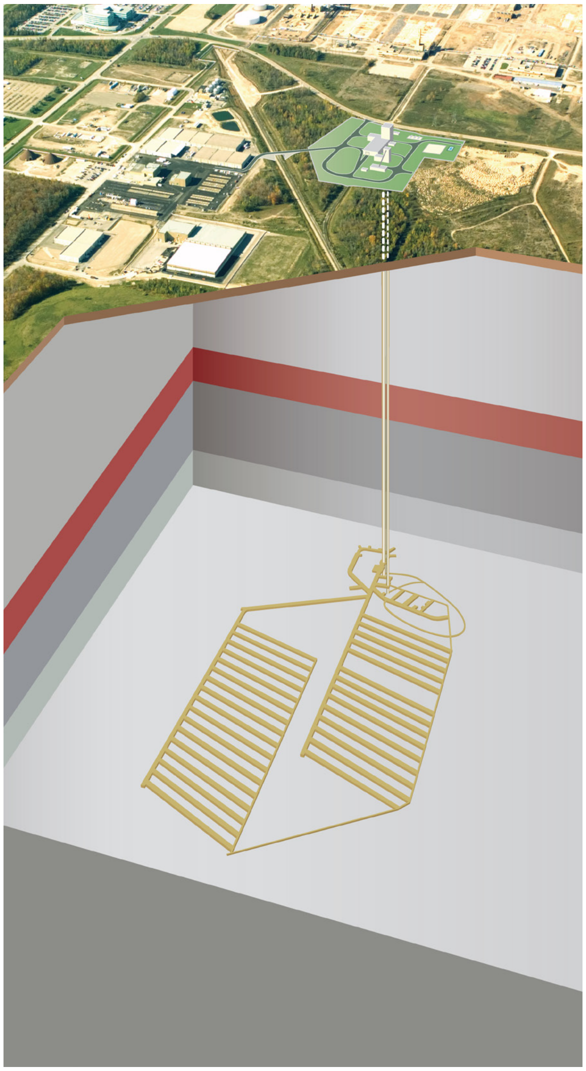
OPG's DEEP GEOLOGIC REPOSITORY PROJECT

For Low & Intermediate Level Waste

March 2011



Environmental Impact Statement

VOLUME 1: MAIN REPORT

00216-REP-07701-00001 R000

OPG's DEEP GEOLOGIC

REPOSITORY

FOR LOW & INTERMEDIATE LEVEL WASTE

Environmental Impact Statement

Volume 1: Main Report

00216-REP-07701-00001-R000

March 2011

Prepared by:
Golder Associates Ltd.

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Golder Associates Ltd.			
Prepared by:	A. Beal, K. Chakhova		
Reviewed by:	M. Rawlings		
Approved by:	M. Rawlings		
Nuclear Waste Management Organization			
Reviewed by:	D. Barker, J. Jacyk, M. Mayhew		
Accepted by:	A. Castellan		

EIS FOR DGR PROJECT

EA Consulting Team

	Golder Associates Ltd.	Environmental Impact Statement Aquatic Environment TSD Atmospheric Environment TSD Geology TSD Hydrology and Surface Water Quality TSD Terrestrial Environment TSD
	AECOM Canada Ltd.	Aboriginal Interests TSD Public Consultation and Engagement Socio-economic Environment TSD
	AMEC NSS Ltd.	Malfunctions, Accidents and Malevolent Acts TSD Radiation and Radioactivity TSD
	Nuclear Waste Management Organization	Environmental Impact Statement Geology TSD Malfunctions, Accidents and Malevolent Acts TSD Public Consultation and Engagement

EXECUTIVE SUMMARY

ES.1 INTRODUCTION

Ontario Power Generation (OPG) is undergoing a multi-year planning and regulatory approvals process for a deep geologic repository (DGR) for the long-term management of low and intermediate level waste (L&ILW). Currently, the L&ILW produced as a result of the operation of OPG-owned nuclear reactors is stored centrally at OPG’s Western Waste Management Facility (WWMF) located on the Bruce nuclear site near Tiverton, Ontario. Although current storage practices are safe and could be continued safely for many decades, OPG’s long-term plan is to manage these wastes in a long-term management facility. Throughout this report, OPG's proposal is referred to as the "DGR Project”.

The DGR Project includes the site preparation and construction, operations, decommissioning, and abandonment and long-term performance of the DGR. The DGR will be constructed in competent sedimentary bedrock beneath the Bruce nuclear site near the existing WWMF. The underground facilities will include access-ways (shafts and tunnels), emplacement rooms and various underground service areas and installations. The surface facilities include the underground access and ventilation buildings, Waste Package Receipt Building (WPRB) and related infrastructure.

An environmental assessment (EA) of the proposed DGR Project is required under the provisions of the Canadian Environmental Assessment Act (CEAA) because the proponent (OPG) will be required to obtain a licence from the Canadian Nuclear Safety Commission (CNSC) to allow the DGR Project to proceed. The findings of the EA are presented in this Environmental Impact Statement (EIS) and Technical Support Documents (TSDs).

ES.2 BACKGROUND

Low and intermediate level waste (L&ILW) from OPG’s nuclear generating plants has been processed and stored on an interim basis at the WWMF, located at the Bruce nuclear site, for nearly 40 years. In 2001, the Municipality of Kincardine requested that OPG consider options for the long-term management of the WWMF’s L&ILW. This led, in 2002, to a Memorandum of Understanding (MOU) between the parties. The MOU set out the terms for a plan to study the long-term management options. An independent consultant was retained to examine the costs, impacts, and benefits of constructing and operating each of four long-term management concepts on the Bruce nuclear site, namely: enhanced processing and storage; surface concrete vaults; deep rock vaults (now referred to as deep geologic repository); and status quo. The study report (known as the Independent Assessment Study) was completed in early 2004, and concluded that all four options were technically feasible and could be safely constructed and operated at the site. All options were assessed in terms of environmental impacts, economic benefits, public attitude and tourism, with favourable conclusions. Communication activities were conducted throughout the duration of the study to inform stakeholders and the public of the study, and obtain their comments on the long-term management options. These activities included stakeholder briefings, a newsletter to the residents of Kincardine and neighbouring municipalities, a project-specific web site, a round of five open houses, and communication with the local First Nations.

With the finalization of the study, Kincardine Council passed a resolution requesting OPG to pursue a deep geologic repository for L&ILW, citing reasons that this option offered the highest margin of long-term safety among the four technical options studied, was consistent with international best practice, provided economic benefit to the residents of the municipality, and offered a permanent solution for all low and intermediate level waste (i.e., deep geologic disposal is the only option of the four that can manage long-lived intermediate level waste). In considering this request, OPG assessed a number of options, including the option of pursuing a greenfield location. In August 2004, the OPG Board of Directors agreed to proceed with a DGR, recognizing the reasons cited above by Kincardine, and also that the project was supported by the community, and that long-term risks associated with the interim storage of L&ILW would be reduced.

A DGR Hosting Agreement was signed in October 2004 between OPG and the Municipality of Kincardine. The agreement allows for the construction and operation of a deep geologic repository (DGR) for the long-term management of L&ILW waste from Ontario's nuclear generating stations, and provides a series of hosting payments to Kincardine and surrounding communities subject to meeting major project licensing and construction milestones. The agreement also required that a clear mandate be provided by the Kincardine community to its council in favour of the DGR. A poll was conducted in early 2005 targeting all Kincardine permanent (by telephone) and seasonal (by mail) residents eighteen years of age or over by an independent polling company working on behalf of the Municipality of Kincardine. With a 71% response rate, 60% of the Kincardine community voted in favour of the DGR, 22% against, 13% neutral, and 5% don't know/refused to answer.

The local First Nations (Saugeen Ojibway Nation [SON]) were first approached in 2003 by OPG to inform them of the Independent Assessment Study. A Communication Protocol was signed in 2004 that included resources and provision for SON to conduct their own independent peer review of the study report. In March 2009, the signing of a Protocol Agreement between SON, OPG, and the Nuclear Waste Management Organization (NWMO) provided SON with the necessary resources to be able to participate in the EA process for the DGR Project. Over the course of the past seven years, there have been a number of meetings, workshops and open houses to discuss the project and share information with the SON and their communities, including the establishment of SON's Environmental Office for the purpose of interfacing with the DGR Project. The engagement process with the SON is ongoing.

Local Métis interests include the Historic Saugeen Métis Community, and the Métis Nation of Ontario-represented citizens in the Georgian Bay Region. The engagement process with these groups began in 2008. An agreement with the Historic Saugeen Métis Community was finalized in 2010 providing capacity to facilitate their engagement on the DGR Project. Discussions with the Métis Nation of Ontario are continuing and are expected to result in a Participation Agreement which would facilitate their participation in the EA process.

A Project Description for the DGR Project was prepared and filed with the CNSC in December 2005, which initiated the regulatory approvals phase for the project. The CNSC presided over a public hearing in October 2006 in Bruce County for the purpose of determining the type of EA process required for this undertaking. In December 2006, the Commission published its report with a recommendation to the federal Minister of Environment that the DGR Project should be referred to a review panel. In June 2007, the federal Minister of Environment referred the project to a joint review panel. Final instructions and guidelines for the preparation of the project EIS were jointly released by the CNSC and the Canadian Environmental Assessment Agency in January 2009.

Beginning in 2006, a comprehensive program of field and technical studies and investigations has been undertaken including the disciplines of geoscience, safety assessment, environmental assessment, public communications and development of the engineering design. Expert review panels in the areas of geoscience, engineering and safety assessment were established to guide and review the study findings. All work was completed in 2010 leading to the regulatory submission.

Over the course of the project lifetime, an extensive public communications program has been in place for the purpose of keeping all interested parties updated on developments with the project. The program includes annual open houses, newsletters, annual reports, technical materials, speaking engagements, and attendance at community events with exhibits. Public surveys have indicated strong overall support for the project from the community and its leaders.

Effective January 2009, the NWMO was contracted by OPG to manage the regulatory approvals phase for the DGR Project. OPG continues to be the owner, and prospective licence holder and operator of the DGR. Financing for the DGR Project is provided from the Decommissioning Fund established under the Ontario Nuclear Funds Agreement.

ES.3 FRAMEWORK OF THE EA

The approach used for assessing effects of the DGR Project supports the philosophy of EA as a planning and decision-making process (see Section 1). The assessment characterizes and assesses the potential effects of the DGR Project in a thorough, traceable, step-wise manner. The approach used in the assessment includes the following steps:

- describe the DGR Project;
- describe the existing environment;
- screen potential project-environment interactions to focus the assessment;
- predict and assess effects, apply mitigation measures to reduce or eliminate the effects and identify residual adverse effects;
- assess cumulative effects with past, present or reasonably foreseeable projects;
- determine significance of residual adverse effects; and
- propose a follow-up program to confirm mitigation measures are effective and the effects are as predicted.

The assessment of effects considers direct and indirect effects of the DGR Project, effects of the environment on the DGR Project, climate change considerations, and effects of the DGR Project on renewable and non-renewable resources. Effects are predicted in the context of temporal and spatial boundaries.

For the purposes of the EA, the environment comprises eight environmental components. Each is the subject of a TSD that supports this EIS. They include all biophysical and social features that may be affected by the DGR Project:

- **Geology**: represents soil and groundwater quality and considers geological and hydrogeological conditions and seismicity;
- **Hydrology and Surface Water Quality**: represents surface water quality and surface water flow conditions;
- **Terrestrial Environment**: represents terrestrial biota and terrestrial habitat;
- **Aquatic Environment:** represents aquatic biota and aquatic habitat;
- **Radiation and Radioactivity**: represents environmental radioactivity, including radionuclide emissions and doses to humans (members of the public and workers) and non-human biota;
- **Atmospheric Environment**: represents air quality, noise, light and vibrations, and considers meteorological and climatic conditions;
- **Aboriginal Interests**: represents Aboriginal communities, Aboriginal heritage resources and traditional use of land and resources; and
- **Socio-economic Environment**: represents population, economic base, municipal services and finance, residents and communities, land use, transportation networks and elements, landscape and visual setting and Euro-Canadian cultural heritage resources.

The TSDs assess the direct and indirect effects of the DGR Project as a result of normal conditions. The EIS Guidelines require an identification of credible malfunctions and accidents, and an evaluation of the effects of the DGR Project in the event that these accidents or malfunctions occur. All of these effects are discussed and assessed in the Malfunctions, Accidents and Malevolent Acts TSD regardless of the element of the environment that is affected.

It is important to note that the assessment of potential radiation and radioactivity effects of the DGR Project is documented in the Radiation and Radioactivity TSD, regardless of the physical media through which they are transported (e.g., air or water). This was done because of the special importance placed on radiation and radioactivity, and the combined effects to the receiving environment regardless of the path of exposure.

The temporal boundaries for the EA establish the timeframes for which the effects are assessed (Section 5). Four temporal phases were identified for the DGR Project:

- site preparation and construction phase;
- operations phase;
- decommissioning phase; and
- abandonment and long-term performance phase.

Spatial boundaries define the geographical extents within which environmental effects are considered (Section 5). As such, these boundaries become the study areas adopted for the EA. Four study areas were selected for the assessment:

- The **Regional Study Area** encompasses Bruce County with the exception of the peninsula communities of the Town of South Bruce Peninsula and Northern Bruce Peninsula Municipality.
- The **Local Study Area** corresponds to the 10 km emergency planning zone (centred on the Bruce nuclear site), as identified by Emergency Measures Ontario.
- The **Site Study Area** corresponds to the property boundary of the Bruce site, including the existing licensed exclusion zone on land and in Lake Huron.
- The **Project Area** corresponds to the boundary of the OPG-retained lands at the centre of the Bruce nuclear site where the DGR Project is being proposed. The Project Area is the area where Project-related effects are most likely to occur and is the area of focus for the EA.

The Project Area, although not specified in the EIS Guidelines, was defined to help describe the potential site-specific effects of the DGR Project. Each study area includes the smaller study areas (i.e., they are not geographically separate). These study areas were adopted for each of the environmental components with modifications as appropriate.

ES.4 PUBLIC CONSULTATION

The EIS Guidelines include a requirement that the assessment be undertaken in consultation with potentially affected stakeholders, including the local public. The EIS describes in detail the community and public consultation program conducted as part of the EA studies (Section 2). The purpose of the program was to identify stakeholder issues, to identify communication/ consultation needs and concerns, to inform stakeholders, to provide opportunities for input from stakeholders, and to document the consultation process and results.

Stakeholders were identified using a systematic process. Various methods were then used in the consultation process to inform and obtain input from the stakeholders. These included: newsletters, notification letters, stakeholder briefings/interviews, Open Houses, committee meetings, workshops, library repositories, a telephone contact number and email address. The results of the consultation process are documented and key issues raised by the stakeholders were considered in the assessment (Section 2).

ES.5 ABORIGINAL ENGAGEMENT

The EIS Guidelines also require that the EIS must describe OPG's involvement of Aboriginal communities, including Saugeen Ojibway Nation (SON) and Métis people in the EA process. The purpose of the Aboriginal engagement program was to keep Aboriginal communities informed on the progress of work for the DGR Project, provide the opportunity for Aboriginal communities to identify and discuss any concerns and to document and respond to questions about the DGR Project. The EIS describes the engagement that was undertaken, meetings and the results, as well as the feedback and insights from the dialogue between OPG, NWMO and the Aboriginal communities and their representatives (Section 2).

ES.6 VALUED ECOSYSTEM COMPONENTS

While all components of the environment are important, it is neither practicable nor necessary to assess every potential effect of a project on every component. The EA focuses on the components that have the greatest relevance in terms of value and sensitivity, and which are likely to be affected by the DGR Project. To achieve this focus, specific Valued Ecosystem Components (VECs) are identified (Section 5). A VEC (e.g., white-tailed deer) is considered to be the 'receptor' for both project-specific effects and cumulative effects. A VEC can be represented by a number of 'indicators', which are features of the VEC that may be affected by the DGR Project (e.g., habitat use). Each indicator requires specific 'measures' that can be quantified and assessed (e.g., changes in habitat availability and suitability). In essence, the nature and magnitude of the potential effects of the DGR Project on these VECs have been studied and their significance determined.

The selected VECs are considered to have legal, scientific, ecological, cultural, social, economic or aesthetic value. Importance may be determined on the basis of cultural values or scientific concerns. From an ecological perspective, VECs can represent features or elements of the natural environment (e.g., a local wetland or stream) considered to be culturally or scientifically important. Such features would be complex, comprising several ecological aspects, and affected by a range of pathways (i.e., routes of exposure or effect). A list of VECs selected for the EA is presented in Table ES-1.

ES.7 ASSESSMENT OF EFFECTS

Where likely measurable changes to VECs were predicted as a result of the DGR Project, a more detailed assessment was conducted to determine if the change is likely to be adverse (Section 7). An adverse effect is a non-trivial change from existing conditions. Where adverse effects were identified, mitigation measures to reduce, control or eliminate the effect were identified. Following an evaluation of these mitigation measures, the assessment was repeated to determine all residual adverse effects (i.e., adverse effects remaining after mitigation is applied).

Table ES-1 presents a summary of the assessment of effects for each environmental component. Beneficial effects were also identified through the assessment process, but have not been included in Table ES-1 because the goal of the EA process is to identify and mitigate adverse effects on the environment.

Table ES-1: Summary of Residual Adverse Effects by Environmental Component

Environmental Component	VEC	Residual Adverse Effect
Geology	Soil Quality	No residual adverse effects
	Overburden Groundwater Quality	No residual adverse effects
	Overburden Groundwater Transport	No residual adverse effects
	Shallow Bedrock Groundwater Quality	No residual adverse effects

Table ES-1: Summary of Residual Adverse Effects by Environmental Component (continued)

Environmental Component	VEC	Residual Adverse Effect
Geology (continued)	Shallow Bedrock Groundwater and Solute Transport	No residual adverse effects
	Intermediate Bedrock Water Quality	No residual adverse effects
	Intermediate Bedrock Solute Transport	No residual adverse effects
	Deep Bedrock Water Quality	No residual adverse effects
	Deep Bedrock Solute Transport	No residual adverse effects
Hydrology and Water Quality	Surface Water Quantity and Flow	Residual adverse effect of decreased flow in the North Railway Ditch, and an increased flow in the existing drainage ditch at the discharge from the DGR Project site
	Surface Water Quality	No residual adverse effects
Terrestrial Environment	Plant Species VECs	Residual adverse effect of removal of a small portion of eastern white cedar
	Wildlife Species VECs	No residual adverse effects
Aquatic Environment	VECs in Lake Huron and Embayments	No residual adverse effects
	VECs in the South Railway Ditch	A loss of a small portion of habitat used by redbelly dace, creek chub, variable leaf pondweed, burrowing crayfish and benthic invertebrates
	VECs in Stream C	No residual adverse effects
	VECs in other Potential Aquatic Habitats	A loss of a small portion of habitat used by burrowing crayfish in the DGR Project site
Radiation and Radioactivity	Humans	No residual adverse effect
	Non-human Biota	No residual adverse effects
Atmospheric Environment	Air Quality	Increased concentrations of indicators in air during the site preparation and construction, operations and decommissioning phases

Table ES-1: Summary of Residual Adverse Effects by Environmental Component (continued)

Environmental Component	VEC	Residual Adverse Effect
Atmospheric Environment (continued)	Noise Levels	Increased noise levels at the Baie du Doré during site preparation and construction, and decommissioning phases
Aboriginal Interests	Aboriginal Communities	No residual adverse effects
	Traditional Use of Lands and Resources	No residual adverse effects
	Aboriginal Heritage Resources	The DGR Project may diminish the quality or value of ceremonial activities undertaken by Aboriginal peoples at the Aboriginal burial site located at the Bruce nuclear site (changed aesthetics, temporarily increased noise and dust) until the DGR Project is decommissioned
Socio-economic Environment	Population and Demographics	No residual adverse effects
	Other Human Assets	No residual adverse effects
	Employment	No residual adverse effects
	Business Activity	No residual adverse effects
	Tourism	No residual adverse effects
	Residential Property Values	No residual adverse effects
	Municipal finance and Administration	No residual adverse effects
	Other Financial Assets	No residual adverse effects
	Housing	No residual adverse effects
	Municipal Infrastructure and Services	No residual adverse effects
	Other Physical Assets	No residual adverse effects
	Inverhuron Provincial Park	No residual adverse effects
	Social Assets	Increased noise levels at Baie du Doré during site preparation and construction, and decommissioning phases may reduce the use and enjoyment of property
Human Health	Overall Health	Increased exposures to acrolein in air during site preparation and construction may affect overall health [a]

Table ES-1: Summary of Residual Adverse Effects by Environmental Component (continued)

Environmental Component	VEC	Residual Adverse Effect
Human Health (continued)	Health of Workers	No residual adverse effects
Ecological Features	Lake Huron	No residual adverse effects
	Stream C	No residual adverse effects
	South Railway Ditch	No residual adverse effects
	Wetland within the Project Area	No residual adverse effects

Note:
a Acrolein concentrations in air are driven by the existing concentrations. The DGR Project contribution to acrolein concentrations is small relative to background levels.

Credible malfunctions, accidents, and malevolent acts are also considered for their potential to affect the environment (Section 8). The assessment of these initiating events considers the unplanned release of radionuclides and chemical contaminants from the project for a variety of scenarios. The assessment identified no residual adverse effects.

ES.8 EFFECTS OF THE ENVIRONMENT ON THE DGR PROJECT

The EIS Guidelines require that the EIS includes an assessment of how the environment could adversely affect the DGR Project. The assessment considered the effects of hazards such as flooding, lake ice, severe weather and seismic events. The assessment found that the identified effects of the environment are not likely to result in residual adverse effects on the DGR Project, taking into account the mitigation measures that are in place on the Bruce nuclear site.

ES.9 CLIMATE CHANGE CONSIDERATIONS

The EIS Guidelines require a consideration of whether the DGR Project and EA conclusions are sensitive to changes in climatic conditions. Three key considerations were addressed:

- How will the future environment affect the DGR Project?
- How will the DGR Project affect the future environment?
- How will the DGR Project affect climate change (e.g., contribution to climate change by the emission of greenhouse gasses)?

The assessment concluded that the future environment affected by climate change will not influence the DGR Project, nor will the DGR Project significantly change the future environment or contribute Greenhouse Gas (GHG) emissions to affect climate change.

ES.10 SIGNIFICANCE OF EFFECTS

The following residual adverse effects were identified:

- decreased flow in the North Railway Ditch and increased flow in the existing drainage ditch from the DGR Project site;
- removal of a small portion of eastern white cedar as a result of land clearing activities;
- loss of a small portion of redbelly dace, creek chub, variable leaf pondweed, burrowing crayfish and benthic invertebrate non-critical habitat in the South Railway Ditch;
- loss of a small portion of habitat used by burrowing crayfish in the Project Area;
- increase in concentrations of indicators in air during the site preparation and construction, operations, and decommissioning phases;
- noticeable increase in noise levels at Baie du Doré during the site preparation and construction, and decommissioning phase of the DGR Project;
- potentially diminished quality or value of ceremonial activities undertaken by Aboriginal peoples at the Aboriginal burial site located at the Bruce nuclear site (changed aesthetics, temporarily increased noise and dust);
- reduction in use and enjoyment of property from increased noise levels at Baie du Doré during site preparation and construction, and decommissioning phases; and
- health effects associated with exposure to acrolein in air during the site preparation and construction phases.

Based on an evaluation of significance, each of these effects was judged to be not significant.

In addition, no radiological adverse effects are predicted. The DGR is expected to safely contain the L&ILW and isolate them from humans and non-human biota, including during the abandonment and long-term performance phase (Section 9). The amount of radioactivity reaching the surface is very small, and would occur far into the future. The isolation afforded by the location and design of the DGR also limits the likelihood of disruptive events having the potential to bypass the natural barriers to a small number of situations with very low probability of occurring. Even if these events were to occur, the contaminants in the waste would continue to be contained effectively by the DGR system.

ES.11 CUMULATIVE EFFECTS

The cumulative effects assessment (Section 10) was undertaken to determine if the DGR Project is likely to have an effect on a VEC in consideration of other projects which have similar effects and overlap with the DGR Project in space and time. The cumulative effects assessment builds on the results of the assessment of residual adverse effects. Existing, certain (future) and reasonably foreseeable projects were identified that could interact with the DGR Project. No residual adverse cumulative effects were identified.

ES.12 CAPACITY OF RENEWABLE RESOURCES

The EIS is required to describe the effects of the DGR Project on the capacity of renewable resources to meet the needs of the present and those of the future. The EA identifies those renewable resources that may be significantly affected by the DGR Project and examines how the DGR Project could affect their sustainability (Section 11). Overall, the DGR Project is not expected to adversely affect sustainable renewable resource use.

ES.13 FOLLOW-UP STUDIES

The EIS Guidelines require that the EIS include a plan for a follow-up monitoring program to verify the accuracy of the environmental assessment and to determine the effectiveness of the measures implemented to mitigate the adverse effects of the DGR Project. Follow-up programs are recommended in Section 12.

ES.14 CONCLUSION

Taking into account the findings of the EA studies, including the identified mitigation measures, it is OPG's conclusion that the DGR Project is not likely to result in any significant adverse effects on the environment.

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1. CONTEXT

Ontario Power Generation (OPG) is undertaking a multi-year planning and regulatory approvals process for a deep geologic repository (DGR) for the long-term management of low and intermediate level waste (L&ILW). Currently, the L&ILW produced as a result of the operation of OPG's nuclear reactors is stored centrally at OPG's Western Waste Management Facility (WWMF) located on the Bruce nuclear site. Although current storage practices are safe and could be continued safely for many decades, OPG's long-term plan is to manage these wastes in a long-term management facility.

A key element of the regulatory approvals process is an environmental assessment (EA), the findings of which are presented in this Environmental Impact Statement (EIS). The EA considers the long-term management of L&ILW currently in interim storage at the WWMF, as well as that produced by OPG-owned or operated nuclear generating stations, in a DGR at the Bruce nuclear site in the Municipality of Kincardine, Ontario. Throughout this report, OPG's proposal is referred to as the "DGR Project". The DGR Project includes the site preparation and construction, operations, decommissioning, and abandonment and long-term performance of the DGR.

OPG is the Proponent for the DGR Project. OPG will own, operate and be the licensee for the DGR. The regulatory approvals phase of the project, including the EA process and the site preparation and construction licensing, has been contracted to the Nuclear Waste Management Organization (NWMO). The NWMO is responsible, with support from OPG, for completing the EA, preparing the EIS, and obtaining the Site Preparation and Construction Licence.

1.1 SETTING

1.1.1 Project Location

The DGR Project is located on OPG-retained lands, centrally located at the Bruce nuclear site. The project location is shown on Figure 1.1.1-1. The Bruce nuclear site is located in the Municipality of Kincardine, Ontario. Although OPG is the owner of the Bruce nuclear site, the majority of the site is controlled, under a leasing agreement, by the current operator of the nuclear generating stations, Bruce Power. Bruce Power also controls all access to the site. Under the leasing agreement between OPG and Bruce Power, OPG has retained control of the portion of the Bruce nuclear site including the WWMF and surrounding lands.

Figure 1.1.1-2 shows an overview of the Bruce nuclear site and the general extent of the OPG-retained lands. The operating Bruce A nuclear generating station is located to the north of the WWMF and the operating Bruce B nuclear generating station is located to the southwest. The WWMF consists of the buildings and structures in the centre of the lands, approximately one kilometre (km) from the Lake Huron shoreline. The DGR Project is proposed in the area immediately north of the WWMF. The DGR Project site is currently vacant. The estimated footprint of the surface facilities for the DGR Project is 30 hectares (ha), including the construction laydown area and waste rock management area. The areal extent of the underground facilities is approximately 40 ha. An artist's rendering of the DGR Project is shown on Figure 1.1.1-3.

1.1.2 Current Land Uses

The land use around the Bruce nuclear site is predominately agricultural in nature. The landscape is predominantly level or gently rolling plains, disrupted by large physical features such as the Niagara Escarpment, which runs from Niagara Falls to the northern end of the Bruce Peninsula. This divide in terrain type has resulted in land use in southern Bruce County being primarily agricultural, while natural systems in northern Bruce County are less disrupted by anthropogenic influences. The current regional land uses, waters and resources, including Aboriginal rights, are described in more detail in Section 6.

1.2 PROJECT OVERVIEW AND PURPOSE

1.2.1 Purpose of the Project

L&ILW is currently processed and stored at OPG's WWMF on the Bruce nuclear site in the Municipality of Kincardine. The L&ILW is transported by truck from the Pickering and Darlington nuclear generating stations to the WWMF, and by truck on-site from the Bruce nuclear generating stations. The existing facilities at the WWMF were designed as interim storage for L&ILW from OPG's nuclear generating stations. The WWMF has an excellent safety record and could be relied upon to protect the health and safety of the public and the environment for many more decades, provided institutional controls exist. OPG is proposing to develop a facility, the DGR, capable of safely isolating the wastes from people and the environment over the hundreds and thousands of years that the wastes remain radioactive.

The DGR Project is proposed because:

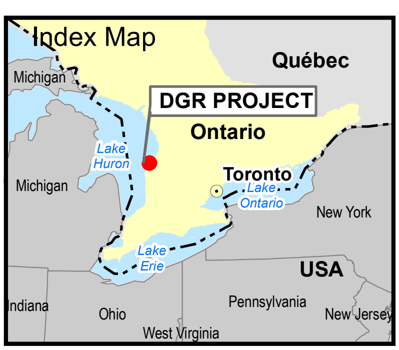
- it is consistent with international best practice;
- it provides a long-term management method for waste streams from OPG-owned or operated nuclear generating stations that will protect health, safety and the environment, and if necessary, will do so in the absence of institutional controls;
- it provides a greater margin of safety than the existing facilities; and
- it is preferred by the host municipality over the other technical options that have been evaluated, including the existing facilities.

The DGR will receive L&ILW currently stored at the WWMF on the Bruce nuclear site, as well as that produced from OPG-owned or operated generating stations. The DGR Project would provide safe long-term management of L&ILW in Ontario.

Nuclear generating stations at Bruce, Pickering and Darlington produce used nuclear fuel as well as L&ILW. Used nuclear fuel is stored and managed within licensed facilities at each of the respective nuclear generating stations. The development of a long-term facility for used fuel is not the subject of the EA for the DGR Project. The NWMO has the responsibility for implementing Adaptive Phased Management, a long-term management approach that is intended, with collaboration, continuous learning and adaptability, to lead to the construction of a separate geologic repository for all of Canada's used fuel in an informed and willing host community.

0 5 10 20 30 40 50

Kilometres



LEGEND

- City
- Highway
- Provincial Highway
- Secondary Highway
- First Nations' Lands
- Niagara Escarpment

REFERENCE

Base Data - MNR NRVIS, obtained 2004, CANMAP v7.3 2003
Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2005
Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

LOCATION OF THE DGR PROJECT

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	FIGURE 1.1.1-1	
GIS	BC	15 Jun. 2010		
CHECK	AB	15 Jun. 2010		
REVIEW	MAR	15 Jun. 2010		

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LEGEND

- Project Area (OPG-retained lands that encompass the DGR Project)
- OPG Retained Land
- Site Study Area [1]

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

OVERVIEW OF THE BRUCE NUCLEAR SITE

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE AS SHOWN	R000
DESIGN	ASB	21 Sept. 2004	FIGURE 1.1.1-2	
GIS	BC	15 Jun. 2010		
CHECK	AB	15 Jun. 2010		
REVIEW	MAR	15 Jun. 2010		

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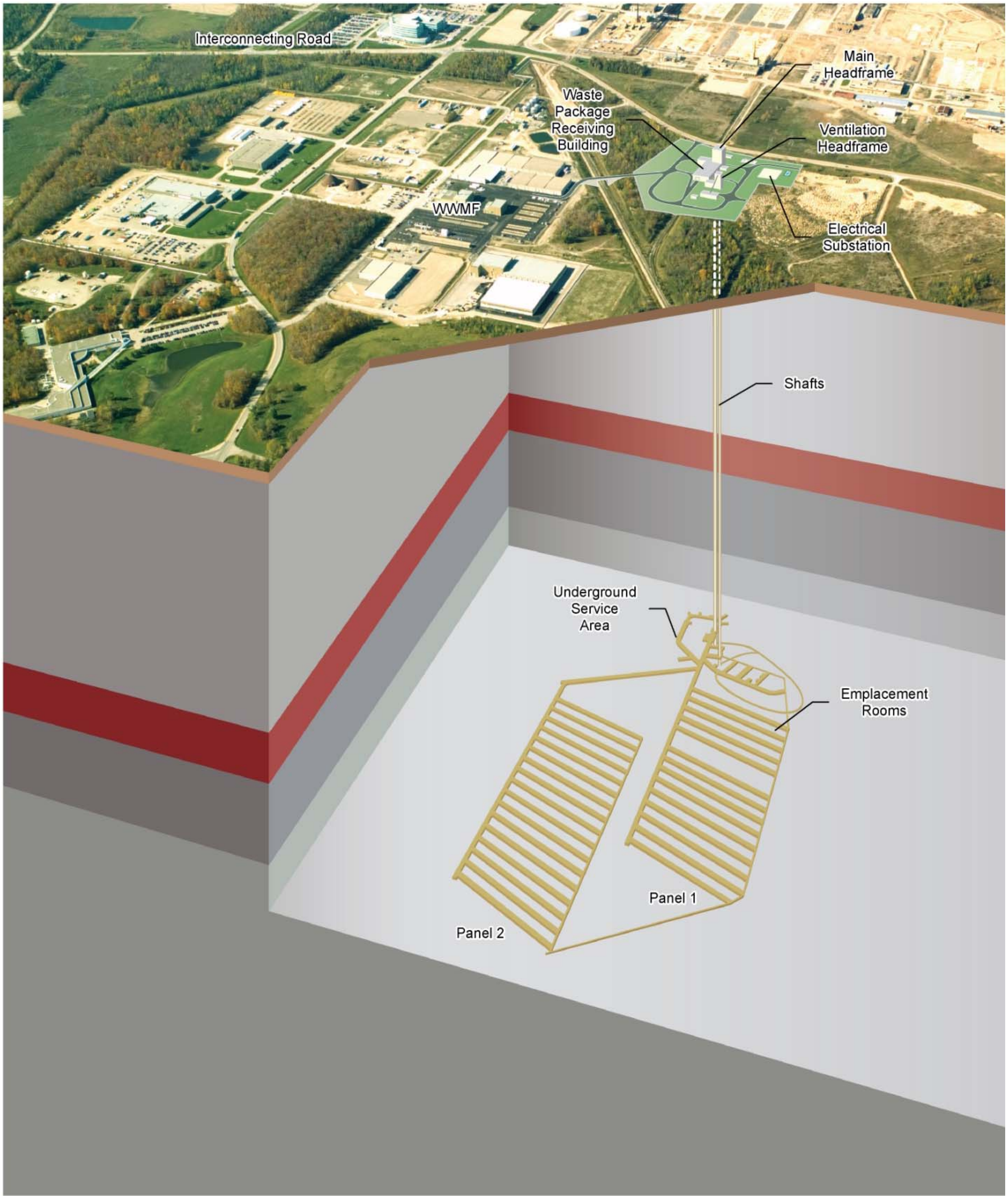

Figure 1.1.1-3: Schematic of the DGR Project

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1.2.2 DGR Project Background

In 2001, the Municipality of Kincardine approached OPG seeking to enter into an agreement to study options for the long-term management of L&ILW at the existing WWMF. Those discussions led to the signing, in April 2002, of a Memorandum of Understanding (MOU) between OPG and the Municipality of Kincardine. The work plan under the agreement included:

- a review of the technical feasibility of the long-term management options for L&ILW at the WWMF;
- a socio-economic impact assessment in the Municipality of Kincardine of the existing operation of the WWMF and of the potential long-term options; and
- a review of European and American models for long-term management of L&ILW, including site visits by Kincardine municipal representatives to look at issues such as technical infrastructure and community acceptance.

The work plan included an Independent Assessment Study of options for the long-term management of low-level waste (LLW), with the existing operation serving as the base case for purposes of comparison. Although the study did not explicitly include the consideration of intermediate-level waste (ILW), it did consider whether or not each of the options could manage some or all of the ILW. The Independent Assessment Study evaluated the geotechnical feasibility, safety, potential environmental effects, and potential social and economic effects of several options. The options considered were enhanced processing, treatment and long-term storage; covered above-ground vaults; and a deep geologic repository (referred to in the Independent Assessment Study as deep rock vault), as well as the status quo option of continuation of L&ILW management at the WWMF. These options are described in further detail in Section 3.3.

A community consultation and communications program was developed and implemented as a part of the Independent Assessment Study. The communications program included one-on-one stakeholder briefings, open houses, newsletters, public attitude research, website, advertising in local newspapers and presentations at regularly scheduled meetings. Stakeholders included municipal, provincial and federal government representatives, and the general public. Representatives of local Aboriginal communities also received information and briefings.

The results of the Independent Assessment Study were documented in a report [1], which concluded that each of the four options examined:

- Is technically feasible. The geology of the Bruce nuclear site is ideal for a deep repository; however, it could also support above-ground concrete vaults.
- Could provide safe storage for some or all of the L&ILW. Radiation doses would be much lower than regulatory criteria and would occur far out into the future.
- Would have no significant residual adverse environmental effects.
- Would have no adverse social effects. The majority of respondents to the Public Attitude Research survey also indicated that none of the long-term options considered for L&ILW management, including the DGR Project, would have an adverse effect on their feelings of personal security or satisfaction with the community or on the community as a place to visit, to operate a business or to live.

- Would have a positive effect on the local economy.

Following a review of the Independent Assessment Study, municipal support was indicated at the April 21, 2004 Kincardine Council Meeting at which the following resolution was carried:

> *Resolution #2004 – 232*
> *"…that Council endorse the opinion of the [Kincardine] Nuclear Waste Steering Committee and select the 'Deep Rock Vault' option as the preferred course of study in regards to the management of low and intermediate level radioactive waste".*

In the fall of 2004, a MOU was also signed between OPG and the Chippewas of Saugeen First Nation and the Chippewas of Nawash Unceded First Nation (collectively referred to as the Saugeen Ojibway Nation [SON]). The MOU outlined terms and a process for OPG and SON to communicate on the Independent Assessment Study.

In October 2004, a DGR Hosting Agreement [2] was signed by OPG and the Municipality of Kincardine. The Agreement required the Municipality of Kincardine to conduct Community Consultation. This was done by completing a community poll, with a positive result, in early 2005. The Community Consultation is discussed in more detail in Section 2.2.1.5. Although the agreement is formally between OPG and the Municipality of Kincardine, OPG received letters of support for the DGR Project from Brockton, Saugeen Shores, Huron-Kinloss, and Arran-Elderslie, the neighbouring municipalities that would benefit from under the DGR Project Hosting Agreement. All eight municipalities in Bruce County have indicated support for the Project.

OPG's submission of a Project Description for the DGR to the Canadian Nuclear Safety Commission (CNSC) on December 2, 2005 initiated the EA process.

1.2.3 Summary Description of the DGR Project

The DGR Project will receive L&ILW currently stored in interim facilities at the WWMF, as well as that produced from OPG-owned or operated nuclear generating stations. The WWMF will continue to receive and volume reduce L&ILW before transferring it to the DGR. Low level waste (LLW) consists of industrial items and materials such as clothing, tools, equipment, and occasional large objects such as heat exchangers, which have become contaminated with low levels of radioactivity. Intermediate level waste consists primarily of used reactor components, including those from refurbishment, as well as resins and filters used to clean the reactor water circuits. The capacity of the DGR is approximately 200,000 m^3 of waste (emplaced volume).

The DGR Project comprises two shafts, a number of emplacement rooms, and support facilities for the long-term management of L&ILW (Figure 1.1.1-3). The DGR Project design is the result of a thorough comparison and evaluation of different alternative methods of implementing the DGR Project. This includes considerations such as the layout of the DGR and construction methods. The evaluation compared each of the alternative means using technical, environmental and economic factors to identify the preferred alternative. This evaluation is presented in Section 3.4. A more detailed description of the DGR Project is provided in Section 4.

1.2.3.1 Surface Buildings and Infrastructure

The surface DGR facilities (Figure 1.1.1-3) will be located on vacant OPG-retained land to the north of the existing WWMF. A new crossing will be constructed across the abandoned rail bed to provide access to the proposed DGR Project site from the WWMF. The surface structures will be grouped in relatively close proximity to facilitate operations and maintenance activities, and provide a compact footprint.

The Waste Package Receiving Building (WPRB) will receive all radioactive waste packages and transfer them to the main shaft cage for conveyance underground. A maintenance workshop and stores for essential shaft-related spares and materials will be attached to the WPRB. An office, main control room and amenities building will also form part of the main shaft complex for administrative purposes, control and monitoring of the DGR, and receiving visitors to the DGR. An electrical sub-station will provide power to the entire facility, both surface and underground, and an emergency power supply will maintain critical systems in the event of an outage.

Waste rock piles for the complete excavated volume of rock will be accommodated to the north-east of the two shafts. A stormwater management system of ditches and a pond will provide treatment and control the outflow of surface runoff and sump discharge water from the site before release into an existing drainage ditch at the Bruce nuclear site, and ultimately Lake Huron. The discharge will be monitored to confirm it meets certificate of approval water quality requirements.

1.2.3.2 Underground Facilities

The underground DGR facilities will be constructed in limestone bedrock (Cobourg Formation) at a nominal depth of 680 m beneath the OPG-retained lands in the centre of the Bruce nuclear site (Figure 1.1.1-3). The overall underground arrangement enables infrastructure to be kept in close proximity to the main shaft, while keeping the L&ILW emplacement areas away from normally occupied and high use areas.

The DGR will have two vertical shafts (main and ventilation shafts) in an island arrangement with a shaft service area in which offices, a workshop, wash bay, refuge stations, lunch room and geotechnical laboratory will be provided. From this centralized area, the two panels of emplacement rooms are connected via access tunnels. The main access tunnel leads from the main shaft station to the east, passing the ventilation shaft and then proceeding towards the emplacement room panels. The main access tunnel continues directly into the Panel 1 access tunnel, while a branch tunnel to the south leads to the Panel 2 access tunnel. End walls may be erected at the room entrance once the rooms are filled.

The emplacement rooms will all be aligned parallel to the assumed direction of the major principal horizontal stresses of the rock mass (east-north-east) to minimize rock fall in the emplacement rooms.

A ventilation supply system will supply air at a controlled range of temperatures to ensure that freezing does not occur in the main shaft and the atmosphere is kept in a reasonably steady and dry state, which is suitable for workers and limits corrosion of structures and waste packages.

1.2.4 Project Schedule

The DGR Project has been developed during several years of conceptual and feasibility studies, including extensive community consultation. The EA and licensing process commenced in 2005 and is expected to last approximately seven years. Following approval, construction is expected to last approximately five to seven years, followed by an operations phase. The operations phase would include some 35 to 40 years when waste will be emplaced, followed by a period of post-emplacement monitoring to confirm the facility's performance. The decommissioning, and abandonment and long-term performance phases would follow the operations phase, including a period of institutional control for up to 300 years.

Further details on the DGR Project schedule for each of the phases are provided in Section 4.

1.2.5 Project Cost

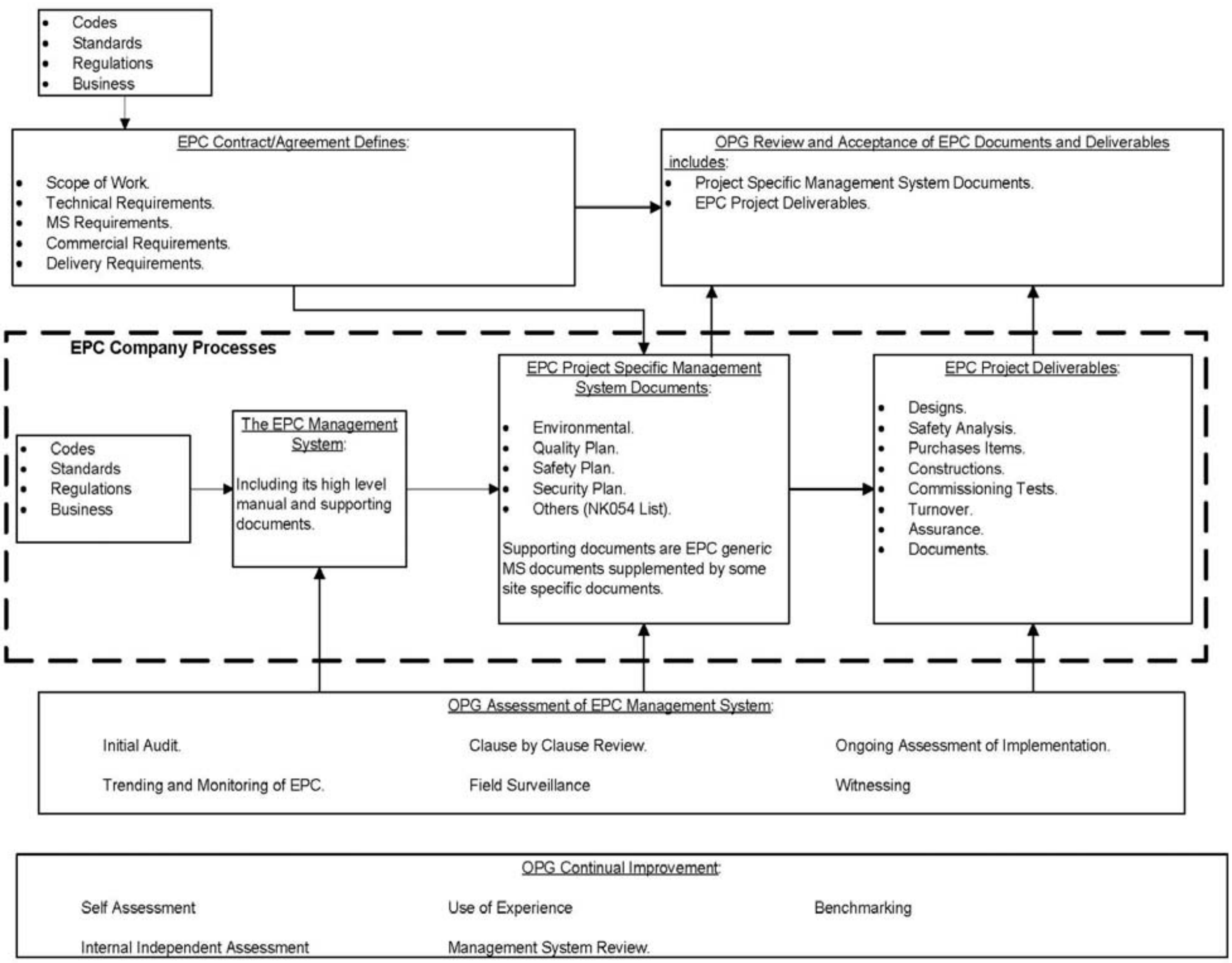
The construction cost of the DGR is currently estimated to be about $1 billion. An existing segregated fund established by OPG (Decommissioning Fund), which has been accumulating funds as part of electricity rates, will be used to pay the cost of the DGR Project.

1.3 PROPONENT

OPG is the Proponent and will be the licensee for the DGR Project. OPG, one of the successor corporations to the former Ontario Hydro, is incorporated pursuant to the Ontario Business Corporations Act and its shares are wholly owned by the Province of Ontario. In addition to hydroelectric and fossil-fuelled power generating stations, OPG owns and operates the Pickering A, Pickering B and Darlington nuclear generating stations, and the Darlington, Pickering and Western Waste Management Facilities. OPG is also the owner of the nuclear generating stations located on the Bruce nuclear site, which are currently operated by Bruce Power under a lease arrangement.

As the Proponent, OPG maintains overall responsibility for the development of the DGR Project; however, its primary role is overseeing and monitoring the performance of the contractor in all aspects of regulatory approvals, design and construction of the DGR Project. The Proponent is committed to ensuring that development, construction, operation, decommissioning and closure of the DGR is carried out in a manner that protects workers, the public and the environment, and meets or exceeds applicable regulatory requirements. The Nuclear Waste Management Organization (NWMO), under contract to OPG, is managing the regulatory approvals phase and the design and construction of the DGR Project on behalf of OPG. NWMO is responsible for preparing the EA and obtaining the Site Preparation and Construction Licence. The NWMO also has accountability for ensuring that the engineering and construction of the DGR is in accordance with nuclear safety, health and safety, economic, environmental, security and quality requirements. This includes the implementation of environmental mitigation measures, environmental monitoring and management of potential adverse effects. This will be achieved through implementation of a Design and Construction Phase Management System [3].

OPG's organizational structure for oversight of the DGR Project is shown in Figure 1.3-1. NWMO's management and organizational structure relevant to the regulatory approvals phase is shown in Figure 1.3-2. The management and organizational structure relevant to the site preparation and construction, and operations phases of the DGR Project is described in Section 4.14.



Note: EPC = Engineering, Procurement and Construction Company
Source: [4]

Figure 1.3-1: OPG's Project Oversight Model

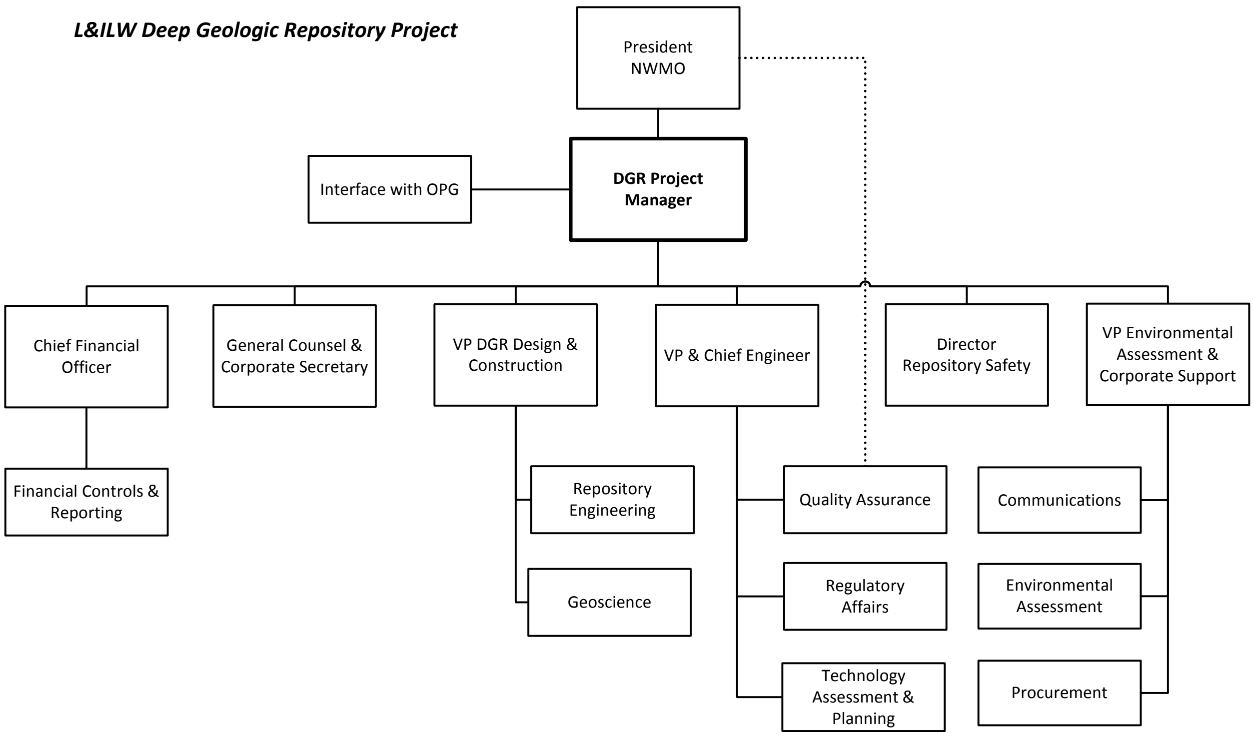


Figure 1.3-2: NWMO's Organization and Management of the DGR Project during Regulatory Approvals

1.4 ENVIRONMENTAL ASSESSMENT AND REGULATORY APPROVALS PROCESS

1.4.1 Initial Determination and Responsible Authority

The CNSC has determined, pursuant to section 5.0 (1)(d) of the Canadian Environmental Assessment Act (CEAA), that an EA is required before the CNSC can authorize OPG to proceed with site preparation and construction of the DGR Project. Under the Nuclear Safety and Control Act, an issuance of a licence for the DGR Project is a 'trigger' for the CEAA under the Law List Regulations. This type of project is identified in the Comprehensive Study List Regulation under the CEAA.

Under the CEAA, the CNSC is identified as the Responsible Authority (RA); however, the Canadian Environmental Assessment Agency also has statutory responsibilities (see Section 1.4.2).

The CNSC issued draft guidelines for a comprehensive study for the DGR Project in June 2006. The draft guidelines were the subject of a public hearing held in Kincardine on October 23, 2006. Following the hearing, Commission members recommended to the federal Minister of the Environment that the DGR Project be referred to a review panel pursuant to section 25 of the CEAA. This decision was recommended given the public concerns, possibility of adverse effects, the first-of-a-kind nature of the project and concerns regarding the comprehensive study's ability to address the questions raised.

The Minister of the Environment referred the EA of the DGR Project to a joint review panel on June 29, 2007. Funding for participation in the EA guideline review was awarded on August 28, 2007 by the Canadian Environmental Assessment Agency to the Saugeen Ojibway Nation, Northwatch Coalition for Environmental Protection, Greenpeace Canada, Citizens for Renewable Energy, Citizens for Alternatives to Chemical Contamination and the Canadian Coalition for Nuclear Responsibility.

Draft guidelines for the preparation of the Environmental Impact Statement (EIS) were issued on April 4, 2008 for a 75-day public review period. The final guidelines for the preparation of the EIS were issued on January 26, 2009. A copy of the final EIS Guidelines is included as Appendix A1.

Concurrent with the draft guidelines, a draft agreement to establish a Joint Review Panel was also issued. The final agreement between the Minister of the Environment and CNSC to establish a Joint Review Panel was issued concurrent with the final EIS Guidelines on January 26, 2009.

The EIS Guidelines require that the EIS is completed to a level that provides sufficient information in order for the Joint Review Panel to prepare and submit a report to the Minister of the Environment that includes recommendations on all factors set out in section 16 of the CEAA. The panel will also consider information and evidence in support of OPG's application for a licence to prepare a site for and construct a DGR for L&ILW in accordance with the Nuclear Safety and Control Act and its regulations. A concordance table showing how this EIS aligns with the EIS Guidelines is included in Volume 2, Appendix A2.

1.4.2 Identification of Other Federal and Provincial Authorities

The Major Projects Management Office has established an Agreement for the DGR Project. This agreement describes the main activities of the federal review process and outlines the key roles and responsibilities of the federal signatories to this agreement in relation to the DGR Project, including the EA, regulatory review, and Aboriginal engagement and consultation. In addition, the Agreement establishes service standards for each milestone of the federal review as the basis for tracking and managing progress.

As noted, the CNSC is the only RA under the CEAA identified for this EA. The Canadian Environmental Assessment Agency is the Federal Environmental Assessment Coordinator (FEAC) for the DGR Project because it is described on the Comprehensive Study List. The role of the FEAC is to coordinate the participation of federal authorities in the EA process and to facilitate communication and cooperation among them.

Through application of the CEAA Federal Coordination Regulations, Natural Resources Canada, Environment Canada and Health Canada have been identified as Federal Authorities for the purpose of providing expert assistance to the CNSC during the EA.[1]

CNSC staff have confirmed with the Ontario Ministry of the Environment that there are no provincial EA requirements under the Ontario Environmental Assessment Act that are applicable to this proposed project. Provincial agencies may participate in the regulatory review process.

1.4.3 Delegation of Assessment Studies

Pursuant to section 17(1) of the CEAA, OPG has been delegated the conduct of the technical support studies for the EA, as well as a public consultation program and the preparation of an EIS [5]. The EIS will be reviewed by the RA and Federal Authorities. The EIS will be used as the basis for the Panel Report required under the CEAA for the DGR Project.

1.4.4 Public Registry

The Canadian Environmental Assessment Agency has established a public registry for the assessment as required by section 55 of the CEAA. This includes identification of the assessment in the Canadian Environmental Assessment Registry (CEAR), which can be accessed on the internet web site of the Canadian Environmental Assessment Agency (www.ceaa.gc.ca). The CEAR reference number for the DGR Project is 06-05-17520.

As part of the registry, the Canadian Environmental Assessment Agency maintains a list of documents pertaining to the EA. Interested parties may obtain copies of specific documents on the list by contacting the Agency as follows:

Deep Geologic Repository Project
Canadian Environmental Assessment Agency
160 Elgin Street
Place Bell Canada
Ottawa, ON K1A 0H3
Telephone: 1-866-582-1884
Email: DGR.Review@ceaa-acee.gc.ca
Web: http://www.ceaa.gc.ca/050/index-eng.cfm

1.4.5 Use of Regulations in the EIS

Throughout the EIS and TSDs, available and proposed regulations and standards have been used as aids for evaluating the magnitudes of the environmental effects of the DGR Project. Use of proposed standards for evaluating effects in the EIS does not necessarily constitute a commitment to comply with those standards, should they not come into force. The DGR Project

[1] Saugeen Valley Conservation Authority has reviewed the DGR Project relative to the Fisheries Act and does not expect that a Section 35(2) authorization will be required for the crossing. Therefore, Fisheries and Oceans Canada is not expected to be involved in this project.

will comply with regulatory requirements in effect at the time of licensing, for the jurisdiction in which is licensed.

1.5 INTERNATIONAL AGREEMENTS AND CONSIDERATIONS

1.5.1 Canada-U.S. Air Quality Agreement

The Canada-U.S. Air Quality Agreement [6] was established in 1991 to provide a "practical and effective instrument to address shared concerns regarding transboundary air pollution". This agreement includes the establishment of emissions targets, sharing of information on assessments, mitigation measures and programs implemented to meet these targets, institutional arrangements and shared scientific studies. Progress reports on the achievements made under this program are reported every two years. The agreement [6] was amended in December 2000 with the Canada-United States Ozone Annex, supplementing the original agreement with new commitments regarding ground level ozone.

Canada's obligation under Article V of the Canada-U.S. Air Quality Agreement [6] requires that a notification form be submitted to Environment Canada for any new air pollution source that would be likely to cause significant transboundary air pollution.

Although non-trivial air quality effects are identified as a result of the DGR Project (Section 7.7.2), they are expected to be limited to the Local Study Area. It is not expected that notification will be required under this agreement; however, the Certificate of Approval for air/noise required for the DGR Project will confirm whether the project meets the notification criteria and that no notification is required.

1.5.2 Great Lakes Water Quality Agreement

The Great Lakes Water Quality Agreement [7] was first signed in 1972 and renewed in 1978 under the Boundary Waters Treaty. This agreement "expresses the commitment of Canada and the United States to restore and maintain the chemical, physical and biological integrity of the Great Lakes Basin Ecosystem". This agreement includes objectives and goals to be met by each nation to maintain water quality in the Great Lakes and communicate effectively regarding issues or progress by either nation.

Since the DGR Project is not expected to result in direct (untreated) discharges to Lake Huron and no non-trivial effects are identified to surface water quantity and flow, or surface water quality (see Section 7.3.2), notification will not be required under this agreement.

1.5.3 Michigan State Act and Resolution

On May 13, 2008, the Macomb County Water Quality Board passed a resolution to protect the waters of the Great Lakes Basin and oppose the proposed DGR Project near Kincardine, Ontario. The resolution is made on the basis of the Michigan Act 204 of 1987 (Low-Level Radioactive Waste Authority Act), which sets out siting criteria for low-level radioactive waste repositories in Michigan and excludes sites located within 10 miles of Lake Huron. The resolution proposes that similar criteria be used in Canada and other locations in the Great

Lakes Basin. However, the Michigan Act 204 of 1987 Section 10 also states that the sub-division does not apply to a site that is located at or adjacent to a nuclear power generating facility. DGR Project is proposed at the Bruce nuclear site adjacent to Bruce A and B nuclear power generating facilities. Therefore, the sub-division, according to the laws of Michigan, does not apply to the DGR Project site. Furthermore, the Macomb County Water Quality Board and Michigan State do not have regulatory jurisdiction in Canada or the Province of Ontario. Finally, neither the Michigan Act 204 nor its resolutions have been endorsed by authorities in Canada.

Notwithstanding the above, representatives of the State of Michigan and Michigan stakeholders have been engaged through the consultation process described in Section 2.7.

1.6 APPROACH TO THE ASSESSMENT

1.6.1 Environmental Assessment as a Planning Tool

An EA is a planning tool used to ensure that projects are considered in a careful and precautionary manner in order to avoid or mitigate the possible adverse effects of development on the environment and to encourage decision makers to take actions that promote sustainable development and thereby achieve or maintain a healthy environment and a healthy economy. The approach used for assessing the DGR Project, as documented in this EIS, supports the philosophy of EA as a planning and decision-making process. The assessment characterizes and assesses the effects of the DGR Project in a thorough, traceable, step-wise manner, proposes measures to mitigate adverse effects and predicts whether there will be likely significant adverse environmental effects after mitigation measures are implemented.

1.6.2 Public Participation

The Canadian Environmental Assessment Act, section 16(1), 21.2 and 22, requires every screening, comprehensive study, mediation or review panel to consider comments from the public that are received in accordance with the Act and regulations. Throughout the course of the DGR Project, an annual communication plan was developed by OPG, or NWMO on behalf of OPG, as an integral component of the engagement activities associated with the EIS. The plans outlined the scope of annual public information programs designed to provide up-to-date information about the DGR Project to members of the public in the host Municipality of Kincardine and the adjacent municipalities of Brockton, Saugeen Shores, Huron-Kinloss, South Bruce, Arran-Elderslie, South Bruce Peninsula, and Northern Bruce Peninsula, local Aboriginal communities and other interested stakeholders. The programs used various forms of media and provided a broad range of opportunities for the public and stakeholders to obtain both background and new information, ask questions, provide comments, data and input to the EA studies, and to identify, and discuss any concerns with the DGR Project.

Notification about key developments in the DGR Project and the EA was provided to the public through:

- a DGR Project website posting information about the project and contact information (phone, email and mailing address);

- distribution of DGR newsletters to about 25,000 households and businesses (increased to 35,000 in November 2009) in the local municipalities including Aboriginal communities;
- placement of project information in local libraries; and
- print and radio advertising.

Other methods of consultation included speaking engagements and non-government organizations (NGO) briefings, open houses in seven local municipalities, a DGR mobile exhibit for community events, employee communications, tours of the WWMF, tours of the DGR site characterization drill sites and DGR core storage facility, DGR videos (three revisions), DGR publications such as Keeping You Informed Booklet (four revisions) and annual reports.

The methods and results of community and stakeholder communications are described in detail in Section 2.

1.6.3 Engagement with Aboriginal Peoples

Providing opportunities for involvement of interested Aboriginal communities is a key component of the DGR Project. There are two First Nations communities located proximate to the proposed DGR Project site. The Chippewas of Saugeen First Nation Reserve No. 29 is located north of Southampton and the Chippewas of Nawash Unceded First Nation is located at the Cape Croker Reserve No. 27, north of Wiarton. These two First Nations together are referred to as the Saugeen Ojibway Nation (SON). Several Métis organizations operate in the vicinity of the site, including the Historic Saugeen Métis Community, and the Métis Nation of Ontario (MNO). The MNO represents citizens in the Georgian Bay Region.

Engagement with the Aboriginal communities began early in the planning process for the DGR Project, including communications with the First Nations initiated in 2003, well before the formal initiation of the EA process for the DGR Project. The communications included meetings to identify and understand the local Aboriginal communities' interests in the DGR Project, to provide information about the DGR Project and its status within the regulatory process, to identify and facilitate opportunities for Aboriginal communities to participate in the regulatory approvals process and to provide an opportunity for discussion on issues and concerns of the Aboriginal communities. Funding was provided, initially through a Memorandum of Understanding, and later through a Protocol, to assist SON in accessing resources to assist them in participating in the DGR Project.

The engagement process with Métis groups began in 2008. An agreement with the Historic Saugeen Métis Community was finalized in 2010 providing capacity to facilitate their engagement on the DGR Project. Discussions with the Métis Nation of Ontario are continuing and are expected to result in a Participation Agreement which would facilitate their participation in the EA process.

Further information on the objectives and methods and the results of engagement with these communities is provided in Section 2.

1.6.4 Traditional Knowledge

This EA considers both western science and traditional and local knowledge, where that information is available. Guidance provided by the Canadian Environmental Assessment Agency describes Aboriginal traditional knowledge as knowledge that is held by, and unique to, Aboriginal peoples [8]. Aboriginal traditional knowledge is a body of knowledge built up by a group of people through generations of living in close contact with nature. It is cumulative and dynamic and builds upon the historic experiences of a people and adapts to social, economic, environmental, spiritual and political change.

Traditional ecological knowledge is a subset of Aboriginal traditional knowledge. Traditional ecological knowledge "refers specifically to all types of knowledge about the environment derived from the experience and traditions of a particular group of people" [9]. There are four traditional ecological knowledge categories:

- knowledge about the environment;
- knowledge about the use of the environment;
- values about the environment; and
- the foundation of the knowledge system.

In this EA, specific traditional knowledge, where available, is incorporated through the characterization of the existing environment and assessment of effects. Issues of importance to Aboriginal communities were identified as part of the Aboriginal Interests Technical Support Document (TSD) through examination of documented information pertaining to general ecological, socio-economic and cultural heritage interests for Aboriginal peoples in Ontario to identify:

- interests raised by Aboriginal communities in relation to previous studies;
- interests raised by Aboriginal communities in the context of dialogue for the current project; and
- insight into traditional knowledge, and interests of general importance to Ojibway and Métis peoples.

This examination identified a range of interests raised by Aboriginal communities that can be used to focus the current EA relative to potential effects on residents of the Aboriginal communities in the proximity to the DGR Project. Throughout this EIS, it is highlighted where Aboriginal traditional knowledge and traditional ecological knowledge was available, and has influenced the assessment.

1.6.5 Sustainable Development

Sustainable development seeks to meet the needs of present generations without compromising the ability of future generations to meet their own needs. EA provides a systematic approach for identifying, predicting and evaluating the potential environmental effects of a project before decisions are made. In addition, EA provides the means to identify mitigation measures for adverse effects.

The DGR Project, including alternative means, takes into account relations and interactions among the various components of the ecosystems. Interactions of various components of the environment are considered through indirect effects throughout the assessment. The extent to which biological diversity may be affected by the DGR Project is considered through the assessment of ecological features of the environment (e.g., Lake Huron) in Section 7.12. The potential effects of the DGR Project on the capacity of renewable resources are assessed in Section 11.

1.6.6 Precautionary Approach

The EA, as a forward-looking planning tool used in early stages of project development, is based on a precautionary approach. This approach is guided by judgement, based on values, and intended to address uncertainties in the assessment. This approach is consistent with Principle 15[2] of the 1992 Rio Declaration on Environment and Development and the Canadian government's framework for applying precaution in decision-making processes [10].

Throughout the EA, the DGR Project has been conservatively considered in a thorough and traceable manner. For example, at each of the screening stages, potential project-related effects are advanced if they cannot be systematically removed from consideration through application of rigorous, sound and credible scientific evidence. In addition, with the exception of malfunctions, accidents and malevolent acts, all identified residual adverse effects are assumed to occur (i.e., probability of occurrence is assumed to be 1), and are assessed for significance.

A further precautionary feature incorporated into the assessment method is that the evaluation of potential effects is based on changes to the existing environment and not solely on regulatory compliance. This captures and assesses changes to the existing environment that may fall outside or below applicable regulatory frameworks.

A summary of how precaution has been taken into account in the assessment of each aspect of the environment is provided at the end of the corresponding assessment section (within Section 7).

1.6.7 Assessment Methods

The approach used in the assessment is illustrated in Figure 1.6.7-1, and includes the following steps:

- **Describe the Project.** As summarized in Section 4, the project is described as a number of works and activities that could affect the surrounding environment.
- **Describe the Existing Environment.** The existing environment is characterized using information from project-specific field studies and other studies, as described in Section 6. The description of the existing environment reflects the cumulative effects of past and existing projects on the environment.

[2] Principle 15 of the 1992 Rio Declaration on Environment and Development states that "Where there are threats of serious or irreversible damage, lack of full scientific certainty must not be used as a reason for postponing cost-effective measures to prevent environmental degradation".

- **Screen to Focus the Assessment.** Two screening steps, first for potential interactions between the project and the environment and secondly for measurable change to the environment, allow the assessment to focus on where effects are likely to occur. These steps are completed using professional judgement; if there is uncertainty, the interaction is advanced for assessment. Section 7 documents these screening steps.
- **Assess Effects.** Where there is likely to be a measurable change, the effects on the environment are predicted and assessed to determine whether there is an adverse effect, as described in Section 7. If adverse effects are predicted, mitigation measures to reduce or eliminate the effect are proposed, and a subsequent assessment is made to determine if there is a residual adverse effect.
- **Assess Cumulative Effects.** Any residual adverse effects identified in Section 7 are then assessed in Section 10 to determine whether they are likely to combine with the effects of past, present or reasonably foreseeable future projects and activities in the surrounding region to produce cumulative effects.
- **Determine Significance.** All residual adverse effects are then assessed in Section 7 (or 10, as appropriate) to determine whether the effect is significant, or not, taking into account the magnitude, extent, duration, frequency, irreversibility and social/ecological context of the effect.
- **Propose Follow-up Programs.** Finally, follow-up monitoring is proposed to confirm that mitigation measures are effective and the effects are as predicted. Monitoring activities are described in Section 12.

The spatial and temporal boundaries for the assessment of the DGR Project are established in Section 5.1 and 5.2, respectively. The assessment of effects of the DGR Project focuses on Valued Ecosystem Components (VECs), which are elements of the environment considered to be important for cultural or scientific reasons. VECs for the DGR Project are identified in Section 5.3. The detailed methods for each of these steps, including how they are applied to each aspect of the environment, are described at the beginning of each of the respective sections.

The screening and assessment steps described above follow a source-pathway-receptor approach. The DGR Project works and activities represent the source of a change, a measurable change to the environment represents a pathway and the VEC represents the receptor. In some cases, the VEC may act as both a pathway and a receptor.

Effects from the DGR Project may occur either directly or indirectly. A direct interaction occurs when the VEC is affected by a project work and activity. An indirect interaction occurs when the VEC is affected by a change in another VEC. For example, surface water quality may be affected by changes in air quality.

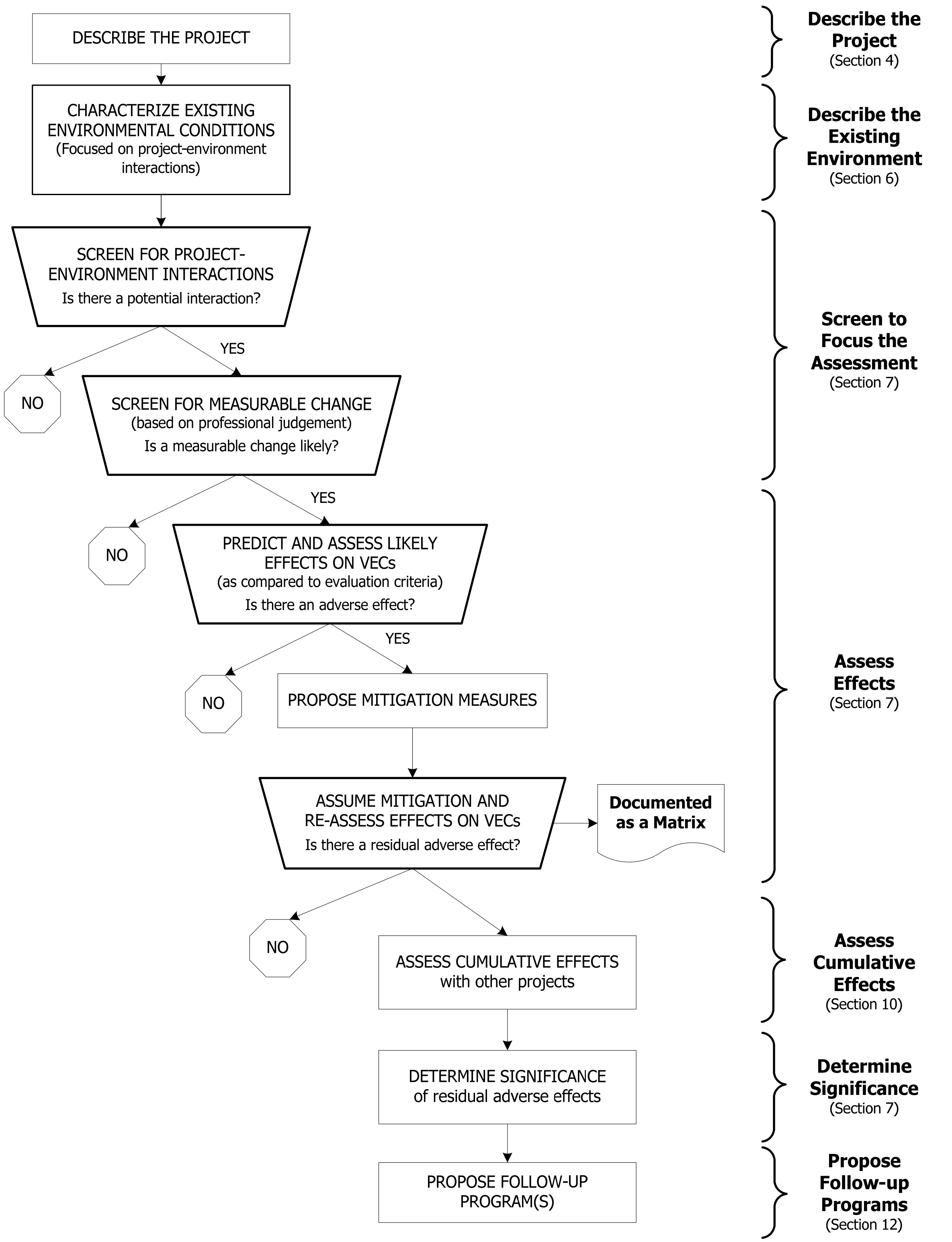


Figure 1.6.7-1: Assessment Approach

1.6.7.1 Environmental Components

The CEAA (s. 2) includes the following definition of the "Environment":

> *"… components of the Earth, and includes*
> *a) land, water and air, including all layers of the atmosphere,*
> *b) all organic and inorganic matter and living organisms, and*
> *c) the interacting natural systems that include components referred to in paragraphs (a) and (b)."*

For the purpose of the EA, the environment comprises the following environmental components:

- **Geology**: represents non-radiological soil and groundwater quality and considers geological and hydrogeological conditions and seismicity;
- **Hydrology and Surface Water Quality**: represents non-radiological surface water quality and surface water flow conditions;
- **Terrestrial Environment**: represents terrestrial biota and terrestrial habitat;
- **Aquatic Environment**: represents aquatic biota and aquatic habitat;
- **Atmospheric Environment**: represents non-radiological air quality, noise, light and vibrations and considers meteorological and climatic conditions;
- **Radiation and Radioactivity**: represents environmental radioactivity, including radionuclide emissions, doses to humans (members of the public and workers) and non-human biota;
- **Aboriginal Interests**: represents Aboriginal communities, heritage resources, and traditional use of land and resources; and
- **Socio-economic Environment**: represents population, economic base, municipal services and finance, residents and communities, land use, transportation networks and elements, landscape and visual setting and Euro-Canadian cultural heritage resources.

The above components include all biophysical and social features likely to be affected by the DGR Project and are each the subject of their own TSD. Each of these environmental components is represented by a number of VECs, which may be affected by the DGR Project (Section 5.3). The environmental components are characterized in Section 6.

These environmental components provide the general framework for assessing the effects of the DGR Project on VECs. There are many linkages and connections between aspects of the physical, biophysical and human environments in an integrated EA. The linkages between different aspects of the environment are described throughout the assessment and are considered through indirect effects.

1.6.7.2 Alternatives to and Alternative Means Evaluation

The EA compiles the evaluation of alternatives to and alternative means completed by the project design team and considers the environmental consequences of each alternative. The evaluation criteria consider environmental aspects (natural and social/cultural) as well as technical and economic considerations. The outcome of the evaluation was the confirmation of each alternative recommendation and the preferred project design. The alternatives evaluation is presented in Section 3.

1.6.7.3 Assessment of Malfunctions, Accidents and Malevolent Acts

The EIS Guidelines outline the requirements for addressing malfunctions, accidents and malevolent acts in the EIS. For the purpose of this EIS, malfunctions and accidents are organized into two categories:

- radiological malfunctions and accidents (i.e., those that could result in the acute release of radioactivity as well as non-radiological substances); and
- non-radiological malfunctions and accidents (i.e., those that involve only non-radiological substances).

In addition, malevolent acts are considered. Malevolent acts are defined as those events where the initiating event for a malfunction or accident was an intentional attempt to cause damage to the facility.

Representative malfunctions, accidents and malevolent acts are identified in Section 4.13 and are assessed in Section 8. Details on the assessment of malfunctions, accidents and malevolent acts can be found in the Malfunctions, Accidents and Malevolent Acts TSD.

1.6.7.4 Assessment of Cumulative Effects

The EIS Guidelines require that the effects of the DGR Project be considered in combination with those of other projects and activities that have been, or will be carried out, and for which the effects are expected to overlap with those of the DGR Project (i.e., overlap in time[3] and geographic area). These effects are referred to as cumulative effects. The assessment of effects is separated into three categories: past and existing projects and activities; certain/planned projects and activities; and reasonably foreseeable projects and activities. Cumulative effects are assessed in Section 10.

1.6.8 Use of Existing Information

Existing sources of information were used in the EA, where available. The sources are clearly referenced and discussed throughout the EIS. The list of references used throughout the EIS is provided in Section 14.

1.7 PRESENTATION OF THE EIS

1.7.1 Organization of the EIS

The EA for the DGR Project is documented in this EIS, which is based on the final EIS Guidelines and the work detailed in a series of technical support documents (TSDs). A number

[3] The effects may overlap, even though the activities causing them do not.

of parallel independent technical studies were completed, information from which was also used in preparing the EIS and TSDs. Finally, the EIS findings are summarized in the EIS Summary. Recommended monitoring is described in the EA Follow-up Monitoring Program. Figure 1.7.1-1 illustrates the relationships between the EIS and summary report, its supporting documents, and the independent technical studies for the DGR Project.

The EIS comprises the following volumes:

- **Volume 1** consolidates and summarizes all aspects of the EIS studies. It includes a description of the EA methods, a description of the DGR Project; a description of the existing environment, an assessment of likely environmental effects, including cumulative effects, a discussion of the proposed follow-up program, and a discussion of the communication and consultation program.
- **Volume 2** contains a series of appendices that support the material in Volume 1, including a copy of the guidelines and human health assessment. It also contains a summary of the community engagement and consultation program along with copies of supporting materials.

The EIS is based on a number of TSDs:

- Atmospheric Environment;
- Hydrology and Surface Water Quality;
- Geology;
- Aquatic Environment;
- Terrestrial Environment;
- Socio-economic environment;
- Aboriginal Interests;
- Radiation and Radioactivity; and
- Malfunctions, Accidents and Malevolent Acts.

The TSDs present information on the existing environment and investigations conducted to facilitate the assessment of the direct and indirect effects of the DGR Project on the environment. With the exception of the Malfunctions, Accidents and Malevolent Acts, TSDs assess the direct and indirect effects of the DGR Project as a result of normal conditions for the site preparation and construction, operations and decommissioning phases. The abandonment and long-term performance phase is assessed in Section 9 of the EIS. The assessment of potential radiation and radioactivity effects of the DGR Project is documented in the Radiation and Radioactivity TSD for all the physical media through which they are transported (e.g., air or water). This was done because of the special importance placed on radiation and radioactivity, and the combined effects to the receiving environment regardless of the path of exposure.

The independent technical reports used in preparing the EIS include:

- Postclosure Safety Assessment [11];
- Geosynthesis [12]; and
- Preliminary Safety Report [13].

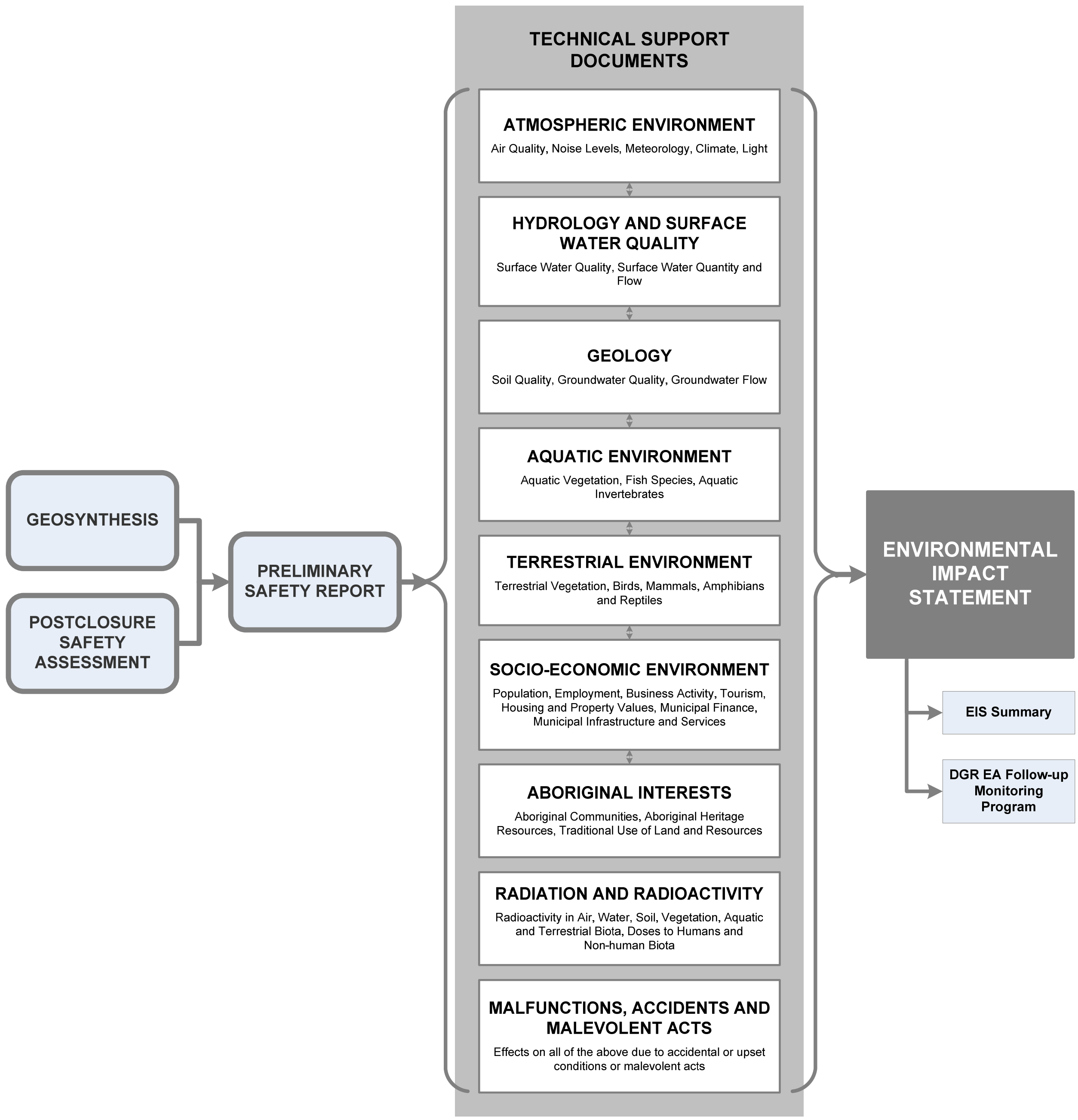


Figure 1.7.1-1: Organization of EA Documentation

1.7.2 Correlation of the EIS Guidelines and EIS

A guide is provided in Appendix A2 that cross-references the EIS Guidelines with the EIS. The guide allows readers to easily locate points raised in the EIS Guidelines within the EIS. In addition, a key subject index is provided in Section 16.

2. PUBLIC PARTICIPATION AND ABORIGINAL ENGAGEMENT

This section describes the Public Participation and Aboriginal Engagement Program undertaken for the DGR Project from the initiation of the discussions between the Municipality of Kincardine and OPG in 2002 to the submission of the EIS in 2011. The program is consistent with OPG's practices on public consultation and is intended to fulfill the requirements for public participation under the Canadian Environmental Assessment Act and the Nuclear Safety and Control Act. The Public Participation and Aboriginal Engagement Program will continue throughout the regulatory approvals process and beyond.

The Public Participation and Aboriginal Engagement Program was guided by communication plans that were developed annually and included the communication objectives, communication strategy, target audiences and key messages. The discussion is presented for both the public participation conducted in the early stage of the DGR Project (April 2002 to November 2005) and public participation conducted since December 2005, following the submission of the Project Description for the DGR Project to the CNSC. The initial public participation program helped to make information available to the community about work that was underway to study the feasibility of management options for long-term storage of L&ILW. It also provided OPG with an understanding of the level of community support for the concept before proceeding with the EA work. The latter consultation program followed the Communication and Consultation Plan described in OPG's Project Description (2005) [14] and the EIS Guidelines.

The engagement activities conducted with Aboriginal communities, government representatives and other stakeholders are also described, along with the trends in feedback and how it was incorporated into the EA. Supporting details and materials are included in Appendix D.

2.1 COMMUNICATION PLANS

The delivery of the Public Participation and Aboriginal Engagement Program for the DGR Project has been governed from the outset by detailed communication plans, which are developed annually to define communication objectives, the communication strategy, spokespersons, target audiences, key messages and communication activities. The communication plans include a broad range of opportunities for stakeholders to obtain information, ask questions and discuss issues and concerns. They also include a process to identify, document and address stakeholder issues. Copies of communications plans are found in Appendix D1.

2.1.1 Communication Objectives

The communication objectives from the annual communication plans can be summarized as follows:

- identify interested individuals and groups in the community and engage them in the EA process, including providing information and opportunities to obtain their feedback;

- inform and educate Bruce County community leaders to ensure they are able to offer meaningful input, emphasizing the importance of local communities actively participating in the process;
- inform and engage Aboriginal communities to ensure they have an opportunity to participate in the regulatory approvals process including providing input to the EA studies;
- build Bruce County community awareness and understanding of the DGR Project to facilitate the EA and site preparation/construction licence approval;
- inform and engage other stakeholders who expressed an interest in the DGR Project; and
- monitor community views on the DGR Project and gauge the level of local support.

2.1.2 Communication Strategy

To achieve the communication objectives, the program employed a planned, multi-pronged, communication strategy. The strategy included:

- using a wide range of communication activities and products such as stakeholder briefings, presentations to interested groups, open houses, newsletters, and other publications, DGR website and outreach events with the DGR mobile exhibit to deliver information on the DGR Project directly to the public;
- providing regular detailed briefings to Bruce County community leaders and stakeholders and Aboriginal community leaders to ensure they are able to participate meaningfully in the EA process, and provide input;
- obtaining community feedback through public participation efforts and public attitude research;
- building and maintaining a working relationship with the local media by regularly providing the media with factual, up-to-date DGR Project information; and
- reviewing and providing feedback on media publications regarding the DGR Project to ensure accuracy and balance.

2.1.3 Target Audiences

Target audiences for the DGR Project are focused in Bruce County, although the DGR website and DGR stakeholder mailing list provide information and access to information to many groups and individuals outside the Bruce County area. Presentations were also available outside the Bruce County area. A number of technical papers, particularly on the geoscientific investigations for the DGR Project, have been presented at international conferences. Specific target audiences include:

- Aboriginal communities and organizations;
- elected representatives from all levels of government;
- appointed government officials;
- the general public;
- regulators;
- OPG/NWMO employees;

- the media;
- local business groups;
- service clubs;
- women's groups;
- Chamber of Commerce and business groups;
- agricultural organizations;
- anglers and hunters;
- OPG/Bruce Power retiree associations;
- beach associations;
- tourism groups;
- non-government organizations;
- the education sector;
- source water protection groups;
- the public health sector;
- scientific groups;
- Michigan elected representatives and their staff;
- staff of Michigan environment and geology agencies;
- representatives of Michigan environment groups; and
- representatives from the nuclear industry such as Bruce Power, Power Workers' Union and Society of Energy Professionals.

2.1.4 Key Messages

There are seven DGR Project key messages.

- OPG encourages public comments on the DGR Project for L&ILW and many opportunities and means for providing comments are available.
- OPG has a proven track record that spans nearly 40 years in the safe management of L&ILW.
- The Municipality of Kincardine preferred the DGR because it wanted a long-term management option for L&ILW that is consistent with best international practice and provides the highest margins of safety for both the public and environment.
- The geology of the proposed location of the DGR Project presents multiple natural barriers that will provide for the safe long-term isolation and containment of L&ILW from the public and the environment for tens of thousands of years.
- The DGR Project will only be constructed following regulatory approval, with community support, and be subjected to international peer review.
- The DGR will not contain used nuclear fuel. It is for the long-term management of L&ILW. The long-term management project for Canada's used fuel is NWMO's Adaptive Phased Management (APM) Project. DGR and APM are separate, distinct projects.
- As the owner, operator and licensee of the DGR, OPG has contracted NWMO to manage the project through the regulatory approvals process.

2.1.5 Transition of DGR Communications to NWMO

Communications for the DGR Project are the accountability of OPG and OPG undertook these activities in the early stages of the project. On January 1, 2009 when OPG contracted the NWMO to manage the DGR Project through the regulatory approvals process, the delivery of DGR Project communications was also transitioned to NWMO. The NWMO, with OPG oversight, was tasked with the delivery of DGR Project communications through the remainder of the DGR Project regulatory approvals process. The objectives of the public participation program remained the same, as did the overall communication activities and methods employed.

2.2 OVERVIEW OF PUBLIC PARTICIPATION AND ABORIGINAL ENGAGEMENT

An overview of the public participation for the DGR Project is documented in two sections based on time period. Section 2.2.1 describes the DGR Project public participation and communications which took place from April 2002 to November 2005 when the Independent Assessment Study was underway. Section 2.2.2 describes the public participation program carried out following the initiation of the EA process for the DGR Project.

2.2.1 Public Participation: April 2002 to November 2005

The DGR Project began with the Municipality of Kincardine approaching OPG to enter into preliminary discussions regarding options for the long-term management of L&ILW at the Bruce nuclear site. Those discussions led to the signing, in April 2002, of a Memorandum of Understanding (MOU) between OPG and the Municipality of Kincardine that set out the terms to develop a work plan for the long-term management of L&ILW at the WWMF located on the Bruce nuclear site. A Kincardine-OPG Steering Committee met regularly during this time to develop and advance the work plan. The MOU work plan included:

- a review of the technical feasibility of the long-term management options for L&ILW at the WWMF;
- a socio-economic impact assessment in the Municipality of Kincardine of the existing operation of the WWMF and of the potential long-term options; and
- a review of European and American models for long-term management of L&ILW, including site visits to look at issues such as technical infrastructure and community agreements.

Kincardine and OPG representatives visited several nuclear waste management facilities in Europe and the United States: Zwilag, Switzerland; Centre de l'Aube, France; Swedish Final Repository for Radioactive Waste (SFR), Sweden; Barnwell, South Carolina, USA; and the Waste Isolation Pilot Plant (WIPP), Carlsbad, New Mexico, USA. These site visits confirmed that there were several feasible technologies for long-term L&ILW management, provided an opportunity for Kincardine representatives to talk to host municipalities, and confirmed that in some cases host community agreements were in place.

2.2.1.1 Independent Assessment Study Communications

The MOU work plan included an Independent Assessment Study of options for the long-term management of L&ILW. This *Independent Assessment of Long-Term Management Options For Low and Intermediate Level Wastes at OPG's Western Waste Management Facility* [15], conducted by Golder Associates Ltd. (Golder), evaluated the geotechnical feasibility, safety, potential environmental effects and the potential social and economic effects of four options, including Enhanced Processing, Treatment and Long-term Storage, Covered Above-ground Vault, Deep Geologic Repository (referred to as Deep Rock Vault in the Independent Assessment Study), and status quo (the WWMF).

Golder developed and implemented a Community Consultation and Communications program as a part of the Independent Assessment Study. The goals of the consultation plan were to:

- include all interested stakeholders and members of the community at a level of involvement suitable to their needs and interests;
- ensure all interested stakeholders and the community were provided with sufficient information on the L&ILW management options; and
- provide stakeholders with an opportunity to comment on the options under consideration.

Community engagement for the Independent Assessment Study began in the spring of 2003 and focussed on the Municipality of Kincardine and the four surrounding municipalities shown in Figure 2.2.1-1. The communications program included five main components: stakeholder briefings, a newsletter, a website, five Open Houses, and Aboriginal engagement.

Briefings were provided to members of federal and provincial parliament, the Grey-Bruce Medical Officer of Health, and representatives of SON Aboriginal communities, Atomic Energy Control Limited (AECL), CNSC, Natural Resources Canada, Ministry of Environment, Ministry of Energy, local Municipal Councils, the Power Workers' Union and Society of Energy Professionals. In general, the feedback indicated an interest in the Independent Assessment Study and acknowledged the effort being made to inform them. Copies of communications materials associated with the Independent Assessment Study are provided in Appendix D2.

Two newsletters were produced in association with the Independent Assessment Study. The newsletters were distributed to residences in the Municipalities of Kincardine, Saugeen Shores, Arran-Elderslie, Brockton and Huron-Kinloss, as well as the Chippewas of the Saugeen First Nation and Chippewas of Nawash Unceded First Nation. The newsletters were delivered to approximately 22,000 permanent and seasonal residences. Copies were also available at Municipal Offices and libraries. The first newsletter was issued in May 2003 and the second in March 2004. Copies of the newsletters are included in Appendix D7.

A website was established in May 2003 to provide information to the general public on the Independent Assessment Study and to receive comments and questions. During the Independent Assessment Study, the websites of the Municipality of Kincardine and OPG also provided a link to this website. The Independent Assessment Study website provided information on the objectives of the Independent Assessment Study, the options being considered, responses to Frequently Asked Questions, copies of printed materials such as newsletters, the Geotechnical Feasibility Study Report, the Preliminary Safety Assessment Report, the Independent Social and Economic Analysis study, the results of the public attitude research and the Independent Assessment Study Report.

A round of open houses was held in June 2003 to inform the community about the purpose of and process for the Independent Assessment Study and to receive input and comment on the study and the long-term management options. The dates and locations of the open houses were June 5 (Kincardine), June 10 (Lucknow), June 13 (Port Elgin), June 14 (Underwood) and June 16 (Chesley). The open houses were held from 3:00 to 8:00 p.m. on weekdays and from 11:00 a.m. to 4:00 p.m. on Saturday, June 14. The Open Houses were advertised in the May 2003 newsletter and in local newspapers, and invitation post cards were delivered by Canada Post mail drop to all businesses and residences in Kincardine, Saugeen Shores, Brockton, Huron-Kinloss and Arran-Elderslie. The Open House Report [16] concluded that the vast majority of visitors to the open houses wanted to obtain information about the project and learn how their community might be affected. A few attendees registered opposition to the production of nuclear waste. It was generally understood that wastes have been produced and must now be addressed for long-term storage.

Communication with the Saugeen Ojibway Nation (SON) (comprising the Chippewas of the Saugeen First Nation and the Chippewas of Nawash Unceded First Nation) was conducted as part of the communications plan. A draft communications protocol was developed to facilitate the exchange of information between these Aboriginal communities and OPG. The protocol was submitted in June 2003 to the two First Nation band councils and initial briefings were held with the SON Joint Council.

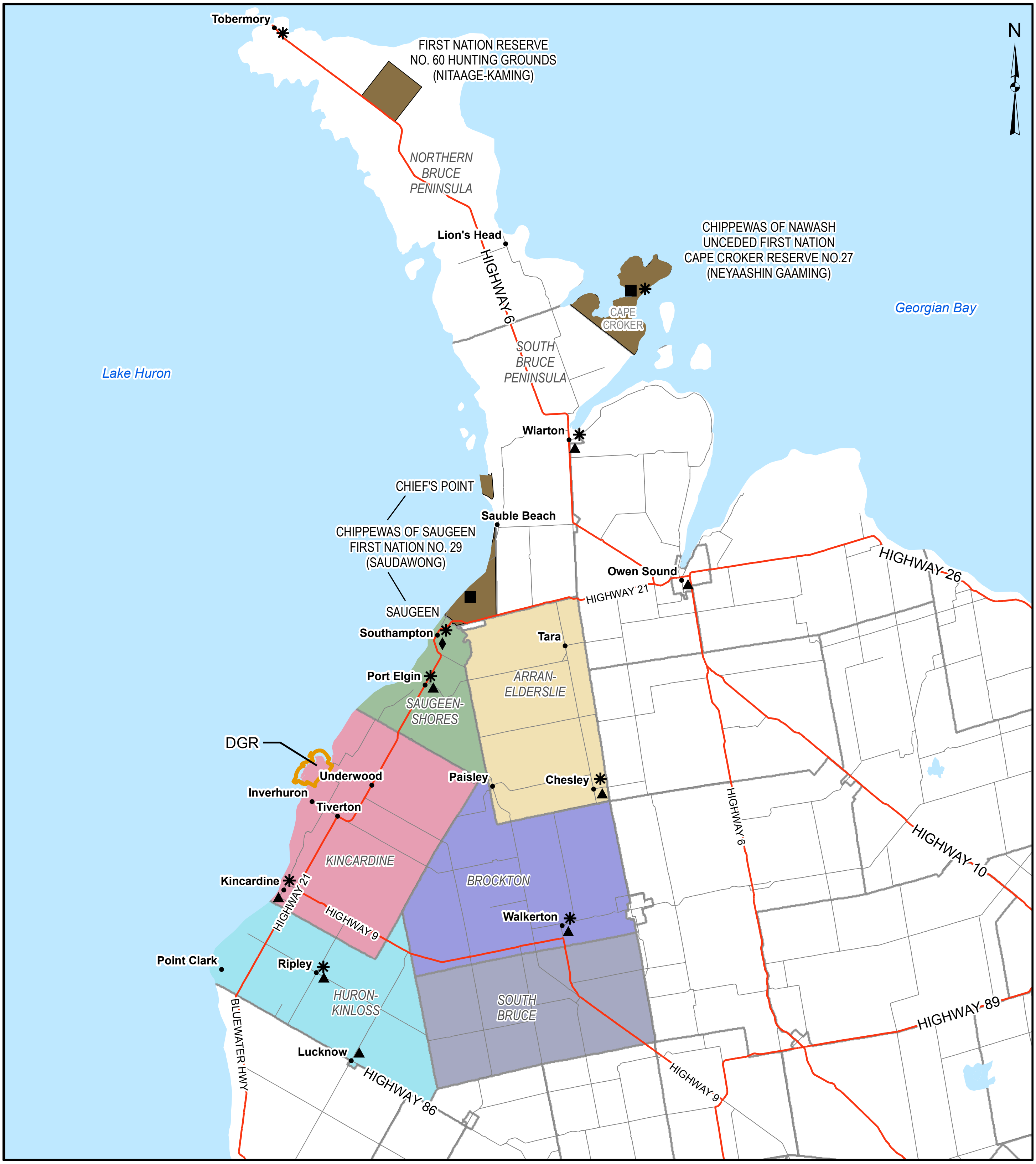
The Independent Assessment Study also undertook public attitude research to examine the potential for OPG's plans for long-term management of L&ILW at the WWMF to affect public attitudes and behaviours and various attributes of the local community. The research was undertaken using a telephone survey among adult residents of Bruce County, excepting Northern Bruce Peninsula, South Bruce Peninsula and South Bruce. Seven hundred and fifty one interviews were completed in June 2003. Additional interviews were conducted with tourists in July 2003.

2.2.1.2 Kincardine Endorses DGR

Following a review of the Independent Assessment Study Report [15], Kincardine Council passed a resolution (#2004-232) on April 21, 2004 to "endorse the opinion of the Nuclear Waste Steering Committee and select the Deep Rock Vault option as the preferred course of study in regards to the management of low and intermediate level radioactive waste". A copy of this council resolution is included in Appendix D3.

The Kincardine Council's decision to support the DGR as its preferred option was based on the following key points:

- it is consistent with international best practice;
- it provides a greater margin of safety;



0 5 10 20 30 40 50

Kilometres

LEGEND

- Library Repositories
- Community Open House Location
- SON Open House Location
- HSMC Open House Location
- Bruce nuclear site
- First Nations' Lands

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc.,
Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m,
Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

LOCAL MUNICIPALITIES

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	**FIGURE 2.2.1-1**	
GIS	BC	31 May. 2010		
CHECK	AB	31 May. 2010		
REVIEW	MAR	31 May. 2010		

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- it provides a permanent storage method for L&ILW, much of which is already at the Bruce nuclear site;
- an EA will be conducted before OPG could receive a licence to proceed with the DGR;
- it provides economic benefit to the residents of the municipality; and
- no high level waste or used fuel will be stored in the facility.

2.2.1.3 DGR Hosting Agreement

The Municipality of Kincardine Council resolution in April 2004 paved the way for OPG and Kincardine to discuss the development of a host community agreement. During their visits to host communities in Europe and the United States, Kincardine officials had confirmed that there was international precedent for agreements for hosting long-term waste management facilities.

The DGR Hosting Agreement [17] was signed by the Municipality of Kincardine and OPG on October 13, 2004. A copy of the Agreement is in Appendix D3. The DGR Hosting Agreement included the following provisions:

- OPG will design, licence, construct and operate a deep geologic repository for OPG's L&ILW , with the support of the community;
- Kincardine, Saugeen Shores, Huron-Kinloss, Arran-Elderslie and Brockton receive $35M (2004 dollars, inflation-protected) paid over 30 years, subject to achieving key milestones;
- no used fuel will be stored in the DGR;
- a property value protection plan would be provided in the event that property value is diminished by contamination resulting from radioactivity at the DGR Project site or beyond the site's boundaries, caused by the operation of the DGR;
- in the event that more reactors come on line in Ontario, the agreement outlines a fee schedule for any additional waste; and
- Kincardine Council obtains community endorsement from Kincardine residents.

Although the agreement is formally between OPG and the Municipality of Kincardine, OPG received letters of support for the DGR Project from Saugeen Shores, Huron-Kinloss, Arran-Elderslie and Brockton.

2.2.1.4 Communications Leading Up To the Community Poll

The Hosting Agreement includes a requirement for the Municipality of Kincardine to demonstrate community endorsement of the Agreement. To gauge the level of community support Kincardine chose to undertake a community poll.

The Municipality of Kincardine and OPG jointly operated a Community Consultation Centre located on the main street of Kincardine Thursday, Friday and Saturday each week, from mid-October 2004 to late January 2005 to provide the community with information about the DGR and the Hosting Agreement in the period leading up to the poll. The Community Consultation Centre served as a readily accessible location where residents could obtain information on the DGR, the benefits to Kincardine, and the process for expressing their views. In total, 312 individuals visited the centre. An "Experts Day" held at the Community Consultation Centre in December 2004 made available a geoscience expert, an EA expert, and a safety assessment expert to discuss the Independent Assessment Study with local residents. The "Experts Day" was advertised in local newspapers in advance.

Prior to the poll, Kincardine and OPG also made presentations on the DGR to community groups. These included presentations to the Kincardine Rotary Club, Kincardine Lions Club, Brucedale and Underwood Women's Institute, Kincardine Chamber of Commerce, Ontario Hydro Retirees' Association, and Kincardine Area Seniors' Action and Advisory Committee.

Also in advance of the poll, a booklet on the DGR, *Keeping You Informed About The Deep Geologic Repository Proposal*, was delivered by Canada Post mail drop to each residence in the Municipality of Kincardine [16]. This pamphlet included background information on radioactive waste, the existing WWMF, the Memorandum of Understanding, the Independent Assessment Study [15], the proposed DGR, the DGR Hosting Agreement [17], the regulatory approvals process and the community consultation process.

Leading up to the poll OPG and Kincardine also placed a number of fact sheets in the local newspapers, providing experts' views, as well as invitations to attend the Community Consultation Centre to obtain information about the DGR. The fact sheet topics included:

- We're Working Together for the Future of the Community: OPG and the Municipality of Kincardine;
- Long-Term Solution: John Davis, Golder Associates Ltd.;
- Getting Your Views: Dr. Duncan Moffett, Golder Associates Ltd.;
- A Geoscientist's Perspective on the DGR Proposal: Mark Jensen, OPG;
- Letter from Kincardine Mayor Glenn Sutton on the DGR Proposal;
- On the Preliminary Safety Assessment for the DGR Proposal: Richard Little, Quintessa;
- Myths and Facts about the DGR: OPG; and
- A Public Health Perspective on the DGR Proposal: Dr. Hazel Lynn, Medical Officer of Health for Grey-Bruce.

A copy of communications materials used during the period leading up to the poll are provided in Appendix D3.

2.2.1.5 Community Poll

The community telephone poll of permanent residents of Kincardine eighteen years of age and older, was conducted in January and February 2005 by an independent company called The Strategic Counsel. Seasonal residents were mailed a copy of the question and asked to respond by mail. A copy of the polling report is found in Appendix D3. Diligent efforts were made to contact each household, and each eligible resident, either by telephone or by mail if no telephone contact could be made. The poll asked residents:

> "*Do you support the establishment of a facility for the long-term management of low and intermediate level waste at the Western Waste Management Facility?*"

The polling drew a 71% response rate with the following results:

- Yes – 60%;
- No – 22%;
- Neutral – 13%; and
- Don't know/refused to answer – 5%.

Based on the positive results of the community poll, OPG began to work on a Project Description document outlining its plans for developing a DGR.

2.2.1.6 2005 DGR Proposal Open Houses

After completion of the community poll OPG followed through on a commitment to increase communications in the surrounding municipalities and held a series of open houses in the spring and summer of 2005 in the municipalities of Saugeen Shores, Arran-Elderslie, Huron-Kinloss and Brockton. Open houses were held in Port Elgin, Walkerton, Ripley and Chesley in May and June and in Point Clark, Southampton and Inverhuron in July, targeting summer residents. Following the open houses the booklet, *Keeping You Informed About the Deep Geologic Repository Proposal*, was delivered by Canada Post mail drop to all residences in the surrounding municipalities. Table 2.2.1-1 lists the 2005 open houses.

Table 2.2.1-1: 2005 DGR Proposal Open Houses

Date	Open House	Outcome
April 28, 29 & 30	Port Elgin	40 attendees, positive interest demonstrated
May 5, 6 & 7	Walkerton	15 attendees, generally supportive
May 13, 14 & 16	Ripley	22 attendees, generally supportive
May 26, 27 & 28	Chesley	3 attendees, generally supportive
July 11	Point Clark	8 attendees, supportive
July 12	Southampton	18 attendees, supportive
July 16	Inverhuron	36 attendees, appreciative of the information, some attendees critical of the DGR Project

2.2.2 Public Participation: December 2005 and Onwards

With the submission of the Project Description to the CNSC in December 2005 signalling the start of the EA process, OPG Public Affairs reviewed its public participation program. As a result of the review, the public participation program was modified and enhanced to meet the requirements for public participation during the EA process.

A review of the goals and objectives of the program identified the need to incorporate additional goals including seeking input on:

- the identification of Valued Ecosystem Components (VECs) to be used in the EA studies;
- the identification of potential issues in the design, operation and decommissioning of the DGR; and
- the prediction and mitigation of potential effects of the DGR Project.

Objectives of the public participation program were reconfirmed and were:

- to be transparent and open in all aspects of the public participation;
- to maintain flexibility to respond to unanticipated issues and public stakeholder and Aboriginal community input throughout the EA study period;
- to identify interested stakeholders, members of the public and interested Aboriginal community members within the study areas, along with the appropriate level of their communications needs and interests;
- to inform public stakeholders and Aboriginal communities in the study areas about the progress of the DGR Project (i.e., key milestones and key activities);
- to provide multiple and various types of opportunities for public stakeholders and Aboriginal community members to identify and discuss any concerns they may have with the DGR Project;
- to document and maintain a record of all communication and consultation processes and outcomes;
- to identify, document and respond to issues, comments and concerns related to the DGR Project as they were raised by public stakeholders and Aboriginal community members;
- to develop and maintain an up-to-date comment and response database; and
- to maintain a public website where information about the DGR Project could be accessed, and to provide information about how questions or comments could be posted through phone or email.

Two main enhancements were made to the program at the start of the EA: 1) to increase the level of communications; and 2) to broaden the consultation area to include all of Bruce County.

Although the communications activities for the EA process focussed on the municipalities surrounding Kincardine: Saugeen Shores, Huron-Kinloss, Arran-Elderslie and Brockton, activities were also held in the Bruce County municipalities of South Bruce, South Bruce Peninsula and Northern Bruce Peninsula, and also in Owen Sound. Efforts were also made to hold activities with the Saugeen Ojibway Nation, the Historic Saugeen Métis Community, and the Métis Nation of Ontario-represented citizens in the Georgian Bay Area. Aboriginal engagement is discussed further in Section 2.3. Information was mailed directly to all those who submitted comments and/or provided their contact information.

Communication activities were increased in 2006 to provide more opportunities for stakeholders to obtain information, ask questions, and provide comments and input to the DGR Project EA. A significant communication effort was made to "take the DGR to the people" by developing a mobile exhibit, video and other community outreach tactics. In 2006 and 2007 the increase in communications was achieved by adding and/or improving the consultation activities as described below.

- A **DGR Speakers Bureau** was created to actively seek out speaking engagements, especially in the expanded consultation area.
- A **DGR Mobile Exhibit** was developed, enabling staff to more easily engage with the people in Bruce County and beyond. The mobile exhibit facilitated attending community events where the public was already gathered. The mobile exhibit was also used to increase the number of opportunities for seasonal residents to learn about the DGR Project.
- A **DGR video** was developed for the mobile exhibit and for use during speaking engagements. It was also available on the website.
- **DGR Open Houses** were planned and held annually, beginning in 2007, with invitations delivered by Canada Post mail drop to approximately 50,000 residences in Kincardine, Ripley, Walkerton, Port Elgin, Owen Sound, Chesley and Wiarton, and in the surrounding communities together with announcements in newspapers covering these areas.
- **The DGR booklet "Keeping You Informed About the DGR"** was updated and mailed to the stakeholder list and used in community engagement activities in surrounding municipalities.
- **The DGR Annual Report** was issued annually, beginning in 2007 until 2009.
- **DGR Media Relations** increased.
- **DGR Media Days** were added.
- A DGR article in the monthly **Bruce County Marketplace Magazine** was added.
- **DGR advertising** increased.
- **Sponsorship** increased with OPG's Corporate Citizenship Program and in 2009 NWMO started its DGR Community Partnership Program.
- **DGR Project Newsletters** were added.
- A **Communications Tracking** process was used to track comments that were received through personal contact, comment cards, emails, phone calls and letters.

2.3 ABORIGINAL ENGAGEMENT

OPG and the NWMO have encouraged the ongoing engagement of Aboriginal peoples in the DGR Project. The overall objective of the program is to encourage the participation of interested First Nations and Métis peoples in the DGR Project to determine if the DGR Project might affect Aboriginal interests.

2.3.1 Saugeen Ojibway Nation Engagement

The Saugeen Ojibway Nation (SON) is the collective name for the Chippewas of Nawash Unceded First Nation and the Chippewas of Saugeen First Nation. The Chippewas of Saugeen First Nation is located just north of Southampton, approximately 24 km from the Bruce nuclear site, and the Chippewas of Nawash Unceded First Nation is located at Cape Croker on the Bruce Peninsula, approximately 80 km from the site (Figure 1.1.1-1). These communities are further described in Section 6.9.5.

Apart from construction employment opportunities at the Bruce nuclear site in the 1960s and 1970s, there was limited interaction between Ontario Hydro and the SON prior to the late 1980s.

In the late 1980s and early 1990s Ontario Hydro and the First Nations established a Bridging Program to qualify First Nations applicants for positions at the Bruce nuclear site. While the program was successful, many of the employment diversity gains were lost during the Ontario Hydro voluntary buy-out programs in 1992 and 1993.

Between 1995 and 2005 Ontario Hydro/OPG communicated with the SON in relation to a number of EAs including:

- Bruce Used Fuel Dry Storage (BUFDS) Facility EA, December 1997;
- Bruce Heavy Water Plant (BHWP) Decommissioning EA Study Report, December 2002;
- Low Level Storage Buildings (LLSB) 9, 10, 11 EA Study Report, March 2004; and
- WWMF Refurbishment Waste Storage Project EA Study Report, October 2005.

The engagement activities associated with those EAs identified several issues and concerns. Actions and activities taken prior to the start of the DGR Project in response to SON's identified concerns included:

- the Jiibegmegoong burial site clean-up;
- the draft Jiibegmegoong burial site ceremony and monitoring protocol;
- the coordination and implementation of burial site ceremonies;
- an archaeological assessment of the BUFDS site;
- a First Nations March Break Program at the Bruce Information Centre; and
- OPG Corporate Citizenship Program (CCP) support for SON programs including the Kabaeshiwim Respite Women's Shelter, First Nations Fisheries Conference and Saugeen Pow Wow.

2.3.1.1 Memorandum of Understanding

OPG initially made contact with the SON regarding the DGR in August 2003. In February 2004, Golder Associates Ltd., on behalf of OPG, made a presentation to the SON Joint Council. Following a second presentation to Joint Council in May 2004, SON selected an administrative coordinator and a technical advisor for the Independent Assessment Study. Further discussions led to signing of a Memorandum of Understanding (MOU) between SON and OPG in October

2004. The MOU outlined terms and a process for OPG and the SON to communicate on the Independent Assessment Study in the short-term.

2.3.1.2 WWMF Site Tours

OPG provided opportunities for members of the SON to visit the WWMF. In total, 16 SON Council members and staff toured the site. Tours were provided on September 28, 2004, September 29, 2004, November 4, 2004, April 27, 2006, and February 4, 2008. The tours provided an opportunity for visitors to see the existing L&ILW operations and ask questions about the waste and the WWMF.

A tour of the WWMF and the DGR site was provided in October 2010 to technical experts retained by the SON in support of their work program under the Protocol Agreement (see Section 2.3.1.8). Five technical experts, SON's legal counsel, one SON councillor and two representatives of the SON environment office toured the WWMF, the DGR Project site, the rock core storage facility and engaged in discussion about the DGR Project with OPG/NWMO staff. Technical presentations were provided on the results of the geoscience investigations, safety assessment and preliminary engineering.

2.3.1.3 Roundtable Meetings

In implementing the MOU described in Section 2.2.1.7, OPG and the SON agreed to begin a series of "roundtable" discussions to explore how to build a better working relationship that would be to their mutual benefit. Five roundtable meetings were held in 2004 and 2005. At the first meeting the SON tabled a list of eight issues that were important to the Bands and which they wanted to discuss further as a part of building a mutually beneficial relationship with OPG, including:

- First Nations integration into the monitoring program;
- increasing First Nations employment, such as through bridging programs;
- energy conservation and alternative production — SON believes they have potential wind energy sites;
- economic development — SON wondered why they had not been included in payments to communities in the past;
- educating band members about the WWMF functions and the language around the management of nuclear waste;
- health studies; and
- business development.

Through the roundtable meetings, the SON identified several priority initiatives on which they were interested in working with OPG to develop proposals. These were:

- SON Environment Office;
- wind energy feasibility;
- employment bridging program; and
- scholarship funding.

Through funding provided for an Administrative Coordinator in 2004 and 2005, SON developed and distributed to its community members an information brochure on the WWMF and L&ILW management and held open houses on the Independent Assessment Study in each of its communities. Tours of the WWMF were also offered to SON Council members. In addition, SON established an Environment Office at the Nawash Reserve, with OPG providing funding to assist with administrative expenses as well as funding for an Environment Coordinator.

OPG also provided a preliminary assessment of potential sites suitable for wind energy at both reserves, as well as providing technical support and advice to the SON for applications for federal government funding on feasibility studies for wind energy on their lands. OPG also offered financial assistance to SON to help them complete wind potential studies at two sites.

In discussing the bridging program, OPG indicated that they have a relatively small number of local employment opportunities relative to other employers in the nuclear industry. A bridging program should incorporate other employers as well.

Although a proposal for scholarship funding was put forward and discussed, agreement was not reached on a mutually acceptable program.

2.3.1.4 SON Peer Review Public Meetings

In April 2005, the SON held "Peer Review Public Meetings" at each Reserve, April 27 at the Chippewas of the Saugeen First Nation, and April 28 at the Chippewas of Nawash Unceded First Nation. A number of independent presenters spoke at the meetings, including Paul McKee, the technical advisor who reviewed the Independent Assessment Study Report on behalf of SON; Anna Stanley, a Ph.D. candidate from the University of Guelph; Dr. Richard Kuhn from the University of Guelph; Dr. Brenda Murphy from Wilfred Laurier University; and Assembly of First Nations representative Melissa Gus, a Nuclear Waste Dialogue Regional Coordinator. The notes provided to OPG following the meeting summarized the presentations and documented the discussion and questions. The discussion and questions focused on what happens if there is an accident, compensation, radiation dose, storage practices elsewhere, natural radiation exposure, health effects and effects on First Nations' land and water.

2.3.1.5 First Nation Open Houses

Open houses were held in May 2005 at the Chippewas of the Saugeen First Nation and the Chippewas of Nawash Unceded First Nation, which provided OPG an opportunity to present information on the DGR, respond to questions and obtain feedback on the DGR. Approximately 12 Band members attended the presentation at the Chippewas of Nawash Unceded First Nation on May 24, 2005. The open house at the Chippewas of the Saugeen First Nation on May 25, 2005 was attended by approximately 15 Band members. Attendee estimates are based on the number who signed in along with an estimate of those who chose not to sign in. The open houses included technical discussions and provided an opportunity for community members to offer feedback on the discussions and the project. At the Nawash open house concerns were expressed about the DGR Project, especially the safety of the project. Several SON community members who participated in the open house at Saugeen First Nation expressed interest in continuing a dialogue and encouraged OPG to return to provide future updates on the DGR.

Although the DGR Exhibit has been at several Pow Wows at Saugeen and Nawash First Nations, the SON Waste Committee has deferred NWMO offers to hold subsequent open houses or other engagement activities in the SON communities.

2.3.1.6 SON Environment Office

OPG provided resourcing in 2007 to assist the SON in establishing an Environment Office in Cape Croker, including funding for an environmental coordinator for the DGR Project. This Environment Office has since expanded to undertake a variety of activities within the two SON communities and with a variety of external projects and EAs.

2.3.1.7 Saugeen and Nawash Pow Wows and Community Events

Since 2005 OPG and NWMO have supported and attended, with the DGR exhibit, a number of Chippewas of the Saugeen First Nation and Chippewas of Nawash Unceded First Nation Pow Wows and other community events. The main comments and questions received at these events are listed below:

- concerns about the proximity of the DGR to Lake Huron;
- concerns about contamination of drinking water;
- concerns that used fuel will be placed in the repository;
- concerns about where they would go if an accident contaminated their lands; and
- questions regarding the appropriateness of placing waste in Mother Earth.

Responses have been provided to these questions.

- The DGR will be located approximately 1 km from the shore of Lake Huron at surface and a distance of more than 400 m below the deepest near-site point of Lake Huron. The DGR is separated vertically from Lake Huron by a low permeability layer of shale, which isolates the waste (Table 2.6.1-1).
- Drinking water quality will not be adversely affected by the DGR. The waste will be placed in very low permeability limestone, overlain by about 200 m of very low permeability shale. The characteristics of these rocks, including their age, stability and their position well below potable water found near the surface, and well below the level of the bottom of Lake Huron, will virtually eliminate the migration of radionuclides. Any migration that does take place will be over a period of hundreds of thousands of years and the radionuclide concentrations will be orders of magnitude below regulatory limits (Table 2.6.2-1, #1).
- The DGR will not receive used fuel (Table 2.6.1-1, #1). OPG's application for licence is for a DGR for L&ILW.
- Studies completed as a part of the licensing submission looked at hypothetical malfunctions and accidents that could potentially occur during all phases of the DGR Project (see Section 8). A broad range of initiating events was identified and categorized into operations, geotechnical and external initiating events. A presentation was offered to SON to discuss this further. SON was also provided a draft copy of the Malfunctions, Accidents and Malevolent Acts TSD for review and comment.

2.3.1.8 Protocol Agreement

A Protocol Agreement, signed between OPG, NWMO and the SON on March 9, 2009, provided a process to ensure that the SON has the capacity to participate in the regulatory approvals process for the DGR Project.

Following the signing of the Protocol Agreement, a working committee with representatives from the SON, OPG and NWMO was established to discuss DGR milestones as a basis for the SON to develop work programs. A first meeting of the working committee took place May 5, 2009, and it was planned that regularly scheduled meetings would be held through the remainder of the regulatory approvals process. A subsequent meeting was held on October 8, 2009. The meeting focused on a discussion introduced by the SON on issues regarding the original siting of nuclear facilities at the Bruce nuclear site, including that they had not been consulted when the decision was made to site the nuclear facility. The SON also confirmed that they preferred their ongoing discussions about the DGR Project to be with the proponent, OPG.

Through discussions on the Protocol Agreement, SON identified several concerns specific to the DGR Project. Reponses to these concerns have also been discussed.

- They did not have the capacity to participate in the regulatory process for the DGR Project.
- Would used fuel would be emplaced in the DGR?
- Waste is being transported into and stored in their traditional territory.
- Where they would go if an accident contaminated their lands?
- Is the proposed DGR site the best site?
- What other sites have been considered?

Responses consistent with the ones listed in Section 2.3.1.7, along with the following, were provided.

- SON, OPG and NWMO signed a Protocol Agreement which provided SON with access to funding to assist with their participation in the environmental assessment process.
- OPG has safely transported waste to the WWMF for nearly 40 years as a part of its ongoing operations. There have been no accidents which resulted in the release of radioactivity.
- The geology at the proposed DGR site is highly suited for safe isolation and containment of the waste. Extensive geoscientific characterization studies have been completed. SON was provided with draft copies of the Phase 1 geoscientific study reports; they and their technical consultants visited the rock core storage facility.
- The Municipality of Kincardine approached OPG. A study of the geologic feasibility of the region was completed [15]. Based on experience in other jurisdictions, a knowledgeable and willing community significantly contributes to the siting of a waste management site. Borehole studies were not conducted at other sites.

2.3.1.9 OPG/NWMO SON Sponsorship

OPG and NWMO continue to seek avenues for sponsorship opportunities with SON. Recent sponsorships have included the Saugeen Pow Wow, Nawash Pow Wow, Saugeen First Nation's Mobile Museum, Bruce County Museum exhibit "On the Threshold of a Dream: Paul Kane's 1845 Journey to Saugeen", North American Indigenous Games, Saugeen archaeological dig, Nawash First Nation Energy Alliance, Nawash Charity Golf Tournament, Nawash Recreation Program Revitalization, Nawash Language Nest Fasting Camp, Nawash Back to the Earth Temporary Structure Fund, Saugeen Little NHL Hockey Tournament, Nawash Little NHL Hockey Tournament, Saugeen First Nation Native Studies Program, Saugeen First Nation website development project and Saugeen Kabaeshiwim Respite Women's Shelter.

2.3.2 Métis Nation of Ontario Engagement

OPG first met with the Métis Nation of Ontario (MNO) to discuss the DGR Project on November 20, 2008. At this meeting OPG provided an overview of the DGR Project, including a description of the existing L&ILW management operation, background on how the DGR Project was initiated, the current engineering concept, information on studies underway to support the application for the site preparation and construction licence, and the current schedule for the DGR Project. The MNO expressed an interest in having an opportunity to review and comment on the Valued Ecosystem Components (VECs) identified for the assessment of the DGR Project, but did not have resources available to undertake a review at the time. The MNO indicated that they may have information, based on their gathering practices about species in the regional study area and the importance of those species. The MNO also provided information on their Métis history, their structure and the role of the MNO relative to the community councils.

NWMO met with the MNO again on February 24, 2009 to provide an overview of the DGR Project and information on the transition of the DGR Project from OPG to NWMO. MNO indicated their desire to have a Protocol Agreement in relation to the DGR Project.

On November 24, 2009 NWMO/OPG provided the MNO with a tour of the WWMF and an update presentation on the DGR Project. MNO representatives asked a number of questions and provided comments. The key questions pertaining directly to the DGR Project included concerns with the repository being used to store used fuel, the potential for earthquakes and their effect on the repository, and the characteristics of the host limestone rock.

NWMO presented information to the MNO on May 20, 2010, including presentations on the preliminary results of the geoscientific investigations, safety assessment, preliminary engineering and environmental assessment. At this meeting MNO indicated that they would need capacity to assist in communicating with its citizens on the DGR Project. OPG and the NWMO, at the time of writing, are in discussions with the MNO on a Participation Agreement for participation in the EA for the DGR Project. These discussions continue and are expected to lead to completion of a Participation Agreement.

2.3.3 Historic Saugeen Métis Community Engagement

OPG first met with representatives of the Historic Saugeen Métis Community (then the Saugingue Métis Council) to discuss the DGR Project on November 7, 2008. At this meeting OPG presented an overview of the DGR Project, including background information on the DGR Project, the regulatory review process, DGR schedule and details of the work ongoing at the site on the geoscientific site characterization program. OPG also provided an overview of current L&ILW operations. The Historic Saugeen Métis Community asked questions about the half-life of the waste, whether the waste would be retrievable and what plans are being considered for long-term monitoring and institutional controls. The Historic Saugeen Métis Community expressed a desire to participate in the regulatory approval process and to develop a Protocol Agreement.

On March 25, 2009 NWMO attended the grand opening of the Historic Saugeen Métis Community storefront office in Southampton. On August 6, 2009 NWMO and representatives of the Historic Saugeen Métis Community met to discuss the development of a Protocol.

NWMO and representatives of the Historic Saugeen Métis Community hosted a DGR Open House at the storefront office in Southampton on March 9, 2010. Approximately 10 Historic Saugeen Métis Community members attended the Open House which was open for two hours. Not all attendees chose to sign the register. NWMO staff greeted the attendees and walked them through the panels on display. No significant issues or concerns were raised; questions related to employment opportunities, the project schedule, the regulatory process and the location of the project.

On March 16, 2010 OPG/NWMO provided a tour of the WWMF and the DGR Core Storage Facility and an update presentation on the DGR to the Historic Saugeen Métis Community. The presentation provided more background information on the DGR Project and the latest information on the geoscientific site characterization program. The Historic Saugeen Métis Community appreciated the opportunity to see the facilities firsthand.

OPG and NWMO continue to seek avenues for sponsorship opportunities with the Historic Saugeen Métis Community. Recent sponsorships have included support for communication upgrades to their Southampton storefront office and sponsorship of their annual Métis Rendezvous community event.

On August 9, 2010 a Letter of Agreement was signed by OPG, the Historic Saugeen Métis Community and NWMO. The agreement includes provision for funding of Historic Saugeen Métis Community participation in the regulatory approvals phase of the DGR Project. Historic Saugeen Métis Community hosted a subsequent meeting for its community members on January 25, 2011. The purpose for the meeting was for Historic Saugeen Métis Community representatives to share with their community members the results of the technical review of various draft Technical Support Documents (Aquatic, Terrestrial, Hydrology and Surface Water Quality) and the geoscientific site investigations. Historic Saugeen Métis Community representatives also provided the NWMO with verbal feedback on the draft Aboriginal Interests TSD at a November 2010 meeting. These comments have been addressed in the final TSD.

2.3.4 Summary of Aboriginal Engagement

Table 2.3.4-1 summarizes the history of OPG engagement with SON and the meetings and interactions held throughout the DGR Project with SON, Métis Nation of Ontario and the Historic Saugeen Métis Community.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile

Date	Project	Interaction	Purpose/Results
Prior to late 1980's	—	Limited interaction between Ontario Hydro and First Nations (SON) at the Bruce.	—
Late 1980's and early 1990's	Aboriginal Bridging Program	Ontario Hydro and First Nations established a Bridging Program to qualify applicants for positions at BNPD.	While the program was successful many of the employment diversity gains were lost during the Ontario Hydro voluntary buy-out programs in 1992 and 1993.
1996 and 1997	CEAA Hearings on Disposal of Used Fuel and Bruce Used Fuel Dry Storage Facility (BUFDSF) (currently the Western Used Fuel Dry Storage Facility)	Nawash Chief Ralph Akiwenzie is opposed to the BUFDSF.	Nawash requested that archaeological surveys be conducted to confirm no burials in the area. Requested access to the site for ceremonies. Expressed concern about radioactive emissions impacting native fishing.
1996 and 1997	BUFDSF	OPG carries out Stage 1 archaeological assessment of the BUFDSF site.	First Nations, expressed doubts to the AECB in May 1997 about the thoroughness of the preliminary archaeological assessment.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile (continued)

Date	Project	Interaction	Purpose/Results
June 1997	BUFDSF	Ontario Hydro senior management met with Chiefs and Council of SON to discuss a path forward resolving concerns about the archaeological study.	Reached agreement that Ontario Hydro technical staff would work with representatives of First Nations to jointly plan and undertake a more detailed and mutually acceptable archaeological cooperative assessment process and to jointly develop a method for monitoring any archaeological effects during BUFDSF site preparation and facility construction.
July 23, 1997	BNPD Burial site ceremony	First Nation Ceremony at BNPD Burial Site. Ontario Hydro facilitated access to the Burial Site for the ceremony. Ontario Hydro participated in the ceremony.	Relationship building opportunity.
August 1997	BUFDSF	Research coordinator for Nawash and Saugeen First Nations met with Ontario Hydro to begin discussion of background information, issues and approach to scoping further archaeological assessment of the proposed BUFDSF.	Reached agreement on the Terms of Reference for the study, a mutually agreed upon consultant, First Nations financing of the study, community observer for key steps in the assessment, and , the research component would include interviews with elders, relatives and associates of archaeologists involved in studies of the site in the 1950s.
November 1997	BUFDSF	Archaeological assessment by. Consultant; study completed in November 1997.	Consultant concluded no evidence of past habitation or burial sites, recommended that "upland portion" of the project site be monitored during site preparation in case any deeply buried remains were found, the Aboriginal burial ground located approximately 1 km south of the proposed project site, identified by Ontario Hydro in the 1970s, is in fact the archaeological site investigated in the 1950s.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile (continued)

Date	Project	Interaction	Purpose/Results
December 1997 and February 1998	BUFDSF	Two meetings with SON to present and discuss the archaeological report.	Nawash/Saugeen research coordinator issued written confirmation to Ontario Hydro that a joint meeting of the Chiefs and Councils of both First Nations had accepted the consultant's draft report.
March 1998	BUFDSF	Correspondence.	Ontario Hydro's Executive Vice President and Chief Nuclear Officer confirmed in writing that Ontario Hydro would continue to work with SON to address issues.
May 1998	First Nation site access protocol	Draft Burial Site protocol developed for First Nation site ceremonies and monitoring arrangements.	Relationship building.
May 19, 1998	First Nations burial site	Meeting between Ontario Hydro senior managers and Saugeen and Nawash Chiefs.	Relationship building meeting. Progress included a joint visit to the burial ground to see the situation first hand and jointly determine how the issues might be addressed.
August 13 and 14, 1998	BUFDSF	Meetings with Chiefs and Council of Nawash and Saugeen on BUFDSF.	SON expressed concern that they were not consulted years ago when the nuclear site was first developed. Also concerned about the long term management of used fuel and that the Bruce nuclear site may become the permanent disposal site for used fuel. In terms of the BUFDSF, SON focused on the possibility of extreme events occurring.
October 14, 1998	First Nations burial site	Jiibegmegoong Reburial Ceremony. Ontario Hydro participated.	Relationship building; remains repatriated.
November 1998	BUFDSF	Public comment period for BUFDSF EA.	Nawash continued their opposition to BUFDSF during CEAA public review period.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile (continued)

Date	Project	Interaction	Purpose/Results
1999	BUFDSF	Response to concerns of First Nations.	Joint OPG and First Nations Whitefish and Diet Study initiated.
Fall 1999	Not project specific	Joint OPG and First Nations Whitefish and Diet Study.	A First Nations display created at the BNPD Information Centre.
December 3, 1999	First Nations burial site	Nawash Burial Committee members visit the Burial Site to walk and monitor the location.	Relationship building.
December 16, 1999	OPG Corporate Citizenship Program (CCP)	CCP support for Kabaeshiwim Women's Shelter.	Corporate citizenship.
March 2000	—	March Break First Nations Children's Program at the BNPD Information Centre. Held annually after 2000.	Relationship building.
July 2001	—	In consultation with First Nations the signs at the Jiibegmegoong Burial Site were updated.	Relationship building activity as new signs were a priority for First Nations.
August 30, 2001	—	Jiibemegoong Burial Site Clean-up. With the assistance of OPG staff, Nawash Councillors visited and cleaned up the rubbish at the Jiibegmegoong Burial Site.	Relationship building activity as the clean-up was a priority for First Nations.
2001	OPG CCP	CCP support for First Nations Fisheries Conference ($3,000).	Corporate citizenship.
February 6, 2002	WWMF Upgrades and WWMF Relicensing	OPG updated Nawash on WWMF upgrades, WWMF Relicensing, Bill C-27 and CCP cheque presentation for support of the First Nations Fisheries Conference.	Chief Akiwenzie restated their concerns with the nuclear site and related health issues. Asked about employment opportunities. Thanked OPG for the support for the Fisheries Conference.
2003	OPG CCP	CCP support for Saugeen Youth Pow Wow ($500).	Corporate citizenship.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile (continued)

Date	Project	Interaction	Purpose/Results
June 27, 2003	Independent Assessment Study for Long-term L&ILW Options at the Bruce nuclear site	Golder Associates Ltd. met with representatives of Saugeen First Nation to provide an introduction to the joint OPG and Kincardine Independent Assessment Study.	First Nations expressed concern about impact on whitefish and burial ground.
July 4, 2003	Independent Assessment Study for Long-term L&ILW Options at the Bruce nuclear site	Golder met with representatives of Nawash First Nation to provide an introduction to OPG and Kincardine Independent Assessment Study.	Nawash expressed concern about impact on whitefish and burial ground on the Bruce nuclear site.
August 8, 2003	Independent Assessment Study for Long-term Options for L&ILW Management at the Bruce nuclear site	OPG letter to the Saugeen and Nawash Chiefs requesting a meeting to discuss long-term options for L&ILW at the Bruce nuclear site.	Information update.
February 2, 2004	Independent Assessment Study for Long-term Options for L&ILW Management at the Bruce nuclear site	Golder, on behalf of OPG, made a presentation to Joint Council providing an overview of the Independent Assessment Study.	Joint Council expressed appreciation for the information, and indicated an interest in continuing discussion to develop a better relationship between OPG and SON.
May 27, 2004	Independent Assessment Study for Long-term Options for L&ILW Management at the Bruce nuclear site	Golder, on behalf of OPG presented the results of the Independent Assessment Study to the Joint Council. Also discussed at the meeting was a draft protocol for communications between SON and OPG.	SON expressed interest in pursuing a communications protocol with OPG.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile (continued)

Date	Project	Interaction	Purpose/Results
June 11, 2004	Independent Assessment Study for Long-term Options for L&ILW Management at the Bruce nuclear site	SON Orientation Session to the existing WWMF operations. Interested First Nations Councillors and elders were given a tour of the existing operation.	SON expressed appreciation for the opportunity to see the facility.
September 2, 2004	Independent Assessment Study for Long-term Options for L&ILW Management at the Bruce nuclear site	OPG met with SON Joint Council to further discuss communications protocol.	Continued interest in proceeding with protocol and discussing other subjects of mutual interest such as feasibility studies for wind, scholarships, health studies, opening an environmental office, and business development opportunities for SON.
September 28 and 29, 2004	Independent Assessment Study for Long-term Options for L&ILW Management at the Bruce nuclear site	OPG provides tour of the WWMF for members of SON Councils and for elders.	There was interest in the facility. They expressed appreciation for the opportunity to see the facility and said the briefing on the DGR proposal was also helpful.
October 6, 2004	Independent Assessment Study for Long-term Options for L&ILW Management at the Bruce nuclear site	OPG and SON sign MOU on Communications Protocol.	Protocol provides agreement on developing a relationship between OPG and SON. OPG agrees to provide funding for SON to have legal review of the MOU, funding for technical review of the Independent Assessment Study and for an administrative coordinator.
November 4, 2004	Independent Assessment Study for Long-term Options for L&ILW Management at the Bruce nuclear site	Members of SON Joint Council and elders are provided a tour of the WWMF and a briefing/introduction to the DGR.	There was interest in the facility. They expressed appreciation for the opportunity to see the facility and said the briefing on the DGR proposal was informative.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile (continued)

Date	Project	Interaction	Purpose/Results
November 24, 2004	Independent Assessment Study for Long-term Options for L&ILW Management at the Bruce nuclear site	OPG and SON continue discussions, under the recently signed MOU, on subjects of mutual interest including funding of scholarships, funding the SON environment office, business development opportunities and wind energy studies.	Working groups are formed for each of four subjects: wind energy, scholarships, business development and health studies. Each working group is tasked with developing a proposal for moving forward with a program. OPG commits to funding feasibility study for wind energy at each reserve; up to three anemometer towers for up to two years and analysis of the wind data. Study was not pursued by SON.
December 2, 2004	Independent Assessment Study for Long-term Options for L&ILW Management at the Bruce nuclear site	OPG's wind energy experts present a half day overview for interested members of Nawash and Saugeen to provide overview of wind energy and the process for going about developing a wind project.	SON was interested and expressed appreciation for the time and effort in coming to make the presentation. Asked questions and sought follow-up information. As a result of the presentation both bands applied for federal funding for wind energy studies.
2004	OPG CCP	CCP support for 50th Anniversary celebration of G. C. Huston Elementary School – serving Southampton and Saugeen Reserve ($250).	Corporate citizenship.
January 21, 2005	Independent Assessment Study for Long-term Options for L&ILW Management at the Bruce nuclear site	Lunch meeting between SON and OPG at SON request.	Meeting to discuss the relationship between OPG and SON regarding the options for long-term waste management.
January 25, 2005	Independent Assessment Study for Long-term Options for L&ILW Management at the Bruce nuclear site	OPG's wind energy experts did a field study at Saugeen First Nation to gather information to lead to identifying candidate sites to locate anemometers for possible wind energy feasibility studies.	Saugeen First Nation participates and assists in locating candidate sites.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile (continued)

Date	Project	Interaction	Purpose/Results
January 25, 2005	Independent Assessment Study for Long-term Options for L&ILW Management at the Bruce nuclear site	Teleconference with SON to discuss OPG's scholarship proposal to SON.	Discussion focused on criteria for scholarship award, how the money would be administered and number of scholarships. Agreed to continue discussions.
February 3, 2005	Independent Assessment Study for Long-term Options for L&ILW Management at the Bruce nuclear site	Round Table Meeting with SON. OPG and SON continued discussion of the DGR proposal. Committees met to exchange proposals for opportunities to further work in the subject areas of scholarships, wind energy feasibility studies, health studies and business development opportunities.	Proposals from Committees were tabled, discussed and further comments were to be provided by committee members.
February 17, 2005	Independent Assessment Study for Long-term Options for L&ILW Management at the Bruce nuclear site	Nawash Councillor asks OPG's wind energy experts for assistance in completing an application for funding for wind studies.	OPG provides assistance to SON in completing applications.
March 9, 2005	Independent Assessment Study for Long-term Options for L&ILW Management at the Bruce nuclear site	OPG wind energy experts meeting with SON to present results of preliminary siting studies for anemometers for wind feasibility studies.	SON expressed appreciation and asked for further information to support their applications for funding for wind energy studies.
April 20, 2005	Independent Assessment Study for Long-term Options for L&ILW Management at the Bruce nuclear site	Round Table meeting held at Nawash.	Discussed the DGR proposal. Also discussed other areas of mutual interest. Agreed to continue to discuss proposals. SON provided a status update on the Open Houses they are planning for providing information to their community on the DGR proposal.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile (continued)

Date	Project	Interaction	Purpose/Results
April 27, 2005	Independent Assessment Study for Long-term Options for L&ILW Management at the Bruce nuclear site	SON holds on-reserve communications meeting for Band Members at Saugeen First Nation. Presentations were made by a technical advisor who reviewed Independent Assessment Study report, as well as a number of other guest speakers from University of Guelph invited by SON.	SON distributed copies of a paper on L&ILW, copies of the Independent Assessment Study report and other relevant documentation to band members.
April 28, 2005	Independent Assessment Study for Long-term Options for L&ILW Management at the Bruce nuclear site	SON holds communications meeting for Band Members at Nawash First Nation. Presentations were made by a technical advisor who reviewed Independent Assessment Study report, as well as by a number of other guest speakers from University of Guelph invited by SON.	First Nations distributed copies of a paper on L&ILW, copies of the Independent Assessment Study report and other relevant documentation to band members.
Summer 2005	Relationship Building	OPG offers employment opportunities for SON students.	One SON student applied and was provided a non-developmental student employment placement.
May 24, 2005	Independent Assessment Study for Long-term Options for L&ILW Management at the Bruce nuclear site	OPG hosts Open House at Nawash First Nation to provide information, answer questions and obtain feedback on the DGR proposal. OPG and Golder representatives were also interviewed on the Nawash radio station about the DGR.	Approximately 12 band members attended the Open House. Band members expressed their distrust for the science behind the DGR Project, expressed interest in participating in monitoring the DGR and were not generally supportive of the proposal.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile (continued)

Date	Project	Interaction	Purpose/Results
May 25, 2005	Proposed DGR Project	OPG hosts Open House at Saugeen First Nation to provide information, answer questions and obtain feedback on the DGR proposal.	Approximately 15 band members attended the Open House. There was significant interest in the DGR Project, including technical discussion and feedback. Concerns about the safety of waste management were evident. Several SON participants asked OPG to come back and to keep the Band aware of progress.
May 25, 2005	Proposed DGR Project	OPG meets with Chief Roote and Chief Akiwenzie to discuss possible terms for a longer term MOU between SON and OPG.	Agreed on general principles for a longer term MOU. OPG agreed to draft general principles and forward to Chiefs early in June.
June , 2005	Proposed DGR Project	OPG forwards draft principles for longer term MOU to Chief Akiwenzie and Chief Roote.	Nawash was approaching an election. Feedback on the draft principles was not provided.
Summer 2005	Refurbishment Waste Storage Building EA	OPG sends letter to SON Chiefs advising them of the proposal to build refurbishment waste buildings and asking them to contact OPG if they wish to participate.	OPG followed up with phone calls and was not successful in arranging meetings.
November 2005	Relationship Building/Follow-up to MOU	OPG wind energy experts conduct a second site visit at Saugeen to confirm information on sites for anemometers.	Continued support for SON wind studies and funding opportunities.
2005	OPG CCP	CCP support for Saugeen Youth Pow Wow ($500).	Corporate citizenship.
2005	OPG CCP	CCP support for the Bruce County Museum's exhibit "On the Threshold of a Dream: Paul Kane's 1845 Journey to Saugeen" ($5,000).	Corporate citizenship.
2005	OPG CCP	CCP support for Saugeen First Nation's "Mobile Museum" ($5,000).	Corporate citizenship.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile (continued)

Date	Project	Interaction	Purpose/Results
January 19-20, 2006	Proposed DGR Project	Chiefs and Band Councils of Saugeen and Nawash First Nations meet with NWMD Senior Management to discuss the nuclear waste management, the proposed DGR and to propose development of a longer term MOU between the parties.	First Nations expressed appreciation for the presentations on the existing operation and the proposed DGR. Their questioning was open and the responses appeared to be well received. Attendees appeared to have a greater level of comfort with the proposal. Council expressed a willingness to consider a longer term MOU, though they would need to have consultation with their band members and to develop communications strategies to communicate with other First Nations bands. SON representatives indicated that they may be able to support an L&ILW DGR but could not support used fuel in this DGR. SON expressed confidence that they can work with OPG. OPG provided $60,000 funding to assist SON in communications programs.
January 2006	Proposed DGR Project – MOU follow-up	To meet commitment made in 2005 OPG provided $40,000 as contribution to start up costs for an environment office.	The environment office is intended to provide employment opportunities for First Nations and to provide a channel for SON to participate in reviews of EAs for OPG projects and other local projects which may impact SON.
February, 2006	Proposed DGR Project – MOU follow-up/ Relationship Building	OPG and Saugeen representatives confirm two locations for towers for anemometers at Saugeen reserve.	Relationship building.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile (continued)

Date	Project	Interaction	Purpose/Results
March, 2006	Proposed DGR Project – MOU follow-up/Relationship Building	OPG and SON begin the development of an MOU specific to wind studies. The purpose is to define roles and responsibilities for Saugeen and OPG in the wind feasibility studies.	Draft MOU prepared for discussion. OPG submits applications for Transport Canada and Navigations Canada permits for selected sites.
Spring, 2006	Proposed DGR Project – MOU follow-up	SON requests funding for technical review of the Golder Geotechnical Feasibility Study and the Mazurek (geosciences) report.	OPG agreed to provide funding and provided names of possible technical reviewers who might have the knowledge to do the work. SON did not follow up with this funding request.
April 21, 2006	Proposed DGR Project – MOU follow-up/Relationship Building	OPG met with Nawash Unceded First Nation at Cape Croker to look for and gather data on potential sites to locate anemometer tower for wind feasibility studies.	OPG identified several candidate sites and asked Nawash to provide additional information on a communications tower which showed potential, and for an aerial photo of a site which showed promise. SON agreed to send the information soon.
April 27, 2006	Proposed DGR Project	Band councillors and community members of Saugeen and Nawash First Nations tour the WWMF.	SON expressed appreciation the opportunity to see the waste management facility first hand.
May 2006	Proposed DGR Project – MOU follow-up/Relationship Building	MOU has been reviewed and commented on by both parties several times, including involvement of SON lawyer. The MOU was left with SON to complete their section on funding and to feedback changes on the final wording.	OPG received approvals for both towers and committed to funding of approximately $150,000 over two years for three anemometer towers, two at Saugeen and one at Nawash.
Summer 2006	Proposed DGR Project – Relationship Building	OPG sought applications from SON students for summer student employment.	One application was received and the student was provided with a summer student placement.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile (continued)

Date	Project	Interaction	Purpose/Results
July 14, 2006	Proposed DGR Project	SON councillors request meeting in Toronto to provide opportunity for their new Chief to meet OPG and provide update on the band's communications activities.	A communications meeting was held by SON at each of Saugeen and Nawash prior to this meeting. The meetings were well attended and the members are generally well informed about the DGR. Many questions were asked and answered. Another meeting is planned later in the year and printed information will be distributed to households. SON indicated that they plan to provide an update on a draft MOU later in the fall. They will meet with the CNSC to scope out the nature and process for consultation on the DGR.
September 22, 2006	Proposed DGR Project	Meeting with SON councillors to hear feedback on communications with band members on a possible MOU and input to the EA.	SON asked OPG to agree to go to the CNSC with a joint proposal to refer the EA to a panel. OPG agreed to document its position on a panel. First Nations agreed to provide a proposal on resources they need to participate in an EA process.
2006	OPG CCP	CCP support for Chippewas of Nawash Annual Pow Wow ($1,000).	Demonstration of corporate citizenship.
2006	OPG CCP	CCP support for Nawash youth participation in the 2006 North American Indigenous games ($2,500).	Demonstration of corporate citizenship.
2006	OPG CCP	CCP support for the Bruce County Museum/Saugeen First Nations project to undertake an archaeological dig at Saugeen ($5,000).	Demonstration of corporate citizenship.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile (continued)

Date	Project	Interaction	Purpose/Results
January 18, 2007	DGR Project	Chiefs and several SON councillors met with OPG to present and discuss the Principles for Proponents working in the Traditional Territories of the SON.	The discussion focused on the Principles Document and options for building a relationship in the future. OPG agreed that SON needs to have capacity to participate in the DGR Project.
February 15, 2007	DGR Project	Funding to assist SON in participating in the process to develop a plan for the SON role in the environmental assessment process.	Demonstration of willingness to assist SON in building capacity to participate in the process.
February 2007	OPG CCP	CCP support for the First Nations Energy Alliance Conference ($1,500).	Corporate citizenship.
February, 2007	OPG CCP	CCP support for the Saugeen Pow Wow, benefiting the Anishnabek Child and Youth Services ($500).	Corporate citizenship.
April 2007	OPG CCP	CCP support for the Nawash First Nation Back to the Earth Temporary Structure Fund ($500).	Corporate citizenship.
May 2007	OPG CCP	CCP support for the Nawash Charity Golf Tournament ($5,000).	Corporate citizenship.
July 2007	OPG CCP	CCP support for the Nawash Recreation Program Revitalization ($3,000).	Corporate citizenship.
August 2007	OPG CCP	CCP support for the Nawash Language Nest Fasting Camp ($840).	Corporate citizenship.
September 21, 2007	DGR Project	The meeting was to provide an update on the status of the DGR Project, in particular the EA process and to discuss the path forward pertaining to continuing to build a relationship between SON and OPG.	Discussed the path forward pertaining to incorporating Principles for Proponents into a more DGR Project specific document.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile (continued)

Date	Project	Interaction	Purpose/Results
October 23, 2007	DGR Project	The purpose of the meeting was for SON and OPG to respectively update each other of the status of activities related to the DGR Project and to discuss how SON will participate in the DGR Project going forward.	The information exchange was good and the meeting overall was congenial. Following the meeting OPG visited the new SON Environment Office. SON agreed to prepare a first draft of a DGR Project specific agreement in advance of the next meeting.
January 31, 2008	DGR Project	OPG provided an update on the activities related to the DGR Project, including the status of the first boreholes, studies associated with the EIS. SON provided information on their discussions with CNSC in relation to the EA process and Duty to Consult. The draft Protocol was reviewed.	Agreed that the draft Protocol is a very good blueprint and basis for moving forward. OPG is to provide comments and alternate wording for several clauses.
February 4, 2008	DGR Project	SON EA Coordinators toured WWMF and Western Used Fuel Dry Storage Facility.	Provided information on the operations, the types of waste and the processing activities. Coordinators appreciated the tour of the operations.
February 5-6, 2008	Nuclear Waste Management	Funding was provided for three independent experts (Anthony Hodge, Gordon Williams and Fred Roots) to participate in a two-day SON Workshop at Nawash.	Provided an opportunity for SON to obtain information from independent experts in the absence of OPG representatives. SON developed the agenda for the workshop and did not share the agenda with OPG.
April 17, 2008	DGR Project	Purpose of the meeting was to finalize the Protocol between SON and OPG.	The result of the meeting was that SON and OPG initialled a Protocol and agreed that the respective lawyers would work together to develop wording for a "Schedule B" which is to outline the funding principles and budget process.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile (continued)

Date	Project	Interaction	Purpose/Results
August 16, 2008	DGR Project	OPG participated in the Nawash Pow Wow with the DGR mobile exhibit.	Members of the Nawash Unceded First Nation community, as well as a number of other First Nations and general public took the opportunity to obtain information about the DGR Project.
August 28, 2008	DGR Project	OPG sponsored and participated in the Nawash Charity Golf Tournament ($3,750).	Demonstration of corporate citizenship.
November 7, 2008	DGR Project	OPG and Saguingue Métis Energy Committee met to initiate discussions about the DGR Project and the role of Saguingue in the environmental assessment process. Saguingue provided an overview of their peoples and history of their peoples. OPG provided an overview of the DGR Project and the timelines.	Saguingue appreciated the opportunity to discuss the DGR Project and indicated that they have an interest in participating in the environmental assessment process.
November 20, 2008	DGR Project	OPG met with representatives of the MNO. MNO provided an overview of the Métis structure and the role of MNO relative to the Community Councils. There are four community Councils in the Georgian Bay Region, where the DGR is located. OPG provided in introduction to the DGR Project and the environmental assessment process.	MNO representatives commented that the extent of communications activities is commendable. There is a need to communicate with Métis Community Councils, an activity which OPG has initiated. The MNO is likely to take a position on the DGR Project consistent with that of the Community Councils.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile (continued)

Date	Project	Interaction	Purpose/Results
January 19, 2009	DGR Project	NWMO and OPG meeting with SON (anticipated signing the Protocol Agreement).	The transition of the DGR Project to NWMO and the roles that NWMO and OPG will have in the future were discussed. The Protocol signing was postponed. SON indicated their preference to sign a Protocol with OPG, the owner and licensee of the DGR.
February 24, 2009	DGR Project	NWMO met with MNO.	NWMO provided an overview of the transition of the DGR Project from OPG to NWMO. An update on the status of DGR Project, along with some key milestones was also provided. MNO indicated that it is their desire to have a Protocol in relation to the DGR Project. A preliminary copy of a Protocol template was provided to NWMO. MNO reiterated that community councils and regional councils will need to have an opportunity to be informed. MNO would like to foster a good working/business relationship. Next steps include: a tour of the WWMF which NWMO will arrange, a list of DGR milestones, and progress on the Protocol.
March 9, 2009	DGR Project	NWMO/OPG meeting with SON to sign the Protocol.	The protocol was signed by SON, OPG and NWMO.
March 2009	OPG CCP	OPG support for the Saugeen First Nation – Little NHL Hockey Tournament ($1,500).	Corporate citizenship.
March 25, 2009	DGR Project	NWMO attended the Historic Saugeen Métis Community (HSMC) Open House in Southampton.	Congratulated HSMC on their new storefront headquarters and discussed the need to meet to work on developing a Protocol.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile (continued)

Date	Project	Interaction	Purpose/Results
May 5, 2009	DGR Project	NWMO/OPG meeting with SON. This was the first meeting of the working committee following the signing of the Protocol.	Discussed the DGR Project, project milestones and developing work programs.
June 9, 2009	DGR Project	NWMO letter to Chief Akiwenzie and Chief Kahgee.	Follow-up to May 5 meeting.
June 30, 2009	DGR Project	NWMO letter to Chief Akiwenzie and Chief Kahgee.	Follow-up to May 5 meeting – to assist in planning SON's participation in the EA.
July 23, 2009	DGR Project	NWMO met with the SON Environmental Assessment Coordinator.	Discussed the DGR Project and SON's participation for HSMC participation in DGR EA process.
July 2009	DGR Community Partnership Program (CPP)	NWMO support for the Star Pathways Hockey Association ($1,000). (Note: The organization disbanded mid-year and returned the cheque.)	Community support.
August 6, 2009	DGR Project	NWMO meeting with HSMC.	Discussed the development of a Protocol.
August 15, 2009	DGR Project	NWMO sponsored and participated in the Nawash Pow Wow with the DGR mobile exhibit ($500).	Nawash community members, as well as a number of other First Nation and general public took the opportunity to obtain information about the DGR Project.
August 26, 2009	DGR CPP	NWMO sponsored and participated in the Nawash Charity Golf Tournament ($3,750).	Community support.
August 26, 2009	OPG CCP	OPG support for the Nawash Charity Golf Tournament (Hole sponsorship) ($1,000).	Corporate citizenship.
October 8, 2009	DGR Project	NWMO/OPG meeting with SON.	The purpose of the meeting was to continue the engagement process with SON for OPG's L&ILW DGR Project. The meeting focused on a discussion introduced by SON on legacy issues.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile (continued)

Date	Project	Interaction	Purpose/Results
November 6, 2009	DGR Project	NWMO letter to Chief Akiwenzie and Chief Kahgee.	Follow-up to October 8 meeting.
November 18, 2009	DGR CPP	NWMO support for Saugeen First Nations, Native Studies Program ($6,824).	Community support.
November 18, 2009	DGR CPP	NWMO support for HSMC, Storefront Office upgrade ($5,000).	Community support.
November 18, 2009	DGR CPP	NWMO support for Saugeen's Kabaeshiwim Respite Women's Shelter ($1,000).	Community support.
November 18, 2009	DGR CPP	NWMO support for Chippewas of Nawash participation in the Little NHL hockey tournament ($2,500).	Community support.
November 24, 2009	DGR Project	NWMO/OPG meeting with MNO.	Provided the MNO with a tour of the WWMF and presentation on the DGR.
December 22, 2009	DGR Project	NWMO letter to Chief Akiwenzie and Chief Kahgee.	Suggested meeting in the new year to discuss dealing with SON invoices and a path forward for SON participation in the DGR.
January 29, 2010	DGR Project	OPG, SON Meeting.	OPG and SON met to discuss roles and relationships, legacy issues and input to the DGR EA.
February 11, 2010	DGR Project	OPG, SON Meeting.	OPG and SON met to discuss the DGR EA and financial matters.
February 26, 2010	DGR Project	NWMO, HSMC Meeting.	The purpose of the meeting was to discuss the revised Draft Protocol and more specifically the work program and funding for HSMC's participation in the DGR EA. Significant progress was made on refining the work program and levels of funding.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile (continued)

Date	Project	Interaction	Purpose/Results
March 2, 2010	DGR Project	NWMO, MNO Meeting.	NWMO met with MNO to discuss starting to work on a participation agreement for the DGR Project.
March 4, 2010	OPG CCP	OPG support for the Saugeen Hockey Association ($1,500).	Demonstration of corporate citizenship.
March 9, 2010	DGR Project	HSMC DGR Open House.	NWMO and HSMC hosted a DGR Open House at their storefront office in Southampton. Approximately 10 people attended the 2 hour Open House. NWMO staff greeted the attendees and walked them through the panels on display. No significant issues or concerns were raised.
March 12, 2010	DGR Project	OPG, SON Meeting.	OPG and SON met to discuss the DGR EA work plan and budget.
March 16, 2010	DGR Project	HSMC WWMF and DGR Core Storage tour and presentation.	OPG provided a tour of the WWMF to HSMC. Following the tour NWMO led the group by the DGR drill sites and over to the DGR Core Storage Facility to see the rock core. NWMO also provided an update on the DGR Project, focusing on the latest information on the geoscientific site characterization program.
March 22, 2010	DGR Project	OPG, SON Meeting.	OPG and SON met to discuss the DGR EA and financial matters.
May 7, 2010	DGR Project	OPG, SON Meeting.	OPG and SON met to discuss the DGR EA work plan and budget.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile (continued)

Date	Project	Interaction	Purpose/Results
May 20, 2010	DGR Project	Métis Nation of Ontario (MNO) Engagement Workshop.	The purpose of the workshop was for NWMO to provide DGR Project information to MNO and to gain an understanding of MNO's potential involvement in the review process.
August 5, 2010	DGR Project	OPG, NWMO Meeting with HSMC.	OPG, NWMO and HSMC discuss the Letter of Agreement for their participation in the DGR EA process. HSM expressed concerns with the delay in signing the agreement. HSMC expressed a desire to have the agreement signed without delay.
August 10, 2010	DGR Project	OPG, NWMO Meeting with HSMC.	OPG and NWMO met with HSMC to present and review the Letter of Agreement and discuss moving forward with HSMC's participation in the DGR regulatory review process. HSMC subsequently reviewed, signed and forwarded the Agreement back to NWMO.
August 14, 2010	DGR CPP	NWMO support for HSMC Rendezvous community event ($2,000).	Community support.
August 26, 2010	OPG CCP	OPG support for the Nawash Charity Golf Tournament (Hole sponsorship) ($1,000).	Corporate citizenship.
August 26, 2010	DGR CPP	NWMO support for the Nawash Charity Golf Tournament. Proceeds benefit the Youth and Cultural Centre ($1,300).	Community support.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile (continued)

Date	Project	Interaction	Purpose/Results
September 7, 2010	DGR Project	SON, OPG and NWMO participate in the first Joint Liaison Committee meeting for the DGR Project.	NWMO provided an update on the status of the technical work associated with the DGR Project. SON reported that their technical advisors have completed approximately 85% of their work. On October 6, 2010, a tour of the WWMF is planned for SON's technical advisors.
September 9, 2010	DGR Project	OPG, NWMO and HSMC Working Group Meeting.	NWMO provided HSM with DGR technical presentations on Preliminary Design, Environmental Assessment, Geoscience and Safety Assessment. HSMC expressed appreciation for the information.
September 14, 2010	DGR Project	OPG, NWMO and HSMC Working Group Meeting.	OPG, NWMO and HSMC discuss HSMC's participation in the DGR regulatory review process. The review of the TSDs was discussed. NWMO to provide HSMC with four copies of select TSDs, as they become available. NWMO to also draft a schedule of review activities to assist HSM in their review. NWMO to provide the Aboriginal Interests TSD by September 30. HSMC will review the documents, compile comments and provide them in writing. NWMO to explain approach to regional study areas.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile (continued)

Date	Project	Interaction	Purpose/Results
October 6, 2010	DGR Project	Meeting with SON – WWMF tour and DGR technical presentations to SON reviewers.	SON EA coordinators, technical reviewers, legal counsel and a band councillor toured the WWMF, visited the DGR site and DGR Core Storage Facility. DGR technical presentations were provided. They included presentations on: Project Overview, Geoscience, Safety Assessment and Engineering.
October 15, 2010	DGR CPP	NWMO support for Saugeen's Kabaeshiwim Respite Women's Shelter ($1,000).	Community support.
October 20, 2010	DGR Project	Aboriginal Interests TSD.	NWMO provides Aboriginal Interests TSD to MNO, SON and HSMC for review.
November 2, 2010	DGR Project	SON, OPG and NWMO Joint Liaison Committee Meeting.	Status updated provided on the respective work programs on the DGR EA and agreed on proposed approach to the Joint Liaison Committee meetings. SON provides list of requested documents for technical reviewers. NWMO seeks feedback on draft Technical Support Documents.
November 4, 2010	DGR Project	OPG, NWMO and Historic Saugeen Métis Community (HSMC) Working Group Meeting.	OPG, NWMO and HSMC review HSMC's comments on the Aboriginal Interests TSD. HSMC also provided overview of their history.
November 9, 2010	DGR CPP	NWMO support for SON's website development project ($10,000).	Community support.

Table 2.3.4-1: Aboriginal OPG/NWMO Interactions – Historical Profile (continued)

Date	Project	Interaction	Purpose/Results
December 7, 2010	DGR Project	SON, OPG and NWMO Joint Liaison Committee Meeting.	NWMO updated the status of the DGR Project licensing submission document and sought input from SON on draft Technical Support Documents. SON indicated they plan to hold community engagement activities in February 2011. OPG presented information on potential employment opportunities associated with the DGR Project.
January 19, 2011	DGR Project	HSMC, OPG and NWMO.	HSMC provides verbal comments on draft Technical Support Documents.
January 25, 2011	DGR Project	SON, OPG and NWMO Joint Liaison Committee Meeting.	NWMO updated status of DGR Project licensing submission and provided information on projected employment opportunities associated with the DGR Project.

Note:
— Not applicable

2.4 GOVERNMENT BRIEFINGS

Briefings and consultations were conducted with municipal, provincial and federal government elected officials and agencies, including:

- local municipal elected officials and staff, committees of council and local agencies; and
- the local Federal Member of Parliament (MP) and Member of Provincial Parliament (MPP) and provincial and federal agency staff (Ministry of Health, Ministry of the Environment, Ministry of Finance, Natural Resources Canada, CNSC).

The objectives of these briefings were to keep elected officials (local, provincial, federal) and agencies informed and updated about the DGR Project, to form and maintain open lines of communication, and to provide them with an open opportunity to provide verbal feedback about issues and concerns with the DGR Project.

These briefings are summarized below.

2.4.1 Briefings with Local Municipalities and Agencies

OPG/NWMO provided regular briefings to local municipal mayors and/or councillors and staff from the Bruce County municipalities of Kincardine, Saugeen Shores, Arran-Elderslie, Huron-Kinloss, Brockton, South Bruce, South Bruce Peninsula and Northern Bruce Peninsula. The first briefings to the municipalities of Kincardine, Saugeen Shores, Arran-Elderslie, Huron-Kinloss and Brockton took place in 2003 and 2004. These briefings, to Kincardine and the municipalities directly surrounding Kincardine, introduced the project and focused on the development of the DGR Hosting Agreement. Support for the project from Kincardine, Saugeen Shores, Arran-Elderslie, Huron-Kinloss and Brockton was indicated in October 2004 at the signing of the DGR Hosting Agreement and the opening of the Community Consultation Centre in Kincardine. Briefings on the project to the municipalities of South Bruce, South Bruce Peninsula and Northern Bruce Peninsula began in 2007.

The Kincardine/OPG Steering Committee was formed at the outset of the project and took the lead in negotiating the DGR Hosting Agreement with OPG. The committee consists of the Kincardine Mayor, Deputy Mayor, two councillors and three OPG/NWMO representatives. The committee meets two to three times per year to provide ongoing input to the DGR Project. A sample of the minutes from the meetings is provided in Appendix D13.

DGR Project progress reports were also regularly provided to the Kincardine Joint Liaison Committee. The committee received an annual DGR status update. The committee includes representation from the Municipality of Kincardine, OPG and Bruce Power. The monthly meeting provides OPG with an opportunity to regularly exchange information with Kincardine about WWMF operations and ongoing projects, including the DGR. These meetings help OPG maintain a positive working relationship with the host municipality of Kincardine and help garner support for the continued safe operation of the WWMF and the development of associated projects. The first monthly briefing on the DGR proposal was provided to the Joint Liaison Committee in January 2003.

Table 2.4.1-1 lists all of the meetings and briefings held throughout the DGR Project with the Municipality of Kincardine.

Table 2.4.1-1: Meetings with the Municipality of Kincardine

Date	Stakeholder	Activity	Purpose/Outcome
April 16, 2002	Municipality of Kincardine	Discussion of Memorandum of Understanding on L&ILW management options at the Bruce nuclear site.	Memorandum of Understanding signed.
September 16, 2002	Kincardine/OPG Steering Committee	Meeting on L&ILW management options at the Bruce nuclear site.	Continuing to move the proposal forward.

