ONTARIO POWER GENERATION INC.

REVIEW OF COST ALLOCATION METHODOLOGY FOR CENTRALIZED SERVICES AND COMMON COSTS

Prepared by

HSG Group, Inc.

August 23, 2013

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Section I. EXECUTIVE SUMMARY

HSG Group, Inc. is pleased to submit this Report to Ontario Power Generation Inc. ("OPG") on our Review of OPG's Cost Allocation Methodology for Centralized Services and Common Costs ("Review").

OPG is primarily organized by generation technology into Business Segments (i.e., Nuclear, Hydroelectric-Thermal - Table 1). Many of the services required by the Business Segments are provided by Centralized Support and Administration ("CSA") departments (Table 2). In addition, OPG incurs Common Costs on behalf of the Business Segments and Service Providers, comprising i) centrally held costs which are primarily labour-related costs (e.g., Pension and OPEB) and insurance premiums, and ii) hydroelectric / Ottawa St. Lawrence ("OSL") shared engineering and operating costs. Together the CSA costs and the Common Costs are referred to as Centralized Services and Common Costs ("CSCC").

The purpose of OPG's cost allocation methodology is to distribute the CSCC among the Business Segments and generating stations[1], using direct assignments and cost drivers selected based on cost causation. The EB-2010-0008 Decision With Reasons accepted OPG's cost allocation methodology and applied the results in setting OPG's approved payment amounts for generation.

HSG Group was engaged by OPG to perform this Review to evaluate if OPG's cost allocation methodology for CSCC costs continues to meet best practices and precedents established by the OEB, including the 3-prong test, in view of OPG's Business Transformation organizational changes.

OPG's generating Business Segments are also charged cost-based Asset Service Fees ("ASFs") for the use of certain assets owned and operated by OPG. A portion of the costs charged is included in the CSA costs. HSG Group was engaged to evaluate the ASF methodology as well.

Our Review included the following steps:

- Understand OPG's business, especially changes from 2010;

[1] The term "stations" is used throughout the report to refer to a generating station for the nuclear and thermal operations and, unless specifically distinguishing between the currently unregulated facilities expected to be regulated and those subject to a supply agreement, to a plant group consisting of a number of individual stations for the hydroelectric operations.

- Review and evaluate OPG's cost allocation methodology including overall design, use of direct assignment, selection of cost drivers and documentation;
- Review the model developed by OPG to implement the methodology;
- Review and evaluate OPG's compliance with the 3-Prong Test, including surveying and interviewing Business Segments and service providers; and
- Review and evaluate the methodology for ASFs.

Based on our Review, which provided sufficient information to support our conclusions, we conclude that OPG's cost allocation methodology is appropriate for OPG, and distributes costs using direct assignments and cost drivers supported by principles of cost causality, consistent with best practices and OEB, including the 3-prong test.

We also conclude that:

- OPG's model correctly calculates the amount to be distributed to each Business Segment and station in accordance with the methodology;
- OPG's use of cost-based ASFs to charge generating Business Units for the use of certain Information Technology ("IT") assets, joint-use hydro-electric properties (including dams) and buildings is reasonable based on the operation of OPG's business and the principles of cost causality; and
- The transfer of employees from generation Business Segments to CSA departments as part of OPG's Business Transformation, did not cause any cost shifts between Business Segments; the costs for the transferred employees have been directly assigned to the Business Segments, which they continue to support.

HSG Group recommended changes to the cost drivers selected for several activities. OPG accepted the changes and will implement them in its Business Plan 2014-16. The effect of these changes in 2014, based on the current business plan, would not be material.

HSG Group recommended changes to OPG's cost allocation model to make the iterative calculation process (which is unavoidable due to the use of internal allocators) more efficient. The effect of these changes on the total cost distributed to any Business Segment was not material. OPG is evaluating these recommendations.

Section II. Introduction

HSG Group, Inc. ("HSG Group" or "we") is pleased to submit this Report to Ontario Power Generation Inc. ("OPG") on our Review of OPG's Cost Allocation Methodology for Centralized Services and Common Costs ("Review").

HSG Group was engaged by OPG to perform this Review to evaluate if OPG's cost allocation methodology for the cost of Centralized Services and Common Costs ("CSCC") continues to meet best practices and precedents established by the Ontario Energy Board ("OEB"), in view of OPG's Business Transformation organizational changes. CSCC includes the cost of Centralized Support and Administrative ("CSA") services, and Common Costs incurred on behalf of Business Segments and Service Providers, comprising i) centrally held costs which are primarily labour-related costs (e.g., Pension and OPEB) and insurance premiums, and ii) hydroelectric / Ottawa St. Lawrence ("OSL") shared engineering and operating costs.

OPG's generating Business Segments are also charged cost-based Asset Service Fees ("ASFs") for the use of certain assets owned and operated by OPG. A portion of the costs charged is included in the CSA costs. HSG Group was engaged to evaluate the ASF methodology as well.

Our evaluation included the following criteria:

- Is the methodology appropriate for OPG based on current and anticipated business and regulatory considerations?
- Does the methodology continue to meet best practices and precedents established by the OEB, including the 3-prong test for affiliate transactions[2]?
- Has the methodology been implemented correctly in the models developed by OPG?
- Are the allocators selected by OPG appropriate and consistent with prior allocators?
- Has the methodology been appropriately applied, considering business and organizational changes at OPG?
- Is OPG's methodology for computing ASFs appropriate?

[2] EBRO 493/494 Decision With Reasons describes the three-pronged test. The three prongs are identified and discussed in Section VI, Part 0

In this Report "regulated" and "unregulated" refer only to regulation by the OEB with respect to the payment amounts OPG receives with regard to its generating stations.

OPG's cost allocation methodology has been reviewed in the past. In *Report on Cost Allocation Methodology Review* dated April 30, 2006 ("2006 Report"), the independent consulting firm R. J. Rudden Associates, Inc. stated, "The methodology used by OPG to distribute the CSA Costs separates the CSA Costs between regulated and unregulated Business Units in a manner that meets current best practices and is consistent with cost allocation precedents established by the OEB". The 2006 Report was filed in EB-2007-0905 as Exhibit F4-T1-S1.

In *Review of Centralized Support and Administrative Cost Allocation Methodology* dated March 5, 2010 ("2010 Report"), the independent consulting firm Black & Veatch Corporation reaffirmed the findings in the 2006 Report, and also stated, "OPG's allocated Centralized Support and Administrative services costs meet the requirements of the OEB's 3 prong test." The 2010 Report was filed in EB-2010-0008, Exhibit F5-2-1. The EB-2010-0008 Decision With Reasons accepted OPG's cost allocation methodology and applied the results in setting OPG's approved payment amounts for generation.

HSG Group is an independent consulting firm specializing in electric and gas utility rate and regulatory matters. Howard Gorman, the President of HSG Group, performed this Review. He was the lead consultant in performing the reviews for the 2006 Report and the 2010 Report. His professional experience is presented in Exhibit D.

Section III. ORGANIZATION OF ONTARIO POWER GENERATION

A. Service Recipients- Business Segments

Ontario Power Generation Inc. is wholly owned by the Province of Ontario. Its principal business is the generation and sale of electricity in Ontario and to interconnected markets. OPG is primarily organized by generation technology. The "Service Recipients" are the Business Segments that receive CSA services, and to which the costs of those services as well as Common Costs are distributed; the Service Recipients are listed in Table 1.

Table 1: Service Recipients- Business Segments Receiving CSA Services and Centrally Held Costs	
Nuclear Generation	Regulated *Nuclear Waste Management is a separate segment for financial reporting but included with Nuclear Generation in this Review*
Hydroelectric Generation	Regulated (A)
Hydroelectric Generation	Unregulated (A)
Thermal (Fossil) Generation	Unregulated (A)
Other Business (Non-generation)	Unregulated *Includes Energy Markets which supports the generation businesses and performs other activities as well*
(A) The Hydroelectric- Regulated, Hydroelectric- Unregulated and Thermal generation business segments are operated together as the Hydro Thermal Operations ("HTO") group. They are represented separately in OPG's cost allocation to allow better matching of cost drivers with cost causation.	

B. Service Providers

Many of the services necessary to support the Business Segments are performed by centralized Service Provider groups within OPG. These groups are listed in Table 2. Exhibit A presents the departmental budgets for 2014 for the CSA Service Providers. Table 2 also includes Common Costs.

