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Supplementary Information

Presentation from Natural Resources Canada

In the Matter of

Ontario Power Generation Inc.

Proposed Environmental Impact Statement for OPG's Deep Geological Repository (DGR) Project for Low and Intermediate Level Waste

Joint Review Panel

September 16 to October 12, 2013

Renseignements supplémentaires

Présentation de Ressources naturelles Canada

À l'égard de

Ontario Power Generation Inc.

Étude proposée pour l'énoncé des incidences environnementales pour l'Installation de stockage de déchets radioactifs à faible et moyenne activité dans des couches géologiques profondes

Commission d'examen conjoint

Du 16 septembre au 12 octobre 2013

Canada

Natural Resources Canada's (NRCan) Technical Review of the Deep Geologic Repository (DGR) Project

Prepared for the DGR Joint Review Panel

Submitted on: August 27, 2013

Presenters: John Clarke, Director Environmental Assessment Division and Dr. Alexandre Desbarats

Natural Resources Canada | Ressources naturelles Canada

Canada

NRCan's Mandate

- Enhance the responsible development and use of Canada's natural resources and the competitiveness of Canada's natural resource products.
- Develop policies and programs that enhance the contribution of the natural resources sector to the economy and improve the quality of life for all Canadians.
- Lead science and technology in the fields of earth sciences, energy, forests, and minerals and metals.

NRCan's Energy Sector

- Lead organization for the development and implementation of federal policy on nuclear energy and radioactive waste management.
  - 1996 Canada's Radioactive Waste Policy Framework
- Support the Minister in administering the *Nuclear Fuel Waste Act.*
- Responsible for policy and oversight of federal programs concerning historic and legacy nuclear wastes.

NRCan's Earth Sciences Sector

- NRCan is the Government of Canada's principal earth sciences agency.
- NRCan plays a pivotal role in the collection and dissemination of earth sciences information of major importance to Canada's energy, mining and forestry sectors.
- NRCan's research in environmental geosciences aims to understand and mitigate the risks of resource development on the environment, to build social licence and to inform regulatory decisions.

NRCan's Minerals and Metals Sector

- Promotes the sustainable development of Canada's minerals and metals resources.

- Provides technical expertise related to the geochemical characterization of rock and strategies for mine waste management.

NRCan's Review of the DGR Project

- NRCan has been participating in review of information and technical reports related to DGR since 2007.

- NRCan is not a regulator for this project and the department has no decision-making role in the environmental assessment.

- NRCan's principal review concerned geology, site characterization and long-term safety case.

NRCan's Review of the DGR Project

NRCan experts considered the following aspects:

- Geology: Bedrock geology
- Hydrogeochemistry: Groundwater chemistry, fracture studies and age interpretation
- Hydrogeology: Intermediate and deep groundwater systems; shallow groundwater
- Seismic hazards: Earthquake shaking, earthquake-generated tsunami, faulting
- Geochemical characterization and management of waste rock

GEOLOGY: STRATIGRAPHY AND SEDIMENTOLOGY OF THE SANDSTONE AND SHALE BEDROCK

NRCan's Review: Bedrock Geology

- Understanding the site geology, including the deep geologic structure is an integral part of the project design.

- Helps minimize the adverse environmental effects of the project and plan the long-term management of the site.

NRCan's Review: Bedrock Geology

- Regional stratigraphy and sedimentology of the sandstone and shale bedrock (host and cap rock for the DGR).