Table 2.4.1-1: Meetings with the Municipality of Kincardine (continued)

Date	Stakeholder	Activity	Purpose/Outcome
December 2, 2002	Kincardine/OPG Steering Committee	Meeting on L&ILW options at the Bruce nuclear site.	Continuing to move the proposal forward.
January 15, 2003	Kincardine Joint Liaison Committee	Golder/OPG presentation on L&ILW management options at the Bruce nuclear site.	Continuing to move the proposal forward.
February 4, 2003	Kincardine/OPG Steering Committee	Golder Associates presents proposal for Independent Assessment Study.	Continuing to move the proposal forward.
March 4, 2003	Kincardine/OPG Steering Committee	Meeting on L&ILW management options at the Bruce nuclear site.	Continuing to move the proposal forward.
March 18, 2003	Kincardine/OPG Steering Committee	Meeting on L&ILW management options at the Bruce nuclear site.	Continuing to move the proposal forward.
April 28, 2003	Kincardine/OPG Steering Committee	Meeting on L&ILW management options at the Bruce nuclear site.	Continuing to move the proposal forward.
July 7, 2003	Kincardine/OPG Steering Committee	Meeting on L&ILW options at the Bruce nuclear site.	Continuing to move the proposal forward.
August 7, 2003	Kincardine CAO	Meeting on L&ILW management options at the Bruce nuclear site.	Continuing to move the proposal forward.
August 7, 2003	Kincardine mayoral candidate	Meeting on L&ILW management options at the Bruce nuclear site.	Expressed appreciation for the information.
September 15, 2003	Kincardine/OPG Steering Committee	Meeting on L&ILW management options at the Bruce nuclear site.	Continuing to move the proposal forward.
November 17, 2003	Kincardine/OPG Steering Committee	Meeting on L&ILW management options at the Bruce nuclear site.	Continuing to move the proposal forward.
November 27, 2003	Municipality of Kincardine	Meeting on the schedule for the L&ILW management options at the Bruce nuclear site.	Continuing to move the proposal forward.
January 12, 2004	Kincardine/OPG Steering Committee	Meeting on L&ILW management options at the Bruce nuclear site.	Continuing to move the proposal forward.

Table 2.4.1-1: Meetings with the Municipality of Kincardine (continued)

Date	Stakeholder	Activity	Purpose/Outcome
February 18, 2004	Kincardine/OPG Steering Committee	Meeting on L&ILW management options at the Bruce nuclear site.	Continuing to move the proposal forward.
February 27, 2004	Kincardine CAO	Meeting on communication plans for the L&ILW management options at the Bruce nuclear site.	Continuing to move the proposal forward.
April 6, 2004	Kincardine/OPG Steering Committee	Meeting on L&ILW management options at the Bruce nuclear site.	Continuing to move the proposal forward.
April 26, 2004	Kincardine/OPG Steering Committee	Meeting on the DGR proposal.	Continuing to move the proposal forward.
May 3, 2004	Kincardine/OPG Steering Committee	Meeting on the DGR proposal.	Continuing to move the proposal forward.
May 14, 2004	Kincardine/OPG Steering Committee	Meeting on the DGR proposal.	Continuing to move the proposal forward.
May 21, 2004	Kincardine/OPG Steering Committee	Meeting on the DGR proposal.	Continuing to move the proposal forward.
June 7, 2004	Municipality of Kincardine Council	Discussions on the hosting agreement.	Continuing to move the proposal forward.
June 11, 2004	Kincardine Mayor, Deputy Mayor and CAO	Teleconference meeting on the DGR.	Continuing to move the proposal forward.
July 5, 2004	Kincardine/OPG Steering Committee	Teleconference meeting on the DGR proposal.	Continuing to move the proposal forward.
August 6, 2004	Kincardine/OPG Steering Committee	Meeting on the DGR proposal.	Continuing to move the proposal forward.
August 9, 2004	Kincardine Mayor and CAO	Teleconference meeting on the DGR proposal.	Continuing to move the proposal forward.
August 26, 2004	Kincardine/OPG Steering Committee	Teleconference meeting on the DGR proposal.	Continuing to move the proposal forward.

Table 2.4.1-1: Meetings with the Municipality of Kincardine (continued)

Date	Stakeholder	Activity	Purpose/Outcome
August 31, 2004	Kincardine/OPG Steering Committee	Teleconference meeting on the DGR proposal.	Continuing to move the proposal forward.
September 8, 2004	Kincardine/OPG Steering Committee	Teleconference meeting on the DGR hosting agreement.	Continuing to move the proposal forward.
September 24, 2004	Kincardine Council	DGR meeting and discussion.	Continuing to move the proposal forward.
October 14, 2004	Municipality of Kincardine	DGR briefing.	Continuing to move the proposal forward.
November 3, 2004	Kincardine/OPG Steering Committee	Teleconference meeting on the DGR.	Continuing to move the proposal forward.
November 8, 2004	Kincardine Mayor and CAO	Teleconference meeting on the DGR.	Continuing to move the proposal forward.
December 9, 2004	Kincardine/OPG Steering Committee	Teleconference meeting on the DGR.	Continuing to move the proposal forward.
April 22, 2005	Kincardine/OPG Steering Committee	Meeting on the DGR proposal.	Continuing to move the proposal forward.
June 28, 2005	Kincardine/OPG Steering Committee	Meeting on the DGR proposal.	Continuing to move the proposal forward.
May 26, 2006	Kincardine/OPG Nuclear Waste Steering Committee	Meeting/update on the DGR proposal.	Continuing to move the proposal forward.
September 15, 2007	Kincardine/OPG Deep Geologic Repository Committee	Meeting/update on the DGR Project.	OPG provided preliminary results on the geoscience program, an update on the regulatory process, and communications.
January 21, 2008	Kincardine/OPG DGR Community Consultation Committee	Meeting/update on the DGR Project.	OPG provided a status update on the regulatory process, an update on the site characterization program, and First Nations engagement.

Table 2.4.1-1: Meetings with the Municipality of Kincardine (continued)

Date	Stakeholder	Activity	Purpose/Outcome
April 28, 2008	Kincardine Municipal Council members	Tour of WWMF, DGR drill site #2 and DGR Core Storage Building.	Expressed interest in the geology and rock samples, no significant issues or concerns raised.
May 20, 2008	Kincardine/OPG Steering Committee	DGR update briefing.	The update focused on the site characterization work, draft EIS guidelines and JRP agreement and preliminary design and engineering work.
March 24, 2009	Kincardine Community Consultation Advisory Group	DGR update briefing.	The briefing focused on the DGR Project transition to NWMO, EA process, safety assessment and geoscience site characterization work.
June 3, 2009	Kincardine Council	DGR update presentation.	Council was provided with updates on developments with the proposed DGR Project as they relate to geoscience activities at the Bruce nuclear site, EA, community engagement and transition of DGR regulatory approvals project management to NWMO. Council expressed appreciation for the update. They were interested in the extent of the geologic features of the Michigan Basin.

Table 2.4.1-1: Meetings with the Municipality of Kincardine (continued)

Date	Stakeholder	Activity	Purpose/Outcome
August 11, 2009	Kincardine Economic Development Committee	DGR update presentation.	The presentation focused on geoscience site characterization, EA process, communications and transition of DGR Project management to NWMO. The committee expressed appreciation for the presentation and asked what kind of supportive role they could play in the process. There was interest in the quantities of aggregate to be excavated and what will happen to it.
September 16, 2009	Liaison Committee	DGR update briefing.	The briefing focused on geoscience site characterization, EA process, communications and transition of the DGR Project to NWMO.
September 15, 2010	Liaison Committee	DGR update briefing.	NWMO provided an update briefing to the Liaison Committee. The briefing focused on the preliminary results of the EA and the EA process next steps. Interest was expressed in the temperature in the repository and where the excavated rock will be stored.

A DGR Community Consultation Advisory Group was formed in 2005, to provide a forum for OPG/NWMO to engage with key municipal stakeholders (Warden, Bruce County Mayors, and Chief Administrative Officers [CAOs]) on the project. The committee was formed to provide a means for municipal representatives to receive periodic updates on project developments and key milestones, discuss emerging issues related to community interests and concerns, and to advise on community consultation activities during the regulatory approvals process. These meetings are held up to four times each year, or at the call of the chair. A sample of the minutes from these meetings is provided in Appendix D13.

DGR Project progress reports were also regularly provided to the South Bruce Impact Advisory Committee. The committee also received an annual DGR update briefing. The Impact Advisory

Committee (IAC) is made up of representatives from the impact municipalities of Kincardine, Saugeen Shores, Arran-Elderslie, Huron-Kinloss and Brockton. The committee also includes representatives from OPG and Bruce Power. The mandate of the committee is "To act as a proactive liaison by enhancing communications and providing perspective from the area BNPD Impact Municipalities, Bruce County, Ontario Power Generation and Bruce Power with the purpose of identifying issues and addressing impacts as they affect the health, safety, environment and economic well-being of the South Bruce area." An introductory briefing on the Independent Assessment Study was provided to the Chair of the South Bruce Impact Advisory Committee in August 2003 and the first briefing to the full committee was made in September 2004. A sample of the minutes from the IAC meetings is provided in D13.

Table 2.4.1-2 lists all of the meetings and briefings held throughout the DGR Project with the municipalities surrounding Kincardine including: Saugeen Shores, Arran-Elderslie, Huron-Kinloss, Brockton, South Bruce, South Bruce Peninsula and Northern Bruce Peninsula. The table includes the DGR Community Consultation Advisory Group meetings, IAC meetings and others.

Table 2.4.1-2: Meetings with Surrounding Municipalities

Date	Group	Activity	Purpose/Outcome
August 7, 2003	Impact Advisory Committee (IAC), Chair	Meeting on L&ILW options at the Bruce nuclear site.	Expressed appreciation for the information.
September 12, 2003	Town of Saugeen Shores Mayor and CAO	Meeting on L&ILW options at the Bruce nuclear site.	Expressed appreciation for the information.
April 13, 2004	Town of Saugeen Shores Council	Briefing on L&ILW options at the Bruce nuclear site.	Supportive of the proposal.
June 7, 2004	Town of Saugeen Shores Mayor and CAO	Update briefing on the DGR proposal.	Continue to move the proposal forward.
June 21, 2004	Town of Saugeen Shores Council	Briefing on the DGR proposal.	Council remains supportive.
August 12, 2004	Mayors and CAOs of Saugeen Shores, Brockton, Huron-Kinloss, Arran-Elderslie and Kincardine	Meeting on DGR hosting agreement.	Continue to move the proposal forward.
August 12, 2004	IAC, Chair	Meeting on DGR.	Continue to move the proposal forward.
September 2, 2004	Township of Huron-Kinloss Council	Briefing on the DGR proposal.	Continue to move the proposal forward.

Table 2.4.1-2: Meetings with Surrounding Municipalities (continued)

Date	Group	Activity	Purpose/Outcome
September 8, 2004	Municipality of Arran-Elderslie Mayor and CAO	Briefing on the DGR proposal.	Continue to move the proposal forward.
September 8, 2004	Municipality of Brockton Mayor and CAO	Briefing on the DGR proposal.	Continue to move the proposal forward.
September 13, 2004	Arran-Elderslie Council	Briefing on the DGR proposal.	Council voted unanimously in support of the DGR proposal.
September 16, 2004	IAC	DGR update briefing.	Continue to move the proposal forward.
September 22, 2004	Brockton Mayor and Kincardine Deputy mayor	Teleconference meeting on DGR.	Continue to move the proposal forward.
September 27, 2004	Brockton Council	DGR update briefing.	Council is supportive, although one councillor expressed concern with the potential effect on the lake and transportation of the waste.
September 27, 2004	Brockton Mayor and Chair of Impact Advisory Committee	DGR meeting.	Continue to move the proposal forward.
November 4, 2004	Town of Saugeen Shores Council	DGR proposal presentation.	Council continues to be supportive of the proposal.
November 12, 2004	Bruce County Council	DGR briefing.	Supportive, but some outlying municipalities had questions and concerns with the hosting agreement.
November 15, 2004	Huron-Kinloss Council	DGR briefing.	Expressed appreciation for the update and supportive of the DGR Project.
November 25, 2004	Mayors of Saugeen Shores, Arran-Elderslie, Huron-Kinloss, Brockton, Kincardine and Kincardine councillors	DGR update briefing by OPG Chairman.	Mayors expressed support.

Table 2.4.1-2: Meetings with Surrounding Municipalities (continued)

Date	Group	Activity	Purpose/Outcome
March 8, 2005	Town of Saugeen Shores Mayor and CAO	Update briefing on the DGR proposal.	Both the Mayor and CAO continue to be supportive of the proposal.
April 4, 2005	Huron-Kinloss Council	DGR proposal update briefing.	Expressed appreciation for the information.
April 11, 2005	Brockton Council	DGR proposal update briefing.	Supportive, with the exception of one councillor who is not supportive of the nuclear industry.
April 25, 2005	Town of Saugeen Shores Council	DGR proposal update.	Expressed appreciation for the information, complimented OPG on communication.
July 13, 2005	IAC, Chair	Meeting on DGR.	Continue to move the proposal forward.
January 11, 2006	Arran-Elderslie Mayor's Breakfast - Councillors and Chambers of Commerce representatives from Paisley, Tara and Chesley	DGR presentation.	30 attendees, presentation well received, no issues raised.
April 20, 2006	DGR Community Consultation Advisory Group	DGR meeting.	CNSC and CEAA attended.
May 29, 2006	IAC	DGR update briefing.	The briefing and discussion focused on the site characterization program.
June 19, 2006	Huron-Kinloss Council	DGR update briefing.	The briefing and discussion focused on the site characterization program and communications.
June 26, 2006	Saugeen Shores Council	DGR update briefing.	The briefing and discussion focused on the site characterization program and communications.
July 10, 2006	Arran-Elderslie Council	DGR update briefing.	The briefing and discussion focused on the site characterization program and communications.

Table 2.4.1-2: Meetings with Surrounding Municipalities (continued)

Date	Group	Activity	Purpose/Outcome
July 10, 2006	Brockton Council	DGR update briefing.	The briefing and discussion focused on the site characterization program and communications.
April 17, 2007	Town of South Bruce Peninsula	DGR briefing and WWMF tour.	Provided the Council with a tour of the WWMF and briefing on the DGR.
July 5, 2007	Bruce County Council	DGR update briefing.	The briefing and discussion focused on the site characterization program.
September 12, 2007	DGR Community Consultation Advisory Group	DGR update briefing.	The briefing and discussion focused on the site characterization program and communications.
November 22, 2007	Municipality of Northern Bruce Peninsula	DGR briefing.	Provided the Council with a tour of the WWMF and briefing on the DGR.
May 15, 2008	IAC	DGR update briefing.	The update focused on the EA process, new DGR Project design and upcoming CNSC/CEAA public meeting. No issues or concerns were raised.
September 23, 2008	DGR Community Consultation Advisory Group	DGR meeting.	DGR update on geotechnical investigations, DGR Project design and communications.
March 24, 2009	DGR Community Consultation Advisory Group	DGR meeting.	DGR update on the transition of the DGR Project to NWMO, EA process and geoscience site characterization work.
August 5, 2009	Township of Huron-Kinloss Mayor and CAO	DGR update briefing.	The DGR update briefing focused on geoscience, environmental field work, regulatory process and communications. Appreciation was expressed for the update. No issues or concerns were raised.

Table 2.4.1-2: Meetings with Surrounding Municipalities (continued)

Date	Group	Activity	Purpose/Outcome
August 20, 2009	Town of Saugeen Shores, Director of Community Services and Manager of Recreation and Culture	DGR update briefing.	Expressed appreciation for the update.
August 31, 2009	Bruce County, Director of Planning	DGR update briefing.	The briefing focused on the transition from OPG to NWMO for management of the DGR Project through the regulatory approvals process.
September 17, 2009	IAC	DGR update briefing.	The briefing focused on the transition to NWMO, EA process, site characterization work and communications
September 30, 2009	DGR Community Consultation Advisory Group	DGR meeting.	Provided an overview of the DGR Project for the committee, as well as for the CNSC President, who was a special guest at the meeting.
February 25, 2010	DGR Community Consultation Advisory Group	DGR meeting.	Provided DGR Project updates on the geoscience work at site, engineering and design work and communications. Results of the community surveys completed in 2009 were also presented.
May 10, 2010	DGR Community Consultation Advisory Group	DGR update briefing.	The committee was provided with updates on geoscience, engineering and communications. Interest was expressed on the DGR status relative to schedule. NWMO was also asked whether there confusion between the DGR Project and the APM project for the long-term management of used fuel.

Table 2.4.1-2: Meetings with Surrounding Municipalities (continued)

Date	Group	Activity	Purpose/Outcome
June 3, 2010	DGR Community Consultation Advisory Group	DGR meeting.	The eight Bruce county mayors were provided with presentations on the preliminary design of the proposed DGR and safety issues as they pertain to fire and radiological safety and underground mine rescue. An update was also provided on the EA process, schedule and preliminary results. The mayors are well informed about the DGR Project and supportive. No issues or concerns were noted. Interest was expressed on the standards utilized to determine what constitutes a significant residual effect.
September 16, 2010	IAC	DGR update briefing.	NWMO provided an update briefing to the IAC. The briefing focused on the preliminary results of the EA and the EA process next steps. The committee expressed appreciation for the update. There was interest in the deep borehole drilling and the technique used to extract the rock core.
February 14, 2011	Brockton Council	DGR update briefing.	NWMO provided an update on the status of the submission and the project schedule. Questions asked related to the number of employment opportunities associated with the project, and whether the DGR would receive waste only from Ontario.

OPG/NWMO also held regular briefings with the local Medical Officer of Health and representatives from the local Ministry of Environment Office. The first meeting was held in

April 2003. In January 2004 the Medical Officer of Health indicated support for the DGR proposal. In an advertisement that appeared in local newspapers in December 2004 the Medical Officer of Health stated "I believe the proposed Deep Geologic Repository (DGR) currently before the community for approval is a safe, long-term solution for the storage of low and intermediate nuclear waste." Appendix D3 includes a copy of the advertisement.

OPG has also participated in the Bruce nuclear site's Regulatory Liaison Committee meetings. These are semi-annual communication meetings held with the Medical Officer of Health, local Ministry of Environment representatives and the CNSC. The first DGR Project briefing to this committee was provided in December 2004. Regular briefings to the committee have been provided throughout the DGR Project. A sample of the minutes from this meeting is provided in Appendix D13.

Table 2.4.1-3 lists all of the meetings and briefings held with the Medical Officer of Health and the Ministry of Environment.

Table 2.4.1-3: Grey-Bruce Medical Officer of Health/Ministry of Environment Meetings

Date	Group	Activity	Purpose/Outcome
April 14, 2003	Local Ontario Ministry of Environment (MOE) Office	Briefing on long-term options for L&ILW at the Bruce nuclear site.	Expressed appreciation for the information and asked to be kept informed through the process.
April 14, 2003	Grey-Bruce Medical Officer of Health	Briefing on long-term options for L&ILW at the Bruce nuclear site.	Expressed appreciation for the information and asked to be kept informed through the process.
January 8, 2004	Grey-Bruce Medical Officer of Health and Local MOE Office	Briefings on the L&ILW options at the Bruce nuclear site.	Supportive of the proposal.
September 14, 2004	Grey-Bruce Medical Officer of Health and Local MOE Office	DGR briefing.	Supportive of the proposal if it will put the waste in a better place.
December 3, 2004	Regulatory Liaison Committee Meeting (MOH/MOE Semi-Annual Communication Meeting)	DGR update – with a focus on communications.	Expressed appreciation for the update.
February 3, 2005	Grey-Bruce Medical Officer of Health and Local MOE Office	DGR briefing.	MOH and MOE remain interested and supportive of the proposal.
June 6, 2005	Regulatory Liaison Committee Meeting (MOH/MOE Semi-Annual Communication Meeting)	DGR update – with a focus on communications.	Expressed appreciation for the update.

Table 2.4.1-3: Grey-Bruce Medical Officer of Health/Ministry of Environment Meetings (continued)

Date	Group	Activity	Purpose/Outcome
December 6, 2005	Regulatory Liaison Committee Meeting (MOH/MOE Semi-Annual Communication Meeting)	DGR update – with a focus on communications.	Expressed appreciation for the update.
May 29, 2006	Grey-Bruce Medical Officer of Health and Local MOE Office	DGR briefing.	DGR discussion focused on the site characterization program.
June 6, 2006	Regulatory Liaison Committee Meeting (MOH/MOE Semi-Annual Communication Meeting)	DGR update – with a focus on communications.	Expressed appreciation for the update.
December 8, 2006	Regulatory Liaison Committee Meeting (MOH/MOE Semi-Annual Communication Meeting)	DGR update – with a focus on communications.	Expressed appreciation for the update.
June 5, 2007	Regulatory Liaison Committee Meeting (MOH/MOE Semi-Annual Communication Meeting)	DGR update – with a focus on communications.	Expressed appreciation for the update.
June 28, 2007	Grey-Bruce Medical Officer of Health and Local MOE Office	DGR briefing.	DGR discussion focused on the site characterization program.
December 12, 2007	Regulatory Liaison Committee Meeting (MOH/MOE Semi-Annual Communication Meeting)	DGR update – with a focus on communications.	Expressed appreciation for the update.
June 23, 2008	Regulatory Liaison Committee Meeting (MOH/MOE Semi-Annual Communication Meeting)	DGR update – with a focus on communications.	Expressed appreciation for the update.
December 1, 2008	Regulatory Liaison Committee Meeting (MOH/MOE Semi-Annual Communication Meeting)	DGR update – with a focus on communications.	Expressed appreciation for the update.

Table 2.4.1-3: Grey-Bruce Medical Officer of Health/Ministry of Environment Meetings (continued)

Date	Group	Activity	Purpose/Outcome
May 20, 2009	Grey-Bruce Health Unit staff	DGR update briefing.	Approximately 25 Health Unit staff received an overview presentation on the DGR. The presentation focused on the geoscience site characterization program.
June 10, 2009	Regulatory Liaison Committee Meeting (MOH/MOE Semi-Annual Communication Meeting)	DGR update – with a focus on communications.	Expressed appreciation for the update.
June 12, 2009	Grey-Bruce Medical Officer of Health and Local MOE Office	DGR update briefing.	No significant issues or concerns were raised.
September 22, 2009	Grey Bruce Public Health staff – South Huron area	DGR presentation.	An overview presentation was provided to 12 community public health workers. They were interested in the DGR as it relates to public health. Questions included: How the geology will protect ground and surface water? How the waste is currently stored? They also asked about the long-term management of used fuel.
December 9, 2009	Regulatory Liaison Committee Meeting (MOH/MOE Semi-Annual Communication Meeting)	DGR update – with a focus on communications.	Expressed appreciation for the update.
June 29, 2010	Regulatory Liaison Committee Meeting (MOH/MOE Semi-Annual Communication Meeting)	DGR update – with a focus on communications.	Expressed appreciation for the update.

Table 2.4.1-3: Grey-Bruce Medical Officer of Health/Ministry of Environment Meetings (continued)

Date	Group	Activity	Purpose/Outcome
September 13, 2010	Grey-Bruce Medical Officer of Health and Local MOE Office	DGR update briefing.	NWMO provided an update briefing to the MOH and MOE. The briefing focused on the preliminary results of the EA and the EA process next steps.

Presentations and engagement were also conducted regularly with the Kincardine and Saugeen Shores Chambers of Commerce as well as with the Walkerton Chamber of Commerce. The Chambers have supported the DGR Project from the outset. Questions and comments from the Chamber of Commerce presentations, along with the responses, are included in Section 2.6.2 Speaking Engagements, and Table 2.6.2-1.

2.4.2 Briefings and Consultation with Federal and Provincial Politicians and Agency Staff

The first meetings regarding the DGR Project with the Huron-Bruce Federal MP and the Huron-Bruce MPP were held in April 2003. Both the MP and MPP thanked OPG for providing the information on the DGR proposal and asked to be kept informed throughout the process. Support for the DGR Project from both the MP and MPP was indicated in October 2004 at the signing of the DGR Hosting Agreement and the opening of the Community Consultation Centre in Kincardine. Annual briefings have been held with the MP and MPP and they each have remained supportive throughout the DGR Project. At a briefing in May 2009 the MPP asked about engagement efforts in the Owen Sound area and suggested that communications be conducted in that area because the nuclear industry is not as well understood there as it is by those who reside closer to the Bruce nuclear site. NWMO enhanced its efforts to engage the communities in the Bruce Peninsula, through participation in events such as the Wiarton Willie Festival. An annual open house has been held in Owen Sound from 2007 to 2010. A sample of the minutes from these meetings is provided in Appendix D13.

Meetings were also held with federal and provincial agency staff as follows:

- CNSC: The first meetings with the CNSC on the project were held in April 2003 and January 2004. Status meetings have been held regularly to provide project updates. CNSC staff asked about the public engagement activities, and whether they had been extended to include the United States. A number of comments on the initial draft guidelines were submitted from the United States. OPG had conducted media interviews with several outlets in Michigan in 2006. In 2010 and 2011, briefings were held with elected representatives, government staff and several NGOs (see Section 2.7).
- Natural Resources Canada (NRCan): The first meeting with NRCan on the project was held in April 2003. Follow-up meetings have been held to provide project updates, particularly in relation to the geoscience program.

- Environment Canada: Representatives of Environment Canada and Health Canada toured the WWMF in June 2006 and received a briefing on the DGR Project. In November 2006 OPG met with Environment Canada to discuss the Project and the Great Lakes Water Quality Agreement.
- Canadian Environmental Assessment Agency: The first DGR briefing to the Canadian Environmental Assessment Agency and representatives from the Office of the Federal Minister of the Environment was made in June 2006.
- Ministry of the Environment (MOE), Owen Sound Area Office: Annual briefings have been held with the local MOE staff, starting in April 2003. These briefings were conducted jointly with the local Medical Officer of Health. The purpose was to provide regular DGR Project updates and solicit feedback. The MOE staff and Medical Officer of Health asked to be kept informed throughout the process.
- Ministry of Energy[4]: The first briefings to the Ontario Ministry of Energy were held in May 2003 and then again in January, March, June and July 2004. Ministry of Finance representatives were also present at the March briefing. The Ministry representatives wanted to be kept informed throughout the process. A follow-up briefing was provided in July 2010, and in January 2011. Ministry of Energy enquired about whether an environmental assessment was required under the Ontario Environmental Assessment Act. OPG (and separately the CNSC) was told that as this is a federally regulated project it is not required. In response to questions about the funding for the project, NWMO indicated that the project would be funded from the segregated fund.
- Source Water Protection Committee: A WWMF tour and DGR Project briefing were provided to the Saugeen, Grey Sauble, Northern Bruce Peninsula Source Water Protection Committee in March 2009. They noted that the results of the deep borehole testing, which show extremely low hydraulic conductivity levels in the limestone and shale, provide very valuable information about the geologic conditions.

Table 2.4.2-1 lists all of the meetings and briefings held with Federal and Provincial politicians and agencies.

Table 2.4.2-1: Meetings with Federal & Provincial Politicians and Agencies

Date	Group	Activity	Outcome
April 11, 2003	CNSC, NRCan	Briefing on long-term options for L&ILW at the Bruce nuclear site.	Expressed appreciation for the information.
April 15, 2003	Huron Bruce MPP	Briefing on long-term options for L&ILW at the Bruce nuclear site.	Expressed appreciation for the information and asked to be kept informed through the process.
April 15, 2003	Huron Bruce MP	Briefing on long-term options for L&ILW at the Bruce nuclear site.	Expressed appreciation for the information and asked to be kept informed through the process.

[4] The Ministry of Energy was also known as the Ministry of Energy and Infrastructure at certain times during the engagement program for the DGR Project.

Table 2.4.2-1: Meetings with Federal & Provincial Politicians and Agencies (continued)

Date	Group	Activity	Outcome
May 1, 2003	Ontario Ministry of Energy	Briefing on long-term options for L&ILW at the Bruce nuclear site.	Expressed appreciation for the information.
January 9, 2004	Huron Bruce MP	Briefing on the L&ILW options at the Bruce nuclear site.	Supportive of the proposal.
January 14, 2004	CNSC	Briefing on the L&ILW options at the Bruce nuclear site.	Expressed appreciation for the information and asked to be kept informed through the process.
January 14, 2004	NRCan	Briefing on the L&ILW options at the Bruce nuclear site.	Expressed appreciation for the information and asked to be kept informed through the process.
January 26, 2004	Ontario Ministry of Energy	Briefing on the L&ILW options at the Bruce nuclear site.	Expressed appreciation for the information and asked to be kept informed through the process.
March 23, 2004	Ontario Ministry of Finance and Ministry of Energy	Briefing on the L&ILW options at the Bruce nuclear site.	Expressed appreciation for the information and asked to be kept informed through the process.
April 5, 2004	Huron Bruce MPP	Briefing on the L&ILW options at the Bruce nuclear site.	Expressed appreciation for the information and asked to be kept informed through the process.
June 17, 2004	Ministry of Energy	Briefing on the DGR proposal.	Expressed appreciation for the information and asked to be kept informed through the process.
July 19, 2004	Huron-Bruce MPP	Teleconference meeting on the DGR hosting agreement.	Continuing to move the proposal forward.
July 19, 2004	Ministry of Energy	Teleconference meeting on the DGR hosting agreement.	Continuing to move the proposal forward.
August 16, 2004	Huron-Bruce MP	Briefing on the DGR.	Remains supportive of the DGR proposal.
February 4, 2005	Huron-Bruce MPP	DGR update briefing.	Continues to be supportive of the proposal.

Table 2.4.2-1: Meetings with Federal & Provincial Politicians and Agencies (continued)

Date	Group	Activity	Outcome
February 4, 2005	Huron-Bruce MP	DGR update briefing.	Continues to be supportive of the proposal.
May 11, 2005	Huron-Bruce MP	DGR update briefing.	Remains supportive of the proposal.
November 2, 2005	CNSC	DGR Project Status Update.	OPG update on progress and plans for implementing the DGR for L&ILW.
December 9, 2005	CNSC	Site Characterization Plan.	Present OPG's site characterization plan for the DGR Project to the CNSC.
May 17, 2006	Huron-Bruce MPP	DGR update briefing.	Continuing to move the proposal forward.
June 13, 2006	Federal Authorities Tour Health Canada and Environment Canada	WWMF tour and DGR briefing.	Expressed appreciation for the tour and briefing and asked and received answers to questions related to WWMF operations.
June 20, 2006	Canadian Environmental Assessment Agency and Office of the Federal Minister of Environment	DGR briefing.	The Offices are aware of the proposed DGR Project and expressed appreciation for the update.
September 28, 2006	CNSC	DGR Project.	Discuss the approach to the safety case for the DGR with CNSC.
November 24, 2006	Environment Canada	DGR briefing.	Appreciated the update.
February 5, 2007	Department of Foreign and International Affairs	Teleconference briefing.	OPG will work to keep NRCan and interested American stakeholders informed.
April 3, 2007	CNSC	DGR status update.	OPG provided an update on the status of activities and studies for the DGR Project.
July 13, 2007	CNSC and CEAA	DGR Project.	Discussed the regulatory process for the DGR Project.

Table 2.4.2-1: Meetings with Federal & Provincial Politicians and Agencies (continued)

Date	Group	Activity	Outcome
July 18, 2007	Huron-Bruce MPP	DGR update briefing.	Continuing to move the proposal forward.
January 2008	CNSC	DGR Project.	OPG provided a briefing on the DGR Project.
November 24 & 25, 2008	Ministry of Natural Resources, Ontario Geological Survey, Geological Survey of Canada	DGR Core Workshop.	Six geoscientists/engineers attended the 2008 DGR Core Workshop to review the rock core and confirm the formation contacts for boreholes DGR-3&-4.
March 27, 2009	Saugeen, Grey Sauble, Northern Bruce Peninsula – Source Water Protection Committee	DGR briefing.	Provided a briefing to 22 members of the Source Water Protection Committee. They toured the WWMF and were given a detailed presentation on the DGR Project. Questions related to the cost of the project, whether future expansion is possible, whether the DGR would accept waste from other countries, reasons behind the hosting agreement, what groups oppose the project, if any, whether the waste is retrievable, and what is being done to safeguard the facility well into the future. One of the members, a hydrogeologist with a PhD, noted that the results of deep borehole testing, which showed hydraulic conductivity to 10^{-13} were very impressive. Those present were also very interested in the interim and long-term management of used fuel.

Table 2.4.2-1: Meetings with Federal & Provincial Politicians and Agencies (continued)

Date	Group	Activity	Outcome
April 15, 2009	CNSC	DGR Project Status Update.	NWMO and OPG provided an update on the status of the DGR Project. Also provided an overview of the contractual arrangement between OPG and NWMO.
May 13, 2009	Huron-Bruce MPP	DGR update briefing.	The briefing focused on the EA process, geoscience work, community consultation, Aboriginal consultation and transition of management of the DGR Project to NWMO. Encouraged consideration be given to increasing engagement efforts in the Owen Sound area.
June 29, 2009	CNSC	Safety Assessment Overview.	NWMO and its safety assessment contractors provided an update on the status of work on the safety assessment for the DGR Project.
July 16, 2009	CNSC and DGR Geoscience Review Group	DGR update presentation and tour.	Toured DGR drill sites, DGR Core Storage and received a DGR update.
August 6, 2009	Huron-Bruce MP	DGR update briefing.	The briefing focused on geoscience, environmental field work, regulatory process and communications. The MP asked for and received clarification of the two repository development projects — DGR Project for L&ILW and NWMO's APM project for the long-term management of used fuel.
September 30, 2009	CNSC Commission members and CNSC staff	DGR drill site tour and DGR presentation.	Toured DGR drill site 1 and the DGR Core Storage Facility and received a DGR overview presentation.

Table 2.4.2-1: Meetings with Federal & Provincial Politicians and Agencies (continued)

Date	Group	Activity	Outcome
October 29, 2009	Ministry of Natural Resources – Petroleum Resources Centre (PRC) staff	DGR presentation and DGR Core Storage Facility visit.	As part of their annual field trip 15 PRC staff visited the DGR Core Storage Facility and received a DGR presentation.
November 30, 2009	NRCan and CNSC	Update on Geosynthesis Activities for the DGR Project.	NWMO and its consultants provided an update on the status of work on the second phase of geosynthesis work for the DGR Project.
March 5, 2010	CNSC and CEAA	WWMF tour and visit to DGR Core Storage.	OPG provided a tour of the WWMF to two CNSC staff and two CEAA staff. Staff also toured the DGR Core Storage Facility and viewed rock core.
April 14, 2010	CNSC	DGR Briefing.	NWMO presented the preliminary engineering design for the DGR Project.
April 19 & 20, 2010	CNSC and NRCan	DGR briefing.	A total of 13 presentations over two days were provided by NWMO and its consultants to CNSC geoscience staff and NRCan staff on the results of the site characterization and geosynthesis work programs.
May 4, 2010	CNSC, CEAA, NRCan, EC	DGR Workshop – presentation of preliminary results of the environmental assessment.	NWMO and its EA Consultant presented an overview of the DGR Project and the preliminary results of the assessment of each of nine components of the environment.

Table 2.4.2-1: Meetings with Federal & Provincial Politicians and Agencies (continued)

Date	Group	Activity	Outcome
May 26 & 27, 2010	Ministry of Natural Resources, Ontario Geological Survey, University of Waterloo and University of Western Ontario	DGR Core Workshop.	Six geoscientists/engineers attended the 2010 DGR Core Workshop to review the rock core and confirm the formation contacts for DGR boreholes 5 & 6.
June 24, 2010	CNSC	Status Update.	NWMO provided an update on the status of the studies associated with the DGR Project.
July 6, 2010	Huron-Bruce MP	DGR update briefing.	The Huron-Bruce MP was provided with an update on the DGR Project in terms of technical studies, communications and engagement with Aboriginal peoples. The MP asked about the differences between OPG's DGR for L&ILW and NWMO's APM approach for all of Canada's used fuel. NWMO staff emphasized that the two are separate projects.
July 9, 2010	Ministry of Energy	DGR Briefing.	NWMO and OPG provided an overview of the current L&ILW waste management operations at the WWMF and an overview of the DGR Project. There was interest in the alternatives considered and whether putting L&ILW and used fuel in a single facility had been considered.

Table 2.4.2-1: Meetings with Federal & Provincial Politicians and Agencies (continued)

Date	Group	Activity	Outcome
October 14, 2010	Huron-Bruce MPP	DGR update briefing.	The Huron-Bruce MPP was provided with a briefing which emphasized the preliminary results of the EA, the conclusion of the geoscientific site characterization work and the results of the public attitude research. The MPP expressed support for the DGR Project.
November 10, 2010	CNSC	Status Update.	NWMO provided an update on the status of the licensing submission package.
January 21, 2011	Ministry of Energy	DGR Project Briefing.	NWMO provided an overview of the DGR Project and schedule.

2.5 STAKEHOLDER BRIEFINGS

Briefings and consultations were conducted with key stakeholders, including:

- local property owner's and ratepayers' associations;
- nuclear industry unions, professional associations, and other groups; and
- non-governmental organizations (NGOs).

As well, many other communication activities, such as open houses, speaking engagements and others, were employed throughout the DGR Project targeting stakeholders and the general public.

The objectives of these briefings and communications were to keep stakeholders and the general public informed and updated about the DGR Project, to form or maintain open lines of communication, and to provide them with an open opportunity to provide verbal feedback about their issues and concerns with the DGR Project and have their questions answered.

2.5.1 Briefings with Property Owner's and Ratepayers' Associations

Five local ratepayers' and property owner's associations were provided with presentations and opportunities for questions and feedback over the course of the DGR Project.

These groups included:

- Inverhuron District Ratepayers' Association;
- Bruce Pines Association;
- Saugeen Shores Beach Association;
- Bruce Beach Association; and
- Point Clark Beach Association.

These associations represent seasonal and permanent property owners on or near the Lake Huron shoreline to the north and south of the Bruce nuclear site in Bruce County, within the EA focus area. Briefings were previously provided to these groups in 2003 to 2005.

The first meeting with the Inverhuron District Ratepayers Association (IDRA) was held in April 2004. They expressed appreciation for the information and asked to be kept informed throughout the DGR Project. After the first meeting, briefings were provided to the IDRA annually or semi-annually, on a frequency determined in discussion with IDRA. At several of these briefings the IDRA indicated that they appreciated OPG's effort to provide ongoing communication on the DGR Project.

At a communication outreach event in Inverhuron in July 2006 one resident expressed concern about the potential for the DGR Project to have an effect on property values. It was explained that the DGR Hosting Agreement includes provision of a Property Value Protection Plan.

At the June 2009 briefing one member of the IDRA Board of Directors asked why the L&ILW and used fuel could not be co-located. It was explained that the DGR would not include used fuel and that the accountabilities and processes for the long-term management of the L&ILW and used fuel are with different organizations.

DGR briefings were also provided annually to the IDRA Annual General Meeting (AGM), beginning in 2005. At the 2008 AGM one member asked about the NWMO being contracted to manage the DGR Project through the regulatory approvals process and if that meant that the DGR would now be taking used fuel. A brief background on the NWMO was provided and it was reinforced that the DGR is strictly for the long-term management of L&ILW.

The Superintendent for Inverhuron and MacGregor Point Provincial Parks attended meetings with the Inverhuron District Ratepayers Association. At the Inverhuron Safety Day Park staff asked questions about the DGR Project, in particular the potential for park visitors to be concerned about noise from blasting during construction. The response indicated that noise effects of the project, including blasting, have been assessed. While there will be increased noise levels at the Bruce nuclear site and at Baie du Doré during site preparation and construction and decommissioning, the noise will be intermittent. The post-submission communications program will include information on construction activities and scheduling.

The Bruce Pines Association was briefed in April 2003, and continued to receive updates on the DGR Project based on their inclusion on the stakeholder mailing list. Similarly, the Saugeen Shores Beach Association was initially briefed in 2005, and received regular updates through their inclusion on the stakeholder mailing list.

Briefings to the Point Clark Beach Association and Bruce Beach Association were provided in July 2010. Both associations expressed appreciation for the DGR Project information.

Table 2.5.1-1 lists the meetings and briefings held with property and ratepayer groups.

Table 2.5.1-1: Meetings with Property and Ratepayers Associations

Date	Group	Activity	Purpose/Outcome
April 30, 2003	Bruce Pines Association	Briefing on long-term options for L&ILW at the Bruce nuclear site.	Expressed appreciation for the information and asked to be kept informed through the process.
April 5, 2004	Inverhuron District Ratepayers Association (IDRA)	DGR briefing at the OPG/IDRA semi-annual communication meeting.	Expressed appreciation for the information and asked to be kept informed.
December 10, 2004	IDRA	DGR briefing at the OPG/IDRA semi-annual communication meeting.	Expressed appreciation for the updated information.
July 30, 2005	IDRA	DGR presentation at the IDRA Annual General Meeting (AGM).	36 attendees, expressed appreciation for the information.
July 30, 2005	Saugeen Shores Beach Association	DGR presentation.	DGR presentation generally well received, with the exception of four people who expressed uncertainty about long-term effects.
July 29, 2006	IDRA	DGR briefing at the OPG/IDRA semi-annual communication meeting.	Discussion focused on the site characterization work.
July 6, 2007	IDRA	DGR briefing to IDRA Board.	Expressed appreciation for the information update.
August 30, 2008	IDRA	DGR presentation at the IDRA AGM.	30 attendees, no major issues or concerns were raised. In response to a question, the NWMO's role in the DGR Project relative to its role in managing used fuel was clarified, confirming that the DGR will not accept used fuel.

Table 2.5.1-1: Meetings with Property and Ratepayers Associations (continued)

Date	Group	Activity	Purpose/Outcome
June 26, 2009	IDRA	DGR briefing to IDRA Board.	Expressed appreciation for the information update. There was interest in why two separate repository sites are proposed, one for each of low and intermediate level waste and used fuel instead of one for all waste.
September 5, 2009	IDRA	DGR briefing at the IDRA AGM.	Approximately 75 people attended the meeting. The briefing focused on the transition to NWMO, EA process, site characterization work and communications.
July 5, 2010	Inverhuron Safety Day	DGR mobile exhibit.	Participated in the IDRA Safety Day with the DGR mobile exhibit. Discussions were held with approximately 20 people. Many people indicated support for the DGR Project. Two people voiced concerns relating to proximity to the lake and concern with contaminating groundwater. The Inverhuron Provincial Park Assistant Superintendent asked about DGR Project construction noise impacts on park campers. (Noise effects of the project are discussed in Section 7.8.)

Table 2.5.1-1: Meetings with Property and Ratepayers Associations (continued)

Date	Group	Activity	Purpose/Outcome
July 17, 2010	Point Clark Beach Association	DGR briefing to their AGM.	An update was provided to about 125 permanent and seasonal residents in attendance at the AGM. The update discussed the completion of the geoscientific site characterization studies as well as the next key milestones for the DGR Project, including the submission of the EIS and the Preliminary Safety Report. No issues or concerns were raised however there was interest in whether the DGR would accept waste from facilities outside of Ontario or Canada. Several members of the group commented that they appreciated the effort to provide them with an update.

Table 2.5.1-1: Meetings with Property and Ratepayers Associations (continued)

Date	Group	Activity	Purpose/Outcome
July 31, 2010	Bruce Beach Association	DGR briefing to their AGM.	About 150 members, the majority of whom are seasonal residents, were present for a brief DGR Project update, which covered the progress to date in terms of communications and technical studies as well as future milestones. Questions about the DGR Project focused on the regulatory process and when it would take place, the structure of a joint review panel and its role, who appoints the panel, whether this is a federal or provincial EA process, how the public can participate in the process, and whether there are any groups opposed to the project. Clarification of the waste streams to be placed in the DGR was sought and whether used fuel would be accommodated in OPG's proposed DGR was asked. Members were very interested in the DGR handout materials. Several members of this association are Michigan residents who summer in the Kincardine area.

Table 2.5.1-1: Meetings with Property and Ratepayers Associations (continued)

Date	Group	Activity	Purpose/Outcome
September 4, 2010	IDRA	DGR briefing at the IDRA AGM.	OPG provided an update briefing on the WWMF and DGR Project. Questions related to why the DGR is proposed at the Bruce nuclear site, the DGR Hosting Agreement payments, and the cost of the DGR Project. It was suggested that communications be undertaken in the summer to target seasonal residents.

2.5.2 Consultation with Nuclear and Energy Industry Employee Organizations and Groups

Unions, professional associations, and employee associations and facility groups were regularly updated and informed about the DGR Project. These employee engagement sessions included staff affiliated with:

- OPG Western Waste Management Facility;
- OPG Nuclear Waste Management Division (Pickering, Darlington, Toronto);
- OPG Inspection and Maintenance Services;
- Nuclear Waste Management Organization;
- Bruce Power;
- Power Workers' Union (PWU) representatives;
- Society of Energy Professionals representatives;
- Grey-Bruce Labour Council;
- Women in Nuclear (WiN);
- Canadian Nuclear Society (CNS);
- Durham Nuclear Health Committee; and
- Darlington Site Planning Committee.

A total of 39 of presentations to these nuclear and energy industry groups were carried out throughout the DGR Project engagement activities. A list of presentations is included in Appendix D9.

Approximately 17 of the presentations were made to OPG, NWMO and Bruce Power staff between 2003 and 2010. Staff expressed appreciation for the briefings and asked to be kept informed throughout the process.

The first briefings to the Power Workers' Union and Society of Energy Professionals were held in April 2003. Both unions expressed appreciation for the information and asked to be kept informed throughout the process. An update briefing was provided in September 2004. A briefing was provided to the Grey Bruce Labour Council, which included representatives from the PWU and Society, in September 2008. As well, a DGR presentation was given to the PWU Council of Chief Stewards in September 2010.

Briefings were provided to the Women in Nuclear (WiN) Bruce branch in 2007 and 2009. As well, OPG/NWMO partnered with WiN to deliver a geology workshop to a local girls' science group in 2008 and 2010. The "Girls and Geology Rocks" workshops were focused on the DGR Project.

A briefing was provided to the Canadian Nuclear Society (CNS) in 2005 and a presentation was made to the CNS Ottawa branch in April 2005. The CNS representatives commented that they thought the DGR was overly conservative for the long-term management of LLW. They also expressed concern about the possibility that used fuel would be placed in the repository. A DGR presentation was provided to the CNS Bruce branch in January 2009. The presentation was well received and included the following questions:

- how will water resources be protected?
- is there water present at the interface between the shale and limestone?
- how long does it take the waste to decay to safe levels?
- what is the long-term management plan for used fuel?
- why build the DGR if what we're already doing is safe?

A presentation on the DGR was made to the Durham Nuclear Health Committee in April 2005. A Greenpeace representative also attended this presentation. A presentation was also made to the Darlington Site Planning Committee in June 2005. They expressed appreciation for the briefing on the DGR Project.

2.5.3 Briefings with NGOs

Briefings were provided to a representative of Energy Probe in February 2006 and May 2010. Energy Probe representatives expressed concern that the DGR, located in limestone, is leading-edge science and that proper studies should be completed before proceeding with the DGR Project. Energy Probe indicated an interest in the DGR Project in the area of seismology and expressed concern about the potential for the retrievability of the waste and the need for monitoring. Energy Probe recommended that the proposal should be subject to a panel review to ensure that an independent body makes the decision.

Briefings were provided to representatives of Citizens for Renewable Energy in February 2006 and March 2010. The group in general is not supportive of nuclear energy and has concerns with the DGR regarding potential impacts on the Great Lakes, the potential for the DGR to receive used fuel, seismicity, retrievability of the waste, and monitoring of the DGR.

Briefings were provided to Greenpeace representatives in March 2006, December 2007, and May 2010. They recommended that the DGR Project should be subject to a panel review.

Greenpeace also asked questions about overall costs of the DGR Project, retrievability of the waste, accepting decommissioning waste, monitoring and the regulatory standards to which the DGR would be subject.

A briefing was provided to Northwatch in May 2010. They were interested in information on peer reviews and seismic activity. They also inquired about NWMO's role in the DGR Project and engagement activities with Aboriginal peoples.

A list of NGO presentations is provided in Appendix D11.

2.6 GENERAL STAKEHOLDER COMMUNICATIONS

This section provides information on the many communication approaches employed throughout the EA process for the DGR Project to engage stakeholders and the general public. As described in Section 2.1, a variety of activities was used to provide a broad range of opportunities for stakeholders and the general public to obtain information, ask questions, provide comments and input to the EA for the DGR Project. The activities included:

- DGR Open Houses;
- speaking engagements;
- DGR Mobile Exhibit;
- DGR Project newsletters;
- DGR website;
- library repositories; and
- telephone communication.

2.6.1 DGR Open Houses

Open houses are open public forums to inform participants about the DGR Project through displays and handouts, providing an opportunity for people to ask and receive answers to questions about the project and the EA process through discussion OPG/NWMO staff. These events provide an opportunity for the public to input to the EA for the project through discussions and comment cards, on topics including:

- input into the selection of Valued Ecosystem Components (VECs);
- input on participant experience at the open house, including their degree of understanding of the DGR Project and the degree to which their information needs had been met;
- feedback on the preliminary results of the environmental assessment; and
- general comments on the DGR Project.

Seven open houses were held in each of 2007, 2008, 2009 and 2010. The open house locations, shown on Figure 2.2.1-1, were Kincardine, Port Elgin, Walkerton, Ripley, Chesley, Owen Sound and Wiarton. In 2010, open houses were also held at MacGregor Point Provincial Park and the Bruce County Museum. Open houses were staffed by NWMO/OPG communications and technical personnel. Open house reports with appendices including notification materials, newspaper coverage, handouts, display panels and comment cards are found in Appendix D4.

Notification to community members about public open houses was provided using a variety of media:

- a postcard-format letter of invitation was delivered by Canada Post's Unaddressed Admail to approximately 50,000 households in communities in the outreach area;
- a newspaper announcement was published in the Kincardine News, Kincardine Independent, Lucknow Sentinel, Walkerton Herald Times, Owen Sound Sun Times, Port Elgin Shoreline Beacon, and the Wiarton Echo, prior to the open houses;
- letters were sent to stakeholders including local elected officials, City and County municipal staff leaders (including police, fire and emergency services), local and regional non-governmental organizations with a potential interest, and local and regional media outlets and others who expressed an interest in the DGR Project; invitations were sent to a number of organizations and individuals in the United States as well;
- radio spots were purchased for local radio stations that serve the open house communities. Different announcements, specific to each open house, were prepared;
- an advertisement was placed in the Marketplace magazine, a local advertising publication; and
- the dates, times and locations of the open houses were posted on the DGR Project website prior to the open houses.

The discussions at the open houses covered a broad range of subjects. Table 2.6.1-1 provides the answers to those questions most frequently asked during the open houses.

Table 2.6.1-1: Frequently Asked Questions and Answers from Open Houses

#	Question and Answer	Further discussed in EIS
1	**Q**: Will used nuclear fuel be stored in the DGR? **A**: The DGR will not receive used nuclear fuel. The Municipality of Kincardine has passed a resolution indicating that no used fuel will be placed in the DGR. OPG is seeking regulatory approval for site preparation and construction of a DGR for low and intermediate level waste only.	Section 1.2 and 2.2.1.2
2	**Q**: Will waste from other producers be stored in the DGR? **A**: No. The DGR will manage low and intermediate level waste currently managed by OPG at the Bruce nuclear site and wastes produced during the operating lives of OPG-owned or operated nuclear generating stations.	Section 1.2

Table 2.6.1-1: Frequently Asked Questions and Answers from Open Houses (continued)

#	Question and Answer	Further discussed in EIS
3	**Q**: Have the potential effects of terrorist activities been evaluated? **A**: Yes. The documentation provided for the regulatory approvals process will include an assessment of potential malfunctions and accident scenarios, as a result of unintentional and intentional acts and accidental or abnormal events that could impact the public and the environment throughout the DGR's lifetime and after its closure. A few examples of abnormal events being evaluated include fire or container breach, unintentional intrusion into the repository, and failure of the shaft seal.	Section 8.4
4	**Q:** Why is the DGR located in proximity to Lake Huron? **A:** The Municipality of Kincardine approached OPG expressing an interest in the feasibility of a long-term waste facility at the WWMF. The DGR is located approximately 1 km inland from the shore of Lake Huron at the surface and a distance greater than 400 metres below the deepest near-site point of Lake Huron. The DGR is separated vertically from Lake Huron by a low permeability layer of shale, which isolates the waste.	Sections 1.1, and 7.12.1
5	**Q**: How will Great Lakes water quality be protected? **A**: Great Lakes water quality will not be adversely affected by the DGR Project. The low and intermediate level waste is being placed in low permeability limestone, overlain by about 200 metres of low permeability shale. The characteristics of these rocks, including their age, stability, and their position well below the level of the bottom of Lake Huron, will contain contiminants, limiting their release into the surface environment. Any migration that does take place will be over a period of hundreds of thousands of years and maximum calculated doses will be orders of magnitude below the current regulatory limits.	Sections 1.2.3.1, 7.3.2, and 7.12.1
6	**Q**: Did OPG consider other sites for the DGR? **A**: Experience in other countries has shown that success in siting a waste disposal facility is greatly improved in situations where the community supports the proposal. The Municipality of Kincardine approached OPG asking to jointly assess the feasibility of hosting a long-term low and intermediate level waste management facility. Once the results of these feasibility studies indicated that the Bruce nuclear site could be a safe and technically feasible site, the Kincardine Municipal Council volunteered to host a DGR for low and intermediate level waste. Results of a telephone poll indicated that a majority of Kincardine residents support the DGR Project. No other sites volunteered to participate in the feasibility studies or to host the facility.	Section 3.4.2

Table 2.6.1-1: Frequently Asked Questions and Answers from Open Houses (continued)

#	Question and Answer	Further discussed in EIS
7	**Q**: How do other countries manage their low and intermediate level nuclear waste? **A**: Several other countries use similar technology for managing low and intermediate level waste: • United States stores transuranic waste in a deep repository in New Mexico; • Sweden manages its low and intermediate level waste in an underground repository approximately 60 m under the seabed, in rock situated below the Baltic Sea and near a nuclear power station; and • Finland manages low and intermediate level waste in an underground repository located near a nuclear generating station and excavated in rock 110 m below ground.	Sections 3.3 and 3.4.10
8	**Q**: How can it be assured that no contaminants will escape to surface waters? **A**: The proposed DGR is about 1 km inland from the lake and more than 400 m below the depth of the lowest point of Lake Huron near the site. The DGR Project will store waste, currently managed safely at surface, underground at a depth of 680 m. The DGR is proposed in a layer of very low permeability limestone and is overlain by a 200 m thick layer of low permeability shale which isolates the repository from surface water resources. Results of safety assessment studies completed to assess the potential for migration of contaminants from the DGR indicate that the maximum calculated dose from the DGR would be far into the future and the dose would be orders of magnitude below the regulatory criterion.	Sections 1.2.3.1, 7.2.1, 7.2.2, and 7.12
9	**Q**: What is the difference between the types of radioactive waste? **A**: Low level waste has low levels of radioactivity and includes protective clothing, floor sweepings, mops, and rags. It can be handled without special radiation protection. Intermediate level waste includes used reactor core components, refurbishment wastes, and resins and filters. It cannot be handled without radiation protection.	Sections 3.1, and 4.5
10	**Q**: What assurance is there that "the door isn't open" for high level waste disposal, or that waste will not be imported from other nuclear companies in Canada or other countries? **A**: The DGR Hosting Agreement between the Municipality of Kincardine and OPG is for the management of waste from OPG-owned or operated reactors. OPG's EIS and application for licence are for L&ILW only from OPG-owned or operated reactors.	Section 2.2.1.3

Table 2.6.1-1: Frequently Asked Questions and Answers from Open Houses (continued)

#	Question and Answer	Further discussed in EIS
11	**Q**: Can the waste be recycled/reused? **A**: OPG processes the waste to reduce to the extent possible the volume of the waste being placed in storage. Opportunities for recycling some components of the waste, such as steam generators, are available. The majority of the L&ILW proposed to be placed in the DGR has no further value for recycle/reuse.	Section 3.4.1
12	**Q**: How will the doses underground compare with those at the surface? **A**: The doses to workers underground from low level waste will be comparable to those currently experienced in the above-ground storage buildings. Similarly, doses to workers handling the intermediate level waste will be about the same as doses to those handling the waste above ground at the WWMF. OPG will have monitoring programs in place to confirm that workers are not exposed to unacceptable doses.	Sections 6.6.10, 6.6.11 and 7.6.2.1
13	**Q**: How many generations of nuclear waste will the DGR accept? **A**: OPG is seeking approval for a DGR for approximately 200,000 m^3 of L&ILW. This was based on the projected volume of L&ILW from Pickering, Darlington and the Bruce generating stations for their lifetimes, assuming that each generating station would be refurbished once.	Section 3.1
14	**Q**: Are there potential health risks associated with nuclear sites in general, including possible links to increased levels of leukemia? **A**: Cancer incidence rates specific to the Regional Study Area were not available. Durham Region, in Radiation and Health in Durham Region 2007, assessed possible health effects from the Pickering and Darlington nuclear generating stations. The Report [18] concludes that disease rates in Ajax-Pickering and Clarington did not indicate a pattern to suggest that the Pickering nuclear generating stations and Darlington nuclear generating station were causing health effects in the population.	Sections 6.11 and 7.11
15	**Q**: When would the DGR be operating? **A**: According to the current schedule, construction could start in 2012/2013 and the DGR could be operating in 2017/2018.	Sections 1.2.4 and 4.2
16	**Q**: What passive controls would be in place to mark the location of the DGR for future generations? **A**: At this time there are no specific plans. Control mechanisms aren't required for another 50 to 100 years. At that time, it is expected several countries will be in the same position, and that a solution will be developed with international consensus.	Section 4.12

Table 2.6.1-1: Frequently Asked Questions and Answers from Open Houses (continued)

#	Question and Answer	Further discussed in EIS
17	**Q**: What is the cost of the project and where will the money come from? **A**: The construction cost of the DGR is currently estimated to be about $1 billion. An existing segregated fund established by OPG (Decommissioning Fund), which has been accumulating funds, will be used to pay the cost of the DGR Project.	Section 1.2.5 and 4.7.2.3
18	**Q**: What routes are used to transport the waste to the WWMF? **A**: Paved provincial and municipal roads suitable for commercial vehicles carrying heavy loads are used to transport the waste unless emergent conditions dictate a need for change. OPG has safely transported waste for nearly 40 years under transport licences issued by Transport Canada. The DGR Project will result in no changes to the volumes, means, or routes for transport. The DGR Project, as indicated in the EIS Guidelines, includes only transfer of waste at the DGR Project site.	—

2.6.2 Speaking Engagements

Each year approximately twenty DGR Project presentations were made to various organizations and service clubs, general interest groups, environmental groups, and school and academic groups, such as:

- local Rotary Clubs, Lions Clubs, Kinsmen Clubs, Probus Clubs, Knights of Columbus, Sorority Clubs, Retiree Associations, Bruce-Grey Federation of Agriculture, Flying Farmers Organization, Federation of Anglers and Hunters (Zone H), and others;
- high school students, university students, academic researchers, MNR Stewardship Rangers; and
- environmental forums, American Geophysical Union, Tunnelling Association of Canada, GeoHalifax, Canadian Geotechnical Society and Ontario Petroleum Institute.

On several occasions the speaking engagements, typically those associated with technical groups, also included scheduled tours of the WWMF, DGR drill sites and DGR core storage building. The tours allowed stakeholders to see the current waste operations firsthand, to better understand the interim nuclear waste management business and the DGR Project site.

Objectives of the speaking engagements and tours were to inform participants about the DGR Project, provide an opportunity for questions and answers with OPG/NWMO staff, and solicit feedback on issues.

For a detailed list of speaking engagements, see Appendix D9.

Information provided about the DGR Project at each of the speaking engagements was well received. Often there were no significant issues or concerns raised. Table 2.6.2-1 presents a summary of answers provided to frequently asked questions received at speaking engagements.

Table 2.6.2-1: Questions and Answers from Speaking Engagements

#	Question and Answer	Further discussed in EIS
1	**Q**: Is there a potential to contaminate drinking water? **A**: Drinking water quality will not be adversely affected by the DGR. The waste will be placed in very low permeability limestone, overlain by about 200 m of very low permeability shale. The characteristics of these rocks, including their age, stability and their position well below potable water found near the surface and well below the level of the bottom of Lake Huron will contain contaminants limiting their release into the surface environment. Any migration that does take place will be over a period of hundreds of thousands of years and the maximum calculated doses will be orders of magnitude below regulatory limits.	Sections 1.2.3.1, 7.2.2 and 7.3.2.2
2	**Q**: How much waste will the DGR handle? **A**: The DGR is designed to manage approximately 200,000 m^3 of L&ILW.	Sections 1.2.3, 3.1 and 4.5
3	**Q**: Will medical waste be accepted in the DGR? **A**: No. Only L&ILW from OPG-owned or operated generating stations will be emplaced in the DGR.	Sections 2.2.1.3, and 4.5
4	**Q**: How long will the DGR take to construct? **A**: Approximately five to seven years.	Sections 4.2, and 5.2
5	**Q:** How many jobs will be created during construction and operations? **A**: There will be an annual average of approximately 160 construction positions and 40 operations positions.	Sections 4.7.2 and 4.8.1
6	**Q**: Will the waste be retrievable? **A**: The DGR wastes have no value and there is no intent to retrieve them; however, the wastes will be retrievable.	Section 4.8
7	**Q**: How will the shafts be sealed? **A**: The current reference design has concrete and clay shaft seals to the top of the Queenston shale formation.	Section 4.11.4
8	**Q**: How will the aggregate from the DGR be managed? **A**: The aggregate will be stored at surface.	Section 4.4.1.3
9	**Q**: Is there salt below the Bruce nuclear site? **A**: No. The salt layers found at Goderich are not evident north of the Kincardine area.	Section 6.2.6

Table 2.6.2-1: Questions from Speaking Engagements (continued)

#	Question and Answer	Further discussed in EIS
10	**Q**: How will the DGR be constructed? **A**: The DGR will be constructed using the traditional drill and blast method.	Section 4.7
11	**Q**: Why locate the DGR in sedimentary rock? **A**: Studies have identified both granitic and sedimentary rock types as being potentially suitable for implementation of long-term radioactive waste management repository concepts. The Cobourg limestone has high clay content, which over geologic time has allowed it to maintain favourable conditions for long-term radioactive waste management (i.e., extremely low rock mass permeabilities).	Sections 3.4.3, 6.2, and 9.4
12	**Q**: Why is the DGR located in the upper portion of the limestone rock? **A**: At 680 m below ground surface geomechanical stability is enhanced and the postclosure safety margin is increased.	Section 3.4.3.1
13	**Q**: What is the risk of an earthquake and what impact would there be on the DGR? **A:** The Bruce nuclear site is located in an area of Canada associated with low seismic hazard. Analysis has shown that earthquakes and glaciers over the last million years have not disturbed the host rock at repository depth, and should not do so in future.	Sections 6.10, 7.13.1, and 9.2.2
14	**Q**: What will happen to waste from new build plants and can the DGR be expanded? **A**: The DGR is designed to manage approximately 200,000 m^3 of L&ILW from OPG-owned or operated nuclear stations. The DGR Hosting Agreement with Kincardine includes a funding formula for waste from new-build. The DGR could be expanded to take additional waste volumes, with the approval of the regulator.	Section 4.10
15	**Q**: How is the low and intermediate level waste currently managed? **A**: L&ILW is currently managed by OPG at the Western Waste Management Facility in surface facilities.	Section 3.1
16	**Q**: Will the waste be repackaged or resorted before being placed in the repository? **A**: In general, only waste packages that are damaged will be repackaged.	Sections 4.5 and 4.8.2.2
17	**Q**: How will the waste be transferred to the DGR? **A**: Waste will be transferred either by forklift or flatbed truck.	Sections 4.4.1.1 and 4.8.2.2
18	**Q**: What is NWMO and what is its relationship with OPG? **A**: NWMO is the Nuclear Waste Management Organization. It is a federal not-for profit company established under the Nuclear Fuel Waste Act. OPG has contracted with NWMO to manage the regulatory approvals phase of the DGR Project.	Sections 1.3 and 4.14

Table 2.6.2-1: Questions from Speaking Engagements (continued)

#	Question and Answer	Further discussed in EIS
19	**Q**: Who will operate the DGR once it is constructed? **A**: OPG.	Section 1.3
20	**Q**: Is there heat from the waste? **A**: There is little heat from the waste.	Section 4.5, Table 4.5.1-3
21	**Q**: Is there gas given off from the waste? **A**: Gases (mostly hydrogen, carbon dioxide and methane) can be generated by corrosion of metals and degradation of organic material. The presence of these gases in the DGR was taken into consideration in the safety assessment.	Section 9.4
22	**Q**: What happens to the high level waste? **A**: High level waste is currently managed at the site where it is produced. In the longer term, the NWMO is implementing a siting process which invites communities who are interested in hosting a repository for used fuel to participate in the process. This process is separate from the DGR Project for L&ILW.	Section 1.2.1
23	**Q**: Will monitoring wells be established? **A**: Yes. Monitoring wells have been established as part of the Geoscientific Site Characterization Program and monitoring will continue during construction and operation of the DGR.	Section 12
24	**Q**: How does communication change as you move farther away from the Bruce nuclear site? **A**: NWMO focuses communications about the DGR Project in Kincardine and surrounding communities. Other stakeholders who are interested have the opportunity to request information and/or meet with the NWMO to discuss the DGR Project. The DGR Project mailing list includes stakeholders throughout the world.	Section 2.1.3
25	**Q**: Why was a hosting agreement signed? **A**: Hosting Agreements are often signed by communities who volunteer to host nuclear waste management sites, including the communities of Port Hope and Clarington.	Sections 2.2.1.3 and 2.2.1.4

2.6.3 DGR Mobile Exhibit

A DGR Mobile Exhibit was created to "take the DGR Project to the people". OPG recognized that not everyone has the time or is available to attend open houses or other scheduled DGR consultation activities. The mobile exhibit was developed to be taken to community events where local residents gather such as Spring Home Shows, Fall Fairs, Farmers' Markets and Flea Markets. These events provided an opportunity for OPG/NWMO to meet the public and engage in face-to-face sharing of information and discussion about the DGR Project. The DGR mobile exhibit, staffed by communications staff, attended on average about 35 events per year between 2007 and 2010.

The majority of people who visited the mobile exhibit at the various community events indicated support for the DGR Project. Comments frequently received included agreement that the waste had been produced and needed to be managed in the long-term, a DGR seemed to be the best approach for long-term waste management, and when would construction begin. However, at most events there was a small number of attendees who identified issues such as opposition to the continued use of nuclear energy, the lack of forethought in developing nuclear energy prior to addressing the long-term waste management issue, and the potential for contaminants to be released from the DGR. The questions and comments that were most frequently received are listed in the tables in Sections 2.6.1 and 2.6.2.

For a detailed list of DGR mobile exhibit events, see Appendix D10.

2.6.4 DGR Project Newsletters

DGR Project newsletters have been produced since 2006. Three to four issues are produced annually and are distributed to approximately 35,000 residences and businesses. They are distributed through area post offices to Aboriginal communities as well as residents within the municipalities of Kincardine, Saugeen Shores, Brockton, Arran-Elderslie, Huron-Kinloss, Northern Bruce Peninsula, South Bruce Peninsula and South Bruce, as well as to stakeholders on a designated mailing list.

Prior to 2006, information about the DGR Project was included in the Neighbours newsletter, published bi-annually, by OPG's WWMF public affairs staff at the Bruce nuclear site. The first issue to include an article on the DGR Project was summer 2002. Updated articles on the DGR Project frequently appeared after this introductory article (see Table 2.6.4-1).

Table 2.6.4-1 lists the DGR Project newsletters, as well as the OPG WWMF Neighbours newsletters which included DGR-related articles. Copies of the newsletters are included in Appendix D7.

Table 2.6.4-1: DGR Newsletters

Newsletters	Article	Date
WWMF Neighbours	DGR Article – MOU Signed on Long-term Management of Low and Intermediate Level Waste	Summer 2002
WWMF Neighbours	DGR Article – Trip to Review Nuclear Waste Management "Best Practices"	Fall 2002
WWMF Neighbours	DGR Article – Long-term Management of Low and Intermediate Level Waste	December 2003
WWMF Neighbours	DGR Article – Assessment of low & intermediate waste management options completed	Winter 2004

Table 2.6.4-1: DGR Newsletters (continued)

Newsletters	Article	Date
WWMF Neighbours	DGR Article – Deep Geologic Repository Proposal	December 2004
WWMF Neighbours	DGR Article – Deep Geologic Repository Project	April 2005
WWMF Neighbour	DGR Article – OPG awards contract to develop site characterization plan for DGR and establishes geoscience review group	December 2005
WWMF Neighbours – Special Edition	Keeping you informed about the Deep Geologic Repository	February 2006
WWMF Neighbours	DGR Article – DGR Project Description Submitted to CNSC	March 2006
WWMF Neighbours – Special Edition	Keeping you informed about the Deep Geologic Repository	June 2006
WWMF Neighbours – Special Edition	Keeping you informed about the Deep Geologic Repository	November 2006
WWMF Neighbours	DGR Article – DGR geoscientific site characterization update	December 2006
WWMF Neighbours	DGR Article – CNSC recommends panel hearing for DGR	February 2007
WWMF Neighbours – Special Edition	Keeping you informed about the Deep Geologic Repository – Focus on geosynthesis	April 2007
WWMF Neighbours – Special Edition	Keeping you informed about the Deep Geologic Repository – Focus on geosciences studies	July 2007
WWMF Neighbours	DGR Article – Another opportunity to talk DGR	October 2007
WWMF Neighbours – Special Edition	Keeping you informed about the Deep Geologic Repository – Articles on open houses, geoscience	November 2007
WWMF Neighbours – Special Edition	Keeping you informed about the Deep Geologic Repository	May 2008
WWMF Neighbours – Special Edition	Keeping you informed about the Deep Geologic Repository – Focus on geoscience	September 2008
WWMF Neighbours – Special Edition	Keeping you informed about the Deep Geologic Repository – Focus on geosciences investigations and open houses	December 2008
DGR For Ontario Power Generation's Low & Intermediate Level Waste	Keeping You Informed About the Deep Geologic Repository – Focus on Safety Assessment	March 2009
WWMF Neighbours	DGR Article – You will see a new name on the DGR mobile exhibit	May 2009
DGR For Ontario Power Generation's Low & Intermediate Level Waste	Keeping You Informed About the Deep Geologic Repository – Focus on geoscientific investigations	June 2009

Table 2.6.4-1: DGR Newsletters (continued)

Newsletters	Article	Date
DGR OPG's Deep Geologic Repository for Low & Intermediate Level Waste	Keeping You Informed About the Deep Geologic Repository – Focus on EA baseline studies	October 2009
OPG Power News	Article – Community Consultation for DGR Continues	November 2009
OPG's Deep Geologic Repository for Low & Intermediate Level Waste	Keeping You Informed	June 2010
OPG's Deep Geologic Repository for Low & Intermediate Level Waste	Keeping You Informed	September 2010
OPG's Deep Geologic Repository for Low & Intermediate Level Waste	Keeping You Informed	December 2010

2.6.5 DGR Website

A DGR website has been operating since 2004. Initially accessed at: www.opg.com/dgr, it was linked to the NWMO website at: www.nwmo.ca/dgr in 2009. The website for the DGR Project provided access to overview information about the DGR Project, newsletters, annual reports, and and information on studies in support of the EA and licensing process. The website included a mailbox where questions about, and comments on, the project could be directed for a response. Comments and questions frequently received online are consistent with those listed in Tables 2.6.2-1 and 2.6.2-2. DGR Project submission materials can also be accessed through the Canadian Environmental Assessment Agency website, as indicated in Section 1.4.4, or at: www.opg.com/dgr.

2.6.6 Library Repositories

DGR Project documents including newsletters, the DGR Annual Reports and the DGR Keeping You Informed booklet were made available at all municipal offices in the EA focus area, as well as the SON Environment Office. Copies of technical reports were also made available in the SON Environment Office and local libraries including those in Kincardine, Port Elgin, Southampton, Ripley, Walkerton, Chesley, Wiarton and Tobermory.

2.6.7 Telephone Communication

Contact information for OPG/NWMO public affairs was advertised to the public on all written and electronic materials and on the DGR website for the public to follow up with for further information or questions. Comments and questions frequently received via the telephone are consistent with those listed in Tables 2.6.1-1 and 2.6.2-1.

2.7 OTHER PUBLIC PARTICIPATION

Briefings and consultation with U.S. stakeholders were undertaken with the objective of introducing the DGR Project to Michigan-based stakeholders and providing an opportunity for questions and answers and input on the EA for the DGR Project.

Seven briefing meetings were conducted with various stakeholders in the State of Michigan on September 23 and 24, 2009, including representatives of:

- members of the U.S. Senate and Congress;
- the Macomb County Board of Commissioners;
- the Michigan Department of Environmental Quality;
- the Michigan Environmental Council;
- the Michigan United Conservation Club; and
- the National Wildlife Federation, Michigan Chapter.

A briefing was also conducted with Detroit and Washington consular and embassy officials from the Department of Foreign Affairs and International Trade (DFAIT) in 2007, and a briefing note on the DGR Project was sent to DFAIT to provide information should there be international enquiries about the DGR Project. Individuals and groups in Michigan were also consulted using a variety of other methods. For example, there were some who submitted comments on the first draft of the EIS Guidelines who were later added to the stakeholder mailing list.

A letter sent to U.S. Congressman Bart Stupak (Michigan First District), inviting him to tour the WWMF, received no response. Information was provided to other key stakeholders including a representative of the Michigan Office of Geologic Survey and the Radiation Protection Section of the Department of Environmental Quality. See Appendix D13 for additional details on these consultations.

Further briefings were provided on February 14 and 15, 2011 to:

- representatives of the Michigan Department of Environmental Quality;
- representatives of Michigan United Conservation Clubs;
- State Senators and House of Representatives members; and
- Governor's Chief of Staff.

Generally, the briefing attendees were not familiar with the DGR Project. The presentations included background on the DGR Project, a description of the wastes managed at the WWMF and to be placed in the DGR, the regulatory approvals process and the status of project. Participants were interested in the process that resulted in a willing host community and the level of community support for the project. The attendees thanked OPG and the NWMO for being proactive in providing information on the DGR Project.

2.8 MEDIA

Local media have been briefed throughout the EA process for the DGR Project. Local media days were held that included tours, information packages and opportunities to interview key technical people working on the DGR Project. Media days helped to ensure the media remained well informed with the progress of the DGR Project and the EA.

Media interviews were readily granted to provide access and transparency, while proactive measures were taken to ensure the DGR Project was featured on live radio and TV talk shows with call-in opportunities for the public. OPG also briefed the Owen Sound Sun Times editorial board on the DGR Project. Press releases and photos were sent out to local media, at relevant project milestones.

Media coverage has included letters to the editor, newspaper reports, radio reports, and radio call-in shows. A list of media coverage that took place in Canada and the State of Michigan is included in Appendix D5. Open house reports in Appendix D4 also provide summaries and clippings of newspaper coverage following open houses.

2.9 ISSUE IDENTIFICATION AND TRACKING

Questions and requests for information about the DGR Project, when received at community events or presentations were responded to verbally and/or with handout materials where possible. If the response was not available at the time, the question was recorded and a follow-up response provided.

2.9.1 Community and Stakeholder Comments and Issues

Formal questions submitted to OPG or NWMO (i.e., emails, letters, requests for more information through comment cards filled out at open houses or community events, phone calls) were recorded. Responses to each inquiry were provided and documented along with the original comment. More than 150 comments/questions were tracked. A sample of the tracking form is provided in Appendix D14.

The distribution of these comments by type is shown in Table 2.9.1-1. It should be noted that not all comment cards included written comments. A questionnaire was incorporated into open house comment cards, and some cards were submitted with only this part of the card completed.

Table 2.9.1-1: Tally of Comments Received by Format for the Period Preceding (2003 to 2005) and During the Development of the EIS (2006 to 2010)

Comment Format	# Received Pre-EA	# Received During EIS Development
Comment card	9	93
Email	59	49

Table 2.9.1-1: Tally of Comments Received by Format for the Period Preceding (2003 to 2005) and During the Development of the EIS (2006 to 2010) (continued)

Comment Format	# Received Pre-EA	# Received During EIS Development
Letter	4	4
Phone call/in-person	13	18
Total	**85**	**164**

Verbal comments were also received during the course of events such as speaking engagements, briefings, events attended by the mobile exhibit, and meetings and workshops with Aboriginal groups. People providing verbal comments were encouraged to submit comment cards, or provide written comments through email or letters. Tables 2.6.1-1 and 2.6.2-1 include questions most frequently asked over the course of the public participation activities for the DGR Project.

2.9.2 Input to Selection of Valued Ecosystem Components (VECs)

Public input was solicited on the selection of VECs at the 21 DGR open houses held from 2007 to 2009. During the 2007 open houses, an initial selection of VECs was provided in handouts and on a display panel, and participants were invited to identify their preferences on these panels (by marking which were of interest to them), and providing any additional VECs they thought were not represented. Results of this process are shown in Figure 2.9.2-1. No additional VECs were proposed at the 2007, 2008 or 2009 open houses.

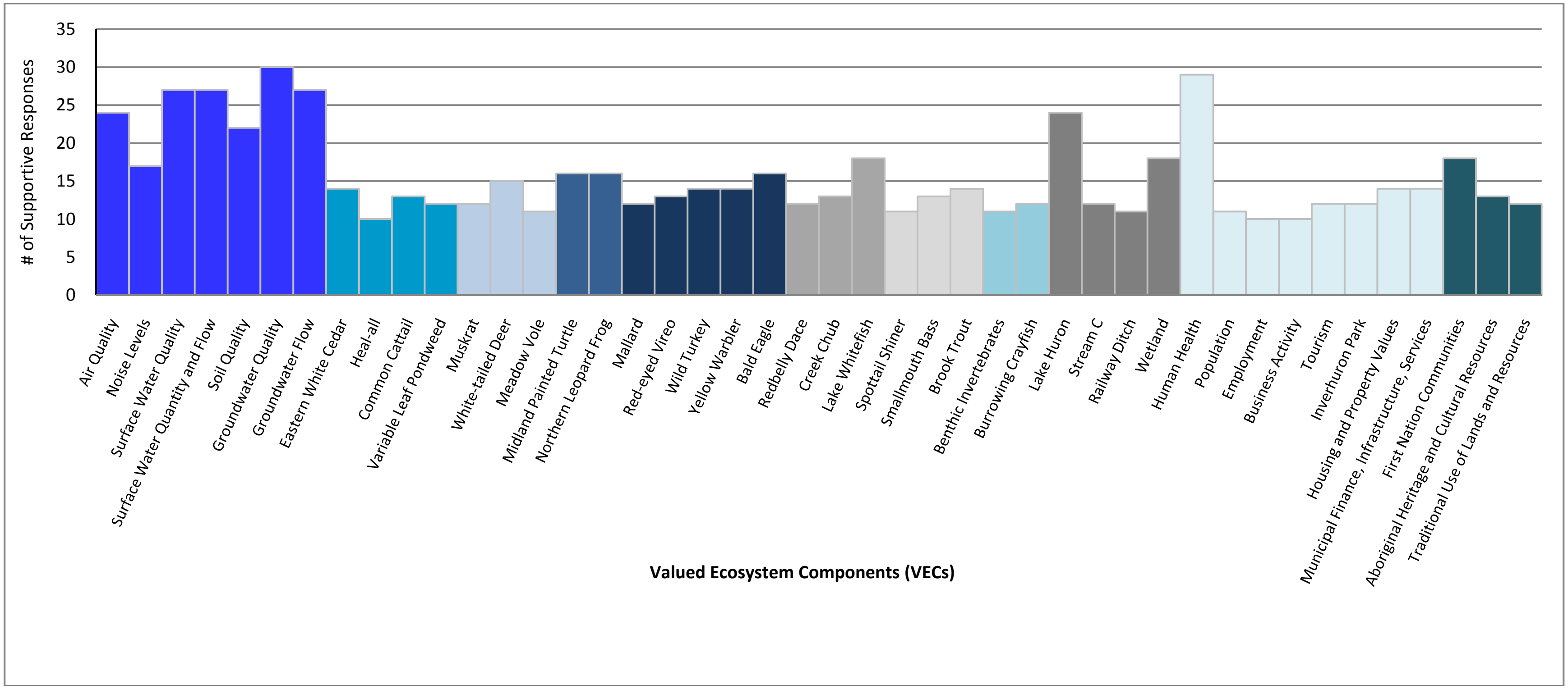
Opportunities were provided to participants in 2008 and 2009 open houses to comment again on the list of VECs via comment cards or through verbal discussion, and no additional comments were received.

The preliminary list of VECs was sent to SON's administrative coordinator to provide them an opportunity to comment. No response was provided.

2.9.3 Input to the Identification of Issues

The issues raised during engagement activities throughout the environmental assessment process conducted for the DGR Project tended to be focused on:

- the process for the EA including timing, type, scenarios being considered in decision-making, the review process, and supporting studies;
- alternatives to the DGR, their feasibility, and the degree to which they had been evaluated;



Note: A total of 191 participants across seven open houses in 2007 provided information on VECs that were important to them. These VECs were also featured during the 2008 open houses, and no additional comments were received.

Figure 2.9.2-1: Summary of VECs Identified by 2007 DGR Open House Participants and the Frequency that each VEC was Identified by Participants as Being Important to Address their Interests

- the health and safety risks of the transportation, handling, incineration, and storage of the waste;
- measures to mitigate health and safety risks in the design, operation, transportation of waste to, and decommissioning of the DGR Project;
- the potential environmental effects related to the construction, operations, and decommissioning of the DGR Project, especially to Lake Huron;
- the nature of waste to be emplaced in the DGR, and its sources; and
- the socio-economic effects and benefits of DGR construction, operations, and decommissioning to local communities, including Aboriginal peoples.

There was a shift in the nature of issues raised when comparing the regulatory approvals phase to the period preceding the EA process (2002 to 2005) (see Table 2.9.3-1). Generally, more specific and sophisticated comments and questions about technical aspects of the DGR Project were expressed during the EA period, as well as more questions about the EA process. There were also fewer comments from those:

- opposed in principle to the DGR Project;
- concerned about the integrity of the geology; or
- concerned that the DGR would hold high-level nuclear waste and/or waste from facilities outside Ontario.

Table 2.9.3-1: A Comparison of the Ten Highest Ranked Issues Raised in Written Comments

Top 10 Issues: 2002 to 2005	# of Comments Received	Top 10 Issues: 2006 to 2010	# of Comments Received
Request for information	12	Public consultation in the approvals process	20
Health and safety risk of radiation and radioactivity	12	General comments about the EA process	18
Opposed to DGR Project	8	Consideration of alternatives to the DGR in the approvals process	12
Content or sources of waste to be placed in the DGR	7	Health and safety risk of radiation and radioactivity	9
Public consultation in the approvals process	6	Content or sources of waste to be placed in the DGR	6
General health risks	6	General comments about the transportation of waste	6
General comments about the EA process	4	The study area for the EA and approvals process	5
The geology of the site	4	General health and safety risk	5
Health and safety risk from accidents and malfunctions	4	Safety issues with transporting the waste	5

Table 2.9.3-1: A Comparison of the Ten Highest Ranked Issues Raised in Written Comments (continued)

Top 10 Issues: 2002 to 2005	# of Comments Received	Top 10 Issues: 2006 to 2010	# of Comments Received
General safety risks	4	Aboriginal involvement in the EA process	5

Comments received prior to and during the EA process have been reflected in the EIS through attention to DGR Project activities and design scenarios, including:

- the range of scenarios and criteria used to guide the safe design, operation, and decommissioning of the repository;
- the degree of operational and post-project safety monitoring, assessment and adaptive measures;
- the location and configuration of the above-ground structures associated with the DGR Project;
- the development of agreements to mitigate the risks and share the benefits of the DGR Project with local municipalities and Aboriginal communities; and
- the conduct of the OPG/Kincardine Steering Committee for the DGR Project in communicating and engaging with Aboriginal communities.

In some cases, comments received are reflected in modifications to the DGR Project design. For example, comments from the general public about the proximity of the DGR Project to Lake Huron resulted in the design team orienting the emplacement rooms, to the extent possible while still aligning with the primary stress direction, to extend inland from the lake.

In response to comments from representatives of the Saugeen Valley Conservation Authority, options were discussed regarding different treatment options for the stormwater management pond, such as including wetlands treatment.

2.10 CONCLUSIONS OF THE ENGAGEMENT

Results of the telephone poll conducted on behalf of the Municipality of Kincardine early in 2005 indicate that the municipality is a willing host for the DGR Project. Results of engagement activities subsequent to the poll continue to demonstrate that the community is knowledgeable of the project and that there is broad community support for it. Public attitude research conducted in 2003 and 2009 in the Municipality of Kincardine and four surrounding municipalities indicate that the DGR and nuclear waste management were not top of mind issues. Overall, the majority of respondents expressed a high level of knowledge and confidence in the nuclear waste management practices and the DGR. The majority of people polled did not anticipate the DGR would change their overall commitment to their community or their level of satisfaction with living in the community.

Leadership surveys in 2006 and 2009 showed strong support for the DGR. Leaders indicated they felt knowledgeable of the project. They believed NWMO and OPG were doing an excellent or good job of addressing questions about the DGR.

2.11 POST-EIS SUBMISSION COMMUNICATION

NWMO, on behalf of OPG, is committed to continuing its Public Participation and Aboriginal Engagement Program throughout the regulatory approvals process and beyond, including (pending regulatory approval), the DGR Project site preparation and construction phase using a variety of approaches. Once the DGR is operating, communications are expected to be integrated with OPG communications.

- **Stakeholder Briefings and Presentations** – Briefings and presentations will continue to be conducted to present information and provide an opportunity to have questions and comments addressed. Regular updates will be presented to elected officials, the DGR Community Consultation Advisory Group and Kincardine Community Consultation Advisory Committee; and other key stakeholders on a frequency commensurate with key DGR Project activities and milestones.
- **DGR Website** – The DGR website will continue to be updated. The website serves as a vehicle to provide access to information, as well as a mechanism to receive input from interested persons as an enhancement of the public participation program.
- **DGR Newsletter** – The DGR Project newsletter will continue to be issued on a frequency commensurate with key DGR Project activities and milestones.
- **DGR Open Houses** – Open houses may occur throughout this period to share information, describe key activities and communicate progress.
- **Media Relations –** Ongoing media relations about the EA will be initiated and maintained by NWMO, on behalf of OPG.
- **Adherence to Agreement with Aboriginal peoples** – OPG and NWMO will continue to support the agreements signed with the Historic Saugeen Métis Community and SON, and will continue communications with MNO.
- **Telephone Communication** - Contact information for OPG/NWMO public affairs will continue to be advertised to the public on all written and electronic materials and on the DGR website for the public to follow up with for further information or questions.
- **Employee Communication** – OPG and NWMO employee communication will continue with articles appearing in electronic and print publications. Staff presentations and lunch and learn sessions will be held.
- **Issues Management and Tracking** – A comment database will continue to be maintained to record and monitor all comments, correspondence and communications with the public and stakeholders.

3. PROJECT JUSTIFICATION

Ontario Power Generation (OPG), with support from the Bruce community, is proposing to construct a Deep Geologic Repository (DGR) for the long-term management of L&ILW. The proposed site for the DGR is located on lands adjacent to the WWMF at the Bruce nuclear site within the Municipality of Kincardine. The proposed DGR Project site was chosen because it holds two attributes that, based on international experience, are essential for the successful development of a long-term waste management facility: technical suitability, in this case geology that offers multiple natural barriers to safely isolate and contain the waste for tens of thousands of years and beyond; and an informed and willing host community.

This section describes the need for the DGR Project, the process used to identify the preferred alternative to meet the need, and the preferred means of implementing the project, as illustrated conceptually in Figure 3-1. This process is sequential with the results of one step providing information that guides the scope of the next. For example, the need for the project helps define the list of alternatives to be considered to meet that need.

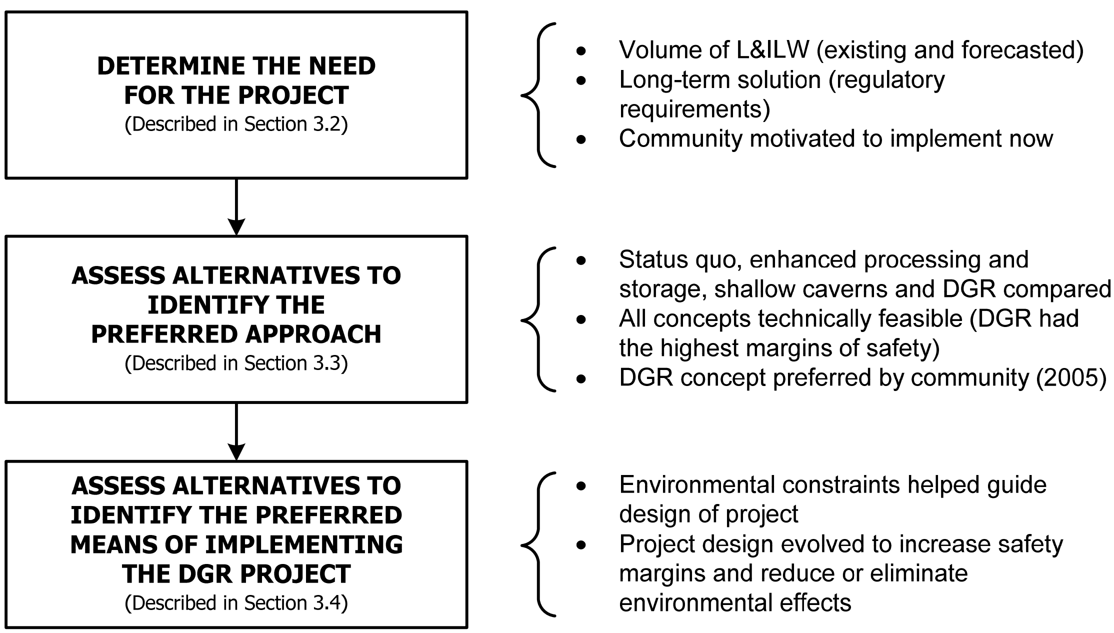


Figure 3-1: Schematic of the Process to Identify the DGR Project

The development of the concept of the DGR Project, as presented in Section 4, is the result of several years of development and consultation with the host community, which included an Independent Assessment Study (discussed in Section 2.2.1 and Section 3.2) and a telephone poll of permanent residents and a mail-based poll of seasonal residents of Kincardine eighteen years of age and older. These first steps (Steps 1 and 2 in Figure 3-1) occurred prior to the decision by OPG to proceed with the regulatory approvals process for the DGR Project, and the issuance of the EIS Guidelines. The identification of preferred alternative means occurred during the preliminary engineering design and EA studies.

3.1 PURPOSE OF THE PROJECT

Each year, approximately 5,000 to 7,000 m^3 of new L&ILW is produced as a result of the operation of OPG owned or operated nuclear generating stations in Ontario, including those at Darlington, Pickering and Bruce. The waste is transported to the WWMF (see Figure 3.1-1) for processing, which may include compaction or incineration. After volume reduction, this results in 2,000 to 3,000 m^3 of additional stored waste annually. To the end of 2010, the existing nuclear reactors in Ontario have produced about 84,000 m^3 of waste. If the fleet of 20 reactors each operate to the planned end of life (a nominal 50 years), which assumes refurbishment of each of the generating stations, approximately 200,000 m^3 (emplaced volume) of operational and refurbishment L&ILW would be produced. It was recently decided that Pickering B will not be refurbished.

Notes:
1 Low-level Storage Buildings (LLSBs) (ten)
2 In-ground Containers for ILW
3 Refurbishment Waste Storage Buildings and additional LLSBs
4 Western Used Fuel Dry Storage
5 Waste Processing Building
North arrow is approximate

Figure 3.1-1: Aerial View of OPG's Western Waste Management Facility (2009)

Operational LLW consists of common industrial items that have become contaminated with low levels of radioactivity during routine clean-up and maintenance at the nuclear generating stations. It consists of mops, rags, paper towels, temporary floor coverings, floor sweepings, protective clothing, and hardware items such as tools.

Where possible, the low level waste (LLW) is processed by either compaction or incineration to reduce volume and the space required for storage and disposal. OPG currently processes this waste at the WWMF. LLW is stored in a variety of stackable carbon-steel containers and these containers are stored in warehouse-like structures, known as Low-level Storage Buildings (LLSBs) shown in Figure 3.1-2.

Figure 3.1-2: Containers Stacked Inside Low-level Storage Building

There are currently eleven LLSBs at the WWMF. The wastes stored in LLSBs and in all other storage structures at the WWMF are continually monitored and can be easily retrieved. All WWMF storage structures have a minimum design life of 50 years.

Wastes that can neither be compacted nor incinerated are stored as-received without processing. The "non-processible" wastes constitute approximately 25% of all wastes received but make up about 55% by volume of the waste stored at WWMF.

Operational intermediate level waste (ILW), because of its physical condition and greater levels of radioactivity, is not processed for volume reduction. ILW consists of ion exchange resins, filters and irradiated reactor core components. These wastes are stored in concrete- and steel-lined structures constructed in augured boreholes (Figure 3.1-3), in concrete-lined and covered trenches, and in concrete above-ground structures (these latter structures are no longer receiving waste). Approximately 300 m^3 of ILW is received at the WWMF each year. About 5% of all waste (excluding used nuclear fuel) received at WWMF is classified as ILW.

Figure 3.1-3: In-ground Containers for Intermediate-level Waste Storage

Several of Ontario's reactors are either undergoing refurbishment or there are future plans for reactor refurbishment. The refurbishment activities include replacement of instrumentation, fuel channels, steam generators and other components. As a result of the refurbishment and improvements activities, it is expected the life of each reactor unit will be extended for up to 25 to 30 additional years. About 21,000 m^3 of radioactive waste will be generated from the planned refurbishment activities.

The irradiated fuel channel wastes are being stored in reinforced concrete containers with inner and outer steel shells. The loaded containers are disposal-ready and weigh about 30 tonnes. Steam generators removed during refurbishment are being transferred intact to storage buildings at the WWMF. The largest steam generator to be handled will weigh about 135 tonnes and have an overall length of 16 m. Current plans are to size-reduce the steam generators prior to placement in the DGR. Bruce Power (current operator of the Bruce nuclear generating stations) has received a licence to transport the steam generators to a facility in Sweden for recycling [19]. If they proceed, the volume of steam generator waste requiring long-term management will be reduced by about 90%.

In the future, an additional approximately 135,000 m^3 of L&ILW is expected to be produced during the decommissioning of the reactors and the associated nuclear waste storage facilities. The majority of this waste (i.e., >85%) will likely be LLW. The currently proposed DGR Project does not include management of decommissioning waste. At the time that each generating station is decommissioned, an EA is expected to be required and it will address management of the decommissioning waste. The cumulative effects assessment presented in Section 10 considers the emplacement of decommissioning waste in the DGR at a conceptual level, as required by the EIS Guidelines.

3.2 NEED FOR THE PROJECT

The basic need for the DGR Project derives from the fact that L&ILW consists of materials that can remain hazardous for hundreds, and is some cases, many thousands of years due the presence of long-lived radionuclides. These long timeframes require that a solution be found that protects humans and the environment, that is passive, and that does not require long-term institutional control. For shorter-lived radionuclides, near-surface disposal facilities can provide the required protection; however, for long-lived radionuclides, deep geologic disposal in suitable rock formations is the solution consistent with international guidance and practice.

The need for the DGR Project is further demonstrated by OPG's regulatory responsibility, a host community interested in implementing a long-term management solution now, and an existing and forecasted waste inventory requiring management. Waste forecasts are updated annually as part of OPG's business planning process. The estimated volumes included in Sections 3.1 and 4.5 of this EIS, take into consideration the effect of the various in-place and planned waste minimization programs. However, even if all future wastes were reduced to zero, the need for the project would not be eliminated because of the stock of existing wastes.

The regulatory context and hosting agreement are described further in the following sections.

3.2.1 Regulation of Nuclear Waste

The federal government is responsible for oversight and regulation of nuclear waste in Canada. Under current legislation, the responsibility for managing L&ILW lies with the waste producer. OPG is therefore responsible for the short and long-term management of L&ILW waste from the Pickering and Darlington nuclear generating stations. Under the terms of its lease agreement with Bruce Power, OPG is also responsible for managing the L&ILW from the Bruce generating stations.

Every aspect of the management of this L&ILW is regulated by the CNSC. The CNSC issues operating licences and inspects all nuclear facilities and related activities. Skilled inspectors ensure that the current operations meet all applicable federal regulatory criteria and do not pose undue risks to people or the environment. In some cases, an EA must be completed under the Canadian Environmental Assessment Act before a licence can be issued. OPG has operated, and continues to operate, in compliance with those regulatory requirements.

3.2.2 Long-term Planning by OPG

The WWMF was originally developed with the concept that it would provide interim storage for the L&ILW until such time as a long-term management facility was developed. The current structures have been designed for a minimum life of 50 years. These structures could, with proper maintenance, continue to safely store the waste much longer than 50 years. However, Canadians have indicated that they do not want to wait another generation for substantial progress to be made on developing long-term solutions for waste management.

In the early 1990s, OPG established a planning scenario for financial planning purposes that assumed that low and short-lived intermediate level radioactive waste would be emplaced in a low level waste repository. Management of selected long-lived intermediate level waste was assumed to be co-located with used fuel in a separate deep geologic repository. These planning scenarios did not include specific locations or plans for identifying a site for either facility.

OPG developed the financial plans on the basis that future generations should not bear the cost of today's operations. OPG makes financial contributions to segregated funds dedicated solely for the long-term management of waste and for the decommissioning of its generating stations. These funds will pay the costs associated with developing and operating a facility for the long-term management of L&ILW, a facility for long-term management of used fuel, and the decommissioning generating facilities. As of end of 2009, the fund was valued at approximately $10 billion [20].

3.2.3 Memorandum of Understanding with Kincardine

The Municipality of Kincardine is host to three nuclear generating stations, Douglas Point, Bruce A and Bruce B, and interim storage facilities for used nuclear fuel from these on-site nuclear generating stations and interim storage facilities for L&ILW from all OPG-owned or operated nuclear generating stations.

In 2001, the federal government introduced Bill C-27, a proposed Nuclear Fuel Waste Act, which deals with the long-term management of used nuclear fuel and not L&ILW. The introduction of this Act spurred the Municipality of Kincardine to raise questions on the long-term management of L&ILW, which was being managed at the WWMF on an interim basis. The Municipal Council held the view that it was important to plan for the long-term management of this waste and that they wished to take responsibility for these actions rather than leaving it to be dealt with by future generations.

Kincardine Council approached OPG with a number of questions related to the long-term management of L&ILW at the WWMF. These discussions led to the signing, in April 2002, of a Memorandum of Understanding (MOU) between OPG and the Municipality of Kincardine.

The MOU set out the terms under which OPG, in consultation with the Municipality of Kincardine, would develop a plan for the long-term management of L&ILW at the WWMF. Under the terms of the MOU, Kincardine and OPG undertook a fact-based assessment of possible long-term management options for L&ILW at the Bruce nuclear site in the Municipality of Kincardine. This assessment of alternatives to the DGR Project is described in more detail in Section 3.3.

3.2.4 Decision by Kincardine

Studies under the MOU were a cooperative effort by a Kincardine and OPG working group. In addition to the study, the working group commissioned several detailed studies and received presentations on these studies. Several members of the working group also visited similar facilities and met with community leaders in France, Sweden, United States and Switzerland.

Based on these collective fact-finding assessments, the Municipality of Kincardine passed a resolution (Resolution #2004-232) in April 2004 [21]:

> *"…that Council endorse the opinion of the [Kincardine] Nuclear Waste Steering Committee and select the 'Deep Rock Vault' option as the preferred course of study in regards to the management of low and intermediate level radioactive waste".*

Municipal support was shown for the deep rock vault as the preferred course of study with regards to management of L&ILW, since it provides a greater margin of safety, it is consistent with international best practice and it provides a permanent storage method for the waste stream, and if necessary, will do so in the absence of institutional controls.

3.2.5 Decision by OPG

Subsequent to the resolution by the Kincardine Council, OPG commissioned more detailed estimates of the cost of the DGR option with the conclusion that the costs were consistent with the financial planning that formed the basis of OPG's balance sheet and segregated funds.

OPG also consulted with other stakeholders, including the Province of Ontario and CNSC, and entered into discussions with Kincardine on the terms of a hosting agreement. Based on the outcome of these discussions, and earlier work under the MOU, OPG decided to support the Kincardine Council resolution and enter into a hosting agreement providing benefits to Kincardine and four surrounding municipalities for the licensing and construction of a DGR for L&ILW. This decision was based on several factors including:

- consistency with international best practice;
- provides a greater margin of safety;
- the Bruce geology is highly suitable;
- long-term solution; and
- requested and supported by the community.

The possibility of pursuing a greenfield site at a location other than Kincardine was considered. Given the level of support in the community, that Bruce geology was most likely highly suited, and that transportation to another location would have additional disruption and cost, it was considered that a DGR at the Bruce nuclear site was the preferred path forward.

As noted in Section 3.2.2, initially, only alternatives for the management of LLW and short-lived ILW were considered. Once a DGR was selected as the preferred alternative (see Section 3.3), OPG decided to also include long-lived ILW in the waste inventory to be placed in the DGR.

3.2.6 Hosting Agreement

During their visits to host communities in Europe and the United States, Kincardine municipal representatives confirmed that there was international precedent for agreements for hosting long-term radioactive nuclear waste facilities. The Port Hope Agreement, signed in 2001 between the Government of Canada, the Township of Hope, the Municipality of Clarington and the Town of Port Hope for the long-term management of historic waste provided a recent Ontario example of a hosting agreement.

As described in Section 2.2.1.3, the DGR Hosting Agreement [22] was signed between the Municipality of Kincardine and OPG on October 13, 2004. Although the agreement is formally between OPG and the Municipality of Kincardine, OPG received letters of support for the DGR from each of the other seven Municipalities in Bruce County.

3.2.7 Community Poll

Kincardine Council determined they would seek formal endorsement of the hosting agreement from Kincardine residents through a telephone poll. The poll asked residents, "Do you support the establishment of a facility for the long-term management of low and intermediate level waste at the Western Waste Management Facility?" As described in Section 2.2.1.4, leading up to the poll, a community information/education plan was put into place to provide all residents an opportunity to obtain information about the DGR concept and the hosting agreement including operating a Community Consultation Centre.

In December 2005, based on the results of the community poll and the Independent Assessment Study (see Section 3.3), OPG decided to proceed with the regulatory approvals phase of the DGR Project at the Bruce nuclear site.

3.3 ALTERNATIVES TO THE PROJECT

The EIS Guidelines require that the EA describe possible alternatives and provide justification for the selection of the DGR Project as the preferred alternative. The study of alternatives to the DGR Project was conducted as part of the Independent Assessment Study [23] from 2003 to 2004. Concurrent with the Independent Assessment Study, OPG and the Municipality of Kincardine had an extensive public engagement program to inform the community, gauge community support, and obtain input into the evaluation of alternatives.

As part of the MOU with the Municipality of Kincardine, an Independent Assessment Study [23] was undertaken concurrent with studies in support of the engineering and geotechnical feasibility of a long list of concepts for LLW management at the WWMF. The options considered were:

- enhanced processing and storage;
- covered above-grade concrete vaults;
- shallow concrete vaults;
- deep concrete vaults;
- shallow rock cavern vaults in near surface dolostone (less than 100 m below surface);
- deep rock cavern vaults in thick salt bed (200 to 400 m below surface);
- deep rock cavern vaults in "tight" shale formation (400 to 600 m below surface);
- deep rock cavern vaults in "tight" limestone formation (600 to 800 m below surface); and
- ongoing management at the WWMF (status quo).

The results of a primary screening analysis eliminated deep concrete vaults and deep rock cavern vaults in thick salt bed from further evaluation because suitable host formations are absent. A secondary geotechnical feasibility screening showed that the shallow concrete vaults and shallow rock cavern vaults were not technically feasible at the WWMF site. The two final deep rock cavern vaults were combined and considered together as deep rock vaults (now referred to as the DGR).

The four short-listed feasible concepts are described in the following sections.

3.3.1 Enhanced Processing and Storage

Enhanced processing and storage is an adaptation and enhancement of the current L&ILW management operations at the WWMF. Specifically, it involved improved waste processing through super-compaction and conditioning and improved waste storage in humidity controlled storage buildings. Enhanced processing and storage is suitable for all LLW and may be suitable for some ILW.

This option would use a 5,000 tonne box super-compactor to compact 1 m^3 sacrificial containers filled with "compactable" waste. Several of these compacted sacrificial containers would then be placed into a larger steel container, known as an "overpack", and the remaining air space in the container filled with cement grout. A new processing and treatment building at the WWMF would be needed for waste processing operations.

The filled overpacks would be transferred by forklift to climate-controlled storage buildings. Administrative support services, waste receiving and transfer operations would continue to be provided from the WWMF. However, the processing and treatment facilities would be a new construction. The Enhanced Processing and Storage option maintains an interim storage facility which would need to be followed by a permanent disposal facility at some time in the future.

A number of countries use the enhanced processing and storage technology for the management of LLW and some ILW. For example, prior to being placed into long-term storage (i.e., up to 100 years) in the Netherlands and Belgium, the volume of LLW is reduced through the use of super-compaction technology.

3.3.2 Surface Concrete Vaults

The surface concrete vaults option involves construction of concrete vaults under a movable shelter that protects the wastes from the weather during transfer. Two parallel bays of vaults would form this facility. Once a vault is full, a concrete cover is poured to completely isolate the waste from the environment. When the site is full, an earth cover is placed over all of the concrete vaults.

Processing of LLW would continue to take place at the WWMF prior to and during the operating phase of the facility. Additional contractor support facilities would be required including a security kiosk, warehouse, equipment storage and maintenance building, roads, parking areas, laydown/stockpile areas and a concrete batch plant. While this option could accommodate some ILW, the design considered did not include this waste. The remaining long-lived ILW would require a separate long-term solution.

There are several international examples of the use of surface concrete vaults including facilities in France and Spain. The facility located at Centre de l'Aube in France, which began operations in 1992 and has a disposal volume of 1,000,000 m^3, has been designed to be Europe's largest repository for L&ILW.

3.3.3 Deep Rock Vaults

The deep rock vaults (i.e., DGR) option is a long-term repository option that involves construction of vaults in low-permeability bedrock. The repository consists of individual excavated vaults with concrete floors and appropriate rock support to protect workers.

The repository is accessed by vertical shaft or ramp and includes a ventilation exhaust gallery around the perimeter of the cavern area. The deep rock vaults would be located adjacent to the WWMF, allowing the use of current WWMF infrastructure and services. Additional support facilities would be required at the surface, and could include administration buildings, waste receiving, waste equipment storage and maintenance buildings, roads, parking areas, and a waste rock storage area. While the option would be intended to accommodate ILW the feasibility design and cost estimate did not include this waste.

Facilities at Loviisa in Finland, Forsmark in Sweden, Waste Isolation Pilot Plant (WIPP) in New Mexico and Konrad Mine in Germany are examples of the use of the deep rock vaults technology for the disposal of L&ILW. The Forsmark facility was commissioned in 1988 and is located adjacent to the Forsmark nuclear power station. The repository was excavated in rock situated a kilometre offshore 60 m below the bottom of the Baltic Sea. The Loviisa facility began operations in early 1997 and is located on Hästholmen Island near the Loviisa nuclear power station. The Loviisa repository is excavated in rock at a depth of 110 m below ground. The WIPP facility was started in 1999 and is located in a mined rock cavern in salt. The Konrad mine is a former iron ore mine in sedimentary rock that is currently being retrofitted and converted into a repository for L&ILW.

3.3.4 Status Quo

The status quo option maintains an interim storage facility which would need to be followed by a permanent disposal facility at some future time. A description of current operations is provided in Section 3.1.

3.3.5 Comparison of Feasible Alternatives to the Project

The four feasible concepts were compared considering technical, environmental and economic factors. The evaluation of the alternatives to the DGR Project and the results of the evaluation are described in Sections 3.3.5 and 3.3.7. Section 3.3.7 provides a summary of the findings for each alternative, by factor.

3.3.5.1 Evaluation Criteria

As part of the Independent Assessment Study, the four feasible concepts were compared using a number of different criteria, including:

- engineering feasibility, which considers the preliminary designs, geotechnical feasibility, construction and operation schedule, and cost and personnel estimates;
- safety and licensibility, which considers the routine releases, intrusion scenarios and licensibility;
- environmental protection and feasibility, including potential effects on the physical, biological and socio-economic environments;
- economic feasibility, including predicted employment, expenditures, municipal taxes, and population and community spending; and
- social factors, including results of public attitude research on the options and tourism research.

These criteria were presented to the public along with descriptions of the alternatives to increase awareness and understanding of the options, and to identify issues and concerns.

3.3.5.2 Technical Feasibility

The engineering feasibility studies found that each of the long-term management options is technically feasible, uses internationally proven technology and is capable of accommodating all of the LLW currently stored and likely to be received in future. In particular, a geotechnical feasibility study concluded that the geology below the Bruce nuclear site was likely ideally suited to a deep repository and could accommodate all LLW.

In addition, each of the options for the long-term waste management facility could be safely constructed and operated and each of the options had potential dose rates well below the target limits associated with long-term management facilities. Since all of the options met international and Canadian safety criteria with a considerable margin of safety, it was assumed that each is capable of being licensed by the CNSC. Site Preparation and Construction and Operating Licences from the CNSC would be required for any of the alternatives. Although all options could be constructed and operated safely, of the alternatives considered, the deep rock vaults were considered to have the highest margin of safety [23].

3.3.5.3 Environmental and Social Feasibility

An environmental screening was completed to examine the potential effects of each of the options on the environment and identify potential adverse effects. The screening determined that, while each the options for the long-term waste management facility had the potential to cause effects on the environment, all the identified potential effects can be appropriately managed using proven mitigation and management methods. Therefore, no significant residual adverse environmental effects were anticipated for any of the options.

The social assessment conducted for the Independent Assessment Study included public attitude research aimed at determining Kincardine and neighbouring municipality residents' knowledge of, and attitudes toward, L&ILW management at the WWMF and, as a result, implementing any of the alternatives.

The public attitude research indicated that nuclear power and radioactive waste were not major issues of concern in Kincardine and the neighbouring municipalities. Although residents were generally aware of the WWMF, it had little to no negative effect on community attitudes, attractiveness, or activities such as use of beaches, trails or parks.

Most of the respondents indicated that they were aware of the initiative for a long-term management facility but there was little concern about it in the community. The public attitude research suggested that the long-term management facility options were not likely to adversely affect the attitudes of the respondents towards the community or the attractiveness of the community. The research also indicated that none of the options would likely cause residents to move from the community or reduce the use of beaches, parks, trails, fishing or boating.

Similarly, the majority of farm respondents in both Kincardine and the neighbouring municipalities indicated that a long-term management facility would not affect their commitment to farming. However, because of the small number of respondents, there was no clear indication of which of the long-term management options was least likely to cause an effect.

The tourism research indicated that there would not be a change in attitudes or activities by tourists in the community. Indeed, few tourists were aware of the WWMF or any plans for long-term management of the wastes. Most of the tourists interviewed felt that the community presents a very positive image and is an attractive place to visit. The briefing interviews showed that the majority of business operators did not believe that a long-term management facility would have an effect on the commercial trade in the community.

3.3.5.4 Economic Impact

There would be meaningful economic benefits to Kincardine and the neighbouring municipalities associated with each of the options. These benefits would be greater than those currently occurring as a result of the operation of the WWMF. The economic analysis did not identify any negative economic effects associated with the options.

3.3.6 Communication and Consultation on Alternatives

The Independent Assessment Study and the comparison of alternatives to the DGR Project were shared with the community, as described below. Bruce County, and more specifically the Municipality of Kincardine, has been host to three nuclear generating stations, and interim storage facilities for L&ILW and used nuclear fuel for nearly 40 years. The Municipality of Kincardine identified themselves as a willing host for the DGR Project. Additional consultation details and copies of communications materials are presented in Section 2 and Appendix D, respectively.

3.3.6.1 Public Attitude Research

Starting in 2003, OPG undertook, in cooperation with the Municipality of Kincardine, an extensive communications and consultation program on the long-term options for L&ILW management with both community and government stakeholders (see Section 2.2.1). It should be noted that international experience has shown that existing nuclear communities are often better informed and more comfortable with the industry, including waste disposal facilities. The goals of the program were to ensure that the community was fully informed about the proposed long-term management proposals and to gauge the level of community support.

In support of the Independent Assessment Study under the MOU, public attitude research was conducted in 2003, with Kincardine residents and of residents of neighbouring municipalities.

Kincardine

The results of this survey work indicated that nearly half of respondents were very or somewhat aware of the existing WWMF. Over 75% of Kincardine residents were very or somewhat confident of existing technologies for processing and treatment of L&ILW. Very few (9%) indicated that the presence of the existing WWMF has had any effect on their daily life. Those that indicated it has had an effect indicate more positive effects than negative.

Initial impressions of approximately 47% of Kincardine residents tended to endorse the long-term storage plans or expressed a lack of concern regarding the proposal. Other initial impressions focused on safety and health concerns and the community involvement aspects of the proposal. Further, the majority of Kincardine respondents, 65%, indicated that none of the long-term management options considered would have an effect on their feeling of personal security. Over 85% of respondents indicated that a long-term management facility would not cause them to move from the community or change their behaviours regarding their recreational activities.

Surrounding Community

In the surrounding community, which includes the municipalities of Saugeen Shores, Arran-Elderslie, Brockton, and Huron-Kinloss, approximately 40% tended to endorse the long-term management plans or expressed a lack of concern regarding the proposal. Respondents who had lived in the neighbouring municipalities for a longer time were more likely than the average to agree with or support the plans for long-term L&ILW management.

3.3.6.2 Aboriginal Community

As described in Section 2.3, the Bruce nuclear site falls within the Saugeen Ojibway Nation (SON) traditional territory[5]. In 2003, OPG initiated discussions regarding the Independent Assessment Study with the SON. Presentations were made to Joint Council, and funding was provided for an administrative coordinator and for peer reviews of technical documents. In April and May of 2005, Open Houses were conducted at each of the Nawash and Saugeen First

[5] In 2008, outreach was expanded to include the Métis communities, as described in Section 2.3.

Nation Community Centres. The April open house was convened by SON, with participation from their peer reviewer and from other independent experts. The May Open Houses provided an opportunity for SON band members to discuss the long-term management of L&ILW with representatives of OPG and Golder Associates Ltd. who were assisting OPG with the Independent Assessment Study.

Throughout this process, SON expressed an interest in obtaining more information about the Independent Assessment Study and continuing to be involved in the process.

3.3.6.3 Nuclear Host Communities

Presentations were made to groups in the nuclear host communities (Pickering and Darlington) to keep them informed of the Independent Assessment Study and options being considered. It also provided an opportunity for communities who had an interest in hosting a long-term waste management facility to become informed.

3.3.6.4 Media

Throughout the Independent Assessment Study process, in addition to OPG's campaign to provide information directly to the public, the media regularly provided updates on the DGR Project. In addition to keeping the public informed about the proposed L&ILW management facility, this provided an opportunity for other communities to be aware of the study process underway.

3.3.6.5 Wider Stakeholder Support

The concept of removing long-lived radioactive waste from the human environment by placing it in deep underground repositories was proposed nearly 50 years ago. Since that time considerable thought, research and development have been applied. Progress has been made in many areas, which provides confidence that a DGR for L&ILW can be licensed, constructed and operated.

3.3.7 Summary of the Comparison of Alternatives to the Project

As part of the Independent Assessment Study, the four feasible concepts were compared with regards to technical feasibility, environmental and social feasibility, and economics. Table 3.3.7-1 summarizes the findings for each alternative by factor. The deep rock vault option was preferred for technical feasibility as well as the environmental and social feasibility. However, the "status quo" option was the preferred economic choice (i.e., it was least expensive). It should be noted that the data in the following table reflect the information available at the time of the Independent Assessment Study, when the preferred alternative was selected.

Table 3.3.7-1: Summary of Results of the Independent Assessment Study

Parameter	Status Quo	Enhanced Processing and Storage	Surface Concrete Vaults	Deep Rock Vault
Technical Feasibility [a]				
Feasibility at Site	Currently being used	Can be constructed on or near the existing WWMF	Suitable soils occur adjacent to the WWMF	Suitable bedrock occurs beneath the Bruce nuclear site (shale and limestone bedrock)
Design Life	Less than 100 years	Assuming refurbishment and rebuilding as required facility could function in perpetuity; however, buildings would have a design life of 100 years	300 years	Greater than 500 years
Ability to Accommodate Waste Types [b]	Currently managing both L&ILW	Suitable for L&ILW	Suitable for LLW and short-lived ILW	Suitable for LLW and all ILW
International Experience	Currently being used	Netherlands, Belgium	France, Spain	Sweden, Finland, US, Germany
Percent of Dose Constraint	<1%	<1% [c]	2.3% [d]	<<0.001% [d]
Time of Maximum Dose	Throughout life of facility	Throughout life of facility	7,500 years after closure	More than 10,000 years after closure
Percent of Dose Constraint (Intrusion Scenario)	Inadvertent intrusion is precluded by access control	Inadvertent intrusion is precluded by access control	3% [b]	0.003% [b]
Summary of Technical Factors	*Will require indefinite access control*	*Will require indefinite access control*	*Feasible at the site; however, cannot manage all ILW*	***Most Preferred*** *Allows for the largest margin of safety for the long-term and can manage all L&ILW*

Table 3.3.7-1: Summary of Results of the Independent Assessment Study (continued)

Parameter	Status Quo	Enhanced Processing and Storage	Surface Concrete Vaults	Deep Rock Vault
Environmental and Social Feasibility				
Surface and Groundwater	— [e]	Effects are anticipated, however they are not expected to be significant		
Land	—	No effects are anticipated		
Air and Noise	—	Effects are anticipated; however, they are not expected to be significant		
Natural Environment	—	Effects are anticipated; however, they are not expected to be significant		
Resources	—	No effects are anticipated		
Socio-economic	—	Effects are anticipated; however, they are not expected to be significant		
Heritage and Culture	—	No effects are anticipated		
Aboriginal	—	Effects are anticipated; however, they are not expected to be significant		
Radiation	—	Effects are anticipated; however, they are not expected to be significant		
Host Community Support	Ongoing Support	Not preferred by Council		Preferred Option for Safety and International Best Practice
Regional Community Support	Ongoing Support	Not preferred by Council		Preferred Option for Safety and International Best Practice
Summary of Environmental and Social Factors	*No adverse environmental effects; however, does not meet with host community requirement for long-term solution*	*No significant environmental effects anticipated; however, not the preferred option by the host community*	*No significant environmental effects anticipated; however, not the preferred option by the host community*	***Most Preferred*** *No significant environmental effects are anticipated and preferred option by the host community*

Table 3.3.7-1: Summary of Results of the Independent Assessment Study (continued)

Parameter	Status Quo	Enhanced Processing and Storage	Surface Concrete Vaults	Deep Rock Vault
Economic Analysis (lifetime)				
Total Expenditures [f]	$648 million	$776 million	$923 million	$927 million
Total Employment [g]	8,654	9,952	12,633	13,051
Total Income-related Spending [f]	$245 million	$285 million	$363 million	$376 million
Summary of Economic Factors	*Least expensive option*	—	*Most costly, largest income-related spending*	

Notes:
a The preliminary designs for the Independent Assessment Study were based on the assumption that 115,000 m^3 of LLW would be managed in the facility, and although ILW could also be managed in some of the facilities, the designs and cost estimates do not reflect this.
b Although the Independent Assessment Study did not consider explicitly ILW, status quo and Enhanced processing and storage could be designed to manage both L&ILW. Surface concrete vaults would not likely be able to manage long-lived ILW based on international experience. Deep rock vaults can manage L&ILW as demonstrated in [23] and in this EA.
c Assumed to be the same as, or less than, existing operations at the WWMF
d Assumes only LLW placed into vaults.
e Environmental protection feasibility was not undertaken for status quo as the current facility is operating in accordance with regulatory requirements.
f $CAN (2002). Costs are for LLW only and reflect construction and lifetime operating costs.
g Number of employment opportunities generated, includes direct, indirect and induced employment for design, construction and operations.
Source: [23]

To summarize, the Independent Assessment Study found that each of the four long-term management options is technically feasible and may be safely constructed at the WWMF. There is considerable international experience using each of the options for the long-term management of L&ILW. Each option is capable of meeting stringent Canadian and international safety standards with a considerable margin for LLW. The ability of the repository concepts to accept ILW was assessed qualitatively.

The deep rock vault option is most preferred considering technical/safety factors and environment/social factors. The low permeability of the host rock is expected to result in deep repository concepts meeting radiological protection criteria. Surface repository concepts would require additional analysis to ascertain the degree to which ILW could be managed. An examination of the environmental protection feasibility of the options showed that all potential adverse effects could be mitigated or managed using known and proven methods. Status quo is most favourable for economic factors (i.e., lowest cost).

As noted, each of the options would have a meaningful economic benefit to Kincardine and the neighbouring municipalities. No adverse economic effects were identified in the economic analysis.

OPG and the host community have identified the need to identify a long-term management solution for L&ILW, and stated a preference for using a deep rock vault at the Bruce nuclear site. Therefore, a deep rock vault (i.e., DGR) is the preferred concept.

3.4 ALTERNATIVE MEANS OF CARRYING OUT THE PROJECT

The EIS Guidelines require that the EIS describe the environmental effects of those alternative means of carrying out the DGR Project that are technically and economically feasible. Technical feasibility of alternative means was based on identification of relevant technical criteria and an assessment of the alternative means relative to the criteria. The criteria and assessment were based on the professional judgement of the DGR Project team, which includes OPG and NWMO personnel, members of independent review groups, engineering consultants, and EA professionals. Economic feasibility was also determined based on the professional judgement of the project team. Environmental effects criteria used to assess the alternative means are described and were evaluated based on the professional judgement of the project team.

Preliminary engineering work updated and advanced the previous concept used in the feasibility studies (as described in Section 3.3), including consideration of alternative methods to implement the DGR Project. The components of the DGR Project where alternative means were considered are:

- radioactive waste reduction at source;
- siting of the DGR in a location outside the OPG-retained lands adjacent to the WWMF;
- siting of the DGR in a different location within the retained lands adjacent to the WWMF;
- layout and design of the DGR;
- construction methods;
- timing options for various components and phases of the project;
- alternative storage systems (applies only to tile-hole equivalents (T-H-E) and resin liners); and
- alternatives to natural containment (i.e., engineered barriers).

A list of the alternative means considered is provided in Table 3.4-1. The approach for all the elements of the study was to review the previous concept, identify changes required as a result of new or updated information, and improve the level of detail of designs where limited work had been previously performed. In all cases, the philosophy was to determine if safer, more reliable and more cost-effective methods and designs could be used. These are described in further detail in the following sections.

Table 3.4-1: Alternative Means to the DGR

Aspect of the Repository	EIS Guideline Requirement	Alternative Means Considered	Described in
Radioactive waste reduction at source	Radioactive waste reduction at source	• Existing and planned programs for reduction	Section 3.4.1
Choice of site	Siting of the DGR in a location outside the OPG-retained lands adjacent to the WWMF	• On and off of the Bruce nuclear site • Alternative sites within the Bruce nuclear site • Waste rock pile location	Section 3.4.2
Location of project	Siting of the DGR in a different location within the retained lands adjacent to the WWMF	• Repository horizon • Surface facility location	Section 3.4.3
Method of repository access	Layout and design of the DGR	• Ramp and shaft • Shaft only	Section 3.4.4
Repository layout	Layout and design of the DGR	• Room and tunnel layout alternatives • Shaft arrangement	Section 3.4.5
Surface facility design	Layout and design of the DGR	• Waste rock management area • Stormwater management approach • Heating options • Abandoned rail bed and ditch crossing	Section 3.4.6
Underground construction method	Construction methods	• Excavation alternatives • Dewatering alternatives	Section 3.4.7
Repository development approach	Timing options for various components and phases of the DGR Project	• Construct then operate (consecutive) • Campaign • Concurrent (build some rooms, emplace waste while building more rooms)	Section 3.4.8
Shielding of ILW	Alternative storage systems (applies only to T-H-E and resin liners)	• Disposable shields • Reusable transfer bells	Section 3.4.9

Table 3.4-1: Alternative Means to the DGR (continued)

Aspect of the Repository	EIS Guideline Requirement	Alternative Means Considered	Described in
Waste containment	Alternatives to natural containment	• Natural containment • Backfill • Enhanced containers • Grout inside containers	Section 3.4.10

This section compiles the evaluation of alternatives and considers the environmental consequences of each alternative. The evaluation criteria consider environmental aspects (natural and social/cultural) of the DGR Project. Each of the means considered is ranked relative to the others for each criterion. The results for each criteria are summed to provide the score for each means. A low ranking is favourable. The outcome of this step is the acceptability, or not, of each alternative means considered.

3.4.1 Radioactive Waste Reduction at Source

Radioactive waste reduction at source is an integral part of OPG and Bruce Power nuclear station operations. The following formal programs are in place at each station to reduce the volumes of radioactive waste produced.

- Minimizing the introduction of unnecessary materials into radiological areas (e.g., packaging for equipment and parts brought into the station).
- Re-using and recycling materials within the station (e.g., decontamination and re-use of tools).
- Replacing disposable products with re-usable ones (e.g., replacing disposable personnel protective equipment with launderable ones).
- Separately collecting wastes which are not likely to be contaminated. These materials, which are termed "likely clean", are subsequently monitored and, if confirmed to be non-contaminated, are diverted from the radioactive stream and dealt with as conventional non-radioactive waste for recycle or disposal.

OPG and Bruce Power are ISO 14001 registered and include the key prevention of pollution principles of ISO 14001 in their environmental policies [24;25]. As part of their environmental management programs, the nuclear generating stations set target limits each year for amount of radioactive waste produced. These are monitored and tracked as part of the stations' performance reporting. For OPG, the volume of L&ILW produced is one of the key Corporate Environmental Performance Benchmarks included in the annual Sustainable Development Report. For 2009, the OPG target for L&ILW produced was 3,408 m^3, while the actual was 3,078 m^3 [24].

Waste management planning is also an integrated part of the stations' outage and work planning process. The waste management practices at each station are periodically audited to measure the success of various reduction programs. These include internal audits by various OPG groups, as well as external audits and peer reviews by industry organizations such as

Electric Power Research Institute (EPRI), World Association of Nuclear Operators (WANO) and Operational Safety Review Team (OSART) [24].

OPG's Nuclear Waste Management Division (NWMD) also has a target for amount of waste stored. This takes into account efficiency of processing and storing of the wastes generated by the stations.

OPG and Bruce Power also investigate and apply new waste processing technologies and disposal approaches to reduce stored radioactive waste volume. This includes several previous campaigns to high-force compact previously stored waste and the exploration of innovative technologies used elsewhere in the world (such as Bruce Power planning the dismantling of steam generators by a contractor in Sweden to separate the non-contaminated portions from the contaminated portions). The effects of these process improvements will be taken into account in future updates of the waste forecasts as they are implemented. There is also the potential to measure the radioactivity of the existing stored wastes (some of which will have decayed for several decades) at the time they are retrieved from storage and apply the clearance criteria contained in the CNSC's Nuclear Substances & Radiation Devices Regulations. This could allow additional volumes of waste to be diverted from the DGR.

As noted previously, waste forecasts are updated annually as part of NWMD's business planning process. The estimated volumes included in Section 4.5 of this EIS take into consideration the effect of the various in-place and planned waste minimization programs as described above. However, even if all future wastes were reduced to zero, the need for the project would not be eliminated because of the stock of existing wastes in storage at the WWMF.

3.4.2 Choice of Site

3.4.2.1 On and Off of the Bruce Nuclear Site

As described in Section 3.2.3, the waste management approach and site were developed through implementation of a Memorandum of Understanding (MOU) with the Municipality of Kincardine. The resulting study indicated that the Municipality is a willing host community for a DGR for L&ILW at the WWMF.

The majority of the waste to be managed in the DGR is already stored at the WWMF. The WWMF site and adjacent lands are, and have been, a nuclear facility for almost 40 years. The land is owned and managed by OPG and the site has suitable technical characteristics to safely manage the waste in the very long term and, by using a location within the Bruce nuclear site, issues associated with the off-site transportation of nuclear waste to a repository are eliminated.

Project-related activities began in 2002 when the Municipality of Kincardine indicated an interest in being considered as a host for the DGR Project. A summary of the comparison of alternatives is provided in Table 3.4.2-1.

3.4.2.2 Sites within the Bruce Nuclear Site

A large portion of the Bruce nuclear site is leased to Bruce Power and for the purpose of project planning it was deemed that these leased lands were not available for the DGR Project.

As shown on Figure 1.1.1-2, there are three large contiguous blocks of land within the Bruce nuclear site that could potentially be used as a site for the DGR Project:

- the lands used for the former heavy water plant (northwest of Interconnecting Road);
- a largely undeveloped/wooded area on the southern portion of the Bruce nuclear site (adjacent to the Inverhuron Provincial Park boundary); and
- lands at the centre of the site, including the WWMF and area north of the abandoned rail bed.

It is expected that the geology at all three locations would be similar. The former heavy water plant lands are vacant, have undergone decommissioning, and are located closer to Lake Huron. The undeveloped lands to the south and east are constrained by areas of higher archaeological potential. The lands adjacent to the WWMF are currently vacant and allow the closest connection with the existing facilities. A summary of the comparison of alternatives is provided in Table 3.4.2-2.

3.4.2.3 Waste Rock Management Area

The excavation of the underground facilities will result in the need to manage a large volume of waste rock. The waste rock pile could be located with the DGR on the Bruce nuclear site or off-site. Similar to the choice of site (Section 3.4.2.1), specific storage locations off-site were not considered. The DGR Project site contains sufficient space to store the waste rock effectively and does not require transportation of waste rock off-site. Reuse alternatives were also considered on- and off-site. It is unlikely that all the rock could be used on-site thus storage would still be required. Off-site use requires transportation. Table 3.4.2-3 summarizes the advantages and disadvantages of each.

Table 3.4.2-1: Comparison of Siting Alternatives On and Off of the Bruce Nuclear Site

Alternative Means	Economic		Worker Health and Safety		Public Health and Safety		Technical		Physical/ Biophysical Environment		Socio-economic Environment		Achievable?	Acceptable?	Preferred Means (Score)
	Does OPG Need to Invest Additional Funds?		Can it constructed and operated in a manner that protects worker health and safety?		Can it constructed and operated in a manner that protects public health and safety?		Is there suitable host rock?		What is the likely nature of environmental effects?		Is there community support? Is the community knowledgeable?				
On the Bruce nuclear site	No – OPG has control of sufficient lands on-site; off-site transportation costs not incurred	1	Yes – can be constructed and operated safely	1	Can be constructed and operated safely Constructed fully within the Bruce nuclear site Would not require off-site transport of wastes Existing security infrastructure in place at the Bruce nuclear site	1	Feasibility studies indicated that geology was likely suitable and consistent; subsequent geoscientific investigations have confirmed	1	The site is a vacant, previously disturbed area of the Bruce nuclear site, effects typical of a large construction project expected	1	Yes – MOU indicates a willing host for DGR at the Bruce nuclear site The repository is compatible with the existing use of the Bruce nuclear site (i.e., it confirms or enhances the character of the site)	1	Yes	Yes	Preferred (6)
Off of the Bruce nuclear site	Possibly– OPG may not have control of sufficient lands off-site with suitable host rock; would incur off-site transportation costs	2	Yes – can be constructed and operated safely	1	Can be constructed and operated safely Will need to be constructed beyond the existing Bruce nuclear site Would require off-site transport of wastes	2	Feasibility studies indicated that geology was likely suitable and consistent; no data is available to verify	2	Unknown – however, it is likely that an off-site location would not be a previously disturbed site and may take agricultural land out of service	2	No – the Hosting Agreement was specific with regards to the location of the DGR within the Bruce nuclear site No – No other communities came forward as willing hosts	2	Unknown	Unknown	(11)

Table 3.4.2-2: Comparison of Siting Alternatives within the Bruce Nuclear Site

Alternative Means	**Economic**		**Worker Health and Safety**		**Public Health and Safety**		**Technical**		**Physical/ Biophysical Environment**		**Socio-economic Environment**		**Achievable?**	**Acceptable?**	**Preferred Means (Score)**
	Has OPG retained control of the lands?		Can it constructed and operated in a manner that protects worker health and safety?		Can it constructed and operated in a manner that protects public health and safety?		Is there sufficient space to construct the surface facilities? Is there access to the WWMF?		What is the nature of likely environmental effects?		What is the nature of likely socio-economic effects?				
Adjacent to the WWMF	Yes – OPG has control of the lands	1	Yes – can be constructed and operated safely	1	Yes – can be constructed and operated safely	1	Yes – suitable surface space is available Yes – shortest distance for connection to WWMF	1	The site is a vacant, previously disturbed area of the Bruce nuclear site, effects typical of a large construction project expected There are limited natural heritage resources on-site	1	None – limited archaeological constraints	1	Yes	Yes	Preferred (6)
Southern Portion of the Bruce Nuclear Site	Yes – OPG has control of the lands	1	Yes – can be constructed and operated safely	1	Yes – can be constructed and operated safely	1	Yes – suitable surface space is available Yes – however, wastes would need to be transported across Bruce Power leased lands	2	Larger contiguous wooded area adjacent to Inverhuron Provincial Park would need to be cleared, effects typical of a large construction project expected	2	Possible – archaeological constraints	2	Yes	Unknown	(9)
Former Heavy Water Plant Lands	Yes – OPG has control of the lands	1	Yes – can be constructed and operated safely	1	Yes – can be constructed and operated safely	1	Yes – suitable surface space is available Yes – however, wastes would need to be transported across Bruce Power leased lands	2	The site is a vacant, previously disturbed area of the Bruce nuclear site Limited natural heritage resources on-site Effects typical of a large construction project expected	1	None – limited archaeological constraints	1	Yes	Yes	(7)

Table 3.4.2-3: Comparison of Alternate Waste Rock Management

Alternative Means	Economic		Worker Health and Safety		Public Health and Safety		Technical		Physical/ Biophysical Environment		Socio-economic Environment		Achievable?	Acceptable?	Preferred Means (Score)
	Does OPG Need to Invest Additional Funds?		Can it constructed and operated in a manner that protects worker health and safety?		Can it constructed and operated in a manner that protects public health and safety?		Is it technically feasible?		What is the nature of likely environmental effects?		What is the nature of likely socio-economic effects?				
Waste Rock Management Area collocated with the DGR	No – OPG has control of sufficient lands on-site	1	Yes	1	Yes – constructed fully within the Bruce nuclear site Aggregate will need to be imported to the site	2	Yes	1	The site is a vacant, previous disturbed area of the Bruce nuclear site, effects typical of a large construction project WRMA would be designed to protect the environment	1	Possible the WRMA would be visible off-site	1	Yes	Acceptable	Preferred (7)
Waste Rock Management Off of the Bruce Nuclear Site	Yes – there are additional costs associated with the transport of the waste rock to an off-site location A financial arrangement may be required for off-site lands	2	Yes	1	Can be constructed and operated safely Will need to be constructed beyond the existing Bruce nuclear site	2	Yes	1	It is likely that an off-site location would not be a previously disturbed site Effects typical of a large construction project WRMA could be designed to protect the environment Would require transportation of waste rock off-site	3	Likely the WRMA would be visible off-site Would require transportation of waste rock off-site	2	Yes	Acceptable	(12)

Table 3.4.2-3: Comparison of Alternate Waste Rock Management (continued)

Alternative Means	Economic		Worker Health and Safety		Public Health and Safety		Technical		Physical/ Biophysical Environment		Socio-economic Environment		Achievable?	Acceptable?	Preferred Means (Score)
	Does OPG Need to Invest Additional Funds?		Can it constructed and operated in a manner that protects worker health and safety?		Can it constructed and operated in a manner that protects public health and safety?		Is it technically feasible?		What is the nature of likely environmental effects?		What is the nature of likely socio-economic effects?				
Use of the Rock as an Aggregate On-site	No – potential cost saving	1	Yes	1	Yes – constructed fully within the Bruce nuclear site	1	Unknown – the rock may not exhibit the qualities necessary for use as an aggregate for concrete and may be limited opportunities for use of the full volume on site	3	No – the site is a vacant previously disturbed area of the Bruce nuclear site Yes – additional air quality effects associated with a crushing plant Unlikely – WRMA would be designed to protect the environment	2	The WRMA would be visible off-site and local aggregate producers could be affected if rock released to local market	2	Unlikely for full volume of rock	Acceptable	(10)
Use of the Rock as an Aggregate Off-site	No	1	Yes	1	Yes – can be operated safely	1	Unknown – without treatment, the rock may not exhibit the qualities necessary for use as an aggregate in concrete	2	No – would reduce or eliminate the need for the WRMA Yes – would require transportation of waste rock to market	2	Effects on existing aggregate producers would have to be managed Would require off-site transportation	3	Likely	Acceptable, if effects on the local aggregate producers are mitigated	(10)

3.4.3 Location of Project

The alternatives locations of the DGR Project consider both the depth of the repository and the surface layout.

3.4.3.1 Repository Horizon

The underground and emplacement rooms in the DGR must be constructed in a competent rock formation and at a location within the sedimentary sequence that will ensure long-term safety. The stratigraphy beneath the Bruce nuclear site has been characterized as part of the DGR Geoscientific Site Characterization Program. The sedimentary rock sequence studied is approximately 840 m thick. The study has generated detailed site-specific geologic, hydrogeologic and geomechanical data which are summarized in Section 6.2. There are a number of properties that are favourable to deep geological disposal:

- predictable rock strata;
- geologic stability;
- low permeability of proposed host rock;
- protection of near-surface freshwater aquifer;
- stagnant deep groundwater flow system;
- good constructability and flexibility of host rock; and
- low resources for oil, gas, minerals and drinkable water.

Based on regional data these properties or attributes likely exist within the Ordovician sediments at nominal depths of 500 to 800 metres below ground surface (mBGS) at the Bruce nuclear site. These Ordovician sediments are comprised of upper Ordovician shales and middle Ordovician carbonates (limestone) in which groundwater is highly saline and considered virtually stagnant. Within these sediments the positioning of the DGR to take advantage of formation specific hydrogeologic and geomechanical properties may allow for enhanced long-term safety. For instance, the Ordovician carbonates may offer the following advantages over the overlying shales:

- improved constructability because of greater geomechanical stability;
- higher potential for waste rock to be usable aggregate material;
- construction experience elsewhere in Ontario has proven limestone as a relatively indurate rock, whereas shale can be susceptible to swelling and spalling when exposed; and
- the geomechanical properties of the shale formation would require the use of larger pillars and additional rock support, and may result in increased costs.

For these reasons, the argillaceous limestone Cobourg Formation was selected as the preferred host rock.

The specific depth within the Cobourg limestone formation was determined taking into account:

- geomechanical stability during operations, including roof, floor, shaft sump and rock loading pocket stability;
- long-term safety, including potential for progressive failure; and
- cost (i.e., the deeper the location, the greater the cost).

It is currently assumed that the invert (floor) depth of the DGR access tunnels and emplacement rooms will be set at a nominal depth of 680 mBGS.

A summary of the comparison of alternatives is provided in Table 3.4.3-1.

3.4.3.2 Surface Buildings and Infrastructure Location

The surface layout of the DGR Project was determined to minimize the DGR Project Site, while taking into account environmental constraints on the site. The existing physical and biological environments have been characterized as part of the EA (see Section 6). The environmental constraints in the DGR Project Area are shown on Figure 3.4.3-1 and include:

- a marsh area in the northeast, where burrowing crayfish have been observed (see Section 6.5.3);
- a swamp area in the south, near the gatehouse, which contains wetland species (see Section 6.5.3);
- Stream C, which contains coldwater fish refugia, and discharges to the Baie du Doré, a Provincially Significant Wetland (see Section 6.5.3); and
- areas of higher archaeological potential, either as identified through previous archaeological assessments or areas to the east of the Nipissing strand line (see Sections 6.9 and 6.10).

The particular elements of the surface buildings and infrastructure are discussed in Section 3.4.6. The surface buildings and infrastructure were sited to avoid these sensitive areas, and include at least a 30 m buffer. All stormwater and DGR Project discharges are collected and redirected to avoid any releases to the Stream C watershed. The result of this siting process is the layout described in Section 4.4.1.

Table 3.4.3-1: Comparison of Repository Horizon Alternatives

Alternative Means	**Economic**		**Worker Health and Safety**		**Public Health and Safety**		**Technical**		**Physical/ Biophysical Environment**		**Socio-economic Environment**		**Achievable?**	**Acceptable?**	**Preferred Means (Score)**
	Is there an incremental cost?		Can it constructed and operated in a manner that protects worker health and safety?		Can it constructed and operated in a manner that protects public health and safety?		Is the DGR constructible?		What is the nature of likely environmental effects?		What is the nature of likely socio-economic effects?				
Limestone	No	1	Yes	1	Yes	1	Yes – better constructability because of greater geomechanical stability	1	Leachate from waste rock pile may require limited treatment Similar volume of excavation required Uses the shale layer above as an additional geologic barrier	1	None	1	Yes	Acceptable	Preferred (6)
Shale	Possibly – excavation in shale may be more expensive than in limestone	2	Yes	1	Yes	1	Yes – however shales can be susceptible to swelling and spalling Requires use of larger pillars and additional rock support	2	Leachate from waste rock pile may require treatment Similar volume of excavation required (may require more access tunnel excavation for additional rooms than in limestone)	2	None	1	Yes	Acceptable	(9)

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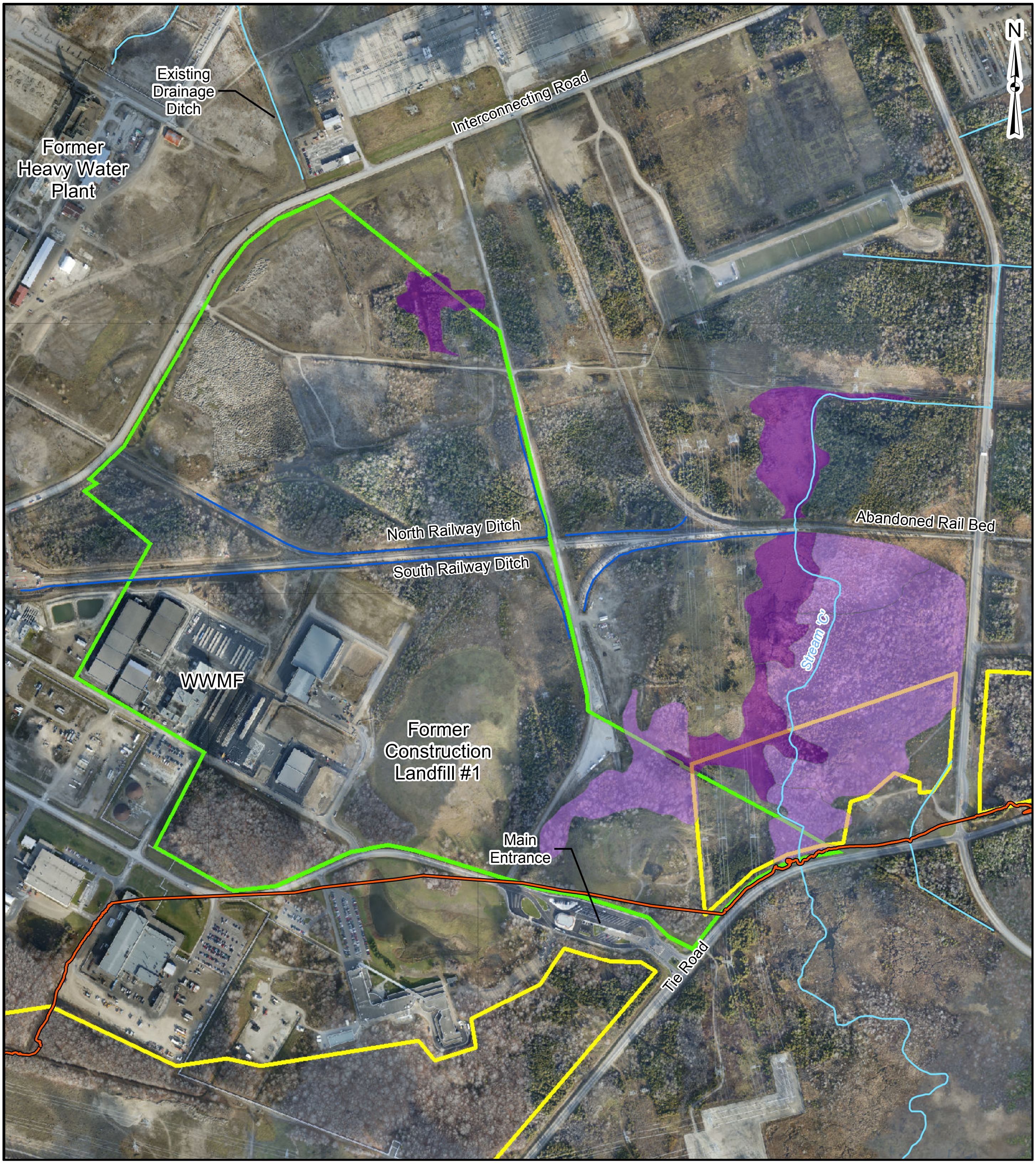

0 125 250 500

Metres

LEGEND

- 4200-2200 B.C. Nipissing Great Lakes Shoreline
- Stream
- Ditch
- Culturally Sensitive Area
- Project Area (OPG-retained lands that encompass the DGR Project)

ELC Group

- Marsh
- Swamp

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

ENVIRONMENTAL CONSTRAINTS

Golder Associates
Mississauga, Ontario

PROJECT No. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	**FIGURE 3.4.3-1**	
GIS	BC	22 Apr. 2010		
CHECK	AB	22 Apr. 2010		
REVIEW	MAR	22 Apr. 2010		

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3.4.4 Method of Repository Access

Two types of access were considered in the preliminary design phase: two vertical shafts and an inclined ramp with a shaft (for ventilation).

Overall, the vertical shaft access was chosen as the preferred alternative by the DGR Project design team because of a greater number of advantages taking into account technical, economic and environmental factors. A ramp would have a longer construction schedule and higher capital cost.

These factors are significantly impacted by the geologic formations that the access-ways must go through to reach the required depth. There is a possibility of water inflows from the dolostone formations, as well as time dependent deformations, and degradation which would require immediate support after excavation. Therefore, a ramp access would likely have to be completely lined with concrete from top to bottom, grouting in dolostones to allow construction of the concrete liner. When compared to shaft access, this results in a significant increase in construction costs and much slower advance rates.

Although these are also risks during shaft development, they are less significant because of the shorter length exposure of a vertical shaft to the aforementioned rock formations. As a result, construction costs are expected to be lower relative to construction costs for ramp access. Regarding environmental factors, the vertical shaft access-way is also the preferred alternative because of reduced requirements for storage of excavated material at the surface, as well as an expectation for a smaller volume of groundwater infiltration that would have to be managed during construction.

The benefits and challenges associated with each option are summarized in Table 3.4.4-1.

3.4.5 Repository Layout

The underground layout was developed following the selection of shafts as the preferred means of repository access (see Section 3.4.4). To select the room configuration for the DGR Project, a number of geometric conceptual layouts were developed and compared by the DGR Project design team. Initially seven alternative layouts were considered with variations on open or closed-ended rooms and parallel or transverse connectors. An initial screening reduced the number of feasible layouts to four. The shaft arrangements considered separated shafts and shaft island layouts. This comparison is summarized in Table 3.4.5-1.

The DGR Project design team concluded that the shaft island arrangement was the preferred arrangement because of the adaptability of the design, reduced surface footprint, preferred operation and security factors, and ease of closure/sealability. Regarding environmental factors, each of the designs are similar; however, the shaft island arrangement has the second smallest volume of waste rock and the most compact surface footprint (see Section 3.4.6).

Another aspect considered for the repository-level layouts was the configuration of emplacement rooms. Four options were evaluated, and the benefits and challenges associated with each option are summarized in Table 3.4.5-2.

Following the decision to move forward with a shaft island panel arrangement, the design of the repository continued to evolve as ongoing site characterization work generated new data and knowledge relating to the stresses and dip of the rock units. The overall evolution of the underground layout is shown on Figure 3.4.5-1.

In the final layout, shown on Figure 3.4.5-1 and assessed in this EA, the emplacement rooms have been aligned east-north-east along with the assumed major horizontal principal stress orientation. In addition, this layout is preferred because of:

- increased flexibility to adapt to the actual major horizontal principal stress orientation once field observations and test data are available following shaft construction;
- increased operational flexibility with multiple panels;
- improved waste package handling with improved turning angles from the access tunnel into the emplacement rooms; and
- the potential of extra development headings providing a contractor with improved performance flexibility.

Table 3.4.4-1: Comparison of Underground Access Method

Alternative Means	Economic		Worker Health and Safety		Public Health and Safety		Technical		Physical/ Biophysical Environment		Socio-economic Environment		Achievable?	Acceptable?	Preferred Means (Score)
	What is the relative cost?		Can it be constructed and operated in a manner that protects worker health and safety?		Can it be constructed and operated in a manner that protects public health and safety?		Is the access method constructible? Can it be safely operated?		What is the nature of likely environmental effects?		What is the nature of likely socio-economic effects?				
Vertical Shaft	Lowest cost	1	Yes	1	Yes	1	Yes - 730 m total excavation length for both shafts, with approximately 200 m of grouting Shorter construction time Custom equipment may be required for large object handling Greater ease in sealing shorter length of shafts at DGR Project decommissioning	1	Smaller volume of waste rock	1	None	1	Yes	Acceptable	Preferred (6)
Inclined Ramp with Shaft	Highest cost	2	Yes; however, concerns relating to transporting packages down a 7 km ramp	2	Yes	1	Yes – however, over 7,000 m for ramp and shaft, and over 2,000 m of grouting Considerably longer construction time Provides simpler handling and moving of ILW and LLW packages up to 60 tonnes Flexible selection of equipment Greater difficulty to seal the ramp because of length	2	Larger volume of waste rock	2	None	1	Yes	Acceptable	(10)

Table 3.4.5-1: Comparison of Shaft Arrangement

Alternative Means	**Economic**		**Worker Health and Safety**		**Public Health and Safety**		**Technical**		**Physical/ Biophysical Environment**		**Socio-economic Environment**		**Achievable?**	**Acceptable?**	**Preferred Means (Score)**
	What are the relative costs differences?		Can it be constructed and operated in a manner that protects worker health and safety?		Can it be constructed and operated in a manner that protects public health and safety?		Can it be constructed and operated safely?		What is the nature of likely environmental effects?		What is the nature of likely socio-economic effects?				
Islanded Shaft	None	1	Yes	1	Yes	1	Yes – operational advantage in having underground and surface facilities nearby	1	Provides a small surface footprint	1	None	1	Yes	Acceptable	Preferred (6)
Separated Shafts	None	1	Yes	1	Yes	1	Yes – flexibility to adjust to ground conditions	1	Larger surface footprint may affect natural features (e.g., marsh and swamp)	2	None	1	Yes	Acceptable	(7)

Table 3.4.5-2: Layout of Emplacement Rooms

Alternative Means	**Economic**		**Worker Health and Safety**		**Public Health and Safety**		**Technical**		**Physical/ Biophysical Environment**		**Socio-economic Environment**		**Achievable?**	**Acceptable?**	**Preferred Means (Score)**
	What are the relative cost differences?		Can it be constructed and operated in a manner that protects worker health and safety?		Can it be constructed and operated in a manner that protects public health and safety?		Can it be constructed and operated safely?		What is the nature of likely environmental effects?		What is the nature of likely socio-economic effects?				
Open-ended (Islanded shafts) (Figure 3.4.5-1d)	None	1	Yes – additional opportunities for egress; does not require duct and fan maintenance at height	1	Yes	1	Yes	1	None	1	None	1	Yes	Acceptable	Preferred (6)
Dead-ended (Parallel) (Figure 3.4.5-1c)	None	1	Yes	2	Yes	1	Yes	1	None	1	None	1	Yes	Acceptable	(7)
Dead-ended (Chevron) (Figure 3.4.5-1b)	None	1	Yes – fewer opportunities for egress from the dead-ended rooms	2	Yes	1	Yes – greater risk of rock instability because rooms not aligned with principle stress direction	2	None	1	None	1	Yes	Acceptable	(8)
Open-ended (Separated shafts) (Figure 3.4.5-1a)	None	1	Yes – additional opportunities for egress	1	Yes	1	Yes	1	Increased surface footprint resulting from two shaft locations	2	No	1	Yes	Acceptable	(7)

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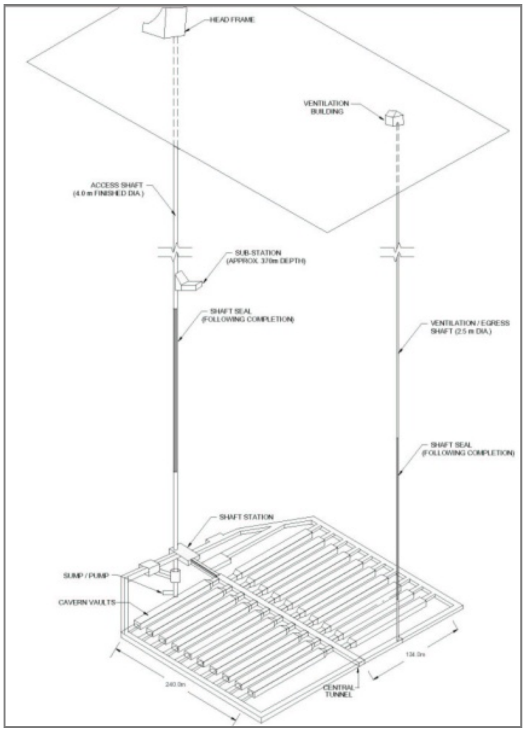
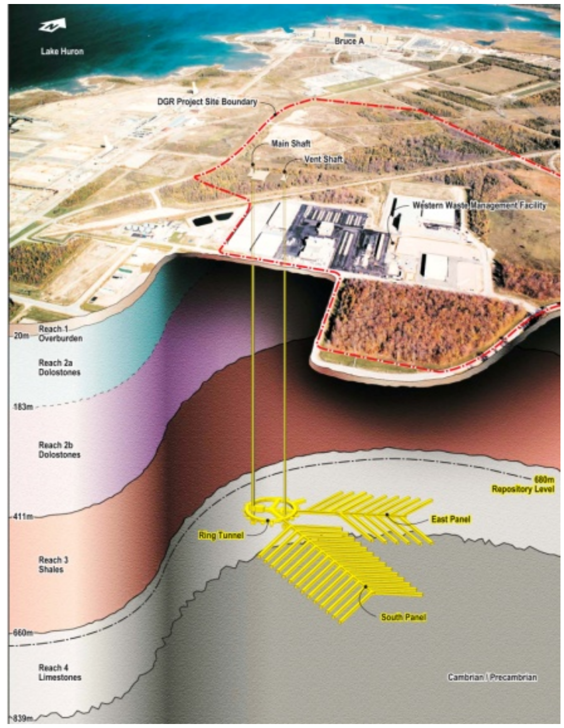
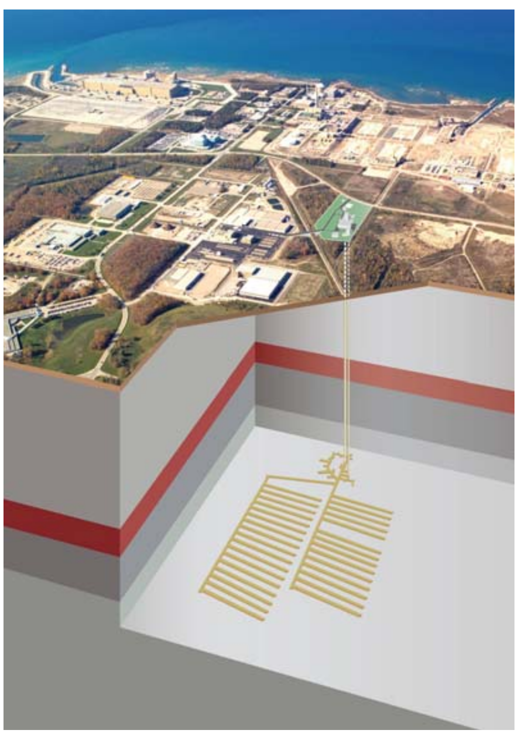


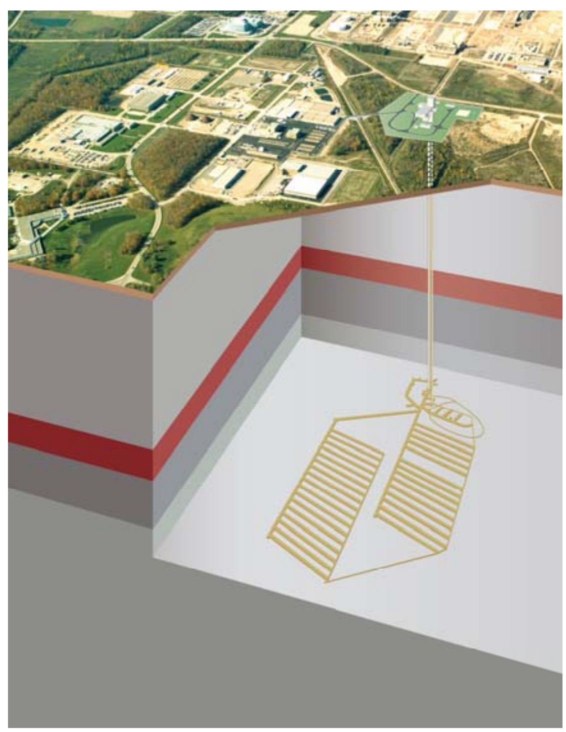
(a) Conceptual Design (2004)



(b) Conceptual Design (2008)



(c) Preliminary Design (2010)



(d) Preliminary Safety Report (2011)

Figure 3.4.5-1: Evolution of the Underground Layout

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3.4.6 Surface Facility Design

Development of the surface layout included locating the surface facilities such as the abandoned rail bed crossing, and the design of the waste rock pile, stormwater management system and heating methods. The surface facilities layout was refined, taking into account:

- construction access for heavy equipment;
- operations access for waste transfer vehicles; and
- environmental constraints (e.g., avoiding sensitive environmental features shown on Figure 3.4.3-1).

The locations of some surface facilities are intrinsically linked to the underground layout (e.g., the shaft headfames must be located with the shafts). Taking into account the above, the surface facilities layout was designed to maintain a DGR Project Site that is as compact as possible.

3.4.6.1 Waste Rock Management Area

As described in Section 3.4.2.3, it was determined that the waste rock was to be managed on-site, within the DGR Project site. The volume of rock to be managed is determined by the underground layout, and will be approximately 1,000,000 m^3. Potential reuse of excavated materials was factored into the design. It is anticipated that:

- overburden materials can be reused on-site for revegetation efforts;
- shales can be used in the construction of berms on-site;
- dolostones can be used to armour drainage ditches or in the construction of access roads; and
- limestones may be able to be used for underground concrete works.

Although reuse of limestones may be possible, it was not accounted for in the sizing of the Waste Rock Management Area (WRMA). Temporary stockpile locations were identified for the overburden, shales and dolostones. The location of the WRMA was determined taking into account technical constraints (i.e., existing site topography and proximity to the shaft locations) and the environmental constraints shown on Figure 3.4.3-1.

The WRMA considered the alternatives of covering and lining versus not covering and lining the limestone pile. Covering the pile at the end of the operations phase was also considered. These are summarized in Table 3.4.6-1. Based on this, it was concluded that capping and lining the limestone pile was not warranted, as no adverse environmental effects are likely in their absence. If dust from the WRMA is noted, this will be addressed through consideration of long-term solutions, such as covering of the pile. The DGR Project assessed in Section 7 considers a capping of the WRMA as part of the decommissioning phase.

3.4.6.2 Stormwater Management

The layout of the stormwater management system was determined taking into account the surface facilities, the environmental constraints (Figure 3.4.3-1), and the existing site topography. Stormwater will be captured from the DGR Project through catchbasins and ditches, and the WRMA through a series of trapezoidal ditches. All stormwater will ultimately be directed to a stormwater management pond to be constructed on-site.

It is anticipated that run-off from the WRMA will contain fines from both exposed rock in the waste rock pile and soil during temporary storage on-site. The stormwater management pond will consist of:

- a retention area for settling of particles;
- an extended storage area for larger storm events; and
- a liner of native material with a protective cover (granular material).

The stormwater management pond could outlet to one of two locations: a drainage ditch to MacPherson Bay, or the North Railway Ditch, which drains to Stream C and, ultimately, Baie du Doré. As described in Section 3.4.3.2, Stream C and Baie du Doré are considered sensitive environmental areas, and DGR Project-related effects should be avoided in these areas. Therefore, to avoid releases to Stream C and Baie du Doré, discharge to MacPherson Bay was chosen as the preferred means. This is summarized in Table 3.4.6-2.

3.4.6.3 Heating Methods

At the DGR Project site, surface temperatures will fall below freezing at various times during the year. To ensure that services are not affected by these temperatures, heating is applied to the air intake for the main shaft to a minimal level to prevent freezing. The methods considered were natural gas, propane and electric. Table 3.4.6-3 summarizes the advantages and disadvantages of each of the heating methods. Based on environmental and technical considerations, and because natural gas is not available at the site, electric was chosen as the preferred means.

3.4.6.4 Crossing of the Abandoned Rail Bed and Ditches

To transfer wastes from the WWMF to the DGR, vehicles will need to cross the abandoned rail bed which has drainage ditches on each side. These ditches are referred to as the North and South Railway Ditches for the purposes of this EA. The location of the crossing is determined by technical factors as there are no environmental differentiating factors along the portion of the abandoned rail bed and ditches adjacent to the WWMF. The methods of crossing the ditch include infilling, culverts or a bridge. These are compared in Table 3.4.6-4. Culverts meet the technical requirements while taking environmental factors into consideration.

Table 3.4.6-1: Comparison of WRMA Methods

Alternative Means	Economic		Worker Health and Safety		Public Health and Safety		Technical		Physical/ Biophysical Environment		Socio-economic Environment		Achievable?	Acceptable?	Preferred Means (Score)
	What is the relative cost difference?		Can it be constructed/ operated in a manner that protects worker health and safety?		Can it be constructed/ operated in a manner that protects public health and safety?		Can it be constructed and operated safely?		What are the likely environmental effects?		What are the likely socio-economic effects?				
Cover and Lining	Most costly	3	Yes	1	Yes	1	Yes	1	Less infiltration but more surface runoff Enhanced reclamation and revegetation	1	None	1	Yes	Acceptable	(8)
No Cover or Lining	Least costly	1	Yes	1	Yes	1	Yes	1	Runoff expected to be of a manageable quality and existing overburden of a suitable quality (permeability) to prevent adverse effects	2	None	1	Yes	Acceptable	Preferred (7)
Cover at the end of the Operations Phase	Additional costs for cap and lining would be incurred in the future	2	Yes	1	Yes	1	Yes	1	Runoff expected to be of a manageable quality and existing overburden of a suitable quality (permeability) to prevent adverse effects Enhanced reclamation and revegetation	1	None	1	Yes	Acceptable	Preferred (7)

Table 3.4.6-2: Comparison of Stormwater Management Pond Discharge Locations

Alternative Means	Economic		Worker Health and Safety		Public Health and Safety		Technical		Physical/ Biophysical Environment		Socio-economic Environment		Achievable?	Acceptable/ Unacceptable	Preferred Means (Score)
	What is the relative cost difference?		Can it be constructed/ operated in a manner that protects worker health and safety?		Can it be constructed/ operated in a manner that protects public health and safety?		Can it be constructed and operated safely?		What are the likely environmental effects?		What are the likely socio-economic effects?				
Railway Ditch (to Stream C)	None	1	Yes	1	Yes	1	Yes	1	None – no discharge to Stream C which contains designated coldwater fish habitat, and Baie du Doré is a Provincially Significant Wetland that provides critical habitat for a variety of flora and fauna	2	None	1	Yes	Possibly	(7)
Drainage Ditch (to MacPherson Bay)	None	1	Yes	1	Yes	1	Yes	1	None – drainage ditch is not designated as fish habitat MacPherson Bay is an unsheltered active mixing zone	1	None	1	Yes	Acceptable	Preferred (6)

Table 3.4.6-3: Comparison of Heating Method Alternatives

Alternative Means	Economic		Worker Health and Safety		Public Health and Safety		Technical		Physical/ Biophysical Environment		Socio-economic Environment		Achievable?	Acceptable?	Preferred Means (Score)
	What is the relative cost difference?		Can it be constructed/ operated in a manner that protects worker health and safety?		Can it be constructed/ operated in a manner that protects public health and safety?		Can it be constructed and operated safely?		What are the likely environmental effects?		What are the likely socio-economic effects?				
Natural gas	Most expensive option because it requires installation of natural gas pipeline to the site	3	Yes – some risk of gas leak and subsequent fire	2	Yes	1	Yes – however, no natural gas line currently on-site	2	Increased local combustion emissions; installation of gas pipeline could have adverse effects	3	None	1	Yes	Acceptable	(12)
Propane	Least expensive option	1	Yes – risk of explosion at the storage tanks	3	Yes	1	Yes	1	Increased local combustion emissions	2	None	1	Yes	Acceptable	(9)
Electric	More expensive option	2	Yes – no ventilation requirements	1	Yes	1	Yes	1	None	1	None	1	Yes	Acceptable	Preferred (7)

Table 3.4.6-4: Comparison of Abandoned Rail Bed Crossing Alternatives

Alternative Means	Economic		Worker Health and Safety		Public Health and Safety		Technical		Physical/ Biophysical Environment		Socio-economic Environment		Achievable?	Acceptable?	Preferred Means (Score)
	What is the relative cost difference?		Can it be constructed/ operated in a manner that protects worker health and safety?		Can it be constructed/ operated in a manner that protects public health and safety?		Is it constructible?		What are the likely environmental effects?		What are the likely socio-economic effects?				
Infill	Low cost	1	Yes	1	Yes	1	Yes	1	Could result in a loss of aquatic habitat in the South Railway Ditch and would create a permanent barrier to fish movement	3	None	1	Yes	Acceptable	(8)
Bridge	Highest cost	2	Yes	1	Yes	1	Possibly – may require a bridge too large for the space available	2	Avoids effects on aquatic habitat	1	None	1	Possibly	Acceptable	(8)
Culverts	Low cost	1	Yes	1	Yes	1	Yes	1	Effects on aquatic habitat and biota can be mitigated	2	None	1	Yes	Acceptable	Preferred (7)

3.4.7 Underground Construction Methods

3.4.7.1 Excavation Methods

The DGR could be constructed using drill and blast techniques or a combination of drill and blast and mechanical excavation. Drill and blast techniques are traditionally used in underground rocks having very high strength. For mining and tunnelling in softer sedimentary rocks, mechanical excavation using road headers is a potentially viable alternative to the traditional drill and blast method.

