidewall spalling and invert heave", yet neither of these conditions were particularly noticeable in the tunnel. Type 4Q is different from Types 5 and 6 in that it omits "continuous overbreak due to slabbing" which occurs throughout the QF. "Continuous overbreak due to discontinuities" was listed for the Formations above the QF but not included in the QF Rock Characteristics, yet overbreak in the QF was often a combination of stress induced fractures and existing discontinuities.

The Rock Characteristics for each of the Rock Conditions within the QF refers to the "crown being more than 3 m of bedding plane"(4Q) or "within 3 m of bedding plane" (5 or 6). DRB observations in the tunnel suggest regular sub horizontal bedding planes in the QF were commonly on fairly close spacing (<0.5 m) and were readily apparent in the crown and upper haunches of the tunnel, especially in overbreak areas. The influence of such bedding planes on overbreak was particularly apparent to the DRB when fairly large portions of the crown were pushed up several inches by the hydraulic drills when installing steel channels and rock bolts, even though such loosening was not visually apparent from the L1 area.

The only different Rock Characteristics between Rock Condition 5 and 6 were the addition to type 6 of "closely broken shear and thrust zones" and the catch all "all other conditions requiring greater support than under Conditions 4Q and 5". This explains why all of the QF encountered in the claimed length of the tunnel has been classified by the Owner as Rock Condition 5.

The Contractor refused to record the conditions encountered in the QF in accordance with this Table, even though the DBA (Section 5.5(c)(1) instructed him to do so. The DRB suspects this was because the Rock Characteristics described in this Table were inadequate to define the rock in a manner that would enable identification of a DSC, i.e. mapping in accordance with the Table would force the Contractor into classifying the rock as one of the 3 rock types listed for the QF.

The DRB agrees that the Table of Rock Conditions and Rock Characteristics is inadequate to be used for the identification of DSCs and, further, that the inclusion of such terms as the "closest match" and "all other conditions" essentially renders the concept of DSCs meaningless and makes the GBR defective. Other contract language has been used in the U.S. in Design-Bid-Build contracts in an effort to avoid DSC claims. Such disclaimer language is contrary to case law and has consistently been thrown out by the U.S. courts. In this DB contract, both Parties jointly developed the GBR document and both Parties should share the shortcomings of the resulting documents.

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 Large Block Failures

There is no DSC. The actual conditions were adequately described in the GBR.

4.2 St. Davids Gorge

Given the provision of the DBA Section 5.5 (e), the Contractor has no claim for any DSC in this 800m long section of QF.

4.3 Insufficient Stand-Up Time

There is no DSC based on insufficient stand-up time, as the Contractor's reported reliance on RMR values stated in the GBR was inappropriate.

4.4 Excessive Overbreak

There is a DSC with respect to the excessive overbreak, provided the defective provisions of the GBR are overlooked, because the GBR contained potentially misleading statements that make the Contractor's position reasonable. Any substantial changes in the designs, means and methods of the support (i.e. Type 4S) were the result of DSCs encountered and not vice versa. Since the development of the GBR was the mutual responsibility of both Parties, we recommend that the Parties negotiate a reasonable resolution based on a fair and equitable sharing of the cost and time impacts resulting from the overbreak conditions that have been encountered and the support measures that have been employed. Both Parties must accept responsibility for some portion of the additional cost, but at the same time the Contractor must have adequate incentives to complete the Work as soon as possible.

4.5 Inadequate Table of Rock Conditions and Rock Characteristics

The Table of Rock Conditions and Rock Characteristics is inadequate to define the subsurface conditions that were encountered. More importantly, the classification of support types based on the "closest match" to rock conditions and rock characteristics given in this Table, together with rock characteristics defined as "all other conditions", renders the concept of DSCs essentially meaningless and the GBR defective. The DRB recommends that the Parties jointly revise the Table of Rock Conditions and Rock Characteristics in such a manner that it describes the rock characteristics to be assumed in terms that are mappable (or otherwise quantifiable) so that it can serve as a clear basis for defining DSCs throughout the remainder of the tunnel excavation. The DRB also recommends that the terms "closest match" and "all other conditions" be removed from the GBR.

This report and the Conclusions and Recommendations presented herein reflect the unanimous views of the Dispute Review Board.

Additional Comment:

The DRB members have rarely experienced such an excellent, cooperative atmosphere between the Parties on a tunnel project. This is especially impressive considering the pioneering nature of the Work and the problems and issues encountered. The Board is confident that the Parties can negotiate an amendment(s) to the DBA that, while not commercially optimum for either Party, will allow the Project to proceed to optimum completion.

Respectfully submitted,

Date: 8/30/08

Peter M. Douglass

Peter M. Douglass, DRB Chair

Date: 8/30/08

Dennis McCarry

Dennis McCarry, DRB Member

Date: 8-30-08

P.E. Sperry

P.E. Sperry, DRB Member

Appendix A – Project Charter

ONTARIO POWER GENERATION

File No. NAW130-00120 T5

PROJECT CHARTER

Project ID – EXEC0007	Revision 01	December 23, 2005

Project Name & Location

Niagara Tunnel Project (the **Project**), Niagara Falls, Ontario

Need & Justification

The Ontario Government, OPG's sole shareholder, has endorsed this Project as being consistent with its objective of promoting the development of cost competitive, environmentally friendly sources of electricity generation. The planned tunnel will facilitate greater utilization of available Niagara River water in the existing Sir Adam Beck (SAB) generating facilities, increasing the average annual energy output by about 1.6 TWh. At an estimated Levelized Unit Energy Cost (LUEC) of approximately 4.8 cents/kWh (2005$), this Project provides a competitive alternative for supplying future needs of the Province.

Objectives

To divert an additional 500 cubic metres per second of water from the upper Niagara River to the SAB complex at Queenston, in a safe, economic and timely manner. This will be done, to the extent practical and possible, in a manner that reflects and meets the requirements of the primary stakeholders. Specifically, the project objectives are to:

- Maintain a safe working environment.
- Execute the Project on schedule and within budget.
- Meet all environmental and mitigation requirements.
- Achieve high quality of design and construction, meeting performance requirements.
- Minimize impacts on the ongoing operation of the Sir Adam Beck complex.
- Maintain a good working relationship with stakeholders, contractors and the affected public.

The Province of Ontario and OPG consider delivery of this project to be a top priority.

Scope and Deliverables

The Project includes the planning, design, construction, commissioning and placing into service of a 10.4 km long diversion tunnel with a nominal 12.7 m internal diameter, including all associated facilities and enabling work.

The Project will be executed in two phases as follows:

Phase 1 (June 2004 to August 2005 – Completed)
This phase included project activation, project planning, conceptual design, permitting / approvals submissions, and procurement of a design / build tunnel contract. The planning and design of enabling work such as road improvements and power hookups was also part of this phase.

PROJECT CHARTER		
Project ID – EXEC0007	**Revision 01**	**December 23, 2005**

Key Deliverables included engagement of the Owner's Representative (OR), contractor pre-qualification, contractor selection, executed design-build contract, applicable permits / approvals and third party agreements, designs for enabling work, a Release Quality Estimate (RQE) and a Business Case for Project approval by OPG's Board of Directors.

Phase 2 (September 2005 to September 2010)
This phase includes obtaining applicable permits / approvals, detail design, construction, testing and commissioning of the diversion tunnel, and construction and installation of enabling works. Key Deliverables include permits / approvals, detailed design and construction of the diversion tunnel and associated facilities, diversion tunnel commissioning, placing into service and performance testing, and a Project close out report.

The scope of the Project is more fully described in the Project Execution Plan (PEP).

Customer(s)

OPG's Niagara Plant Group

Key Stakeholders

Province of Ontario (OPG's sole shareholder)
Regional Municipality of Niagara
City of Niagara Falls
Town of Niagara-on-the-Lake
Ontario Ministry of the Environment
Ontario Ministry of Natural Resources
Ontario Ministry of Finance
Niagara Parks Commission
Niagara Peninsula Conservation Authority
Fisheries and Oceans Canada (DFO)
International Niagara Board of Control

Major Milestones

The current project schedule is as follows:

Start Phase 1	June 2004	Actual
OPG Board Approval	July 2005	Actual
Award Design / Build Contract	August 2005	Actual
Phase 1 Completion	August 2005	Actual
Start Construction	September 2005	Actual
In-Service Date	October 2009	
Phase 2 Completion (includes Contingency)	September 2010	

Budget
A budget of $985 million was approved by the OPG Board of Directors on July 28, 2005 conditional on approval of financing for the Project by the Government of Ontario which was obtained on August 17, 2005. The approved budget includes funding for OPG's obligations under the Niagara Exchange Agreement (to secure water rights for the tunnel and facilitate reversion of the Ontario Power GS and Toronto Power GS buildings to the Niagara Parks Commission) valued at $32.4 million. This work is addressed under a separate Charter and a separate Project Execution Plan.

Constraints & Limitations
The Government of Ontario, through the Ministry of Energy, indicated a strong desire for the Niagara Tunnel to be completed in the shortest possible time. The selected design / build contracting approach provides the best means to achieve this objective. The work must be performed in compliance with the Environmental Assessment (EA) approval conditions.

Project Execution and Management
The Project will be substantially undertaken by a design / build contractor, with oversight provided by OPG staff and Owner's Representative staff. Specialist contractors and consultants may also be engaged on an as needed basis. The Project Director will ensure that a detailed Project Execution Plan (PEP) for acceptance by members of the project team and approval by the Project Sponsor. The PEP will include a description of the Project organization and associated roles and responsibilities. It will also include a reporting plan, describing the proposed flow of information and documentation to the Project Sponsor and ultimately to OPG's Board of Directors. All significant proposed changes to project configuration (including scope, budget, timeline and quality) must be submitted to the project Change Control Board for evaluation before submission to OPG's senior management.

Authority of Project Director
This document authorizes the Project Director to undertake the Project, reasonably utilizing OPG resources and third party resources as appropriate. More specifically, the Project Director is authorized to: o Approve project in-scope expenditures up to approved Project funds ($985M), in collaboration with OPG's management and in accordance with OPG's Organizational Authority Register. o Directly request assistance from OPG functional departments, as necessary. o Retain contractors and consultants, as required. o Commit OPG, in discussions / negotiations with regulatory agencies and other stakeholders with respect to satisfying conditions of the EA Approval.

Signatures		
Project Director (R. Everdell) R Everdell		Date 08 Feb 2006
Niagara Plant Group Manager (D. Heath) David Heath		Date: 08 Feb 2006
Project Sponsor (E. Elsayed) Emad Elsayed		Date: Feb 9, 2006

SEC Interrogatory #044

Ref: D1/2/p.138

Issue Number: 4.5
Issue: Are the proposed test period in-service additions for the Niagara Tunnel Project appropriate?

Interrogatory

Did OPG not undertake any other geotechnical investigations after 1993?

Response

OPG did not undertake any geotechnical investigations for the Niagara Tunnel Project after 1993.

AMPCO Interrogatory #016

Ref: Exhibit D1, tab 2, Schedule 1 Niagara Tunnel Project (NTP)

Issue Number: 4.4
Issue: Do the costs associated with the Niagara Tunnel Project that are subject to section 6(2)4 of O. Reg. 53/05 and proposed for recovery, meet the requirements of that section?

Interrogatory

a) Pages 24 – OPG indicates the five proponents were invited to present their views in a 2004 meeting with OPG on the Geotechnical Baseline Report (GBR) provided. Please summarize Strabag AG's comments or concerns related to the GBR and how they were considered by OPG.

b) Page 25 – OPG indicates that in Ed. Zublin AG's view, building such a large tunnel would be a significant challenge. Please identify any challenges identified by Ed. Zublin AG related to the subsurface conditions and how they were considered by OPG.

c) Page 28 – OPG estimated a $96 M cost contingency and 36 week schedule contingency for the tunnel portion of Strabag !G's proposal to achieve a 90 per cent probability that the project would remain within budget and schedule. Please discuss how OPGs contingencies for the tunnel portion of the other four proponents differed from Strabag !G's and why.

d) Page 28 – OPG indicates five amendments to the invitation documents were issued in response to issues raised by the proponents. Please indicate if any amendments were related to issues raised regarding the GBR and subsurface conditions.

e) Page 29 -As part of the RFP process proponents were asked to include a response to the GBR. The RFP score for the response to the GBR was 45 points which represented 9% of the RFP evaluation. Please summarize Strabag AG's response to the GBR.

f) Page 45 – OPG indicates the subsurface risks were investigated and analyzed by Acres and Hatch. Please provide this analysis.

g) Page 113 –Chart 6 Cost Changes between the DBA and the ADBA – The Chart shows a variance of $614.8 M. i) Please provide the percentage of the variance that is associated with the cost overrun due to the adverse subsurface condition issue. ii) Please add a column to the Chart that shows a breakdown of the costs associated with the adverse subsurface condition issue.

h) Page 129 – OPG concludes that the entire amount of project costs should be recovered by ratepayers. Please discuss if OPG considered any cost sharing arrangements regarding the

$614.8 M in additional costs compared to the original budget as shown in Chart 6 on Page 113.