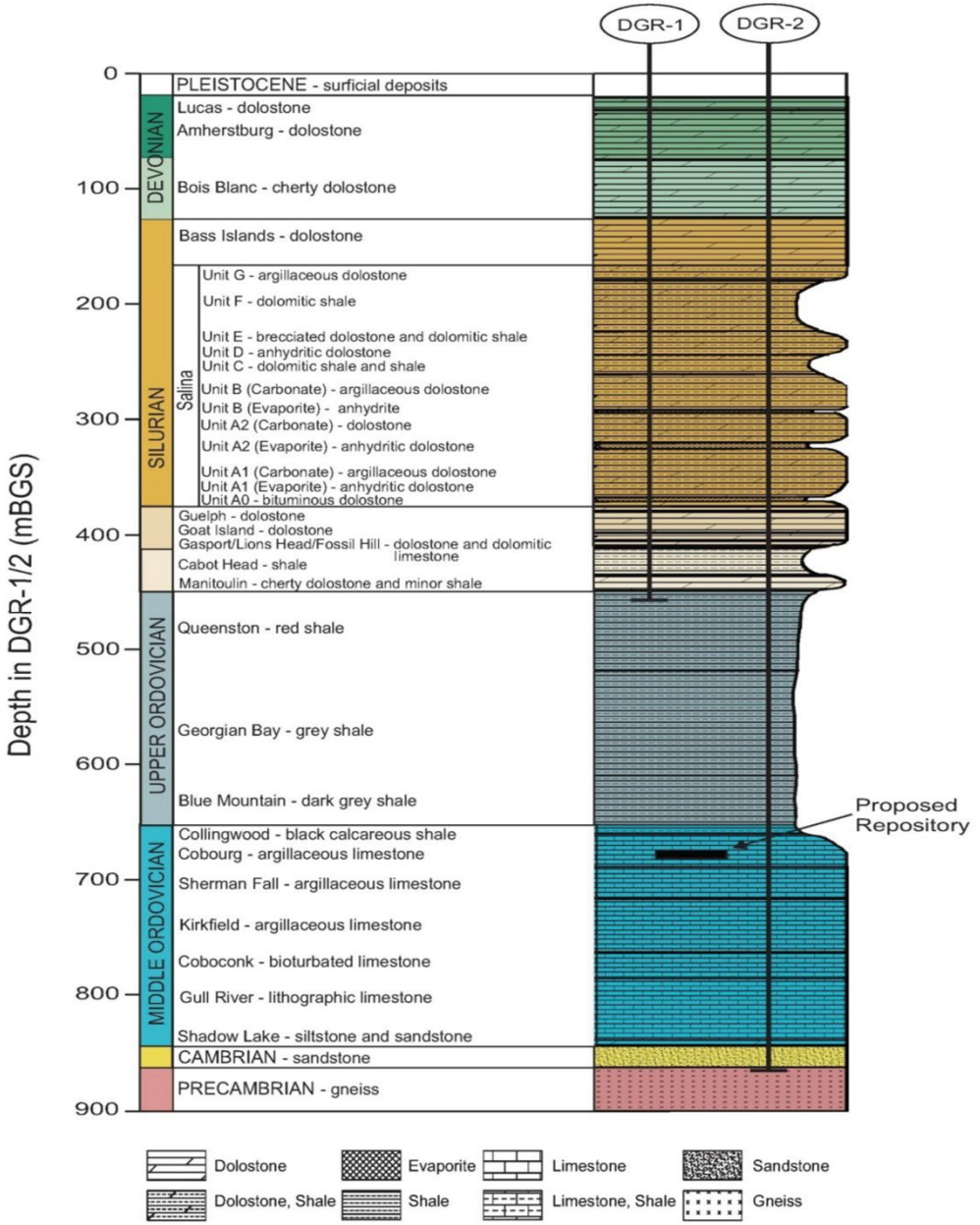


Figure 1:
Reference Stratigraphic Column for the Bruce Nuclear Site *(taken from NWMO DGR-TR-2011-24 Descriptive Geosphere Model - March 2011)*

NRCan's Review: Bedrock Geology

NRCan reviewed the proponent's characterization of the bedrock, including:

- The integrity and permeability of the host and cap rocks, including faults and fractures
- The hydrocarbon potential and fluid migration

NRCan's Review: Bedrock Geology

- NRCan requested additional information on:
  1. Cap-Rock Seal and its impacts on the regional seal capability
  2. Un-Mapped vertical faults and fractures and movement of hot fluids through deep-rooted faults and fractures
  3. Hydrocarbon Potential and mitigation strategies to ensure DGR integrity
  4. Potential migration path of contaminated groundwater through sandstone

NRCan's Review: Bedrock Geology

- NRCan is satisfied with the information provided by OPG.
  - Adequate understanding of the geologic environment in order to describe the risks and plan mitigation measures to address these risks.

- OPG has not conducted a quantitative assessment of the potential for hydrocarbons at the DGR site.