By its nature, blasting results in overbreak and the development of an extended fracture zone in the rock around the excavation perimeter. While the use of controlled blasting using pre-split and other methods can reduce the amount of overbreak, mechanical excavation methods, such as a roadheader, are superior to blasting in this regard. Drill and blast has been proven to be a suitable excavation technique in similar rock conditions during shaft sinking operations. The benefits and challenges with each option are summarized in Table 3.4.7-1.

3.4.7.2 Groundwater Management

The sinking of the shafts will require excavating through fractured reaches of the shallow bedrock. To manage construction, this water will need to be either collected or a form of ground treatment applied to minimize the inflow of water. Table 3.4.7-2 summarizes this comparison. It was concluded that ground treatment is required, as inflows are expected to be too high to manage during construction of the shaft. Of the ground treatment technologies considered, grouting to 180 m was preferred.

3.4.8 Repository Development Approach

Three alternative approaches for repository development were considered: campaign development, concurrent development and sequential development. In a campaign development, a fraction of the total number of rooms would be excavated during initial construction. Construction would then cease while waste was emplaced in the rooms over the next several years. Emplacement activities would then stop for the construction of the next set of rooms and so on. Concurrent development would have some construction activities occurring while emplacement activities are ongoing simultaneously in another part of the DGR. In a sequential development approach, all emplacement rooms would be constructed during initial construction followed by emplacement activities.

The benefits and challenges with each option are summarized in Table 3.4.8-1.

The DGR Project design team concluded that a sequential development approach was the preferred arrangement because of the advantages in terms of cost, constructability, operability, ventilation system requirements and safety. With regards to environmental factors, each of the approaches is similar.

3.4.9 Shielding of ILW

3.4.9.1 Resin Liners

Different means for handling resin liners and tile-hole-equivalent (T-H-E) liners were considered. For resin liners, the alternatives considered are disposable shields, and emplacement room shielding with transfer underground via a reusable transfer bell. To accommodate the packages with different dose rates, a variety of resin shield thicknesses were considered (i.e., to accommodate very low emitters, low emitting ILW, high emitting ILW, and highest emitting ILW). For reusable transfer bells, a number of different alternatives for underground emplacement were considered:

- vertical concrete pipe arrays above grade in emplacement rooms;
- cored holes below grade in emplacement room floors;
- vertical pipe arrays in large, shallow pit in emplacement rooms;
- vertical silo-type structures similar to the Swedish Final Repository for Radioactive Waste (SFR); and
- stacking behind concrete shielding walls as also used in the SFR.

The transfer bell and disposable shield options are evaluated in Table 3.4.9-1. The disposable shield option was the preferred alternative as they are less expensive, offer fewer technical risks, and require less material handling. The reusable transfer bell options would also require changes in terms of design to equip the forklifts with winches, or require a separate winch system to enable forklifts to drive over the floor openings.

3.4.9.2 Tile Hole Equivalants

Because of the long and slender shape of the IC-2 and IC-18 T-H-E liners, both the shielding and structural design aspects of the alternatives were considered. For T-H-E liners, the alternatives considered were a disposable rectangular box shield, cylindrical disposable shields, a reusable bell transfer and repackaging the waste into smaller containers. The rectangular box shield, cylindrical shields and reusable bell transfer system apply to the full length liners (up to 11 m long) and would require major design changes in hoisting and handling systems to meet the technical requirements. Therefore, repackaging into smaller containers is the preferred method for transferring the wastes in T-H-E liners. This is summarized in Table 3.4.9-2.

As described in Section 3.4.10, other repository concepts may apply different conditioning methods, depending on the need of that system. In most cases, these methods are designed for near-surface facilities and are not applicable to the geologic barriers of the DGR (see Section 3.4.10).

Table 3.4.7-1: Comparison of Construction Method Alternatives for Shaft Sinking and Lateral Development

Alternative Means	Economic		Worker Health and Safety		Public Health and Safety		Technical		Physical/ Biophysical Environment		Socio-economic Environment		Achievable?	Acceptable?	Preferred Means (Score)
	What is the relative cost difference?		Can it be constructed/ operated in a manner that protects worker health and safety?		Can it be constructed/ operated in a manner that protects public health and safety?		Has it been proven in similar circumstances?		What are the likely environmental effects?		What are the likely socio-economic effects?				
Drill and Blast	None	1	Yes	1	Yes	1	Yes – has been successfully used in similar rock conditions	1	Effects can be managed	1	None	1	Yes	Acceptable	Preferred (6)
Roadheader with Drill and Blast	None	1	Yes	1	Yes	1	No for shaft sinking Not widely used for lateral development in hard rock (rocks with strengths greater than 100 MPa)	2	Effects can be managed	1	None	1	Possibly	Acceptable	(7)

Table 3.4.7-2: Comparison of Groundwater Management Alternatives for Shaft Sinking

Alternative Means	Economic		Worker Health and Safety		Public Health and Safety		Technical		Physical/ Biophysical Environment		Socio-economic Environment		Achievable?	Acceptable?	Preferred Means (Score)
	What are the relative cost differences?		Can it be constructed/ operated in a manner that protects worker health and safety?		Can it be constructed/ operated in a manner that protects public health and safety?		Will it control water inflow to allow construction?		What are the likely environmental effects?		What are the likely socio-economic effects?				
Dewatering	High cost	3	No – inflow volumes cannot be safely managed	3	Yes	1	No – inflow volumes cannot be safely managed	3	Inflow could cause a measurable change in the groundwater levels Flow has to be managed	3	None	1	No	Unacceptable	—
Surface-based Grouting (perimeter grouting)	Low cost	1	Yes – grouting could be established to maintain a safe work environment	1	Yes	1	Yes – grouting could be established to maintain a safe work environment	1	Effects on groundwater table not likely to be measurable	1	None	1	Yes	Acceptable	Preferred (6)
Cover Grouting (grout as you go)	Moderate cost	2	Yes – some risk of unexpected water inflow	2	Yes	1	Yes – some risk of unexpected water inflow	2	No likely effect on groundwater flow Could be some flow to be managed	2	None	1	Yes	Acceptable	(10)
Ground Freezing	High cost	3	Yes – freezing could be established to maintain a safe work environment	1	Yes	1	Yes – freezing could be established to maintain a safe work environment	1	Effects on groundwater table not likely to be measurable	1	None	1	Likely	Acceptable	(8)

Table 3.4.8-1: Comparison of Repository Development Approach Alternatives

Alternative Means	Economic		Worker Health and Safety		Public Health and Safety		Technical		Physical/ Biophysical Environment		Socio-economic Environment		Achievable?	Acceptable?	Preferred Means (Score)
	What is the relative cost difference?		Can it be constructed/ operated in a manner that protects worker health and safety?		Can it be constructed/ operated in a manner that protects public health and safety?		Can it be constructed and operated safely?		What are the likely environmental effects?		What are the likely socio-economic effects?				
Campaign Development	Additional costs incurred because of building in a nuclear facility	2	Yes – however, requires construction in an operating nuclear facility	2	Yes	1	Yes – requires remobilization of mining equipment Allows early start for operations	1	Air quality effects continue for longer duration of construction activities	2	None	1	Yes	Acceptable	(9)
Concurrent Development	Highest cost	3	Yes – however, requires construction in an operating nuclear facility	2	Yes	1	Yes – provides the most flexibility for sizing Requires the most complicated ventilation system Allows early start for operations	2	Air quality effects continue for longer duration of construction activities	2	None	1	Yes	Acceptable	(11)
Sequential Development	Lowest cost	1	Yes	1	Yes	1	Yes – most efficient alternative Allows earliest completion of all construction, but latest start of operations	1	Shortest duration of construction activities	1	None	1	Yes	Acceptable	Preferred (6)

Table 3.4.9-1: Comparison of Resin Liner Shielding Alternatives

Alternative Means	**Economic**		**Worker Health and Safety**		**Public Health and Safety**		**Technical**		**Physical/ Biophysical Environment**		**Socio-economic Environment**		**Achievable?**	**Acceptable?**	**Preferred Means (Score)**
	What are the incremental cost differences?		Can it be constructed/ operated in a manner that protects worker health and safety?		Can it be constructed/ operated in a manner that protects public health and safety?		Can it be constructed and operated safely?		What are the relative differences in environmental effects?		What are the relative differences in socio-economic effects?				
Disposable Shields	Low cost	1	Yes	1	Yes	1	Yes	1	None	1	None	1	Yes	Acceptable	Preferred (6)
Reusable Transfer Bell	Higher cost	2	Yes – however, requires additional handling of wastes	2	Yes	1	Yes – can reduce the amount of room occupied by shielding More technical risks associated with waste handling and emplacement	2	None	1	None	1	Yes	Acceptable	(9)

Table 3.4.9-2: Comparison of T-H-E Waste Handling Alternatives

Alternative Means	Economic		Worker Health and Safety		Public Health and Safety		Technical		Physical/ Biophysical Environment		Socio-economic Environment		Achievable?	Acceptable?	Preferred Means (Score)
	What is the relative cost difference?		Can it be constructed/ operated in a manner that protects worker health and safety?		Can it be constructed/ operated in a manner that protects public health and safety?		Can it be constructed and operated safely?		What are the relative differences in environmental effects?		What are the relative differences in socio-economic effects?				
Rectangular Concrete Box Shields	Higher cost	2	Yes	1	Yes	1	No – package weight would exceed hoist capacity for the DGR Complex handling operations of long items in hoist and underground requires very specialized equipment	3	None	1	None	1	No	Unacceptable	-
Cylindrical Concrete Shield	Higher cost	2	Yes	1	Yes	1	Possibly – package weight may exceed hoist capacity Complex handling operations of long items in hoist and underground requires very specialized equipment	2	None	1	None	1	Possibly	Acceptable	(8)

Table 3.4.9-2: Comparison of T-H-E Waste Handling Alternatives (continued)

Alternative Means	Economic		Worker Health and Safety		Public Health and Safety		Technical		Physical/ Biophysical Environment		Socio-economic Environment		Achievable?	Acceptable?	Preferred Means (Score)
	What is the relative cost difference?		Can it be constructed/ operated in a manner that protects worker health and safety?		Can it be constructed/ operated in a manner that protects public health and safety?		Can it be constructed and operated safely?		What are the relative differences in environmental effects?		What are the relative differences in socio-economic effects?				
Reusable Steel Transfer Bell	Higher cost	2	Yes	1	Yes	1	Possibly – complex handling operations of long items in hoist and underground requires very specialized equipment Requires specially constructed concrete storage array underground, which would make future retrieval more difficult for these wastes, if required	2	No	1	No	1	Yes	Acceptable	(8)
Repackaging Into Smaller Containers	Lower cost	1	Yes	1	Yes	1	Yes – simplifies DGR Project design and waste handling Meets all technical requirements for the DGR Does not require specialized handling equipment	1	No	1	No	1	Yes	Acceptable	Preferred (6)

3.4.10 Waste Containment

According to the IAEA Waste Management Glossary, a "waste package" is essentially a container plus its contents that have been prepared in accordance with the requirements (waste acceptance criteria) for handling, transport, storage and/or disposal.

The primary purpose of the "waste container" is to act as a convenient vessel to safely hold the waste during handling, transportation and storage. It provides a uniform way to handle the waste and allows for stacking to improve storage efficiency. The container may also provide shielding for higher activity wastes. In some near-surface repository concepts, the container provides structural support to the repository system (e.g., to prevent subsidence of the cover or cap). This is not the case for a deep underground facility in a rock formation, such as the DGR.

In some repository systems, the waste container also forms part of the engineered system for the containment of radionuclides by providing a physical or chemical barrier against the migration of radionuclides. Despite the fact that metal and/or concrete containers are expected to remain substantially intact for several decades or more in the dry repository environment expected for the DGR Project, no credit is taken in the DGR postclosure safety assessment for the ability of containers to slow the migration of radionuclides. That is to say, the long-term safety of the DGR in no way relies on the integrity of the waste containers.

There are currently in excess of 100 different waste containers that have been used for storage of L&ILW at the WWMF. For the purposes of this report, containers of similar design have been grouped and only containers typical of those found in each group are presented. Typical DGR container types are described in Section 4.5. All waste containers will meet the Waste Acceptance Criteria (WAC) for the DGR (described in Section 4.8.2.1).

Table 3.4.10-1 provides a summary of the waste containment alternatives. Natural containment, which is the containment provided by the host rock and sealing of the shafts, provides excellent margins of safety without additional processing or backfilling. Therefore, the incremental benefits of backfilling rooms and/or tunnels are insufficient to justify the additional expense. Grouting and/or enhanced containers will only be used where needed to meet waste handling requirements (see Section 3.4.9).

The other important component of a "waste package" is the contents, which is the waste material, plus any conditioning that has been applied. The IAEA Radioactive Waste Management Glossary defines conditioning as:

> *"Those operations that produce a waste package suitable for handling, transport, storage and/or disposal. Conditioning may include the conversion of the waste to a solid waste from, enclosure of the waste in containers, and, if necessary, providing an overpack."*

As shown in Table 3.4.10-2, other repository concepts may apply different conditioning methods, depending on the need of that system. In most cases, these methods are designed for near-surface facilities and are not applicable to the geologic barriers of the DGR.

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Table 3.4.10-1: Comparison of Waste Containment Alternatives

Alternative Means	Economic		Worker Health and Safety		Public Health and Safety		Technical		Physical/ Biophysical Environment		Socio-economic Environment		Achievable?	Acceptable?	Preferred Mean (Score)
	What is the relative cost difference?		Can it be constructed/ operated in a manner that protects worker health and safety?		Can it be constructed/ operated in a manner that protects public health and safety?		Is it technically feasible?		What are the relative differences in environmental effects?		What are the relative differences in socio-economic effects?				
Natural Containment	Lowest cost	1	Yes	1	Yes	1	Yes	1	None	1	None	1	Yes	Acceptable	Preferred Mean (6)
Backfill Repository	Higher cost	2	Yes – will result in increased dose as workers spend more time near containers	2	Yes	1	Yes; however leads to higher repository gas pressures in the long-term	2	None	1	None	1	Yes	Acceptable	(9)
Enhanced Containers	Higher cost	2	Yes – will result in increased worker dose as workers repackage the wastes	2	Yes	1	Yes – if using steel would increase gas generation	1	None	1	None	1	Yes	Acceptable	(8)
Grout Inside Containers	Higher cost	2	Yes – will result in increase in worker dose	2	Yes	1	Yes – technically challenging within existing containers	2	None	1	None	1	Likely	Acceptable	(9)

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Table 3.4.10-2: Examples of Waste Conditioning and Containers Used Internationally

Country	Disposal type	Typical waste conditioning methods	Typical disposal containers	Comments
Finland	Underground, rock cavern	Wet wastes solidified in cement or bitumen other wastes packed in 200 L drums	200 L carbon steel drums; ~10 m^3 concrete disposal container (Olkiluoto only)	Silos at Olkiluoto backfilled with grout as layers of disposal containers are emplaced
France	Surface, modular vault	Most wastes are processed by incineration or high-force compaction then grouted into containers	200 L carbon steel drums; 4 m^3 carbon steel boxes; 1 m^3 concrete boxes	Layers of waste packages are surrounded by grout or gravel in vaults Waste package is required to support structural load of cast in place concrete roof of modular vaults
Germany	Deep underground, disused mine	Most wastes are processed by incineration or high-force compaction then grouted into drums placed in larger steel containers	11 m^3 carbon steel "Konrad container"; 1 m^3 cylindrical concrete containers	Standard waste package used for handling geometry Waste package forms part of engineered barrier system
Japan	Near surface, modular vault	Most wastes are processed by incineration or high-force compaction then grouted into containers	200 L carbon steel drums	Waste package is required to support structural load of cast in place concrete roof of modular vaults
Spain	Surface, modular vault	Most wastes are processed by incineration or high-force compaction then grouted into larger concrete containers	11 m^3 concrete disposal container (with various other containers inside, such as 220 L drums or 1.3 m^3 steel boxes)	Structural load of cast in place vault roof is supported by concrete disposal container. Gravel is used as backfill around concrete disposal containers

Table 3.4.10-2: Examples of Waste Conditioning and Containers Used Internationally (continued)

Country	Disposal type	Typical waste conditioning methods	Typical disposal containers	Comments
Sweden	Underground, rock cavern	Some wastes are processed by incineration or compaction; some wastes immobilized in grout or bitumen	200 L carbon steel drums; ISO freight containers; 3 m^3 concrete tanks for ion exchange (IX) resins; 1.7 m^3 carbon steel boxes; 1.7 m^3 concrete boxes	Layers of ILW containers are grouted in place to meet package stacking requirements of ILW silo LLW is stacked in vaults without backfill
UK	Surface vault	Most wastes are processed by incineration or high-force compaction then grouted into larger containers	Half-height ISO freight container, carbon steel	Waste package is required to support structural load of cap and cover system
USA	Near surface, trenches	Some wastes are processed by incineration or compaction	Various carbon steel containers such as B25 box; cylindrical carbon steel, stainless steel and HDPE vessels for IX resins; grout filled large components	Waste package is required to support structural load of cap and cover system Waste packages which do not meet load bearing capacity (stability) requirements are placed inside concrete overpacks to provide structural support
USA	Deep underground, salt formation	Some wastes processed by compaction; some wastes solidified in cement grout	55, 85 & 100 gal steel drums; steel "standard waste boxes" (~2 m^3); "10-drum overpacks" (~5 m^3); "TransUranic (TRU) waste canisters" (0.89 m^3)	Waste packages are stacked in rooms mined in salt Waste package does not provide structural support (salt will eventually creep and backfill the rooms

3.4.11 Summary of Evaluation of Alternative Means

The above discussion focussed the design of the DGR Project on means that are technically, environmentally and economically feasible. The preferred means are summarized in Table 3.4.11-1.

Table 3.4.11-1: Summary of Alternative Means Assessment

Aspect	Project (Preferred Alternative)	Alternatives Considered
Location of the Project (Sections 3.4.2 and 3.4.3)	• Locating the DGR on the Bruce nuclear site	• Locations on the Bruce nuclear site • Locations off of the Bruce nuclear site
	• Locating the DGR adjacent to the WWMF	• Adjacent to the WWMF • Southern portion of the Bruce nuclear site • Former Heavy Water Plant lands
	• Management of waste rock collocated with the DGR	• Waste rock management area collocated with the DGR • Waste rock management off of the Bruce nuclear site • Use of rock as an aggregate on-site • Use of rock as an aggregate off-site
	• Repository horizon within the limestone	• Within the limestone • Within the shale
Method of Repository Access (Section 3.4.4)	• Vertical shaft	• Inclined ramp with shaft • Vertical shaft
Repository Layout (Section 3.4.5)	• Shaft island arrangement	• Islanded shaft • Separated shafts
	• Open-ended rooms	• Open-ended (islanded shafts) • Open-ended (separated shafts) • Dead-ended (parallel) • Dead-dead (chevron)
Surface Facility Design (Section 3.4.6)	• No cover or lining on WRMA • Cover at end of operations	• Cover and lining • No cover and lining • Cover at end of operations phase
	• Stormwater management discharge to drainage ditch to MacPherson Bay	• Discharge to drainage ditch to MacPherson Bay • Discharge to North Railway Ditch to Stream C

Table 3.4.11-1: Summary of Alternative Means Assessment (continued)

Aspect	Project (Preferred Alternative)	Alternatives Considered
Surface Facility Design (Section 3.4.6) (continued)	• Electric heating	• Propane • Natural gas • Electric
	• Culvert crossing over the abandoned rail bed	• Infill • Bridge • Culverts
Underground Construction Methods (Section 3.4.7)	• Drill and blast excavation	• Drill and blast • Roadheader with drill and blast
	• Surface-based grouting (perimeter grouting)	• Dewatering • Surface-based grouting (perimeter grouting) • Cover grouting (grout as you go) • Ground freezing
Repository development approach (Section 3.4.8)	• Sequential (construct and then operate)	• Sequential (construct then operate) • Campaign • Concurrent (build some rooms, emplace waste while building more rooms)
Shielding of ILW (Section 3.4.9)	• Disposable shields	• Disposable shields • Reusable transfer bell
	• Repackaging into smaller containers	• Rectangular Concrete Box Shields • Cylindrical Concrete Shield • Reusable Steel Transfer Bell • Repackaging Into Smaller Containers
Waste Containment (Section 3.4.10)	• Natural containment	• Natural containment • Backfill repository • Enhanced containers • Grout inside containers

4. DESCRIPTION OF THE PROJECT FOR EA PURPOSES

4.1 INTRODUCTION

This section provides a description of the main features of the DGR Project and the wastes to be emplaced in the DGR, and identifies the works and activities that are required to construct and operate the facility, focusing on those activities that could potentially affect the environment. Decommissioning and eventual abandonment activities are described conceptually, thus providing information for the entire project-life cycle.

This DGR Project description is largely derived from documentation that supports the application for a licence to prepare the site and construct the DGR, namely the Preliminary Safety Report [26], Postclosure Safety Assessment [27] and Geosynthesis [28].

4.2 THE PROJECT

The DGR Project includes the site preparation, construction, operations, decommissioning, abandonment and long-term performance of above-ground and below-ground facilities for the long-term management of OPG's L&ILW. The DGR Project, if approved, will be constructed in competent sedimentary bedrock beneath the Bruce nuclear site. The DGR is designed to be safe in the long term, relying on the favourable and stable geology at the site which, combined with effective sealing of the repository, provides a good basis for long-term containment and isolation arguments.

The design for the DGR Project takes into account the OPG-retained lands within the Bruce nuclear site and the reference waste volumes to be placed in the repository (see Section 4.5). Two panels of waste emplacement rooms will be constructed nominally 680 m below ground surface (mBGS) within low permeability limestone in the Cobourg Formation.

Overall, the DGR Project will be constructed in sequential stages. All site preparation activities will be completed, followed by construction of the surface infrastructure, including the shaft headframes. The two shafts (main and ventilation) will be developed simultaneously, followed by the construction of the underground services area infrastructure and access and exhaust ventilation tunnels. The emplacement rooms will then be developed. All construction activities will be completed prior to commencement of operations. The operations phase of the DGR Project is expected to last 40 to 45 years, followed by decommissioning. Once decommissioning activities are completed, the DGR Project will enter the abandonment and long-term performance phase. A timeline for these DGR Project phases is shown on Figure 4.2-1.

The following sections present the different phases of the DGR Project and describe the works and activities anticipated in each phase. Emphasis is placed on the systems, components and activities of the DGR Project that may be expected to affect the environment. All activities will be carried out in compliance with appropriate health, safety and environmental protection requirements. The DGR Project works and activities provide the Basis for the EA, and are summarized in Section 4.18.

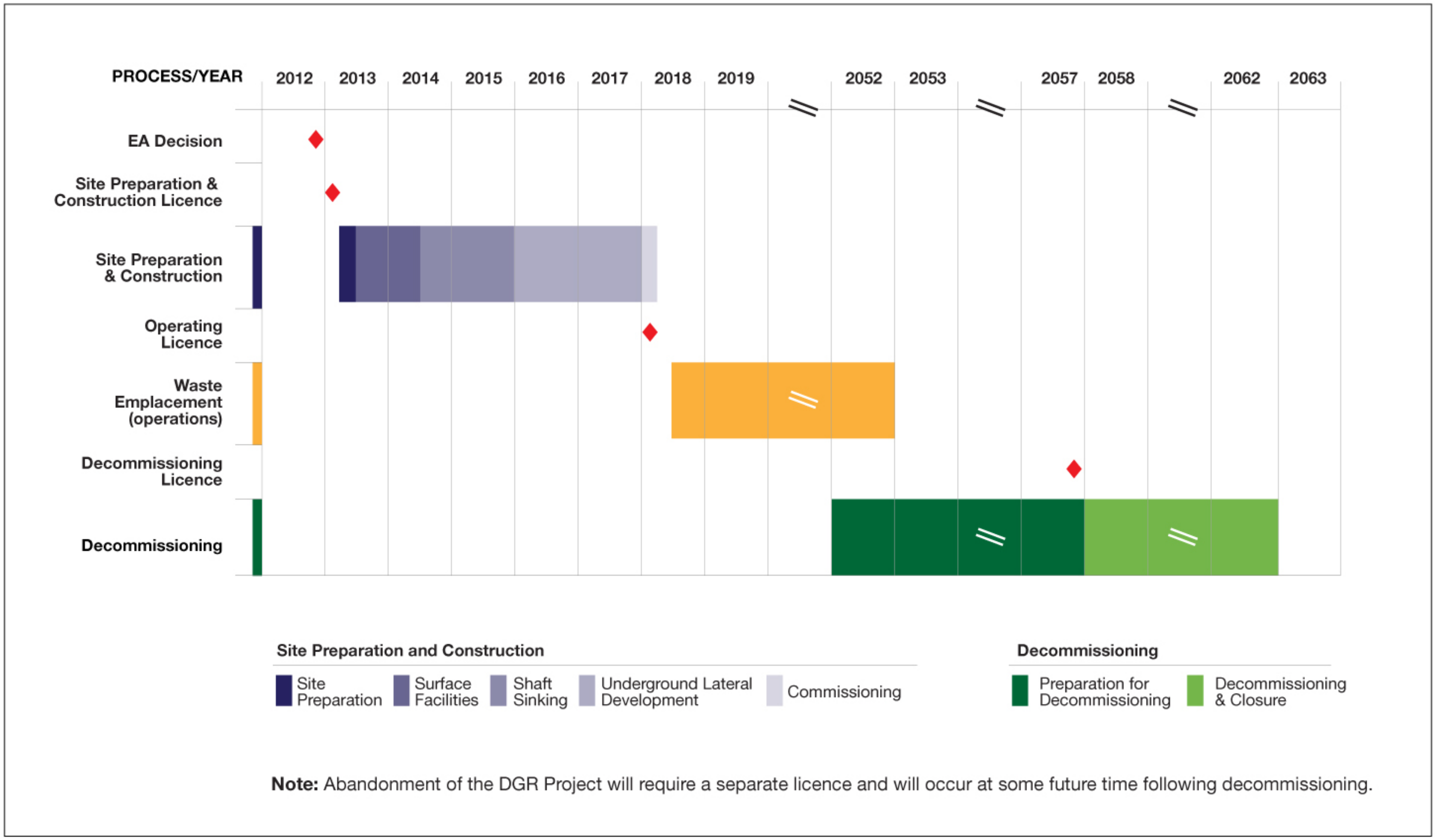


Figure 4.2-1: Timeline for Project Implementation

4.3 LOCATION

The DGR Project will be situated on the Bruce nuclear site, which is located about mid-way between Kincardine and Port Elgin, at a longitude of 81°34' west and latitude of 44°19' north. The location of the 932-hectare (ha) Bruce nuclear site is shown on Figure 1.1.1-2. Although OPG is the owner of the Bruce nuclear site, the majority of the site is controlled under a leasing agreement with the current operator, Bruce Power. Bruce Power also controls all access to the site. Under the leasing agreement between OPG and Bruce Power, OPG has retained control of a portion of the Bruce nuclear site, including the WWMF and adjacent lands.

The DGR Project will be located on the OPG-retained lands at the centre of the Bruce nuclear site. Figure 1.1.1-1 shows an overview of the Bruce nuclear site and the general extent of the OPG-retained lands centred on the WWMF. The DGR Project will be located in the area immediately north of the WWMF, approximately 1 km from the Lake Huron shoreline. The operating Bruce A nuclear generating station is situated to the north of the DGR Project site and the operating Bruce B nuclear generating station is located to the southwest.

The size of the DGR Project surface facilities will be approximately 30 ha, including the construction laydown areas and the area designated for waste rock management. The areal extent of the underground facilities will be approximately 40 ha. An overall schematic of the DGR Project is shown on Figure 1.1.1-3.

4.4 DGR CONCEPT AND FACILITY DESCRIPTION

The surface infrastructure for the DGR Project consists of a waste package receiving, staging and transfer area, shaft headframes and ancillary areas. The waste packages will be transferred underground via the main shaft to the repository level, nominally 680 mBGS. The main shaft will be the intake for repository ventilation, with the heater house and intake fans located adjacent to the headframe. The ventilation shaft and headframe complex will be used to transport the rock generated from the repository development to the surface, and to pull the exhaust air out of the repository. Waste rock piles, some temporary in nature, for the full excavated volume of rock will be accommodated on the DGR Project site, within a waste rock management area (WRMA).

The underground facilities comprise access-ways (shafts and tunnels), emplacement rooms and various underground service areas and installations. All surface and underground facilities will be located within the boundaries of the DGR Project Area, which is delineated on Figure 1.1.1-2.

Information on the construction, operation and eventual decommissioning of the DGR Project is provided in Sections 4.7, 4.8 and 4.11, respectively. The following sections highlight key features of the DGR Project. Section 6.1.2 of the Preliminary Safety Report [26] includes a listing of the regulations and major standards and codes applicable to the design and operation of the DGR.

4.4.1 Surface Buildings and Infrastructure

The DGR surface buildings and infrastructure are located in one of three areas on the DGR Project site: main shaft area; ventilation shaft area; and the WRMA. An artist's rendering of the DGR surface facilities including the access roadway to the WWMF is shown on Figure 4.4.1-1. Descriptions of the structures and facilities within these areas, as well as descriptions of the various ancillary areas, are provided in the following sections. The general layout of the surface facilities and the roadway connecting the DGR Project site with the WWMF are shown on Figure 4.4.1-2.

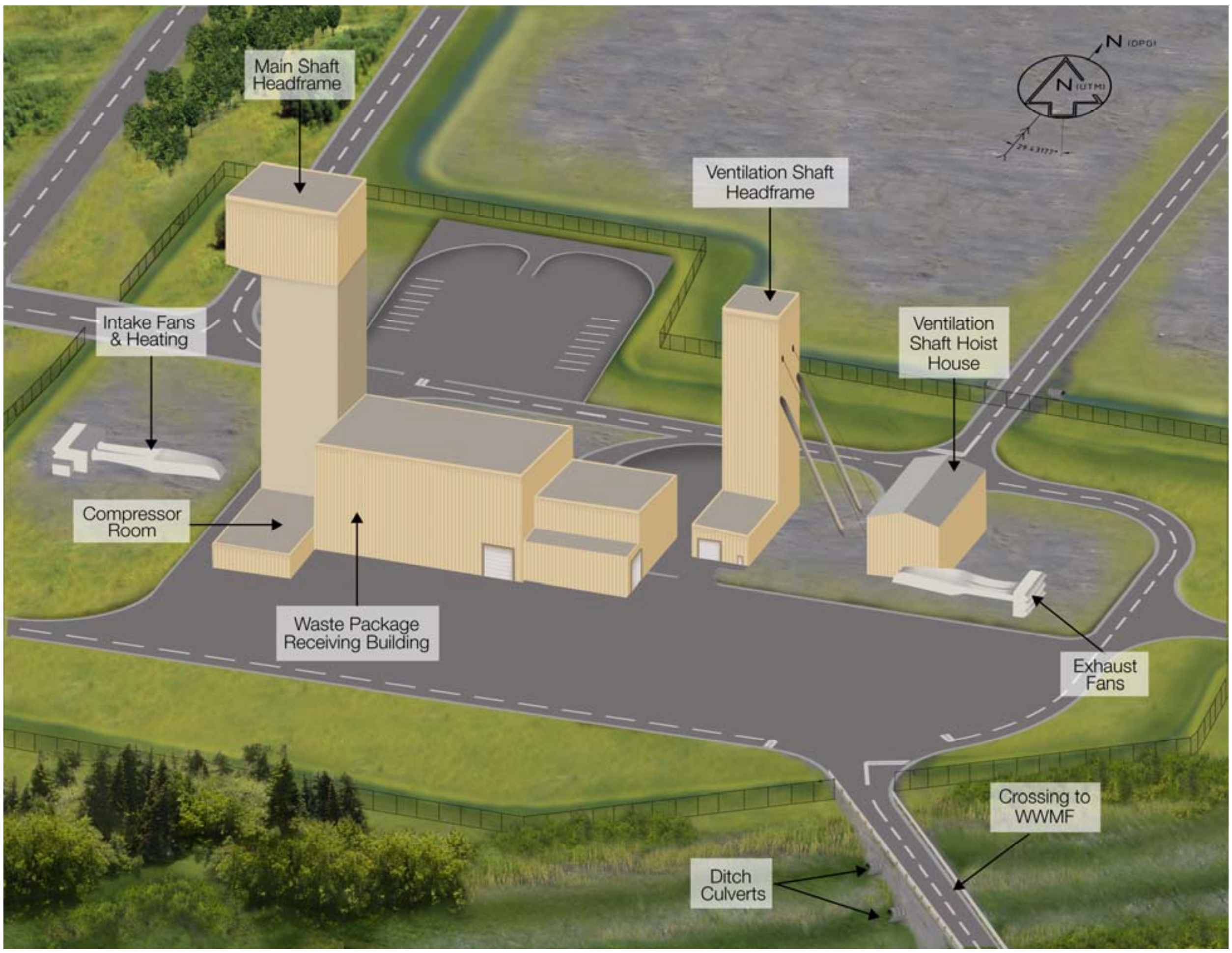
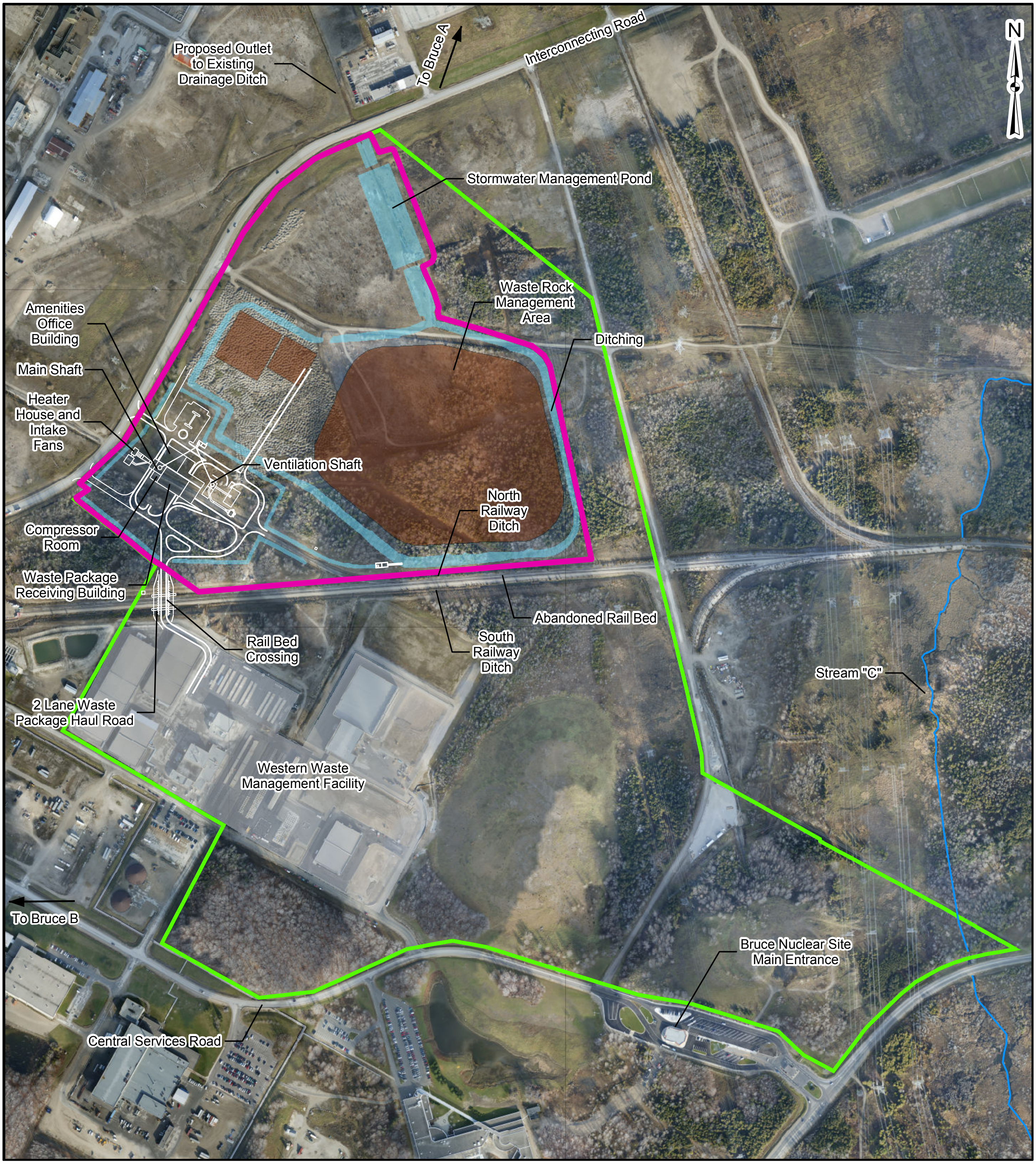
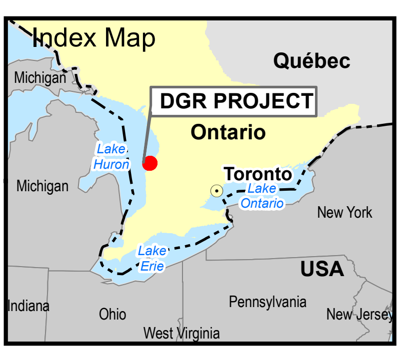


Figure 4.4.1-1: Artist's Rendering of DGR Surface Infrastructure





LEGEND

- DGR Project Site
- Project Area (OPG-retained lands that encompass the DGR Project)
- Soils and Rock Stockpile
- Stormwater Management System

0 125 250 500

Metres

REFERENCE

Base Data Provided by 4DM, Nov 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

LAYOUT OF DGR SURFACE INFRASTRUCTURE

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	AB	16 Mar. 2010	FIGURE 4.4.1-2	
GIS	BC	25 Nov. 2010		
CHECK	KC	25 Nov. 2010		
REVIEW	AB	25 Nov. 2010		

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4.4.1.1 Main Shaft Area

The main shaft area includes buildings and equipment that provide the fresh air requirements for the repository and primary access underground for transfer of waste packages, personnel, equipment and materials. The main shaft area includes the following structures:

- **Main Shaft Headframe:** The main shaft headframe is a nominal 60 m high reinforced concrete structure with a plan area of 225 m² (15 × 15 m). The headframe contains tower-mounted 4.27 diameter and 1.4 diameter Koepe friction hoists and other related equipment. The main shaft hoist room is located at the top of the main shaft headframe and has nominal external dimensions of 15 × 22 m with a height of 12.5 m. This height provides an open area for large equipment to be received at the top of the headframe for construction and maintenance activities. The hoist room houses all the controls and electrical equipment necessary to operate the hoist along with a local operating station.
- **Waste Package Receiving Building (WPRB):** The WPRB is immediately adjacent to and connected with the main shaft headframe. The WPRB is nominally 40 × 25 m and 20 m high. A receiving area allows delivery of waste packages by forklift or flatbed truck, as well as a covered docking area. The WPRB has a staging area for up to 24 LLW bin-type packages and two ILW packages. Waste packages will be loaded onto self-propelled rail carts inside the WPRB and then the loaded carts will be moved into the main shaft cage for transfer to the underground repository. A maintenance and storage area adjoins the WPRB. This building is nominally 20 × 20 m and 16 m high, and provides storage space for materials and spare equipment. Minor repairs and preventative maintenance tasks for the shaft components and equipment used within the WPRB will be carried out in this area, while major overhauls of equipment, if required, will be performed off-site.
- **Compressor Building:** This building, located nearby the main shaft, houses two compressors that will provide compressed air for surface and underground maintenance. One compressor will normally operate with the other compressor on stand-by. In the unlikely event of an underground emergency, these compressors will provide breathing air to the underground refuge stations. The building has an approximate footprint of 9 × 10 m, and will be designed to act as an acoustic enclosure.
- **Intake Fans and Heater House:** This system includes the surface intake fans and electric heating plant located at the main shaft intake plenum. The site layout includes provision for a refrigeration plant and bulk air cooler if required in the future, as noted in Section 4.10.1. The fresh air intake will be constructed west of the main shaft headframe, and is positioned with consideration of the exhaust fans and prevailing wind conditions to minimize potential for intaking exhaust ventilation. The main purpose of the surface intake fans is to provide the required air flow to the DGR. Two fans, including silencers as required, will be located at the intake of the heater house. The function of the surface heaters is to raise the ambient air temperature of the air drawn in to a minimum of 5°C so that services within the main shaft and headframe are not influenced by cold weather conditions. The approximate footprint of the heater house is 7 × 10 m.
- **Offices, Main Control Room and Amenities Building**: The offices and main control room are part of the amenities building that will be attached to the north side of the main shaft headframe and WPRB. The approximate size of the building is 25 × 25 m and two storeys high. There is parking available to the north of the building. Staff and visitors

will all report to this complex through the Zone 1 area. Radiological badging will be received prior to entry into Zone 2 areas. Section 4.15.1.1 discusses the application of zoning to the DGR Project. Lockers, change room and showering facilities, lunch room and training/visitors area are located in this complex. The main control room, forming a part of the amenities area, will be equipped with computing, control, and monitoring equipment to marshal all signals and data transmitted from underground. Other facilities include a lamp room, mechanical equipment rooms and storage.

4.4.1.2 Ventilation Shaft Area

The ventilation shaft area includes the ventilation headframe and hoist house, as well as buildings and equipment supporting the exhaust ventilation system. Additionally, the ventilation shaft provides the means to remove excavated rock from the repository during construction. It also provides a second egress from underground, which will be available for use in emergency situations[6]. The ventilation shaft area includes several key structures, namely: ventilation headframe and collar house, hoist house, and exhaust fan building. Brief descriptions of these structures follow:

- **Ventilation Shaft Headframe and Collar House**: The ventilation shaft headframe will be an insulated and clad steel structure. The headframe is nominally 43 m high and includes a tipping path and chutes that will be used during the site preparation and construction phase for discharge of waste rock**.** During the operations phase, the ventilation shaft is the primary conduit for repository services (e.g., service water, power, communications), and could be used for emergency secondary egress. The collar house will be a nominal 15 × 10 m and 5 m high clad steel-framed building that is used for general maintenance and storage of shaft hardware and equipment spares.
- **Ventilation Shaft Hoist House**: The hoist house (nominally 13 × 24 m and 12 m high) will be an insulated and clad steel-framed building that houses the 3.66 m diameter double drum hoist for the ventilation shaft. The hoisting equipment is common for shaft sinking, waste rock removal during repository development and egress during operations. The double drum configuration of the hoist allows a two-compartment conveyance. The building contains all the electrical equipment and control station, roll up doors for access, and a monorail for installation and maintenance of the hoist.
- **Exhaust Fan Building**: Exhaust fans will be located at the exit of the ventilation shaft plenum. Although the main exhaust ventilation fans are located near the ventilation shaft on the repository level, the surface fans assist in directing the exhaust through the plenum and not up through the ventilation headframe. The building will be steel with cladding and the fans will be equipped with acoustic baffled silencers to reduce noise.

4.4.1.3 Waste Rock Management Area (WRMA)

The WRMA is the location where all rock excavated during underground construction of the DGR is managed. Approximately 1,000,000 m^3 of waste rock will be produced during underground construction of the DGR. The waste rock produced from the repository level development will be transferred from underground to surface via the ventilation shaft, as noted

[6] The ventilation shaft will not be used as an egress point from underground on a day-to-day basis.

previously. At surface, it will be loaded from the muck bay by front-end loader into off-highway trucks and delivered to the WRMA. The waste rock will be stored in adjacent piles according to material type. Approximately 80,000 m^3 of soil and rock is identified as being re-usable for site construction. The balance of the rock (832,000 m^3 of limestone) will be managed over the long-term in a rock pile that covers 9 ha and measures 15 m high. The overall footprint of the WRMA, including its stormwater management system (see Section 4.4.1.5) is approximately 17 ha.

Clearing and grubbing is required in portions of the WRMA to remove existing vegetation. The entire site requires grading to promote run-off to a system of ditches that surrounds the WRMA. This ditch network ties into the stormwater management system as described in Section 4.4.1.5. Berms and vegetation along the perimeter of the DGR Project site will be used to control dust and noise, as well as to limit views of the rock piles.

4.4.1.4 Road Connection to WWMF

A crossing over the abandoned rail bed is required to provide direct access between the WWMF and the DGR Project site (Figure 4.4.1-2). This crossing will be a two-lane road situated on a fill embankment over the abandoned rail bed and existing ditches (i.e., the North Railway Ditch and the South Railway Ditch). Culverts will be used to provide for water flow in the two existing ditches. The road allows for vehicle and personnel passage and will be fenced along both sides, connecting with the fencing around the WWMF and the DGR surface facilities. While decommissioning (Section 4.11) is only described in a preliminary manner at this early planning stage, it is assumed this crossing will remain in place after operations have ceased.

4.4.1.5 Stormwater Management System

The surfaces around the DGR surface facilities are designed with suitable gradients so that drainage is directed away from all structures to a system of perimeter ditches. These ditches are described in more detail in Section 4.7.1.3. This ditch system will also receive water that is pumped to surface from the underground dewatering sump.

All stormwater run-off from the DGR surface infrastructure area, the WRMA and underground water will drain into the stormwater management pond. The pond is sized to retain stormwater run-off for a sufficiently long period of time to settle out suspended solids. The entire stormwater management system is sized to safely pass run-off from a large storm event (e.g., 1:100 storm event) with no damage to the system. The stormwater management pond will be constructed with a low permeability base (e.g., natural or composite) and will discharge into the existing Bruce nuclear site drainage ditch network for release to MacPherson Bay (Lake Huron). Additional details on the stormwater management system design are provided in Chapter 6 of the Preliminary Safety Report [26].

The assessment of surface water effects (Hydrology and Surface Water Quality TSD) has identified suspended solids, un-ionized ammonia and some trace metals as the primary project-related parameters that may occur in run-off from the WRMA. The stormwater management pond is sized to provide a retention area for settling of particles and the ability to retain the 6 hour, 25 mm rain event. Additionally, water treatment will be employed in the drainage system upstream of the stormwater management pond for the duration of the site preparation and construction phase, and possibly the first two years of operations depending on monitoring results. This temporary water treatment plant is further described in Section 4.7.5.4. In the unlikely event that monitoring detects concentrations exceeding established limits, it is possible to close the gate at the discharge location, thereby containing the contaminated water. Appropriate actions would then be taken to treat the water so that it could be safely discharged from the pond.

4.4.2 Description of Underground Facilities

The preliminary layout of the underground repository is shown on Figure 4.4.2-1. Access to the underground repository from ground surface is via two vertical concrete-lined shafts that lead to the shaft and services area at the repository level. The underground repository consists of two panels of emplacement rooms that are nominally 250 m in length and arranged in parallel to the assumed direction of the major principle horizontal in situ stress of east-northeast (ENE). Panel access and exhaust ventilation tunnels run parallel to one another. End walls, or bulkheads, are constructed at the end of the emplacement rooms where they meet with the exhaust ventilation tunnel. These end walls allow for the installation of ventilation regulators and personnel access doorways for egress when rooms are empty. The repository has 31 rooms, accommodating approximately 200,000 m^3 of waste (emplaced volume).

4.4.2.1 Shafts

Two shafts provide access to the repository, allowing the movement of materials and waste rock to and from the repository, and provide ventilation to the repository during the construction and operations phases.

The main shaft provides the following functions:

- transporting staff to and from the repository;
- transporting materials and equipment for development and operation of the repository;
- providing a secondary conduit for supply of electricity, communications, compressed air and water;
- providing fresh air to the repository;
- providing an alternative route for transport of any collected water from underground to the surface; and
- transferring L&ILW to the repository.

The ventilation shaft provides the following functions:

- hoisting of excavated rock from the repository to the surface;
- providing the primary conduit for supply of electricity, communications, compressed air and water;
- providing emergency access for staff to and from the repository; and
- routing for exhaust air from the repository.

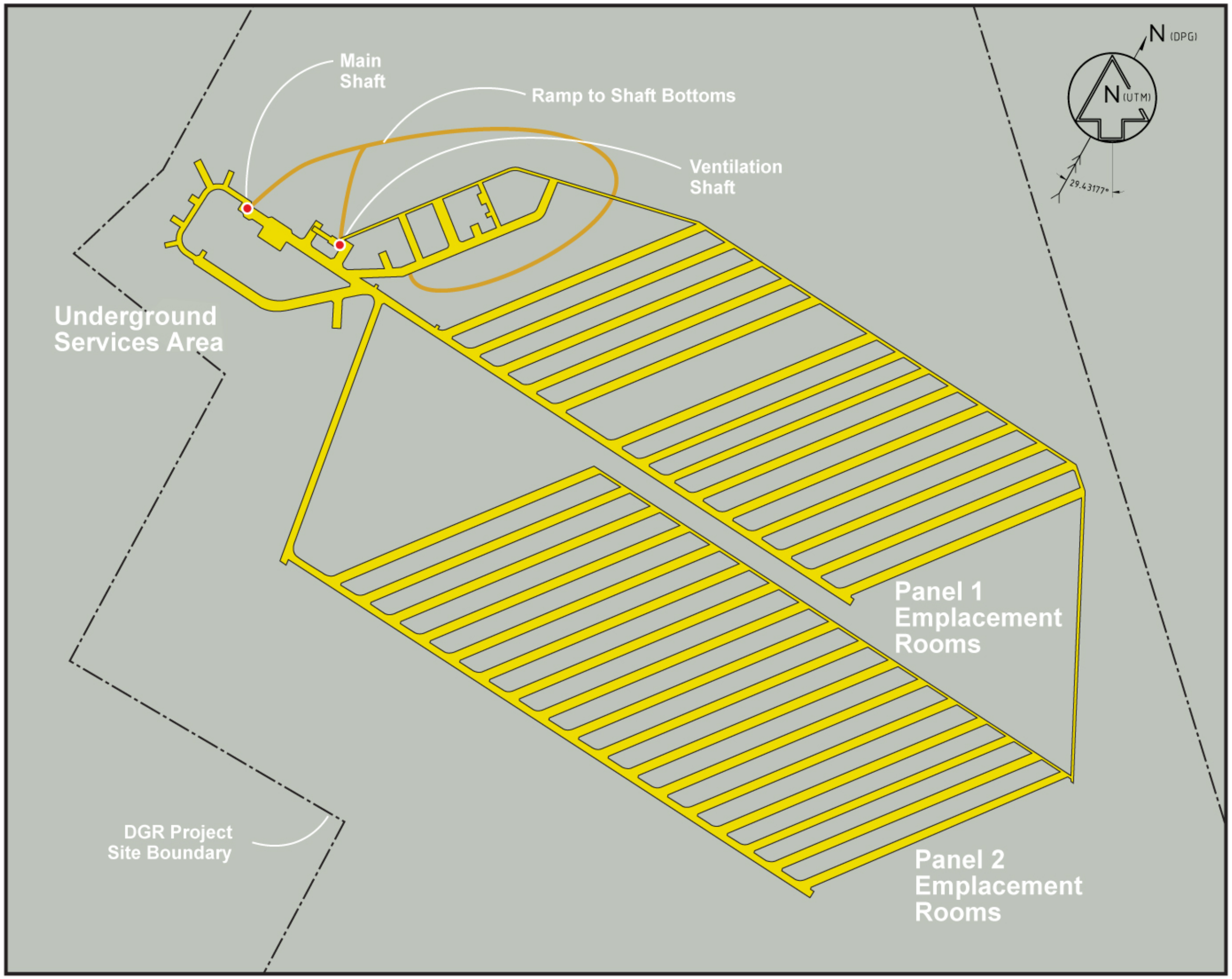

Figure 4.4.2-1: Preliminary Layout of the Underground Repository

The main shaft will have a nominal finished internal diameter of 6.5 m and the ventilation shaft will have a nominal finished internal diameter of 5.0 m. Both shafts will extend from ground surface to the repository horizon located at a nominal 680 m depth plus an additional 40 m (main shaft) and 65 m (ventilation shaft) to shaft bottom for a total excavated shaft length of 720 and 745 m, respectively. A ramp from the repository level will provide access to the loading pocket, which is used only during construction for loading waste rock into a conveyance for delivery to surface. The ramp will also provide access to the bottom of both shafts for the construction and operations phases.

4.4.2.2 Underground Services Area

The two vertical shafts are located in an "island" configuration with underground services located in close proximity. This arrangement enables most of the underground infrastructure to be kept close to the shafts, while keeping the waste emplacement areas away from areas that are normally occupied by workers. The underground services area (Figure 4.4.2-1) contains the amenity and equipment maintenance areas. The amenities include a lunchroom/refuge station, which has radiological protection controls at the entrance to prevent spread of contamination into this eating area during the operations phase. There is an additional refuge station in this area in close proximity to the ventilation shaft. Both are equipped with emergency supplies of fresh water, compressed air (with a secondary built-in scrubber air exchange unit), a fire-rated door with sealing materials and a communications link with the surface. In addition, there is a provision for placement of portable refuge stations in the panel access tunnels. The maintenance shop and diesel fuel bay are used for servicing underground equipment. Other services in this area include the high and low voltage substations, geotechnical office and core storage, sanitary areas and general storage.

4.4.2.3 Access Tunnels

Access to the emplacement rooms from the main shaft and ventilation shaft stations will be via two tunnels. Both access tunnels are designed for single vehicle passage and have poured concrete floors. A portion of the Panel 1 access tunnel will have rail embedded in the concrete floors to allow movement of rail carts loaded with large and heavy packages into the first three emplacement rooms of the panel.

Parallel to the panel access tunnels are the exhaust ventilation tunnels. The Panel 1 and Panel 2 exhaust ventilation tunnels are connected to provide a continuous path to the ventilation shaft for spent air. The exhaust ventilation tunnels are not typically occupied other than for inspection and maintenance of the ventilation regulators and monitoring equipment. These tunnels also provide a means of secondary egress until waste emplacement commences.

4.4.2.4 Emplacement Rooms

Emplacement rooms are arranged parallel to expected stress conditions and are dimensioned to maximize packing efficiencies. The length of the rooms will be nominally 250 m accounting for package placement orientations. The dimensions of the emplacement rooms vary 1.4 m in width and 1.2 m in height with the nominal dimensions being 8 m wide and 7 m high. The waste packages will be systematically arranged in the various room layouts based on the type of package (LLW or ILW), size of the package and whether or not the package can be stacked.

The floors of the emplacement rooms will be poured concrete, which provides a suitable surface to facilitate packing efficiencies and forklift movement. The ends of the rooms are interconnected with the exhaust ventilation tunnel and a bulkhead established to regulate ventilation from the room. The entrance of the emplacement room will allow sufficient space for end walls to be constructed once the rooms are filled to restrict access and provide shielding, as required.

4.4.3 Common Services

4.4.3.1 Ventilation System and Dust Control

Ventilation System

The reliable delivery of a supply of fresh air to the underground workplaces is critical for the health and safety of workers. This air supply is used to maintain safe working conditions throughout the DGR Project. The total volume of air supplied to the DGR takes into account the nature of the work being performed, the number of active and non-active rooms and will be periodically adjusted throughout the life cycle of the repository. Ventilation air will be supplied to the DGR to ensure the following:

- there is breathable air available for all underground personnel;
- contaminants are diluted and removed;
- personnel are not exposed to levels of noxious gases that exceed regulatory limits;
- levels of explosive gases do not exceed explosive limits; and
- temperatures within the DGR are maintained so that it remains safe and acceptable for both personnel health and infrastructure integrity.

The ventilation system design, as described in Chapter 6 of the Preliminary Safety Report [26], is a flow-through system where fresh air travels from the main shaft through the access tunnels and emplacement rooms, and returns to the ventilation shaft via the exhaust ventilation tunnels.

While designed as a pull-type ventilation system, low-pressure fans will be used to deliver a controlled air volume from the surface intake fans to the collar of the main shaft so that main exhaust fans do not cause a "negative pressure" condition in the main shaft headframe. The fresh air supply fans will deliver air at a volume and pressure such that a positive pressure is imparted to the main shaft headframe. This positive pressure ensures that, should there be an incident at the surface facilities, potentially contaminated air is not sent down the shaft and through the repository level.

The primary consideration in the ventilation system requirements is the amount of diesel equipment operating at any given point underground. Taking into account the diesel equipment to be used at the same time during repository construction, it is determined that the expected maximum airflow through the DGR is 130 m^3/s. Chapter 6 of the Preliminary Safety Report [26] describes the ventilation system planned for the DGR Project in detail, and should be referred to for additional information.

The ventilation system is a critical component of the facility and a monitoring and maintenance program will be established for the operation of the system. The selection of equipment and degree of on-hand critical spares is determined by the specific fan and configuration ultimately selected for the DGR Project. It is assumed that the vendor(s) will specify the requisite inspection schedule and maintenance program for the ventilation system components, which will form the basis for the procedures implemented for ventilation equipment maintenance. Ventilation equipment and flow monitoring throughout the facility will provide information to the main control room for both specific equipment performance, as well as the performance of the overall system.

Air quality underground will be monitored to ensure that the health and safety of personnel within the repository is not compromised. The monitoring system will ensure the following:

- levels of noxious and explosive gases do not exceed regulatory limits (s.294, R.R.O 854 [29]); and
- airflow remains adequate for the equipment and activity in active work areas.

Airflow, carbon monoxide (CO), and nitrogen dioxide (NO_2) will be measured at the ventilation shaft. Explosive gas monitors will also be installed to monitor a range of gases that may potentially occur, including methane and hydrogen. Instrumentation measuring airflow, temperature, relative humidity and other pertinent parameters will be installed at the main shaft. Emplacement room exhaust regulators will be equipped with combustible gas monitors to monitor a range of gases (e.g., methane and hydrogen). All measurements will be monitored remotely on surface at the main control room and will also be available to be monitored underground.

Dust Control

During construction, underground dust control will be through conventional mining practices of washing down and misting muck piles. Air misting through the use of foggers could be incorporated in high dust areas such as the waste rock dump and loading pocket. The ventilation system requirements set a minimum and maximum velocity of 0.5 and 6 m/s, respectively. Air flow below 0.5 m/s is not sufficient to clear dust and contaminants such as diesel exhaust, while velocities in excess of 6 m/s can contribute to airborne dust. During operations, the need for dust control is expected to be minimal since the floors will be concrete throughout the repository.

Surface dust control measures during site preparation and construction are described in the Atmospheric Environment TSD. Best management practices, such as watering, will be employed when required.

4.4.3.2 Electrical Supply

Electrical power will be supplied to the DGR's electrical switchgear and repository-level substation by a 13.8 kV transmission line from an existing Hydro One substation located on the Bruce nuclear site. The main DGR electrical substation is located on surface in close proximity to the line power supplied to the DGR Project site.

An emergency power system, using diesel generators, will be installed to maintain critical equipment in the event of a grid power failure. These generators have a capacity of about 1,750 kVA to serve the site loads that are essential for personnel safety and to maintain DGR dewatering equipment. The emergency power system is located in close proximity to the main shaft and feeds equipment through the cables and switchgear used for operations. These generators would power-up critical components within 30 seconds of an unscheduled power outage; however, the emergency power system would not support continued waste placement operations. The loads that would be served by the emergency power system are as follows:

- ventilation shaft hoist to remove personnel from underground to surface in emergency situations;
- main shaft auxiliary hoist;
- main shaft Koepe hoist brakes and controls allowing for controlled lowering of the cage by gravity using the brakes without requiring use of the motor;
- repository dewatering system;
- one air compressor; and
- emergency lighting and communications at repository level and at surface.

Specialized controls and switchgear are used to initiate the start-up of the generators and shed non-critical loads following a power outage. There would be an uninterrupted switchover when the supply grid is re-energized. Preventative maintenance and inspection programs will be implemented to ensure the reliability of the emergency power system.

4.4.3.3 Communications System

The communications system will be available throughout the DGR and operates at surface and underground. The system utilizes a fibre optic network from which the various functions link. Cable will be supplied in both the main shaft and ventilation shaft for redundancy. The system accounts for telephone, emergency analogue phone, radio, and business and process control networks. Hard-wired emergency telephones will be installed at the surface main control room, at the main shaft and ventilation shaft stations, and at each refuge station. These phones can be used for emergency communication in the event other voice communication systems (e.g., radio, ethernet-based IP telephones) fail.

The fire detection/suppression and hoist control systems will utilize dedicated signal transmission infrastructure. Outputs from these two systems will be accepted by the DGR communication system for inclusion on the operator's screens in the main control room. Additional information on the control and monitoring systems is provided in the next section (Section 4.4.3.4). Fire protection systems and emergency response are described in Section 4.17.

4.4.3.4 Control and Monitoring Systems

The main control room is the main location to monitor the system. The DGR will have a main control room. The operator can view custom-configured control screens that display equipment and system status and allow inputs to be executed through a mouse/keyboard interface. The operator can also monitor key areas through the use of closed circuit video monitors. In the off-shift hours, selected main control room monitoring functions will be transferred to the WWMF main control room, which is continually staffed, allowing an operator to monitor the facility and respond to any alarms. Shaft hoisting operations are controlled from the respective control terminals. Hoisting operations can be automated or controlled manually. A certified hoist operator is on-site at all times that the hoists are in operation.

The following underground equipment will be monitored and controlled from the main control room:

- sump and dewatering pumps;
- power distribution facilities including motor starters and some switchgear; and
- ventilation fans and air heaters.

The following equipment will only be monitored in the main control room because this equipment either does not require control or will be controlled locally:

- uninterruptible power supplies (status monitoring);
- water quality monitoring, as required;
- air quality monitoring, as required;
- ground support monitoring, as required; and
- hoist system monitoring.

The fire detection and suppression system will report into the main control room but will be monitored and controlled by a separate and isolated framework or infrastructure.

The control and monitoring system allows for connection and activation of alarm devices to notify personnel of abnormal or unsafe conditions. Alarm notification devices are used within the main control room and, as necessary, underground.

4.4.3.5 Fuel Storage

Surface diesel and unleaded fuel storage for mobile equipment is limited to the site preparation and construction phase, and will be removed prior to operations with the exception of the emergency power system fuel storage. The temporary fuel storage consists of above-ground double walled tanks located within a secured area demarcated and protected by concrete bollards. During operations, diesel fuel storage at surface is limited to the emergency power system fuel supply, which is contained in a 10,600 L double walled tank located adjacent to the emergency generator.

Fuel requirements for operations will utilize the existing WWMF fuel station. Fuel totes for the underground diesel fuel bay and for use by underground equipment will be filled at the WWMF and transported underground via the main shaft handling equipment. The repository level fuel storage design is typical of commercially available systems, and includes two 2,700 L double walled steel fuel totes in an integrated unit with built-in leak containment and fire suppression system. Space for only one piece of mobile equipment will be provided in the underground refuelling station to reduce risk of fire incidents. Fuel pumps will be connected directly to the fuel tote, with empty totes cycled back to surface for refilling at the existing WWMF fuel station.

Both surface and underground fuel storage areas will be provided with sufficient sump capacity to collect accidental spillage that could occur during fuel transfer or leakage from any tanks or pipes. Berms will be constructed as needed to ensure that any spillage of fuel or lubricant will be retained within the storage and refuelling areas.

Fuel storage is further described in Section 4.7.5.2 for site preparation and construction and Section 4.8.5.2 for operations.

4.4.3.6 Potable, Industrial and Fire Water

Potable water for the surface facilities will be provided through connection to the existing Bruce nuclear site supply. Bottled water will be supplied for underground use.

Industrial water will be supplied through the existing Bruce nuclear site industrial, or process, water network via connection to the west of the DGR Project site. This water supplies both surface and underground industrial water needs. Heavy-wall steel pipe down the ventilation shaft, with back-up piping in the main shaft, provides industrial water for use in construction and operations activities at the repository level.

Fire water will be supplied through the existing Bruce nuclear site network. As with the industrial water, the DGR Project site will connect into the existing lines and distribute on surface. Fire water is only used for surface fire protection as all underground suppression systems will be dry chemical based, as described in Section 4.17.

4.4.3.7 Sewage System

During the site preparation and construction phase, all sewage will be managed by the contractor using an off-site service contractor. During operations, all sewage from surface facilities will be treated through the existing on-site sewerage system operated by Bruce Power. The management of materials from repository level sanitary facilities (e.g., toilets and hand washing stations) is described in Section 4.8.5.1.

4.5 WASTE TO BE PLACED IN THE DGR

The DGR will accept operational and refurbishment L&ILW[7]. The DGR will not accept used nuclear fuel or recognizable fuel fragments.

A summary of the wastes to be emplaced in the DGR is presented in this section. This includes information on waste sources, inventories, and the physical, radiological and chemical characteristics of the wastes. It also provides information on representative containers that will be emplaced into the DGR. This information is based on the Preliminary Safety Report [26] and the Reference Inventory Report [30].

Radioactive wastes to be accepted by the DGR are classified as solid low-level or solid intermediate-level. The classification is as described below, and is consistent with Canadian Standards Association (CSA) N292.3 [31].

Low level waste (LLW) consists of non-fuel waste in which the concentration or quantity of radionuclides is above the clearance levels and exemption quantities established by the Nuclear Substances and Radiation Devices Regulations [32], and which contain primarily short-lived radionuclides (i.e., half-lives shorter than or equal to 30 years). LLW normally does not require significant shielding for worker protection during handling and storage.

Intermediate level waste (ILW) consists of non-fuel waste containing significant quantities of long-lived radionuclides. ILW often requires shielding for worker protection during handling.

The L&ILW are generated from a variety of activities. For the purposes of safety assessment and engineering, it is convenient to distinguish the operational L&ILW from refurbishment L&ILW. A third general category, decommissioning L&ILW is not included in this discussion.

A wide variety of waste types are generated as a result of the operation of nuclear generating stations. OPG currently tracks about 70 different waste types. However, many of these are small volume items, or have similar properties to other waste types. Therefore, for purposes of describing the DGR waste inventory, these waste types have been grouped into about 20 waste categories. Tables 4.5-1 and 4.5-2 provide descriptions and sources of the L&ILW categories tracked for the DGR.

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[7] Throughout this report, refurbishment L&ILW may be referred to as reactor refurbishment waste or "RRW".

Table 4.5-1: LLW Categories

Waste Category	Description
Bottom Ash	Heterogeneous ash and clinker from waste incineration
Baghouse Ash	Fine homogeneous ash from waste incineration
Compact Bales	Generally compactible solid LLW; for example empty waste drums, rubber hoses, rubber area floor matting, light gauge metals, welding rods, plastic conduit, fire blankets and fire retardant material, metal cans, insulation, ventilation filters, air hoses, metal mop buckets and presses, electric cable (<1/4" diameter), lathe turnings, metal filings, glass, plastic suits (Mark III/IV), rubbers, Vicraft hoods, rubber gloves
Box Compacted	Same as compact bales
Non-Processible Boxed	Solid LLW that is non-compactible or has contact dose greater than 2 mSv/h; for example, heavy gauge metal (e.g., beams, ion exchange (IX) vessels, angle iron, plate metal), concrete and cement blocks, metal components (e.g., pipe, scaffolding pipes, metal planks, motors, flanges, valves), wire cables and slings, electric cables (>1/4" diameter), Comfo respirator filters, tools, paper, plastic, absorbent products, laboratory sealed sources, feeder pipes
Non-Processible Drummed	Generally small, granular or solidified LLW; for example, floor sweepings, cleaners and absorbents (e.g., Dust Bane, Stay Dry), metal filings, glassware, light bulbs, bitumenized low-level waste
Non-Processible Other	Large and irregularly shaped objects such as heat exchangers, Encapsulated Tile Holes (ETH), shield plug containers, and other miscellaneous large objects (e.g., fume hoods, glove boxes, processing equipment)
LL/ALW Resin	Spent Low-level (LL) IX resin arising from light water auxiliary systems, and/or Active Liquid Waste (ALW) treatment systems
ALW Sludge	Sludge from Bruce two-stage ALW Treatment System
Steam Generators	Steam generators removed from service

Table 4.5-2: ILW Categories, including Reactor Refurbishment Waste

Waste Category	Description
Moderator Resin	Spent IX resin arising from moderator purification systems
Primary Heat Transport (PHT) Resin	Spent IX resin arising from PHT purification systems
Miscellaneous Resin	Spent IX resin arising from station auxiliary systems (e.g., heavy water upgraders)

Table 4.5-2: ILW Categories, including Reactor Refurbishment Waste (continued)

Waste Category	Description
CANDECON Resin	Spent IX resin from chemical decontamination process for nuclear heat transport systems
IX Columns	Spent IX resin mainly arising from Pickering PHT purification system; comes as package with steel container
Irradiated Core Components	Various replaced core components, notably flux detectors and liquid zone control rods
Filters and Filter Elements	Filters and filter elements from various station process systems
Retube – Pressure Tubes [a]	Fuel channel waste from large scale retube
Retube – End Fittings [a]	Fuel channel waste from large scale retube
Retube – Calandria Tubes [a]	Fuel channel waste from large scale retube
Retube – Calandria Tube Inserts [a]	Fuel channel waste from large scale retube

Note:
a Reactor Refurbishment Waste

4.5.1 Waste Volumes

Most L&ILW is inherently heterogeneous, with considerable variability both across waste categories, and also from package to package within a waste category. OPG has therefore supported a waste characterization program for many years. The characteristics of various waste types have been identified, and information recorded on waste packages in an electronic records system called IWTS, the Integrated Waste Tracking System.

The amount of waste and number of packages projected over the life of OPG's nuclear program is calculated based on the existing inventory tracked in IWTS, and a future waste receipt projection. Based on the existing plus projected inventory, it is estimated that approximately 53,000 packages representing a total emplaced volume of approximately 200,000 m^3 will be sent to the DGR. The actual number of packages may be different (e.g., depending on future decisions about processing and packaging new wastes and repackaging current wastes); however, the information provided in this section is sufficient for EA planning.

Table 4.5.1-1 shows the waste volume breakdown for the reference forecast. Figure 4.5.1-1 shows the relative distribution of waste by volume. As can be seen on the figure, about 75% of the emplaced volume is operational LLW. Note that while refurbishment L&ILW only makes up about 10% of the emplaced volume, it accounts for more than 60% of the radionuclide inventory at 2062.

Table 4.5.1-1: Waste Volumes in Reference Forecast (Rounded)

Volume	Operations LLW	Operations ILW	Refurbishment L&ILW	Total
Net waste volume (m^3)	95,100	9,300	11,200	115,600
As-stored volume (m^3)	135,000	13,500	21,700	170,200
Emplaced volume (m^3)	154,700	27,600	21,700	204,000

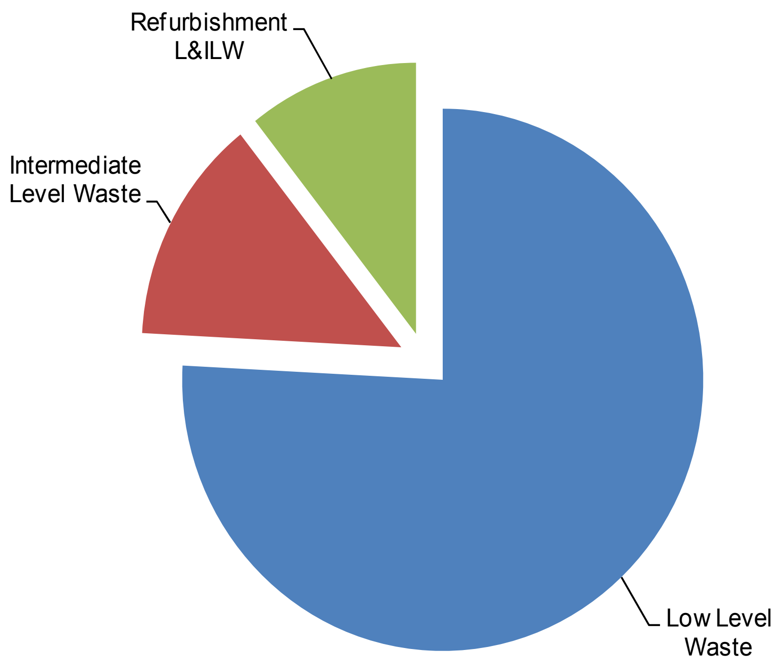

Figure 4.5.1-1: Relative Waste Volumes Planned for Emplacement in the DGR (emplaced volume)

Table 4.5.1-2 summarizes the forecast of operational and refurbishment L&ILW packages as they would arrive at the receiving area of the DGR. This forecast is based on the planning assumption of refurbishment of all reactor units at or near their mid-life, and then operating for a further 25 to 30 years after refurbishment.

The waste volume forecast is subject to changes to the nuclear operating and refurbishment program; standardization across stations; improvements to waste processing technology; and changes to repository storage technology. For example, this forecast does not take into account OPG's recent decision not to refurbish Pickering B. However, approximately half of the projected waste volume is already stored at the WWMF site, and the projection is based on actual experience with the stations. Therefore, the overall waste volumes are expected to be similar to this forecast. The total emplaced waste volume will be limited by the excavated volume of the repository.

Table 4.5.1-2: Forecast of Operational and Refurbishment L&ILW Packages

Container Type	Number of Containers	Emplaced Volume (m³)	Dimensions L×W×H (m)	Avg. Full Mass (kg)	Comments
Representative LLW Packages					
Bale Racks	1,383	4,702	2.29 × 1.22 × 1.2	1,400	—
Compactor Boxes	6,135	17,177	1.84 × 1.12 × 1.3	2,722	—
Non-Processible Bins	24,164	73,483	1.96 × 1.32 × 1.19	1,460	Volume/mass based on NPB47 container
Drum Racks	2,903	9,870	2.29 × 1.22 × 1.2	1,490	6 drums per Rack
Drum Bins	4,615	12,922	1.96 × 1.32 × 1.03	1,450	6 drums per Bin
LL Resin Pallet Tanks	2,085	5,627	1.24 × 1.24 × 1.68	2,000	Without overpack
LLW Container Overpacks	3,212	27,303	2.54 × 1.78 × 1.88	Max 5,400	Overpacking for 1,100 ash bins, 80 LL resin boxes, 1,709 ALW sludge boxes, and 323 drum racks
Shield Plug Containers	26	309	3.0 × 1.8 × 1.8	26,000	—
Heat Exchangers	98	2,775	Various e.g., 2 (OD) × 4.6 (OL)	10,000 – 30,000	Assume 25% of 98 heat exchangers will be segmented in half
Encapsulated Tile Hole	66	504	1.5 (OD) × 4.6 (OL)	25,000	—
Steam Generator Segments	512	8,387	1.8–3.6 (OD) × 2.0–4.3 (OL)	25,730	Does not include grout
Representative ILW Packages					
Resin Liners	286	858	1.63 (OD) × 1.8 (OL)	4,545	Does not include sacrificial pallet
Resin Liner Overpacks	400	1,640	1.68 (OD) × 1.91 (OL)	6,000	Does not include sacrificial pallet

Table 4.5.1-2: Forecast of Operational and Refurbishment L&ILW Packages (continued)

Container Type	Number of Containers	Emplaced Volume (m^3)	Dimensions L×W×H (m)	Avg. Full Mass (kg)	Comments
Resin Liner 250 mm Shield	646	10,467	2.2 (OD) × 4.25 (OL)	26,850	Two resin liners per shield
Resin Liner 350 mm Shield	164	3,295	2.4 (OD) × 4.45 (OL)	36,150	Two resin liners per shield
Resin Liner 350 mm Shield with Steel Insert	140	1,925	2.53 (OD) × 2.74 (OL)	28,965	One resin liner per shield
Alternative Tile Hole Equivalent Liner (ATHEL) Waste Package 350 mm Shield	300	4,140	2.53 (OD) × 2.74 (OL)	23,500	One ATHEL package per shield
Tile Hole Liners	201	176	0.61 (OD) × 3.4 (OL)	2,000	Without shield/rack
Retube Waste Containers	1,353	13,298	1.70 × 3.35 × 1.92	33,500	Volume/mass based on Bruce A RWC-EF container
ILW Shield	3,952	5,137	1.63 (OD) × 1.8 (OL)	2,290	Replaces T-H-E Liners
Total (rounded)	**52,600**	**204,000**	—	—	—

Notes:
OD = Outer Diameter
OL = Outer Length

As indicated in the table above, the waste packages encompass a variety of waste container types. In fact, there are currently in excess of 100 different waste containers used for storage of L&ILW at the WWMF (see Figure 4.5.1-2 for examples of some of these containers). The primary purpose of the waste container is to act as a convenient vessel to safely hold the waste during handling, transportation, and storage. It provides a uniform way to handle the waste and allows for stacking to improve storage efficiency. The container may also provide shielding for higher activity waste. The waste acceptance criteria (WAC) for the DGR Project are summarized following Figure 4.5.1-2. Details regarding treatment that some waste packages may require prior to being emplaced in the DGR are included in Section 4.8.2.1.

B25 Compacted Waste Box

DBIN Drum Bin

BINOPK LLW Container Overpack

NPB47 Non-Processible Waste Container

RLSS 3 m³ Resin Liner

SPC Shield Plug Container

RWC-EF Retube Waste Container – Endfittings

ETH Encapsulated RWOS 1 Tilehole

Figure 4.5.1-2: Examples of Waste Containers for Emplacement in DGR

All LLW and ILW will be transferred to the DGR in waste packages that meet the DGR WAC. The DGR WAC were developed to ensure that the wastes emplaced in the DGR are within the bounds of the safety assessment, design basis and regulatory requirements. The criteria are summarized in Table 4.5.1-3.

Table 4.5.1-3: Summary of Waste Acceptance Criteria

Criteria	Summary Description
Waste characterization	• physical, chemical, radiological characteristics of each package
Documentation	• waste packages must be tracked in OPG Integrated Waste Tracking System (IWTS) with waste characteristics, dose rates, and description of contents • verified load statements • supplemental info such as radiological surveys, chemical analyses, loading checklists • notes on package design documentation, such as drawings, technical specifications, and design requirements • transfer documents for wastes subject to additional controls
Acceptable waste package designs	• all DGR waste package designs must be approved
Condition of waste container	• no significant rusting • sound structural integrity • no leakage • no wobbling or tilting
Mass limits	• 35 Mg, subject to maximum design limit for each waste package type
Size limits	• must fit within internal dimensions of the DGR cage
Containment	• wastes and contamination shall be contained during handling • all containers shall have lids
Venting	• where the potential for gas build-up exists and containers are not designed to withstand the pressure, the containers shall be vented
Identification/labelling	• containers bar-coded with IWTS tracking number on two adjacent vertical sides • additional information including gross mass, dose rate, and significant non-radiological hazards to be marked on packaged with lettering at least 25 mm high
Stackability	• stable, self supporting stack of up to 6 m high • use of standard footprints strongly encouraged
Handling	• conventional material handling equipment such as forklifts with loads of up to 35 Mg
Fire resistance	• non-combustible containers

Table 4.5.1-3: Summary of Waste Acceptance Criteria (continued)

Criteria	Summary Description
Dose rate limits	• 2 mSv/h on contact with external surface of waste package or shielding • 0.1 mSv/h at 1 m from transportation package • exceptions approved by responsible health physicist
Radionuclide composition	• package amount must be reported for tritium, carbon-14, clorine-36, cobalt-60, strontium-90, zirconium-93, niobium-94, technetium-99, iodine-129, cesium-135, cesium-137, uranium-235, uranium-238, plutonium-239, plutonium-240, plutonium-241
Contamination limits	• removable surface contamination on package exterior to be less than 4 Bq/cm^2 beta-gamma and 0.4 Bq/cm^2 alpha when averaged over 300 cm^2
Heat load limits	• no restriction if less than 0.01 W/m^3 of waste package external dimensions • up to 10 W/m^3 by prior notification and approval for special cases
Waste form	• solids only • sludges must have slump of less than 150 mm
Residual liquids	• generally must be less than 1% free liquid by volume • bulk IX resins must be less than 5% free water by volume
Gas generation	• must not generate toxic gas on exposure to water
Excluded wastes	• reactive wastes, polychlorinated biphenyl (PCB) wastes, pathological wastes, ignitable wastes • explosives, corrosives, compressed gases • used nuclear fuel and recognizable fuel fragments • high thermal cobalt-60 sources
Special notice wastes	• wastes containing significant levels of Occupational Health and Safety Act (OHSA) designated substances • leachate toxic wastes
Chelating agents	• must be less than 1% by weight of package
Petroleum oils	• must be less than 1% by weight of package

4.5.2 Total Radionuclide Inventory of Waste

The radionuclide inventory described in this section includes the increase each year as more waste is emplaced in the DGR and the decrease each year attributable to decay. The total inventory estimate is based on assuming that the DGR will start operations in 2018 and be filled by around 2052, with 2062 as the assumed date for completing decommissioning. The estimated total decay corrected radionuclide inventory of operational and refurbishment L&ILW in the DGR at 2062 is summarized in Table 4.5.2-1. The values are based on the L&ILW

characteristics given in the Reference Inventory Report [30], and the projected L&ILW volumes calculated for each year (past and historical) with decay-correction. The results for the assumed repository decommissioning date of 2062 indicate the total radioactivity will be dominated by tritium (H-3), carbon-14, niobium-94 and nickel-63. A more complete listing of radionuclides in the waste is given in the Reference Inventory Report [30].

Table 4.5.2-1: Estimated L&ILW Radionuclide Inventory at 2062

Nuclide	Half-life [a] (a)	Operations LLW (Bq)	Operations ILW (Bq)	Refurbishment L&ILW (Bq)	Total (Bq)
Ag-108m	1.3E+02	3.3E+07	1.0E+09	2.0E+13	2.0E+13
Am-241	4.3E+02	5.5E+10	2.2E+11	2.1E+12	2.4E+12
Am-242m	1.5E+02	5.1E+07	0.0E+00	2.3E+09	2.4E+09
Am-243	7.4E+03	6.8E+07	1.7E+08	2.9E+09	3.1E+09
Ba-133	1.1E+01	7.1E+08	0.0E+00	0.0E+00	7.1E+08
C-14	5.7E+03	1.4E+12	5.4E+15	6.6E+14	6.1E+15
Cf-252	2.6E+00	1.2E+06	0.0E+00	0.0E+00	1.2E+06
Cl-36	3.0E+05	5.4E+08	7.4E+08	1.4E+12	1.4E+12
Cm-243	2.9E+01	0.0E+00	0.0E+00	2.7E+09	2.7E+09
Cm-244	1.8E+01	2.7E+09	7.0E+10	2.2E+11	2.9E+11
Co-60	5.3E+00	1.7E+11	3.5E+12	9.0E+14	9.0E+14
Cs-134	2.1E+00	5.6E+07	3.1E+10	3.1E+06	3.1E+10
Cs-135	2.3E+06	4.3E+06	1.3E+08	2.3E+08	3.6E+08
Cs-137 + Ba-137m [b]	3.0E+01	1.3E+13	9.4E+13	5.4E+11	1.1E+14
Eu-152	1.3E+01	3.7E+07	1.5E+12	1.2E+09	1.5E+12
Eu-154	8.8E+00	7.1E+09	1.2E+11	3.2E+09	1.3E+11
Eu-155	5.0E+00	5.1E+07	1.7E+09	3.3E+08	2.1E+09
Fe-55	2.7E+00	3.8E+10	3.8E+11	5.5E+13	5.5E+13
H-3	1.2E+01	8.5E+14	1.5E+14	4.8E+12	1.0E+15
I-129	1.6E+07	1.2E+06	1.3E+08	1.0E+06	1.3E+08
Ir-192m	2.4E+02	0.0E+00	4.9E+07	1.1E+10	1.1E+10
Mn-54	8.6E-01	0.0E+00	0.0E+00	2.7E+02	2.7E+02
Mo-93	3.5E+03	0.0E+00	4.5E+08	1.0E+12	1.0E+12

Table 4.5.2-1: Estimated L&ILW Radionuclide Inventory at 2062 (continued)

Nuclide	Half-life [a] (a)	Operations LLW (Bq)	Operations ILW (Bq)	Refurbishment L&ILW (Bq)	Total (Bq)
Nb-93m	1.4E+01	0.0E+00	2.9E+10	9.2E+12	9.2E+12
Nb-94	2.0E+04	2.2E+10	1.2E+11	4.6E+15	4.6E+15
Ni-59	7.5E+04	2.1E+09	3.6E+11	3.6E+13	3.6E+13
Ni-63	9.6E+01	2.4E+11	3.9E+13	3.9E+15	3.9E+15
Np-237	2.1E+06	3.2E+06	1.1E+07	1.2E+08	1.3E+08
Pb-210	2.2E+01	3.2E+10	0.0E+00	0.0E+00	3.2E+10
Pt-193	5.0E+01	0.0E+00	3.1E+09	1.1E+13	1.1E+13
Pu-238	8.8E+01	8.5E+09	2.7E+10	4.6E+11	5.0E+11
Pu-239	2.4E+04	2.2E+10	7.7E+10	8.2E+11	9.2E+11
Pu-240	6.5E+03	3.0E+10	1.1E+11	1.2E+12	1.3E+12
Pu-241	1.4E+01	6.8E+10	1.6E+12	1.9E+11	1.9E+12
Pu-242	3.8E+05	3.2E+07	1.0E+08	1.2E+09	1.3E+09
Ra-226	1.6E+03	3.8E+09	0.0E+00	0.0E+00	3.8E+09
Ru-106	1.0E+00	3.0E+06	1.5E+08	0.0E+00	1.5E+08
Sb-125	2.8E+00	3.4E+08	1.8E+11	3.9E+11	5.7E+11
Se-79	3.8E+05	1.5E+06	4.5E+06	1.3E+10	1.3E+10
Sm-151	9.0E+01	1.0E+07	3.2E+08	1.7E+09	2.0E+09
Sn-119m	8.0E-01	0.0E+00	0.0E+00	2.4E+01	2.4E+01
Sn-121m	5.5E+01	0.0E+00	5.9E+11	7.7E+13	7.8E+13
Sn-126	2.1E+05	2.3E+07	7.0E+08	1.2E+07	7.4E+08
Sr-90 + Y-90[b]	2.9E+01	3.0E+12	4.2E+13	9.3E+12	5.4E+13
Tc-99	2.1E+05	5.2E+07	8.4E+08	6.0E+10	6.1E+10
U-232	7.2E+01	4.9E+06	0.0E+00	2.3E+08	2.3E+08
U-233	1.6E+05	6.6E+06	0.0E+00	3.1E+08	3.2E+08
U-234	2.5E+05	3.6E+07	1.1E+08	1.3E+09	1.4E+09
U-235	7.0E+08	5.6E+05	1.9E+06	2.1E+07	2.3E+07
U-236	2.3E+07	6.4E+06	2.1E+07	2.5E+08	2.8E+08
U-238	4.5E+09	4.2E+09	1.4E+08	1.7E+09	6.0E+09

Table 4.5.2-1: Estimated L&ILW Radionuclide Inventory at 2062 (continued)

Nuclide	Half-life [a] (a)	Operations LLW (Bq)	Operations ILW (Bq)	Refurbishment L&ILW (Bq)	Total (Bq)
Zr-93	1.5E+06	1.6E+06	6.7E+11	2.1E+14	2.1E+14
Total		**8.7E+14**	**5.7E+15**	**1.1E+16**	**1.7E+16**

Notes:
a Isotope half-life in years
b Activity listed is total for parent plus progeny in secular equilibrium
0.0E+00 indicates value is not significant.

Figures 4.5.2-1 and 4.5.2-2 display the time dependence of the projected L&ILW inventory. As shown, the LLW radioactivity decreases relatively quickly because of the tritium. ILW decays more slowly due primarily to the presence of carbon-14 in the ILW resins. The peak refurbishment wastes inventory is assumed to occur in 2020, coinciding with the forecasted end of retubing activities followed by the decay of iron-55. After a few hundred years, the total DGR radioactivity will be dominated by carbon-14 and niobium-94, and eventually zirconium-93.

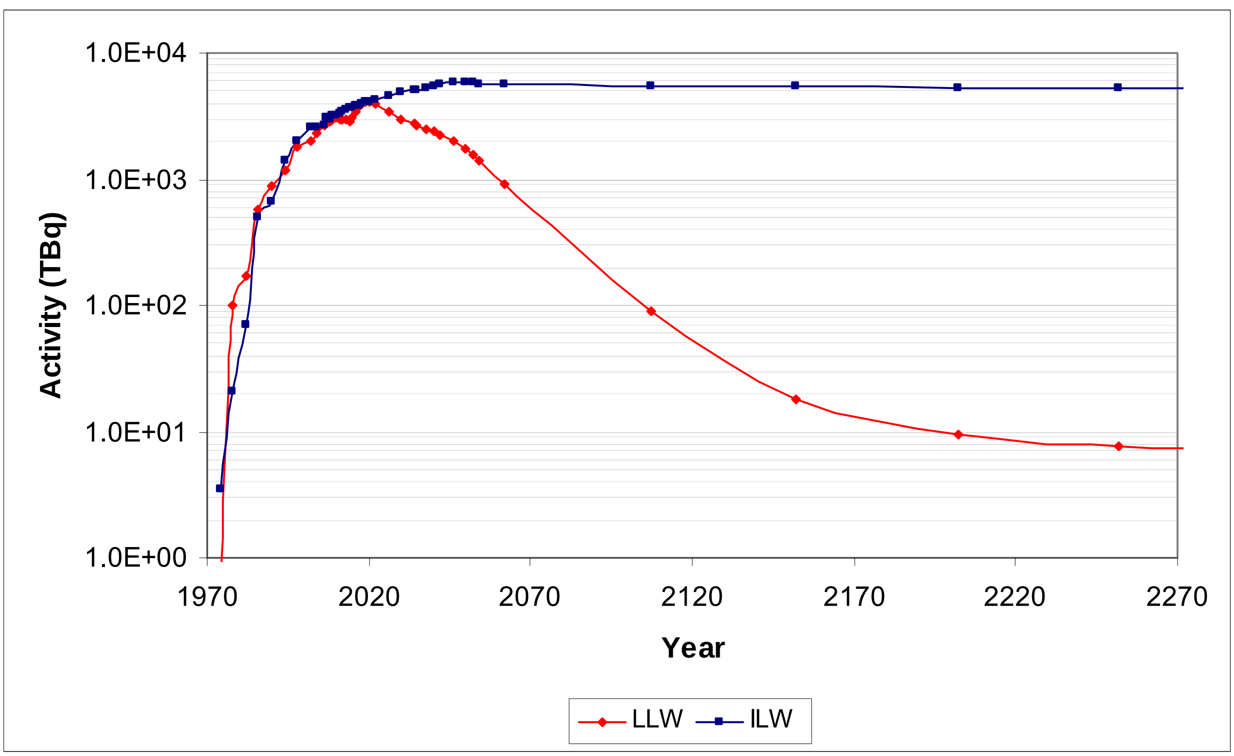

Figure 4.5.2-1: Change in Radioactivity for Operational L&ILW as a Function of Time

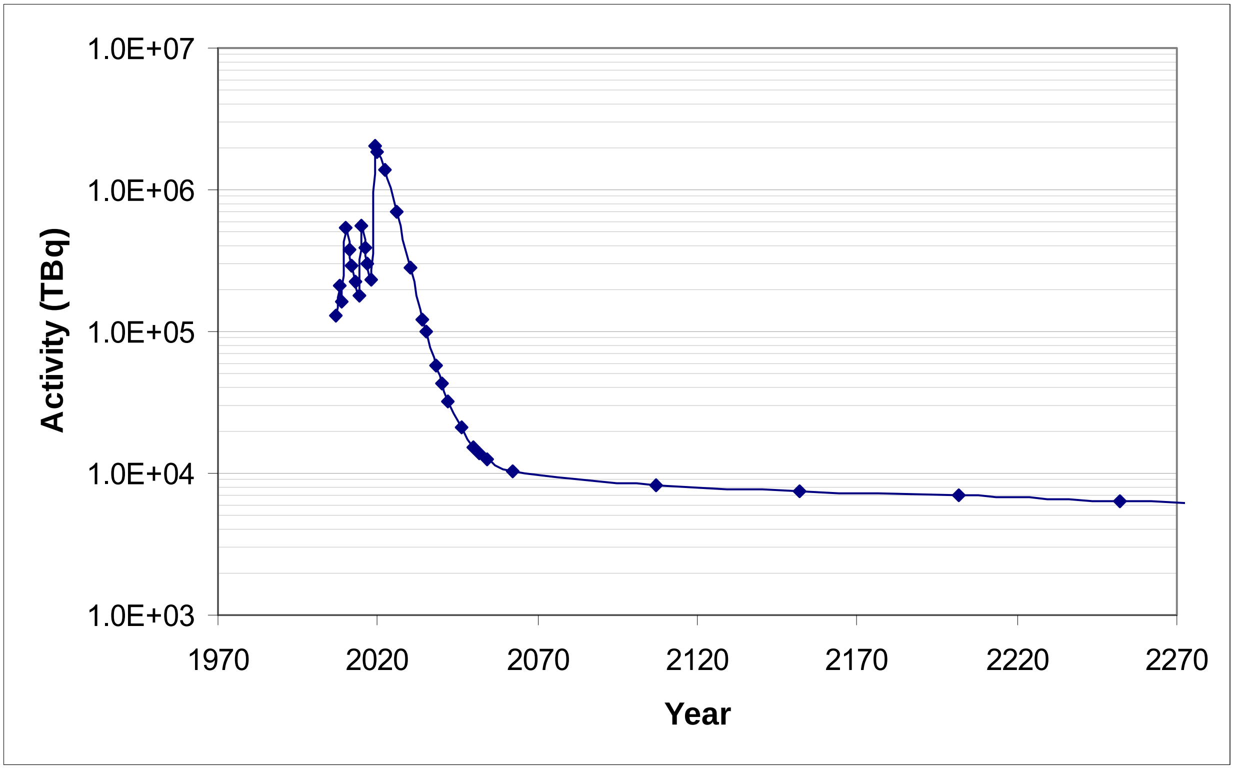

Figure 4.5.2-2: Change in Radioactivity for Refurbishment L&ILW as a Function of Time

One important radiological characteristic of the wastes to be emplaced in the DGR is that they are non-fissile. As noted previously, used fuel and recognizable fuel fragments will not be accepted for emplacement. The amount of fissile radionuclides that will be present in the DGR will be small, and will be dispersed across approximately 200,000 m^3 waste (emplaced volume) in many separate packages in different emplacement rooms. In particular, the total mass of plutonium-239 and plutonium-241 is estimated at 0.4 kg, and the plutonium will not be present in pure form in any location.

Similarly, the total mass of fissile uranium-235 at the time of repository closure is approximately 1 kg. Most of this uranium-235 is present in trace amounts from failed fuel and from depleted uranium shielding. Fissile uranium present in the waste is dispersed within the DGR and is mostly diluted in uranium-238 at less than natural isotopic concentrations.

Taking the preceding paragraphs into consideration, criticality is not a credible scenario for the DGR Project.

4.5.3 Chemical Inventory of Wastes

Most of the wastes to be emplaced into the DGR are normal industrial materials, which are further described in Section 4.5.4. The L&ILW may contain varying amounts of chemicals or elements that can be hazardous. These include asbestos (originally used as insulating material in some stations), heavy metals like uranium, cadmium, mercury, chromium, and lead, and certain organic materials such as polycyclic aromatic hydrocarbons (PAHs), chlorinated benzenes and phenols, and dioxins and furans produced in the incinerator and trapped in the ash. There are also metals like chromium, nickel, and lead that are present in container materials (i.e., stainless steel, lead shielding).

The main chemical (non-radioactive) components of the operational and refurbishment L&ILW are summarized in Table 4.5.3-1. The DGR will not accept liquid wastes (except for small amounts of incidental liquids associated with the solid wastes), highly reactive or pressurized wastes.

Table 4.5.3-1: Chemical Inventory of Operational and Refurbishment L&ILW

Element/Species	Operations LLW (kg)	Operations ILW (kg)	Refurbishment L&ILW (kg)	Total (kg)
Aluminum	2.8E+05	3.8E+03	6.6E+02	2.8E+05
Antimony	3.2E+03	2.0E+00	2.2E+01	3.2E+03
Arsenic	2.8E+02	1.2E+01	1.3E+02	4.3E+02
Barium	9.4E+03	1.6E+02	1.1E-02	9.6E+03
Beryllium	1.1E+02	2.1E+01	5.2E-03	1.3E+02
Bismuth	5.4E+00	5.2E+00	5.6E-02	1.1E+01
Boron	1.5E+03	5.2E+03	2.4E+00	6.7E+03
Bromine	1.3E+02	4.2E-01	4.5E-02	1.3E+02
Cadmium	1.1E+04	1.9E+01	7.9E-01	1.1E+04
Calcium	3.5E+05	4.1E+03	2.3E+01	3.5E+05
Cerium	1.3E-01	8.2E-02	7.1E-02	2.8E-01
Cesium	5.5E-01	2.1E-01	1.6E-02	7.7E-01
Chlorine	8.2E+04	4.9E+03	2.6E+00	8.7E+04
Chromium	4.1E+05	3.6E+04	5.4E+05	9.8E+05
Cobalt	3.4E+02	2.2E+01	2.8E+02	6.4E+02
Copper	3.3E+06	4.0E+03	3.0E+03	3.4E+06
Fluorine	0.0E+00	1.3E+02	2.4E+00	1.3E+02
Gadolinium	0.0E+00	5.4E+03	6.7E+01	5.5E+03
Hafnium	0.0E+00	0.0E+00	2.6E+02	2.6E+02
Iodine	6.6E+01	1.1E-01	8.8E-03	6.6E+01
Iron	7.9E+06	9.0E+05	1.1E+07	2.0E+07

Table 4.5.3-1: Chemical Inventory of Operational and Refurbishment L&ILW (continued)

Element/Species	Operations LLW (kg)	Operations ILW (kg)	Refurbishment L&ILW (kg)	Total (kg)
Lead	1.5E+06	2.8E+02	3.8E+00	1.5E+06
Lithium	4.5E+01	5.9E+03	1.3E-02	5.9E+03
Magnesium	7.2E+04	9.1E+02	4.7E+00	7.3E+04
Manganese	6.8E+05	6.2E+03	1.6E+05	8.5E+05
Mercury	6.8E+01	2.9E-01	8.7E-02	6.9E+01
Molybdenum	2.2E+02	4.8E+01	9.3E+02	1.2E+03
Nickel	3.0E+04	4.5E+04	1.6E+06	1.7E+06
Niobium	1.0E+02	0.0E+00	1.2E+04	1.2E+04
Phosphorus	1.1E+05	3.3E+03	6.0E+02	1.1E+05
Potassium	1.1E+04	1.5E+03	8.7E-02	1.3E+04
Rubidium	2.4E-01	0.0E+00	1.4E-01	3.8E-01
Scandium	2.3E+01	5.6E-02	5.6E-01	2.3E+01
Selenium	8.1E+01	4.9E+00	1.8E-01	8.6E+01
Silicon	3.2E+06	9.4E+04	7.7E+03	3.3E+06
Silver	5.1E+00	9.7E-01	1.2E+00	7.3E+00
Sodium	2.1E+05	1.2E+04	9.3E-02	2.2E+05
Strontium	3.2E+03	3.3E+01	1.7E-01	3.2E+03
Sulphur	2.0E+05	3.0E+05	3.1E+00	5.0E+05
Tellurium	2.0E+02	0.0E+00	6.6E-02	2.0E+02
Thallium	2.4E-01	2.8E-01	2.3E-02	5.4E-01
Thorium	5.5E+00	1.8E+00	1.1E-01	7.7E+00
Tin	1.4E+02	1.6E+01	2.4E+03	2.5E+03
Titanium	1.5E+05	3.3E+01	8.8E+01	1.5E+05
Tungsten	1.2E+00	1.0E+01	1.3E+02	1.5E+02
Uranium	3.4E+02	2.4E+01	1.4E+02	4.9E+02
Vanadium	9.0E+01	4.3E+00	9.5E+02	1.0E+03
Zinc	1.5E+05	2.0E+03	1.6E+01	1.5E+05
Zirconium	7.4E+02	1.2E+00	6.0E+05	6.0E+05
Asbestos	3.0E+05	0.0E+00	0.0E+00	3.0E+05
EDTA	0.0E+00	4.8E+04	0.0E+00	4.8E+04

Table 4.5.3-1: Chemical Inventory of Operational and Refurbishment L&ILW (continued)

Element/Species	Operations LLW (kg)	Operations ILW (kg)	Refurbishment L&ILW (kg)	Total (kg)
PAH	3.4E+00	0.0E+00	0.0E+00	3.4E+00
Cl-Benzenes & Cl-Phenols	2.8E+00	0.0E+00	0.0E+00	2.8E+00
Dioxins & Furans	9.3E-02	0.0E+00	0.0E+00	9.3E-02
PCB	1.3E-01	0.0E+00	0.0E+00	1.3E-01

Notes:
Does not include full amount of common elements, especially carbon, hydrogen, oxygen and nitrogen.
EDTA Ethylenediaminetetraacetic acid
PAH Polycyclic aromatic hydrocarbons
PCB Polychlorinated biphenyls
0.0E+00 indicates value is not significant.

4.5.4 Physical and Chemical Characteristics of the Bulk Material Inventory

The physical composition of most of the waste is normal industrial materials. The bulk material compositions in the LLW, ILW, and Refurbishment L&ILW to be emplaced in the DGR are shown in Tables 4.5.4-1, 4.5.4-2 and 4.5.4-3, respectively. Figure 4.5.4-1 shows the relative distribution of waste by mass.

Over long periods of time, it is expected that the wastes and their containers will degrade. The various metals present will degrade into inorganic salts, oxides or minerals consistent with the local saline, reducing conditions that are present at the DGR Project site (refer to Section 6.2 for a description of the relevant existing conditions). The organic materials will degrade into simpler compounds under microbially-mediated reactions that will be slow under the saline, reducing environment. The degradation products will encompass a wide range of compounds from simple volatile species like methane to recalcitrant bitumen-type compounds. The potential effects of the key chemical elements and species were assessed as part of the Postclosure Safety Assessment [27] and the Preliminary Safety Report [26].

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Table 4.5.4-1: Inventory of Bulk Materials in LLW

Waste Type	Ash (kg)	Cellulose (kg)	Rubber (kg)	Plastics (kg)	Resins[a] (kg)	Bitumen (kg)	Other Organic (kg)	Carbon Steel (kg)	Stainless Steel (kg)	Other Metal (kg)	Concrete (kg)	Other Inorganics (kg)
Bottom Ash	1.2E+06	—	—	—	—	—	—	—	—	—	—	—
Baghouse Ash	1.4E+05	—	—	—	—	—	—	—	—	—	—	—
Compact Bales	—	4.9E+05	1.2E+05	6.4E+05	—	—	5.2E+04	2.6E+05	—	—	—	—
Box Compacted	—	4.0E+06	9.9E+05	5.2E+06	—	—	4.2E+05	2.1E+06	—	—	—	—
Non-Processible	—	2.2E+06	2.6E+05	6.4E+05	—	1.9E+05	2.6E+05	1.3E+06	1.4E+06	3.4E+06	7.7E+05	3.6E+06
Non-processible Drummed	—	4.9E+05	9.4E+04	2.4E+05	—	—	3.3E+05	4.7E+05	4.7E+05	—	2.8E+05	1.3E+06
Non-processible Other	—	—	—	—	1.6E+04	—	—	4.8E+03	—	—	—	—
LL /ALW Resin	—	—	—	—	1.5E+06	—	—	—	—	—	—	—
ALW Sludge	—	—	—	—	—	—	—	—	—	—	—	4.0E+06
TOTAL	**1.3E+06**	**7.2E+06**	**1.5E+06**	**6.7E+06**	**1.5E+06**	**1.9E+05**	**1.1E+06**	**4.1E+06**	**1.9E+06**	**3.4E+06**	**1.1E+06**	**8.9E+06**

Notes:
a Resin weight does not include bound water (approximately 40% by weight) or interstitial water.
— Not applicable

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Table 4.5.4-2: Inventory of Bulk Materials in ILW

Waste Type	Total Mass (kg)				
	Resins	**Carbon Steel**	**Stainless Steel**	**Inorganics**	**Plastic**
ILW Resin (PHT, Moderator, Misc., CANDECON)	3.7E+06	—	—	—	—
IX Columns	1.9E+05	4.0E+05	—	—	—
Filters and Filter Elements	—	5.0E+05	9.2E+04	7.4E+04	9.8E+04
Irradiated Core Components	—	1.3E+04	4.8E+02	—	—
TOTAL	**3.9E+06**	**9.1E+05**	**9.2E+04**	**7.4E+04**	**9.8E+04**

Notes:
ILW resin weight does not include bound water (approximately 40% by weight) or interstitial water.
— Not applicable

Table 4.5.4-3: Inventory of Bulk Materials in Refurbishment L&ILW

Waste Type	Total Mass (kg)				
	Zircaloy	**Carbon Steel**	**Stainless Steel**	**Other Metals**	**Concrete**
Pressure Tubes	4.4E+05	—	—	—	—
Calandria Tubes	1.7E+05	—	—	—	—
Calandria Tube Inserts	—	—	2.1E+04	—	—
End Fittings	—	—	2.3E+06	—	—
Steam Generators	—	8.4E+06	—	2.8E+06	1.9E+06
TOTAL	**6.1E+05**	**8.4E+06**	**2.3E+06**	**2.8E+06**	**1.9E+06**

Note:
— Not applicable

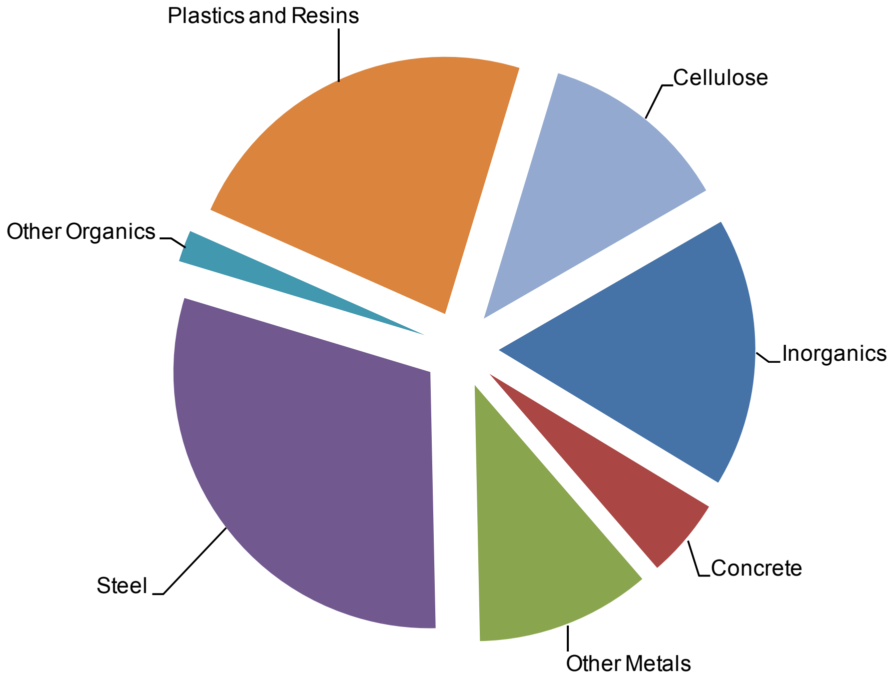

Figure 4.5.4-1: Mass of Main Waste Materials Planned for Emplacement in the DGR

4.6 PROJECT PHASES

For the purpose of this assessment, the DGR Project is divided into four phases, as named in the bulleted list, below. An overall DGR Project timeline is shown on Figure 4.2-1. This approach is consistent with the EIS Guidelines. The DGR Project phases are as follows:

- Site preparation and construction phase, which includes all activities associated with developing the DGR Project up until operations commence with the placement of waste. This phase is expected to last five to seven years. The works and activities in this phase are described in Section 4.7.
- Operations phase, which includes the period during which waste is emplaced in the DGR, as well as a period of monitoring prior to the initiation of decommissioning activities. This phase is expected to last approximately 40 to 45 years, with waste being placed for the first 35 to 40 years and the subsequent monitoring carried out for a period that would be decided at some future time in consultation with the appropriate authority. The works and activities during this phase are described in Section 4.8.
- Decommissioning phase, which includes dismantling surface buildings and sealing the shafts, is expected to begin immediately following operations and to take approximately five to six years to complete. The activities associated with this phase are described in Section 4.11.

- Abandonment and long-term performance phase, which begins once decommissioning is completed. This phase includes institutional controls for a period up to three hundred years, and is described in Section 4.12.

The following sections describe the main works and activities that are expected to occur during the different DGR Project phases. The descriptions of the DGR Project works and activities are focused on identifying and characterizing aspects of the DGR Project that have the potential to interact, and thus result in a likely change to the surrounding environment during site preparation and construction, operations, and decommissioning of the DGR Project. The abandonment and long-term performance phase of the DGR Project is also described at a conceptual level; however, there are no specific works and activities during this phase.

Credible malfunctions, accidents, and malevolent acts postulated for consideration in this assessment are described in Section 4.13.

The information provided in the following sections provides the Basis for the EA, which is presented in Section 4.18. Several DGR Project works and activities identified in the Basis for the EA are not discussed in the following sections since they are not specifically related to design aspects of the DGR Project. For example, the "presence of the DGR facility" work and activity is linked to intangible feelings people may associate with the existence of the DGR Project within their community. Similarly, certain activities addressed under specific DGR Project works and activities in the basis table (Table 4.18-1) are not discussed in the following sections since, again, they are not design features of the DGR Project.

4.7 SITE PREPARATION AND CONSTRUCTION PHASE

All surface facilities and underground facilities will be constructed during the site preparation and construction phase. A high-level schedule for construction is shown on Figure 4.7-1. For shaft sinking, the two headframes will be constructed, complete with the ventilation shaft hoist house, intake fans, heater house and the exhaust fan building. Temporary hoist houses for the main shaft sinking hoist and sinking winches for both shafts will be constructed. Temporary systems are used for ventilation during shaft sinking. The permanent intake fans, heater house and exhaust fans will be installed after shaft sinking.

An environmental management plan (Section 4.7.8.7) will be implemented for site preparation and construction to control environmental effects associated with above-ground construction activities. The environmental management plan will be similar to that used in other recent construction projects at the WWMF and includes measures such as water spraying to control dust, vehicle maintenance standards to reduce noise and emissions, and scheduling of certain activities during daylight hours.

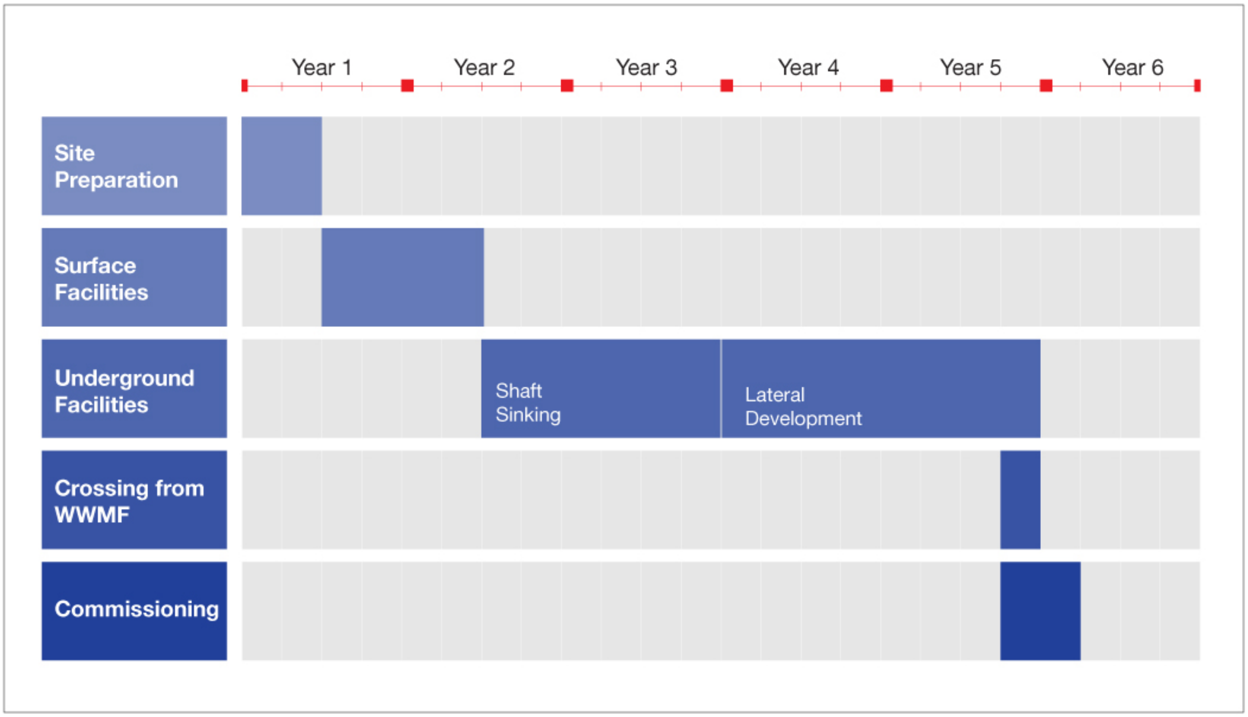

Figure 4.7-1: Conceptual Schedule for Site Preparation and Construction Activities

4.7.1 Site Preparation

Site preparation involves the preparation of the site infrastructure for construction activities. Site preparation will begin following receipt of a licence to prepare the site and construct the DGR, and includes clearing approximately 30 ha of the DGR Project site and preparing the construction laydown areas. The site preparation activities will take approximately six months to complete. Infrastructure, such as waste rock and stormwater management areas and roads, will also be constructed as part of site preparation activities. A workforce of approximately 10 heavy equipment operators is required to complete these activities.

Site preparation activities include earth-moving activities and conventional civil construction activities. Equipment typically used in these activities is shown in Table 4.7.1-1. Note this equipment is not required over the full duration of these activities. A feller buncher and chipper are also used for clearing treed areas of the site.

Table 4.7.1-1: Equipment Used in Site Preparation Activities

Typical Equipment	Estimated Quantity
Excavator	1
Front End Loader	1
Bulldozer	1
Articulated Rubber-tired Truck	2
Compactors	1
Grader	1
Feller Buncher	1
Paver	1

Specific activities associated with site preparation include the following:

- removing brush and trees and transferring for storage or use as mulch on OPG-retained lands;
- excavating, removing and stockpiling topsoil for later use elsewhere on the DGR Project site or on other OPG-retained lands on the Bruce nuclear site;
- grading the DGR Project site, including grading of construction access roads, construction laydown areas, the WRMA and various building locations;
- constructing the site drainage system including excavating all ditches and constructing the stormwater management pond; and
- implementing a ground improvement program (grouting), if required, for the main shaft and ventilation shaft in advance of shaft sinking to control potential groundwater inflows.

It is not anticipated that blasting is required to complete site preparation activities, and explosives will not be on-site until excavation activities are initiated.

Although line power should be available at the start of the site preparation and construction phase, diesel generators may be used for emergency back-up power. During this time period, fuel will be stored within the construction island (Section 4.7.5.2).

4.7.1.1 Land Clearing, Grubbing and Site Grading

The total land area to be cleared is approximately 30 ha, some of which is treed. Where required, trees will be felled, skidded and piled in the cut area, and if salvageable, chipped and reused for landscaping on the DGR Project site or elsewhere on the Bruce nuclear site. Unsalvageable cuttings may be disposed of by chipping or piling. Roots, stumps, embedded logs and debris will be removed by grubbing and disposed of according to existing management practices. Stripping of the soil is required to remove top soil and organic material, where necessary. The top soil will be protected and kept in segregated piles until it is reused for finished grading. Grading will be completed for stormwater drainage (Sections 4.4.1.5 and 4.7.1.3), waste rock storage (Section 4.4.1.3 and 4.7.5.3), and building locations.

4.7.1.2 DGR Site Access

All personnel and materials necessary to implement each phase of the DGR Project will arrive through the main gates to the Bruce nuclear site, where access is controlled by Bruce Power security staff. The entire DGR construction island, including the WRMA, will be fenced to isolate the DGR Project from other OPG, Bruce Power, AECL and Hydro One facilities. A separate gated entrance to the DGR Project site will be established directly off the Interconnecting Road and/or a new road along the abandoned rail bed to the east of the DGR Project site. There is no direct connection with the WWMF during site preparation and the majority of construction. The construction entrance(s) will not regularly be used after construction, but will remain available throughout operations.

As part of site preparation, granular construction roads will be installed for access to the main and ventilation shafts, and the construction laydown, waste rock management, and stormwater management pond areas. Additionally, temporary construction roads will be established for accessing trailers and material storage. The construction roads are designed to accommodate heavy construction traffic and maximize construction laydown areas, including the concrete batch plant. The location of the construction entrance(s) and roads are shown on Figure 4.7.1-1.

4.7.1.3 Site Drainage and Stormwater Management

A network of trapezoidal drainage ditches will be constructed around the DGR Project site including the perimeter of the WRMA. These trapezoidal ditches will be vegetated to reduce erosion. Vegetation will be managed to ensure that it does not hinder the flow of stormwater through the drainage ditch network. As noted in Section 4.4.1.5, the entire drainage network established for the DGR Project directs run-off to a stormwater management pond, shown on Figure 4.4.1-2. The specific geometry of the stormwater management pond will be determined during detailed design. Section 4.4.1.5 also provides additional detail on the stormwater management pond.

During site preparation, surface run-off that drains to the ditch along the abandoned rail bed (the North Railway Ditch) under existing conditions will be redirected into the aforementioned drainage ditch network. This design ensures that no run-off from the DGR Project is allowed to discharge into portions of the existing drainage network that interconnect with Stream C. No re-alignment of the existing drainage ditch network servicing the WWMF and the Bruce nuclear site is planned as part of the DGR Project. If necessary, improvements will be made to the existing drainage network downstream of the stormwater management pond discharge location to ensure unobstructed flow of water to Lake Huron (via MacPherson Bay). These improvements could include replacing the existing culverts beneath the Interconnecting Road, and cleaning and/or enlarging the existing ditch between the Interconnecting Road and Lake Huron.

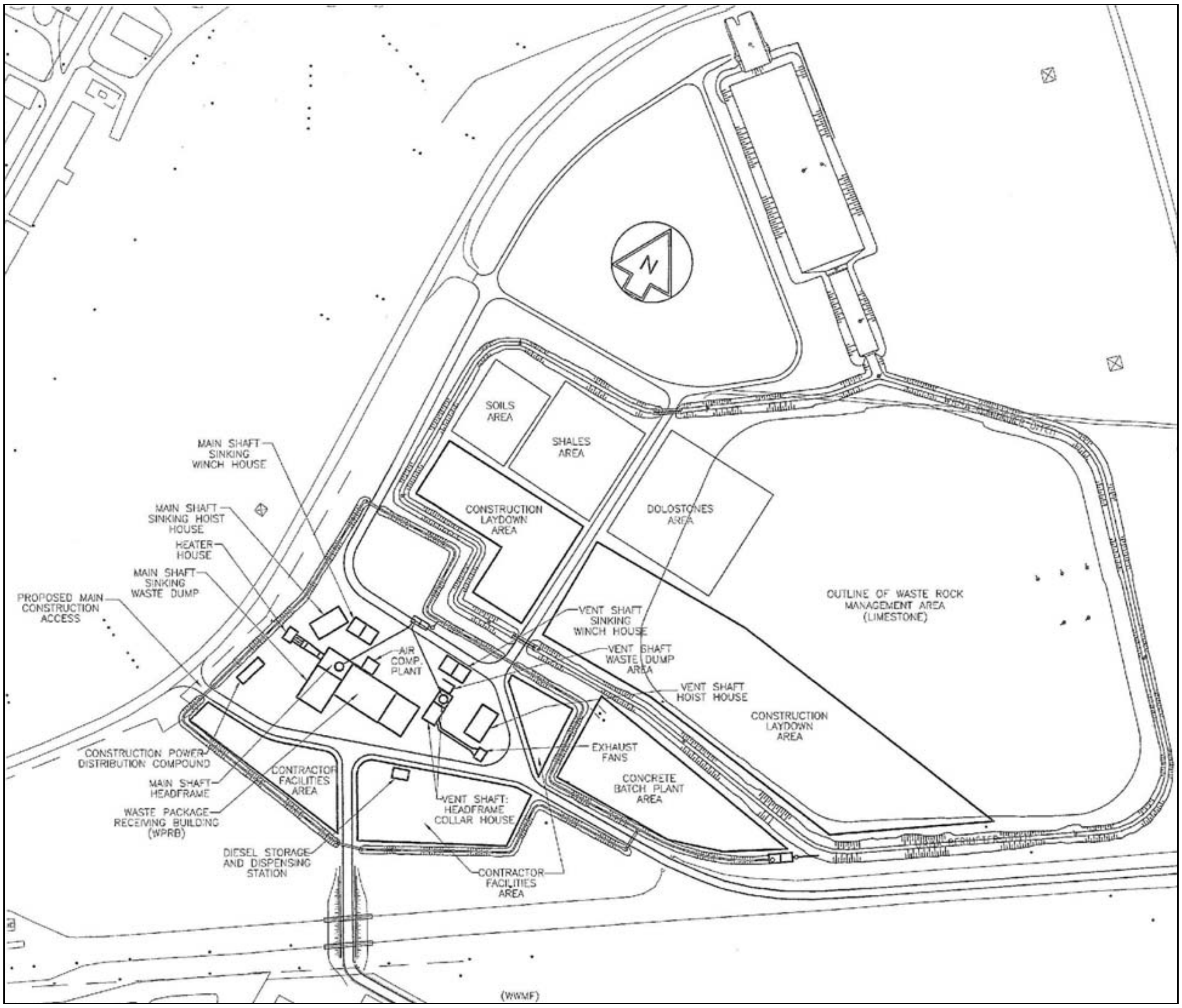

Figure 4.7.1-1: Site Preparation and Construction Phase Layout

4.7.2 Workers, Payroll and Purchasing

4.7.2.1 Construction Labour

Shaft sinking and underground development will be performed on a 24/7 basis over 350 days per year. Table 4.7.2-1 summarizes the expected averaged labour requirements during construction including contractors. Allowance is made for reduced productivity during winter to account for extreme weather conditions that could halt external activities for short durations of time. However, further planning can enable the heavy construction work to be scheduled for summer months with internal works (e.g., headframe furnishings, hoist installation) performed in winter.

The construction is planned over five to seven years and has a variable labour force depending on the number of parallel activities being performed. The averaged labour force over the duration of the phase is in the order of 160, with peak manpower expected to be close to 200 persons.

Table 4.7.2-1: Ranges of Labour Requirements for the Site Preparation and Construction Phase

Category	Number of Workers
DGR Project and Construction Management	30 – 40
Technical Support Staff	10 – 20
Miner	100 – 130
Surface Equipment Operator	10 – 20
Skilled Trade	60 – 80
General Labour	40 – 60

The construction of the DGR facility will be regulated under Ontario's Occupational Health and Safety Act. Given the nature of the DGR Project, it is expected that the Ontario Ministry of Labour will administer their regulatory supervision of the DGR Project primarily under the Mines and Mining Plants Regulation, RRO 1990, O. Reg 854 [29].

4.7.2.2 DGR Project-related Traffic

It is expected that most construction workers will reside in the Local and Regional Study Areas while employed by the DGR Project. Conservatively, it is assumed workers will commute to the DGR site using their own vehicle; however, in reality some people may choose to carpool or possibly bicycle. In addition to DGR Project worker-related traffic, it is assumed that up to 10 trucks per day will be used to ship materials on and off the DGR Project site throughout the site preparation and construction phase.

4.7.2.3 Construction Capital Costs

Capital costs for the DGR Project are incurred while the facility is under construction. These include expenditures on necessary equipment, engineering, and labour. For the purposes of the EA, a capital cost for the site preparation and construction phase of $1,000,000,000 (CAD, 2010$) is used. Of this total cost, about one fifth is attributed to labour expenditures and one tenth is associated with equipment expenditures. The remaining costs represent contract lump sums, consumables, and undefined allowances.

4.7.3 Construction of Surface Facilities

The key surface structures are the Waste Package Receiving Building (WPRB), the headframes and hoisting structures, and the ventilation complexes. Since shaft sinking is planned to occur 24/7, 350 days per year, a temporary heating and fan house is installed to provide controlled air temperatures to the shaft crew.

Surface construction methods will be consistent with those used for typical light industrial buildings. A concrete batch plant will be established to support construction activities. The pre-sink activities (shaft collars) will require dewatering, and the infrastructure for shaft sinking dewatering will be established at that time. All other building foundations will be well above grade in comparison and will not require dewatering.

The proposed layout of the site preparation and construction phase surface facilities is shown on Figure 4.7.1-1. A description of the DGR Project site utilities is provided in Section 4.4.3.

4.7.3.1 Permanent Surface Structures

After completion of shaft sinking, the temporary structures associated with sinking activities (e.g., temporary main shaft sinking hoist house, main shaft and ventilation shaft winch houses) will be removed. The main shaft headframe will be furnished for the permanent operations including installation of the main and auxiliary Koepe hoists. Figure 4.4.1-2 illustrates the main surface infrastructure in place for the operations phase, including the crossing from the WWMF to the DGR Project site. This crossing is briefly introduced in Section 4.4.1.4, and is described in more detail in Section 4.7.3.3, below.

4.7.3.2 Temporary Structures

All temporary structures will be removed from the site following completion of construction activities. In addition to the structures identified in Section 4.7.3.1, the temporary offices, fuel storage, storage structures and concrete batch plant will be removed from the DGR Project site.

4.7.3.3 Site Access and Roadways

Roadways will be developed to support construction activities as required. The majority of site preparation and construction phase roads will be granular, and will be maintained with graders and water trucks to manage fugitive dust. Following the majority of underground development and waste rock management, permanent roads on the DGR Project site and the connection to the WWMF will be constructed. The majority of permanent roads in the main facilities area will be paved.

The crossing from the WWMF provides short, direct access between the WWMF and the DGR, and is designed to support the maximum weight of transport packages and vehicles. It is expected the crossing will be a two-lane road situated on a fill embankment, with culverts to accommodate water flow, over the existing ditches and abandoned rail bed. Excavated material from shaft sinking and lateral development will be used as embankment fill material. The assumed general layout of the crossing is shown on Figure 4.7.3-1. The location of the crossing is shown on Figure 4.4.1-2.

A 20 m width embankment will accommodate wide road lanes (4 m minimum), shoulders (1.5 m minimum), walking area (2 m on each side), and adequate space for snow storage (1.5 m minimum) during winter operations, and a concrete barrier (1 m) on both sides of the road.

These works will be undertaken towards the end of the site preparation and construction phase (Figure 4.7-1) so that operations roads are not damaged during construction activities. This scheduling also maintains the isolation of the DGR Project site from operating OPG facilities. The work carried out directly within the two ditches along the abandoned rail bed is expected to be completed in several days, limiting the period of direct disturbance to the aquatic habitat and its associated biota.

4.7.4 Excavation and Construction of Underground Facilities

4.7.4.1 Shaft Excavation

Pre-sink activities for the main and ventilation shafts will commence near the end of the first year of construction. The main shaft and ventilation shaft will be excavated in parallel to depth.

The depth of the overburden layer in the area of the shafts is in the range of 10 to 14 m. Construction of the shaft collars through the overburden will be done using conventional civil construction methods (e.g., excavator, bulldozer and trucks). The overburden will be removed to the bedrock contact and sloped to maintain a safe excavation. The shaft collar will be excavated, formed and poured, and the excavation backfilled with the exception of the plenum location to allow for its construction.

The shafts will be excavated using controlled drill and blast techniques. Blasting activities are designed to address the specific requirements of the Bruce nuclear site regarding noise and vibration impacts. Explosives handling will be done in accordance with the Ministry of Natural Resources and Ontario Mining Regulations and considers handling of explosives on-site, both for surface and underground usage, as well as underground storage. Chapter 6 of the Preliminary Safety Report provides details on the underground powder magazine and detonator magazine, including locations. The expected quantity of explosives stored underground will be in the range of 30 to 40 tonnes. Appendix I (Vibrations) of the Atmospheric Environment TSD provides detail regarding the use of explosives for shaft development. Final support of the shafts is cast-in-place concrete liners for the full depth of the shaft. The liner is designed to control water.

The upper 180 m of dolostones at the two shaft locations is expected to be permeable, which may lead to groundwater inflows that could impede shaft construction. If necessary, ground improvement techniques will be employed in advance of sinking activities (i.e., grouting or freezing) to limit groundwater inflows during shaft construction. As the shaft advances, holes will be drilled ahead of the excavated face, probing for permeable zones with potentially high groundwater inflow rates. Should such zones be encountered, cover grouting can be performed in advance of the shaft bottom in these permeable zones, allowing shaft excavation to continue.

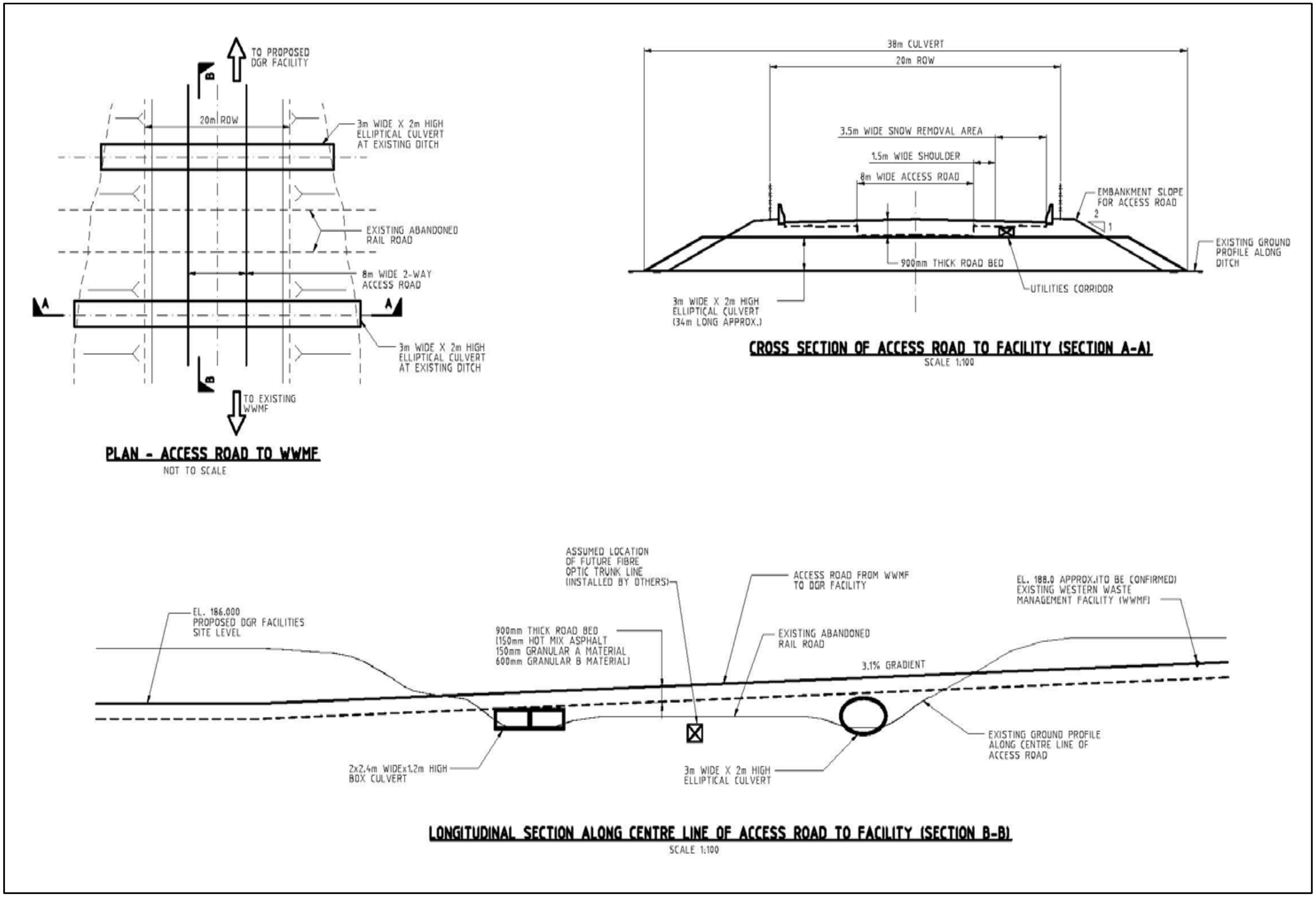

Figure 4.7.3-1: General Layout of Crossing from the WWMF to the DGR

4.7.4.2 Repository Construction

Construction of underground openings at the repository level will commence following completion of the shafts. The underground services area will be developed first. Once the underground services area is developed, all access and exhaust ventilation tunnels are developed providing access to both panel areas and allowing simultaneous development of emplacement rooms in each panel.

The repository level will be developed using controlled drill and blast techniques. Load-haul-dump (LHD) front end loaders and rubber-tired trucks will be used to remove the excavated rock. Diesel-electric equipment (e.g., bolter, jumbo, sprayer) will be used for drilling and ground support requirements. Other diesel equipment (e.g., concrete transmixers, explosives carrier/loader) will be used as required and accounted for in the ventilation design. The reference list of equipment assumed to be operating concurrently to size the ventilation system is shown in Table 4.7.4-1.

A concrete floor will be poured to provide a level floor in the access tunnels and emplacement rooms with a flat and stable surface for stacking operations and plumb waste package stacks.

Table 4.7.4-1: Diesel-powered Equipment Required for Underground Construction Activities

Equipment	Number of Units	Power (kW) per Unit
Bolter/Jumbo/Sprayer	1	58
LHD	1	200
Transmixer	2	179
Haul Truck	3	304
Explosives Carrier/Loader	1	179

4.7.4.3 Dewatering

Following the completion of the shafts (shaft dewatering is discussed in Section 4.7.4.1), temporary sumps will be developed and the water collected will be pumped to surface, treated as required and then will enter the water management system as described in Section 4.4.1.5. It is expected that all sumps will receive water during construction activities and that most of the water would be process water used in the construction activities. As construction progresses, the facility sumps that will be utilized throughout operations will be excavated. Each emplacement panel will have a sump located off the access tunnel at the start of the panel. These sumps will pump via submersible pumps into the main DGR sump and pumping station located in the ramp close to the ventilation shaft. There will be two shaft sumps located off of the ramp at the base of the shafts. These sumps will also pump into the main dewatering sump.

The main dewatering sump will be equipped with large positive displacement pumps connected to a dewatering line in the ventilation shaft (with a back-up line in the main shaft). All sumps have pump redundancy and are sized to accommodate expected flows. The shaft sumps and main sump are sized considering a hypothetical shaft liner failure and inflow of 15 L/s over the expected construction flow of 5 L/s (i.e., total inflow of 20 L/s). As noted in Section 4.4.3.2, the pumps will also be connected to the emergency power system load in the event of power failure at the DGR Project site. All pumps will have the ability to operate remotely from the control room or locally at source.

4.7.5 Construction Waste Management

All wastes that arise as a result of site preparation and construction, and operations activities will be safely managed so as to protect the environment from avoidable adverse effects. Operations phase waste management is described in Section 4.8.5. Note that construction-related gaseous and liquid releases to the environment are described in Section 4.7.6.

As discussed in Section 4.7.1, site preparation involves clearing and preparing an area of approximately 30 ha. The largest volume of waste from this activity will be brush and trees, which are managed as described in Section 4.7.1.1. During construction, waste management includes managing the waste rock and conventional wastes that are generated as part of the works and activities. No radioactive waste will be generated during the site preparation and construction phase. In the unlikely event any material is found to be contaminated with radioactive material, it will be separated and managed according to existing procedures established for the WWMF operations, which are consistent with applicable regulations.

4.7.5.1 Conventional Waste

Conventional waste generated during the site preparation and construction phase will comprise consumables and sanitary waste, where the former will be sent to a landfill that is licensed to accept these types of waste. Types of consumables include non-reusable/recyclable construction materials, and other regular waste generated at an industrial work site. Construction materials will be re-used or recycled, if possible.

Each contractor on-site will be responsible for their own housekeeping and waste handling/disposal. Consumables will be collected in receptacles located throughout the site, both on surface and underground. Once the receptacles are full, the collected waste will be transferred off-site for appropriate management. There is no requirement for an on-site waste collection area or temporary dumping facility. As noted in Section 4.4.3.7, the sanitary wastes will be taken off-site by the construction contractor for treatment. The main contractor selected for the site preparation and construction phase of the DGR Project is required to develop and implement a detailed Environment Management Plan (EMP), which includes conventional waste management. The EMP is further discussed in Section 4.7.8.7.

The amount of conventional waste produced during the construction of the DGR Project is estimated around 25,000 to 35,000 kg per year of domestic waste, and 8,000 to 12,000 kg per year of sanitary waste.

4.7.5.2 Hazardous Materials

A number of materials that are explosive or flammable in nature are required to construct the DGR. This includes diesel fuel and lubricants to operate the mobile equipment and explosives for miscellaneous rock excavation. Underground storage of these materials will be in the respective areas of the underground services area (i.e., explosive and detonator magazines, diesel fuel bay, mechanical shop).

During shaft construction, explosives are required on a daily basis. Explosives will be delivered as required by the explosive supplier to the underground magazine once the underground services area is completed. For underground storage, explosives will be delivered directly to the main shaft headframe and transferred underground to the magazines immediately. Handling explosives on the DGR Project site (both surface and underground) will be in accordance with Part VI of the Mines and Mining Plants Regulations (O. Reg. 854 [29]). Explosives are not be necessary for the operations works and activities, and therefore, will not be present once construction is completed. The underground explosives and detonator magazines will be decommissioned at the end of underground construction activities, and the space will be prepared for general storage during operations.

Diesel fuel will be temporarily stored on surface for the site preparation and construction phase only, with the exception of the emergency power system fuel supply as described in Section 4.4.3.5. The fuel will be stored in a 5,000 L above-ground, double-walled tank equipped with metered dispensing equipment. The underground repository level fuel storage area will continue to be utilized throughout the operations phase, and is described in more detail in Section 4.4.3.5.

Used oils, lubricants, batteries, and other construction-related hazardous wastes will be generated at the DGR Project site. As such, solid waste and liquid waste will be produced and require disposal according to existing regulations. These waste streams have suitable collection and containment vessels available and will be kept separate from the conventional waste. Once collected by a licensed hazardous waste disposal company, these wastes will be transferred off-site for treatment/disposal at a licensed facility. There is not expected to be waste associated with the use of explosives; however, in the event that explosives are damaged these will be collected and transferred to surface where they will be returned to the supplier for off-site disposal. The projected range of output for hazardous materials during site preparation is as follows:

- 35,000 to 45,000 L per year of oils and grease;
- 150 to 200 kg per year of batteries; and
- 1,500 to 2,500 L per year of solvents and paints.

4.7.5.3 Waste Rock Management

The rock materials excavated during the construction of the DGR Project will be stored on-site at the WRMA and re-used in future, as applicable. The estimated quantities of excavated materials are presented in Table 4.7.5-1.

Table 4.7.5-1: Estimated Quantities of Excavated Materials by Material Type

Material Type	Approximate Depth	Volume (m^3)	
		In Situ	**Bulked**
Overburden	0 – 20 m	1,400	2,000
Dolostone and shale	20 – 410 m	34,300	48,000
Shale	410 – 660 m	21,200	29,700
Limestone	660 – 840 m	594,200	832,000
Total		**651,100**	**911,700**

Overburden, shales and dolostones only require interim storage as they are consumed as part of the construction activities. For EA purposes it is assumed that limestone is stored in the long-term on-site, as shown on Figure 4.4.1-2.

The WRMA is divided into sections for each rock type (i.e., dolostones, shales and limestones) as a result of different requirements and potential re-use opportunities as described in Section 4.4.1.3. The storage area also includes temporary storage of soils adjacent to the main access roadway. A silt fence barrier will be placed around the soil pile to contain any sediment run-off during storm events.

Materials excavated from the overburden layer during shaft sinking and creation of drainage ditches will be re-used on-site during construction. Uses of overburden materials include capping of the shale storage pile, if stored longer than one year following final placement, and berms. If soils are left in place for a period of greater than one year, they will be vegetated to reduce erosion; however, it is expected that overburden materials will be re-used in less than one year. The limestone pile will not be capped, but it will be covered and vegetated with native plant stock, as appropriate, during decommissioning activities (see Section 4.11.3 for further details).

All rock storage piles are designed with slope ratios of 2.5:1 to ensure stability. The largest stockpile is for the limestone and will have an area of approximately 9 ha. It is estimated this pile will be 15 m high when complete with the top of the pile graded to avoid ponding of water. As previously noted, the rock will be transferred from the ventilation shaft muck bay to the storage area via rock haulage trucks. A bulldozer would move and grade the rock accordingly. Best management practices, including application of water or misting, will be used to reduce fugitive dust creation from the haulage roads and excavated materials.

A setback or buffer of 200 m from Interconnecting Road is included in the design of the long-term rock storage area. Visual screening (i.e., trees) will be planted, but will not provide a complete visual screen of the pile. Section 8.3.3 of the Hydrology and Surface Water Quality TSD and Section 7.3.2 outline the expected constituents of the run-off from the waste rock.

4.7.5.4 Water Management

For the site preparation and construction phase, the maximum underground water inflow rate is estimated to be 5.4 L/s (maximum assumed rate for purposes of preliminary sizing of sumps and pumps). This includes inflitation of groundwater through the shafts, water from development activities (e.g., dust control, drill water) and possible condensation in the ventilation shaft. The dewatering system is described in Section 4.7.4.3.

The sump water pumped to surface will normally discharge into the drainage network that is described in Sections 4.4.1.5 and 4.7.1.3. However, a temporary water treatment plant, provided by the selected contractor, will be located in the vicinity of the shafts to receive water pumped from underground in the event there are abnormally high concentrations of oil, grease and/or grit in the water. This temporary treatment system would also discharge to the aforementioned ditch network.

As noted, the temporary water treatment plant would be used, as required, to remove excess oil, grease and grit before discharge into the drainage network. It, however, will not be used to treat water in the stormwater management pond in the unlikely event contaminant concentrations in the water exceed the discharge limits established through the permitting process for the DGR Project. As indicated in Section 4.4.1.5, the gate at the discharge point from the stormwater management pond can be closed, thereby containing the contaminants. Appropriate actions would then be taken to treat the water so that it could be safely discharged from the pond.

4.7.6 Site Preparation and Construction Phase Emissions and Effluents

As noted previously, the site preparation and construction phase of the DGR Project will not involve handling, transporting or storing radioactive materials; therefore no radioactive releases are expected. Potential emissions to the environment and possible sources of nuisance effects are identified and assessed for groundwater quality (Section 7.2), soil/sediment quality (Section 7.2), surface water quality (Section 7.3), air quality (Section 7.7) and noise levels (Section 7.8).

4.7.7 Preliminary Commissioning Plan

After the DGR facility is constructed, commissioning work will be carried out to prepare the facility for operations. Commissioning plans for the DGR Project are discussed in Section 4.7.8.8. The activities associated with commissioning are the last carried out during the site preparation and construction phase of the DGR Project. Commissioning tests all components, systems and equipment, and verifies that they are installed and can operate in accordance with their design intent. This includes pre-start and post-start inspections, verification of vendor requirements and safety and monitoring controls. The commissioning team will verify that vendor recommended maintenance procedures are available.

4.7.8 Site Preparation and Construction Phase Program Requirements

A number of plans and procedures have been developed to protect the environment, and health and safety of the public and workers for the site preparation and construction phase of the DGR Project. These will also apply, as appropriate, over the course of the detailed design. Detailed information on these requirements including roles and responsibilities, organization, training, and reporting are provided in the Design and Construction Phase Management System [33]. The following sections provide a summary of this information. Each of the procedures, plans, standards, policies, and manuals noted in the following sections are identified in the Design and Construction Phase Management System [33].

As further explained in Section 4.14, OPG is the owner and licensee of the DGR throughout the entire lifecycle of the DGR Project. OPG, through its organization, performs DGR Project oversight to ensure that the DGR Project goals are achieved. The NWMO has been contracted by OPG to manage regulatory approvals and detailed design of the DGR, as well as the site preparation and construction phase of the DGR Project.

4.7.8.1 Engineering Project Management

The NWMO procedure for Design Management, NWMO-PROC-EN-0001 [34], describes the minimum requirements to ensure the design work for the DGR is defined, controlled and appropriately verified. The procedure requires the preparation of a Design or Engineering Management Plan.

The Engineering Management Plans for the DGR Project will be prepared by the design responsible organizations in accordance with the design management requirements. A Human Factors Engineering Plan, which identifies the scope, activities, deliverables and schedule for the human factors assessment of the design of the DGR, will normally be incorporated into the Engineering Management Plan. A Human Factors Verification and Validation Plan will support the Human Factors Engineering Plan and will identify the activities, deliverables and schedule of various verification and validation activities to be performed during construction and commissioning of the DGR facility. The Human Factors Verification and Validation Plan will normally be incorporated into the Construction Management Plan and the Commissioning Management Plan, which are described in Section 4.7.8.7 and 4.7.8.8, respectively.

4.7.8.2 DGR Project Change Control

Modifications to the DGR Project, including the process that would be followed should the design of the DGR Project be largely altered following receipt of the site preparation and construction licence, are described in Section 4.10.

4.7.8.3 Community Engagement

The DGR Community Engagement Plan, DGR-PLAN-06020-1001 [35], will be prepared to ensure that appropriate communications and engagement with the communities surrounding the DGR Project site are planned. The plan will include preparation of materials as well as a schedule of activities to continue to build community awareness and understanding of the DGR Project, and build and strengthen relationships with key stakeholders and community leaders. Communications and engagement activities following the submission of the EIS are further described in Section 2.10.

4.7.8.4 Document Management Control

The NWMO procedure for records management, NWMO-PROC-AD-0002 [36], and the NWMO standards for controlled documents, NWMO-STD-AD-0001 [37], provide overall direction for the management of documents and records for the regulatory approvals phase and the design and construction of the DGR Project. A DGR Project-specific Document Management Plan, DGR-PLAN-00121-1002 [38], and associated instructions will be prepared for the purpose of day-to-day control of various DGR Project documents. The plan will also include requirements for technical drawings numbering and equipment labeling systems.

4.7.8.5 Procurement and Contracts

A Procurement and Contracts Management Plan, DGR-PLAN-00800-1001, will be prepared for the DGR Project. The plan will be compliant with the requirements of the NWMO Procurement Procedure, NWMO-PROC-FN-0006 [39], and will be available prior to the start of procurement of materials and equipment for the DGR Project.

4.7.8.6 Training and Competency

A Training Management Plan, DGR-PLAN-08920-1001, will be prepared for the DGR Project. The plan will be consistent with the requirements of NWMO human resources policies and with the principles of a systematic approach to training. The plan will include requirements for evaluation of training programs to ensure that training is effective and the overall plan remains effective.

4.7.8.7 Construction

Construction Management Plan

The Construction Management Plan, DGR-PLAN-00180-1001, will define the responsibilities of the Construction Manager and construction management staff as well as the strategies and policies to manage the construction of the facilities at the DGR Project site. It will be supported by project-specific procedures and standards, such as the Health and Safety Management Plan, DGR-PLAN-08962-1001, which also directs performance of the construction management activities. The Construction Management Plan describes the construction project and the facilities to be constructed as well as the processes that will be used to execute and complete the work and accomplish the construction objectives and requirements including schedule. The construction management plan also includes the contingency plan and procedures to ensure a managed safe response to unplanned events such as flooding that could occur during construction. The contingency plan will be revised and tested as the construction proceeds from surface construction to shaft sinking to underground lateral development.

Health and Safety Management Plan

The Health and Safety Management Plan, DGR-PLAN-08962-1001, will be aligned with NWMO Health and Safety Policy, NWMO-POL-WM-0002 [40], and will be based on an assessment of health and safety risks. The Health and Safety Management Plan describes how all construction and commissioning activities will be conducted in a manner that ensures employee and contractor health and safety. The site emergency response plan will be included in the plan and it will be updated as the works and activities progress.

Environment Management Plan

The Environment Management Plan, DGR-PLAN-07002-1001, will be aligned with the NWMO Environment Policy, NWMO-POL-ES-0001 [41]. The plan describes how all construction and commissioning activities will be conducted in a manner that ensures that pollution is minimized and the environment is protected from adverse effects. The site spills and release response plan will be included in the Environment Management Plan. Section 4.15 provides additional information on environmental protection policies and procedures, including monitoring, that will apply to the DGR Project.

Design and Construction Project Quality Plan

The L&ILW DGR Design and Construction Project Quality Plan, DGR-PLAN-00120-0006 [42], describes the quality objectives for the DGR Project, the roles and responsibilities of DGR Project personnel and the minimum requirements necessary to ensure the DGR Project quality objectives are achieved. The document also describes the minimum requirements for construction contractor quality assurance plans as well as the minimum requirements for monitoring and audit of quality assurance and quality control activities.

Constructon Quality Assurance Plan

The Construction Quality Assurance Plan, DGR-PLAN-01916-1001, defines the sequence, schedule and various systematic actions that will be taken in the field by NWMO staff and contractors to provide assurance that the DGR facility is being constructed to meet the design specifications. In particular, the plan defines the requirements for performance of field tests and inspections to confirm the DGR facility is being built in accordance with the approved engineering drawings and specifications. A key aspect of the construction quality assurance program during the site preparation and construction phase will be field test quality control. The plan will describe the use of a Field Quality Inspection Manual (DGR-MAN-01916-1002), which will provide detailed requirements for various in-the-field quality control activities.

4.7.8.8 Commissioning

Commissioning is the process of verifiying that all the subsystems achieve the project requirements as intended by the DGR owner (OPG), and as designed by the DGR engineers. The Commissioning Management Plan, DGR-PLAN-00920-1001, defines the commissioning process with detailed activities and schedule for the commissioning of the DGR. The

Commissioning Change Control Procedure, DGR-PROC-00920-1001, is described in Section 4.10.

4.8 OPERATIONS PHASE

Emplacement operations are assumed to commence when construction is complete. A volume of approximately 200,000 m³ of waste (emplaced volume) will be stored in the DGR emplacement rooms. The majority (approximately 60%) of the total waste volume will be in storage at the WWMF before the assumed commencement of emplacement operations in 2018.

Once the packages in storage at the WWMF are cleared and transferred into their final disposal location in the repository, the DGR will only receive waste packages with new waste generated at the nuclear power stations. It should be noted that all waste materials will continue to be shipped to the WWMF for waste processing, sorting and packaging. Delivery of waste packages will be planned with the DGR Project controller to ensure that underground emplacement allocations are made available to suit the planned delivery schedule from the WWMF. Materials placed in the DGR are considered waste and the need for retrieval is not anticipated; however, retrieval can be achieved.

4.8.1 Workers, Payroll, and Purchasing

A workforce of approximately 40 people is required throughout the operations phase of the DGR Project. The operations phase workers required by skill and/or occupation are summarized in Table 4.8.1-1.

Table 4.8.1-1: Estimated Labour Requirement for Operations Phase

Operations Stage	Number of Workers
Management and Support	5
Hoisting and shafts	4
Mechanical/Technician	9
Waste Handling (forklift)	8
Technical Support	6
Planning	3
Operator	5

The facility will operate five days per week with a single 8-hour shift for emplacement activities. Limited maintenance and inspection will occur in off-shift hours. Similar to construction, it is assumed that each staff member will commute to work in their own vehicle.

4.8.1.1 Project Security

The surface structures of the DGR Project, including the main and ventilation shaft complex, and the site infrastructure, will be encompassed by a fence. Access to the DGR facility will be exclusively from within the Bruce nuclear site. Access to the Bruce nuclear site itself is strictly controlled by Bruce Power Security personnel. OPG contracts Bruce Power to provide security for its facilities on the Bruce nuclear site. A fence surrounds the perimeter of the Bruce nuclear site. The WWMF is surrounded by a separate fence. Access to the existing L&ILW facilities is restricted to qualified personnel and those escorted by qualified personnel. Visitors register with security, including providing photo identification, and their vehicles are subject to search prior to entering the Bruce nuclear site. Visitors who access zoned areas are escorted and must provide photo identification and pass monitoring ports before entering.

4.8.2 Above-ground Transfer of Waste and Receipt of Waste

4.8.2.1 Description of Waste Packages

Waste packages retrieved from the WWMF will be transferred in a DGR-ready state. The packages will be inspected to ensure that damage has not occurred in transfer and to confirm that WAC criteria are met (Table 4.5.1-3 outlines the WAC). Some packages will require overpacking and some will require special treatment. Both will occur before transferring to the DGR, as detailed in Table 4.8.2-1. Section 4.5 provides information on the design of the waste packages.

The DGR Project WAC (Table 4.5.1-3) require that each package meets the following two specific dose rate limits:

- 2 mSv/h on contact with external surface of waste package or shielding; and
- 0.1 mSv/h at 1 m from transportation package.

All waste packages are designed to meet the WAC limits, although some packages with high dose rates may require spot shielding or temporary shields to achieve this as part of a specific ALARA (As Low As Reasonably Achievable) plan to protect workers.

The maximum allowable mass for any waste package is 35 tonnes. However, an additional 9 tonnes is allocated for the rail cart, as well as any rigging and attachments in the design of the main shaft hoisting system. This gives a maximum cage payload of 44 tonnes.

Table 4.8.2-1: Summary of Waste Package Handling, Shielding and Repackaging

Waste Package Type	Waste Package Description
Low Level Waste	
LLW Bin-type Package	Most LLW bins will be transferred "as is" from WWMF storage. Shielded overpack containers will be used if the dose rates of packages exceed dose limits set out for the DGR WAC.
Shield Plug Containers	These containers will be retrieved last from WWMF trench storage, allowing reduction in dose rates and safe transfer into the DGR without excessive amounts of additional shielding. Additional shielding, if required, would be placed upon removal from storage at the WWMF.
Encapsulated Tile Hole	Encapsulated Tile Hole package comprises an outer cylindrical steel pipe (9.5 mm thick walls) that encapsulates the waste-filled tile hole that was once in the ground. The contents of the tile hole are stabilized with grout and the annular space between the steel pipe and the tile hole is also filled with grout. Concrete is used to seal the base of the steel pipe.
Heat Exchangers	Protuberances (e.g., nozzles, supports) from the heat exchangers will be cut off. Openings will be welded closed with a seal plate. Internal components will not be grouted prior to transfer into the DGR.
Steam Generators	Each steam generator will be filled with light-mass grout to stabilize the internal parts, then cut into sections using a diamond wire saw. Each segment will be sealed with a plate welded to each cut end. These plates will serve a dual purpose of increasing the shielding of the grouted segment and providing a flat surface to aid stacking in the emplacement rooms. Forklift pockets will be welded onto one seal plate on each segment to facilitate safe lifting and transfer.
Intermediate Level Waste	
Tile Hole Liner	The tile hole liners are a steel tube, which is filled with stabilizing and shielding grout. Overpacking is not required because of protection from shielding grout.
Resin Liners	Resin liners are stored in quadricells and In-Ground Containers (ICs) under existing conditions. The quadricells are assumed to be disposal-ready. The dose rates emitted by the resin liners vary. Various configurations of packaging will be employed to account for underground packing efficiencies while ensuring the waste package radiation emissions do not exceed the WAC dose rate limits.
T-H-E Wastes	Wastes from T-H-E liners will be retrieved into newly designed steel containers of similar dimensions to the resin liners. Shielding similar to that envisioned for resin liners will be employed as required to meet the WAC radiation dose rate limts.
ILW Shield	After 2018, the current method for storing all tile hole wastes in IC-18 T-H-E liners is assumed to be discontinued. These wastes will be disposed of in new, yet to be designed, shield containers.

Table 4.8.2-1: Summary of Waste Package Handling, Shielding and Repackaging (continued)

Waste Package Type	Waste Package Description
Retube Waste Container	Specialized retube waste containers will be used for pressure tubes, calandria tubes, calandria tube inserts and uncut end-fittings. The containers will be of stackable steel-concrete-steel construction with a maximum loaded mass of 35 tonnes.

Waste conditioning methods employed at repositories in countries other than Canada are described in Section 3.4.10. For the purposes of the DGR Project, conditioning consists mainly of enclosing the waste in containers and overpacks, plus some additional methods described in Table 4.8.2-1, above, for specific waste package types.

4.8.2.2 DGR Waste Handling Equipment and Procedures

All packages being transferred to the DGR WPRB from the WWMF will be shipped in a DGR-ready state on flat-bed transporters, covered transporters, or forklifts. The WPRB is described in Section 4.4.1.1. The packages will be transported across the abandoned rail bed crossing shown on Figure 4.4.1-2. At the WPRB, packages will be off-loaded by forklift or overhead crane and placed into the staging area, or loaded directly onto an empty rail cart prior to transfer into the shaft cage. A controller based at the main shaft control room will co-ordinate the process and ensure that all packages received are in accordance with planning manifests. Waste packages will be tracked regarding their location within the DGR.

All packages are loaded onto the rail carts in the WPRB (Table 4.8.2-2). The self-propelled and electric-tethered rail carts can only proceed towards the main shaft once the rail stop is removed. Once the main cage is in position at the station and chaired (chairing restricts vertical movement of the cage from loading and unloading), the rail stop is removed and the tether is connected to the rail cart. The cart traverses into the cage and the tether is disconnected, automatically locking the rail cart brakes. The rail cart is locked into position, the cage door is closed and the chairing mechanism is released.

Table 4.8.2-2: Summary of Equipment and Above-ground Handling Procedures

Waste Package Type	Package Handling Equipment	Above-ground Transfer Procedures
LLW bin-type waste packages	Rail Cart and Light Duty Forklift	Standard packages transported from the WWMF, off-loaded and stacked in a staging area by a light duty forklift. A forklift transfers the packages to awaiting rail carts for loading into the main shaft cage.

Table 4.8.2-2: Summary of Equipment and Above-ground Handling Procedures (continued)

Waste Package Type	Package Handling Equipment	Above-ground Transfer Procedures
Heat exchangers and shield plug containers	Rail Cart and Crane	The containers are lifted on to a flat bed truck, and off-loaded by an overhead crane at the WPRB. An overhead crane places onto a railcar for transfer underground.
Unshielded resin liners, tile hole liners, ILW Shields	Rail Cart and Light Duty Forklift	Packages are off-loaded at the WPRB by light duty forklift and are placed in the staging area or directly onto an empty rail cart for transfer underground.
Encapsulated Tile Holes, resin liners in concrete shields, ATHEL waste packages in concrete shields, retube waste containers, steam generator segments	Rail Cart, Overhead Crane, and Heavy Duty Forklift	Heavy waste packages capable of being lifted by a forklift will be off-loaded at the WPRB using the heavy duty forklift or possibly overhead crane, and then placed on a rail cart for transfer underground.

4.8.3 Underground Transfer of Waste

The main shaft is used to transfer waste packages to the underground repository. Table 4.8.3-1 summarizes the equipment and handling procedures for the underground transfer of waste. The rail carts are moved from inside of the cage to the underground staging area. Depending on the mass of the waste package, either a light-duty or heavy-duty forklift pick up the waste packages and deliver them to an emplacement room. In the case of the large and heavy waste packages that cannot be transferred by forklift, the rail cart is used to deliver the waste package to an emplacement room equipped with rail. Once at the emplacement room, a gantry crane is used to move the waste package into its final location in the room.

Table 4.8.3-1: Summary of Equipment and Below-ground Handling Procedures

Waste Package Type	Package Handling Equipment	Below-ground Transfer Procedures
LLW bin-type waste packages	Rail Cart and Light Duty Forklift	Bins are off-loaded from the rail cart in the underground staging area. Underground forklift places waste packages in final position within emplacement room.
Heat exchangers and shield plug containers	Rail Cart and Crane	Rail carts are off-loaded from the cage and traverse by rail to one of the rail-access emplacement rooms. Waste packages are lifted off the rail cart and stacked on the floor by gantry crane.

Table 4.8.3-1: Summary of Equipment and Below-ground Handling Procedures (continued)

Waste Package Type	Package Handling Equipment	Below-ground Transfer Procedures
Unshielded resin liners, tile hole liners, ILW Shields	Rail Cart and Light Duty Forklift	Waste packages are off-loaded from the rail cart in the underground staging area. Underground forklift places waste packages in final position within emplacement room.
Encapsulated Tile Holes, resin liners in concrete shields, ATHEL waste packages in concrete shields retube waste containers, steam generator segments	Rail Cart and Heavy Duty Forklift	Waste packages are off-loaded from the rail carts in underground staging area by heavy-duty forklift. Heavy duty forklift will place package in final position in an emplacement room.

Typical emplacement room configurations for LLW and ILW are provided on Figures 4.8.3-1 and 4.8.3-2, respectively.

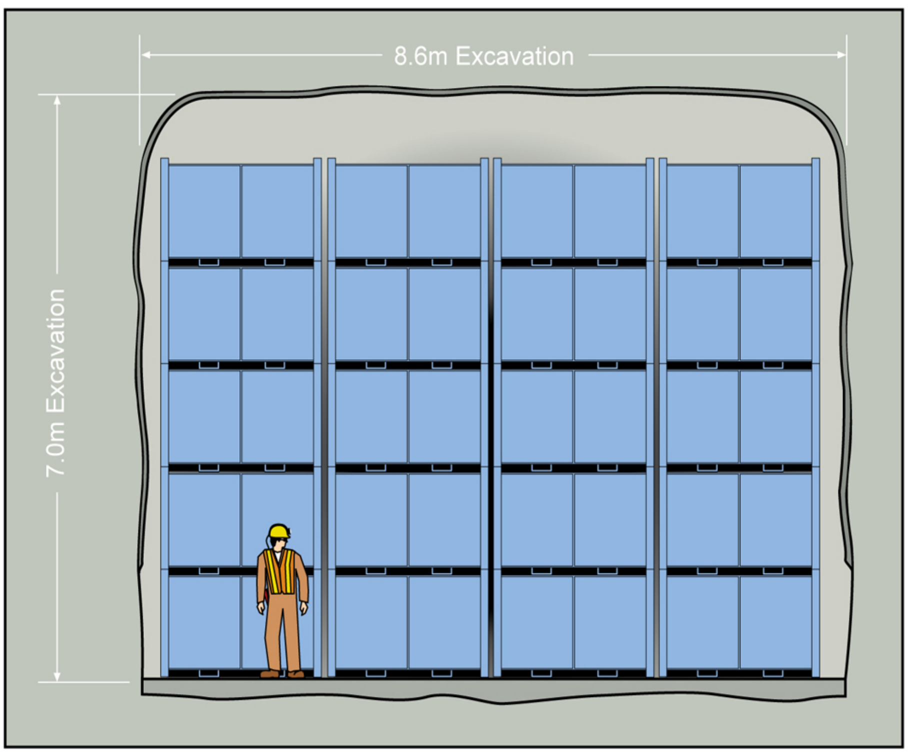

Figure 4.8.3-1: Typical Emplacement Room Configuration for LLW

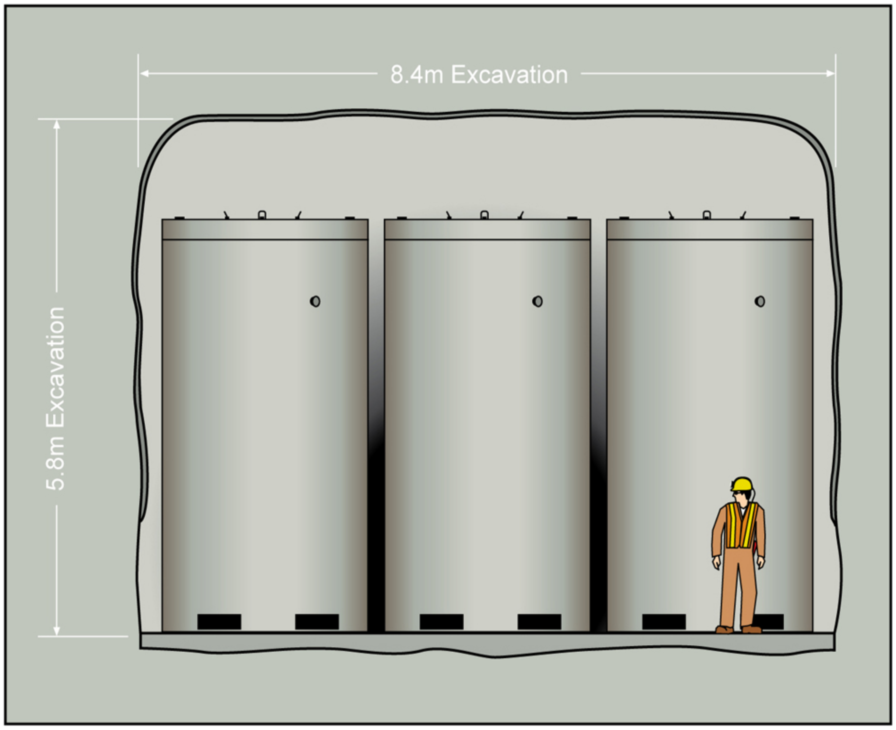

Figure 4.8.3-2: Typical Emplacement Room Configuration for ILW

4.8.3.1 End Walls and Room Closure

Once an emplacement room is filled with waste, an end wall is installed to restrict access, and if required, reduce radiation fields in the adjacent access tunnel. The top of the wall is open to allow air to enter the room to maintain the continuous ventilation requirements.