Response

a) During the November 2004 meeting, Strabag AG identified that they had no major comments with the draft GBR. There was discussion about the need for more information. OPG identified its intent to complete the GBR for the contract. For the RFP process, OPG also made available additional information in the form of the Geotechnical Data Report ("GDR") to proponents in the data room.

b) Ed. Zublin AG did not raise specific concerns with subsurface conditions, but did express concern about the TBM size, tunnelling logistics and tunnelling schedule.

c) OPG did not specifically assess contingencies for proponents other than Strabag. OPG's quantitative risk assessment process was conducted in two stages. The initial risk assessment (conducted by consultant URS – Ex. D1-2-1, Attachment 3) was performed concurrently with the RFP process and was based on the reference tunnel concept included in the RFP. This was followed by a specific risk assessment based on Strabag's proposal, which was performed after Strabag had been identified as the preferred proponent (Ex. D1-2-1, Attachment 4).

d) Amendments 3 and 4 to the invitation documents, included changes to the GBR that were related to questions raised by proponents. Specifically, in response to a proponent question that asked "What is the bottom elevation of [the] St. David Gorge at the centerline of the tunnel alignment?", the following was added to the GBR in Amendment 3:
    a. Figure 4.3 *"Buried St. David's Gorge – Baseline Elevations for Bottom of Gorge*".
    b. Section 4.4.4.3 *"Bedrock at St. Davids Gorge*" to describe Figure 4.3 and to provide a more detailed explanation about the elevations.

   Amendment 4 modified section 8.1.2.1 of the GBR to remove the requirement for a shielded tunnel boring machine for the tunnel excavation in response to the following proponent question: "Chapter 9.1 of the Owner's Mandatory Requirements calls for a shielded Tunnel Boring Machine suitable for safely excavating the ground conditions as described in the GBR. It is our understanding that an open type TBM equipped with roof support shield, finger shield and side support shields can equally or better meet the requirements. Please confirm."

e) Strabag's response, GBR-B (ILF Consulting Engineers document dated May 2, 2005), is attached (Attachment 1).

f) Beginning in 1988, Ontario Hydro (now OPG) engaged Acres (now Hatch) to provide engineering services that included geotechnical investigations and analysis as outlined in Ex. D1-2-1 Appendix B – Summary of Geological Investigations and in Ex. F5-6-1 Niagara Diversion Tunnel Report prepared by Roger Ilsley. Based on these geotechnical investigations and analysis, Hatch (formerly Acres) prepared the Geotechnical Baseline Report ("GBR") included in the Design Build Agreement (Ex. D1-2-1 Attachment 6). The GBR captures the results of the extensive geotechnical investigations and analysis to detail the subsurface conditions expected to be encountered during design and construction of the Niagara Tunnel.

g) OPG considers that 100% of the variance relative to the originally approved budget of $985.2M is due to the more adverse subsurface conditions experienced during the tunnel construction. This includes direct increases in tunnel contract costs and additional time related costs in categories such as interest during construction, OPG Project Management and Owner's Representative costs.

Project Cost Flow Estimate ($M) **(including Contingency)**	**Original Approval (DBA)**	**Revised Estimate (ADBA)**	**Estimated Capital Cost at Completion** [1]	**Costs Associated with Adverse Subsurface Conditions**
OPG Project Management	4.4	6.0	5.0	0.6
Owner's Representative	25.4	40.4	36.2	10.8
Other Consultants	4.0	5.9	6.5	2.5
Environmental / Compensation	12.0	9.6	8.7	(3.3)
Tunnel Contract (including Incentives)	723.6	1,181.7	1,112.9	389.3
Other Contracts / Costs	78.9	69.8	68.4	(10.5)
Interest	136.8	286.6	234.5	97.7
Total Project Capital	985.2	1,600.0	1,472.0	486.8

Notes: 1) Estimated Capital Cost at Completion as noted in response to Board Staff Interrogatory #28.
2) Numbers may not calculate due to rounding.

h) OPG did not consider any cost sharing arrangements for the costs above the $985.2 M approved by OPG's Board of Directors prior to OEB regulation. As fully documented in the evidence, the amount OPG spent on the NTP represents the true cost of completing the project given the subsurface conditions actually encountered. OPG acted prudently in planning and executing this project and in addressing the differing subsurface conditions encountered. Since any cost sharing arrangements would amount to a disallowance of prudently incurred costs, OPG did not consider them.

Board Staff Interrogatory #021

Ref: Exh D1-1-2 page 13, Exh D1-2-1 page 2, Attachment 8B and EB-2007-0905/Exh D1-1-2 Attachment A Appendix C page 3

Issue Number: 4.4
Issue: Do the costs associated with the Niagara Tunnel Project that are subject to section 6(2)4 of O. Reg. 53/05 and proposed for recovery, meet the requirements of that section?

Interrogatory

OPG indicates that it placed $1,474.2M in service in 2013 for the NTP. OPG also states that O. Reg. 53/05, section 6(2)4 requires the Board to ensure that OPG recovers the capital and non-capital costs of the NTP approved by the OPG Board of Directors prior to the first payment amounts order and to determine the prudence of any expenditures beyond the OPG Board approved amount.

In the Recommendation for Submission to the Board of Directors, dated May 21, 2009, OPG states:

> Once in-service, the NTP will form part of OPG's regulated rate base. Under O.Reg 53/05 the OEB is required to ensure that OPG recovers the original project budget of $985M approved by OPG's Board and this amount will not be subject to a prudence review by the OEB. However, the incremental project costs above the original approval will be subject to a prudence test. Under the OEB's prudence test, OPG's actions are assumed to be prudent unless challenged on reasonable grounds. In assessing prudence, the OEB will consider what information was known or should have been known at the time key decisions were made and what third-party expert advice was sought to assist in decision making. Hindsight is not to be used in determining prudence. Given the extensive volume of studies conducted prior to project execution and the nature of independent advice sought throughout the process (leading international consultants, academia, Dispute Review Board, Contract Oversight Committee, etc.), OPG is well positioned to make the case that the entire capital cost should be recoverable. OPG will, of course, have to demonstrate ongoing diligence in project execution as part of its case for recoverability. However, given the significant cost over-runs associated with the project, the OEB will be likely to review the matter in detail and therefore regulatory risk remains.

In the original Full Release Business Case Summary ("BCS"), dated July 28, 2005, filed in the 2008-09 Payments Amounts proceeding, at page 3 OPG indicated that "Under Ontario Regulation 53/05, effective April 1, 2005, the Project will become part of OPG's regulated hydroelectric assets and OPG will be given a fair opportunity to recover prudently incurred costs through regulated rates."

a) Of the total NTP related costs that have been or are proposed to be recovered from ratepayers, please confirm whether $985M is the amount that OPG considers as "OPG Board of Directors approved". What is the exact amount that OPG views as in excess of the OPG Board approved amount?

b) Appendix C of the BCS, dated July 28, 2005, provides a project risk profile for the NTP. Mitigating activity is identified regarding the risk that the contractor may encounter subsurface conditions that are more adverse than described in the Geotechnical Baseline Report ("GBR"). Mitigating activities include "The GBR is based on extensive field investigations carried out over a 10-year period and knowledge gained through the construction of the SAB2 tunnels." and "The 3-stage GBR process used facilitates contractor input and concurrence before construction begins".
   i. Are the SAB2 tunnels at the same depth as the NTP?
   ii. To what extent, as compared to the planned route for the NTP, do the SAB2 tunnels travel through the same Queenston shale environment?

c) Please compare and contrast the excavation or boring technique used for SAB2 with that used in the NTP. Is it the case that the only risk mentioned in Appendix C of the BCS regarding Queenston shale, the host rock formation for the majority of the tunnel, is its swelling properties when exposed to fresh water? At the time the Business Case was prepared was OPG aware of any other geotechnical risks that could be associated with Queenston shale?

d) In OPG's view how successful were the aforementioned mitigating activities in reducing, if not eliminating the noted risk?

e) To what extent would the costs in excess of $985M be greater had the mitigating activities not taken place?

Response

a) The original budget of $985.2M was approved by the OPG Board of Directors ("OPG Board") prior to the OEB's first order with respect to payment amounts for OPG's prescribed facilities under Section 78.1 of the Ontario Energy Board Act (see Ex. D1-2-1, page 2, and Ex. D1-2-1, Attachment 5, BCS July 28, 2005). This is the amount that OPG considers to be the "OPG Board of Directors approved" for purposes of section 6.(2)4. of O. Reg. 53/05. The OPG Board subsequently approved a revised budget of $1,600M (see Ex. D1-2-1, page 115, and Ex. D1-2-1, Attachment 8a, Superseding BCS May 21, 2009). The actual project cost is currently estimated at $1,476.6M which is $491.4M over the original OPG Board approval but $123.4M below the superseding OPG Board approval.

b) I) No, the SAB2 tunnels are not as deep as the NTP.
   ii) No portion of the SAB2 tunnels is in the Queenston shale formation.

c) A tunnel boring machine ("TBM") was not used for the SAB2 tunnels. Instead, the 15.55m diameter SAB2 tunnels were blasted through the rock in two stages. First, the top 9.0m was excavated and supported with steel ribs. Second, the bottom 6.55m was excavated. For additional information please see the response to Ex. L-6.12-1 Staff IR-160 c). The NTP was excavated by a 14.44m diameter TBM with steel ribs, rock bolts and shotcrete installed behind the TBM cutterhead to support the tunnel crown.

In addition to swelling properties, OPG was aware of several potential geotechnical risks associated with the Queenston shale formation such as potential rock squeeze, slabbing and block failures and these were documented in the Risk Assessment (see Ex. D-1-2-1, Attachment 1) and the Design Build Agreement which includes the Geotechnical Baseline Report (see Ex. D-1-2-1, Attachment 6, Appendix 5).

d) Despite the mitigating measures (Design Build Agreement, Geotechnical Baseline Report, Dispute Resolution Board, liquidated damages, etc.) the subsurface conditions encountered proved to be more adverse than anticipated in terms of cost and schedule impacts.

e) OPG cannot quantify the cost impact if the mitigating activities had not taken place.

Board Staff Interrogatory #022

Ref: Exh F5-6-1 and Exh D1-2-1

Issue Number: 4.4
Issue: Do the costs associated with the Niagara Tunnel Project that are subject to section 6(2)4 of O. Reg. 53/05 and proposed for recovery, meet the requirements of that section?

Interrogatory

In the Executive Summary of the Niagara Diversion Tunnel Report (the "Report"), dated September 9, 2013, the author, Roger Ilsley notes that he was requested by "Tory's [sic] to review all pertinent geotechnical investigations conducted and reports prepared for the design and construction of the 14.4m excavated diameter, approximately 10.4 Km long (as designed vs. 10.2 Km constructed), Niagara Tunnel Diversion." The author indicates that he "…. formed an opinion that these site investigations addressed the appropriate design and construction issues and that the studies undertaken were completed to professional standards and exceeded those standards in some cases."

a) Please provide a copy of the Terms of Reference or equivalent between OPG and Roger Ilsley that engaged Roger Ilsley to prepare the Report.

b) Is it correct that the Tunnel Boring Machine ("TBM") which was used to bore/ construct the tunnel was at that time the largest open gripper main beam TBM in the world? In preparing the report did Mr. Ilsley specifically review whether the geotechnical investigations conducted by OPG were appropriate for the boring technology actually utilized?

c) The Report summarizes the recommendations made by the Dispute Resolution Board ("DRB"). With respect to the issue of Excessive Overbreak, the Report states that, "Although the Design Build Agreement indicated that if Differing Surface Conditions are encountered, the resolution of such claims should be held in abeyance until tunnel excavation was compete, the DRB believed that the consequences of the misunderstandings that had led to both the large overbreak quantities and the related impacts had been so material that some form of resolution was needed."
   i. Please elaborate on the nature of the misunderstandings that consequently led to the large overbreak.
   ii. Please explain why OPG considers it reasonable that OPG's ratepayers bear 100% of the portion of the costs that are in excess of the initial ~$0.9B budget approved by OPG's Board of Directors, which resulted from this misunderstanding between OPG and Strabag.