NRCan's Review: Bedrock Geology

Recommendation:

- With respect to hydrocarbon potential, the panel should consider what additional mitigation measures or institutional controls might be put in place to ensure restricted access to the DGR site for the long-term.

HYDROGEOCHEMISTRY:
GROUNDWATER CHEMISTRY, FRACTURE STUDIES AND THE INTERPRETATION OF THE AGE OF FRACTURES

NRCan's Review: Hydrogeochemistry

- NRCan's review considered whether OPG has appropriately characterized groundwater chemistry and solute transport as they relate to the formation and interpretation of fracture systems.
- NRCan's review considered whether OPG had adequately characterized the fractures and appropriately interpreted the age of fractures systems in the region of the DGR.

NRCan's Review: Hydrogeochemistry

- Understanding geochemical aspects of the project, including the age and timing of the fractures at the study site, will inform whether the effects of the project on the environment have been adequately characterized.

NRCan's Review: Hydrogeochemistry

- NRCan highlighted inconsistencies in OPG's information, referenced external research and requested additional information to verify that the interpretation of age of fractures.

NRCan's Review: Hydrogeochemistry

- NRCan requested clarification on OPG's conclusion that dewatering would be the only situation where high pore pressures could occur.
  - In NRCan's view, maximum burial or petroleum generation can also lead to elevated pore pressures.
  - Recent glaciation is also known to cause very high overpressures in underlying sedimentary basins.

NRCan's Review: Hydrogeochemistry

- OPG provided additional information and indicated that work is ongoing to verify the interpretation of age of various fractures.
- NRCan view is that OPG has provided sufficient information to support conclusions related to the history of fracture formation and fluid movement in the basin, describe the risks and uncertainties and develop mitigation measures.

SEISMIC HAZARDS

NRCan's Review: Seismic Hazards

- Considered whether OPG had adequately characterized:
  - The probability of contemporary earthquake shaking hazard
  - The longer-term seismic hazard
  - The earthquake-generated tsunami hazard
  - The faulting hazard

NRCan's Review: Seismic Hazards

Recommendations:

- Conservatism on the mean shaking levels should be considered during detailed design because of the low maximum magnitudes adopted and the kernel smoothing approach in the PSHA.
- Detailed design should consider mitigation strategies or plans for conditions of "beyond-design" ground motions.

GEOCHEMICAL CHARACTERIZATION AND MANAGEMENT OF WASTE ROCK

NRCan's Review: Geochemical Characterization and Management of Waste Rock

- Determining successful mitigation measures depends on an accurate prediction of future drainage chemistry, which is a technical subject involving a large number of methods, properties and processes.

NRCan's Review: Geochemical Characterization and Management of Waste Rock

- NRCan reviewed OPG's geochemical characterization and management plan for waste rock.
  - Whether OPG had undertaken an appropriate analysis of the potential for acid generation and metal leaching from the waste rock.

NRCan's Review: Geochemical Characterization and Management of Waste Rock

- NRCan's view is the assessment of the acid generating potential of the waste rock is sound.
- However, uncertainty in the results remain due to the compositional variability of the rock formations, sampled along a limited number of drill holes.
- Additionally, metal(loid) leaching can occur at neutral and slightly elevated pH.

NRCan's Review: Geochemical Characterization and Management of Waste Rock

Recommendation:

- Require OPG to continue to refine the results of the geochemical characterization program prior to and during the development phase of the DGR. This could include conducting additional shake flask tests, kinetic tests and field cell tests on the excavated material.

HYDROGEOLOGY:
INTERMEDIATE AND DEEP GROUNDWATER SYSTEMS

NRCan's Review: Intermediate and deep groundwater systems

- For natural evolution scenarios of the Deep Geological Repository, groundwater is the only pathway for released radionuclides to migrate to the biosphere and potentially cause adverse environmental or human health effects.