Table 2: Service Providers and Common Costs

Group	Primary Departments or Services	2014 Budget ($ millions)	% Total
BAS – IT Outsourcing	Infrastructure Management, Application Management, Data Centre, Service Management, Data & Voice Network	$72.8	12.1%
BAS- IT Work Programs	Application Software, Telecom, IMO Services, IM Projects, Hardware, Non-capital projects	52.6	8.8%
BAS – Supply Chain	Nuclear Supply Chain, Corporate Supply Chain Corporate Supply Chain and HTO Supply Chain	69.3	11.6%
BAS - Real Estate and Business Services	Real estate services, Enterprise services, Facility Services, Fleet services	124.6	20.8%
People and Culture	Training (Fleet operations, Fleet support services, Fleet maintenance, Fleet simulator), Total rewards & solutions, Safety & wellness, Talent management, Employee & labour relations, Business partnerships	117.2	19.5%
Finance	Finance and controllership, Corporate financial processing, Treasury, Investment planning, Assurance (Internal audit and Nuclear oversight), Fund management, CFO office	62.2	10.4%
Corporate Centre	Executive, Law, Corporate relations & communications, Executive operations, Corporate business development, Strategic initiatives, Business transformation	59.0	9.8%
CO&E	Integrated revenue planning, Market operations, Term trading & outage management, Fuels, Commercial services, Bruce lease management, Environment, Regulatory affairs, OEB costs	42.0	7.1%
Total CSA Costs		**599.7**	**100.1%**
Hydroelectric / OSL Shared		76.6	
Centrally held costs in OPG's cost allocation model- primarily labour-related costs, insurance premiums		479.7	
Total Common Costs		**556.3**	
Total CSCC (CSA costs plus Common Costs)		**$1,156.0**	

BAS = Business & Administrative Services; CO&E = Commercial Operations & Environment

Starting in 2012, OPG implemented a Business Transformation, in which employees who had reported to generation Business Segments were transferred to CSA departments. As a result, the total dollars in the CSA department budgets, and in OPG's cost allocation, increased. However these costs have been directly assigned to the Business Segments that are supported, and the transfer of employees as part of OPG's Business Transformation did not cause any costs shifts between Business Segments. The increase in costs allocated to a Business Segment in the allocation process was offset by an equal decrease in directly incurred costs. The Business Transformation is discussed further in Section V Part A. A summary of the effect of the Business Transformation on the 2013 Budget for Service Recipients and Service Providers is presented in Exhibit C.

Section IV. SUMMARY OF REVIEW APPROACH

A. Overview of OPG's Cost Allocation Methodology

Most of the departments in the Service Provider groups support more than one Business Segment. For those departments, it is necessary to distribute the cost of the department's resources among the Business Segments. In many cases, specific resources (individual employees and specific costs) can be identified to a particular Business Segment or station, or the portions of resources (employees' time and other costs) that are spent on each Business Segment or station can be estimated. In these cases, there is a direct relationship between the department's costs and the Business Segments or stations that cause the costs to be incurred.

In addition, the Common Costs reflecting centrally held labour-related costs and insurance premiums are incurred on behalf of all the Business Segments and Service Providers, and Common Costs reflecting hydroelectric / OSL shared costs are incurred primarily on behalf of the hydroelectric plants.

In cases where neither specific identification nor estimation of costs to a Business Segment are possible, it is necessary to allocate the costs of the resources to the Business Segments or stations using cost drivers. A cost driver is a formula for sharing costs among those who cause the costs to be incurred. The use of cost drivers to allocate costs of shared resources conforms to regulatory precedent and is widely accepted.

The selection of cost drivers should be based on cost causation, with consideration to the practicality of obtaining the data necessary to develop the allocator, the stability of the data over time and whether additional data would materially affect the result of the cost allocation.

The types of cost drivers used typically include:

- Physical (e.g., full-time employees or FTEs; LAN IDs)
- Financial (e.g., labour costs; total OM&A cost;)
- Blended (e.g., capital plus OM&A); and
- Internal (e.g., BAS costs allocated for Finance are re-allocated to Business Segments and stations in proportion to the overall allocation of Finance costs).

The criteria for the selection of cost drivers, and the types of cost drivers used by OPG, have remained the same in the 2006 Report, the 2010 Report and this Report.

B. Description of Tasks

Our Review comprised the tasks listed in Table 3.

Table 3: Tasks	
Task	**Description**
Task 1	Understand OPG's business and organization, and the departments included in CSA Costs, and identify changes from 2010.
Task 2	Review and evaluate the methodology used by OPG to distribute 2014 CSA costs, as well as Common Costs, including overall design, use of direct assignment, selection of cost drivers and documentation.
Task 3	Review the model developed by OPG to implement the methodology.
Task 4	Review and evaluate OPG's compliance with the 3-Prong Test.
Task 5	Review Asset Service Fee methodology.
Task 6	Prepare Report on the Review, including conclusions and recommendations.

C. Scope

Consistent with standard practice for independent review consulting assignments, HSG Group relied on the genuineness and completeness of all documents (including spreadsheets) presented to us by OPG and we accepted factual statements made to us by OPG (e.g., budget dollars; specific time assignments), subject only to overall reasonableness considerations and actual contrary knowledge, but without independent confirmation.

The total CSA Costs for 2014 in OPG's Business Plan 2013-2015 are budgeted to be $599.7 million. This amount was the basis for our judgments based on materiality in this Report.

Section V. OPG'S COST ALLOCATION METHODOLOGY

A. Understand OPG's business and organization (Task 1)

The purpose of this task was to understand how OPG is organized, to identify the departments included in CSA Costs, and to identify changes from 2010. Information was obtained from OPG public and internal documents and discussions with OPG personnel.

OPG's business and organization are discussed in Section III. The Service Recipients for the CSA services are the Business Segments identified in Table 1; the Service Providers also support each other (e.g., BAS supports Finance and People & Culture). The Service Providers are the groups and departments identified in Table 2.

Common Costs includes centrally held labour-related costs that are applicable to all Business Segments and Service Recipients (approximately 89% of Common Costs), insurance premiums approximately (6%) and other items (approximately 5%).

There were no organizational changes from 2010 that would indicate the cost allocation methodology is not appropriate or should be revised.

Business Transformation

Starting in 2012, OPG implemented a Business Transformation, in which employees who had reported to operating Business Segments (e.g., Nuclear) were transferred to the CSA Service Providers (e.g., Finance). The purpose of the Business Transformation was to create a more center-led organization. OPG believes that the center-led organization will provide opportunities for cost-saving by facilitating standardization and cross-training, and making it easier to share resources and achieve economies of scale.

A summary of the effect of the Business Transformation on the 2013 Budget for each of the Service Recipients and Service Providers is presented in Exhibit C.

As a result of the Business Transformation, the total dollars in the CSA departments, and in OPG's cost allocation, have increased; but the costs for individuals who were transferred have been directly assigned in the cost allocation to the Business Segments they support. The activities performed by the transferred employees did not change, only their reporting relationships. The Business Transformation did not cause any costs shifts between Business Segments. The increase in costs allocated to a Business Segment in the allocation process was offset by an equal decrease in directly incurred costs.

Some employees of CSA groups who at present provide services to only one Business Segment and are directly assigned to that Business Segment, will, in the future, provide services to more than one Business Segment. OPG believes that it will be possible to allocate their time appropriately because much of the work will be project-based, and management will be able to estimate their time accurately.

The allocation of Common Costs is not affected by Business Transformation.

B. Review and evaluate OPG's cost allocation methodology (Task 2)

In this task, we review and evaluate OPG's cost allocation methodology for CSA costs, and Common Costs, including overall design, use of direct assignment, selection of cost drivers and documentation.

The purpose of the methodology is to distribute CSA Costs, and Common Costs, among the Business Segments and generating stations. Information was obtained from the following sources:

- Discussions with OPG personnel
- Review of 'Allocation Templates' for each department, discussed below
- Review of the methodology for consistency with that presented by OPG in EB-2010-0008.
- Review of the document "OPG Revenue and Cost Assignment and Allocation Methodology", draft provided by OPG as of April 18, 2013.

The costs are distributed based on the following relationships:

- Direct assignment to Business Segment or to generating station
- Time and cost basis, using actual records or estimates
- Allocation using cost drivers; the primary cost driver types used by OPG are: OM&A and Capital Blend; FTEs; Labour costs; LAN IDs

If the relationships identified above do not have sufficient detail to enable costs to be distributed to stations, a re-distribution is needed. For example, certain Business & Administrative Services costs are distributed to the Business Segments, then re-distributed to the stations based on the users of the applications.

Design

In evaluating the design of OPG's methodology, we considered the following:

- *Does the methodology reflect how the business is organized and operated?*

Evaluation: OPG's methodology follows its organizational structure, in which the majority of the CSA services are integral to running the Business Segments (e.g., and human resources and information technology), and Business Segments receive many of their necessary support services from CSA departments rather than decentralized resources reporting to the business units, however a significant portion of these resources are located at business unit sites. This permits extensive use of direct assignment of the CSA costs.

Most of the Common Costs are centrally held labour-related costs and can also be directly assigned.

In addition, the use of internal allocators to re-distribute costs initially distributed to CSA Service Provider departments (e.g., Finance), is appropriate because the purpose of the CSA groups is to support the Business Segments and stations.

- *Are sufficient resources devoted to the cost allocation process? Do management and the users understand and support the process?*

Evaluation: OPG's cost allocation process has the support of senior management including the assignment of dedicated resources to the process. The heads of the organizations that HSG Group interviewed are knowledgeable about the cost allocation methodology and understand how to work within it to meet the needs of their businesses. The Service Recipients can, and do, challenge and influence decision-making by Service Providers regarding the services to be provided and the costs to be incurred, through forums such as budget meetings and Executive Leadership Team meetings. The Service Recipients are aware of how their decisions (regarding services provided by the CSA groups) affect their costs.

- *Is sufficient information gathered from reliable sources to support specific identification, time estimation and selection of appropriate cost drivers?*

Evaluation: Consistent with OPG's approach in EB-2010-0008, the methodology relies on the judgments of department and Business Segment managers to make specific identification of labour and non-labour costs, and time estimation. These are the people in the best position to determine how resources are used. Representatives of the Controller's department that support each Business Segment, as well as representatives of Business Segments, review the resulting estimates.

The department heads that we interviewed believe the cost drivers selected are appropriate, and they have the opportunity to review and challenge them if they believe necessary. Obtaining input from the people closest to the resources improves the quality of decisions as to cost drivers.