Response

a) Roger Ilsley was retained by OPG's counsel, Torys. A copy of his retention letter is Attachment 1 to this response.

b) Yes, the Tunnel Boring Machine ("TBM") used on the Niagara Tunnel Project was the largest diameter open gripper main beam TBM in the world. The second part of the question has the logical order reversed. The TBM was selected based on the rock conditions anticipated as a result of the geotechnical research and investigation undertaken prior to the project.

c) i) The quoted portion of the report was referencing the section of the Dispute Resolution Board's report discussing excessive overbreak (pages 16-17). This section reads as follows:

> **3.6 Excessive Overbreak**
> During hearing testimony, the Contractor explained that it anticipated only - 15,000 m^3 of overbreak using its anticipated means and methods in the QF (27% steel channels bolted against the rock surface in the crown of the QF and 73% steel sets for immediate support within the QF, followed by shotcrete installed over the entire perimeter to resist long term loads associated with swelling and further squeeze). The OR, on the other hand, indicated that it had estimated - 45,000 m^3 of total overbreak (3 times as much as the Contractor) even though the OR maintains it anticipated full round steel sets on closely spaced centers and installed under or immediately behind the TBM shield (retaining any loose rock behind the wire mesh) throughout most of the QF portion of the tunnel excavation. This is the exact opposite of what the Board would have expected for the two support methods and when the DRB queried the Parties for an explanation of this apparent inconsistency, there was no logical explanation forthcoming. Nonetheless, the GBR set the total overbreak quantity at 30,000 m^3, the average of the two estimates. This leads the DRB to believe there was a serious misunderstanding between the Parties with respect to overbreak.
>
> As discussed in the foregoing sections of this report, the Board considers that the large overbreak quantities in the QF are the result of the means and methods being employed by the Contractor. Normally steel set support retains the loose rock and would lead to less overbreak. The Board, however, also considers that the support methods being used are appropriate for the ground being encountered, considering the type of TBM being used, the Designer's concern over possible voids left outside the initial liner, and the potential impact of such voids on the construction and long term performance of the final liner.
>
> The Owner's Mandatory Requirements require that the Contractor design and construct a final liner that will perform without significant repair for an extraordinarily long 90-year service life and the Board understands this was an important factor in the Owner's award of the contract to Strabag. The

> Contractor's design requires that no voids remain outside the initial liner and the Designer stated on its rock support drawings contained in the Contractor's proposal: "loose rock to be removed". The decision as to what means and methods satisfactorily ensure that no voids remain outside the initial liner must lie with the Contractor.
>
> Based on the GBR provisions "closest match" and "all other conditions requiring greater support" that would invalidate the concept of a DSC, as discussed previously, the DRB would conclude that the GBR is defective. In addition to being defective, the DRB concludes that the GBR was misleading based on imprecise terms used in the document and the exclusion of "rock pressure generally exceeding rock mass strength" in the rock characteristics for rock condition 4Q in the QF. In combination, these led the Contractor to a reasonable but incorrect interpretation of anticipated subsurface conditions within the QF at the time the DBA was signed. Thus the DRB concludes that, were it not for the defective GBR, a DSC with respect to excessive overbreak would exist.
>
> Whether the GBR was defective or simply misleading, both Parties developed the GBR jointly and therefore both Parties must share in the consequences in resolving the issue.
>
> Further, the large overbreak quantity encountered throughout much of the QF mined to date has impacted the rate of advance of the TBM and it appears that the total quantity of overbreak will exceed the GBR quantity by a significant amount. Although the DBA indicates that if DSCs are encountered, the resolution of such claims should be held in abeyance until tunnel excavation is complete, the DRB believes that the consequences of the misunderstandings that have led to both the large overbreak quantities and the related impacts have been so material that some form of resolution is needed at this time in the best interests of the project.

As the quoted section makes clear, the misunderstanding concerned interpretation of how the rock in the Queenston Formation would behave during excavation of the tunnel. The actual rock behavior during tunneling caused Strabag to adjust the rock support methods employed in order to ensure that no voids remained behind the initial liner so that the tunnel could meet the required 90-year design life. The rock characteristics, the rock support methods employed to address them and the need to remove loose rock to ensure long-term performance of the tunnel caused the amount of overbreak experienced to exceed the quantity anticipated in the DBA.

c) ii) The costs incurred beyond the project's initial OPG Board of Directors approved budget of $985.2M did not result from any misunderstanding between Strabag and OPG. Rather, they were the direct result of subsurface conditions that differed from those anticipated based on the geotechnical studies and investigations undertaken, including an exploratory adit. These geotechnical investigations are summarized in Ex. D1-2-1, Appendix B (pages 136-140).

Both the scope and quality of these investigations were reasonable and appropriate for a project of this magnitude.

ONTARIOPOWER GENERATION

BUSINESS CASE SUMMARY

Niagara Tunnel Project (EXEC0007)
May 2009 (Confidential)

SUPERSEDING RELEASE FOR NIAGARA TUNNEL PROJECT (EXEC0007)

1. RECOMMENDATION:

Approve the release of $615 M additional funding for design and construction of the Niagara Tunnel Project (the "Project"), bringing the total Project cost estimate to $1,600 M including $985 M previously approved. Based on the amended design / build agreement, the tunnel will be in-service by December 2013, will increase the diversion capacity of the Sir Adam Beck Niagara GS complex by 500 m^3/s and facilitate a 1.6 TWh increase in average annual energy output from the Sir Adam Beck generating stations.

The Niagara Tunnel Project has been delayed due primarily to difficulties encountered by the contractor, Strabag Inc. (Strabag) in excavating the tunnel through the Queenston shale formation. Following an unsuccessful attempt to resolve Strabag's claim for cost and schedule relief, the parties submitted the dispute to the Dispute Review Board (DRB), as provided in the Design Build Agreement between OPG and Strabag. Following receipt of the DRB's recommendations OPG and Strabag have negotiated a settlement to ensure the tunnel is completed both safely and expeditiously.

Total Investment Cost: $1,600 M (including $985 M previously approved)

Year	To 2008	2009	2010	2011	2012	2013	2014	Totals
Project Capital	435	200	275	274	206	216	(6)	1,600
2009 Business Plan	432	173	235	143	2	-	-	985
Variance	3	27	40	131	204	216	(6)	615

Type of Investment: Strategic Projects (OAR - Section 1.3)

Release Type: Superseding

Funding: The financing for the project is arranged through the Ontario Electricity Financial Corporation (OEFC). The amended agreement increasing the facility limit of $1B to $1.6B will be executed following the OEFC's third quarter Board meeting in September 2009.

Investment Financial Measures: The increased energy output resulting from the Project will receive a regulated rate as part of OPG's regulated hydroelectric assets. With a Levelized Unit Energy Cost of under 7 ¢/kWh and an equivalent Power Purchase Agreement price of less than 10 ¢/kWh, the Niagara Tunnel Project continues to remain attractive and economic relative to other generation alternatives. Other project financial metrics and sensitivities are presented in the Financial Analysis section of this BCS.

2. SIGNATURES

Submitted by:

Carlo Crozzoli
Carlo Crozzoli
Vice President
Hydro Development

Recommended By:

John Murphy
Exec. VP
Hydro

Approved By:

D. Hanbidge
Donn Hanbidge
Chief Financial Officer

Approved By:

T. Mitchell
Tom Mitchell
President and CEO

3. BACKGROUND & ISSUES

Background

- On July 28, 2005, OPG's Board of Directors approved the Execution Phase of the Niagara Tunnel Project. The approved budget and in service date were $985 M and June 2010, respectively. This new water diversion tunnel will increase the amount of water flowing to existing turbines at the Sir Adam Beck generating stations in Niagara Falls. This tunnel will allow the Sir Adam Beck generating facilities to utilize available water more effectively and is expected to increase annual generation on average by about 1.6 TWh (14%).

- The decision to proceed with the Execution Phase was taken after comprehensive geological studies, engaging an international tunnelling/mining consulting expert (Hatch Mott MacDonald) as OPG's Owner's Representative (OR), engaging Torys to provide legal oversight and advice, and conducting an international competition to select a Design Build contractor (Strabag).

- Preparation for the new Niagara Tunnel commenced more than 25 years ago, in 1982, when Ontario Hydro (predecessor of OPG) began to study the possible expansion of its hydroelectric facilities on the Niagara River. Detailed engineering, environmental and socioeconomic studies were conducted from 1988 through 1994 with an environmental assessment (EA) submitted in 1991 for the then planned project (two 500 m^3/s water diversion tunnels, a three-unit 900-MW underground generating station and transmission improvements between Niagara Falls and Hamilton). Among the commitments made through the EA process, was to utilize a tunnel boring machine (TBM) to excavate the tunnels from the outlet end, under the buried St. Davids gorge and following the route of the existing SAB2 tunnels through the City of Niagara Falls. The EA received approval from Ontario's Minister of the Environment in 1998, including provisions to begin with construction of one tunnel, the Niagara Tunnel Project.

- Through an international proposal competition, a fixed price Design Build Agreement (DBA) was awarded to Strabag AG on August 18, 2005 and construction commenced in September 2005. The TBM was acquired and assembled within 12 months and it commenced excavation of the tunnel on September 1, 2006.

- Significant challenges excavating and supporting the Queenston shale formation, due to overstressing and insufficient, unsupported stand-up time, resulted in excessive overbreak of rock from the tunnel crown, impeded TBM advance and required significant modifications to the initial support area immediately behind the TBM cutterhead.

- Upon entering the Queenston shale formation in April 2007, Strabag encountered subsurface conditions that resulted in significantly slower than planned progress. Strabag alleged large block failures, insufficient stand-up time and excessive overbreak encountered were not consistent with the conditions described in the DBA. Strabag alleged these claims constituted a Differing Subsurface Condition (DSC), and as a result, it should be entitled to cost and schedule relief.

- Following unsuccessful attempts to resolve the issue, Strabag submitted the claim to the Dispute Review Board (DRB). The DRB is part of the dispute resolution process set out in the DBA and consists of three tunnelling experts who were regularly updated on project progress and issues. The claim was heard over four days in June 2008.

- The DRB issued its non-binding recommendations in August 2008. The DRB ruled that the excessive overbreak encountered during the tunnel drive constituted a Differing Subsurface Condition and recommended that:

  "There is a DSC with respect to excessive overbreak" (and) "both Parties must accept responsibility for some portion of the additional cost, but at the same time the Contractor must have adequate incentives to complete the Work as soon as possible."

- To settle the dispute concerning the alleged differing subsurface conditions in the Queenston shale formation and all other outstanding claims prior to November 30, 2008, OPG and Strabag agreed to convert the fixed price DBA into a target cost DBA with cost and schedule incentives and disincentives, and incorporate changes in the tunnel route to minimize further excavation with the crown in the challenging Queenston shale formation. Negotiated changes to the DBA include a target in-service date of June 15, 2013, target cost of $985 M and a significant shift in the risk profile for completion of the tunnel construction.

Financing

- In 2005, financing for the project was arranged through the OEFC with a facility limit of $1B. Preliminary discussions have taken place with the OEFC regarding an increase in the facility, to $1.6B, as well as a timing extension. However, staff have indicated that given their current priorities it would be difficult to expedite the required "Minister Directive" because OPG's Niagara Tunnel Project spend is currently well below the $1B facility limit. OEFC currently plans to have the final amendment executed after its third quarter Board meeting in September 2009.

Project Execution Strategy

- During October and November 2008, the parties negotiated a non-binding Principles of Agreement that would settle all claims up to November 30, 2008 and move to a Target Cost Contract for the remainder of the project with schedule and cost incentives and disincentives. The key tenets of the Principles of Agreement were as follows:

    - Strabag claimed that it had incurred a loss of $90M up to November 30, 2008. Under the Principles of Agreement, OPG would pay Strabag $40M to settle all claims up to November 30, 2008, leaving Strabag with a loss of approximately $50M.

    - Should the $90M loss not be substantiated, the agreement allows OPG to claw back the $40M on a prorated basis.

    - From December 1, 2008 onwards, Strabag could earn a $20M completion fee plus maximum cost and schedule incentives of $40M. If both Target Cost and Schedule are met, Strabag's loss will be reduced from $50M to $30M. Maximum incentives for early completion and lower cost will result in Strabag making a profit of $10M. If the project is late or cost is exceeded, Strabag will incur a $50M loss.

    - The incentive (bonus / liquidated damages) associated with the Guaranteed Flow Amount[1] (tunnel flow capacity more or less than 500 m^3/s) remains unchanged.

- On November 19, 2008, OPG's Major Projects Committee reviewed the Principles of Agreement and endorsed management's plan to proceed to build upon the Principles of Agreement by negotiating a Term Sheet followed by an Amended Design Build Agreement with Strabag. On February 9, 2009, OPG and Strabag executed a non-binding Term Sheet that further elaborates on the Principles of Agreement.

- Since then, the parties negotiated a Target Schedule of June 15, 2013 and a Target Cost of $985M. Both of these targets were developed on an open book basis with the OR and OPG auditors having access required to verify the reasonableness of key inputs. The Target Schedule is premised on a horizontal realignment that reduces the tunnel length by approximately 200 m, and a vertical realignment to exit the Queenston shale and move to the overlying rock formations where tunnelling conditions are expected to improve.

[1] Guaranteed Flow Amount means the tunnel flow capacity guaranteed by the contractor at the reference hydraulic head and the reference elevation of energy grade line defined in the Design / Build Agreement.

Project Management

- A strong team remains in place for management and execution of the Niagara Tunnel Project and includes:
    - The OPG Project Director empowered to ensure effective integration of internal and external resources and timely communications between the project team and other stakeholders
    - Other OPG personnel representing Niagara Plant Group, Water Resources, Law Division, Supply Chain, Finance, Real Estate, Health & Safety and Risk Services
    - Hatch Mott MacDonald (HMM), an Ontario-based consultant with considerable experience in tunnel design and construction, has been engaged as Owner's Representative and holds primary responsibility for project management, design review and construction oversight with Hatch Energy providing assistance in the areas of geotechnical and hydraulic engineering, environmental agency liaison and third party liaison
    - Torys has been engaged as external legal counsel and has been part of the core project team providing advice on contractual, procedural fairness, environmental, real estate and regulatory matters
    - Strabag (a large Austrian construction group, supported by ILF Beratende Ingenieure of Austria, Morrison Hershfield of Toronto, Dufferin Construction of Oakville, and other speciality subcontractors), the engaged Design / Build Contractor, has extensive international experience in tunnelling and heavy civil underground works.
    - Expert consultants and contractors are engaged, as required, to provide support in areas such as project risk assessment, financial modeling, teambuilding, field investigations, surveying, geotechnical engineering, TBM tunnel construction, construction litigation, ICC arbitration, etc.
- Decision authority for this Project remains with OPG and delegation will be in accordance with OPG's Organization Authority Register (OAR).
- A Project Execution Plan has been developed and issued to provide the framework for management of the Niagara Tunnel Project, and it will be reviewed and revised as necessary during project execution.