Migration Mechanisms of radionuclides in Groundwater: ***Advective Transport***

- Dissolved radionuclides migrate relatively rapidly within groundwater flowing under a hydraulic gradient
- Advective transport is dominant in rock formations that are relatively permeable

*Migration Mechanisms of radionuclides in Groundwater: **Diffusive Transport***

- Dissolved radionuclides migrate very slowly in groundwater through the process of chemical diffusion driven by a concentration gradient

- Diffusive transport is dominant in stagnant groundwater found in rocks having a very low permeability

Site Attributes for Hydrogeological Suitability

- Multiple Natural Barriers: multiple low permeability bedrock formations enclose and overlie the DGR
- Contaminant Transport is Diffusion Dominated: deep groundwater regime is ancient showing no evidence of glacial perturbation or cross-formational flow
- Shallow Groundwater Resources are Isolated: near-surface groundwater aquifers are isolated from the deep saline groundwater system

NRCan's Review: Intermediate and deep groundwater systems

- NRCan's review focused on permeable formations of the intermediate and deep groundwater systems where diffusion is NOT the dominant transport

- Advective transport in these formations has the greatest potential to drive radionuclide migration beyond the lateral boundaries of the repository

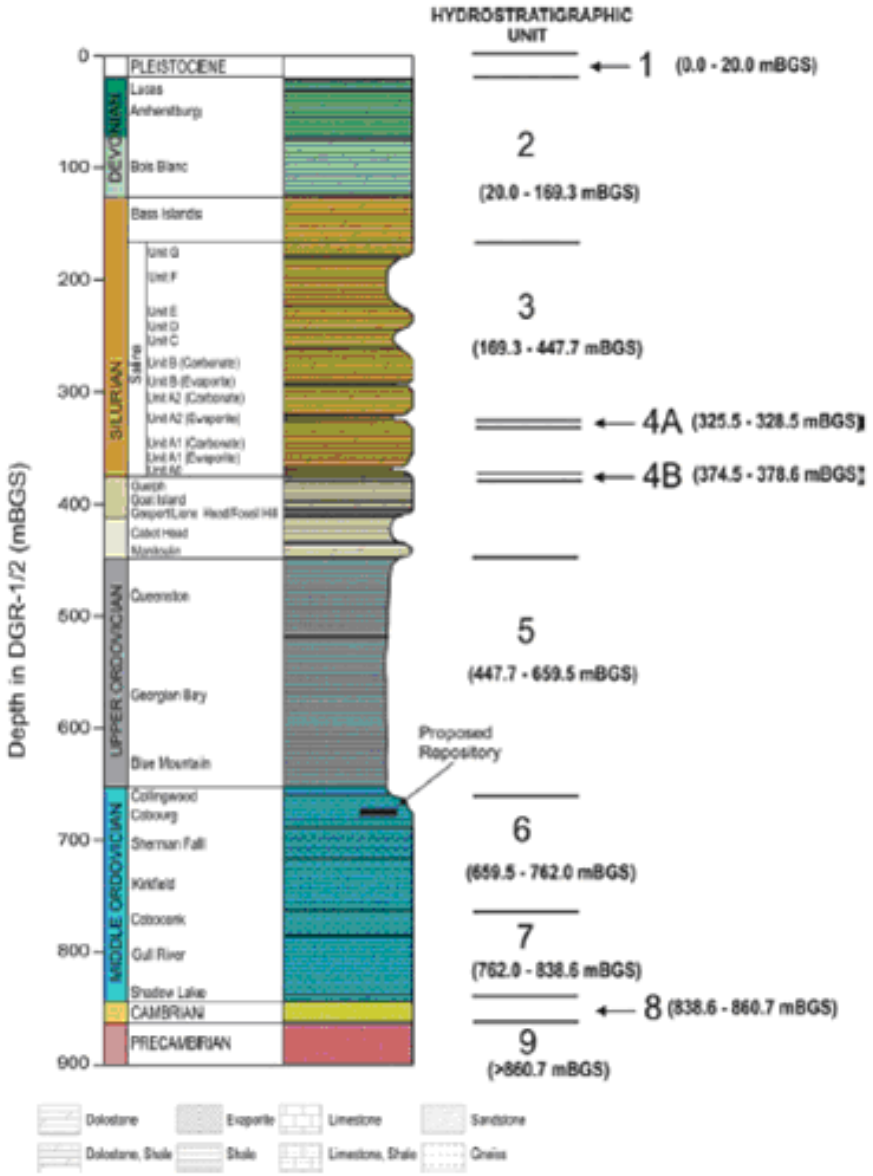


Figure 4.106: Reference Stratigraphic Column Showing Hydrostratigraphic Units at the Bruce Nuclear Site