After a group of rooms has been filled with waste packages, closure walls are constructed in the access and exhaust ventilation tunnels to fully isolate this group of rooms. The underground space behind the closure wall is not ventilated and all services are terminated. These closure walls are designed to limit the release of tritiated air, natural and waste-generated methane, and other off-gases from the waste packages (e.g., H_2 and CO_2). They also limit the release of potentially contaminated water. In the very unlikely event that explosive gases build up behind the closure walls and an explosion occurs, the air blast from the explosion would be contained by the closure walls.

The closure walls would consist of mass concrete within the access tunnel. Grout holes would be drilled through the concrete into the surrounding host rock for provision of high pressure consolidation/contact grouting. This closure wall would resist pressure through friction between the concrete plug and the rough surface of the access tunnel along the entire length of the seal.

4.8.4 Materials Handling System

Aside from the waste packages, the main materials that will be handled are oils, lubricants, and fuels. The handling and storage of these materials are described in the following section. Table 4.8.4-1 summarizes the substances present in larger quantities that will be used during DGR operations, and focuses on those that could have an effect on the environment. As discussed in Section 4.4.3.5, fuel for the operations phase of the DGR Project will be provided from the existing WWMF fuel station.

Table 4.8.4-1: Chemicals, Lubricants, and Oils Used at the DGR

Substance	State	Annual Consumption	Usage
Fuel (diesel)	Liquid	40,000 – 50,000 L/a	Vehicles, emergency generator
Lubrication oils	Liquid	750 – 1,000 L/a	Pumps, motors, hydraulics
Miscellaneous solvents and paints	Liquid	100 – 200 L/a	General maintenance
Batteries	Solid	90 – 135 kg/a	Equipment operation

Conventional industrial and office supplies will be shipped to the DGR by truck, and will generally be stored at the location they are used. Some items, such as small mechanical parts, may be kept in a centralized storage area until needed.

4.8.5 Operations Waste Management

This section identifies the types of wastes that can be expected to be generated during the operations phase of the DGR Project. It considers conventional, hazardous, and radioactive materials, and outlines the processes for collecting, handling, transporting, storing, and disposing of such materials. Note that operations-related releases (i.e., emissions and effluents) to the environment are discussed in Section 4.8.6.

4.8.5.1 Conventional Waste

The conventional waste produced by the DGR Project operations activities will include regular waste generated at an industrial site. Dry solid waste will be collected at regular intervals both at surface and the repository level. Any waste that comes into contact with radioactive material will be treated separately. Recyclable materials will be sent off-site to an appropriate facility. Hazardous materials will be dealt with separately, as described in the next section. The remaining conventional solids will be transported to a landfill for disposal. OPG operates a landfill at the Bruce nuclear site, and there are several other landfill options in the study areas (refer to the Socio-economic Environment TSD and Section 6.10).

Personnel working underground will be provided with potable water in either bottles or jugs for both drinking and hand washing. The underground hand washing stations use stands integrated with a small reservoir, pump, and water heater similar to those used at mines. The water from the hand washing stations will be collected in totes and brought to surface to be discharged into the surface sanitary system. Toilets will be provided at the two sanitary areas located at the repository level. These toilets are typical of underground mining operations, and use compressed air to function as simple, small-scale sewage treatment plants. The self-contained toilets function for approximately 18 months before a fluid clean-out is required. Using forklifts, the toilet units will be taken to surface for clean-out and replacement, and then returned underground for continued use. The cleaned-out material will be taken off-site for disposal.

The projected range of annual output of conventional waste is 3,000 to 5,000 kg of domestic waste and 1,000 to 1,500 kg of sanitary waste.

4.8.5.2 Hazardous Materials

Hazardous waste consists of chemicals and materials generated during the operations phase that are not radioactive, but cannot be discharged to the environment. This type of waste generally occurs in liquid form, and will be collected in containers (e.g., drums) that are suitable for segregating and storing it until it can be sent off-site for management at an appropriately licensed facility.

During operations, the underground fuelling area is the same as that utilized during the site preparation and construction phase and includes a diesel storage area and a refuelling/lubrication bay. The fuel storage arrangement is described in Section 4.4.3.5. As noted in the description of hazardous materials management during the site preparation and construction phase of the DGR Project (Section 4.7.5.2), no surface storage of fuel will be required other than the emergency generator tank, which is also described in Section 4.4.3.5.

To minimize potential contamination, the maintenance shop and the diesel fuel bay will each be equipped with an isolated containment sump. These sumps are suitable for containing any accidental fluid spills including fuel, oil, or engine coolant. Captured fluids would be pumped into a tote at the repository level, and then taken to the surface via the main shaft cage for appropriate treatment and/or disposal at a licensed facility.

Hazardous waste such as expired chemicals, cleaners, paints, aerosol cans, batteries, and electronic components will be managed in compliance with all federal and provincial requirements. It is estimated that approximately 400 to 600 L of used oils and greases will be generated on an annual basis over the course of the operations phase of the DGR Project. Approximately 25 to 50 L of waste solvents and paints are estimated to be generated annually. Between 90 and 135 kg of used batteries are estimated to be generated annually.

4.8.5.3 Radioactive Waste

Approximately 50 m^3 of LLW will generated each year over the course of the operations phase. This includes mostly maintenance waste consisting of rags, paper, protective clothing, and possibly some contaminated metal parts. This waste will be collected and returned to the WWMF for processing and packaging as part of the normal waste stream.

4.8.5.4 Water Management

A series of sumps equipped with submersible pumps directs all water received at the repository level to the main dewatering sump and pump station during the operations phase of the DGR Project. Water inflow volumes are expected to be small, and a rate of 2 L/s has been assumed. However, it is important to note that during operations, it is anticipated that sumps installed in the panels will be dry since the rock is tight and no groundwater inflow is expected. Small amounts of groundwater inflow at the shafts and down into the shaft sumps may occur.

The dewatering sump is located at the repository level near the ventilation shaft, where water will be pumped to the surface via a positive displacement pump through the ventilation shaft discharge column. A back-up discharge column is provided in the main shaft. At surface, the pumped water will be discharged to the DGR Project stormwater management ditch network. The stormwater management system in place throughout the operations phase is the same as that described for the site preparation and construction phase of the DGR Project. Refer to Section 4.7.5.4 for additional detail.

4.8.6 Operations Phase Emissions and Effluents

DGR Project emissions and effluents are identified and assessed in Section 7. These include assessment of liquid effluents (groundwater quality, Section 7.2; surface water quality, Section 7.3), radioactive releases (radiation and radioactivity, Section 7.6), gaseous emissions (air quality, Section 7.7) and noise emissions (noise levels, Section 7.8).

4.8.7 Operations Phase Program Requirements

For the DGR, operational programs and procedures will be developed to protect the environment, and health and safety of the public and the workers. These programs will be developed prior to the start of DGR operations to assure compliance with applicable provincial and federal legislation, and applicable regulations. Details of the programs including roles and responsibilities, training, reporting and records are described in Chapter 10 of the Preliminary Safety Report [26]. The following sections summarize this information. Each of the programs, procedures, policies and records acknowledged in the following sections is identified in Chapter 10 of the Preliminary Safety Report [26].

4.8.7.1 Radiation Protection Program

A radiation protection program for the DGR will be based on OPG's existing Radiation Protection Program N-PROG-RA-0013 [43] as required by Section 4 of the Radiation Protection Regulations (SOR/2000-203) [44]. The program will be used to manage radiological risks that could contribute to public and occupational radiation doses when the DGR becomes operational.

This program complies with the CNSC requirement that all licensees implement a radiation protection program, and establishes a quality program.

This program is designed to comply with the radiation protection program requirements of the following acts and regulations as applied to licensed OPG facilities and licensed OPG activities:

- Nuclear Safety and Control Act (NSCA, 1997, c.9);
- General Nuclear Safety and Control Regulations (SOR/2000-202) [45];
- Radiation Protection Regulations (SOR/2000-203) [44];
- Class I Nuclear Facilities Regulations (SOR/2000-204) [46]; and
- Nuclear Substances and Radiation Devices Regulations (SOR/2000-207) [32].

Further discussion of the proposed DGR radiation protection program is provided in Sections 4.15 and 4.16.

4.8.7.2 Keeping Doses As Low As Reasonably Achievable (ALARA)

Exposure to radiation is managed through the following processes:

- limiting individual worker dose;
- establishing facility design optimized on the basis of ALARA considerations;
- assessing hazards for planning and to maintain knowledge of conditions; and
- planning and performing radioactive work to keep exposures ALARA and avoid unplanned exposures.

A key practice in maintaining control of radiation exposure and contamination is through the use of zoning as per OPG's procedure on Radiological Zoning, Personnel/Material Monitoring and Transfer Permits N-PROC-RA-0014 [47]. Further discussion on the control of radiation exposure and contamination is provided in Section 4.15.1.

4.8.7.3 Conventional Occupational Health and Safety Program

The operation of the DGR facility will be regulated under the OHSA. Worker health and safety aspects included under the Mines and Mining Plants Regulations (O. Reg. 854 [29]) will also be applicable.

An overall Occupational Health and Safety Program will be implemented for the DGR that will meet the requirements of OPG's Environmental, Health and Safety Management Program W-PROG-ES-0001 [48] applicable to its nuclear facilities. The program will also be consistent with the OPG Health and Safety Policy OPG-POL-0001 [49] and the OPG Nuclear Safety Policy N-POL-0001 [50]. Additionally, the program is consistent with OPG management systems, and British Standards Institution's Occupational Health and Safety Assessment Series (OHSAS) 18001, Management System Specification. The OPG management systems and OHSAS 18001 are based on a Plan→Do→Check→Review cycle.

The goal of OPG's Conventional Safety Program is to ensure workers work safely in a healthy and injury-free workplace by managing and mitigating risks associated with activities, products and services of OPG operations. Risk reduction is primarily achieved through compliance, by competent workers, to effective operational controls, developed through effective risk assessment and safe work planning. The Program is compliant with applicable legislative, corporate and nuclear business requirements.

4.8.7.4 Hazardous Materials Program

The DGR facility will contain a variety of non-radiological materials typically found in industrial buildings. The handling of hazardous materials will be controlled and will meet provincial regulations, in particular the OHSA and the Environmental Protection Act for non-radiological hazards. Material Safety Data Sheets for hazardous materials will be readily available as required by Workplace Hazardous Materials Information System (WHMIS) legislation.

4.8.7.5 Personal Protective Equipment

The selection, use and maintenance of personal protective equipment for the above-ground portion of the DGR will be governed by OPG's existing Safety Management System Program OPG-HR-SFTY-PROG-0001 [51]. For radiological hazards above ground, OPG's procedure N-PROC-RA-0025 [52] will be applied. The requirements for personal protective equipment under the Mines and Mining Plants Regulations (O. Reg. 854 [29]) will be complied with for underground operations.

4.8.7.6 Environmental Protection Program

Environmental protection policies, programs and procedures will be established and will meet the requirements of the:

- OPG Environmental Policy OPG-POL-0021 [53];
- Biodiversity Policy OPG-POL-0002 [54];
- Land Assessment and Remediation Policy OPG-POL-0016 [55];
- Spills Management Policy OPG-POL-0020 [56]; and
- Policy for Use of Ozone Depleting Substances OPG-POL-0015 [57].

Execution of the program will be accomplished through an integrated set of documented activities, typical of an Environmental Management System. It will be consistent with the CNSC regulatory standard S-296 [58] and the International Organization for Standardization (ISO) standard 14001, and will meet the requirements of OPG's Environmental, Health and Safety Management Program W-PROG-ES-0001 [48]. Section 4.15 provides additional detail on environmental protection policies and procedures that will apply to the DGR Project.

4.8.7.7 Monitoring Program

As part of the Environmental Management System, an environmental monitoring program will be implemented for the DGR Project. The monitoring plan will address radiological contaminants, chemical contaminants and physical stressors that may present a risk to either human health or non-human biota.

The objectives of the monitoring program during the operations phase are as follows:

- to assess performance of various structures, systems, equipment and components relative to design specifications and baseline conditions;
- to monitor changes in underground rock/excavation conditions (e.g., rock movement, stress) over time;
- to assess preclosure safety and environmental performance relative to defined standards or limits, and baseline conditions; and
- to monitor for changes in groundwater quality as a result of the operation of the DGR facility.

Environmental monitoring programs are discussed further in Section 4.15.2 and Chapter 10 of the Preliminary Safety Report [26].

4.8.7.8 Staffing and Training Program

A Staffing and Training Program will be developed to ensure the presence of a sufficient number of qualified workers to carry out activities safely and in accordance with the Nuclear Safety and Control Act and its Regulations.

Where applicable, a minimum number of workers with specific qualifications, known as the minimum staff complement, will be identified by a systematic analysis to ensure that there are adequate staffing levels to successfully respond to all credible events.

Training meeting the requirements of OPG's Training Program N-PROG-TR-0005 [59] will be established and maintained. Only qualified staff will be assigned to work on tasks independently. All staff will be skilled and knowledgeable to perform the tasks to which they have been assigned.

4.8.7.9 Fire Protection Program

The DGR will use OPG's Nuclear Waste Management Division (NWMD) Fire Protection Procedure W-PROC-ES-0011 [60] to ensure compliance with the applicable national codes and standards that will be specified in the operating licence issued by the CNSC.

4.8.7.10 Emergency Preparedness and Emergency Response Program

Emergency response at the DGR will be conducted in cooperation with Bruce Power, as described in NWMD Employee Emergency Response Procedure W-PROC-ES-0002 [61]. OPG will ensure that an effective response can be made to address an emergency affecting the health and safety of OPG employees, its business continuity and its property, contractors at the DGR, the environment, and the public.

The DGR is not considered to be a mine under the OHSA; however, trained and qualified mine rescue teams will be provided as required by the Mines and Mining Plants Regulations (Reg 854). As required by the Mine Rescue program, a second team is required at site before the first team can go underground and a third team must be on-route. Back-up will be provided by nearby mine rescue teams through mutual assistance agreements. Further information is provided in Section 4.17.

4.8.7.11 Inspection and Maintenance Program

Implementation and control of maintenance activities are primarily achieved by instituting a maintenance program consistent with requirements specified in OPG's Conduct of Operations and Maintenance Program W-PROG-OM-0001 [62].

In compliance with Section 6(d) of Class I Nuclear Facilities Regulations [46], an Inspection and Maintenance Program consisting of polices, processes, and procedures will be developed with an objective to maintain the structures, systems and components of the DGR as per design specifications. The program will cover a range of inspection and maintenance activities including, but not limited to, monitoring, inspecting, testing, assessing, calibrating, servicing, repairing or replacing parts.

Further to the Class I Nuclear Facilities Regulations requirements [46], the DGR will also be required to comply with the Mines and Mining Plants Regulations (O. Reg. 854 [29]) for mining operations. Underground operations will require the development of inspection and maintenance plans that will include but are not limited to mobile equipment, ventilation systems, shaft and hoisting systems, and excavations.

4.8.7.12 Records and Document Control

All records for OPG's nuclear facilities are managed in accordance with OPG's Records and Document Control N-PROG-AS-0006 [63]. The following documents provide further detail regarding the management for records in the areas of quality assurance, radiation protection and dose, licensing, and training:

- records identified as controlled documents (including all licensing documents) will be managed as per OPG's Controlled Document Management Procedure N-PROC-AS-0003 [64];
- all dose records will be managed as per OPG's Creating and Maintaining Dose Records N-HPS-03413.1-0004 [65];
- records governed by the Radiation Protection Program will follow OPG's Radiation Protection Requirements N-RPP-03415.1-10001 [66]; and
- training records will be managed as per OPG's Records and Documentation Procedure N-PROC-TR-0012 [67].

4.9 RISK MANAGEMENT

Workers will be exposed to typical risks associated with working in a nuclear environment, an industrial setting, an underground environment, and, at times, a construction site. The risks are identified and evaluated in the Preliminary Conventional Safety Report [68] and the Preliminary Safety Report [26]. The construction-related risks will be typical of those at any construction site and are associated mainly with being in close proximity to heavy equipment and carrying out excavations to depth. The operations risks will be similar to those at the WWMF and typical of underground mine activities.

The Malfunctions, Accidents and Malevolent Acts TSD (summarized in Section 8) identifies potential risks to workers, the public and the environment in various accident and malfunction scenarios. A summary of the risks attributable to malfunctions and accidents is provided in Section 4.13 and Section 8. These sections also consider the risks associated with malevolent acts.

Environmental protection measures will be established to prevent the uncontrolled release of soil materials, chemicals or wastes into the environment at, or near, the source. As described in Section 4.7.8.7, the site spills and release response plan will be included in the Environment Management Plan DGR-PLAN-07002-1001 established for the site preparation and construction phase. During operations, contingency plans for uncontrolled release of substances will be consistent with the requirements of the Spills Management Policy OPG-POL-0020 [56]. Dust abatement measures associated with the construction and use of roadways will be implemented during the construction period. Training will be a key component of the plan to increase environmental awareness and to develop contingencies for emergency response (e.g., spills response plans and procedures). A monitoring plan will assess the effectiveness of these environmental protection measures during construction.

A Construction Quality Assurance Plan DGR-PLAN-01916-1001, described in Section 4.7.8.7, will verify the construction of the DGR to ensure that the DGR has been constructed according to the DGR Project design and meets design requirements. As per NWMO's governance, the Construction Management Plan DGR-PLAN-00180-1001 applies to the activities ahead of the site preparation and construction phase.

The Geoscientific Verification Plan [69] will be implemented during the site preparation and construction phase and will verify geoscientific parameters that influence repository safety.

Emergency response is currently supplied to the WWMF by the Bruce Power emergency response team (ERT). It is expected that this service will be extended to the DGR construction and operations. Further details are provided in Section 4.17.1.

4.10 MODIFICATIONS TO THE PROJECT

The EA considers the effects of site preparation, construction, operations, decommissioning, abandonment and long-term performance of the DGR. As the EA process is carried out in the planning stages of DGR Project development, a number of decisions regarding some specific elements of DGR infrastructure will be made during the development of the detailed design.

The following sections provide a brief description of the potential design changes that may occur, and discuss the possibility of future expansion. Finally, the process that would be followed by NWMO and/or OPG in the unlikely event that the DGR Project was to be largely altered at any stage is outlined.

Carrying out the EA is a key step in deciding to implement the DGR Project. It is logical to assume that once the EA is satisfactorily completed, and the many other necessary approvals and licences are obtained to proceed with the DGR Project, it is highly improbable that a decision to discontinue or significantly alter the DGR Project would be made. An attempt to identify such circumstances that may necessitate or lead to decisions of this nature would be highly speculative.

4.10.1 Design Changes

The following design elements have the potential to change during the development of the detailed design for the DGR Project. These potential modifications are not expected to result in environmental effects that are substantially different or increased from those identified in the EIS:

- changing the ventilation shaft hoist from a ground mounted double drum hoist to a tower mounted Koepe hoist;
- changing the ventilation shaft headframe material from steel to concrete;
- adding refrigeration and bulk air coolers for the ventilation system;
- changing the layout of the underground facility to better align with the measured principle stress;
- changing the location of some ancillary facilities from those shown in the EA preliminary design to refine the layout; and
- changing the underground rock support system.

The DGR Project change control procedure will describe the management process for control of project change. It will include prompt identification of DGR Project Change Notices (PCNs) and an approval process that results in appropriate review and authorized changes to scope, budget, and/or schedule. Changes to the DGR Project design will be managed in accordance with NWMO Design Management, NWMO-PROC-EN-0001 [34]. The Commissioning Change Control Procedure, DGR-PROC-00920-1001, describes the process by which change can be made to the design or operation of the DGR during commissioning. No change will be implemented unless it is determined to be necessary (e.g., a flaw that renders equipment or process inoperable or endangers health or safety), and the change receives independent review and approval, design verification, and appropriate validation testing during commissioning.

4.10.2 Additional Emplacement Rooms

The DGR is designed based on volume estimates and assumptions about volume reduction efficiency. If these assumptions are not realized, there may be a need to increase the number of emplacement rooms. If additional storage is required, waste transfer operations will be discontinued and construction activities resumed. The waste rock handling facilities would be commissioned and a similar sequence of works and activities as those described in

Section 4.7.4 would occur. Waste could be stored at the WWMF during the development of additional emplacement rooms, as necessary.

It is expected that there will only be five emplacement rooms active in Panel 1 at the end of the planned DGR Project life. Three of these rooms have rail access and are designed to include some additional capacity for future large waste packages. It is likely that the access to Panel 1 will be controlled and would not be accessible to the construction activities undertaken for the creation of additional emplacement rooms, but would be monitored and ventilated.

The process that would be undertaken should a decision be made to expand the DGR at some future point in time is similar to that described, above, for design changes.

4.10.3 Discontinuation of the Project

In the event the DGR Project was cancelled, for any reason, during the site preparation and construction phase or prior to waste emplacement operations having begun, the DGR Project site would be decommissioned as described in Section 4.11. The main difference would be the absence of any radioactive materials in the emplacement rooms, and decommissioning would not involve any radiological considerations. Chapter 13 of the Preliminary Safety Report [26] provides additional information on this scenario, including a schedule for decommissioning activities that would be required at the end of construction.

OPG, which will hold the licence for the site preparation and construction phase of the DGR Project, has the financial capacity to ensure the plan could be carried out. Reasons for halting site preparation prior to completion, or making a decision to not complete construction activities are speculative, and could be associated with policy, business, technical considerations or other developments.

Should the DGR Project be cancelled for any purpose during the operations phase, the DGR facility would be decommissioned as described in the Preliminary Decommissioning Plan [70], which has been submitted as part of the permitting application. Section 4.11 outlines a conceptual plan for decommissioning the facility, and demonstrates there is sufficient technical knowledge and expertise to ensure decommissioning is effective. OPG, as licensee, will be required to financially guarantee the safe shutdown of the DGR.

4.10.4 Public Communications

NWMO will continue to implement a public information program following the submission of the EIS. Additional targeted communications would be initiated in the event of a proposal to modify the DGR Project in ways which would result in a meaningful change. These include, but are not limited to changes to the:

- layout of the DGR facility;
- characteristics or sources of waste to be emplaced in the DGR;
- capacity of the DGR;
- life cycle schedule for the DGR Project;

- monitoring program for the DGR Project; and
- socio-economic considerations (e.g., employment or spending).

Notification of these DGR Project modifications would be made, at a minimum, to members of the public residing in the Bruce municipalities as well as other interested stakeholders. The Saugeen Ojibway Nation as well as the Historic Saugeen Métis Community and the Métis Nation of Ontario would also be contacted.

A detailed communication plan including objectives, strategy, spokespeople, target audiences, key messages and communication activities would be prepared to govern how the information would be relayed for each proposed modification to the DGR Project. The communication plan would provide a targeted approach for communicating the specific proposed modification and may include briefings and interviews with key stakeholders, updated website, media briefings and press releases, advertising, notification letters, newsletters, workshops, open houses and community information sessions.

A comment database would be maintained to record and monitor all comments, correspondence and communications with stakeholders and Aboriginal peoples interested in the proposed modifications to the DGR Project. Concerns or issues identified through this communication process would be considered in a manner similar to that employed for addressing issues raised throughout the EA process.

4.11 DECOMMISSIONING PHASE

A summary of the decommissioning activities is provided in the sections below. Decommissioning planning is summarized in Chapter 13 of the Preliminary Safety Report [26]. As noted in Section 4.10.3, a Preliminary Decommissioning Plan [70] has been prepared, and submitted as part of the lincensing application, for the DGR Project. This plan meets:

- CNSC Regulatory Guide G-219 Decommissiong Planning for Licensed Activities [71]; and
- CSA N294-09 Decommissioning of Facilities Containing Nuclear Substances [72].

Planning for decommissioning is an on-going process, and planning assumptions are expected to change over time. The Preliminary Decommissioning Plan [70] will be reviewed and revised periodically to incorporate changes in the planning assumptions.

As indicated in Section 4.6, decommissioning is expected to take approximately five years to complete. Chapter 13 of the Preliminary Safety Report [26] includes an outline schedule for completing the decommissioning work program. At the time of writing, the projected workforce averages 115 persons over the course of the decommissioning phase including NWMO and OPG staff plus contractors.

4.11.1 End-state Objectives

The objective of decommissioning is to permanently retire the DGR facility from service in a manner that ensures the health and safety of the public and the workers, and protection of the environment. Decommissioning involves closing the DGR and restoring it to an agreed end-state. Upon completion of decommissioning and obtaining a licence to abandon the site, the site would be in a condition that will make it available for other uses while under institutional controls.

4.11.2 Decommissioning Strategy

The decommissioning strategy for the DGR is based upon the fundamental assumption that no radioactive wastes emplaced in the DGR will be removed as part of the decommissioning. The decommissioning strategy is based on a combination of prompt decommissioning and in situ confinement as defined in CSA N294-09 [72]. Decommissioning will be followed by a period of institutional controls.

The DGR is unique in that it combines aspects of mining with a nuclear facility. Even though the DGR does not meet the legal definition of a mine, Mine Development and Closure Regulations (O. Reg. 240/00) under Part VII of the Mining Act [73] provides useful information on the installation of concrete caps atop decommissioned mine shafts. In general, a reinforced concrete cap, certified by a qualified professional engineer is placed atop decommissioned mine shafts. The caps installed atop the main and ventilation shafts will be consistent with the requirements given in O. Reg. 240/00 [73].

An overview of the principal hazards and protection strategies envisioned for decommissioning is provided in Section 4.11.6.

4.11.3 Decommissioning of Facilities

Decommissioning will begin following a period of monitoring after all of the waste has been emplaced and a Decommissioning Licence has been obtained.

Decommissioning at the repository level will largely consist of preparing the underground services area for the construction of a concrete monolith. Decommissioning of the underground facilities will include the assessment of equipment to determine whether or not it should be removed and salvaged, or remain in the repository for closure. Particular attention will be given to areas where potentially hazardous materials, such as waste fluids from mobile equipment, may exist. At the time of writing, it is assumed that most permanent equipment and materials will remain within the repository and that only mobile equipment, which has been tested and does not contain residual radioactive contamination, will be removed to surface. As described in Section 4.11.4, the ventilation shaft steel-work and services will be placed in the repository for closure. All repository services will be disconnected and the underground shaft and services area will be prepared to construct the concrete monolith. The monolith will be located at the base of both shafts and extend into the shaft and services area of the repository level.

The majority of surface facilities will be decommissioned following completion of the shaft seals, as the infrastructure will be required to maintain service to the shafts during the installation of the sealing materials. Some of the surface facilities components and equipment, which are determined to be contaminated (e.g., main surface exhaust fans and associated equipment) can be removed and placed in the repository prior to sealing the shaft.

Following removal of all surface facilities, the DGR Project site will be graded and vegetated. The location of the shafts will be appropriately secured. The construction of the shaft sealing system is further explained in Section 4.11.4.

The stormwater management pond and the drainage ditches established for the DGR Project will be decommissioned during site restoration activities.

The waste rock remaining in the WRMA will be covered by a soil cap and vegetation. The waste rock pile will be capped with a minimum of 150 mm of soil and topsoil that is suited to the requirements of the local flora. Surface materials will be stabilized and the surface will be contoured to promote drainage and to minimize erosion. Wind breaks will be established, if necessary, for erosion control until such time that the vegetation is sufficiently established. Waste materials anticipated to be generated during the decommissioning phase are discussed and quantified in Section 4.11.5.

4.11.4 Decommissioning of the Shafts

Decommissioning of the shafts will consist of sequential removal of shaft infrastructure and installation of the shaft sealing materials. As noted, all internal shaft support structures (e.g., steel sets) and infrastructure connections (power, ventilation, water) will be disconnected and removed before sealing work begins in a shaft. A new ventilation system will be established in each shaft to allow the workers to safely decommission the shafts.

Prior to placing shaft sealing materials, the concrete monolith will have been constructed at the base of each shaft (Figure 4.11.4-1). The concrete monolith would be then overlain by a column of compacted bentonite/sand. An asphalt column would be placed above the first bentonite/sand layer to provide a redundant low permeability sealing material against upward or downward fluid flow.

A series of bentonite/sand columns are separated by concrete bulkheads to provide structural components to the column and provide additional sealing capability. These design features contribute towards isolation and containment of the waste.

The preferred design approach for the shaft seal focuses on the use of simple, proven materials and methods for emplacement, using currently available technology. Since the shaft seal will not be implemented for several decades, there is time to incorporate new information learned during operation of the DGR as well as long-term sealing tests at the DGR and internationally. Therefore, the design described here is intended to provide reasonable assurance that a competent shaft seal can be constructed.

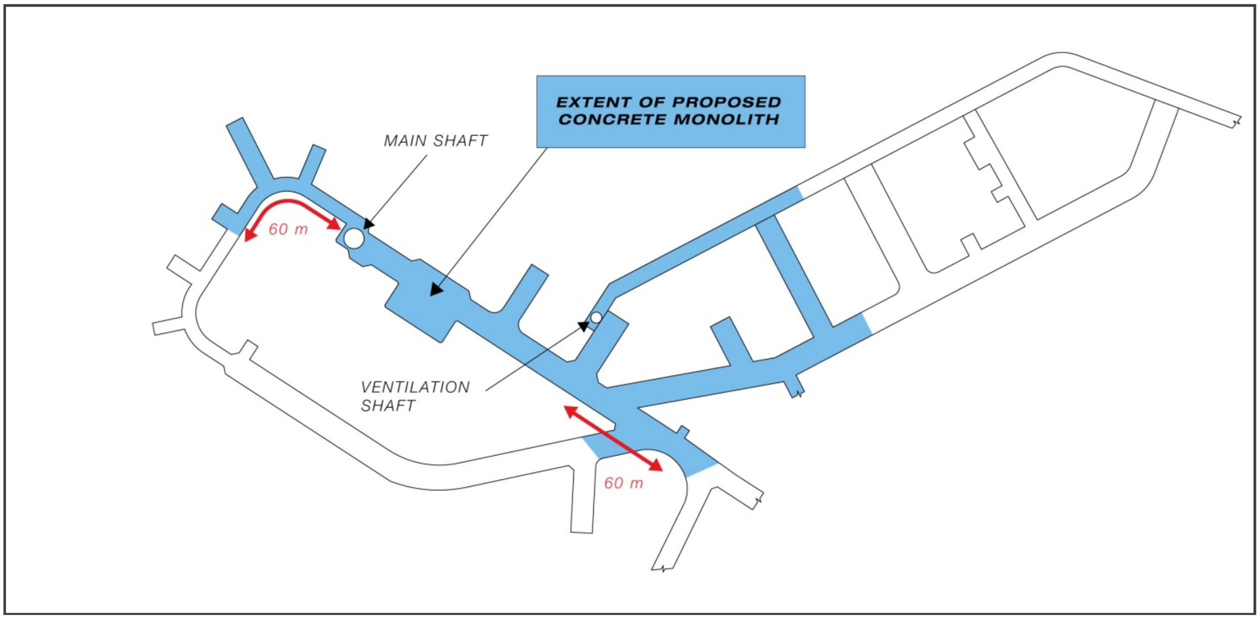

Figure 4.11.4-1: Extent of the Proposed Concrete Monolith

4.11.4.1 Seal Materials

The approach for the shaft seal design and construction has focused on the use of simple, relatively well understood and durable materials, and use of proven methodologies for emplacement. Concrete, bentonite/sand mixture and asphalt will be the sealing materials used in each shaft. An engineered fill material based on rock excavated during shaft sinking or some other suitable material will be used in the upper portion of each shaft as shown on Figure 4.11.4-2. Additional information on the seal materials is provided in the following section.

4.11.4.2 Construction of Shaft Seal

As noted, a concrete monolith will be placed at the base of the seal system (Figure 4.11.4-1). Concrete will provide a stable foundation for the overlying seal materials. The monolith will be constructed in two stages, one for the ventilation shaft, followed by another for the main shaft. They will form a contiguous mass concrete structure with no structural reinforcement within the concrete. All services and utilities will be stripped out of the excavations to be filled by the monolith.

Throughout all seal sections up to the top bulkhead, shown on Figure 4.11.4-2, shaft support structures and concrete liners will be removed to ensure a complete seal of the shaft column to the surrounding low permeability host rock. Also, it is assumed that an additional 500 mm of host rock will be excavated beyond the initial shaft diameter to remove any damaged rock that may have formed during shaft sinking and the operations phase of the DGR Project.

The column of sealing materials in each shaft is largely composed of a compacted bentonite/sand mixture (Figure 4.11.4-2). Once saturated, the compacted bentonite/sand materials will act as a low permeability barrier to retard the movement of radionuclides out of the repository and minimize the potential for groundwater flow down into the repository. Compacted clays or clay/sand mixtures are the most commonly proposed sealing materials for nuclear waste repositories.

Sand will be added to the bentonite to act as a filler without compromising the hydraulic conductivity and swelling potential of the bentonite dominant material. The use of sand will improve workability during placement, ease compaction and dust control.

As the compacted bentonite/sand materials saturate with groundwater from the surrounding rock, they will generate swelling pressures, which will aid in the development of a tight seal against the shaft wall and provide a confining pressure to the rock surface.

A 60 m thick asphalt column will be placed above the lowermost bentonite/sand column. The asphalt column extends over a length of the Georgian Bay Formation to just above the Queenston/Georgian Bay contact. Asphalt was selected because it has the ability to flow and make good contact with host rock. Immediately upon emplacement, the asphalt will create an effective barrier to water flow. Furthermore, the use of another low permeability sealing material provides an additional level of redundancy to the sealing system against upward or downward fluid flow.

Asphalt will be pumped to the shaft and placed through the use of a slickline and header. The slickline will require heating to maintain the asphalt's viscous state. Asphalt will be placed in controlled lifts. Following placement of an asphalt lift, placement operations will cease to allow for cooling of the asphalt and to ensure a safe environment for workers starting the subsequent placement of sealing materials. Ventilation into the shaft will be maintained during this period to promote cooling and to remove any hazardous fumes. Air temperature and quality will be remotely monitored to establish when it would be safe to resume shaft sealing activities. Leading up to the top bulkhead, there are two higher permeability units within the surrounding geosphere: the Guelph Formation and the upper 4 m of the Salina A1 carbonate unit (see Section 6.2.7). As a result of the expected lateral flow along this unit, a concrete cylinder will be placed along the full extent (approximately 6 m) of this unit. To ensure structural stability, the underlying concrete structure will be constructed to a height slightly larger than the diameter of the excavated shaft, and the concrete bulkhead will be keyed into the surrounding host. The concrete mix will be similar to that selected for the concrete monolith. The concrete/rock interface will also be pressure-grouted to minimize groundwater flow along the interface.

A concrete bulkhead will be installed at the upper 4 m of the Salina A1 carbonate unit and the design will be the same as that proposed for the Guelph Formation.

Salina Unit F represents a lower (at least one order of magnitude) permeability zone within the dolostones (an aquitard) between a fresh water aquifer above and more saline water-bearing formations below. To prevent movement of the poor quality, saline groundwater from the lower Salina Formation upwards through the shaft cross-section into the upper fresh water aquifer, a concrete bulkhead will be constructed at this location.

As with the monolith, concrete for the bulkheads will be placed in mass and with no reinforcing steel, and using measures to control heat build-up. Contact/seal grouting will be applied around the bulkheads to minimize the potential impacts of shrinkage at the interface with the host rock formation. Concrete will be poured directly onto the bentonite/sand columns located below each bulkhead.

The uppermost portion of each shaft will be filled with an engineered fill (e.g., 'Granular A' material). The engineered fill will be topped by a surficial concrete cap, which is the final element of the seal system. The cap will serve the following functions:

- further reduce the potential for subsidence, as concrete is stronger than compacted fill;
- provide a marker for the shaft locations; and
- reduce the potential for inadvertent human entry by providing a restrictive barrier at the surface.

The surficial cap will be constructed using concrete. Air entrainment within the concrete is required to minimize adverse effects of freeze/thaw action on the concrete cap.

4.11.5 Decommissioning Waste Management

This section identifies the types of wastes that are anticipated to be generated during the decommissioning phase of the DGR Project. It considers conventional, hazardous and radioactive materials. Wherever appropriate, mechanisms and materials decommissioned from surface and underground facilities will be recycled or reused elsewhere to reduce requirements for disposal. Those materials that are not recyclable will be disposed of in a licensed facility. Any materials or equipment in surface facilities that would be considered radioactive waste will be removed near the start of decommissioning and placed in the repository prior to the start of shaft sealing.

4.11.5.1 Conventional and Hazardous Wastes

Conventional and hazardous waste will be produced during the decommissioning phase of the DGR Project. These wastes will consist of consumable materials such as rags and coveralls used for maintenance and clean-up, solids generated from underground sanitary facilities, and other miscellaneous wastes. All waste materials will be collected in waste bins or totes, sent to treatment as necessary, and disposed of at licensed facilities.

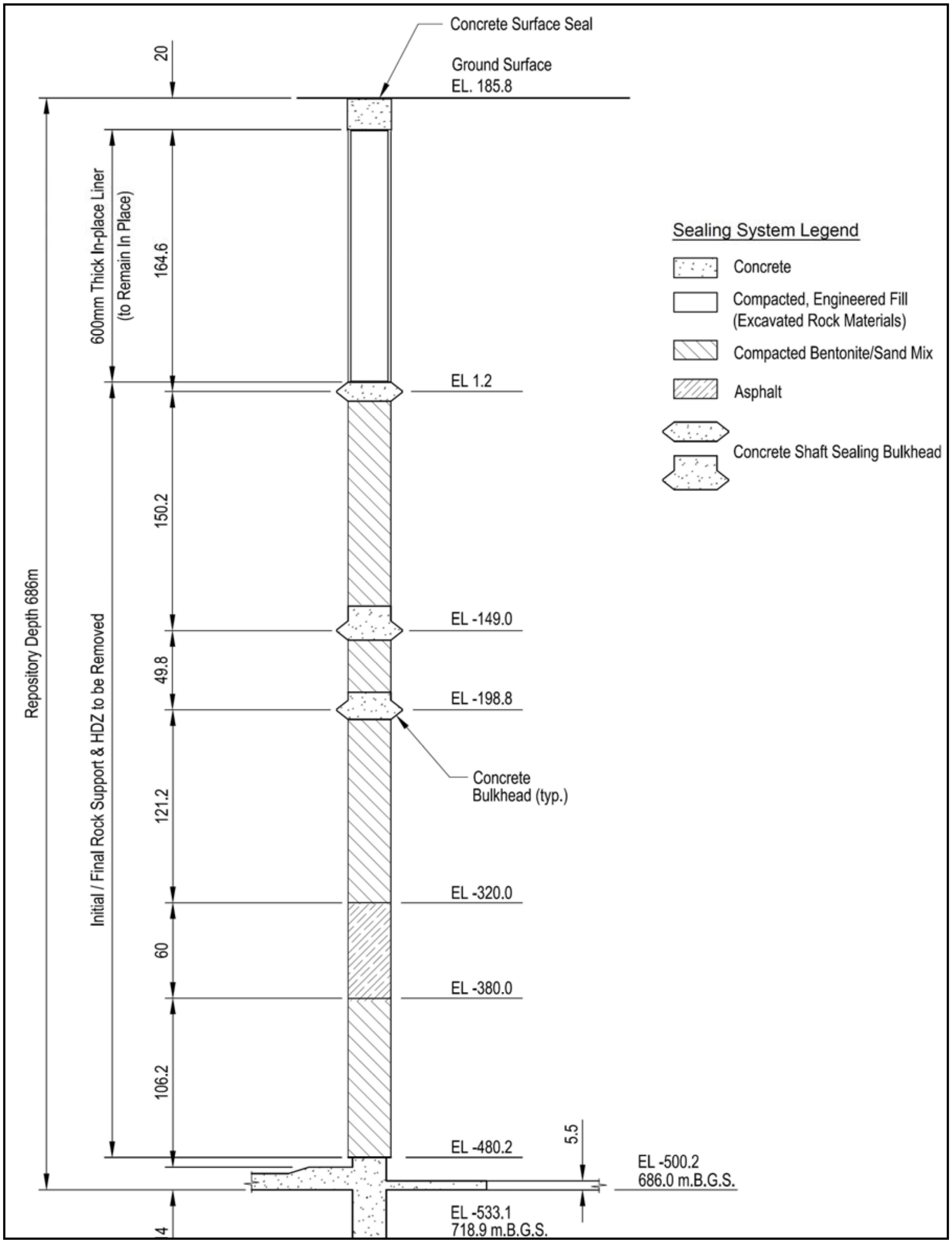

Figure 4.11.4-2: Arrangement of Shaft Seal Components

As described in Section 4.11.3, it is assumed that underground mobile equipment will be removed to the surface. Once at surface, it is possible that some of the equipment could be salvaged for reuse or for its scrap metal. Alternatively, if the equipment has no value and space is available and approval is received to do so, then the mobile equipment could remain underground. All fluids (e.g., fuel, lubricants, and hydraulic fluids) and any other hazardous materials (e.g., batteries) would be removed prior to leaving any equipment underground.

Waste materials resulting from the removal of ventilation shaft and main shaft infrastructure (such as shaft steelwork and concrete lining) will be brought to the surface and reused/recycled wherever possible. Similarly waste rock resulting from excavation of any damaged rock in the shafts will be reused on site wherever possible (e.g., as engineered fill in upper portion of shafts as described in Section 4.11.4) or could be placed in the WRMA. Materials from decommissioning of the ventilation shaft and main shaft that cannot be reused or recycled will be sent to a licensed disposal facility.

Table 4.11.5-1 presents the estimated quantity of waste materials that would arise from the decommissioning of the DGR facility. The projected range of conventional and hazardous waste materials that would be produced during decommissioning is shown in Table 4.11.5-2.

Table 4.11.5-1 Waste Materials Arising from Decommissioning

Structure	Material Type	Quantity[a]
Ventilation shaft	Steel	490 tonnes
	Concrete	5,600 m^3 [b]
	Waste rock (HDZ)[c]	7,000 m^3
Ventilation shaft headframe	Steel	520 tonnes
	Concrete	260 m^3
Main shaft	Steel	780 tonnes
	Concrete	9,100 m^3
	Waste rock (HDZ)[c]	8,800 m^3
Main shaft headframe and WPRB	Steel	380 tonnes
	Concrete	8,700 m^3
Other items such as miscellaneous cabling, panels, and other equipment		

Notes:
a Volumes (in m^3) of material are bulked volumes.
b It is assumed that less than 10% of the ventilation shaft concrete could be contaminated; however, it would be impractical to separate the contaminated concrete from the remainder of the concrete liner.
c Highly Damaged Zone (HDZ)

Table 4.11.5-2: Projected Range of Conventional and Hazardous Wastes Arising from Decommissioning

Waste Material	Projected Range of Output
Oils and grease	15,000 – 18,000 L per year
Batteries	60 – 80 kg per year
Solvents	1,500 – 2,500 L per year
Domestic waste	25,000 – 35,000 kg per year
Sanitary waste	8,000 – 12,000 kg per year

4.11.5.2 Radioactive Waste

During operations, all waste packages will be checked for contamination, and decontaminated if necessary, before they are emplaced in the DGR. Abnormal operating occurrences may result in some contamination events during the course of operations; however, it is anticipated that any such contamination would be removed whenever it is discovered. It is expected that there will be little or no radioactive contamination on facility structures, systems and equipment. Consequently, the volume of radioactive waste generated during the decommissioning will be limited to 10 m^3, in addition to the waste identified in Section 4.11.5-1. Operational experience and radiological surveys will be used to prepare a revised estimate.

4.11.6 Decommissioning Hazards and Protection Strategies

As previously noted, a Preliminary Decommissioning Plan [70] has been prepared in support of the licence application to prepare the site and construct the DGR facility. It describes planning work that has been completed to comply with CSA Standard N294-09, Decommissioning of Facilities Containing Nuclear Substances [72] and CNSC Regulatory Guide G-219, Decommissioning Planning for Licensed Activities [71]. This plan describes the intended approach based on current information that would be taken to decommission all structures, systems and components found within the DGR Project site. It is intended to demonstrate that decommissioning can be completed, with existing technology, in a manner that ensures the protection and safety of workers, members of the general public and the environment. More specifically, the Preliminary Decommissioning Plan [70] identifies the following:

- the types of activities that could pose a significant hazard to workers, the public or the environment;
- the role of existing procedures for managing hazards; and
- the specific activities for which additional protection/mitigation procedures will be required at the detailed planning stage.

4.12 ABANDONMENT AND LONG-TERM PERFORMANCE PHASE

An application for a Licence to Abandon the facility will be submitted to the CNSC following decommissioning. An abandonment plan will be developed in support of the application for a Licence to Abandon. The application will include:

- the results of the decommissioning; and
- the results of the environmental monitoring programs.

The results of the environmental monitoring will include the information collected during the course of the decommissioning and during any other monitoring period. This report will describe the decommissioning work that has been performed, the outcome of that work, the results of the final surveys that were performed and the interpretation of those results. Other information required by the applicable regulations will also be included.

A period of institutional control, currently assumed to last up to 300 years, will follow the decommissioning. A Licence to Abandon issued by the CNSC may include conditions that would apply throughout the period of institutional control. Institutional controls will help prevent or reduce the likelihood of human actions inadvertently interfering with the waste or causing degradation of the safety features of the repository. More information on institutional controls can be found in CNSC G-219, Decommissioning Planning for Licensed Activities [71], CNSC Guide G-320, Assessing the Long Term Safety of Radioactive Waste Management [74] and IAEA Safety Standard WS-R-4, Geological Disposal of Radioactive Waste [75].

Given the type of facility and the nature of the hazards present, it is assumed that:

- a period of passive institutional control will be applied to the L&ILW DGR which may include local land use controls; local, national and international records; and the use of durable surface and/or subsurface markers;
- the site will be available for other purposes that are consistent with any applicable land use restrictions; and
- the period of institutional controls would be up to 300 years.

This is consistent with national guidance and international practice. Additional details of the nature of institutional controls will be included in the detailed decommissioning plan. Section 9 of this report provides additional details demonstrating the long-term safety of the DGR.

4.13 MALFUNCTIONS, ACCIDENTS AND MALEVOLENT ACTS

This section describes the identification of the potential malfunctions or accidents associated with the DGR Project. The identification and screening of credible malfunctions and accidents was carried out in the Malfunctions, Accidents and Malevolent Acts TSD. That TSD also addresses malevolent acts. Section 8 of this EIS summarizes the assessment related to malfunctions, accidents and malevolent acts.

Malfunctions or accidents could occur throughout all phases of the DGR Project. They could take place as internally-initiated events (such as equipment failures) and externally-initiated events (including human activity such as traffic accidents, and natural hazards such as tornados or earthquakes). For the EA, malfunctions and accidents associated with the DGR Project are grouped into two categories:

- radiological accidents; and
- non-radiological (i.e., conventional) accidents.

Radiological accidents refer to those which could result in the acute release of radioactivity to the environment and potentially affect all or part of the subcomponents of the radiation and radioactivity environment (atmosphere, surface water, groundwater, aquatic biota, terrestrial biota, members of the public and workers). Conventional accidents refer to those which involve only non-radiological substances and will not result in adverse radiological effects on the environment or human beings.

4.13.1 Radiological Malfunctions and Accidents

4.13.1.1 Site Preparation and Construction Phase

No radiological accidents are postulated for the site preparation and construction phase of the DGR Project since the associated works and activities do not involve any radioactive materials.

4.13.1.2 Operations Phase

Potential radiological accidents were considered to occur both above-ground or at various locations below-ground. Potential accident scenarios involving a source of hazards, initiating event, and potential hazardous events/consequence were considered. The result of this analysis was a list of specific accident scenarios. Based on the frequency of the initiating events and the likelihood of the events/consequence, accident scenarios which are considered non-credible are screened out as the risk associated with these scenarios is deemed to be acceptable.

Potential sources of hazards which could affect waste packages are grouped into the following:

- geology;
- radioactive waste packages;
- non-radioactive combustible materials;
- heavy equipment; and
- utilities.

A list of credible initiating events that are applicable to the Bruce nuclear site and the DGR facility design was developed (Table 3.2-1 in the Malfunctions, Accidents and Malevolent Acts TSD).

The frequency of the initiating events was then estimated by considering three classes:

- possible events: annual frequency of $>10^{-2}$;
- unlikely events: annual frequency between 10^{-2} and 10^{-7}; and
- non-credible events: annual frequency of $\leq 10^{-7}$.

The assessment identified the following hazardous events for further consequence analyses:

- Fire:
  - ILW Packages (with combustible material);
  - LLW Packages (with combustible material);
  - steam and volatile species release from shielded ILW packages;
- Breach:
  - ILW Packages;
  - LLW Packages;
- inadequate ILW package shielding; and
- ventilation system failure.

After the initial screening of the accident scenarios, a list of bounding accident scenarios was developed. The bounding accident scenarios were selected for each type of hazardous event identified (e.g., waste package fire, waste package breach). The criteria for selection of the bounding accident scenarios were based on the qualitative estimation of the magnitude of the consequences which, in turn, is a function of the type and number of waste packages affected and the location of the hazardous event. The lists of bounding accidents for above-ground and underground operations of the DGR are provided in Tables 4.13.1-1 and 4.13.1-2, respectively. The detailed assessment of the bounding scenarios is provided in Section 8.3 and the Malfunctions, Accidents and Malevolent Acts TSD.

Table 4.13.1-1: List of Potential Accidents in the DGR Above-ground Operations

Accident Type	Bounding Scenario	Selected Waste Type	Number of Packages at Risk
Fire	Outdoor Unshielded Waste Package Fire	Box Compacted	8
		Non-Processible Boxed	8
		Non-Processible Drummed	8
		Moderator Resin (Unshielded)	1
	Indoor Unshielded Waste Package Fire	Box Compacted	24
		Non-Processible Boxed	24
		Non-Processible Drummed	24
		Moderator Resin (Unshielded)	1

Table 4.13.1-1: List of Potential Accidents in the DGR Above-ground Operations (continued)

Accident Type	Bounding Scenario	Selected Waste Type	Number of Packages at Risk
Fire (continued)	Indoor Unshielded Waste Package Fire (continued)	Combined LLW and ILW Packages	24 Non-processible drummed + 2 moderator resin (unshielded)
	Shielded ILW Package Steam Release	Moderator Resin (Outdoors)	1
		Moderator Resin (Indoors)	1
Low Energy Container Breach	Outdoor Waste Package Breach	Bottom Ash	8
		Box Compacted	8
		Non-Processible Boxed	8
		Non-Processible Drummed	8
		Moderator Resin (Unshielded)	1
		Moderator Resin (Shielded)	1
	Indoor Waste Package Breach	Bottom Ash	24
		Box Compacted	24
		Non-Processible Boxed	24
		Non-Processible Drummed	24
		Bottom Ash	1
		Box Compacted	1
		Non-Processible Boxed	1
		Non-Processible Drummed	1
		Moderator Resin (Unshielded)	1
		Moderator Resin (Shielded)	1
		Combined LLW and ILW Packages	24 Non-processible drummed + 2 moderator resin (unshielded)
		Moderator Resin (Shielded)	1
Other	Inadequate Shielding	Moderator Resin	1

Table 4.13.1-2: List of Potential Accidents in the DGR Underground Operations

Accident Type	Bounding Scenario	Selected Waste Type	Number of Packages at Risk
Fire	Unshielded Waste Package Fire During Transfer	Box Compacted	1
		Non-Processible Boxed	1
		Non-Processible Drummed	1
		Moderator Resin (Unshielded)	1
	In Room Unshielded Waste Package Fire	Box Compacted	2,400
		Non-Processible Boxed	2,400
		Non-Processible Drummed	2,400
		Moderator Resin (Unshielded)	1,200
	Shielded ILW Package Steam Release	Moderator Resin (Transfer)	1
		Moderator Resin (In Room)	1
Low Energy Container Breach	Waste Package Breach During Transfer	Bottom Ash	1
		Box Compacted	1
		Non-Processible Boxed	1
		Non-Processible Drummed	1
		Moderator Resin (Unshielded)	1
		Moderator Resin (Shielded)	1
	In Room Waste Package Breach	Bottom Ash (Old)	3
		Box Compacted	4
		Non-Processible Boxed	5
		Non-Processible Drummed	5
		Moderator Resin (Unshielded)	4
		Moderator Resin (Shielded)	3
High Energy Container Breach	Cage Fall	Bottom Ash	2
		Box Compacted	2
		Non-Processible Boxed	3
		Non-Processible Drummed	3
		Moderator Resin (Unshielded)	2
		Moderator Resin (Shielded)	1
		Retube-End Fittings	1

Table 4.13.1-2: List of Potential Accidents in the DGR Underground Operations (continued)

Accident Type	Bounding Scenario	Selected Waste Type	Number of Packages at Risk
Loss of Ventilation	Ventilation System Failure	All Waste	—

Note:
— Not applicable

4.13.1.3 Decommissioning Phase

No radiological accidents are postulated for the decommissioning phase of the DGR Project since the associated works and activities are associated with sealing the shafts, removing surface facilities, and regrading and vegetating the site. As described in Section 4.11.5.2, it is expected that there will be little or no radioactive contamination on facility structures, systems and equipment.

4.13.1.4 Abandonment and Long-term Performance Phase

Malfunctions and accidents could occur during the abandonment and long term performance phase that would result in radiological consequences. The Postclosure Safety Assessment [27] identifies four disruptive scenarios, shown in Table 4.13.1-3. All of these scenarios are assessed in Section 8.3 and the Malfunctions, Accidents and Malevolent Acts TSD.

Table 4.13.1-3: Disruptive Scenarios during Abandonment and Long-term Performance Phase

Scenario	Brief Description
Human intrusion	Inadvertent intrusion into the DGR via an exploration borehole
Severe shaft seal failure	Very poor performance of the shaft seals
Poorly sealed borehole	Site investigation borehole not properly sealed
Vertical fault	A transmissive vertical fault in the vicinity of the DGR

4.13.2 Conventional Malfunctions and Accidents

Non-radiological accidents were considered to occur both above-ground or at various locations underground during the site preparation and construction, operations, and decommissioning phases of the DGR Project. Conventional accidents during the abandonment and long-term performance phase are not considered since the repository and shafts will be sealed, surface facilities removed, and the site returned to an agreed-to end state, as described in Section 4.11.1. The list of credible conventional accidents during the DGR Project includes:

- electrical accident;
- loss of ventilation;
- spill of fuel, chemicals, lubricants or oils;
- exposure to substances hazardous to health;
- entrapment;
- structural instability;
- material handling accidents;
- shaft damage;
- fire/smoke;
- explosion/detonation;
- asphyxiation or severe reduction in air quality;
- vehicle accident; and
- occupational accidents.

Each credible malfunction and accident was screened to determine if it could reasonably result in an adverse environmental consequence and warrant further consideration, as documented in Section 8.3.1 and the Malfunctions, Accidents and Malevolent Acts TSD. Similarly, each credible malfunction and accident was screened to determine if it could reasonably be expected to result in an adverse consequence to members of the public. Based on this screening, bounding non-radiological accident scenarios were identified. The two bounding accidents advanced for further consideration are: (1) explosion/detonation, and (2) spill of fuel, chemicals, lubricants or oils.

Occupational hazards to workers were identified in the Preliminary Conventional Safety Assessment [68]. The assessment of hazards to workers was conducted systematically using a screening process hazard analysis method combined with a job hazard analysis approach. The list of credible hazards to workers is presented in the Malfunctions, Accidents and Malevolent Acts TSD.

The assessment of conventional malfunctions and accidents is presented in Section 8.3.

4.13.3 Malevolent Acts

There are four broad categories of potential malevolent acts: threats of violence; sabotage; theft; and attack. Threats and theft are not considered in this assessment.

The DGR is entirely contained within the Bruce nuclear site and will remain well protected by the Bruce nuclear site security forces from the start of site preparation and construction through decommissioning of the facility. A suite of security measures will be in place at the DGR facility, as described in the Malfunctions, Accidents and Malevolent Acts TSD.

Potential malevolent acts are considered for each DGR Project phase: site preparation and construction; operations; decommissioning; and abandonment and long-term performance. Malevolent acts are described and assessed in Section 8.4.

4.14 ORGANIZATION AND MANAGEMENT

4.14.1 Site Preparation and Construction Phase

During the regulatory approvals and site preparation and construction phases, OPG, as the proponent of the DGR Project, will maintain overall responsibility for its development, although its primary role will be in overseeing and monitoring the performance of its contractor, the NWMO. The OPG management system applicable to the DGR is described in OPG's Deep Geologic Repository Management System [76]. Figure 1.3-1 shows OPG's organization and management structure for the site preparation and construction phase. The NWMO, under contract to OPG, is managing regulatory approvals and the design and construction[8] of the DGR Project on behalf of OPG. The operational responsibility for the DGR Project will reside with OPG's Nuclear Waste Management Division. Figure 4.14.1-1 shows the NWMO organization and management structure for the site preparation and construction phase.

The NWMO will manage the engineering, site preparation and construction work for the DGR Project. The Project Quality Plan for the site preparation and construction phase will be compliant with CAN/CSA N286-05 [77] and ISO 9001:2008 quality management standards, include project specific quality objectives, and describe the quality requirements for all the functional areas of site preparation and construction for the DGR. The Project Quality Plan will ensure that quality continues to be integrated into final design decisions so that component configurations, materials specifications, functional performance, safety and constructability are optimized. During construction, the Project Quality Plan will be focused on providing assurance that there is strict conformance to these final design and planning decisions. The Project Quality Plan will include the specification of quality requirements in engineering design deliverables, contract documentation, materials and equipment acceptance, construction documentation and the required level of quality assurance for validation testing, inspections and commissioning.

The project design consultant will also develop a Project Quality Plan that achieves the following:

- meets the minimum NWMO requirements;
- identifies responsibilities for quality assurance and control;
- specifies auditing and corrective actions requirements; and
- maintains a register of quality compliance relating to reviews, and checks of designs.

The quality program includes provisions for systematic planned audits and assessments designed to provide a comprehensive, critical and independent evaluation of project activities. These audits and assessments cover the overall quality program, sub-tier programs, and interfaces between programs. The audits and assessments monitor compliance with governing procedures, standards and technical requirements, and confirm that quality program requirements are being effectively implemented. Audit and assessment results are documented, reported to and evaluated by a level of management having sufficient breadth of responsibility to assure actions are taken to address the findings.

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[8] The NWMO will also be the constructor for the DGR Project.

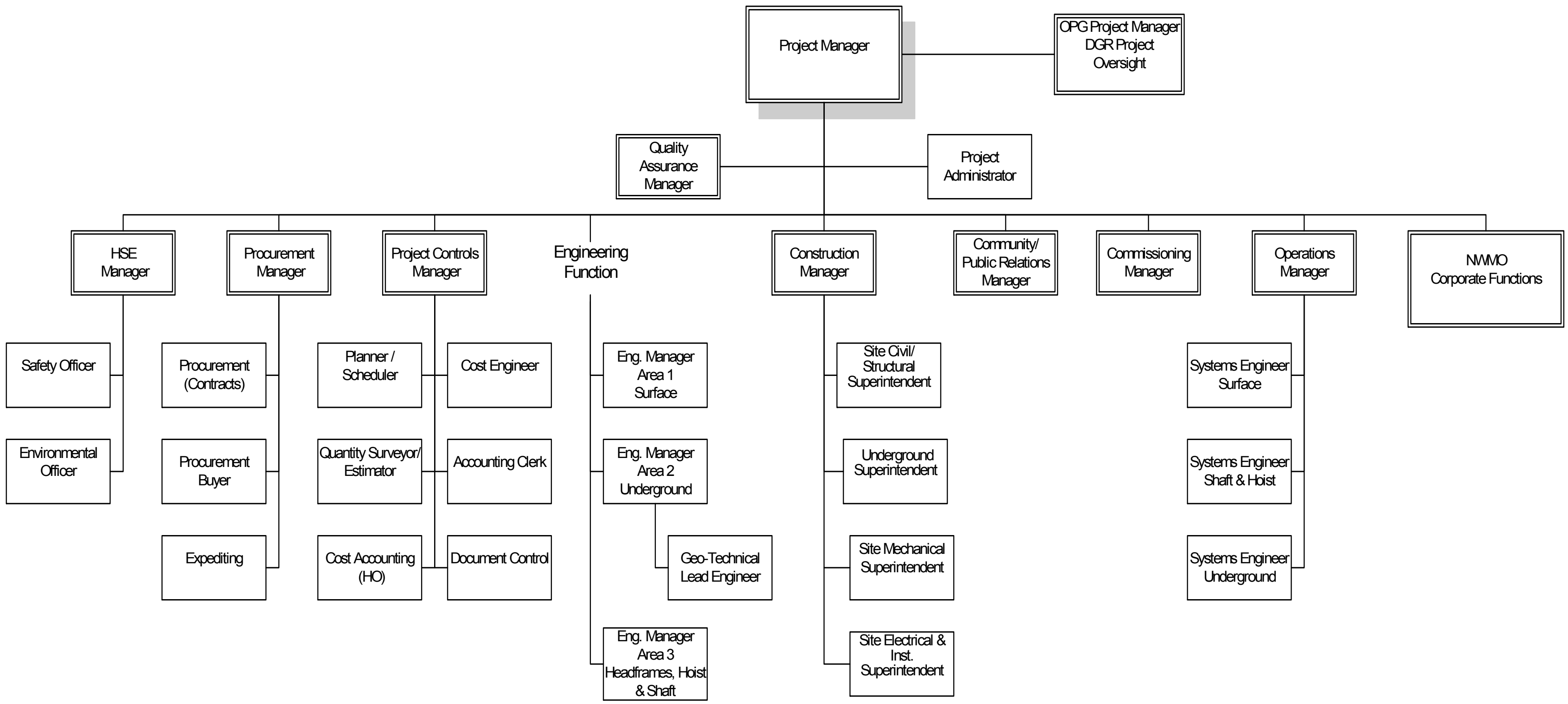

Figure 4.14.1-1: NWMO's Site Preparation and Construction Phase Organization

Additional oversight of activities is provided through self-assessment and the non-conformance and corrective action program. In particular, the corrective action program assures that non-conformance conditions are identified, documented, reported, evaluated and corrected in a timely manner.

The Project Quality Plan is supported by NWMO governance that establishes expectations for engineering and design, safety assessment, procurement, occupational health and safety, environmental protection, product and services approval, document control and records keeping. Additional information on these requirements is provided in Section 4.7.8.

4.14.2 Operations Phase

OPG will have accountability for operation of the DGR in accordance with nuclear safety, health and safety, economic, environmental, security and quality requirements, including the implementation of environmental mitigation measures, environmental monitoring and management of potential adverse effects.

Operation of the DGR will fall within the responsibility of OPG's NWMD. It is expected that the DGR will operate using governance and an organizational structure appropriate for a nuclear waste management facility and consistent with those currently in place at the WWMF, including the Nuclear Waste Management Program, which describes the organizational responsibilities, interfaces and key program elements for the management of nuclear waste. Governing documents provide the means to ensure that only specified and accepted processes and practices are used, are carried out by qualified staff, and meet the requirements of applicable standards. The program establishes the overall system for the NWMD and incorporates, directly or by reference, the controls necessary to meet the requirements of CSA N286-05, ISO 14001, and OHSAS 18001, and others as appropriate to the DGR, its related facilities and activities.

The Vice President of Nuclear Waste Management holds overall responsibility for the operation of the DGR facility. Managers within the organization are responsible for ensuring implementation of their individual assigned area. Figure 4.14.2-1 shows the current management structure within OPG's NWMD and identifies the anticipated placement of DGR Manager within the overall organizational structure.

4.14.3 Decommissioning Phase

Organization and management of the decommissioning phase will be the responsibility of OPG and will follow OPG governance in place at the time.

4.15 ENVIRONMENTAL PROTECTION POLICIES AND PROCEDURES

The OPG Environmental Policy OPG-POL-0021 [53] has been adopted by the NWMD as its environmental policy. The policy provides the guiding principles for environmental management and environmental performance within the division. The four key principles of the environmental policy are:

- practice pollution prevention;
- meet or exceed regulations;
- continual improvement in environmental performance; and
- monitor and report on environmental performance.

The guiding policy statement is: "OPG will strive to continually improve its environmental performance by committing to the following seven requirements:

- **Meet or Exceed Legal Requirements**: Meet all legal requirements and OPG's voluntary commitments, with the objective of exceeding those standards where appropriate and feasible.
- **Advance Environmental Stewardship**: Contribute to environmental protection, pollution prevention and energy and resource use efficiency.
- **Maintain ISO 14001 System**: Maintain registrations to the International Organization for Standardization (ISO) 14001: 2004 Environmental Management System.
- **Integrate Environment in Decision-Making**: Integrate environmental factors and stakeholder considerations into our planning, decision-making and business practices.
- **Engage Employees**: Engage and educate employees to conduct their activities in a manner that respects and protects the environment.
- **Contribute to Our Communities**: Contribute to and enhance the environmental well-being of the communities in which we operate and the broader public who grant us our licence to operate.
- **Communicate**: Measure and publicly communicate our environmental performance with employees, governments, local communities, contractors and other stakeholders."

Environmental procedures for construction are under development and will be finalized once the detailed DGR Project design has been established. A detailed Environmental Management Plan DGR-PLAN-07002-0001 will be developed and implemented by the contractor for the site preparation and construction of the DGR Project, and will be consistent with accepted practices and standards.

OPG's existing Environmental Management System (EMS) is ISO 14001 certified, and will serve as the governing document during the operations phase of the DGR Project. The ISO 14001 EMS system helps OPG to make certain that its environmental policies are managed, implemented, checked and reviewed within an overall context of continuous improvement. Within operations, the EMS is instrumental in assisting the business units to manage their potential environmental effects.

All OPG employees have accountability for protecting the environment and for complying with applicable policies and procedures.

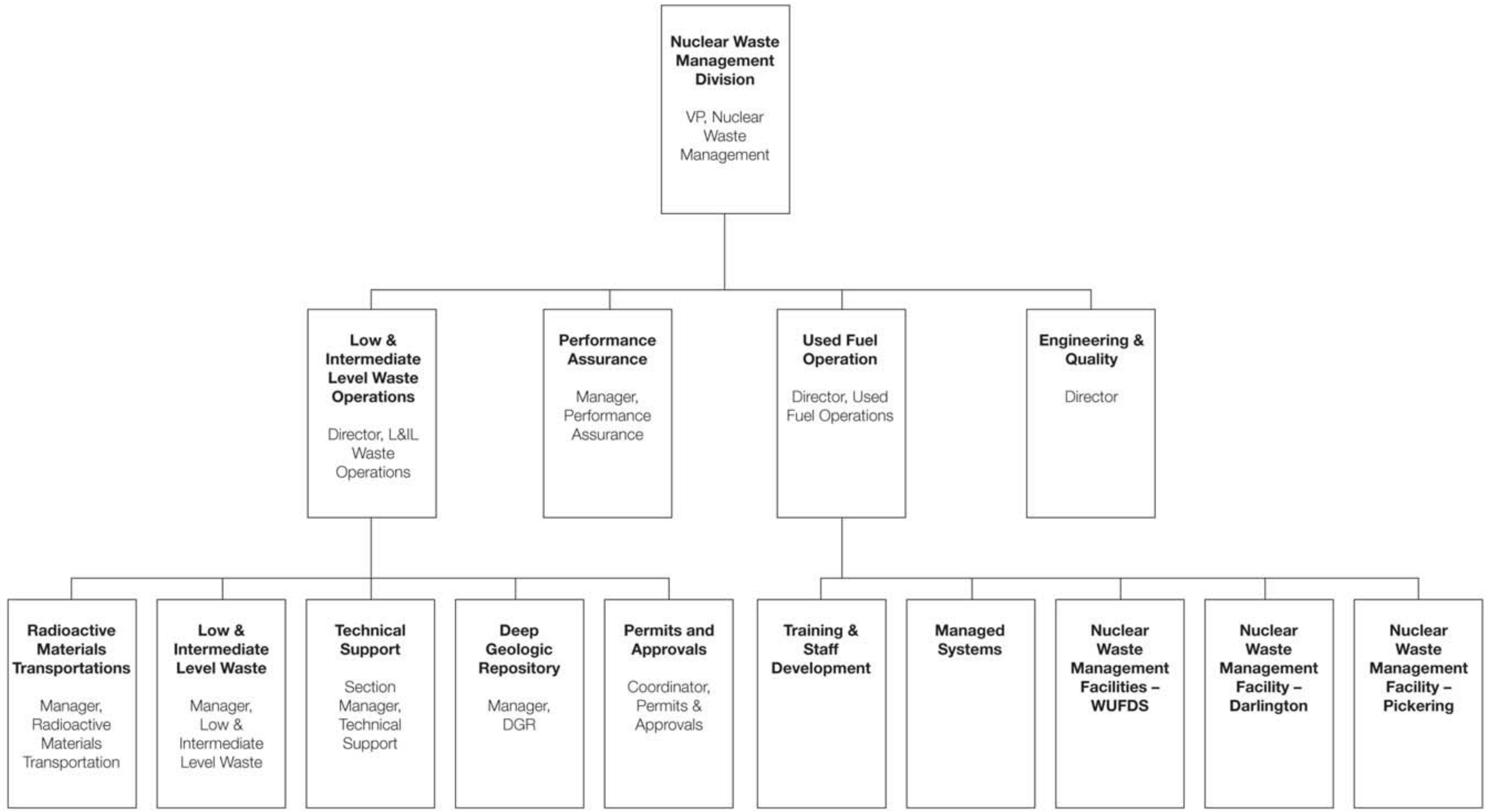

Figure 4.14.2-1: Operations Phase Organization

4.15.1 Environmental Protection

Environmental protection policies, programs and procedures will be established as described in Section 4.7.8 (site preparation and construction phase) and Section 4.8.7 (operations phase).

Execution of the programs will be accomplished through an integrated set of documented activities, typical of an EMS and it will also integrate the documentation activities related to the DGR EA Follow-up Monitoring Program [78]. A conceptual EA follow-up monitoring plan is described in Section 12 of this report. The results of the follow-up monitoring carried out during the site preparation and construction, and operations phases of the DGR Project will contribute to the overall EMS.

4.15.1.1 Control of Radiation Exposure and Contamination

A key practice in maintaining control of radiation exposure and contamination is through the use of zoning. The two radiological zones to be used for the DGR Project are defined as follows:

- Zone 1 is a clean area which is not a radiological zone and may be considered the equivalent of a normal public access area.
    - Zone 1 shall not contain radioactive sources other than those found in normal industrial establishments, or those specifically approved for use in applications such as training and demonstrations.
    - Fixed contamination levels in Zone 1 shall not exceed the established contamination limit for Zone 1 surfaces. No detectable loose contamination shall be permitted in Zone 1.
    - Zone 1 shall have a very low probability of cross-contamination from adjacent areas and shall have a low general radiation background, not exceeding the established limit.
- Zone 2 is a radiological zone that is normally free of contamination but is subject to infrequent cross-contamination due to the movement of personnel and equipment from contaminated areas.
    - Zone 2 is normally free of radioactive sources other than those found in normal industrial establishments, or those specifically approved (e.g., waste containers in the case of the DGR).
    - Zone 2 shall have a low general radiation background.
    - Where appropriate, local containment systems shall be used when radioactive systems in Zone 2 are opened or leaking.
    - If local containment systems are not used, a rubber area shall be established when radioactive systems in Zone 2 are opened or leaking, and it shall be removed promptly when work on the system is complete.

Generally accessible areas outside the DGR will be maintained at Zone 1 within the dose rate constraint ≤0.5 μSv/h. All spaces within the DGR facility perimeter will be classified in accordance with the potential for contamination. All areas of the DGR associated with the handling of radioactive waste will be designated as Zone 2. These include the crossing from the WWMF to the WPRB, the WPRB, shafts and the underground areas. Office and amenities areas at the DGR will be designated Zone 1. A Zone 1 and Zone 2 boundary is located within the amenities area for the movement and tracking of personnel. As all areas underground (i.e. below the shaft collars) will be Zone 2, access to the lunchroom underground will require the use of the whole body and small article monitors.

Minimizing the spread of radioactive contamination relies on the skills and knowledge of workers and their diligence in exercising good contamination control practices. These good practices may entail the use of additional effort in detecting and controlling contamination. Furthermore, inter-zonal monitoring will provide the final barrier to the spread of radioactive contamination to the public domain.

Safety measures at the DGR for visitors will be similar to current safety measures for visitors at the WWMF. The safety of members of the public who take part in tours of OPG's WWMF is accomplished by following strict conventional and radiological safety practices. First of all, visitors are required to wear the appropriate general PPE consisting of a hard hat, safety glasses, and safety shoes and to use hearing protection when required. As it relates to radiation protection, visitors are taken on approved tour routes limited to areas with radiation hazards well below limits that require posting per the CNSC requirements. Secondly, all visitors participating in facility tours in radiologically zoned areas are required to wear a dosimeter (thermoluminescent dosimetry badge, which is used to measure radiation exposure) and be subjected to comprehensive whole body monitoring for contamination upon exiting from that area. Finally, the WWMF Routine Radiological Survey program continuously monitors, assesses and reports on the radiological conditions of the facility to ensure it meets the stringent requirements of the OPG Corporate Radiation Protection Program and applicable CNSC regulations.

4.15.2 Environmental Monitoring Programs

Environmental monitoring of the DGR Project will be comprehensive in terms of substances, media and locations, and will include, at the minimum, the following:

- sampling and analyzing run-off leaving the DGR Project site;
- groundwater monitoring;
- monitoring airborne emissions from the WPRB;
- measuring average ambient radiation dose rates at the perimeter of the DGR Project site;
- storage structure integrity checks; and
- contamination checks and radiation surveys within the DGR Project site.

OPG and Bruce Power have established comprehensive environmental monitoring programs that apply to the Bruce nuclear site and will apply to the DGR Project. The purpose of these programs is to ensure compliance with the Nuclear Safety and Control Regulations, applicable federal and provincial legislation, and corporate requirements.

Non-radioactive releases to the environment are regulated by the Ontario Ministry of the Environment (MOE). Certificates of Approval will be obtained as required for the DGR Project. OPG will monitor environmental releases in accordance with these Certificates of Approval and report the results as required. OPG will comply with other regulatory requirements as well, such as reporting requirements under the National Pollutants Release Inventory [79] and O. Reg.127/01 [80].

Overviews of the programs are provided in the following sections. DGR Project monitoring programs are expected to be similar to the existing WWMF monitoring programs. Additional information on monitoring programs is available in Chapter 10 of the Preliminary Safety Report [26].

4.15.2.1 Facility Controls and Monitoring

Control and monitoring systems will perform several functions:

- monitoring and alarming any detection of fire, noxious or explosive gases;
- monitoring radioactivity and other contaminants in underground water (in the shaft sumps) and air (at the exhaust fan intakes);
- monitoring the status of equipment and installations;
- tracking the location of vehicles underground;
- monitoring the status of the shaft hoists and positions of conveyances;
- tracking waste package locations;
- providing input to the planning system for control of waste package movement and transfer schedule; and
- monitoring changes in underground rock/excavation conditions (e.g., rock movement, stress).

As well as providing real time data for daily management and safety control, the monitoring system will capture and save data over time to establish the DGR facility and environmental baseline conditions, and assess the performance of various DGR structures, systems and components relative to design specifications and baseline conditions.

Underground rock and shaft concrete structures will be monitored using rock mass and pillar convergence instrumentation, embedded and surface-mounted concrete load cells in the shaft linings, and rock dowel load cells. Real-time data will be transmitted to the surface control room for collection and analysis as stated above.

The quality of air delivered to access tunnels and rooms will be monitored to ensure concentration of potential contaminants is below acceptable limits for worker safety. Similarly, the quality of air that is exhausted to atmosphere via the ventilation shaft will be monitored to ensure the concentrations of potential contaminants comply with Certification of Approval limits.

Once all of the emplacement rooms have been filled and closed, the DGR will be monitored to ensure that it is performing as expected prior to decommissioning. This period of monitoring prior to the start of decommissioning is included in the operations phase, as described in Section 4.6. The length of the monitoring period will be decided at some future time in consultation with the regulator.

In the longer term, the borehole monitoring systems will be dismantled and permanently sealed. Regulatory approval processes at that time may require implementation of continuing institutional controls to prevent the public from accessing the site for some period of time. Further monitoring could be required, but at a reduced level. Any remaining facilities would ultimately be dismantled.

4.15.2.2 Effluent Monitoring

A follow-up monitoring program is recommended to ensure that the concerns identified in the EIS are carried forward. This program is discussed in Section 12, and outlines the effluent monitoring program elements that will be carried. Where possible, effluent monitoring will be integrated with existing WWMF monitoring programs.

4.15.2.3 Bruce Nuclear Site Radiological Environmental Monitoring Program

The WWMF radiological monitoring program is a component of the Bruce nuclear site Radiological Environmental Monitoring Program (REMP) administered by Bruce Power. The REMP is designed to measure environmental radioactivity in the vicinity of the Bruce nuclear site from all site sources. Data from the REMP are used to assess off-site public dose consequences resulting from the operation of nuclear facilities at the Bruce nuclear site, including the WWMF.

The REMP is conducted at fixed locations within the Bruce nuclear site and at control areas 10 to 20 km from the Bruce nuclear site. Monitoring is carried out for radioactivity in the atmosphere, water, aquatic biota, sediments and terrestrial foodstuffs. In all environmental monitoring programs, the media sampled, locations, frequency of sampling and the analyses performed are in accordance with four primary objectives:

- to confirm that discharges of radioactive materials are under control;
- to verify that site-specific release limits (Derived Release Limits or DRLs) assumptions remain valid;
- to permit an estimate of doses to the public resulting from emissions; and
- to provide data to aid development and/or evaluation of models that describe the movement of radionuclides through the environment.

WWMF operations are carried out such that radiological exposures to workers and the public, and effects on the environment, are maintained within regulatory limits and kept as low as reasonably achievable (ALARA). Normal WWMF process operations do not have any significant radiological off-site consequences to members of the public or detectable radiological effects on the environment, as described in Section 6.6. WWMF emissions are typically only a small fraction of emissions from the Bruce nuclear site.

The REMP will continue to assess the off-site consequences of all Bruce nuclear site operations, including those of the DGR Project, and will continue to report environmental monitoring data and trends. For public dose purposes, it is impossible to distinguish between contributions from Bruce Power operated facilities and the WWMF, hence reporting is done on a Bruce nuclear site-wide basis.

4.16 OCCUPATIONAL HEALTH AND SAFETY PROGRAMS

Occupational Health and Safety programs will be implemented as part of the DGR Project. Section 4.7.8.7 outlines the Health and Safety Management Plan DGR-PLAN-08962-1001 for the site preparation and construction phase, and Section 4.8.7 outlines several occupational health and safety programs that will be implemented for the operations phase of the DGR Project. OPG believes that healthy employees working safely in an injury-free and healthy workplace is good business, and OPG integrates public safety considerations into business practices and decisions.

OPG and its contractors will meet all applicable health and safety legislative requirements. OPG will also meet other associated standards to which it subscribes with the objective of moving beyond compliance. OPG will require that contractors and their subcontractors maintain a level of safety equivalent to that of OPG employees while at OPG workplaces.

The safety program elements in place at the WWMF that are applicable to the DGR Project include the following:

- Occupational Radiation Protection Program;
- Occupational Radiological Risks; and
- Occupational Non-radiological (Conventional) Safety Management.

These programs are described further, below. In addition, as previously noted in Section 4.7.2.1, the DGR does not fall under the definition of a mine in the OHSA and the Ontario Mining Regulations [29]; however, there are many aspects of the facility (hoists and shafts) that are not covered adequately in any regulations other than the Mining Regulations. OPG intends to apply the OMR, as appropriate, to the DGR Project to ensure protection of workers.

4.16.1 Occupational Radiation Protection Program

As described in Section 4.8.7.1, an Occupational Radiation Protection Program is currently in place for the WWMF, and is expected to form the basis for the DGR radiation protection program. The program identifies operations and materials that have the potential to contribute to occupational dose. The program provides guidelines and procedures to monitor and minimize occupational dose and reduce the potential for contamination at the WWMF, and these guidelines and procedures will also be applicable to the DGR.

The occupational radiation safety practices implemented under the program are consistent with OPG Radiation Protection Requirements for nuclear facilities and radiography operations,the Nuclear Safety and Control Regulations, and the ALARA (As Low As Reasonably Achievable) principle. Existing and proposed structures within the WWMF have been designed with consideration for these requirements, as has the DGR.

4.16.1.1 Occupational Dose Control

The doses arising from routine waste management operations are monitored and assessed against dose targets. Thermoluminescent Dosimeter (TLD) badges will be worn as a minimum external dosimetry requirement for personnel involved in the operation of the DGR Project.

Consistent with current WWMF procedures, access to the buildings/structures associated with the DGR Project will be limited to designated personnel and those escorted by qualified personnel. The WWMF is designated as a Radiological Controlled Area. As described in Section 4.15.1.1, the DGR and portions of the associated surface infrastructure (e.g., the WPRB) will also be designated as a Radiological Controlled Area.

4.16.1.2 Contamination Control

During storage, the containers are monitored for loose contamination. Any occurrence of loose contamination is removed by manually wiping with a cloth, or by wet methods if necessary, taking appropriate measures for containment of contamination at the source and personnel protection.

The presence of detectable loose contamination is considered an abnormal operating condition. Personnel are trained to respond to such events according to procedures. Follow-up would also be undertaken, including appropriate communications and actions by WWMF and waste generator personnel to reasonably prevent reoccurrence. Contamination controls are in place to prevent the spread of contamination throughout the WWMF, and it is expected such controls would extend to the DGR.

4.16.1.3 Radiological Hazard Monitoring

Existing Radiation Protection Program requirements include area gamma radiation monitoring and routine radiological surveys, as well as contamination monitoring. The main objective of monitoring is the timely detection of changes in radiological hazard levels so that appropriate remedial actions can be taken and radiation exposures avoided. Routine gamma radiation surveys are performed to cover the entire sequence of WWMF operations including:

- monitoring for overall changes in radiation levels; and
- initiating corrective action, if needed, as per approved radiation protection procedures to maintain occupational safety standards.

4.16.1.4 Occupational Radiological Risks

Potential occupational radiological hazards associated with the DGR Project operations can be categorized as:

- chronic radiological hazards associated with normal operations; and
- acute radiological hazards associated with malfunctions and accidents.

A discussion of chronic radiological hazards is provided in Section 7.6. Malfunctions and accidents are discussed in the Malfunctions, Accidents and Malevolent Acts TSD and are summarized in Section 8.

4.16.2 Predicted Worker Doses

The radiological doses predicted for the workers involved with the associated operations activities during the operations phase are presented in Section 7.6. Details of the prediction methods are provided in Chapter 7 of the Preliminary Safety Report [26].

4.16.3 Occupational Non-Radiological (Conventional) Safety Management

The goal of the Conventional Safety Program will be to ensure workers work safely in a healthy and injury-free workplace by managing and mitigating risks associated with activities, products and services of OPG operations. Risk reduction will be primarily achieved through compliance, by competent workers, to effective operational controls, developed through effective risk assessment and safe work planning.

Occupation conventional safety as it applies to the DGR Project is documented in detail in the Preliminary Conventional Safety Assessment [68]. Section 4.7.8.7 provides a summary of the Health and Safety Management Plan that will apply during site preparation and construction. As noted in Section 4.8.7.3, an overall Occupational Health and Safety Program will be implemented for the operations phase of the DGR Project. This program will be consistent with the requirements of OPG's Conventional Safety Program that is applicable to its nuclear facilities.

4.17 FIRE PROTECTION AND EMERGENCY RESPONSE

The Bruce nuclear site is served by its own internal Emergency Response Team, medical aid and fire prevention facilities. In addition, a comprehensive on- and off-site emergency response plan is in place. Response teams have been trained and are equipped to respond to potential emergencies such as personal injury, fire or non-routine releases of radioactivity. The municipal fire department, the Regional Medical Officer of Health and Kincardine's health and safety service providers work co-operatively with Bruce Power, which coordinates site-wide fire protection and emergency response, to ensure that additional support and response capability is in place.

As stated in Section 4.8.7.10, trained and qualified mine rescue teams will be provided as required by the Mines and Mining Plants Regulations (O. Reg. 854 [29]).

4.17.1 Emergency Response

Three types of events could occur at the DGR that will require a planned emergency response:

- **Fire:** Immediately following a fire alarm, all workers would report to a refuge station. Workers in the vicinity of the fire will assess the situation and use the nearest fire extinguisher. If the fire is not extinguished promptly, the nearest mine rescue team will be called. A second team will be called to the site, as back-up to the first team. The mine rescue team will evacuate the workers after a fresh air passage can be guaranteed to the surface.

- **Rock fall:** In the unlikely event of a rock fall, the mine rescue team will be used to assess the situation and initiate a recovery strategy depending on the circumstances.
- **Radiological contamination release:** For a container failure in an emplacement room, the ventilation system will pull any contamination in the air stream away from the workers. Workers will evacuate to a refuge station. Management will initiate a pre-developed plan for rescue of the personnel, similar to that described by procedures implemented by a fire alarm.

Malfunctions and accidents are further discussed in Sections 4.13 and 8.

4.17.2 Fire Protection Systems

Fire safety is an important consideration for the design and operation of the DGR. The wastes for emplacement in the DGR are all in non-combustible containers and pallets, and the DGR and its associated infrastructure are designed to avoid or minimize combustible materials. Additionally, as described previously, only small quanities of diesel fuel and no explosives will be stored on the DGR Project site during the operations phase. The following sections describe the fire protection systems design.

4.17.2.1 Surface Facilities

All DGR surface facilities will be equipped with fire detection and protection systems in accordance with the National Building Code of Canada [81] and the National Fire Code of Canada [82] requirements. In the event of power failure, the system will be powered by the emergency generator power supply, as described in Section 4.4.3.2. Smoke detectors and heat detectors will be located throughout the buildings to provide means for early detection of fire.

A number of fire hydrants will be located near main entrances to the buildings. Office, maintenance and locker room areas will be protected with large volume Class ABC fire extinguishers consistent with National Fire Code requirements.

4.17.2.2 Underground Facilities

There are multiple independent communication systems that will alert workers in the unlikely event of a fire underground. During construction and operations a "stench gas" system will be employed as the prime notification system for fire. A distinct and foul smelling but safe gas is introduced to the intake air and distributed through the ventilation system. This type of system is widely used in Ontario mines effectively as a warning agent to workers.

An underground fire detection system will consist of smoke and carbon monoxide detectors located throughout the underground workings (i.e., intake plenum, underground working areas and emplacement rooms through all stages and the main exhaust ventilation ducts). This system will alarm to the control panel and will also be audible underground. This system is intended for the operations phase of the DGR Project.

Underground fire suppression systems will be chemical-based as opposed to water-based. The following suppression methods are included:

- handheld foam-based extinguishers located at clearly marked locations in high traffic areas (i.e., diesel fuel bay, mechanical shop) as well as on mobile equipment;
- a mobile foam generator will be based underground for use in open emplacement rooms; and
- diesel equipment will be equipped with on-board foam suppression systems that are heat triggered (i.e., automatic system), and could also be manually activated by the operator in the event of a fire.

4.18 BASIS FOR THE EA

The Basis for the EA is a summary of the specific works and activities for the DGR Project. These works and activities are assembled into groups, allowing the potential interactions of the DGR Project with the environment to be evaluated in a logical, replicable and concise manner. Most of the DGR Project works and activities fall under one of the specific DGR Project phases identified in Section 4.6, though some works and activities span multiple DGR Project phases (e.g., waste management). There are no specific works and activities associated with the abandonment and long-term performance phase, and the abandonment of the DGR facility work and activity is considered to occur at the close of the decommissioning phase for the purposes of this EA. Table 4.18-1 presents the works and activities used to assess the likely effects of the DGR Project on the environment.

Although site preparation, construction, and operations activities will generally be implemented in a sequential development approach as shown on Figure 4.2-1, some activities may also apply to one or more phases.

Table 4.18-1: Basis for the EA of the DGR Project

Project Works and Activities	Description
Site Preparation	Site preparation would begin after receipt of a Site Preparation Licence and would include clearing approximately 30 ha of the DGR Project site and preparing the construction laydown areas. Activities would include: • Removal of brush and trees and transfer by truck to on-site storage; • Excavation for removal and stockpiling of topsoil and truck transfer of soil to stockpile on-site; • Grading of sites, including roads, construction laydown areas, stormwater management area, ditches; • Receipt of materials including gravel, concrete, and steel; • Installation of construction roads and fencing; • Receipt and installation of construction trailers and associated temporary services; and • Install and operate fuel depot for construction equipment.
Construction of Surface Facilities	Construction of surface facilities will include the construction of the waste transfer, material handling, shaft headframes and all other temporary and permanent facilities at the site. Activities would include: • establish a concrete batch plant; • receipt of construction materials, including supplies for concrete, gravel, and steel by road transportation; • excavation for and construction of footings for permanent buildings, and for site services such as domestic water, sewage, electrical; • construction of permanent buildings, including headframe buildings associated with main and ventilation shafts; • receipt and set up of equipment for shaft sinking; • construction of abandoned rail bed crossing between WWMF and the DGR site; • fuelling of vehicles; and • construction of electrical substation and receipt and installation of standby generators.
Excavation and Construction of Underground Facilities	Excavation and construction of underground facilities will include excavation of the shafts, installation of the shaft and underground infrastructure (e.g., ventilation system) and the underground excavation of the emplacement and non-storage rooms. Activities will include: • drilling and blasting (use of explosives) for construction of main and ventilation shafts, and access tunnels and emplacement rooms; • receipt and placement of grout and concrete, steel and equipment; • dewatering of the shaft construction area by pumping and transfer to the above-ground stormwater management facility; • temporary storage of explosives underground for construction of emplacement rooms and tunnels; • receipt and installation of rock bolts and services; and • installation of shotcrete.

Table 4.18-1: Basis for the EA of the DGR Project (continued)

Project Works and Activities	Description
Above-ground Transfer and Receipt of Waste	Above-ground handling of wastes will occur during the operations phase of the DGR Project and will include receipt of L&ILW from the WWMF at the staging area in the DGR Waste Package Receiving Building (WPRB) and on-site transfer to shaft. Above-ground handling of wastes includes: • receipt of disposal-ready waste packages from the WWMF by forklift or truck • offloading of waste packages at the WPRB; • transfer of waste packages within the WPRB by forklift or rail cart; • temporary storage of waste packages inside the WPRB.
Underground Transfer of Waste	Underground handling of wastes will take place during the operations phase of the DGR Project and will include: • receipt of waste packages at the the main shaft station; • offloading from cage and transfer of waste packages by forklift to emplacement rooms; • rail cart transfer of some large packages (Heat Exchangers/Shield Plug Containers) to emplacement rooms; • installation of end walls on full emplacement rooms; • remedial rock bolting and rock wall scaling; • fuelling and maintenance of underground vehicles and equipment; • receipt and storage of fuel for underground vehicles. Emplacement activities will be followed by a period of monitoring to ensure that the DGR facility is performing as expected prior to decommissioning.
Decommissioning of the DGR Project	Decommissioning of the DGR Project will require a separate environmental assessment before any activities can begin. Decommissioning of the DGR Project will include all activities required to seal shafts and remove surface facilities including: • removal of fuels from underground equipment; • removal of surface buildings, including foundations and equipment; • receipt and placement of materials, including concrete, asphalt, sand, bentonite for sealing the shaft; • construction of concrete monolith at base of two shafts, removal of shaft infrastructure and concrete liners, and reaming of some rock from the shafts and shaft stations; • sealing the shaft; and • grading of the site. The waste rock pile (limestones) will be covered and remain on-site.
Abandonment of the DGR Facility	Timing of abandonment of the DGR facility will be based on discussion with the regulator. Activities may include removal of access controls.

Table 4.18-1: Basis for the EA of the DGR Project (continued)

<table>
<tr><th>Project Works and Activities</th><th>Description</th></tr>
<tr><td>Presence of the DGR Project</td><td>Presence of the DGR Project represents the meaning people may attach to the existence of the DGR Project in their community and the influence its operations may have on their sense of health, safety and personal security over the life cycle of the DGR Project. This includes the aesthetics and vista of the DGR facility.</td></tr>
<tr><td>Waste Management</td><td>Waste management represents all activities required to manage waste during the DGR Project. During construction waste management will include managing the waste rock along with conventional waste management. During operations, waste management would include managing conventional and radiological wastes from the underground and above-ground operations. Decommissioning waste management may include management of conventional and construction wastes. Activities include:
transfer of waste rock, by truck to the WRMA;
placement of waste rock on the storage pile;
collection and transfer of construction waste to on-site or licensed off-site facility;
collection and transfer of domestic waste to licensed facility;
collection, processing and management of any radioactive waste produced at the DGR facility; and
collection, temporary storage and transfer of toxic/hazardous waste to licensed facility.</td></tr>
<tr><td>Support and Monitoring of DGR Life Cycle</td><td>Support and monitoring of DGR life cycle will include all activities to support the safe construction, operation, and decommissioning of the DGR Project. This includes:
operation and maintenance of the ventilation fans, heating system, electrical systems, fire protection system, communications services, sewage and potable water system and the standby generator;
collection, storage, and disposal of water from underground sumps, and of wastewater from above-and below ground facilities;
management of surface drainage in a stormwater management facility;
monitoring of air quality in the facility, exhaust from the facility, water quality of run-off from the developed area around the shafts and Waste Rock Management Area, water quality from underground shaft sumps and geotechnical monitoring of various underground openings;
maintenance and operation of fuel depots above-ground (construction only) and below-ground; and
administrative activities above- and below-ground involving office space, lunch room and amenities space.</td></tr>
<tr><td>Workers, Payroll and Purchasing</td><td>Workers, payroll and purchasing will include all workers required during each phase to implement the DGR Project. Activities include:
spending in commercial and industrial sectors;
transport of materials purchased to the site; and
workers travelling to and from site.</td></tr>
</table>

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5. ENVIRONMENTAL ASSESSMENT BOUNDARIES

The assessment of the effects of the DGR Project on the environment is completed in the framework of spatial and temporal boundaries that are common to all of the environmental components (with some modifications). This focuses the assessment of project-related effects in a defined area. The assessment of project-related effects uses Valued Ecosystem Components (VECs) to focus the assessment on the relevant issues and concerns, as well as aspects of the environment likely to be affected by the project.

5.1 SPATIAL BOUNDARIES AND SCALE

Spatial boundaries define the geographical extent(s) within which environmental effects are considered. Therefore, these boundaries become the study areas adopted for the EA.

The DGR Project EIS Guidelines require that the study areas encompass the environment that can reasonably be expected to be affected by the DGR Project, or which may be relevant to the assessment of cumulative effects. Specific study areas are defined by boundaries to encompass all relevant components of the environment including the people, land, water, air and other aspects of the natural and human environment.

Four study areas were selected for the assessment of the DGR Project: the Regional Study Area, Local Study Area, Site Study Area and Project Area. The Project Area, although not specified in the EIS Guidelines, was defined to help describe the potential site-specific effects of the DGR Project. Generally, each study area includes the smaller study areas (i.e., they are not geographically separate). These study areas are described in the following sections.

5.1.1 Regional Study Area

The EIS Guidelines define the Regional Study Area as:

> *"…the area within which there is the potential for cumulative biophysical and socio-economic effects. This area includes lands, communities and portions of Lake Huron around the Bruce nuclear site that may be relevant to the assessment of any wider-spread direct and indirect effects of the project."*

The Regional Study Area (Figure 5.1.1-1), generally adopted for the EA corresponds to Bruce County with the exception of the peninsula communities of the Town of South Bruce Peninsula and the Township of Northern Bruce Peninsula.

5.1.2 Local Study Area

The EIS Guidelines define the Local Study Area as:

> *"…that area existing outside the Site Study Area boundary, where there is a reasonable potential for direct effects on the environment from any phase of the*

> *project, either through normal activities, or from possible accidents or malfunctions. The Local Study Area should include all of the Bruce nuclear site and the lands within the Municipality of Kincardine closest to it, as well as the area of Lake Huron adjacent to the facility. The boundaries must change if appropriate following an assessment of the spatial extent of potential effects."*

The Local Study Area (Figure 5.1.2-1) generally corresponds to the 10 km emergency planning zone (centred at the Bruce nuclear site), as identified by Emergency Management Ontario.

5.1.3 Site Study Area

The EIS Guidelines define the Site Study Area as:

> *"…the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the DGR is proposed."*

The Site Study Area (Figure 5.1.3-1) corresponds to the property boundary of the Bruce nuclear site, including the existing licensed exclusion zone on land and within Lake Huron.

5.1.4 Project Area

The Project Area (Figure 5.1.3-1) corresponds to the boundary of the OPG-retained lands at the centre of the Bruce nuclear site where the DGR Project is being proposed and encompasses an area of 95 ha and captures the surface and underground features of the DGR Project.

5.1.5 Project Site

The term DGR Project site is also labelled on some figures throughout the assessment (see Figure 5.1.3-1). This boundary corresponds to the portion of the Project Area that will be disturbed as part of the site preparation and construction of the surface facilities (i.e., the surface footprint). It is not used in assessing the effects of the DGR Project, but is included here for completeness.

LEGEND

- Site Study Area [1]
- First Nations' Lands
- Local Study Area
- Regional Study Area
- County Boundary

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

REGIONAL STUDY AREA

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007		
GIS	BC	14 Jun. 2010		
CHECK	AE	14 Jun. 2010		
REVIEW	MAR	14 Jun. 2010		

FIGURE 5.1.1-1

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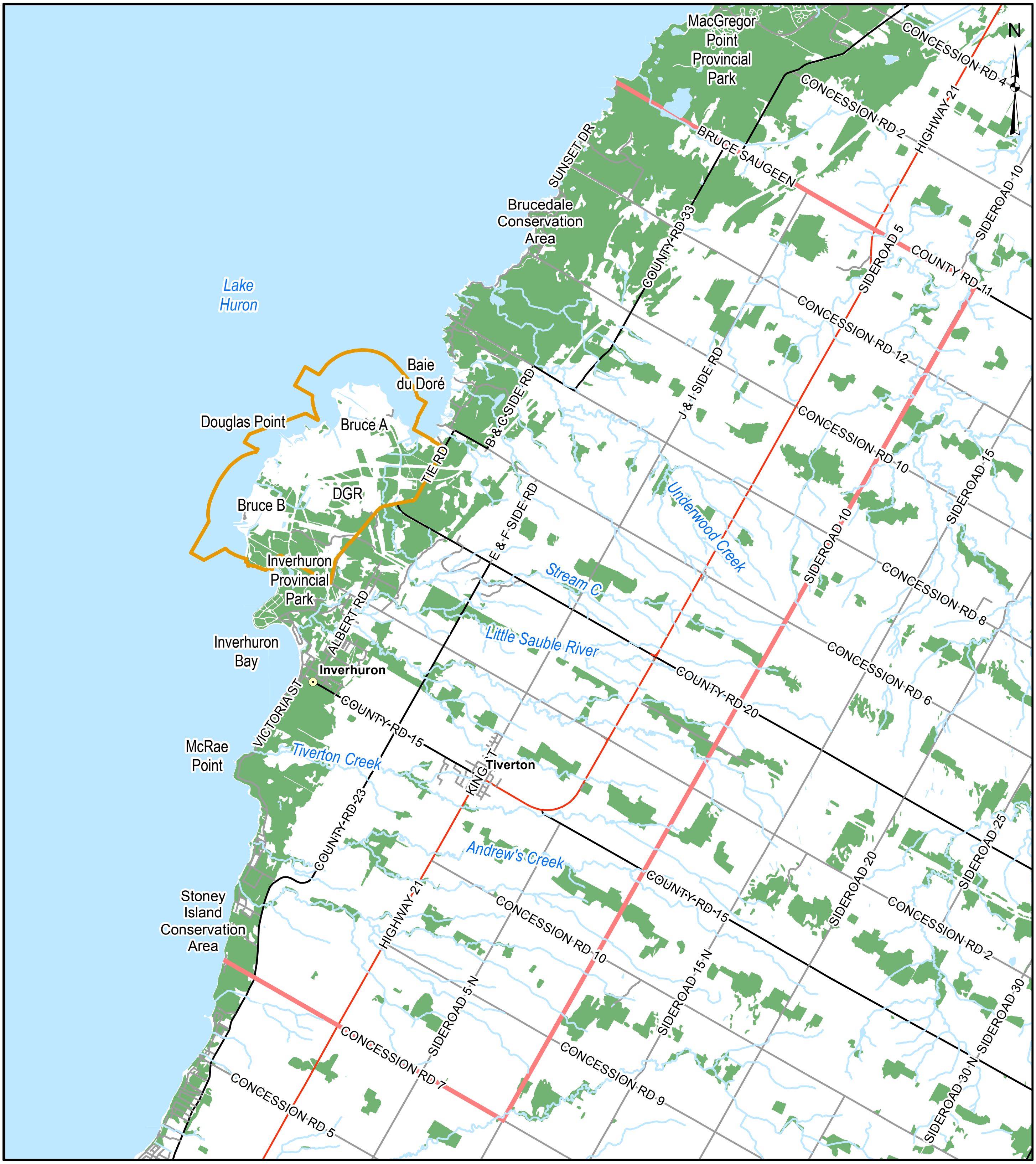

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LEGEND

- Site Study Area [1]
- Local Study Area

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

LOCAL STUDY AREA

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct 2007	**FIGURE 5.1.2-1**	
GIS	BC	14 Jun. 2010		
CHECK	AE	14 Jun. 2010		
REVIEW	MAR	14 Jun. 2010		

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LEGEND

- DGR Project Site
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

SITE STUDY AREA AND PROJECT AREA

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007		
GIS	BC	14 Jun. 2010	**FIGURE 5.1.3-1**	
CHECK	AE	14 Jun. 2010		
REVIEW	MAR	14 Jun. 2010		

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5.1.6 Modification of Study Areas

The application of these general study areas varies by environmental component to allow possible effects to be fully considered. Specific descriptions of any modifications to the study areas adopted for each of the environmental components are provided, including the rationale for their selection, in the individual sections of Section 6 and in each of the individual TSDs. A summary of all modifications of the study areas is provided in Table 5.1.6-1.

Table 5.1.6-1: Adaptation of General Study Areas

Environmental Component	Regional Study Area	Local Study Area	Site Study Area and Project Area
Atmospheric Environment	Expanded to encompass monitoring stations in Waterloo, Sarnia and London	Extends into Lake Huron	No modifications
Hydrology and Surface Water Quality	Corresponds to the regional watersheds and extends 4 km offshore into Lake Huron	Corresponds to the Stream C and Underwood Creek watersheds and extends 2 km offshore into Lake Huron	No modifications
Geology	Expanded to correspond to the 35,000 km^2 3D Geological Framework domain	Corresponds to the Stream C and Underwood Creek watersheds	No modifications
Aquatic Environment	Corresponds to the regional watersheds and extends 4 km offshore into Lake Huron	Corresponds to the Stream C and Underwood Creek watersheds and extends 2 km offshore into Lake Huron	No modifications
Terrestrial Environment	No modifications	Expanded to the north to include MacGregor Point Provincial Park	No modifications
Radiation and Radioactivity	No modifications	No modifications	No modifications
Socio-economic Environment	No modifications	Expanded to include the entirety of the Municipality of Kincardine	No modifications

Table 5.1.6-1: Adaptation of General Study Areas (continued)

Environmental Component	Regional Study Area	Local Study Area	Site Study Area and Project Area
Aboriginal Interests	No modifications; however, Aboriginal communities who have expressed an interest in the DGR Project are also considered	No modifications	No modifications

5.2 TEMPORAL BOUNDARIES

The temporal boundaries for the EA establish the timeframes for which the direct, indirect and cumulative effects are assessed. Four temporal phases were identified for the DGR Project.

- **Site Preparation and Construction Phase**, which includes site preparation and all activities associated with the construction of the DGR Project, up until operations commence with the placement of waste. All of the construction activities at the DGR Project will occur during this phase. The site preparation and construction phase is expected to last approximately five to seven years.
- **Operations Phase**, which covers the period during which waste is emplaced in the DGR Project, as well as a period of monitoring prior to the start of decommissioning. Activities include receipt and on-site handling of waste packages, transfer underground and emplacement of L&ILW in rooms in the DGR Project, and activities necessary to support and monitor operations. The operations phase is expected to last approximately 40 to 45 years with waste being emplaced for the first 35 to 40 years. The length of the monitoring period would be decided at some future time in consultation with the regulator.
- **Decommissioning Phase**, which begins immediately after the operations phase for the DGR. Activities include preparation for decommissioning, decommissioning and may include monitoring following decommissioning. The decommissioning activities, including dismantling surface facilities and sealing the shaft, are expected to take five to six years.
- **Abandonment and Long-term Performance Phase**, which begins once decommissioning activities are completed. This period will include institutional controls for a period up to three hundred years.

These timeframes are intended to be sufficiently flexible to capture the effects of the DGR Project. The assessment in Section 7 generally focuses on the first three phases as there are no project activities occurring during the abandonment and long-term performance phase. Although there will be no activities, the effects of the DGR Project during the abandonment and long-term performance phase in the potentially affected components (i.e., geology, malfunctions and accidents) are assessed and the results provided in Section 9.

The abandonment and long-term performance phase will continue for over 1,000,000 years beyond when the peak radiological effects may occur, taking into account the hazardous lifetime of the L&ILW and the design life of the engineered barriers. This period would include many climatic cycles (i.e., glaciation).

5.3 VALUED ECOSYSTEM COMPONENTS

5.3.1 Overall Approach to Selecting VECs

The purpose of an EA is to determine whether a project will have an effect on the environment, the extent to which the project affects the environment, and to identify means by which the effects can be mitigated. The assessment considers not only the physical and biological elements of the environment, but also the broader human and socio-economic aspects. While all components of the environment are important, it is neither practicable nor necessary to assess every potential effect of a project on every component of the environment. An EA focuses on the components that have the greatest relevance in terms of value and sensitivity, and which are likely to be affected by the project. To achieve this focus, specific Valued Ecosystem Components (VECs) are identified and selected as endpoints for the assessment. The selected VECs are considered to have legal, scientific, ecological, cultural, social, economic or aesthetic value. Importance may be determined on the basis of cultural values or scientific concerns. VECs can be an individually valued component of the environment or species or a collection of components that represent one aspect of the environment.

The Canadian Environment Assessment Agency describes VECs as:

> *"Any part of the environment that is considered important by the proponent, public, scientists and government involved in the assessment process. Importance may be determined on the basis of cultural values or scientific concerns."* [83]

Selected VECs can incorporate aspects of the physical environment, biological environment, and socio-economic environment. They are typically selected through an issues scoping exercise that identifies the particular attributes or components of the environment for which there is public, regulatory or scientific concern. The VECs provide structure and focus for the EA and ensure that the likely effects of a project are considered. Since the VECs are assessment endpoints, it is important that the selected VECs can be used to meaningfully measure the effects that may be caused by the project.

From an ecological perspective, VECs can represent features or elements of the natural environment (e.g., a local wetland or stream) considered to be culturally or scientifically important. Such features would be complex, comprising several ecological aspects, and affected by a range of pathways (i.e., routes of exposure or effect). In essence, these ecological feature VECs encompass a number of individual VECs such as:

- an aspect of the physical environment (e.g., air or water quality);
- an individual plant or animal species (e.g., bald eagle or brook trout); or

- a range of species that serve as a surrogate for species that interact similarly with the environment (e.g., benthic invertebrates).

From a human and socio-economic perspective, VECs could represent an aspect of community well-being (e.g., population, employment).

A VEC is considered to be the receptor for both project-specific effects and cumulative effects. A VEC can be represented by a number of 'indicators'. Indicators are features of the VEC that may be affected by the DGR Project (e.g., aquatic habitat). Each indicator requires specific 'measures' that can be quantified and assessed (e.g., changes in habitat suitability and/or quality).

5.3.1.1 Consideration of Traditional and Local Knowledge

An EA should consider both western science and traditional and local knowledge, where that information is available. Where available, specific traditional and local knowledge was used to conduct the EA, and has been incorporated into existing studies. Studies have included relevant traditional and local knowledge, for example, regarding Aboriginal burial grounds and Aboriginal commercial and traditional fisheries. The preliminary list of VECs was forwarded to the Saugeen Ojibway Nation Environmental Office for comment on February 1, 2007. A revised list of VECs was included in the draft guidelines for the EIS, which were issued for public review on April 4, 2008.

5.3.1.2 Consideration of Public Input

As described in Section 2.6.1, VECs for the DGR Project were available for discussion and comment at the DGR Project Open Houses held in October 2007, November 2008, November 2009 and summer/fall 2010. At the November 2008 Open House, the public was encouraged to add VECs to the list and to identify the VECs that were most important to them. The public also had the opportunity to provide input on the list of VECs during the public review of the draft guidelines.

5.3.2 Identification of VECs

The selection of VECs is an important early step in any EA. The technical specialists carrying out the EA identified a preliminary list of VECs and provided them to interested parties for confirmation and suggestion of other VECs, as noted above. This process resulted in the list of VECs shown in Table 5.3.2-1.

In selecting VECs for use in assessing the DGR Project, the following questions were considered:

1. What major or special ecological features of the site or surrounding area should be protected from adverse effects of the DGR Project?
2. What aspects of the physical environment could be sensitive to the effects of the DGR Project?

3. What individual species or range of species, of wildlife and plants could be sensitive to the effects of the DGR Project?
4. What aspects of the socio-economic environment should be considered in assessing the effects of the DGR Project?

The multi-feature VECs identified in Table 5.3.2-1 represent aspects of the environment consisting of, and affected, by several social, physical or biological components. Individual components of each of these VECs are described in their respective TSDs and then are collectively assessed in the EIS.

Table 5.3.2-1: List of VECs for the DGR Project

Grouping	VEC	Environmental Component
Physical	Air Quality	Atmospheric Environment
	Noise Levels	
	Surface Water Quantity and Flow	Hydrology and Surface Water Quality
	Surface Water Quality	
	Soil Quality	Geology
	Overburden Groundwater Quality	
	Overburden Groundwater Transport	
	Shallow Bedrock Groundwater Quality	
	Shallow Bedrock Groundwater and Solute Transport	
	Intermediate Bedrock Water Quality	
	Intermediate Bedrock Solute Transport	
	Deep Bedrock Water Quality	
	Deep Bedrock Solute Transport	
Biological	Eastern White Cedar	Terrestrial Environment
	Heal-all	
	Common Cattail	
	Muskrat	
	White-tailed Deer	
	Northern Short-tailed Shrew [a]	
	Midland Painted Turtle	
	Northern Leopard Frog	
	Mallard	

Table 5.3.2-1: List of VECs for the DGR Project (continued)

Grouping	VEC	Environmental Component
Biological (continued)	Red-eyed Vireo	Terrestrial Environment
	Wild Turkey	
	Yellow Warbler	
	Bald Eagle	
	Redbelly Dace	Aquatic Environment
	Variable Leaf Pondweed	
	Creek Chub	
	Lake Whitefish	
	Benthic Invertebrates	
	Burrowing Crayfish	
	Smallmouth Bass	
	Brook Trout	
	Spottail Shiner	
Radiological	Terrestrial Invertebrates	Radiation and Radioactivity
	Benthic Invertebrates	
	Aquatic Vegetation	
	Benthic Fish	
	Pelagic Fish	
	Aquatic Birds	
	Aquatic Mammals	
	Terrestrial Vegetation	
	Terrestrial Birds	
	Terrestrial Mammals	
	Amphibians and Reptiles	
	Humans	
Socio-economic Environment	Population and Demographics	Socio-economic Environment
	Other Human Assets	
	Employment	
	Business Activity	
	Tourism	

Table 5.3.2-1: List of VECs for the DGR Project (continued)

Grouping	VEC	Environmental Component
Socio-economic Environment (continued)	Residential Property Values	Socio-economic Environment
	Municipal Finance and Administration	
	Other Financial Assets	
	Housing	
	Municipal Infrastructure and Services	
	Other Physical Assets	
	Inverhuron Provincial Park	
	Other Social Assets	
Aboriginal Interests	Aboriginal Heritage Resources	Aboriginal Interests
	Traditional Use of Lands and Resources	
	Aboriginal Communities	
Human Health	Overall Health of Local Residents	Human Health
	Overall Health of Members of Aboriginal Communities	
	Overall Health of Seasonal Users	
	Health of Workers	
Multi-feature Physical	Lake Huron [b]	Various components
	Stream C	
	South Railway Ditch	
	Wetland within the Project Area	

Notes:
a The meadow vole was identified as a VEC in the EIS Guidelines. However, small mammal trapping surveys conducted in 2009 did not confirm the presence of meadow voles in the Project Area. Therefore, northern short-tailed shrew, which was caught in the surveys, has been adopted as a small mammal VEC for this assessment.
b Includes embayments (e.g., Baie du Doré).

5.3.2.1 Modifications to the EIS Guildeline VECs

For the physical environment, the preliminary VECs proposed in the EIS Guidelines included groundwater quality, and groundwater quantity and flow. For the purpose of the assessment, these VECs are subdivided according to stratigraphic depth intervals which are appropriate to the description and assessment of direct and indirect effects of the DGR Project on the geology/hydrogeology environment, from the ground surface to the repository level. This also allows a focussed assessment of the DGR Project on potential receptors, such as Stream C and Lake Huron. Based on the stratigraphic sequence and characteristics within the sequence, the various formations at the DGR Project site were categorized into four different geologic packages: overburden, shallow bedrock, intermediate bedrock and deep bedrock. The terms groundwater transport and solute transport are used to distinguish between those layers where transport is dominated by the bulk movement of groundwater and those layers where transport is dominated by diffusion (i.e., the intermediate and deep bedrock), respectively.

For biological VECs, the preliminary VECs proposed in the EIS Guidelines included the meadow vole (*Microtus pennsylvanicus*) as a representative small mammal VEC for the DGR Project. This species lives in a variety of habitats such as meadows, marshes, swamps, open areas and forests, and is an important food source for birds of prey and carnivorous mammals. However, small mammal trapping surveys conducted in 2009 failed to confirm that meadow voles are actively utilizing the natural and anthropogenic habitat units within the Project Area. The field program did, however, result in the capture of numerous northern short-tailed shrews (*Blarina brevicauda*). Due to similarities between these two species in terms of niche occupation and role in the foodweb, the northern short-tailed shrew has been identified as a VEC in place of the meadow vole.

The socio-economic assessment of the DGR Project is organized according to the five "community asset" domains as defined within the Sustainable Livelihoods Framework [84][9]. Organizing the assessment in this manner is a means for identifying, predicting, assessing, and managing adverse socio-economic effects (i.e., avoiding negative effects on community assets) and enhancing positive ones (i.e., strengthening community assets). Comparable frameworks have been adopted for other studies in Canada [85] and internationally [86;84].

For human health, the VEC was subdivided into overall health of local residents, overall health of members of Aboriginal communities, overall health of seasonal users and health of workers in order to fully address potential health concerns for each group.

5.3.3 Linkage Between VECs and Disciplines

There are many linkages between aspects of the physical, biological and socio-economic environment in an integrated EA. Effects from the DGR Project may occur either directly or indirectly. A direct interaction occurs when the VEC is affected by a project work and activity (e.g., a direct loss of eastern white cedar as a result of site clearing). An indirect interaction occurs when the VEC is affected by a change in another VEC (e.g., changes in air quality [a VEC in the Atmospheric Environment TSD] could affect the eastern white cedar [a VEC in the Terrestrial Environment TSD]).

Throughout the EIS, linkages between VECs and the flow of information between environmental components have been highlighted. Cross-references to the appropriate sections where information is relied upon are provided.

[9] Only the five domains or "community assets" as defined within the Sustainable Livelihoods Framework [84] are used in this socio-economic assessment. The entire Sustainable Livelihoods Framework is not applied in this socio-economic assessment.

All aspects for the radiation and radioactivity assessment are considered within one section (i.e., no information is taken from or passed to any of the other components). In addition, there are number of multi-feature VECs that solely rely upon the results of the assessment on a number of individual VECs (e.g., Lake Huron can be indirectly affected by changes in surface water quality and fish species VECs).

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6. EXISTING ENVIRONMENT

This section presents a summary description of existing environmental conditions as they relate to the DGR Project. This characterization of the existing environment serves as the baseline on which predictive incremental changes and predicted environmental effects associated with the DGR Project are added, and against which they are assessed. The description of the existing environment has been focused on those components of the environment that may be affected by the DGR Project.

For the purposes of this EA, "existing conditions" are defined as those present during the period from 2006 through 2010, unless otherwise noted. Accordingly, these conditions reflect ongoing operations at the WWMF, Bruce A Units 1 and 2 in refurbishment, and Bruce A Units 3 and 4 and Bruce B Units 5 to 8 in operation. The description of the existing environment for the environmental components presents a compilation and review of existing information and the results of the field programs conducted as part of the EA.

The following summary descriptions of existing conditions are derived from the individual TSDs developed for each environmental component. The reader is directed to each of the appropriate TSDs for a detailed description of the existing environment.

6.1 METHODS

6.1.1 Environmental Components

The environment is defined, for the purposes of the EA, within individual environmental components each of which represents physical, biophysical or social features most likely to be affected by the DGR Project. The environmental components are consistent with those described in the EIS Guidelines developed for the DGR Project (Appendix A1).

For the assessment, each environmental component has a number of VECs identified that represent fundamental constituent features that were used to focus the assessment of the effects of the DGR Project. The descriptions of the existing environment are provided in terms of the study areas defined in Section 5.1.

6.1.2 Description of the Existing Environment

The description of the baseline conditions for each environmental component is focused on the specific aspects that are relevant to the DGR Project. Characterization of the existing environment was completed by reviewing information from the following key reports:

- Geosynthesis [87] and the Descriptive Geosphere Site Model (DGSM) [88];
- Western Waste Management Facility Refurbishment Waste Storage Project Environmental Assessment [89];
- Bruce Used Fuel Dry Storage Facility Environmental Assessment [90];
- Bruce Heavy Water Plant Decommissioning Environmental Assessment Study Report [91];

- Bruce Nuclear Site Ecological Effects Review [92];
- Bruce Nuclear Site Bioinventory Study [93];
- Technical Support Documents (TSDs) from previous Bruce Power and OPG EAs [94;95;96;97;98;99;100];
- 2000-2003 Phase II Environmental Site Assessment (ESA) investigations of the Bruce nuclear site and follow-up monitoring programs [101;102;103;104;105;106]; and
- follow-up studies for these EAs, where applicable.

A series of field studies, summarized in Table 6.1.2-1, were also completed to characterize the existing environment for a number of the environmental components.

Table 6.1.2-1: Field Studies Undertaken in Support of the DGR Project

Environmental Component	Survey	Location	Date
Geology	Deep geologic drilling	Project Area	• 2006 to 2010
Hydrology and Surface Water Quality	Geomorphic assessment	Site Study Area (Stream C)	• September 11, 2009
	Surface water quality sampling	Site Study Area	• May 3, June 14 and October 12, 2007 • May 25, September 11 and October 27, 2009
	Confirmation of drainage pathways and directions	Site Study Area	• Same as above
Terrestrial Environment	Breeding bird surveys	Site and Local Study Areas	• May 23 to 25, 2007 • June 19 to 21, 2007 • May 28 to 30, 2009 • July 2 to 4, 2009
	Amphibian call counts	Site and Local Study Areas	• April 25 and May 7, 2007 • May 7, June 3 and June 17, 2009
	Muskrat habitat usage	Site and Local Study Areas	• May 7 and 8, 2007
	Wild turkey habitat use and suitability	Site and Local Study Areas	• Between February 19 and 27, 2007
	Waterfowl habitat utilization	Site and Local Study Areas	• September 4 and 5, 2007 • October 1 and 2, 2007

Table 6.1.2-1: Field Studies Undertaken in Support of the DGR Project (continued)

Environmental Component	Survey	Location	Date
Terrestrial Environment (continued)	Small mammal surveys	Site Study Area	• September 2 and, 2009 • Between October 2 and 7, 2009
	White-tailed deer (and other incidental wildlife)	Site and Local Study Areas	• November 22, 2009
	Ecological Land Classification	Site Study Area	• 2007 • August 11 and 12, 2009
Aquatic Environment	Electrofishing	Site Study Area	• 2007 and 2009
	Seine netting and minnow traps	Site Study Area (MacPherson Bay)	• July 21 and 22, 2007
	Burrowing crayfish reconnaissance	Project Area	• June 2006 and May 2009
	Habitat survey	Site Study Area (Stream C)	• August 12, 2009
Atmospheric Environment	Continuous and spot noise monitoring	Local Study Area	• May 4 to 11, 2005 • May 8 to 22, 2007

For more detail on the above field studies, please refer to the appropriate environmental component TSD.

6.2 GEOLOGY

The geology within the study areas is described in terms of the following components:

- **soil quality**, which includes the characterization of soil as defined by chemical and physical analysis;
- **overburden geology**, which includes the unconsolidated materials underlying the study area; and
- **bedrock geology**, which includes the sedimentary and crystalline bedrock formations underlying the study area;
- **hydrogeology,** which includes groundwater zones, environmental heads and conductivity, porosity, fluid density and hydrogeological modelling;
- **hydrogeochemistry,** which includes regional scale characterization, spatial distribution of water, origin of brines, as well as groundwater and pore water compositions;
- **geomechanics,** which includes geomechanical properties, in-site stress and orientation; and

- **regional seismicity**, which includes earthquake magnitudes and seismic potential.

For context, the geological setting in the study areas is also described. For additional details, refer to the Geology TSD and the Geosythesis [87].

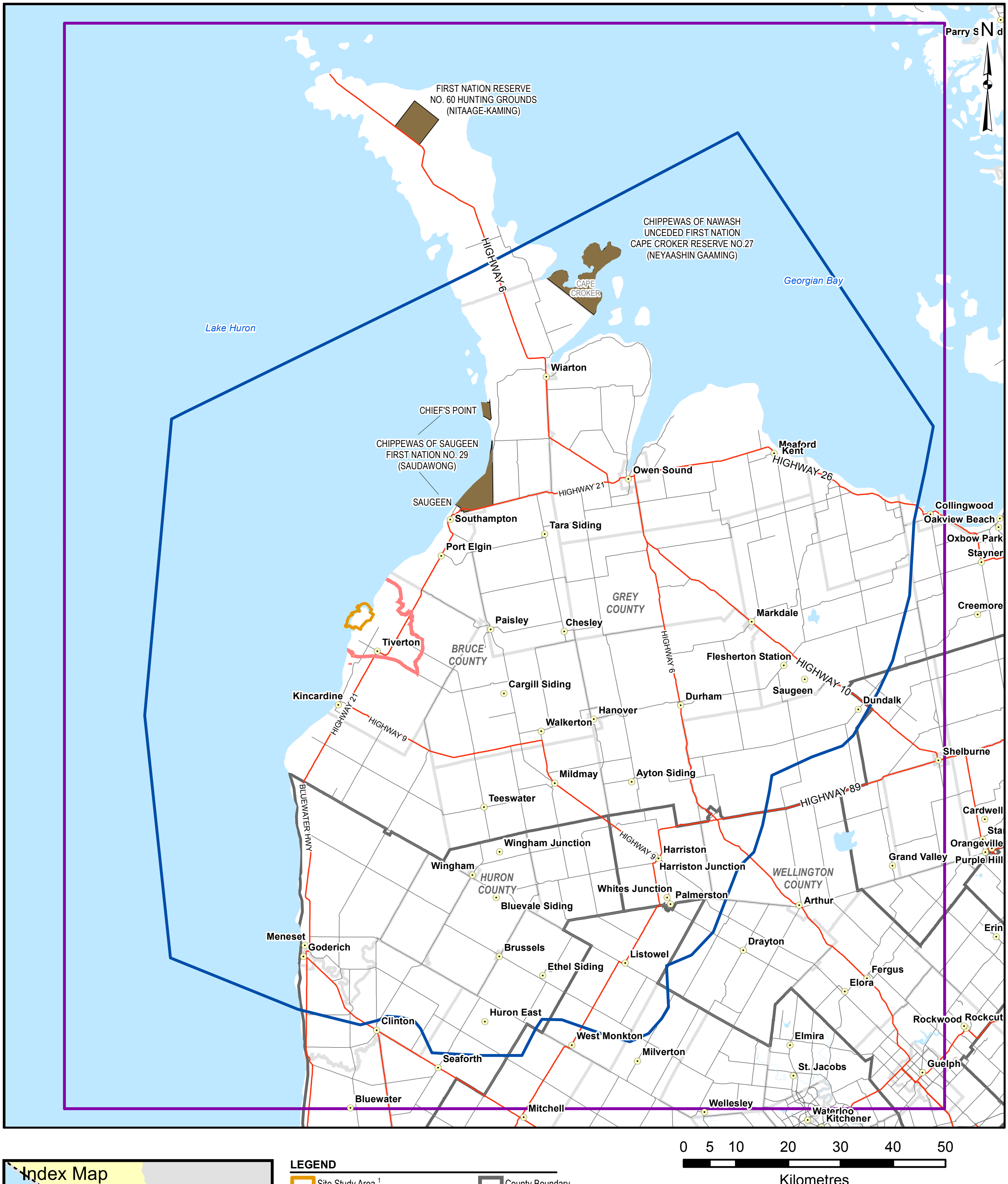
6.2.1 Spatial Boundaries

The study areas were modified to encompass likely effects on geology as a result of the DGR Project as follows:

- The **Regional Study Area** for geology is shown on Figure 6.2.1-1. It corresponds to the regional 3-Dimensional Geologic Framework, which includes an area of approximately 35,000 km^2 surrounding the DGR. The regional geology provides a framework for understanding and extrapolating site conditions beyond the Bruce nuclear site boundary. The Regional Study Area boundary fully encompasses the regional hydrogeologic modelling domain [87]. The hydrogeologic modelling domain (approximately 18,000 km^2) is the area used to describe the regional-scale groundwater system hydrodynamics.
- The **Local Study Area**, also shown on Figure 6.2.1-2, is an area of approximately 127 km^2, including the communities of Underwood, Tiverton, and the Bruce nuclear site on Douglas Point. It includes the drainage basins of Underwood Creek, Stream C, Little Sauble River and Tiverton Creek. This Local Study Area was selected because it corresponds to the regional watershed for the Bruce nuclear site and its immediate surroundings.
- The **Site Study Area** and **Project Area**, shown on Figure 5.1.3-1, were used without modification.

6.2.2 Valued Ecosystem Components

The VECs identified in the guidelines have been expanded to encompass the geological conditions within the entire Paleozoic sedimentary sequence underlying the Bruce nuclear site. This is illustrated conceptually in Figure 6.2.2-1. Table 6.2.2-1 presents the VECs for geology along with the rationale for their selection and the specific indicators and measures used in the assessment.



LEGEND

- Site Study Area [1]
- Local Study Area
- Regional Study Area
- Regional Hydrogeologic Modelling Domain
- County Boundary
- First Nations' Lands

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

REGIONAL STUDY AREA FOR GEOLOGY

Golder Associates
Mississauga, Ontario

PROJECT No. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	FIGURE 6.2.1-1	
GIS	BC	5 May. 2010		
CHECK	AB	5 May. 2010		
REVIEW	MAR	5 May. 2010		

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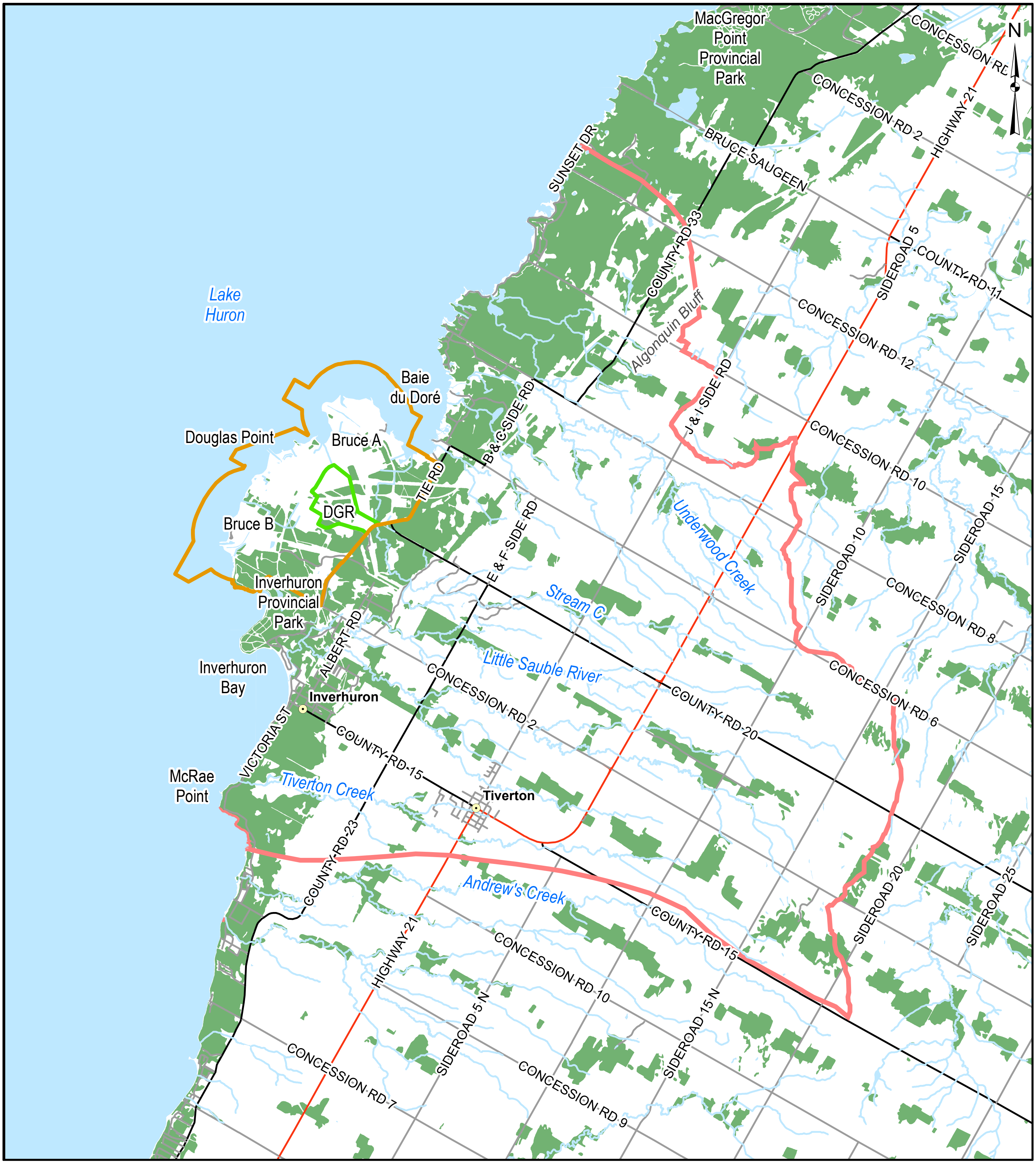

LEGEND

- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]
- Local Study Area

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

LOCAL STUDY AREA FOR GEOLOGY

Golder Associates
Mississauga, Ontario

PROJECT No. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct 2007		
GIS	BC	5 May. 2010	**FIGURE 6.2.1-2**	
CHECK	AB	5 May. 2010		
REVIEW	MAR	5 May. 2010		

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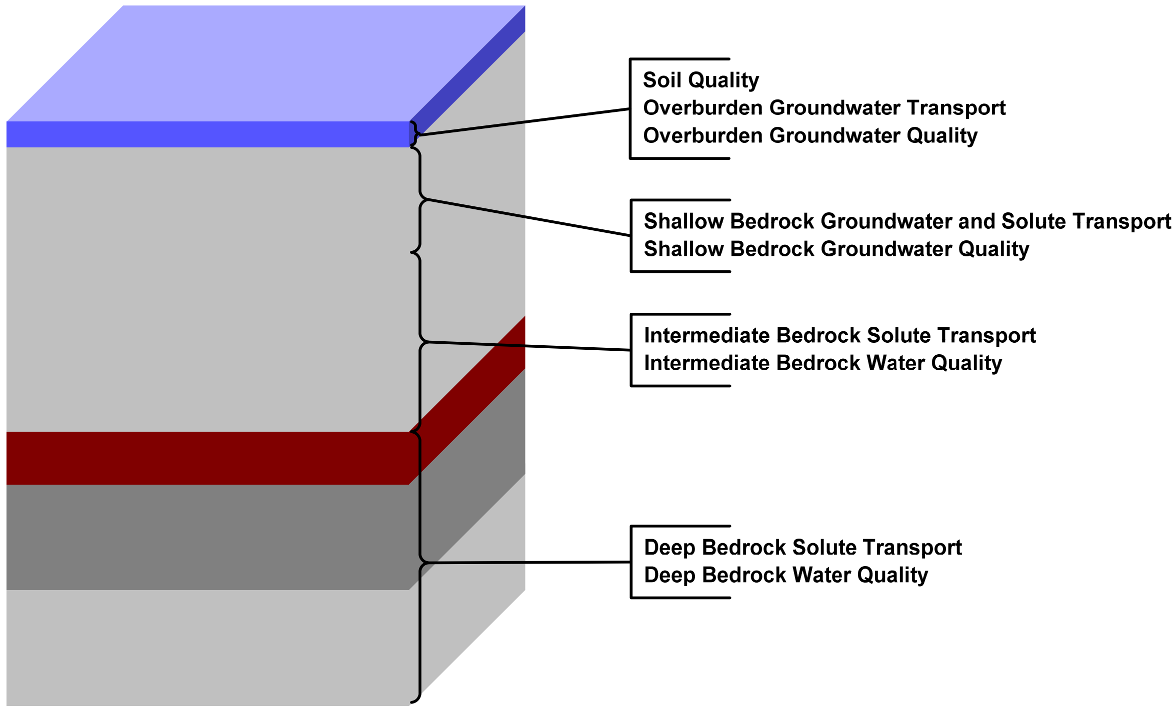

Figure 6.2.2-1: Conceptual Illustration of the Geology VECs

Table 6.2.2-1: VECs Selected for Geology

VEC	Rationale for Selection	Indicators	Measures
Soil Quality	Environmental effects on soil quality could provide a pathway for effects on humans, biological components and their corresponding VECs	• Soil quality parameters	• Changes in soil quality parameters

Table 6.2.2-1: VECs Selected for Geology (continued)

VEC	Rationale for Selection	Indicators	Measures
Overburden Groundwater Quality	Environmental effects on shallow (i.e., <20 m) groundwater quality could provide a pathway for effects on humans, biological components, receiving watercourses, and their corresponding VECs	• Groundwater quality parameters	• Changes in groundwater quality parameters
Overburden Groundwater Transport	Effects of the DGR Project on shallow (i.e., <20 m) groundwater flow direction, quantity, velocity and recharge could affect receiving watercourses	• Advective transport • Diffusive transport	• Stratigraphy • Hydraulic gradients • Hydraulic conductivity • Environmental tracers • Recharge
Shallow Bedrock Groundwater Quality	Environmental effects on shallow (<170 mBGS) bedrock groundwater quality could provide a pathway for effects on humans, biological components, receiving watercourses, and their corresponding VECs	• Groundwater quality parameters	• Changes in groundwater quality parameters
Shallow Bedrock Groundwater and Solute Transport	Environmental effects on shallow (<170 mBGS) bedrock groundwater flow and solute transport could provide a pathway for effects on humans, biological components, receiving watercourses, and their corresponding VECs	• Advective transport • Diffusive transport	• Stratigraphy • Hydraulic gradients • Hydraulic conductivity • Environmental tracers • Recharge

Table 6.2.2-1: VECs Selected for Geology (continued)

VEC	Rationale for Selection	Indicators	Measures
Intermediate Bedrock Water Quality	Environmental effects on intermediate (170 to 450 mBGS) bedrock water quality could provide a pathway for effects on humans, biological components, receiving watercourses, and their corresponding VECs	• Intermediate bedrock porewater solute concentrations	• Changes in intermediate bedrock porewater solute concentrations
Intermediate Bedrock Solute Transport	Environmental effects on intermediate (170 to 450 mBGS) bedrock can occur because of solute migration, which could provide a pathway for effects on humans, biological components, receiving watercourses, and their corresponding VECs	• Advective transport • Diffusive transport	• Stratigraphy • Hydraulic gradients • Hydraulic conductivity • Environmental tracers
Deep Bedrock Water Quality	Environmental effects on deep (450 to >860 mBGS) bedrock can occur because of solute migration, which could provide a pathway for effects on humans, biological components, receiving watercourses, and their corresponding VECs	• Deep bedrock porewater solute concentrations	• Changes in deep bedrock porewater solute concentrations

Table 6.2.2-1: VECs Selected for Geology (continued)

VEC	Rationale for Selection	Indicators	Measures
Deep Bedrock Solute Transport	Environmental effects on deep (450 to >860 mBGS) bedrock can occur because of solute migration, which could provide a pathway for effects on humans, biological components, receiving watercourses, and their corresponding VECs	• Advective transport • Diffusive transport	• Stratigraphy • Hydraulic gradients • Hydraulic conductivity • Environmental tracers

6.2.3 Setting

The Site Study Area is situated on the east shore of Lake Huron on the Douglas Point promontory, a feature of comparatively low relief that juts 2.5 to 3.0 km into the lake over a distance of approximately 5 km between Inverhuron Bay in the southwest and Baie du Doré in the north (Figure 5.1.3-1). The Douglas Point promontory is a bedrock-controlled feature with nearly flat-lying dolostone bedrock outcropping along the shoreline, resulting in the resistance of the promontory to lake erosion.

The centre of the Project Area is approximately 2 km from Bruce A, 1.6 km from Bruce B, and about 1.4 km from Lake Huron (Figure 5.1.3-1). At present, the WWMF above ground structures are located within the south-central portion of the Project Area. Former Construction Landfills Nos. 1 and 2 are located within the southeast portion of the Project Area (Figure 5.1.3-1).

The Local Study Area (see Figure 6.2.1-2) encompasses an area of approximately 127 km², including the communities of Underwood and Tiverton and the Bruce nuclear site development located on the Douglas Point promontory. The dominant physiographic feature within the Local Study Area, inland from Lake Huron, is the Algonquin Bluff, which rises approximately 30 m. The terrain above the Algonquin Bluff consists of comparatively flat clay plains, which include the networks of streams that drain westward to Lake Huron (Figure 6.2.1-1).

The Regional Study Area (Figure 6.2.1-1) comprises the regional 3-Dimensional Geologic Framework for an area of approximately 35,000 km² surrounding the DGR. The Regional Study Area boundary was delineated in order to fully encompass the Regional Hydrogeologic Modelling Domain [107].

6.2.4 Soil Quality

Soil quality beneath the Site Study Area within the former Heavy Water Plant area was evaluated through Phase I and Phase II Environmental Site Assessments (ESAs), conducted in 1998 [102] (Figure 5.1.3-1).

The Phase I ESA identified 41 different areas that were assessed as being either potentially or actually contaminated (a 1999 addendum to the report indicated there were 39 areas). A review of the Phase I ESA identified 19 areas of actual or potential contamination that are located within the former Heavy Water Plant footprint and vicinity. Of these, a total of 13 areas are in close proximity to the Project Area. The contaminants identified in these areas included seal oil, lube oil, insulating oil and/or PCB-contaminated insulating oil, iron, manganese, phosphorus, sulphur and diethylamine/methyldiethylamine (DEA/MDEA).

A Phase II ESA was undertaken to identify, confirm and delineate, or demonstrate the absence of contamination at the locations identified in the Phase I ESA [102]. More than 200 soil samples were collected and analyzed. Parameters that were included in the analysis can be categorized into several groups including metals; oils and grease; benzene, toluene, ethylbenzene, xylene (BTEX); polychlorinated biphenyls (PCBs); O. Reg. 347; and volatile organic compounds (VOCs). Not all parameter groups were analyzed for each sample. Only the results where parameters were exceeded are summarized below.

Of the 154 samples analyzed, the MOE guidelines for one or more parameters were exceeded in 15 samples (including one duplicate) from 10 different locations within the former Heavy Water Plant lands. A total of six samples from six locations were in close proximity to the Project Area [102]. Copper, nickel and zinc were the metals most commonly reported to exceed the guidelines. The majority of samples exceeding the guidelines were collected at the ground surface and likely reflect the presence of metallic scale and rust particles that are accompanied by rust colour staining observed at the surface.

More than 180 soil samples were analyzed for total petroleum hydrocarbons (TPH), heavy oil, extractable petroleum hydrocarbons (EPH), and purgeable petroleum hydrocarbons (PPH) within the BHWP (Figure 5.7.2-2 in the Geology TSD). Both the potable and the non-potable groundwater guidelines for TPH were exceeded in numerous samples. Overall, values exceeding the guidelines are limited to several specific locations where high concentrations of TPH are located at surface and at shallow depths. Five of these locations (see Figure 5.7.2-2 in the Geology TSD) were in close proximity to the Project Area, within the Former Heavy Water Plant lands:

- E7 Substation;
- Main Substation D;
- NE corner of E4 Pad;
- Substation B; and
- East of the E3 Pad.

Concentrations were found to decrease with increasing depth at individual sampling locations.

6.2.5 Overburden Geology

6.2.5.1 Site Study Area and Project Area

Within the Site Study Area the dominant unconsolidated surficial material consists of stony, sandy or silty till of the Elma-Catfish Creek Till unit [108]. There are also thin, approximately shoreline-parallel bands of sand and gravel beach deposits and minor gravel-dominated glaciofluvial outwash. A large portion of the shoreline also exposes the underlying dolostone bedrock of the Middle Devonian Lucas Formation.

In general terms, the thickness of overburden throughout the site study area varies from about 0 to 20 m in thickness, depending on location. Near the shoreline of Lake Huron, overburden thicknesses are low (0 to 3 m). Towards the central portion of the Site Study Area, overburden thicknesses increase, with the maximum thicknesses (between 12 and 20 m) indicated within the Project Area lands. Recent drilling for a separate project indicates that overburden thickness increases to the northeast of the Project Area, to greater than 25 m in the vicinity of Tie Road.

The area of surficial deposits within the Bruce nuclear site that has been subjected to the most intensive hydrogeological investigation lies within the WWMF, comprising the south-central portion of the Project Area [109;110;111;112]. Generally, this portion of the Project Area consists of 13 to 18 m of surficial deposits overlying bedrock and the bedrock surface varies in elevation between 171.0 and 177.5 mASL. The overburden thickness beneath the northern portion of the WWMF is approximately 6 to 12 m. The overburden thickness decreases to less than 3 m beneath the former Heavy Water Plant, coinciding with a rise in the bedrock surface to elevations of between 180 and 185 mASL. Overall, the bedrock surface slopes eastward to north-eastward beneath the Project Area from elevations of approximately 180 to 186 mASL.

The shallow groundwater zone at the DGR Project site is characterized by layers with high permeability and a groundwater composition with relatively low total dissolved solids (TDS) concentrations [87]. The shallow zone includes the glacially deposited sediments, the Devonian Lucas, Amherstburg and Bois Blanc limestone and dolostone formations, and the Silurian Bass Islands Formation. Hydraulic gradients within the shallow bedrock groundwater system are governed primarily by surface topography. Solute transport in the shallow groundwater zone is dominated by advection and related mechanical dispersion.

Local perched groundwater conditions can occur within the thin surface layer of sand (or sand and gravel) and the shallow weathered till horizon attributed to surface infiltration collecting above the low permeability unweathered Upper Till horizon. Where this Upper Till horizon is thin, infiltration can pass into the Middle Sand aquifer, which is likely to occur beneath the southwestern portion of the WWMF portion of the Project Area, where the Upper Till is thin or absent. The Middle Sand aquifer can also directly recharge the bedrock surface where the Lower Till is thin or absent.

Overall, the groundwater levels indicate downward hydraulic gradients from the overburden to the bedrock beneath the west-central portion of the Bruce nuclear site, in the vicinity of the Project Area. These downward hydraulic gradients, in the range of 40%, indicate that the dominant direction of groundwater flow in the overburden within the Project Area is downward toward the underlying bedrock.

Based on the stratigraphy encountered, surficial deposits can be subdivided into five main layers which are listed below in descending order from ground surface downward [112;113;114]:

- a Surficial Sand and Gravel Unit;
- an Upper Weathered Silt Till Unit;
- an Upper Unweathered Silt Till Unit;
- a Middle Sand/Layered Till Unit; and
- a Lower Unweathered Silt Till Unit.

The various units are discussed below.

Surficial Sand and Gravel Unit

The Surficial Sand and Gravel Unit contains boulders with numerous cobbles, as well as beach shingle, and is generally less than 1.5 m thick in the vicinity of the WWMF portion of the Project Area. This upper sand layer is irregular in thickness and locally infills channels in the till surface. In the vicinity of the former Heavy Water Plant, this unit ranges from zero to less than 1.5 m thick, as the overburden deposits thin to the north and west. This unit has been noted to increase substantially in thickness southeast of the WWMF as a raised ancient shoreline. This surficial unit is overlain by a thin veneer of topsoil and humus (0.3 m).

Upper Weathered Silt Till Unit

The Upper Weathered Silt Till Unit consists mostly of weathered, brown silt till with fractures extending to depths of approximately 3 m. The till surface is irregular, contains depressions infilled with the surficial sand and gravel, and is comprised predominantly of carbonate (calcite and dolomite) and quartz mineral grains.

Upper Unweathered Silt Till Unit

The Upper Unweathered Silt Till Unit is a dense silt till with varying amounts of clay size rock flour. The rock flour is quartz and carbonate with minor illite and chlorite clay minerals. This till unit is greater than 10 to 15 m thick along the south side of the Project Area, and within the southwest part of the former Heavy Water Plant lands, immediately east of the Project Area. The unit generally decreases in thickness to the north and east, and is largely absent near the Lake Huron shoreline.

Middle Sand/Layered Till Unit

The Middle Sand/Layered Till Unit is composed of beds of silty fine sand to well sorted permeable sand with occasional gravel layers and contains interbeds of unsorted silty till from 0.03 to 0.4 m thick. The Middle Sand unit is a permeable groundwater bearing horizon that constitutes an aquifer contiguous with or underlying the Upper and Lower Till Units

(Figure 6.2.5-1). It occurs within the south-central portion of the Project Area, largely underneath the WWMF.

The Middle Sand was found to be thickest beneath the western half of the WWMF portion of the Project Area, measuring between 4 and 8 m thick. Toward the south edge of the WWMF portion of the Project Area, this unit thins and occurs at or near the bedrock surface. In the northwest area of the site near the South Railway Ditch and LLSB3, the Middle Sand is relatively thick, up to 6 m, and occurs near ground surface. The trend of the sand horizon is from the southeast to the northwest beneath the WWMF portion of the Project Area. This unit is absent beneath the former Heavy Water Plant.

The upper surface of the Middle Sand unit occurs between approximately 180 and 186 mASL beneath the western part of the WWMF portion of the Project Area. The upper surface of this unit slopes downward to the northeast within the WWMF portion of the Project Area, where it occurs between elevations of approximately 175 to 178 mASL, at depths of approximately 6 to 8 m below ground surface.

The Layered Till within the Middle Sand unit contains layers of both well-graded silt till and fine to coarse sand, which are hydraulically connected to the Middle Sand layer. In this regard, it can be considered an extension of the Middle Sand layer. The stratified or layered till unit is typically adjacent to or overlying the middle sand unit. Although called a till, this unit is likely of glaciolacustrine origin. The presence of sand interbeds in this layer results in increased permeability compared to the Upper and Lower Till layers.

Although discontinuous beneath the WWMF site, the Middle Sand unit is considered to be an important layer to the groundwater flow system beneath the Project Area. The lateral and vertical extent of the unit is complex and has been inferred to provide vertical connection to the underlying carbonate bedrock where the Lower Till is thin or absent. It should be noted that the Middle Sand unit is confined to the WWMF, largely south of the abandoned rail bed. This unit is not expected to exist within the area where the DGR shafts will be located.

Lower Unweathered Silt Till Unit

The Lower Unweathered Silt Till Unit is generally extensive beneath the WWMF portion of the Project Area; however, it has been noted that windows in the till may connect the Middle Sand and bedrock [112;111]. The composition of the Lower Till is similar to the lower portions of the Upper Unweathered Till unit. In locations where the Middle Sand layer is absent, the Lower Till is not a distinct, separate layer from the Upper Till section. Occasional occurrences of sand and gravel are found between the Lower Unweathered Till layer and the bedrock surface. The distribution of the Lower Unweathered Till Unit between the WWMF and former Heavy Water Plant portions of the Project Area is not well understood because of limited borehole data but is considered to likely be continuous through this area.

The glacial till units are generally laterally continuous, although thicknesses may vary from 0.3 to 15 m. The glacial till overlying the Middle Sand aquifer and bedrock is wedge shaped, thicker inland and thinning towards Lake Huron. The till deposits have occasional lenses of clay, sand, and sand and gravel. Based on the available data these isolated inter-till lenses are not considered to be laterally extensive or hydrogeologically interconnected [112;114].

0 125 250 500
Metres

LEGEND

- Approximate Sub-Surface Extent of Middle Sand Aquifer >1.2m Thick
- Project Area (OPG-retained lands that encompass the DGR Project)

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m,
Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

MIDDLE SAND AQUIFER

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	**FIGURE 6.2.5-1**	
GIS	BC	5 May. 2010		
CHECK	SM	5 May. 2010		
REVIEW	SM	5 May. 2010		

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Groundwater Quality

In 1998–99, OPG undertook a project to identify all potential sources of contamination at areas within the Bruce nuclear site [101]. There were nine potential areas of contamination that may be hydrogeologically relevant to the Project Area. They are all located within the Site Study Area, and within or proximal to the Project Area. All nine potential areas of contamination were determined to require further evaluation (i.e., Phase II ESAs).

The nine potential areas of contamination considered relevant to the Project Area include the following:

- Bunker C Oil ASTs and Oil Delivery System (BCOA) (site 1);
- Former Bruce Nuclear Standby Generators (BNSG) (site 2);
- Former Spent Solvent Treatment Facility (SSTF) (site 3);
- Distribution Station #2 and #4 (DS#2 and DS#4) (site 4);
- Former Construction Landfill #1 (CL1) (site 5);
- Former Construction Landfill #4 (CL1) (site 6);
- Fire Training Facility (FTF) (site 7);
- RWOS/WWMF (site 8); and
- Former Heavy Water Plant lands (site 9).

These nine areas are considered to be up-gradient to cross-gradient of the Project Area and can be seen on Figure 6.2.5-2. Radiological water quality monitoring data for the till and the middle sand aquifer, specifically regarding tritium levels, is described in the Radiation and Radioactivity TSD.

Supplementary Phase II ESAs were conducted in 2001 to 2002 at the nine sites listed previously [101;104;103] (among other sites within the Site Study Area). These sites represent a legacy from past site construction and operations activities. Investigation, management, and remediation of these areas constitute part of the Bruce nuclear site's Contaminated Lands Program.

Detailed site-specific information for the former Heavy Water Plant is available from a Phase II ESA, which was undertaken in 1998 [102]. The groundwater monitoring network established during the Phase II ESA included seven upstream monitoring wells (upgradient of the source and the enriching towers), 16 downstream monitoring wells (downgradient of groundwater flow, along the shoreline of Lake Huron) and eight monitoring wells within the DGR Project site.

A comparison of the 1998–99 groundwater chemistry to the then applicable MOE Table B criteria (current MOE Table 3 Site Condition Standards [SCS]) indicated that there was no significant impact to the environment, as none of the analytes measured in the down-gradient monitoring wells showed appreciably higher concentration levels than those measured in the wells located upgradient of the former BHWP. None of the analytes measured from monitoring wells located in the interior of the former BHWP site exceeded the MOE Guideline for Use at Contaminated Sites in Ontario (GUSCO) criteria for non-potable groundwater, although one parameter (selenium) in one well was at the SCS for that parameter (50 µg/L).

The monitoring well network was re-sampled in 2005 as part of the follow-up monitoring program for the BHWP Demolition Phase. A comparison of the groundwater chemistry to MOE Table 3 SCS for non-potable groundwater [115] indicates no exceedances of contaminants of concern was identified during the 1998 Phase II ESA. Concentrations of all parameters that were measured in all of the BHWP monitoring wells were below the MOE Table 3 SCS during 2005.

6.2.5.2 Local Study Area

The surficial geology of the Local Study Area is shown on Figure 6.2.5-3, reproduced from part of an Ontario Geological Survey Preliminary Map [108]. The Quaternary sediments in the Local Study Area described in [116] are composed of unconsolidated materials consisting mainly of the following:

- ground moraine or glacial till, locally stony, sandy, silty and/or clayey, and laid down directly by the ice;
- glaciofluvial deposits, the sand and gravel deposited by water from the melting glacier;
- glaciolacustrine deposits, the clays, silts, and sands deposited in glacial lakes;
- ice contact deposits formed at the margin of the glacier; and
- sandy and/or gravelly beach deposits [108].

The surficial deposits below the Algonquin Bluff and underlying the Bruce nuclear site include silty to sandy till of the Elma (Catfish Creek) Till sequence overlying the bedrock surface. This till sequence varies in thickness from about 1 m at the lakeshore up to approximately 20 m in the south-eastern part of the Site Study Area and overlying the Palaeozoic rocks at the DGR drill sites [88]. The sequence locally contains interbedded sequences of sand, based on previous investigations at the Bruce nuclear site [110;117]. The till is locally overlain by sand and gravel beach deposits related to the former glacial Lake Algonquin and Lake Nipissing shorelines. The glacial Lake Nipissing shoreline is marked by the less prominent Nipissing Bluff, situated below (west of) the Algonquin Bluff. The shoreline areas also include deposits of till and areas of boulders, exposed by shore erosion of the till.

Groundwater flow within the surficial deposits and bedrock of the Local Study Area is directed north-westward toward Lake Huron, generally sub-parallel to the well established surface drainage pattern. Shallow groundwater discharges within the streams running off of this area, while a component of deeper groundwater flow discharges within the swampy areas below the Algonquin Bluff.

Above the Algonquin Bluff, groundwater hydraulic gradients are downward from surface toward the bedrock. Upward hydraulic gradients are observed adjacent to Lake Huron, where groundwater in the bedrock, recharged over time from locations above the bluff, discharges into the lake. Lake Huron is the ultimate receptor of groundwater within the Local Study Area.

Fresh groundwater is available within the Local Study Area from sand and gravel lenses within the clayey glacial deposits and from the bedrock. These horizons provide water supplies for domestic and municipal services throughout the Local Study Area. There are also several communal wells in the Local Study Area. Kincardine and Tiverton now obtain their water supply directly from Lake Huron and are no longer supplied by municipal wells.

The MOE water well records indicate that there are approximately 1,000 domestic wells in the Municipality of Kincardine. All of these wells were completed within either the surficial deposits or within the underlying bedrock. Approximately 80% of the wells are completed in bedrock, typically to depths of 30 to 100 m into the upper bedrock of the Lucas, Amherstburg and Bois Blanc Formations. Over 95% of all wells were reported in the MOE records as having encountered fresh water. Shallow wells typically 3 to 6 m deep are largely associated with lakeshore cottages and farms. There may also be additional dry wells completed in the surficial deposits for which records may not exist.

Water well records for the Municipality of Kincardine indicate that the direction of groundwater flow is westward from the Tiverton and Underwood (220 to 240 mASL) areas towards the Bruce nuclear site and Lake Huron (176 mASL). The Bruce nuclear site is downgradient (downstream) from neighbouring groundwater users in the Municipality of Kincardine and the Regional Study Area.

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0 125 250 500
Metres

LEGEND

- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]
- 1, Bunker C Oil ASTs and Oil Delivery System
- 2, Bruce Nuclear (Steam Plant) Standby Generators
- 3, Former Spent Solvent Treatment Facility
- 4, Distribution Station #2 and #4
- 5, Former Construction Landfill #1
- 6, Former Construction Landfill #4
- 7, Fire Training Facility
- 8, WWMF
- 9, Former Bruce Heavy Water Plant

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007. Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

AREAS OF POTENTIAL CONTAMINATION IN THE SITE STUDY AREA

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007		
GIS	BC	16 Jun. 2010	**FIGURE 6.2.5-2**	
CHECK	CK	16 Jun. 2010		
REVIEW	MAR	16 Jun. 2010		

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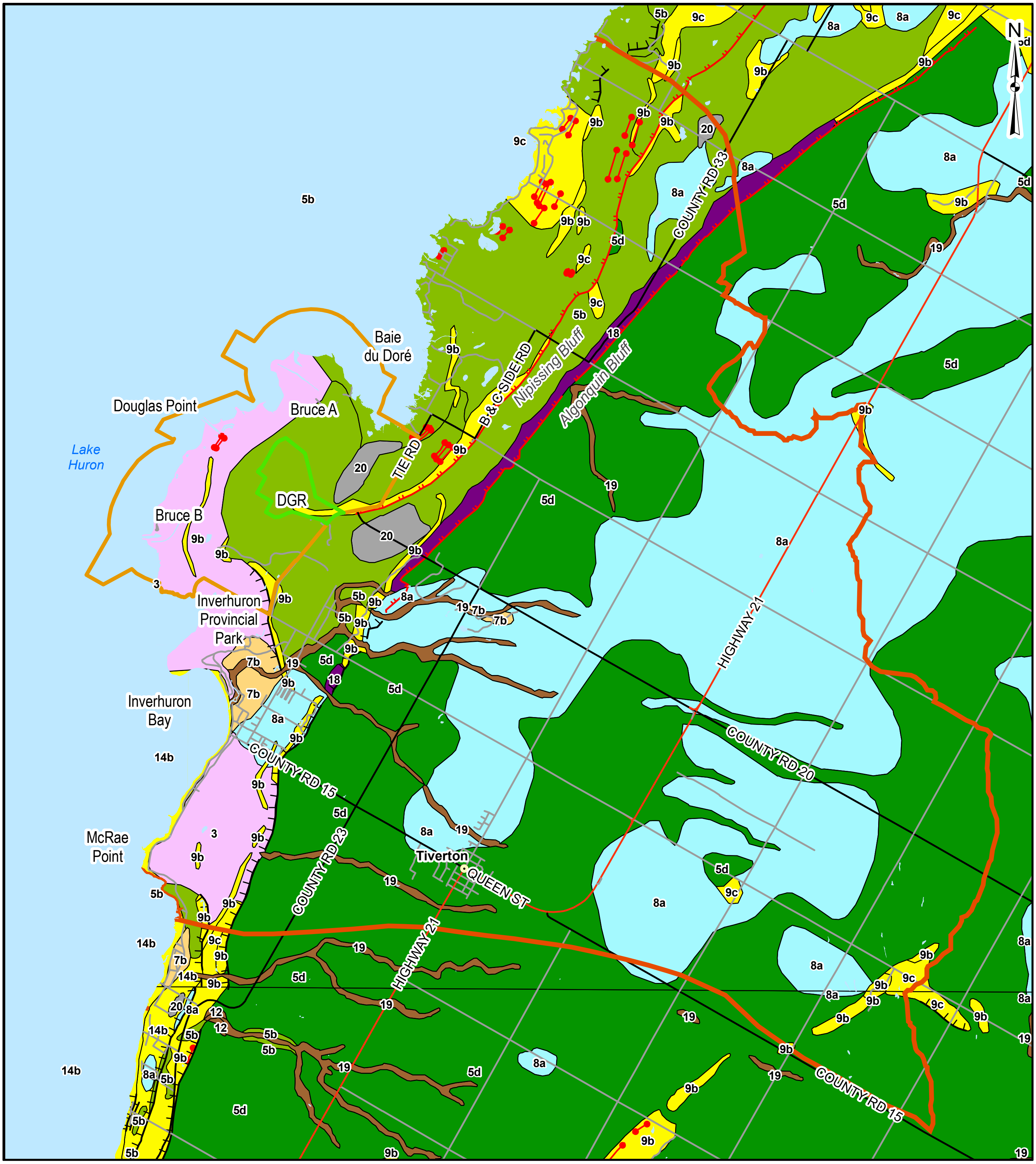

0 0.5 1 2 3 4 5
Kilometres

LEGEND

- Project Area (OPG-lands that encompass the DGR Project)
- Site Study Area [1]
- Local Study Area
- beach
- bluff
- terrace

- 3: Paleozoic bedrock
- 5b: Stone-poor, carbonate-derived silty to sandy till
- 5d: Glaciolacustrine-derived silty to clayey till
- 6: Ice-contact stratified deposits
- 7: Glaciofluvial deposits
- 7a: Sandy deposits
- 7b: Gravelly deposits
- 8a: Massive-well laminated
- 9a: Deltaic deposits
- 9b: Littoral-foreshore deposits
- 9c: Foreshore-basinal deposits
- 12: Older alluvial deposits
- 14b: Littoral-foreshore deposits
- 18: Colluvial deposits
- 19: Modern alluvial deposits
- 20: Organic deposits

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007. Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

DGR LOCAL SURFICIAL GEOLOGY

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct 2007	**FIGURE 6.2.5-3**	
GIS	BC	16 Jun. 2010		
CHECK	CK	16 Jun. 2010		
REVIEW	MAR	16 Jun. 2010		

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6.2.6 Bedrock Geology

Southern Ontario is underlain by Upper Cambrian (~510 Ma) to Devonian/Mississippian (354 Ma) sedimentary rocks, resting unconformably upon Precambrian basement along the southern margin of the Canadian Shield (Figures 6.2.6-1 to 6.2.6-4). The basement is characterized by Precambrian (ca. 1600 to 540 Ma) gneisses and metamorphic rocks of the Grenville Province of the Canadian Shield [118]. The Regional Study Area, which is centered on the Bruce nuclear site, is situated on the northeastern margin of the Michigan Basin (Figures 6.2.6-1 and 6.2.6-2). This area forms part of the northwestern flank of the Algonquin Arch (Figure 6.2.6-1), which is a subsurface basement high overlain by these Paleozoic sediments (e.g., [118]).

The Paleozoic succession thins from a maximum of approximately 4,800 m at the centre of the Michigan Basin to approximately 850 m at the Bruce nuclear site on the flank of the Algonquin Arch. In general, the strata dip gently from all margins at between 4 and 17.5 m/km, or 0.23° to 1° toward the centre of the basin deposits in central Michigan [119;120;121]. Bedding dips reported from the southern Bruce Peninsula, and formation top dips beneath the Bruce nuclear site, all fall within this range [88;122]. Figure 6.2.6-3 presents a geological cross-section through the Bruce nuclear site.

The Regional Study Area is underlain by low to moderate relief basement rocks of the Huron Domain of the Central Gneiss Belt (Figure 6.2.6-4) and is located southeast of the surface trace of the Grenville Front Tectonic Zone (GFTZ) [118;123;124;125]. The basement geology is understood by extrapolation of inferred basement structural boundaries beneath the Paleozoic cover (Figure 6.2.6-4). This process is aided by seismic, aeromagnetic, and gravity map interpretation (e.g., [126;127]), and by geochemical, geochronological, and petrographic analyses of samples recovered from drill cuttings and core [118;123;128].

The following sections provide a high-level summary of the existing geology at the Bruce nuclear site. The locations of boreholes in the Project Area used to characterize the existing conditions are shown on Figure 6.2.6-5. For additional detail refer to the Geology TSD and the Geosynthesis [87].