4. <u>ALTERNATIVES AND ECONOMIC ANALYSIS</u>

Key Project and Financial Assumptions:

- The Project is estimated to cost $1,600 M, including the previously released funding.
- The sunk cost on the Project to date (to the end of April 2009) is $463 M.
- The Project will receive a 10-year "holiday" for Gross Revenue Charge (GRC) payments.
- The Project will be funded through financing arranged with the OEFC.
- Other Assumptions are listed in Appendix B.

Status Quo – Proceed Under the Existing DBA (Not Recommended)

- Considering the significant schedule delay, contractor claims regarding differing subsurface conditions (primarily in the Queenston shale formation), recommendations of the Dispute Review Board in August 2008 that OPG and Strabag should equitably share the cost and schedule impacts, difficulties experienced in excavating and supporting the Queenston shale, and significant liquidated damages included in the existing DBA, there is a high risk that the contractor would abandon the project, requiring completion of the tunnel by another contractor with higher costs and a significant delay (see Alternative 2), and causing OPG to expend considerable resources on legal proceedings. This alternative is not recommended.

Alternative 1 – Proceed Under a Target Cost Amended DBA (Preferred Alternative)

- Complete design, construction and commissioning of the Niagara Tunnel under an amended DBA that features a target cost / target schedule with cost and schedule incentives and disincentives and incorporates changes in the tunnel alignment to minimize further excavation with the tunnel crown in the Queenston shale formation. This approach settles all of Strabag's outstanding claims to November 30, 2008, establishes a sharing of incremental costs and provides incentives for Strabag to complete the tunnel in a timely manner. The remaining cost for this alternative is $1,137 M and the total cost is $1,600 M. This is considered to be the least cost alternative for completion of the Project and is the recommended alternative. Appendix A provides a more detailed breakdown of the Project costs.

Alternative 2 – Engage another Contractor to Complete the Project (Not Recommended)

- Complete design, construction and commissioning of the Niagara Tunnel by terminating the existing DBA with Strabag and engaging another contractor. This approach would result in a further delay of 18 to 24 months to engage another contractor, unknown higher costs (actual plus mark-up), loss of experience gained to date and key personnel (contractor, designers and subcontractors) and require OPG to expend considerable resources on legal proceedings to recover damages from Strabag. This alternative is not recommended.

Alternative 3 – Cancel the Project (Not Recommended)

- Abandon design, construction and commissioning of the Niagara Tunnel, incurring additional costs in the order of $100 M to secure the site in a safe and environmentally acceptable state, and forego the opportunity to generate additional clean, renewable hydroelectric energy averaging 1.6 TWh per year for at least 90 years at the Sir Adam Beck generating stations. With this alternative, there is a low likelihood of recovering any of the $563 M incurred costs through the regulated rates. This alternative is not recommended.

Financial Analysis

- While the Niagara Tunnel is expected to be part of OPG's regulated hydroelectric assets and receive a regulated rate reflecting cost recovery and a return on capital, it is appropriate to consider several financial metrics, as follows, to ensure that this is an economic investment relative to other generation options:

    - Levelized Unit Energy Cost (LUEC) represents the price required to cover all forecast costs, including a return on capital over the service life, escalates over time at the rate of inflation, and it permits a consistent cost comparison between generation options with different service lives and cost flow characteristics.
    - Equivalent Power Purchase Agreement (PPA) represents the price required if one were to bid the project into the renewable RFP. It is similar to LUEC except only 20% of the PPA escalates at the Consumer Price Index.
    - Revenue Requirement is a measure that represents the annual accounting cost of this project including an allowed return on capital employed. Revenue Requirement generally declines over time as the rate base is depreciated.
    - These metrics are equivalent in present value terms over the life of the asset and reflect full recovery of costs including a return on the investment.

Financial Measure	**Original Approval July 28, 2005 ($985M; June 2010 In-Service)**		**Superseding Release May 21, 2009 ($1.6B; Dec. 2013 In-Service)**	
		in 2009 $		**in 2009 $**
LUEC (¢/kWh)	(2005$) 4.8	5.2	(2009$) 6.8	6.8
PPA (¢/kWh)	(2011$) 6.7	6.7	(2014$) 9.5	9.4
Revenue Requirements (¢/kWh)	(2011$) 5.8	5.6	(2014$) 8.7	7.9
Revenue Requirements Post GRC Holiday (¢/kWh)	(2021$) 9.4	7.4	(2025$) 13.0	9.5

- The proposed Green Energy Act includes a "Feed-In-Tariff" (FIT) for 10 – 50 MW hydroelectric projects of 12.2 ¢/kWh (2009$). This proposed program is comparable to the PPA measure noted in the table above except that the FIT contract is for 40 years instead of 50 years assumed in the PPA calculation.

Financial Analysis – Alt 1	¢/kWh
Revenue Requirement (2014$)	8.7
Revenue Requirement for OPG Baseload Hydroelectric without the Tunnel (2014$)	4.0
Revenue Requirement for OPG Baseload Hydroelectric including the Tunnel (2014$)	4.4

- Completion of the Project will result in a significant increase in average annual energy output from the Sir Adam Beck GS complex with an increase of 0.4 ¢/kWh, from 4.0 to 4.4 ¢/kWh (2014$), in the estimated regulated rate for OPG's hydroelectric assets.

Financial Sensitivity Analysis

- Financial sensitivity analysis of the Project is summarized below and indicates economic results that compare favourably with other future electrical energy supply options in Ontario, including recent submissions for renewable generation options.

Sensitivity Analysis [Dec-2013 In-Service Date]	Project Costs ($B)	Incremental Energy TWh	LUEC ¢/kWh in 2009$	Equivalent PPA Price ¢/kWh in 2014$	Revenue Requirement ¢/kWh in 2014$
Preferred Alternative (total costs)	1.6	1.6	6.8	9.5	8.7
Preferred Alternative – Going Forward Costs(3) only	1.1	1.6	4.3	6.2	n/a
Incremental Impact					
Water Availability					
Lower quartile flow for first 5 years of service(1)		(0.9)	0.7	1.3	n/a
Upper quartile flow for first 5 years of service(1)		0.8	(0.5)	(0.9)	n/a
Overall reduction of 5% in Niagara River Flow(2)		(0.4)	1.1	1.7	n/a
Project Costs					
Higher Capital Costs (+10% going forward costs)	0.1		0.4	0.6	0.5
Project Costs $100 M Higher	0.1		0.4	0.5	0.5
Project Delayed 6 Months	0.09		0.4	0.5	0.5
Interest During Construction Rate +50 Basis Points	0.02		0.0	0.0	0.1
Shorter Service Life (30 year Life)			0.9	0.7	2.2
Elimination of 10 year Holiday on Gross Revenue Charge			0.6	1.5	1.5

(1) Calculated for the first 5 years of service only
(2) Annual flows assumed to be reduced by 5% each year, compared to historical flows for the life of the tunnel
(3) Project costs today of $0.5B are sunk and not included in LUEC or PPA calculation

- Based on the above economic analysis, it is concluded that completing the tunnel as outlined in Alternative 1 is economic when compared with alternative supply options and that the recommended alternative is the lowest cost option for completing the Niagara Tunnel. The sensitivity analysis confirms that this conclusion is robust over a broad range of scenarios.

5. THE PROPOSAL

- Enter into an amended Design / Build Agreement with Strabag Inc to design, construct and commission a new diversion tunnel to convey approximately 500 m^3/s of water from the upper Niagara River to the Sir Adam Beck GS complex at Queenston. The concrete-lined tunnel will be approximately 10 km long and have an average internal diameter of 12.7 m. Flow will exceed the increased diversion capacity only about 15% of the time compared to the current 65%, and resultant incremental average annual energy output from the Sir Adam Beck generating stations is estimated at 1.6 TWh (14%). The project includes a new intake and associated modifications to the existing International Niagara Control Works, an outlet incorporating the emergency closure gate near the existing PGS reservoir, and removal of the PGS canal dewatering structure. The new tunnel will be in-service by December 2013.

- Extend the contract with Hatch Mott MacDonald, supported by Hatch Energy, as Owner's Representative for project management, design review, geotechnical and hydraulic engineering, environmental agency liaison, third party liaison and construction oversight.

- Remedial work has been completed at the retired Ontario Power and Toronto Power generating stations related to the reversion of these stations to the Niagara Parks Commission (NPC) to secure agreement that the NPC will grant water rights to no party other than OPG.

- The estimated project cost of $1,600 M includes a negotiated target price for completion of the Niagara Tunnel by Strabag, agreed payments under the Community Impact Agreement, agreed compensation paid for Welland River issues, actual costs incurred with respect to the Niagara Exchange Agreement (OP, TP and future water rights), Owner's Representative costs, and OPG direct costs, and an overall contingency of approximately $164 M (17% of remaining pre-contingency costs) to address remaining project risks.

- The target Substantial Completion (In-Service) Date negotiated with Strabag is June 15, 2013, however a schedule contingency of approximately 6.5 months is added to address potential schedule extension due to residual OPG risks. This contingency brings the expected completion date to December 2013.

- The target cost approach recommended for completion of the Niagara Tunnel changes the project risk profile from that included in the current release. OPG has retained risks associated with specific remaining tunnel construction risks (TBM main bearing failure, significant damage to the tunnel conveyor, unexpected subsurface geological conditions, etc) and with specific baselined target cost parameters (extent of overbreak in the tunnel crown, escalation, diesel fuel prices, etc). Accordingly, cost and schedule contingencies have been included in this superseding release, as described above.

- The estimated project cost flow is as follows.

Project Cost Flow Estimate ($M) (including Contingency)	To 2008	2009	2010	2011	2012	2013	2014	Totals
OPG Project Management	2.5	0.6	0.7	0.7	0.7	0.4	0.4	6.0
Owner's Representative	15.3	5.6	6.4	5.4	4.4	1.9	1.4	40.4
Other Consultants	4.5	0.7	0.3	0.1	.0.1	0.1	0.2	5.9
Environmental / Compensation	8.3	1.1	0.1	0.1	0.1	0.0	0.0	9.6
Tunnel Contract	308.9	162.5	216.6	207.4	128.1	166.4	(8.3)	1,181.7
Other Contracts / Costs	57.6	1.1	8.5	2.5	0.1	0.0	0.0	69.8
Interest	37.6	28.2	42.7	58.3	72.9	47.1	0.0	286.6
Total Project Capital	434.5	199.8	275.3	274.5	206.4	215.9	(6.4)	1,600.0

Note: Cost flow in 2014 includes ($20 M) maximum cost and schedule disincentive triggered by exceedence of Target Cost and/or Target Schedule.

Explanation of Schedule Variances

Project Schedule (including Contingency)	Current Approval	Revised Estimate	Variance
Start Project Execution	September 2005	September 2005	-
In-Service Date	June 2010	December 2013	42 months
Project Duration	57 months	99 months	42 months

- The primary activities to complete the project, along with their planned duration and daily progress rates are as follows.

Activity	Start Date	End Date	Duration (days)	Avg Rate (m/day)
Award DBA	18-Aug-05	18-Aug-05	0	n/a
TBM Supply & Assembly	01-Sep-05	01-Sep-06	365	n/a
TBM to 3,619m	01-Sep-06	02-Mar-09	913	4.0
TBM - 3,619m to Intake	03-Mar-09	28-Apr-11	786	8.4
Invert Concrete	15-Dec-08	20-Jan-12	1,131	9.0
Overbreak Infill	01-Sep-09	08-Apr-12	950	10.7
Arch Concrete	11-Mar-10	11-Oct-12	945	10.8
Liner Contact Grouting	11-May-11	12-Dec-12	581	17.6
Liner Pre-Stress Grouting	01-Feb-12	24-Mar-13	417	24.5
Complete Intake Structure	28-Dec-09	28-Dec-10	365	n/a
Complete Outlet Structure	01-Jan-11	30-Jul-11	210	n/a
Install Intake Gates	23-Feb-13	28-Feb-13	5	n/a
Install Outlet Gates	01-Jul-12	19-Sep-12	80	n/a
Fill Outlet Canal & Tunnel	26-Mar-13	31-Mar-13	5	n/a
Remove Intake Cofferdam	01-Mar-13	14-Jun-13	105	n/a
Remove Outlet Rock Plug	01-Apr-13	14-Jun-13	74	n/a
Tunnel In-Service Date	15-Jun-13	15-Jun-13	0	n/a

Note: The Target Schedule was based on actual progress to March 2, 2009 (3,619 m).