Salina Upper A1 Carbonate

Guelph Formation

Cambrian sandstone

Observed Advective Velocities

Formation	Groundwater Velocity (m / year)	Flow Direction
Salina Upper A1 Carbonate	0.7	west
Guelph	0.04	east
Cambrian sandstone	4.2	east

NRCan's Review: Intermediate and deep groundwater systems

NRCan's concerns:

- OPG's groundwater flow and transport models do not adequately represent the magnitude and direction of lateral advective transport in thin permeable units of the intermediate and deep groundwater systems

NRCan's Review: Intermediate and deep groundwater systems

- NRCan requested that OPG revise the regional/site specific groundwater models:
  - Refine representation of the Salina Upper A1 Carbonate and Guelph formations
  - Combine the Cambrian sandstone and Shadow Lake Formation into a continuous basal permeable unit across model domain
  - Reproduce hydraulic gradients and advective velocities observed in the thin permeable units

NRCan's Review: Intermediate and deep groundwater systems

- OPG's new modeling shows a very low concentration plume of the radionuclide Chlorine-36 moving away from Lake Huron, in the Cambrian sandstone layer.

NRCan's Review: Intermediate and deep groundwater systems

- OPG refined the vertical representation of the Upper A1 Carbonate and Guelph units
- This refinement resulted in an increase in the predicted advective velocity within these layers and a better match to observed values
- This refinement also resulted in slower vertical radionuclide migration through the Niagaran units because of a longer pathway for diffusive transport

NRCan's Review: Intermediate and deep groundwater systems

- NRCan also requested that OPG revise the Postclosure Safety Assessment 3D Simplified groundwater model:
  - Lower the base of the model in order to be able to assess lateral advective radionuclide transport in the Cambrian sandstone

NRCan's Review: Intermediate and deep groundwater systems

- OPG lowered the base of the Post-closure Safety Assessment 3D-Simplified model to include the Cambrian sandstone

- The supplementary modeling shows a very low concentration radionuclide plume moving away from Lake Huron, in the Cambrian sandstone as well as horizontal plumes in the other permeable units