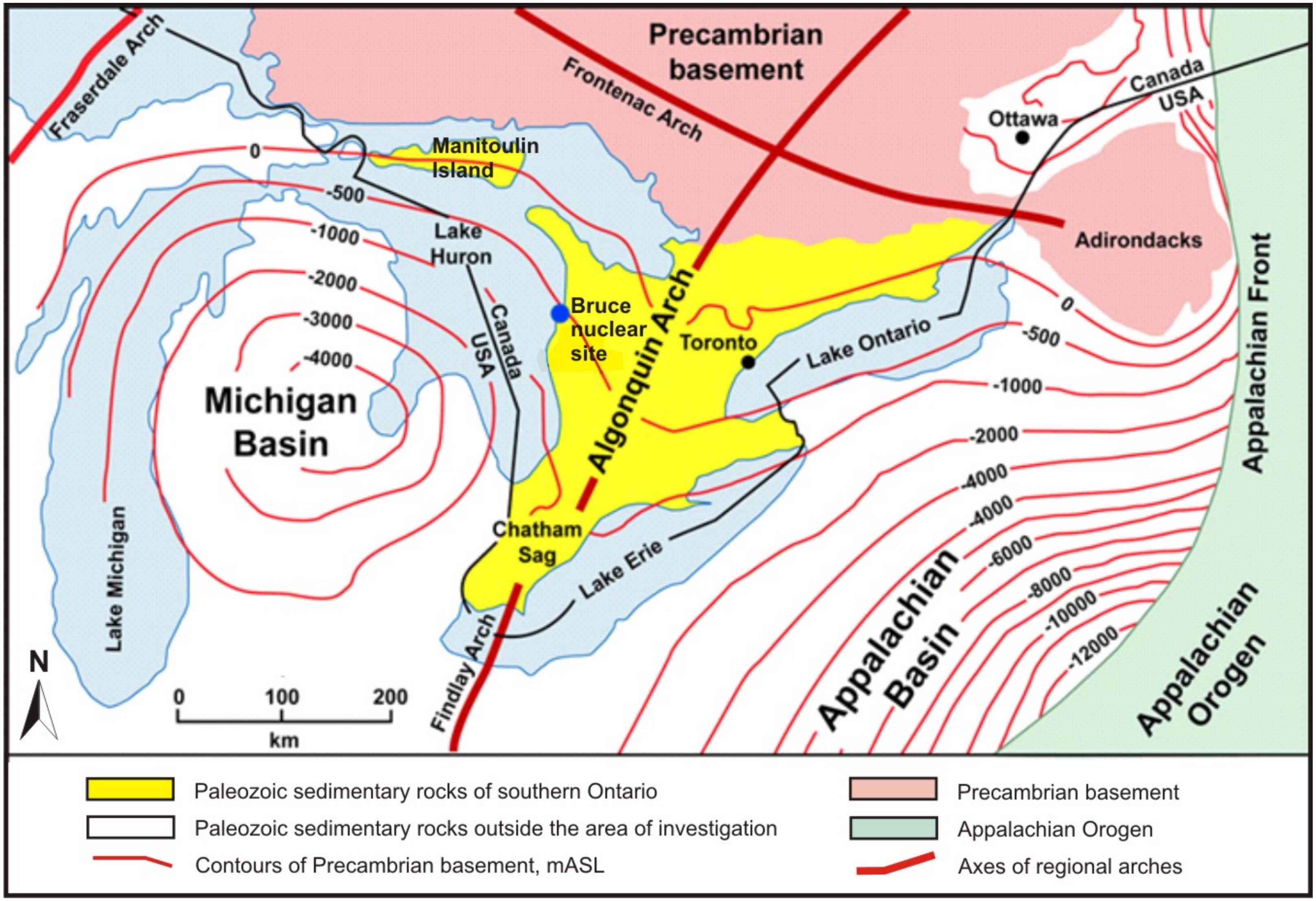
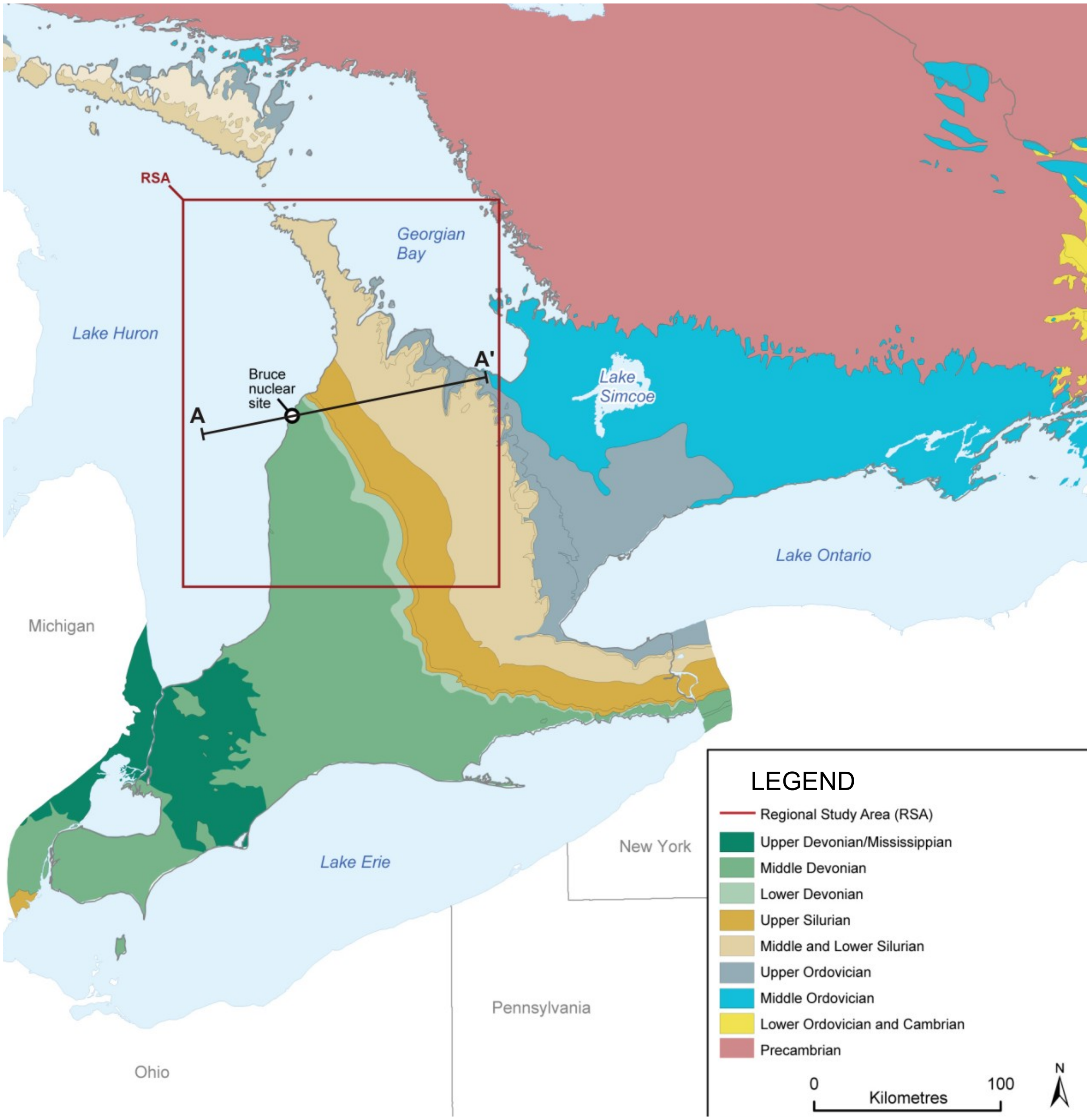
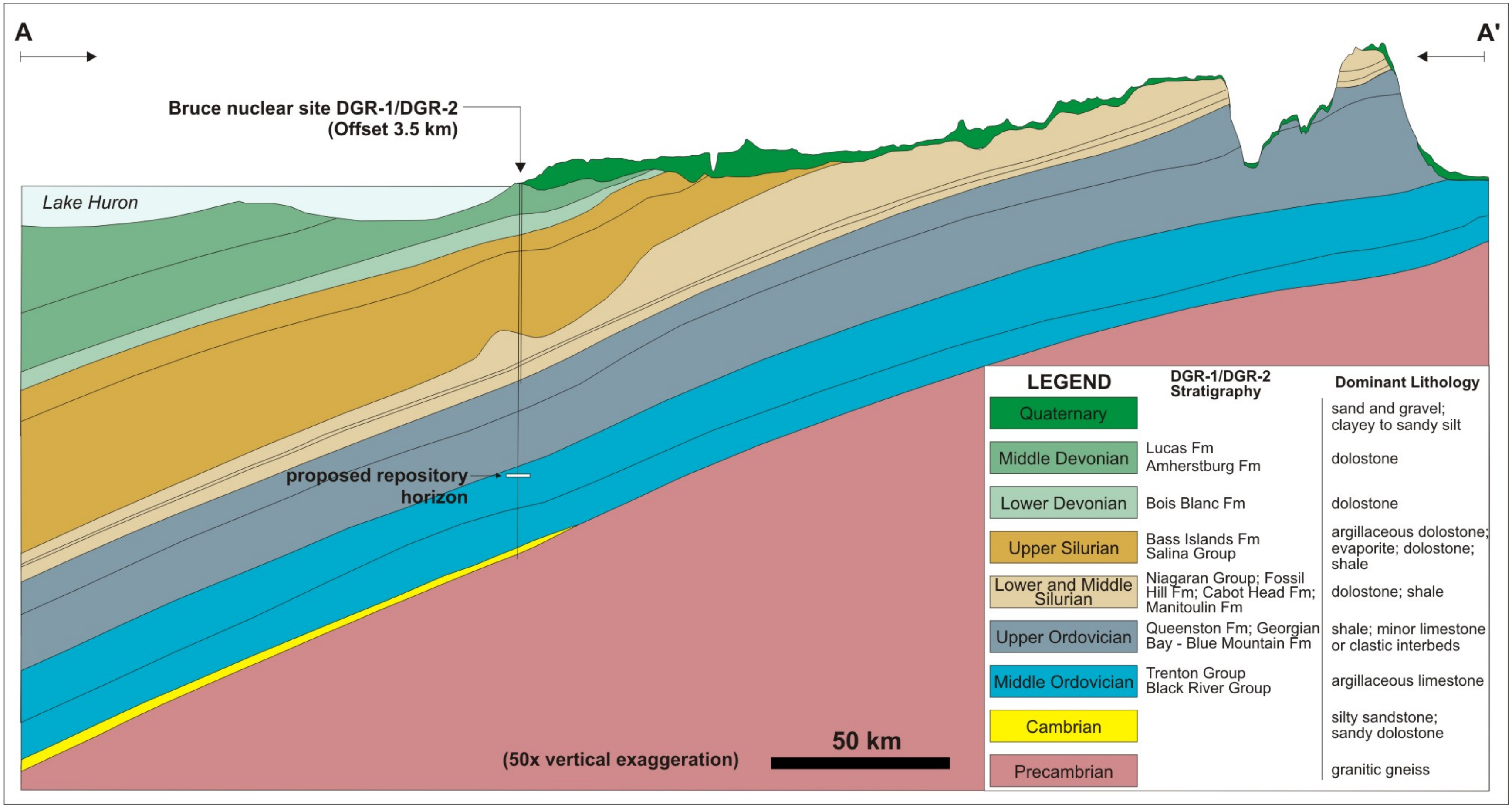


Figure 6.2.6-1: Geologic Features of Southern Ontario



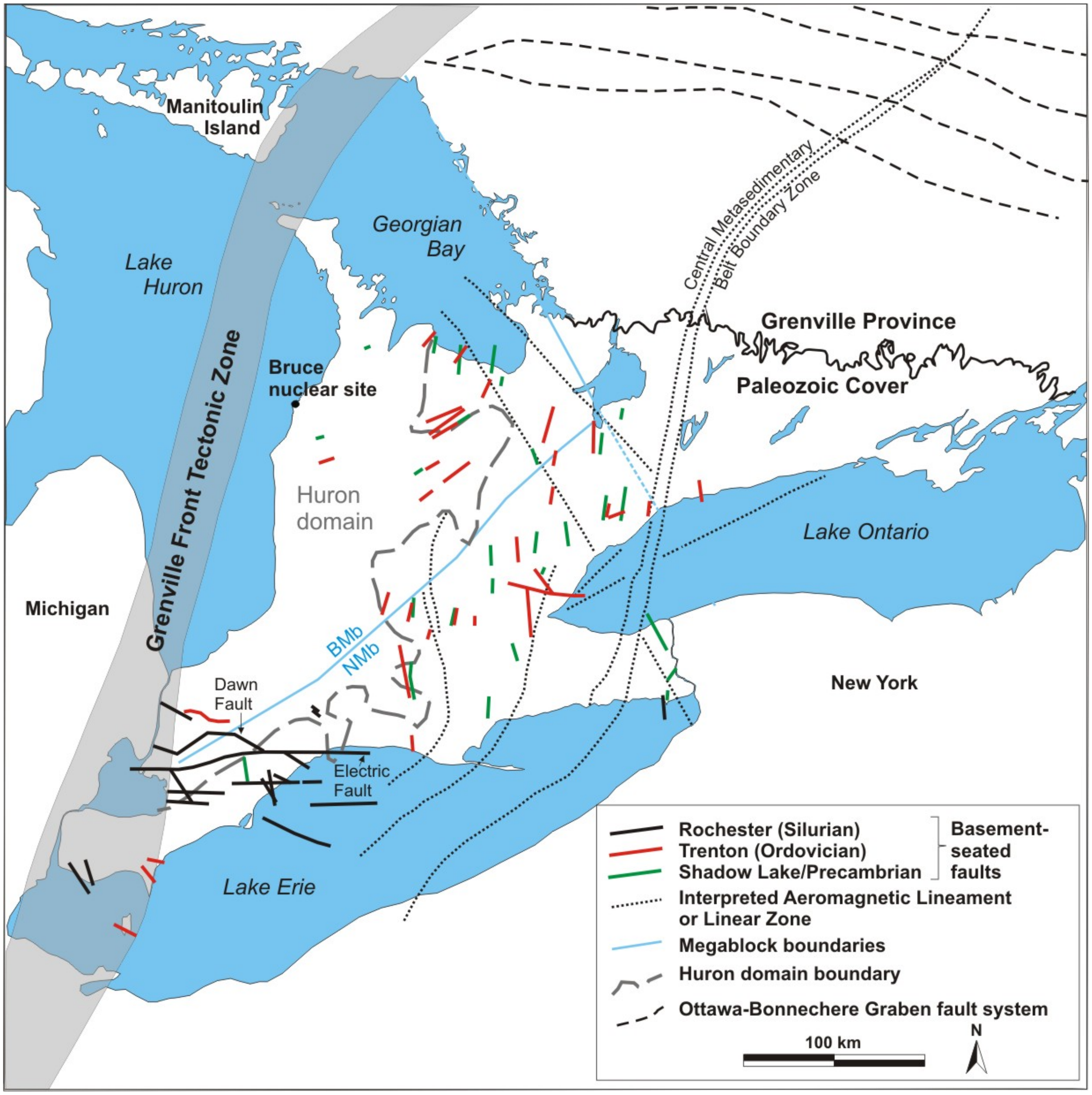
Note:
Section along line A-A' is shown in Figure 6.2.6-3. See Figure 6.2.6-6 for detailed stratigraphic nomenclature.
Source: Modified from Ontario Geological Survey bedrock geology map as drawn in [129] and [130].

Figure 6.2.6-2: Geologic Map of Southern Ontario



Note:
Fm – Formation. The subsurface trace of boreholes DGR-1 and DGR-2 have been projected onto the cross-section. Simplified stratigraphy is from [88]. Detailed stratigraphic nomenclature is shown in Figure 6.2.6-6.
Source: Modified from Figure 2.23b of [87].

Figure 6.2.6-3: Geological Cross-Section through the Regional Study Area



Notes:
Contacts are based on field mapping and interpretations aided by subsurface drilling, borehole stratigraphic correlation, and from: [119] and compiled by [131;132;133;118;128;123;127;126;134;135;130]. BMb – Bruce Megablock; NMb – Niagara Megablock. See text for further discussion.
Source: Modified from Figure 2.5 of [87].

Figure 6.2.6-4: Interpreted Boundaries and Fault Traces in Southern Ontario

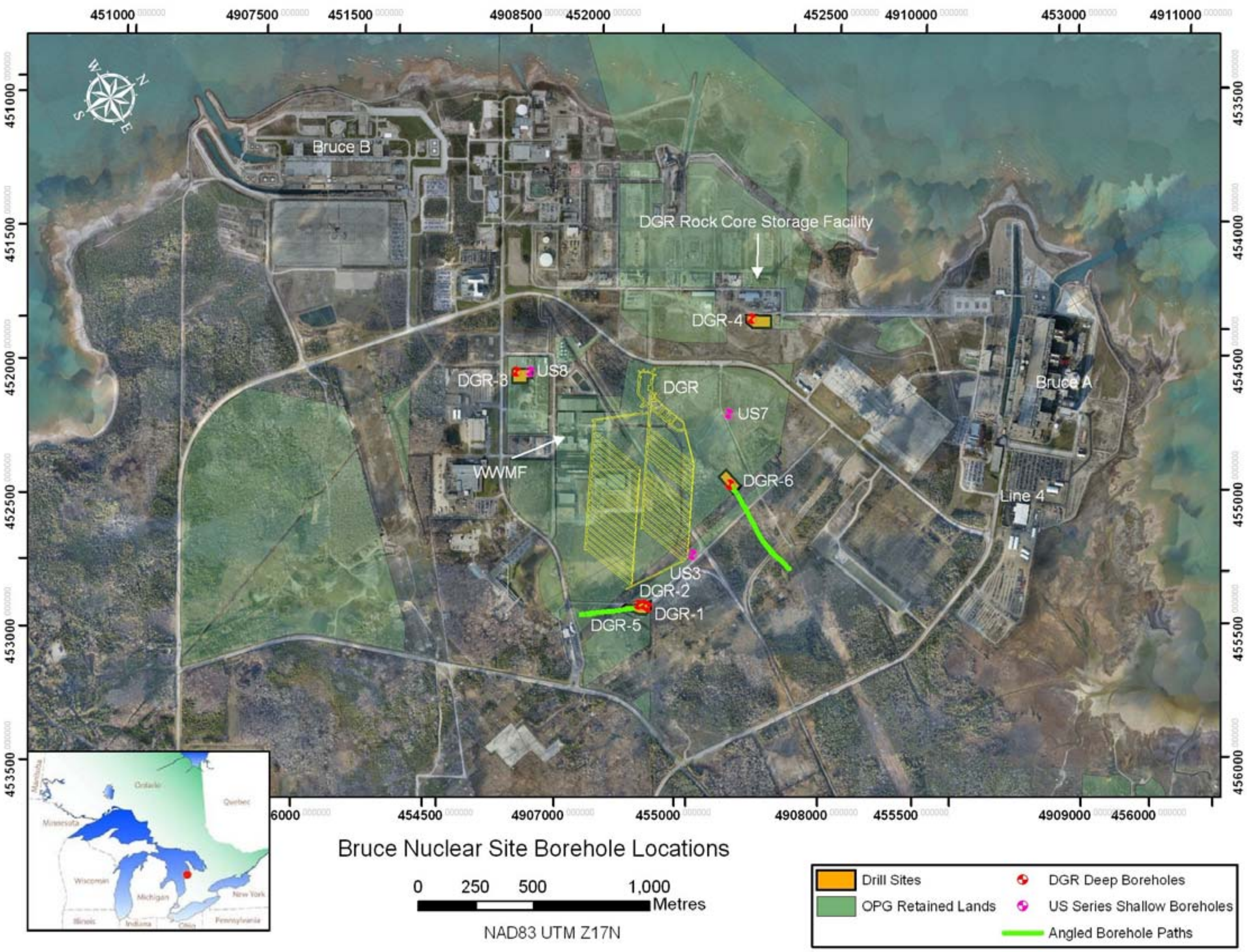


Figure 6.2.6-5: Location of Deep DGR-series and Shallow US-series Boreholes

6.2.6.1 Regional Stratigraphy

The nearly flat-lying Paleozoic succession was deposited over a broad carbonate and clastic shelf and platform setting that extended from the eastern margin of the Appalachian Basin to beyond the western margin of the Michigan Basin (Figure 6.2.6-1). The central column in Figure 6.2.6-6 shows the Paleozoic stratigraphy that is encountered beneath the Bruce nuclear site and region [129]. Importantly, this group- and formation-scale stratigraphy is traceable from the Michigan Basin in southwestern Ontario (left column in Figure 6.2.6-6) across the arch and into the Appalachian Basin (right column in Figure 6.2.6-6). This is to be expected because depositional environments that controlled lithofacies associations evolved at a scale much larger than the Regional Study Area (e.g., [136;116], Figure 2.9 of [87]). It therefore follows that the stratigraphy throughout the Regional Study Area is generally predictable across large distances.

A three-dimensional geological framework (3DGF) model was constructed for the Regional Study Area in order to better define the stratigraphic and spatial continuity of the Paleozoic succession in a 35,000 km² region surrounding the Bruce nuclear site [137]). The final 3DGF model geometry is consistent with the regional geological framework based on published literature, maps and cross-sections of the region [129;130]. Armstrong and Carter [129] describe the occurrence of 31 formations, members or units within the Paleozoic succession from its Cambrian base to the Devonian Lucas Formation, the youngest exposed bedrock in the Regional Study Area (Figure 6.2.6-6). The Salina A-1, A-2, and B units are further divided into evaporite and carbonate sub-units, totalling 34 recognizable stratigraphic entities.

A recently published update of the Paleozoic stratigraphy of southern Ontario includes minor modifications to the stratigraphic nomenclature shown in Figure 6.2.6-6 [130]. The middle Silurian designation has been removed and now the Upper and Lower Silurian are separated at the top of the Eramosa Member of the Guelph Formation. In addition, the Black River and Trenton Groups are now both included in the Upper Ordovician Period. Acknowledging these recent re-interpretations, the stratigraphy at the Bruce nuclear site is organized according to the original framework shown in Figure 6.2.6-6 [129].

A detailed description of the regional Paleozoic geology, tectonic history, structures and fractures is provided in Section 5.5 of the Geology TSD, as well as the Geosynthesis [87]. Figure 6.2.6-6 shows the Paleozoic stratigraphy of southwestern Ontario from locations in the Michigan Basin, the Bruce nuclear site on the western flank of the Algonquin Arch, and the Appalachian Basin.

6.2.6.2 Site Study Area

Stratigraphy

Drilling, logging, and testing of boreholes DGR-1 through DGR-6 at the Bruce nuclear site led to the identification of 34 distinct Paleozoic bedrock formations, members, or units of approximately 840 m cumulative thickness beneath a thin veneer (7 to 20 m) of Pleistocene overburden and unconformably overlying Precambrian granitic gneiss (Figure 6.2.6-7; [88]). The proposed DGR underground facilities will be located within argillaceous limestone of the

Middle Ordovician Cobourg Formation and situated beneath a thick (greater than 200 m) Upper Ordovician shale-dominated sequence (Figure 6.2.6-3).

A detailed description of the Bruce nuclear site stratigraphy is provided in Section 5.5 of the Geology TSD, as well as the Geosynthesis [87]. Figure 6.2.6-7 shows the stratigraphic sequences encountered during drilling at the Bruce nuclear site.

Karst Occurrences

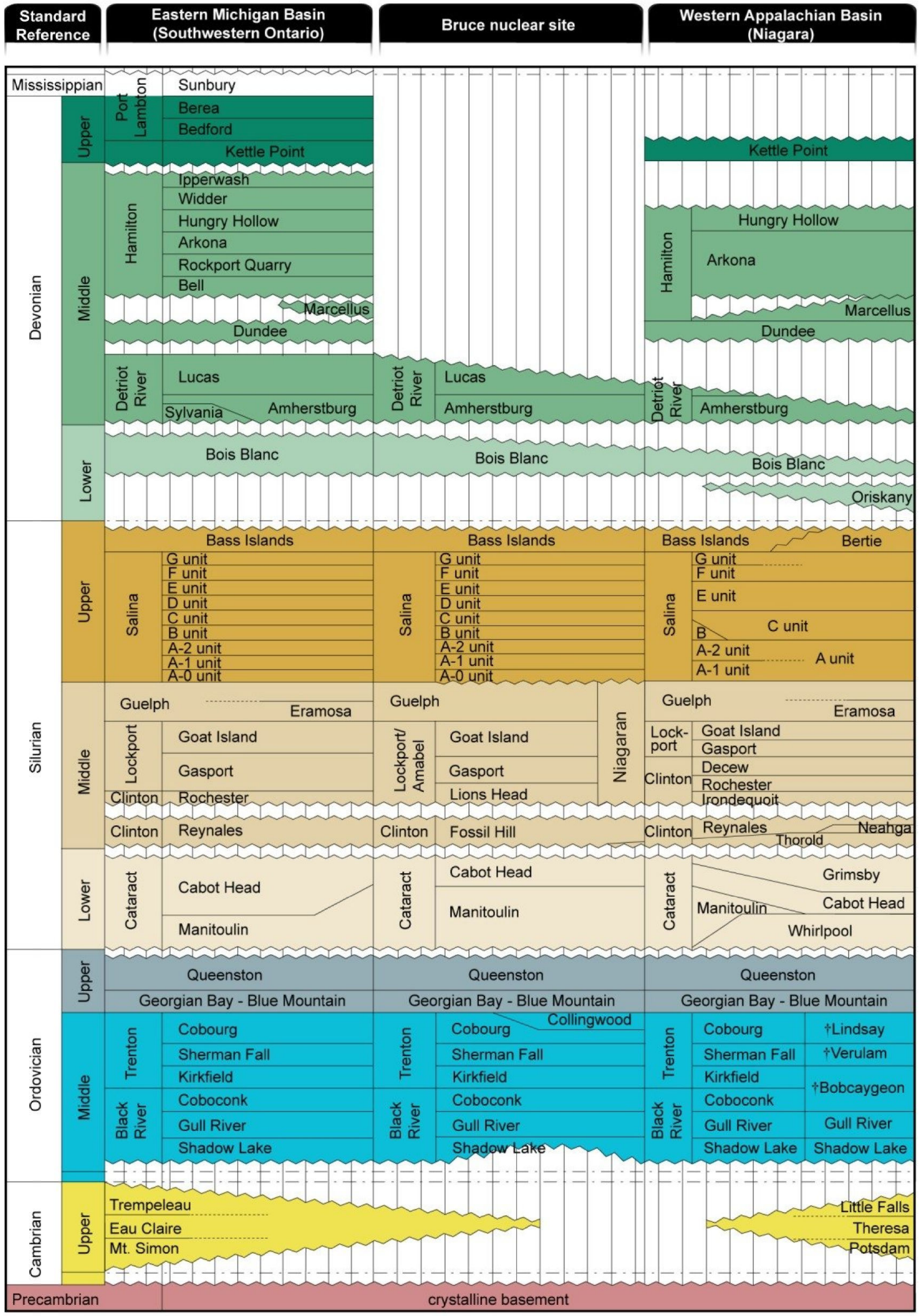
Based on the recognition that karst is common in exposed Ordovician, Silurian, and Devonian age bedrock throughout southern Ontario ([138]; see Section 2.2.5.5 of [87]), an evaluation of the distribution of karst beneath the Bruce nuclear site was undertaken [139]. The pertinent results of the karst study are summarized below:

- The top approximately 170 m (borehole DGR-1 reference depth) of bedrock at the Bruce nuclear site is recognized as a zone of active karst development. This zone is characterized by higher permeability than is found in the deeper units, and groundwaters that range in TDS from fresh (greater than 0.5 g/L) to brackish (approximately 5.0 g/L) near the bottom of this groundwater zone.
- With the exception of two approximately 4 m thick dolostone intervals, which display hydraulic conductivities of approximately 10^{-7} to 10^{-8} m/s [88], the groundwater system below 170 mBGS has very low hydraulic conductivities and is characterized by saline to brine groundwater or pore fluids. Despite the relatively higher permeability, the two thin aquifer zones are characterized by Na-Cl waters with TDS values in the A1 carbonate of 29 g/L and the Guelph Formation of 371 g/L.
- The deep groundwater system in the Ordovician strata at the Bruce nuclear site is characterized by very low hydraulic conductivities ($\leq 10^{-12}$ m/s). There is no evidence that freshwater has penetrated into this deeply buried ancient system during the Quaternary and conditions suitable for karst processes are not present.

Predictability of the Ordovician Sedimentary Rocks and Lithofacies Analysis

Based on the regional geology of southern Ontario, the site lithology (shale, evaporite, carbonate, and clastic content) defining broad facies assemblages is well predicted by the regional data [116;129;130].

Intersection of the Ordovician formations by the DGR boreholes, except for the deepest formations in DGR-5 and DGR-6, allows for an assessment of the uniformity in formation thickness and attitude (strike and dip). Formation strike and dip are remarkably similar through the Ordovician. Similarly, individual and total Ordovician thicknesses are consistent between boreholes.



*modified from Armstrong and Carter (2006) after Winder and Sanford (1972)
†outcrop nomenclature for Southern and Eastern Ontario

NOTE

INCLUDES NOMENCLATURE FROM LOCATIONS IN THE MICHIGAN BASIN (LEFT), BRUCE NUCLEAR SITE (CENTRE), AND APPALACHIAN BASIN (MODIFIED FROM [129]).

REFERENCE

MODIFIED FROM FIGURE 2.8 IN [87]

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

PALEOZOIC STRATIGRAPHIC NOMENCLATURE OF SOUTHWESTERN ONTARIO

PROJECT No. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	**FIGURE 6.2.6-6**	
GIS	BC	10 Feb. 2011		
CHECK	BT	10 Feb. 2011		
REVIEW	MAR	10 Feb. 2011		

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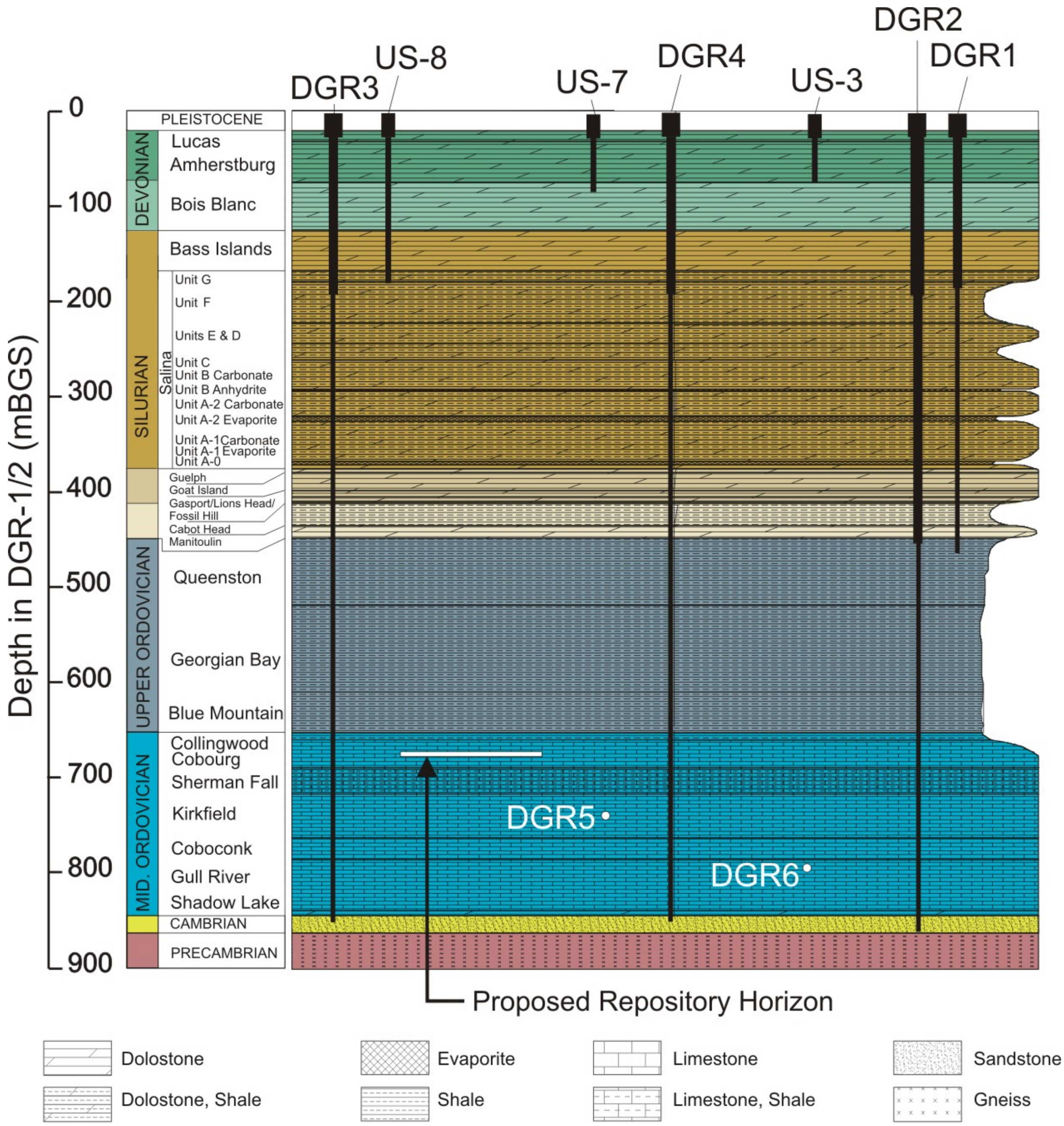


Notes:
White dots indicate approximate depth of penetration for angled boreholes DGR-5 and DGR-6.
A recently published update of the Paleozoic stratigraphy of southern Ontario includes minor modifications to the stratigraphic nomenclature shown in this figure [130].
Source: Figure was developed based on information from [88] and modified from Figure 2.25 of [87].

Figure 6.2.6-7: Stratigraphic Sequence Encountered During Drilling at the Bruce Nuclear Site

In order to fully assess the degree of predictability of individual lithofacies at the site-scale, an evaluation of the lateral (horizontal) homogeneity and vertical variation of lithofacies within key Ordovician intervals was conducted (see also [87]). Important conclusions based on this work are discussed below:

- The natural gamma ray profiles for the Ordovician section from each of boreholes DGR-1/2, DGR-3 and DGR-4, as plotted in Figure 5.5.2-6 of the Geology TSD, show a consistent bimodal distribution of counts per second (CPS) values. A high CPS count in the upper interval highlights the greater than 200 m thick shale-dominated Upper Ordovician rock sequence, which represent the primary cap rock to the proposed DGR, above the low CPS count and carbonate-rich Middle Ordovician sequence.
- The general consistency in natural gamma profile distribution supports the assessment of uniform unit thicknesses and a structurally simple geometry across the site [121].
- Lithological variation is likely to occur as minor, dm- to cm-scale typically, conformable changes in quantities of mm- to cm-thick beds of shale, siltstone, or limestone as demonstrated by minor variation of the gamma ray profiles between boreholes.

Several laterally continuous marker beds were identified during DGR core logging activities and provide a further indication of formation lateral continuity at the site-scale [121;140]. These marker beds are typically 10 to 20 cm thick beds with visually identifiable lithofacies features and/or borehole geophysical logging signatures that are distinct from the surrounding rocks.

Rock Minerology and Geochemistry

Samples of core recovered from the DGR-series of boreholes were subjected to a suite of laboratory tests to determine the intact rock mineralogy and lithogeochemistry, as well as to confirm or modify the stratigraphy and lithology of the bedrock sequence as described regionally [129;130]. Notable results for the Ordovician interval are discussed below (see also Section 2.3.5 in [87]):

- The Upper Ordovician shales are dominated by sheet silicates, with increasing amounts of quartz with depth and moderate amounts of calcite and dolomite, particularly in the Queenston Formation, and decreasing in percentage with depth. Predictably, the Middle Ordovician limestone formations consist of typically greater than 80% calcite, with the remainder being variously composed of sheet silicates, dolomite, and quartz.
- Dolomitization is evident in varying proportions in parts of the Queenston, Georgian Bay, Blue Mountain, Collingwood, Shadow Lake, and lower Gull River Formations.
- Sheet silicate content ranges between 25 to 70% within the Ordovician shales of the Queenston, Georgian Bay, and Blue Mountain Formations. Illite and mica together represent greater than 50% of the sheet silicate mineral constituents, followed by chlorite at 20 to 45% and with minor kaolinite and interstratified illite-smectite. The interstratified illite-smectite is predominantly illite, with only 5 to 10% smectite layers [141]. In all cases, the major sheet silicate mineral is illite and the minor phase is chlorite [88]. The sheet silicate content of the Ordovician limestones is typically less than 20%.
- Pyrite is the principal iron mineral throughout the entire Ordovician interval, although hematite is observed in the Queenston Formation.

Fracture Filling and Halite Occurrence

Self-sealing by a precipitating mineral phase is a naturally occurring time-dependent process that leads to a reduction in the hydraulic transmissivity of a fracture. When fully self-sealed, the fracture is not a preferential pathway for fluid migration. If partially self-sealed, the fracture may act as a pathway but at a lower transmissivity than when it was open. Halite was specifically targeted for identification and distribution analysis because of its high solubility (approximately 6,000 mmol/kgw) and its role as a groundwater tracer. The presence of halite within a formation or group of formations is a strong indicator that there has been no flow of fresh, or halite-undersaturated, water through that rock sequence since the halite was precipitated [88].

Halite was detected visually during core logging, and via optical microscope, XRD, and SEM/EDS analyses [88;142]. Observed occurrences included: mineral infilling of subhorizontal and steeply-dipping fractures; voids and cavities; a grain-boundary mineral phase within a matrix dominated by gypsum, dolomite, calcite, or silicate minerals; and, as disseminated grains and irregular, discontinuous stringers. Halite was found in abundance throughout the Upper Ordovician shales, as a minor mineral phase throughout the Cobourg, Sherman Fall, and Gull River formations, and the Cambrian [88;142;143] and was most commonly observed infilling mm-scale to hairline thickness fractures throughout the Upper Ordovician shales.

Ordovician Cap Rock Seal

An assessment of the cap rock integrity and seal potential of the DGR cap rock was undertaken based upon evaluation of the seal quality of cap rocks to petroleum deposits in the Appalachian and Michigan basins [144]. The purpose of this study was to explore whether the thick package of Upper Ordovician shale rocks at the Bruce nuclear site would provide a natural barrier to migration of fluids. The cap rock for the proposed DGR includes the Middle Ordovician organic shale-rich Collingwood Member and the overlying Upper Ordovician shale-dominated Blue Mountain, Georgian Bay and Queenston formations totalling greater than 200 m of low-permeability shale-rich rocks overlying the proposed Bruce nuclear site. Main conclusions reached by the study which attest to the longevity in seal integrity of the Bruce nuclear site cap rocks include the following [144]:

- In a similar manner that seal longevity is evident from the recognition of regional over-pressures in the northern Appalachian Basin and under-pressures in the southern Appalachian Basin, the under-pressured nature of the Ordovician shales indicates that this sedimentary package represents a long-lived and stratigraphically-controlled cap rock seal.
- Limited hydrocarbon maturation at the Bruce nuclear site is a result of subsidence that reached a total burial depth of approximately 1.5 km and certainly no more than 2 km, creating temperatures that only marginally crossed the oil generation window (approximately 70ºC for the Collingwood Member). This lack of thermal maturity precluded the development of gas-generated natural hydraulic fractures (NHF), and this relationship was confirmed by extensive coring. In contrast, gas generating conditions within in the Appalachian Basin lead to extensive and pervasive NHF development.
- The distribution of hydrocarbons at the site, as shown in Figure 5.5.2-9 of the Geology TSD, suggests that these Upper Ordovician shales provide an adequate seal.

- The youngest strata in the Regional Study Area affected by basement-seated faults are the Ordovician-aged Trenton Group limestones [130]. The lack of any appreciable volume of hydrothermal dolomite at the Bruce nuclear site [88] argues against the likelihood of a proximal major Paleozoic fault system having been active in the vicinity in the ancient past and that could have disrupted the seal integrity of the cap rocks.

Therefore, the shale-dominated cap rocks at the Bruce nuclear site represent a natural greater than 200 m thick seal that has demonstrated long-term integrity over geological time and is well suited to continue acting as a primary barrier to contaminant transport in the subsurface [144].

Site-scale Structural Geology

Studies undertaken as part of the Geosynthesis work program which focused on understanding the structural geological framework of the Bruce nuclear site included a two-dimension seismic reflection survey, a detailed fracture mapping exercise, and several aspects of the drilling and core logging activities undertaken during site characterization [88;120;145]. The 2D seismic interpretation suggested the existence of two structural features (faults) within the proposed DGR footprint. The inclined drilling of boreholes DGR-5 and DGR-6 was specifically oriented to intersect these interpreted structural features, and no evidence for their existence was found in the recovered core.

6.2.6.3 Natural Resources

Oil and Gas

Commercial quantities of oil and gas have been discovered in a total of over 300 separate pools or reservoirs within the Paleozoic succession in southwestern Ontario (as shown in Figure 2.20 of the Geosynthesis [87]) (e.g., [146;147;148]). Of more than 21,000 documented wells drilled in Ontario, only 27 petroleum exploration wells have been drilled within a 40 km radius of the proposed DGR and there is no commercially active hydrocarbon extraction at present in this area [149]. Current exploration interest is focussed on targets in the southwestern tip of Ontario in Middle Ordovician carbonates and Upper Cambrian sandstones at depths of 800 to 1,000 m [150]. The majority of exploration is concentrated within the geographic triangle between London, Sarnia, and Chatham-Kent [87].

From an evaluation of existing literature [87], the probability of future identification of potential economic oil and/or gas resources adjacent to the proposed Bruce nuclear site is very low. This conclusion is based on several factors:

- Although porous Cambrian sediments have been identified in core within the Regional Study Area, no commercial oil or gas accumulations were encountered during site characterization activities [88].
- None of the Silurian reefs adjacent to the DGR encountered commercially viable resources. In addition, the Bruce nuclear site is located within an inter-reef lithology [87]. Minor oil showings in the Silurian Guelph Formation from the DGR core are associated with similarly non-commercial hydrocarbon accumulations [88].

- The Devonian Hamilton Group provides the cap rock for Devonian hydrocarbon plays; however, it is absent at the site. Similarly, the Upper Devonian Kettle Point Formation shale, which might represent good candidate biogenic shale gas plays in southwestern Ontario (e.g., [151]), has been eroded away across the entire Regional Study Area.
- An average total organic carbon (TOC) content of the Upper Ordovician shales of less than 1.0% (Figure 3.14 in [88]), the recognition of low thermal maturity throughout the Regional Study Area, which indicates that these sedimentary rocks only reached the lower threshold of the oil window [152;153;144], and the absence of remarkable natural gas shows during drilling of the DGR boreholes [88], argues against the likelihood of commercial accumulations of either thermogenic or biogenic shale gas beneath the Bruce nuclear site [144].

Aggregate Resources

Although a number of areas in the Regional Study Area have been identified by the Ontario Geological Survey and Ministry of Natural Resources as containing significant resources of sand and gravel [116], it is concluded that none have been identified within 20 km of the Bruce nuclear site [149].

The Upper Silurian Salina Group is characterized by dolomite, shale, gypsum, and salt and has little value as a source for crushed stone aggregate.

Salt

The Salina salt has been dissolved and removed over most of the Regional Study Area and beneath the Bruce nuclear site through natural processes and therefore does not represent a commercial resource in this area.

6.2.6.4 Geology Summary

The Paleozoic sedimentary rocks beneath the Bruce nuclear site are predictable, include multiple natural barriers to contaminant transport, have low resource potential, and are located in a seismically quiet environment. A summary of the key lines of evidence which support this assertion is provided below:

- The 3DGF model geometry of the Regional Study Area is consistent with the regional geological framework based on published literature, maps and cross-sections of the region. The 34 stratigraphic formations, members, or units recognized regionally were also recognized beneath the Bruce nuclear site during site characterization activities.
- The Ordovician stratigraphy exhibits uniform unit thicknesses, traceable marker beds and predictable distributions of formation-scale lithologies, major mineralogical components and fracture in-filling minerals (including halite). A detailed lithofacies analysis determined that the Ordovician stratigraphy at the Bruce nuclear site can be considered laterally homogeneous and predictable at the dm- to m-scale between the vertical DGR boreholes spaced less than 1 km apart.

- Two inclined boreholes were directionally-drilled in order to investigate potential sub-vertical fault structures imaged by the 2D seismic survey. Continuous core retrieved from both boreholes showed no evidence of faulting.
- Present day karst features are confined to the shallow groundwater zone and this zone is effectively isolated from the deeper groundwater system beneath the site. This interpretation is supported by the observed distribution of halite within the deep system.
- No commercial oil or gas accumulations were encountered during site characterization activities. Low average TOC (less than 1%) in the Upper Ordovician shales and a low degree of thermal maturity argue against the likelihood of commercial hydrocarbon accumulations within the DGR footprint.
- The distribution of hydrocarbons at the site attest to the seal capacity of the Upper Ordovician shales and that this sedimentary interval has provided a long-lived barrier to hydrocarbon migration. The low degree of thermal maturity, which barely reached the oil window in terms of hydrocarbon generation, precluded the development of gas-generated natural hydraulic fractures which could have disrupted the Upper Ordovician seal.

6.2.7 Hydrogeology

The regional scale groundwater domain has been subdivided into three zones:

- a shallow zone comprising any surficial soil deposits and about 170 m of Devonian and Upper Silurian dolostones;
- an intermediate zone of Silurian shales and dolostones; and
- a deep zone of Ordovician shales and limestones, including the underlying Cambrian sandstone and Precambrian basement.

These are further subdivided into a series of nine hydrostratigraphic (HS) units in the Descriptive Geosphere Site Model [88] (Figure 6.2.7-1). Units 1 and 2 represent the shallow zone; Units 3, 4A and 4B represent the intermediate zone; and Units 5 to 9 represent the deep zone.

6.2.7.1 Shallow Groundwater System

The shallow groundwater zone at the Bruce nuclear site is characterized by layers with high permeability, and a groundwater composition with relatively low total dissolved solids (TDS) concentrations [87]. The shallow zone includes the glacially deposited Quaternary sediments, the Devonian Lucas, Amherstburg and Bois Blanc limestone and dolostone formations, and the Silurian Bass Islands Formation. The direction of groundwater flow in the shallow zone is strongly influenced by topography. As a result of the low TDS concentrations, the higher groundwater velocities in the shallow zone are dependent on energy gradients that are relatively independent of fluid density. Solute transport in the shallow groundwater zone is dominated by advection and related mechanical dispersion.

Overburden at the Bruce nuclear site (HS Unit 1) is of variable thickness ranging from a thin veneer near Lake Huron to upwards of 20 m in the southeastern part of the site near US-6 and DGR-1/2. In the vicinity of the proposed DGR at DGR-1/2, the overburden consists of 2 to 3 m layers of granular fill and basal gravel overlying and underlying 15 m of sandy silt till, which classifies the overburden as an aquitard. Overburden is further described in Section 6.2.5.

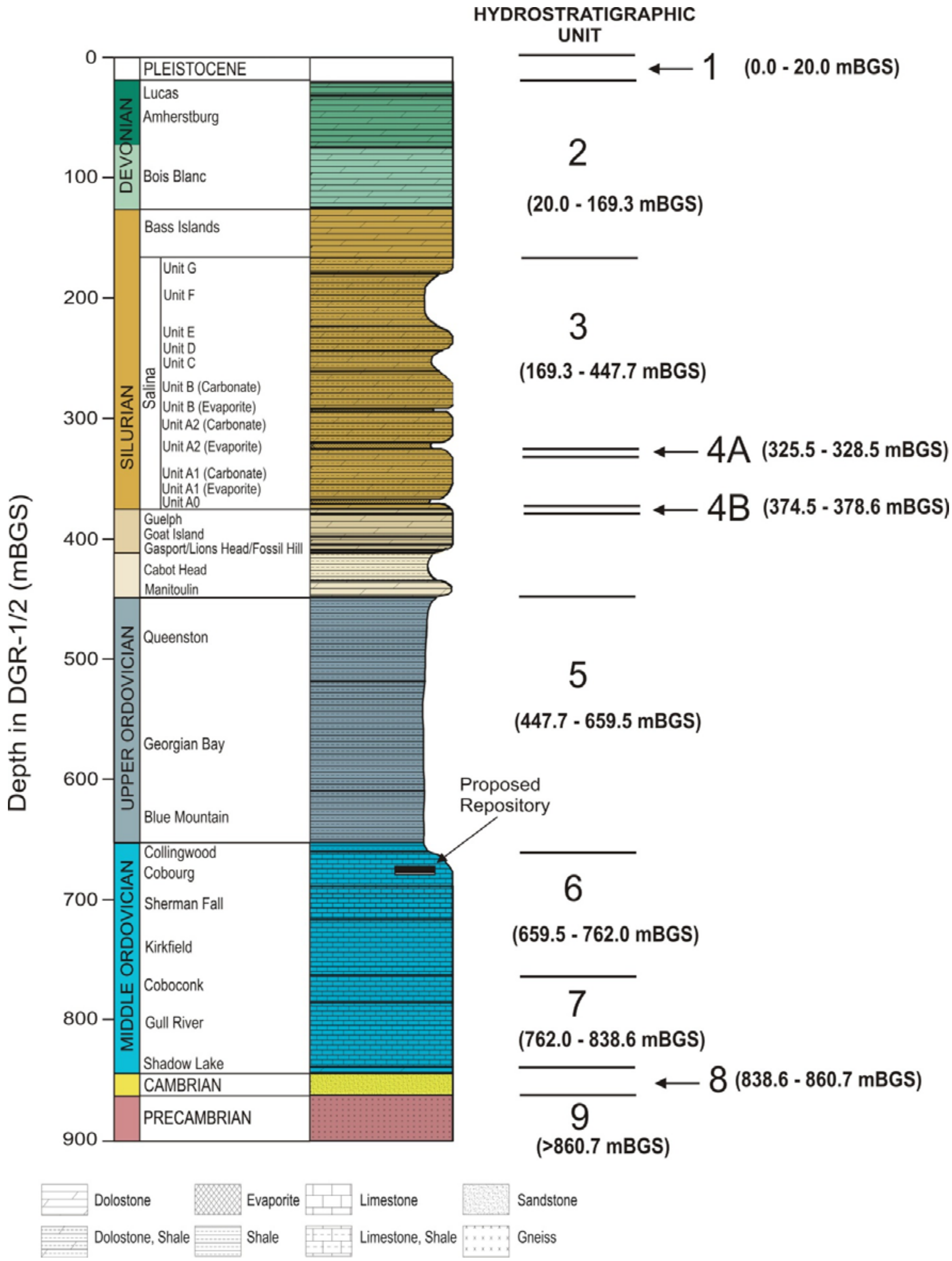
The underlying bedrock (HS Unit 2) comprises of a permeable dolostone aquifer from top of bedrock to reference depth of 169.3 mBGS at DGR-1. It includes the Lucas, Amherstburg, Bois Blanc, and Bass Islands formations. In the DGR boreholes the Unit is 149 to 179 m thick. HS Unit 2 includes the regional groundwater supply aquifer that typically extends to depths of 50 to 100 m, and the deeper, less permeable bedrock to the top of the Salina Formation.

6.2.7.2 Intermediate Groundwater System

Separating the shallow and deep groundwater zones are the layers of the intermediate groundwater zone, which extends from the base of the Bass Islands Formation to the bottom of the Lower Silurian Manitoulin Formation. Within this zone, the low permeability aquitard units within the Salina Formation, where present, isolate the topographically driven shallow flow system from that of the underlying Ordovician shale and limestone formations. The Lower to Middle Silurian dolostones form the most permeable layer in the intermediate zone.

HS Unit 3 comprises the low permeability Upper Silurian shale, dolostone and anhydrite rocks from DGR-1 reference depths of 169.3 to 447.7 mBGS. HS Unit 3 includes three aquitards: upper, middle and lower separated by two Silurian dolostone aquifers (Hydrostratigraphic Units 4A and 4B) which are found at DGR-1 reference depths of 325.5 and 374.5 mBGS. The upper aquitard comprises the Salina Units G, F, E, D, C, B and most of A2 found at reference depths of 169.3 to 325.5 mBGS. The middle aquitard includes the Salina A1 and A0 Units found at reference depths of 328.5 to 374.5 mBGS. The lower aquitard consists of the Goat Island, Gasport, Lions Head, Fossil Hill, Cabot Head and Manitoulin formations, found at reference depths of 378.6 to 447.7 mBGS. Hydrostratigraphic Unit 3 has a combined thickness of 260.7 to 271.3 m in DGR boreholes.

HS Unit 4 comprises two thin porous and permeable aquifers evident in core logging, borehole geophysical logging, hydraulic testing and groundwater sampling completed in DGR boreholes. The upper aquifer (4A) is found at reference depths 325.5 to 328.5 mBGS in DGR-1 and is the upper 3.0 to 3.7 m of the Salina A1 Unit dolostone in DGR boreholes. The lower aquifer (4B) is found at reference depths 374.5 to 378.6 mBGS in DGR-1 and is the entire thickness of the Guelph Formation dolostone. The lower aquifer ranges in thickness from 4.1 to 5.4 m thickness in DGR boreholes.



Source: [88]

Figure 6.2.7-1: Reference Stratigraphic Column Showing Hydrostratigraphic Units at the Bruce Nuclear Site

6.2.7.3 Deep Groundwater System

The deep groundwater zone comprises the layers beneath the Manitoulin Formation, including the Ordovician limestones and shales, the Cambrian sandstones, and the crystalline Precambrian basement. Groundwater in the deep zone can be characterized as stagnant, with high TDS concentrations that can exceed 300 g/L, and a corresponding specific gravity of approximately 1.2. Because the deep groundwater zone is isolated from any local topographic effects by the very low hydraulic conductivities of the overlying Silurian sediments, the horizontal energy gradients will be very low and strongly influenced by density gradients. The most permeable formation in the deep zone is the Cambrian; however, published evidence indicates that in the vicinity of the Bruce nuclear site this layer is relatively thin and discontinuous within tens of kilometres to the east of the site. The following sections provide a summary of the results of the analysis of the deep groundwater zone. Refer to the Geology TSD for more information.

HS Unit 5 comprises the very low permeability massive Ordovician shale sequence from reference depths of 447.7 to 659.5 mBGS in DGR-1/2. HS Unit 5 includes the Queenston, Georgian Bay and Blue Mountain formation shales, and the Collingwood Member shale of the Cobourg Formation. The Unit is 211.8 to 216 m thick in DGR boreholes.

HS Unit 6 comprises the very low permeability argillaceous limestone of the Lower Member of the Cobourg Formation — the proposed DGR repository horizon — and the underlying limestones of Sherman Fall and Kirkfield formations. HS Unit 6 is found at reference depths of 659.5 to 762.0 mBGS at DGR-2. The Unit is 101.5 to 104.1 m thick in DGR boreholes.

HS Unit 7 comprises the low permeability Ordovician limestone sequence from reference depths of 688.1 to 838.6 mBGS at DGR-2. HS Unit 7 includes the Coboconk and Gull River formations (i.e., the Black River Group limestones). In DGR boreholes, the Unit is 75.4 to 76.6 m thick.

HS Unit 8 comprises the permeable Cambrian sandstone and the overlying permeable Shadow Lake siltstone found at reference depths of 838.6 to 860.7 mBGS at DGR-2. In DGR boreholes the Unit is estimated to be 22.1 m thick. The hydraulic properties of HS Unit 8 are dominated by the high hydraulic conductivity and hydraulic heads of the middle to lower parts of the Cambrian rocks.

HS Unit 9 comprises the moderate to low permeability basement rock of the Precambrian granite gneiss underlying the Cambrian sandstone. At DGR-2 the Unit is found at reference depth of 860.7 mBGS. Based on appearance of the 1.55 m of core obtained from DGR-2, HS Unit 9 is composed of competent, moderately fractured, weathered felsic granite gneiss.

6.2.7.4 Environmental Heads and Hydraulic Conductivity

Hydraulic Conductivity

The calculated formation hydraulic conductivities of DGR boreholes are summarized versus depth and formation in Figure 6.2.7-2. No straddle-packer hydraulic test results are available for the Shadow Lake Formation and Cambrian sandstone because of the installation of temporary product-injection packer (PIPs) to control formation fluid flow from the Cambrian sandstone.

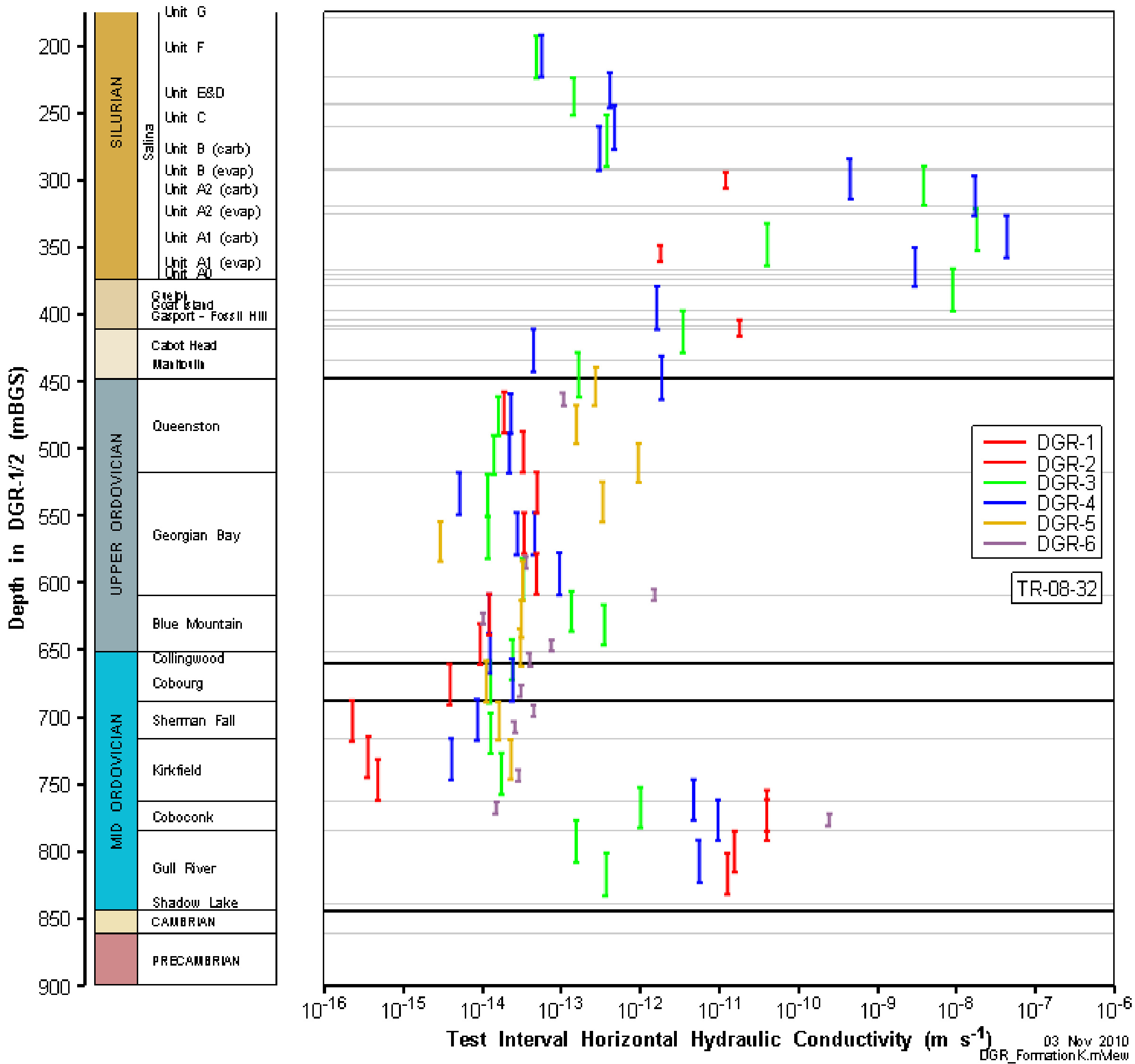
The calculated test interval hydraulic conductivities in DGR boreholes below the Salina G Unit range from 1×10^{-16} to 1×10^{-8} m/s. The lowest measured test interval hydraulic conductivities of less than 1×10^{-15} m/s were determined from testing of the Sherman Fall and Kirkfield formations in DGR-2. The highest test interval hydraulic conductivities of greater than 1×10^{-8} m/s were determined for tests that included the porous and permeable sections of the Salina Upper A1 Unit and the Guelph Formation. The bedrock below the Guelph Formation to the Queenston shale has test interval hydraulic conductivities between 1×10^{-14} and 1×10^{-11} m/s. The bulk of the Ordovician shales and all the Ordovician limestones from the Cobourg Formation to the Kirkfield Formation (i.e., the Trenton Group) have very low test interval hydraulic conductivity values of less than 1×10^{-15} to 1×10^{-14} m/s. Slightly higher test interval hydraulic conductivities (9×10^{-14} to 3×10^{-13} m/s), attributed to identified single fractures or zones of closely spaced fractures, were measured within one test interval in each DGR borehole (lower Georgian Bay in DGR-2 and DGR-4, Blue Mountain in DGR-3). The deeper Ordovician limestones of the Black River Group (Coboconk and Gull River formations) have higher test interval hydraulic conductivities between 1×10^{-13} and 1×10^{-11} m/s.

Environmental Heads

The available pressure measurements from all the DGR borehole shows the following general environmental head conditions related to over-pressures and under-pressures:

- under-pressures in the Salina Formation, with maximum under-pressures occurring within the C and B Units and environmental heads of 70 mBGS;
- over-pressures in the Salina A1 and A0 Units, and Gasport to Fossil Hill Formations with maximum over-pressures equal to environmental heads of 75 metres above ground surface (mAGS);
- under-pressures in the Ordovician shales and Trenton Group limestones with maximum under-pressures occurring within the Blue Mountain Formation, and environmental heads of 300 mBGS; and
- over-pressures in the Black River Group limestones and siltstones and the Cambrian sandstone with maximum over-pressures equal to environmental heads of 165 mAGS.

The cause of the observed under-pressures and over-pressures and heads in DGR boreholes are not evident at this time and are not in hydrodynamic equilibrium with local topography and surface water elevations.



Source: [88]

Figure 6.2.7-2: Profile of Test Interval Hydraulic Conductivity Estimates Determined from Field Straddle-packer Testing in DGR Boreholes

Groundwater Flow Directions

For the deeper permeable units intersected by DGR boreholes, horizontal groundwater flow directions are calculated from measured formation pressures obtained from MP55 casings considering the density of the aquifer fluids and the dip of the formations. The results show the groundwater flow directions in the Upper A1 Unit aquifer are the same as those in the shallow dolostones, being to the northwest toward Lake Huron. In contrast, the calculated groundwater flow directions for the Guelph Formation and the Cambrian sandstone are outward from the middle of the Michigan Basin being toward the northeast (Guelph Formation) and to the east (Cambrian sandstone).

Porosity

Total porosity (also known as physical porosity) is the ratio of the pore volume to the total volume of the rock sample, and was typically determined from bulk dry and grain density data. Liquid porosity is the volume of voids occupied by liquid (pure water plus dissolved solutes and oil). Water-loss porosity is the volume of the voids occupied by pure water divided by the total volume of the sample. Total porosity should equal liquid porosity plus porosity occupied by any gas (e.g., methane).

The total and liquid porosity measurements in the uppermost Silurian Salina F through A2 Units range from 5 to 30%, often exceeding 10%. The highest measurements of liquid porosity occur in the Salina C Unit dolomitic shale and a shaly dolostone sample found in the Salina A2 Unit with values of 14 to 30%. The mean liquid porosities reported for the Devonian and Silurian Units and Formations range from 0.7% for the Salina A1 Unit Evaporite to 20.5% for the Salina C Unit dolostone. Silurian argillaceous dolostone and shale sequences as represented by the Salina G and F Units and Cabot Head Formation show liquid porosities of 17, 13 and 12%, respectively. Other Silurian dolostone sequences including the Bass Islands, Goat Island and Manitoulin Formations, and Salina A1 Unit, show variable liquid porosity ranging from 1.9 to 7.7%. For many of the core samples collected from the Salina Formation where gypsum ($CaSO_4 \cdot 2H_2O$) may be present as secondary mineralogy (e.g., G Unit to A2 Unit Carbonate), the liquid porosities are likely overestimations attributed to release of the hydration water during heating.

The total and liquid porosity profiles display a very pronounced reduction in porosity in the Lower Silurian formations and immediately above the Ordovician shales. This reduction in porosity is generally to below 5% and is consistent with the porosity values observed in the Ordovician limestones and also the limestone/siltstone "hard beds" found in the Ordovician shales.

The total and liquid porosities for the Ordovician shale formations are clustered by two groupings and that the liquid porosities are slightly larger than the total porosities. The two groupings of porosity data reflect the different mineralogy of samples tested within the Ordovician shale formations. The more massive shale samples show formation mean total porosity of 7.1 to 7.5% and liquid porosity of 7.8 to 8.5%. The lower porosity data (mean formation total porosity 1.1 to 2.9%, mean formation liquid porosity 1.1 to 3.2%) are for "hard beds" within these shale formations that are primarily limestone and/or siltstone.

The total and liquid porosity data for the Ordovician limestones are very similar with overall mean values of 1.8 and 1.7%, although some high values (6 to 15%) at the base of the Ordovician limestones (i.e., bottom of Gull River Formation) were also reported. Porosity data for the Shadow Lake and Cambrian sandstone are similar for total porosity (mean 9.5%) and liquid porosity (mean 8.1%).

Diffusion

The D_e measurements were conducted with sodium iodide and tritiated water (HTO) tracers, using radiography and through-diffusion methods. The details of each method are provided in the associated technical reports: Laboratory Diffusion Testing of DGR-2 Core, and Laboratory Diffusion Testing of DGR-3 and DGR-4 Core [154]. The through-diffusion technique is well established and data acquired with this method have been published by numerous authors [155;156]. The radiography technique was pioneered by Tidwell et al [157]; the radiography technique was modified for application to samples from the DGR Project and was benchmarked against results from the through-diffusion method [154].

With the exception of just a few samples from the Upper Silurian, the D_e values measured from DGR drill cores are all less than 1×10^{-12} m²/s. The highest values occur in the Upper Silurian Salina B, C, E and F units, with values greater than 1×10^{-11} m²/s in the silty shale of the Salina B. The lowest D_e values, on the order of 3×10^{-14} to 5×10^{-14} m²/s, are obtained in the gypsum-anhydrite layers of the Salina A0-A2 units, in the carbonate "hardbeds" within the Georgian Bay Formation, and in several limestone samples from the Gull River Formation. These extremely low values may be the lowest measured for sedimentary rocks anywhere. The majority of the D_e values are in the range 1×10^{-13} to 1×10^{-11} m²/s, with Lower Silurian and Upper Ordovician shale samples representing the higher end of this range because of their relatively high porosity (~10%). Fifteen diffusion measurements have been made on samples of the Lower Member of the Cobourg Formation, which is the proposed DGR host rock; the results indicate consistently low D_e values of 1×10^{-13} to 1×10^{-12} m²/s.

The D_e data display systematic variability as a function of the tracer used to make the measurements, and D_e values obtained with HTO tracer are on average 1.9 times greater (range of 0.8 to 4.9) than D_e values obtained with iodide tracer.

Fluid Density

Groundwater and porewater chemistry data and field and laboratory fluid density measurements were used to generate a profile of formation fluid density for the Paleozoic bedrock column at the Bruce nuclear site [158]. A reference density profile is required to calculate environmental water heads from fresh water heads in variable density fluid systems as exist at the Bruce nuclear site.

The density profile transitions from fresh water (ρ=990 to 1,000 kg/m³) in the upper dolostone units (Lucas, Amherstburg, Bois Blanc and Bass Islands Formations) though brackish water (ρ=1,010 kg/m³) in the Salina F Unit to brine (ρ=1,070 kg/m³) in Salina Formation B Unit. From the Salina B Unit down to the upper A1 Unit aquifer the water density decreases to the saline water that characterizes the upper A1 Unit aquifer (ρ=1,018 kg/m³). There is then a significant increase in water density from the upper A1 Unit aquifer to the brine found within the Guelph Formation (ρ=1,234 kg/m³), which is the highest TDS and fluid density measured at the DGR Project site. From the Guelph Formation downward the water density decreases to 1,180 kg/m³ in the Goat Island and Manitoulin Formations. Through the Ordovician shales the fluid density decreases from 1,180 kg/m³ in the upper Queenston Formation to 1,160 kg/m³ at the bottom of the Collingwood Member. Further reductions in porewater density occur down through the Ordovician limestones to the top of the Gull River Formation with fluid density of 1,105 kg/m³.

Fluid density then increases through the Gull River and Shadow Lake Formations to an average groundwater density of 1,156 kg/m³ within the Cambrian sandstone.

6.2.7.5 Hydrogeological Modelling Summary

The hydrogeologic characteristics of the Bruce nuclear site and surrounding region were explored through the development of a 3-dimensional numerical model of groundwater and solute migration within the Paleozoic sedimentary sequence [107]. This 3-dimensional model provided a structured framework on which to integrate regional and site-specific information governing hydrostratigraphy, hydrogeochemistry and boundary conditions.

The performance measure used in the analysis of the regional scale groundwater model is Mean Life Expectancy (MLE). This is an estimate of the time required for a water particle at a specific position in a groundwater system to reach a potential outflow point, considering both advective and dispersive transport processes. The results of the analyses provide a reasoned basis to understand the evolution of the regional and site-specific groundwater systems as they relate to implementation of the DGR concept at the Bruce nuclear site. Results from the simulations include the following:

- Base case and sensitivity simulations indicated that diffusion was the dominant transport mechanism in the Ordovician rocks. MLEs from the repository horizon to the surface were typically greater than several millions of years.
- Base case and sensitivity analyses demonstrate the effectiveness of near-horizontally layered Silurian and Ordovician aquitards/aquicludes to maintain a stable hydrogeologic setting at the proposed DGR horizon.
- Simulation of anomalous vertical hydraulic head distributions within the Ordovician and Cambrian rocks indicate that groundwater movement is converging on the Ordovician formations. Depending on the assumed hydraulic conductivity anisotropy (i.e., 10:1 to 1,000:1) re-equilibration of these heads to present day boundary conditions may require 1 million years (Ma) or longer.
- The origin of the anomalously low hydraulic heads observed in the Ordovician rocks is unlikely to be attributed to glacial events as a consequence of the predicted loading-unloading cycle.
- Extensive low permeability strata overlying the Cambrian Formation are required for the maintenance of the observed hydraulic over-pressures. Analyses indicate that to preserve the hydraulic over-pressure for 1 Ma vertical hydraulic conductivities of 1×10^{-14} m or less are required.

6.2.8 Hydrogeochemistry

This section summarizes key findings of the hydrogeochemical investigation described in the Geology TSD and Geosynthesis [87]. Conclusions are as follows:

- The current understanding regarding the origin of brines from the Michigan Basin indicates that they were formed by evaporation of sea water and subsequently modified by dilution, halite dissolution, and water-rock interaction processes. The regional data

(Cl-Br, $\delta^{18}O$-$\delta^{2}H$) and the data from the Bruce nuclear site are very similar, indicating that the brines at both the regional scale and the site scale are of similar origin and evolution.

- The widespread occurrence of ancient brines in the basin demonstrates that, under most conditions prevalent since the Paleozoic, it has not been possible for hydraulic heads generated in freshwater aquifers to drive infiltration events capable of displacing the brines. Glacial melt water infiltration has been identified to maximum depths of 200 to 300 mBGS along the northern margins of the Michigan Basin. Consistent with regional observations, glacial melt water infiltration is identified to a maximum depth of 328.5 mBGS at the Bruce nuclear site within the permeable Salina A1 Unit carbonate aquifer.
- At the Bruce nuclear site, concentrated brines occur at all depths below the top of the Silurian Guelph Formation.
- $\delta^{18}O$ enrichment with respect to the GMWL in the majority of the Ordovician porewaters suggests long periods of water rock interaction (i.e., long residence times in the sedimentary system).
- Separation between biogenic CH_4 in the Upper Ordovician shales and thermogenic CH_4 in the Middle Ordovician carbonates, as well as the separation between He with different $^{3}He/^{4}He$ ratios in the Upper Ordovician shales and the Middle Ordovician carbonates, suggests that diffusion is extremely slow and that there is a barrier to vertical solute migration within the Cobourg Formation.
- Radiogenic $^{87}Sr/^{86}Sr$ ratios in the Middle and Upper Ordovician porewater are interpreted to result from a combination of water-rock interaction, in situ ^{87}Rb decay, and diffusion of ^{87}Sr upward from an enriched end member in the shield. All of these mechanisms indicate a very long residence time, on the order of tens to hundreds of millions of years.
- The redox conditions in the Ordovician and Cambrian formations are strongly reducing, in the range of iron- and/or sulphate reduction and methanogenesis.
- Illustrative modelling suggests that the time frames required for the development of the salinity and $\delta^{18}O$ profiles within the Ordovician sediments are on the order of 300 Ma; the results are consistent with the assertion that solute transport in the Ordovician is diffusion dominated. .

6.2.9 Geomechanics

The purpose of this section is to present an understanding of the properties of the deep sedimentary formations at and surrounding the Bruce nuclear site. This includes establishing the existing geomechanical knowledge as it relates to site material strength properties, ground stress distribution, and seismicity. Site specific data available from site characterization work, when combined with regional data, provide quantitative "best estimates" of the physical properties that will control the geomechanical behaviour of the rock mass beneath the Bruce nuclear site during and after the construction of the DGR.

6.2.9.1 Geomechanical Properties: Rock Strength and Deformation

A good understanding of the geomechanical properties of rock is necessary to allow the prediction of the current and long-term behaviour of the proposed facility. The geoscientific site-characterisation work included an investigation of the geomechanical properties of the Paleozoic sedimentary formations at the Bruce nuclear site [88]. The aim of the site-characterization multi-phase geomechanical testing of samples from DGR-1 through DGR-6 was to provide a comprehensive suite of site specific geomechanical data of the rock material. A detailed summary of the types of testing and results are presented in the Descriptive Geosphere Site Model (DGSM) [88] and the Geosynthesis [87]. Figure 6.2.9-1 shows the distributions of general geomechanical properties of all rock units with depth. In addition to the peak intact rock strength obtained from uniaxial compressive test, Figure 6.2.9-1 also presents elastic modulus and Poisson's ratio. Results from other geomechanical tests, including triaxial compression, cross anisotropic, free and semi-confined swelling, and long-term strength degradation tests, are documented in the DGSM report [88].

The following sections are mainly focused on the DGR host rock — the Cobourg Formation of middle Ordovician age (Trenton Group) — and the caprock (Queenston and Georgian Bay formations) of upper Ordovician age. Only brief descriptions of the overlying rocks are included.

The UCS results from DGR-2 through DGR-6 show a consistent distribution and range within the formation when they are plotted versus depth (Figure 6.2.9-1). The variation in strength noted in the UCS test results is a result of the variation in material properties within the formation, induced damage while drilling — as a result of sampling (unloading) from great depth, and local platen interference and/or other boundary effects during laboratory testing.

The discontinuity data from the DGR series of deep boreholes also provides an opportunity to further characterize the rock mass. Competent rock formations, illustrated by their high RQD values and low fracture frequencies, were encountered in formations below 200 m in boreholes DGR-1 through DGR-6 (Figure 6.2.9-2). The upper 200 m of rock consists mostly of dolostones, which contain highly fractured and permeable zones with highly variable RQD values. Based on RQD, the Cobourg Formation is classified as an excellent quality rock, has a very low fracture frequency and few inclined to vertical joints (none were encountered in the DGR series of boreholes). Rock joint orientation measurements and spacing were obtained from the two inclined boreholes (DGR-5 and DGR-6) in Silurian and Ordovician rocks. Fractures at depth are tight and usually cemented with gypsum, anhydrite and/or calcite.

In Situ Stresses

Magnitude

The regional in situ stress data in Paleozoic rock from over 20 sites in the Great Lakes region indicates the presence of relatively high horizontal compressive stresses and is characterized as that of a thrust fault regime ($\sigma_v < \sigma_h < \sigma_H$).

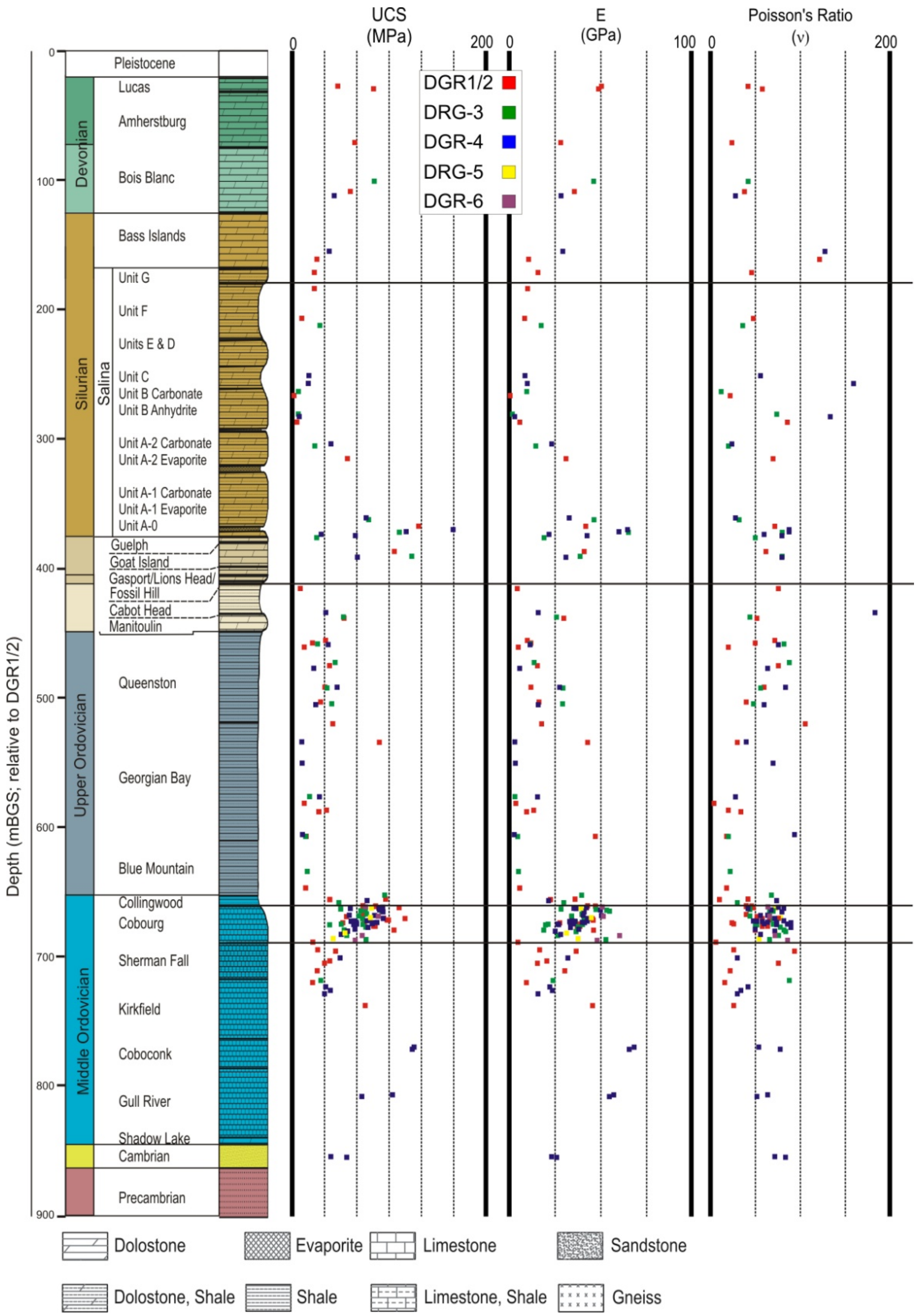


Figure 6.2.9-1: Stratigraphic Column showing Uniaxial Compression Test Results at the Bruce Nuclear Site for Boreholes DGR-1 to DGR-6

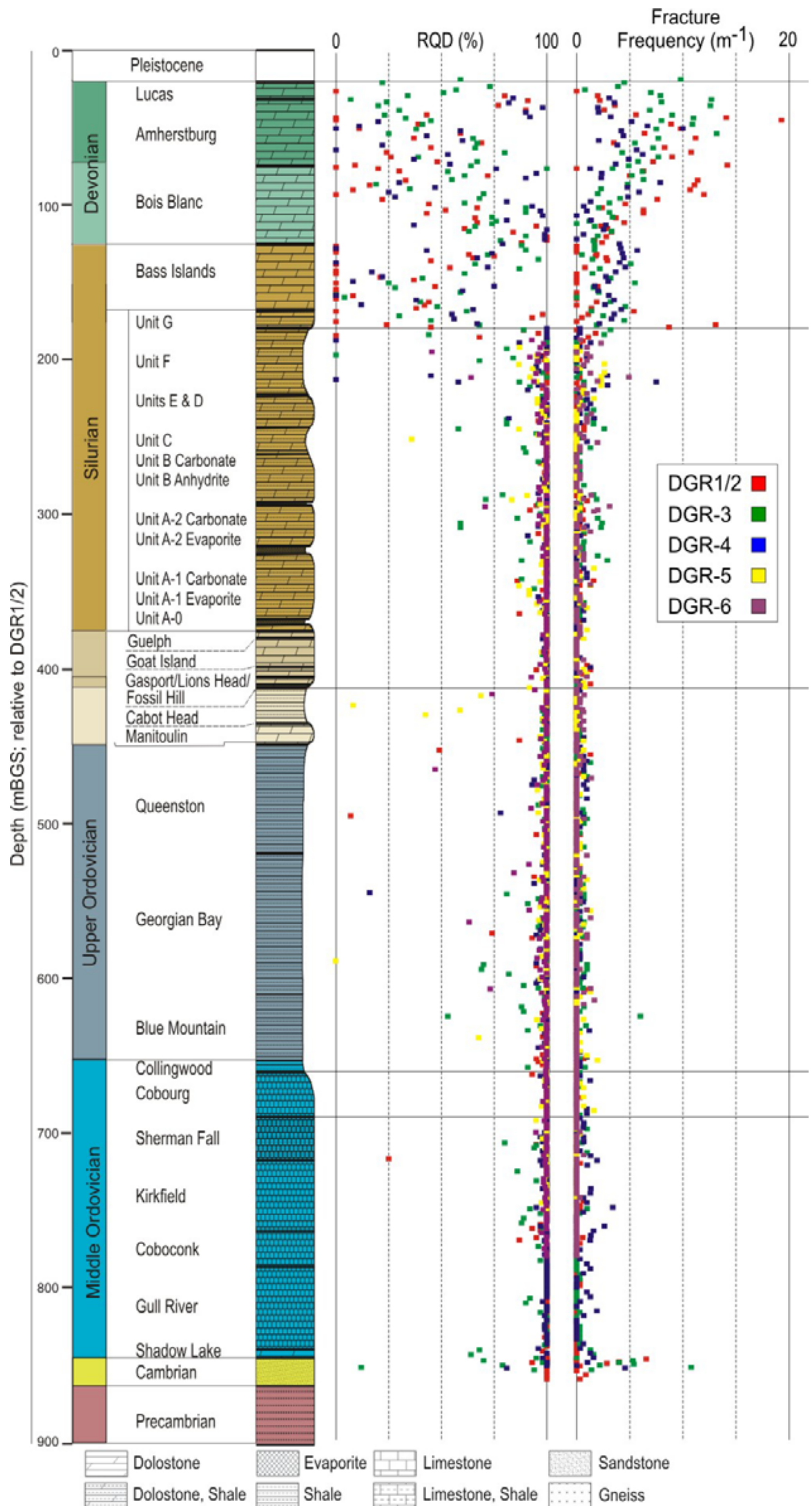


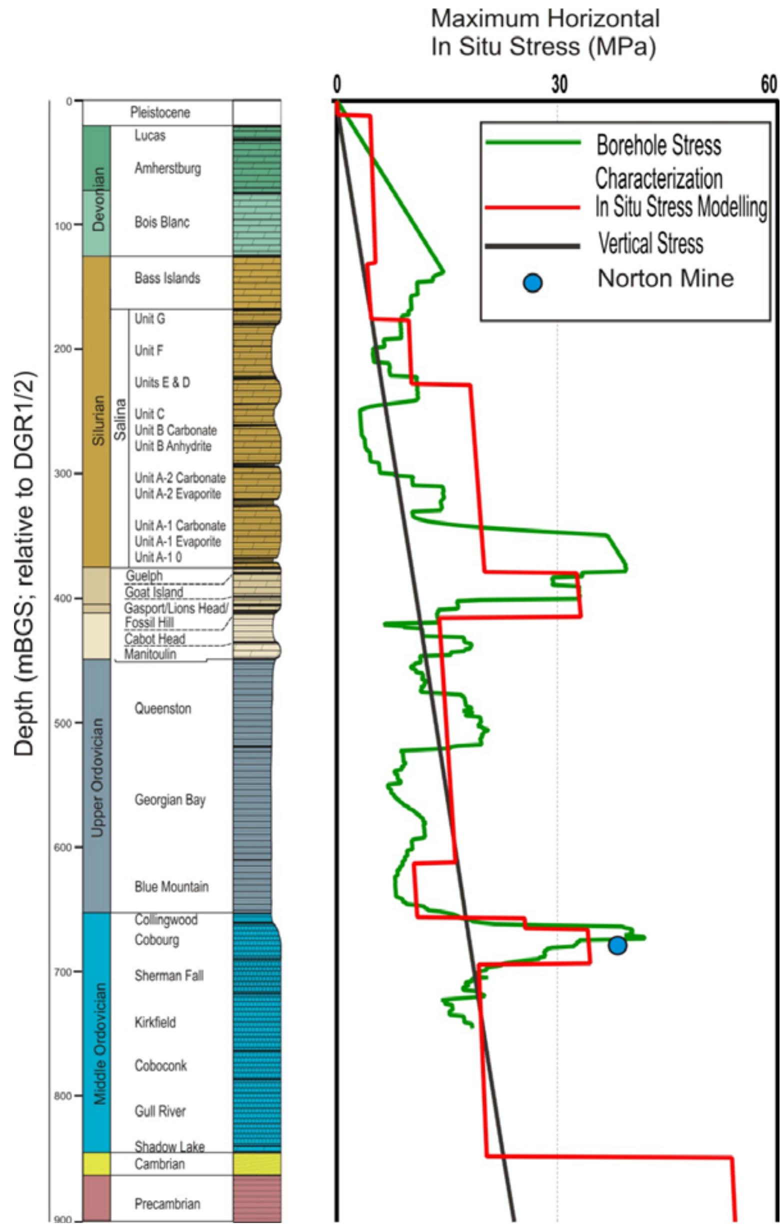
Figure 6.2.9-2: Stratigraphic Column Showing RQDs and Fracture Frequency from DGR-1 and DGR-6 at the Bruce Nuclear Site

There are great challenges in obtaining, with confidence, the in situ stress magnitude and orientations at the depths of interest from a surface-based exploratory borehole. This is particularly true in horizontally bedded formations where the vertical stress is less than the horizontal stresses, as hydrofracture techniques cannot be used with confidence in this situation [159]. While traditional strain-relief methods (e.g., overcoring) are suitable for relatively shallow measurements, such testing from within an exploration borehole at the approximately 680 m depth of the DGR has not been successfully demonstrated. Consequently, no measurements of the in situ stresses at the depth of the proposed repository at the Bruce nuclear site were undertaken during the site characterization investigations. Borehole core and televiewer data from DGR-1 to DGR-4 were analyzed to determine the physical response of these deep boreholes to the surrounding stress field. The objective of such review was to back-calculate the in situ stress magnitudes at the site scale that were consistent with the measured stability of the borehole wall. Valley and Maloney [160] assessed the possible range of the maximum in situ stress magnitudes that could exist without inducing failure of the borehole wall. Assessing the lack of borehole-wall failure must assume a strength value for the borehole wall strength. Strength and stiffness profiles were created by averaging UCS strength and elasticity modulus over a 30 m moving window along the borehole. Assuming a 100% of UCS threshold rock strength with the characteristic of no failure observation along borehole walls, the maximum allowable horizontal stress could be estimated for each section of the borehole and the results are summarized in Figure 6.2.9-3. The 100% UCS threshold, which represents no failure, is shown on the figure by a green line.

During the site-scale investigations, replacement of the Westbay casings in DGR-2 and DGR-3 provided two opportunities to re-inspect their borehole walls. ATV inspection detected no evidence of borehole breakouts or drilling-induced tension fractures over an 18-month period for DGR-2 and a 6-month period for DGR-3. This supplements previous observations that found no evidence of drilling-induced tension fracturing or borehole breakouts in these holes.

A model of the DGR stratigraphy was constructed using *FLAC3D* to further evaluate the vertical distribution of in situ stress within the sedimentary succession in the subsurface below the Bruce nuclear site. The model simulates the stiffness variability of individual rock formations oriented in the direction of the maximum horizontal principal stress. The model was strained horizontally in both directions to simulate tectonic strains observed at the Norton mine, in Ohio, which has a similar depth horizon and stratigraphy. The results indicate that stiffness contrasts in adjacent rock units plays a significant role governing formation specific in situ stress distributions. A comparison of the estimated maximum horizontal in situ stress from the modelling and the constraints deduced from the analysis based on lack of borehole breakout observation using 100% UCS as borehole wall strength (Figure 6.2.9-3).

At the repository horizon (about 680 mBGS) with σ_v assumed equal to the approximate gravity load of superincumbent materials, σ_H/σ_v is estimated to range from 1.5 to 2.0 and σ_H/σ_h from 1 to 1.2 [88].



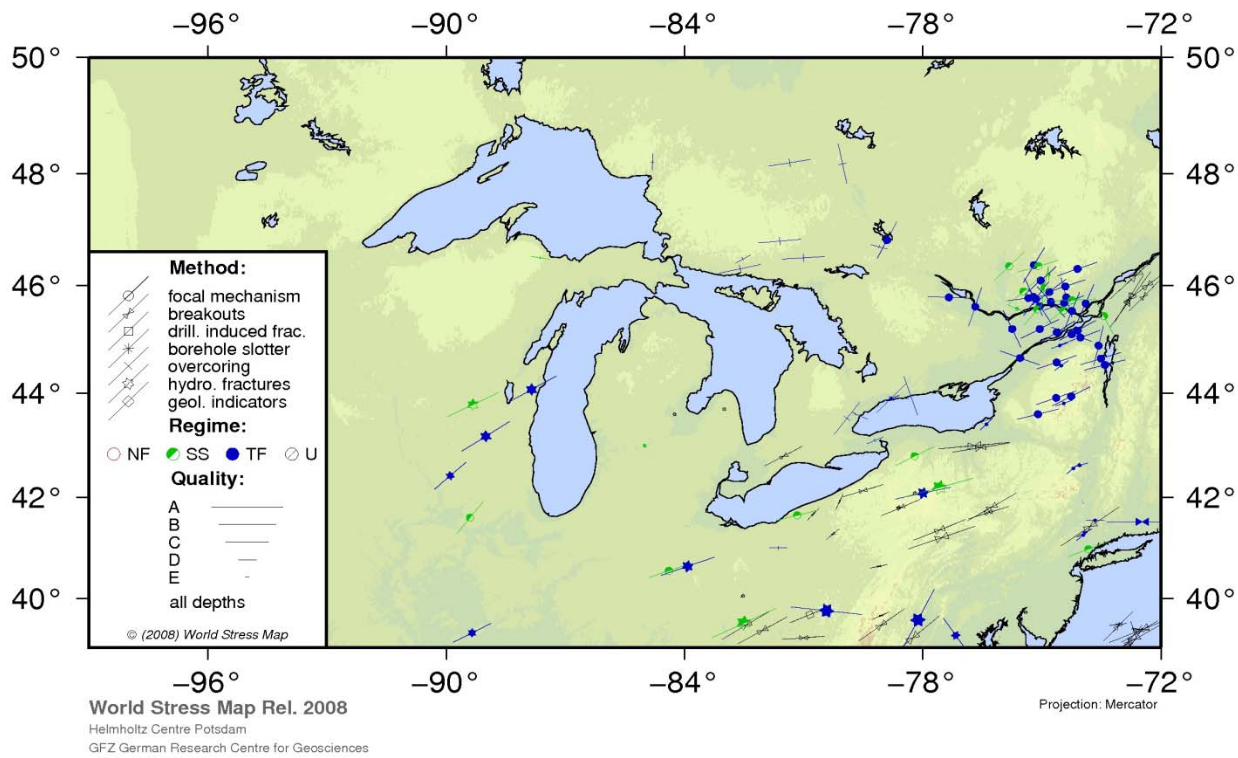
Note:
Numerical modelling results (red line) plotted against vertical stress profile (black line) and the absence of borehole failure constraint based on borehole wall strength of 100% UCS (green line). Figure is based on data from Itasca [161] and Valley and Maloney [160].

Figure 6.2.9-3: Comparison of Calculated Maximum Horizontal In Situ Stress Profiles

Orientation

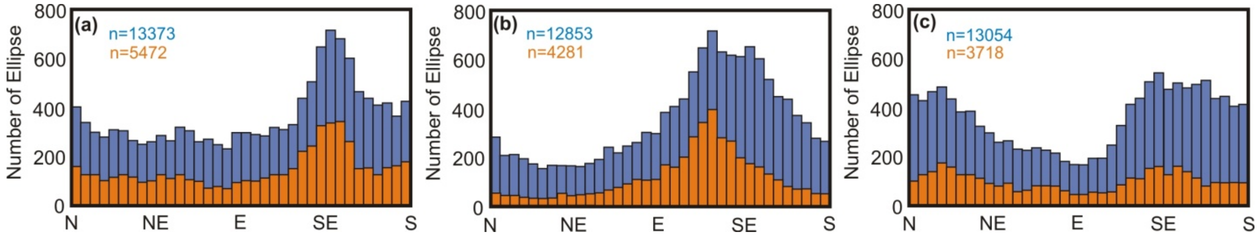
The principal sources for estimating regional in situ stress orientations are the database compiled for the World Stress Map project (Figure 6.2.9-4) [162] and the regional in situ stress database as described in the Regional Geomechanics report [163]. In brief, the regional principal horizontal in situ stress is consistently oriented in a north-easterly to east-northeasterly direction throughout north-eastern North America, including southwestern Ontario and the Bruce nuclear site in particular. This data is reliably constrained by numerous surface and borehole measurements including shallow (<100 m) over-coring measurements and deep (up to about 5 km) hydrofracturing measurements [163].

Acoustic televiewer (ATV) logs from DGR-1 to DGR-4 utilized ellipticity detection analyses to fit ellipses on borehole sections measured from the acoustic travel time logs over 10 cm intervals. From the analysis, the lengths of the ellipse's long and short axes, as well as their orientations, were determined. The results reveal the length difference between the ellipse axes is typically less than 0.5%. The orientations of the long axis of the ellipses are erratic for most of the borehole length in DGR-1, DGR-2 and DGR-4, except in the (Lower) Cobourg, Sherman Fall and Kirkfield formations (660 to 760 mBGS) where the orientations are systematic in a SE (138º in DGR-1 and DGR-2, and 131o in DGR-4) direction. The same systematic southeast (141°) borehole elongation in the Ordovician limestones was observed in borehole DGR-3. Figure 6.2.9-5 shows the histograms of the orientation of the ellipse long axis for all boreholes. It appears that the systematic southeast borehole elongation could possibility be stress related (i.e., the direction of the maximum horizontal stress is northeast). This orientation is consistent with the regional trend.



Note: NF = normal-fault regime, SS = strike-slip regime, TF = thrust fault regime, and U= regime unknown
Source: [162]

Figure 6.2.9-4: Stress Map of Greater Study Area



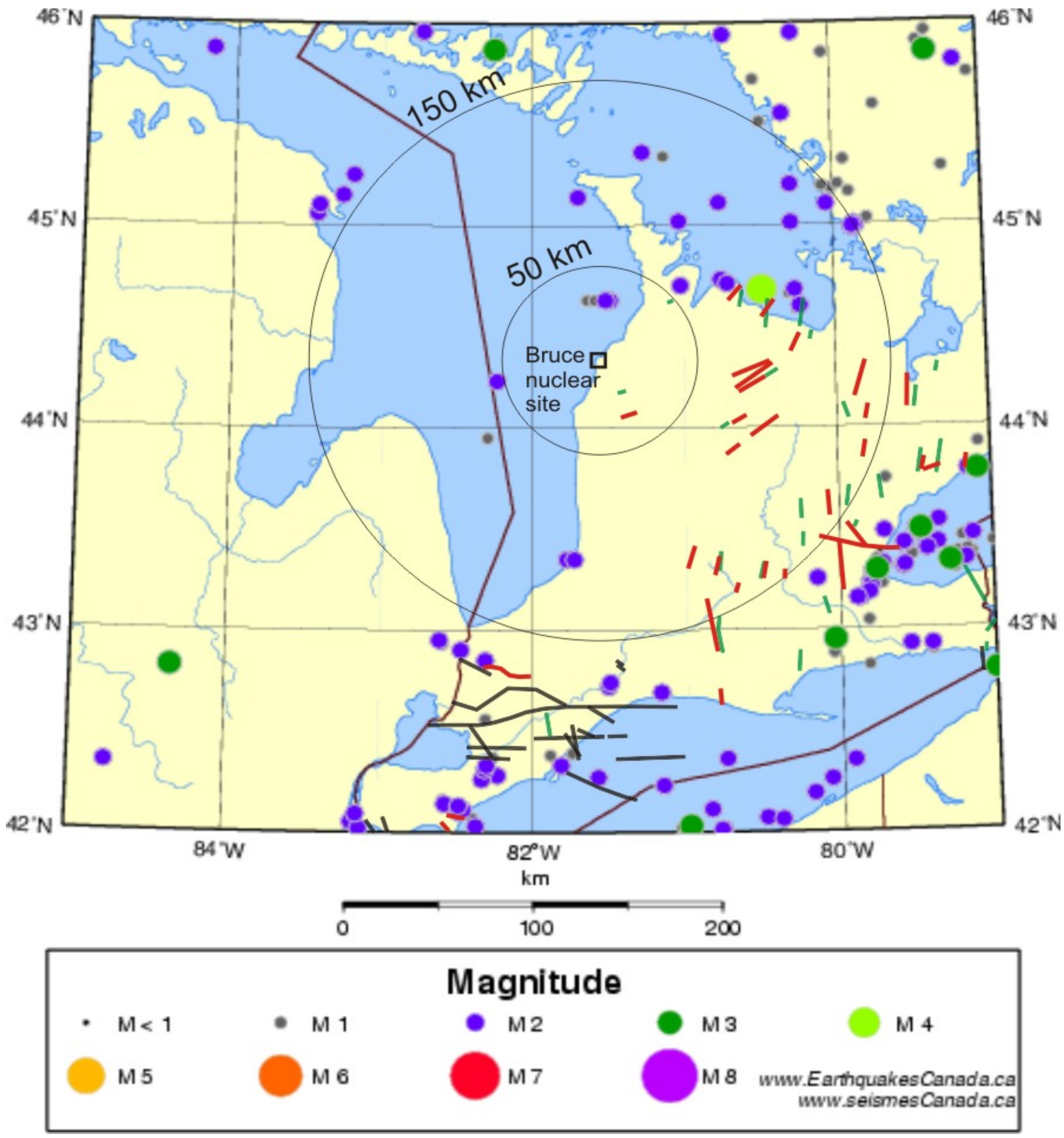
Note: (a) DGR-1 and DGR-2, (b) DGR-3, and (c) DGR-4. Peak values are interpreted to indicate the orientation of the minimum horizontal in situ stress for all orientations (blue) and for axis ratios greater than 1.0025 (orange).

Figure 6.2.9-5: DGR Borehole Long Axis Orientation Histograms for Middle Ordovician Formations

6.2.10 Regional Seismicity

Southwestern Ontario and the Bruce region lie within the tectonically stable interior of the North American continent. This stable interior region of North America is characterized by low rates of seismicity. Figure 6.2.10-1 shows all known earthquakes in the region up to December 2010 [164] based on historical records since the late 1800s and the monitoring results from the seismograph stations around the Bruce nuclear site. Most recorded events have a magnitude of less than M3, with rare occurrences of larger events within a 150 km radius from the Bruce nuclear site. The local magnitude scale is the Nutti magnitude (mN), which is an extension of the Richter Scale, and is the magnitude scale used for reporting of seismic activity in regions of North America to the east of the Rocky Mountains. Twenty-six events have been detected in this region since 1952 with a maximum magnitude of 4.2 measured 15 km north of Meaford near Owen Sound. The historical record is considered to be relatively complete for events of about M > 3.5. It has become more complete for lower magnitude events over the last 10 years owing to the increased station density in the region.

To improve the detection of the local pattern of low-level seismicity, three highly sensitive borehole seismometer stations were installed within an approximate 40 km radius of the Bruce nuclear site during the summer of 2007. The threshold for detection was further lowered to M1.0. The objectives of this new array are to capture microseismic events in the immediate area and to determine if they delineate seismogenic features deep in the bedrock. The data collected since the station installation suggests that, in general, the Regional Study Area experiences sparse seismic activity and there are no major seismogenic features or active faults of concern. This is confirmed by a recently completed remote-sensing and field-based study [165] that looked at landforms and sediments within 50 km of the Bruce nuclear site and found no evidence for neotectonic activity associated with the most recent glacial cycle within the Regional Study Area.



Note: All events plotted in local magnitude (M=mN)
Source: [166]

Figure 6.2.10-1: Seismicity in the Bruce Region from 1985 to 2010 Overlain with Mapped Faults in Southern Ontario

6.3 HYDROLOGY AND SURFACE WATER QUALITY

The existing hydrology and surface water quality within the study areas is described in terms of the following components:

- **Hydrology**, which includes flow direction and velocity of surface waters in Lake Huron and the on-site drainage patterns; and
- **Surface Water Quality**, which includes conventional (non-radioactive) chemical characteristics of surface water in the study areas.

For additional information, please refer to the Hydrology and Surface Water Quality TSD.

6.3.1 Spatial Boundaries

The study areas presented in Section 5.1 were modified to encompass likely effects on the hydrology and surface water quality as follows:

- The **Regional Study Area**, shown on Figure 6.3.1-1, includes the lands bound by regional watersheds, extends 4 km offshore. The northern and southern limits have been selected to include municipal Water Supply Plant intakes at Southampton and Kincardine. Consistent with the EIS Guidelines, this is the area within which there is the potential for cumulative or wider-spread effects.
- The **Local Study Area**, shown on Figure 6.3.1-2, corresponds to the Stream C and Underwood Creek watersheds for the on-land (non-lake) portion. The Local Study Area also extends approximately 2 km offshore of the Bruce nuclear site into Lake Huron, from MacGregor Point Provincial Park in the north to McRae Point in the south. Consistent with the EIS Guidelines, this is the area outside of the Site Study Area with a reasonable potential for direct hydrology and surface water quality effects.
- The **Site Study Area and Project Area**, shown on Figure 5.1.3-1, were used without modification. The Project Area specifically includes the WWMF because of its proximity to the DGR Project site and shared drainage pathways. For convenience, the Project Area and Site Study Area are discussed together.

6.3.2 Valued Ecosystem Components

Table 6.3.2-1 presents the VECs for hydrology and surface water quality along with the rationale for their selection and the specific indicators used in the assessment. These VECs are consistent with those identified in the guidelines (see Appendix A.1).

Table 6.3.2-1: VECs Selected for Hydrology and Surface Water Quality

VEC	Rationale for Selection	Indicators	Measures
Surface Water Quantity and Flow	• Maintaining natural flows in local streams during specific times is critical to various life stages of sensitive species	• Seasonal stream flow	• Changes in seasonal stream flow

Table 6.3.2-1: VECs Selected for Hydrology and Surface Water Quality (continued)

VEC	Rationale for Selection	Indicators	Measures
Surface Water Quality	• Aquatic species, recreational use and aesthetics are sensitive to water quality	• Total suspended solids • Nutrients • Metals • Temperature • Salinity • pH	• Concentrations of indicator compounds • Changes in temperature

6.3.3 Overview of Key Features

This section provides a brief overview of the key surface water features that are associated with this assessment. The intent of this section is to provide the reader with an introduction to the key features and how they relate to each other. Detailed descriptions of these key features are provided in the following sections. Key features are shown on Figure 6.3.3-1.

The Bruce nuclear site is primarily drained by a network of constructed ditches and drains that have been divided into several drainage areas (Section 6.3.4.3). The DGR Project site is mostly located within the MacPherson Bay South Drainage Area and drains into MacPherson Bay (Section 6.3.4.2) via an un-named ditch (Section 6.3.4.3).

A small portion of the DGR Project site currently drains to the east via the North Railway Ditch (Section 6.3.4.3). The North and South Railway Ditches flow adjacent to an abandoned rail bed toward Stream C (Section 6.3.4.4). Stream C is a diverted tributary of the Little Sauble River that passes through the eastern portion of the Bruce nuclear site. Stream C provides drainage for the Stream C Drainage Area and ultimately drains into Baie du Doré located to the northeast of the Bruce nuclear site.

Both MacPherson Bay and Baie du Doré are shallow embayments of Lake Huron (Section 6.3.4.1).

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LEGEND

- Municipal Water Supply
- Site Study Area [1]
- Local Study Area
- Regional Study Area

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

REGIONAL STUDY AREA FOR HYDROLOGY AND SURFACE WATER QUALITY

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct 2007	**FIGURE 6.3.1-1**	
GIS	ASB	14 Apr. 2010		
CHECK	AB	14 Apr. 2010		
REVIEW	MAR	14 Apr. 2010		

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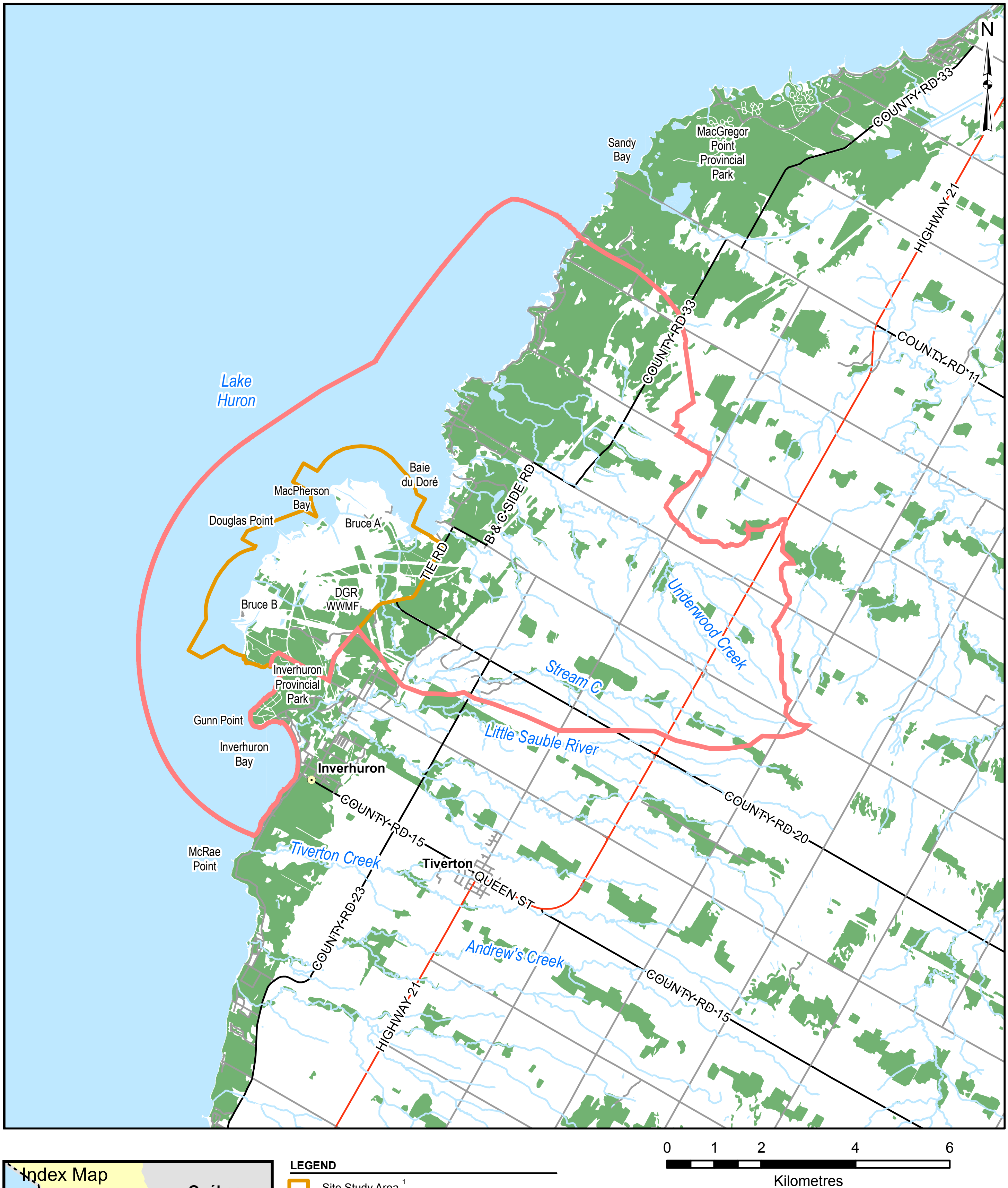

LEGEND

- Site Study Area [1]
- Local Study Area

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

LOCAL STUDY AREA FOR HYDROLOGY AND SURFACE WATER QUALITY

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct 2007	**FIGURE 6.3.1-2**	
GIS	BC	10 Apr. 2010		
CHECK	AB	10 Apr. 2010		
REVIEW	MAR	10 Apr. 2010		

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Figure 6.3.3-1: Key Features of the Bruce Nuclear Site

6.3.4 Hydrology

6.3.4.1 Lake Huron

In general, water depths in the nearshore zone of the lake range from 6 to 20 m, except in Baie du Doré where depths do not exceed 5 m. Bedrock substrate predominates in the shallow areas of the open shoreline, grading to a mixture of pebble, cobble and boulder at the 7 to 12 m depths. Extensive marsh areas are located along the shore of Baie du Doré.

Nearshore currents in Lake Huron have been measured during the ice-free period since the early 1970's. Current direction in the Regional Study Area is predominantly parallel to the shoreline with a northeastern direction being the most common. Currents to the southwest also occur but on a less frequent basis [167].

Although there are extensive networks of small rivers and creeks feeding into Lake Huron in the Local Study Area (Figure 6.3.1-1), there are no major rivers near the Site Study Area. The nearest river is the Little Sauble, a small river shown on Figure 6.3.1-2. There are two small east to west drainage courses entering the lake adjacent to the Bruce nuclear site; Underwood

Creek empties into the Baie du Doré to the north and the Little Sauble River, which forms the southern boundary of Inverhuron Provincial Park, empties into Inverhuron Bay to the south. In addition, a small stream (i.e., Stream C), enters the Baie du Doré through the Bruce nuclear site. The local drainage areas are shown on Figure 6.3.4-1.

To the west and northwest, Lake Huron stretches uninterrupted for approximately 128 km. The nearest land across the lake is Port Hope, Michigan, USA, approximately 98 km southwest of the Bruce nuclear site.

6.3.4.2 MacPherson Bay

MacPherson Bay is a small bay of Lake Huron located immediately south of the Bruce A nuclear generating station and is bounded by MacPherson Point to the north and Douglas Point to the south. MacPherson Bay is approximately 1,000 m wide where it meets the main body of Lake Huron and is approximately 600 m long. MacPherson Bay is generally shallow with depths less than 1 m. The maximum depth is approximately 3 m at the outer edges of the bay [168]. The bottom is characterized as either sand, cobble or bedrock [169].

MacPherson Bay receives direct runoff from the Bruce nuclear site, specifically from the MacPherson Bay North and South Drainage Areas shown on Figure 6.3.4-2. Runoff from the proposed DGR Project is expected to be discharged into MacPherson Bay via the un-named drainage ditch described in Section 6.3.4.3.

6.3.4.3 Surface Runoff and Drainage

Large portions of the inland Regional Study area east of the Bruce nuclear site are within the Saugeen River Watershed, which drains into Lake Huron at Southampton. Most of the land is developed for livestock and cash crop farming. Areas not developed for agriculture are generally either forested or consist of small rural communities. Surface water runoff in the Local Study Area generally drains directly to Lake Huron via small local watersheds.

The Bruce nuclear site is located within two small local watersheds (Stream C and MacPherson Bay, bounded by the Underwood Creek watershed to the north and the Little Sauble River watershed to the south as shown on Figure 6.3.4-2 (based on [170]). The Bruce nuclear site, including the OPG-retained areas, has an extensive drainage system consisting of catch basins, manholes, open ditches and culverts. All of the drainage is directed to Lake Huron via several outfalls and natural drainage features. Natural drainage enters the Bruce nuclear site via Stream C, a former tributary of the Little Sauble River that was diverted to Baie du Doré during the initial development of the Bruce nuclear site in the 1960s.

Historically, the Bruce nuclear site has been divided into 15 small catchment areas (A through O), representing individual stormwater management zones [171]. The relationship between the larger drainage areas shown on Figure 6.3.4-2 and the historic catchment areas is summarized in Table 6.3.4-1.

0 2.5 5 10 15

Kilometres

LEGEND

- Watershed Boundary
- Local Site Drainage
- Site Study Area [1]
- Local Study Area
- Regional Study Area

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

LOCAL DRAINAGE AREAS

Golder Associates
Mississauga, Ontario

PROJECT No. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct 2007	**FIGURE 6.3.4-1**	
GIS	BC	19 Apr. 2010		
CHECK	KC	19 Apr. 2010		
REVIEW	AB	19 Apr. 2010		

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0 0.25 0.5 1 1.5

Kilometres

LEGEND

- Little Sauble and Stream C Watershed Divide
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]
- Approximate Catchment Boundary
- Drainage Outfall
- Plant Discharge Channels

Drainage Area	Historic Catchment Area [170]
Bruce A	M, N, O
Bruce B	B, C, D
Bruce B North	E
Bruce B South	A
Douglas Point	H, G, F
Douglas Point North	I
MacPherson North	L, part of K
MacPherson South	J, part of K
Stream C	part of K

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007. Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

SITE DRAINAGE AREAS

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007		
GIS	BC	28 Apr. 2010		
CHECK	KC	28 Apr. 2010		
REVIEW	AB	28 Apr. 2010		

FIGURE 6.3.4-2

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Table 6.3.4-1: Relationship between Drainage Areas and Catchment Areas on the Bruce Nuclear Site

Drainage Area [a]	Historic Catchment Area [b]
Bruce A	M, N, O
Bruce B	B, C, D
Bruce B North	E
Bruce B South	A
Douglas Point	H, G, F
Douglas Point North	I
MacPherson North	L, part of K
MacPherson South	J, part of K
Stream C	part of K

Notes:
a Refer to Figure 6.3.4-2 for drainage areas
b Historic catchment areas are defined in [170]

A review of the Interim Stormwater Management Plan for Zone K [172] indicates that the DGR Project is located primarily within Catchment K, though a small portion of the DGR Project site along Interconnecting Road falls within Catchment J. Catchment K drains to Lake Huron via Catchment Areas J and L (south of MacPherson Point) and to Baie du Doré via the Railway Ditches and Stream C. As part of the field program, a site visit was conducted to verify the site drainage and identify any standing water. The existing drainage conditions shown on Figure 6.3.4-2 were updated to reflect minor differences identified during the site visit (e.g., some of the drainage ditches along Interconnecting Road at the north-eastern portion of Catchment K were found to drain in different directions than shown previously). These catchments consist largely of vacant land and electrical switchyards.

Catchment K is generally flat with an average slope of 0.006 m/m and is drained by a system of ditches along roadways and railways [167]. With the exception of the South Railway Ditch and Stream C, the drainage ditches in Catchment K are expected to be dry the majority of the time with flow occurring only during and following periods of significant rain or snowmelt. The proposed DGR Project location primarily consists of open grassed areas and light brush cover. Some construction debris exists; however, there are few impervious surfaces (i.e., paved areas) in Catchment K.

Catchments J and L are small, relatively flat drainage areas located between Interconnecting Road and Lake Huron just south of MacPherson Point. Drainage of these areas is through a series of catch basins, sewers and roadside ditches. These catchments include mostly vacant land and electrical switch yards. The southern section of Catchment J also drains part of the lands of the decommissioned heavy water plant.

The existing drainage areas and estimated flows in the portion of the Project Area where the surface buildings and infrastructure of the DGR will be located are summarized in Table 6.3.4-2.

Table 6.3.4-2: Drainage Areas and Flows in the DGR Surface Footprint

Drainage Area Location	Existing Drainage (ha)	Average Annual Flow (L/s)[a]	1:2 Year Peak Flow (L/s)[b]	1:100 Year Peak Flow (L/s)[b]
Stream C at point of discharge from Bruce nuclear site (North Access Road)	1,042.4	144.6	2,090	3,760
South Railway Ditch at Stream C	43.4	6.0	170	600
North Railway Ditch at Stream C	26.1	3.6	60	350
Drainage Ditch at Point of Discharge from DGR Project site (Interconnecting Road)	41.3	5.7	N/A	N/A

Notes:
a Based on mean annual precipitation Wiarton (1,041.3 mm) and assumed runoff coefficient of 0.42 for all the assessed drainage areas
b Reported in August 2000 'Interim Stormwater Management Plan – Zone K' [172]
N/A Not available

Un-named Drainage Ditch

Runoff from the proposed DGR Project site will be conveyed directly to MacPherson Bay via an existing un-named drainage ditch (Figure 6.3.3-1). Under the existing conditions, the ditch drains the portion of the MacPherson Bay South Drainage Area to the southeast of Interconnecting Road. Immediately upstream of Interconnecting Road the ditch is more appropriately described as a swale (a shallow sloped, grass lined ditch). The ditch is approximately 1.5 m deep near the road. Further upstream, the ditch is barely distinguishable from the surrounding flat terrain. Most of the ditch bottom is either grass lined or filled with cattails. The section immediately downstream of Interconnecting Road has been lined with cobbles, presumably to reduce erosion during large rainfall events.

The ditch conveys flow under Interconnecting Road via three culverts (each approximately 600 mm in diameter). These culverts are currently partially blocked with sediment and aquatic plants.

Downstream of Interconnecting Road, the ditch follows a straight path towards MacPherson Bay. For the most part, this section of the ditch is also a grassy swale with some cattail filled areas. The depth of the ditch gradually increases as it nears MacPherson Bay.

North and South Railway Ditches

Both the North and South Railway Ditches flow eastward towards Stream C adjacent to an abandoned rail bed. The North and South Railway Ditches were likely constructed during the initial development of the Bruce nuclear site in the 1960s.

The South Railway Ditch is straight with a channel width of approximately 5 m at the top of the bank throughout the reaches within the Project Area as shown on Figure 6.3.4-2. Historical investigations of the ditch documented a wetted channel width of 3 m and a mean water depth of 0.15 m [89]. The channel is choked with thick stands of cattail in some places, which serves to reduce water velocity. Flowing water was not observed during the September 11, 2009 water sampling event. There are also open channel sections that appear to have been subjected to clean-out/dredging in the past. The banks are covered with a mix of grasses, trees and shrubs.

The North Railway Ditch (see Figure 6.3.4-2) is similar in size to the South Railway Ditch and is also filled with thick stands of cattails. The North Railway Ditch is usually dry and only conveys water after large rainfall events.

6.3.4.4 Stream C

Stream C is located to the east, largely outside of the Project Area (see Figure 6.3.3-1). Stream C transects the southeast corner of the Project Area. As described in Section 6.3.3, it is a former tributary of the Little Sauble River that was diverted to Baie du Doré during the initial development of the Bruce nuclear site in the 1960s. It is the largest stream entering Baie du Doré.

Stream C enters the Bruce nuclear site via a culvert under Tie Road. The culvert is located approximately 300 m east of the main security gate. Downstream of Tie Road, Stream C flows north through a broad flood plain for approximately 700 m before passing under the abandoned rail bed via a large culvert. Stream C passes through a small pond immediately downstream of the culvert before meandering towards the confluence with the roadside ditch at the North Access Road. Stream C then flows north alongside the road for approximately 250 m before turning eastward under the North Access Road via a large culvert. Stream C then continues to the northeast for approximately 1,000 m before draining into the southeast portion of Baie du Doré.

A field reconnaissance was undertaken at a portion of Stream C on September 11, 2009, as part of the baseline characterization. The purpose of the reconnaissance was to characterize existing channel conditions and identify areas of potential concern regarding erosion and deposition (if any).

Upstream of Abandoned Rail Bed

The section of Stream C located immediately upstream (south) of the existing abandoned rail bed drains to the north and was generally characterized by a single to multiple thread channel with a marked meandering pattern and limited bed form morphology.

Secondary or "high flow" channels were observed in places, likely demonstrating historic flooding and strong connection between the stream and floodplain. A marsh/wetland feature was noted along the eastern side of the floodplain with an approximate area of 2 ha.

Depositional features (i.e., areas where sediments accumulate) were typically observed on the inside of meander bends; however, some instances of mid-channel or lobate sediment bars were noted. Minor bank erosion (mostly undercut) was noted on the outside and apex of several meanders.

Downstream of Abandoned Rail Bed to Confluence with Roadside Ditch

Stream C is directed beneath the abandoned rail bed via a corrugated steel pipe and then outlets to a small pond with an approximate area of 0.1 ha. From there, flows are directed north to a well defined channel that is generally characterized by relatively low sinuosity (or a negligible meandering pattern) and modest riffle-pool sequences or transitional runs. The floodplain was broad and well vegetated; predominated by grasses and shrubs with some forest cover, particularly along the right overbank area (i.e., east and south of the channel).

The stream flows to the north for approximately 225 m, and then abruptly turns, and drains to the east for roughly 300 m (flanked to the north by a utilities corridor) before it joins the roadside ditch where it is again directed to the north. The observed channel pattern suggests historic re-alignment (i.e., straightening), likely to accommodate previous/existing land uses.

Depositional features were typically observed along channel margins; however, more extensive sediment accumulation (mostly organics) was noted along a section of channel from approximately 125 and 175 m downstream (north) of the abandoned rail bed. In general, observed bank erosion (i.e., scour and/or undercut) was relatively minor and largely limited to the section of the stream oriented east-west. However, notable bank scour and possible bank slump was identified along the section of channel located immediately downstream of the small pond. The channel at this location was characterized by two sweeping meander bends over a distance of approximately 50 m. Bank erosion was observed on the outside of the respective meanders; vertically from toe to near top of bank and laterally for approximately 5 to 10 m.

Roadside Ditch

Stream C drains along the west side of the North Access Road for approximately 250 m via a roadside ditch that is approximately 3 to 4 m wide and trapezoidal in shape. The banks of the roadside channel were generally well vegetated with mostly grasses and herbs.

Stream C Downstream of North Access Road

At the end of the roadside channel, Stream C turns to the northeast and passes under the North Access Road via a large culvert. The banks of the channel immediately downstream of the road were generally well vegetated with mostly grasses and herbs. The bed form along this reach was relatively muted. Stream C ultimately drains to Lake Huron approximately 1 km downstream (i.e., to the north) of the road crossing.

6.3.5 Surface Water Quality

6.3.5.1 Lake Huron

The conventional chemical characteristics of Lake Huron are presented because it will ultimately be the receiving waterbody for any potential releases from the DGR Project.

Nearshore samples were collected in MacPherson Bay (SW6) in 2007 and 2009 as a part of the field studies associated with this EA. Water quality sampling results were generally within the appropriate range of water quality guidelines (Table 6.3.5-1). Previous water quality sampling results [173;174;175] were generally similar to those collected in MacPherson Bay (SW6) during the 2007 and 2009 surface water sampling program. When compared to the earlier results, the water quality in MacPherson Bay was similar to samples taken further offshore in terms of dissolved solids, pH, conductivity, suspended solids, hardness and un-ionized ammonia. However, higher concentrations of iron, calcium, sodium and potassium were observed in MacPherson Bay compared to the historic Lake Huron results. Two of the samples collected in 2007 at SW6 showed total iron concentrations higher than the previous studies, and were above the PWQO for iron (300 µg/L).

6.3.5.2 Water Quality in Surface Drainage Features in Site Study Area

The characterization of the existing water quality conditions in the Site Study Area was based on results of a number of existing studies [170], and additional surface water sampling completed in 2007 and 2009. Sampling locations are shown on Figure 6.3.5-1.

Water quality characteristics are discussed for five categories: total suspended solids (TSS), nutrients, temperature, metals and organic contaminants. The characteristics are discussed below, and include a summary of the sampling results for the 2007 and 2009 sampling. A complete list of sampling results is provided in Appendix E of the Hydrology and Surface Water Quality TSD. Lake Huron water quality is discussed separately in Section 6.3.5.1. Sediment quality is discussed in Section 6.3.5.3.

Where appropriate, results from the sampling programs are compared to the Provincial Water Quality Objective (PWQO) [176] and the Canadian Council of Ministers of the Environment (CCME) Guidelines [177]. In general, the PWQOs provided more stringent criteria than the CCME Guidelines and therefore most of the discussions below reference the PWQO criteria instead of the CCME Guidelines.

Total Suspended Solids

Total suspended solids (TSS) is a measure of the amount of particulate material present in a water sample. TSS concentrations vary widely with location and can increase significantly during and after rainfall events. Prolonged high TSS concentrations are generally considered to have a negative impact on aquatic biota.

TSS analysis was completed at sampling locations at the WWMF in 2004 as part of the WWMF Integrated EA Follow-up Program [178]. The seven sampling locations were within the South Railway Ditch with an additional three control stations (one at Goderich and two in the Little Sauble River). Samples were collected in June 2004. The analytical results for TSS concentrations in the Site Study Area samples ranged from <2 to 20 mg/L. TSS concentrations in the Goderich and Little Sauble River samples ranged from 5.5 to 284 mg/L.

Table 6.3.5-1: Summary of Lake Huron Water Quality Sampling Results

Parameter	Sampling Programs					Guidelines		
	U of T Study 1959/1960 [173] [d]	Ontario Hydro 1969/ 1970 [173] [d]	Ontario Hydro 1973-81 [174] [e]	2001 EA Study (Lake Huron Location) [175] [f]	2007 & 2009 Surface Water Sampling (SW6)	Provincial Water Quality Objectives [176]	Ontario Drinking Water Objectives [179]	Canadian Environmental Quality Guidelines [177]
Turbidity (NTU)	1.0-2.5	0.1-1.0	1.1	—	—	—	5	5
pH	7.5-8.45	7.9-8.4	8.1	8.1	7.4-8.2	6.5-8.5	6.5-8.5	6.5-8.5
Specific Cond. at 25^{o}C (micromhos/cm)	183-218	202-210	185	204	210-244	—	—	—
Chloride (mg/L)	4.9-6.0	5.0-8.0	—	7.7	—	—	250 [b]	<250
Sulphate (mg/L)	5.9-13.5	12-15	—	15.8	—	—	500 [b]	<500
Iron (mg/L)	0[g]-0.22	0.08	—	<0.03	<0.5–0.54[h]	0.3	—	<0.3
Calcium (mg/L)	26-29.6	25-28	26.2	27.1	26-93	—	—	—
Magnesium (mg/L)	6.7-8.4	6.9-9.0	7.0	7.25	7.7-24	—	—	—
Sodium (mg/L)	3.0-4.5	2.8-4.0	—	3.9	4.5-140	—	200 [b]	<200
Potassium (mg/L)	0.8-1.8	0.9-1.3	—	0.9	0.9-1.8	—	—	—
Dissolved Solids (mg/L)	112-134	116-131	121	90	121-160	—	500 [b]	<500
Suspended Solids (mg/L)	—	—	2.0	5	<10-35	—	—	—
Total Hardness (mg/L)	94-106	93-104	—	—	94-110	—	80-100 [c]	—

Table 6.3.5-1: Summary of Lake Huron Water Quality Sampling Results (continued)

Parameter	Sampling Programs					Guidelines		
	U of T Study 1959/1960 [173] [d]	Ontario Hydro 1969/ 1970 [173] [d]	Ontario Hydro 1973-81 [174] [e]	2001 EA Study (Lake Huron Location) [175] [f]	2007 & 2009 Surface Water Sampling (SW6)	Provincial Water Quality Objectives [176]	Ontario Drinking Water Objectives [179]	Canadian Environmental Quality Guidelines [177]
Oxygen Consumed (mg/L)	0.6-1.9	0.5-1.3	—	0.8	—	—	—	—
Silica (mg/L)	—	0.6-1.9	1.4	0.55	—	—	—	—
Nitrate (mg/L)	—	0.2-0.5	1.1	0.4	—	—	10	13
Free Ammonia (mg/L)	—	0.01-0.06	—	<0.03	<0.002-0.006	0.02	—	—
Total Phosphorus (µg/L)	—	—	13.6	10	—	0.02 [a]	—	—
Total Phosphate (mg/L)	—	<0.1	—	<1	—	—	—	—

Notes
a Interim PWQO
b Aesthetic objective
c Operational guideline
d Original reference only provides range of the observed data but does not provide raw data, number of samples or sample locations.
e Reported average of three samples collected between 1979 and 1981 and an undisclosed number of samples between 1973 and 1975.
f Results based on one sample (June 27, 2001) collected 1 km south of Bruce B.
g No method detection limit was reported
h MDL is greater than the PWQO
— Parameter not analyzed/reported.

Stormwater monitoring was conducted during 1996 [172] and results showed that the TSS concentrations were considerably higher during spring runoff and rainfall events. During these events, the TSS concentrations ranged from 22 to 775 mg/L.

The Bruce A Storm Water Study [170] measured TSS concentrations in Stream C, which ranged from 5 to 50 mg/L upstream of the Bruce nuclear site and 4 to 22 mg/L at the point where Stream C leaves the Bruce nuclear site. The same study reported that the TSS concentrations entering Lake Huron from Catchments J and L ranged from <2 to 84 mg/L in 1996. Subsequent sampling in 2003 reported TSS concentrations in Catchment L ranging from 2 to 5 mg/L [171].

In 2007, all the samples had TSS concentrations below the method detection limit of 10 mg/L with the exception of SW3 and SW5 on July 14, 2007 and SW3 on October 12, 2007. These samples had TSS concentrations of 18, 19 and 51 mg/L, respectively. Given the dry conditions that prevailed throughout 2007, all samples collected during the 2007 sampling program would be representative of dry weather conditions.

In 2009, most (>75%, including duplicates) of the samples reported had TSS concentrations below the detection limit of 10 mg/L. Exceptions ranged from 24 to 90 mg/L and were reported at SW3, SW4, SW5 and SW6 on either May 25, 2009 or October 27, 2009. Both the May 25, 2009 and October 27, 2009 sampling events occurred after periods of rain (i.e., within the previous 24 hours) and are indicative of wet weather conditions.

Nutrients

Nutrient concentrations of total phosphorous and nitrogen (ammonia, nitrate, Total Kjeldahl Nitrogen [TKN]) are generally used to assess the potential for effects on macrophyte and algae growth. Excessive nutrients can cause nuisance growth of macrophytes and algae that can impact water quality and aquatic organisms.

Nutrient analysis was available for the South Railway Ditch samples collected in 2003 and 2004 [178]. These results showed that the nutrient concentrations in the South Railway Ditch were consistent with the samples collected at the control sites.

The un-ionized ammonia concentrations measured in 2003 and 2004 ranged from 0.02 to 0.03 mg/L in the South Railway Ditch and exceeded the PWQO for un-ionized ammonia of 0.02 mg/L [178]. In 2007 and 2009, the measured un-ionized ammonia concentrations ranged from <0.002 to 0.013 mg/L, and were consistently below the PWQO. The Bruce A Storm Water Study measured phosphorous concentrations in the flow entering Lake Huron from Catchment L to be less than 50 µg/L in 1996 [170] and 2003 [171].

The total phosphorus concentrations measured in 2003 and 2004 ranged from 20 to 100 µg/L in the South Railway Ditch and exceeded the PWQO for total phosphorus of 20 µg/L (i.e., the level to avoid nuisance growth of algae) [178]. In 2007 and 2009, the measured total phosphorus concentrations ranged from <2 to 28 µg/L.

LEGEND

- Geomorphic Assessment
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]
- Water and Sediment Sample Location
- Flow Assessment Point

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

SURFACE WATER SAMPLING LOCATIONS

Golder Associates
Mississauga, Ontario

PROJECT No. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	**FIGURE 6.3.5-1**	
GIS	BC	23 Apr. 2010		
CHECK	KC	23 Apr. 2010		
REVIEW	AB	23 Apr. 2010		

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Water Temperature

Water temperature was not documented in the study area prior to the surface water quality sampling in 2007 and 2009. Water temperatures were recorded at the six locations on the six different sampling dates.

The water temperatures ranged from 9.1ºC on October 27, 2009 at SW2 and SW5 to 23ºC on June 14, 2007 at SW5. In general, the water temperatures at all the locations correlated reasonably well with the average ambient air temperature.

Metals

The presence of metals in water samples can be the result of natural background conditions or can be an indication of contamination from industrial sources. Metals concentrations significantly higher than the relevant PWQO [176] or other criterion (such as the CCME Guidelines [177]) may indicate an impact to the aquatic environment.

Water samples collected in the South Railway Ditch in 2003 and 2004 exceeded the respective PWQO for aluminum, cadmium, cobalt, copper, iron, selenium and zinc [178]. Exceedances of these parameters were also observed for the control samples collected at Goderich and in the Little Sauble River.

Water samples collected in 1996 during the stormwater monitoring were analyzed for iron, copper and zinc [170]. Exceedances of the PWQO for iron were observed during two events, while only one exceedance of the PWQO for copper was recorded. No exceedances of the zinc PWQO were reported. Stormwater sampling conducted in 2001 and 2003 [171] reported exceedances of the PWQO for zinc in samples collected in Catchment L.

In general, the 2007 and 2009 metals analytical results showed low concentrations of metals and only a few exceedances of the PWQOs for copper, iron and zinc (one, 14, and 12 of 33 samples, respectively). The samples collected in the South Railway Ditch (SW3 and SW4) typically had higher concentrations, while the lowest concentrations were recorded in MacPherson Bay (SW6).

Organic Contaminants

Organic contaminants refer to parameters such as chlorinated solvents and petroleum products. These contaminants are generally the result of industrial releases but some parameters such as Oil & Grease can be found to occur naturally.

The presence of the Spent Solvent Treatment Facility (SSTF), the Waste Chemical Transfer Facility (WCTF) and an abandoned oil unloading facility indicate that there is a potential for the presence of organic contaminants in the Site Study Area [89].

Limited information regarding organic contaminants is available for the Site Study Area. During stormwater monitoring in 1996 [170], 2001 and 2003 [171], stormwater samples were analyzed for oil and grease and PCBs. The PCB concentrations were consistently less than the method detection limits in 1996 [170], 2001 and 2003 [171]. The oil and grease concentrations were generally below the method detection limits, though some sample results showed concentrations up to 13 mg/L [172;170;171].

In 2007 and 2009, all sample results had values below the method detection limit for all volatile organic compounds (VOCs). There were no exceedances of the PWQO for VOCs. The results were generally less than the method detection limit (0.5 mg/L) for Oil & Grease; however, four samples had concentrations between 0.5 and 2.1 mg/L.

6.3.5.3 Sediment Quality

In addition to the water quality samples collected, sediment samples were collected at the surface water monitoring locations shown on Figure 6.3.5-1. All the samples were collected on September 11, 2009. The results of the sediment sampling are provided in Appendix F of the Hydrology and Surface Water Quality TSD.

Analysis results were compared to both the CCME Sediment Guidelines [177] and the Ministry of the Environment (MOE) Soil, Groundwater and Sediment Standards – Table 1 [115]. The following points outline some of the general results of the sediment sampling and analysis:

- Exceedances of the criteria for copper and zinc were reported at SW3, SW4 and SW5 (South Railway Ditch and ditch under Interconnecting Road). Additional exceedances of the criteria for arsenic, cadmium and nickel were reported at SW3.
- No exceedances of metals were reported at SW1, SW2 and SW6.
- Concentrations for PCBs and BTEX were consistently below the method detection limits in all samples.
- Petroleum Hydrocarbons (PHC) concentrations were generally below the detection limits with some exceptions. In samples SW1, SW3, SW4 and SW5 the reported concentrations of F3 (C_{16} to C_{34} hydrocarbons) PHC ranged from 13 to 720 µg/g. Additionally, an F4 (C_{34} to C_{50} hydrocarbons) PHC concentration of 460 µg/g was reported at SW3 (South Railway Ditch – West).

The WWMF Integrated EA Follow-Up [178] reported exceedances of criteria in the sediment for cadmium, copper, manganese, nickel and zinc for the samples collected in the South Railway Ditch. These occurrences are consistent with the data collected in 2009.

6.4 TERRESTRIAL ENVIRONMENT

This section provides a summary of the existing environmental conditions for the terrestrial environment. The existing terrestrial environment within the study areas (Section 5.1) is described in terms of the following components:

- **vegetation communities and species**, which includes plant species and communities and records of significant species;
- **wildlife habitat**, including the biota and abiotic components of wildlife habitat, which are linked with plant communities;
- **natural heritage system,** including brief descriptions of significant or designated areas such as provincial parks and significant wetlands;
- **wildlife communities and species**, comprising bird, mammal, and herpetofaunal species and records of significant populations; and
- **significant species,** including plants and wildlife.

For additional details, please refer to the Terrestrial Environment TSD. The description of the existing environment includes field work completed for the DGR Project EA, as well as information compiled as part of other studies on-site (as summarized in Section 6.1.2). This is to capture the range and natural variability of populations over time.

6.4.1 Spatial Boundaries

The study areas were modified to encompass likely effects on the terrestrial environment as follows:

- The **Regional Study Area**, shown on Figure 5.1.1-1, was adopted without modification.
- The **Local Study Area**, shown on Figure 6.4.1-1, expands northward to include the MacGregor Point Provincial Park Life Science Area of Natural and Scientific Interest (ANSI). The Local Study Area was determined based on the direct and indirect interconnections of habitats from the Regional to Site Study Area scales, and the linkages that species and communities may utilize for movement through these habitats.
- The **Site Study Area and Project Area**, shown on Figure 5.1.3-1, were adopted without modification.

6.4.2 Valued Ecosystem Components

Table 6.4.2-1 presents the VECs for the terrestrial environment, the rationale for their selection and the specific indicators used in the assessment. These VECs are consistent with those identified in the EIS Guidelines (see Appendix A1).

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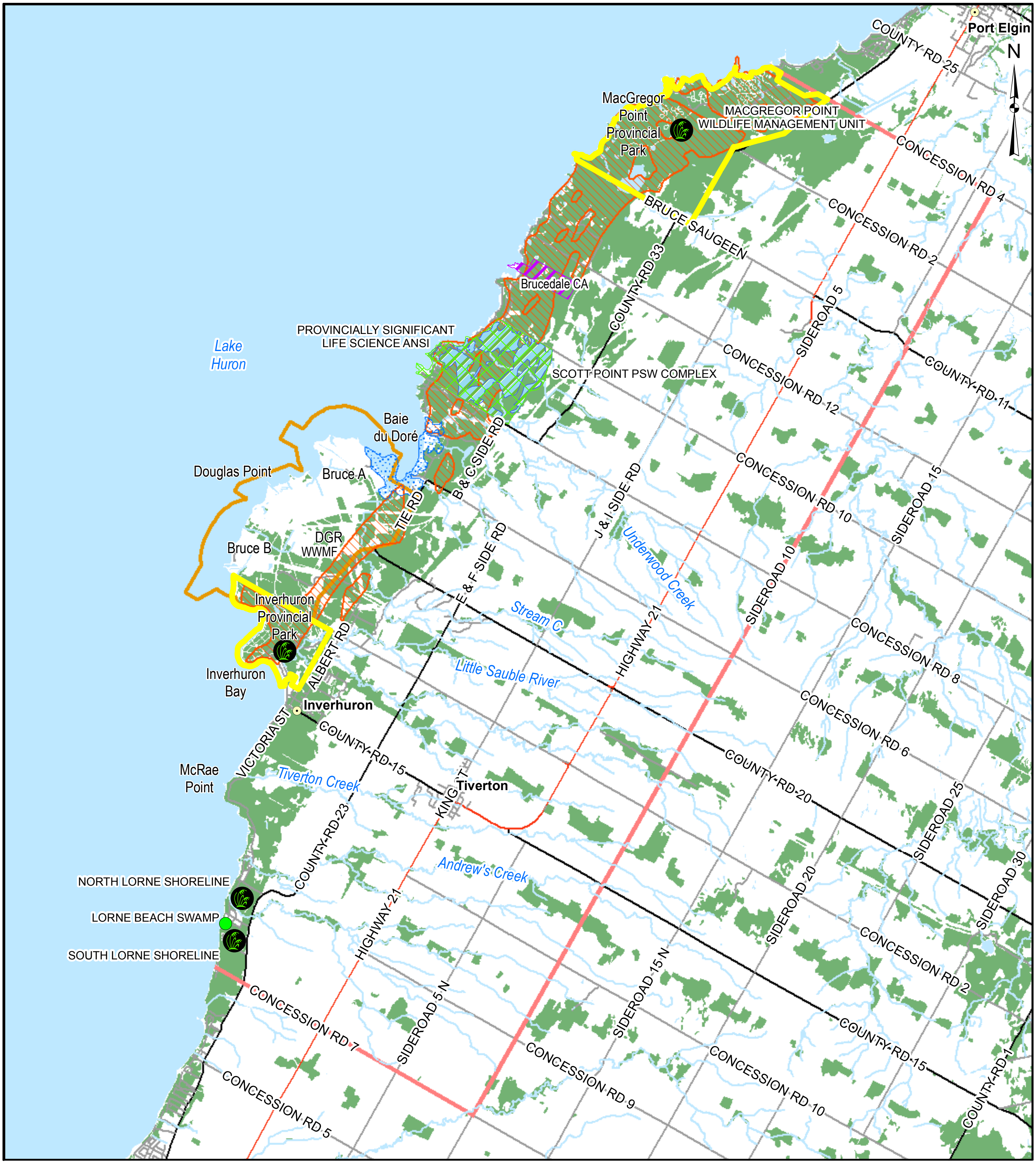

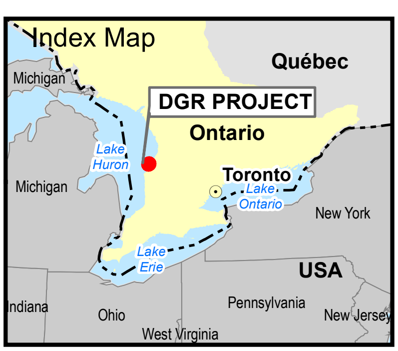

LEGEND

- Regionally Significant Wetland
- International Biological Program Site
- Site Study Area [1]
- Local Study Area
- Baie du Doré Provincally Significant Wetland
- Scott Point Provincially Significant Wetland
- Provincially Significant Life Science ANSI
- Provincial Park
- Huron Fringe Deeryard
- Brucedale CA

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

LOCAL STUDY AREA FOR THE TERRESTRIAL ENVIRONMENT

Golder Associates
Mississauga, Ontario

PROJECT No. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct 2007	FIGURE 6.4.1-1	
GIS	BC	20 Apr. 2010		
CHECK	AB	20 Apr. 2010		
REVIEW	MAR	20 Apr. 2010		

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Table 6.4.2-1: VECs Selected for the Terrestrial Environment

VEC	Rationale for Selection	Indicators	Measures
Plants			
Eastern White Cedar (*Thuja occidentalis*)	• An abundant tree species in the Local Study Area. • The eastern white cedar is slow-growing, and plays an important role in providing conditions that support wildlife habitat and presence of plant species. • The eastern white cedar is preferred by white-tailed deer for both shelter and as an important food source in the winter, and is also used by such animals as snowshoe hare, porcupine and red squirrel. • As a coniferous plant, the eastern white cedar may be more susceptible to foliar damage from changes in air quality.	• Presence • Distribution • Abundance in plant species communities	• Changes in area of vegetation communities
Heal-all (*Prunella vulgaris*)	• Abundant native flowering perennial plant (forb) in the Site Study Area. • Heal-all grows quickly in a variety of habitats, and is typically found in meadows, grasslands, open woodlands and along roadsides. • Heal-all has long been used as a folk medicine, is used in eastern traditional medicine, and on-going scientific research suggests a variety of extracts may have pharmaceutical value. • As a fast-growing, herbaceous species, heal-all is susceptible to abrupt changes in soil characteristics.	• Presence • Distribution • Abundance in plant species communities	• Changes in area of vegetation communities
Common Cattail (*Typha latifolia*)	• Common cattail is a native emergent wetland species. • This species grows intermittently in drainage ditches within the Site Study Area. • Cattail is known for its ability to filter wastewater, which may lead to pollutant (including heavy metals) accumulation in the plant tissues. • It is used by red-winged blackbird for nesting and by muskrat as a primary food source and as a shelter material. • It can be used to assess the effects of non-radiological emissions, in particular those to the surface water environment, on vegetation.	• Presence • Distribution • Abundance in plant species communities	• Changes in area of vegetation communities

Table 6.4.2-1: VECs Selected for the Terrestrial Environment (continued)

VEC	Rationale for Selection	Indicators	Measures
Mammals			
Northern Short-tailed Shrew [a] (*Blarina brevicauda*)	• This species lives in meadows, grasslands, open areas and forests. They are rarely found in dry habitats. • Burrows in loose soils. • They are omnivorous and eat almost their own weight daily. Their diet includes ground-dwelling species (e.g., earthworms) and plant matter. • They are an important food source for birds of prey, foxes and coyotes. • This species can be used to assess the effects of non-radiological emissions (airborne and waterborne) that may, in turn, influence forage opportunities.	• Presence • Distribution • Abundance	• Changes in habitat availability and suitability • Effects on individuals
Muskrat (*Ondatra zibethicus*)	• Muskrats are found locally in ditches in the Site Study Area. • This is a small mammal species with limited home range that can occur in high densities in areas with appropriate food and shelter (i.e., cattail marsh). • Muskrats can be used to assess the effects of non-radiological emissions on local vegetation and surface water resources by assessing whether the ability of muskrats to continue to use their habitat is affected.	• Presence • Distribution • Relative abundance • Habitat use	• Changes in habitat availability and suitability • Behavioural effects on individuals
White-tailed Deer (*Odocoileus virginianus*)	• Sustainable population of white-tailed deer on and surrounding the Bruce nuclear site that overwinters in the coniferous forest cover and grazes in the fields and woodlands from spring to fall. • Evidence that the on-site deer population has influenced the development of forested communities within the Site Study Area through selective browsing. • The white-tailed deer can be used to assess the effects of non-radiological emissions that may, in turn, influence forage opportunities, the potential effects of road-related wildlife mortality within the Bruce nuclear site and noise disturbance associated with traffic, construction equipment, and increased human activity.	• Presence • Distribution • Relative abundance • Habitat use	• Changes in habitat availability and suitability • Effects on individuals

Table 6.4.2-1: VECs Selected for the Terrestrial Environment (continued)

VEC	Rationale for Selection	Indicators	Measures
Birds			
Red-eyed Vireo (*Vireo olivaceus*)	• Red-eyed vireo have been observed in forest units within the Site Study Area. • Are a sensitive species. • A forest-dwelling nearctic-neotropical migrant songbird that breeds within deciduous and mixed forests within the Site Study Area. • During the breeding season, red-eyed vireo is primarily insectivorous while a mixed diet of fruit and insects is important for fat deposition during migration. • Red-eyed vireo is sensitive to edge disturbance and forest fragmentation; therefore, the species can be used to assess the effects of the loss of upland forested habitat and effects of non-radiological emissions that may, in turn, influence forage and nesting opportunities.	• Presence • Distribution • Relative abundance • Habitat use	• Changes in habitat availability and suitability • Effects on individuals
Wild Turkey (*Meleagris gallopavo*)	• Wild turkey is a territorial ground dwelling bird using deciduous forest habitat near open communities. • Wild turkey is an important subsistence, cultural and recreational feature of the study areas that was nearly extirpated from Canada because of unrestrained hunting and habitat loss, but has been successfully re-established in southern Ontario through MNR reintroduction and conservation efforts. • This species over-winters within appropriate habitat on the Bruce nuclear site (deciduous forest and coniferous swamp). • This species can be used to assess the effects of habitat loss on ground-dwelling game birds with larger territorial areas as well as noise disturbance associated with traffic, construction equipment, and increased human activity.	• Presence • Distribution • Relative abundance • Habitat use	• Changes in habitat availability and suitability • Effects on individuals

Table 6.4.2-1: VECs Selected for the Terrestrial Environment (continued)

VEC	Rationale for Selection	Indicators	Measures
Yellow Warbler (*Dendroica petechia)*	• The yellow warbler occurs commonly in the Site Study Area. • This species is likely a regular breeder in the Local Study Area. • It breeds most commonly in wet, deciduous thickets, especially those dominated by willows, and in disturbed and early successional habitats. • The yellow warbler can be used to assess the effects of non-radioactive emissions that may, in turn, affect its ability to continue to use its habitat.	• Presence • Distribution • Relative abundance • Habitat use	• Changes in habitat availability and suitability • Effects on individuals
Mallard (*Anas platyrhynchos*)	• The mallard is a waterfowl species that is common in the Local Study Area, utilizing stable shallow areas for foraging and nesting. • This omnivorous species primarily feeds on aquatic vegetation, seeds, acorns and grains, and occasionally on fish and other aquatic organisms. • The mallard can be used to assess the effects of non-radioactive emissions (airborne and waterborne) that may, in turn, influence forage opportunities as well as noise disturbance associated with traffic, construction equipment, and increased human activity.	• Distribution • Relative abundance	• Changes in habitat availability and suitability • Effects on individuals
Bald Eagle (*Haliaeetus leucocephalus*)	• Bald eagle utilizes shoreline found in the Site Study Area and has an established winter population in the Local Study Area. • It is regulated under Ontario's Endangered Species Act and is considered a species of Special Concern in southern Ontario. • It is an apex predator and is a socially important species that represents a healthy environment.	• Presence • Distribution • Relative abundance • Habitat use	• Changes in habitat availability and suitability • Effects on individuals

Table 6.4.2-1: VECs Selected for the Terrestrial Environment (continued)

VEC	Rationale for Selection	Indicators	Measures
Herpetofauna			
Midland Painted Turtle (*Chrysemys picta marginata*)	• Midland painted turtle can be found in the shallow water and shallow marsh habitats of the Baie du Doré wetland and appropriate habitats throughout the Local Study Area. • The midland painted turtle has been selected because it is sensitive to non-radiological emissions, in particular water discharges, and road-related mortality is an important consideration for sustainability for Ontario turtle populations.	• Presence • Distribution • Relative abundance • Habitat use	• Changes in habitat availability and suitability • Effects on individuals
Northern Leopard Frog (*Rana pipiens*)	• Northern leopard frog is common in the Site Study Area where it can be found in shallow water, wetland and open field areas. • This species has been recorded calling within the Site Study Area. • It uses both aquatic (drainage ditches and wetland areas) and terrestrial environments (cultural and meadow communities) for various life stages. • As an amphibian, it is more vulnerable than birds and mammals to direct contact with non-radioactive airborne emissions and water discharges and changes in soil quality. • Since this species spends the majority of its adult life stage in terrestrial environments, it is susceptible to road-related mortality.	• Presence • Distribution • Relative abundance • Habitat use	• Changes in habitat availability and suitability • Effects on individuals

Note:
a The meadow vole was identified as a VEC in the EIS Guidelines. However, small mammal trapping surveys conducted in 2009 did not confirm the presence of meadow voles in the Project Area. Therefore, northern short-tailed shrew has been adopted as a small mammal VEC for this assessment.

6.4.3 Vegetation Communities and Species

6.4.3.1 Site Study Area and Project Area

An ecological land classification (ELC) for the Bruce nuclear site was conducted in 2007 using the ELC system for southern Ontario [180] to identify and characterize the plant communities on the site. In 2009, this was refined focussing on the ELC in the Project Area. The field data was collected to:

- examine the condition and qualities of the wetlands on and within 100 m of the Project Area and inventory the vascular plants in those features;
- identify and locate any culturally significant vegetation or species of vascular plants; and
- identify and locate any plants that may have particular significance to local residents, including Aboriginal residents of Bruce County.

A total of 195 plant community polygons were identified within the Site Study Area, representing 12 broad categories and 30 specific community-types (Figure 6.4.3-1). The broad categories of vegetation types found within the Site Study Area include alvar (AL), beach (BB), cultural barren (CB), cultural grassland (CUG), cultural meadow (CUM), cultural thicket (CUT), forest (FO), industrial barren (IB), industrial lands (IND), marsh (MA), open water (OA) and swamp (SW).

Forest-type polygons occur most frequently in the larger Site Study Area, including 30 conifer forest polygons, 13 hardwood forest polygons and 30 mixed woods forest (a mix of hardwoods and conifers) polygons. In both the conifer and mixed woods forest communities, eastern white cedar is a principal or co-dominant species, as it is for most of the Regional and Local Study Areas (Sections 6.4.3.3 and 6.4.3.2, respectively). In the deciduous forest communities, sugar maple is dominant in the majority of community-types, but a trembling aspen (*Populus tremuloides*) dominated community is present on some of the moister sites and a number of sub-dominant species, including beech (*Fagus grandifolia*), ironwood (*Ostrya virginiana*) and trembling aspen, are present in the different communities (Figure 6.4.3-1). The second most abundant community-type is the 57 cultural communities, some of which are old field communities of agricultural grasses, colonizing herbs and sapling trees and shrubs. The minor vegetation community units identified in the Site Study Area include 11 beach communities, nine swamp communities, six marsh communities, five open water units and one alvar community.

Previously disturbed (culturally affected) lands predominate the Project Area lands with approximately 63% of the area in active industrial use or in barrens that have been created by past clearing and/or grading and filling. The extent of anthropogenic activities is considerable and even the naturally-occurring vegetation has, in some areas, been greatly affected by past human activity. Fill has been placed in some areas and mounded in others. A breakdown of the areas occupied by each vegetation type is provided in Table 6.4.3-1.

Table 6.4.3-1: Plant Communities Identified in the Project Area in 2009

Community Type	Area (ha)	Percentage
Industrial lands	17.2	18.0
Barrens	42.8	44.7
Cultural meadow	8.1	8.5
Woodland	23.7	24.7
Marsh	0.9	0.9
Swamp	3.1	3.2
Total	**95.8**	**100.0**

The two wetland features that occur in the Project Area are, in part, defined by fill placement (i.e., previous activities at the Bruce nuclear site resulted in changes in drainage patterns). The wetland located in the northeast corner of the Project Area (Figure 6.4.3-1) is a shallow marsh dominated by the aquatic mermaidweed (*Proserpinaca palustris*) and the emergent reed canary grass (*Phalaris arundinacea*). A diversity of other narrow-leaved emergents is present in the wetland, including various species of *Carex* (mainly *C. pseudocyperus* and *C. flava*), spikerush (*Eleocharis* spp.), rush (*Juncus* spp.) and bulrushes (*Schoenoplectus* spp. and *Scirpus* spp.).

The woodlands appear relatively young and no stems above 30 cm diameter at breast height were observed in the 2007 and 2009 field studies. Though fragmented into 12 separate units, woodlands represent a total of nearly 25% of the Project Area. Most of the woodlands on the site are dominated by eastern white cedar. Minor components are balsam fir and white birch (*Betula papyrifera*). Trembling aspen and red maple (*Acer rubrum*) occur as scattered trees or small patches at the woodland edges. The understory is relatively sparse and patchy. Poison-ivy (*Rhus radicans*) and dwarf raspberry (*Rubus pubescens*) are two of the more frequent species. Others such as red-osier dogwood (*Cornus stolonifera*), choke cherry (*Prunus virginiana*) and red raspberry (*Rubus idaeus*) occur as scattered stems, often at the edges of the stands. Ground cover is sparse and varies greatly from stand to stand. Few plants are present where the cedar canopy is dense. Under hardwoods and in glades, species such as wild columbine (*Aquilegia canadensis*), sarsaparilla (*Aralia nudicaulis*), Canada mayflower (*Maianthemum canadense*) and large-leaved aster (*Symphyiotrichum macrophyllum*) occur as scattered stems or small patches.

The various barrens that occupy most of the Project Area appear to be areas in which some historical grading and movement of fill has occurred. Substrates are shallow and most have a high gravel content. Bare ground is prevalent and plants occur as sparse scattered individuals or as small clusters of both single species and multiple species. Scattered tree stems include white birch, white spruce (*Picea glauca*), white pine (*Pinus strobes*), balsam poplar (*Populus balsamifera*) and white cedar. Most of the white spruce and white pine appear to have been planted. The other species have colonized the areas from the adjacent woodland patches. The great majority of shrubs and herbaceous plants that are present are colonizing species but because the drainage is bedrock-controlled, these areas also mimic shoreline habitats and a variety of shoreline colonizing species are also present, including shrubby St. John's-wort (*Hypericum kalmianum*), shrubby cinquefoil (*Potentilla fruticosa*), Baltic rush (*Juncus balticus*) and silverweed (*Potentilla anserina*). The non-native colonizing species include the knapweeds (*Centaurea jacea* and *C. maculosa*), wild carrot (*Daucus carota*), viper's bugloss (*Echium vulgare*), narrow-leaved plantain (*Plantago lanceolata*) and common mullein (*Verbascum thapsus*).

Important vegetation-types found in the Site Study Area include alvar (AL) and beach (BB). The alvar community noted in the Site Study Area is categorized as ALS 1-2, which constitutes a dwarf shrub alvar dominated by creeping juniper (*Juniperus horizontalis*), with scattered shrubby St. John's-wort, and shrubby cinquefoil. Alvar communities of this type can be found occasionally in the Local Study Area, and are ranked as "very rare" (S2) in Ontario by the Natural Heritage Information Centre (NHIC), with usually between five to 20 occurrences in the province. Additionally, the NHIC ranks this type of vegetation community as 'imperilled globally'

(G2?[10]) because of extreme rarity or because of some factor(s) making it very vulnerable to extinction throughout its range.

Beach communities in the Site Study Area were classified as BBO 1, BBO 2, BBS 2 and BBT 2. BBO 1 is considered open beach of unconsolidated sand, shingle and cobbles with scattered patches of herbaceous plants, including some widely scattered shrub species such as the red osier dogwood. BBO 2 is open beach of carbonate bedrock shelves with very little vegetation. BBS 2 is an open beach of carbonate bedrock with shingle and cobbles, with scattered patches of willow thicket. BBT 2 is open beach of carbonate bedrock with shingle and cobbles with groves and coalescing patches of trees. The eastern white cedar is the most common species, with balsam poplar and trembling aspen scattered around the edges of patches.

Vascular Plants in the Site Study Area and Project Area

The flora of the Site Study Area is typical of the Huron-Ontario Section of the Great Lakes-St. Lawrence Forest Region as delineated by Rowe [181]. Characteristic species include such trees as sugar maple, red maple (*Acer rubrum*), beech, white and black ash (*Fraxinus americana* and *F. nigra*), red oak (*Quercus rubra*) and white elm (*Ulmus americana*). Characteristic shrubs are the swamp fly-honeysuckle (*Lonicera oblongifolia*), choke cherry (*Prunus virginiana*) and meadowsweet (*Spiraea alba*). Typical herbaceous plants include jack-in-the-pulpit (*Arisaema triphyllum*), yellow trout-lily (*Erythronium americanum*), false Solomon's-seal (*Maianthemum racemosum*), hairy Solomon's-seal (*Polygonatum pubescens*), white trillium (*Trillium grandiflorum*) and barren strawberry (*Waldsteinia fragarioides*). The boreal floristic element [182] is represented by species such as balsam fir (*Abies balsamea*), white birch (*Betula papyrifera*), tamarack (*Larix laricina*), white spruce (*Picea glauca*) and eastern white cedar, as well as the shrubs dwarf birch (*Betula pumila*), bunchberry (*Cornus canadensis*), twinflower (*Linnaea borealis*) and bristly black currant (*Ribes lacustre*) and such herbaceous plants as red baneberry (*Actaea rubra*), goldthread (*Coptis trifolia*) and rattlesnake plantain (*Goodyera tesselata*). Two species characteristic of the Great Lakes floristic element [182] are the marram grass (*Ammophila breviligulata*) and shrubby St. John's-wort, both of which are shoreline species of restricted distribution in the Site Study Area.

Although more than 500 species of vascular plants occur in the vicinity of the Bruce nuclear site, only a modest subset of that number occurs in the Project Area (see Appendix D of the Terrestrial Environment TSD). As discussed above, the lands within the Project Area have been affected by anthropogenic factors, as a result the diversity of vegetative species is lower than in the Site Study Area. The habitats in the Project Area are also smaller in size (area) than the habitats that have been documented within the larger Bruce nuclear site. For the Project Area, a total of 181 taxa of vascular plants have been identified, including 16 species of trees, 19 species of shrubs and woody vines, five species of ferns and fern allies, 50 graminoids (plants with grass-like leaves) and 91 forbs (all herbaceous flowering plants, excluding graminoids).

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[10] A question mark (?) is assigned to global ranks when there is insufficient information available from which to properly determine rank.

LEGEND

- Site Study Area [1]
- Project Area (OPG-retained lands that encompass the DGR Project)
- DGR Site

ELC Group

- Alvar
- Beach
- Cultural Barren
- Cultural Grassland
- Cultural Meadow
- Cultural Thicket
- Forest
- Industrial Barren
- Industrial land in active use
- Open Water
- Marsh
- Swamp

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

2. The ELC data within the Site Study Area was collected during 2007. The ELC data within Project Area was updated during 2009 survey.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m,
Datum: NAD 83 Projection: UTM Zone 17N

0 125 250 500 750 1,000
Metres

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

ELC MAPPING IN THE SITE STUDY AREA

Golder Associates
Mississauga, Ontario

PROJECT No.06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	03 Aug. 2006	**FIGURE 6.4.3-1**	
GIS	BC	20 Apr. 2010		
CHECK	KC	20 Apr. 2010		
REVIEW	AB	20 Apr. 2010		

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Culturally Significant Plants Species and Communities

No plant community previously considered of special significance to Aboriginal peoples has been identified in the Project Area, and no vascular plant species with special significance have been identified. Eastern white cedar is a species with a multitude of uses in crafts, but it is widely abundant on the site, in the broader study areas and across Bruce County. As the most abundant tree species across Bruce County, it is too common to map on an individual basis. Additionally, wild strawberry, raspberry species and common heal-all have been documented during field data collection. These species are also common and abundant in Bruce County and provincially. No species with a limited or restricted distribution on the site has previously been identified as of special significance for Aboriginal peoples. Further consideration of Aboriginal interests is found in the Aboriginal Interests TSD.

6.4.3.2 Local Study Area

The Local Study Area is located within the Alleghanian or Transition Life Zone, which corresponds to the northern fringe of the deciduous forest zone. This zone supports fauna and flora from both northern and southern affinities, and may represent unique groupings of species [95]. The Local Study Area also includes the Huron Fringe woodland, which is a narrow stretch of woodland along the shore of Lake Huron comprising terraces created by glacial Lake Algonquin. This area stretches south from Tobermory to Sarnia and contains wetland, sand dune, and ridge areas. Vegetation in the Huron Fringe ranges from alvar, bog, swamp, fen, and marsh species to dune grasses [183]. Much of the natural forest cover within the Local Study Area, similar to that within the Regional Study Area (Section 6.4.3.3), has been historically cleared for agriculture. Remnant forested areas in the Local Study Area are primarily associated with the Lake Huron shoreline, valleys and areas with steep topography, and poorly drained sites [184]. The primary environments in which vegetation communities and species are found in the Local Study Area are as follows:

- shallow water (inland ponds less than two metres deep);
- wetlands (marshes, swamps and fens present in the Baie du Doré wetland);
- forests (white cedar coniferous, hardwood, mixed);
- cultural lands (old fields); and
- beach/bar and sand dunes (remnant shoreline of glacial Lake Nippissing).

6.4.3.3 Regional Study Area

The Regional Study area is situated within the landscape of Bruce County, which has been influenced by glaciations, resulting in cliffs, dunes, talus slopes, karst[11] environments and wetlands. The Niagara Escarpment runs along the east side of the Bruce Peninsula, which forms the north portion of Bruce County. The escarpment is recognized as a World Biosphere Reserve because of the significance of its natural and physical environment features. Natural areas present along the escarpment form a regional corridor supporting a variety of unique

[11] Karst refers to a type of topography that is formed over limestone, dolomite, or gypsum by solution of the rock and is characterized by closed depressions or sinkholes, caves and underground drainage.

natural communities, including cliffs, alvars, wetlands, and prairie. Approximately 25% of Bruce County is forested, with much of the north portion of the County, the Bruce Peninsula, under forest cover [185]. The Bruce Peninsula acts as a transition zone between southern deciduous and northern boreal forests. As a result, representative species of a variety of natural areas are present in this area, often at the extreme limits of their range [186]. These forested areas include both lowland and upland deciduous, mixed, and coniferous forests. Bruce County is within the Huron-Ontario section of the Great Lakes-St. Lawrence Region. This physiographic region is generally characterized by sugar maple (*Acer saccharum*) and beech climax forests, often in association with green ash (*Fraxinus pennsylvanica*), white ash (*Fraxinus americana*), yellow birch (*Betula alleghaniensis*), wild black cherry (*Prunus serotina*), American basswood (*Tilia americana*), northern red oak (*Quercus rubra*), white oak (*Quercus alba*) and Bur (mossy-cup) oaks (*Quercus macrocarpa*) [181]. Eastern hemlock (*Tsuga canadensis*), eastern white pine, and balsam fir (*Abies balsamea*) are frequently located in drier or upland areas. Eastern white cedar is frequently recorded along swampy depressions. Upland coniferous forests in this area often support provincially significant plant species [187].

6.4.4 Wildlife Habitat

6.4.4.1 Site Study Area and Project Area

The wildlife habitat functions of the remnant woodland habitat units within the Site Study Area are limited by their small size, high degree of fragmentation, and disturbed nature. These areas are capable of supporting wildlife species that are not dependent on forest interior; however, they may be part of habitat areas used by wildlife with larger territorial ranges (e.g., wild turkey and white-tailed deer). The Site Study and Project Areas have been extensively modified, limiting the availability of topsoil. The site does not provide good habitat for burrowing species of mammals, and the stony nature of the soils limits the growth of herbaceous groundcover in some of the more open habitats.