- Based on Strabag's baseline schedule, the average TBM advance rate was expected to be 14.55 m per day over 715 days with TBM hole-through expected in August 2008. The TBM commenced boring the tunnel as planned on September 1, 2006, but the actual TBM progress rate to date has averaged only 4.07 m per day (27% of the planned rate). The primary reasons for the slower than planned TBM progress to date include:
  - delays associated with worker training, high groundwater inflow, cementitious ground-up rock clogging and damaging the TBM cutters, and difficulties installing full-ring rock support through the initial decline from the tunnel portal (contractor subsequently eliminated further full-ring rock support).
  - challenges experienced in safely excavating and supporting the overstressed Queenston shale (Sta 0+800 m to Sta 3+900 m, including the buried St. Davids gorge area), resulted in excessive crown overbreak and required several TBM outages for modifications to the initial support area immediately behind the cutterhead, and facilities to remove excess rock from the tunnel invert.

- Permanent tunnel lining operations have been delayed by the slow TBM advance to date, such that invert concrete placement, planned to start in October 2007, did not begin until December 2008.

- Rerouting of the tunnel between Sta 2+974 m and Sta 9+000 m to minimize remaining excavation with the tunnel crown in the Queenston shale formation shortens the tunnel length by about 200 m to 10.2 km and is expected to facilitate TBM advance rates averaging 8.4 m per day for the remainder of the tunnel drive due to tunnelling in rock with higher strength and lower in-situ stress resulting in reduced crown overbreak and reduced initial rock support requirements. Slower TBM advance rates than originally planned are expected due to:

    - Worse than expected conditions in the Queenston shale beyond the St. Davids gorge resulting in continuing excessive overbreak requiring spiling and additional rock support throughout the Queenston shale. These conditions caused Strabag to begin the vertical realignment to the upper formations in December 2008 at Sta 3+300 m.

    - Spending a longer duration in the upper formations results in more mixed face mining. Some of these rock formations are harder and more abrasive, causing greater cutter wear and requiring more frequent replacement. The mixed face conditions also result in "eccentric loading" on the cutterhead that will be managed by reducing the penetration rate to less than 1.5 m/hr in order to avoid damaging the TBM main bearing.

    - The higher alignment will bring the tunnel to within about 85 m of the existing SAB diversion tunnels with a potential for increased water ingress resulting in reduced productivity.

- Returning the tunnel to a circular profile prior to installing the concrete lining has necessitated an overbreak restoration operation. Adding this fourth, concurrent operation adds significant complication and risk to the project logistics.

- Strabag revised its estimate for a two-stage completion of the work at the Intake (allowing for delay of completion of the structure in order to remove equipment from the tunnel) and removal of tunnel equipment.

Explanation of Cost Variances

Project Cost Flow Estimate ($M) (including Contingency)	Current Approval	Revised Estimate	Variance	Variance (%)
OPG Project Management	4.4	6.0	1.6	36
Owner's Representative	25.4	40.4	15.0	59
Other Consultants	4.0	5.9	1.9	48
Environmental / Compensation	12.0	9.6	(2.4)	-20
Tunnel Contract (including Incentives)	723.6	1,181.7	458.1	63
Other Contracts / Costs	78.9	69.8	(9.1)	-11
Interest	136.8	286.6	149.8	110
Total Project Capital	985.2	1,600.0	614.8	62

- The estimated increase in the cost for OPG Project Management is directly related to the extended duration of the Project.

- The estimated increase in the cost for the Owner's Representative is directly related to the extended duration of the Project.

- The estimated increase in the cost for Other Consultants is attributable to surveys for subsurface property rights acquisition for tunnel realignment and to the extended duration of the Project.

- The estimated decrease in the cost for Environmental / Compensation is due to reduction in the compensation for sewage handling and treatment under the Community Impact Agreement.

- The estimated increase in the Tunnel Contract cost is due to the conversion from a fixed-price to target cost plus mark-up (5%) for head office overhead recovery, due to the extended duration of the tunnel construction and due to the contingency included to address additional construction risks assumed by OPG.

- The estimated decrease in Other Contracts / Costs includes additional insurance premiums associated with the extended duration of the tunnel construction offset by the reduction in agreed compensation for Welland River water level fluctuations.

- The estimated increase in Interest is due to the increased direct costs of the work and the extended duration of the Project.

6. <u>QUALITATIVE FACTORS</u>

- Sustainable Energy Development
    - The new tunnel will enable increased generation at the Sir Adam Beck GS complex utilizing Niagara River flow available to Canada for power generation that exceeds the capability of the existing diversion system (canal and two tunnels), and reducing spill over Niagara Falls from approximately 65% to approximately 15% of the time.
    - Rehabilitation of Sir Adam Beck GS No.2, completed in April 2005, including overhaul or replacement of primary mechanical / electrical equipment, improving conversion efficiency, increasing discharge capacity by 11% and adding 194 MW (15%) of capacity increases the gap between the existing diversion capacity and generating station discharge capacity.
    - There is potential to upgrade units at Sir Adam Beck GS No.1 by 100 to 150 MW, including conversion of the 25 Hz units, and further optimize conversion efficiency of the additional water to be supplied by the Niagara Tunnel Project.
    - Completion of the Niagara Tunnel Project in advance of an 8 to 12 month outage planned for 2017 for rehabilitation of the Sir Adam Beck GS No.1 diversion canal will significantly reduce associated energy losses (2.7 to 4.0 TWh) and financial losses.

- Community, Government & Customer Relations
    - The Province, through the Ministry of Energy and Infrastructure, has indicated a strong desire for the Niagara Tunnel Project to be completed in the shortest possible timeframe.
    - There is broad support for the project in the host communities.
    - There will be significant benefits to the local economy during the construction period.

- Regulatory Approvals & Third Party Agreements
    - Conditions of the EA Approval have been addressed.
    - The Community Impact Agreement, signed with host communities on December 23, 1993 addresses predicted impacts on tourism, roads, domestic water supply and sewage treatment during construction of the Project, and includes provisions for engagement of local contractors, suppliers and labour and for local road improvements. Agreed compensation payments were made to the host municipalities. The negotiated reduction in compensation for sewage treatment may be reversed as a result of the extended duration of the Project.
    - The Project incorporates work and associated costs required under terms of the agreement between the Niagara Parks Commission (NPC) and OPG. This work has been completed and the Ontario Power GS and Toronto Power GS properties were returned to NPC on August 1, 2007.
    - Issues with Welland River water level fluctuations raised by the Niagara Peninsula Conservation Authority were addressed and agreed compensation was paid.

- Technical / Operational Considerations
  - The Niagara Tunnel design life is 90 years without the need for any planned maintenance.

- Health & Safety
  - Safety program / performance was a significant factor in contractor pre-qualification.
  - The Design / Build Contractor has implemented comprehensive project site specific plans for construction safety and for public safety and security.
  - Strabag and its subcontractors have achieved commendable Health and Safety performance to date with a Lost Time Injury Frequency of 0.8 per 200,000 hours worked, less than half of the average for Ontario's heavy civil construction industry.

- Staff Relations
  - An agreement was reached with The Society of Energy Professionals regarding "purchased services" required for the Niagara Tunnel Project. Further discussions are expected in regard to additional services required for the extended project duration.
  - Purchased Services Agreement discussions were completed with the Power Workers Union.
  - In accordance with the Chestnut Park Accord Addendum, trades work has been assigned to the Building Trades Unions.
  - Electric Power Systems Construction Association (EPSCA) conditions apply to the performance of this work.

7. RISKS

- Prior to project execution, OPG, with the assistance of URS (a specialist consultant), conducted a comprehensive risk assessment (qualitative and quantitative) for design and construction of the Niagara Tunnel. Major project risks were identified through a series of workshops involving the project team and key stakeholders. During project execution, a Risk Register and associated Risk Management Plan have been maintained to manage residual risks.

- As required by the underwriters of the builder's all risk insurance policy, OPG (represented by OR) and the Contractor developed and maintain a Combined Risk Register for management of the tunnel construction risks.

- OPG's Risk Services Group facilitated the updating of the original risk registers. The input data was gathered through five separate facilitated workshops involving OPG project team and OR representatives who were asked to provide individual estimates of both the likelihood and the impact of 13 key risks that they had previously identified. Further details on the key risks are summarized in Appendix C.

- In addition, six schedule uncertainty risks (TBM mining, invert concreting, infill shotcreting, arch concreting, contact grouting and pre-stress grouting) were similarly assessed.

- These cost and schedule uncertainties were combined using Monte Carlo simulations to generate estimates of possible cost and schedule outcomes at various levels of confidence. The results indicated that a cost contingency of $164 million would likely be sufficient to cover the cost uncertainties at a 90% confidence level for the 13 identified risks and six schedule uncertainty risks.

- The estimated in-service date is December 31, 2013, including a 6.5 month schedule contingency beyond Target Schedule date of June 15, 2013. The schedule contingency was based on management judgement.

- The financial analysis completed for the recommended alternative is based on spending the entire cost and schedule contingency and is therefore considered to be conservative and robust.

8. POST IMPLEMENTATION REVIEW (PIR) PLAN

Type of PIR	Target Project In Service Date	Target PIR Completion Date
Comprehensive	June 2013	December 2013

Measurable Parameter	Current Baseline	Target Result	How will it be measured?	Who will measure it? (person/group)
Tunnel Capacity	500 m^3/s	500 m^3/s	Flow test using tracer transit time method.	Independent Testing Contractor
In-Service Date Including Contingency	December 2013	June 2013	Compared with contracted Substantial Completion Date and approved changes.	
Actual Cost	$1,600 M	Less than $1,600 M	Compared to the approved release.	

Responsibilities

- The OPG Project Director will be responsible for the execution of the Project, and will be responsible for the completion of the PIR.
- The PIR will be undertaken after Substantial Completion of the Project (within 3-6 months).

Project Execution Monitoring

- The OPG Project Director, with the assistance of the Owner's Representative, will monitor on an ongoing basis and summarize as part of the PIR:
  - Project costs and Cost Performance Index (CPI) to ensure there are no material variances,
  - Project schedule and Schedule Performance Index (SPI) to track progress and to ensure completion in accordance with the contract,
  - Compliance with legislation and project-specific permits and approvals including periodic audits and non-compliance reporting
  - Compliance with the Project Execution Plan including scope management, deliverables, program and resource management, execution, risk management and the handling of health and safety issues.

- Disruption to the local community is to be minimized and will be measured by the public reaction including the number of complaints received.

- Oversight by the Major Projects Committee will include frequent updates and guidance provided to the project team at critical points of Project development.

Remedial Work at Ontario Power GS and Toronto Power GS

- Confirm the completion of remedial work required at the retired Ontario Power and Toronto Power generating stations and the subsequent reversion of these facilities to the Niagara Parks Commission.

Tunnel Flow Capacity Verification

- Verification will be completed using the tracer transit time method established by the International Electrotechnical Commission Publication 41 (IEC 41), with testing performed under the direction of a Chief of Test jointly engaged and witnessed by OPG and the contractor. This testing will be used to determine whether a bonus or liquidated damages apply relative to the contracted Guaranteed Flow Amount.

Project Financial Analysis

- Re-evaluate financial metrics and compare to Business Case Summary as applicable.

Lessons Learned

- Document over-all lessons learned for future improvement in other projects.
- Review effectiveness of the design and construction contract arrangements and how effectively they were implemented, including an assessment of any disincentives or incentives paid.

APPENDIX A

ONTARIOPOWER GENERATION	**PROJECT** **Summary of Estimate**	Date	24-Apr-2009
		Project #	**EXEC0007**

Facility Name:	
Project Title:	**Niagara Tunnel Project**

Estimated Cost in Million $

Year	To 2008	2009	2010	2011	2012	2013	2014	Totals	%
OPG Project Management	2.5	0.6	0.7	0.7	0.7	0.4	0.4	6.0	0.4
Consultants	19.8	6.3	6.7	5.5	4.5	2.0	1.6	46.3	2.9
Design & Construction	308.9	158.5	208.5	201.8	126.5	21.8	(8.3)	1,017.7	63.6
Other Contracts / Costs	65.8	2.1	8.4	2.5	0.1	0.0	0.0	79.0	4.9
Interest	37.6	28.2	42.7	58.3	72.9	47.1	0.0	286.6	17.9
Contingency	0.0	4.1	8.3	5.8	1.7	144.7	.0.0	164.4	10.3
Totals	434.5	199.8	275.3	274.5	206.4	215.9	(6.4)	1,600.0	100.0

Notes:

1. Schedule — Start Date: Jun-2004; In-Service Date: Dec-2013
2. Interest and Escalation rates are based on current allocation rates provided by Corporate Finance
3. Includes Removal Costs of: **n/a**
4. Includes Definition Phase Costs of: **n/a**
5. Percentages above relate to the total cost.
6. Cost flow in 2014 includes ($20 M) maximum cost and schedule disincentive triggered by exceedence of Target Cost and/or Target Schedule.