Radionuclide Plumes in Permeable Units

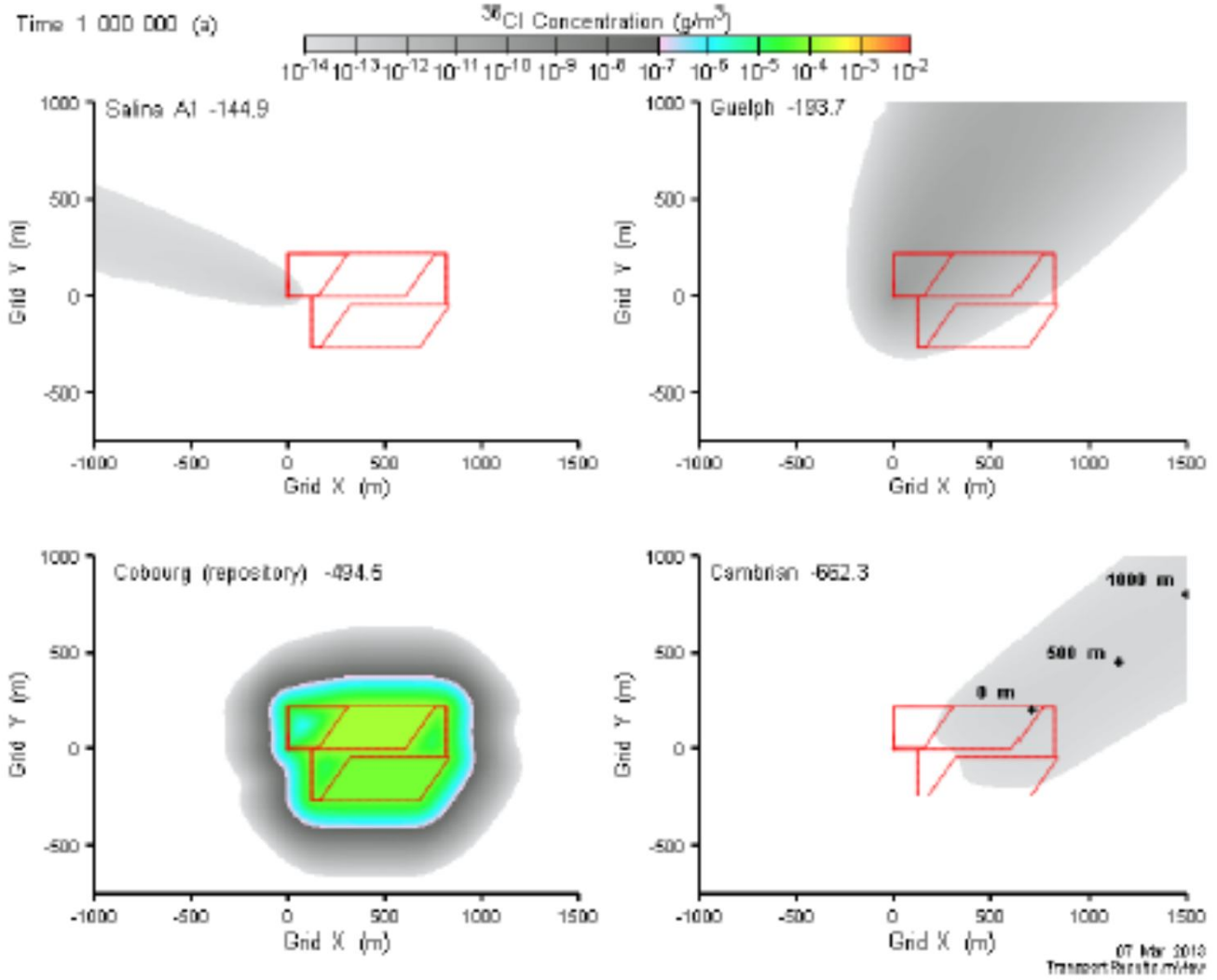


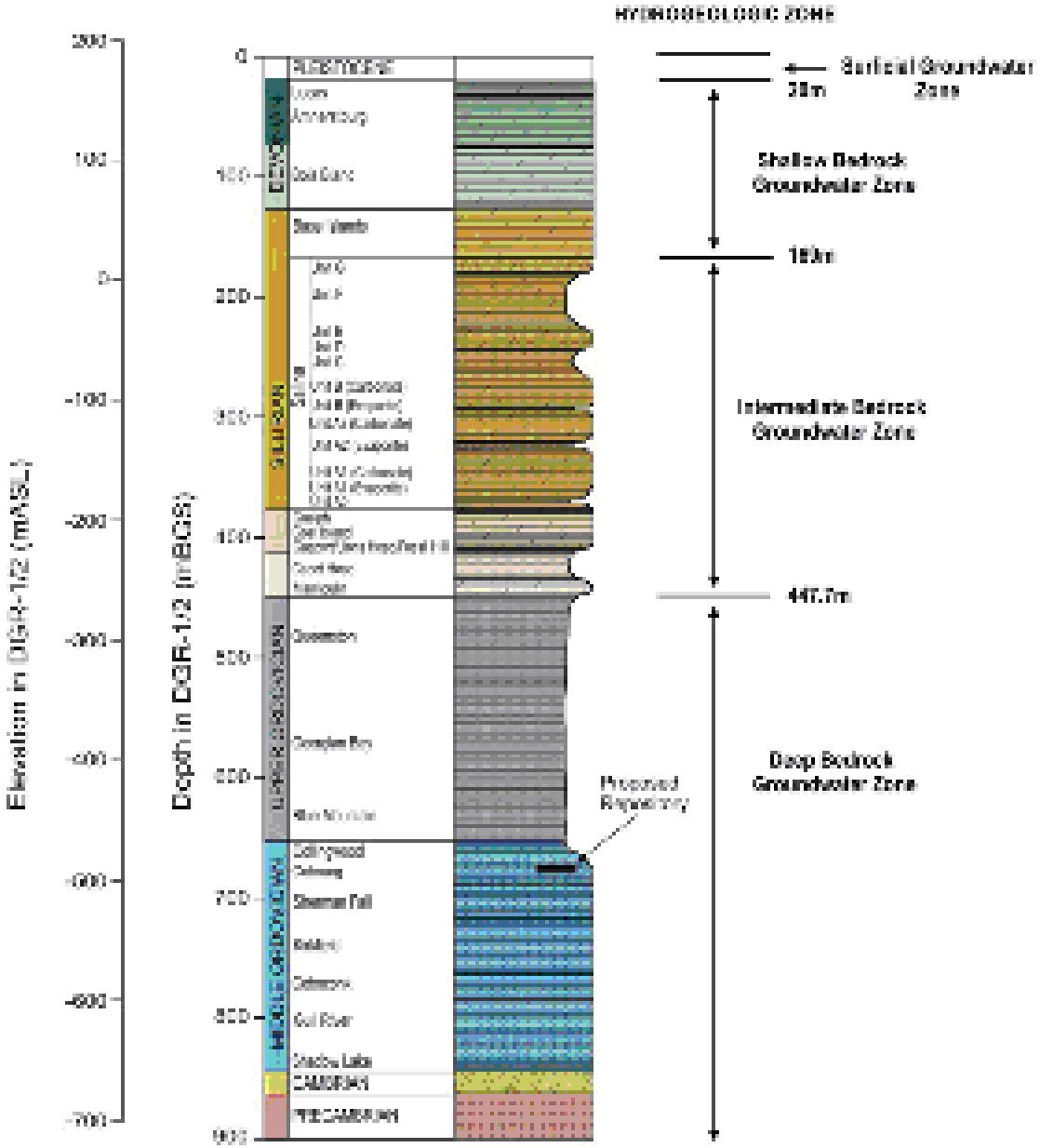
Figure 3: 3DSD Plan view concentrations of Cl-36 at 1 Ma at four elevations corresponding to the Salina A1 Formation, the Guelph Formation, the Cobourg (repository) Formation, and the Cambrian Formation