A wild turkey habitat use and suitability survey conducted in February 2007 revealed that at least two distinct flocks of 20 to 30 birds occur on the Bruce nuclear site. Turkey roosting on the site is habitat-specific, with a preference for a combination of open field areas edged by a mix of larger deciduous and coniferous tree stands (Figure 6.4.4-1). No roosts were identified within the Project Area. Disturbed areas within the Site Study Area create suitable feeding/breeding ground for wild turkeys, as manicured grasses, snow clearing, hydro corridors and landfills provide vegetation necessary for winter survival and spring breeding. Additionally, the proximity of travel corridors linking Inverhuron Provincial Park and surrounding farm fields and woodlots provide substantial diversity and range of habitats for wild turkeys within the Site Study Area.

In a muskrat habitat suitability and usage survey conducted in May 2007, active muskrat houses were observed at one of two study sites within the Project Area where cattails were available (Figure 6.4.4-2). At a reference site in MacGregor Point Provincial Park, three active muskrat houses were observed.

LEGEND

- Eastern Wild Turkey
- Roosting Tree
- Project Area (OPG- retained lands that encompass the DGR Project)
- Site Study Area [1]
- Significant Turkey Habitat

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.
2. Wild turkey survey conducted February 19 and 27, 2007

REFERENCE

Base Data Provided by 4DM, November 2007. Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

WILD TURKEY HABITAT IN THE SITE STUDY AREA

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	**FIGURE 6.4.4-1**	
GIS	BC	20 Apr. 2010		
CHECK	NS	20 Apr. 2010		
REVIEW	AB	20 Apr. 2010		

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0 125 250 500

Metres

LEGEND

- Muskrat Burrow
- Location of Muskrat Lodge
- Meadow Vole (Sept 2-3 and Oct. 2-7, 2009)
- Muskrat Habitat Survey Sites (May 7-8, 2007)
- Project Area (OPG- retained lands that encompass the DGR Project)
- Site Study Area [1]

NOTES

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007. Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

SMALL MAMMAL SURVEY LOCATIONS

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	**FIGURE 6.4.4-2**	
GIS	BC	20 Apr. 2010		
CHECK	NS	20 Apr. 2010		
REVIEW	AB	20 Apr. 2010		

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Vernal ponds within the Site Study Area provide a number of habitats that are utilized by amphibians during various life stages. In the Project Area, northern leopard frog egg masses have been recorded [178], and a variety of species including northern spring peeper, green frog, gray treefrog, wood frog and yellow-spotted salamander (*Ambystoma maculatum*) have been historically recorded [188]. In a survey of the Project Area completed during April and May 2007, a total of four actively breeding species of frogs including northern spring peeper, northern leopard frog, chorus frog (*Pseudacris maculata*) and gray treefrog were identified (Figure 6.4.4-3). Breeding activity was most intense within wetland communities with the greatest amount of surface water.

As part of the breeding bird survey conducted in the Site Study Area in 2007, five locations were surveyed within the Project Area (see Figure 6.4.4-3). A total of 37 individual birds of 21 species were observed showing breeding behaviour over the three-day periods in May and June with a total of 19 individuals of 16 species in May and 11 individuals of 11 species in June 2007. All of the species observed are common to Ontario. The highest number of species was observed in deciduous forest habitat with a total of eight species.

6.4.4.2 Local Study Area

Wildlife habitat in the Local Study Area is generally associated with vegetation communities such as forests, meadow and other cultural lands, wetlands and the Lake Huron shoreline. Some important habitat areas found in the Local Study Area are found in MacGregor Point Provincial Park, Inverhuron Provincial Park and within the Bruce nuclear site. However, larger areas of natural habitat within the perimeter fence of the Bruce nuclear site show more evidence of human disturbance than similar habitat areas outside the limits of the Bruce nuclear site [93]. The range of wildlife habitat and lack of barriers to wildlife movement suggest that wildlife groups and species likely utilize the habitat in the Local Study Area connected with habitats in the Regional and Site Study Areas.

Second-growth upland coniferous and mixed forest communities in the Local Study Area including much of the Bruce nuclear site are dominated by eastern white cedar. The extensive coniferous content of the forest cover provides important overwintering and feeding sites for white-tailed deer. The deer populations within the Local Study Area, including those recorded on the Bruce nuclear site, make use of the large Huron Fringe Deer Yard that extends from Inverhuron Provincial Park in the south to MacGregor Point Provincial Park in the north.

Short to medium height cover of field grasses and herbs characterize the cultural meadow/old field habitat found in the Local Study Area, which also includes some limited shrub and tree cover. These areas support several ground nesting bird species as well as other species that forage on the ground. These habitats also attract raptors that hunt over the open field. Wild turkey habitat also exists within the Local Study Area including within the perimeter fence of the Bruce nuclear site because of the varied habitat including open meadow, cleared hydro corridor and forests.

Open-water habitat throughout the Local Study Area, particularly associated with the Lake Huron shoreline supports waterfowl and herpetofaunal breeding. Ponds within the Local Study Area vary from constructed to natural with steep to gentle sloping sides and shoreline vegetation ranging from dune grasses to forest edge. Species observed in ponded habitats in the Local Study Area include birds such as blue-winged teal, bufflehead, Canada goose, mallard, wood duck, common snipe; herptiles such as northern leopard and green frogs, painted turtle, spotted turtle, salamander species; and mammals such as muskrat and beaver. Other aquatic environments, such as ditches, ephemeral ponds, and streams represent habitat for fish, herpetofauna, and some birds and mammals [93].

The most common waterfowl species observed within 150 m of the shoreline were mallard, common merganser and double-crested cormorant. Large numbers of Canada goose, ring-billed gull and herring gull were also seen. The habitat along the shoreline is quite exposed with a cobble surface that generally lacks vegetation. During winter, warm water discharged from the cooling water systems at the two existing Bruce generating stations may prevent the lake from freezing near the point of the discharges [167]. As a result, waterfowl are found near the discharges in higher densities than the surrounding area.

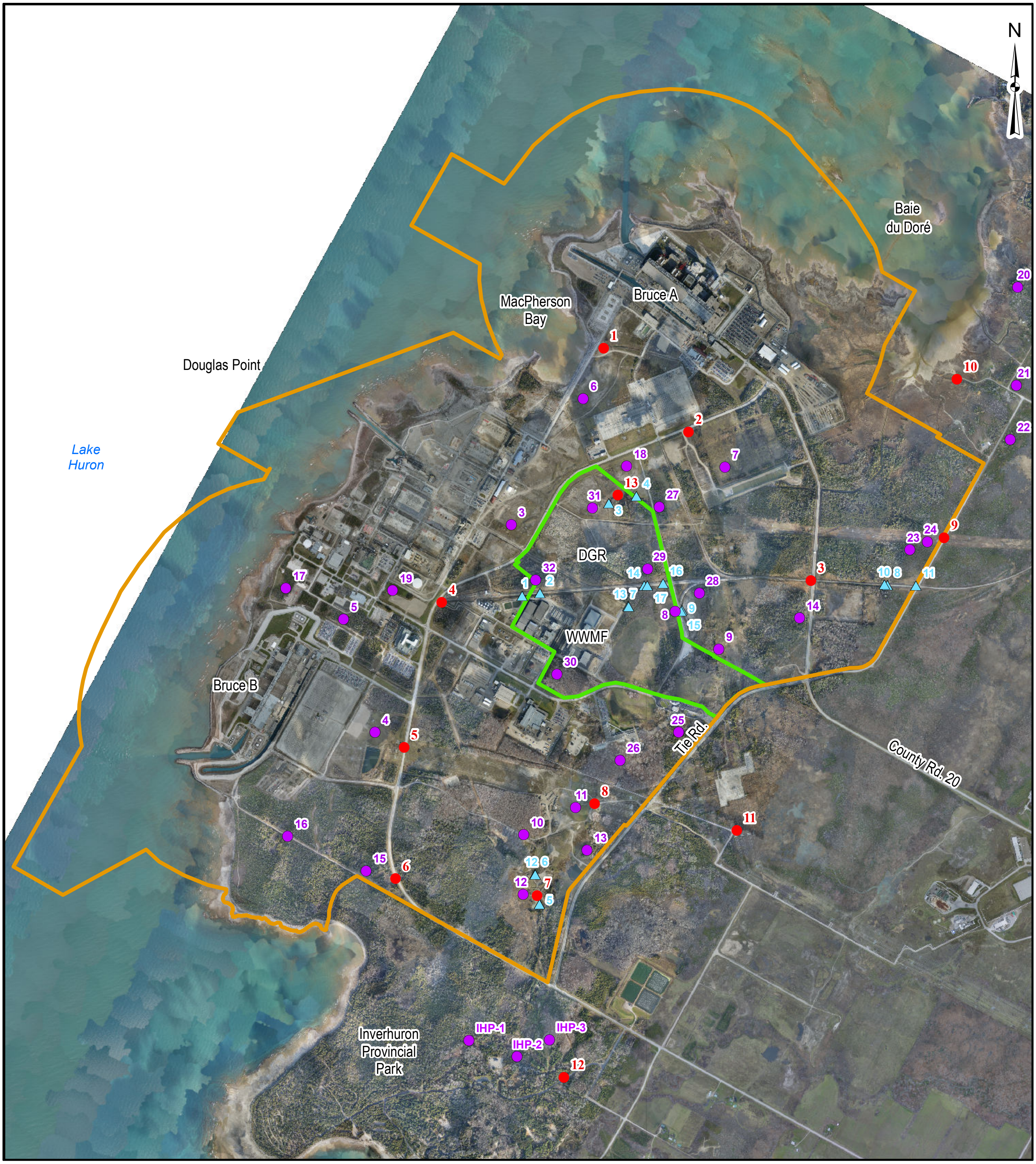
A number of bird species of concern have been observed in the Local Study Areas, including a winter-resident population of bald eagles (*Haliaeetus leucocephalus*) that appears to feed on fish in the discharge channel of the Bruce A and Bruce B stations and roost along the shore of Lake Huron, particularly within portions of the Baie du Doré wetland [189]. Other species with special conservation status that have been identified in the Local Study Area are the endangered Acadian flycatcher (*Empidonax virescens*) and the following species of special concern: short-eared owl (*Asio flammeus*), red-headed woodpecker (*Melanerpes erythrocephalus*) and yellow-breasted chat (*Icteria virens*). None of these birds are reported to nest in the Site or Local Study Areas, though they may be local foragers [93].

The Baie du Doré wetland provides diverse habitat including shallow open-water ecosystems and shallow shoals to shrub fen communities. The wetland is a shallow, flat shoreline area within an embayment that provides a sheltered environment from Lake Huron with partial wind protection toward the back of the embayment [190]. The Baie du Doré wetland provides habitat for a number of species at risk, and includes an overwintering population of bald eagle, which are a species of Special Concern in the Endangered Species Act (Ontario 2007) [191].

The varied habitats at MacGregor Point Provincial Park make it a notable area of wildlife habitat that supports a relatively high diversity of species, including forests, ponds, wetlands and shoreline, resulting in a wide variety of habitat types. Over two-thirds of all bird species found in Grey and Bruce Counties make use of habitat within the park, including the provincially rare black-crowned night-heron [183]. Moist forest and fen-pond complex communities at MacGregor Point are also suited to amphibian and reptile populations. A constructed pond at the park is a very important area within the Local Study Area for both migrating and breeding bird species.

6.4.4.3 Regional Study Area

Wildlife habitat in the Regional Study Area is generally associated with the Lake Huron shoreline, the Saugeen River riparian corridor and associated wetland complexes, and the Niagara Escarpment and naturally vegetated areas including: upland forest, cultural meadow, marsh and swamp communities. The built environment structures and surfaces also provide habitat for some species of birds and mammals that are habituated to anthropogenic land use and human disturbance.



0 0.5 1 2

Kilometres

LEGEND

- Breeding Amphibian Survey Sites (April 25 and May 7, 2007; June 16 and May 7, 2009)
- Turtle Basking Survey Locations (June 3,16 and Aug. 12, 2009)
- Breeding Bird Survey Locations (May 23 - 25 and June 19-21, 2007; May 29 - 31 and July 2 - 4, 2009)
- Project Area (OPG- retained lands that encompass the DGR Project)
- Site Study Area [1]

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.
2. Breeding Bird wetland survey was completed at Station 12 (Breeding Birds)

REFERENCE

Base Data Provided by 4DM, November 2007. Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

BREEDING BIRD AND HERPETOFAUNAL SURVEY LOCATIONS

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	**FIGURE 6.4.4-3**	
GIS	BC	20 Apr. 2010		
CHECK	KC	20 Apr. 2010		
REVIEW	AB	20 Apr. 2010		

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Within the Bruce Peninsula, large stands of contiguous upland coniferous and mixed forest provide habitat for many species of wildlife. Features of the Niagara Escarpment, including cliffs, alvars, talus slopes, wetlands and prairies provide a vast diversity of wildlife habitat within a small geographic range, and are associated with the Regional Study Area attributed to the interconnected nature of terrestrial systems. The cliffs of the Niagara Escarpment provide habitat for a large variety of bird species, including species of special concern like black tern (*Chlidonias niger*) and red-shouldered hawk (*Buteo lineatus*) [192;193]. Rock cliffs in the area near the shoreline also present potential habitat for turkey vulture summer roosting areas [194]. Broken rock piles at the base of cliffs and karst features along the escarpment provide potential habitat for snakes and turtles to overwinter in concentrations referred to as hibernacula [194]. Bat hibernacula for five out of the eight species of bats found in Ontario are found in humid caverns and crevices that occur on the Bruce Peninsula as karst features [186;187].

The varied wetland communities found throughout the Regional Study Area range from shallow marshes to bog environments, which support diverse wildlife including breeding reptiles and amphibians like massassauga rattlesnake and the nationally endangered spotted turtle (*Clemmys guttata*), and migrating birds including hawks and owls. These wetland areas include potential habitat for bullfrogs (*Rana catesbeiana*) [194]. Ridge-top forest areas provide habitat for rare Ontario species including massassauga rattlesnake and southern flying squirrel (*Glaucomys volans*) [186]. Open lands including meadow and grassland communities are also used by the massassauga rattlesnake and species of raptors such as short-eared owl (*Asio flammeus*) for winter feeding and roosting, as they support large communities of small mammals [194].

As described in Section 6.3.3, major river systems within the Regional Study Area include the Saugeen and Sauble. These rivers are associated with a number of smaller streams, the valley systems of which contribute to the network of habitat corridors and riparian habitat throughout Bruce County. As well, there are a number of inland lakes and natural ponds which represent habitat for a variety of plant species [186]. Fen and marsh wetland areas are common with fewer bog areas within Bruce County. The Greenock Swamp, located in the southeastern portion of the Regional Study Area, is one of Ontario's largest remaining wetlands, approaching 8,000 ha in size. The Lake Huron shoreline, which runs along the west edge of the County, provides a natural habitat corridor that extends north along the Bruce Peninsula. Open water, shallow marsh, fen and bog environments create habitat for a range of species, within the large continuous wetland and aquatic areas found in the southern half of Bruce County (including the Regional Study Area).

The Ontario Provincial Policy Statement considers colonial bird nesting sites to represent significant wildlife habitat [195]. Chantry Island and the Bruce Peninsula are recognized as providing significant wildlife habitat for breeding and migrating birds. Chantry Island, located one kilometre to the west of the Lake Huron shoreline at Southampton, is recognized in Canada as a national migratory bird sanctuary and internationally as an Important Bird Area (IBA) by Bird Life International [196;197].

6.4.5 Natural Heritage System

6.4.5.1 Site Study Area and Project Area

A review of the NHIC database indicates that no designated or significant natural areas occur within the boundaries of the Project Area, but Inverhuron Provincial Park and Baie du Doré PSW occur partially within the boundaries of the Site Study Area [193]. As noted in Section 6.4.4.1, above, the woodland units in the Site Study Area are highly fragmented and have been subjected to considerable disturbance, including heavy deer browse [188].

6.4.5.2 Local Study Area

Features associated with the Lake Huron shoreline dominate the Natural Heritage System in the Local Study Area. A network of small rivers and streams extends inland from Lake Huron providing habitat corridors that link features along the shoreline with areas of habitat further inland. As previously noted, watercourses within the Local Study Area include Tiverton Creek, Little Sauble River, Stream C and Underwood Creek (Figure 6.3.4-1). A number of Natural Heritage System components in the Local Study Area are intrinsically part of the Regional Study Area or have ecological functions that are important at both the local and regional scales. The following core natural areas are present within the Local Study Area (see Figure 6.4.1-1):

- Inverhuron Provincial Park, which is an International Biological Program (IBP) Site and Provincial Park (Historical);
- Baie du Doré PSW;
- Scott Point PSW Complex and Provincially Significant Life Science ANSI;
- MacGregor Point Provincial Park which is a PSW Complex, a Regionally Significant Life Science ANSI and a Provincial Park (Natural Environment);
- MacGregor Point Wildlife Management Unit, which is an IBP Site;
- Lorne Beach Swamp, which is a Regionally Significant Wetland;
- South Lorne Shoreline IBP Site;
- North Lorne Shoreline IBP Site; and
- Huron Fringe Deeryard.

6.4.5.3 Regional Study Area

The diverse habitat features and unique landscape that exists in the Regional Study Area include a number of noteworthy landscape-scale features, based on a review of the NHIC database. As introduced in previous sections, landscape-scale features in the Regional Study Area include the Niagara Escarpment, the Lake Huron shoreline, the headwaters of the Saugeen River, and the shoreline of the historic glacial Lake Nippissing. A large number of other natural heritage features have been evaluated and designated as significant by the Ontario Ministry of Natural Resources (OMNR), including:

- Provincially Significant Wetland (PSW);
- Regionally Significant Wetland;
- Life Science Area of Natural or Scientific Interest (ANSI);

- Earth Science ANSI;
- Provincial Parks and Conservation Areas;
- International Biological Program sites (IBP); and
- Life Science Site, Natural Area of Regional Significance (NARS).

6.4.6 Wildlife Communities and Species

6.4.6.1 Site Study Area and Project Area

The wildlife communities and species in the Project Area tend to be subcomponents (e.g., metapopulations) of populations and communities of species at the Regional, Local and/or Site Study Areas scales since habitats are linked. Accordingly, this discussion focuses on the species most likely to use the habitats identified within the Project Area.

Birds

The bioinventory study of the Site Study Area [93] identified 83 species of birds as having potential for breeding within the Site Study Area. Approximately 40 species were identified as having breeding potential within the Project Area, including one confirmed breeder [93]. It was postulated that noise and disturbance from construction activities at the WWMF adjacent to some of the survey locations may have resulted in a decreased number and diversity of species recorded than would normally make use of habitat in that area [93]. The list of species recorded includes mainly forest species such as great crested flycatcher, red-eyed vireo, blue jay, black-capped chickadee and black-and-white warbler.

Twenty-five bird species were identified in a field study within the immediate area of the WWMF carried out in 2004 as part of the WWMF Refurbishment Waste Storage Project terrestrial environment study [188]. Four species were confirmed breeders in the area: northern flicker, chipping sparrow, American robin and black-capped chickadee. Noise and disturbance from use of heavy equipment at the WWMF adjacent to the survey location near the north storage area is mentioned as a potential influence on the number and diversity of species recorded [188].

Breeding bird surveys were conducted in 2007 and 2009 at five plots in the Project Area (Figure 6.4.4-3). In total, there were 37 birds observed exhibiting breeding behaviour within the Project Area representing 21 different species in the 2007 field study. American redstart (*Setophaga ruticilla)* was the most commonly observed species overall (three in May, two in June), followed by eastern wood-pewee (two in both May and June) and red-eyed vireo (two in each of May and June). Breeding bird surveys were updated as part of the 2009 field data collection season. A more detailed survey for potential wetland bird species was completed at one location to determine the potential for king rail (*Rallus elegans*), a provincially endangered species breeding in this location. Two breeding bird surveys were conducted over two three day periods from May 29 to 31, and July 2 to 4, 2009. No evidence of king rail was documented during this survey. Lists of all of the species that were recorded during breeding bird surveys within the Project Area and surrounding areas is located in Appendix C of the Terrestrial Environment TSD . A total of 83 species was identified during these surveys.

Species at Risk (SAR) documented during these surveys were limited to two incidental sightings. Two black-crowned night-herons (*Nycticorax nycticorax*) were observed flying over the Bruce nuclear site on July 2, 2009. The black-crowned night-heron is not listed federally or provincially in Ontario, although it is ranked as a vulnerable species in the province of Ontario by the NHIC [198]. Additionally, one common nighthawk was documented as an incidental sighting in Inverhuron Provincial Park, which is located outside of the Site Study Area, during the July 2009 surveys. This species is considered to be threatened in Canada by Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and Special Concern in Ontario by COSSARO.

Mammals

Evidence of star-nosed mole, groundhog, eastern chipmunk, racoon and white-tailed deer were recorded as part of historic environment studies [188;93] within the Project Area. Historical evidence of beaver activity was noted in the north storage area. White-tailed deer, muskrat and water shrew were also observed as part of this study.

Incidental observations of mammals within the Site Study Area as part of field studies undertaken in 2007 included beaver, cottontail rabbit, coyote, grey squirrel, snowshoe hare, striped skunk, weasel and white-tailed deer. Most mammals were observed in the wooded area at the southwest corner of the Site Study Area, adjoining Inverhuron Provincial Park, including four snowshoe hares, two coyotes and several white-tailed deer.

Small mammal surveys completed in 2009 field data collection season, which were designed to determine habitat use and distribution of meadow voles (*Microtus pennsylvanicus)* (initially selected as a small mammal VEC) with incidental records of other rodent species. None of the traps contained any rodent species, and only one trap (Trap #8) showed evidence of any rodent activity (droppings on lid of trap).

A second survey event captured a number of non-target species of rodents, including both deer mouse and northern short-tailed shrew. All captured specimens were determined to be adults. Despite considerable effort, meadow voles were not captured during this program and the small mammal VEC was changed to northern short-tailed shrew.

A late fall wildlife aerial survey was completed within the Site Study Area in 2009 to document white-tailed deer habitat use within the site to determine where concentration areas and movement corridors exist. Only one white-tailed deer (male) was documented in the Site Study Area. An additional survey of the land immediately surrounding the Site Study Area, within the Local Study Area, was completed to determine if deer were using an off-site movement corridor to access agricultural fields for feeding. A total of eight deer were documented in a recently harvested corn field located 0.75 to 1.0 km east of the Site Study Area. No wild turkey or white-tailed deer were documented within the Project Area during this survey; however several turkey were identified in the Site Study Area.

Herpetofauna

Spring peeper and American toad are the most commonly recorded amphibian species found on the Site Study Area [188]. In suitable ephemeral habitats in the Site Study Area, the most widely distributed amphibian species were northern leopard frog, green frog, grey treefrog, American toad, northern spring peeper, and wood frog, in order of frequency [93]. As part of the WWMF Refurbishment Waste Storage Project terrestrial environment study carried out in 2004 within the Project Area, northern leopard frog and green frog were observed [188]. In the North and South Railway Ditches, two northern watersnakes and several eastern gartersnakes were observed. Field studies on the Bruce nuclear site in spring 2007 reinforced the historical findings as spring peeper, northern leopard frog, chorus frog and gray treefrog were identified as actively breeding within the Site Study Area (in order of dominance).

Field studies were updated as part of the 2009 field data collection season. A number of species were documented during the field surveys, including spring peeper, grey treefrog, American toad, northern leopard frog and green frog, which were all recorded during the 2007 field data collection season. A new species for the site, western chorus frog was added to the species list in 2009. The species found in the greatest numbers included spring peeper, green frog, American toad and grey treefrog. Breeding activity was found to be most common in wetland areas within the Site Study Area with the greatest amount of surface water.

A total of 30 individual turtles were recorded during the 2009 basking turtle survey, 20 during the June surveys and 10 during the August survey. Of the 30 individuals documented, 29 were midland painted turtles, a VEC species for the DGR Project, and one was a common snapping turtle, a provincial species of Special Concern. Surveys completed indicate that the preferred turtle basking habitat found within the Site Study Area is located in the pond adjacent to the landfill site (location 5 on Figure 6.4.4-3). This water body includes both open water habitat and basking structures, including logs, woody materials and debris. A total of 13 turtles have been documented here. Midland painted turtles were also observed in the South Railway Ditch during field surveys.

6.4.6.2 Regional and Local Study Areas

The Local and Regional Study Area contain many of the same communities; therefore, wildlife communities and species may be similar between the two study areas since habitats are linked.

Birds

The Local Study Area is a subset of the Regional Study Area, but contains many of the same communities, and thus many similar species of birds. One hundred and thirty-four species have been historically recorded in the various habitats found in the Local Study Area. Included on this list are bald eagle, a national species of conservation concern, red-headed woodpecker (*Melanerpes erythrocephalus*), which is classified as special concern by COSEWIC and the OMNR, great egret, a provincially imperilled species, black-crowned night-heron, caspian tern and dunlin which are all considered sensitive in Ontario.

Mortality of various waterbirds has been reported along the shoreline in the Local Study Area and documented occurrences in other areas of Lake Huron in recent years [100]. Waterbirds usually reported in these die-offs include gulls, common loons (*Gavia immer)*, and double-crested cormorants. The main cause of these die-offs is typically Type E botulism [100]. Botulism is a paralytic condition brought on by the consumption of a naturally occurring toxin produced by the bacterium *Clostridium botulinum*. The botulism poison works its way up the food chain as the bacterium *C. botulinum* Type E found in bottom mud, aquatic invertebrates, and fish. Die-offs often occur during the fall when the lake waters begin to cool, characterized by the sinking and mixing of cooler, dense water from the surface, displacing warmer and lighter water below. While these outbreaks can kill a significant number of piscivorous birds locally, they typically do not impact waterbird species on a population or community level. Shorebird, loon, cormorant and waterfowl mortalities associated with Type E botulism exposure are attributed to natural occurrence of the toxin, and are not influenced by the operations at the Bruce nuclear site.

Mammals

Mammal records for the Local Study Area are based on evidence of presence (e.g., tracks, scat) or actual sightings as indicated in the background literature. A number of species that are found in the Local Study Area have adapted to living in close proximity to human development.

Based on the most recent (2000-2001) Bioinventory Study of species within and outside the Bruce nuclear site, white-tailed deer was found to be the most common species, occurring in every naturally vegetated habitat and within the built environments [93]. White-tailed deer are known to overwinter in the coniferous forest of the Huron Fringe Deeryard (see Figure 6.4.1-1) [95], and are commonly found in the Local Study Areas outside of the perimeter fence [93].

Herpetofauna

Frog and toad species are found within cultural meadows and forested habitats during the summer months. They may also use coniferous swamp edges and cultural thicket habitats for breeding. Some toad species are opportunistic and use a wide variety of habitats. Salamanders have been observed both on the Bruce nuclear site and in MacGregor Point Provincial Park. Snake species are also found on the Bruce nuclear site, in wetland habitat and in forested habitats.

6.4.7 Significant Species

6.4.7.1 Site Study Area and Project Area

Neither historical studies nor current database searches identified habitat use by species listed under Schedule 1 of the Species At Risk Act or rare or endangered species as identified by the province in the Project Area.

Some wildlife species that occur within the Site Study Area and Project Area are valued for cultural or recreational reasons. Most notably, distinct flocks of wild turkey, a popular game bird, utilize the Site Study Area year-round.

6.4.7.2 Regional and Local Study Area

Flora

Table 6.4.7-1 presents the 19 plants that are vulnerable (S3), imperilled (S2) or critically imperilled (S1) in the Local Study Area, based on a review of the NHIC database and other relevant background literature sources. A list of provincially significant flora found in the Regional Study Area can be found in Appendix C of the Terrestrial Environment TSD.

Table 6.4.7-1: Provincially Significant Plants in the Local Study Area Based on a Review of the NHIC Database

Scientific Name	Common Name	Habitat [b]	COSEWIC Status [a]	COSSARO Status [a]	OMNR Provincial Ranking [a]	Global Ranking [a]
Tree						
Juglans cinerea	Butternut	Forest and forest edge	END	END	S3?	G3G4
Shrub, small tree and woody vine						
Salix myricoides var. myricoides	Blue-leaf Willow	Sand Dunes	—	—	S2S3	G4T4
Forb						
Arnoglossum plantagineum	Tuberous Indian-plantain	Riparian, shoreline, and wetland	SC	SC	S3	G4G5
Astragalus neglectus	Cooper's Milkvetch	Alvar, riparian area, forest, and forest edge	—	—	S3	G4
Cirsium pitcheri	Pitcher's Thistle	Sand dune and shoreline	END	END	S2	G3
Cypripedium arietinum	Ram's-head Lady's-slipper	Alvar, wetland, forest and forest edge	—	—	S3	G3
Cypripedium candidum	Small White Lady's-slipper	Open grassland and wetland	END	END-R	S1	G4
Drosera linearis	Slenderleaf Sundew	Wetland	—	—	S3	G4
Iris lacustris	Dwarf Lake Iris	Alvar, sand dunes, shoreline, wetland, and forest	THR	THR	S3	G3

Table 6.4.7-1: Provincially Significant Plants in the Local Study Area Based on a Review of the NHIC Database (continued)

Scientific Name	Common Name	Habitat [b]	COSEWIC Status [a]	COSSARO Status [a]	OMNR Provincial Ranking [a]	Global Ranking [a]
Liatris cylindracea	Slender Blazing-star	Alvar, open grassland, and forest	—	—	S3	G5
Linum medium var. medium	Stiff Yellow Flax	Shoreline and wetland	—	—	S3	G5T?
Lithospermum caroliniense	Plains Puccoon	Sand dunes and open grassland*	—	—	S3	G4G5
Panax quinquefolius[c]	American Ginseng	Forest	END	END[d]	S3[d]	Not available
Graminoid						
Ammophila breviligulata	American Beachgrass	Sand dune and shoreline	—	—	S3	G5
Calamovilfa longifolia var. magna	Sand Reed Grass	Sand dune	—	—	S3	G5T3T5
Eleocharis rostellata	Beaked Spike-rush	Shoreline and wetland	—	—	S3	G5
Elymus lanceolatus ssp. psammophilus	Great Lakes Wheatgrass	Sand dune and shoreline	—	—	S3	G5T3
Scleria verticillata	Low Nutrush	Shoreline	—	—	S3	G5
Moss						
Pseudocalliergon turgescens	Moss sp.	All habitats where moisture regime permits growth*	—	—	S2	G3G5

Notes:

— Not Applicable
a Based on records in the NHIC database, unless otherwise noted [193].
b Habitat designations are based on those provided in *Significant Wildlife Habitat Technical Guide* [194], except where noted with *.
c This record is from the MacGregor Point Provincial Park where the species is considered to have been extirpated since 1997 [183].
d This ranking is based on a review of the *Significant Wildlife Habitat Technical Guide* [194]; NHIC does not provide ranking information for American ginseng on its searchable database.

Global Ranks:
G1 Extremely rare
G2 Very rare
G3 Rare to Uncommon

Table 6.4.7-1: Provincially Significant Plants in the Local Study Area Based on a Review of the NHIC Database (continued)

G4 Common
G5 Very Common
G#G# A numeric range rank (e.g., G2G3) is used to indicate any range of uncertainty about the status of the species or community
T Denotes that the rank applies to a subspecies or variety
G? Unranked, or, if following a ranking, rank tentatively assigned (e.g., G3?)

Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Designations:
END Endangered
THR Threatened
SC Special Concern
NAR Not at Risk

Provincial Ranks and OMNR Status:
S1 Critically Imperilled
S2 Imperilled
S3 Vulnerable
S#S# Range Rank —A numeric range rank (e.g., S2S3) is used to indicate any range of uncertainty about the status of the species or community. Ranges cannot skip more than one rank (e.g., SU is used rather than S1S4, where SU is currently unrankable because of the lack of information or because of substantially conflicting information about status or trends).
S? Not Ranked Yet; or if following a ranking, Rank Uncertain (e.g., S3?). S? species have not had a rank assigned.
THR Threatened
SC Special Concern
END-R Endangered (Regulated under the *Ontario Endangered Species Act*)
END Endangered (not regulated)

Source: [193;183;194]

6.4.7.3 Fauna

Table 6.4.7-2 presents the 23 wildlife species that are considered either endangered, threatened or of special concern by COSEWIC and/or COSSARO, and/or provincially ranked as vulnerable (S3), imperilled (S2) or critically imperilled (S1) in the Local Study Area, based on a review of the NHIC database and other relevant background literature sources. A list of provincially significant fauna found in the Regional Study Area can be found in Table 5.8.3-2 of the Terrestrial Environment TSD.

Table 6.4.7-2: Provincially Significant Wildlife Species in the Local Study Area Based on a Review of the Natural Heritage Information Centre Database

Scientific Name	Common Name	COSEWIC Status [b]	COSSARO Status [a]	OMNR Provincial Ranking [a]	Global Ranking [a]
Bird					
Ardea alba [d]	Great Egret	—	—	S2, SZN	G5
Aythya Americana [d]	Redhead	—	—	S2, SZN	G5

Table 6.4.7-2: Provincially Significant Wildlife Species in the Local Study Area Based on a Review of the Natural Heritage Information Centre Database (continued)

Scientific Name	Common Name	COSEWIC Status [b]	COSSARO Status [a]	OMNR Provincial Ranking [a]	Global Ranking [a]
Aytha valisineria	Canvasback	—	—	S1B,S2N	G5
Bucephala albeola[e]	Bufflehead	—	—	S3B, SZN	G5
Calidris alpine [d]	Dunlin	—	—	S3B, SZN	G5
Calidris melanotos [d]	Pectoral Sandpiper	—	—	SHB, SZN	G5
Haliaeetus leucocephalus [d]	Bald Eagle	NAR	SC	S4, SZN	G4
Lanius ludovicianus	Loggerhead Shrike	END	END-R	S2B,SZN	G4
Larus marinus	Great Black-backed Gull	—	—	S2B,SZN	G5
Melanerpes erythrocephalus [d]	Red-headed Woodpecker	SC	SC	S3, SZN	—
Nycticorax nycticorax	Black-crowned Night-heron	—	—	S3B,SZN	G5
Podiceps auritus[f]	Horned Grebe	—	SC	S1B, SZN	
Sterna caspia	Caspian Tern	NAR	NAR	S3B,SZN	G5
Chordeiles minor	Common nighthawk	THR	SC	S4B	G5
Contopus cooperi	Olive-sided flycatcher	THR	SC	S4B	G4
Caprimulgus vociferus	Whip-poor-will	—	SC	S4B	G5
Chaetura pelagica	Chimney swift	THR	SC	S4B, S4N	G5
Herpetofauna					
Clemmys guttata	Spotted Turtle	END	END	S3[c]	G5
Elaphe gloydi	Eastern Foxsnake	THR	THR (Georgian Bay)	S3	G3
Chelydra serpentina	Snapping turtle	SC	SC	S3	G5

Table 6.4.7-2: Provincially Significant Wildlife Species in the Local Study Area Based on a Review of the Natural Heritage Information Centre Database (continued)

Scientific Name	Common Name	COSEWIC Status [b]	COSSARO Status [a]	OMNR Provincial Ranking [a]	Global Ranking [a]
Lampropeltis triangulum	Eastern Milksnake	SC	SC	S3	G5
Thamnophis sauritus	Eastern Ribbonsnake	SC	SC	S3	G5
Regina septemvittata	Queen Snake	THR	THR	S2	G5

Notes:
— Not Applicable
a Based on records in the NHIC database, unless otherwise noted [193].
b Based on records in the COSEWIC database.
c This ranking is based on a review of the *Significant Wildlife Habitat Technical Guide* [194]; NHIC does not provide ranking information for spotted turtle on its searchable database.
d Based on records in the Ontario Breeding Bird Atlas [199].
e Presence based on field study conducted for *Bruce A Units 3&4 Restart Environmental Assessment Study Report* [200].
f Presence based on field study conducted for *2004 Annual Monitoring Report Environmental Assessment Bruce A Units 3 & 4 Restart Follow-up Program* [201].

Global Ranks:
G3 Rare to Uncommon
G4 Common
G5 Very Common

Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Designations:
END Endangered
THR Threatened
SC Special Concern
N/A Not Available

Provincial Ranks and OMNR Status:
S1 Critically Imperilled
S2 Imperilled
S3 Vulnerable
S4 Apparently Scarce
SH Possibly Extirpated (Historical)
S#B Indicates breeding and rank
SZN Non-breeding migrants/vagrants.
END-R Endangered (Regulated under the *Ontario Endangered Species Act*)
END Endangered (not regulated)

Source: [193;194;199;200;201]

6.5 AQUATIC ENVIRONMENT

The existing aquatic environment within the study areas is described in terms of the following component:

- **Aquatic Species and Communities**, which includes baseline information on macrophytes, fish, aquatic invertebrates and some aquatic habitat features.

For context, the description of existing conditions includes a description of aquatic habitat in which the aquatic species and communities live. The description of the existing environment includes field work completed for the DGR Project EA, as well as information compiled as part of other studies carried out on-site (as summarized in Section 6.1.2). By using current and historical data to describe the existing environment, the range and natural variability of populations over time is incorporated into the baseline for the aquatic environment.

6.5.1 Spatial Boundaries

The general study areas were adapted to encompass likely effects on the aquatic environment as follows:

- The **Regional Study Area**, shown on Figure 6.3.1-1, includes the lands bound by regional watersheds and extends 4 km offshore. To be consistent with the hydrological analysis of the DGR Project (presented in the Hydrology and Surface Water Quality TSD), the northern and southern limits of the Regional Study Area have been selected to include municipal Water Supply Plant intakes at Southampton and Kincardine. The Regional Study Area encompasses larger-scale aquatic biological resources and systems potentially affected by the DGR Project because of their interconnections, and consider its associations with biological resources and systems in the Site Study Area and Local Study Area.
- The **Local Study Area**, also shown on Figure 6.3.1-2, corresponds to the Stream C and Underwood Creek watersheds for the on-land (non-lake) portion. The Local Study Area also extends approximately 2 km offshore of the Bruce nuclear site into Lake Huron, from MacGregor Point Provincial Park in the north and approaches McRae Point in the south.
- The **Site Study Area and Project Area**, shown on Figure 5.1.3-1 were used without modification. The Site Study Area includes the nearshore waters of Lake Huron (small embayment immediately south of Bruce A known as McPherson Bay), which receive the surface water runoff from catchment areas draining water from portions of the Project Area. The Site Study Area also includes the lower section of the Stream C watershed, which drains the remainder of the Project Area.

6.5.2 Valued Ecosystem Components

Table 6.5.2-1 presents the VECs for the aquatic environment along with the rationale for their selection and the specific indicators used in the assessment. These VECs are consistent with those identified in the guidelines (see Appendix A1).

Table 6.5.2-1: VECs Selected for the Aquatic Environment

VEC	Rationale for Selection	Indicators	Measures
Redbelly Dace (*Chrosmus eos*)	• Inhabits quiet, slow flowing/sluggish creeks and ponds over a bottom of organic muck or vegetation • A common fish species in the South Railway Ditch and also inhabits Stream C • A valuable food resource for predatory fish and wildlife • May be affected by changes in surface water quality, quantity or flow	• Habitat	• Change in habitat quality and quantity
Creek Chub (*Semotilus atromaculatus*)	• Inhabits small, clear streams • A common fish species in the South Railway Ditch and Stream C • A valuable food resource for predatory fish and wildlife • May be affected by changes in surface water quality, quantity or flow	• Habitat	• Change in habitat quality and quantity
Brook Trout (*Salvelinus fontinalis*)	• Inhabits cold, well-oxygenated waters of streams, rivers and lakes • Brook trout are present in Stream C • May be affected by changes in surface water quality, quantity or flow	• Habitat	• Change in habitat quality and quantity
Variable Leaf Pondweed (*Potamogeton gramineus*)	• Found in shallow, non-flowing water such as the South Railway Ditch and Baie du Doré • An important cover for fishes, supports and shelters many aquatic invertebrates, and is an indicator of habitat type/quality	• Habitat	• Change in habitat quality and quantity
Burrowing Crayfish (*Fallicambarus fodiens* and *Orconectes immunis*)	• Inhabit marshy fields, drainage ditches, marshes, ponds, shallow, slow moving streams with muddy substrates and rooted aquatic vegetation • Inhabits the marsh and all the drainage ditches including the North and South Railway Ditches within the Project Area • Both species build burrows to escape drying habitats associated with seasonal water level fluctuations • Requires clayey soils for burrow construction • May be affected by changes in water quality, quantity or flow	• Habitat	• Change in habitat quality and quantity

Table 6.5.2-1: VECs Selected for the Aquatic Environment (continued)

VEC	Rationale for Selection	Indicators	Measures
Lake Whitefish (*Coregonus clupeaformis*)	• Historically important species for Aboriginal and non-Aboriginal commercial fisheries around Lake Huron • Focus of concern on other EAs on the Bruce nuclear site • Utilizes shoals north of Baie du Doré and areas off Gunn Point for spawning and rearing • May be affected by changes in surface water quality, quantity or flow	• Habitat	• Change in habitat quality and quantity
Spottail Shiner (*Notropis hudsonius*)	• Inhabits large rivers and lakes, in sandy or rocky shallows with sparse vegetation • A common fish species in MacPherson Bay, Baie du Doré and Stream C • An important prey species for other fish and birds, as well as an important bait fish for anglers • May be affected by changes in surface water quality, quantity or flow	• Habitat	• Change in habitat quality and quantity
Smallmouth Bass (*Micropterus dolomieui*)	• Important sport fish, which reproduces in the Baie du Doré coastal wetland, and Bruce A and B discharges • May be affected by changes in surface water quality, quantity or flow	• Habitat	• Change in habitat quality and quantity
Benthic Invertebrates	• Valuable food resource for higher trophic levels • Inhabit a wide variety of permanent, intermittent and ephemeral aquatic habitats • Remain in a localized area and may therefore respond to localized changes in the aquatic environment • May be affected by changes in surface water quality, quantity or flow	• Habitat	• Change in habitat quality and quantity

6.5.3 Aquatic Habitat and Biota

At the regional scale, the major watersheds are the Saugeen River watershed and the Sauble River watershed. These watersheds are naturally diverse, supporting a variety of both natural and anthropogenic (man-made) habitats, including wetlands, warm and coldwater streams, springs, ponds and inland lakes. All watercourses and waterbodies ultimately empty into Lake Huron.

The Local Study Area includes both the Stream C and Underwood Creek drainage areas and the Site Study Area includes MacPherson Bay, a portion of Stream C and a portion of Baie du Doré. Stream C is a diverted drainage channel that has become naturalized over time. Stream C crosses through the southeastern portion of the Project Area; however, the DGR Project site does not provide any natural aquatic habitat. An illustration of the location of these aquatic features are provided on Figures 6.3.1-1 and 6.3.1-2. The discussion of aquatic habitat and biota focuses on: the South Railway Ditch, Stream C, and Lake Huron and embayments (including MacPherson Bay and Baie du Doré). Figure 6.5.3-1 illustrates the location of these features.

6.5.3.1 South Railway Ditch

The South Railway Ditch drains the WWMF site as well as three discharge pipes from the facilities on the WWMF site. The Saugeen Valley Conservation Authority (SVCA) classified the South Railway Ditch as fish habitat [93].

The South Railway Ditch is straight with a channel width of approximately 5 m at the top of the bank throughout its reaches within the Project Area. During the habitat reconnaissance and fish collection conducted in 2007, flow was stagnant in the ditch. Historical investigations of the ditch documented a wetted channel width of 3 m and a mean water depth of 0.15 m [89]. The channel is choked with thick stands of cattail in some places, which serves to reduce water velocity, thus minimizing erosion and increasing the rate of settling for sediments that may enter the ditch system. There were also open channel sections that appear to have been subjected to clean-out/dredging in the past. Fish were caught in 2007 in these open channel sections in water depths of 0.2 to 0.25 m. The banks are stabilized with a mix of grasses and other herbaceous species, shrub species and trees.

Aquatic invertebrate life in the South Railway Ditch includes leeches (*Macrodbella decora* and *Placobdella ornata*) and snails (*Helisoma spp*., *Lymnaea spp*., and *Physidae physa*) [202]. Aquatic crayfish are also common [188;203;202]. These aquatic crayfish are different species than the burrowing crayfish species discussed.

The dominant aquatic macrophyte in the South Railway Ditch is cattail (*Typha spp*.). In areas of the ditch that appeared to have been recently dredged, five other macrophyte species occur: muskgrass (*Chara sp*), variable leaf pondweed, sago pondweed (*Stuckenia pectinata*), floating leaf pondweed (*Potamogeton natans*) and water plantain (*Alisma plantago-aquatica*). All the aquatic macrophyte species observed are common and widespread throughout southern Ontario.

The South Railway Ditch supports a warmwater baitfish community. Six fish species were identified in the South Railway Ditch during the 2007: brassy minnow (*Hybognathus hankinsoni*); brook stickleback (*Culaea inconstans*); central mudminnow (*Umbra limi*); creek chub (*Semotilus atromaculatus*); fathead minnow (*Pimephales promelas*); and redbelly dace. These fish represent a mix of species that are typical of warmwater creeks and wetland conditions, and are tolerant of a wide range of environmental conditions. These species are common and wide-spread throughout central and southern Ontario.

The terrestrial burrowing crayfish species *Orconectes immunis* and *Fallicambarus fodiens* are found in and adjacent to the South Railway Ditch (as well as in wetland areas) as is evident by the observations of crayfish chimneys in the Project Area during the 2006, 2007 and 2009 field investigations [204]. The locations of the burrows observed from combined studies within the Project Area are shown on Figure 6.5.3-2. The two burrowing crayfish species identified as VECs (*O. immunis* and *F. fodiens*) are ranked S4 by the Natural Heritage Information Centre (NHIC), which is a section of the Ontario Ministry of Natural Resources (OMNR). A rank of S4 indicates that they are secure species in Ontario and the NHIC describes them as common species in Ontario. The World Wildlife Fund and the Canadian Nature Federation have offered the opinion that they feel *F. fodiens* is threatened in Ontario [205].

6.5.3.2 Stream C

Stream C is generally located to the east of the Project Area. It is a former tributary of the Little Sauble River that was diverted to Baie du Doré during the initial development of the Bruce nuclear site in the 1960s. It is the largest stream entering Baie du Doré.

The reach upstream (south) of the abandoned rail bed consists of a shallow, braided channel through low-lying areas dominated by eastern white cedar and cattails. Watercress (indication of a groundwater fed stream) was observed in-stream at the culvert. Downstream (north) of the point where Stream C crosses beneath the abandoned rail bed, there is an approximately 15 m long, 1.5 m deep outlet pool. This pool contained schools of minnows (some identified as northern redbelly dace). The main channel downstream of the outlet pool ranges from 3 to 4 m wide (wetted) and consists mostly of flats with some pools and riffles. Further downstream, Stream C flows through an approximately 2.5 m wide culvert under the North Access Road, where it exits the Bruce nuclear site. Flow velocity and water depth within this reach of Stream C are likely influenced by the backwater effect from Baie du Doré/Lake Huron. A description of Stream C morphology is provided in Section 6.3.4.4.

Stream C is designated by Fisheries and Oceans Canada (DFO) as coldwater fish habitat, as the fish community includes brook trout (*Salvelinus fontinalis*), rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*). Spawning activity of brook trout, rainbow trout, brown trout and chinook salmon (*Onchorynchus tshawytscha*) has also been documented in this stream [206]. Various sucker (*Castostomus spp*) and cyprinid species including spottail shiner are also known to inhabit or have been observed in Stream C [207]. In July 2007, the pools located immediately downstream (north) of where Stream C crosses the abandoned rail bed and immediately upstream (south) of the North Access Road were sampled for fish. Given the warm surface water temperatures observed in July, these locations appeared to be providing coldwater refugia. A total of 14 different fish species were captured including spottail shiner, rainbow darter, creek chub and central mudminnow. Brook trout, both adults and juveniles, were only captured in the pool immediately upstream of the North Access Road. However, previous studies have documented the presence of rainbow trout, brown trout and brook trout in the pool immediately downstream of the abandoned rail bed [206]. There were no barriers to fish flow noted in the reaches downstream of the abandoned rail bed during the 2009 aquatic habitat assessment.

0 125 250 500

Metres

LEGEND

- Stream
- Ditch and Flow Direction
- Stream C Habitat Survey
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]

ELC Group

- Marsh
- Swamp

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

AQUATIC FEATURES ON THE SITE

Golder Associates
Mississauga, Ontario

PROJECT No. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	**FIGURE 6.5.3-1**	
GIS	BC	22 Apr. 2010		
CHECK	AB	22 Apr. 2010		
REVIEW	MAR	22 Apr. 2010		

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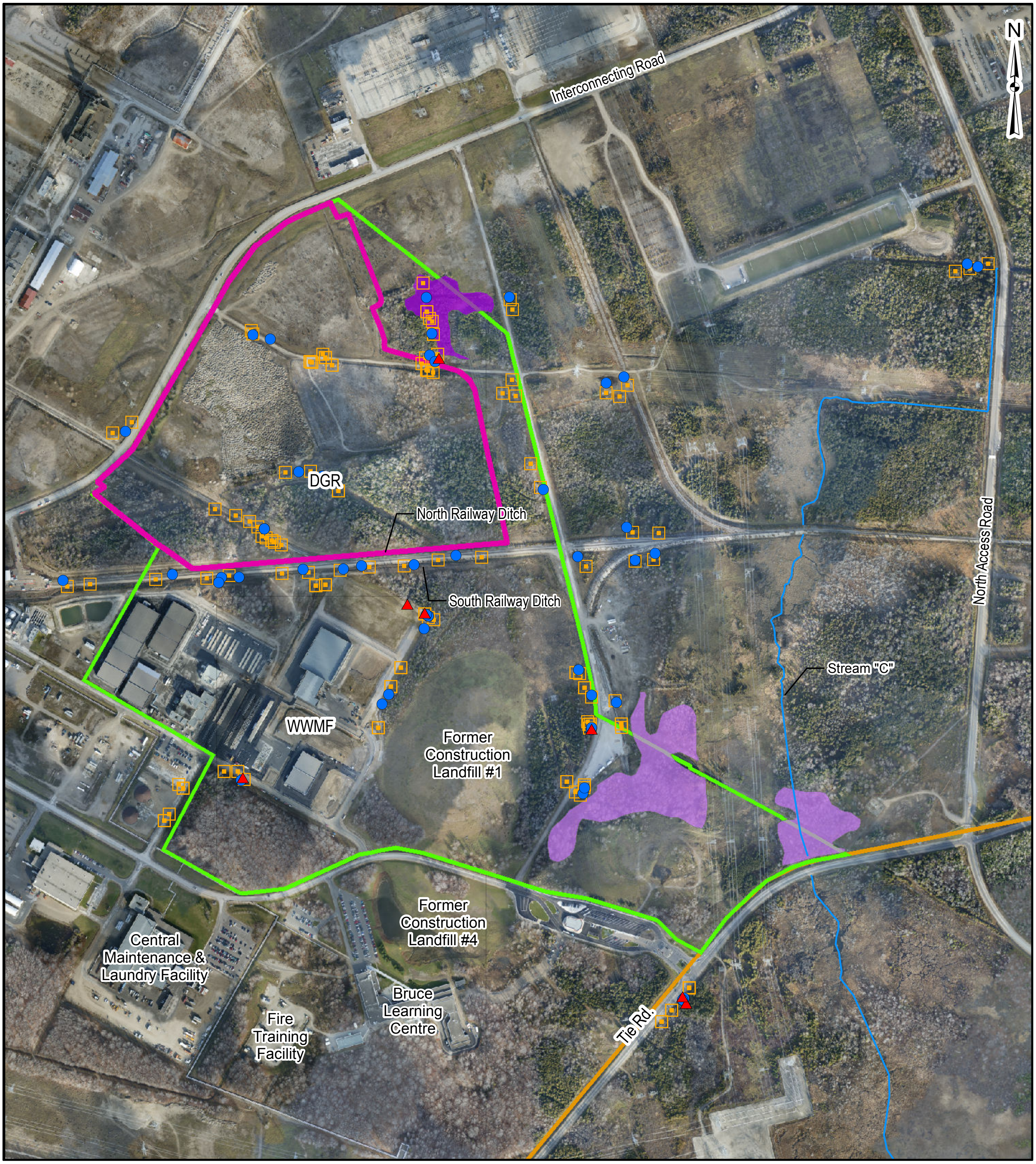

0 125 250 500

Metres

LEGEND

- Trap
- Chimney
- Crayfish Caught
- DGR Project Site
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]

ELC Group

- Marsh
- Swamp

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, Nov 2007. Chimmney & Trap: Source [204]
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

LOCATION OF CRAYFISH CHIMNEYS IN THE PROJECT AREA

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	**FIGURE 6.5.3-2**	
GIS	BC	15 Apr. 2010		
CHECK	AB	15 Apr. 2010		
REVIEW	MAR	15 Apr. 2010		

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6.5.3.3 Lake Huron and the Embayments

Within Lake Huron near the Bruce nuclear site there are two main habitats, the near shore and offshore. The near shore habitat consists mainly of rocky areas which are exposed to the wind and wave action of the Lake Huron shoreline (e.g., MacPherson Bay) and sheltered bays such as Baie du Doré, which provide a more constant environment, protected from wave and current action. Offshore habitat consists of the deep, cool, open waters of Lake Huron.

In the open waters of Lake Huron the species encountered are those that are well adapted to the cold water and utilize open lake or deeper coastal habitats for the majority of their life cycles or the majority of the year. Species included in this category are round whitefish (*Prosopium cylindraceum*), lake whitefish, lake trout (*Salvelinus namaycush*) and deepwater sculpin (*Myoxocephalus thompsoni*). Most make use of the nearshore areas only during spawning and prefer offshore deeper waters, particularly during the warmer summer months. Studies focusing on lake whitefish and round whitefish spawning in the vicinity of the Bruce nuclear site indicated that larvae of both species are present in the spring, but in lower numbers than at a reference sampling sites located north of the Bruce nuclear site, where extensive spawning shoals exist [207].

The exposed nearshore environment of MacPherson Bay is continually being swept out by wave action allowing for large coarse substrates to persist and fine substrates to be transported out of the bay to open water. By comparison, Baie du Doré is a calmer environment with depositional areas in the inner portion where fine sediments (sand) accumulate. The deposition of fine sediments allows for an increase in productivity because of the establishment of primary producers (e.g. aquatic macrophytes such as variable leaf pondweed) in Baie du Doré and a more stable/productive temperature regime for many species. It has been previously noted that Baie du Doré is the most important rearing and nursery area in the Local Study Area, and is used by many fish species [207;208;209]. Some small streams (e.g., Stream C) and creeks enter the inner portion of Baie du Doré, providing additional habitat.

Fish found in the nearshore areas such as the inner, protected portion of the Baie du Doré are generally warmwater species. Shallow shoal areas within Baie du Doré provide spawning, nesting, rearing and feeding habitats for fish. Species known to use this habitat are smallmouth bass, northern pike (*Esox lucius*), spottail shiner and bowfin (*Amia calva*) [207;208;209]. Smallmouth bass are common in the discharge channels of the Bruce A and B generating stations and Baie du Doré, and have been observed spawning in these areas [207;208;209].

Because MacPherson Bay is not sheltered from coastal effects, its function as fish habitat is restricted. The coarse substrates in the bay limit primary production (growth of aquatic macrophytes) and offers little by way of cover for fish in its clear shallow waters. MacPherson Bay is unsuitable for critical life history functions of many fish species (e.g., spawning/nursery areas for many species including smallmouth bass and pike), and likely offers minimal foraging opportunities for some species and very limited spawning and nursery habitat for a small proportion of the populations of a few coastal species like the invasive round goby and bluntnose minnow. During the 2007 aquatic field program, 14 species of fish were caught in the shallow nearshore waters of MacPherson Bay, seven of which are generally regarded as nearshore species. These were round goby (*Neogobius melanostomus*), spottail shiner, white sucker (*Catostomus commersoni*), longnose gar (*Lepisosteus osseus*), emerald shiner (*Notropis* *atherinoides*), spotfin shiner (*Notropis spilopterus*) and bluntnose minnow (*Pimephales notatus*). Round gobies accounted for 78% of the catch by numbers and are an invasive species to the Great Lakes.

The continual wave and current action along the shoreline creates unstable substrates and promotes continual removal of fine substrates (prohibits deposition) and rapid dilution of suspended sediments. Prior to commissioning of Bruce A, the benthic invertebrate community was observed to be characteristic of the unstable, relatively severe conditions typically found on exposed coastlines in the Great Lakes. Several studies undertaken since the commissioning of Bruce A have shown that the benthic invertebrate communities in the wave-washed nearshore zone are reduced in both density and diversity of organisms, and that only a few species are able to colonize this hostile habitat [174;209]. No organisms were observed on the exposed bedrock surfaces, which is evidence that physical conditions or exposure to predation may render these areas too harsh for colonization by most benthic organisms. Similarly, it was found that the abundance and diversity of benthic invertebrates was limited in sandy depositional areas; however, it was noted that, in general, diversity and abundance of benthic invertebrates is highest within Baie du Doré.

Several drainage ditch/stormwater conduits drain the Bruce nuclear site and discharge to McPherson Bay. The majority (41.3 ha) of the northern portion of the Project Area is drained by a ditch that runs alongside Bruce A to empty into MacPherson Bay (see Figure 6.3.4-2). The SVCA did not categorize this ditch as providing fish habitat [93].

Overall, Baie du Doré and its largest tributary (i.e., Stream C) are considered more diverse, sensitive and productive than MacPherson Bay and its man-made, drainage ditch tributaries.

6.5.3.4 Other Potential Aquatic Habitat

Other potential aquatic habitats include those areas of the Project Area that may support aquatic VECs (e.g., burrowing crayfish) that are not designated by the SVCA. This includes the marsh and swamp in the Project Area, the North Railway Ditch, and other drainage ditches within the Project Area.

There are two wetland features within the Project Area (see Figure 6.5.3-1). The vegetation communities within the Site Study Area have been classified according to Ecological Land Classification for Southern Ontario (ELC) [180] as discussed in Section 6.4.3.1. One of the communities located in the southeast portion of the Project Area is classified as a seasonal swamp. It is approximately 3.1 ha. The other wetland community, located in the northern portion of the Project Area, is a marsh and is approximately 0.9 ha in size.

Burrowing crayfish species *F. fodiens* and *O. immunis* were observed within the Project Area (Figure 6.5.3-2) in both wetland communities as well as within the North and South Railway Ditches and an abandoned railway spur. Field study results also indicate that burrowing crayfish populations are present within the Local and Regional Study Areas in areas where suitable wetland and soil conditions exist.

6.6 RADIATION AND RADIOACTIVITY

This section describes the existing conditions of ionizing radiation and radioactivity in the environment. These environmental conditions reflect the current situation of the area where the DGR Project will be implemented and the status of other nuclear facilities at the Bruce nuclear site, including the WWMF, nuclear power generating stations Bruce A and Bruce B, and the Central Maintenance and Laundry Facility (CMLF).

The existing radiation and radioactivity within the study areas is described in terms of the following components:

- **Radioactivity in the Atmospheric Environment**, which includes gamma radiation, gaseous radioactivity and radioactive particulate in air and precipitation;
- **Radioactivity in Surface Water**, which includes radioactivity in Lake Huron and nearby municipal water supply plants;
- **Radioactivity in the Aquatic Environment**, which includes radioactivity in sediments, fish and radiation doses to aquatic biota;
- **Radioactivity in the Terrestrial Environment**, which includes radioactivity in vegetation, animals and foods, soil and radiation doses to terrestrial biota;
- **Radioactivity in Groundwater**, which includes radioactivity in soils, shallow wells recharged with precipitation and deep wells;
- **Radiation Doses to Members of the Public**, which includes the doses received by the most exposed members of the public; and
- **Radiation Doses to Workers**, which includes the doses received by nuclear energy workers and other staff on the Bruce nuclear site.

To provide context, background sources of radiation and radioactivity and radioactive releases to the environment are also discussed. For further details please refer to the Radiation and Radioactivity TSD.

6.6.1 Spatial Boundaries

The general study areas described in Section 5.1 and shown on Figures 5.1.1-1, 5.1.2-1 and 5.1.3-1, were adapted, without change, to assess the DGR Project-related likely effects of radiation and radioactivity.

6.6.2 Valued Ecosystem Components

Table 6.6.2-1 presents the VECs for radiation and radioactivity along with the rationale for their selection and the specific indicators and measures used in the assessment.

Table 6.6.2-1: VECs Selected for Radiation and Radioactivity

VEC	Rationale	Indicators	Measures
Humans	• Nuclear Energy Workers (NEWs)[12] are expected to receive radiation doses as a result of the DGR Project	• NEWs	• Dose to NEWs
	• Other workers at the Bruce nuclear site (non-NEWS) are expected to receive minimal radiation doses during site preparation and construction, operations and decommissioning phases as a result of the DGR Project	• Other workers (non-NEWs)	• Dose to non-NEWs
	• Members of the public living and working in the vicinity of the DGR Project site are expected to be exposed to very low doses of radiation from the DGR Project	• Members of the public including Aboriginals	• Dose to members of the public
Benthic Invertebrates	• There is a potential that aquatic species will be exposed to radiation as a result of the DGR Project	• Burrowing crayfish	• Dose to aquatic indicator species
Aquatic Vegetation		• Variable leaf pondweed	
Benthic Fish		• Lake whitefish • Redbelly dace • Creek chub	
Pelagic Fish		• Spottail shiner • Smallmouth bass • Brook trout	
Aquatic Birds		• Double-crested cormorant • Mallard	

[12] Nuclear Energy Worker (NEW) is defined as a person who is required, in the course of the person's business or occupation in connection with a nuclear substance or nuclear facility, to perform duties in such circumstances that there is a reasonable probability that the person may receive a dose of radiation that is greater than the prescribed limit for the general public [210].

Table 6.6.2-1: VECs Selected for Radiation and Radioactivity (continued)

VEC	Rationale	Indicators	Measures
Aquatic Mammals		• Muskrat	
Terrestrial Invertebrates	• There is a potential that terrestrial species will be exposed to radiation as a result of the proposed DGR Project	• Earthworm	• Dose to terrestrial indicator species
Terrestrial Vegetation		• Eastern white cedar Common cattail • Heal-all	
Terrestrial Birds		• Bald eagle • Yellow warbler • Wild turkey • Red-eyed vireo	
Terrestrial Mammals		• White-tailed deer • Northern short-tailed shrew • Red fox	
Amphibians and Reptiles		• Midland painted turtle • Northern leopard frog	

6.6.3 Background Sources of Radiation and Radioactivity

This section describes radiation and radioactivity that is present in the environment from natural and anthropogenic sources such as the fallout from nuclear weapons testing. Baseline conditions are those existing in 2009, to the extent that information is available.

The following discussion is based on the data from provincial and national areas that are not influenced by releases of radiation and radioactivity from nuclear facilities at the Bruce nuclear site. Nevertheless, the background levels are expected to apply equally to the Regional, Local and Site Study Areas defined for this work.

6.6.3.1 Dose from Natural Radiation

The magnitudes of radiation dose from natural sources vary greatly — both spatially and temporally — and are mainly attributable to:

- ionizing radiation from cosmic rays;
- naturally occurring radionuclides in air, water and food; and
- naturally occurring radionuclides in the soil, rocks and building materials used in homes.

Cosmic rays are high-energy particles from the sun and other galactic sources, which deliver radiation doses to people at all latitudes. Cosmogenic radionuclides, such as carbon-14, are formed in the atmosphere as a result of cosmic rays. The average annual dose from cosmic radiation in Canada is approximately 300 microSieverts per year (μSv/a) [211].

Naturally occurring radionuclides, such as potassium-40 and other isotopes from the decay chains of uranium and thorium, are present in soils, rocks and building materials used in homes. They contribute to the external gamma radiation dose. The average annual dose from external gamma radiation from the ground is estimated to be approximately 350 μSv/a [211].

Therefore, the total external gamma dose from cosmic rays and radionuclides on the Earth's surface is about 650 μSv/a. Health Canada measured total external dose rates in 26 cities across Canada [212]. The monitoring data show the variability of external gamma dose across the country and indicate that, at a given location, the external gamma dose rate can be up to 60% higher than the national average. For example, a recent measurement in 2009 [213] showed that the annual dose at 26 stations across Canada ranged from 201 μSv in Resolute, Nunavut to 578 μSv in Montreal, Quebec and Yellowknife, Northwest Territories, with a mean of 365 μSv (assuming 1 Sievert = 1 Gray). In Ontario, the external gamma dose measured at four stations in 2009 ranged from 272 μSv to 569 μSv.

Uranium and thorium decay chains and potassium-40 enter the body through the ingestion of food, the consumption of water and the inhalation of air. These media all contain naturally occurring radioactivity that was incorporated from surrounding soils and rock. The average internal dose from this source in a typical human body is 350 μSv/a [211].

Radon gas and its radioactive decay products often contribute the highest annual dose from naturally occurring radioactivity. Based on approximately 14,000 measurements across Canada, the annual effective inhalation dose related to radon-222 and radon-220 was calculated at 926 μSv/a. Radon gas is a product of the decay of uranium series radionuclides in soil. The three-month summer average has been measured at 5 to 103 Becquerels per cubic metre (Bq/m^3) in outdoor air in cities across Canada [214]. Radon gas also passes through foundation walls into building basements and accumulates to higher levels on all floors indoors. The average dose from radon and its radioactive decay products in the air of houses in different Canadian cities ranges from approximately 200 to 2,200 μSv/a [211], depending on the concentration of radionuclides in soil, rock and groundwater, as well as building ventilation rates.

The total population-weighted average annual effective dose to Canadians from all sources of natural background radiation was estimated to be 1,769 μSv/a [215]. However, there are wide variations in radioactivity concentrations in soil and surrounding materials and in external gamma fields. Because of these factors, a wide range of annual doses from natural sources is observed, which could be up to 3,000 μSv/a [211].

6.6.3.2 Background Levels of Tritium

Tritium is produced in the atmosphere by the interaction of cosmic radiation and elements in the atmosphere. Tritium is also present in the environment as a result of the atmospheric testing of nuclear weapons and as a by-product of nuclear power generation. Annual average tritium concentrations in air at background sites in Ontario were reported as less than the detection limit in 2009 [216] .

In 2006, the average tritium concentration in precipitation at background sites across Canada was found to be less than 3.7 Bq/L in Calgary, Alberta and Saskatoon, Saskatchewan and 6.8 Bq/L in Fredericton, New Brunswick [217]. Precipitation is potentially a source of drinking water via surface water and shallow groundwater systems. In 2009, the tritium concentration in drinking water supplies at background sites across Ontario averaged 3.0 Bq/L [216].

The mean concentrations of tritium in water in vegetation samples collected in 2009 at background sites in Ontario (i.e., Sarnia, Picton and Bancroft) ranged from 3.0 Bq/L at Sarnia to 6.7 Bq/L at Picton [216]. These concentrations of tritium in vegetation are expected to be typical of the values across Ontario because of long-term and long-range mixing in the atmosphere.

6.6.3.3 Background Levels of Carbon-14

Carbon-14, present in air as carbon dioxide, is ubiquitous in the atmosphere because of the interaction of cosmic radiation and nitrogen, oxygen and carbon in the atmosphere. It may also be produced by atmospheric testing of nuclear weapons. Carbon-14 can be incorporated into all living tissues (e.g., plants, terrestrial organisms and aquatic organisms) through the photosynthetic uptake by plants and subsequently through the food web.

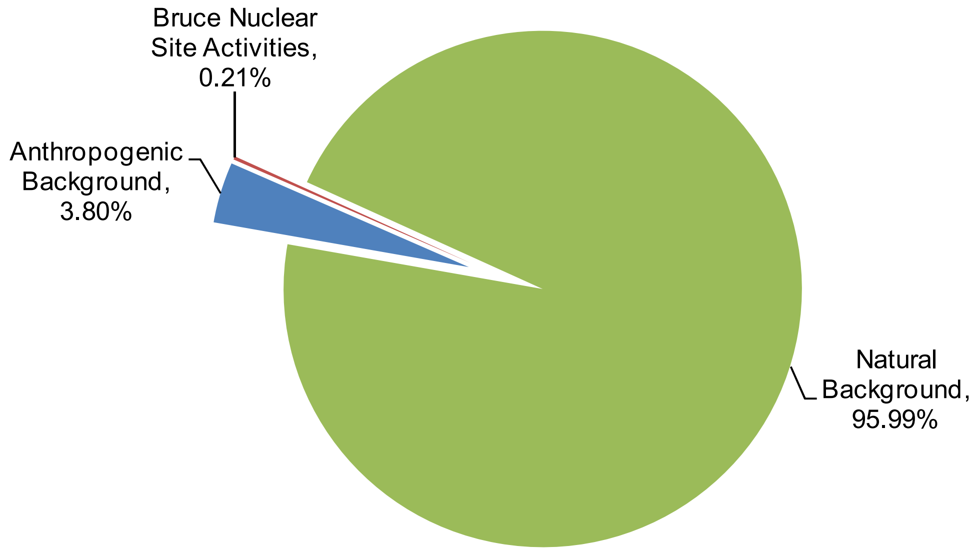
Levels of carbon-14 in biota were determined in 2009 at several Ontario background sites. The current background level of carbon-14 in vegetation at these sampling sites ranged from 222 Becquerels per kilogram carbon (Bq/kg-C) in Picton to 232 Bq/kg-C in Bancroft [216]. Prior to atmospheric testing of atomic weapons, background carbon-14 levels were measured at 226 Bq/kg-C [218]. Given the relatively long half life of carbon-14 (~5,700 years), these data indicate weapons testing did not produce noteworthy amounts of this radionuclide across Ontario.

6.6.3.4 Other Sources of Human Exposure

Other sources of human exposure include:

- radionuclides in atmosphere, soil and water from global fallout from open-air nuclear weapons testing, Chernobyl accident and satellite accidents;
- consumer products (e.g., cigarettes, smoke detectors and cathode ray tube type colour televisions and computer monitors);
- waste from human activities concentrating and/or releasing naturally occurring radionuclides (e.g., coal power plants, abstraction of oil and gas, smelting metals, manufacturing of fertilizer and building materials);
- medical procedures involving exposure (e.g., diagnostics and radiotherapy); and
- exposure to cosmic rays during long-haul flights as a result of the lack of protection from the atmosphere.

Figure 6.6.3-1 compares the dose to humans (represented by the critical group identified in Bruce Power's Radiological Environmental Monitoring Program) as a result of all activities at the Bruce nuclear site in relation to background doses in Ontario, Canada. The total dose represented by this figure is approximately 2,100 μSv/a [216].



Source: [216]

Figure 6.6.3-1: Public Dose Attributed to Bruce Nuclear Site in Relation to Background Doses in Ontario

6.6.4 Radioactive Releases to the Environment

There are no significant anthropogenic sources of radiation and radioactivity within the Regional Study Area, except the facilities at the Bruce nuclear site. Therefore, this section focuses on the radioactive releases from facilities at the Bruce nuclear site, including Bruce A, Bruce B, the WWMF and the CMLF.

6.6.4.1 Releases to Air

The total annual radiological releases to air from four facilities on the Bruce nuclear site during 2009 are shown in Table 6.6.4-1. Bruce A and Bruce B are the major contributors of airborne emissions at the Bruce nuclear site. In 2009, radionuclide emissions to air from these two facilities were 1.54×10^{15} Bq, which amounts to over 97% of the total release to air from the Bruce nuclear site [216]. Airborne emissions from the WWMF account for a small portion of the total release from the Bruce nuclear site. All releases from the WWMF were far less (<0.1%) than the corresponding annual Derived Release Limits (DRLs). The DRL is the limit at which the release of a radionuclide occurring from a nuclear facility will not result in doses to individual members of the public exceeding the dose limits set by the CNSC.

Table 6.6.4-1: 2009 Annual Releases to Air in Gaseous Effluent from Bruce Nuclear Site

Parameter	Total Release from Bruce Nuclear Site (Bq)	Release from WWMF [a]	
		(Bq)	(% of Total)
Tritium Oxide	1.44×10^{15}	4.95×10^{13}	3.44
Noble Gas	1.44×10^{14}	n/a [b]	n/a
Iodine-131	6.04×10^{7}	6.45×10^{4}	0.11
Radioactive Particulate	1.22×10^{8}	4.08×10^{4}	0.03
Carbon-14	2.45×10^{12}	3.92×10^{9}	0.16

Notes:
a Fugitive emissions are not included in WWMF emissions data.
b Noble gases are not released from the WWMF.
n/a Not available
Source: [216]

6.6.4.2 Releases to Water

The total annual releases of radioactivity to water from facilities on the Bruce nuclear site during 2009 are shown in Table 6.6.4-2. Waterborne emissions from the WWMF account for a small portion of the total release from the Bruce nuclear site. Water collected from structures in the WWMF, such as sumps in the Low Level Storage Buildings (LLSBs) and some of the in-ground containers are transferred to the Bruce A Active Liquid Waste System for treatment and discharge. As shown in Table 6.6.4-2, waterborne emissions of tritium from the WWMF in 2009 were 8.83×10^{10} Bq, which was less than 0.01% of the total release of tritium to water from the Bruce nuclear site [216].

Table 6.6.4-2: 2009 Annual Releases to Water in Liquid Effluent from Bruce Nuclear Site

Parameter	Total Release from Bruce Nuclear Site (Bq)	Release from WWMF	
		(Bq)	(% of Total)
Tritium Oxide	6.28×10^{14}	8.83×10^{10}	0.01
Gross Beta-gamma Activity	3.49×10^{9}	1.23×10^{8}	3.52

Source: [216]

However, it was observed that the action level for the emission of gross beta, 1×10^{7} Bq/month, was exceeded in 2009 [219;220;221]. Initial investigations indicated that there was no evidence of an operational occurrence to cause the exceedance, and the exceedances were because of the use of road salt as a de-icing compound on the asphalt surfaces at the WWMF and the lab techniques, which could lead to overestimating the gross beta concentration [219;221].

6.6.5 Radioactivity in the Environment

The following sections summarize the monitoring results, including tritium in air, tritium in precipitation, radioactive particulate, carbon-14 in air and radioactive noble gas, for 2009. Bruce Power and Health Canada routinely measure the concentrations of selected radionuclides in the atmosphere at designated locations in the study areas and across the province. These measurements reflect the concentrations of natural background and anthropogenic radioactivity as described previously, and the concentrations of radioactivity attributable to releases from nuclear facilities at the Bruce nuclear site, most notably Bruce A and Bruce B. Sampling locations in the Local and Regional Study Areas are shown on Figures 6.6.5-1 and 6.6.5-2, respectively.

6.6.5.1 Tritium in Air

Airborne tritium release takes place in the form of gaseous tritiated water (HTO) and elemental tritium. Tritium concentrations in air are measured on a regular basis by Bruce Power at locations in the vicinity of the Bruce nuclear site and at a number of more distant locations, including Paisley, Port Elgin and Kincardine. The tritium concentrations in air measured by the active sampling method in 2009 are summarized in Table 6.6.5-1. In general, tritium concentrations in air decrease with distance from the sources because of atmospheric dispersion. The concentration of tritium in air also varies with direction, with the highest concentration being measured in the direction down gradient of the prevailing wind.

During 2009, the average concentrations of airborne tritium in the Local Study Area ranged from 0.82 Bq/m³ at Site B11 to 3.08 Bq/m³ at Site B4 (shown on Figure 6.6.5-1). The corresponding average concentrations of airborne tritium in the Regional Study Area ranged from 0.2 Bq/m³ in Paisley (Site B6) to 0.36 Bq/m³ in Kincardine (Site B9, as shown on Figure 6.6.5-2)[13] [216]. These concentrations are substantively higher than the provincial average level of 0.03 to 0.05 Bq/m³ measured at Nanticoke and Lambton [222].

Table 6.6.5-1: 2009 Annual Average Tritium Concentrations in Air (Bq/m³)

Location	2009
Local Study Area	
B2	2.80
B3	2.18
B4	3.08
B5	1.35
B7	2.49
B10	1.31

[13] Bruce A recorded high levels of airborne tritium because of Vault Vapour Recovery not performing to its design capabilities. Procedures and processes are being improved to reduce emissions, and preventative maintenance and monitoring are being enhanced to identify maintenance requirements.

Table 6.6.5-1: 2009 Annual Average Tritium Concentrations in Air (Bq/m^3) (continued)

Location	2009
B11	0.82
Regional Study Area	
B6	0.20
B8	0.27
B9	0.36
Provincial Locations	
Lambton	0.05
Nanticoke	0.03

Source: [223]

6.6.5.2 Tritium in Precipitation

Tritium levels observed in precipitation are related to the concentration of tritium in air, as rain or snow scavenge the tritium and fall to the ground. Precipitation can be a significant component in the recharge of shallow groundwater aquifers, which may be used as a source of drinking water in the region. This is a potential pathway for human exposure. For this reason, the tritium concentration in precipitation is compared to the Ontario Drinking Water Quality Standards (ODWQS) limit for tritium of 7,000 Bq/L [224].

Annual average tritium concentrations in precipitation for 2009 ranged from 14.3 to 274.6 Bq/L as shown in Table 6.6.5-2. Average concentrations at all monitoring locations were well below the ODWQS of 7,000 Bq/L for drinking water [224]. Within the Site Study Area, tritium in precipitation was monitored at the WWMF during the period of 2000 to 2002. The mean tritium concentration measured at the WWMF ranged between 371 and 1,440 Bq/L [225].

Table 6.6.5-2: 2009 Annual Average Tritium Concentrations in Precipitation (Bq/L)

Location	2009
Local Study Area	
B2	274.6
B3	132.0
B4	235.2
B5	125.8
B7	158.3
B10	119.3
B11	75.3

Table 6.6.5-2: 2009 Annual Average Tritium Concentrations in Precipitation (Bq/L) (continued)

Location	2009
Regional Study Area	
B6	14.3
B8	21.6
B9	14.8

Source: [223]

6.6.5.3 Radioactive Particulate

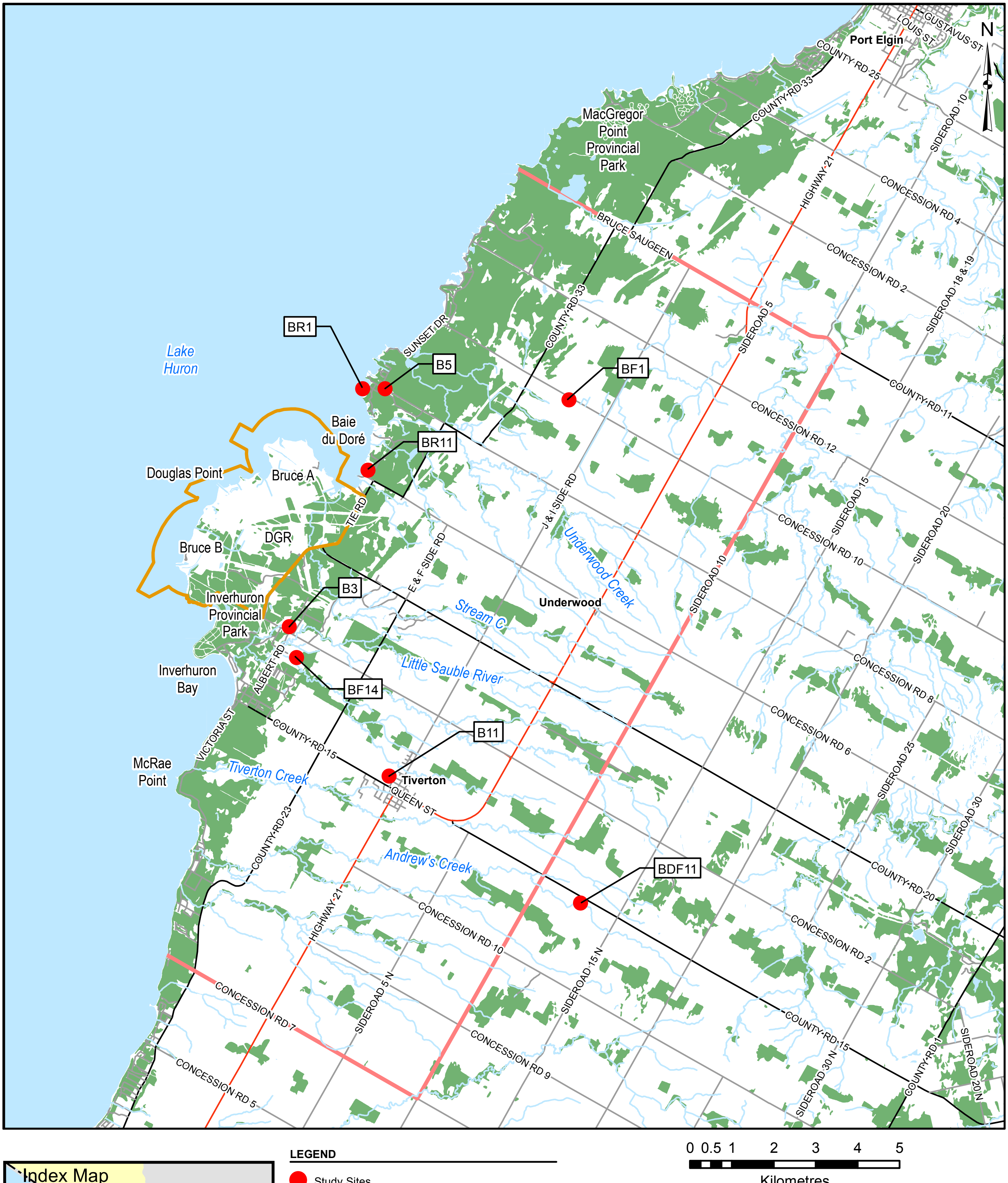
The deposition of radioactive particulate can result in the long-term accumulation of long-lived radionuclides onto the surfaces of vegetation and the ground. This can contribute to the external gamma dose to humans and other terrestrial biota. Also these radionuclides can enter the food web by deposition onto plants and uptake from the soil.

Bruce Power measures radioactive particulate deposition rates at the same locations used for sampling tritium in air. The rates in 2009 ranged from 14.9 to 19.5 Bq/m^2 per month as shown in Table 6.6.5-3.

Table 6.6.5-3: 2009 Annual Average Gross Beta Deposition Rate (Bq/m^2×month)

Location	2009
Local Study Area	
B2	19.0
B3	18.6
B4	18.9
B5	17.4
B7	18.7
B10	19.5
B11	15.7
Regional Study Area	
B6	15.3
B8	14.9
B9	16.0

Source: [223]



LEGEND

- Study Sites
- Site Study Area [1]
- Local Study Area

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

RADIOLOGICAL MONITORING LOCATIONS FOR AIR

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct 2007		
GIS	BC	14 Jun. 2010		
CHECK	AE	14 Jun. 2010		
REVIEW	MAR	14 Jun. 2010		

FIGURE 6.6.5-1

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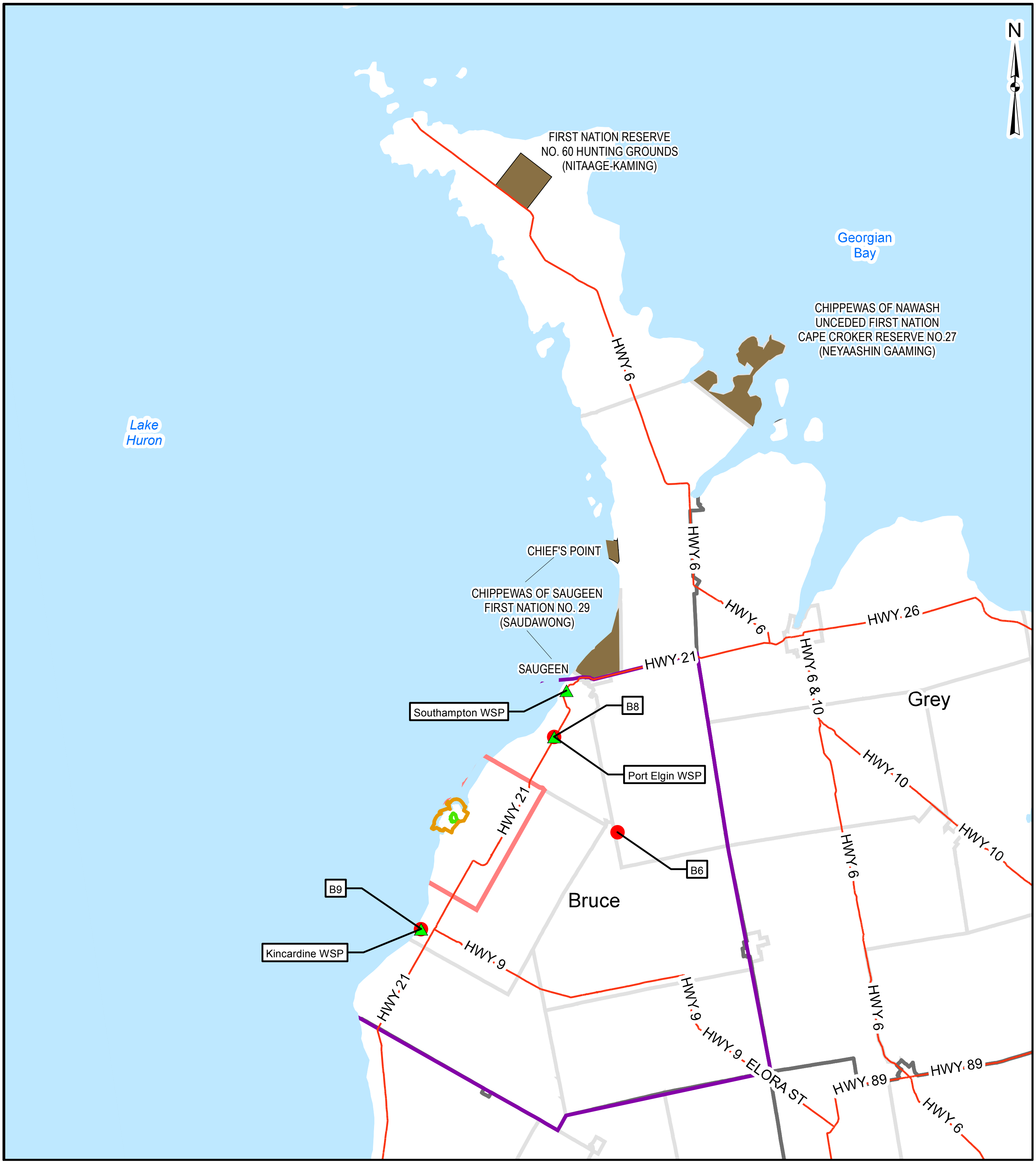

0 5 10 20 30 40 50

Kilometres

LEGEND

- Surface Water Monitoring Locations
- Atmospheric Monitoring Locations
- Site Study Area [1]
- Project Area (OPG-retained lands that encompass the DGR Project)
- Local Study Area
- Regional Study Area
- First Nations' Lands

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

RADIOLOGICAL MONITORING LOCATIONS FOR AIR AND SURFACE WATER

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	**FIGURE 6.6.5-2**	
GIS	BC	14 Jun. 2010		
CHECK	AE	14 Jun. 2010		
REVIEW	MAR	14 Jun. 2010		

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These deposition rates are within the range of gross beta in fallout in North America, which normally averages from 5 to 100 $Bq/m^2 \times month$ on an annual basis [222]. Within the Site Study Area, OPG measured the radioactive particulates during the period of 2000 to 2002 by analyzing gross beta of precipitation samples collected at the WWMF. The mean gross beta concentrations in precipitation measured at the WWMF ranged from 0.10 to 0.22 Bq/L [223].

6.6.5.4 Carbon-14 in Air

In recent years, carbon-14 concentrations in air have been measured by Bruce Power on a regular basis. Annual average carbon-14 concentrations in air in the Local Study Area for 2009 are shown in Table 6.6.5-4, along with the data obtained from provincial monitoring locations. Some of these values are higher than those reported at provincial background locations, which averaged 245 Bq/kg-C [223], but not by a statistically significant amount. It is reasonable to conclude that any increased carbon-14 concentrations in air are a result of the emission of carbon-14 from the Bruce nuclear site.

Table 6.6.5-4: 2009 Carbon-14 Activity in Air (Bq/kg-C)

Location	Passive sampling
Local Study Area	
B3	223
B5	246
B11	231
BR1	244
BR11	258
BF1	242
BF14	258
BDF11	231
Provincial Locations	
Lambton	239
Lakefield	232
Bancroft	246
Barrie	266
Belleville	242
Picton	248
Provincial average	245

Source: [226;227;228;229;222;217;230;223;216]

The concentration of carbon-14 in air within the Site Study Area was also investigated. It was reported that airborne carbon-14 inside LLSB1 and LLSB6, storage structures located at the WWMF, was measured at the range of 2,000 to 67,000 Bq/m^3 during 1997 and 1998. In 1999, airborne carbon-14 was measured at 14 outdoor locations on the WWMF property. The average concentrations ranged from <3,000 Bq/kg-C in the vicinity of the LLSBs to 20,000 Bq/kg-C in the vicinity of the in-ground containers and quadricells. For comparison, the carbon-14 concentration in air at locations outside the WWMF ranged from 350 to 3,500 Bq/kg-C [225].

6.6.5.5 Radioactive Noble Gas

Noble gas in the environment is conservatively estimated using actual stack releases and a calculated atmospheric dilution factor. The estimated noble gas concentration in the Local Study Area in 2009 ranged from 0.06 to 0.34 Becquerel MegaElectron volt per cubic metre (Bq-MeV/m^3). Radioactive noble gases have historically accounted for a significant portion of the calculated dose to members of the public from the operation of nuclear facilities at the Bruce nuclear site, although the reported dose to the public from noble gas emissions has been gradually decreasing over the past two decades.

6.6.6 Radioactivity in Surface Water

Liquid wastes generated at the Bruce nuclear site are discharged to Lake Huron after treatment. In this section, existing conditions of radioactivity in surface water are discussed.

6.6.6.1 Tritium and Gross Beta in Surface Water

Bruce Power has historically reported drinking water monitoring data for three[14] water supply plants in the Regional Study Area (i.e., Kincardine, Port Elgin and Southampton, see Figure 6.6.5-2), where Lake Huron serves as a source of drinking water for these three communities.

Grab samples of treated water are collected twice a day at the water supply plants, weekly composites are measured for tritium, and monthly composites are measured for gross beta activity. The respective 2009 annual average concentrations of tritium and gross beta in treated water ranged from 6.1 to 152.5 Bq/L, and from less than the detection limit to 0.16 Bq/L, respectively. The results are shown in Table 6.6.6-1.

[14] The Port Elgin water treatment plant went out of service in 2008. The community is now being supplied by the Southampton water supply plant.

Table 6.6.6-1: 2009 Tritium and Gross Beta Levels in Surface Water (Bq/L)

Sample Location	Tritium	Gross Beta
Regional Study Area		
Kincardine Water Supply Plant	6.1	0.07
Southampton Water Supply Plant	8.8	0.07
Site Study Area		
BEC Steam Condensate	12.5	Ld
Stream C	152.5	0.16

Note: Ld = Lower than detection limit.
Source: [216]

The average concentration of tritium in water from the water supply plants was higher than the tritium concentration measured at provincial monitoring locations (averaged at 3.0 Bq/L) but well below the Maximum Acceptable Concentration (MAC) for tritium in drinking water (7,000 Bq/L) listed in the ODWQS. The average concentrations of gross beta radioactivity in water from the water supply plants were similar to the provincial average value of 0.05 Bq/L at sample locations across the province.

Within the Site Study Area, surface water samples were collected from two monitoring locations, Stream C and BEC (renamed to Bruce Eco-Industrial Park) steam condensate. The annual average tritium concentrations in the samples were above the provincial background location average tritium concentrations of 3.0 Bq/L but well below the ODWQS of 7,000 Bq/L. The annual average gross beta concentration in water samples collected in these two locations was similar to those measured at the provincial background locations.

6.6.6.2 Other Radionuclides in Surface Water

The concentrations of cesium-137, cesium-134 and potassium-40 (naturally occurring) were measured in grab samples of water taken from Lake Huron in the vicinity of the Bruce nuclear site beginning in 1991. It was reported that the concentrations of cesium-137 and cesium-134 in Regional Study Area and background samples are all less than the method detection limits of 0.001 to 0.002 Bq/L, and therefore such measurements ended in 2000 [231]. The concentrations of potassium-40 in water samples are within the expected range [231].

In the Project Area, surface water samples collected from the South Railway Ditch were also monitored for other radionuclides including cobalt-60, cesium-134, cesium-137, potassium-40, strontium-90, iodine-129, technetium-99 and chlorine-36. It was reported that concentrations of these radionuclides in water samples were all less than corresponding method detection limits (MDLs). However, it was found that carbon-14 concentrations in water samples from the North and South Railway Ditches and from the Little Sauble River (Local Study Area) were slightly above the MDL.

6.6.7 Radioactivity in the Aquatic Environment

This section presents the results of measurements of radioactivity in sediments and fish in Lake Huron, shoreline gamma scans in the vicinity of Bruce A and B and a discussion of radiation doses to aquatic biota.

6.6.7.1 Radioactivity in Sediments

Sediment samples are collected annually by Bruce Power from Lake Huron in the Regional and Local Study Areas. Sediment samples are analyzed for radionuclides including cesium-137, cesium-134, cobalt-60 and potassium-40 and the results are expressed as Becquerels per kilogram (Bq/kg) of dry sediment.

The major portion of the activity in the sediments is attributable to the existence of potassium-40, a naturally occurring radionuclide. In the Regional Study Area, potassium-40 concentrations in sediment samples collected near Southampton in 2009 ranged from 246.6 to 250.5 Bq/kg [216]. In the Local Study Area, concentrations ranged from 276.1 (Inverhuron) to 590 Bq/kg (Scott Point).

Cesium-137, a product of both global fallout and reactor operation, was detected in all sediment samples. For sediment samples collected in the Regional Study Area (Southampton), the concentration of cesium-137 was in the range of 0.21 to 0.23 Bq/kg in 2009. The corresponding values for samples from the Local Study Area ranged from 0.19 Bq/kg at Scott Point to 8.90 Bq/kg at Baie du Doré [216].

Cobalt-60 and cesium-134 are mainly present in the environment because of reactor operation. Cobalt-60 was detected in all lake bottom sediment samples collected in the Bruce A and Bruce B discharge channels (Site Study Area) in 2009, ranging from 0.50 to 0.76 Bq/kg. For sediment samples collected from the locations in the Local Study Area, cobalt-60 was in the range of less than 0.20 to 0.85 Bq/kg. Concentrations of cobalt-60 in samples collected in the Regional Study Area were all below the detection limits. In 2009, the concentrations of cesium-134 in all sediment samples collected from all locations were below the detection limit [216].

Radioactivity in sediments in the Project Area was measured during the period from 2000 to 2004 [178]. The maximum sediment concentration of cesium-137 (27 Bq/kg) is lower than that reported for the pre-construction phase (37 Bq/kg). For gross comparative purposes, the maximum concentration of cesium-137 is considerably lower than the guideline value of 450 Bq/kg suggested by the United States' National Council on Radiation Protection and Measurement (NCRP) for contaminated soil [232]. The highest tritium activity in sediment was measured to be 2,368 Bq/kg at one location in the South Railway Ditch. This compares to a concentration of less than 18.5 Bq/kg at the Goderich control site, and below 600 Bq/kg at all other sampling sites. It should be noted that there is no NCRP suggested guideline level for sediment contamination.

6.6.7.2 Shoreline Gamma Survey

In the fall of 2000, a ground gamma survey was carried out along a 15 km stretch of shoreline from Inverhuron Provincial Park, south of Bruce B, to Scott Point, north of the Bruce nuclear site [218]. Cobalt-60 was not detected at an MDL of 15 Bq/kg during the scans. The highest cesium-137 activity, of around 50 Bq/kg, was found on the Bruce nuclear site shoreline in the area of Bruce A and Baie du Doré [231].

A follow-up survey was conducted by Bruce Power in 2002. Three samples from Baie du Doré had cesium-137 activities of approximately 50 Bq/kg. Cobalt-60 was present in the samples at a low level (<4 Bq/kg). These results confirmed that past emissions from the Bruce nuclear site have contributed to observed levels as cobalt-60 is not a product of global fallout and is not naturally occurring [226].

6.6.7.3 Radioactivity in Fish

The fish living in Lake Huron are potentially exposed to radioactive emissions to water from operations at the Bruce nuclear site. Samples of fish are collected annually by Bruce Power from Lake Huron adjacent to the Bruce nuclear site (i.e., Baie du Doré) and from the background sampling locations (the opposite side of Lake Huron). The fish target species are white sucker, with brown bullhead (*Ameiurus nebulosus)* as the backup species, and lake whitefish, with round whitefish as the backup species. Throughout the period 2001 to 2009, fish were caught and analyzed for carbon-14, gamma emitters (e.g., cesium-137, cesium-134 and potassium-40) and tritium, including tritiated water (HTO) and organically bound tritium (OBT).

The major portion of the activity in fish is naturally occurring potassium-40 and carbon-14. In 2009, the potassium-40 concentrations in the sampled fish ranged from 125 to 146 Bq/kg, consistent with the range measured in other years. In the same year, the concentration of carbon-14 was found at levels above the provincial background (in the range of 225 to 270 Bq/kg-C) in fish caught in the immediate vicinity of the Bruce nuclear site [216]. The data for the past seven years (from 2003 to 2009) indicate a decreasing trend in carbon-14 concentrations. This parallels the waterborne emissions trend, which indicates a decrease in waterborne carbon-14 emissions of approximately 50% from 2002 levels.

Low concentrations of cesium-137 are usually present as a result of global fallout and reactor operation. During 2009, cesium-137 was detected in all fish caught in the immediate vicinity of the Bruce nuclear site. The concentrations ranged from 0.18 to 0.43 Bq/kg, similar to the background sampling conducted at provincial sites [216]. The overall decreasing trend is likely a result of the declining levels of radioisotopes from historical weapons testing [216].

Tritium (as Tissue-Free Water Tritium, TFWT) levels measured in fish taken from the immediate vicinity of the Bruce nuclear site in 2009 were reported in the range of 7.6 to 30.5 Bq/L (water). The average tritium concentration in fish showed an increasing trend from 2003 to 2006, which parallels the increase in waterborne tritium emissions from the Bruce nuclear site. The trend has been decreasing since 2006. Although 2009 data shows an increase in tritium in fish as a result of waterborne emissions released during 2009, a decrease of approximately 45% has occurred since 2006 [216].

In 2009, OBT measurements were carried out on fish samples collected from the immediate vicinity of the Bruce nuclear site. The OBT in whitefish and sucker samples are 9.6 and 10.5 Bq/L, respectively, showing a decreasing trend since 2006. This is consistent with the measurement results of TFWT in fish samples.

6.6.7.4 Radiation Doses to Aquatic Biota

Radioactive releases to water may result in a measurable dose to aquatic biota. Currently, there are no internationally agreed criteria that explicitly address protection of aquatic biota from ionizing radiation, although many international agreements and statutes call for protection against pollution, including radiation [233]. At present, there are various benchmarks available in the literature, typically in the range of 0.6 to 10 milliGray per day (mGy/d).

A series of calculations was carried out to estimate the doses to aquatic biota in the vicinity of Bruce nuclear site under existing conditions. A variety of ecological receptors were used in the assessment, including the aquatic environment VECs identified for the DGR Project. Detailed description of the methods used to estimate radiation doses in this work and calculation results are provided in Appendix C of the Radiation and Radioactivity TSD. Calculated dose rates for aquatic biota VECs (Section 6.4.2) under existing conditions range from 2.0×10^{-4} mGy/d (double-crested cormorant) to 4.6×10^{-4} mGy/d (benthic and pelagic fish VECs). These dose rates are much less than the reference values (see the Radiation and Radioactivity TSD), which are expected to ensure the survival of populations.

6.6.8 Radioactivity in the Terrestrial Environment

Airborne and waterborne emissions may result in measurable changes to the terrestrial environment. This section summarizes the baseline levels of radioactivity in vegetation, milk and radiation from soil. It also discusses radiation doses to terrestrial biota under existing conditions.

6.6.8.1 Vegetation

Bruce Power collects samples of garden fruits and vegetables and agricultural plants in the vicinity of the Bruce nuclear site on an annual basis. The produce collected includes apples, leafy vegetables, above ground vegetables, root vegetables, tomatoes, soy beans, and corn among many other varieties. For comparison, fruits and vegetable samples are collected at a variety of provincial background locations. The samples are analyzed for carbon-14 and tritium in water in the plant material, which is distinguished from organically bound tritium that has been incorporated into the organic component of plant tissues.

For grain samples, the concentrations of tissue-free water tritium in samples collected during 2009 ranged from 18.1 to 123.8 Bq/L in soy beans [216]. The concentrations of carbon-14 in grains were in the range of 205 to 240 Bq/kg-C.

The tritium and carbon-14 concentrations for apples are summarized in Table 6.6.8-1. The results of routine monitoring of tritium and carbon-14 in vegetation show that, in general, the tissue-free water tritium and carbon-14 concentrations in vegetation decrease with distance from the Bruce nuclear site. This is to be expected since the concentration of tritium and carbon-14 in vegetation is directly related to the concentration of tritium and carbon-14 in air.

Within the Site Study Area, four replicated terrestrial vegetation samples were collected at two locations during a 2000 monitoring program. It was reported that the concentrations of cesium-137, cesium-134 and cobalt-60 in vegetation samples were all below detection limits. The levels of naturally-occurring potassium-40 in the vegetation samples were detectable, with a maximum concentration of 350 Bq/kg measured at one of the locations within the Site Study Area. However, the same concentration (350 Bq/kg) was also measured at the control location [225].

Table 6.6.8-1: 2009 Concentrations of Radionuclides in Apples in the Local Study Area

Monitoring Location	Tritium (Bq/L)	Carbon-14 (Bq/kg-C)
BG1	214.4	283
BG 3	131.4	262
BG 4	45.2	238
BG 5	41.1	263
BG 7	42.3	244
BG 10	99.8	267
BG 16	66.3	252

Note:
Locations are shown on Figure 6.6.8-1
Source: [216]

6.6.8.2 Milk

Airborne emissions from nuclear facilities at the Bruce nuclear site may affect the concentrations of radionuclides in animal products (e.g., milk, egg, meat, honey). This represents a potential internal pathway for human exposure. In the following section, milk is used as an example to illustrate the activities of radionuclides in animal products.

Bruce Power collects milk samples weekly from three dairy farms within the Local Study Area (Figure 6.6.8-1). For comparison, milk samples are also collected from more distant farms in Belleville and London, Ontario. The monitoring results for 2009 are summarized in Table 6.6.8-2.

The average tritium concentration in milk in the vicinity of the Bruce nuclear site has increased since 2005, approaching 11 Bq/L in 2009. Carbon-14 concentrations in milk have decreased from over 300 Bq/kg-C in 1991 to natural background levels between 240 and 250 Bq/kg-C in recent years. Iodine-131 was detected at a concentration of less than 0.2 Bq/L in milk samples from the Bruce Power sampling locations in 2009, similar to the results from the provincial background sites [216].

Table 6.6.8-2: 2009 Radiological Concentrations in Milk in the Local Study Area

Monitoring Location	Carbon-14 (Bq/kg-C)	Tritium (Bq/L)
Local Study Area		
BDF9	237	7.9
BDF1	237	13.9
Provincial Locations		
Belleville	231	3.9
London	222	<3.3-4.5

Note:
Sample locations are shown on Figure 6.6.8-1
Source: [216]

6.6.8.3 External Gamma Radiation

Emissions of noble gases, radioactive particulate and iodine-131 from the Bruce nuclear site have the potential to contribute to external gamma radiation levels observed in the study areas. This section discusses the external gamma radiation by Thermoluminescent Dosimeter (TLD) measurements, a flyover gamma survey and the ground gamma survey of selected locations.

External gamma radiation doses are measured on a continuous basis in the Regional and Local Study Areas by Bruce Power. The TLDs used for these measurements are sensitive to gamma radiation from the surrounding soil and air, but not to cosmic radiation. The annual doses from external gamma radiation reported by Bruce Power for 2009 ranged from 44.0 to 63.6 nGy/h as shown in Table 6.6.8-3. Monitoring locations are the same as for radioactivity in air (see Figures 6.6.5-1 and 6.6.5-2).

Table 6.6.8-3: 2009 Annual Average External Gamma Dose Rate in Air (nGy/h)

Location	2009
Local Study Area	
B2	53.7
B3	50.6
B4	46.6
B5	44.0
B7	45.0
B10	63.6
B11	56.4
Regional Study Area	
Site B6 Paisley TS	45.6

Table 6.6.8-3: 2009 Annual Average External Gamma Dose Rate in Air (nGy/h) (continued)

Location	2009
Site B8 Port Elgin	44.1
Site B9 Kincardine TS	44.8
Provincial Locations	44.2 – 69.1

Source: [216]

During 2009, the external gamma dose rates measured in the Regional Study Area are within the range of dose rates observed at sites across Ontario, suggesting that air emissions from the Bruce nuclear site are not contributing to higher than normal gamma radiation levels [216]. In the Site Study Area, OPG routinely measures ambient radiation dose rate at various monitoring locations within and along the WWMF perimeter fence. In 2009, the quarterly gamma dose rates ranged from <0.04 to 0.16 µGy/h (i.e., 40 to 160 nGy/h), below the OPG target of 0.5 µGy/h (i.e., 500 nGy/h) [219;234;220;221].

6.6.8.4 Radioactivity in Soil

Bruce Power collects soil samples at monitoring locations in the Local Study Area and at the provincial background locations on an annual basis. These samples are analyzed for cesium-137, cesium-134, cobalt-60 and potassium-40.

As found in previous years, the dominant radionuclide measured in the soil samples in 2009 was the naturally occurring potassium-40 [216]. For the soil samples collected in the Local Study Area, potassium-40 concentrations ranged from 294.5 to 626.0 Bq/kg (dry weight), compared to the concentrations of 446.0 to 500.0 Bq/kg measured from samples collected from provincial background locations. Cesium-137 concentrations in soil samples collected in the Local Study Area ranged from 0.91 to 8.02 Bq/kg, compared with concentrations ranging from 2.68 to 3.94 Bq/kg measured at provincial background locations. The concentrations of cobalt-60 and cesium-134 in all soil samples were negligible.

Within the Site Study Area, soil samples were collected from 18 locations at the WWMF in 2000 [225]. The soil samples were collected using a 100 cm long tube with a diameter of 3.8 cm. The top 30 cm of each soil core was used for the radionuclide analysis. It was reported that cobalt-60, cesium-134, along with carbon-14 concentrations in the majority of samples were below their method detection limits. Tritium concentrations ranged from approximately 40 to 120 Bq/kg, which is three to five orders of magnitude below OPG's screening limit of 3×10^6 Bq/kg. Also, it was found that the mean concentrations for the Western Used Fuel Dry Storage Facility (WUFDSF) sampling locations and the remaining WWMF locations for each radionuclide were within the corresponding radionuclide concentrations at the control sites, except for cesium-137. The cesium-137 concentrations on the WUFDSF site and the remainder of the WWMF sampling locations averaged 6.9 and 3.2 Bq/kg, respectively. The corresponding values at Goderich and the Bruce nuclear site main gate are 5.7 and <2.3 Bq/kg, respectively. However, it should be noted that cesium-137 is a product of both global fallout and all reactor operations, and its concentration varies widely in the environment.

6.6.8.5 Radiation Doses to Terrestrial Biota

Radioactive releases to water and the atmosphere may result in a measurable dose to terrestrial biota. Currently, there are no internationally agreed criteria that explicitly address protection of the terrestrial biota from ionizing radiation, although many international agreements and statutes call for protection against pollution, including radiation [233]. At present, there are various benchmarks available in the literature, typically in the range of 0.6 to 10 mGy/d.

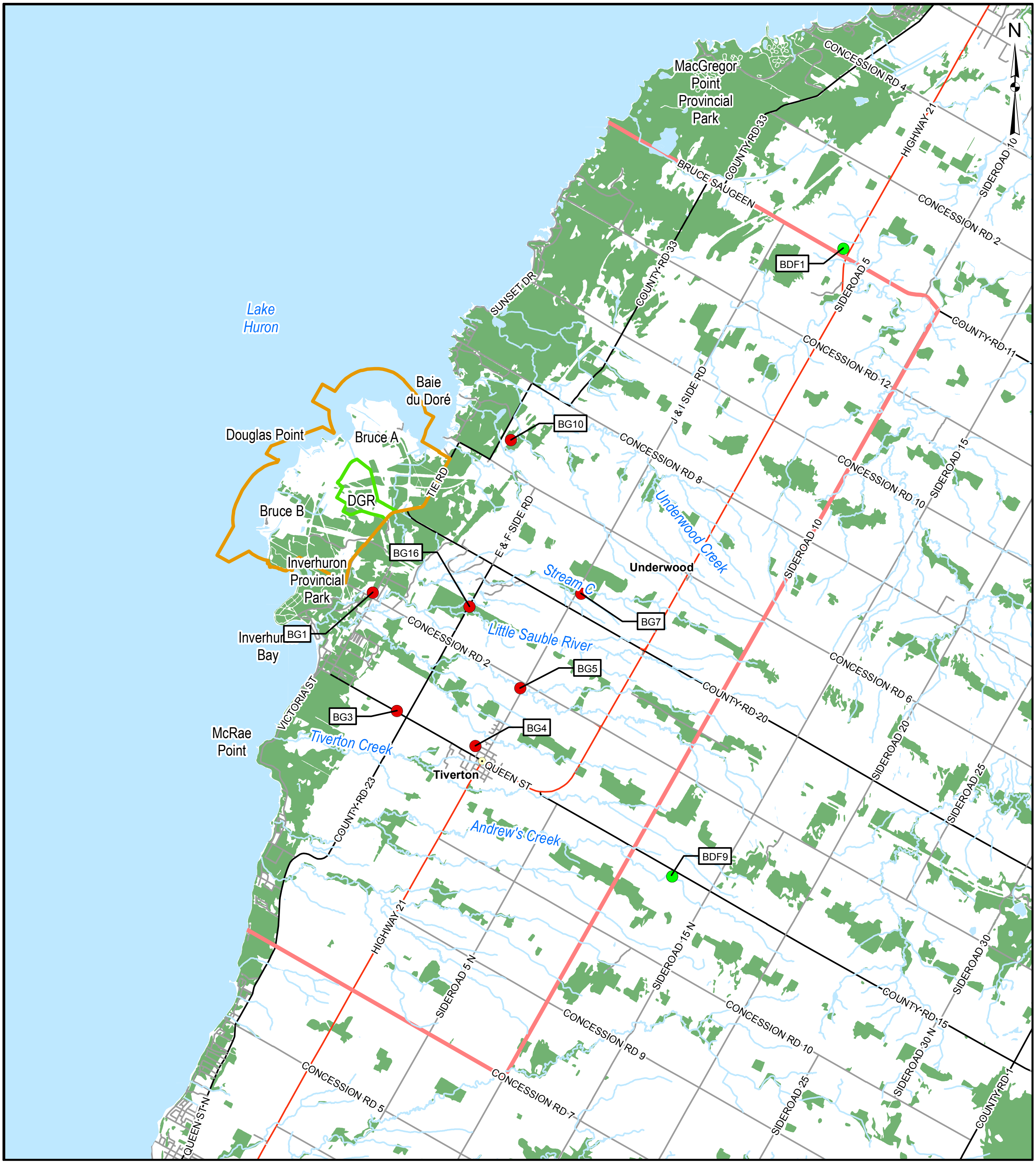
Radiation dose to terrestrial biota under existing conditions was estimated for the terrestrial VECs (Section 6.4.2) identified for the DGR Project to range between 2.1×10^{-5} (yellow warbler) and 3.8×10^{-3} mGy/d (white-tailed deer). A detailed description of the methodology used to estimate radiation doses and calculation results are provided in Section 8 and Appendix C of the Radiation and Radioactivity TSD. All calculated doses are much less than the dose benchmarks selected for this assessment.

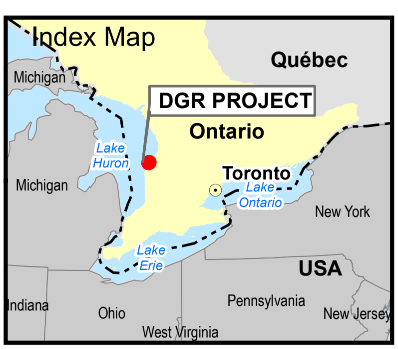
6.6.9 Radioactivity in Groundwater

There is a possibility that groundwater, a potential pathway for human exposure, is contaminated with radionuclides as a result of the various activities on the Bruce nuclear site. To investigate the radiation and radioactivity level in groundwater, routine groundwater monitoring programs are carried out by Bruce Power and OPG.

Within the Local Study Area, Bruce Power collects samples of well water from a number of deep wells and shallow wells for tritium analyses. Monitoring for gross beta at most wells has been discontinued as any small contribution by releases from the stations is expected to be negligible compared to natural background levels. Monitoring results for 2009 are provided in Table 6.6.9-1. Tritium concentrations in the deep well water samples ranged from below the MDL to 22.8 Bq/L.

A routine groundwater monitoring program was established at WWMF to detect both temporal and spatial trends in groundwater quality that may be a result of the storage of low level radioactive waste. In 2009, the tritium concentrations in Well 231 reached a maximum value of approximately 8.0×10^{4} Bq/L. This is still far less (i.e., orders of magnitude) than the generic screening criteria of 3×10^{6} Bq/L for non-potable groundwater. Currently, Well 231 is sampled twice a month, compared with the quarterly sampling frequency at other WWMF monitoring wells. It is believed, based on the understanding of the site hydrogeology, that the trends in tritium concentration correspond to the trends in the mass loadings of tritium in the LLSB foundation drains. Precipitation is also a factor influencing trends in tritium concentration. Additional details on tritium in groundwater and historic monitoring details can be found in Section 5.9 of the Radiation and Radioactivity TSD.





LEGEND

- Monitoring Locations for Milk
- Monitoring Locations for Apples
- Site Study Area [1]
- Project Area (OPG-retained lands that encompass the DGR Project)
- Local Study Area

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

RADIOLOGICAL MONITORING LOCATIONS FOR APPLES AND MILK IN THE LOCAL STUDY AREA

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct 2007	FIGURE 6.6.8-1	
GIS	BC	14 Jun. 2010		
CHECK	AE	14 Jun. 2010		
REVIEW	MAR	14 Jun. 2010		

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Table 6.6.9-1: 2009 Annual Average Tritium Activity in Deep Well Water (Bq/L)

Local Study Area	2009
BM 12 and 13	Ld
BM6	Ld
BM2	Ld
BM9	Ld
BR1	Ld
BR8	Ld
BR25	Ld
BR37 [a]	22.8
BF1	Ld
BF14	Ld
BDF11	Ld

Notes:
a Sample collection at location BR37 was initiated in year 2008. This location is close to Inverhuron Bay and well water appears to be under the influence of water from Lake Huron.
Ld Lower than detection limit
Source: [216]

6.6.10 Radiation Doses to Members of the Public

This section provides a description of the baseline radiation dose to members of the public that is attributable to radiation and radioactivity releases from the Bruce nuclear site.

For the purpose of the EA, critical groups are used to estimate the maximum realistic effects of emissions. According to the CSA N288.1 Standard, the critical group is "a fairly homogeneous group of people whose location, habits, diet, etc., cause them to receive doses higher than the average received by typical people in all other groups in the exposed population" [235].

The human attributes that determine the degree of exposure to, or intake of, radionuclides present in environmental media were drawn from the default values in the DRL guidance document [236] used by both OPG and Bruce Power. The default rates in the DRL guidance document represent the 90th percentile values for the population. Values for some of the more prominent parameters, from the perspective of performing dose calculations, are outlined in Table 6.6.10-1.

Table 6.6.10-1: Human Attributes

Parameter	Units	Adult	1 yr Infant	1 yr Infant at Dairy Farm
Inhalation Rate	m^3/a	8,103	1,883	1,883
Water Ingestion Rate	L/a	840	292	76
Grain Intake	kg/a	231	59	59
Fruit & Berry Intake	kg/a	174	66	66
Vegetable Intake	kg/a	234	44	44
Mushrooms Intake	kg/a	1.5	0.2	0.2
Beef Intake	kg/a	66.3	10.6	10.6
Lamb Intake	kg/a	0.7	0	0
Poultry Intake	kg/a	19.7	4.6	4.6
Egg Intake	kg/a	30	8.4	8.4
Deer Intake	kg/a	5.6	1.5	0.6
Milk Intake	kg/a	265	0	371
Total Animal Ingestion Rate	kg/a	417	28	398
Fish Ingestion Rate	kg/a	7.9	1.6	0.3

Source: [223]

As part of its Radiological Environmental Monitoring Program (REMP), Bruce Power calculates annual doses to members of the public in the vicinity of the Bruce nuclear site, based on the measured concentrations of radionuclides in different media, and estimated values where monitoring data are not available. It should be noted that the reported doses to members of the public exclude contributions from naturally occurring or anthropogenic radioactivity, which are not attributable to the Bruce nuclear site. The estimated doses to members of the public are then compared to current regulatory limits specified in the Regulations under the Nuclear Safety and Control Act [210], specifically the annual dose limit of 1 mSv/a (1,000 μSv/a) for members of the public.

As shown in Table 6.6.10-2, the estimated doses are considerably less than 1% of the regulatory limit of 1 mSv/a for members of the public. The values are also quite small compared to the variation in background radiation from natural sources. Also, it is noteworthy that the baseline dose is less than the *de minimis* dose level of 10 μSv/a recommended by the Canadian Advisory Committee on Radiological Protection (ACRP) and the Advisory Committee on Nuclear Safety (ACNS) [237] for the 18th consecutive year.

Table 6.6.10-2: Doses from Radionuclides to Members of Public

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Critical group	Infant at BR1	Infant at BR1	Infant at BR1	Infant at BR1	Infant at BR1	Infant at BR1	Adult at BF14	Adult at BR11	Adult at BF14
Dose (μSv/a)	2.0	2.26	2.08	1.58	1.98	2.45	2.07	2.70	4.41
Percentage of the dose limit (%)	0.20	0.23	0.21	0.16	0.20	0.25	0.21	0.27	0.44

Source: [226;227;228;229;222;217;230;223;216]

6.6.11 Radiation Doses to Workers

6.6.11.1 Radiation Doses to Nuclear Energy Workers

The occupational doses received by Nuclear Energy Workers (NEWs) at the WWMF and other nuclear facilities at the Bruce nuclear site are closely monitored by comprehensive personal dosimetry programs. Under these programs, radiation doses from external gamma radiation, neutron radiation and from internal radioactivity (inhaled and transferred across the skin) are measured, recorded and reported. The following paragraphs describe the existing radiation doses to workers at licensed nuclear facilities.

NEWs at the WWMF

During 2009, the maximum individual annual whole body dose received by NEWs at the WWMF was 2.8 mSv, which was well below the current regulatory limit of a maximum of 50 mSv in a single year and 100 mSv over any five years [238]. Meanwhile, the collective annual whole body doses received by workers at the WWMF were estimated to be 6.5 person-mSv. This value is much less than OPG's Action Level of 40 person-mSv/a for the WWMF [225].

6.6.11.2 NEWs at Other Nuclear Facilities at the Bruce Nuclear Site

As at the WWMF, the designated NEWs at other nuclear facilities at the Bruce nuclear site such as Bruce A and Bruce B are monitored for radiation dose. In 2006, the maximum individual dose and collective whole body dose received by workers at Bruce A were 10.2 mSv and 2.0 person-Sv, respectively [96]. For the same year, the maximum individual dose and collective doses received by workers at Bruce B were 12.3 mSv and 3.8 person-Sv, respectively [96]. In 2009, the collective doses received by workers at Bruce A and B were 2.7 person-Sv and 4.3 person-Sv, respectively. The reported data were based on publically available data. No publically available data on maximum individual whole body doses were available for either Bruce A or Bruce B during the period from 2007 to 2009.

6.6.12 Radiation Dose to Non-NEWs

For those workers who are working at the Bruce nuclear site but are not designated as NEWs, the regulatory dose limit of 1 mSv/a is applied [238]. The activities of non-NEWs, including access and movement, in the Site Study Area and the Project Area (OPG-retained land) are controlled by Bruce Power and OPG, respectively. Radiation doses to these workers from licensed nuclear activities are strictly monitored and controlled.

In 2009, the highest dose rate measured at the RWOS1 and WWMF perimeter fences was 0.16 μSv/h [219;234;220;221]. This is below the perimeter dose rate limit of 0.5 μSv/h based on maximum 2,000 hours per year occupancy for non-NEWs as described in the WWMF operating licence documentation [219;234;220;221].

If there is any likelihood that the dose to workers may exceed 100 μSv/a (0.1 mSv/a), then such activities are carried out by NEWs. Therefore, current doses to non-NEWs do not exceed 100 μSv/a, which represents 10% of the annual dose limit to the general public.

Each year, some individuals or groups visit the Bruce nuclear site. Radiation doses to these visitors are monitored and strictly controlled by OPG and Bruce Power. For example, TLDs are used to measure external doses to visitors on tours in zoned areas to ensure the regulatory limit of 1 mSv/a is not exceeded.

6.7 CLIMATE, WEATHER CONDITIONS AND AIR QUALITY

Within the atmospheric environment, the physical processes referred to as meteorology and climate will have profound effects on how the DGR Project may affect air quality. Meteorology refers to the day-to-day, or hour-to-hour variations in parameters such as wind, precipitation or temperature. Climate, on the other hand, represents the expected values for parameters such as wind, precipitation or temperature. The climate of an area is described using normals, which are averages calculated over a 30-year period (the latest accepted normals period is 1971 to 2000) [239]. For additional details, refer to the Atmospheric Environment TSD.

6.7.1 Spatial Boundaries

The general study areas were adapted to encompass likely effects on climate, weather and air quality as follows:

- The **Regional Study Area**, shown on Figure 6.7.1-1, encompasses the areas used to describe the existing air quality in the vicinity of the DGR Project. The Regional Study Area includes the local municipalities within Bruce County as far north as Wiarton and extends to include the ambient air quality monitoring stations in Waterloo, Sarnia and London.
- The **Local Study Area,** shown on Figure 6.7.1-2, generally corresponds to the 10 km emergency planning zone (centered on the Bruce nuclear site), as identified by Emergency Management Ontario, and extends into Lake Huron.
- The **Site Study Area and Project Areas**, shown on Figure 5.1.3-1, were used without modification.

LEGEND

- On-site Meteorological Tower
- Meteorological and Climate Station
- Site Study Area [1]
- Local Study Area
- Regional Study Area

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

REGIONAL STUDY AREA FOR THE ATMOSPHERIC ENVIRONMENT

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct 2007		
GIS	BC	18 May. 2010	FIGURE 6.7.1-1	
CHECK	AB	18 May. 2010		
REVIEW	SM	18 May. 2010		

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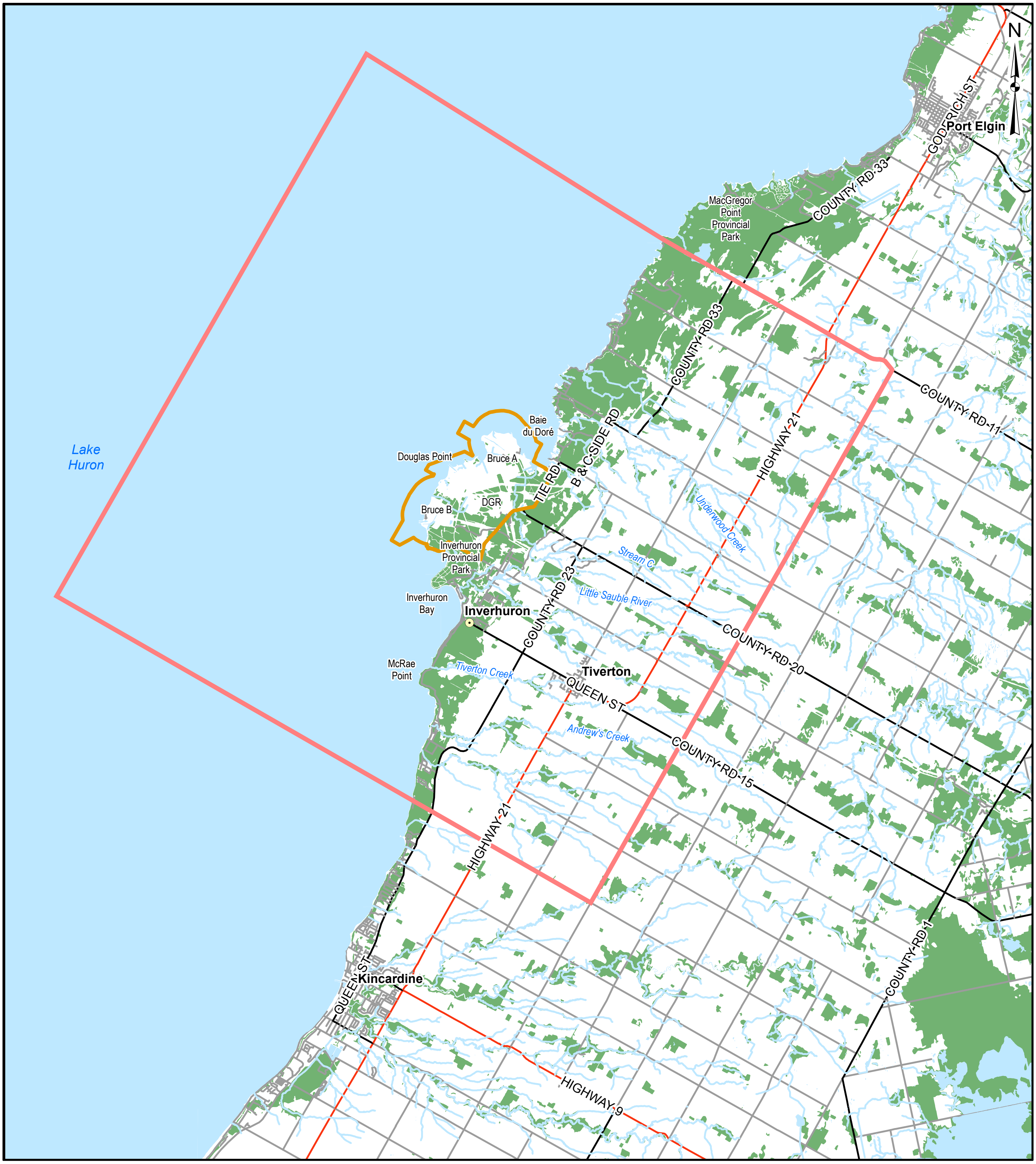

0 2 4 8 12

Kilometres

LEGEND

- Site Study Area [1]
- Local Study Area

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

LOCAL STUDY AREA FOR THE ATMOSPHERIC ENVIRONMENT

Golder Associates
Mississauga, Ontario

PROJECT No. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct 2007	FIGURE 6.7.1-2	
GIS	BC	18 May. 2010		
CHECK	AB	18 May. 2010		
REVIEW	SM	18 May. 2010		

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6.7.2 Valued Ecosystem Components

Table 6.7.2-1 presents the VEC for climate, weather conditions and air quality along with the rationale for its selection and the specific indicators used in the assessment. This VEC is consistent with those identified in the guidelines (see Appendix A.1).

Table 6.7.2-1: Atmospheric Environment VECs Selected for Air

VEC	Rationale for Selection	Indicators	Measures
Air Quality	• Has been identified as an important aspect of the environment by both public and regulators • Changes to air quality attributed to the DGR Project are possible	• Nitrogen dioxide (NO_2) • Sulphur dioxide (SO_2) • Carbon monoxide (CO) • Suspended particulate matter (SPM) • Airborne particles with aerodynamic diameters of 10 µm or less (PM_{10}) • Airborne particles with aerodynamic diameters of 2.5 µm or less ($PM_{2.5}$)	• Changes in air concentrations of indicator compounds • Concentrations of indicator compounds

6.7.3 Climate and Meteorology

6.7.3.1 Data Sources

A five year dispersion meteorological data set was developed using data collected at the Bruce nuclear site (2005 to 2009). On-site data was chosen for use in the modelling so that the effects of Lake Huron and local topography are reflected in the dispersion modelling. It was identified in the review of the available data (see Appendix C of the Atmospheric Environment TSD) that the data from the 50 m tower would be more reliable; however, data from the 10 m level on that tower was most appropriate for use. Since the majority of the sources of emissions at the DGR Project are located close to the ground, data from the lower (i.e., 10 m) level was more appropriate for use as dispersion meteorology. Data from the Meteorological Services of Canada (MSC) station at the airport in Wiarton, Ontario was used to provide the additional meteorological observations that were not available from the on-site station. Finally, upper air data used in describing the boundary level profile were taken from the station in Gaylord, Michigan. On-site meteorological data (i.e., the 10 m level on the 50 m tower) is more appropriate for use in modelling emissions at the Bruce nuclear site than data from other stations in the region (i.e., Kincardine and Hanover). Neither the Kincardine nor Hanover stations collect data to the exacting standards used for on-site data collection at the Bruce nuclear site or for the data collected at either Wiarton or Gaylord, Michigan.

Climate data from the Wiarton and Paisley climate stations was selected to describe the long-term climate for the region, as well as for comparison with the dispersion meteorology. The data used to describe the region's climate consists of climate normals data from 1971 to 2000 for the Wiarton Airport — WMO ID 71633 (meets standards of the World Meteorological

Organization for stations that transmit observations in international meteorological formats) and Paisley climate station, as published by Environment Canada [240].

The dispersion meteorological data developed for use in assessing the DGR Project was also compared to climate normals data from both the stations in Wiarton and Paisley. The temperatures, precipitation, and winds speeds and direction for the dispersion meteorology show a good agreement with the climate normals for both Wiarton and Paisley.

6.7.3.2 Temperatures

Surface temperature is an indirect measure of the energy present in the lower levels of the atmosphere. This energy is important for dispersion as it drives local meteorology and affects regional weather patterns. Table 6.7.3-1 provides a summary of the dispersion meteorology seasonal temperatures used in assessing the DGR Project. For comparison, Table 6.7.3-2 provides a similar summary of the long-term seasonal temperature normals for Wiarton Airport.

Table 6.7.3-1: Seasonal Temperature Summary for the Dispersion Meteorology

Parameter	Spring	Summer	Fall	Winter	Year
Daily Average (°C)	5.9	18.8	10.7	-3.1	8.2
Daily Maximum (°C)	9.7	22.2	13.8	-0.3	11.4
Daily Minimum (°C)	1.9	14.9	7.4	-5.8	4.7
Extreme Maximum (°C)	28.3	31.8	29.3	17.2	31.8
Extreme Minimum (°C)	-18.7	3.4	-9.3	-21.1	-21.1
Days with Maximum Above 30°C	0	2	0	0	2
Days with Minimum Below -10°C	2	0	0	20	23

Notes:
The numbers in the table above are calculated using the five-year dispersion meteorology (2005 to 2009). The values are correct, but because of rounding may not appear to match the totals shown above.
Temperature data from the on-site 50 m tower is collected at a height of 10 m, rather than the typical 2 m height used for collecting data at Wiarton and Paisley.
Source: [241]

Table 6.7.3-2: Seasonal Temperature Normals for Wiarton

Parameter	Spring	Summer	Fall	Winter	Year
Daily Average (°C)	4.5	17.4	8.3	-5.7	6.1
Daily Maximum (°C)	9.5	22.8	12.6	-1.7	10.8
Daily Minimum (°C)	-0.6	11.9	4.1	-9.6	1.4
Extreme Maximum (°C)	30.5	35.0	35.6	18.1	35.6
Extreme Minimum (°C)	-30.7	-1.6	-18.0	-36.4	-36.4
Days with Maximum Above 30°C	0	3	0	0	3
Days with Minimum Below -10°C	9	0	1	41	50

Notes:
The numbers in the table above are calculated using the 1971 through 2000 climate normals. The values are correct, but because of rounding may not appear to match the totals shown above.
Source: [239]

6.7.3.3 Precipitation

Although not directly used in the dispersion modelling, precipitation can have an influence on the emission rates for fugitive dust sources, as well as the rate at which particles and gases are removed from the air via wet deposition. Table 6.7.3-3 provides a summary of the seasonal precipitation data for the Wiarton Airport.

Table 6.7.3-3: Seasonal Precipitation Normals for Wiarton

Parameter	Spring	Summer	Fall	Winter	Year
Average Rainfall (mm)	165.8	230.8	268.9	74.9	740.4
Average Snowfall (cm)	62.8	0.0	52.1	311.6	426.6
Average Total Precipitation (mm) [a]	216.8	230.8	310.9	282.8	1,041.3
Extreme Daily Precipitation (mm)	48.8	104.6	88.6	48.6	104.6
Days with Measurable Precipitation	39	32	48	64	183

Notes:
The numbers in the table above are calculated using the 1971 through 2000 climate normals. The values are correct, but because of rounding may not appear to match the totals shown above.
a Average rainfall (mm) and average snowfall (cm) cannot be directly added together to equal average total precipitation.
Source: [239]

6.7.3.4 Wind Speed and Direction

Wind speed and wind direction are important parameters in determining the dispersion meteorology of an area. Wind speeds and directions also vary by the time of day and time of year. Figure 6.7.3.1 shows wind-roses for the annual and seasonal wind speed and direction for the dispersion meteorology used to evaluate the DGR Project. A wind-rose figure is often used to illustrate the frequency of wind direction and the magnitude of the wind speed. The lengths of the bars on the wind-rose indicate the frequency and speed of the wind. The wind direction (blowing from) is illustrated by the orientation of the bar in one of 16 cardinal directions.

6.7.3.5 Other Meteorological and Climate Parameters

There are a number of other parameters used when describing the existing meteorology and climate for the DGR Project. These parameters, which have been fully described in Appendix C of the Atmospheric Environment TSD, include the following:

- relative humidity and dew point;
- atmospheric stability;
- inversions and mixing heights;
- atmospheric pressure;
- solar radiation, cloud cover and bright sunshine;
- geophysical parameters; and
- severe and unusual weather.

6.7.4 Climate Change

It is now widely accepted that climate is changing; therefore, consideration of these changes needs to be incorporated in the EA of the DGR Project. To facilitate the consideration of climate change in the EA, Tables 6.7.4-1 and 6.7.4-2 have been provided. These tables provide a summary of the past and future trends for temperature and precipitation, respectively. The tables show how climate in the region has changed, as well as how it is projected to change over the life of the DGR Project. These data will be used by each of the disciplines when evaluating how climate change may affect the conclusions reached regarding the assessment of the effects of the DGR Project on the environment. Appendix D of the Atmospheric Environment TSD provides further details on the climate change assessment methods.

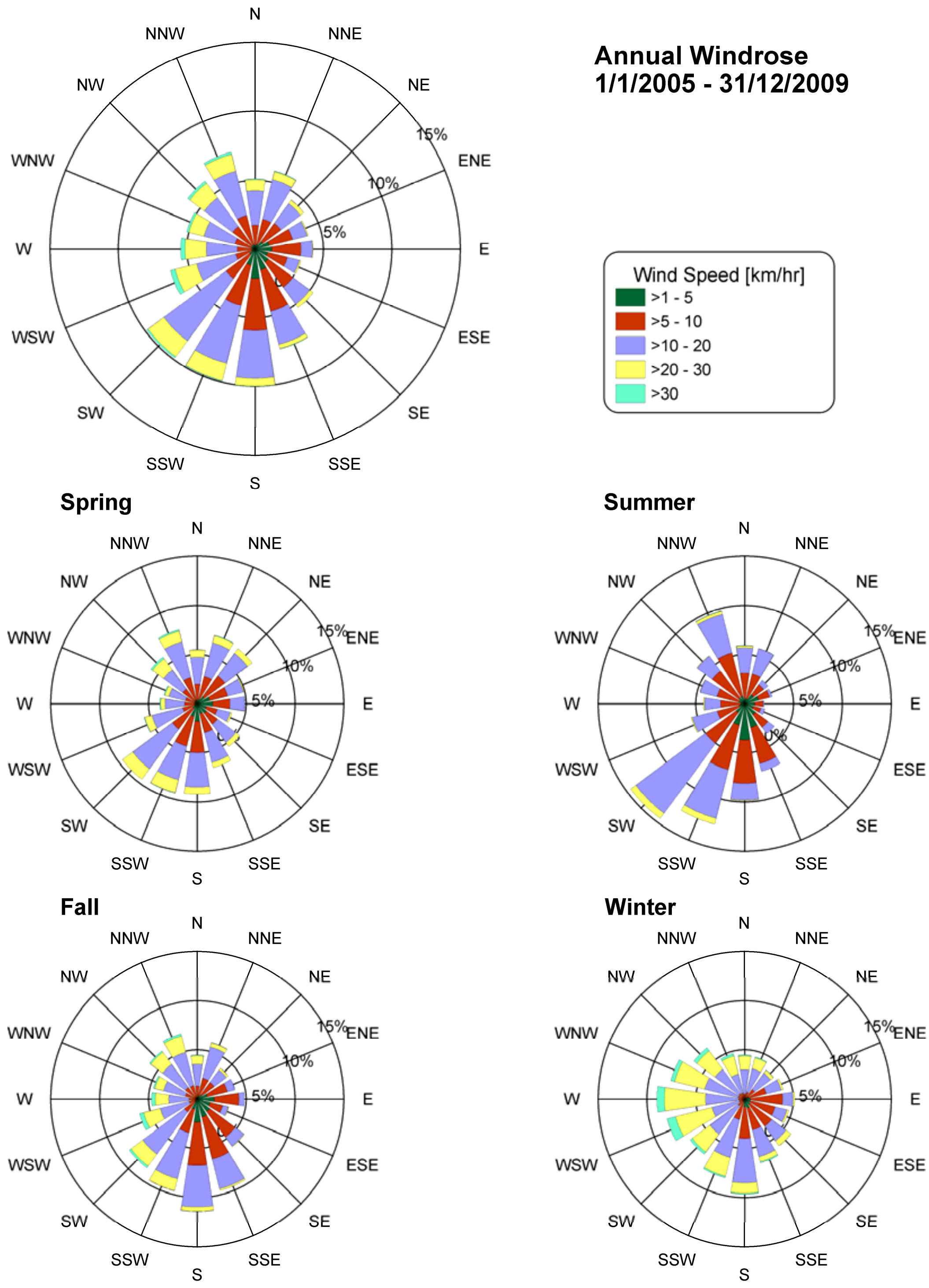

Figure 6.7.3-1: Annual and Seasonal Wind-Roses for Dispersion Meteorology

Table 6.7.4-1: Historic and Future Temperature Trends

Criteria	1971-2000 Normals (°C)	1971-2000 Trend (°C/decade)	2011-2040 Forecast (°C/decade)			2041-2070 Forecast (°C/decade)			2071-2100 Forecast (°C/decade)		
			Low	Average	High	Low	Average	High	Low	Average	High
Annual	6.1	+0.31	+0.00	+0.41	+1.05	+0.15	+0.34	+0.66	+0.20	+0.33	+0.51
Spring	4.5	+0.50	+0.00	+0.45	+1.09	+0.14	+0.35	+0.69	+0.19	+0.34	+0.54
Summer	17.4	+0.26	+0.00	+0.43	+1.10	+0.15	+0.34	+0.69	+0.21	+0.34	+0.52
Fall	8.3	+0.05	+0.00	+0.36	+1.02	+0.12	+0.30	+0.63	+0.19	+0.32	+0.49
Winter	-5.7	+0.68	+0.00	+0.40	+0.99	+0.16	+0.33	+0.63	+0.21	+0.33	+0.50

Note:
The low and high data correspond to the forecasts for the scenario with the smallest and largest respective changes in temperature for each forecast horizon. The average represents the arithmetic average of the available forecasts. Refer to Appendix D of the Atmospheric Environment TSD for the derivation of trends.

Table 6.4.7-2: Historic and Future Precipitation Trends

Season	1971-2000 Normals (mm)	1971-2000 Trend (mm/decade)	2011-2040 Forecast (%/decade)			2041-2070 Forecast (%/decade)			2071-2100 Forecast (%/decade)		
			Low	Average	High	Low	Average	High	Low	Average	High
Annual	1,041.3	+0.13%	+0.00%	+1.44%	+3.57%	+0.36%	+1.11%	+2.09%	+1.39%	+1.30%	+2.25%
Spring	216.8	+3.23%	+0.00%	+2.59%	+5.39%	+0.62%	+1.51%	+2.72%	+1.88%	+2.24%	+4.05%
Summer	230.8	-0.51%	+0.00%	-1.65%	-3.40%	-0.95%	-1.13%	-0.42%	-0.68%	-0.85%	-0.61%
Fall	310.9	+4.41%	+0.00%	+2.09%	+4.35%	+2.28%	+1.67%	+2.75%	+2.11%	+1.65%	+1.85%
Winter	282.8	-4.65%	+0.00%	+2.39%	+7.30%	-0.27%	+1.82%	+3.08%	+2.05%	+1.92%	+3.32%

Note:
The low and high data correspond to the forecasts for the scenario with the smallest and largest respective changes in temperature for each forecast horizon. The average represents the arithmetic average of the available forecasts. Refer to Appendix D of the Atmospheric Environment TSD for the derivation of trends.

6.7.5 Existing Air Quality

6.7.5.1 Existing Air Quality in the Regional Study Area

The existing air quality in the Regional Study Area is characteristic of the general air quality in Southwestern Ontario, and has been described using monitoring data from stations operated by the MOE. The MOE recently has made the hourly air quality data collected at its stations available for use [242].

Oxides of Nitrogen

Oxides of nitrogen (NO_X) in the atmosphere are composed primarily of two compounds: nitrogen dioxide (NO_2) and nitric oxide (NO). Emissions of NO_X occur mainly from high-temperature combustion processes. In Ontario, the transportation sector accounts for approximately 64% of the NO_X emissions [243]. Although the majority of NO_X emissions are in the form of NO, these rapidly oxidize in the presence of hydrocarbons and sunlight to form NO_2. The NO_2 also reacts to form nitrate precursors, which contribute to the secondary formation of fine particulate matter ($PM_{2.5}$). Nitrogen dioxide (NO_2) was selected as an indicator for this assessment since it is the only oxide of nitrogen (NO_X) that has ambient criteria in Canada. Literature indicates that NO_2 can affect bronchial activity in asthmatics, and people suffering from bronchitis at levels as low as 470 µg/m³ [244].

A summary of the available 1-hour and 24-hour NO_2 monitoring results is presented in Table 6.7.5-1. There were no hourly readings that exceeded the ambient air quality criteria (AAQC) in Ontario of 0.200 ppm (i.e., 200 ppb). None of the 24-hour ambient monitoring results exceed the ambient air quality criteria (AAQC) of 0.100 ppm (i.e., 100 ppb).

Table 6.7.5-1: Ambient 1-hour and 24-hour NO_2 Monitoring Results

Parameter	Kitchener	London	Sarnia	Tiverton	AAQC
Maximum 1-hour (ppm)	0.071	0.151	0.156	0.034	0.200
Maximum 24-hour (ppm)	0.050	0.059	0.050	0.014	0.100

Sulphur Dioxide

Sulphur dioxide (SO_2) is formed when sulphur in fuel reacts with oxygen during the combustion process. Emissions of SO_2 are a precursor to acid rain and fine particulate matter (i.e., $PM_{2.5}$). Seventy-one percent of SO_2 emissions in the province of Ontario can be attributed to smelting operations and power generation [243].

Table 6.7.5-2 presents a summary of the 1-hour and 24-hour SO_2 concentrations. There were no hourly readings that exceeded the ambient air quality criteria (AAQC) of 0.250 ppm, at Kitchener, London or Tiverton. There were only two hours during the eight years of available data when the hourly concentrations in Sarnia exceeded the Ontario AAQC (one hour during each of 2001 and 2002). None of the 24-hour ambient monitoring results at the Kitchener, London or Tiverton stations exceeded the daily ambient air quality criteria (AAQC) of 0.100 ppm (i.e., 100 ppb). However, there were four days during the eight years of available data when the 24-hour concentrations in Sarnia exceeded the Ontario AAQC (two days during each of 2001 and 2006).

Table 6.7.5-2: Ambient 1-hour and 24-hour SO_2 Monitoring Results

Parameter	Kitchener	London	Sarnia	Tiverton	AAQC
Maximum 1-hour (ppm)	0.142	0.039	0.263	0.026	0.250
Maximum 24-hour (ppm)	0.017	0.016	0.131	0.009	0.100

Carbon Monoxide

Carbon monoxide (CO) is produced primarily through the incomplete combustion of hydrocarbons. The main source of CO produced in Ontario is from the transportation sector [243]. CO is a colourless, odourless, tasteless gas that can replace oxygen in the bloodstream, reducing the oxygen that is delivered to organs and tissues.

A summary of the available 1-hour and 8-hour CO monitoring results is presented in Table 6.7.5-3. Ambient CO data were not available at the Tiverton station. All of the stations with monitored data had hourly readings significantly lower than the ambient air quality criteria (AAQC) of 30 ppm. The recorded 8-hour CO levels at the remaining stations were also well below the AAQC of 13 ppm.

Table 6.7.5-3: Ambient 1-hour and 8-hour CO Monitoring Results

Parameter	Kitchener	London	Sarnia	Tiverton	AAQC
Maximum 1-hour (ppm)	5.380	3.500	3.860	—	30
Maximum 8-hour (ppm)	2.783	1.434	1.686	—	13

Note:
— Data not Available

Ozone

Ozone (O_3) is an essential part of the upper atmosphere that protects us from most of the sun's harmful ultra-violet radiation. Ozone can also be present at the earth's surface. Ground-level ozone can be attributed to three causes in Canada: photochemical ozone formation; stratospheric intrusion; and long-range transport.

Photochemical ozone forms when large volumes of oxides of nitrogen (NO_X) and volatile organic compounds (VOCs) are present during specific meteorological conditions. This type of ozone formation occurs during the daylight hours in the summer months when hot, sunny, stagnant conditions favour the necessary chemical reactions. Stratospheric intrusion of ozone is low in southern Canada; however, the transport of ozone over long distances occurs in several regions of Canada. In southern Ontario, photochemical ozone is frequently transported into Canada from larger cities in the United States.

Ozone was not identified as a key indicator for the assessment as the DGR Project does not directly emit ozone, nor does it emit precursor compounds in sufficient volumes to results in enhanced ozone formation. However, ozone is important in the conversion of nitric oxide (NO), the major constituent of NO_X emissions, to nitrogen dioxide (NO_2) in the atmosphere.

A summary of the available 1-hour ozone monitoring results is presented in Table 6.7.5-4. All of the stations had hourly readings that exceeded the ambient air quality for the 1-hr criteria (AAQC) of 0.080 ppm (i.e., 80 ppb). In 2007, the number of days per year when 1-hour O_3 exceeded the AAQC was eight, six, 19 and 20 days at the Kitchener, London, Sarnia and Tiverton stations, respectively.

Table 6.7.5-4: Ambient 1-hour O_3 Monitoring Results

Parameter	Kitchener	London	Sarnia	Tiverton	AAQC
Maximum 1-hour (ppm)	0.109	0.116	0.128	0.136	0.080

Currently there is no 8-hour AAQC for ozone, but there is a Canada-Wide Standard [245] that has been used for comparison to the data. Compliance with the Canada-Wide Standard is based on the fourth highest 8-hour value annually, averaged over a 3-year period. These concentrations at all of the stations (Kitchener, London, Sarnia and Tiverton) exceeded the Canada-Wide Standard of 0.065 ppm (i.e., 65 ppb).

Fine Particulate Matter

Airborne particulate matter in Ontario is described using three size categories. Suspended particulate matter (SPM) is the largest category and includes those airborne particles with an aerodynamic diameter nominally less than 44 µm. The portion of the SPM with a nominal aerodynamic diameter of 10 µm, or less is referred to as PM_{10}. The PM_{10} sized particles are small enough to be inhaled into the upper respiratory tract. The fraction of the SPM and PM_{10} with a nominal aerodynamic diameter of 2.5 µm or less is referred to as $PM_{2.5}$. The $PM_{2.5}$ sized particles are small enough to be drawn into the lungs, and are sometimes described as the respirable fraction of airborne particles. While periodic monitoring of SPM and PM_{10} is still done in Ontario, only the continuous $PM_{2.5}$ monitoring data is available electronically for review and presentation.

A summary of the available daily $PM_{2.5}$ monitoring results is presented in Table 6.7.5-5. While there is no AAQC for $PM_{2.5}$, the Canada-Wide Standard [245] has been used to compare to the data. However, compliance with the Canada-Wide Standard is based on the 98th percentile of the monitoring data, averaged over a 3-year period. The $PM_{2.5}$ levels monitored at Kitchener, London and Sarnia exceeded the Canada-Wide Standard of 30 µg/m³ (based on the 98th percentile). However, data at Tiverton shows that the Canada-Wide Standard was met at this station.

Table 6.7.5-5: Ambient 24-hour $PM_{2.5}$ Monitoring Results

City	3-Year 98th Percentile 24-hour $PM_{2.5}$ (µg/m³) [a]		
	2003 to 2005	**2004 to 2006**	**2005 to 2007**
Kitchener	32.0	30.1	28.9
London	34.3	31.3	27.9
Sarnia	39.9	37.1	35.8
Tiverton	28.2	25.8	24.7
Canada-Wide Standard (µg/m³) [b]	**30**	**30**	**30**

Notes:
a $PM_{2.5}$ monitoring data were available from 2003 to 2007 (see Table 5.4.1-2 in the Atmospheric Environment TSD).
b Compliance with the Canada-Wide Standard is based on the 98th percentile of the monitoring values, averaged over a 3-year period.

6.7.5.2 Background Air Quality

Air monitoring data collected within the Regional Study Area represent the combined effect of emissions from sources near each of the monitoring stations, as well as the effect of the emissions transported into the region. The emissions transported into the region could be considered to be the "background air quality". Based on feedback from regulators, the 90th percentile of the available monitoring data is considered a conservative estimate of background air quality [246]. Table 6.7.5-6 provides a listing of the 90th percentile concentrations from the air monitoring stations in the Regional Study Area, as well as background concentrations derived from the monitoring results.

Table 6.7.5-6: Background Air Quality

Indicator	Background (µg/m³)	90th Percentile of Monitored Data (µg/m³)			
		Tiverton	**London**	**Kitchener**	**Sarnia**
1-hour NO_2	13.2	13.2	47.0	52.7	52.7
24-hour NO_2	12.0	12.0	41.0	43.7	45.4
Annual NO_2	5.4	5.4	23.4	25.8	27.0
1-hour SO_2	10.5	10.5	15.7	55.0	15.7
24-hour SO_2	9.3	9.3	14.8	64.3	14.1
Annual SO_2	3.6	3.6	7.2	23.8	6.6

Table 6.7.5-6: Background Air Quality (continued)

Indicator	Background (μg/m³)	90th Percentile of Monitored Data (μg/m³)			
		Tiverton	London	Kitchener	Sarnia
1-hour CO	816.5	—	816.5	678.5	517.5
8-hour CO	945.9	—	945.9	823.4	606.6
24-hour SPM	52.1 [a]	—	—	—	—
Annual SPM	23.0 [a]	—	—	—	—
24-hour PM_{10}	22.7 [a]	—	—	—	—
24-hour $PM_{2.5}$	13.6	13.6	17.4	22.8	19.1

Notes:
a The background levels of SPM and PM_{10} are derived from background $PM_{2.5}$ data. A description for the derivation of these background values is provided in Appendix E of the Atmospheric Environment TSD.
— Data not available.

6.7.5.3 Existing Air Quality in the Local Study Area

The existing air quality in the Local Study Area is described using a combination of background air quality and the modelled air quality resulting from the emissions from existing sources at the Bruce nuclear site. The AERMOD dispersion model (Version 09292) was run to predict maximum concentrations resulting from existing sources at the Bruce nuclear site. The background air quality for the region was then added to these predictions to yield existing air quality in the Local Study Area.

Modelled Air Quality from Existing Sources

To model the existing air quality in the Local Study Area, the emissions associated with the existing operations at the Bruce nuclear site are input to the same dispersion model used to evaluate the effects of the DGR Project on air quality. While there are currently four units operating at Bruce B and two units operating at Bruce A, the existing conditions are considered to be those that would correspond with the completion of the refurbishment activities described in Bruce A Refurbishment for Life Extension and Continued Operations Project Environmental Assessment [247], such that all eight existing units are operational.

Table 6.7.5-7 lists the daily emission rates from the Bruce nuclear site (including the Bruce Power facilities, Atomic Energy of Canada Limited [AECL] facilities and OPG facilities) that were used to characterize the air quality in the Local Study Area from existing sources.

Table 6.7.5-7: Existing Daily Emissions at the Bruce Nuclear Site

Indicator Compound	Average Daily Emission Rates (kg/d)			
	Bruce Power [a]	WWMF	Passenger Vehicles [b]	Fugitive Dust [c]
NO_X	2,442.02	6.05	0.36	—
SO_2	5,921.84	1.73	0.00	—
CO	282.86	0.00	7.11	—
SPM	485.16	0.27	0.02	0.64
PM_{10}	411.41	0.27	0.02	0.11
$PM_{2.5}$	270.09	0.27	0.01	0.00

Notes:
a Bruce Power includes Bruce Power facilities, including Bruce Power worker vehicles travelling on-site.
b Includes tailpipe emissions from all of the OPG worker vehicles on-site.
c Includes all fugitive dust, including road dust, generated by on-site traffic.
— Indicates that data is not available.

Table 6.7.5-8 provides a summary of the dispersion modelling results for those compounds and averaging periods that were used when evaluating how emissions from the DGR Project could affect air quality. The table lists results for the Local Study Area, outside of the Bruce nuclear site. Consistent with guidance in Ontario [240], concentrations within the Site Study Area would be excluded when comparing modelling results to criteria or standards.

Table 6.7.5-8: Modelled Air Quality in the Local Study Area from Existing Sources

Indicator	Maximum Modelled Concentration (µg/m³)
1-hour NO_2	97.2
24-hour NO_2	14.5
Annual NO_2	1.4
1-hour SO_2	308.4
24-hour SO_2	42.0
Annual SO_2	1.4
1-hour CO	764.1
8-hour CO	255.9
24-hour SPM	18.9
Annual SPM	2.1

Table 6.7.5-8: Modelled Air Quality in the Local Study Area from Existing Sources (continued)

Indicator	Maximum Modelled Concentration (µg/m³)
24-hour PM_{10}	3.3
24-hour $PM_{2.5}$	1.8

Note:
a The maximum predicted value from the model at any receptor location. The maximums were predicted to occur at the fenceline of the Bruce nuclear site.

Existing Air Quality in the Local Study Area

As noted, the existing air quality is the sum of background air quality and the concentrations attributed to emissions from existing sources at the Bruce nuclear site. Table 6.7.5-9 provides a summary of the existing air quality in the Local Study Area.

Table 6.7.5-9: Existing Air Quality in the Local Study Area

Indicator	Maximum Modelled Concentration from Existing Sources [a] (µg/m³)	Background Air Quality [b] (µg/m³)	Existing Air Quality [c, d] (µg/m³)
1-hour NO_2	97.2	13.2	110.4
24-hour NO_2	14.5	12.0	26.5
Annual NO_2	1.4	5.4	6.8
1-hour SO_2	308.4	10.5	318.9
24-hour SO_2	42.0	9.3	51.3
Annual SO_2	1.4	3.6	5.0
1-hour CO	764.1	816.5	1,580.6
8-hour CO	255.9	945.9	1,201.8
24-hour SPM	18.9	52.1	71.0
Annual SPM	2.1	23.0	25.1
24-hour PM_{10}	3.3	22.7	26.0
24-hour $PM_{2.5}$	1.8	13.6	15.4

Notes:
a See Table 6.7.5-8.
b See Table 6.7.5-6.
c Existing air quality represents the sum of maximum modelled concentrations from existing sources and background air quality.
d The numbers in the table above are correct, but because of rounding may not appear to add up to the existing air quality concentrations shown above.

6.8 NOISE LEVELS

The existing noise environment has been characterized using available monitoring data, supplemented by a focused noise field investigation. This investigation, conducted in May 2007, included monitoring in the Local Study Area, and some Site Study Area noise measurements. The potential effects of the DGR Project are expected to be negligible in the Regional Study Area. For further details see the Atmospheric Environment TSD.

6.8.1 Spatial Boundaries

The general study areas used to assess noise effects of the DGR Project are the same as the study areas used for assessing the effects on climate, weather conditions and air quality (Section 6.7.1 and as shown on Figures 6.7.1-1, 6.7.1-2 and 5.1.3-1).

6.8.2 Valued Ecosystem Components

Table 6.8.2-1 presents the VEC for noise along with the rationale for selection and the specific indicator used in the assessment.

Table 6.8.2-1: Atmospheric Environment VECs Selected for Noise

VEC	Rationale for Selection	Indicators	Measures
Noise Levels	• Has been identified as an important aspect of the environment by both public and regulators • Changes in noise levels because of the DGR Project are possible	• 1-hour energy equivalent noise level (L_{eq})	• Changes in the 1-hour L_{eq} from existing levels • Resulting L_{eq}

6.8.3 Field Programs

The noise field study program is divided into two separate activities: continuous noise monitoring and spot noise measurements, which are described as follows:

- Continuous noise monitoring was carried out at three off-site locations (i.e., R1, R2 and R3 on Figure 6.8.3-1) to collect the existing noise levels for daytime (0700 to 1900) and night-time (1900 to 0700) periods at points of reception near the site.
- Spot noise measurements including the spectral content (i.e., frequency components) at the various monitoring locations (on and off-site) were carried out during the daytime and night-time periods to characterize the nature of existing noise levels at the same locations.

Continuous noise monitoring was carried out at points of reception R1 and R2 between May 4 and 11, 2005, with acoustical parameters logged every hour over a continual 182 hours of monitoring. Additionally, continuous long-term noise monitoring at R3 was completed between May 8 and 22, 2007. These off-site noise points of reception are described as follows (see Figure 6.8.3-1):

- R1 – Off-site monitoring Location One is located on Albert Road adjacent to Inverhuron Provincial Park approximately 2 km from the WWMF. The acoustic environment at this location is dominated by sounds of nature, however, road traffic noise from Albert Road and Concession 2 is also audible at this location. It was noted during the field program that Bruce nuclear site operations were not audible at this location during daytime and night-time site visits.
- R2 – Off-site monitoring Location Two is located across Baie du Doré approximately 2 km from the WWMF. The acoustic environment at this location is dominated by water noise on the shore of Lake Huron and other sounds of nature. Noise emissions from Bruce A were faintly discernable at this location during the field program.
- R3 – Off-site monitoring location three is located within Inverhuron Provincial Park at an existing camp site and is approximately 2 km from the WWMF. The acoustic environment at this location is dominated by sounds of nature and water noise on the shore of Lake Huron. Noise from the Bruce nuclear site was barely audible from this location.

Overall, a total of 182 and 333 hourly values were recorded in the 2005 and 2007 monitoring programs, respectively. The recorded data included the following acoustical indices:

- L_{eq} – energy averaged equivalent sound level;
- L_{95} – sound level exceeded 95% of the time;
- L_{90} – sound level exceeded 90% of the time;
- L_{50} – sound level exceeded 50% of the time; and
- L_{10} – sound level exceeded 10% of the time.

6.8.4 Existing Noise Levels (Local and Site Study Areas)

6.8.4.1 Noise Monitoring Results

Table 6.8.4-1 summarizes the results of the off-site noise monitoring program. The table lists the measured minimum and maximum hourly sound level (i.e., L_{eq}), as well as the associated L_{90} measured at each of the off-site monitoring locations. This data indicates that the existing off-site noise levels are reflective of a rural environment (i.e., sound levels are generally less than 50 dBA) and are characterized by sounds of nature (i.e., rustling leaves, waves on the shore of Lake Huron and birds).

Table 6.8.4-1: Summary of Noise Levels at Off-Site Monitoring Locations

Location	Minimum / Maximum 1-Hour L_{eq} (dBA)	Associated 1-Hour L_{90} (dBA)	Date	Time
R1 – Albert Road	36.3 (min)	35.7	May 6, 2005	23:00 – 00:00
	74.3 (max)	40.2	May 5, 2005	15:00 – 16:00
R2 – Baie du Doré	37.2 (min)	35.7	May 6, 2005	00:00 – 01:00
	76.1 (max)	36.3	May 4, 2005	11:00 – 12:00
R3 – Inverhuron Provincial Park	34.6 (min)	34.5	May 22, 2007	03:00 – 04:00
	65.8 (max)	43.3	May 9, 2007	10:00 – 11:00

When assessing the potential for adverse effects of the DGR Project on noise levels, the quietest existing hourly noise level for each of the three monitoring locations is used, because changes would be most noticeable during the quietest hour of any day. Table 6.8.4-2 summarizes the minimum hourly noise levels for each of the three off-site noise receptors considered in the assessment.

Table 6.8.4-2: Existing Noise Levels at Off-Site Noise Monitoring Locations

Location	Minimum 1-Hour L_{eq} (dBA)	Date	Time
R1 – Albert Road	36	May 6, 2005	23:00 – 00:00
R2 – Baie du Doré	37	May 6, 2005	00:00 – 01:00
R3 – Inverhuron Provincial Park	35	May 22, 2007	03:00 – 04:00

Note:
The maximum 1-hour L_{eq} measurements have been rounded to the nearest whole number for use in the assessment.

0 0.5 1 2
Kilometres

LEGEND

- Noise Receptor
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

NOISE MONITORING AND MEASUREMENT LOCATIONS

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	FIGURE 6.8.3-1	
GIS	BC	18 May. 2010		
CHECK	AB	18 May. 2010		
REVIEW	SM	18 May. 2010		

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6.9 ABORIGINAL INTERESTS

This section characterizes the existing environment for Aboriginal interests. For further detail refer to the Aboriginal Interests TSD.

6.9.1 Spatial Boundaries

The general study areas described in Section 5.1 and shown on Figures 5.1.1-1, 5.1.2-1 and 5.1.3-1, were adapted, without change, to assess the DGR Project-related likely effects on Aboriginal interests. Lands relevant to the Saugeen Ojibway Nation (SON), the Historic Saugeen Métis Community (HSMC) and the Métis Nation of Ontario (MNO) represented citizens in the Georgian Bay Region are also considered.

6.9.2 Valued Ecosystem Components

The interests of Aboriginal peoples from which VECs were defined were identified through reviews of the following:

- correspondence between the proponent and Aboriginal representatives and minutes of meetings between the proponent and Aboriginal organizations between 2003 and 2010;
- literature pertaining to Aboriginal treaties, land claims, fishing and harvesting rights;
- Aboriginal communities expressing interests in the Regional Study Area;
- general ecological, socio-economic and cultural heritage interests for Ojibway and Métis peoples in Ontario; and
- previous EAs for projects at the Bruce nuclear site.

Discussions between OPG and Aboriginal people were initiated in 2003 in reference to the EA of the DGR Project (see Section 2). Records of communication, including correspondence, records of meetings, site visits and telephone calls were reviewed. The Aboriginal interests identified through the historic record of communication included the following:

- the need for the Crown to fulfill its duty to consult and accommodate;
- the preservation and access to Aboriginal burial grounds at the Bruce nuclear site;
- respect for cultural heritage, traditional knowledge and Ojibway spiritual interests, land claims, traditional territory and long-term use of lands and waters;
- fishing and harvesting rights;
- health of members of Aboriginal communities;
- environmental health; and
- economic benefits and/or effects (includes alternative energy, scholarships, employment, procurement, and tourism).

In addition, the Saugeen Ojibway Nation (SON)[15] has identified an issue with the siting of the original facilities at the Bruce nuclear site, previously known as the Bruce Nuclear Power Development (BNPD).

OPG undertook to follow up on the legacy issue concerns. On January 28, 2010 OPG executive management met with the Chiefs of Nawash and Saugeen First Nations. At that meeting the Chiefs indicated that the First Nations had not been consulted in the past, when decisions were first made regarding the Bruce nuclear site, nor were they involved in subsequent decisions regarding the various nuclear waste management facilities at the site. Concern was also expressed over the impact of nuclear plant operations on the fishery and regarding health effects from nuclear plant operations.

OPG offered to implement an issue resolution process, based on its experience addressing past grievances raised by other First Nations. OPG provided SON with a draft memorandum of understanding that described the proposed process, including reporting, confidentiality and financial matters. OPG and SON have held regular meetings to develop and implement an issue resolution process to the mutual satisfaction of all parties.

An examination of previous EA studies, spanning the time period of 1997 to 2008, for a variety of nuclear power generation, waste management and electricity transmission projects related to the Bruce nuclear site was also conducted to identify Aboriginal interests that may be relevant to the DGR Project. The full list of EA studies that have been examined is provided in Section 4.1 of the Aboriginal Interests TSD.

Information regarding Aboriginal rights and treaty information was drawn from Indian Treaties and Surrenders, Volume 1: Treaties 1-138 [248] and various federal and provincial government documents. Additional information drawn from the literature is provided in Sections 4.2 and 5.2 of the Aboriginal Interests TSD.

6.9.2.1 Aboriginal Rights, Aboriginal Title or Treaty Rights

Aboriginal Rights

First and foremost, among the Aboriginal interests communicated to OPG by Aboriginal people or documented in the literature and previous EAs are those related to Aboriginal rights and Aboriginal title.