Conclusion on Design: OPG's methodology reflects how OPG is organized and operated. OPG has devoted substantial and sufficient resources to the cost allocation process. The process is understood and supported by management and the users. Sufficient information is gathered from reliable sources to support specific identification, time estimation and selection of cost drivers.

Use of Direct Assignment

- *Is the use of direct assignment appropriate?*

Evaluation: Direct assignment is preferable to allocation because it is means there is a direct relationship between the costs incurred and the Business Segment or Station causing it to be incurred. OPG informed us that costs are directly assigned whenever possible; Table 4 shows that approximately 80% of the total costs to be distributed (CSA costs incurred by Service Providers plus Common Costs) are directly assigned.

Conclusion on Direct Assignment: The OPG methodology uses direct assignment wherever possible.

Selection of Cost Drivers

- *Are the cost drivers selected by OPG appropriate*?

Evaluation: Exhibit B lists the cost drivers selected by OPG for those instances where less than all costs could be distributed by direct assignments. OPG's cost driver selections are appropriate based on the nature of the costs, are consistent with the principles stated in the 2006 Report and re-affirmed in the 2010 Report, and are consistent with the allocators used in OPG's presentations in EB-2007-0905 and EB-2010-0008.

In the cost allocation methodology, Service Provider department budgets are broken into many detailed activities, and labour and non-labour costs are assigned or allocated separately; greater detail permits OPG to distribute costs based on direct assignment or allocation, in a manner that most closely reflects cost causation.

OPG has standardized the allocators used in the cost allocation methodology, which promotes transparency and consistency.

HSG Group recommended changes to the cost drivers selected for several activities. OPG agreed that the allocators that we recommended were more appropriate based on cost causality, and will implement them in its Business Plan 2014-2016. The effect of these changes in 2014, based on the current Business Plan 2013-2015, would not be material. The 2013 budget was completed before our Review, therefore the changes were not made in 2013 in order to make actual results comparable to budget; we agree with this treatment.

<u>Conclusion on Selection of Cost Drivers</u>: The cost drivers used by OPG are appropriate based on the principles and selection criteria discussed in this Report and on the operation of OPG's business, and are consistent with the allocators used in EB-2007-0905 and EB-2010-0008 which were accepted by the OEB.

- *Is the documentation for the methodology adequate? Does it support the implementation of the methodology?*

<u>Evaluation</u>: The document "OPG Revenue and Cost Assignment and Allocation Methodology" is a detailed description of OPG's cost allocation methodology. The document presents the information in a standardized format, tailored to the many different areas it addresses. Because people with many perspectives participate in the CSA cost allocation process, this is important.

The 'Allocation Templates' developed for each department provide excellent documentation of the activities performed by the department, the budgeted resources for that activity, and the rationale for directly assigning or allocating the cost of those resources. The 'Allocation Templates' provide a useful link between the inputs to the model and the results.

<u>Conclusion on Documentation of the Methodology</u>: OPG's documentation for its cost allocation methodology provides a reasonable explanation of the methodology, promotes consistent application of principles and makes the methodology easier to adapt as the business changes. OPG has developed an interface for users of the model, which encourages consistency and completeness.

Overall Conclusion on OPG's Cost Allocation Methodology for CSA Costs and Common Costs

The cost allocation methodology used by OPG for CSA costs and for Common Costs (together, CSCC) reflects how the company is organized and operated. The process is understood and supported by management and the users. Sufficient information is gathered from reliable sources to support specific identification, time estimation and selection of cost drivers. Direct assignment is used wherever possible. The cost drivers selected and implemented for OPG's Business Plan 2013- 2015 are appropriate based on the principles and selection criteria discussed in this Report and on the operation of OPG's business, and produce a result that fairly allocates the cost of the CSA groups and Common Costs.

The documentation prepared by OPG explains the methodology, promotes consistent application of principles and makes the methodology easier to adapt as the business changes. The 'Allocation Templates' provide excellent documentation of the implementation of the methodology, including the rationale for the direct assignments and allocations selected.

HSG Group believes that OPG's cost allocation methodology is appropriate for OPG, and it allocates costs based on cost drivers / allocation factors supported by principles of cost causality, consistent with best practices and OEB precedent.

C. Review the model developed by OPG to implement the methodology (Task 3)

HSG Group reviewed a working copy of the Cost Allocation Model ("CAM") developed by OPG. The purpose of the CAM is to automate calculations, to make it easier to update information and to support compliance with the cost allocation methodology. The CAM comprises numerous Excel® spreadsheets, with a user interface to manage the input and output process; the inputs are now directly accessed from OPG's accounting system in order to reduce the potential for input errors.

Our review included tracing the inputs to the CAM back to the Allocation Templates; confirming all calculations; and reviewing the logic of the CAM to determine if it reflects OPG's cost allocation methodology. Based on our review, we conclude the following about the CAM:

- The CAM faithfully reflects OPG's cost allocation methodology.
- Inputs from the Allocation Templates are properly reflected in the CAM.
- The CAM correctly calculates allocation percentages for external and internal allocators. The use of an iterative process is reasonable due to the use of internal allocators and the need to re-allocate some of the costs (i.e., costs that are allocated from one CSA department to another must be re-allocated to the Business Segments).

However the model and the calculations could be more efficient, and we have provided our suggestions to OPG on doing so.

- The CAM correctly calculates the amount to be allocated to each Business Segment and each station, based on the inputs and the methodology.

D. Summary of Direct Assignments and Cost Drivers Selected- Exhibit B

This Section describes Exhibit B, which shows how the cost of each major service performed by the CSA Service Provider departments is distributed to the Business Segments and to the stations.

Column A lists the CSA Service Providers and the major services they provide to the Business Segments.

Column B shows each activity's percentage of the 2014 departmental budget. Each department sums to 100%.

Columns C-F show how departmental costs are distributed to the Business Segments and the stations. If a portion of costs are directly assigned to one or more Business Segments or stations, Column C shows the direct assignment method, and Column D shows the cost as a percentage of the 2014 budget for the Service Provider. The primary direct assignment methods listed in Column C are:

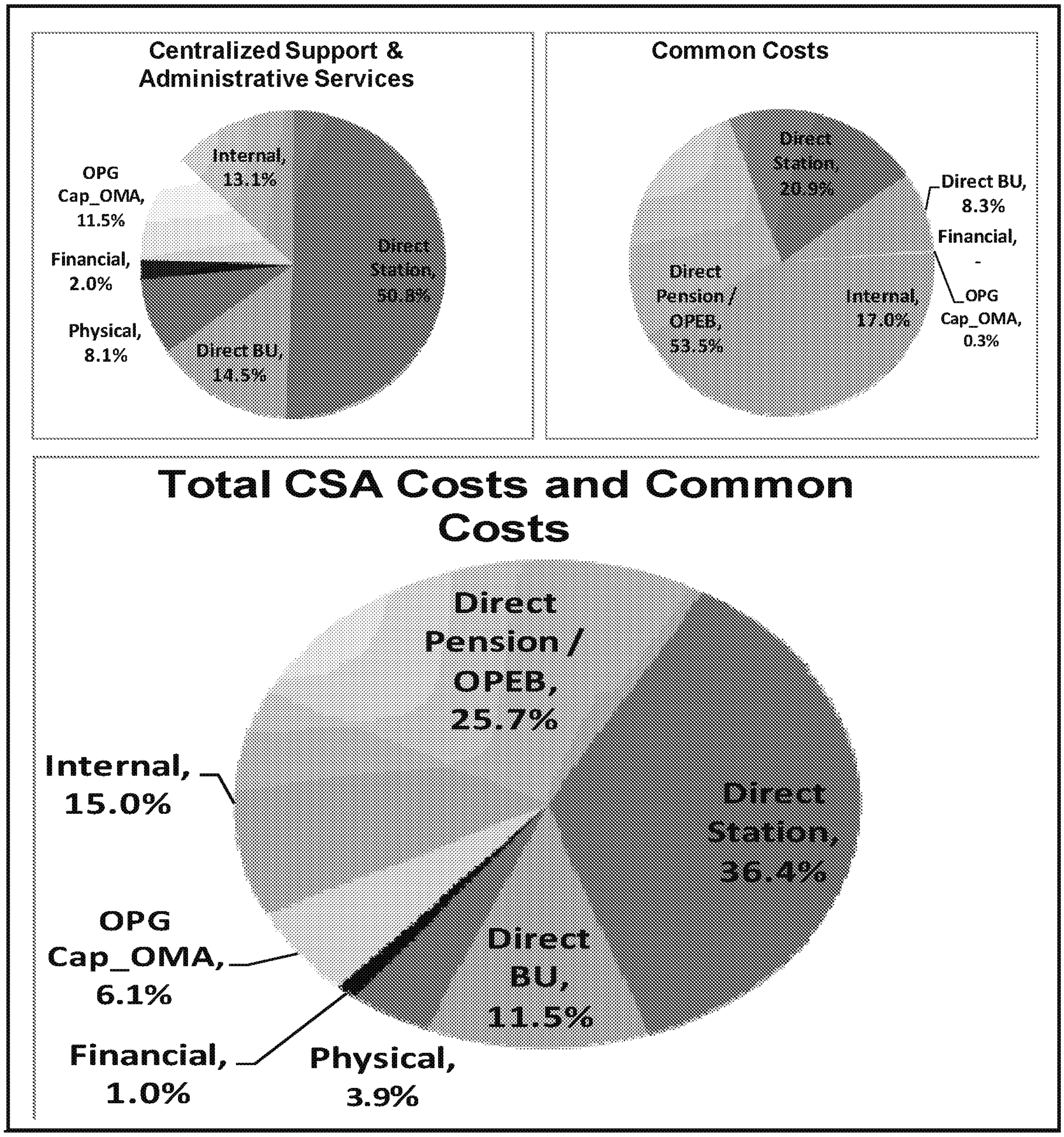
- Specific, indicating specific identification of labour or other resources;
- Estimates, indicating management estimates of time;
- Asset Service Fees, for utilities costs based on location; and
- Pension / OPEB, based on amounts charged to payroll.