Prepared by:	**Approved by:**
Rick Everdell Project Director – Niagara Tunnel	Carlo Crozzoli Vice President – Hydro Development

Appendix B:
Niagara Tunnel Financial Model – Assumptions

Following are the key assumptions used during the modeling of the Niagara Tunnel Project.

Project Cost Assumptions:

1. Design/Build contract costs of $1189M which include $985 for tunnel contract and $40M for recovery of overheads, completion fee bonuses, performance disincentive, GFA (Guaranteed Flow Amount) bonus allowance and $164M contingency
2. Other cost of $132M which include $0.4M for contingency
3. Interest during Construction (IDC) of $287M
4. Total project costs of $1600M

Financial Assumptions:

1. Debt Rate of 6%
2. Return on Equity (ROE) of 8.65%
3. Debt Ratio of 53%

Project Life Assumptions:

1. Substantial Completion Date provided by the proposed Design/Build contractor of June, 2013.
2. 28 weeks of contingency has been added to arrive at the in-service date of December 2013
3. The tunnel life is 90 years

Energy Production Assumptions:

1. The tunnel will contribute an additional ~1.6 TWh/yr to the production at the SAB facilities
2. The tunnel will "re-capture" ~1.1 TWh during the SAB1 canal outage in 2017

Operating Cost Assumptions:

1. When energy production begins OPG will realize a 10 year holiday on Gross Revenue Charge (GRC)
2. GRC based on $40/MWh escalated at CPI after 2013
3. Annual incremental OM&A costs of ~$.1M
4. 27% tax rate

Appendix C - Niagara Tunnel Project Major Risks Table

Risk #	Risk	Objectives	Cause of Risk	Mitigation	Remediation/Plan B	Assumptions	Milestones	Comments
1	TBM Main Bearing Failure delays project completion and increases project costs	On time and on budget	Main bearing failure, damaged seals, dirt in hydraulics, rock conditions, and poor maintenance.	1. L10 life with sufficient safety factor; 2. Selection of a TBM with a proven design; 3. Contingency planning; 4. Bi-weekly oil sampling; 5. Careful adjustment of thrust with mixed face; 6. Regular inspections by remote camera; and 7. Secure bearing and bring bearing closer to site (Ohio possibly).	Replace TBM main bearing.	Spare bearing exists. Burn Rate: Contractor - $240,000/day OPG & Hatch - $20,000/day Interest - $160,000/day Total - $420,000/day	Risk expires at the end of tunnel mining April 2011(i.e. TBM @ CH 10,170 m).	If bearing is not available, then the delay is 18 months to manufacture the bearing. Consider shipping delays due to winter weather. P5 Is best case scenario where lining work has not started yet and so less delay. Cost of bearing is 1.5 million euros. L10 (15,000 hours) based on operating/drilling time, so even though the project duration lengthened. 6,000 hours aclual expected drilling time. Financial impact does not include labour costs. Labour included in schedule delay cosls.
2	Main Conveyor Failure delays project completion and increases project costs (10 km belt failure)	On time and on budget	Rock conditions, steel or rock slicing the belt, poor maintenance and poor operating practices/ monitoring.	1. Metal detection; 2. Contingency planning; 3. Keep critical spare parts and belts on site; 4. Video monitoring cameras on conveyor belt; 5. Increased visual monitoring; 6. Conveyor structural (rollers) inspection.	Replace the conveyor belt.	10 km conveyor belt failure (5 km of tunnel). Belt readily available to install Is P5 scenario. Burn Rate: Contractor - $240,000/day OPG/Hatch - $20,000/day Interest - $160,000/day Total - $420,000/day	Risk expires at the end of tunnel mining April 2011 (i.e. TBM @ CH 10,170 m).	Financial impact does nol include labour costs. Labour included in schedule delay costs.
3	Inundation or flooding of tunnel from intake	On time, on budget and safety	Cofferdam breach	1. Cofferdam height designed for 50 year return. 2. Design checks by contractor. 3. Review by OR. 4. Close contact and cooperation with INCW operators. 5. Monitoring system to check phreatic surfaces within cofferdam cells. 6. Leakage monitoring of cofferdam. 7. Seasonal inspection, as well as translational and tilting movements of the cells throughout the entire period when the cofferdam is dewatered and reviewed by cofferdam designer (Isherwood). 8. Ensure valve is locked out and cannot be operated. 9. Maintenance plan for extended life.	Dewater, restore all equipment, repair/replace cofferdam cells.	Worst case: everything floods. Flood TBM, invert carrier, and arch carrier. 8 weeks to repair cofferdam, 4 months to dewater (need to procure pumps and deliver). P5 - everything survived. P95 - replace concrete, repair damaged carrier. Assume no loss of life. Burn Rate: Contractor - $200,000/day OPG/Hatch - $20,000/day Interest - $200,000/day Total - $420,000/day Financial impact does not include labour. Assume minimal cost to repair cofferdam. P5 - Insurance covers equipment and materials repair.	Starts upon completion of tunnel mining (i.e. April 2011) until gates at intake are in place (i.e. March 2013).	Original contractual removal date is September 2009.
4	Critical work impeded by winter restrictions	On time, on budget, and safety	Ice conditions preventing marine activity.	Plan the work to minimize the amount of marine activity required.		Worst case: cofferdam removal occurs during winter months. Cofferdam removal is currently scheduled during winter 2013. Burn Rate: Contractor - $200,000/day OPG/Hatch - $15,000/day Interest - $210,000/day Total - $425,000	Starts December 2012 and ends mid-April 2013 (end of winter conditions).	
5	Tunnel collapse	On time, on budget, safety and quality	Liner overstress, support failure, engineering error/omission, rock conditions and water ingress.	1. Independent design reviews by Contractor and OR. 2. Geotechnical presence on site (full time). 3. Regular interfacing with designer. 4. Design/adjustments as required during construction. 5. Tunnel Instrumentation and monitoring of rock support. 6. Clearly defined support for the whole range of expected ground conditions. 7. Material testing (rock dowels, shotcrete). 8. Monitoring, Convergence monitoring for cracks 9. Regular review of convergence measurements by designer/ Experienced supervision/ Design of TBM minimizes unsupported length of tunnel/ On-site presence of tunnel designer (ILF) from June 2009 onwards.	Repair and restore tunnel.	Locelized collapse of tunnel (of 10 - 20 m) that damages major equipment (i.e. TBM, invert forms, conveyor, ventilation etc). Insurable event with $1,000,000 deductible. Worst case: collapse of temporary liner, since permanent liner collapse would lead to more localized collapse. P5 is minor localized damage etc. Burn Rate: Contractor - $240,000/day OPG/Hatch - $20,000/day Interest - $200,000/day Total - $460,000/day Insurance deductible for P5.	Risk expires October 2012 (i.e. arch lining completion).	Emergency evacuation plan in place

Appendix C - Niagara Tunnel Project Major Risks Table

Risk #	Risk	Objectives	Cause of Risk	Mitigation	Remediation/Plan B	Assumptions	Milestones	Comments
6	Community Impact Agreement renegotiation	On budget and corporate reputation	Increased project duration leads to additional impact on Niagara community infrastructure	1. Effective negotiation strategy and communication with stakeholders. 2. Ensure continued compliance with terms of Community Impact Agreement (CIA).		Project end date of June 2013.	Expires June 2013 (Completion of project)	Existing money in the CIA fund and can be used instead of additional funds. This item should be moved to base estimate.
7	Unanticipated problems removing equipment	On time and on budget	Access and spatial constraints, logistics, etc.	Proper planning (including staging of equipment (e.g. cranes, cutting equipment).		Craning and spatial constraints for TBM and arch carrier are the biggest/most complex pieces of equipment to remove from tunnel, therefore more prone to unanticipated problems. Assume arch lining operation and grouting operation interference. Critical path, if arch carrier catches up with TBM. Burn Rate: Contractor - \$240,000/day OPG/Hatch - \$20,000/day Interest - \$200,000/day Total - \$460,000/day Does not adjust the target cost or target schedule, but does affect actual schedule.	Risk commences May 2011 and expires March 2013 (i.e. scheduled removal of all equipment from tunnel).	Is there a crane big enough with the reach needed to remove the main bearing?
8	Delays in providing outage for rock plug removal	On time and on budget	Inability to provide outage when contractor requires it	1. Early engagement of Independent Electricity System Operator (IESO) to understand consequence of rock plug outage and improve chance of getting outage when it is needed. Communicate request for flexibility to IESO. 2. Communicate outage changes to IESO as soon as possible.		Source of outage delay comes from IESO. Note: IESO needs 18 months notice and NTP can only provide approximately 6 months notice of when they think rock plug removal would be required. Spring or fall might be easier to get an outage from IESO since there could be less demand, however system status could be a factor (e.g. nuclear station vacuum building outages). Burn Rate: Contractor - \$200,000/day OPG/Hatch - \$10,000/day Interest - \$210,000/day Total - \$420,000/day Assume bonus for 200,000/day for Contractor.	According to schedule April 2013 to June 2013 (i.e. Water-up procedure).	Dewatering structure in canal to be removed because it reduces flow. Outage only applies to Sir Adam Beck Pump Generating Station (SAB PGS).
9	Delayed tunnel mining due to health and safety hazards	Safety, on time and on budget	Falling rock conditions, silica, methane, hydrogen sulphide, carbon monoxide and oxygen concentration.	1. Design ventilation and dust abatement systems. 2. Implementation of ventilation and dust abatement systems (e.g. foam in cutterhead, water mist sprays). 3. Regular operation of ventilation system and optimization/maintenance of dust abatement system. 4. Wearing of personal protective equipment (PPE).	Respirators (full face masks). Worker training.	High Silica concentration is worst case. Assume hazard is identified before major event through monitoring of conditions. Use of full faced respirator due to high silica in Whirlpool Sandstone is not included in scheduled labour progress. Burn Rate: Contractor - \$240,000/day OPG/Hatch - \$20,000/day Interest - \$120,000/day Total - \$380,000/day Does not include any health claims after project completion. 50/50 effect of schedule delay to critical path.	According to schedule April 2009 to January 2010. TBM mining in Whirlpool formation to Power Glen 2 formation).	
10	Prototype overbreak infill operation prolongs schedule	On time, on budget, safety and quality	Prototype operation for arch infill and initial setup delays (i.e. procurement & delivery of equipment).	1. 3 months of planned float in the schedule. 2. Planned learning curve via slow initial progress rate. 3. Properly designed system.	Timely modifications to improve the efficiency of the infill operation.	Critical path. Scheduled advance rate is based on expected average shotcrete delivery and discharge rate (i.e. site shotcrete limitations). 3 month float in schedule. 3 km length for infill operation. Burn Rate: Contractor - \$200,000/day OPG/Hatch - \$20,000/day Interest - \$200,000/day Total - \$420,000/day Based on 24/7 operation, 2 production shifts.		Some flavour of concurrent activities, could cause double counting. 7 months until it becomes critical path. 3 months float at the end (i.e. conditioning work, not infill activities). In worst case, then 2 months impact on critical path. Delivery & procurement could be 2 months delay. Delay in critical path due to late delivery of carrier (delays start date). Financial impact is slower progress in Queenston Shale.

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Appendix C - Niagara Tunnel Project Major Risks Table