As defined in the DGR Project EIS Guidelines, Aboriginal rights mean those rights of Aboriginal peoples that are not found in treaties or land claims agreements. Aboriginal title means the form of land ownership belonging to Aboriginal people and the rights coming from the Aboriginal relationship with the land. Aboriginal rights vary from group to group depending on the customs, practices and traditions that have formed part of their distinctive cultures. Aboriginal rights are protected under s.35 of the Constitution Act, 1982 [249].

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[15] The Saugeen Ojibway Nation (SON) is the collective name for the Chippewas of Saugeen First Nation and the Chippewas of Nawash Unceded First Nation. These two First Nations share the same Aboriginal and treaty rights, including rights to fish commercially in the waters around the Bruce Peninsula.

In general, the concerns expressed by the SON have related to the need for all parties within their traditional territory to respect and acknowledge the SON's sovereignty and maintaining the relationship established by the treaties, their traditional land use and harvesting activities, and way of life. For example, the available documentation indicates that:

> *"The First Nations feel it is of extreme importance that the land surrenders experienced did not affect or diminish their Aboriginal rights in the surrounding waters, which are part of their traditional territory, or the fishing rights traditionally exercised by their people since time immemorial. Rights in these waters and to their fishery have also been assured through treaty rights and these Aboriginal and treaty rights have been recognized and affirmed in s. 35 of the Constitution Act, 1982"* [200].
>
> *"The land itself is important, but the lake bed is perhaps of even greater importance to us"* [250].

The HSMC have asserted the Aboriginal right to hunt and harvest in Regional Study Area. MNO-represented citizens have asserted the Aboriginal right to hunt and harvest in the Regional Study Area.

Summary of First Nation Treaties

The following treaty information is drawn from Indian Treaties and Surrenders. Volume 1: Treaties 1-138 [248]. The treaties are illustrated on Figure 6.9.2-1.

The Bond Head Treaty 45½, August 9, 1836

Surrender of the "Sauking Territory", which includes the current Bruce County, Grey County, and portions of Huron, Wellington, Dufferin and Simcoe Counties. The area extends along the Lake Huron shoreline from Southampton in the north to south of Goderich. As a result of this treaty, the Aboriginal peoples within the area moved north of the treaty area, the northern border of which extends along a line roughly between Southampton and Owen Sound, into the Bruce Peninsula. In return for the surrender of the land, the Crown indicated that it would protect the Aboriginal lands on the Bruce Peninsula, the islands and fishing from settlers.

Treaty 67, September 2, 1851

Surrender of a one-kilometre-wide strip of land stretching between Southampton and Owen Sound (between the two reserves). This treaty was signed with the understanding that the government would build a road in between the two reserves to facilitate improved communications between the communities. The total land surrendered was approximately 1,940 ha (4,800 acres). The land was surrendered in trust for the purpose of being sold, with the proceeds to be invested by the Government of Canada for the benefit of the First Nations and their posterity.

Treaty 72, October 13, 1854

Surrender of the Bruce Peninsula with the exception of the Saugeen Tract (reserve No. 29 at Southampton), Chief's Point reserve No. 28, Cape Croker reserve No. 27, Owen Sound reserve (Nawash), Colpoy's Bay reserve, and the hunting grounds (reserves No. 60A and 60B). The treaty indicated that the area of land at the mouth of the Saugeen River was to be divided into lots and sold immediately for the benefit of the First Nations. The interest of the principal sum arising from the sale of the ceded lands was to be regularly paid to the First Nations as long as community members exist.

Treaty 82, February 9, 1857

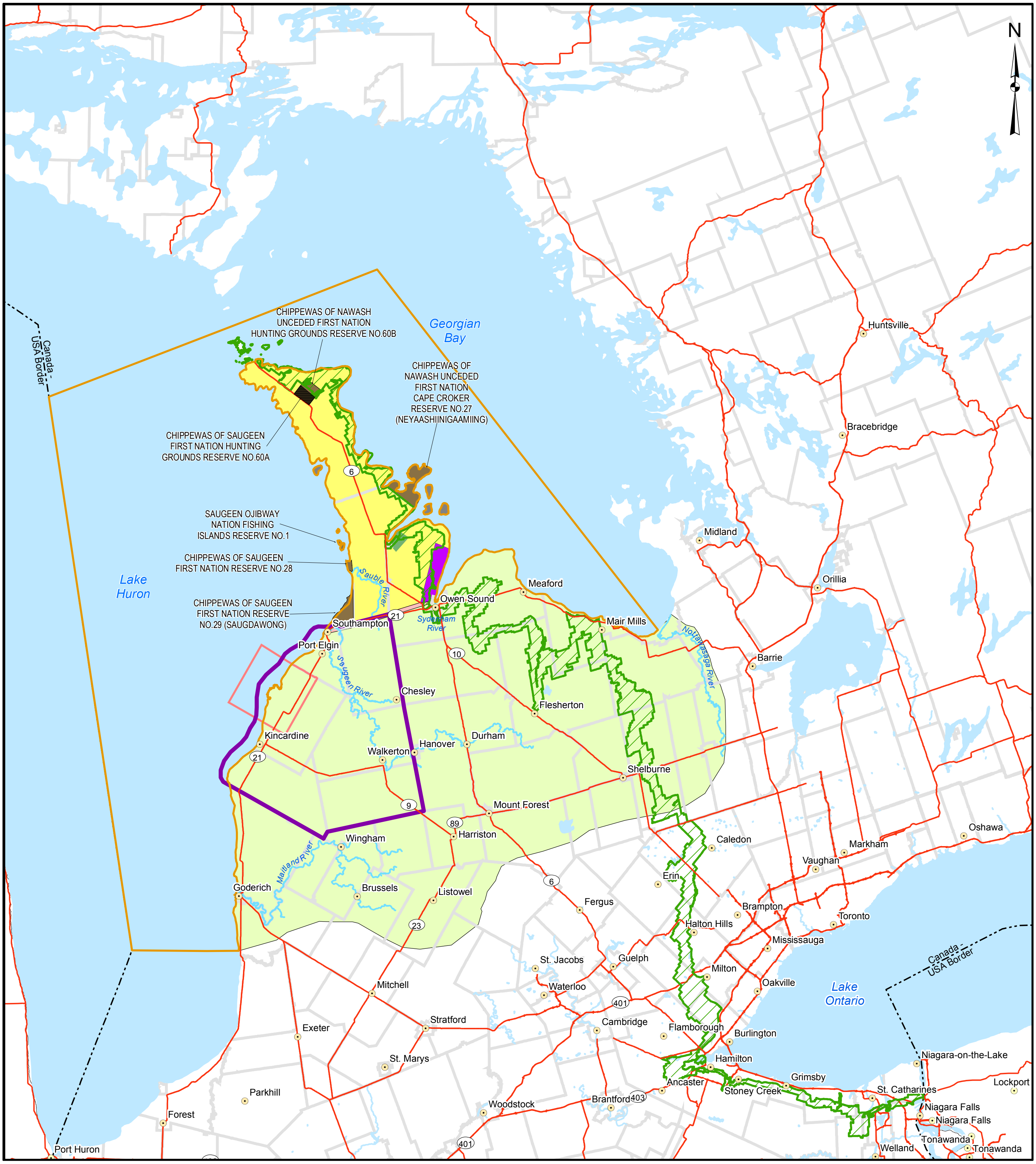
Surrender of the Owen Sound (Nawash) reserve. It was agreed that the surrendered land (approximately 4,050 ha or 10,000 acres) would be sold for the benefit of the First Nations. In return for the land surrender, every First Nations family was to receive 10 ha (25 acres) of land for cultivation at Cape Croker along with a house, and the community was to receive funds to erect a church and conduct other permanent improvements as approved by the Governor General. In addition, a plot of land was to be set aside for a burial ground.

Treaty 93, August 16, 1861

Surrender of the Colpoy's Bay reserve. The total area surrendered was approximately 2,400 ha (6,000 acres). This land was surrendered in trust to be sold for the benefit of the First Nations [248].

SON Land Claims

In 1973 the federal government recognized two broad categories of land claims: specific claims; and comprehensive claims. Specific claims result from the breach or non-fulfillment of government obligations found in treaties, agreements or statutes. Comprehensive claims are based on Aboriginal title that has not been dealt with through a treaty or other legal means, and include issues such as land title, Aboriginal rights, and financial compensation [251].



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LEGEND

- Aboriginal Title Claim Area
- Regional Study Area
- Local Study Area
- Niagara Escarpment
- First Nations' Lands 2004
- Treaty 93 (1861) Area
- Treaty 67 (1851) Area
- Treaty 45 1/2 (1836) Area
- The Islands Around The Peninsula Were Subject To Various Treaties But Many Small Islands On The Lake Huron Side Were Returned To The First Nations In 1980
- Treaty 82 (1857) Area
- Treaty 72 (1854) Area

REFERENCE

Treaty areas approximated from www.bmts.com ~dibaudjimoh / page 120.html media release. "Nawash & Saugeen FNs lay claim to the lake bed of Lake Huron and Georgian Bay" Jan. 2004.
Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

SAUGEEN OJIBWAY NATION TRADITIONAL TERRITORY

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	12 Mar. 2007		
GIS	BC	14 Jun. 2010	**FIGURE 6.9.2-1**	
CHECK	AE	14 Jun. 2010		
REVIEW	MAR	14 Jun. 2010		

[PAGE LEFT INTENTIONALLY BLANK]

The SON attempted to resolve the land claims arising from the treaties in the late 1980s; however, the claims could not be classified as specific or comprehensive claims since they did not fit the criteria of either type of claim, and the discussions dwindled [252].

In 1994, the SON launched a claim on the Saugeen (Bruce) Peninsula for compensation for lands included under Treaty 72, alleging that the Crown had breached its fiduciary obligation to protect Native lands from the encroachment of non-Native settlers, which was something that Lieutenant Governor Francis Bond Head promised to do during the negotiations of Treaty Number 45½ in 1836. The SON is seeking the return of approximately 20,500 ha (50,000 acres) of lands that have not been paid for or that are now in the hands of governments. The majority of this land is road allowances and river and lake bottoms, which were never sold by the Crown after Treaty 72. Lands legitimately patented and owned by third parties are not to be included. In lieu of land not available for repatriation, the Bands are claiming its monetary value, plus compensation for loss of its use. The monetary value of the claim is $90 billion [253]. The claim remains active at the time of writing.

At an international conference in Duluth, Minnesota, the Chief of the Saugeen First Nation announced the Duluth Declaration, which is an assertion of jurisdiction over the waters around the Saugeen/Bruce Peninsula in their entirety, the fisheries, lands and minerals, above and below the waters, including the lake bed. The declaration indicates that this jurisdiction extends to the median point in the water between the Saugeen Nation territory, water and land, and all other national territory [254].

SON Fishing and Harvesting Rights

Fishing rights of the SON in both Lake Huron and Georgian Bay have been a fundamental issue related to territorial rights and claims of the SON, history of the communities in the Bruce Peninsula, and the Bruce nuclear site activities and related EAs.

The *Jones-Nadjiwon* decision on April 26, 1993, was a pivotal judgement that established claims rights for the SON to fish in the waters adjacent to the Bruce nuclear site. The judgement confirmed that the SON retained their rights to a commercial fishery in waters around the Bruce Peninsula [255].

In June 2000, the first Fisheries Agreement to manage the commercial fishery in Lake Huron and Georgian Bay around the Bruce Peninsula was signed by members of the Chippewas of Nawash and Saugeen First Nations and the provincial and federal governments. The people of these two First Nations gained access to all of the peninsula's fisheries, and agreed not to fish in Owen Sound and Colpoy's Bay since recreational anglers are most active at these locations.

SON Reserve Lands

The Chippewas of Nawash Unceded First Nation reside on an approximately 7,200 ha (72 km²) reserve, the Cape Croker or Neyaashiinigamiing Reserve No. 27, on the eastern shore of the Bruce Peninsula. The reserve is approximately 26 km from Wiarton, 64 km from Owen Sound and approximately 80 km north of the Bruce nuclear site (Figure 5.1.1-1).

The Chippewas of Saugeen First Nation reside on an approximately 3,800 ha reserve, the Saugeen Reserve No. 29, located adjacent to the community of Southampton on the shoreline of Lake Huron, between the mouths of the Saugeen and Sauble Rivers. The reserve is approximately 24 km north of the Bruce nuclear site (Figure 5.1.1-1). The Chippewas of Saugeen First Nation also includes approximately 5 km^2 of reserve lands at Chief's Point Reserve No. 28, located to the north of reserve No. 29 [256].

The SON use hunting grounds near the tip of the Bruce Peninsula on Highway 6. There are two hunting ground reserves located in the same area: the Saugeen First Nation Hunting Grounds Reserve No. 60A; and the Cape Croker Hunting Grounds Reserve No. 60B. The hunting grounds are approximately 730 ha and 890 ha, respectively. Hunting is not permitted within the Bruce nuclear site because of security restrictions.

The SON have reserve lands at the Saugeen and Cape Croker Fishing Island Reserve No. 1, which consists of 89 islands in Lake Huron, east of the Bruce Peninsula townships of Albermarle, Amabel, Eastnor and St. Edmunds. The islands of the reserve make up approximately 0.1 km^2 [257].

Métis Communities and Métis Rights

The Métis are a distinct Aboriginal people with a unique history, culture, language and territory that includes the waterways of Ontario, surrounds the Great Lakes and spans what was known as the historic Northwest. In Ontario, the Métis people were interconnected by their highly mobile lifestyle, the fur trade network, seasonal rounds, extensive kinship connections and a shared collective history and identity.

The Métis are included in s.35 of the Canadian Constitution. Through inclusion in the Constitution, Canada recognizes and values the Métis and recognizes the importance of enhancing their survival as distinctive communities. The Métis view the purpose of s.35 as protecting the "rights" practices that were historically important to the Métis, and which have continued to be important in modern Métis communities. The Supreme Court of Canada, in the historic Powley decision, describes these practices as "integral" to the Métis and provides Métis with harvesting rights. The Court said that the framers of the Constitution Act, 1982 recognized that Métis communities must be protected along with other Aboriginal communities.

The Historic Saugeen Métis Community (HSMC) is a self-governed Métis community at the mouth of the Saugeen River, Southampton, Ontario. The HSMC are a rights-bearing community that asserts harvesting rights. They have historically hunted, fished, traded and lived in the traditional Saugeen territory since the early 1800s. The HSMC became independent and self-governing in 2008.

The Métis Nation of Ontario includes MNO Community Councils. MNO Community Councils obtain their mandate to support local governance from the MNO through signed Community Charter agreements. In 1995 the MNO implemented the MNO Harvesters Policy as a way to facilitate the harvest in Ontario. This Policy includes a Captains of the Hunt system, provisions for the issuance of MNO Harvesters Cards, as well as the identification of traditional harvesting areas throughout Ontario [258].

Under the Harvesters Policy, registered Métis citizens are permitted to take or transport wildlife or fish for the purpose of personal consumption or social or ceremonial purposes, or for barter in kind of wildlife or fish within or among Aboriginal peoples, as long as this is not done for commercial purposes. There are also restrictions if conservation objectives might be considered to be put at risk, such as the destruction of habitat; fishing in fish sanctuaries that are closed at all times of the year; hunting in waterfowl sanctuaries; the taking or possession of rare, threatened or endangered species; the taking of wildlife or fish in quantities that will put conservation objectives at risk; or the wilful spoilage of wildlife or fish [259].

6.9.2.2 Aboriginal Traditional Knowledge

Guidance provided by the Canadian Environmental Assessment Agency [260] describes Aboriginal traditional knowledge as knowledge that is held by, and unique to, Aboriginal peoples. Further, according to the DGR Project EIS Guidelines, traditional knowledge (including traditional ecological knowledge or TEK) refers to the broad base of knowledge held by individuals and collectively by communities that may be based on spiritual teachings, personal observation and experience or passed on from one generation to another through oral and/or written traditions.

Traditional Ojibway Spiritual Worldview

Of particular relevance to the DGR Project EA is the traditional Ojibway spiritual worldview which, according to Usher's traditional knowledge categorization [261], would constitute the foundation of the SON knowledge system.

The traditional Ojibway spiritual worldview is that the physical world, including the rock of the earth, is the first order of creation upon which the other orders of creation — the plant world, the animal world and the human world — depend upon for sustenance and existence. The Aboriginal Interests TSD includes a description of the traditional Ojibway spiritual interests in the rock of the earth.

6.9.2.3 Valued Ecosystem Components

Table 6.9.2-1 presents the Aboriginal interests VECs along with their rationale for selection and the specific indicators used in the assessment.

Table 6.9.2-1: VECs Selected for the Aboriginal Interests

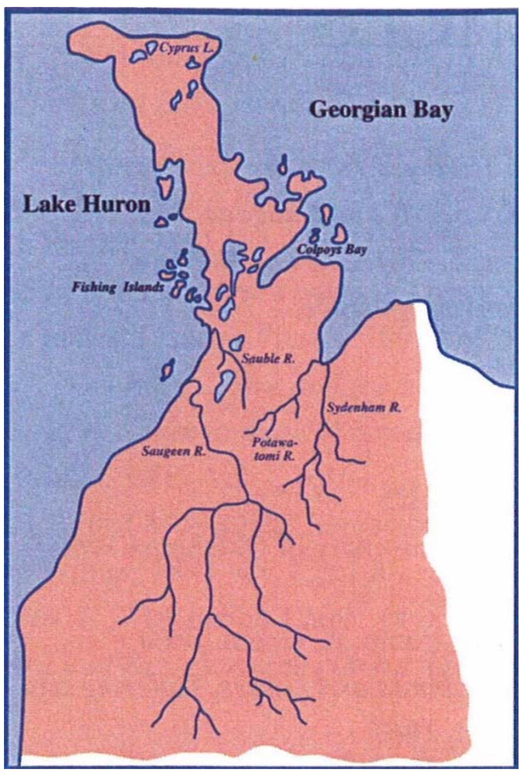
VEC	Rationale for Selection	Indicators	Measures
Aboriginal Communities [a]	• The DGR Project may affect the economic base, levels of service, social structure, and/or community stability of Aboriginal communities and residents	• Population levels • Local employment • Local business activity	• DGR Project-related change in population levels • DGR Project-related change in employment opportunities • DGR Project-related change in business opportunities
Aboriginal Heritage Resources	• Aboriginal heritage resources such as archaeological sites may be affected by the excavation of previously undisturbed lands or deeply buried artifacts • Specific cultural or spiritual sites (i.e., places that have historical, religious or cultural significance to Aboriginal people) may be affected	• Archaeological sites/burials and artifacts • Culturally-sensitive areas	• DGR Project-related change to archaeological/ burial sites and artifacts • Location of DGR Project in relation to culturally-sensitive areas
Traditional Use of Land and Resources	• Aboriginal people have traditionally made use of lands and resources for their personal and community needs throughout the Regional Study Area • The DGR Project may affect plants and animals that Aboriginal people fish, hunt, trap or gather for food, cultural, or economic purposes	• Atmospheric Environment • Hydrology and Surface Water Quality • Aquatic Environment • Terrestrial Environment • Geology • Radiation and Radioactivity • Attitudes towards traditional use of lands and resources	• DGR Project-related change in natural environments • Changes in attitudes towards traditional use of lands and resources attributed to the DGR Project

Note:
[a] Aboriginal communities consist of those individuals who are officially recognized by the Saugeen Ojibway Nation (SON), or the Métis Nation of Ontario (MNO), or the Historic Saugeen Métis Community (HSMC). For First Nations, the term "Aboriginal communities" refers primarily to their settlement areas on-reserve, but also includes those individuals living off-reserve. For Métis, the term "Aboriginal community" refers to distinctive Métis collectives who have developed their own customs, way of life, and group identity separate from their European and First Nation forebears and who have interests in the Regional Study Area. This broad definition allows for the analysis to be conducted at both an individual and a community level, respecting the perspectives of both First Nation peoples and the Métis.

6.9.3 The History of the Ojibway People in the Saugeen Region

First Nations people have lived in the Great Lakes region for at least 12,000 years. Historically, the two primary languages in the area were Algonquian and Siouan [262]. The Ojibway, also known as the Chippewa, are part of the Algonquian language group, the most widespread native language group in North America [263].

The traditional territory of the Ojibway in the Saugeen region covers the watersheds bounded by the Maitland River and the Nottawasaga River east of Collingwood on Georgian Bay, two million acres of farmland and a portion of the Niagara Escarpment Biosphere (see Figure 6.9.3-1). The area includes the Bruce Peninsula, all of Grey and Bruce Counties, and parts of Huron, Dufferin, Wellington and Simcoe Counties. Its shoreline is over 800 km long and, according to SON accounts, is the breeding ground for over 170 species of birds and supports more than 40 species of wild orchids. It is also home to grouse, rabbits, ducks, Canada geese, white-tailed deer and black bears. The surrounding waters still have large populations of whitefish, steelhead, hybrid lake trout, Chinook salmon, pike, bass and perch. Their traditional territories also include the land under the waters of Lake Huron to the international boundary, and the land under the waters of Georgian Bay to the mid point [253].



Source: [264]

Figure 6.9.3-1: The Nawash and Saugeen First Nations' Traditional Territories

French explorers and missionaries connected with the Ojibway in the mid-seventeenth century at Sault Ste. Marie. The French, who were accustomed to nations with strong centralized governments, did not realize that the First Nations communities in the region formed a single people. The French treated the First Nations communities as separate nations, but later tried to classify them into tribes and create organizations that had not previously existed. As a result, loosely allied groups of Ojibway were drawn together and became more united as a people [263].

The Odawa (Ottawa) lived on Manitoulin Island and the Saugeen ("mouth of river") peninsula, the Ojibway on the north shore of Georgian Bay and Lake Superior, and the Potawatomi in the thumb of Michigan. Together, these tribes were known as "The Council of the Three Fires" or "The Nations of the Three Fires" [262].

As immigration from Europe increased, rivalries among the French, the Dutch, and later the British led these nations to ally themselves with different First Nations groups on the eastern seaboard. Each tribe needed new and wider hunting grounds as fur-bearing animals in demand by Europeans became scarce. The pressure for hunting territory led to wars among the tribes. Hostility increased between the Hurons and the Iroquois, long-time enemies, when the latter sided with the English and the former with the French. In 1649–50 intertribal wars over the fur trade resulted in the decimation of the Hurons by the Iroquois. In 1653, the Iroquois were defeated by the Ojibway in a battle north of Manitoulin Island [265].

Around the beginning of the 1700s, Ojibway people used the lands in southern Ontario to harvest, hunt and fish [266]. The Ojibway migrated into southern Ontario from north of Lake Superior after defeating the Iroquois in the Ojibway-Iroquois fur trade wars. The Battle of Skull Mound was a decisive Ojibway-Iroquois battle that took place at the mouth of the Saugeen River around 1696 [266].

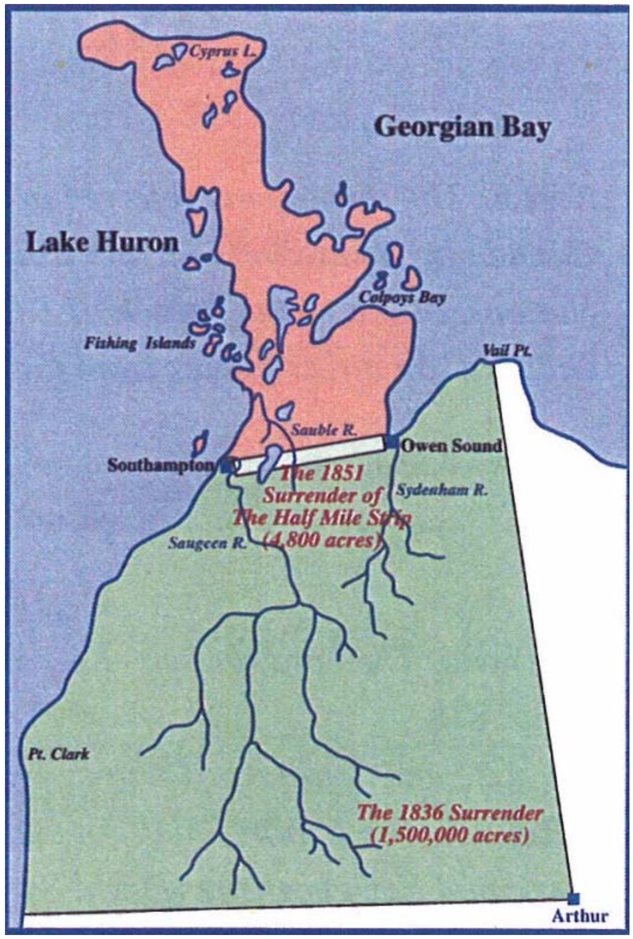
At the mouth of the Saugeen River (known as Sahgeenh in Ojibway) [266] there was an important Ojibway settlement [267]. This historic settlement is about 25 km to the northeast of the Bruce nuclear site. Fish were plentiful near the mouth of the Saugeen River and the area became an important gathering point. Each spring, summer and fall the waters were harvested for sturgeon, salmon, trout, pickerel, herring, whitefish, bass and suckers. During the winter, the Ojibway trapped and hunted [267].

The Nations of the Three Fires fought for the French against the British for about one hundred years. This came to an end in 1763 when the French were defeated in The Seven Years War. In 1763, following the Seven Years War, the British government outlined an approach to work with First Nations people. The Royal Proclamation of 1763 rested on four main points:

- establishment of a fixed boundary between First Nations and Crown lands;
- purchase of First Nations' land only through treaties made by the central government;
- government regulation of all trade with First Nations people; and
- a special government official (or department) to handle all political and diplomatic relations with First Nations tribes [263].

In the late 1830s, there was a large influx of American First Nations people that resulted in them outnumbering the Canadian First Nations people by six to one [268]. First Nations people from Upper Canada who were displaced because of an increase in British settlers were also arriving to the area [268]. Following Lieutenant Governor Sir Francis Bond Head's visit to Manitoulin

Island for the purpose of distributing annual presents to the nearly 1,500 First Nations people, seven Europeans and four First Nations people signed Treaty Number 45½ on August 9, 1836 in relation to 1.5 million acres of land (Figure 6.9.3-2) [248].



Source: [264]

Figure 6.9.3-2: Changes in First Nations Lands (1836 to 1851)

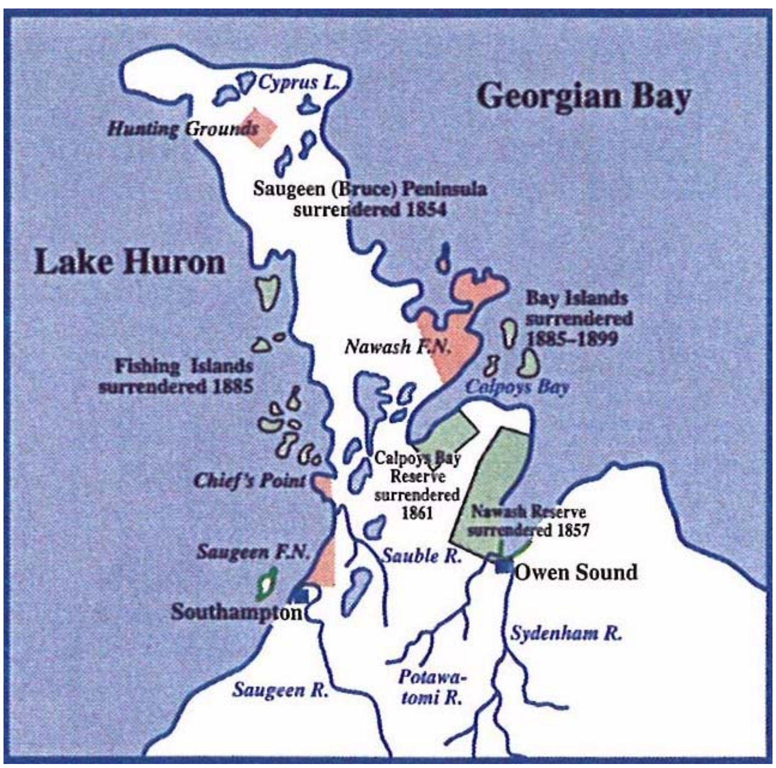
There are different interpretations regarding the manner in which this treaty was signed [268]. Of their two million acres of land, the Treaty of 1836 left them with 450,000. The Saugeen First Nation people petitioned the Secretary of State to obtain compensation for the land and a guarantee that their remaining land would not be taken from them. In 1846–47, a Royal Deed of Declaration was issued stating that the Saugeen First Nation people and their descendants would have rights to the remaining land and a small compensation was paid for the land that was dispossessed [268;264].

The Ojibway in the Bruce Peninsula area had developed a portage route across the base of the peninsula to facilitate travel between Lake Huron and southern Georgian Bay. To avoid the long water route around the Bruce Peninsula, the portage crossed the base of the peninsula, with an eastern section from around the Town of South Bruce Peninsula and Colpoy's Bay at

Wiarton, and a western section with one route running south across Boat Lake and along the Rankin and Sauble Rivers to Lake Huron, and second route running south across Boat Lake to Spry Lake and overland to the Lake Huron shore opposite the Fishing Islands [269].

The route from Boat Lake along the Rankin and Sauble Rivers was followed by Ojibway people visiting the historic Aboriginal village that was once situated at the mouth of the Saugeen River. This portage route was well used for social visits and for fishing, hunting and trading between the Ojibway communities that are now known as the Chippewas of Nawash Unceded First Nation and the Saugeen First Nation [269].

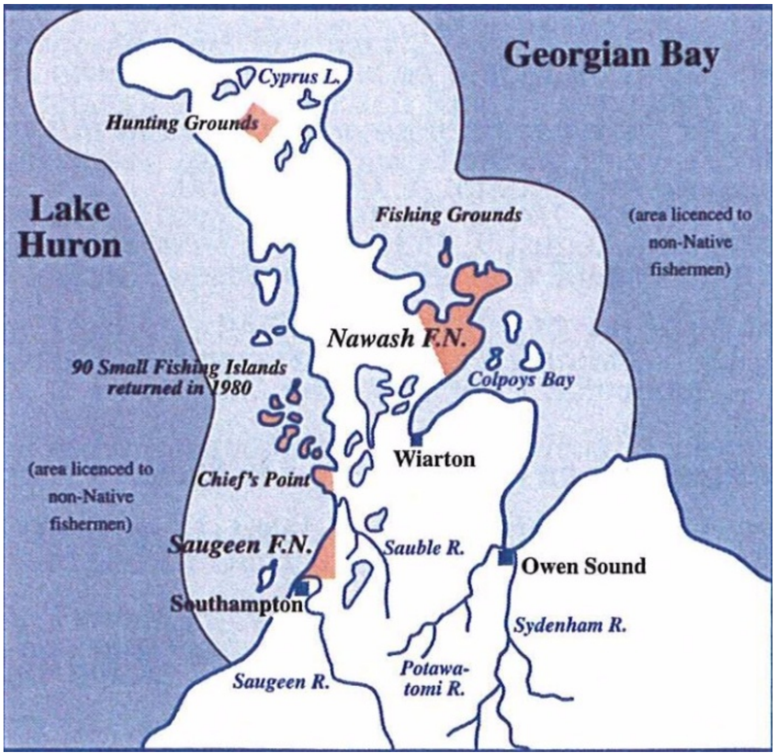
Between 1851 and 1852, the British engaged the Saugeen First Nation people regarding a half-mile strip between the Nawash and Saugeen settlements for the purposes of a road to be constructed between the two nations (Figure 6.9.3-2) [268;264]. Treaty No. 72 was eventually signed on October 13, 1854 [264;248], with the Saugeen First Nation people retaining 9,000 acres at Saugeen, 1,280 acres at Chief's Point, 10,000 acres at Nawash, 6,000 acres at Colpoy's Bay and 18,686 acres at Cape Croker [268] (Figure 6.9.3-3).



Source: [264]

Figure 6.9.3-3: Changes in First Nations Lands (1854 to 1899)

The Nawash and Saugeen First Nation's current land and fishing grounds can be seen on Figure 6.9.3-4. As indicated on the map, these do not include the land at Colpoy's Bay, Nawash and several islands in Lake Huron and Georgian Bay.



Source: [264]

Figure 6.9.3-4: Current Nawash Unceded First Nation and Saugeen First Nation Lands and Fishing Grounds

6.9.4 History of Métis Peoples with Interests in the Regional Study Area

Historian Arthur Ray asserts that Métis communities began forming in the upper Great Lakes area sometime after the establishment of the earliest French trading posts in the area in the late 16th century [270]. Historian Jacqueline Peterson concludes that by the 1820's, "a sizeable population of Métis, inhabiting a growing network of towns and villages, had established themselves as economic middlemen, intercultural brokers, and interpreters linking tribal peoples and Angloamerican patrons interested in the fur trade… the Great Lakes Métis artfully amalgamated elements of dissimilar cultures and belief systems and were in the process of developing a group consciousness and identity…" [271]. The Supreme Court of Canada in the Powley decision discussed the fact that there may be more than one "Métis peoples" in Canada.

The post-contact fur trading economy of the Saugeen River area began with the arrival of trader Pierre Piché in 1818. By 1826 the Hudson's Bay Company established a post as Saguingue (the name attached to the post near the mouth of the Saugeen River) and employed First Nations, Métis, French and British traders who sourced furs and skins from Ojibway hunters. By 1832 the supply of high quality furs was low and the Hudson's Bay Company closed its post. However, fur trading continued into the mid-nineteenth century when Southampton was founded [267].

The presence of the Hudson' Bay Company helped make the Southampton Métis community what historian David T. McNab referred to as "a hub of the Great Lakes and the centre of Aboriginal trade and trading until at least the late nineteenth century… the physical space of the community remains and with it the Métis people's special understanding of the place — a place of meeting grounds. It is here that Aboriginal trade and trading occurred with ubiquity and also where sovereignty continued to reside." [272]

6.9.5 Aboriginal Communities – Saugeen Ojibway Nation

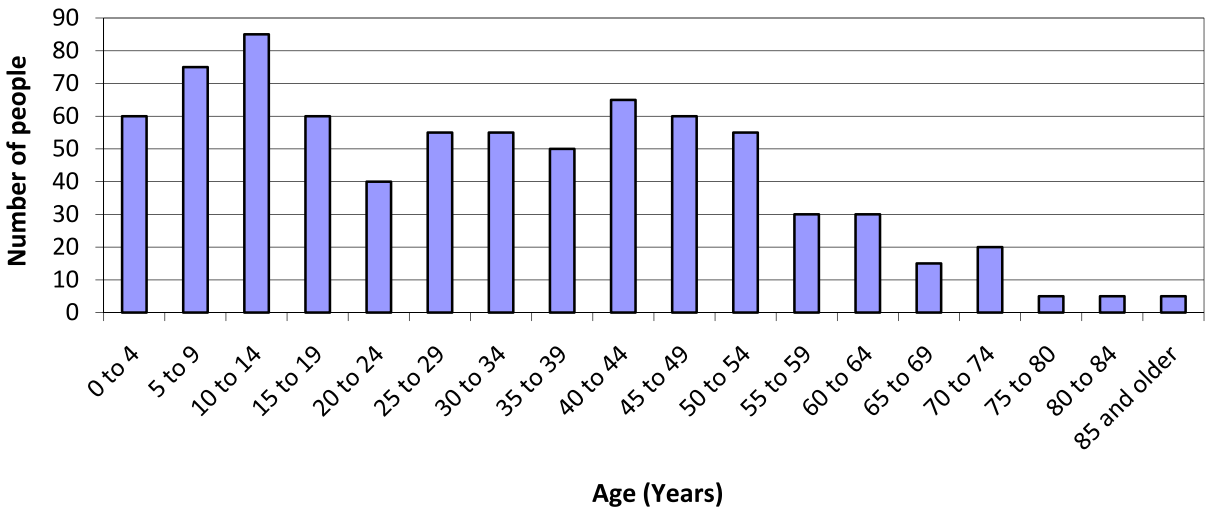
The Saugeen Ojibway Nation (SON) is the collective name for the Chippewas of Saugeen First Nation and the Chippewas of Nawash Unceded First Nation. The two First Nations share the same Aboriginal and treaty rights, including rights to fish commercially in the waters around the Bruce Peninsula. The SON share the Saugeen and Cape Croker Fishing Island Reserve No. 1, which is located off the western shore of the Bruce Peninsula north of Chief's Point. Historically, the two communities were joined by the important Bruce Peninsula portage route described in Section 6.9.3.

6.9.5.1 Chippewas of the Saugeen First Nation - Reserve No. 29

The Chippewas of Saugeen First Nation Reserve No. 29 is located adjacent to the community of Southampton on the shoreline of Lake Huron between the mouths of the Saugeen and Sauble Rivers, approximately 24 km north of the Bruce nuclear site (Figure 5.1.1-1). The Saugeen First Nation Chief's Point Reserve No. 28 is located at Chief's Point to the north of Sauble Beach, at the base of the Bruce Peninsula. The First Nation also uses the Saugeen Hunting Grounds Reserve No. 60A, which is located along Highway 6 in the north of the Bruce Peninsula, adjacent to the Bruce Peninsula National Park.

Population and Economic Base

According to 2006 Census data available from Statistics Canada, the Saugeen First Nation has an on-reserve population of 760 members, an increase of approximately 12% from the 2001 Census population of 677. The median age for the community is approximately 31 years, which is well below the Provincial average of 39 years. The three largest age cohorts are the 5 to 9 age group (75 persons), 10 to14 age group (85 persons), and the 40 to 44 age group (65 persons) (Figure 6.9.5-1) [273].

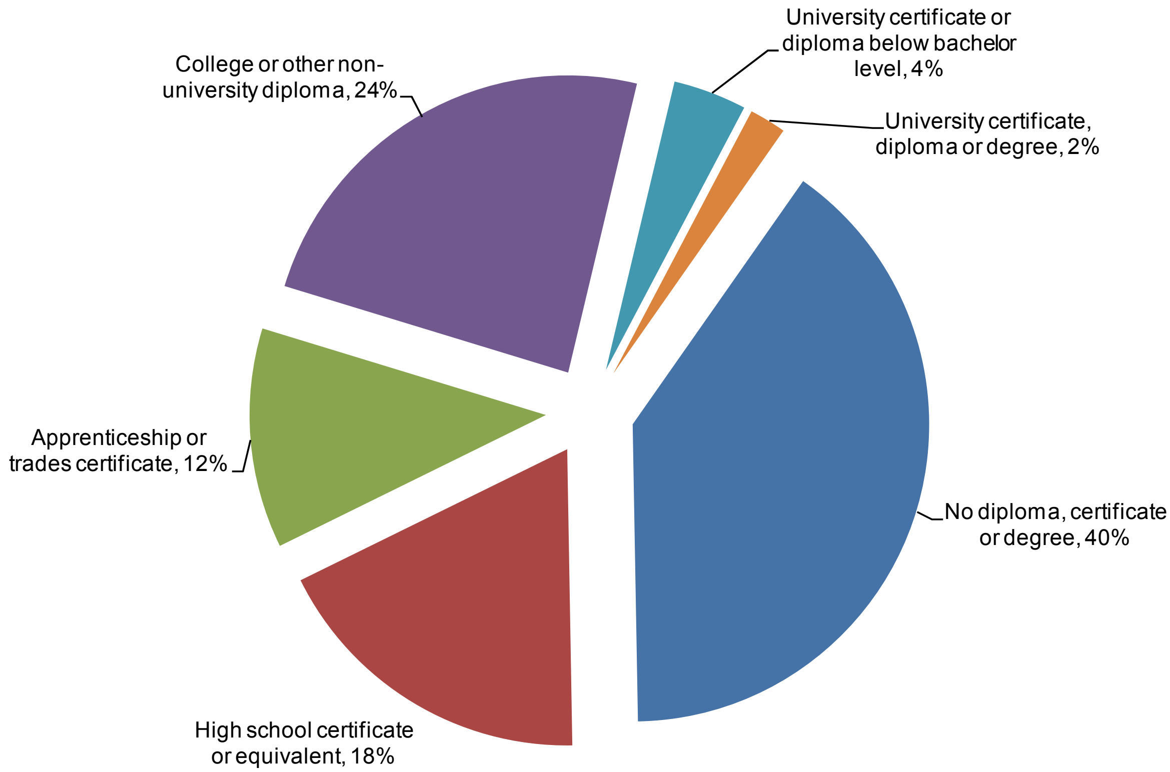


Source: [273]

Figure 6.9.5-1: Age Characteristics of the Saugeen First Nation

The 2006 Census data shows that the mother tongue of 590 of the 750 residents is English, while 155 identified their mother tongue as neither French nor English [273].

Data regarding the highest level of education attained by persons 15 years of age and over is presented in Figure 6.9.5-2. Approximately 60% of the total population 15 years of age and older hold a certificate, diploma, or degree from an educational institution. Of these, approximately 18% have a high-school certificate or equivalent, 12% have an apprenticeship or trades certificate or diploma, 24% have a college or other non-university certification, 4% have a university certificate or diploma below the bachelor level, and 2% have a university certificate, diploma or degree [273].



Source: [273]

Figure 6.9.5-2: Highest Educational Attainment of the Saugeen First Nation Community

Twenty five percent of the working population is employed in sales and service occupations; 23% in trades or in the transport and equipment operator occupations; and 14% in social science, education, government service, or religious occupations [273].

Community Infrastructure

The 2006 Census data indicates that the Saugeen reserve has 275 private dwellings, of which 65 households have children, 45 households are without children, 75 are one-person households, and 85 are classified as other household types. The 2006 Census data also indicates that of the total occupied private dwellings, 98% can be characterized as single detached. Of the total occupied private dwellings, 38% are in need of major repair [273].

Elementary school-aged children are bussed to public school in Southampton and secondary school students are bussed to Port Elgin, both of which are part of the Bluewater District School Board. The School Board hired an Aboriginal Advisor in January of 2006. The Aboriginal Advisor supports the development of learning environments that engage Aboriginal learners; improves communication with students, parents and staff; helps parents support their children's learning; contributes to creating a welcoming and inclusive environment for parents; and supports the development of learning circles and alternative support programs [274].

The Saugeen First Nation Education Department provides access to education opportunities and self-development for Saugeen First Nation members. The Education Department is located on the Saugeen Reserve [275].

The Saugeen Amphitheatre is located on Highway 21 in the village of Chippewa Hill. This unique outdoor amphitheatre is the vision of the late Reverend Earl Stotesbury whose goal was to develop a greater understanding and friendship between First Nations people and non-First Nations people. The Saugeen First Nation supplied the manual labour and technical expertise in the construction of the amphitheatre and it remains a source of pride for the band members. Capable of sitting 1,500 people, the Saugeen Amphitheatre is visited by thousands of people each year and has become popular for wedding ceremonies [276].

Community Services

Table 6.9.5-1 lists the services available to community members and their locations.

Table 6.9.5-1: List of Services On and Off-Reserve for the Chippewas of Saugeen First Nation

Service	Location
Band Administration	On-Reserve
Health Centre	On-Reserve
Police Department and Fire Centre	On-Reserve
School	Off-Reserve
Recreation Centre	On-Reserve
Heat/Hydro/Water Utility	On-Reserve
Garbage/Sewer Facility	Off-Reserve

Source: [275]

Several community service centres can be found on the Saugeen reserve. These include the G'Shawdagawin day care, the Kabaeashawim women's shelter, and an elder's facility [275]. Every August the community hosts an annual competition Pow Wow [277]. In 2010, the 40th Annual Saugeen First Nations contest Pow Wow was held in Southampton, Ontario.

High-speed Internet is used in the Band administration office, health centre and police detachment. There is a community access point for high-speed Internet at the library and at the M'Wikwedong Native Cultural Resource Centre (Friendship Centre) in Owen Sound. There are no SchoolNet sites on the reserve. Less than 25% of households subscribe to the Internet at home and less than 25% of households subscribe to satellite television [275].

Community Government and Administration

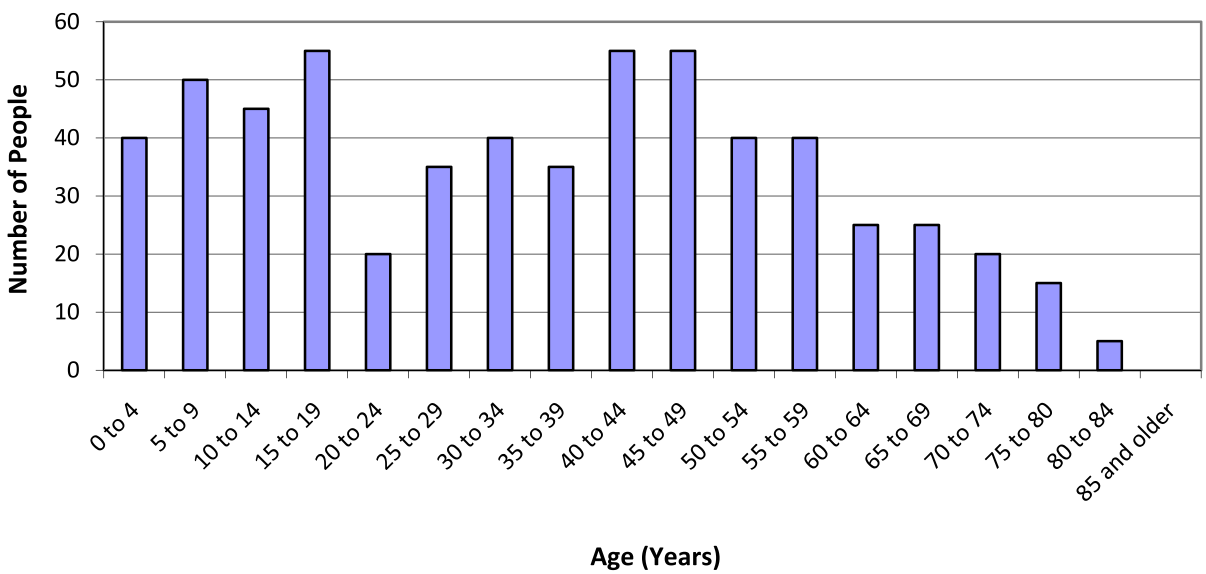
Saugeen First Nation Government consists of a Chief and nine Councillors. The Chippewas of Saugeen elect a new Chief and Council every two years.

6.9.5.2 First Nations Communities – Chippewas of Nawash Unceded First Nation – Cape Croker Reserve No. 27

The Chippewas of Nawash Unceded First Nation is centred at Cape Croker Reserve No. 27, located on the north side of Colpoy's Bay and the east shore of the Bruce Peninsula north of the town of Wiarton, approximately 80 km north of the Bruce nuclear site (Figure 5.1.1-1). The First Nation also uses the Cape Croker Hunting Grounds Reserve No. 60B, which is located on Highway 6 in the north of the Bruce Peninsula, adjacent to the Bruce Peninsula National Park.

Population and Economic Base

According to 2006 Census data available from Statistics Canada, Nawash has an on-reserve population of 591 members, up slightly from the 2001 Census population of 587. The median age for the community is 37 years, which is slightly below the provincial average of 39 years. The three largest age cohorts include the 15 to 19 age group (n=55), 40-44 age group (n=55), and the 45-49 age group (n=55) (Figure 6.9.5-3) [273].

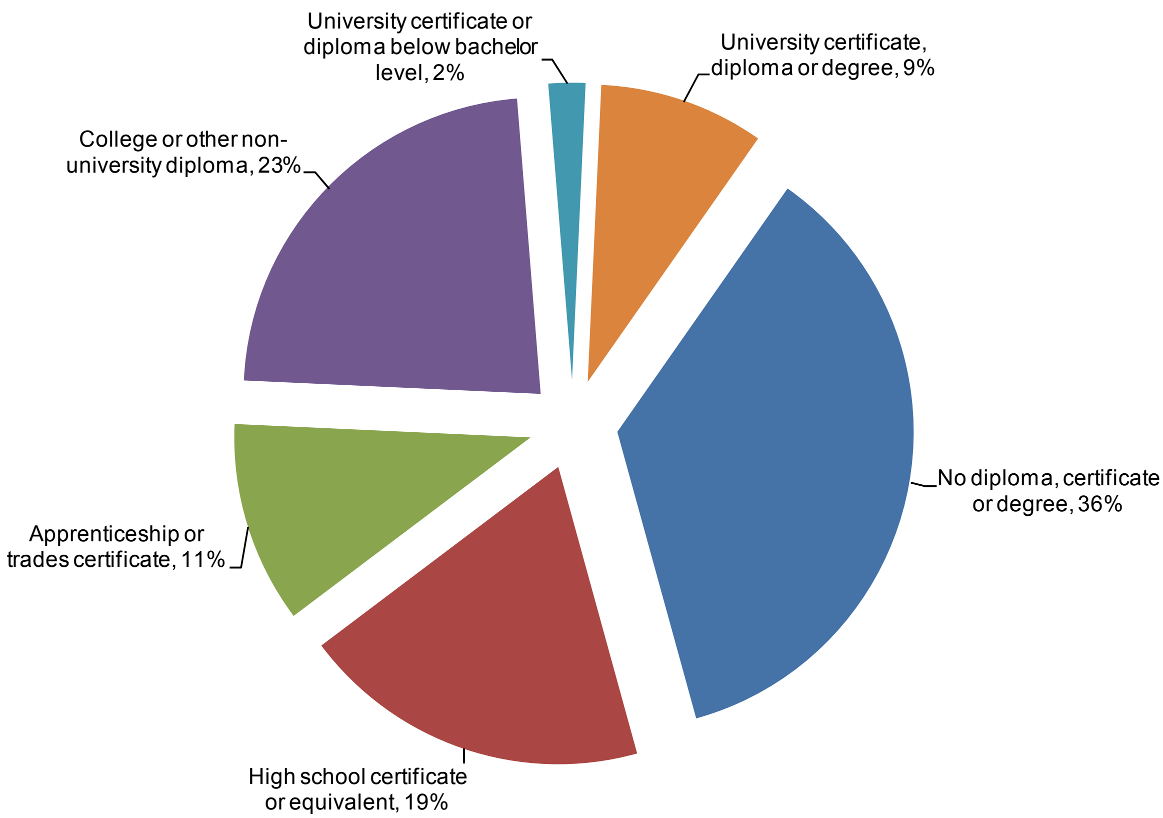


Source: [273]

Figure 6.9.5-3: Age Characteristics of the Nawash First Nation Community

The linguistic affiliation of the community is Algonkian, with a mother tongue being Ojibwa [278]. The first language of 515 of the 591 community members is English, while 70 identified their first language as neither French nor English [273].

Data regarding the highest level of education attained by persons 15 years of age and over is presented in Figure 6.9.5-4. Approximately 64% have a certificate, diploma or degree from an educational institution; of these, approximately 19% attained a high-school or equivalent diploma, 11% have an apprenticeship, trades certificate or diploma, 23% have a college or other non-university diploma, 2% hold a university certificate or diploma below the bachelor level, and 9% have a university certificate, diploma or degree [273].



Source: [273]

Figure 6.9.5-4: Highest Educational Attainment of the Nawash First Nation Community

A total of 16% of the workforce is employed in health care and social services, 14% in business services, 12% in agriculture and other resource-based industries, 8% in construction, 7% in education, 5% in retail, and the remaining 38% in other services [273].

The SON lake whitefish fishery represents a source of livelihood for many community members. The traditional fishing waters of the SON represent approximately 10,600 km² in surface area and cover the eastern main basin of Lake Huron extending to the Canada-United States border and the western half of Georgian Bay [279].

Community Infrastructure

The 2006 Census data indicates that the reserve has approximately 245 private dwellings, of which 60 households have children, 50 households are without children, 80 are one-person households, and 50 are classified as other household types [273]. The 2006 Census data also indicates that of the total occupied private dwellings, 94% can be characterized as housing and 6% can be characterized as apartments in buildings with fewer than five stories. Of the total occupied private dwellings, 26% are in need of major repair [273].

Elementary school-aged children attend the Cape Croker Elementary School, which employs 17 full and part time staff. High-school aged students are bussed to Wiarton and Lion's Head. In March 2009 the Government of Canada announced the building of a new school in the community, with support from Canada's Economic Action Plan. The new school, which will replace the existing school, will include a new 2,350 m² facility, complete with play areas, soccer field, track, and basketball court. Once constructed, the new school will replace the current Cape Croker Elementary School, which provides Junior Kindergarten to Grade 8 education. The existing school is located near MacGregors' Harbour and consists of the main building and two portables [278].

The community has a water main system with a pumping system, a sewage system that is under construction, a refuse site on reserve, and is provided with electricity by Hydro One.

Community Services

Community services and facilities include a fire hall, pumper and tanker fire trucks; one Roman Catholic, one United and one Wesley United Church; a community centre, a recreation centre, and a library; a health clinic with a Community Health Representative; a day care centre; homemakers program, counselling services; and Ontario First Nations Policing Arrangements with four constables [278]. Table 6.9.5-2 lists the services available to community members and their locations.

Table 6.9.5-2: List of Services On and Off-Reserve for the Chippewas of Nawash First Nation

Service	Location
Band Administration	On-Reserve
Health Centre	On-Reserve
Police Department and Fire Centre	On-Reserve
School	On-Reserve
Recreation Centre	On-Reserve
Heat/Hydro/Water Utility	On-Reserve
Garbage/Sewer Facility	On-Reserve

Source: [275]

Many of community services can be found within the community itself. There is dial-up Internet available at no charge to residents at the Band Administration Office. A broadband Internet connection is available at the Cape Croker Health Centre and dial-up Internet is used at the police department. There are two SchoolNet sites and a community access point for high-speed Internet at the library and at the M'Wikwedong Friendship Centre, located in Owen Sound. Less than 25% of households subscribe to the Internet at home. Between 51 and 75% of households subscribe to satellite television [275].

Services and community programs available within the community include:

- Band Representation Program;
- Capital Planning;
- D'binooshnowin Crisis Centre and 24-hour Crisis Line (a temporary shelter for women and their children that provides counselling and outreach services);
- CHRN 100.1 FM radio station;
- Cape Croker Park;
- Youth Work Experience;
- Workshops: General Educational Development (GED), computer training, project submission training, job enhancement maintenance training, business plan development;
- Home and Community Care Program;
- Nawash Lands Management;
- Literacy;
- Public Works;
- Recreation;
- Maadookii Seniors Centre;
- Senior's apartment complex;
- Nawash Native Child Welfare;
- Nawah N'shiime Day Care; and
- Ninda Kiksendjigae Wigammik Library. [280]

Every August the community hosts an annual competition Pow Wow. In 2010, the Cape Croker traditional Pow Wow was held in Neyaashingaming, Ontario.

Community Government and Administration

Chief and Council are elected every two years. The Administration Building for the Chippewas of Nawash Unceded First Nation houses several different programs, including Accounts Payable, Payroll, Lands, Estates and Membership, Social Services (Ontario Works), Fisheries Assessment and Biology, Bylaw, Housing, Capital Planning, Band Representatives, Public Works, and Reception. The Chief's Office, the Tribal Secretary and the Band Administrator are also housed in this building [280].

6.9.5.3 M'Wikwedong Native Cultural Resource Centre (Friendship Centre) – Owen Sound, Ontario

Supplementing programs and services provided within the Chippewas of Nawash and Chippewas of Saugeen communities is the M'Wikwedong Native Cultural Resource Centre (Friendship Centre) located in Owen Sound, Ontario. Some of the off-reserve programs and services operated by the Centre include:

- the Community Action Program for Children (CAP-C);
- Canada Prenatal Nutrition Program;
- AKWE:GO, a program for urban Aboriginal children;
- Aboriginal Healing and Wellness Strategy;
- Life Long Care;
- UMAYC Youth FX Project; and
- community access to high-speed Internet [281].

6.9.6 The Métis

Métis people having interests in the Regional Study Area may be represented by the Métis Nation of Ontario (MNO) or by the Historic Saugeen Métis Community (HSMC).

According to the 2006 Census information from Statistics Canada [282], 360 Métis persons reside in Bruce County, and 825 Métis persons reside in Grey County. The Métis people participate fully in the community and for the purposes of this EIS are assumed to be enumerated with the regional population. Because of this, the effects of the DGR Project on Métis people are assumed to be included in the effects on the broader community as presented in the socio-economic environment and the human health assessment, with the exception of effects on traditional harvesting activities or culture.

6.9.6.1 Métis Nation of Ontario

The Métis Nation of Ontario (MNO) was initially formed in 1994 and considers itself to be a representative body of Métis people at the provincial and national levels within Canada and at the international level. Its principles are based on the right of self-determination and inherent right of self-government. The MNO has a province-wide governance structure. The MNO delivers a range of programs and services in the areas of health, labour market development, education and housing to Ontario Métis and other Aboriginal groups.

In April 2009, the MNO created a Regional Consultation Protocol that covers the Métis traditional territory of Georgian Bay for the regional rights-bearing Métis community that lives in, uses and relies on the Georgian Bay Métis traditional harvesting territory [283].

The Great Lakes Métis Council operates a community centre at 380 9th Street East, Owen Sound.

6.9.6.2 Historic Saugeen Métis Community

The Historic Saugeen Métis Community (HSMC) people are an independent rights-bearing community. This Métis community is one of the formally organized Métis communities in Ontario that is not represented by the MNO. They have historically lived, fished, hunted and traded alongside the local First Nations [284].

The HSMC has been recognized by the Canadian government, as well as the Ministry of Natural Resources (MNR), to have an asserted claim of Aboriginal rights, and consequently the community asserts that there is a duty to consult with the community [285]. The HSMC has its offices at 204 High Street, Southampton.

6.9.7 Aboriginal Heritage Resources

6.9.7.1 Archaeological and Burial Sites

Archaeological investigations have been conducted in and around the Bruce nuclear site since the 1950s. These studies reveal that the shorelines of Lake Huron and its ancestors — Lake Algoma, the Nipissing Great Lakes and Main Lake Algonquin, have been the foci of intense cultural activity during the past 11,000 years. Therefore, there are numerous registered archaeological sites in the Regional Study Area. Based on the Stage 1 Archaeological Assessment [286] there are 16 registered archaeological sites either on or within 7.5 km of the Bruce nuclear site, most of which are located on or in the immediate vicinity of Inverhuron Provincial Park. The scarcity of identified archaeological sites within the Bruce nuclear site is in contrast to the high density of registered and unregistered sites of Aboriginal people's habitation, resource-procurement, ritual and burial below the Lake Algonquin shoreline and along the shore of Inverhuron Bay and the Little Sauble River. The Stage 2 Archaeological Assessment [287] identified and confirmed two registered archaeological sites, Upper Mackenzie and Dickie Lake, within the confines of the Bruce nuclear site.

As part of the Stage 2 Archaeological Assessment [287], culturally-sensitive areas were defined on the basis of a field inspection strategy presented in July 2007 to the Chiefs and Councils of the SON. The completion of the Stage 2 Archaeological Assessment [287] resulted in the definition of four culturally-sensitive areas (A, B, C and D) within the Bruce nuclear site (Figure 6.9.7-1). In consideration of Aboriginal interests, a culturally sensitive area was considered one at which there was a known archaeological site or feature (e.g., portage route) or where there may be deeply buried archaeological sites or burials.

Upper Mackenzie (BbHj-6)

The Upper Mackenzie (BbHj-6) site is located just inside the south entrance to the Bruce nuclear site on the north side of the South Access Road. Aerial photographs from 1938 show that the Upper Mackenzie site was an expansive, exposed sandy terrace along the Nipissing Great Lakes shoreline. Based on the location of the site, and in the absence of dated artifacts, Upper Mackenzie likely dates somewhere within the 2500 – 800 BC Late Archaic period [287]. The extent of the site has never been defined.

In 1961, the site was damaged during the construction of the South Access Road into the Bruce nuclear site. Bulldozing had disturbed an area of about one acre on the north side of the road, exposing at least two cultural features. The scarcity of cultural artifacts on the site was noted during investigations by Wright, Lee and Knechtel [287].

The areas on either side of the South Access Road have not been appreciably modified since the road was constructed in the 1960s. If any of the site survived the road construction, it should remain intact today.

Dickie Lake/Jiibegmegoong (BbHj-12)

The Dickie Lake site, which dates from the Late Archaic (1000 – 800 BC) or Early Woodland (800 – 300 BC) [286], is located along the Nipissing Great Lakes shore complex. Investigations at the site in the 1950s and 1960s found two wind-exposed human burials and an abundance of crude cobble tools, but found little evidence of habitation or related activities. The burial site was opened in the 1950s and the remains of two individuals buried there were moved from the site in 1957.

In the 1970s, it was believed that a third heritage area, the "Indian Burial Ground" was identified by Ontario Hydro and demarcated by signposts in the early 1980s. A joint council meeting of the Chippewas of Nawash and Chippewas of Saugeen on March 10, 1998 resolved that the site previously known as Dickie Lake and the "Indian Burial Ground" were in fact the same site, and were assigned an Ojibway name. The Dickie Lake site is now referred to as Jiibegmegoong (Spirit Place). The Jiibegmegoong site is located approximately 3 km from Bruce A and 1 km from Bruce B, the WWMF and the road leading to the main gate. Historical documentation may identify the name of the site with the alternative spelling of Chiibegmegoong.

The human remains removed from Jiibegmegoong were reinterred in 1998 [286]. Both Chippewas of Nawash and Chippewas of Saugeen have requested and have received approval to access the Bruce nuclear site to conduct ceremonies or monitoring at the Jiibegmegoong burial ground [288]. The condition of the Jiibegmegoong site was examined in 2007. The on-going erosion at the site did not appear to be appreciable from the last observation [286].

6.9.8 Traditional Use of Land and Resources

The SON have asserted their interests with regard to the traditional use of lands and resources in several forums. In 1995, at an international conference in Duluth, Minnesota, the Chief of the Saugeen First Nation announced the Duluth Declaration, which is an assertion of jurisdiction over:

> *"The waters around the Saugeen/Bruce Peninsula in their entirety, which includes the fisheries, lands and minerals, above and below the waters, including the lake bed. We do so for the immediate purpose of the full regulation and management of these resources, over which we have inherent rights, treaty rights and unextinguished sovereign authority. This jurisdiction extends to the median point in the water between the Saugeen Nation territory, water and land, and all other national territory".* [254]

The Chippewas of Nawash Unceded First Nation describes its traditional territory as the waters and fisheries that surround their traditional lands. Further to this they state that "along with indigenous peoples everywhere, the relationship with traditional lands, waters and resources is profound, ongoing and an essential part of their identity and culture as well as the economy of our people that sustains us to this day."

In 2005, the Ontario Ministry of Natural Resources (MNR) announced that a five-year agreement had been signed with the SON to manage the commercial fishery in the waters of Lake Huron and Georgian Bay around the Bruce Peninsula. The terms of the agreement state that the SON will be responsible for using catch sampling to monitor the commercial fishery, and will designate community fishers. The agreement applies only to commercial fishing rights, and does not affect traditional fishing activities [289]. At the time of publication, the status of this Agreement was unknown.

The MNR reports annually on the major commercial fish species in Lake Huron. The catch of the commercial fishery is predominately composed of lake whitefish (main target species), lake trout (by-catch[16]), and chinook and coho (Pacific) salmon (by-catch). There are four commercial fishing tugs in operation on the Saugeen First Nation, which employ approximately 12 people. All four boats do not operate simultaneously. The Chippewas of Nawash Unceded First Nation has four fishing tugs and three punts, and employs 18 people directly in fishing activities [290]. Between 50 and 60 members of the Chippewas of Nawash Unceded First Nation are employed in fishing and related activities, and an economic analysis prepared for the First Nation found that the fishery accounted for about one half of all private commercial earnings in Cape Croker between 1996 and 1997. That study estimated the net benefit of the fishery to be $387,584 over the same period [291].

The Chippewas of Nawash Unceded First Nation have stated that the fish harvest, particularly lake whitefish from Lake Huron in the vicinity of the Bruce nuclear site, is the single largest component of the Nawash commercial fishery [292]. This is consistent with MNR's estimates of the total dollar value of eight major species of fish caught in the Lake Huron Management Area 4-4. Management Area 4-4 is the area of Lake Huron in the vicinity of the Bruce nuclear site. Within this Management Area, MNR estimated that the total value of the commercial catch at $646,706 in 2008, with $615,318 from lake whitefish [293].

[16] By-catch meaning that it is not targeted by commercial anglers.

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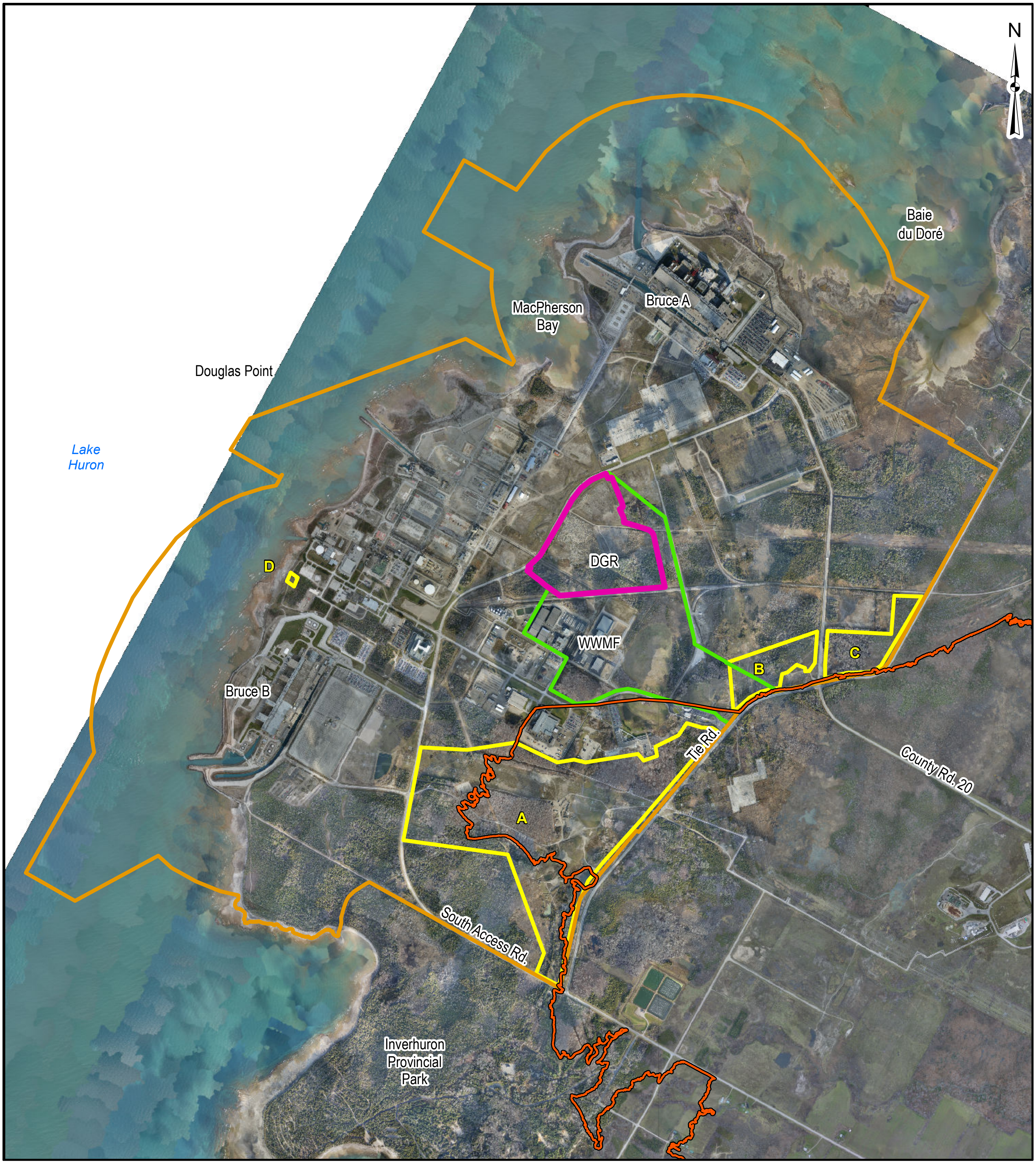

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Kilometres

LEGEND

- 4200-2200 B.C. Nipissing Great Lakes Shoreline
- DGR Project Site
- Culturally Sensitive Area
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc.,
Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m,
Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

CULTURALLY SENSITIVE AREAS IN THE SITE STUDY AREA

Golder Associates
Mississauga, Ontario

PROJECT No. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007		
GIS	BC	7 Apr. 2010	**FIGURE 6.9.7-1**	
CHECK	KC	7 Apr. 2010		
REVIEW	AB	7 Apr. 2010		

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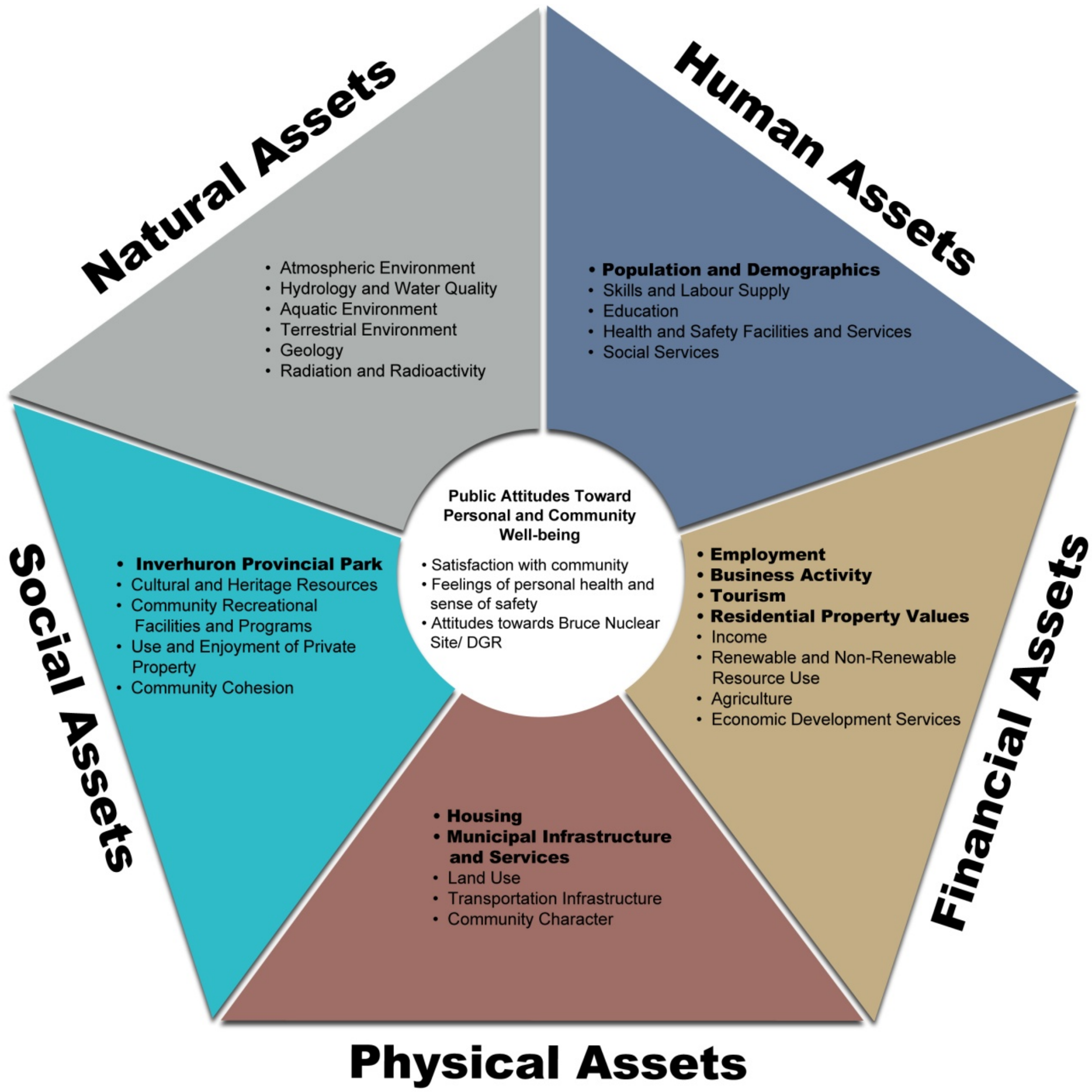
6.10 SOCIO-ECONOMIC ENVIRONMENT

The existing socio-economic environment within the study areas is described in terms of the community assets framework shown on Figure 6.10-1. The community assets framework encompasses the following components:

- Human Assets, which include population and demographics, skills and labour, education, health and safety facilities and services, and social services;
- Financial Assets, which include employment, business activity, nuclear industry, tourism, residential property values, municipal finance and administration, income, renewable and non-renewable resource use, agriculture and economic development services;
- Physical Assets, which include housing, municipal infrastructure and services, water supply, waste water treatment, conventional solid waste management, land use, transportation infrastructure and community character;
- Social Assets, which include Inverhuron Provincial Park, cultural and heritage resources, community recreational facilities and programs, use and enjoyment of private property and community cohesion; and
- Natural Assets, which include the atmospheric environment, hydrology and surface water quality, aquatic environment, terrestrial environment, geology and radiation and radioactivity.

For additional information, please refer to the Socio-economic Environment TSD.



Note: **Bold** highlights denote preliminary VECs identified in the EIS Guidelines

Figure 6.10-1: Community Assets Framework

6.10.1 Spatial Boundaries

The study areas presented in Section 5.1 were modified to encompass likely effects on the socio-economic environment as follows:

- The **Regional Study Area**, shown on Figure 5.1.1-1, was adopted. Although geographically located in the Regional Study Area, the assessment of effects on the Regional Study Area does not include Kincardine. This is to highlight or make apparent the difference between Kincardine (i.e., the Local Study Area) and the neighbouring municipalities.

- The **Local Study Area**, shown on Figure 6.10.1-1, corresponds to the municipal boundary for the Municipality of Kincardine. This area represents the host community for the DGR Project. The focus on the host community is consistent with socio-economic impact assessment professional practice and emphasizes the area that has the most direct relationship with the WWMF and is anticipated to be the receptor for the majority of the social and economic effects. Effects on other communities (e.g., Town of Saugeen Shores) are discussed where there are notable differences from those of the host community (i.e., Municipality of Kincardine).
- The **Site Study Area and Project Area**, shown on Figure 5.1.3-1, were adopted without modification.

6.10.2 Valued Ecosystem Components

To assess the effects of the DGR Project on the socio-economic environment, the concept of "community well-being" is used as an overall analytical framework (Figure 6.10-1). Among other related concepts are: community quality-of-life, individual and community health and community capacity. There are many overlaps and linkages among these various concepts, including overlap in the social information and indicators associated with each concept and the use of similar participatory methodologies and sociological tools to collect and examine quantitative and qualitative socio-economic information. Therefore, for the purposes of this EIS, various aspects of these other concepts have been incorporated into the community well-being framework, where they are relevant to the assessment of the social and economic effects of the DGR Project.

Table 6.10.2-1 presents the VECs for the socio-economic environment along with their rationale for selection and the specific indicators used in this assessment. Where necessary, some of the VECs identified in the EIS Guidelines have been reorganized to fit within the community assets framework; however, all of the guideline VECs remain and fit well within the framework.

Natural assets of a community are an important part of the community well-being framework; however, they are not a VEC for the socio-economic assessment. DGR Project-related changes to natural assets may indirectly affect any of the socio-economic environment VECs, thus altering the socio-economic environment. Changes to the natural assets are assessed through the analysis of indirect effects attributed to changes in the natural environment.

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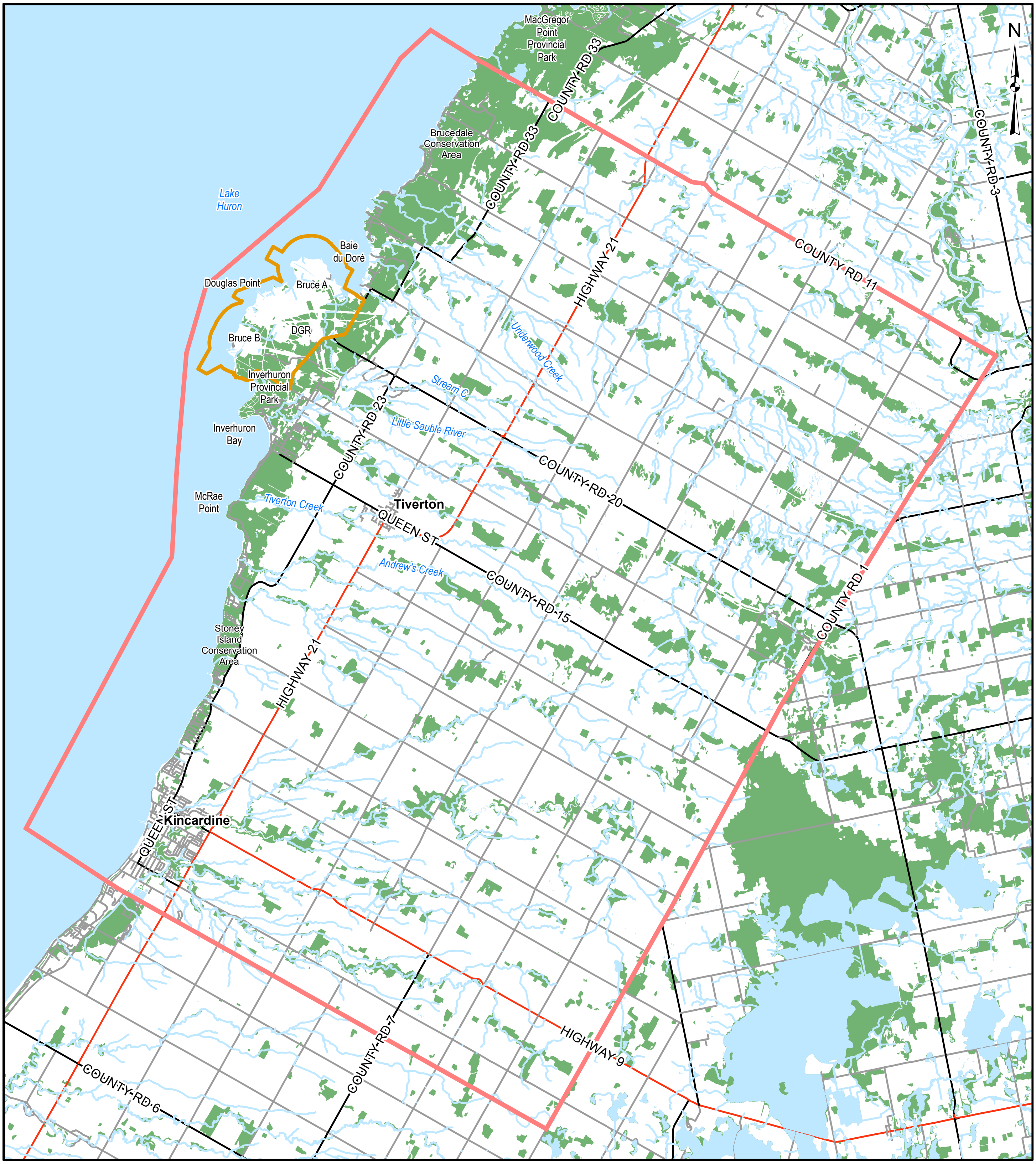

0 2 4 8
Kilometres

LEGEND

- Site Study Area [1]
- Local Study Area

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

LOCAL STUDY AREA FOR THE SOCIO-ECONOMIC ENVIRONMENT

Golder Associates
Mississauga, Ontario

PROJECT No. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct 2007	**FIGURE 6.10.1-1**	
GIS	BC	31 May. 2010		
CHECK	AB	31 May. 2010		
REVIEW	MAR	31 May. 2010		

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Table 6.10.2-1: VECs Selected for the Socio-economic Environment

VEC	Rationale for Selection	Key Indicators	Measures
Human Assets			
Population and Demographics	• The DGR Project may cause changes to population and demographics attributed to in-migration related to the DGR employment opportunities or changes in public attitudes and behaviours in relation to the presence of the DGR Project	• Population levels • Population mobility • Demographic characteristics (i.e., family size, composition, age profile)	• DGR Project associated population levels and distribution • Changes in public attitudes and behaviours attributable to the DGR Project
Other Human Assets	• The DGR Project will require skills and labour from within and possibly from outside the Local/Regional Study Areas • Increased population associated with the DGR may add to school enrolment • The unique aspects of the DGR Project may offer educational opportunities • Increased population associated with the DGR and potentially changed demographics may add to social service, health and safety service demands • Special requirements of the DGR construction and/or operations may add to health and safety service demands or require changes to emergency preparedness plans	• Availability of skills and labour supply • Capacity of schools and availability of educational opportunities • Availability of social services • Availability of health and safety facilities and services	• DGR Project skills and labour requirements • DGR Project employment and distribution • DGR Project associated school enrolment • DGR Project associated population levels and distribution • DGR Project associated average unit service demands • Presence/absence of socio-economic features (e.g., schools, health and safety facilities, emergency preparedness plans) • DGR Project-related effects on natural assets and/or other community assets. • Changes in public attitudes and behaviours attributable to the DGR Project

Table 6.10.2-1: VECs Selected for the Socio-economic Environment (continued)

VEC	Rationale for Selection	Key Indicators	Measures
Financial Assets			
Employment	• The DGR Project may cause changes to the level of employment	• Employment opportunities	• DGR Project direct, indirect and induced employment • DGR Project employment distribution
Business Activity	• The DGR Project may directly and indirectly change business activity in local and regional economies	• Business opportunities	• DGR Project related requirements for goods and services • DGR Project employment and distribution • Presence/absence of socio-economic features (e.g., sensitive commercial business operations) • DGR Project-related effects on natural assets and/or other community assets
Tourism	• Tourism related businesses and attractions might be affected if the DGR Project adversely affects natural assets and/or other community assets that make them attractive to tourists • Tourist accommodation providers might benefit from an increase in DGR Project related employees • Tourist accommodation providers may be adversely affected if the DGR Project results in competition for temporary accommodation	• Tourist visitation patterns	• Presence/absence of socio-economic features (e.g., tourist attractions or features) • Trends in visitation to selected tourist attractions or features • DGR Project employment • DGR Project-related effects on natural assets and/or other community assets • Changes in public attitudes and behaviours attributable to the DGR Project

Table 6.10.2-1: VECs Selected for the Socio-economic Environment (continued)

VEC	Rationale for Selection	Key Indicators	Measures
Residential Property Values[a]	• Changes to residential property values may occur as a result of changes in noise, dust, traffic and/or a change in overall community character	• Likelihood of changes in residential property values attributable to the DGR Project	• DGR Project-related effects on natural assets and/or other community assets • Changes in public attitudes and behaviours attributable to the DGR Project • Presence/absence of a property value protection plan
Municipal Finance and Administration[b]	• Municipal finances may be directly influenced through DGR Project related revenues or changes in municipal expenditures • Municipal finances may change indirectly because of a change in DGR Project associated population or changes in residential property values	• Municipal revenues • Municipal expenditures	• DGR Project related sources of revenue • Municipal expenditure requirements related to the DGR Project

Table 6.10.2-1: VECs Selected for the Socio-economic Environment (continued)

VEC	Rationale for Selection	Key Indicators	Measures
Other Financial Assets	• The DGR Project related employment may result in changes in labour income • Agricultural activities may be affected by a direct loss of agricultural land and or disturbance to agricultural related activities • The DGR Project may affect or change the demand on renewable and non-renewable resources • Economic development services may need to respond to the presence of the DGR Project, to meet DGR Project requirements or to support change in economy resulting from the DGR Project	• Income levels • Agricultural activities • Renewable and non-renewable resource use	• DGR Project labour income and distribution • DGR Project related demand for renewable or non-renewable resources • DGR Project-related effects on natural assets and/or other community assets
Physical Assets			
Housing [a]	• Population associated with the DGR Project may increase demand for housing	• Availability of housing	• DGR Project related housing demand and distribution • Size of available housing stock • Housing stock distribution
Municipal Infrastructure and Services [b]	• The DGR Project may directly add to demands on municipal infrastructure and services • Population associated with the DGR Project may increase demand for municipal infrastructure and services	• Availability of Municipal Water and Sewer Infrastructure and Services • Availability of Waste Management Facilities and Services	• DGR Project associated population levels and distribution • DGR Project municipal water sewage and waste management service demands

Table 6.10.2-1: VECs Selected for the Socio-economic Environment (continued)

VEC	Rationale for Selection	Key Indicators	Measures
Other Physical Assets	• The DGR Project (i.e., its works, activities, buildings and structures) may be incompatible with existing or planned land uses on or in the vicinity of the Bruce nuclear site • The DGR Project may add to traffic using the existing road network • The DGR Project (i.e., the presence of a new or unfamiliar nuclear facility) and its environmental effects can affect the fundamental or unique characteristics of the host municipality and/or region	• Compatibility with existing and planned land use • Traffic levels • Community character	• DGR Project compatibility with existing and planned land uses • Changes in levels of service at key intersections along the road network • Visibility of DGR Project buildings and structures • Changes in public attitudes and behaviours attributable to the DGR Project
Social Assets			
Inverhuron Provincial Park	• Inverhuron Provincial Park might be affected if the DGR Project adversely affects natural assets and/or other community assets which affect the use and enjoyment of tourists and day users	• Use and Enjoyment of Inverhuron Provincial Park	• DGR Project associated population levels and distribution • DGR Project-related effects on natural assets and/or other community assets • Changes in public attitudes and behaviours attributable to the DGR Project

Table 6.10.2-1: VECs Selected for the Socio-economic Environment (continued)

VEC	Rationale for Selection	Key Indicators	Measures
Other Social Assets	• The DGR Project's construction activities may disturb cultural and heritage resources • A change in the population associated with the DGR Project or a change in population demographics may change the demand for community and recreational facilities and programs • People's use and enjoyment of their private property might be affected if the DGR Project adversely affects natural assets and/or other community assets which, in turn, affects their use and enjoyment of private property • A change in the population associated with the DGR Project or a change in population demographics may change community cohesion • The DGR Project may affect community assets that contribute to community cohesion	• Archaeological or cultural heritage sites • Culturally-sensitive areas • Availability of community recreational facilities and programs • Use and enjoyment of private property • Community cohesion	• Measurable DGR Project-related effect on archaeological or cultural heritage sites • Potential for DGR Project-related effects on deeply buried artifacts in culturally-sensitive areas. • DGR Project associated population levels and distribution • Visibility of DGR Project buildings and structures • DGR Project-related effects on natural assets and/or other community assets • Changes in public attitudes and behaviours attributable to the DGR Project • DGR Project related contribution to community cohesion

Notes:

a Housing and Residential Property Values were presented as one VEC (Housing and Property Values) in the EIS Guidelines but have been identified separately and arranged by community asset in this EA.

b Municipal Finance and Administration and Municipal Infrastructure and Services were presented as one VEC (Municipal Finance, Infrastructure, Services/Resources) in the EIS Guidelines but have been identified separately and arranged by community asset in this EA.

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6.10.3 Human Assets

The VECs that are considered within this component of the framework are presented in Table 6.10.2-1 and are described in the following sections.

6.10.3.1 Population and Demographics

According to the most recent available Census (2006) [294], the total population of the Municipality of Kincardine is 11,173, or 21.6% of the combined Local and Regional Study Areas population (Table 6.10.3-1). Of the neighbouring municipalities, Saugeen Shores has the largest population base at 11,720, or 22.7% of the combined study area population. The Municipality of Brockton makes up 18.6% of the combined study area population and the smaller populations of Arran-Elderslie, Huron-Kinloss and South Bruce account for 13.0%, 12.6% and 11.5% of the combined study area population base.

The level and distribution of population across the combined study area has not changed substantially since 1996. From 1996 to 2001, the population of Kincardine decreased by 7.4% but rebounded somewhat over the next five years, with an increase of 1.3% from 2001 to 2006. Similarly, during the period of 1996 to 2001, the neighbouring municipalities experienced a decline in population ranging from 1.0% in Huron-Kinloss to 5.8% in Saugeen Shores. During the following five years, population levels in Brockton and South Bruce continued to decline (0.2% and 2.0% reduction, respectively), while Arran-Elderslie, Huron-Kinloss and Saugeen Shores all experienced increases in population. Huron-Kinloss experienced the strongest population growth during that period, with a 4.7% increase from 2001 to 2006. Overall, the combined study area population declined by 4.9% from 1996 to 2001 but recovered from 2001 to 2006 with an overall increase of 1.6%.

Table 6.10.3-1: Population – Local and Regional Study Area (1996 to 2006)

Year	Municipality of Kincardine		Regional Study Area Municipalities												Total	
			Arran-Elderslie		Brockton		Huron-Kinloss		Saugeen Shores		South Bruce			
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
1996	11,908	22.2	6,851	12.8	10,163	19.0	6,284	11.7	12,084	22.6	6,248	11.7	53,538	100
2001	11,029	21.7	6,577	12.9	9,658	19.0	6,224	12.2	11,388	22.4	6,063	11.9	50,939	100
2006	11,170	21.6	6,745	13.0	9,640	18.6	6,515	12.6	11,720	22.7	5,940	11.5	51,730	100
1996-2001 Change (%)	-7.4		-4.0		-5.0		-1.0		-5.8		-3.0		-4.9	
2001-2006 Change (%)	1.3		2.6		-0.2		4.7		2.9		-2.0		1.6	

Source: [294;295;296;297;298;299;300;301;302;303;304;305;306]

6.10.3.2 Other Human Assets

Skills and Labour Supply

According to the 2006 Census data [294;295;299;298;296;297], an experienced labour force of 27,845 individuals resided in the Municipality of Kincardine and neighbouring municipalities [294]. The experienced labour force distribution within the study areas is presented in Table 6.10.3-2.

Table 6.10.3-2 shows that 62.4% of the experienced labour force in the Local and Regional Study Areas was located in three municipalities (Saugeen Shores, Kincardine and Brockton), with 21.3% of the total in the Municipality of Kincardine itself. Across all study area municipalities, five industrial categories accounted for over 70% of the labour force. The labour force distribution by industrial category indicates that the top five categories are manufacturing and construction, utilities, wholesale and retail, health care and education and business services. Selected occupational categories particularly relevant to the DGR Project skills and labour requirements are noted in Table 6.10.3-3.

Table 6.10.3-2: Experienced Labour Force Distribution (2006)

Municipalities	Employees	% of Total
Kincardine	5,935	21.3
Arran-Elderslie	3,490	12.5
Brockton	5,300	19.0
Huron-Kinloss	3,385	12.2
Saugeen Shores	6,150	22.1
South Bruce	3,585	12.9
Total	**27,845**	**100**

Source: [294;295;296;297;298;299]

Table 6.10.3-3: Labour Force Distribution by Selected Occupation Category (2006)

Category	Municipality of Kincardine		Regional Study Area Municipalities										Total	
			Arran-Elderslie		Brockton		Huron-Kinloss		Saugeen Shores		South Bruce			
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Total labour force 15 years and over by occupation	5,930	100	3,490	100	5,300	100	3,385	100	6,150	100	3,580	100	13,415	100
H. Trades, transport and equipment operators and related occupations														
H0. Contractors and supervisors in trades and transportation	45	0.8	30	0.9	75	1.4	35	1.0	30	0.5	30	0.8	97	0.7
H1. Construction trades	120	2.0	95	2.7	175	3.3	140	4.1	160	2.6	120	3.4	430	3.2
H2. Stationary engineers, power station operators and electrical trades and telecommunications occupations	350	5.9	115	3.3	120	2.3	120	3.5	385	6.3	45	1.3	561	4.2
H3. Machinists, metal forming, shaping and erecting occupations	65	1.1	45	1.3	25	0.5	75	2.2	80	1.3	55	1.5	215	1.6
H4 Mechanics	190	3.2	155	4.4	165	3.1	70	2.1	90	1.5	140	3.9	307	2.3
H5. Other trades, not elsewhere classified.	55	0.9	30	0.9	35	0.7	0	0.0	45	0.7	50	1.4	97	0.7
H6. Heavy equipment and crane operators, including drillers	35	0.6	50	1.4	55	1.0	25	0.7	40	0.7	45	1.3	113	0.8
H7. Transportation equipment operators and related workers, excluding labourers	220	3.7	180	5.2	195	3.7	110	3.2	200	3.3	160	4.5	481	3.6
H8. Trades helpers, construction and transportation labourers and related occupations	120	2.0	85	2.4	210	4.0	70	2.1	150	2.4	110	3.1	338	2.5

Table 6.10.3-3: Labour Force Distribution by Selected Occupation Category (2006) (continued)

Category	Municipality of Kincardine		Regional Study Area Municipalities										Total	
			Arran-Elderslie		Brockton		Huron-Kinloss		Saugeen Shores		South Bruce			
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
J. Occupations unique to processing, manufacturing and utilities														
J0. Supervisors in manufacturing	105	1.8	20	0.6	25	0.5	10	0.3	75	1.2	30	0.8	117	0.9
J1. Machine operators in manufacturing	65	1.1	75	2.1	120	2.3	50	1.5	75	1.2	120	3.4	251	1.9
J2. Assemblers in manufacturing	40	0.7	85	2.4	215	4.1	35	1.0	35	0.6	135	3.8	210	1.6
J3. Labourers in processing, manufacturing and utilities	30	0.5	40	1.1	170	3.2	90	2.7	20	0.3	140	3.9	257	1.9
Selected Occupations (Groups H & J) Total	1,440	24.3	1,005	28.8	1,585	29.9	830	24.5	1,385	22.5	1,180	33.0	3,475	25.9

Note:
The numbers in the above table are correct; however, they may not appear to add up because of rounding.
Source: [294;295;299;298;296;297]

Education

The Local and Regional Study Areas are served by two school boards that provide services across Bruce and Grey Counties. The boards provide both elementary and secondary school services.

The Bluewater District School Board is the Public School Board that operates 15 elementary and four secondary schools in the Local and Regional Study Areas [307;308]. The Bruce-Grey Catholic District School Board is the Separate School Board that operates seven elementary schools in the Local and Regional Study Areas and one secondary school in the Regional Study Area [309;310].

Area schools in closest proximity to the Bruce nuclear site are located in Kincardine and Port Elgin with Kincardine Township Tiverton Public School being in closest proximity to the Project Area, at 15 km.

Post-secondary education for residents in the Local and Regional Study Areas is provided by a number of post-secondary institutions located outside the study areas within 1 to 2.5-hour drive of communities in Bruce County [311]. The closest facility, Georgian College of Applied Arts and Technology Owen Sound campus, offers a wide array of educational options including full and part-time studies, course upgrading, and a Continuous Learning Program, which offers night courses in a variety of disciplines.

The Bruce Power Learning Centre, located at the Bruce nuclear site, offers training to Bruce Power staff in the operation, maintenance and safety aspects of CANDU® reactors. It is one of two nuclear training facilities in Ontario. This centre is staffed by 150 training experts and support personnel. The facility has two full-size nuclear power plant simulators and a safety and fire training complex, which provides safety and emergency response training [311]. The nearby Bruce Technology Skills Training Centre in Tiverton, which is owned, managed and operated by the Power Workers' Union, provides training facilities to Bruce Power for skills training of new employees. Programs include training for operators and an apprenticeship program for trades personnel. The apprenticeship program is approved by the Ontario Ministry of Trades, Colleges and Universities [312;313].

Health and Safety Facilities and Services

The key health and safety assets of a community include health care services, policing, fire services and emergency preparedness. To an individual, family or household these services play a crucial role in maintaining people's feelings of health and sense of safety on a daily basis and during crisis situations, thus affecting people's satisfaction with the community.

Health Care Services

The Regional and Local Study Areas are served by Grey Bruce Health Services (GBHS) and South Bruce Grey Health Centre (SBGHC). The SBGHC has one hospital located in each of Walkerton, Chesley and Kincardine [314]. The GBHS network has one rural hospital located in Southampton.

In 2003, a report by the District Health Council concluded that the Counties of Grey and Bruce require another 94 doctors to meet the Ontario average doctor to patient ratio [315]. Also in 2003, the Municipality of Kincardine built a medical clinic adjacent to the Kincardine hospital for local doctors [316]. The clinic houses family practices, a retail pharmacy and a blood services and diagnostic laboratory, and has been instrumental in attracting new physicians to the area. Currently, nine family doctors work from this location [317]. In addition to this clinic, Kincardine has a holistic health clinic, dental offices, optometrists and an ambulance service.

There are two community-based medical clinics in Saugeen Shores (located in the Regional Study Area). The Saugeen Shores Medical Building in Southampton houses six doctors and one nurse practitioner, and the Dr. Earl Health Centre in Port Elgin has six family physicians on-site [318].

Police Services

The South Bruce Detachment of the Ontario Provincial Police (OPP) provides policing service across most of Bruce County. A new building was opened in Kincardine in 2008. The Detachment employs 55 constables, seven sergeants, one staff sergeant, one inspector, as well as seven part time court security officers and an administrative staff of five. The South Bruce Detachment services approximately 35,000 people in the winter and 60,000 people in the summer months [319]. The detachment's Marine Unit has six trained launch operators and the unit is responsible for patrolling Lake Huron from Goderich to Tobermory. The unit responds to boaters in distress as well as enforcing liquor laws, the Criminal Code and the Small Vessel Regulations of the Canada Shipping Act. In 2008, the South Bruce detachment investigated a total of 829 motor vehicle collisions and 639 property crimes [319].

The OPP has a liaison officer who participates in the development and maintenance of emergency preparedness plans. The OPP detachment takes part in these exercises approximately once every two years. Bruce Power has on-site resources that are responsible for access control and security at the Bruce nuclear site, and the OPP supports Bruce Power security staff when requested. Bruce Power, OPG and the Saugeen Shores Police Department co-operate regarding security training and occasionally share equipment and other resources.

Fire Protection Services

Within the Local Study Area, the Kincardine Fire Department operates two fire stations, one in Kincardine and the other in Tiverton. The Kincardine location is staffed by 26 firefighters, including 24 volunteer firefighters and two full-time staff. Tiverton is staffed by 22 volunteer firefighters and one full-time staff [320]. Interviews with fire department representatives indicated that Bruce Power and OPG work co-operatively with the departments through shared fire/emergency drills, mutual aid, public education and the supply of equipment and other resources. Bruce Power also provides program training to local fire departments as they are first response off-site. A significant number of the volunteer firefighters (about 75%) also work at the Bruce nuclear site, where many are career firefighters.

Emergency Preparedness

Emergency preparedness in Ontario is governed by the Emergency Management and Civil Protection Act. The Act sets out clear roles and responsibilities for all federal and provincial ministers across the full spectrum of emergency management, including prevention/mitigation, preparedness, response and recovery and critical infrastructure protection [321]. In accordance with this Act, all upper and lower tier municipalities in Ontario must have approved plans in place to deal with large-scale emergencies.

Emergency response planning for the unlikely event of an accident at the DGR Project that could affect people outside the Bruce nuclear site is the responsibility of a Provincial government agency, Emergency Management Ontario. Bruce Power and OPG work with Emergency Management Ontario and other local emergency responders to assist in the development and testing of emergency response plans [322].

It is the responsibility of all levels of government and the nuclear facility operators to respond to nuclear emergencies; however, in any nuclear emergency the Province will take the lead and issue direction for all off-site responses. The Province of Ontario, Provincial Nuclear Emergency Response Plan – Part I Master Plan [323] and Provincial Nuclear Emergency Response Plan – Part III Bruce Power Specific Emergency Plan [324] are the guiding documents that provide emergency orders to manage all off-site responses to nuclear incidences at the Bruce nuclear site. The Municipality of Kincardine's Emergency Response Plan describes how the municipality will react to a nuclear emergency at the Bruce nuclear site at the municipal level and how it will implement the Provincial Directives [325].

Social Services

Social services are designed to assist families and individuals in the community to address their social/family or individual needs such as unemployment, housing assistance and child care. These services play an important role in the community to help maintain personal well-being. Within the Local and Regional Study Areas private, not for profit and government providers supply many accessible social services. Social services available in Bruce County include long-term care facilities, social housing, affordable housing, child care services and the Ontario Works program.

Long-term Care Facilities

Community Care Access Centres are connectors to home care, nursing, long-term care destinations and other services in the community [326]. Within the Regional Study Area, the Southwest Community Care Access Centre provides five long-term care facilities. Two other retirement facilities were identified in the Local Study Area.

Social Housing

Bruce County operates the Social Housing division, which is responsible for the funding and administration of the social housing programs [327]. The Bruce County Housing Corporation owns and manages approximately 605 units throughout the county and aims to provide safe, affordable and well maintained homes for residents. Housing and support for adults with serious mental illness is provided by the Grey-Bruce Community Health Corporation, which is a non-profit charitable organization.

Affordable Housing

To address local affordable housing needs, Bruce County has actively participated in a number of initiatives in recent years to plan for and develop new affordable rental and ownership housing. The Bruce County Long Term Housing Strategy [328] was approved on September 16, 2010. This current strategy sets affordable housing targets for the next 10 years. Several strategic actions are identified to address to the current housing issues facing Bruce County. Overall, the goal of the Strategy is to create 335 new affordable housing units in Kincardine and Saugeen Shores, and 25 units in the remaining four municipalities of the Regional Study Area.

Initiatives to increase the stock are ongoing. In particular, under the Canada-Ontario Affordable Housing Program, a total of 35 additional affordable rental housing units were to have been available in municipalities of Bruce County by the end of 2010 [329].

Child Care Services

To help manage the local child care system, and to provide assistance to those families in need Bruce County provides several child services programs. Children First for Bruce County is a division of Bruce County Social Services that is responsible for the development of a number of programs within Bruce County. Types of services range from general child and early care services, nursery and pre-schools and before and after school programs [330].

Ontario Works Program

Ontario Works is an initiative that the Ontario Government designed to help Social Assistance Recipients become job ready and re-enter the workforce. Bruce County Ontario Works provides access to programs through two Resource Centres located in the Regional Study Area (Walkerton and Port Elgin) and one in Kincardine [331].

6.10.4 Financial Assets

The VECs that are considered within the financial assets component of the framework are presented in Table 6.10.2-1 and are described briefly in the following sections.

6.10.4.1 Employment

Current and historic employment levels within the Local and Regional Study Areas are presented in Table 6.10.4-1. From 2001 to 2006, employment in Kincardine increased by 4.9%. Across the combined Local and Regional Study Areas the increase in employment was 3.4% over this period. The highest increase in employment was in the Township of Huron-Kinloss, at 9.5%.

Table 6.10.4-1: Employment – Local and Regional Study Area (2001 to 2006)

Year	Municipality of Kincardine		Regional Study Area Municipalities												Total	
			Arran-Elderslie		Brockton		Huron-Kinloss		Saugeen Shores		South Bruce					
	#	%	#	%	#	%	#	%	#	%	#	%	#	%		
2001	5,460	21.1	3,260	12.6	5,070	19.6	3,000	11.6	5,720	22.1	3,370	13.0	25,880	100		
2006	5,725	21.4	3,350	12.5	5,105	19.1	3,285	12.3	5,820	21.7	3,475	13.0	26,760	100		
2001-2006 Change (%)	4.9		2.8		0.7		9.5		1.7		3.1		3.4			

Source: [294;295;296;297;298;299;300;301;303;304;305;306]

In 2009 employment at the Bruce nuclear site included approximately 4,000 Bruce Power employees, 400 refurbishment contractors (Units 1 and 2), 183 OPG employees at the WWMF and 123 AECL employees.

Based on information from a 2005 analysis of worker residence locations, it is expected that most of the Bruce Power workforce (90%) resides within Bruce County. Within Bruce County, more than 75% of Bruce Power employees reside either in the Municipality of Kincardine or Saugeen Shores. The Municipality of Kincardine accounts for 40% of all Bruce Power employees and Saugeen Shores accounts for 35% [322].

6.10.4.2 Business Activity

The primary components of the Local and Regional Study Areas' economies include agriculture, tourism, the Bruce nuclear site and industrial and commercial businesses, including retail and service activity, businesses associated with the Bruce Eco-Industrial Park and wind energy developments. Bruce County has a thriving retail and service industry. Its small manufacturing sector, located in the southern portion of the County, is far less developed than in other counties in southwest Ontario, where there is a greater concentration of manufacturers.

Based on information provided by the Economic Development Office in Kincardine, the largest non-nuclear industry employers in the Local Study Area are outlined in Table 6.10.4-2.

Table 6.10.4-2: Largest Non-nuclear Industry Employers in the Local Study Area (2010)

Employer	# of Employees
Municipality of Kincardine	164
Kincardine Hospital [a]	130
Sobey's	125
Brucetelecom	105
Trillium Court	80
Superheat Industries	75

Note:
a 2009 data.
Source: [332]

Nuclear Industry

The Bruce nuclear site (formerly known as the Bruce Nuclear Power Development) is one of the largest centres of energy production in the world. The Douglas Point Nuclear Generating Station (DPNGS) entered service in 1968 and was permanently shut down in 1984. The station is located in the southern portion of the Bruce nuclear site and adjacent to the Bruce B station. AECL maintains the DPNGS in a "safe storage" state prior to complete decommissioning.

In 1998, Ontario Hydro placed Bruce A into a temporary lay-up state, which resulted in the redeployment and relocation of many employees to other nuclear facilities on and off the Bruce nuclear site. In 2001, Bruce Power leased the Bruce A and Bruce B nuclear generating stations from OPG and continued their operation. At the time of writing, four units (Units 5-8) are operating at Bruce B. Two units at Bruce A (Units 1&2) are undergoing refurbishment. The other two units at Bruce A (Units 3&4) are operating and approval is in place for future refurbishment. OPG currently operates the WWMF at the site. Bruce Power and OPG issue contracts to businesses across Canada and internationally for a wide variety of goods and services for the Bruce nuclear site facilities.

Stakeholder interviews for this assessment indicated that the majority of the local business operators' credit Bruce Power as contributing positively to local economic stability and growth, largely in terms of employment and the spin-offs associated with employee spending. A few indicated that adverse effects on the local economy were evident after the Bruce A station was laid-up in 1998 and some indicated that the "boom and bust" cycle associated with the facility has made it difficult to plan for the future. Others indicated a need for the economy to be more diversified to avoid complete dependency on the jobs generated by the presence of the Bruce nuclear site.

Other Industry

One of the major industrial developments within Bruce County is the Bruce Eco-Industrial Park. This is a 485-ha serviced industrial park located immediately southeast of the Bruce nuclear site. It was established in 1986 with the intent to develop an industrial ecopark where waste and by-products of one industry could become the feedstock for a neighbouring industry. Currently there is one established business at the Bruce Eco-Industrial Park — a dehydration plant. The Bruce Technology Skills Training Centre is also located at the Bruce ECO-Industrial Park.

The wind energy industry has grown substantially in the Local and Regional Study Areas. The Municipality of Kincardine Official Plan [333] supports the development of wind energy facilities as a source of renewable energy. Large local projects include Enbridge Ontario Wind Farm in Kincardine (182 MW) and Ripley Wind (76 MW). A third large local project is the Knightsbridge Wind I & II (39.6 MW) in Goderich, just outside the Regional Study Area. Each of these projects employed 70 to 150 people during construction [334].

6.10.4.3 Tourism

The tourism industry is one of the most important business sectors of the economy in the Local and Regional Study Area. The Lake Huron shoreline area is recognized for its diverse natural beauty with over 2,400 km of Great Lakes shoreline, the Saugeen River and many other inland lakes and rivers.

In 2008, Bruce County attracted over 1.2 million visitors from Canada, United States and overseas, who spent over $145.1 Million in Bruce County on tourism-related expenditures including food and beverages, accommodation, transportation, retail and entertainment [335].

This activity is down somewhat from 2007 levels where visits to the County reached 1.3 million and spending during that year was over $187.8 Million [336].

Overall, the tourism industry directly employs one in seven people [337]. Taxes generated for all levels of government from tourism activity in 2007 (the latest available data) amounted to approximately $69.8 Million, including $5.5 Million in municipal taxes that accrued to Bruce County [336].

The major types of tourist establishments in Bruce County include retail stores (42%), food and beverage establishments (16%) and accommodation (12%). The Lake Huron shoreline area also boasts several arts, entertainment and recreation facilities (8%) and a large artisan community.

In terms of tourist accommodation, the existing stock consists largely of RV parks and campgrounds (29%), motels (29%), and hotels (9%). Bed and breakfast establishments and housekeeping cottages and cabins are also important contributors at 9% and 11%, respectively.

In 2008, 40% of all visits were same day visits in Bruce County compared to the Provincial trend of about 58% of visits being same-day stay [335;338].

In 2008, approximately 65% of all overnight tourists to the area were housed in private accommodation, including cottages or private homes, while 17% stayed at roofed commercial accommodations. Tourism related to visiting friends and relatives is particularly important during the non-peak tourist season (i.e., October through December).

In 2008, the most popular activities on a trip to Bruce County tended to be outdoor or sporting activities (45%), visiting National/Provincial Nature Parks (11%), and boating (10%). The Lake Huron shoreline is in itself an important natural attraction, offering some of the best beaches in Ontario. It is the shoreline that draws tourists to the area whether it is for the beaches, fishing, boating, hiking or biking.

Parks, beaches and trails along the Lake Huron shoreline are heavily used by tourists. 2009 surveys with visitors, at Inverhuron Provincial Park, MacGregor Point Provincial Park and Brucedale Conservation Area, indicated that the activities they partook in included camping (20%), hiking (18%) and wildlife viewing or bird-watching (12%).

Discussions at a tourism round table in 2003 confirmed that the Bruce nuclear site has a low profile among tourists, particularly as the existing nuclear generating stations are not visible from the nearest highway [339].

The Bruce nuclear site and the Bruce Power Visitors' Centre can be considered an industrial tourist attraction. It is located along the main access road to the Bruce A and B stations from Highway 21 between Kincardine and Port Elgin. This attraction provides visitors with numerous exhibits, displays and pre-arranged guided tours that explain the production of nuclear electricity. Bruce Power also runs "come & see" programs, Discover Energized Environmental Resources (DEER) programs and conferences at the Visitors' Centre.

In October and November 2009, interviews were conducted with motel, inn, bed and breakfast, cabin, cottage and campground operators in the Municipalities of Kincardine, Saugeen Shores and surrounding areas. These tourist accommodation providers within the Local and Regional Study Areas indicated that there has been an influence on their business as the result of activities at the Bruce nuclear site. Out of the 22 interviews that took place, 91% attributed some of their business to the presence of the Bruce nuclear site, its employees or activities. A few operators indicated that up to 70% of their business can be attributed to Bruce nuclear site employment. Most stated that the presence and operation of the Bruce nuclear site has had a positive effect on their business activity by bringing more people to the area (and more clientele for them) and extending the business season because of contractors renting on weekdays and off-season.

The presence and nuclear operations at the Bruce nuclear site have had a positive influence on local motels and hotels. They rely on corporate clientele, and Bruce Power and OPG employees for a large portion of their business activity. Few of those interviewed indicated that people tended to link their products or services with the Bruce nuclear site. The majority of tourism operators believed that tourists do not associate the accommodation provider with the presence of the Bruce nuclear site or WWMF.

Marinas and recreational fishing are also integral to the tourism product offered locally. To investigate the influence of the Bruce nuclear site on these local businesses, interviews were conducted in October and November 2009. The main issues that respondents identified as having the most affect on their business activities were the economy, weather, gas prices and the amount of fish present in Lake Huron. All of the marinas/recreational fishing business owners interviewed indicated that the Bruce nuclear site has had a positive influence on their business activity. The Bruce A and Bruce B outfalls warm the water around the nearshore area adjacent to the Bruce nuclear site and attract different species of fish. This makes the areas near the Bruce nuclear site an attractive and popular fishing destination.

OPG is a participant and sponsor of many festivals and events that draws tourists to the area. OPG also supports operations at the Bruce County Museum and Cultural Centre. The Museum holds many events such as exhibits, lecture series, summer camps and actively supports the thriving local art community. Additional activities that draw tourists include the local theatres as well as First Nations Pow Wows throughout the area.

6.10.4.4 Residential Property Values

An analysis of real estate data, carried out for the period 1996 to 2000 as part of the EA for the Restart of Bruce A Units 3 and 4 [340], indicates that the number of properties sold in municipalities adjacent to the Bruce nuclear site was variable over these years, peaking in 1999. The data indicated that declines in property value were experienced in Kincardine, Tiverton and Port Elgin in 1998 and 1999. Average housing prices in Tiverton and Port Elgin had recovered and exceeded those prior to the Bruce nuclear site lay-up, while average housing prices in Kincardine had remained low. In 2001, the announcement by Bruce Power that it intended to restart two units at Bruce A (i.e., Units 3 and 4) resulted in increased confidence in the local housing market. By May of 2001, average prices across Kincardine fully recovered and were at approximately $117,000 per unit.

Data on the number of sales and residential property values for the period of 2001 to 2010 is provided in Table 6.10.4-3. The data indicates a strong housing market, especially during the periods of 2001 to 2004 and in the year 2007.

Table 6.10.4-3: Residential Sales and Property Values (2001 to 2010)

Year	Kincardine		Saugeen Shores	
	Sales (#)	Average Value ($)	Sales (#)	Average Value ($)
2001	173	117,047	202	122,881
2002	269	127,914	268	136,171
2003	245	146,200	275	172,339
2004	284	177,481	309	194,636
2005	174	177,951	246	208,562
2006	172	199,132	201	231,226
2007	200	238,787	238	268,298
2008	159	234,196	156	268,344
2009	158	248,762	220	265,520
2010 (Jan-Sep)	122	246,272	156	279,703

Source: [341;342;343]

6.10.4.5 Municipal Finance and Administration

The availability and quality of public services and infrastructure affect the well-being of individuals who live, work or visit Kincardine and the Regional Study Area. The status of municipal finances and administration affects the availability of services and the confidence people have in the governance of their community.

Table 6.10.4-4 presents the 2009 property tax rates across property types in Kincardine. Applicable tax rates for Kincardine, Bruce County and the area school boards (Bluewater District School Board and Bruce-Grey Catholic District School Board) are noted with the final column indicating the total property tax rate for each property type.

Table 6.10.4-4: Property Tax Rates in Kincardine for Kincardine, Bruce County, and Local School Boards (%) (2009)

Property Type	Kincardine	Bruce County	Schools	Total
Residential	0.413231	0.448138	0.252000	1.113369
Multi-Residential	0.413231	0.448138	0.252000	1.113369

Table 6.10.4-4: Property Tax Rates in Kincardine for Kincardine, Bruce County, and Local School Boards (%) (2009) (continued)

Property Type	Kincardine	Bruce County	Schools	Total
Commercial/Office Building – Fully Occupied	0.509555	0.552599	1.336758	2.398912
Commercial – Vacant/Excess Land	0.356688	0.386819	0.935731	1.679238
Industrial Occupied	0.722203	0.783210	2.095036	3.600449
Industrial Vacant/Excess Land	0.469430	0.509087	1.361773	2.340291
Farmland	0.103308	0.112034	0.063000	0.278342
Managed Forest	0.103308	0.112034	0.063000	0.278342

Note: Property tax payable is calculated by multiplying the assessed property value by the tax rate.
Source: [344].

In 2008, the Municipality of Kincardine total revenue fund revenues were $19.6 million. The principle sources of revenue were taxation (48%), user fees and charges (17%) and other revenues (15%). Payments-in-lieu contributed 1%. Municipal revenues are generated by the current land use activity at the Bruce nuclear site. In 2009, OPG made property tax payments of approximately $5 million for its lands, buildings and structures at the Bruce nuclear site. Approximately $472,200 was for its waste management operations at the site.

The Municipality of Kincardine distribution of expenditures in 2008 was such that transportation services was the dominant expenditure category at 23% followed by environmental services at 19% and recreational and cultural services at 18%.

In 2008, Bruce County total revenue fund revenues, that is revenue from all external sources, were $70.4 million. Taxes are the largest revenue source accounting for 46% of total revenues followed by grants (33%) and user fees and charges (13%). Payments-in-lieu contributed 1%.

In 2008, the distribution of Bruce County expenditures was such that social and family services accounted for 46% of the monies dispersed, followed by transportation services (15%) and health services (13%).

6.10.4.6 Other Financial Assets

Income

Current and historic average household income levels within the Local and Regional Study Areas are presented in Table 6.10.4-5. In 2006, the average household income across the Local and Regional Study Areas was approximately $73,200, ranging from approximately $56,550 in Arran-Elderslie to approximately $89,900 in Saugeen Shores. The average household income in Kincardine was the second highest in the Local and Regional Study Areas at approximately $80,400.

Between 2001 and 2006, average household income increased in each municipality. Across the Local and Regional Study Area, this increase was 27%, or an average 5.4% per year. The strongest growth in average household income was found in Saugeen Shores (39%), while the lowest increase occurred in South Bruce (11%). Over the 5-year period, the average household income in Kincardine increased by 33%, or 6.6% annually.

Table 6.10.4-5: Average Household Income – Local and Regional Study Area (2001 to 2006)

Year	Municipality of Kincardine	Regional Study Area Municipalities					Average
		Arran-Elderslie	Brockton	Huron-Kinloss	Saugeen Shores	South Bruce	
2001	$60,279	$50,135	$53,515	$56,952	$64,917	$55,125	$57,877
2006	$80,399	$56,547	$64,093	$68,355	$89,915	$61,379	$73,216
2001–2006 % Change	33%	13%	20%	20%	39%	11%	27%

Source: [294;295;296;297;298;299;300;301;303;304;305;306]

Renewable and Non-Renewable Resource Use

Renewable and non-renewable resource use is an important financial asset. Commercial fishing, forestry and mineral aggregates are all forms of business activity which can contribute to income and employment levels, which, in turn, will contribute to the quality of life and sense of personal security of individuals, families or households.

Commercial Fishing

The Bruce nuclear site is located within Lake Huron's quota Management Area 4-4, which extends from Point Clark (in the Township of Huron-Kinloss) in the south to approximately Stokes Bay (in the Municipality of Northern Bruce Peninsula) in the north. Catch, harvest and quota data for all key commercially caught fish species in this area in 2008 is presented in Table 6.10.4-6. The total harvest of fish by commercial fishers in 2008 was 242,291 kg, with an estimated value of $646,706. The lake whitefish harvest accounted for the vast majority of the total harvest.

Table 6.10.4-6: Commercial Fish Harvest Data for Lake Huron's Quota Management Area 4-4 (2008)

Species	Catch (kg)	Harvest (kg)	Quota (kg)	% Quota Taken	Value ($)
Lake Trout	22,900	22,900	7,998	286.3	26,757
Lake Whitefish	218,052	218,052	424,368	51.4	615,318
Walleye	509	509	742	68.6	2,570
Yellow Perch	568	568	9,372	6.1	1,991

Source: [293]

The Saugeen Ojibway First Nations (SON) holds exclusive rights to the commercial fishery in the vicinity of the Bruce nuclear site through a commercial fishing agreement in place with the Ontario Ministry of Natural Recourses. The SON area extends from Point Clark to Craigleith (in Grey County) to the International border. Further discussion of use of traditional territory for harvesting, hunting and fishing can be found in Section 6.9.8.

Forestry

Data on forestry activity in the Local and Regional Study Areas were not readily available. The sector was not mentioned in stakeholder interviews and is not considered to be a significant activity in the study area economy. Information regarding plant communities within the study areas is presented in Section 6.4 and the Terrestrial Environment TSD.

Non-renewable Resource Use

Mineral aggregate is a basic non-renewable resource that forms a key ingredient in the production of concrete and concrete products, asphalt pavements and sub-surface fills. Over 7,000 people are employed directly by the aggregate industry in Ontario and an estimated 34,000 are involved indirectly through transportation and equipment services in Ontario. In 2009, 3,759 licensed aggregate sites were on private land and 3,038 were permitted on Crown lands [345]. Overall production of mineral aggregates in 2009 totalled approximately 153 million tonnes across Ontario, down 14 million tonnes or 8.4% from the previous year. Production from licensed operations was approximately 139 million tonnes, down 15 million tonnes or 9.7% from 2008. In 2009, the Local and Regional Study Areas combined produced approximately 1% of Ontario's aggregates from licensed operations.

Agriculture

Agriculture is an important component of Bruce County's economy. Bruce County has over 3,750 farm operators that generate over $255 million in gross sales annually. Approximately 62% of the County's land area is dedicated to the agricultural industry. The County is ranked first in Ontario for total cattle production, with 51% of farms dedicated to the production of beef cattle. The County is ranked third in Ontario in sheep production, with $1 million in sales annually. Bruce County is also the top producer of oats and the second largest producer of canola, barley and hay in Ontario. Approximately 63% of all Bruce County farms are family owned and operated, and together Bruce County farms generate over 28,000 weeks of direct full-time and part-time employment per year [346].

Based on 2006 and 2001 census data, the number of farms within Kincardine and Regional Study Area Municipalities decreased by 2.5% from 2001 to 2006. Kincardine experienced the highest loss in number of farms over this period, a 6% loss. However, the average area of farms increased by 4% across Kincardine and the Regional Study Area, and average gross farm receipts increased by 12% from 2001 to 2006 [347;348].

Economic Development Services

Economic development in the Local and Regional Study Areas is a co-ordinated activity among many local, provincial and federal government organizations. For the Local Study Area, the Municipality of Kincardine issued a "Community Plan" in February 2010. A series of economic development initiatives are identified in this plan aimed at creating an environment that supports existing businesses and industry while promoting economic growth [349].

In the Regional Study Area, the Bruce Community Futures Development Corporation (BCFDC) plays a central role in co-ordinating research and implementing economic development programs and has prepared an economic diversification plan for the South Bruce area [350]. This plan was prepared in response to the 1998 lay-up of Bruce A. It recognizes that economic diversification of the local economy is critical to the future of the County. The plan identifies a number of community-based actions for each of the major sectors of the local economy (i.e., industry, tourism, agriculture) and for infrastructure/transportation, training and small business development.

6.10.5 Physical Assets

The VECs that are considered within this sub-component of the framework are presented in Table 6.10.2-1 and are described in the following sections.

6.10.5.1 Housing

The inventory of housing stock in Bruce County was estimated in the 2006 Census at 38,432 units [351], of which approximately 25,000 dwellings were within the Municipality of Kincardine and the Regional Study Area municipalities. Of these 25,000 units, 65% were found in the three more populated municipalities (i.e., Saugeen Shores, Kincardine and Brockton), with 22% of the total in the Municipality of Kincardine itself. Permanent private dwellings represent more than 80% of this housing stock (20,490 units). Of those, about 83% are single detached houses. The majority of the rest are found in buildings with two to four units.

In a 2003 analysis of seasonal homes versus year-round residential properties, there were an estimated 22,439 assessment parcels that were coded as year-round residential and 11,235 coded as seasonal recreational properties. This information indicates that seasonal visitors can be expected to play an important role in the Local and Regional Study Areas. As property owners they have a voice in the community, and use of the properties can be expected to contribute to local business and other community activity.

6.10.5.2 Municipal Infrastructure and Services

Water Supply

The Kincardine Water Treatment Plant (WTP) draws its supply from Lake Huron. The maximum day plant rated capacity is 11,578 cubic metres per day (m^3/day). The current reserve capacity of 4,550 m^3/day is available for supply to infill plus future growth. The plant will eventually service a total population of 13,476 people. The community of Tiverton is serviced by a separate system (two wells) with a maximum day design capacity of 1,028 m^3/day (2004).

In Saugeen Shores, the Southampton WTP is located approximately 20 km northeast of the Bruce nuclear site. The plant draws its raw water from Lake Huron and provides water to both Southampton and Port Elgin. The Port Elgin WTP was taken out of service as of October 31, 2008 [352]. Following recent upgrades, the Southampton WTP has sufficient maximum day treatment capacity for the 20 year maximum day design flow [353].

The Bruce nuclear site has its own potable water supply. Bruce B supplies water to the facilities at the centre of the site, including the WWMF. Municipal potable water is available at the site boundary with Inverhuron Provincial Park, but is not used at the Bruce nuclear site [97].

Waste Water Treatment

Waste water treatment services are provided by the Kincardine Sewage Treatment Plant and a treatment plant located at the Bruce Eco-Industrial Park [354]. With an average design capacity of 5,910 m^3/day, the Kincardine Sewage Treatment Plant provides sewer service to the urban centre of Kincardine and shoreline properties north to Inverhuron. A remaining uncommitted hydraulic capacity of 1,515 m^3/day is available for future growth and development.

The community of Tiverton and portions of Inverhuron, as well as Inverhuron Provincial Park receive waste water treatment services from the Bruce Eco-Industrial Park Sewage Treatment Plant. This plant has an average design flow of 2,200 m^3/day. Approximately 404 new residential lots have been approved that will utilize some of the available capacity. The remaining uncommitted treatment flow capacity, which could service future, unidentified growth is 107 m^3/day. The Bruce Eco-Industrial Park Sewage Treatment Plant discharges its treated effluent through the Bruce B discharge channel [354].

In Saugeen Shores, the Port Elgin Water Pollution Control Plant (WPCP) serves a population of over 7,000 and handles an average daily flow of between 2,120 and 2,786 m^3/day. The Water and Sewer Servicing Master Plan (2009) indicates that no substantial upgrades in terms of average daily capacity are required. The Southampton WPCP serves a population of approximately 3,100 and handles an average daily flow of between 1,425 and 1,734 m^3/day. The Master Plan indicates that this plant has capacity for the 20-year average daily sewage flow [353].

The Bruce nuclear site has a sewage treatment plant that handles all sewage from the site and discharges clean effluent via the Douglas Point outfall. The plant is at capacity, largely because of process inefficiencies (e.g., the large amount of non-sewage water diverted to the plant). Bruce Power is investigating the necessary improvements to the sewage treatment plant [97].

Conventional Solid Waste Management

The Municipality of Kincardine operates three solid, non-hazardous, conventional waste management landfill sites. The Ward 1 Kincardine Landfill is at capacity. A new waste management centre at the Ward 2 landfill site located in Armow will have sufficient waste disposal capacity for the entire municipality for 40 years. The Ward 3 landfill site has 15 years of capacity remaining [332].

Conventional solid waste generated at the Bruce nuclear site is either recycled or reused where feasible, or disposed of at an on-site landfill. Construction waste and contaminated materials may be disposed of at off-site facilities that are licensed for the specific waste materials.

6.10.5.3 Other Physical Assets

Land Use

This section documents land use conditions associated within the Site, Local and Regional Study Area. Existing land use designations in Bruce County and within the Municipality of Kincardine and the Town of Saugeen Shores and corresponding permitted uses are described along with relevant policies within the respective Official Plans. Both levels of government (i.e., Bruce County and the municipalities of Kincardine and Saugeen Shores) have approved and in-effect Official Plans. There are no provincial land use plans that specifically apply to the study areas.

Bruce County Official Plan

One of the goals of the County, as expressed in its Official Plan [355], is to "maintain the small community environment and enhance the quality of life in Bruce County." To ensure the protection of agricultural and rural areas, the Official Plan focuses future growth in the County to Primary and Secondary Urban Communities and Hamlet Communities. Primary Urban Centres such as the town of Kincardine are expected to function as regional service centres by "accommodating the largest concentration and widest range of residential, economic and social opportunities, services and facilities available in the County" [355]. Secondary Urban Centres such as the Town of Saugeen Shores are expected to accommodate a range of similar services. The Official Plan recognizes both types of urban centres for their tourism potential in the County economy. Hamlet communities such as Inverhuron, located to the south of the Bruce nuclear site, are to be protected as settlement areas "providing limited services and facilities, and offering an alternative living area."

The lands along the shoreline to the north and south of the Bruce nuclear site are designated primarily as Shoreline Development Areas. The Official Plan [355] identifies Shoreline Development Areas as the principal areas for tourism and recreation in the County, while providing for limited permanent residential development. Immediately south of the Bruce nuclear site is Inverhuron Provincial Park, designated as Major Open Space Area. There are a number of Special Policy Areas within Bruce County, including several in the vicinity of the Bruce nuclear site. Of relevance is Special Policy Area "H", which applies to the Bruce Eco-Industrial Park, located to the east of the Bruce nuclear site. "The intent of this area was to encourage new development to utilize the electricity and heat energy from the Bruce nuclear site for industrial development."

The Official Plan [355] acknowledges the contribution made by the Bruce nuclear site to the County's economy (Section 4.5.2 of the Official Plan). Other policies relevant to the Bruce nuclear site intend to encourage improvements to recreational and commercial harbour facilities along the Lake Huron and Georgian Bay shorelines. Specifically, this policy states, "County Council will encourage a deep sea port facility near the Bruce Nuclear Power Development (BNPD) area for the transportation of goods and products beneficial to the BNPD and industries located at the BNPD or the Bruce Energy Centre."

Apart from these specific references, the Bruce County Official Plan [355] does not apply to the Bruce nuclear site. The lands are considered outside the jurisdiction of the County.

Municipality of Kincardine Official Plan

The Municipality's Official Plan [333] provides local planning policies for areas within the Local Study Area including the Bruce Eco-Industrial Park (formerly known as the Bruce Energy Centre), the Community of Inverhuron, the Community of Kincardine, and the Lakeshore Area that extends along Lake Huron. Section B1 (Basis of the Plan) recognizes that the Bruce nuclear site (referred to as the BNPD in the Official Plan) is a dominant force in the Municipality, while acknowledging that "agriculture, tourism and retail also continue to play an important role in the economy of the Municipality as well as contributing to the character of the area".

Policies dealing with energy also reflect the importance of the Bruce nuclear site. For example, policy C4.3.1 states, "The Municipality will continue to initiate, endorse and promote proposals to … utilize power from the Bruce Nuclear Power Development to its full potential." Similarly, policy C4.3.2 states, "it is the intent of this Plan to support efforts to attract industries to the area based on electricity from the Bruce Nuclear Power Development." The Municipality is committed to promoting the Bruce Eco-Industrial Park and the development of secondary industry necessary to support the activities at the Bruce nuclear site. Within the Bruce Eco-Industrial Park, the majority of the land is designated as either Industrial, or Natural Environment, and a small portion is designated "Open Space." One of the objectives of the Industrial designation is to encourage secondary industries related to the Bruce nuclear site to locate in the Bruce Eco-Industrial Park. Policies also place emphasis on preserving historic areas such as Inverhuron and promote tourism associated with the Municipality of Kincardine.

Town of Saugeen Shores Official Plan

Like the Municipality of Kincardine, the predominant land use in the Town of Saugeen Shores is Residential. Much of the Town's expected population growth can be attributed to the Bruce nuclear site's contribution as a major employer in the County [356].

The Official Plan [356] provides for a range of land use designations along the lakefront, including Shoreline Residential, Environmental Hazard, Marine Commercial, and Parks and Open Space. Regarding the latter, Section 4.8.1.2 of the Plan recognizes the waterfront as an important recreational, economic and natural resource in the Town and supports "the continued and enhanced use of the waterfront for a diverse range of community, recreational, tourism, parks and open space uses". One such use is a proposed continuous Waterfront Trail that will be connected to existing waterfront public open spaces and other points of interest along the waterfront.

6.10.5.4 Transportation Infrastructure and Services

Information in this section is based on the Traffic Impact Study prepared for the DGR Project [357]. Transportation analysis site employment assumptions are described first, followed by information regarding existing traffic, site access and intersection data and analysis.

Existing Bruce Nuclear Site Employment

The employees at the Bruce nuclear site include the existing (permanent) Bruce Power employees, OPG, Hydro One and AECL employees, as well as temporary Bruce A refurbishment workers. Of these, the largest number are the approximately 4,000 permanent Bruce Power employees. These workers generally have a flexible eight-hour day, although 130 of the workers adhere to a specific 8 p.m. to 8 a.m. day. In addition, there are 400 refurbishment workers at Bruce A at the time of writing, of which approximately 75% are construction staff working 10-hour days Monday to Thursday, and 25% are support staff working 8-hour days Monday to Friday. OPG and AECL have a staff of 306 employees, who work a flexible eight-hour day.

Traffic Data Collection

The traffic data collected for five intersections within the study area as part of the Bruce Power New Nuclear Power Plant Project Traffic Impact Study [358] were used in this study. Additional turning movement counts were undertaken at the intersections of County Road 23/County Road 20 (formerly Bruce Concession 4) and Highway 21/Bruce Concession 2 over an 8-hour period on May 22, 2008. A comparison of the traffic volumes near the Bruce nuclear site revealed a large volume of traffic using Sideroad J/1. The peak hour traffic volumes at the intersections of Sideroad J/1 and Bruce Concession 2 and Bruce County Road 20 were estimated by comparing the change in traffic volumes between Highway 21 and Bruce County Road 23 as well as considering the road surfaces along Sideroad J/1.

The AM peak hour for the year 2010 was determined to occur from 6:15 – 7:15 with 2,384 vehicles entering the Bruce Power site and 209 vehicles exiting. The PM peak hour for the year 2010 was determined to occur from 16:00 – 17:00 with 2,135 vehicles exiting the site and 159 vehicles entering the site. An estimated breakdown of peak hour traffic volumes by employee type is shown in Table 6.10.5-1.

Table 6.10.5-1: Existing Peak Hour Traffic Volumes

Type of Employee	A.M. Peak Hour		P.M. Peak Hour	
	Inbound	**Outbound**	**Inbound**	**Outbound**
Permanent Staff				
Bruce A and B Employees	2,026	177	143	1,874
OPG & AECL	155	14	11	143

Table 6.10.5-1: Existing Peak Hour Traffic Volumes (continued)

Type of Employee	A.M. Peak Hour		P.M. Peak Hour	
	Inbound	Outbound	Inbound	Outbound
Refurbishment Workers				
Construction	157	14	2	82
Support	46	4	3	36
Total	**2,384**	**209**	**159**	**2,135**

Source: [358]

Site Access

There are currently three entrances to the Bruce nuclear site. The northern entrance at Tie Road/Bruce Concession 4 provides access primarily for plant workers at Bruce A and refurbishment workers. The south entrance at Tie Road/Bruce Concession 2 provides signalized access primarily for plant workers at Bruce B, which has all four reactors in operation. The north and south entrances operate as inbound only during the morning and outbound only during the afternoon. The main entrance is located on Tie Road, provides two-way access to the centre of the site and is the primary access used by OPG and AECL workers as well as all visitors.

The Bruce nuclear site is also serviced by shuttle buses for Port Elgin and Kincardine; however, in 2007 only 1.5% of plant workers utilized the shuttle buses on a regular basis. The majority of the permanent staff and refurbishment workers drive their own vehicles to work and park on-site. The distribution of vehicles between the three entrances was found to be nearly equal in both the AM and PM peak hours.

Existing Intersection Operations

Existing A.M. and P.M. peak hour intersection levels of service were analyzed using the Synchro analysis software. The level of service analysis indicated that all intersections except Tie Road/Bruce Main Entrance and Highway 21/Bruce Concession 2 are operating at unacceptable levels of service 'E' or 'F'. These are the intersection at Tie Road and Bruce County Road 20 (LOS 'F'), and the intersection at County Road 23 and Bruce County Road 20 (LOS 'E'). During the P.M. peak hour, two intersections are operating at unacceptable levels of service 'E' or 'F'. These are the intersection at Tie Road and Bruce County Road 20 (LOS 'E'), and the intersection at Highway 21 and County Road 20. At some intersections, there may be individual turning movements that operate at unacceptable levels of service, but operations at the intersection as a whole are reflective of acceptable intersection delay. Level of service 'A' through 'D' would be reflective of acceptable intersection delay. A summary of the current conditions during AM and PM peak hours is shown in Table 6.10.5-2.

Table 6.10.5-2: Existing Intersection Level of Service

Intersection	A.M. Peak Hour	P.M. Peak Hour
1 - Tie Road and Bruce County Road 20 [a]	F	E
Eastbound Left-Through-Right	—	E
Northbound Left	F	—
Northbound Through-Right	E	F
Southbound Left	E	—
Southbound Through-Right	F	—
Westbound Left – Through – Right	F	—
2 - Tie Road and Bruce Main Entrance	B	A
3 - Tie Road and Bruce Concession 2 [a]	C	B
4 - County Road 23 and Bruce County Road 20	E	C
Northbound Left-Through-Right	F	—
5 - County Road 23 and Bruce Concession 2	D	C
Northbound Left-Through-Right	F	—
6 - Sideroad J/1 and Bruce County Road 20	D	D
Northbound Left-Through-Right	F	—
7 - Sideroad J/1 and Bruce Concession 2	B	A
8 - Highway 21 and Bruce County Road 20	D	E
Eastbound Left-Through	—	F
9 - Highway 21 and Bruce Concession 2	A	A

Notes:
a Signalized Intersection
— Data not available
Levels of Service 'A' through 'D' reflect acceptable traffic operating conditions, 'E' reflects increasing traffic congestion, and 'F' reflects traffic operating at or beyond capacity.
Source: [358]

Collision Analysis

The traffic report [358] provides an analysis of reported collisions between 2002 and 2006 at the nine off-site intersections examined nearest to the Bruce nuclear site. The number of collisions with white-tailed deer is quite low, averaging less than one per year over this period. Only three collisions that did not involve wildlife were reported over this time period.

6.10.5.5 Community Character

For the purposes of the following section, much of the data regarding people's attitudes towards their community, including levels of satisfaction with the community as a place to live, major community issues and key attributes of living in the area are based on data from Public Attitude Research (PAR) undertaken for the DGR Project [359]. This research targeted residents in the Local and Regional Study Areas' municipalities. Other data regarding people's attitudes towards their community are drawn from the Stakeholder Interviews, Community Leader Surveys, Site Neighbour Survey and Tourist and Day User Surveys undertaken for this analysis.

Image of Kincardine and the Surrounding Area

Table 6.10.5-3 summarizes the results of the PAR. The majority of the residents in the Local and Regional Study Areas identified Lake Huron, the waterfront, beaches and the lighthouse as the first image of the municipalities they live in (34% viewed this as positive and less than 1% as negative in the Local Study Area and 24% viewed this as positive and 1% as negative in the Regional Study Area). Residents also felt that the beauty of the area, nature and scenery were all positive images (8% in the Local Study Area and 8% in the Regional Study Area).

The Bruce nuclear site was identified more often in the Regional Study Area (13% as a positive image and 2% as a negative image) than the Local Study Area (5% as a positive image and less than 1% as a negative image). It is notable that 87% of the respondents who name the Bruce nuclear site consider it a positive image. Therefore overall, the Bruce nuclear site is not seen by many respondents as a negative influence on community character or image. Based on the PAR results, there are no strong indications that a stigma has been attributed to the Municipality of Kincardine and the neighbouring municipalities because of the Bruce nuclear site.

Tourist and day users of MacGregor Point and Inverhuron Provincial Parks, as well as from the Brucedale Conservation Area, were also asked to describe their first image of Kincardine and the surrounding municipalities, as well as to describe if this image was positive or negative. The majority of responses (64%) were that the first image of Kincardine and the surrounding municipalities as of a green or pleasant environment. Approximately 16% of the responses identified tourism or other points of interest as their first image; while 8% stated their first image was of the Bruce nuclear site. Of these responses (i.e., the 8% identifying the Bruce nuclear site), all were positive, except for one. Overall, 98% of the tourist and day user responses of the first image of Kincardine and the surrounding municipalities were positive. Table 6.10.5-4 summarizes these responses.

Table 6.10.5-3: Image of the Municipality of Kincardine and the Neighbouring Municipalities from the PAR

Image	Local Study Area (Total Number of Responses=393)				Regional Study Area (Total Number of Responses=385)			
	Positive		Negative		Positive		Negative	
	%	Number of Responses	%	Number of Responses	%	Number of Responses	%	Number of Responses
Lake Huron/Waterfront/ Beaches Lighthouse	34	133	<1	1	24	92	1	3
Beautiful/Nature/Scenery/Sunset	12	48	0	0	9	36	0	0
Farmland	7	27	1	3	8	31	1	4
Close-knit/Community Minded/ Friendly People	6	22	0	0	4	15	1	2
Bruce Nuclear Site	5	20	<1	1	13	50	2	8
Quiet/pleasant/good image	4	17	<1	1	4	16	0	0
Tourism	4	16	0	0	5	19	0	0
Countryside/Cottage Country	3	13	1	2	2	7	<1	1
Great Place to Live/Home	2	9	0	0	1	5	<1	1
Heritage Festivals/Sites	2	8	<1	1	1	3	0	0
Windmills	2	6	2	6	1	5	3	11
Quality of Drinking Water/Clean Air	2	6	0	0	2	6	0	0
Safety	1	5	0	0	1	2	<1	1
Nothing	0	0	0	0	1	2	0	0
Growth of economy	1	5	<1	1	1	5	1	2
Not well represented politically	1	2	2	8	1	3	1	4
Access to health care	<1	1	<1	1	1	2	1	2

Table 6.10.5-3: Image of the Municipality of Kincardine and the Neighbouring Municipalities from the PAR (continued)

Image	Local Study Area (Total Number of Responses=393)				Regional Study Area (Total Number of Responses=385)			
	Positive		Negative		Positive		Negative	
	%	Number of Responses	%	Number of Responses	%	Number of Responses	%	Number of Responses
Education	<1	1	0	0	<1	1	<1	1
Discrimination	0	0	0	0	0	0	1	2
Other	1	9	2	8	4	16	3	10
Don't know/refused	3	11	<1	1	3	13	1	4
Total	—	359	—	34	—	329	—	56

Notes:
Percentages are expressed as percentage of total number of responses per study area. Percentages may not sum to 100% because of rounding.
— Not applicable
Source: [359]

Table 6.10.5-4: Image of the Municipality of Kincardine and the Surrounding Municipalities from Tourist and Day User Surveys

Image	Positive Image (Number of Responses)	Negative Image (Number of Responses)	Total Number of Responses	%
Green/Pleasant Environment	83	0	83	64
Tourism/Points of Interest	21	0	21	16
Bruce Nuclear Site	9	1	10	8
Other	5	0	5	4
Activities & Recreation	4	0	4	3
Windmills	2	1	3	2
Rural Area/Farmlands	2	0	2	2
Close Proximity to Permanent Residence	1	0	1	1
Total	**127**	**2**	**129**	**100**

Notes:
The total number of responses is greater than the number of people surveyed as some people gave more than one response. Percentages may not appear to sum to 100% because of rounding.

Attractiveness as a Place to Live and for Tourism

Local and Regional Study Areas' respondents positive image of the Municipality of Kincardine and the Neighbouring Municipalities is further demonstrated in people's assessments of the attractiveness of the area as a place to live. As noted in Table 6.10.5-5, over 70% of the respondents state that the Municipality of Kincardine and the neighbouring municipalities are "very attractive" or "somewhat attractive" as a place to live (96% Kincardine, 95% neighbouring municipalities).

Table 6.10.5-5: Attractiveness of the Municipality of Kincardine and the Neighbouring Municipalities based on PAR

Response		Local Study Area (%)	Regional Study Area (%)
Place to Live	Very attractive	71	59
	Somewhat attractive	26	36
	Somewhat unattractive	2	4
	Very unattractive	2	1

Notes:
Cases may not sum to 401 for the total of Bruce County or 408 for Kincardine where 'no opinion' is excluded.
Percentages may not appear to sum to 100% because of rounding.
Source: [359]

Tourists and day users were asked to provide an opinion on the attractiveness of Municipality of Kincardine and the areas near MacGregor Point and Inverhuron Provincial Parks as well as the Brucedale Conservation Area as a place to visit. These results are summarized in Table 6.10.5-6. The majority of respondents (73%) stated that this area was "very attractive" and 27% stated that this area was "somewhat attractive". Only one respondent (less than 1%) stated that this area was "very unattractive".

Table 6.10.5-6: Tourist and Day User Ratings of Local Provincial Parks and Conservation Area

Response	Total	%
Very Attractive	82	73
Somewhat Attractive	30	27
Somewhat Unattractive	0	0
Very Unattractive	1	1
Total	**113**	**100**

Notes:
The total number of responses is less than the number of people surveyed as one person did not provide a response to this question. Total may not appear to sum to 100% because of rounding.

Landscape and Visual Setting

The physical landscape and visual setting is often a significant element in defining community character of a place or region. The following discussion describes the existing conditions component of the visual assessment undertaken for the Bruce nuclear site [360]. The Visual Study Area was defined as 20 km radius from the Bruce nuclear site and encompassed the areas that might be visually impacted by activities at the Bruce nuclear site.

Based on available geographic information system (GIS) data, agricultural fields are the dominant land use (73% by area) followed by forest cover (19%). The remaining areas are composed of transportation routes (3%), wetlands (2%), built-up areas (2%), extraction areas (0.5%) and open water (0.5%). These land uses and their effects on viewscapes are discussed in Section 5.6.3.3 of the Socio-economic Environment TSD.

There is an industrial appearance of the existing Bruce nuclear site and the high visibility of some of its components. The shoreline within the Visual Study Area, has high potential for visual impact from the Bruce nuclear site. The Algonquin Bluff and forested areas greatly reduces the visibility of the Bruce nuclear site from inland viewpoints. County Road 20 leads straight into the Bruce nuclear site from the east and views from this road are greatly influenced by the existing Bruce nuclear site. Intermittent views from Highway 21 are also possible. Additionally, the Bruce nuclear site is visible from a few points along the Lake Huron shoreline, including part of Boiler beach in Kincardine and along North Shore Road in Port Elgin.

6.10.6 Social Assets

The VECs that are considered within this sub-component of the framework are shown in Table 6.10.2-1 and are briefly described in the following sections.

6.10.6.1 Inverhuron Provincial Park

Inverhuron Provincial Park is located along the eastern shore of Lake Huron approximately 14 km north of Kincardine and 22 km southwest of Port Elgin and is within the Local Study Area. The park is 288 ha in size and has been in operation since 1959. The park property is owned by OPG. The Ministry of Natural Resources (MNR) has a long term lease agreement with the corporation allowing continued operation of the park. The next closest provincial park is MacGregor Point Provincial Park located 17 km to the northeast.

Inverhuron Provincial Park is classified as a "Recreation Park". From 2001 to 2009 park visitation grew steadily, with visits ranging from approximately 35,600 to approximately 65,000 visitors per year and averaging about 48,700 visitors annually (shown in Table 6.10.6-1).

The park was converted from a day-use only to overnight camping in 2005. Inverhuron Provincial Park has 162 camping sites; and 80 additional camping sites planned for the next few years. This park has discontinued the use of groundwater for its water supply and is connected to the municipal water supply system.

Table 6.10.6-1: Visitation at Inverhuron Provincial Park (2001 to 2008)

Year	Total Number of Visitors
2001	35,605
2002	49,253
2003	38,463
2004	37,811
2005	41,837
2006	55,760
2007	58,304
2008	56,054
2009	65,383
Average	**48,719**

Source: [361;362;363;364]

6.10.6.2 Other Social Assets

Cultural and Heritage Resources

The following sections summarize the cultural landscapes and the Euro-Canadian heritage resources in the study area. Aboriginal heritage resources are discussed in the Aboriginal Interests TSD.

As described in Section 6.9.7, a Stage 1 and 2 Archaeological Assessment [286;287] was completed for the DGR Project. Based on the Stage 1 and 2 Archaeological Assessments, in the mid-19th century it was planned that three towns and ports would surround the Douglas Point peninsula along Lake Huron, with Inverhuron to be developed to the south of the peninsula; and Port Bruce and Malta to the north. The most effective means of linking these proposed communities was to build a road along the slightly elevated band of loamy soil at the base of Douglas Point, avoiding the lower-lying, mucky wetlands that occurred on either side.

The completion of the Stage 2 Archaeological Assessment [287] resulted in the definition of four culturally-sensitive areas (A, B, C and D, shown on Figure 6.9.7-1) within the Bruce nuclear site. For the purposes of this socio-economic assessment, a culturally-sensitive area is one that is known to contain a Euro-Canadian archaeological site or within which there is potential for one to be encountered as a result of ground disturbance. The Stage 2 Archaeological Assessment confirmed the presence of three Euro-Canadian archaeological sites:

- *Smith (BbHj-33)* is located within culturally-sensitive area A (CSA A). Here there exists the ruins of a cobble foundation and several nearby depressions on the west side of Tie Road/Bruce Road 33 where it passes through Lot 18. They can be attributed to the Euro-Canadian homestead established after the September 27, 1854 land sale of Bruce Township lots. The Stage 1 assessment of Lot 18 details the Euro-Canadian history of the homestead site.
- *Bonnett (BbHj-32)* is located within culturally-sensitive area B (CSA B). Here there exists a band of low-relief cobble piles, generally less than 2 m in diameter, stretching along a 150 m section of a cobble terrace adjacent to a large conifer swamp that spreads to the northwest and north. A section of a collapsed snake rail fence straddles the terrace and swamp along the Lot 21/Lot 22 line.
- *Lime Kiln (BbHj-31)* is located within culturally sensitive area D (CSA D). Here there is a ruin of a lime kiln located approximately 200 m southwest of the DPNGS on the terrace immediately above the active Lake Huron shoreline. Quicklime was an essential 19th century building (mortar, plaster, whitewash), disinfecting, and agricultural product. The site features the kiln's cylindrical burning chamber, which had been constructed from igneous and metamorphic cobbles and small boulder. The collapsed front opening of the chamber faces Lake Huron. The opening would have served for fuel insertion, air intake, and the removal of the burned lime.

Culturally-sensitive area C (CSA C) is part of the Bruce Power leased lands and consists of a series of well-defined wooded, sandy beach ridges attributable to the high-water and recessional phases of the Nipissing Great Lakes and the Lake Algoma shoreline (ancestral Baie du Doré). Its physiography is identical to that found at the sandy head of Inverhuron Bay where cultural sites spanning the Late Archaic to Late Woodland periods are concentrated. CSA C was defined for its potential to contain Aboriginal heritage resources and is discussed further in the Aboriginal Interests TSD.

The Stage 2 Archaeological Assessment [287], concluded that the remainder of the Bruce nuclear site, including the DGR Project site is considered to be cleared of further archaeological concern.

Community Recreational Facilities and Programs

Community recreational facilities and programs (e.g., parks, trails, community recreation centres and arenas) play an important role in maintaining community cohesion and the satisfaction of residents with their community. The Davidson Centre (approximately 23 km from the Bruce nuclear site) is the main community centre in the Local Study Area.

Outdoor activities that are conducted at community facilities may be sensitive to changes in environmental quality. Some of the many outdoors activities include:

- organized sporting activities;
- fishing, boating, swimming, sailing and other water based recreational activities;
- unorganized play/playground activities and picnics; and
- walking, hiking and biking.

Area Provincial Parks, conservation areas and recreational trails are not only important tourist features but also provide important recreational opportunities for local residents offering good access to the Lake Huron shoreline. Presented in Table 6.10.6-2, 2009 survey data indicates that the majority of residents in the Local Study Area either regularly or occasionally use the area parks and recreational trails.

Table 6.10.6-2: Frequency of Use of Provincial Parks, Conservation Areas and Recreational Trails by Local Residents (2009)

Frequency	Kincardine	Regional Study Area Municipalities
Regularly	34%	16%
Occasionally	42%	34%
Never	22%	49%
Number of Responses	396	401

Note: Percentages may not appear to sum across to 100% because of rounding.
Source: [359]

The following sections describe some key recreation facilities in Kincardine and the Regional Study Area as well as a number of popular recreational pursuits of the community. It discusses use and visitation at facilities and data from the PAR study conducted for the DGR are presented to illustrate resident participation in a range of outdoor activities.

Provincial Parks and Conservation Areas

Inverhuron Provincial Park is described in Section 6.10.6.1. MacGregor Point Provincial Park is a 1,204 ha natural environment park located along the shoreline of Lake Huron, approximately 15 km north the Bruce nuclear site, within the Regional Study Area. It currently offers approximately 360 developed camping sites. Park visitation grew steadily from about 135,000 visitors in 2001 to more than 167,600 visitors in 2004 and then decreased to 160,668 in 2009. On average, over 156,000 people visited the park annually over the period of 2001 to 2009 (Table 6.10.6-3). This park recently discontinued use of surface water for its water supply and is now connected to the municipal water supply system.

Table 6.10.6-3: Visitation at MacGregor Point Provincial Park (2001 to 2009)

Year	Total Number of Visitors
2001	135,187
2002	134,275
2003	160,150
2004	167,671
2005	165,413
2006	161,630
2007	166,347
2008	160,606
2009	160,068
Average	156,816

Source: [361;362;363]

The increasing trends in visitation at MacGregor Point Provincial Park indicate that the ongoing presence of the Bruce nuclear site has not had a "stigma" effect and that activities at the park have continued and visitation has grown. The Bruce nuclear site has not had a negative influence on community character and this is indicated by the increasing visitation trends at the park.

Stoney Island Conservation Area and Brucedale Conservation Area are both located within the Local Study Area. Brucedale Conservation Area is a 49 ha area offering 52 overnight camping sites and attracting approximately 100 visitors annually [365]. Stoney Island Conservation Area is a 40 ha area containing no camping sites but provides 6 km of nature trails and is open for public use year round. No data was available on visitation rates at this conservation area [366].

Recreational Trail Systems

There are a number of promoted and signed trail systems throughout the study area that are available to visitor and local residents, these include: canoe/kayak routes, cycling and hiking trails, and snowmobiling and cross-country ski trails. For example, there are over 360 km of snowmobiling trails that connect the communities of Kincardine, Tiverton, Southampton/Port Elgin, Sauble Beach and Paisley. Inverhuron and MacGregor Point Provincial Parks and the Kincardine boardwalk are used extensively for hiking [337].

Recreational Fishing and Boating

A recreational fishing survey published by Fisheries and Oceans Canada [367] indicates that a wide variety of fish are targeted or caught by recreational anglers. The most popular fish species caught by recreational anglers on Lake Huron are smelt, perch, smallmouth bass and pike, which account for approximately 74% of all fish caught. Approximately half of the fish caught on Lake Huron are kept, while others are released.

Marinas and fishing charter businesses and the proximity of Kincardine to Lake Huron offer recreational boating and fishing opportunities for local residents and tourists alike. The results from the PAR indicate that 33% of residents in Kincardine and 24% of residents in the Regional Study Area go fishing and boating occasionally or on a regular basis.

Bird Watching and Nature Viewing

The natural beauty of the Lake Huron shoreline is a major attraction for both residents and tourists. The two Provincial Parks, local beaches, the Brucedale and Stoney Island Conservation Areas and other hiking and cross-country ski trails provide access to the shoreline and wooded areas for nature enthusiasts. Inverhuron Provincial Park, the wooded areas surrounding the Bruce nuclear site and Baie du Doré, located immediately north of the Bruce nuclear site are popular locations for bird watching and nature viewing. The annual Huron Fringe Bird Festival organized by MacGregor Point Provincial Park in May attracts an average of 300 participants to observe birds and their habitats across the local area [322]. The Baie du Doré wetland is designated as a Provincially Significant Wetland (PSW) and supports a wide diversity of plant species and is used by deer and waterfowl. Rare flora and fauna have been observed at this location. There are also several other environmentally significant areas in the vicinity of the Bruce nuclear site. Section 6.4.5 provides more information regarding the natural heritage features in the study areas.

Community Cohesion

Community cohesion refers to people's sense of belonging to a self-defined community and is considered a social asset. Several factors contribute to the cohesiveness of a community. These include length of residency in a community and the demographic characteristics of the households in that community (composed of young families or not for example). Factors contributing to resident's feelings of community character and direct comments from residents regarding their feelings are presented in this section.

Length of Residency and Households with Children

The length of residency is a useful indicator of community cohesion. Experience indicates that the longer people have lived in their communities the more likely they are to express satisfaction with their property, homes and community. From the 2006 census data, it is clear that many of the residents have lived at their current address for the past five years (68% in the Local Study Area and 69% in the Regional Study Area). From the PAR, it is evident that the local population is aging and over 62% of Local Study Area respondents have lived at their present address for 21 years or more. Slightly fewer (59%) of the Regional Study Area respondents have lived at their present address for 21 years or more.

The 2006 census data in Table 6.10.6-4 indicate household characteristics in the Local and Regional Study Area. Approximately 27% of households in the Local Study Area are composed of couples with children. This number is slightly higher in the Regional Study Area (30%). These data illustrate that the families in the Local Study Area, when compared to the Regional Study Area tend to have fewer households with children, or one person households.

Table 6.10.6-4: Household Characteristics from Statistics Canada

	Local Study Area		Regional Study Area	
	%	n	%	n
Total Private Households	100	4,605	100	15,885
Households containing a couple with children	27	1,245	30	4,790
Households containing a couple without children	38	1,755	36	5,790
One-person households	26	1,175	24	3,820
Other household types	9	425	9	1,475

Notes: Percentages may not appear to sum to 100% because of rounding.
n = Number of respondents
Source: [294;295;296;297;298;299]

Community Cohesion and Community Well-being

Other useful indicators of community cohesion come from the PAR results and other survey methods employed in this study. Respondents in these surveys were asked to describe the attributes that they thought should be maintained or enhanced in their community. In some cases, aspects of community cohesion were described as very important to respondents' view of community well-being.

In the PAR, 31% of the Local Study Area and 32% of the Regional Study Area respondents named social assets as attributes to be maintained or enhanced to support community well-being. More specifically, 12% of the Local Study Area and 16% of the Regional Study Area respondents named community cohesion (small town community and friendly people) as important attributes to be maintained or enhanced. In addition, four of the 77 stakeholders and four of the 23 community leaders also stated that community cohesion was an important attribute to be maintained or enhanced.

Social and Community Organizations

In addition to the direct contributions of individuals to community cohesion, social and community organizations contribute to the cohesiveness of their communities by promoting social interaction, integration and mutual support. They also serve as a means for community expression, thereby influencing the 'self image' of community members, the organization and the community as a whole. Table 6.10.6-5 lists some of the social and community organizations that serve the Local Study Area.

Table 6.10.6-5: Selected Social and Community Organizations in the Local Study Area

Type of Organization	Selected Organizations Operating in the Local Study Area
Social Service	• Community Living Kincardine and District • Big Brothers and Sisters of Kincardine • Bruce County Legal Aid • Community Food Bank • Day Away Program • Newcomers Club • Women's House Serving Bruce and Grey • Big Brothers and Sisters
Health and Safety	• Canadian Cancer Society
Arts and Recreation	• Bruce Bowling Lanes • Gymbags Health and Fitness • Kincardine Curling Club • Kincardine Karate Dojo • Davidson Centre • Tiverton Sports Arena • Tiverton Lions Bingo Hall • Whitney Crawford Community Centre • Kincardine Yacht Club and Marina • Kincardine Power and Sail Squadron • Kincardine Scottish Pipe Band • Kincardine Community Singers • Kincardine Sunset Quilters Guild • Kincardine Tartan Twirlers • Kincardine Theatre Guild
Environmental/Advocacy	• South Bruce Amnesty
Ratepayers	• Inverhuron and District Rate Payers Association

Table 6.10.6-5: Selected Social and Community Organizations in the Local Study Area (continued)

Type of Organization	Selected Organizations Operating in the Local Study Area
Community Organizations	• Knights of Columbus • Rotary Club of Kincardine • Tiverton Lions Club • Kincardine and District Lions Club • Air Cadets • Boy Scouts • Kincardine and District Horticultural Society • Bruce County Historical Society • Kincardine Area Seniors Advisory Action Committee • Merry Kin Club • Bruce Shrine Club

OPG's Contribution to Community Cohesion

Corporate involvement and support for community activities can help strengthen community character and cohesion. Through its Corporate Citizenship Program (CCP), OPG provides financial support and hands-on involvement to registered charities and not-for-profit community, educational and environmental organizations [368]. OPG provided contributions of $140,000 in 2009 and has planned contributions of $100,000 in 2010. OPG also provides the Educational Excellence program with an annual contribution of $100,000.

OPG supports more than 120 local non-for-profit initiatives and over 75 community events and clubs each year. Some of these include support of the Kincardine Scottish Festival and Highland Games Heavy Events, Port Elgin's Pumpkinfest, the Bruce County Museum and Cultural Centre, local food banks, minor sports, environmental initiatives and First Lego Leagues.

Some other examples of OPG's involvement in local communities are summarized in Section 2. Several stakeholders and community leaders remarked that OPG has, in the past, been an excellent community partner.

NWMO has taken a similar approach and interest in supporting community cohesion. From the outset, the DGR Project has been developed in partnership with Kincardine and surrounding Bruce County municipalities. The DGR Project has enjoyed strong community. support over the years. To maintain and strengthen community partnerships, the DGR Community Partnership Program was developed and implemented by the NWMO [369]. The DGR Community Partnership Program provides annual support of $100,000 for five years starting in 2009.

6.10.7 Natural Assets

The natural assets component of the community assets framework considers the biophysical environment upon which community well-being depends. For the purposes of this EIS, the existing environment of the natural assets VECs are described in the following sections:

- Geology (Section 6.2);
- Hydrology and Surface Water Quality (Section 6.3);
- Terrestrial Environment (Section 6.4);
- Aquatic Environment (Section 6.5);
- Radiation and Radioactivity (Section 6.6); and
- Atmospheric Environment (Sections 6.7 and 6.8).

6.10.8 Public Attitudes Toward Personal and Community Well-being

The final component of the community well-being framework is an integrated concept of public attitudes toward personal and community well-being. Three broad indicators were examined that reflected public attitudes towards their own well-being and that of their community as a whole. The first two indicators include peoples':

- people's feelings of personal health and sense of personal safety; and
- people's satisfaction with community.

These attitudes are often considered indicators of individual and community well-being [370;371;372]. The use of these as indicators of community well-being assumes that greater community well-being is achieved when more people feel that they are healthy, safe and satisfied living in their communities.

Finally, because of the fact that the DGR Project has the potential to affect communities that are located in proximity to the DGR Project site, people's attitudes towards the WWMF and the Bruce nuclear site as a whole are also considered an important DGR Project-specific indicator of community well-being. To this end, a third indicator of community well-being has been included. This is:

- people's attitudes towards the Bruce nuclear site and the WWMF.

Overall attitudes toward community well-being were examined through people's attitudes towards the greatest threats to their community and those attributes of their communities that they would like to be maintained or enhanced. Though not an indicator of public attitudes toward community well-being, these attitudes indicate the assets that are most important to residents, community leaders and community stakeholders.

6.10.8.1 Feelings of Personal Health and Sense of Personal Safety

The use of people's feelings of personal health and sense of personal safety as an indicator of community well-being assumes that greater community well-being is achieved when more people feel healthy living in their community and feel safe living in their community. The results of the PAR are listed in Table 6.10.8-1.

Table 6.10.8-1: Ratings on Overall Feelings of Personal Health and Sense of Personal Safety

Rating:	Feeling of Personal Health				Sense of Personal Safety			
	Local Study Area		Regional Study Area		Local Study Area		Regional Study Area	
	%	*n*	%	*n*	%	*n*	%	*n*
Excellent	33	133	30	121	63	251	54	218
Good	53	211	51	209	34	136	40	163
Not sure	<1	1	1	4	<1	2	<1	2
Fair	11	44	15	62	2	10	5	20
Poor	3	12	3	12	<1	2	1	5

Note: Percentages may not appear to sum to 100% because of rounding.
Source: [359]

In the Local Study Area, 86% of respondents rate their feeling of personal health as "excellent" or "good", 11% as "fair" and 3% as "poor". The vast majority (97%) of Local Study Area respondents rate their sense of personal safety as "excellent" or "good" and 2% as "fair". With regards to the Regional Study Area specifically, 81% rate their feeling of personal health as "excellent" or "good", 15% as "fair" and 3% as "poor". The majority (94%) of Regional Study Area respondents rate their sense of personal safety as "excellent" or "good", 5% as "fair" and 1% as "poor". These results indicate that residents in the Local and Regional Study Areas feel that they have a high sense of personal health and an even greater sense of personal safety.

To further understand what contributes to these responses, respondents in the PAR were asked to describe the things or issues in their community that most strongly affect their feelings of personal health or sense of safety the most. These things or issues are detailed in Table 6.10.8-2:

Table 6.10.8-2: Community Issues that Affect Feelings of Personal Health or Sense of Personal Safety

Issues	Local Study Area		Regional Study Area	
	%	Number of Responses	%	Number of Responses
Human Assets:	**57**	**230**	**45**	**184**
Healthcare services/facilities	38	152	24	98
Community safety – policing, drugs	18	74	20	81
H1N1 virus/vaccine	1	4	1	5

Table 6.10.8-2: Community Issues that Affect Feelings of Personal Health or Sense of Personal Safety (continued)

Issues	Local Study Area		Regional Study Area	
	%	Number of Responses	%	Number of Responses
Natural Assets:	**9**	**37**	**9**	**35**
Pollution	4	15	3	12
Weather – climate, global warming	2	9	2	7
Water quality	2	7	3	13
Environment	1	6	1	3
Attitude towards Bruce Nuclear Site/DGR:	**6**	***24***	**3**	***14***
Bruce Nuclear Power Plant	6	24	3	14
Physical Assets:	**6**	**21**	**4**	**21**
Infrastructure	2	7	1	5
Urban development/growth/congestion	2	7	1	6
Road safety/too many cars speeding	2	7	2	10
Financial Assets:	**4**	**16**	**2**	**8**
Economy	2	9	1	3
Wind turbines/noise/health concerns	2	7	1	5
Social Assets:	**1**	**6**	**2**	**7**
Community services/facilities	1	6	2	7
Other responses:	**34**	**137**	**45**	**185**
Nothing/feel safe	12	48	17	71
Other	5	19	5	22
Don't know/refused	17	70	23	92
Total Number of Respondents	—	401	—	408

Notes:
Percentages sum to more than 100% since up to two responses were accepted.
— Not applicable
Source: [359]

The results in the above table indicate that the overwhelming factors that affect the Local Study Area and Regional Study Area residents' sense of personal health and safety are related to healthcare services and facilities and overall community safety (related to policing and crime).

Six percent of the respondents from the Local Study Area and 3% from the Regional Study Area stated that the Bruce nuclear site affects their overall feelings of personal health and safety.

This indicates that for the majority of the residents in the area, the Bruce nuclear site does not play a major role in their feelings of personal health and safety.