Column E shows the allocation type for costs that were not directly assigned, and Column F shows the cost as a percentage of the 2014 budget for the Service Provider.

E. Summary of Cost Driver Types

Table 4 summarizes the types of costs drivers used to distribute CSA Costs and Common Costs (together, CSCC) to the Business Segments and the stations; the percentages are based on the 2014 Budget.

Table 4: Direct Assignments And Cost Drivers Used For Distribution Of CSA Costs and Common Costs To Business Segments



Section VI. 3-Prong Test

As discussed below, the three-prong test applies to corporate centre costs that are allocated among affiliates, and to transactions between affiliates. The CSA costs meet this definition and fall under the test. Common Costs do not fall under the three-prong test; they do not involve services provided or other transactions between affiliates, they are merely reflect how OPG records and pays for these items.

A. Approach to determine OPG's compliance with 3-Prong Test (Task 4)

Background for evaluation of 3-prong test

In its Decision with Reasons for OPG's filing at Docket EB 2007-0905, the OEB wrote, "The Board expects the next independent review to include an evaluation of the cost allocation methodology and consideration of the Board's 3-prong test." In the 2010 Report, OPG's methodology was found to comply with the 3-prong test. The 3-prong test is summarized as follows:

1. Cost incurrence: Were the corporate centre charges prudently incurred by, or on behalf of, the utility for the provision of services required by Ontario ratepayers?
2. Cost allocation: Were the corporate centre charges allocated appropriately to the recipient companies based on the application of cost drivers/allocation factors supported by principles of cost causality?
3. Cost / benefit: Did the benefits to the Company's Ontario ratepayers equal or exceed the costs?

At OPG, many of the shared CSA services are provided to the Service Recipients (i.e., the Business Segments) by dedicated personnel at the Service Providers; therefore the OPG methodology must capture the costs of specific personnel and activities so they can be assigned correctly.

As discussed in Section V, as a result of OPG's Business Transformation, the total dollars in the CSA departments, and in OPG's cost allocation, have increased. The Business Transformation did not cause any costs shifts between Business Segments. The increase in costs allocated to a Business Segment in the allocation process was offset by an equal decrease in directly incurred costs.

In addition, the majority of the costs of the CSA services are integral to running the Business Segments (e.g., human resources and supply chain). The Service Providers for these services and the Service Recipients must work together closely to ensure the needs of the Service Recipients are met, the level of service is appropriate and the costs are correctly assigned or allocated.

Use of surveys

We evaluated OPG's compliance with the 3-prong test in part by asking Service Recipients and Service Providers to complete surveys and by reviewing the completed surveys with them. Each survey question was designed to provide information about one or more of the prongs; similar surveys completed for the 2010 Report were used as a starting point for developing the survey questions.

Selection of Service Recipient and Service Provider Respondents

HSG Group requested that surveys be completed by the following groups:

- *Service Recipients*: Nuclear Business Segment and Hydro Thermal Operations Business Segment, which includes all regulated operations (and some unregulated). These two segments represent over 90% of the allocated CSA costs, and
- *Service Providers*: BAS Chief Information Office, BAS Supply Chain, BAS Real Estate Services, Finance, People & Culture and Corporate Relations & Communication (department in Corporate Office), representing over 80% of CSA Service Provider costs.

These surveys, and our review and follow-up interviews (discussed below), provided sufficient evidence for us to evaluate the 3-prong test and reach our conclusions.

Review of Survey Responses

HSG Group reviewed all of the survey responses. Each of the responses provides information as to whether the services provided are prudently incurred in order to serve to Ontario ratepayers, and how the Service Providers take into account the needs of the Service Recipients in determining the level and quality of service and cost effectiveness.

In addition, HSG Group contacted the survey respondents. The purpose of these discussions was to validate the survey responses, to confirm the respondents' familiarity with the allocation process and methodology and to obtain further information on specific items. We found that the respondents completed the surveys based on their personal experience. The Service Recipients discussed how their Business Segments work with the Service Providers to establish the services to be provided, as well as the level and quality of service, and how these decisions are made. The Service Providers discussed this process from their perspectives.

HSG Group also confirmed that the survey responses applied to costs that are charged through Asset Service Fees.

B. Cost Incurrence

Were the corporate centre charges prudently incurred by, or on behalf of, the utility for the provision of services required by Ontario ratepayers?

Both Nuclear and HTO confirmed the description of the services they receive, and described how each service is used in their respective Business Segments.

Nuclear and HTO explicitly stated that the services they receive from the Service Providers are necessary to running their Business Segments. The descriptions of services received by Nuclear and HTO are detailed and demonstrate familiarity with the nature of the services received, which was confirmed in the interviews with Nuclear and HTO.

HTO stated that the services received are required for it to: 1) fulfill the Shareholder mandate/relationship; 2) maintain stewardship of hydro and thermal assets; 3) ensure compliance with typical corporate governance and the Ontario Business Corporation Act; 4) operate and comply with all external regulatory and other requirements; and 5) ensure proper due diligence in the areas of safety, environment, and risk and asset management.

HTO also stated that there is extensive input and shared decision-making regarding the services provided and level of service, for any item that affects it. For OPG-wide required services (e.g., external financial reporting; compliance with labour laws), HTO follows the requirements established by the corporation.

BAS is the largest service provider, and HTO has determined that approximately 80% of the IT costs charged to it are "core" costs associated with WAN, LAN, specific HTO business systems such as ERIS/EPAS, specific Hydro projects such as fibre optics and SCADA upgrades. The costs are flat or declining over the planning period, and HTO believes they may be able to improve further. HTO confirmed that if the BAS group disappeared, it would have to put in its own systems because they are required.

Nuclear stated that each of the CSA services, and the level of service received, are essential to its operations, and provided examples of how the CSA services are required in its operations. Nuclear also provided examples of how it has been working with

Service Providers to identify and meet its changing needs, and to reduce costs while providing the required levels of service. Nuclear identified instances where it was served by dedicated resources within the Service Providers, but also where the center-led organization is helping to identify and introduce efficiencies.

For example, Nuclear and BAS are increasing efficiency by increasing the automation of data transfers. Nuclear and Supply Chain are working to reduce inventory levels and to remove specialists from the ordering process (but not specification or vendor qualification) for commodity-type consumables. Nuclear relies on People & Culture for succession planning, performance management, shift schedules, training and talent management. In addition, People & Culture is the lead organization for Business Transformation. Finance supports many non-finance initiatives, such as benchmarking studies and demonstrations of prudency of costs to stakeholders.

The Service Providers BAS work with Nuclear, HTO and other users (e.g., Service Providers such as Finance and People & Culture) to determine the services needed and the levels of service. These decisions are based on collaborative cost / benefit analyses. The Service Providers stated that the needs of the users are the primary criteria in determining the services they perform and the level of service they provide. BAS has Customer Relationship Managers who work with users to determine what new projects are needed and what benefits are expected. The users participate in ranking the projects to determine which are approved; the ranking process includes measures of financial return.

While the Service Recipients work closely with BAS to determine the need for and cost of any incremental projects, BAS is responsible to manage its baseline services and related costs. For baseline services, BAS must balance the cost goals established for it against the performance expectations of the Service Recipients. An important reason that BAS is able to do this, is that its costs are scalable due to the structure of its outsourcing contract for many baselines services.

Finance and People & Culture also report that they must balance the cost goals established for them against the performance expectations of the Service Recipients.

<u>Conclusion on Cost incurrence</u>: The Service Recipients / Business Segments have very close working relationships with the Service Providers, and rely on them for many aspects of operations. The Service Providers tailor their services to meet the needs of the Service Recipients, and the levels of service they provide are adequate but not excessive. The Service Providers must balance meeting the balance the cost goals

established for them (top-down) against the performance expectations of the Service Recipients (bottom-up). OPG has controls in place to determine that costs are reasonable based on the requirements of the users. The CSA costs were prudently incurred for the benefit the Service Recipients, to enable them to meet the needs of the Ontario ratepayers they serve.

C. Cost Allocation

Were the corporate centre charges allocated appropriately to the recipient companies based on the application of cost drivers/allocation factors supported by principles of cost causality?

HSG Group reviewed OPG's cost allocation methodology as part of Task 1, Task 2 and Task 3 identified in Table 3.

In addition, HSG Group found that the Service Recipients are familiar with the cost allocation methodology, and understand that costs can be either directly assigned or allocated to their Business Segment. They have the opportunity to challenge both the level of services provided and the costs they are allocated.

HTO believes that OPG's cost allocation methodology is based on "rationale and logic", and has been refined as business activities have changed.

Nuclear reports that they understand which Service Providers their costs are coming from and what they have to do to reduce costs. HSG Group considers the ability of a cost allocation methodology to respond to changes in levels of service, as a strong indicator of its appropriateness.

These are important secondary indicators of the appropriateness of the cost allocation methodology. For example, the ability to produce reasonably stable costs enables Service Recipients to forecast costs. In addition, the ability of a methodology to reflect changes in the level of service received is very important.