NRCan's Review: Intermediate and deep groundwater systems

- OPG's additional modeling results better document lateral advective radionuclide transport in thin permeable layers of the deep and intermediate groundwater systems
- The more thorough investigation of advective transport processes enhances confidence in the DGR Performance Safety Assessment

NRCan considers that its technical comments have been resolved satisfactorily

HYDROGEOLOGY:
SHALLOW GROUNDWATER


HYDROGEOLOGIC ZONE
Elevation in DGR-1/2 (mASL)
Depth in DGR-1/2 (mBGS)
Surficial Groundwater Zone
Shallow Bedrock Groundwater Zone
Intermediate Bedrock Groundwater Zone
Deep Bedrock Groundwater Zone
Proposed Repository

Shallow Groundwater System: Permeability

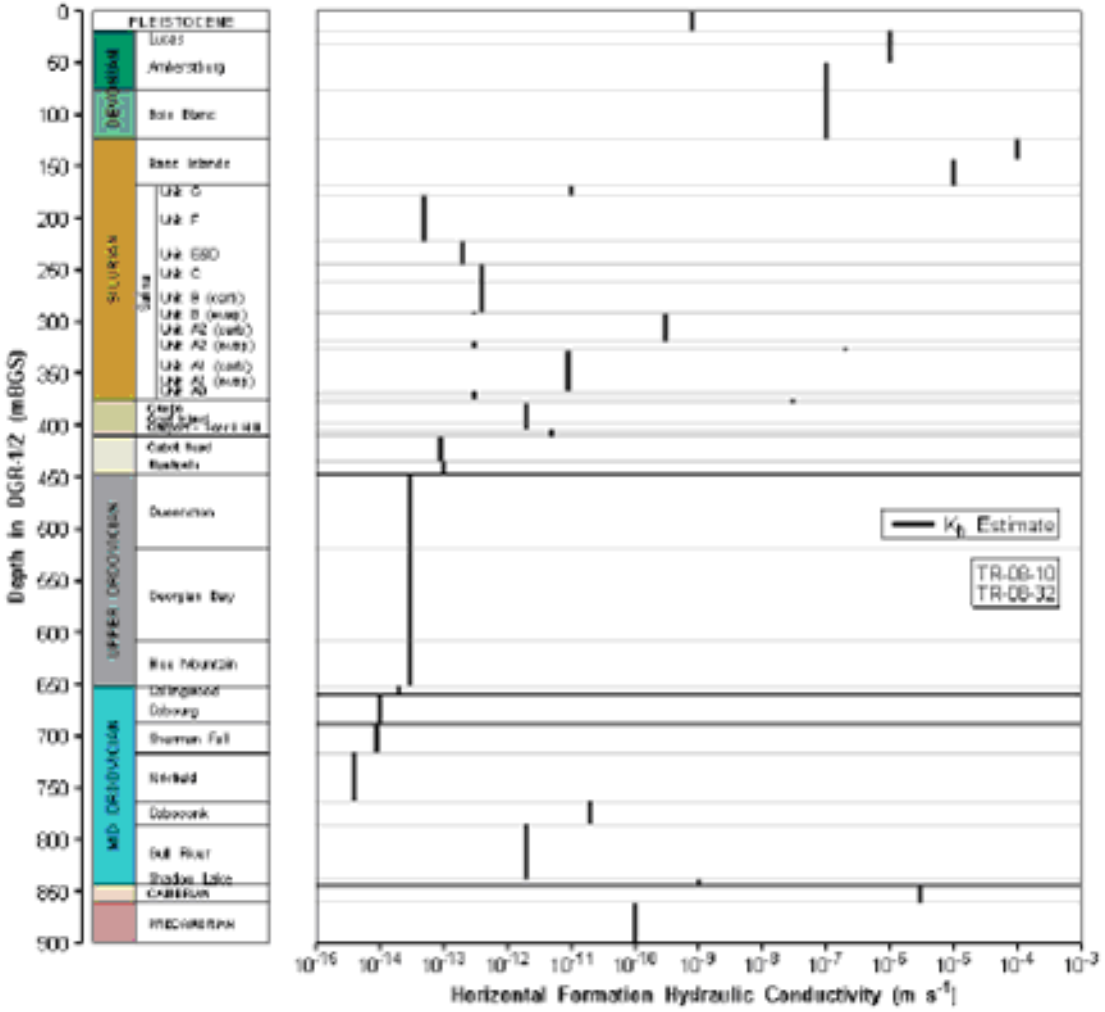


Figure 4.90: Estimates of Formation Horizontal Hydraulic Conductivity for Overburden and Bedrock Formations at the DGR Site

NRCan's Review: Shallow Groundwater System

NRCan was requested to review supplementary numerical modeling carried out in order to predict:

- The hydraulic influence of dewatering during shaft collar construction and shaft excavation on groundwater flow patterns and tritium migration in the vicinity of the Western Waste Management Facility
- Collar and shaft seepage rates, and resultant zone of hydraulic influence within the uppermost groundwater system

NRCan's Review: Shallow Groundwater System

NRCan was requested to review supplementary numerical modeling carried out in order to assess:

- The influence of surface recharge beneath the proposed Waste Rock Management Area and Storm Water Management Pond on the shallow groundwater regime

NRCan's Review: Shallow Groundwater System

NRCan Conclusions:

- OPG's responses with respect to shaft inflow quantity and quality, and impacts of dewatering on tritium plume migration patterns are sufficient

- However, OPG's modeling used very low hydraulic conductivities in the Bass Islands formation which are not consistent with values stated in the DGSM report

NRCan's Review: Shallow Groundwater System

NRCan Conclusions:

- Shaft inflows at the depth of the Bass Islands Formation (circa 124 m) are unlikely to cause perturbations to the shallow groundwater flow system that could affect migration patterns of the Tritium plume in the overburden and uppermost Lucas Formation.

NRCan's Review: Shallow Groundwater System

NRCan Conclusions:

- The upper 20 m of the Bass Islands Formation represents an additional potential critical phase for shaft excavation where proper grouting may be essential to stem groundwater inflows

- OPG's responses with respect to effects of the Waste Rock Management Area and Storm Water Management Pond on local groundwater flow regime are sufficient

NRCan's Review: Shallow Groundwater

Recommendations:

- Require OPG to continue to collect baseline data on shallow groundwater flows in order to refine the groundwater model.
- Require OPG to confirm whether grouting will be required to stem groundwater inflows from the upper 20m of the Bass Islands Formation, and to develop mitigation measures, as appropriate.

In Closing

- NRCan appreciates the opportunity to participate in these public hearings.
- In addition to this presentation, NRCan will be presenting on seismic hazards during the long-term safety case session.
- NRCan experts are available to respond to questions as they relate to the expertise provided.