Risk #	Risk	Objectives	Cause of Risk	Mitigation	Remediation/Plan B	Assumptions	Milestones	Comments
11	Concurrent activities delay progress	On time, on budget	Logistics of concurrent activities.	1. Proper planning of logistics in the tunnel. 2. Adequate passing bays in the tunnel. 3. Traffic control system. 4. Ensure TBM mining is on schedule. 5. Ensure arch infill carrier is launched on schedule.		Worst case: shutdown arch lining activities because of too many concurrent activities. Assume that it does not occur at the end. Burn Rate: Contractor - $240,000/day OPG/Hatch - $20,000/day Interest - $160,000/day Total - $420,000/day	Risk expires in April 2011 (i.e. when TBM mining complete).	Short window where TBM and arch infill activities occur concurrently. Impact of TBM mining rate affects this risk.
12	Nonconformance and/or noncompliance is identified and requires rework	Quality, on time, and on budget	Contractor performance leads to inadequate design and construction quality, inadequate quality control and assurance.	1. OPG full-time presence during construction. 2. Structured submittal and stringent design review process by Hatch and Strabag. 3. Monitoring of construction works against plan (Hatch and Strabag). 4. Review formal non-compliance process of Contractor QC reports regularly 5. Full time quality assurance manager built into contract.		Worst case: re-pouring of concrete, tearing out localized areas f liner and membrane (i.e. aggregate of 25 m) because of substandard concrete/thickness, etc. Concrete placement at $40,000 per m and removal at $20,000 per m. Assumes all nonconformances/noncompliances are detected. Quality concerns discovered during operation are outside the scope of this analysis. Assume no schedule delay so no burn rate.	March 2010 (i.e. arch lining commences) to October 2012 (i.e.arch lining completion).	Adjust target if structure is removed and no problem is found.
13	Contract management problems increases project costs	On budget, on time, quality aspects	Unanticipated claims, inadequate Design Build Agreement contract, successful subcontractor claims, inadequate owner involvement during contract execution, frivolous claims	1. Revision and use of project execution plan (PEP) and detailed project procedures. 2. Periodic review and update of PEP. 3. OPG conducting intermittent audits. 4. Well defined contract language around disallowed costs. Adequate contract language to clearly define contractor's obligations. 5. Adequate and proactive Owner oversight.		Worst Case: unexpected ground conditions (e.g. sidewalls spalling effecting gripper efficiency). Frequency and magnitude of occurrence captured in P95. Assume no schedule delay so no burn rate.	Risk expires one year after project completion (i.e. 1 year limitation on claims).	Target date extended due to claims.
14	Lower than planned TBM progress in each rock strata due to overbreak above baseline	On time and on budget	Rock conditions	1. Reviewed historical TBM progress in different strata and incorporated into schedule. 2. Set target rates for anticipated overbreak. 3. Engagement of field engineer to optimize solutions for dealing with rock conditions.		No contingency in TBM mining schedule. Schedule includes planned maintenance and historical unplanned outages. Estimates includes slower than anticipated progress due to rock conditions, unanticipated cutter destruction and unanticipated machine issues. Burn Rate: Contractor - $240,000/day OPG - $20,000/day Interest - $160,000/day Total - $420,000/day Assume exceeding overbreak calculations already built into schedule.	Risk expires afterTBM mining (i.e. scheduled April 2011).	
15	Adverse impact to existing structures	Impact to OPG, on budget, on time	Effects of tunneling near existing tunnels and structures			Worst case is damaging the tunnel. $500 million/year to repair tunnel. Lost revenue for one tunnel $300k/day. Dewatering time is 365 days.		
16	OPG Abandons Project	Reputation, Costs, Impact to OPG	Shareholder does not approve financing, OPG chooses not to proceed with project					The quantitative analysis is based on the expectation that the Niagara Tunnel Project is completed under a new Design Build Agreement with Strabag. It is recommended that this risk and its financial impact be considered as an alternative in the superseding business case.
17	Cost Recovery Uncertainty	Impact to OPG	Non prudent costs associated with the project are incurred					This is not an execution phase project risk. It is recommended that the financial impact of this risk be included in the operating revenue of the superseding business case NPV calculations.
18	Tunnel does not meet 90 year life or does not meet substantial performance requirements	Quality, on time, and on budget	Contractor performance leads to inadequate design and construction quality, inadequate QC and assurance					This is not an execution phase project risk. It is recommended that the financial impact of this risk be included in the operating revenue of the superseding business case NPV calculations.
19	Contractor defaults on its obligations	On time, on budget, impact on OPG	Potential of significant loss					The quantitative analysis is based on the expectation that the Niagara Tunnel Project is completed under a new Design Build Agreement with Strabag. The approach taken by the project team is to consider the consequences of this risk should it occur through another superseding business case.

ONTARIOPOWER GENERATION

Recommendation for Submission to the Board of Directors

May 21, 2009

Niagara Tunnel Project

EXECUTIVE SUMMARY:

The purpose of this submission is to seek the approval of the Board of Directors to complete the Niagara Tunnel Project under an amended Design Build Agreement with the current contractor, to increase the capital cost from $0.985B to $1.6B and to extend the schedule from June 2010 to December 2013.

The Niagara Tunnel Project has been delayed due primarily to difficulties encountered by the contractor, Strabag Inc. (Strabag) in excavating the tunnel through the Queenston shale formation. Following an unsuccessful attempt to resolve Strabag's claim for cost and schedule relief, the parties submitted the dispute to the Dispute Review Board (DRB), as provided in the Design Build Agreement between OPG and Strabag. Following receipt of the DRB's recommendations OPG and Strabag have negotiated a settlement to ensure the tunnel is completed both safely and expeditiously.

The financing for the project is arranged through the Ontario Electricity Financial Corporation (OEFC). The amended agreement increasing the facility limit of $1B to $1.6B will be executed following the OEFC's third quarter board meeting.

With a Levelized Unit Energy Cost of under 7 ¢/kWh and an equivalent Power Purchase Agreement price of less than 10 ¢/kWh, the Niagara Tunnel Project continues to remain attractive and economic relative to other generation alternatives.

Due diligence exercised by OPG prior to and during project execution will help ensure that OPG is well positioned to make the case to the OEB that the entire capital cost should form part of OPG's regulated rate base. However, given the significant cost over-runs associated with the project, the OEB will be likely to review the matter in detail and therefore regulatory risk remains.

RECOMMENDATION:

It is recommended that the Board of Directors approve:

1. the revised schedule and capital cost of the Niagara Tunnel Project,
2. the amendment and execution of the Design Build Agreement with Strabag Inc.,
3. the resolution attached as Appendix A, Approval of Cost and Schedule Variances of the Niagara Tunnel Project,
4. the additional project financing, and
5. the resolution attached as Appendix B, Amendment to the Niagara Tunnel Financing Agreement.

Recommended By:

(original signed by)

John Murphy
Executive Vice President, Hydro

(original signed by)

Pierre Charlebois
Executive Vice President &
Chief Operating Officer

Approved for Submission to the Board of Directors:
(original signed by)

Jim Hankinson
President & Chief Executive Officer

This Board memorandum was reviewed and approved for submission to the Board of Directors by the Major Projects Committee on May 8, 2009.

The Niagara Tunnel Project (NTP) has been delayed due primarily to difficulties encountered by the contractor, Strabag Inc. (Strabag) in excavating the tunnel through the Queenston shale formation. These difficulties have resulted in a significant delay to the projected completion of the tunnel, as well as a significant increase in the cost of the project. OPG and Strabag have negotiated a settlement to ensure the tunnel is completed both safely and expeditiously. This submission is structured as follows:

I. Background
II. Geological Studies
III. Claim for Differing Subsurface Conditions
IV. Settlement of Dispute
V. Amended Design Build Agreement
VI. Project Economics
VII. Risk Assessment
VIII. Financing
IX. Communication Plan

Appendices
A. Resolution – Approval of Cost and Schedule Variances
B. Resolution – Amendment to the Niagara Tunnel Financing Agreement
C. Milestone Schedule
D. Amended Design Build Agreement Summary of Key Terms
E. Major Risk Table

I. Background:

On July 28, 2005, OPG's Board of Directors approved the Execution Phase of the Niagara Tunnel Project (NTP). The approved budget and in service date were $985 million and June 2010, respectively. This new water diversion tunnel will increase the amount of water flowing to existing turbines at the Sir Adam Beck (SAB) generating stations in Niagara Falls. This tunnel will also allow the SAB generating facilities to utilize available water more effectively and is expected to increase annual generation on average by about 1.6 TWh (14%).

The decision to proceed with the Execution Phase was taken after comprehensive geological studies, engaging an international tunnelling/mining consulting expert (Hatch Mott MacDonald) as OPG's Owner's Representative (OR), engaging Torys to provide legal oversight and advice and conducting an international competition to select a Design Build contractor (Strabag).

II. Geological Studies

A number of iterations of the NTP had been under study since the 1980's. Beginning in 1983, OPG began to assemble an extensive amount of geological data to support the study of various alternatives to increase generation at the Sir Adam Beck complex. The resulting data can be divided into four categories:

1. Geotechnical Data – 58 boreholes were drilled during the course of project development.
2. Definition of Buried St. Davids Gorge – Geophysical testing was conducted to determine the extent and depth of the buried St. Davids Gorge beneath which the tunnel had to pass.
3. Swelling of Queenston Shale – An extensive amount of laboratory testing was done to determine the swelling characteristics of the Queenston shale.
4. Feasibility of Rapid Mining in Queenston Shale – An exploratory adit and trial enlargement were excavated to assess the ability to use rapid mining techniques (Tunnel Boring Machine) in the Queenston shale.

From this data, the rock and rock mass characteristics, jointing and groundwater conditions of the rock were estimated which are the relevant parameters needed to assess the behaviour of the tunnel under excavation. The amount of data collected was significant and somewhat greater than would be typically collected for this type of project. OPG/Ontario Hydro engaged leading technical experts to conduct analysis and provide advice throughout the process. The experts included Acres, Golder Associates, professors from the University of Western Ontario and University of Toronto, Hatch Mott MacDonald and Hatch Acres.

From the above, a Geotechnical Baseline Report (GBR) was prepared and included in the Design Build Request For Proposal documents. Strabag refined the GBR to incorporate its planned means and methods. Finally, a GBR was negotiated by OPG and Strabag and included in the Design Build Agreement (DBA) with a fixed price of $623M.

III. Claim for Differing Subsurface Conditions

Upon entering the Queenston shale formation in May 2007, Strabag encountered subsurface conditions that resulted in significantly slower than planned progress. Strabag alleged large block failures, insufficient stand-up time and excessive overbreak encountered were not consistent with the conditions described in the DBA. Strabag alleged these claims constituted a Differing Subsurface Condition (DSC), and as a result, it should be entitled to cost and schedule relief.

Following unsuccessful attempts to resolve the issue, the parties submitted the claim to the Dispute Review Board (DRB). The DRB is part of the dispute resolution process set out in the DBA and consists of three tunnelling experts who were regularly updated on project progress and issues. The claim was heard over four days in June 2008.

The DRB issued its non-binding recommendations in August 2008. The DRB ruled that the excessive overbreak encountered during the tunnel drive constituted a DSC.

> "There is a DSC with respect to the excessive overbreak…Both Parties must accept responsibility for some portion of the additional cost, but at the same time the Contractor must have adequate incentives to complete the Work as soon as possible."

IV. Settlement of Dispute

In April 2008, a Contract Litigation Oversight Committee (Oversight Committee) was established to provide OPG's CEO with advice independent from the project team on the contractual dispute. The committee consists of Donn Hanbidge (OPG CFO and Chair of committee), Barry Leon (Partner at Torys and expert in litigation and international arbitrations), John Hester (international tunnelling expert) and Norm Inkster (former Commissioner of the RCMP). The Oversight Committee has been kept abreast of the dispute and status of negotiations and has endorsed the strategy adopted by management to settle the dispute.

During October and November 2008, the parties negotiated a non-binding Principles of Agreement that would settle all claims up to November 30, 2008 and move to a Target Cost Contract for the remainder of the project with cost and schedule incentives and disincentives. The key tenets of the Principles of Agreement were as follows:

- Strabag claimed that it had incurred a loss of $90M up to November 30, 2008. Under the Principles of Agreement, OPG would pay Strabag $40M to settle all claims up to November 30, 2008, leaving Strabag with a loss of approximately $50M.

- Should the $90M loss not be substantiated, the agreement allows OPG to claw back the $40M on a prorated basis.

- From December 1, 2008 onwards, Strabag could earn a $10M fee upon completion of tunnelling, a $10M fee upon Substantial Completion and maximum cost and schedule incentives of $40M. Under this arrangement Strabag would incur a loss $30M if cost and schedule performance are on target. Incentives and disincentives could result in a maximum profit of $10M or a maximum loss of $50M.

On November 19, 2008, OPG's Major Projects Committee reviewed the Principles of Agreement and endorsed management's plan to proceed to build upon the Principles of Agreement by negotiating a Term Sheet followed by an Amended Design Build Agreement with Strabag. On February 9, 2009, OPG and Strabag executed a non-binding Term Sheet that further elaborates on the Principles of Agreement.

Since then, the parties negotiated a Target Schedule of June 15, 2013 and a Target Cost of $985M. Both of these targets were developed on an open book basis. The Target Schedule is premised on a horizontal realignment that reduces the tunnel length by approximately 200 metres as well as a vertical realignment to exit the Queenston shale and move to the upper formations where rock conditions are expected to improve. The primary drivers for the schedule extension are as follows:

- Based on Strabag's original baseline schedule, the average Tunnel Boring Machine (TBM) advance rate was expected to be 14.55 m per day over 715 days with TBM hole-through expected in August 2008. The TBM commenced boring the tunnel as planned on September 1, 2006, but the actual TBM progress rate to date has averaged only 4.07 m per day (27% of the planned rate). The primary reasons for the slower than planned TBM progress to date include:

  - 0 to 800m – Delays associated with worker training, high groundwater inflow, cementitious ground-up rock clogging and damaging the TBM cutters, and difficulties installing full-ring rock support through the initial decline from the tunnel portal.

  - 800m to 3900m – Excavating and supporting the overstressed Queenston shale formation, including the buried St. Davids gorge area, resulted in excessive crown overbreak, slow daily progress rates and required several TBM outages for modifications to the initial support area immediately behind the cutterhead.

- Permanent tunnel lining operations have been delayed by the slow TBM advance to date, such that invert concrete placement, planned to start in October 2007, did not begin until December 2008.

- The difficulties experienced in excavating the Queenston shale formation resulted in a decision to horizontally and vertically realign the tunnel path between 2974m and 9000m. This shortened the tunnel length by about 200m to 10.2 km and is expected to facilitate TBM advance rates to an average of 8.4m per day due to tunnelling in rock with higher strength and lower in-situ stress resulting in reduced crown overbreak and reduced initial rock support requirements. Nevertheless, these rates are still slower than the initial planned rate due largely to:

  - More mixed face mining in the upper formations resulting in additional cutter wear and replacement and a reduction in the TBM penetration rate.

- o The higher alignment will bring the tunnel to within approximately 85m of the existing tunnels with a potential for increased water ingress resulting in reduced productivity.