Conclusion on Cost allocation: HSG Group reviewed the cost allocation methodology separately, as discussed in Section V of this Report, has concluded that it is appropriate for OPG, and it distributes costs based on direct assignment and cost drivers / allocation factors that are supported by the principles of cost causality. In addition, the Service Recipients are familiar with the cost allocation methodology, and believe the cost allocations are appropriate and reflect differences in levels of service.

D. Cost / Benefit

Did the benefits to the Company's Ontario ratepayers equal or exceed the costs?

Nuclear and HTO work with Service Providers in BAS such as Real Estate & Business Services, Outsourcing and Work Programs and Supply Chain to determine the nature and level of services provided in a collaborative process, and costs are considered in this process. For BAS , many activities and service offerings are discretionary or at least can be provided at varying levels of service, therefore a collaborative planning process is appropriate and provides the opportunity to weigh explicitly the benefits and costs for each potential activity service offering.

As discussed above under *Cost incurrence*, BAS works with the users to rank potential projects; the ranking process includes measures of financial return. BAS manages its baseline costs to meet cost and performance targets; these costs are scalable due to the structure of its outsourcing contract for many baselines services.

Nuclear stated that services and the level of service are tailored to its needs- the level of service received is adequate but not more than is needed.

HTO meets with senior BAS management on a regular basis to validate and prioritize IT base and project work; the objective is to ensure that the IT project plan provides the best overall value for OPG and that it remains consistent with OPG's strategic business direction, strategic IT direction, ROI expectations as well as being consistent with OPG's safety, reliability, regulatory and environmental objectives.

Nuclear and HTO work collaboratively with Service Providers Finance and People & Culture to determine their service requirements, but these Service Providers do not involve them in setting cost budgets. This is appropriate because certain services provided by Finance and People & Culture relate to statutory and legal requirements (e.g. external reporting, taxation, safety), therefore it is not possible to compare benefits and costs for an individual business unit as this work is executed in order to operate the entire corporation of which the business is a part.

In addition, services can be challenged by the Executive Leadership Team, where the cost / benefit value of the service to the company as a whole can be evaluated.

Corporate Relations and Communications helps both Nuclear and HTO to build relationships with stakeholders including towns, cities, First Nations and community groups.

Supply Chain was formed as a result of BT initiatives. Supply chain organizations from three business units were amalgamated to form one centrally lead organization in May 2012. In 2013 and the near future, the people that transferred to Supply Chain still work exclusively (or nearly exclusively) on the Business Segments from which they transferred. The costs incurred by Supply Chain, and distributed to the Business Segments, are driven by the purchasing requirements of the businesses.

OPG uses benchmarks extensively to identify opportunities to improve service and reduce costs, and works with other businesses to develop plans to do so.

<u>Conclusion on Cost / benefit</u>: Service Providers explicitly consider the needs of the Service Recipients in developing their budgets, and often weigh explicitly the benefits and costs of activities they are considering. Service Providers are continually evaluating how to meet the needs of the Service Recipients and other users, while meeting cost targets; to do so they are actively planning work and managing costs.

E. Overall Conclusion on 3-Prong Test

The Service Providers and Service Recipients (Business Segments and other users) at OPG work together in a collaborative effort to determine what CSA services should be provided and what should be the level and quality of service. There is continual communication in both directions. Both Service Providers and Service Recipients discussed the need to meet service requirements, to reduce costs and to improve both continuously. As a result, services and the level and quality of service are tailored to meet the needs of the Service Recipients, and the levels of service they provide are adequate but not excessive.

Service Providers are measured by OPG senior management against spending targets, including comparisons to industry benchmarks. Service Providers continually balance the needs of the Service Recipients against the costs to provide the services.

In conclusion, the CSA costs are prudently incurred for the benefit the Service Recipients (and other users), to enable them to meet the needs of the Ontario ratepayers served by OPG. The responses to the surveys, including the interviews conducted by HSG Group, as well as other information reviewed, provide sufficient, reliable evidence that OPG's allocated CSA costs meet the requirements of the OEB's 3 prong test.

Section VII. Asset Service Fees

OPG generating Business Segments are also charged Asset Service Fees ("ASFs") for the use of certain assets owned and operated by OPG. A portion of the costs charged is included in the CSA costs. The ASFs are cost based charges. The assets for which ASFs are computed include Real Estate assets and IT assets. HSG Group was engaged to evaluate the ASF methodology.

ASFs include depreciation expense, return on net book value including income taxes, and operating costs not otherwise charged (e.g., property taxes). In the 2006 Report and 2010 Report, the methodology OPG uses to determine ASFs and to allocate them to the users of the assets was found to be reasonable. OPG confirms that the same approach is used at present, and HSG Group believes OPG's approach remains reasonable based on the operation of OPG's business and the principles of cost causality.

Asset Service Fees for Newly Regulated Hydro

Hydroelectric generating assets that are currently unregulated and not subject to Hydro-electric Supply Agreements ("HESAs") with the Ontario Power Authority may become subject to regulation by the OEB in the future ("newly regulated hydro").

OPG has facilities such as control dams and service centers that support both newly regulated hydro stations and stations that sell output pursuant to a HESA.

For assets where more than 90% of the aggregate station capacity served represents newly regulated hydroelectric capacity, the asset is considered a newly regulated hydro-electric facility and is included in the regulated rate base.

Other joint-use assets are not included in the regulated rate base; the newly regulated hydroelectric stations and HESA stations are charged a cost-based ASF for the use of these assets, based on the capacity of the stations (i.e., MW). The asset fee structure is the same used to charge certain real estate and corporately held IT costs to regulated operations.

HSG Group believes that OPG's treatment of these assets is reasonable. It is reasonable for assets used exclusively or nearly-exclusively by a business to be directly assigned to that business, and the application of cost-based ASFs reflects the operation of OPG's business and cost causality.

Section VIII. SUMMARY OF CONCLUSIONS

OPG's cost allocation methodology for Centralized Services and Common Costs (including Asset Service Fees) distributes / charges those costs to Business Segments and to stations in a manner that meets current best practices and is consistent with cost allocation precedents established by the OEB. The responses provided by Service Recipients and Service Providers to the surveys, and the interviews conducted by HSG Group as well as other information reviewed, provide sufficient, reliable evidence that OPG's allocation of CSA costs meets the OEB's 3 prong test. The results of the allocation based on the 2014 year in the Business Plan 2013-15 are presented in Table 5.

Table 5: Results of Allocation for 2014 in Business Plan 2013-15 ($ millions)

Service Provider	Nuclear	Hydro-Regulated	Hydro Unregulated	Thermal	Other Business	Total
BAS - Outsourcing	$57.3	$2.7	$6.4	$3.2	$3.2	**$ 72.8**
BAS- Work Programs	33.3	3.4	7.7	5.2	3.0	**52.6**
BAS – Supply Chain	60.8	1.4	2.5	2.9	1.7	**69.3**
BAS - Real Estate	114.2	1.5	3.2	4.3	1.4	**124.6**
People & Culture	92.1	4.4	9.3	7.5	3.9	**117.2**
Finance	45.5	3.4	6.0	4.6	2.7	**62.2**
Corporate Centre	32.7	5.1	11.6	6.7	2.9	**59.0**
CO&E	17.9	8.0	6.4	5.8	3.9	**42.0**
CSA Groups	**453.8**	**29.9**	**53.1**	**40.2**	**22.7**	599.7
Hydro / OSL Common	3.8	7.6	56.5	8.5	0.2	**76.6**
Centrally held costs	358.1	21.1	49.1	49.0	2.4	**479.7**
Total	**$ 815.7**	**$ 58.6**	**$ 158.7**	**$ 97.7**	**$ 25.3**	**$1,156.0**

BAS = Business & Administrative Services; CO&E = Commercial Operations & Environment

OPG CENTRALIZED SUPPORT AND ADMINISTRATIVE COSTS
IEW OF CENTRALIZED SUPPORT AND ADMINISTRATIVE COST ALLOCATION METHODOL
DEPARTMENTAL BUDGETS FOR 2014 (BP 2013-2015)

DEPARTMENT / Activities	2014 Budget $000s	% of CSA Costs	% of All Costs
People & Culture	$117,155	19.5%	10.1%
Corporate Center Group			
Executive Office	4,959	0.8%	0.4%
Law	7,358	1.2%	0.6%
Strategic Initiatives	4,355	0.7%	0.4%
Business Transformation Project	3,650	0.6%	0.3%
Corporate Relations and Communications	18,079	3.0%	1.6%
Corporate Executive Operations	3,457	0.6%	0.3%
Corporate Business Development	17,177	2.9%	1.5%
	59,035	9.8%	5.1%
Finance Group			
Finance & Chief Controller	42,847	7.1%	3.7%
Treasury	2,288	0.4%	0.2%
Investment Planning	3,463	0.6%	0.3%
Assurance	9,468	1.6%	0.8%
Fund Management	1,448	0.2%	0.1%
CFO Office	2,637	0.4%	0.2%
	62,150	10.4%	5.4%
Commercial Operations & Environment	42,010	7.0%	3.6%
	42,010	7.0%	3.6%
BS&IT Group			
BS&IT Outsourcing	72,782	12.1%	6.3%
BS&IT Work Programs	52,637	8.8%	4.6%
Supply Chain	69,318	11.6%	6.0%
	194,736	32.5%	16.8%
Real Estate Group			
Real Estate Services	29,511	4.9%	2.6%
Enterprise Services	43,758	7.3%	3.8%
Facilities Services	47,838	8.0%	4.1%
Fleet Services	377	0.1%	0.0%
Vice President's Office	3,112	0.5%	0.3%
	124,596	20.8%	10.8%
Total CSA Costs (excl. Centrally Held and Hydroelectric	**599,681**	**100.0%**	**51.9%**
Hydroelectric Common Costs	76,649		6.6%
Centrally Held Costs	479,648		41.5%
Total	**$1,155,978**		**100.0%**

OPG CENTRALIZED SUPPORT AND ADMINISTRATIVE COSTS
COST ALLOCATION METHODOLOGY REVIEW
SUMMARY OF DISTRIBUTIONS
BP2014 - BP2013-2015

		DISTRIBUTION TO BUSINESS UNITS			
		Direct Assignment		Allocation	
DEPARTMENT / Activities	Activity % of Dept.	Method	BU Direct Assign %	Cost Driver	BU Allocation %
(A)	(B)	(C)	(D)	(E)	(F)
PEOPLE & CULTURE					
Fleet Operations Training	22.6%	Specific/Estimates	22.6%		-
Total Rewards & Solutions	8.7%	Specific/Estimates	2.5%	FTEs	6.2%
Fleet Support Services	8.6%	Specific/Estimates	8.6%	FTEs	0.0%
Business Partners Hydro Thermal	8.1%		8.1%		-
Safety & Wellness	8.1%	Specific/Estimates	5.6%	FTEs	2.5%
Fleet Maintenance Training	7.9%	Specific/Estimates	7.9%	FTEs	0.0%
VP Learning & Development and Other Training	7.9%	Specific/Estimates	7.8%	FTEs	0.1%
Fleet Simulator & CBT	7.6%	Specific/Estimates	7.6%		-
Employee & Labour Relations	4.1%	Specific/Estimates	1.4%	FTEs	2.7%
Senior Vice President's Office	3.6%		-	FTEs	3.6%
Talent Management & Business Change	3.5%	Specific/Estimates	2.2%	FTEs	1.3%
Business Partners Nuclear	3.2%	Specific/Estimates	3.2%		-
Training Primary Pay	1.7%	Specific/Estimates	1.7%	FTEs	0.0%
HR Labour Adjustment	1.7%		-	FTEs	1.7%
Business Partners Corporate	1.5%	Estimates	0.8%	FTEs	0.7%
HR Primary Pay	1.3%		-	FTEs	1.3%
	100.0%		79.9%		20.1%
CORPORATE CENTER GROUP- EXECUTIVE OFFICE					
Executive Office	100.0%		-	Blend - OM&A / Capital	100.0%
	100.0%		-		100.0%
CORPORATE CENTER GROUP- LAW					
Law Division	96.8%	Specific/Estimates	67.4%	Blend - OM&A / Capital	29.3%
Law Payroll	1.7%		-	Blend - OM&A / Capital	1.7%
SVP Office	1.6%		-	Blend - OM&A / Capital	1.6%
	100.0%		67.4%		32.6%
CORPORATE CENTER GROUP- STRATEGIC INITIATIVES					
Strategic Initiatives	100.0%		-	Blend - OM&A / Capital	100.0%
	100.0%		-		100.0%
CORPORATE CENTER GROUP- BUSINESS TRANSFORMATION PROJECT					
Business Transformation Project	100.0%		-	Blend - OM&A / Capital	100.0%
	100.0%		-		100.0%
CORPORATE OFFICE - CORPORATE RELATIONS & COMMUNICATIONS					
Corp & Comm Centre	54.9%	Specific/Estimates	29.6%	Blend - OM&A / Capital	25.3%
Communication Services	24.3%	Specific/Estimates	19.4%	Blend - OM&A / Capital	4.9%
Stakeholder & Government Relations	19.3%	Specific/Estimates	9.9%	Blend - OM&A / Capital	9.4%
Corp & Comm Payroll	1.5%		-	Blend - OM&A / Capital	1.5%
	100.0%		58.9%		41.1%
CORPORATE OFFICE - CORPORATE EXECUTIVE OPERATIONS					
Corporate Executive Operations	100.0%		-	Blend - OM&A / Capital	100.0%
	100.0%		-		100.0%

OPG CENTRALIZED SUPPORT AND ADMINISTRATIVE COSTS
COST ALLOCATION METHODOLOGY REVIEW
SUMMARY OF DISTRIBUTIONS
BP2014 - BP2013-2015

		DISTRIBUTION TO BUSINESS UNITS			
		Direct Assignment		Allocation	
DEPARTMENT / Activities	Activity % of Dept.	Method	BU Direct Assign %	Cost Driver	BU Allocation %
CORPORATE OFFICE - CORPORATE BUSINESS DEVELOPMENT					
Hydro Business Development OM&A Projects	20.6%	Specific/Estimates	20.6%		-
Enterprise Risk Management	18.5%	Estimates	0.9%	Blend - OM&A / Capital	17.6%
Thermal Business Development	18.4%	Specific/Estimates	18.4%		-
Corporate Strategy	11.8%		(0.4%)	Blend - OM&A / Capital	12.2%
CBD Payroll	8.5%		-	Blend - OM&A / Capital	8.5%
Business Development Services	7.1%	Specific	7.1%		-
Hydro Business Development	6.5%	Specific/Estimates	6.5%		-
SVP Office	5.0%		-	Blend - OM&A / Capital	5.0%
CBD VP Office	3.5%	Specific/Estimates	3.5%		-
	100.0%		56.8%		43.2%
FINANCE GROUP- FINANCE & CHIEF CONTROLLER					
Business Planning & Reporting	19.4%	Estimates	1.2%	Blend - OM&A / Capital	18.2%
Nuclear Controllership	19.2%	Estimates	19.2%		-
Accounting	16.5%	Estimates	7.2%	Blend - OM&A / Capital	9.3%
Corporate Financial Processing Services	15.1%	Estimates	3.1%		11.9%
Hydro Thermal Controllership	12.7%	Estimates	12.7%		-
Corporate Functions Controllership	8.4%	Estimates	0.8%	Blend - OM&A / Capital	7.6%
Income & Commodity Tax	6.6%		-	Blend - OM&A / Capital Blend - Material & EPS	6.6%
VP Finance, Chief Controller & CAO Office	2.1%			Blend - OM&A / Capital	2.1%
	100.0%		44.4%		55.6%
FINANCE GROUP- TREASURY					
Treasury Financing & Operations	100.0%	Estimates	11.8%	Blend - OM&A / Capital	88.2%
	100.0%		11.8%		88.2%
FINANCE GROUP- INVESTMENT PLANNING					
Investment Planning	100.0%	Specific/Estimates	84.2%	Blend - OM&A / Capital	15.8%
	100.0%		84.2%		15.8%
FINANCE GROUP- ASSURANCE					
Nuclear Oversight	55.8%	Specific/Estimates	55.8%		-
Internal Audit	44.2%	Specific/Estimates	17.9%	Blend - OM&A / Capital Re-allocate EM	26.3%
	100.0%		73.7%		26.3%
FINANCE GROUP- FUND MANAGEMENT					
Fund Management Services	100.0%	Specific	62.5%	Blend - OM&A / Capital	37.5%
	100.0%		62.5%		37.5%

OPG CENTRALIZED SUPPORT AND ADMINISTRATIVE COSTS
COST ALLOCATION METHODOLOGY REVIEW
SUMMARY OF DISTRIBUTIONS
BP2014 - BP2013-2015

		DISTRIBUTION TO BUSINESS UNITS			
		Direct Assignment		Allocation	
DEPARTMENT / Activities	Activity % of Dept.	Method	BU Direct Assign %	Cost Driver	BU Allocation %
FINANCE GROUP- CFO OFFICE					
CFO Primary Pay	72.9%		-	Internal - Finance Overall	72.9%
CFO Office	21.0%		-	Internal - Finance Overall FTE	21.0%
Pension Fund Review	6.1%		-	FTE	6.1%
	100.0%		-		100.0%
COMMERCIAL OPERATIONS & ENVIRONMENT					
Environment	21.2%	Specific/Estimates	18.8%	Blend - OM&A & Capital	2.3%
Integrated Revenue Planning	16.8%	Specific/Estimates	8.7%	Blend - OM&A & Capital Re-allocate EM	8.1%
Market Operations	14.6%	Specific	14.6%		-
OEB	13.4%	Specific	13.4%		-
Regulatory Affairs	9.8%	Specific/Estimates	6.4%	Blend - OM&A & Capital Re-allocate EM	3.5%
Term Trading & Outage Management	9.3%	Specific/Estimates	9.1%	Blend - OM&A & Capital	0.2%
Fuels	6.4%	Specific/Estimates	5.5%	Blend - OM&A & Capital	0.8%
Commerical Services	4.4%	Specific	4.4%		-
CO&E Payroll variance	2.4%		-	Internal	2.4%
CS&C - Bruce Relationships	1.4%	Specific	1.4%		-
CO&E - SVP's Office	0.3%		-	Blend - OM&A & Capital	0.3%
	100.0%		82.4%		17.6%
BAS GROUP- Outsourcing					
Infrastructure Mgmt Service	31.3%	Specific	24.9%	Primary driver - LAN ID's & storage	6.4%
Application Mgmt Service	13.0%	Specific	9.7%	Primary driver - Users of variable applications maintenance	3.3%
Data Centre Services	9.4%	Specific	8.3%	Primary driver - Data Centre support	1.0%
Disaster Recovery & BCP Services	1.4%	Specific	0.9%	Primary driver - Allocation of major applications	0.4%
Service Management Services	1.2%	Specific/Estimates	0.8%	Primary driver - Service management support	0.4%
Data & Voice Network Services	0.9%	Specific/Estimates	0.8%	Primary driver - Field technician support	0.1%
Common Base Services	0.6%	Estimates	0.5%	Lan ID's	0.1%
Application Maintenance Services	0.2%		-	Primary driver - Allocation of fixed application maintenance support	0.2%
End Users Services	0.0%	Specific	0.0%	Primary driver - end Uers	