- o The significant overbreak in the tunnel crown, which at times exceeded 4m, must be filled in to restore the tunnel to a circular profile prior to installing the concrete lining. Adding this fourth, concurrent operation adds significant complication and risk to the project logistics.

The primary activities to complete the project, along with their planned duration and daily progress rates are presented in Appendix C in both table form and in the form of a time-way schedule.

The parties are in the final stages of negotiating an Amended Design Build Agreement (ADBA) to reflect the Term Sheet and Principles of Agreement. A summary of the key terms of the ADBA are presented in the following section.

V. Amended Design Build Agreement:

OPG engaged Torys as external counsel in the negotiation and drafting of the ADBA. The key terms of the ADBA are summarized below. A more detailed description is provided in Appendix D.

Actual Cost: Strabag's Actual Cost being all amounts paid to Strabag prior to December 1, 2008 plus the accumulated Allowed Costs from December 1, 2008 will be used to calculate the applicable cost incentives and disincentives which apply to Strabag.

Allowed Costs: Strabag will be reimbursed for all costs it incurs to complete the project that are not specified to be Disallowed Costs in the ADBA.

Disallowed Costs: Strabag will not be reimbursed for certain costs that are specified to be disallowed. Disallowed Costs include costs arising from Strabag failing to meet a defined standard of care (negligence) or wilful misconduct, head office costs, interest costs, costs arising from breach of Applicable Law, certain insurance deductibles, costs for warranty work, costs of uncovering and recovering in certain cases, costs to correct or remove a defective part of the project and third party liability.

Overhead Recovery Fee: Strabag will be entitled to apply an overhead recovery fee of 5% to Allowed Costs from December 1, 2008 onwards.

Target Cost: $985M (does not include the Overhead Recovery Fee noted above)

Baseline Adjustment Items: The Target Cost will be adjusted to reflect changes in costs for certain items. Baseline assumptions were included in the Target Cost calculation with the Target Cost to be adjusted up or down to reflect actual circumstances. For example, the Target Cost will be adjusted if the Construction Products Inflation Index differs from the baseline inflation assumption or if actual diesel fuel costs differ from the baseline assumptions.

Target Schedule: June 15, 2013

Interim Completion Fee: Strabag will be entitled to a $10M fee upon completion of TBM mining activities.

Substantial Completion Fee: Strabag will be entitled to a $10M fee upon achieving Substantial Completion.

Cost Performance Incentive/Disincentive: A Cost Performance Incentive/Disincentive will be calculated as 50% of the difference between Actual Costs and the Target Cost.

Schedule Performance Incentive/Disincentive: A Schedule Performance Incentive of $200,000/day will apply for each day the Substantial Completion Date is prior to the Target Schedule Date. A Schedule Performance Disincentive of $67,000/day will apply for each day the Substantial Completion Date is after the Target Schedule Date.

Maximum Incentive/Disincentive: The maximum aggregate Cost and Schedule Incentive will be $40M. The maximum aggregate Cost and Schedule Disincentive will be $20M.

Guaranteed Flow Amount Incentive/Disincentive: Consistent with the original DBA, an incentive or disincentive will be applied to the extent measured flow varies from the Guaranteed Flow Amount of 500 cubic metres per second.

Major Risk Events: Should a Major Risk Event occur the Target Cost and Schedule will be adjusted in the manner set out in the Major Risk Table. The Major Risk Events are as follows:

- Main bearing failure, except due to negligence
- Conveyor belt damage greater than 1 km, not due to negligence
- Gas concentration above Ontario Occupational Health and Safety Act limits
- Water ingress greater than 100 litres/second
- BTEX levels greater than threshold accepted by Ministry of the Environment
- Unexpected subsurface geotechnical conditions requiring a material change to means and methods or having a material impact on cost and schedule
- Measured crown overbreak depth and volume greater than baseline only if progress slower than planned
- Critical marine work at intake area affected by operational constraints at the International Niagara Control Works
- Unknown subcontractor claims
- Deductibles for certain insurable events

Warranties: Consistent with the original DBA, a one year warranty period will apply with the possibility of extension where rework is required to correct or replace any Defective part of the project.

Other Performance Guarantees: In addition to the schedule and cost incentives and disincentives introduced as part of the change to a Target Cost contract, performance guarantees continue to be required consistent with the original DBA. Hence there are incentives and disincentives applicable with respect to Strabag’s commitment to the Guaranteed Flow Amount, and Strabag must maintain a parental indemnity, a Letter of Credit and a Maintenance Bond to secure its obligations and performance under the ADBA.

Occupational Health and Safety Act: Strabag will remain as the Constructor and OPG will retain Owner Only status.

Dispute Resolution: Disputes not settled at the project level will be brought to a Steering Committee consisting of one senior representative from each of OPG and Strabag. The Steering Committee may seek either advice or non-binding recommendations from an expert(s). As was the case in the original DBA, all unresolved disputes shall be finally settled by arbitration under the Rules of Arbitration of the International Chamber of Commerce (ICC) and only after Substantial Completion occurs; however, the Steering Committee members may mutually agree to submit a dispute to ICC arbitration before such time.

Default: Events of default remain largely unchanged from the original DBA although the breaches of covenants, representations and warranties are triggered by material breach only. Should OPG terminate the agreement as a result of an event of default, Strabag will be liable for all of OPG's incremental costs in completing the project (losses suffered from the default, correcting defective work and costs to finish) in excess of the Target Cost.

Liability Regime: Strabag is subject to an overall liability cap equal to the Target Cost ($985M). There is no cap on Disallowed Costs.

OPG Caused Events and OPG Interference: The ADBA includes the concept that if OPG actions have an impact on cost or schedule, the Contractor will be entitled to an adjustment in the Target Cost and Contract Schedule. This is to deal with provisions in the ADBA that require Strabag to obtain OPG's consent such as a change or addition to Major Subcontractors or which impose obligations on OPG that may impact cost or schedule (e.g., OPG fails to provide sufficient lands).

VI. Project Economics

Total project costs are estimated to be $1.6B which includes a contingency of $164M, or approximately 17% of pre-contingency going forward project costs. The cost contingency was developed based on a quantitative assessment of 13 key risks as well as an additional 6 schedule uncertainty risks. The cost contingency is based on a 90% confidence level.

The estimated in-service date is December 31, 2013, including a 6.5 month schedule contingency beyond Target Schedule date of June 15, 2013. The schedule contingency was based on management judgement.

Project Cost Estimate ($M) (including Contingency)	Original Approval (July 2005)	Superseding Release (May 2009)	Variance
OPG Project Management	4	6	2
Owner's Representative and Other Consultants	29	46	17
Environmental / Compensation	12	10	(2)
Tunnel Contract	724	1,182	458
Other Contracts / Costs	79	70	(9)
Interest	137	286	149
Total Project Capital	985	1,600	615

Key financial metrics utilized are:

- Levelized Unit Energy Cost (LUEC) represents the price required to cover all forecast costs, including a return on capital over the service life, escalates over time at the rate of inflation, and permits a consistent cost comparison between generation options with different service lives and cost flow characteristics. LUEC is expressed in current dollars and incorporates all forecast future costs.
- Equivalent Power Purchase Agreement (PPA) Price represents the price required if one were to bid the Project into the renewable RFP. It is similar to LUEC except only 20% of the PPA escalates at the Consumer Price Index.
- Revenue Requirement is a measure that represents the annual accounting cost of the Project including an allowed return on capital employed. Revenue Requirement generally declines over time as the rate base is depreciated.
- Equivalent PPA Price and Revenue Requirement are calculated in dollars of the year of the first full year of tunnel operation.
- These metrics are equivalent in present value terms over the life of the asset and reflect full recovery of costs including a return on the investment.

A summary of the financial analysis is as follows:

Financial Measure	Original Approval July 28, 2005 ($985M; June 2010 In-Service)		Superseding Release May 21, 2009 ($1.6B; Dec. 2013 In-Service)	
		in 2009 $		**in 2009 $**
LUEC (¢/kWh)	(2005$) 4.8	5.2	(2009$) 6.8	6.8
PPA (¢/kWh)	(2011$) 6.7	6.7	(2014$) 9.5	9.4
Revenue Requirements (¢/kWh)	(2011$) 5.8	5.6	(2014$) 8.7	7.9
Revenue Requirements Post GRC Holiday (¢/kWh)	(2021$) 9.4	7.4	(2025$) 13.0	9.5

The proposed Green Energy Act includes a “Feed-In-Tariff” (FIT) for hydroelectric projects under 50 MW of 12.9 ¢/kWh. This proposed program is comparable to the PPA measure noted in the above table except that the FIT contract is for 20 years instead of 50 years assumed in the PPA calculation.

Once the Niagara Tunnel is in service, the revenue requirement for OPG’s regulated hydroelectric assets is expected to increase from 4.0 ¢/kWh to 4.4 ¢/kWh (2014$).

Based on the financial metrics presented above, the Niagara Tunnel Project continues to remain attractive and economic relative to other generation alternatives.

Once in-service, the NTP will form part of OPG’s regulated rate base. Under O.Reg 53/05 the OEB is required to ensure that OPG recovers the original project budget of $985M approved by OPG's Board and this amount will not be subject to a prudence review by the OEB. However, the incremental project costs above the original approval will be subject to a prudence test. Under the OEB's prudence test, OPG’s actions are assumed to be prudent unless challenged on reasonable grounds. In assessing prudence, the OEB will consider what information was known or should have been known at the time key decisions were made and what third-party expert advice was sought to assist in decision making. Hindsight is not to be used in determining prudence. Given the extensive volume of studies conducted prior to project execution and the nature of independent advice sought throughout the process (leading international consultants, academia, Dispute Review Board, Contract Oversight Committee, etc.), OPG is well positioned to make the case that the entire capital cost should be recoverable. OPG will, of course, have to demonstrate ongoing diligence in project execution as part of its case for recoverability. However, given the significant cost over-runs associated with the project, the OEB will be likely to review the matter in detail and therefore regulatory risk remains.

VII. Risk Assessment

Prior to project execution, OPG, with the assistance of URS (a specialist consultant), conducted a comprehensive risk assessment (qualitative and quantitative) for design and construction of the Niagara Tunnel. Major project risks were identified through a series of workshops involving the project team and key stakeholders. During project execution, a Risk Register and associated Risk Management Plan have been maintained to manage residual risks. As required by the underwriters of the builder’s all risk insurance policy, OPG (OR) and Strabag developed and maintain a Combined Risk Register for management of the tunnel construction risks.

Beginning in March of this year, at the request of the project team, OPG's Risk Services Group facilitated the updating of the original risk registers using a widely accepted risk quantification methodology known as Monte Carlo simulation. A key step in this methodology involves the creation of input data that once gathered, is inserted into a software application. The input data was gathered through five separate facilitated workshops involving OPG project team and OR representatives who were asked to provide individual estimates of the both the likelihood and the impact of 13 key risks that they had previously identified. These risks included the Major Risk Events delineated in the ADBA and described in Section V. to this memo. In addition, six schedule uncertainty risks (TBM mining, invert concreting, infill shotcreting, arch concreting, contact grouting and pre-stress grouting) were similarly assessed. Once the software tool has the required data, various estimates of possible cost and schedule outcomes at various levels of confidence are generated.

This methodology concluded that a cost contingency of $164 million would likely be sufficient to cover the costs at a 90% confidence level in the event that all 13 identified risks and six schedule uncertainty risks occurred as expected.

The estimated in-service date is December 31, 2013, including a 6.5 month schedule contingency beyond Target Schedule date of June 15, 2013. The schedule contingency was based on management judgement.

A Risk Register and associated Risk Management Plan will be maintained throughout project execution to manage residual risks.

Further details on individual risks are provided in the Major Risk Table presented in Appendix E.

VIII. Financing

The financing for the project was arranged through the OEFC with a facility limit of $1B. The process to amend the existing loan agreement will be as follows:

1. OPG Board to approve a financing resolution for the revised project amount (Appendix B).
2. Minister of Finance will likely be required to provide a directive to the OEFC Board to execute an amendment to the existing agreement for the revised project amount.
3. OEFC Board to approve a resolution to execute the amended financing agreement.

Preliminary discussions have taken place with the OEFC regarding an increase in the facility as well as a timing extension. However, staff have indicated that given their current priorities it would be difficult to expedite the "Minister directive" since OPG's Niagara Tunnel Project spend is currently well below the $1B facility limit. OEFC currently plans to have the final amendment executed after its third quarter Board meeting in September 2009.

IX. Communication Plan

Management has developed a communication plan that will guide the public positioning of the revised cost and schedule of the NTP. The communication plan will focus on the following key messages:

- OPG's number one priority is to progress the project safely.
- The NTP is an ambitious project that employs the largest diameter (14.4m) hard rock Tunnel Boring Machine in the world.

- OPG carried out all the proper due diligence on rock conditions. OPG undertook extensive geological studies over many years and sought advice at key decision points from leading consultants, law firms and academia.
- Even with the extended cost and schedule, the NTP remains among the most economic new renewable energy projects available in Ontario and will continue to deliver benefits for almost a century.
- OPG has been open and transparent in communicating the difficulties with the project.