OPG CENTRALIZED SUPPORT AND ADMINISTRATIVE COSTS
COST ALLOCATION METHODOLOGY REVIEW
SUMMARY OF DISTRIBUTIONS
BP2014 - BP2013-2015

		DISTRIBUTION TO BUSINESS UNITS			
		Direct Assignment		Allocation	
DEPARTMENT / Activities	Activity % of Dept.	Method	BU Direct Assign %	Cost Driver	BU Allocation %
BAS GROUP- WORK PROGRAMS					
Application Software	9.9%	Specific/Estimates	7.0%	Primary driver - Lan ID's based on major users	2.9%
Telecom	7.0%	Estimates	5.0%	Primary Driver - Historical data / Management estimate	2.0%
IMO Services	5.5%	Estimates	3.6%	Primary Driver - Management estimate	1.9%
IM Projects	2.8%	Estimates	1.9%	Primary Driver - Management estimate	0.8%
SVP - BAS	2.7%	Estimates	-	Blend - OM&A & Capital Internal- CIO Allocation	2.7%
IM Transition	1.8%	Estimates	1.1%	Primary Driver - Management estimate	0.8%
Hardware	1.6%	Specific/Estimates	1.3%	Lan ID's	0.3%
Non-Capital Projects	10.7%	Specific / Estimates	7.4%		3.2%
	100.0%		73.3%		26.7%
Note: Outsourcing Contract renegotiated for 2010					
Supply Chain GROUP - WORK PROGRAMS					
Nuclear Supply Chain (new)	93.5%	Estimates	90.2%	Blend - OM&A & Capital	3.3%
Corporate Supply Chain	6.5%	Specific/Estimates	5.0%	Blend - OM&A & Capital	1.5%
	100.0%		95.2%		4.8%
REAL ESTATE GROUP- REAL ESTATE SERVICES					
Rent & Utilities- Nuclear Facilities	76.3%	Specific	76.3%		-
Rent & Utilities- OPG Head Office	18.1%	Service Fees	18.1%		-
Labor Costs	9.3%	Estimates	9.3%		-
Rent & Utilities- Kipling Site	7.4%	Service Fees	7.4%		-
External Purchase Services	5.1%	Specific/Estimates	5.1%		-
Rent & Utilities- Wesleyville Site	2.0%	Service Fees	2.0%		-
Rent & Utilities- Hydro Thermal	1.0%	Specific	1.0%		-
Murray St/Tenant Imp/COGS (Other Business)	(19.2%)	Specific	(19.2%)		-
	100.0%		100.0%		0.0%
REAL ESTATE GROUP- ENTERPRISE SERVICES					
NSS Admin	35.7%	Estimates	35.7%		-
Records/Admin	31.6%	Estimates	31.6%		-
Business Services East	23.9%	Estimates	23.9%		-
Business Services - Office Services	8.8%	Estimates	2.5%	FTEs	6.2%
	100.0%		93.8%		6.2%

OPG CENTRALIZED SUPPORT AND ADMINISTRATIVE COSTS
COST ALLOCATION METHODOLOGY REVIEW
SUMMARY OF DISTRIBUTIONS
BP2014 - BP2013-2015

		DISTRIBUTION TO BUSINESS UNITS			
		Direct Assignment		Allocation	
DEPARTMENT / Activities	Activity % of Dept.	Method	BU Direct Assign %	Cost Driver	BU Alloc-ation %
REAL ESTATE GROUP- FACILITY SERVICES					
Facility Services Nuclear	72.1%	Specific/Estimates	72.1%		-
Facility Services Central	8.1%	Service Fees	0.8%	Internal - Corp. Functions Overall Re-allocate EM	7.3%
Facility Services West - Admin	5.7%	Service Fees	4.4%	Internal - Corp. Functions Overall Re-allocate EM	1.3%
Facility Services East	4.7%	Estimates	4.5%	Internal - Corporate Functions Overall	0.2%
Facility Services West - Bruce	3.5%	Estimates	3.5%		-
OPG Head Office	3.1%	Service Fees	1.5%	Internal - Corporate Functions Overall	1.6%
Facility Services Admin	2.8%	Estimates	0.9%	Internal - Corporate Functions Overall	2.0%
	100.0%		87.6%		12.4%
REAL ESTATE GROUP- FLEET SERVICES					
Fleet Services	100.0%		-	FTEs	100.0%
	100.0%		-		100.0%
REAL ESTATE GROUP- VICE PRESIDENT					
Real Estate Pay	86.8%		-	Internal - Real Estate Overall	86.8%
Real Estate Vice President's Office	13.2%		-	Internal - Real Estate Overall	13.2%
	100.0%		-		100.0%
CENTRALLY HELD COSTS					
Pension / OPEB- Amortization of Deferred Costs	79.1%	Pension / OPEB Costs	61.6%	Pension / OPEB Costs	17.5%
Employee Incentives	6.1%	Specific (historical)	6.1%		-
Insurance Premiums	4.0%	Specific	4.0%		-
Ontario Nuclear Funds Management	2.7%	Specific	2.7%		-
Provincial Fee- CNSC	1.5%	Specific	1.5%		-
Vacation Accrual	1.5%	Labour costs	1.5%		-
Fiscal Calendar Payroll Adjustment	1.2%	Labour costs	1.2%		-
First Nations Provision	1.0%	Specific	1.0%		
Burden Rate True-up	1.0%	Specific	1.0%		-
BS&IT Contingency	1.0%			BT Overall allocator	1.0%
Pension Guarantee Fee	0.4%			Blend - OM&A & Capital	0.4%
Pandemic Provision	0.4%	Specific	0.4%		-
Bruce - LLW/ILW	0.0%	Specific	0.0%		-
	100.0%		81.0%		19.0%

OPG CENTRALIZED SUPPORT AND ADMINISTRATIVE COSTS
COST ALLOCATION METHODOLOGY REVIEW
SUMMARY OF DISTRIBUTIONS
BP2014 - BP2013-2015

		DISTRIBUTION TO BUSINESS UNITS			
		Direct Assignment		Allocation	
DEPARTMENT / Activities	Activity % of Dept.	Method	BU Direct Assign %	Cost Driver	BU Allocation %
HYDROELECTRIC THERMAL BUSINESS UNIT COMMON SUPPORT COSTS					
Engineering & Technical Services	72.0%	Specific	72.0%		-
Strategy & Business Support	11.9%	Specific	11.9%		-
Dam & Public Safety	5.4%	Specific	5.4%		-
Project and Delivery Execution	3.8%	Specific	3.8%		-
Hydro Thermal Pay	3.2%	Estimate	3.2%		-
Executive Vice President's Office	3.2%	Specific	3.2%		-
Coal Closure	0.6%	Specific	0.6%		-
	100.0%		100.0%		0.0%
OTTAWA-ST. LAWRENCE COMMON SUPPORT COSTS					
Production/Project Mgt - Madawaska	46.6%	Specific	46.6%		-
Production/Project Mgt - Ottawa	39.5%	Specific	39.5%		-
Compliance & Environment	4.7%	Specific	4.7%		-
Drafting Services	1.1%	Specific	1.1%		-
Engineering & Technical Services	3.8%	Specific	3.8%		-
Programming	2.4%	Specific	2.4%		-
Plant Group Management	3.1%	Specific	3.1%		-
Asset Management & Technical Support Services	(0.1%)	Specific	(0.1%)		-
Other	(0.9%)	Specific	(0.9%)		-
	100.0%		100.0%		0.0%

OPG CENTRALIZED SUPPORT AND ADMINISTRATIVE COSTS
COST ALLOCATION METHODOLOGY REVIEW
BUSINESS TRANSFORMATION TRANSFERS

Business Area		2013 Budget, $ millions		
		Transfers Out	Transfers In	Net Effect
Service Recipients (Business Segments):				
Nuclear Generation	*Details below*	$215,101	$2,378	($212,723)
Hydro / Thermal Generation	*Details below*	30,392		(30,392)
Service Providers:				
Commerical Operations and Environment		17,973	10,285	(7,688)
Business Applications & Services			143,920	143,920
Finance		4,595	13,264	8,669
People & Culture		2,607	66,910	64,303
Corporate Business Development & Risk			16,428	16,428
Corporate Relations & Communications			20,239	20,239
Corporate Executive Operations		439		(439)
Law		3,090		(3,090)
Strategic Initiatives			773	773
		$274,197	$274,197	$0

Transferred from Nuclear to:	
Commerical Operations and Environment	$5,504
Business Applications & Services	139,806
Finance	12,972
People & Culture	56,819
	$215,101

Transferred from Hydro / Thermal to:	
Commerical Operations and Environment	$4,334
Business Applications & Services	4,114
People & Culture	7,001
Corporate Business Development & Risk	12,122
Corporate Relations & Communications	2,048
Strategic Initiatives	773
	$30,392

RESUME OF
HOWARD S. GORMAN
PRESIDENT – HSG GROUP, INC.

SUMMARY

Mr. Gorman has more than 25 years of experience in the energy industry, including 15 years in rate and regulatory proceedings, and more than 30 years experience overall in accounting, finance and rate and regulatory matters.

Mr. Gorman has testified as an expert witness regarding utility revenue requirements, class cost of service, revenue allocation and rate design. He has testified as an expert witness before the Massachusetts Department of Public Utilities, New Jersey Board of Public Utilities, New Hampshire Public Utilities Commission, New York State Public Service Commission, Ontario Energy Board, Pennsylvania Public Utility Commission and Rhode Island Public Utilities Commission.

Mr. Gorman has performed financial analyses of energy infrastructure projects for acquisitions and in support of due diligence for financing, and has negotiated and completed construction and term loans, tax-exempt and taxable bonds and subordinated debt. His experience includes financial modeling, financial analysis and forecasting.

Mr. Gorman also has experience in financial accounting, as Controller and Treasurer of Trigen Energy Corporation, where he built the finance function, managed subsidiary controllers and supported an IPO with NYSE listing.

PROFESSIONAL EMPLOYMENT

2010 - Present	HSG Group, Inc. • *President*
1997 - 2010	Black & Veatch Corporation (R.J. Rudden Associates, Inc. before 2005) • *Principal Consultant*
1995 - 1997	Independent Consultant
1987 – 1995	Trigen Energy Corporation • 1987-1993 *Corporate Controller*; Trigen was formed in 1987 • 1993-1995 *Treasurer*; Trigen had IPO with NYSE listing in 1994
1982 - 1987	Coleco Industries, Inc. • *Director, Treasury*
1976 - 1979	Touche Ross & Co. • *Staff Accountant*

PROFESSIONAL EXPERIENCE

Rate and Regulatory Support for Utilities

Mr. Gorman has provided rate and regulatory support for numerous electric and gas utilities in several jurisdictions, including performing the following:

- Developing utility revenue requirements
- Performing class cost allocation studies and marginal cost studies
- Recommending class revenue allocation
- Analyzing and recommending rate design structures
- Reviewing interaffiliate cost allocation methodology

A list of rate case dockets in which Mr. Gorman has provided expert testimony is presented in the table '**Expert Testimony**' at the end of this resume.

Energy Project Analysis

Mr. Gorman has performed financial analyses of energy-related assets, including electric and gas distribution companies, power plants and transmission operators. These analyses included developing cash flows and financial statements for both regulatory and accounting purposes, and included review of assumptions, analysis of data, modeling, sensitivity testing and stress testing.

Among these analyses are: valuations of power plants, financial projections for cogeneration heat and power plants and energy companies for the purpose of acquisition, valuation of waste-to-energy assets, valuation of a publicly traded multi-jurisdiction utility, and assessment of strategic fit and valuation for a utility considering diversifying into energy-related services.

Energy Project Financing

Mr. Gorman has sourced, structured, negotiated and completed transactions including construction and term loans, tax-exempt bonds, taxable bonds, subordinated debt and asset-backed (receivables and inventory) revolving credit facilities.

Mr. Gorman has supported energy projects in connection with due diligence for financing, including contract review, financial modeling, supply analysis, forward price projections, and economic valuation with cash flow forecasting, and the identification, assessment and mitigation of financial and operating risks for the project and its investors.

Financial Management

Mr. Gorman has extensive experience in financial accounting. As Controller and Treasurer of Trigen Energy Corporation, he built the finance and accounting function, developed reports, procedures and management tools, and managed subsidiary controllers across North America, including an IPO with NYSE listing (1994).

He managed the corporate insurance portfolios and the benefit plans for Trigen Energy Corporation and for Coleco Industries.

Computer Modeling and Decision Support

Mr. Gorman is an accomplished modeler with expertise in spreadsheet and database applications, as well as the use of programming tools. He has developed analytical tools to perform valuations, projections and simulations. These models have been applied to financial analysis, cost allocations, rate design and pricing, forecasting revenue requirements, numerous tax and accounting matters, supply modeling and optimizations. Several of these models have contained interactive modules for automated scenario testing and sensitivity analysis.

Publications And Presentations

"What Wall Street Needs From FERC," published in R. J. Rudden Financial, LLC's *Energy Capital Markets Report*, September 2002

"A Balanced Look at Balance Sheets," published in R.J. Rudden Financial, LLC's *Energy Capital Markets Report,* June 2002

"From Wires To Riches: Shareholder Value Creation In The T&D Business," April 2002 (co-authored).

"Assessment of Retail Choice Programs," presented at the American Gas Association Rate and Strategic Issues Committee Conference, March 2002

"Value Creation With Transmission Assets," quoted in *Electrical World's Special Edition Quarter 1, 2002*, March 2002

"The Remarkable Story on Enron," published in Scudder's *Annual End of Year Issue*, December 2001

Education

New York University, B.S., Accounting, 1976

Harvard Business School, MBA, 1981

Expert Testimony Submitted by Howard S. Gorman				
Jurisdiction	**Docket**	**Client**	**Date**	**Subject Matter**
Pennsylvania	R-2013-2372129	Duquesne Light Company	2013	Electric class cost of service; revenue allocation; rate design
New Hampshire	DE13-063	Granite State Electric Company	2013	Electric class cost of service (marginal cost); revenue allocation; rate design
New York	12-E-0201	Niagara Mohawk Power Corporation	2012	Electric class cost of service; revenue allocation
Rhode Island	RIPUC 4323	Narragansett Electric	2012	Electric class cost of service
New York	11-E-0590	Village of Rockville Centre	2011	Electric revenue requirements; rate design; sales forecast
New York	11-G-0142	Chautauqua Utilities, Inc.	2011	Gas revenue requirements, rate design
Pennsylvania	R-2010-2179103	Kellogg Company (intervener)	2010	Water class cost of service; revenue allocation
Pennsylvania	R-2010-2179522	Duquesne Light Company	2010	Electric class cost of service; revenue allocation; rate design
Pennsylvania	R-2010-2172662	Wellsboro Electric Company	2010	Electric revenue requirements, class cost of service, revenue allocation, rate design
Pennsylvania	R-2010-2172665	Citizens' Electric Company of Lewisburg, PA	2010	Electric revenue requirements, class cost of service, revenue allocation, rate design
Pennsylvania	R-2010-2174470	Valley Energy, Inc.	2010	Gas revenue requirements, rate design
Pennsylvania	R-2010-2161592	PECO Energy (Gas)	2010	Gas class cost of service; revenue allocation; rate design
Pennsylvania	R-2010-2161575	PECO Energy (Electric)	2010	Electric class cost of service; revenue allocation; rate design

Expert Testimony Submitted by Howard S. Gorman				
Jurisdiction	**Docket**	**Client**	**Date**	**Subject Matter**
New York	10-E-0050	Niagara Mohawk Power Corporation	2010	Electric class cost of service
New York	09-E-0862	Jamestown Board of Public Utilities	2009	Electric revenue requirements
Pennsylvania	R-2009 2139884	Philadelphia Gas Works	2009	Gas class cost of service; revenue allocation
Rhode Island	RIPUC 4065	Narragansett Electric	2009	Electric class cost of service; revenue allocation; rate design
Massachusetts	DPU 09-39	Massachusetts Electric and Nantucket Electric	2009	Electric revenue requirements; adjustment mechanisms; class cost of service; revenue allocation; rate design
Pennsylvania	R-2008-2028394	PECO Energy (Gas)	2008	Gas class cost of service; revenue allocation; rate design
Pennsylvania	R-00072350	Wellsboro Electric Company	2007	Electric revenue requirements; rate design
Pennsylvania	R-00072348	Citizens' Electric Company of Lewisburg, PA	2007	Electric revenue requirements; rate design
Pennsylvania	R-00072349	Valley Energy, Inc.	2007	Gas revenue requirements; rate design
Pennsylvania	R-00061931	Philadelphia Gas Works	2006	Gas class cost of service; revenue allocation; rate design
New York	06-E-0911	Village of Freeport	2006	Electric revenue requirements; rate design
Ontario	EB-2007-0905 et al	Ontario Power Generation Inc.	2006, 2010	Electric Cost allocation methodology
Pennsylvania	R-00061346	Duquesne Light Company	2006	Electric class cost of service; revenue allocation; rate design

Expert Testimony Submitted by Howard S. Gorman				
Jurisdiction	**Docket**	**Client**	**Date**	**Subject Matter**
Ontario	EB-2005-0378 et al	Hydro One Networks Inc.	2005, 2006, 2008, 2009, 2010, 2012	Electric Transmission and Distribution Cost allocation; OH capitalization rates
New York	03-E-1568	Village of Rockville Centre	2003	Electric revenue requirements; rate design; sales forecast
New Jersey	ER02080506 et al	Gerdau AmeriSteel aka Co-Steel (intervenor)	2002	Electric cost allocation and rate design; industrial rates
New Jersey	ER02050303 et al	Gerdau AmeriSteel aka Co-Steel (intervenor)	2002	Electric cost allocation and rate design; industrial rates
Pennsylvania	M-00021612	Philadelphia Gas Works	2002	Gas rate unbundling
Pennsylvania	R-00017034	Philadelphia Gas Works	2002	Gas class cost of service
Pennsylvania	R-00006042	Philadelphia Gas Works	2001	Gas class cost of service; recovery of fixed costs

Filed: 2013-09-27
EB-2013-0321
F5-6-1

NIAGARA DIVERSION

TUNNEL REPORT

Prepared for Ontario Power Generation

Roger C. Ilsley

9 September 2013

Page of Contents

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 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.