6.10.8.2 Satisfaction with Community

The use of satisfaction with and commitment to community as an indicator of community well-being assumes that greater community well-being is achieved when more people are satisfied with living in their community. People tend to consider a wide variety of issues in making a determination of their level of satisfaction with and commitment to living in a community and how committed they are to remaining in that area.

PAR was undertaken across the Regional and Local Study Areas to gain an understanding of how people rate their level of satisfaction with living in their communities and how committed they are to remaining in their community [359]. The results of this research are summarized in Tables 6.10.8-3 and 6.10.8-4.

Table 6.10.8-3: Local and Regional Study Areas Residents' Satisfaction with Living in their Community

Satisfied:	Local Study Area		Regional Study Area	
	%	Number of Responses	%	Number of Responses
Very	70	278	70	286
Somewhat	28	112	27	109
Not very	2	7	1	5
Not at all	1	3	1	6

Note: Percentages may not appear to sum to 100% because of rounding.
Source: [359]

Table 6.10.8-4: Local and Regional Study Areas Residents' Commitment to Living in their Community

Committed:	Local Study Area		Regional Study Area	
	%	Number of Responses	%	Number of Responses
Very	70	276	69	279
Somewhat	24	94	24	97
Not very	3	13	5	22
Not at all	4	14	2	8

Note: Percentages may not appear to sum to 100% because of rounding.
Source: [359]

These results indicate that overall, residents of the Local and Regional Study Areas are satisfied with living in their communities (98% in the Local Study Area and 97% in the Regional Study

Area) and are also committed to living in their community (94% in the Local Study Area and 93% in the Regional Study Area). Furthermore, the majority of these respondents stated that they were "very" satisfied with living in their community (70% in the Local Study Area and 70% in the Regional Study Area) and that they were also "very" committed to living in their community (70% in the Local Study Area and 69% in the Regional Study Area). Clearly, in addition to having a positive sense of personal health and safety, residents of the Local and Regional Study Areas are satisfied living in their communities and are committed to living there.

6.10.8.3 Public Attitudes toward the Bruce Nuclear Site and the WWMF

From a social effects perspective, the WWMF may represent many different things to different people. As such, understanding people's attitudes towards the WWMF is important. Through the PAR, existing public attitudes towards the existing WWMF were examined in terms of people's awareness of the facility, how often they think about the fact that they live near a radioactive waste management facility, and their overall assessment of the effect of the WWMF on their daily lives.

Respondents in the PAR were asked how often in their "day-to-day living" and how they "think about the fact that they live near the WWMF". Overall, the results indicate that few people think about the existing WWMF on a daily basis; 83% of Local Study Area and 83% of Regional Study Area residents think about the fact that they live near the WWMF "not very" frequently or "never".

Very few Kincardine (9%) or Neighbouring Municipality (10%) respondents indicate that the presence of the existing WWMF has had any effect on their daily life. Those that indicate that the facility has had an effect, identify more positive than negative effects:

- Positive effects of the existing WWMF included employment opportunities (26% in the Local Study Area and 18% in the Regional Study Area) and increased incomes (24% in the Local Study Area and 28% in the Regional Study Area).
- Negative effects of the existing WWMF included increased cost of living (9% in the Local Study Area and 8% in the Regional Study Area) as well as other effects to human and natural assets (Table 6.10.8-5).

Table 6.10.8-5: Effects of the WWMF on People's Daily Life

Response	Local Study Area		Regional Study Area	
	%	Number of Responses	%	Number of Responses
No	91	360	90	364
Yes	9	34	10	39
If Yes: What Effects:				
Financial Assets:	**59**	**20**	**54**	**21**
Employment opportunities	35	12	15	6

Table 6.10.8-5: Effects of the WWMF on People's Daily Life (continued)

Response	Local Study Area		Regional Study Area	
	%	Number of Responses	%	Number of Responses
Positive – increased income	18	6	31	12
Increased cost of living	6	2	8	3
Human Assets:	**18**	**6**	**18**	**6**
Health concerns	18	6	18	6
Natural Assets:	**6**	**2**	**3**	**1**
Water quality concerns	6	2	3	1
Other responses:	**18**	**6**	**28**	**11**

Note: Percentages may not appear to add up to 100% because of rounding.
Source: [359]

6.10.8.4 Perspectives on Community Well-Being

The research conducted as part of this socio-economic assessment indicates that there are various perspectives regarding community attributes that ought to be maintained or enhanced and regarding the greatest threats to community well-being.

Respondents from the PAR, Community Leader Surveys and Community Stakeholder Interviews were asked to describe the attributes of their community that ought to be maintained or enhanced to ensure community well-being now and in the future and the greatest threats to their community's well-being. Their responses represent a range of perspectives, including those of the general public (PAR), leaders in the community (Community Leader Surveys) and such as representatives from businesses, community organizations, municipalities, tourist organizations, health and safety officials, educational institutions and other community members (Community Stakeholder Interviews).

Summary of Perspectives on Community Well-Being

Overall the field research results show that the Local and Regional Study Areas' residents, Community Leaders and Stakeholders tend to feel that the greatest threats to community well-being are related to financial assets, and that these financial assets, along with physical and social assets are those that ought to be maintained or enhanced to support community well-being. More specifically, the Bruce nuclear site clearly plays a prominent role in the community and is seen by the community to be important to its financial well-being. Many respondents stressed the importance of the community's dependence on the Bruce nuclear site for employment and economic opportunities. The community views its financial assets as being very important to community well-being; therefore, the loss of the nuclear industry would be devastating to the local communities.

6.11 HUMAN HEALTH

According to the World Health Organization (WHO), "health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" [373]. The WHO defines determinants of health as factors that affect the health of individuals and communities; specifically, the social and economic environment, the physical environment, as well as person's individual characteristics and behaviours [374]. In order to evaluate human health in accordance with the WHO definition, physical determinants, socio-economic determinants, cultural determinants and emotional determinants were all characterized, and used as indicators. These individual indicators were combined to produce a description of "overall health" that encompass a more holistic approach for considering the potential DGR Project-related effects on human health. Full details are provided in Appendix C.

6.11.1 Sources of Existing Information

The sources of information used to characterize the existing environment for human health includes the TSDs of the environment components, as well as the following sources:

- Statistics Canada CANSIM Database [375;376] by subject:
  - Well-being: perceived health, very good or excellent and perceived mental health, very good or excellent.
  - Health Conditions: overweight males and females, obesity, arthritis, diabetes, asthma, high blood pressure and injury-hospitalization
  - Human Function: participation and activity limitation and disability-free life expectancy.
  - Life Expectancy: life expectancy and infant mortality
  - Health Behaviours: dietary practices, leisure-time physical activity, active or moderately active, smoking and consumption of alcohol.
  - Cancer Incidence: all invasive primary cancer sites, colon, rectum and rectosigmoid junction cancer, bronchus and lung cancer, female breast cancer, and prostate cancer.
- Canadian Institute for Health Information (CIHI) Health Indicator Reports (2007 to 2008) [377]; and
- Cancer Care Ontario [378].

6.11.2 Spatial Boundaries

The generic study areas described in Section 5.1 are used for the human health assessment. For the purposes of the health assessment, information is reported for the geographic area representing either the Local or Regional Study Area. The health status statistics are reported for the Grey Bruce Health Unit. A public health unit (PHU) is an official health agency established by a group of urban and rural municipalities to provide a more efficient community health program, carried out by full-time specially qualified staff.

Education statistics are reported for the South-West Local Health Integration Network (LHIN), Ontario (3502). LHINs were created by the province of Ontario to provide efficient and effective health care services to Ontario on a regional basis. Residents in the Regional and Local Study Area are served by the South West LHIN, which includes 227 service providers.

6.11.3 Valued Ecosystem Components

Table 6.11.3-1 presents the VECs for human health along with their rationale for selection and the specific indicators and measures used in the assessment.

Table 6.11.3-1: VECs Selected for Human Health

VEC	Rationale for Selection	Indicators	Measures
Overall Health of Local Residents	• Local residents will have different characteristics (e.g., occupancy, use and consumption), which may result in different health effects than other groups	• Physical environment determinants • Socio-economic determinants • Cultural determinants • Emotional determinants	• Changes in physical environment determinants • Changes in socio-economic determinants • Changes in cultural determinants • Changes in emotional determinants
Overall Health of Members of Aboriginal Communities	• Members of Aboriginal communities will have different characteristics (e.g., occupancy, use and consumption), which may result in different health effects than other groups	• Physical environment determinants • Socio-economic determinants • Cultural determinants • Emotional determinants	• Changes in physical environment determinants • Changes in socio-economic determinants • Changes in cultural determinants • Changes in emotional determinants
Overall Health of Seasonal Users	• Seasonal users will have different characteristics (e.g., occupancy, use and consumption), which may result in different health effects than other groups	• Physical environment determinants • Socio-economic determinants • Cultural determinants • Emotional determinants	• Changes in physical environment determinants • Changes in socio-economic determinants • Changes in cultural determinants • Changes in emotional determinants

Table 6.11.3-1: VECs Selected for Human Health (continued)

VEC	Rationale for Selection	Indicators	Measures
Health of Workers	• Workers at the DGR Project would experience different exposures during their work day, which may result in different health effects than other groups	• Radiological exposures • Non-radiological hazards	• Magnitude of radiological exposures • Potential health and safety consequence(s) as a result of exposure to non-radiological hazards

6.11.4 Physical Environmental Determinants

6.11.4.1 Air Quality

Existing air quality in the Regional and Local Study Areas is summarized in Section 6.7. However, these data represent existing air quality in a general sense. Potential human receptors were identified as people who live in or use areas in the vicinity of the DGR Project. The following receptors were identified and are considered to be present at the locations indicated on Figure 6.11.4-1 as follows:

- local residents (AR1, AR2, AR3);
- members of the nearest Aboriginal communities (AR5, AR6); and
- seasonal users (AR2, AR4).

Residential communities were identified at AR1, AR2 and AR3. Members of the nearest Aboriginal communities are considered to be members of the Saugeen Ojibway Nation (Chippewas of Saugeen First Nation Reserve No. 29, Chippewas of Nawash Unceded First Nation Cape Crocker Reserve No. 27). Members of the Saugeen Ojibway Nation (SON) were conservatively considered to be present at AR5, which is located at the limits of the air modelling domain, aligned between the DGR Project and the closest SON reserve. However, the actual reserve is approximately 17 km further from the DGR Project site than this location. Because AR5 is closer to the DGR Project than the community, the actual exposures and risks to members of the SON would be less than is estimated in this human health assessment. The second Aboriginal receptor, AR6, was placed at the burial ground (Jiibegmegoong) on the Bruce nuclear site. This receptor was identified as a location where members of the Aboriginal community may periodically spend time (assumed to be once per month in the assessment).

Seasonal users may be park users or cottagers who would live or vacation in the Local Study Area for part of the year. Seasonal users may use the recreational areas around AR2 and AR4 (Inverhuron Provincial Park and Baie du Doré, respectively) and were considered to be present at these locations for approximately two months of the year.

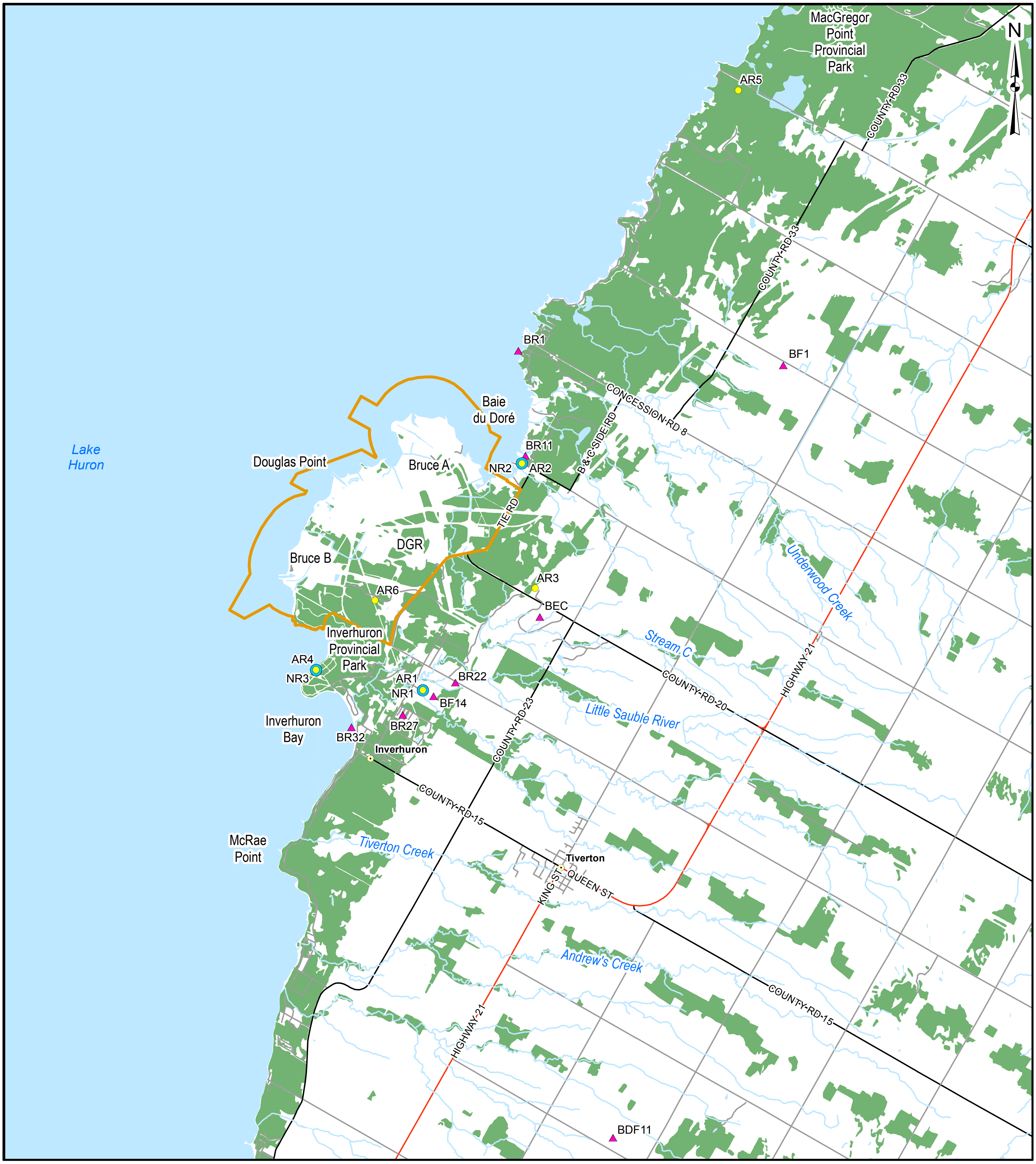
The assessment of air quality associated with the DGR Project included predictions of the existing concentrations at these receptors (presented in Appendix J to the Atmospheric Environment TSD). These predictions were compared in Appendix C to the EIS to established screening health based criteria to yield hazard quotients (HQ) of target compounds at the above human receptors. The results are presented in Table C2.3.1-2 of Appendix C to the EIS. Predicted air concentrations of target compounds, resulting from existing sources at the Bruce nuclear site do not exceed HQ of 1.0, with the exception of acrolein.

6.11.4.2 Noise Exposure Levels

The assessment of noise associated with the DGR Project is presented in the Atmospheric Environment TSD, and includes measurements of the existing noise levels in the context of established Health Canada criteria at the three health receptors (NR1 – Albert Road, NR2 – Baie du Doré and NR3 – Inverhuron Provincial Park). These receptors correspond to R1, R2 and R3 in the Atmospheric Environment TSD and are shown on Figure 6.11.4-1. Health Canada has published a draft national guideline for evaluating health impacts of noise [379], which considers the characteristics of noise. The following two measures are included in the Health Canada document:

- the percentage of the exposed population that could be "highly annoyed" by increased noise levels caused by projects (%HA); and
- the specific impact, or impulse noise, indicator (HCII).

Table 6.11.4-1 provides a summary of the existing noise exposures for the human health receptor locations for the existing %HA and HCII measures. A change in %HA of 6.5 is considered to have the potential for adverse effects on human health. An exceedance of 75 dBA for HCII is considered to have the potential for adverse effects on human health. Based on the existing noise levels, there are no health concerns.



0 1 2 4

Kilometres

LEGEND

- Radiological Potential Critical Group Location
- Noise Receptor
- Air Receptor
- Site Study Area [1]

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m, Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

HUMAN HEALTH RECEPTOR LOCATIONS

Golder Associates
Mississauga, Ontario

PROJECT NO. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct 2007	**FIGURE 6.11.4-1**	
GIS	BC	22 Jun. 2010		
CHECK	RS	22 Jun. 2010		
REVIEW	SM	22 Jun. 2010		

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Table 6.11.4-1: Existing Noise Levels at Human Health Receptors (%HA and HCII)

Receptor	Existing HCII (dBA)	Baseline %HA
NR1 – Albert Road	47	1.5
NR2 – Baie du Doré	50	2.1
NR3 – Inverhuron Provincial Park	50	2.1

6.11.4.3 Radiation Exposure Levels

The highest existing dose among the nine potentially critical groups representing members of the public was 4 µSv/a. The existing doses are considerably less than the regulatory limit of 1,000 µSv/a for members of the public. The values are also quite small compared to the variation in background radiation from natural sources.

For workers, at the WWMF the collective annual whole body doses for NEWs were 6.52 person-mSv, and collective dose of 2.7 and 4.3 person-Sv at Bruce A and Bruce B, respectively during 2009. For non-NEWs, the current doses do not exceed 100 µSv/a, which represents 10% of the annual dose limit to general public.

6.11.4.4 Surface Water Quality, Soil Quality and Groundwater Quality

Lake Huron is a source of drinking water for a number of the local communities. There are no existing human health concerns with regards to surface water quality.

Local residents, recreational users and members of the Aboriginal communities would not have direct contact with soils on the DGR Project site, as site access would be restricted to workers and supervised visitors. Workers at the DGR Project site during the site preparation and construction, and decommissioning phases of the DGR Project may be exposed to soils in the Project Area. Therefore, the presence of contaminated soils within the Project Area is relevant to worker health. However, there are no existing human health concerns with regards to soil quality.

Groundwater conditions beyond the Site Study Area, but within the Regional Study Area are considered relevant to human health because of the potential contact to local residents, seasonal users and members of the Aboriginal communities via drinking water, recreational usage, discharges to surface water and agricultural usage. Groundwater quality within and upgradient of the Project Area are considered relevant to the health of workers because workers may be exposed to groundwater during excavation activities during the site preparation and construction and decommissioning phases of the DGR Project. There are no existing human health concerns with regards to groundwater quality.

6.11.4.5 Foods

In 2002, a Nawash FISHES Study [380] was completed to determine the risk due to eating fish caught in Lake Huron that may have come into contact with the Bruce nuclear site. As part of this study, a dietary survey was completed for members of the Chippewas of Nawash First Nation. The study concluded that there is no health risk from radioactive chemicals due to eating fish [380].

6.11.5 Socio-economic Determinants

Poor dietary practices, lack of physical activity, smoking and frequent alcohol consumption are behaviours known to be detrimental to overall health. Table 6.11.5-1 summarizes the health behaviour statistics for local residents for the Grey Bruce Health Unit (HU) for 2008 and 2009 and Aboriginal communities in Ontario in 2000/2001 and 2003.

The income, education, healthcare and social services, and employment are also considered to form socio-economic determinants and are discussed in Section C2.4 of Appendix C.

6.11.6 Cultural Determinants

Cultural determinants are relevant the overall health and well-being of local residents, members of the Aboriginal communities and seasonal users. The cultural and heritage resources of importance to Euro-Canadian and Aboriginal people are discussed in Sections 6.10.6.2 and 6.9.7, respectively.

6.11.7 Emotional Determinants

Characterization of the existing environment for human health regarding emotional determinants can be found in Section 6.10.8. In addition, well-being is discussed in the context of overall health in Section 6.11.4.4.

6.11.8 Overall Health

The discussion of general well-being and human health incorporates health indicators consistent with those established by the CIHI for the Health Indicator Framework. For the purpose of describing health and well-being, the following measures are used:

- well-being;
- health conditions;
- human function;
- life expectancy; and
- cancer incidence.

Table 6.11.5-1: Health Behaviour Statistics

	Ontario		Grey Bruce HU		Difference[a]	Ontario Aboriginal Population	
	2008	2009	2008	2009		2000/2001	2003
Dietary Practices (5 or more servings daily of fruits/vegetables) (%)	40.5	44.1	43.6	43.5	↔	36	36.4
Leisure-time physical activity Active or moderately active (%)	49.5	50.7	55.3	52.6	↔	48.9	52.5
Smoke daily or occasionally (age 12+ years) (%)	19.8	18.6	18.8	18.1	↔	55.3	39.5
Heavy drinking (%)	15.5	15.6	21.2	18.4	↑	n/a	n/a
Heavy drinking – (5 or more drinks on one occasion, less than 12 times a year) (%)	n/a	n/a	n/a	n/a	n/a	28.7	33.4
Heavy drinking – (5 or more drinks on one occasion, 12 or more times a year) (%)	n/a	n/a	n/a	n/a	n/a	30.6	22.1

Notes:
a Difference is indicated using symbols as follows: ↑ statistically significant increase, ↓ statistically significant decrease, ↔ change not statistically significant, does not compare Aboriginal population results.
n/a Data not available
Source: [375;381]

6.11.8.1 Well-being

Table 6.11.8-1 provides a summary of the indicators chosen to reflect the self-rated health and well-being of individuals in the community. There was no statistical difference (p>0.05) between the Grey Bruce HU and the Ontario population. In general, the Ontario Aboriginal population had a lower percentage of individuals who perceived their health as very good or excellent when compared to individuals in the Grey Bruce HU on the non-Aboriginal Ontario population.

Table 6.11.8-1: Well-being

	Ontario		Grey Bruce HU		Statistical Difference[a]	Ontario Aboriginal Population	
	2008	2009	2008	2009		2000/ 2001	2003
Perceived health, very good or excellent(%)	59.3	61.2	61.8	61.7	↔	48.7	43.8
Perceived mental health, very good or excellent(%)	74.7	74	72.2	74.4	↔	n/a	n/a

Notes:
a The difference between Ontario and Grey Bruce HU is indicated using symbols as follows: ↑ statistically significant increase, ↓ statistically significant decrease, ↔ change not statistically significant; does not compare Aboriginal population results
n/a Data not available
Source: [375;381]

6.11.8.2 Health Conditions

Health conditions can be indicated by body mass index (BMI), occurrence of diabetes, asthma, high blood pressure, arthritis/rheumatism and injury hospitalization. The BMI is a method of classifying body weight according to health risk. Occurrence of diseases and conditions give an overview of the general health of the community. The injury hospitalization indicator contributes to an understanding of the adequacy and effectiveness of injury prevention efforts, including public education, product development and use, community and road design, and prevention and treatment resources. The Statistics Canada data for the Southwest LHIN for 2008 and 2009 is presented in Table 6.11.8-2.

Table 6.11.8-2: Health Conditions

	Ontario		Grey Bruce HU		Statistical Difference[a]	Ontario Aboriginal Population	
	2008	2009	2008	2009		2000/ 2001	2003
Overweight - males 18 years and over (%)	40.8	40.1	44.1	34.4	↔	37.2	47.5

Table 6.11.8-2: Health Conditions (continued)

	Ontario		Grey Bruce HU		Statistical Difference[a]	Ontario Aboriginal Population	
	2008	2009	2008	2009		2000/ 2001	2003
Obese - males 18 years and over (%)	18.5	18.6	23.2	26.9	↔	22.1	25.8
Overweight - females 18 years and over (%)	28.2	27.8	34.7	31.7	↔	26.9	37
Obese - females 18 years and over (%)	15.6	16.3	24.1	20.5	↑	30.8	27
Arthritis (%)	16.9	16.8	25.3	21	↑	21.6	23.2
Diabetes (%)	6.2	6.4	5.3	9.2	↔	7.1	5.4
Asthma - males 12 years and over (%)	7.2	6.8	7.9	8.8	↔	11.6	13.4
Asthma - females 12 years and over (%)	9.4	9.6	11	8.1	↔	20.5	21
High blood pressure (%)	16.6	17.2	20.7	19	↑	11	13.2
Injury hospitalization (age-standardized rate/100,000)[b]	431	420	611	697	↑	n/a	n/a

Notes:
a The difference between Ontario and Grey Bruce HU is indicated using symbols as follows: ↑ statistically significant increase, ↓ statistically significant decrease, ↔ change not statistically significant, does not compare Aboriginal population results
b Years 2007 and 2008
n/a Data not available
Source: [375;377;381]

6.11.8.3 Human Function

Human function (Table 6.11.8-3) can be characterized through participation and activity limitation, and disability-free expectancy. Disability-free life expectancy is a more comprehensive indicator than that of life expectancy because it introduces the concept of quality of life. It is used to distinguish between years of life free from any activity limitation and years experienced with at least one activity limitation. The emphasis is not exclusively on the length of life, as is the case for life expectancy, but also on the quality of life.

Table 6.11.8-3: Human Function

	Ontario		Grey Bruce HU		Statistical Difference[a]	Ontario Aboriginal Population	
	2007	2008	2007	2008		2000/ 2001	2003
Participation and activity limitation (%)	33.2	29.6	37	28.5	↔	44.1	46
Disability-free life expectancy (years) (1996)[b]	68	n/a	67.2	n/a	↔	n/a	n/a

Notes:
a The difference between Ontario and Grey Bruce HU is indicated using symbols as follows: ↑statistically significant increase, ↓ statistically significant decrease, ↔ change not statistically significant, does not compare Aboriginal population results
b Based on the 1996 Census
n/a – Data not available
Source: [375;382;381]

There was no statistical difference (ρ>0.05) between the Grey Bruce HU and the Ontario population. In general, the Ontario Aboriginal population had a higher percentage of individuals who had participation and activity limitation when compared to individuals in the Grey Bruce HU and in Ontario.

6.11.8.4 Life Expectancy

Health status through deaths can be indicated through infant mortality rates and life expectancy. Infant mortality is a long-established measure, not only of child health, but also of societal well-being (see Table 6.11.8-4). It reflects the level of mortality, health status and health care of a population and the effectiveness of preventative care and the attention paid to maternal and child health. Life expectancy measures the quantity of life rather than the quality of life. The Statistics Canada survey did not have information regarding Ontario Aboriginal population infant mortality rates or life expectancy. Therefore, no comparisons to the Ontario non-Aboriginal populations could be made.

Table 6.11.8-4: Life Expectancy

	Ontario		Grey Bruce HU		Statistical Difference[a]
	1997	2001	1997	2001	
Infant mortality (rate per 1,000 total births)	5.3[b]	5.1[c]	6.8[b]	5.3[c]	↔
Life expectancy – males (years)	76.2	77.4	75.6	76.2	↓
Life expectancy – female (years)	81.4	82	81.2	81	↓

Notes:
a The difference between Ontario and Grey Bruce HU is indicated using symbols as follows: ↑ statistically significant increase, ↓ statistically significant decrease, ↔ change not statistically significant
b The infant mortality data is not based on data from 1997 and 2001. It is based on a three year average of data from 2000 to 2002
c The infant mortality data is not based on data from 1997 and 2001. It is based on a three year average of data from 2005 to 2007
Source: [383;384;381]

There was no statistical difference ($\rho>0.05$) between the Grey Bruce HU and the Ontario infant mortality rates. The infant mortality rates are the three year average from 2000 to 2002 and 2005 to 2007 [383;384;381]. The life expectancy for individuals in the Grey Bruce HU was significantly lower ($\rho<0.05$) than those in Ontario.

6.11.8.5 Cancer Incidence

Cancer incidence rates can be an indicator of overall health in a community, as cancers are associated with lifestyle and environmental exposures as well as hereditary factors. Given the radiological nature of the DGR Project and the association of certain cancers with radiological exposures, existing cancer incidence statistics warrant consideration in this assessment.

Non – Aboriginal Population

Cancer incidence rates specific to the Regional Study Area or Grey Bruce HU were not available. However, data was available for Ontario and the South West LHIN (see Appendix C) and have been presented below in Table 6.11.8-5.

Table 6.11.8-5: Cancer Incidence Rates in the General Population

	Ontario			South West LHIN			Grey Bruce PHU		
	2001	2002	2003	2001	2002	2003	2001	2002	2003
All invasive primary cancer sites (including in situ bladder), both sexes	398	393	391.5	419.7	415.2	409.7	403.6	395.5	385.6
Colon, rectum and rectosigmoid junction cancer, both sexes	50.9	49.2	48.3	55.6	53.6	51.8	52.7	50.0	50.0

Table 6.11.8-5: Cancer Incidence Rates in the General Population (continued)

	Ontario			South West LHIN			Grey Bruce PHU		
	2001	2002	2003	2001	2002	2003	2001	2002	2003
Bronchus and lung cancer, both sexes	52.7	50.4	48.9	53	50.6	49	49.9	48.8	46.0
Female breast cancer, females	100.5	99.1	98.6	102.2	103	102.4	94.2	96.1	—
Prostate cancer, males	134.2	131.2	128.4	149.3	148.3	141.8	158.3	150.9	—

Notes:
Rates are based on a three-year average. The 2001 and 2002 data are based on the July 2005 Canadian Cancer Registry (CCR) file, whereas the 2003 data are based on the June 2007 CCR file.
Data presented as age-standardized rate per 100,000 population.
Source: [375;376]

The statistical significance of the differences between the South West LHIN and Ontario was not available. In general, cancer incidence rates are higher in the South West LHIN compared to the province as a whole. With the exception of prostate cancer, cancer incidence rates in the South West LHIN and Grey Bruce are within 10% of than Ontario incidence rates for the same type of cancer. As such, the South West LHIN and Grey Bruce PHU cancer incidence rates are considered to be comparable to Ontario rates due to many confounding factors that require consideration including lifestyle (smoking, alcohol consumption, obesity, etc.), genetic predisposition, access to medical care, and education. Also, while incidence rates appear to fluctuate, there are no apparent increasing trends for all types of cancers including prostate cancers.

Aboriginal Population

Cancer incidence rates for First Nations and the statistical significance of differences between these rates and those of Ontario in general are presented below in Table 6.11.8-6 [378]. In general, cancer incidence rates are lower in First Nations communities compared to the general population; however, rates are reportedly increasing as a result of rapid rises in colorectal and lung cancers.

Table 6.11.8-6: Cancer Incidence Rates in First Nations in Canada

Cancer	Ontario	First Nations	Statistical Difference[a]
Males			
Colorectum cancer	55	65	↔
Prostate cancer	119	61	↓
Lung cancer	63	57	↔
Kidney cancer	15	20	↔
Lymphoma	22	15	↔

Table 6.11.8-6: Cancer Incidence Rates in First Nations in Canada (continued)

Cancer	Ontario	First Nations	Statistical Difference[a]
Females			
Breast cancer	114	65	↓
Lung cancer	41	36	↔
Colorectum	37	35	↔
Lymphoma	19	10	↔
Cervical cancer	9	11	↔

Notes:
a The differences between Ontario and First Nations statistics are indicated using symbols as follows: ↑ statistically significant increase, ↓ statistically significant decrease, ↔ change not statistically significant
Age-standardized rate/100,000 based on the 1991 Canadian population ages 15-74.
Based on data from 1997-2001
Source: [378]

6.11.8.6 Overall Health of Seasonal User

A seasonal user may reside in the Regional or Local Study Area for only part of the year. Thus, his or her overall health would also be dependent of the physical, socio-economic, cultural and emotional factors of the other community in which they spend the remainder of the year. For the purpose of this assessment, it is assumed that the existing overall health of the seasonal user is consistent with that of the local resident.

6.11.8.7 Health of Workers

The DGR Project workforce will comprise local residents living in Bruce, Grey, Huron and Perth Counties and members of Aboriginal communities. The reported health statistics presented in sections above would be representative of the workers at the DGR Project site.

Rates of injury or illness related to workplace exposures or accidents are also relevant to the health of workers. Table 6.11.8-7 shows the number of type of injuries at the WWMF by year.

Table 6.11.8-7: Incidents at WWMF by Number of Injuries and the Type of Injury

	2003	2004	2005	2006	2007	2008	2009	2010 Q2	Total
First Aid	4	5	6	5	3	3	10	3	39
Lost Time Injury	—	—	—	1	—	—	1	0	2
Medical Treatment	2	2	4	1	—	2	6	0	17
No Attention	1	1	4	7	11	18	7	1	50
No Injury	12	8	10	9	9	18	8	4	78
Total	19	16	24	23	23	41	32	8	186

Note:
— Data not available.

Activities during the site preparation and construction phase of the DGR Project are can be represented by those common in the mining sector. The lost time injury or illness claims for the mining sector for the years from 2000 to 2009 are presented in Section C2.8 of Appendix C to the EIS.

6.12 SUMMARY OF EXISTING ENVIRONMENT

Table 6.12-1 provides a summary of the existing environment by VEC.

Table 6.12-1: Summary of Existing Environment

VEC	Existing Environment
Geology	
Soil Quality	• Several areas of metals and TPH contamination in the vicinity of the Project Area (former BHWP).
Overburden Groundwater Quality	• TPH in a localized area of the former BHWP, largely downgradient of the Project Area. • Localized free product (PHCs) in the former FTF, upgradient of the Project Area. • Shallow groundwater in the WWMF is hard, mineralized calcium and magnesium bicarbonate dominated water with varying amounts of sulphate as the major ion chemistry.
Overburden Groundwater Transport	• Groundwater flow from the Project Area is towards Lake Huron. • Strong downward gradients within the Project Area, especially where the Middle Sand Aquifer is present.

Table 6.12-1: Summary of Existing Environment (continued)

VEC	Existing Environment
Shallow Bedrock Groundwater Quality	• Groundwater quality ranges from fresh at the top of bedrock to brackish (Ca-SO_4) at the base of the shallow system. Groundwater TDS values range between 0.5 and 5.0 g/L within the shallow system. • Stable H and O isotopic compositions are representative of meteoric water(s) and cold-climate water(s) from near surface to the base of the shallow system. The isotopic signatures indicate that the shallow groundwater system is open to infiltration of meteoric and cold-climate waters.
Shallow Bedrock Groundwater and Solute Transport	• Vertical hydraulic gradients in the shallow bedrock are typically low, with flow gradients directed upward and laterally to the northwest toward Lake Huron. • Average hydraulic conductivities in the upper 100 m range from 2×10^{-6} to 8×10^{-8} m/s, generally decreasing with depth. The highest K_H values are measured in the more permeable sections of the upper Bass Islands Formation, where values approximate 10^{-4} m/s in the interval between 125 and 145 mBGS. Below 145 mBGS, K_H values decrease to an average of 10^{-6} m/s. • Advection is the dominant solute transport mechanism within the shallow system.
Intermediate Bedrock Water Quality	• Groundwater chemistries are transitional in the intermediate system between brackish (Ca-SO_4; TDS of 10 g/L) in the Salina G Unit to saline brine within, and below, the Guelph Formation (Na-Cl; TDS of ≥250 g/L). • A significant decrease in salinity is noted within the Salina A1 Unit carbonate aquifer (TDS of 30 g/L), which represents the maximum depth of glacial melt water infiltration at the Bruce nuclear site. • Below the Salina G Unit, Cl and Br concentrations increase with depth and then rebound to very low concentrations within the Salina A1 Unit carbonate aquifer. Below the A1 Unit carbonate aquifer, Cl concentrations increase sharply toward the Guelph Formation and remain relatively constant with depth to the base of the Manitoulin Formation. Br concentrations also increase sharply below the Salina A1 Unit carbonate aquifer, reaching maximum concentrations within the Manitoulin Formation at the base of the intermediate system.

Table 6.12-1: Summary of Existing Environment (continued)

VEC	Existing Environment
Intermediate Bedrock Solute Transport	• Hydraulic properties of the Ordovician sediments indicate that fluid flow is diffusion-dominated. • Diffusion coefficients parallel to bedding are larger than normal to bedding by factors of 1.7 to 3, which is suggestive of a significant barrier to cross-formational flow. • Hydraulic properties of the intermediate system suggest that solute transport is a combination of both advective and diffusive transport mechanisms. K_H values are generally quite low (10^{-14} to 10^{-10} m/s), with the exception of a few high-permeability units (Salina A1 Unit carbonate aquifer and Guelph Formation) where K_H values are 2×10^{-7} and 3×10^{-8} m/s, respectively. • In the interval between the Salina A1 Unit carbonate aquifer and the Guelph Formation, a vertical distance of approximately 50 m, rock permeabilities are interpreted to be extremely low due to the presence of high salinity gradients in the groundwaters and porewaters of the respective rock units (TDS of 30 g/L in the Salina A1 Unit; TDS of 375 g/L in the Guelph Formation); solute transport within this interval is asserted to be dominated by diffusion.
Deep Bedrock Water Quality	• Porewaters and groundwaters occurring at all depths below the top of the Queenston Formation (447.65 – 860.7 mBGS) are high-TDS (>150 g/L), saline brines. • The Cl and Br compositions of the brines are consistent with an evaporated seawater origin. • There is no evidence for infiltration of glacial melt water or recent meteoric water(s) into the Ordovician and Cambrian formations below the Bruce nuclear site. • Redox conditions in the Ordovician and Cambrian formations are strongly reducing, in the range of iron- or sulphate-reduction (Queenston Formation) or possibly methanogenesis (Georgian Bay Formation and below). Eh values within the Ordovician fluids are estimated to be approximately -150 mV.
Deep Bedrock Solute Transport	• Hydraulic properties of the Ordovician sediments indicate that solute transport is diffusion dominated. K_H values range between 10^{-11} and 10^{-15} m/s, with the lowest values measured in the interval between the top of the Georgian Bay and the bottom of the Kirkfield formations, and De values in the deep system range from 10^{-11} to 10^{-13} m^2/s. • The enriched $\delta^{18}O$ values within the Ordovician porewaters are indicative of long residence times within the formations (i.e., long time frames for water-rock interaction), further supporting the assertion the solute transport is diffusion dominated. • Based on the low permeabilities of the deep sedimentary formations, and on the anisotropy of the De values (average horizontal:vertical De anisotropy of 2:1), vertical hydraulic conductivities (K_V) are assumed to be an order of magnitude, or more, lower than K_H; these properties of the Ordovician sediments indicate that vertical solute transport is very slow. Within the Cobourg limestone, there appears to be a barrier to vertical solute migration, as evidenced by the isotopic compositions of methane (CH_4) and helium (He).

Table 6.12-1: Summary of Existing Environment (continued)

VEC	Existing Environment
Hydrology and Surface Water Quality	
Surface Water Quantity and Flow	• The North Railway Ditch (Project Area) at Stream C has a drainage area of 26.1 ha. The South Railway Ditch at Stream C has a drainage area of 43.4 ha. The North and South Railway Ditches generally have little flow and are dominated by emergent vegetation such as cattails. • Stream C (Site Study Area) is a perennial stream and has a drainage area of 1,042.4 ha. Outside of the Bruce nuclear site, it is generally an agricultural watershed. Areas within the Bruce nuclear site drain into Stream C via constructed drainage ditches. • The drainage ditch to MacPherson Bay (Site Study Area) has a catchment area of 41.3 ha. Drainage is via constructed ditches that generally only have measurable flows during storm events.

Surface Water Quality	• Total suspended solids concentrations ranged from <10 mg/L to over 750 mg/L during storm events (Site Study Area and Project Area).
	• Metal concentrations were generally below the relevant PWQOs in the Site Study Area:
	  • Total copper (PWQO of 5 µg/L) ranged between <1 and 2 µg/L in both Stream C and the South Railway Ditch;
	  • Total iron (PWQO of 300 µg/L) ranged between 58 and 680 µg/L in Stream C and <50 and 790 µg/L in the South Railway Ditch; and
	  • Total zinc (PWQO of 20 µg/L) ranged between <5 and 11 µg/L in Stream C and 6 and 72 µg/L in the South Railway Ditch.
	  • Total phosphorous concentrations in the South Railway Ditch (Project Area) ranged from 20 to 100 µg/L which exceed the PWQO for phosphorous (20 µg/L to avoid growth of nuisance plants).
	• Total aluminum ranged between 25 and 330 µg/L in Stream C (Site Study Area) and 13 and 150 µg/L in the South Railway Ditch (Project Area). Surface water samples were not filtered; therefore, the results cannot be compared to the PWQO of 75 µg/L, which applies to clay free samples only.
	• Water temperatures correlated reasonable well with the average daily air temperature in the Site Study Area and Project Area.

Terrestrial Environment	
Eastern White Cedar	• The eastern white cedar is the most common species in conifer communities in the Site Study Area and Project Area. This species provides winter cover habitat for both white-tailed deer and wild turkey in the Site Study Area and Project Area. • Second-growth upland coniferous and mixed forest communities in the Local Study Area, including much of the Bruce nuclear site, are dominated by eastern white cedar. • This is a common and abundant species within the Regional Study Area, being the most widely distributed coniferous tree species in this area.
Heal-all	• Heal-all is a typical groundcover species found in the mixed forest and open habitat communities within the Project, Site, Local and Regional Study Areas.

Table 6.12-1: Summary of Existing Environment (continued)

VEC	Existing Environment
Common Cattail	• Cattail samples were collected within the North and South Railway Ditch in the Project Area in June 2004 and analyzed for metals. Elevated metal results are likely historic and not attributed to recent undertakings in vicinity of the WWMF. • Found throughout the Project Study Areas in wetland communities and along wetted ditches. • Cattail is an important food source and shelter material for muskrat within the Site and Local Study Areas. • Common wetland plant located in shallow marsh communities throughout the Regional Study Area.
Northern Short-tailed Shrew	• Northern short-tailed shrew is a common and abundant species within the Site Study Area, found in grassland communities and forests. This species provides an important food source for species of raptors and small to medium sized predators. • This burrowing species feeds mainly on insects and snails.
Muskrat	• In May 2007, active muskrat houses were observed at one of two study plots within the Project Area. • Muskrats inhibit marsh communities, and are observed utilizing ditches and wetland features in the Project and Site Study Areas that support dense stands of cattail species. • One of many furbearing mammal species potentially hunted and trapped in the Regional Study Area.
White-tailed Deer	• White-tailed deer are known to overwinter in the coniferous forest of the Huron Fringe Deer Yard, and are commonly found in the Local Study Area, as well as throughout the Site Study Area. • Population using the Site Study Area is estimated at greater than 100 animals. • White-tailed deer is a common species throughout the Bruce Peninsula, and draws hunters to the Regional Study Area.
Red-eyed Vireo	• Red-eyed vireo was identified in two of the four habitat types observed in the Project Area and is found throughout forested habitat in the Local and Regional Study Areas. • It is one of the commonly observed species with evidence of breeding in the Site Study Area. • Red-eyed vireo is found in the forested habitat in the Local and Regional Study Areas.
Wild Turkey	• Wild turkey has been observed in the Project Area; however, no roosts were identified within the Project Area. • At least two distinct flocks of 20 to 30 birds occur on the Bruce nuclear site. Disturbed areas within the Site Study Area create suitable feeding/breeding ground for wild turkeys. • Wild turkey is a popular game bird that occurs year-round throughout the various habitats in the Regional, Local and Site Study Areas.

Table 6.12-1: Summary of Existing Environment (continued)

VEC	Existing Environment
Yellow Warbler	• Yellow warbler habitat is found within the Project and Site Study Areas, and this species has been documented during site specific studies in both of these areas. • Yellow warbler is found within shrub fen, thicket swamp and wetland edge habitat in the Local Study Area. • Yellow warbler has been documented in the Atlas of the Breeding Birds of Ontario [385] in all but one of the atlas squares.
Mallard	• Potential habitat for this species exists in the Project and Site Study Areas in wetland communities with open water habitat. • One of the species observed in ponded habitats in the Local Study Area, and offshore of the Bruce nuclear site. • Common and abundant species found in all of the land based Atlas of the Breeding Birds of Ontario [385] atlas squares within the Regional Study Area.
Bald Eagle	• This species has not been documented within the Project Area. • Bald eagle has been recorded foraging near the condenser cooling water discharges of Bruce Power A and B in the Site Study Area. • Bald eagle is identified as a species at risk that is resident in the Regional and Local Study Areas. It is listed as Special Concern by the OMNR, and has been observed in Baie du Doré.
Midland Painted Turtle	• A basking turtle survey completed in 2009 indicated that approximately 30 individual turtles use the Project and Site Study Areas as habitat. • Midland painted turtle uses shallow marshes, mixed swamp, ponded areas, and the Lake Huron shoreline in the Local Study Area. • This species is common and abundant in the Regional Study Area in suitable habitat.
Northern Leopard Frog	• Northern leopard frog breeding adults and egg masses have been recorded in the Project Area. • Northern leopard frog is a common and abundant species which utilizes the cultural meadow communities located within the Site Study Area, and is widely distributed in the Local Study Area. • Northern leopard frog is common and abundant within the Regional Study Area in shallow marshes, open water and meadow/grassland communities.
Aquatic Environment	
Redbelly Dace	• Inhabits the South Railway Ditch (Project Area). • Warmwater species common in wetland conditions, and tolerant of a wide range of environmental conditions.
Creek Chub	• Inhabits the South Railway Ditch and Stream C (Project Area and Site Study Area). • Warmwater species common in wetland conditions, and tolerant of a wide range of environmental conditions.

Table 6.12-1: Summary of Existing Environment (continued)

VEC	Existing Environment
Brook Trout	• Inhabits Stream C; spawning behaviour in Stream C observed (Site Study Area). • Coldwater fish species intolerant of turbidity.
Variable-leaf Pondweed	• Grows in the South Railway Ditch (Project Area) in the open areas that are regularly dredged for drainage purposes.
Burrowing Crayfish	• In the Project Area, burrowing crayfish are found along the north and South Railway Ditch and within the marsh. • Inhabits areas within the Regional, Local and Site Study Areas where substrate is appropriate.
Lake Whitefish	• Benthic-oriented species which spends most of the spring, summer and fall offshore in deeper, cooler water beyond the influence of the Bruce nuclear site (Site Study Area). • Spawn at sites with cobble, boulder and gravel substrates at depths greater than 2 m, outside the shallow inshore littoral zone (Local Study Area).
Spottail Shiner	• Forage fish species that inhabits Baie du Doré, MacPherson Bay and Stream C. • Warmwater species that inhabits the nearshore of Lake Huron.
Smallmouth Bass	• Common in Baie du Doré; observed spawning in this area (Local Study Area). • Warmwater species that prefer a temperature of 20°C and inhabit shallow, nearshore areas of Lake Huron (Regional and Local Study Areas). • They spawn in the spring/early summer in bays and other protected areas where water temperatures reach at least 12°C.
Benthic Invertebrates	• High density and diversity of benthic invertebrates occurs in Baie du Doré, which offers protection from waves and currents, while lower density and diversity occurs along the exposed shoreline in MacPherson Bay. • Benthic invertebrates in Stream C, South Railway Ditch and other aquatic habitats also provide valuable food source for other aquatic and terrestrial species.
Radiation and Radioactivity	
Humans	• The highest dose among nine potentially critical groups of public studied was adult in Group BF14 located to the southeast of the Bruce nuclear site, with dose during 2009 being 4.41 μSv/a. • For NEWs at the WWMF, the collective annual whole body doses and the maximum individual whole body dose were 6.5 person-mSv, and 2.8 mSv, respectively. • For non-NEWs, the current doses do not exceed 100 μSv/a, which represents 10% of the annual dose limit to general public.

Table 6.12-1: Summary of Existing Environment (continued)

VEC	Existing Environment
Benthic Invertebrates	• The major portion of the activity in the sediments is attributable to naturally occurring potassium-40. • The concentrations of cesium-137 ranged from 0.21 to 0.23 Bq/kg in the sediments in the Regional Study Area and from 0.19 to 8.90 Bq/kg in the Local Study Area. • Cobalt-60 in sediments ranged from 0.20 to 0.85 Bq/kg in the Local Study Area and samples were all below the detection limits for the Regional Study Area.
Aquatic Vegetation	• Modelled existing doses are well below established benchmarks
Benthic Fish Pelagic Fish	• Potassium-40 levels ranged from 125 to 146 Bq/kg. • Carbon-14 levels ranged from 225 to 270 Bq/kg-C. • Cesium-137 concentration ranged from 0.18 to 0.43 Bq/kg, comparable to background levels. • Tritium levels ranged from 7.6 to 30.5 Bq/L (water). • The OBT in whitefish and sucker were 9.6 and 10.5 Bq/L, respectively • Cesium-134 and cobalt-60 were not detected in any fish samples in the Local Study Area.
Aquatic Birds	• Modelled existing doses are well below established benchmarks.
Aquatic Mammals	• Modelled existing doses are well below established benchmarks.
Terrestrial Invertebrates	• Modelled existing doses are well below established benchmarks.
Terrestrial Vegetation	• Tritium ranged from 18.1 Bq/L to 123.8 Bq/L in soy beans. • The concentrations of carbon-14 in grains were in the range of 205 to 240 Bq/kg-C. • For apples, tritium ranged from 41.1 to 214.4 Bq/L and carbon-14 ranged from 238 to 283 Bq/kg-C in listed monitoring locations. • Tritium and carbon-14 concentrations in vegetation decreased with distance from the Bruce nuclear site, and also vary with direction.
Terrestrial Birds	• Modelled existing doses are well below established benchmarks.
Terrestrial Mammals	• Modelled existing doses are well below established benchmarks.
Amphibians and Reptiles	• Modelled existing doses are well below established benchmarks.

Table 6.12-1: Summary of Existing Environment (continued)

VEC	Existing Environment
Atmospheric Environment	
Air Quality	• Air quality in the Regional Study Area and indicated that air quality across the region does not vary dramatically from one station to the next. Although, air quality at the regional stations occasionally exceed the relevant Ontario criteria, these situations are not common. • Overall, the background air quality in the Local Study Area complies with the relevant criteria. • The existing air quality (i.e., background and modelled sources from the Bruce nuclear site) in the Local Study Area complies with relevant criteria.
Noise Levels	• Noise levels in the Local Study Area are consistent with typical rural environments. Noise from the operations at the Bruce nuclear site were audible at receptors R2 and R3.
Aboriginal Interests	
Aboriginal Communities	• Saugeen First Nation has an on-reserve population of 760 members, up 12% from the Census 2001 population of 677. • Twenty five percent of the Saugeen working population is employed in sales and service occupations; 23% in trades or in the transport and equipment operator occupations; and 14% in social science, education, government service, or religious occupations. • Nawash has an on-reserve population of 591 members, up slightly from the Census population of 587 in 2001. • 16% of the Nawash workforce is employed in health care and social services, 14% in business services, 12% in agriculture and other resource-based industries, 8% in construction, 7% in education, 5% in retail, and the remaining 38% in other services.
Aboriginal Heritage Resources	• There are three identified culturally sensitive areas in relation to Aboriginal heritage resources within the boundary of the Site Study Area; these areas are associated with ancient shorelines. • Upper Mackenzie and Dickie Lake are registered archaeological sites located in CSA A on the Bruce nuclear site but outside the OPG-retained lands where the DGR Project is planned.
Traditional Use of Land and Resources	• There are four commercial fishing tugs in operation on Saugeen First Nation, which employ approximately 12 people. • Between 50 and 60 members of the Chippewas of Nawash Unceded First Nation are employed in fishing and related activities. • The MNR has estimated that the total dollar value of eight major species of fish caught in Area 4-4 to commercial fishing (Aboriginal and non-Aboriginal) was $646,706 in 2008, with $615,318 from lake whitefish. • SON has access to the Fishing Islands reserve and the hunting grounds on the Bruce Peninsula (see Figure 6.9.2-1).

Table 6.12-1: Summary of Existing Environment (continued)

VEC	Existing Environment
Socio-economic Environment	
Human Assets	• The combined study area population declined by 4.9% from 1996 to 2001 but recovered in recent years with an average increase across municipalities of 1.5% from 2001 to 2006. • The age profile of the Municipality of Kincardine population is similar to the age profile of the population in the combined Local and Regional Study Areas, with the largest proportions in the 25-44, 45-54 and 65+ year categories. • The study area population is served by a broad range of health care, fire, police, emergency, social services; however the challenges in meeting the healthcare requirements in these communities emerged as a significant issue. • School boards in the Local and Regional Study Areas report available capacity to accommodate anticipated growth.
Financial Assets	• The economic base of Kincardine is largely dependent on agriculture and tourism and the nuclear industry plays a large role; Bruce Power is the largest single employer in the municipality. • The Municipality of Kincardine accounts for 40.5% of all Bruce Power employees and Saugeen Shores for 35.5%. • Although the number of properties sold was variable year over year, average housing prices were constantly increasing from 2001 to 2008, with a slight downturn in 2009 based on first 8 months data. • Average property values increased over the period 2001 to 2009 by 95% in the Municipality of Kincardine and by 101% in Saugeen Shores.
Physical Assets	• Overall, residents of the Regional and Local Study Area are served by a broad range of municipal infrastructure and services, and study area municipalities have experienced growth in their housing stock from 2001 to 2006. • Municipalities have sufficient capacity in their water, sewage, and waste management systems to meet future demands. • Analysis of transportation infrastructure in the vicinity of the Bruce nuclear site in 2007 indicated some requirements for improvements to meet operating standards.
Social Assets	• Inverhuron Provincial Park is located within the Local Study Area. • Visitation to Inverhuron Provincial Park averages at approximately 48,700 visitors annually. • There are a wide range of other community and recreational facilities throughout the Local and Regional Study Area, including community centres, sports complexes/arenas, parks and conservation areas and museums. • Residents in Kincardine and neighbouring municipalities either regularly or occasionally use the lands and waters in the vicinity of the Bruce nuclear site for birdwatching or nature viewing and the Provincial Parks and Conservation Areas are actively used by residents and tourists for camping and other outdoor activities.

Table 6.12-1: Summary of Existing Environment (continued)

VEC	Existing Environment
Natural Assets	• See the existing environment for geology, hydrology and surface water quality, terrestrial environment, aquatic environment and radiation and radioactivity.
Public Attitudes Toward Personal and Community Well-being	• Both Regional and Local Study Area residents provided high ratings of the feelings of personal health, sense of safety, overall community satisfaction; residents are satisfied living in their communities and are committed to living there. • The municipalities in the Local and Regional Study Areas can be characterized as having a healthy balance of community assets that contribute to their well-being.
Human Health	
Overall Health of Local Residents	• Predicted air concentrations of target compounds, resulting from existing sources at the Bruce nuclear site do not exceed selected ambient air screening standards, with the exception of acrolein. • The Grey Bruce HU reported higher percentages of overweight and obese individuals, individuals with arthritis, diabetes, males (>18 years of age) with asthma, high blood pressure and injury hospitalization than the Ontario average in 2009. • There is no difference in average infant mortality between the Ontario average and the Grey Bruce HU. • Life expectancy is slightly lower for individuals in the Grey Bruce HU than those in Ontario. • In general, cancer incidence rates are higher in the South West LHIN compared to the province as a whole.
Overall Health of Members of Aboriginal Communities	• Ontario Aboriginal population health statistics were presented, as available, but Statistics Canada does not provide comparison to the Ontario population. • In general, cancer incidence rates are lower in First Nations communities compared to the general population; however, rates are reportedly increasing as a result of rapid rises in colorectal and lung cancers.
Overall Health of Seasonal Users	• The existing overall health of the seasonal user is assumed to be consistent with that of the local resident.
Health of Workers	• Historical safety performance for the WWMF is expected to be representative for the DGR Project.

7. EFFECTS PREDICTION, MITIGATION MEASURES AND SIGNIFICANCE OF RESIDUAL EFFECTS

This section describes, predicts and assesses the likely effects of the DGR Project on the biophysical and social environment. Section 7.1 provides a summary of the methods used to complete the assessment. The subsequent sections then provide the full assessment for each discipline, starting with the identification of interactions, and proceeding to the determination of the significance of any residual adverse effects.

7.1 ASSESSMENT METHODS

The assessment characterizes and assesses the effects of the DGR Project in a thorough, traceable step-wise manner. The overall approach used in the assessment is illustrated in Figure 1.6.7-1. For the purpose of this EIS, the environment encompasses the following environmental components, which include all biophysical and social features likely to be affected by the DGR Project:

- Geology;
- Hydrology and Surface Water Quality;
- Terrestrial Environment;
- Aquatic Environment;
- Radiation and Radioactivity;
- Air Quality;
- Noise and Vibrations;
- Socio-economic Environment;
- Aboriginal Interests; and
- Human Health.

These are described in Sections 7.2 through 7.11. Each of these environmental components is represented by a number of Valued Ecosystem Components (VECs), which may be affected by the DGR Project (Section 5.3). The existing conditions for each of the environmental components are described in Section 6.

In addition, ecological multi-feature VECs are assessed in Section 7.12. These VECs comprise a number of individual VECs that are part of different environmental components. The assessment of ecological features considers combined effects resulting from the adverse effects on the individual VECs. The following ecological features are considered:

- Lake Huron;
- Stream C;
- Railway Ditches; and
- Wetland within the Project Area.

This section provides a summary of the predicted effects, identification of mitigation measures and determination of the significance of residual adverse effects. The assessment includes both direct and indirect effects of the DGR Project as a result of normal conditions for the site preparation, construction, operation and decommissioning of the DGR Project. Effects during the abandonment phase are described where there is a potential for long-term effects (i.e., geology); however, the effects that could occur during the long-term performance are discussed in Section 9.

The effects resulting from malfunctions, accidents and malevolent acts are collectively assessed in Section 8. This was done since a single initiating event could affect multiple aspects of the environment. It is important to note that the assessment of potential radiation and radioactivity effects of the project are documented collectively in Section 7.6, despite the physical media through which they are transported (e.g., air or water). This was done because of the special importance placed on radiation and radioactivity, and the combined effects to the receiving environment regardless of the path of exposure.

The approach used in the assessment includes the following broad steps:

- **Screen to Focus the Assessment.** Two screening steps, first for potential interactions and secondly for likely measurable change, allow the assessment to focus on where effects are likely to occur. These steps are completed using professional judgement; if there is uncertainty, the interaction is advanced for assessment.
- **Assess Effects.** Where there is likely to be a measurable change, the effects on the environment are predicted and assessed as to whether or not they are adverse. If adverse effects are predicted, mitigation measures to reduce or eliminate the effect are proposed. Once mitigation measures are proposed, the likely adverse effect is re-evaluated with the mitigation measures in place to identify whether any residual adverse effects remain. Residual adverse effects are then advanced for a determination of significance.
- **Determine Significance.** All residual adverse effects are then assessed to determine whether the effect is significant, or not, taking into account the magnitude, geographic extent, duration, frequency, irreversibility and social/ecological context of the effect.

A summary matrix for each environmental component is presented at the end of the assessment and identifies the results of the assessment. Small dots (•) on the summary matrix represent potential DGR Project-environment interactions involving VECs identified in the initial screening. These interactions were considered further to determine those interactions that may result in a likely measurable change to the VEC under consideration. Squares (■) represent DGR Project-environment interactions resulting in a measurable change in VECs. In some cases a benefit to a VEC may be identified. Plus signs (+) on the matrix represent a benefit to the environment resulting from the DGR Project (e.g., employment associated with the DGR Project). A residual adverse effect on a VEC is marked with a diamond (◆).

If residual adverse effects are identified in the assessment, they are assessed to determine if the residual adverse effect is significant. The criteria used for judging and describing the significance of effects are shown in Table 7.1-1. The criteria used to evaluate magnitude are specific to each of the VECs under consideration and are presented in the evaluation of significance section of each environmental component, where applicable.

Table 7.1-1: Effects Criteria and Levels for Determining Significance

Effect Criteria	Effects Level Definition		
Magnitude (of effect)	**Low**	**Medium**	**High**
	The effects level definitions for magnitude are provided in each environmental component section, where appropriate		
Geographic Extent (of effect)	**Low**	**Medium**	**High**
	Effect is within the Site Study Area	Effect extends into the Local Study Area	Effect extends into the Regional Study Area
Timing and Duration (of conditions causing effect)	**Low**	**Medium**	**High**
	Conditions causing effect are evident during the site preparation and construction phase, or the decommissioning phase	Conditions causing effect are evident during the operations phase	Conditions causing effect extends beyond any one phase
Frequency (of effect)	**Low**	**Medium**	**High**
	Conditions or phenomena causing the effect to occur infrequently (i.e., several times per year)	Conditions or phenomena causing the effect to occur at regular, although infrequent intervals (i.e., several times per month)	Conditions or phenomena causing the effect to occur at regular and frequent intervals (i.e., daily or continuously)
Degree of Irreversibility (of effect)	**Low**	**Medium**	**High**
	Effect is readily (i.e., immediately) reversible	Effect is reversible with time	Effect is not reversible (i.e., permanent)

Probability of occurrence was not explicitly included as a criterion for the assessment of significance of residual adverse effects. The assessment recognizes the widest, reasonable range of likely environmental effects without specific regard for their respective probability of occurrence. The focus is on evaluating the possible impact of such effects on the environment and VECs and the consideration of feasible mitigation measures that can be incorporated to control, reduce or eliminate the effect.

The screening and assessment steps described above follow a source-pathway-receptor approach. The DGR Project works and activities, described in Section 4, represent the source of a change, a measurable change to the environment represents a pathway and the VEC represents the receptor. In some cases, the VECs may act as both pathways and receptors.

Effects from the DGR Project may occur either directly or indirectly. A direct interaction occurs when the VEC is affected by a change resulting from a project work and activity (e.g., collisions with worker vehicles may affect individual white-tailed deer). An indirect interaction occurs when the VEC is affected by a change in another VEC (e.g., changes in air quality could affect the eastern white cedar).

The assessment is completed within the framework of the temporal and spatial boundaries described in Section 5. The assessment takes into account a precautionary approach (Section 1.6.6) and incorporates Aboriginal traditional knowledge (Section 1.6.4), where available. Summaries of how the assessment considered a precautionary approach and how Aboriginal traditional knowledge was incorporated are provided in Sections 7.15 and 7.16, respectively.

7.1.1 Effects of the Environment on the DGR Project

The EA must include a consideration of how the environment could adversely affect the DGR Project. Firstly, potential conditions in the environment that may affect the DGR Project are identified. For example, the EA evaluates how environmental hazards such as flooding are likely to affect the DGR Project. For each environmental condition that could potentially affect the DGR Project, the mitigation measures incorporated into the project design are identified and evaluated for effectiveness. Their likely effectiveness is evaluated based on past experience at the Bruce nuclear site and professional judgement of the study team. Residual adverse effects, if identified, are evaluated for significance using the method described in Section 7.1. This evaluation is based on the available data and the experience and judgement of the study team. The assessment of effects of the environment on the DGR Project is described in Section 7.13.

7.1.2 Climate Change Consideration

The EIS Guidelines (Appendix A) require a consideration of whether the DGR Project and EA conclusions are sensitive to changes in climatic conditions. For the purpose of this EIS, climate change is considered over the life of the DGR Project spanning the site preparation and construction, operations, and decommissioning phases only. Shifts in climate that occur from one epoch to the next (e.g., glaciation) have been considered as part of the Postclosure Safety Assessment [386] and are summarized in Section 9.

The requirement of the EIS Guidelines to consider climate change has been addressed by considering the following:

- How will the future environment affect the DGR Project?
- How will the DGR Project affect the future environment?
- How will the DGR Project affect climate change (e.g., contribution to climate change by the emission of greenhouse gases)?

Establishing how the climate may change over the life of the DGR Project is an initial requirement for addressing the first two considerations. A determination of how climate has been changing and how it might change over the DGR Project life is made based on historic climate data, scientifically accepted climate forecasts, literature review and the professional experience of the technical specialists conducting the EA. The climate data used to describe the future climate over the life of the DGR Project for the Regional Study Area are described in Appendix D of the Atmospheric Environment TSD. These predictions of future climate are used by all environmental disciplines for the assessment of the consequences of climatic conditions on both the assessment of the effects for the first two considerations.

The consideration of climate change is presented in Section 7.14. Assessment methods are also discussed further within Section 7.14.

7.2 GEOLOGY

Geology comprises nine VECs (introduced in Section 6.2) that are grouped by geological packages. The geologic packages and their corresponding VECs are summarized as follows:

- overburden – soil quality, groundwater quality and groundwater transport;
- shallow bedrock – groundwater quality, and groundwater and solute transport;
- intermediate bedrock – water quality and solute transport; and
- deep bedrock – water quality and solute transport.

The terms groundwater transport and solute transport are used to distinguish between those layers where transport is dominated by the bulk movement of groundwater and areas where transport is dominated by diffusion (i.e., the intermediate and deep bedrock).

The results of the geology assessment are summarized in Section 7.2.2.4. The existing environmental features are described in Section 6.2 and the Geology TSD. In addition to considering the first three phases of the DGR Project (i.e., site preparation and construction, operations, and decommissioning), the assessment of geology also considers the effects during the long-term performance phase, since the continued presence of the DGR may interact with the local geology. The long-term performance phase interactions are considered collectively for all of the geology VECs in Sections 7.2.1.4 and 7.2.2.3.

7.2.1 Screening to Focus the Assessment

7.2.1.1 Soil Quality

Direct Interactions and Measurable Changes

The following project works and activities are identified as having direct interactions with the soil quality VEC:

- site preparation – grading of soils on-site;
- decommissioning of the DGR Project – interaction with shaft sealing materials;
- waste management – specifically, the waste rock management activity, which includes the establishment and maintenance of the waste rock management area (WRMA); and
- support and monitoring of DGR life cycle – specifically, the operation of the stormwater management system.

Soils will be removed, graded and stockpiled during the site preparation work and activity. No non-native materials will be brought in during this phase. Therefore, it is unlikely that site grading activities will measurably change soil quality. This interaction is not considered further.

During decommissioning, materials such as sand, bentonite, concrete and asphalt will be emplaced into the subsurface during the sealing of the main and ventilation shafts. In the case of soil quality, the shaft sealing materials near surface (0 to 187 mBGS) will be engineered fill comprising native earthen/rock materials that is crushed and screened prior to placement [387]. The fill materials in the upper shaft seals are a mixture of the native soils and some crushed rock. Some of this rock may be elevated in chloride, sulphate and sodium. These parameters, however, will be largely in porewater trapped within the rock, and will not be readily released for ion exchange by groundwater migrating through the upper seal materials. In addition, the volume of material that will be emplaced in the shaft within the soil horizon (approximately 550 m^3 per shaft) is relatively small when compared to the volume of soil and bedrock down-gradient from the shafts (approximately 120,000 m^3). Accordingly, this project-environment interaction is not advanced to the assessment of likely environmental effects.

Precipitation, as it infiltrates through the waste rock piles, may take up minerals and carry them to the subsurface soil at the WRMA. Physicochemical processes can result in the adsorption of minerals onto soil particles. However, the native till soil also has a very low potential for infiltration (conservatively estimated at 5 to 10 cm/a); therefore, precipitation that percolates through the rock pile is more likely to flow from the base of the rock pile to the stormwater management system than it is to infiltrate to the subsurface. Leachate testing also indicated that certain formations represented in the waste rock itself could generate concentrations of some parameters above their respective PWQO; however, water infiltrating from the waste rock is a small percentage of an already limited infiltration potential [388]. Therefore, direct changes to the soil quality VEC as a result of waste management are not considered to be measurable, and are not considered further.

The perimeter drainage network and stormwater management pond will not be lined; therefore, it is likely that a component of stormwater runoff from the WRMA will infiltrate the subsurface soils, transporting some chemical parameters into the near-surface soils. The vast majority of precipitation that reaches the native soil in the drainage ditches or from sheet runoff towards the management pond will migrate along the till surface, as opposed to infiltrating into the till. Further, the surface area of the drainage ditch and stormwater pond that is available for potential infiltration is a small percentage of the area of the DGR Project site. Dilution by horizontally migrating groundwater will be on the order of 10 times the volume of vertically infiltrating groundwater. Therefore, the operation of the stormwater management system will not constitute a direct measurable change to the soil quality VEC. Accordingly, this project-environment interaction is not considered further.

The following works and activities are not expected to interact with soil quality as they do not result in any additional surficial soil alteration:

- excavation and construction of surface facilities;
- construction of surface facilities;
- above-ground transport of waste;
- underground transfer of waste;

- abandonment of the DGR facility; and
- workers, payroll and purchasing.

The potential effects of spills on soil quality are considered in the assessment of malfunctions, accidents and malevolent acts in Section 8.3.2.1. The presence of the DGR Project interaction will only occur in the abandonment and long-term management phase. Changes in the abandonment and long-term performance phase are collectively described in Section 7.2.1.4.

Indirect Interactions and Measurable Changes

Air Quality

An indirect interaction is identified between changes in air quality and the soil quality VEC. Changes in air quality (i.e., airborne dust and associated contaminants) are predicted in the Atmospheric Environment TSD. This dust deposits itself on the surface of the shallow soil and it will be subjected to wind dispersion and entrainment due to surface water runoff from precipitation. It is not expected that dust will persist on the surface long enough to impart measurable concentrations to the subsurface. This will be a temporary condition due to construction and operations. Therefore, there is no measurable indirect change to the soil quality VEC and this indirect interaction is not considered further.

Overburden Groundwater Quality

Changes in overburden groundwater quality were considered to have a potential interaction with the soil quality VEC during all phases of the DGR Project. No measurable changes in overburden groundwater quality are identified (see Section 7.2.1.2). Therefore, no measurable changes to soil quality from changes in overburden groundwater quality during site preparation and construction, operations, and decommissioning phases are likely. Changes in the abandonment and long-term performance phase are described in Section 7.2.1.4. Accordingly, this indirect interaction is not considered further.

7.2.1.2 Overburden, Shallow Bedrock, Intermediate Bedrock and Deep Bedrock Solute Transport

Direct Interactions and Measurable Changes

The following project works and activities are identified to have the potential to directly interact with the overburden groundwater, shallow bedrock groundwater and solute, intermediate bedrock solute and deep bedrock solute transport VECs:

- Site preparation – the installation/construction of impervious surfaces (roads, buildings, storage areas) can potentially reduce the area for groundwater recharge from precipitation (overburden groundwater transport VEC).
- Construction of surface facilities – the installation/construction of impervious surfaces (roads, buildings) may potentially reduce the area for groundwater recharge from precipitation and pumping during excavation of building foundations may affect the local

flow regime (overburden groundwater transport and shallow bedrock groundwater and solute transport VECs).

- Excavation and construction of underground facilities – dewatering would be used to provide safe and manageable conditions during underground excavation and construction. Dewatering of the shallow and intermediate systems could temporarily alter hydraulic gradients and groundwater flow conditions (overburden groundwater transport, shallow bedrock groundwater and solute transport, intermediate and deep bedrock solute transport VECs).
- Decommissioning of the DGR Project – shaft sealing materials could potentially create changes to the localized flow patterns in the vicinity of the shafts (overburden groundwater transport, shallow bedrock groundwater and solute transport, intermediate and deep bedrock solute transport VECs).
- Waste management – the presence of the waste rock piles could potentially alter the localized recharge characteristics within the Project Area (overburden groundwater transport VEC).
- Support and monitoring of DGR life cycle – some stormwater may infiltrate into the subsurface soils, locally altering the groundwater recharge regime (overburden groundwater transport VEC).

The installation/construction of impervious surfaces (roads, buildings, storage areas) during the site preparation and surface facility construction works and activities can potentially reduce the area for groundwater recharge because of precipitation. The decrease in the amount of area available for precipitation to infiltrate to groundwater can also affect the overburden groundwater flow regime.

For the construction laydown areas during site preparation, the sites will be cleared of brush, and graded, but will not be made impervious. The roads established during the site preparation activity will not be paved. Some impervious surfaces will be created by resting equipment, but much of this will runoff onto the ground during precipitation events.

During construction of surface facilities, the construction of buildings and paved roads will result in an additional 9% of impervious surface area on the DGR Project site.

It is considered that the potential reduction in recharge will not be measurable (i.e., negligible) in comparison to baseline conditions, and therefore there will be no change in the overburden groundwater flow regime because of site preparation or construction of surface facilities. Accordingly, the overburden transport VEC is not assessed further in relation to site preparation or construction of surface facilities.

Dewatering may be used to lower the water table in the vicinity of a given building footprint to allow for dry foundation emplacement during construction of surface facilities. Dewatering activities directly affect the groundwater flow regime through the lowering of the water table during pumping and creation of a zone of influence (ZOI) (i.e., a region of lowered water table). A conservative estimate for the potential depth of foundations is 4 m for the shaft buildings, which are the largest surface structures associated with the DGR Project.

The water table is expected to be near ground surface within the glacial tills underlying the Project Area. The soils are expected to be the relatively low permeability Unweathered Till. The amount of dewatering that will be required will be very low, and will be directed to the DGR Project drainage ditch network, where some of this water may re-infiltrate into the subsurface. The expected ZOI from this dewatering will be very localized, and will be of ephemeral duration (i.e., days to weeks). Although this zone of influence can theoretically be measured during dewatering (through water level monitoring of nearby monitoring wells), it is not likely that the zone of influence will extend beyond several metres in radius from a given foundation trench(es).

There will be no measurable long-term change as a result of this dewatering, and the influence on the overburden or shallow bedrock groundwater flow regimes within the Project Area will be restricted to the immediate vicinity of the foundation trenches. Therefore, the direct effect of the surface facility construction on the overburden groundwater and shallow bedrock groundwater and solute transport VECs is considered to be negligible, and will not constitute a measurable change to these VECs. Therefore, this project-environment interaction (construction of surface facilities) is not advanced for assessment of likely environmental effects.

Ground treatment in advance of shaft sinking through the overburden and shallow bedrock may not negate the requirement for dewatering; however, it will reduce the effective (or bulk) hydraulic conductivity of the surrounding soils and bedrock, greatly reducing the pumping requirements for dewatering. For the purposes of dewatering estimation, the advance grouting is assumed to conservatively result in a bulk hydraulic conductivity (K) of 1×10^{-7} to 1×10^{-8} m/s over the upper 170 m of each shaft (i.e., overburden and shallow bedrock). Notwithstanding grouting, dewatering during shaft sinking is likely to result in a measurable zone of influence, and is advanced for assessment in Section 7.2.2.

For the intermediate and deep bedrock strata, where K values are generally 1×10^{-12} m/s or lower, the inflow estimates are on the order of litres per day over the entire reach under consideration and the radius of influence was not quantifiable. Therefore, there is no measurable change to the intermediate and deep bedrock solute transport VECs because of excavation and construction.

There is a potential for changes to local solute transport patterns of the overburden and various stratigraphic formations as a result of emplacement of sealing materials in the main and ventilation shafts during shaft closure during the decommissioning phase. The main shaft will have a finished internal diameter of approximately 6.5 m and the ventilation shaft will have a finished internal diameter of approximately 5.0 m. The sealing materials will be of similar or higher permeability than the surrounding soils and shallow bedrock (0 to 170 mBGS). Groundwater in close proximity of the shafts will tend to flow towards the sealed shafts in the horizontal plane. This perturbation of very localized transport direction is expected to only extend several metres from the sealed shaft walls, and will not be noticeable within the scale of the Project Area or Site Study Area.

In the intermediate and deep bedrock packages, the hydraulic conductivity in the rock (1×10^{-12} to 1×10^{-15} m/s) will be much lower than any seal can provide (1×10^{-10} m/s in the seal below 170 mBGS). The rate of migration of porewater into the shaft seals will be so low that there will not be a discernible effect on the solute transport patterns.

Therefore, the direct interaction of the decommissioning (i.e., shaft sealing) of the DGR Project on the groundwater and solute transport VECs is considered to be negligible, and will not constitute a measurable change to the transport VECs.

There is potential for a component of runoff water collected in the stormwater management system to infiltrate into the subsurface soils, locally altering the groundwater recharge regime. Infiltration of stormwater through the drainage ditches and stormwater management pond to the subsurface is constrained by the infiltration capacity of the receiving Unweathered Till soils, which is considered to be low, conservatively estimated to be in the range of 5 to 10 cm/a [389]. As the ditches and stormwater pond are not hydraulically lined, the infiltration rates of the water into the till overburden will remain unchanged. Therefore, the potential recharge of water through the stormwater management system within the Project Area will not constitute a measurable change to the overburden solute transport VEC. Accordingly, this interaction is not considered further.

The following works and activities are not expected to interact with groundwater flow VECs during normal conditions as they do not involve any potential change to recharge areas or pumping:

- above-ground transport of waste;
- underground transfer of waste;
- abandonment of the DGR facility; and
- workers, payroll and purchasing.

The presence of the DGR Project interaction will only occur in the abandonment and long-term management phase. Changes in the abandonment and long-term performance phase are described collectively in Section 7.2.1.4.

Indirect Interactions and Measurable Changes

Overburden Groundwater Transport

An indirect interaction is identified between the overburden solute transport VEC and changes in surface water quantity and flow by affecting recharge characteristics. Changes in surface water quantity and flow are predicted in the Hydrology and Surface Water Quality TSD. Some of the surface flow to the North Railway Ditch will be redirected to the stormwater management system and discharged to the drainage ditch at Interconnecting Road.

Some of the water in the North Railway Ditch may contribute to the recharge of the overburden groundwater system. A small portion of water may be redirected to the stormwater management system and drainage ditch. It is likely that the small portion of redirected water flow will now recharge through the stormwater management system and drainage ditch floor. Therefore, overall redirection of surface flows is unlikely to affect current groundwater recharge characteristics. Therefore, there is no measurable indirect change to the overburden solute transport and this indirect interaction is not considered further.

Indirect measurable changes on surface water quantity and flow attributed to groundwater discharge are discussed in Section 7.3.1.1.

Shallow Bedrock Groundwater and Solute Transport

No potential indirect interaction pathways were identified for the shallow bedrock groundwater and solute transport VEC in the first screening of project-environment interactions.

Intermediate Bedrock Solute Transport

Two potential indirect interaction pathways were identified for the intermediate bedrock solute transport VEC in the first screening of project-environment interactions:

- changes in shallow bedrock solute transport; and
- changes in deep bedrock solute transport.

The interaction between the shallow bedrock and the intermediate bedrock is predominantly through diffusion and gas transfer (i.e., <1 mm/year). Therefore, it is unlikely that a change in shallow bedrock solute transport would cause a measurable change downward in the near term (i.e., <65 years). Accordingly, this potential indirect interaction is not considered further. Measurable changes during the long-term performance of the DGR are considered in Section 7.2.1.4.

The interaction between the deep bedrock and the intermediate bedrock is through diffusion and gas transfer only, within rock with very low hydraulic conductivites ($<1\times10^{-12}$ m/s). Therefore, it is unlikely that a change in deep bedrock groundwater transport would cause a measurable change in the intermediate bedrock in the near term (i.e., <65 years). Therefore, this interaction is not considered further. Measurable changes during the long-term performance of the DGR are considered in Section 7.2.1.4.

Deep Bedrock Solute Transport

No potential indirect interaction pathways were identified for the deep bedrock solute transport VEC in the first screening of project-environment interactions.

7.2.1.3 Overburden Groundwater, Shallow Bedrock Groundwater, Intermediate Bedrock Water and Deep Bedrock Water Quality

Direct Interactions and Measurable Changes

The following project works and activities have a direct interaction with the water quality VECs:

- site preparation – reduction in recharge attributed to creation of impervious surfaces (overburden groundwater quality);
- construction of surface facilities – reduction in recharge attributed to creation of impervious surfaces (overburden groundwater quality);

- decommissioning of the DGR Project – interaction with the shaft sealing materials (overburden and shallow bedrock groundwater quality, intermediate and deep bedrock water quality);
- waste management – specifically, the waste rock management activity, which includes the establishment and maintenance of the WRMA (overburden groundwater quality); and
- support and monitoring of DGR life cycle – specifically, the operation of the stormwater management system (overburden groundwater quality).

The installation/construction of impervious surfaces (roads, buildings, storage areas) during the site preparation, surface facility construction, and waste management works and activities can potentially reduce the area for groundwater recharge from precipitation. A potential reduction in the area for local recharge may affect groundwater quality through a potential reduction in the mixing of infiltrating surface water within the Project Area with the underlying, migrating shallow groundwater. For the construction laydown areas, the sites will be cleared of brush, and graded, but will not be made impervious. Some impervious surfaces will be created by resting equipment, but much of this will runoff onto the ground during precipitation events. The new infrastructure will result in 9% of new impervious surface area.

The reduction in areas for recharge is lower than the variation in precipitation from year to year [390]. Therefore, there is no foreseen measurable change in overburden groundwater quality through a potential reduction in the mixing of infiltrating surface water within the Project Area with the underlying, migrating shallow groundwater. In addition, stormwater runoff from roads will be directed to the stormwater management system. This water will eventually discharge to Lake Huron, which is the same outlet as the current groundwater system. Based on this, no measurable difference is expected in the total discharge of water to Lake Huron. Accordingly, these project-environment interactions are not considered further.

After sealing of the shafts during decommissioning, migrating groundwater will interact with the various sealing materials. The seal materials that are selected for the shallow reaches of the shaft (i.e., overburden and shallow bedrock) are engineered fill comprising native soil and crushed rock. The quality of the fill materials will therefore be broadly similar to the surrounding native soils. In addition, as with the interaction with soil quality (see Section 7.2.1.1), only a minimal amount of groundwater will migrate through the seals relative to the surrounding materials.

In the case of the intermediate and deep bedrock groundwater interacting with the shaft seal material, the quality of the water (including porewater) ranges from fresh to brine. As described in Section 4.11.4, the materials that will be emplaced in shaft sealing are largely bentonite, sand and concrete with a minor component of asphalt. This material is largely considered inert, except for the asphalt, which was selected for its compatibility with the hydrocarbon-bearing layers of the Georgian Bay Formation [387].

Therefore, the presence of the shaft seal will not constitute a direct measurable change to the groundwater quality VECs. Accordingly, these project-environment interactions are not considered further.

Infiltration of precipitation through the WRMA has the potential to uptake minerals from the rock and transport some portion to the underlying shallow groundwater resource. This could potentially alter the mineralization of the overburden groundwater resource. For the same rationale as described in Section 7.2.1.1, this project-environment change is not likely to be measurable and is not considered further.

The infiltration of stormwater into the shallow subsurface has the potential to transport dissolved chemical parameters into the underlying shallow groundwater resource. This could potentially alter the quality of the groundwater resource. Applying the same rationale as in Section 7.2.1.2, it is unlikely that the operation of the stormwater management system will constitute a measurable change to the groundwater quality VEC and is not considered further.

The following works and activities are not expected to interact with overburden groundwater, shallow groundwater, intermediate water and deep bedrock water quality VECs:

- excavation and construction of underground facilities;
- above-ground transfer of waste;
- underground transfer of waste;
- abandonment of the DGR facility; and
- workers, payroll and purchasing.

The presence of the DGR Project interaction will only occur in the abandonment and long-term management phase. Changes in the abandonment and long-term performance phase are described collectively in Section 7.2.1.4.

Indirect Interactions and Measurable Changes

Overburden Groundwater Quality

There were three potential indirect interactions identified for the overburden groundwater quality VEC in the first screening:

- changes in surface water quality;
- changes in soil quality; and
- changes in overburden groundwater transport.

Changes in surface water quality were identified that could affect overburden groundwater quality. The Hydrology and Surface Water Quality TSD evaluated potential effects on surface water quality. No adverse effects on surface water quality were identified. Stormwater will ultimately discharge via a controlled outlet into the existing drainage ditch along Interconnecting Road. The discharge will be monitored to confirm it meets water quality permitting requirements. Therefore, this indirect interaction is not carried forward for assessment.

Changes in soil quality could potentially affect overburden groundwater quality. No measurable changes in soil quality are identified (see Section 7.2.1.1). Therefore, this indirect interaction is not forwarded for assessment.

Changes in groundwater flow could potentially affect overburden groundwater quality. Changes in overburden groundwater transport may be measurable during the site preparation and construction phase (see Section 7.2.1.2). Therefore, this indirect measurable change to overburden groundwater quality is forwarded for further consideration in Section 7.2.2.

Shallow Bedrock Groundwater Quality

Three potential indirect interactions were identified for the shallow bedrock groundwater quality VEC in the first screening of project-environment interactions:

- changes in overburden groundwater quality;
- changes in shallow bedrock groundwater and solute transport; and
- changes in intermediate bedrock water quality.

Changes in overburden groundwater quality could indirectly affect shallow bedrock groundwater quality through leakage of overburden groundwater into the shallow bedrock groundwater. In Section 7.2.1.2, a likely measurable change in overburden groundwater quality is identified during the site preparation and construction, operations, and decommissioning phases. Accordingly, this indirect interaction is advanced to the assessment of the likely environmental effects.

Changes in shallow bedrock groundwater and solute transport were identified as having the potential to interact with shallow bedrock groundwater quality through concentration or dilution of parameters. A measurable change in shallow bedrock solute transport is identified during the site preparation and construction phase. Accordingly, this indirect interaction is advanced for further consideration in Section 7.2.2.

Changes in intermediate bedrock water quality could indirectly affect shallow bedrock groundwater quality through diffusion of intermediate bedrock groundwater into the shallow bedrock groundwater. Although there is some potential for upward diffusion, the proportion of groundwater diffusing upward from the intermediate into the shallow bedrock will be largely masked due to the greater quantity and movement of water within the shallow formations. No measurable change in shallow bedrock groundwater quality is identified. Therefore, this indirect interaction is not forwarded for assessment.

Intermediate Bedrock Water Quality

The following indirect interactions were identified for the intermediate bedrock water quality VEC:

- changes in shallow bedrock groundwater quality;
- changes in intermediate bedrock solute transport; and
- changes in deep bedrock water quality.

Transport between the shallow bedrock and the intermediate bedrock is predominantly through diffusion and gas transfer. Therefore, it is unlikely that a change in shallow bedrock groundwater quality would cause a measurable change in intermediate bedrock water quality in the near term (i.e., <65 years). Accordingly, this potential indirect interaction is not considered further.

Changes in intermediate bedrock solute transport could interact with intermediate bedrock water quality through concentration or dilution of parameters. As described above, no measurable changes in intermediate bedrock solute transport are likely. Therefore, this indirect interaction is not considered further.

Transport between the deep bedrock and the intermediate bedrock is through diffusion and gas transfer within these very low permeability materials. Therefore, it is unlikely that a change in deep bedrock water quality would cause a measurable change in intermediate bedrock water quality in the near term (i.e., <65 years). Accordingly, this potential indirect interaction is not considered further.

Deep Bedrock Water Quality

No indirect interactions were identified with deep bedrock water quality.

7.2.1.4 Abandonment and Long-term Performance Phase

The behaviour of the DGR system was predicted as part of the Postclosure Safety Assessment [386], using a Normal Evolution Scenario. The Normal Evolution Scenario describes the expected long-term evolution of the repository and site following closure. Disruptive Scenarios (i.e., unlikely or "what if" cases that test the robustness of the DGR system) were also predicted and are described in Sections 8 and 9, and the Malfunction, Accidents, and Malevolent Acts TSD.

The assessment considered several routes through which contaminants can potentially be released and migrate from the repository and shafts, including diffusion-dominated solute transport, advective solute transport, and gas migration. These transport mechanisms can occur within the geosphere surrounding the shafts and through the sealed shafts themselves. The routes of potential transfer are illustrated schematically in Figure 7.2.1-1. The mechanism for each type of transfer is described in detail in Chapter 8 of the Preliminary Safety Report [387] and in the Postclosure Safety Assessment [386].

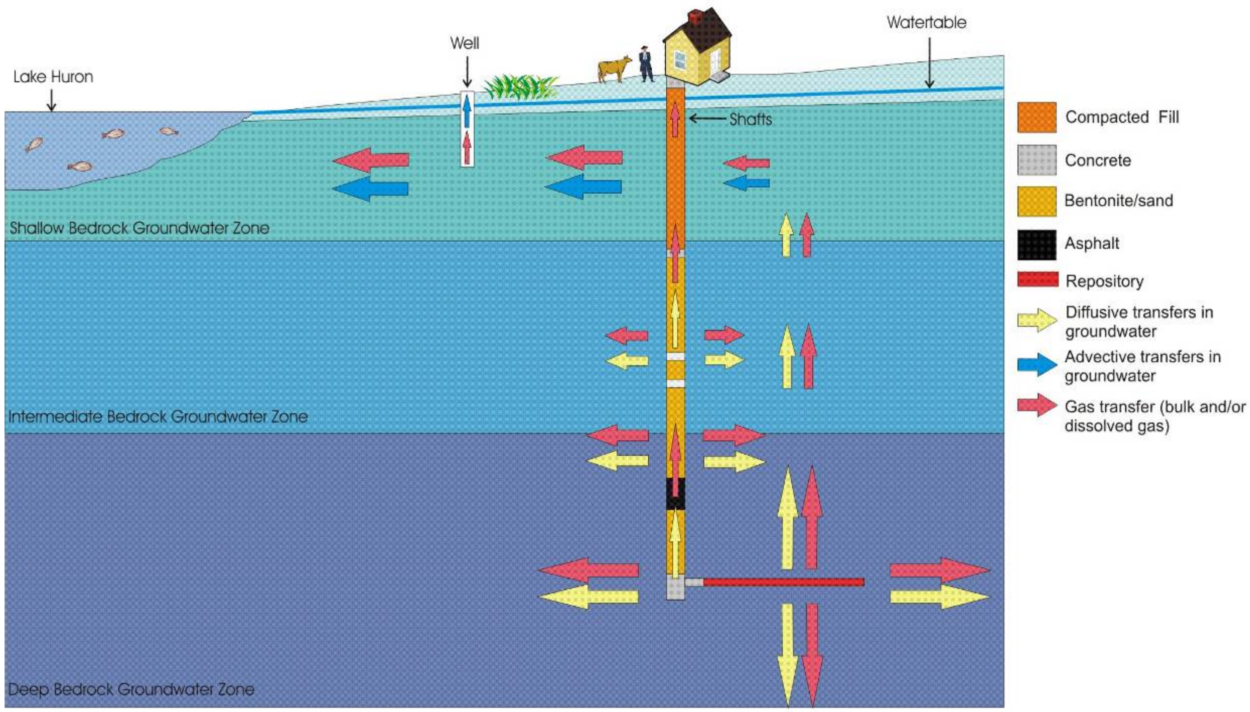

Figure 7.2.1-1: Schematic Representation of Potential Transport Pathways for the Normal Evolution Scenario

Within the EA context, these potential interactions are identified as follows:

- direct interaction between the shaft (presence of the DGR Project) and each of the water quality and groundwater and solute transport VECs; and
- indirect interactions between the geological packages:
    - soil quality may interact with overburden groundwater quality;
    - overburden groundwater quality may interact with soil quality and shallow bedrock groundwater quality;
    - shallow bedrock groundwater quality may interact with intermediate bedrock water quality;
    - intermediate bedrock water quality may interact with shallow bedrock groundwater quality; and
    - deep bedrock water quality may interact with intermediate bedrock water quality.

The predicted changes in flow and quality are not expected to be measurable in the long-term. However, in keeping with a precautionary approach, all potential interactions in the abandonment and long-term performance phase have been assumed to be measurable and are advanced to Section 7.2.2 for an assessment of likely effects.

7.2.2 Identification and Assessment of Effects

The geology VECs were screened for measurable changes, as described above. The following measurable changes were identified:

- direct measurable changes to overburden groundwater transport and shallow bedrock groundwater and solute transport as a result of excavation and construction of underground facilities;
- indirect measurable changes in overburden groundwater quality as a result of changes in overburden groundwater transport; and
- indirect measurable changes in shallow bedrock groundwater quality as a result of changes in overburden groundwater quality and shallow bedrock groundwater and solute transport.

No direct or indirect measurable changes were identified for soil quality, intermediate bedrock water quality, intermediate bedrock solute transport, deep bedrock water quality and deep bedrock solute transport. Measurable changes were also identified during abandonment and long-term performance phase of the DGR Project for all of the geology VECs. These are assessed in Section 7.2.2.3

7.2.2.1 Overburden Groundwater, and Shallow Bedrock Groundwater and Solute Transport

Linkage Analysis

The evaluation of the effects of the DGR Project on the overburden groundwater and shallow bedrock groundwater and solute transport VECs used changes in advective and diffusive transport characteristics to measure direct and indirect project effects.

Dewatering during excavation, which is included as part of the excavation and construction of underground facilities work and activity, was identified as having a likely measurable direct effect on the overburden groundwater and shallow bedrock and groundwater solute transport VECs. No indirect effects were identified that could affect the overburden groundwater and shallow bedrock groundwater and solute transport VECs.

Changes in overburden groundwater transport were also identified as having the potential to interact with hydrology and surface water quality VECs (Section 7.3), VECs in the terrestrial (Section 7.4) and aquatic (Section 7.5) environments, Aboriginal interests VECs (Section 7.9) and socio-economic VECs (Section 7.10).

In-design Mitigation

Ground treatment in the upper 170 m of the two shafts is an in-design mitigation designed to minimize the amount of dewatering that will be required [387]. The stormwater management pond is also an in-design mitigation measure, as all pumped water will be directed to the pond, which eventually will discharge to Lake Huron.

Likely Effects

Dewatering will be used to provide dry conditions for underground excavation and construction. Dewatering of the overburden and shallow bedrock could potentially have an effect on the groundwater and solute transport regimes within these systems.

Dewatering activities directly affect the groundwater flow regime by lowering the water table/potentiometric surface during pumping, resulting in the creation of a ZOI (i.e., a region of lowered water table/potentiometric surface). Within the ZOI, local shallow groundwater resources are directed towards the excavations where pumping is occurring. A ZOI is created for the duration of dewatering activities, and persists during the recovery time period when local shallow groundwater levels to recover after the cessation of pumping. Based on the site preparation and construction phase timeline for the sinking of the main and ventilation shafts, the duration of pumping is estimated to be two to three years.

For the purposes of dewatering estimation, the advance grouting of the shaft wall is assumed to conservatively result in a bulk hydraulic conductivity (K) of 1×10^{-7} to 1×10^{-8} m/s over the upper 170 m (overburden and shallow bedrock) of each shaft (from ground surface to the top of the Salina Formation F Unit). The ZOI was estimated to be approximately 54 m, with an inflow of approximately 50 L/min over the top 170 m of the shaft. There is no groundwater use that could be affected by this ZOI (i.e., no nearby overburden groundwater users), nor will the ZOI approach any surface water courses. Therefore, no adverse effects on base flow to surface water bodies (e.g., South Railway Ditch, Stream C) are anticipated.

In conclusion, the ZOI created by the dewatering during shaft sinking through the overburden and shallow bedrock will not create an adverse effect on local groundwater resources, water levels, or discharge to Lake Huron. Therefore, no adverse effects are identified for overburden groundwater, and shallow bedrock groundwater and solute transport VECs.

Mitigation Measures

No direct or indirect adverse effects were identified provided that the monitoring and mitigation measures that have already been incorporated into ground treatment and the conceptual design of the stormwater management system are implemented. Therefore, no mitigation measures are required for the overburden and shallow bedrock solute transport VECs.

Residual Adverse Effects

No direct or indirect environmental effects were identified. Therefore, it is concluded that the DGR Project will not result in residual adverse effects on the overburden groundwater and shallow bedrock groundwater and solute transport VECs. No further consideration is warranted.

7.2.2.2 Overburden and Shallow Bedrock Groundwater Quality

Linkage Analysis

The evaluation of the effects of the DGR Project on the overburden groundwater quality VEC uses changes in groundwater quality parameters to measure direct and indirect project effects. The assessment considered chemical characteristics of the groundwater, namely:

- general chemistry parameters (pH, anions, cations, nutrients);
- selected metal parameters; and
- petroleum hydrocarbon indicator compounds (PHCs).

No direct measurable changes were identified that could affect the overburden groundwater quality VEC. A potential measurable indirect change in overburden and shallow bedrock groundwater quality was identified because of changes in overburden groundwater and shallow bedrock groundwater and solute transport.

Changes in overburden groundwater quality were also identified as having the potential to affect hydrology and surface water quality VECs (Section 7.3), VECs in the terrestrial (Section 7.4) and aquatic (Section 7.5) environments and human health (Section 7.11).

Likely Effects

As described in Section 7.2.2.1, no effects on overburden groundwater quality were identified; therefore, there will be no likely adverse effect on the shallow bedrock groundwater quality VEC.

As described in Section 7.2.2.1, there are no likely adverse effects on overburden groundwater and shallow bedrock groundwater and solute transport. Therefore, there will be no likely adverse indirect effects on the overburden and shallow bedrock groundwater quality VECs.

Mitigation Measures

No direct or indirect adverse effects were identified; therefore, no mitigation measures are required for the overburden and shallow bedrock groundwater quality VECs.

Residual Adverse Effects

No direct or indirect adverse effects were identified for overburden and shallow bedrock groundwater quality. Therefore, it is concluded that the DGR Project will not result in residual adverse effects on the overburden and shallow bedrock groundwater quality VECs. No further consideration is warranted.

7.2.2.3 Abandonment and Long-term Performance Phase

The long-term (and near-term) movement of groundwater and gas from the repository has been modelled as part of the postclosure assessment of the DGR [386]. Although the migration of contaminants in groundwater and gas is considered not to create an adverse effect, this project-environment interaction was advanced to the assessment of the likely environmental effects, as this interaction is of scientific and social importance to the DGR Project.

Pathways for movement of groundwater and gas from the repository include movement up the shaft seal, and movement into the geosphere (Figure 7.2.1-1).

Direct interactions were identified for all of the geology VECs (presence of the DGR Project). The following indirect measurable changes were also identified:

- soil quality may affect overburden groundwater quality;
- overburden groundwater quality may affect soil quality and shallow bedrock groundwater quality;
- shallow bedrock groundwater quality may affect intermediate bedrock water quality;
- intermediate bedrock water quality may affect shallow bedrock groundwater quality; and
- deep bedrock water quality may affect intermediate bedrock water quality.

The modelling methods for the long-term performance of the DGR are provided in Section 9.

In-design Mitigation Measures

The principal mitigation measure for the Normal Evolution Scenario for the DGR is the site setting itself. The extensive studies from the site characterization program and the postclosure safety assessment have demonstrated that the geological/hydrogeological setting underneath the Bruce nuclear site provides excellent isolation and protection of the geosphere from the repository wastes.

Likely Effects

The postclosure safety assessment considers a Normal Evolution Scenario. This is the expected long-term evolution of the repository and site following closure. Over the 1 million years assessment timescale, the scenario includes waste and packaging degradation, rockfall, earthquakes and, after about 60 ka, glacial cycles. The assessment considers both a reference case, as well as variant calculation cases which explore the importance of uncertainties associated with the normal evolution scenario. Disruptive Scenarios are also considered, which assess the consequences of unlikely events in which the key barriers are bypassed. These are discussed in the Malfunctions, Accidents and Malevolent Acts TSD.

The key results for the Normal Evolution Scenario are as follows:

- The resaturation of the repository is gradual, taking more than 1 million years, due to the low permeability of the host rock and gas generation in the repository. The majority of the water seeps into the repository from the surrounding host rock rather than the shafts.
- Contaminants are contained within the repository and host rock, thereby limiting their release into the surface environment and their subsequent impacts. Reference Case

calculations estimate that less than 0.1% of the initial waste radioactivity is released into the geosphere around the repository, and much less is released into the shafts.

- Gases are contained within the repository and geosphere. The gas pressure is anticipated to equilibrate at 7 to 9 MPa, i.e., around the 7.4 MPa equilibrium hydrostatic pressure at the repository level, and well below the lithostatic pressure of about 17 MPa at the repository level. The gas will be primarily methane in the long term.
- The geosphere and shaft attenuate the release of contaminants, providing time for radioactive decay.
- For the Normal Evolution Scenario, essentially no radioactivity reaches the surface environment. The maximum calculated effective dose is many orders of magnitude below the public dose criterion.
- These results apply to a hypothetical family assumed to be living on the site in the future, and obtaining all of its food from the area. The potential dose would decrease rapidly with distance from the site. For example calculated doses to a "downstream" group exposed via consumption of lake fish and water from Lake Huron are more than six orders of magnitude lower than the dose to the family living on the site.

The modelling assessments concentrated on radiological parameters, which are not the subject of this environmental component. Radiological parameters are considered in Section 9 (long-term safety). Transport modelling for inorganic and organic non-radioactive elements was also undertaken, and those are the pertinent parameters for the assessment of effects in this section. The simulation of non-radiological parameters indicated:

- less than 3% of the non-radiological species in the wastes are released from the DGR over a one million year timeframe; and
- the calculated concentrations of non-radioactive contaminants in biosphere media for the Reference Case are also much smaller than the environmental quality standards for groundwater, soils, surface water and sediments designed to protect human health and the environment.

The relevant environmental quality standards that the simulated concentrations were compared to are provided in the Geology TSD and Table 3.4 in Postclosure Safety Assessment [386].

Based on the above, the direct effects of the postclosure behaviour of the repository will not have an adverse environmental effect on the soil, overburden groundwater, shallow bedrock groundwater, intermediate bedrock water or deep bedrock water quality VECs.

The dominant flow (transport) characteristics within the overburden, shallow bedrock, intermediate bedrock and deep bedrock regimes do not change appreciably as a result of the postclosure presence of the DGR. Dominant flow is horizontal advective flow within formations in the more permeable shallow formations. The dominant groundwater migration mechanism in the lower permeable intermediate rocks and the deep formations is diffusion; this is the principal mechanism for movement of water and contaminants within the stratigraphic column. Apart from the immediate vicinity of the repository and shafts, where movement from the repository into the geosphere will eventually occur, there is likely no measurable change in the various bedrock groundwater and solute transport regimes.

Mitigation Measures

No adverse effects are likely; therefore, no mitigation is required.

Residual Adverse Effects

No likely environmental effects were identified during the abandonment and long-term performance phase. Therefore, it is concluded that the DGR Project will not cause a residual adverse effect on the geology VECs. No further assessment is warranted.

7.2.2.4 Summary of Assessment

Table 7.2.2-1 provides a summary of the assessment of geology for the DGR Project. The direct effects during the abandonment and the long-term performance phase of the DGR Project are considered under the presence of the DGR Project work and activity and effects that only occur during this phase are marked in the summary table with "(LT)". The indirect effects on the geology VECs during the abandonment and long-term performance phase are considered as indicated in the text above but are not marked in the summary table.

7.2.3 Significance of Residual Adverse Effects

No residual adverse effects were identified for any of the geology VECs. Hence, no further assessment is warranted.

Table 7.2.2-1: Summary of Effects Prediction and Assessment for Geology

Project Work and Activity	Soil Quality	Overburden Groundwater Quality	Overburden Groundwater Transport
Direct Effects			
Site Preparation	•	•	•
Construction of Surface Facilities		•	•
Excavation and Construction of Underground Facilities			■
Above-ground Transfer of Waste			
Underground Transfer of Waste			
Decommissioning of the DGR Project	•	•	•
Abandonment of the DGR Facility			
Presence of the DGR Project[a]	■ (LT)	■ (LT)	■ (LT)
Waste Management	•	•	•
Support and Monitoring of DGR Life Cycle	•	•	•
Workers, Payroll, and Purchasing			
Indirect Effects			
Changes in Air Quality	•		
Changes in Surface Water Quantity and Flow			•
Changes in Surface Water Quality		•	
Changes in Soil Quality		•	
Changes in Overburden Groundwater Quality	•		
Changes in Overburden Groundwater Transport		■	
Changes in Shallow Bedrock Groundwater Quality			
Changes in Shallow Bedrock Groundwater and Solute Transport			
Changes in Intermediate Bedrock Water Quality			
Changes in Intermediate Bedrock Solute Transport			
Changes in Deep Bedrock Water Quality			
Changes in Deep Bedrock Solute Transport			

Notes:

a Presence of the DGR Project work and activity captures the effects during the abandonment and long-term performance phase of the DGR Project. ■ (LT) occur only in the long-term performance phase. Indirect interactions during abandonment and long-term performance phase are discussed in text but are not included in this table.

The matrices are meant to indicate when the activity occurs and do not imply how long the effect will last.

• Potential project-environment interaction
■ Measurable change
Blank No potential interaction

Table 7.2.2-1: Summary of Effects Prediction and Assessment for Geology (continued)

Project Work and Activity	Shallow Bedrock Groundwater Quality	Shallow Bedrock Groundwater and Solute Transport	Intermediate Bedrock Water Quality
Direct Effects			
Site Preparation			
Construction of Surface Facilities		•	
Excavation and Construction of Underground Facilities		■	
Above-ground Transfer of Waste			
Underground Transfer of Waste			
Decommissioning of the DGR Project	•	•	•
Abandonment of the DGR Facility			
Presence of the DGR Project[a]	■ (LT)	■ (LT)	■ (LT)
Waste Management			
Support and Monitoring of DGR Life Cycle			
Workers, Payroll, and Purchasing			
Indirect Effects			
Changes in Air Quality			
Changes in Surface Water Quantity and Flow			
Changes in Surface Water Quality			
Changes in Soil Quality			
Changes in Overburden Groundwater Quality	■		
Changes in Overburden Groundwater Transport			
Changes in Shallow Bedrock Groundwater Quality			•
Changes in Shallow Bedrock Groundwater and Solute Transport	■		
Changes in Intermediate Bedrock Water Quality			
Changes in Intermediate Bedrock Solute Transport			•
Changes in Deep Bedrock Water Quality			■
Changes in Deep Bedrock Solute Transport			

Notes:
a Presence of the DGR Project work and activity captures the effects during the abandonment and long-term performance phase of the DGR Project. ■ (LT) occur only in the long-term performance phase. Indirect interactions during abandonment and long-term performance phase are discussed in text but are not included in this table.

The matrices are meant to indicate when the activity occurs and do not imply how long the effect will last.
• Potential project-environment interaction
■ Measurable change
Blank No potential interaction

Table 7.2.2-1: Summary of Effects Prediction and Assessment for Geology (continued)

Project Work and Activity	Intermediate Bedrock Solute Transport	Deep Bedrock Water Quality	Deep Bedrock Solute Transport
Direct Effects			
Site Preparation			
Construction of Surface Facilities			
Excavation and Construction of Underground Facilities	●		●
Above-ground Transfer of Waste			
Underground Transfer of Waste			
Decommissioning of the DGR Project	●	●	●
Abandonment of the DGR Facility			
Presence of the DGR Project	■ (LT)	■ (LT)	■ (LT)
Waste Management			
Support and Monitoring of DGR Life Cycle			
Workers, Payroll, and Purchasing			
Indirect Effects			
Changes in Air Quality			
Changes in Surface Water Quantity and Flow			
Changes in Surface Water Quality			
Changes in Soil Quality			
Changes in Overburden Groundwater Quality			
Changes in Overburden Groundwater Transport			
Changes in Shallow Bedrock Groundwater Quality			
Changes in Shallow Bedrock Groundwater and Solute Transport	●		
Changes in Intermediate Bedrock Water Quality			
Changes in Intermediate Bedrock Solute Transport			
Changes in Deep Bedrock Water Quality			
Changes in Deep Bedrock Solute Transport	●		

Notes:
a Presence of the DGR Project work and activity captures the effects during the abandonment and long-term performance phase of the DGR Project. ■ (LT) occur only in the long-term performance phase. Indirect interactions during abandonment and long-term performance phase are discussed in text but are not included in this table.

The matrices are meant to indicate when the activity occurs and do not imply how long the effect will last.
● Potential project-environment interaction
■ Measurable change
Blank No potential interaction

7.3 HYDROLOGY AND SURFACE WATER QUALITY

The hydrology and surface water quality assessment comprises two VECs: surface water quantity and flow and surface water quality. The results of the hydrology and surface water quality assessment are summarized in Section 7.3.2.3. The existing environmental features are described in Section 6.3 and the Hydrology and Surface Water Quality TSD.

7.3.1 Screening to Focus the Assessment

7.3.1.1 Surface Water Quantity and Flow

Direct Interactions and Measurable Changes

The project work and activities were screened for potential interactions with surface water quantity and flow. The diversion of flow from the Stream C watershed to MacPherson Bay was identified as a potential direct interaction as a result of the following project works and activities:

- site preparation;
- construction of surface facilities;
- excavation and construction of underground facilities;
- decommissioning of the DGR facility; and
- support and monitoring of DGR life cycle.

These works and activities share the same effect (i.e., same changes in drainage area), and the effects are examined collectively. All changes in drainage will be directed to and considered further as part of the operation of the stormwater management system considered in the support and monitoring of the DGR life cycle work and activity. The total diverted drainage area is 8.2 ha. The changes in stream flow were considered at the following four locations (see Figure 6.3.3-1:

- Stream C;
- South Railway Ditch at Stream C;
- North Railway Ditch at Stream C; and
- drainage ditch at discharge from the Project Area (at Interconnecting Road).

Changes in flow are estimated based on the relative changes in drainage area (i.e., flows are directly proportional to drainage area). For the purposes of surface water quantity and flow, a measurable change in flow in any stream would be determined by a change to the drainage area of the stream, or any direct addition or abstraction of flow from the stream. The changes in drainage areas are presented in Table 7.3.1-1. A measurable change is considered to occur at Stream C, the North Railway Ditch at Stream C and the drainage ditch at Interconnecting Road. These likely measurable changes are carried forward to the effects assessment.

Table 7.3.1-1: Summary of Measurable Changes to Drainage Areas

Flow Assessment Point [a]		Existing Drainage (ha)	Proposed Drainage (ha)	Change (ha)	Measurable Change
A	Stream C (at discharge from Bruce nuclear site – North Access Road) [b]	1,042.4	1034.2	-8.2	**Yes**
B	South Railway Ditch at Stream C	43.4	43.4	0	No
C	North Railway Ditch at Stream C	26.1	17.9	-8.2	**Yes**
D	Drainage ditch at point of discharge from DGR Project site (Interconnecting Road)	41.3	49.5	+8.2	**Yes**

Notes:
a Flow assessment locations are shown on Figure 6.3.5-1.
b Drainage area A includes both drainage areas B and C and represents the cumulative effect on Stream C.

During the excavation and construction of underground facilities, dewatering may increase flows in adjacent drainage ditches. Additionally, the placement of material in the WRMA may change drainage patterns in the area. For purposes of the assessment, it was conservatively assumed that the maximum design dewatering flow rates would occur continuously. In reality, the contribution from dewatering is expected to be lower. During excavation, inflows will need to be on the order of 1 L/s to facilitate construction. The water discharged during excavation will be directed into the DGR Project site drainage ditches of the stormwater management system, and then directed towards MacPherson Bay through the existing drainage ditch system. Therefore, the effect of excavation water discharge on surface water quantity and flow is carried forward to the assessment (these are captured in the stormwater management system as part of the support and monitoring of DGR life cycle activity) in Section 7.3.2.1.

Water pumped from the shaft sumps during operations may have an effect on the quantity of stream flow. The maximum sump pumping design flows are 2.3 L/s during operations. However, the DGR will be designed with the objective of operating largely as a dry facility with little to no seepage collecting in the shaft sumps. These may result in a measurable change to stream flow to the drainage ditch under Interconnecting Road. Therefore, the effect of sump water pumping is carried forward to the assessment (support and monitoring of DGR life cycle activity) in Section 7.3.2.1.

The following works and activities are not expected to directly interact with surface water quantity and flow, as they do not have any potential for discharges or changes to drainage patterns:

- above-ground transfer of waste;
- underground transfer of waste;
- abandonment of the DGR facility;
- presence of the DGR Project;

- waste management; and
- workers, payroll and purchasing.

Therefore, these works and activities are not forwarded for assessment.

Indirect Interactions and Measurable Changes

For indirect interactions, a measurable change was considered possible if there was a likely adverse effect identified for the other VEC.

Changes in groundwater flow may indirectly interact with surface water quantity and flow into the streams. Analysis presented in Section 7.2.2.3 and the Geology TSD indicates that there will be no adverse effect on groundwater levels caused by the DGR Project at any of the streams and ditches in the Site Study Area. Consequently, there would not be a measurable change in water quantity or flow in the streams and ditches attributed to changes in groundwater flow. Therefore, no further consideration is warranted.

There are no expected indirect interactions with surface water quantity and flow as a result of changes in air quality, noise levels, surface water quality, soil quality and groundwater quality. The rationale for this screening is provided in the Hydrology and Surface Water Quality TSD. Therefore, these are not considered further.

7.3.1.2 Surface Water Quality

Direct Interactions and Measurable Changes

The discharge of stormwater during the site preparation and construction, operation and decommissioning phases of the DGR Project were all identified as having the potential to directly interact with surface water quality in the drainage ditch to Lake Huron. These effects are the result of the following project works and activities:

- site preparation;
- construction of surface facilities;
- excavation and construction of underground facilities;
- above ground transfer of waste;
- decommissioning of the DGR Project;
- waste management;
- support and monitoring of DGR life cycle; and
- workers, payroll and purchasing.

All of these works and activities share the same effect (i.e., changes in the quality of runoff directed to the stormwater management system), and all changes in water quality are captured at one endpoint at the stormwater management pond (support and monitoring of DGR life cycle). Therefore, only this work and activity is considered further. Potential effects include increased suspended solids, hydrocarbons and road salt from construction activities and vehicle traffic, and changes in water chemistry caused by runoff from the waste rock piles.

There will be no releases from the DGR Project to either the North or South Railway Ditch, or Stream C (to which they drain). Therefore, the DGR Project will not have a direct effect on the surface water quality in those water bodies.

For changes in surface water quality, a measurable change was considered if the change in any water quality parameters is beyond the natural variability of the water body. The range of parameter concentrations for each indicator for water quality is presented in Section 6.3.5.

The amount of suspended sediment resulting from construction activities is influenced by factors such as weather conditions, site conditions, construction practices and the effectiveness of sediment control measures. Without mitigation, it is likely that increased sediment contributions will measurably change water quality.

Similarly, the constituents of the runoff from the waste rock piles are influenced by factors such as rock composition, particle size, weather conditions and cover material. The runoff could cause a measurable change in water quality. Specific parameters of concern include salinity, explosive residue and metals in the waste rock piles.

Some explosives, specifically emulsion and ammonium nitrate/fuel oil (ANFO), will be used during the construction of the underground works. Typically a portion of the explosives used will not detonate and will contribute to small amounts of ammonia, nitrate and fuel oil in the runoff from the waste rock piles.

The natural weathering of the waste rock may contribute various amounts of trace metals and salt to the runoff from the WRMA. Therefore, potential changes in surface water quality from operation of the stormwater management system are carried forward to the effects assessment (support and monitoring of DGR life cycle activity).

Discharges from the stormwater management system could potentially change the temperature of receiving water bodies if the water entering the system is of a notably different temperature than that exiting the system. As the stormwater management system will largely handle surface runoff, it is not expected to cause a direct measurable change in temperature. Potential measurable changes in temperature through changes in surface water quantity and flow are considered in the following subsection.

The following works and activities are not expected to directly interact with surface water quality, as they do not have any potential for discharges:

- underground transfer of waste;
- abandonment of the DGR facility; and
- presence of the DGR Project;

Therefore, these works and activities are not considered further.

Indirect Interactions and Measurable Changes

For potential indirect changes, a measurable change was considered possible if there was a likely adverse effect identified for the other VEC.

Changes in surface water quantity and flow could affect water quality through concentration or dilution of parameters. As summarized in Table 7.3.1-1, a measurable change in stream flow is predicted in Stream C, the North Railway Ditch and in the drainage ditch at Interconnecting Road. Therefore, this potential change in surface water quality is forwarded for assessment in Section 7.3.2.2.

Changes in drainage area and the associated changes in flow could indirectly change the water temperatures in the local drainage features. For this portion of the assessment, a measurable change in average annual temperature is a change in a water body temperature greater than the reported accuracy of the instruments used during the field program (i.e., ±0.5ºC).

The maximum recorded difference in water temperature between Stream C (SW2) and the South Railway Ditch (SW4) was 2.4ºC during the field monitoring program carried out in 2007 and 2009. This occurred on May 25, 2009 when the temperatures in Stream C and the South Railway Ditch were 16.4ºC and 14.0ºC, respectively. Although temperature measurements are not available for the North Railway Ditch, it is assumed that they would generally be similar to the South Railway Ditch. It follows then, that the difference in water temperature between the North Railway Ditch and Stream C could also be as much as 2.4ºC. Consequently, a change in the volumes of water from these ditches contributing to Stream C could potentially change the temperature in Stream C.

The change (reduction) in drainage area contributing to Stream C due to the proposed diversion of flow from the North Railway Ditch is approximately 0.8% (i.e., less than 1%). Therefore, assuming that change in flow volume is roughly proportional to change in drainage area and for a temperature differential of 2.4ºC, the potential impact on temperatures in Stream C downstream of the point of diversion would be 0.02ºC (i.e., 0.8%×2.4ºC). This is much less than the ±0.5ºC measurement criterion proposed above, and it follows that there should be no measurable change in the water temperature in Stream C as a result of the proposed drainage area diversion.

The increased flow discharging (via existing ditches) to MacPherson Bay is approximately 20% due to the proposed drainage area diversion. The temperature differential between MacPherson Bay (SW6) and the various ditches can be as much as 5 to 6ºC, though most of the time the temperature differences between these water bodies are within ±2ºC. Given the usually small differential in temperature and the extremely large volume of water in MacPherson Bay (compared to the relatively small additional volumes being discharged via the drainage ditch), no measurable increase in the average water temperature of the bay is expected.

As there are no expected measurable changes in water temperature as a result of the DGR Project, effects on water temperature are not considered further.

Changes in air quality could potentially contribute to increased suspended sediment concentrations caused by deposition of dust on the water surface. Additionally, the deposited dust could include residues from the blasting agents. Nitrate and dust deposition rates have been predicted, and although likely to be small, in keeping with a precautionary approach, are advanced for assessment.

Potential changes in soil quality could indirectly interact with surface water quality through stormwater runoff or could be re-suspended and deposited as dust on the water surface. However, as discussed in Section 7.2.1.1 and the Geology TSD, no adverse effects to soil quality are expected. Therefore, this indirect interaction is not considered further.

Potential changes in groundwater quality could indirectly interact with surface water quality through groundwater discharge to surface water bodies. Analysis presented in Section 7.2.2.2 and the Geology TSD indicates that the change in groundwater quality resulting from the DGR Project would not be measurable at any of the streams and ditches in the Site Study Area. Consequently, no measurable change in water quality in the streams and ditches is anticipated. Therefore, this indirect interaction is not carried forward for assessment.

Changes in groundwater flow may indirectly interact with the surface water quality in the streams. However, as mentioned in Section 7.2.2.3 and the Geology TSD, no adverse effect in groundwater levels (i.e., overburden groundwater transport) is expected and subsequently no measurable change in surface quality is anticipated. Therefore, no further consideration is warranted.

No other potential indirect interactions were identified.

7.3.2 Identification and Assessment of Environmental Effects

Hydrology and surface water quality VECs were screened for measurable changes, as described above. The following measurable changes were identified and are therefore assessed:

- diversion of surface runoff as a result of the operation of the stormwater management system will have a direct measurable change to surface water quantity and flow during the site preparation and construction, operations and decommissioning phases;
- water from the underground workings will be released to the stormwater management system during site preparation and construction, and operations phases, which will have a measurable change to surface water quantity and flow;
- water entering the stormwater management system will have direct measurable change to surface water quality during the site preparation and construction, operations and decommissioning phases;
- indirect measurable change to surface water quality as a result of changes in flow in Stream C, the North Railway Ditch and the drainage ditch at Interconnecting Road during site preparation and construction, operations, and decommissioning phases of the DGR Project; and
- indirect measurable change to surface water quality as a result of changes in air quality (i.e., deposition) during the site preparation and construction phase.

7.3.2.1 Surface Water Quantity and Flow

Linkage Analysis

Measurable changes in surface water quantity and flow are identified in three separate catchments as a result of one drainage diversion, namely:

- the catchment draining to Stream C;
- the catchment draining to the North Railway Ditch; and
- the catchment draining to the drainage ditch (Interconnecting Road), and ultimately to MacPherson Bay.

The operation of the stormwater management system, which includes the discharge from underground shaft sump pumping system, is included as part of the support and monitoring of the DGR life cycle work and activity. This measurable change will occur during the site preparation and construction, operations, and decommissioning phases of the DGR Project.

No indirect effects were identified that could measurably change the surface water quantity and flow VEC.

Changes in surface water quantity and flow may affect the surface water quality VEC, which is assessed in Section 7.3.2.2. Changes in surface water quantity and flow also have the potential to interact with overburden groundwater transport (flow) (Section 7.2), VECs in the terrestrial (Section 7.4) and aquatic (Section 7.5) environments, Aboriginal communities (Section 7.9), socio-economic environment VECs (Section 7.10) and human health (Section 7.11).

In-design Mitigation

Some effects on surface water quantity and flow have been avoided or reduced through items inherent in the project design (i.e., in-design mitigation). The DGR Project site drainage ditches, stormceptors and stormwater management pond, which collectively form the stormwater management system are inherent in the project design and are accounted for during the assessment of adverse effects. All stormwater runoff from the DGR Project site and the waste rock management area will be collected in drainage ditches and directed to the stormwater management pond.

The shaft liner is designed to minimize the volume of seepage into the shaft. This will reduce the ultimate volume of water discharged to the pond; however, the assessment conservatively assumes the maximum constant flow rate is sustained.

Likely Effects

Changes to the surface water quantity and flow are calculated based on changes to the drainage areas (e.g., flow diverted from one catchment to another). The changes in flow are calculated by pro-rating the flows by changes in drainage areas. As well, additional flows from shaft pumping during construction and operations are added. An adverse effect on surface water quantity and flow was considered to be one that could be detected by using standard stream flow measurement techniques. This was considered to be a change in flow of more than ±15% [391]. Changes in flow that are less than ±15% are lower than the typical accuracy of in-stream flow measurements. The rationale for developing this criterion is described fully in Appendix C of the Hydrology and Surface Water Quality TSD.

The assessment of effects on surface water quantity and flow is summarized in Table 7.3.2-1.

The decrease in drainage area for Stream C is calculated to be -0.8% and is below the adverse effect criteria (i.e., >±15% change) and this location is not considered further in the assessment. The decrease in the drainage flow to the North Railway Ditch is 31%. The increase in catchment area to the drainage ditch at the point of discharge from the Project Area is 20%. These changes are above the adverse effect criteria (i.e., >±15% change).

In addition to the redirected drainage area flows, an increase in the average annual flow rate to the drainage ditch at Interconnecting Road will also result from dewatering of the shaft excavation during construction and shaft sump pumping during operations. The maximum total flow rate of pumped water that could be experienced is 5.3 L/s[17] during construction [387]. The dewatering discharge could increase the average annual flow in the drainage ditch under Interconnecting Road by approximately 93% during construction. When combined with the increase in flow associated with the diverted drainage areas (i.e., +20%), the average flow could increase by approximately 114%. This increase exceeds the adverse effect criteria of ±15%.

The maximum sump water pumping flows that could be experienced is 2.3 L/s[18] during operations. This flow is 40% of the estimated average annual flow in the outlet ditch for existing conditions (i.e., 5.7 L/s) and is expected to cause a measurable increase in flow. When combined with the increase in flow associated with the diverted drainage areas (i.e., +20%), the average flow in the drainage ditch could increase by approximately 61% during operations. This increase exceeds the adverse effect criteria of ±15%. An adverse effect on surface water quantity and flow is likely as a result of the DGR Project.

Additional Mitigation Measures

For the drainage ditch under Interconnecting Road, the channel capacity should be evaluated during detailed design to ensure that the ditch can properly convey the expected flows from the stormwater management pond. However, no credit has been taken in the assessment for this. Therefore, the residual adverse effect is advanced for further consideration.

[17] For purposes of the assessment, it was conservatively assumed that the maximum dewatering flow rates would occur continuously. In reality, the contribution from dewatering is expected to be lower. During excavation, inflows will need to be on the order of 1 L/s to facilitate construct.

[18] The peak flow includes an allowance for a temporary inflow attributed to a leak in the shaft lining. In reality, the liner will be designed with the objective of little to no seepage through the shaft lining.

Table 7.3.2-1: Likely Adverse Effects on Surface Water Quantity and Flow

Flow Assessment Point	Location	Existing Drainage Area (ha)	Existing Flow (L/s) [a]	Proposed Drainage Area (ha)	Proposed Flow (L/s)			Total Change (%)	Adverse Effect?
					From Drainage Area [a]	From Shaft Sump Pumping	Total		
A	Stream C (at point of discharge from Bruce nuclear site – North Access Road)	1,042.4	144.6	1,034.2	143.4	0	143.4	-0.8%	No
C	North Railway Ditch at Stream C	26.1	3.6	17.9	2.5	0	2.5	-31%	**Yes**
D	Drainage ditch at point of discharge from DGR Project Site (Interconnecting Road)	41.3	5.7	49.5	6.9	5.3 [b]	12.2	+114%	**Yes**
					6.9	2.3 [c]	9.2	+61%	**Yes**

Notes:

a Annual Average Flow from Table 5.4.3-2 of the Hydrology and Surface Water Quality TSD as calculated using the drainage area, precipitation and runoff coefficients (see Appendix G of the Hydrology and Surface Water Quality TSD for sample calculation).

b For purposes of the assessment, it was conservatively assumed that the maximum dewatering flow rates would occur continuously. In reality, the contribution from dewatering is expected to be lower. During excavation, inflows will need to be on the order of 1 L/s to facilitate construct.

c The peak flow includes an allowance for a temporary inflow attributed to a leak in the shaft lining. In reality, the liner will be designed with the objective of little to no seepage through the shaft lining.

Residual Adverse Effects

Based on the analysis, there is a residual adverse effect on the drainage ditch and the North Railway Ditch associated with the operation of the stormwater management pond on surface water quantity and flow. This residual adverse effect is advanced to Section 7.3.3 for an evaluation of significance. No adverse effects are identified on either the South Railway Ditch or Stream C as a result of changes in surface water quantity and flow.

7.3.2.2 Surface Water Quality

Linkage Analysis

The evaluation of the effects of the DGR Project on the surface water quality VEC used changes in the concentrations of indicator compounds and changes in temperature to measure direct and indirect project-related changes. The assessment considered the following indicators:

- total suspended solids;
- nutrients;
- metals;
- temperature;
- pH; and
- salinity.

The operation of the stormwater management pond, which is included as part of the support and monitoring of the DGR life cycle work and activity, was identified as having a measurable change to the surface water quality VEC during all phases of the project.

Changes to the surface water quantity and flow VEC (see Section 7.3.2.1) were identified as having a likely measurable change to the surface water quality VEC.

Changes to the air quality VEC (see Section 7.3.1.2) were also identified as having a likely measurable change to the surface water quality VEC as a result of deposition.

Changes in surface water quality also have the potential to affect the overburden groundwater quality (Section 7.2), VECs in the terrestrial (Section 7.4) and aquatic environments (Section 7.5), Aboriginal interests (Section 7.9), socio-economic environment VECs (Section 7.10) and human health (Section 7.11).

In-design Mitigation

A system of water sampling and testing is proposed to confirm that all water released from the DGR Project site via the stormwater management pond has concentration levels below the certificate of approval discharge criteria. Two stormceptors located in the shaft services facility area, are designed to mitigate for oil and grease and suspended sediments, prior to discharge to the stormwater pond. The stormwater pond is designed to settle out suspended solids and provide sufficient storage during storm events. A normally open manual control gate will control the discharge of water from the management pond. The gate will be closed if water samples from the pond show concentrations above certificate of approval discharge criteria.

Discharges from the stormwater management system will be directed to the drainage ditch along the Interconnecting Road and ultimately to MacPherson Bay. No releases from the site will be directed to the North or South Railway Ditch or the Stream C watershed.

Likely Effects

If the DGR Project results in the concentration of any of the indicator compounds that exceed the applicable criteria, adverse effects on water quality are likely. The range of existing concentrations of indicator compounds is provided in Section 6.3.5.

All underground water from the DGR Project and surface runoff (up to the design storm event) will be captured in the stormwater management pond. The water will be tested and compared against discharge criteria. In the event that water quality does not meet criteria treatment may be applied. Provided that the certificate of approval discharge criteria are met, there are no adverse effects on surface water quality expected from the DGR Project.

A measurable change to surface water quality in Stream C was identified as a result of the deposition of dust from the construction of the DGR facility. This effect includes potential increases in total suspended solids and residual nitrates from the use of explosives. The deposition rates were provided for two sub-catchments of Stream C, upstream of Tie Road (e.g., outside the Bruce nuclear site boundary) and downstream of Tie Road (e.g. inside the Bruce nuclear site boundary). Table 7.3.2-2 provides calculations that relate the atmospheric deposition rates to estimated changes in Stream C water quality.

Table 7.3.2.-2: Estimated Effects on Suspended Solids and Nitrate Concentration in Surface Water Due to Atmospheric Deposition during Construction

Stream C Catchment Areas	Upstream Catchment	Downstream Catchment	Total Catchment
Average TSS Increase (mg/L)	1.89	0.79	2.68
Average Nitrate Increase (μg/L)	0.032	0.013	0.045

The total increase in total suspended solids is expected to be approximately 2.7 mg/L. This increase is expected to be trivial since it is less than the Method Detection Limit for suspended solids of 10 mg/L. The total increase in nitrate is expected to be less than 0.05 μg/L. This increase is expected to be trivial since it is less than 0.1% of the reported nitrate concentrations in Lake Huron (see Section 6.3.4.1). The increase is well below the Ontario Drinking Water Objective for nitrate of 10 mg/L [392]. Therefore, no adverse effects on water quality are likely from changes in air quality.

A measurable indirect change to water quality as a result of a measurable change in surface water quantity and flow in the North Railway Ditch and Stream C was identified in Section 7.3.1.2. Since runoff to the North Railway Ditch is the primary source of indicators in surface water, a decrease in runoff will reduce both the loading to the North Railway Ditch, and subsequently Steam C, as well as the water available to dilute the indicator concentrations. These are expected to balance each other. Therefore, no adverse effects on water quality are likely from indirect effects.

Additional Mitigation Measures

The discharge from the stormwater management system will be subject to discharge criteria stipulated in the Certificate of Approval for Industrial Sewage Works (Section 53 of the Ontario Water Resources Act). The criteria in the certificate of approval will be determined during the approval process and may differ from those values presented in Appendix D in the Hydrology and Surface Water Quality TSD. If required, a water treatment plant could be applied in order to meet these criteria.

Residual Adverse Effects

Surface water will not be allowed to discharge from the pond unless it meets the certificate of approval discharge criteria. Therefore, no residual adverse effects on surface water quality are expected from the DGR Project. No further consideration is warranted.

7.3.2.3 Summary of Assessment

Table 7.3.2-3 provides a summary of the assessment of the hydrology and surface water quality VECs for the DGR Project. Diamonds (◆) on this matrix represent likely project-environment interactions resulting in a residual adverse effect on a VEC. These interactions are advanced to Section 7.3.3 for a consideration of significance. In this case, a residual adverse effect was identified for surface water quantity and flow.

Table 7.3.2-3: Summary of Effects Prediction and Assessment for Hydrology and Surface Water Quality

Project Work and Activity	Surface Water Quantity and Flow	Surface Water Quality
Direct Effects		
Site Preparation	•	•
Construction of Surface Facilities	•	•
Excavation and Construction of Underground Facilities	•	•
Above-ground Transfer of Waste		•
Underground Transfer of Waste		
Decommissioning of the DGR Project	•	•
Abandonment of the DGR Facility		
Presence of the DGR Project		
Waste Management		•
Support and Monitoring of DGR Life Cycle	◆	■
Workers, Payroll and Purchasing		•
Indirect Effects		
Changes in Air Quality		■
Changes in Noise Levels		
Changes in Surface Water Quantity and Flow		■
Changes in Surface Water Quality		
Changes in Soil Quality		•
Changes in Groundwater Quality		•
Changes in Groundwater Flow	•	•

Notes:
The matrices are meant to indicate when the effect occurs and do not imply how long the effect will last. The duration of the effect is assessed in Section 7.3.3.

- • Potential project-environment interaction
- ■ Measurable change
- ◆ Residual adverse effect
- Blank No potential interaction

7.3.3 Significance of Residual Adverse Effects

As described in Section 7.3.2, three residual adverse effects of the DGR Project on surface water quantity and flow VECs were identified:

- 31% reduction in surface water quantity and flow in the North Railway Ditch upstream of Stream C attributed to reduction in drainage area from the construction of the stormwater management system;
- 114% increase during the site preparation and construction phase in surface quantity and flow in the drainage ditch at Interconnecting Road attributed to increase in drainage area from the construction of the stormwater management system and the shaft sump pumping; and
- 61% increase during the operations phase in surface quantity and flow in the drainage ditch at Interconnecting Road attributed to increase in drainage area from the construction and operation of the stormwater management system and the shaft sump pumping.

No residual adverse effects were identified for surface water quality.

The criteria used for judging and describing the significance of effects are shown in Table 7.1-1. Significance is rated using these criteria and the magnitude criteria applicable to surface water quantity and flow shown in Table 7.3.3-1.

Table 7.3.3-1: Effects Levels for Assigning Magnitude for Surface Water Quantity and Flow

VEC	Magnitude Level Definition		
	Low	Medium	High
Surface Water Quantity and Flow	15 to 50% change (increase or decrease) [a]	50 to 100% increase or 50 to 75% decrease [a]	>100% increase or >75% decrease[a]

Note:
a Change measured as percent change from mean annual flow

The level of significance is assigned by using a decision tree model illustrated in Figure 7.3.3-1. Firstly, magnitude, geographic extent, timing and duration, frequency, and degree of irreversibility are combined to identify an environmental consequence. Then the social and/or ecological importance of the VEC being affected is considered to determine significance. This decision tree is specific to hydrology and surface water quality and the effects level criteria defined in Tables 7.1-1 and 7.3.3-1. Some of the guiding principles are:

- all effects within the natural variability of the water body (i.e., low magnitude) would result in a low environmental consequence and would not be considered significant;
- generally, effects that are limited to the Site Study Area (i.e., low extent) or are evident only during the site preparation and construction phase (i.e., low timing and duration) result in a low environmental consequence and would not be considered significant; and

- effects with a high magnitude and extent would result in a high environmental consequence and may be considered significant.

A residual adverse effect can be determined to be:

- not significant;
- may not be significant; or
- significant.

An effect that "may not be significant" is one that in the professional judgement of the specialists would not be significant; however, follow-up monitoring should be implemented to confirm significant adverse effects do not occur.

As shown in Table 7.3.3-2, and based on the decision flow shown in Figure 7.3.3-1, even though the magnitude level was assessed as high, the increase in flow at the Interconnecting Road during site preparation and construction was assessed to be not significant because of the low geographic extent and the low timing and duration.

The increase in flow at the Interconnecting Road during operations was assessed to be not significant because of the medium magnitude and low geographic extent (see Figure 7.3.3-1). These effects are expected to have a medium duration because the operation of the system will occur during the operations phase. However, the frequency is expected to be medium because the effect will only be observed during certain times (i.e., high flow events caused by summer storm or snowmelt runoff).

The decrease in flow in the North Railway Ditch is assessed to be not significant because of the low magnitude.

All changes in flow are not expected to be measurable in Lake Huron beyond the point of discharge.

Figure 7.3.3-1: Determination of Significance of Residual Adverse Effects for Hydrology and Surface Water Quality VECs

Table 7.3.3-2: Summary of Residual Adverse Effects and Significance Levels for Hydrology and Surface Water Quality

Residual Adverse Effect	Magnitude	Geographic Extent	Timing and Duration[a]	Frequency	Degree of Irreversibility	Overall Assessment
Surface Water Quantity and Flow						
Increased Flow in drainage ditch at Interconnecting Road (during site preparation and construction)	**High** • >100% increase	**Low** • Effect is limited to the Site Study Area	**Low** • Effect occurs during the site preparation and construction phase	**Medium** • Conditions causing the effect occur several times per month	**Medium** • Effect is reversible with time	**Not significant**
Increased Flow in drainage ditch at Interconnecting Road (during operations)	**Medium** • 50 to 100% increase	**Low** • Effect is limited to the Site Study Area	**Medium** • Effect occurs during the operations phase	**Medium** • Conditions causing the effect occur several times per month	**Medium** • Effect is reversible with time	**Not significant**
Decreased Flow in North Railway Ditch	**Low** • 15% to 50% change in flow (decrease)	**Low** • Effect is limited to the Site Study Area	**High** • Effect extends beyond the operations phase	**Medium** • Conditions causing the effect occur several times per month	**Medium** • Effect is reversible with time (i.e., the drainage system will be removed prior to abandoning the DGR)	**Not significant**

Note:
a The duration in the above table is based on the magnitudes of the identified effects. For example, a high magnitude is predicted during the site preparation and construction phase. Therefore, the duration for this effect (i.e., the effect of a high magnitude) is low. In a similar manner, activities during the operations phase are predicted to have a medium magnitude on surface water quantity and flow. Because these occur during the operations phase, these effects (i.e., the effects of a medium magnitude) were assigned a medium duration.

7.4 TERRESTRIAL ENVIRONMENT

The terrestrial environment comprises thirteen VECs, as presented in Section 5.3. The VECs have been grouped for discussion by plants (i.e., eastern white cedar, heal-all, common cattail), mammals (i.e., northern short-tailed shrew, muskrat, white-tailed deer), herpetofauna (i.e., midland painted turtle, northern leopard frog) and birds (i.e., mallard, red-eyed vireo, wild turkey, yellow warbler, bald eagle). The results of the terrestrial assessment are summarized in Section 7.4.2.4. The existing environmental features are described in Section 6.4 and the Terrestrial Environment TSD.

7.4.1 Screening to Focus the Assessment

Where a mechanism for interaction with terrestrial environment VECs is identified, the individual project work or activity is advanced for further consideration of measurable changes. Where no potential interaction is identified, no further screening or assessment is conducted. The analyses are based on qualitative data, as well as the professional judgement and experience of the EA team with regard to the physical and operational features of the project and their potential interactions with the environment. To determine likely direct measurable changes, a judgement was made using qualitative and quantitative information, as available. For the purposes of the terrestrial environment, the thresholds provided in Table 7.4.1-1 provide the criteria for a measurable change to VECs.

Table 7.4.1-1: Terrestrial Environment Criteria for Measurable Change

VEC	Criteria for Measurable Change
Eastern White Cedar	Loss of some trees at a few locations; reduction in conifer forest type by >5% or mixedwoods forest type by >10 % in the Project Area compared with baseline
Heal-all	Loss of >50% of the plants in the Project Area
Common Cattail	Loss of >50% of the plants in the Project Area
Northern Short-tailed Shrew	Relocation or loss of a few animals (>25)
Muskrat	Mortality increase of several individuals (>3 per year) resulting in a noticeable change in the local population, relocation or avoidance of suitable habitat by individuals in the local population
White-Tailed Deer	Mortality of several individuals (>3 per year) resulting in a noticeable change in the local population, relocation or avoidance of suitable habitat by individuals in the local population
Red-eyed Vireo	Avoidance/relocation or mortality of a number of individuals resulting in a noticeable change in the local population
Wild Turkey	Mortality increase of several individuals (>5 per year) resulting in a noticeable change in the local population, relocation or avoidance of suitable habitat by several individuals in the local population
Yellow Warbler	Avoidance/relocation or mortality of a number of individuals resulting in a noticeable change in the local population

Table 7.4.1-1: Terrestrial Environment Criteria for Measurable Change (continued)

VEC	Criteria for Measurable Change
Mallard	Loss of foraging habitat (>5%) associated with wetland edges or open water
Bald Eagle	Loss of nesting habitat or winter foraging opportunities
Midland Painted Turtle	Mortality increase of a few individuals (>2 per year), relocation or avoidance of suitable habitat by individuals in the local population
Northern Leopard Frog	Mortality increase of several individuals (>5 per year) resulting in a noticeable change in the local population, relocation or avoidance of suitable habitat by several individuals in the local population

7.4.1.1 Plant Species

Direct Interactions and Measurable Changes

Site preparation involves land clearance and preparation of construction laydown areas. The removal of brush and trees and transfer by truck to on-site storage completed as part of site preparation has the potential to interact with terrestrial plant species VECs as a result of their physical removal. Therefore there is a potential interaction between site preparation work and activity and terrestrial plant species (i.e., eastern white cedar, heal-all, common cattail).

The land to be cleared for the DGR Project, including construction laydown areas, will total approximately 30 ha, all of which is located exclusively in the Project Area. The amount of vegetation to be removed during site preparation and the percentage of ELC communities within the Project Area that would be lost as a result of that clearing are summarized in Table 7.4.1-2.

Table 7.4.1-2: Areas of Vegetation Removal and Percentage Change in ELC Communities in the Project Area and Site Study Area

ELC Community	Baseline Extent in Project Area (ha) (2009)	Baseline Extent in Site Study Area (ha) (2009)	Vegetation Removal Area (ha)	% Change in Project Area	% Change in Site Study Area
Cultural Barren	12.7	73.9	0	None	None
Cultural Grasslands	0	25.1	0	None	None
Cultural Meadow	8.1	45.4	0	None	None
Cultural Thicket	0	4.7	0	None	None
Industrial Barren	30.1	187.0	21.7	**-72**	**-12**
Industrial Land	17.2	280.7	0	None	None
Total Cultural	**68.1**	**616.8**	**21.7**	**-32**	**-4**

Table 7.4.1-2: Areas of Vegetation Removal and Percentage Change in ELC Communities in the Project Area and Site Study Area (continued)

ELC Community	Baseline Extent in Project Area (ha) (2009)	Baseline Extent in Site Study Area (ha) (2009)	Vegetation Removal Area (ha)	% Change in Project Area	% Change in Site Study Area
Alvar, Shrub	0	0.6	0	None	None
Beach/Bar, Open	0	72.7	0	None	None
Beach/Bar, Shrub	0	0.7	0	None	None
Beach/Bar, Treed	0	6.8	0	None	None
Forest, Conifer	5.5	174.6	0	None	None
Forest, Mixedwoods	11.5	78.5	8.9	**-77**	**-11**
Forest, Deciduous	6.7	43.7	0	None	None
Aquatic, Open	0	2.5	0	None	None
Swamp, Deciduous	0	4.9	0	None	None
Swamp, Mixedwoods	3.1	15.3	0	None	None
Swamp, Thicket	0	3.2	0	None	None
Marsh, Meadow	0.9	3.4	0	None	None
Marsh, Shallow	0	11.0	0	None	None
Total Natural	**27.7**	**417.9**	**8.9**	**-32**	**-2**

Considering the location of the land clearing activities, the following plant species VECs may be affected: eastern white cedar and heal-all. This mixedwoods forest removal represents a loss of 77% of the area covered by this plant community within the Project Area (a decrease of 11% in the Site Study Area). A 77% loss of a single vegetation type community within the Project Area would be considered to be a measurable change to eastern white cedar, and land clearing as part of the site preparation activities has been forwarded for assessment.

Heal-all is found in open woodland, meadows, pastures, waste areas, roadsides, lawns, and around buildings. Due to its ability to grow in many different habitats, including previously disturbed areas, it is expected that heal-all will regrow in the Project Area after the disturbance and there will not be a measurable change to this VEC. Therefore, no further consideration is warranted.

A potential interaction with common cattail in the North and South Railway Ditches is anticipated during construction. However, activities within the North and South Railway Ditches are limited to installation of a crossing and associated culvert, which will only cause a small amount of temporary disturbance to the existing plants species and communities found in this feature. After completion of construction activities, naturalization of this feature to baseline conditions will occur. Accordingly, no measurable change to common cattail is identified and no further consideration is warranted.

No interactions are identified between plant species VECs and the following works and activities, as there is no additional removal or alteration of habitat associated with these works and activities:

- construction of surface facilities;
- excavation and construction of underground facilities;
- above-ground transfer of waste;
- underground transfer of waste;
- decommissioning of the DGR Project;
- abandonment of the DGR facility;
- presence of the DGR Project;
- waste management;
- support and monitoring of DGR life cycle; and
- workers, payroll and purchasing.

Indirect Interactions and Measurable Changes

Changes in air quality have the potential to interact with plant species VECs. As shown in Table 7.4.1-3, changes in air quality at the ecological receptor locations (see Figure 7.4.1-1) may occur from increases in nitrogen dioxide (NO_2) and suspended particulate matter (SPM) emissions during the site preparation and construction phase and the operations phase of the DGR Project.

Table 7.4.1-3: Likely Measurable Changes in Air Quality at Ecological Receptors

Indicator	Maximum Existing Concentrations (µg/m³)	Site Preparation and Construction Phase		Operations Phase	
		Maximum Concentrations (µg/m³)	Measurable Change?	Maximum Concentrations (µg/m³)	Measurable Change?
1-hour NO_2	81.6	499.5	**Yes**	184.0	**Yes**
24-hour NO_2	22.9	154.1	**Yes**	96.8	**Yes**
Annual NO_2	7.1	32.6	**Yes**	11.1	**Yes**
1-hour SO_2	133.9	133.9	No	133.9	No
24-hour SO_2	40.5	40.6	**Yes**	40.5	No
Annual SO_2	5.7	5.8	**Yes**	5.8	**Yes**

Table 7.4.1-3: Likely Measurable Changes in Air Quality at Ecological Receptors (continued)

Indicator	Maximum Existing Concentrations (µg/m³)	Site Preparation and Construction Phase		Operations Phase	
		Maximum Concentrations (µg/m³)	Measurable Change?	Maximum Concentrations (µg/m³)	Measurable Change?
24-hour SPM	63.3	182.5	**Yes**	63.5	**Yes**
Annual SPM	25.0	46.5	**Yes**	25.1	**Yes**

Note: The above numbers do not include predications at ER5 (currently industrial barren) where the waste rock management area is to be located.
Source: Appendix J to the Atmospheric Environment TSD

Since measurable changes have been identified, the potential effect of changes in air quality on plant species VECs is forwarded for assessment in Section 7.4.2.1.

Changes in surface water quantity and flow could potentially interact with those plant species VECs that reside in or around the waterbodies and wetlands on-site. This includes common cattail and eastern white cedar. Section 7.3.2.1 identifies an adverse effect to surface water quantity and flow in the North Railway Ditch, upstream of the confluence with Stream C. These changes may affect common cattail, but would not affect eastern white cedar as they are remotely located from the affected features. Hence, the potential effect of this measurable change in surface water quantity and flow on common cattail is advanced for assessment in Section 7.4.2.1.

Changes in surface water quality could also potentially interact with common cattail and eastern white cedar. The assessment of surface water quality in Section 7.3.2.2 concluded that taking stormwater management into account, no adverse effects on surface water quality are expected as a result of the DGR Project. Accordingly, there is no potential for a measurable change to common cattail or eastern white cedar. No further consideration is warranted. Additionally, the increase in hardened surfaces associated with parking areas and potential new access roads will require an increase in the amount of road safety salt applied during winter months, which has the potential to be transferred to the terrestrial environment though water running off of roads. This increase is not expected to measurably change plant species or communities, because of the resilience of species encountered in surrounding features, and has therefore not been advanced for further consideration.

Changes in soil quality could indirectly interact with plant species VECs. As discussed in Section 7.2.1.1, no adverse effects were identified in for soil quality as a result of the DGR Project. Accordingly, there is no potential for measurable indirect changes to the plant species VECs through this pathway, and no further consideration is warranted.

Eastern white cedar is common in the forested swamp communities within the Project Area. It was identified that a potential pathway of effect may exist between groundwater flow and eastern white cedar if the water level in the swamp community was dependent on groundwater levels. However, the wetland communities within the Project Area appear to be maintained by seasonal and surface water flow. Therefore, this interaction is not considered further.

There are no expected indirect interactions with plant species as a result of changes in noise levels, light levels and groundwater quality. Therefore, these are not considered further.

7.4.1.2 Mammals

Direct Interactions and Measurable Changes

Vegetation removal during site preparation may interact with habitat utilization of northern short-tailed shrew, muskrat and white-tailed deer. However, no vegetation communities supporting northern short-tailed shrew and muskrat sheltering, foraging, or nesting activities will be removed during site preparation; therefore, a measurable change is not anticipated. The optimum habitat for white-tailed deer is a mixture of open areas and young forest with suitable cover, which is well-represented in the Site Study Area. While 8.9 ha of mixedwoods forest will be removed during site preparation (Table 7.4.1-2), this is a small area which represents only 11.4% of this type of habitat available for sheltering and foraging within the Site Study Area. Accordingly, no measurable changes to habitat utilization opportunities are expected, and in turn, white-tailed deer are not likely to relocate. No further consideration is warranted.

The above-ground transfer of waste by transport truck and traffic associated with workers, payroll and purchasing have the potential to directly interact with northern short-tailed shrew, muskrat and white-tailed deer as a result of increased vehicle strikes. The required project workforce is expected to be largest during the site preparation and construction phase. Up to 313 staff will be required for completion of the site preparation and construction phase works and activities, which will result in peak hour volume of 218 car trips associated with workers travelling to and from the site [393]. In the context of the workforce on the Bruce nuclear site, peak workforce requirement contributes very little to the overall Bruce nuclear site traffic. This increase in project-related vehicles may result in a small increase in northern short-tailed shrew and muskrat mortality (less than 25 and three individuals, respectively); however, this increase is considered to be negligible since the loss of a few individuals will not affect the local populations. Therefore, no direct measurable change to northern short-tailed shrew and muskrat populations is anticipated.

Table 7.4.1-4 shows the number of white-tailed deer collisions with vehicles recorded on the Bruce nuclear site for the years 2002 through 2006. Based on these data, the annual average collision rate between white-tailed deer and on-site vehicles is calculated to be 3.3 per million vehicles. Potential vehicle strikes with white-tailed deer associated with the above ground transfer of waste is expected to be minimal as this activity involves the movement of vehicles over a distance of 200 to 250 m between the WWMF and the DGR at low speeds. The traffic associated with workers, payroll and purchasing is also expected to be negligible compared to the existing traffic on-site. Therefore, no measurable change in white-tailed deer populations is anticipated and no further assessment is warranted.

0 250 500 1,000

Metres

LEGEND

- Ecological Receptor
- Project Area (OPG-retained lands that encompass the DGR Project)
- Site Study Area [1]

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc.,
Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m,
Datum: NAD 83 Projection: UTM Zone 17N

PROJECT

DGR PROJECT
ENVIRONMENTAL IMPACT STATEMENT

TITLE

LOCATION OF ECOLOGICAL RECEPTORS

Golder Associates
Mississauga, Ontario

PROJECT No. 06-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	17 Oct. 2007	**FIGURE 7.4.1-1**	
GIS	BC	20 Apr. 2010		
CHECK	KC	20 Apr. 2010		
REVIEW	AB	20 Apr. 2010		

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Table 7.4.1-4: Number and Average White-tailed Deer – Vehicle Collisions on Roadways Within the Bruce Nuclear Site (Site Study Area)

White-tailed Deer – Vehicle Collisions	Number of Collisions with White-tailed Deer						Average Annual Collision Rate [a]
	2002	2003	2004	2005	2006	Average	
Total	8	7	7	5	9	7.2	3.3
Injury	3	3	7	3	7	4.6	2.1
Fatality	5	4	0	2	2	2.6	1.2

Note:
a The collision rate is defined as the number of collisions occurring per million vehicles entering the Bruce nuclear site. Since detailed records of the exact location of each strike are not kept, a conservative estimate of collision rates was determined by dividing the average number of collisions within the Bruce nuclear site (2002-2006) by the number of vehicles entering the Main Gate intersection (2.2 million entering Tie Road at Main Gate). The majority of traffic that enters the Bruce nuclear site does so through the Main Gate.
Source: [394]

Decommissioning of the DGR Project involves the demolition of the surface facilities associated with operations phase of the project. This work and activity may potentially interact with northern short-tailed shrew. Northern short-tailed shrew may utilize the built environment habitat provided by the surface facilities for marginal shelter and forage opportunities. However, northern short-tailed shrew would continue to rely on primarily cultural vegetation communities to support itself. Accordingly, no measurable changes to habitat utilization opportunities, and in turn, northern short-tailed shrew populations are anticipated to occur as a result of decommissioning. No further consideration is warranted.

No interactions are identified between mammal species VECs and the following works and activities, as there is no additional removal or alteration of habitat associated with these works and activities:

- construction of surface facilities;
- excavation and construction of underground facilities;
- underground transfer of waste;
- abandonment of DGR facility;
- presence of the DGR Project;
- waste management; and
- support and monitoring of DGR life cycle.

Indirect Interactions and Measurable Changes

Changes in air quality have the potential to interact with all mammal VECs. Changes in air quality at the ecological receptors are shown in Table 7.4.1-5. Increase in nitrogen dioxide (NO_2) and suspended particulate matter (SPM) emissions were identified during the site preparation and construction phase and the operations phase of the DGR Project. Therefore, this measurable change in air quality is advanced for assessment of effects on northern short-tailed shrew, muskrat and white-tailed deer.

Changes in noise levels have the potential to indirectly interact with northern short-tailed shrew, muskrat and white-tailed deer. Increases in noise levels at the ecological receptor locations were identified during the site preparation and construction, and operations phases. Noise levels during the decommissioning phase are expected to be similar to the site preparation and construction phase. Predicted changes in linear noise levels (as dB_{lin}) are summarized in Table 7.4.1-5. The locations of ecological receptors are shown on Figure 7.4.1-1. For the purpose of this study, it is assumed that a change of 3 dB or more in linear noise levels is likely to produce a measureable change to wildlife. Only receptors that experienced changes in linear noise levels of more than 3 dB are considered to experience measurable changes. Therefore, measurable changes in noise levels affecting the mammal species VECs have been forwarded to the assessment in Section 7.4.2.2.

Table 7.4.1-5: Likely Measurable Changes in Noise Levels at Ecological Receptors

Receptor	Ambient Noise Levels During the Site Preparation and Construction Phase (dB_{lin})	Existing Noise Levels (dB_{lin})	Project-related Change Relative to Existing Noise Levels (dB)	Measurable Change?
Site Preparation and Construction Phase				
ER1	69	68	+1	No
ER2	72	71	+1	No
ER3	71	61	+10	**Yes**
ER4	85	65	+20	**Yes**
ER5	80	67	+13	**Yes**
ER6	73	67	+6	**Yes**
ER7	74	70	+4	**Yes**
Operations Phase				
ER1	68	68	0	No
ER2	71	71	0	No
ER3	64	61	+3	No
ER4	68	65	+3	No
ER5	73	67	+6	**Yes**
ER6	69	67	+2	No
ER7	71	70	0	No

Source: Appendix J to the Atmospheric Environment TSD

Increases in light levels at the ecological receptor locations were identified during the site preparation and construction, and operations phases. Light levels during the decommissioning phase are expected to be similar to the site preparation and construction phase. Therefore, measurable changes in light levels affecting the mammal species VECs have been forwarded to the assessment of effects in Section 7.4.2.2.

Changes in surface water quantity and flow could indirectly interact with mammal species VECs that depend on open bodies of water for at least a portion of their life cycle (i.e., muskrat) and those that require water to drink (northern-short-tailed shrew, white tailed deer). The assessment of surface water quantity and flow was completed in Section 7.3.2.1. Measurable changes in flow in the North Railway Ditch and drainage ditch to MacPherson Bay were identified, and are advanced to determine any adverse effects mammal species VECs.

Changes in surface water quality could indirectly interact with all of the mammal species VECs. The assessment on surface water quality was completed in Section 7.3.2.2. It was concluded that taking stormwater management into account, no adverse effects on water quality are expected as a result of the DGR Project. Accordingly, there is no potential for measurable indirect changes to mammal species VECs via the surface water quality pathway and no further consideration is warranted.

Changes in soil/sediment quality could indirectly interact with mammal species VECs through contact with the soil, burrowing in the soil or consuming species that come in direct contact with the soil (e.g., earthworms). The assessment on soil quality was completed in Section 7.2.1.1. No measurable changes were identified for soil quality as a result of the DGR Project. Accordingly, there is no potential for measurable indirect effects to the mammal species VECs through this pathway, and no further consideration is warranted.

There are no expected indirect interactions with mammal species VECs as a result of changes in groundwater quality and groundwater flow. Therefore, these are not considered further.

7.4.1.3 Herpetofauna

Direct Interactions and Measurable Changes

Site preparation will result in vegetation removal and may interact with herpetofauna VECs (i.e., midland painted turtle and northern leopard frog) because of limiting habitat utilization opportunities. Table 7.4.1-2 shows that no vegetation communities (i.e., marsh, open water, and grassy fields) key to supporting herpetofauna sheltering, foraging, or breeding activities will be removed during site preparation. As shown in Figure 6.4.3-1, the DGR Project site is not located adjacent to the majority of wetland (marsh, swamp, open water) communities within the Site Study Area where breeding is expected to be most intense. Accordingly, no measurable changes to habitat utilization opportunities, and in turn, herpetofauna populations are anticipated to occur as a result of site preparation. No further consideration is warranted.

Above ground transfer of waste and workers, payroll and purchasing works and activities may interact with herpetofauna VECs because of injury/mortality from vehicle strikes. Road-related mortality is an important consideration for both midland painted turtle and northern leopard frog largely because of their terrestrial nature, which involves excursions during migration or movements overland between one body of water and another. Potential vehicle strikes associated with the above ground transfer of waste is expected to be minimal as this activity involves the movement of vehicles over a distance of 200 to 250 m between the WWMF and the DGR at low speeds. For this reason, the above ground transfer of waste is not forwarded for further consideration. Up to 313 staff will be required for completion of the site preparation and construction phase works and activities, which will result in peak hour volume of 218 car trips per peak hour associated with workers travelling to and from the site [393]. Although herpetofauna travel through terrestrial areas, this migration is performed to get from one wetland area to another. Large wetland areas exist east of the DGR Project Area and the assumed access route does not bisect the two wetland areas that they could be travelling between. Therefore, vehicle collisions may affect individual animals, but will have a negligible effect upon the local population of herpetofauna. Accordingly, no further consideration is warranted.

No interactions are identified between herpetofauna VECs and the following works and activities, as there is no additional removal or alteration of habitat associated with these works and activities:

- construction of surface facilities;
- excavation and construction of underground facilities;
- underground transfer of waste;
- decommissioning of the DGR Project;
- abandonment of DGR facility;
- presence of the DGR Project;
- waste management; and
- support and monitoring of DGR life cycle.

Indirect Interactions and Measurable Changes

Changes in air quality have the potential to interact with midland painted turtle and northern leopard frog. Changes in air quality at the ecological receptors are shown in Table 7.4.1-3. Increase in nitrogen dioxide (NO_2) and suspended particulate matter (SPM) concentrations are identified during the site preparation and construction phase and the operations phase of the DGR Project. Therefore, this measurable change in air quality is advanced to Section 7.4.2.2 for assessment of effects on midland painted turtle and northern leopard frog.

Changes in noise levels have the potential to indirectly interact with midland painted turtle and northern leopard frog. Increases in noise levels at the ecological receptor locations are identified during the site preparation and construction, and operations phases in Table 7.4.1-5. Noise levels during the decommissioning phase are expected to be similar to the site preparation and construction phase. Therefore, measurable changes in noise levels affecting midland painted turtle and northern leopard frog have been forwarded for the assessment in Section 7.4.2.2.

Increases in light levels at the ecological receptor locations were identified during the site preparation and construction, and operations phases, as described in Appendix H of the Atmospheric Environment TSD. Light levels during the decommissioning phase are expected to be similar to the site preparation and construction phase. Therefore, measurable changes in light levels affecting the herpetofauna VECs have been forwarded in the assessment.

Changes in surface water quantity and flow could indirectly interact with VECs which depend on open bodies of water for at least a portion of their life cycle (i.e., midland painted turtle and northern leopard frog). The assessment of surface water quantity and flow was completed in Section 7.3.2.1. Measurable changes in flow in the North Railway Ditch and drainage ditch to MacPherson Bay were identified, and are advanced to determine any adverse effects to midland painted turtle and northern leopard frog.

Changes in surface water quality could indirectly interact with the midland painted turtle and northern leopard frog. The assessment on surface water quality was completed in Section 7.3.2.2. It was concluded that taking stormwater management into account, no adverse effects on water quality are expected as a result of the DGR Project. Accordingly, there is no potential for measurable indirect change to midland painted turtle and northern leopard frog via the surface water quality pathway and no further consideration is warranted.

Changes in soil quality could indirectly interact with VECs through contact with soil. The assessment on soil quality was completed in Section 7.2.1.1. No measurable changes are identified for soil quality as a result of the DGR Project. Accordingly, there is no potential for measurable indirect effects to midland painted turtle and northern leopard frog through this pathway, and no further consideration is warranted.

The diets of midland painted turtle consist of aquatic species represented by the VECs selected in the Aquatic Environment TSD. There are residual adverse effects predicted for redbelly dace, creek chub, burrowing crayfish and variable leaf pondweed in the aquatic assessment. However, the residual adverse effects were determined to be of a low consequence, limited to the South Railway Ditch, and not significant. Therefore, the effects on terrestrial environment VECs would not be measurable, and is not considered further.

There are no expected indirect interactions with herpetofauna VECs as a result of changes in groundwater quality and groundwater flow. Therefore, these are not considered further.

7.4.1.4 Birds

Direct Interactions and Measurable Changes

Site preparation will result in vegetation removal and may interact with all bird species VECs (i.e., mallard, red-eyed vireo, wild turkey, yellow warbler, bald eagle) because of limiting habitat utilization opportunities. Table 7.4.1-2 shows that no vegetation communities key to supporting sheltering, foraging, or breeding activities of mallard, yellow warbler and bald eagle will be removed during site preparation. Accordingly, no measurable changes to habitat utilization opportunities, and in turn, mallard, yellow warbler and bald eagle populations are anticipated to occur as a result of site preparation. No further consideration is warranted. However, 8.9 ha of mixed forest are scheduled to be removed as part of the site preparation activities, which accounts for a removal of 77% of the mixed forest in the Project Area (11% in the Site Study Area). This habitat may be utilized by red-eyed vireo and wild turkey. Therefore, a measurable change to red-eyed vireo and wild turkey is forwarded for assessment in Section 7.4.2.2.

Above ground transfer of waste may interact with the wild turkey and mallard VECs because of injury/mortality from vehicle strikes. Potential vehicle strikes associated with the above ground transfer of waste is expected to be minimal as this activity involves the movement of vehicles over a distance of 200 to 250 m between the WWMF and the DGR at very low speeds. For this reason, the above ground transfer of waste has not been forwarded for further consideration.

Workers, payroll and purchasing works and activities may interact with all bird species VECs because of injury/mortality from vehicle strikes. While a few individuals could be lost because of project-related vehicle strikes, it will have a negligible effect upon the local populations of the bird species VECs. Accordingly, no further consideration is warranted.

Birds can collide with buildings due to confusion with the lighting and/or glass reflection. The proposed surface facilities to be constructed on site are shaft headframes, exhaust fans, intake fans and heaters. These structures are not expected to be reflective. Therefore, bird injury/mortality due to collision with the buildings on the DGR Project site is not expected to cause a measurable change to the local population and is not considered further.

No interactions are identified between bird species VECs and the following works and activities, as there is no additional removal or alteration of habitat associated with these works and activities:

- excavation and construction of underground facilities;
- underground transfer of waste;
- decommissioning of the DGR Project;
- abandonment of DGR facility;
- presence of the DGR Project;
- waste management; and
- support and monitoring of DGR life cycle.

Indirect Interactions and Measurable Changes

Changes in air quality have the potential to interact with all bird species VECs. Changes in air quality at the ecological receptors are shown in Table 7.4.1-3. Increase in nitrogen dioxide (NO_2) and suspended particulate matter (SPM) emissions were identified during the site preparation and construction phase and the operations phase of the DGR Project. Therefore, this measurable change in air quality is advanced for assessment of effects on bird species VECs.

Changes in noise levels have the potential to indirectly interact with all bird species VECs. Increases in noise levels at the ecological receptor locations were identified during the site preparation and construction, and operations phases in Table 7.4.1-5. Noise levels during the decommissioning phase are expected to be similar to the site preparation and construction phase. With the exception of the bald eagle, all of the bird species VECs are known to be at least semi-permanently found within the Site Study Area. Therefore, this indirect project-environment interaction is likely to result in a measurable displacement of and/or disruption to birds in the Site Study Area (i.e., mallard, red-eyed vireo, wild turkey, yellow warbler) and is advanced for assessment of effects.

Increases in light levels at the ecological receptor locations were identified during the site preparation and construction, and operations phases. Light levels during the decommissioning phase are expected to be similar to the site preparation and construction phase. These changes in light levels may cause VECs to change their habitat use (e.g., avoidance). Therefore, measurable changes in light levels affecting the bird species VECs have been forwarded to the assessment in Section 7.4.2.2.

Changes in surface water quantity and flow could indirectly interact with VECs which depend on open bodies of water for at least a portion of their life cycle (i.e., mallard, wild turkey, yellow warbler). The assessment of surface water quantity and flow was completed in Section 7.3.2.1. Measurable changes in flow in the North Railway Ditch and drainage ditch to MacPherson Bay were identified, and are advanced to determine any adverse effects to mallard, wild turkey and yellow warbler.

Changes in surface water quality could indirectly interact with all bird species VECs. The assessment on surface water quality was completed in Section 7.3.2.2. It was concluded that taking stormwater management into account, no adverse effects on water quality are expected as a result of the DGR Project. Accordingly, there is no potential for indirect change to bird species VECs via the surface water quality pathway and no further consideration is warranted.

Changes in soil quality could indirectly interact with all bird species VECs. The assessment on soil quality was completed in Section 7.2.1.1. No measurable changes were identified for soil quality as a result of the DGR Project. Accordingly, there is no potential for measurable indirect effects to all bird species VECs through this pathway, and no further consideration is warranted.

Wild turkeys rely on groundwater seeps/springs in forested swamp communities as winter foraging areas and as such a potential pathway of effects was determined. However, the wetland communities within the Project Area appear to be maintained by seasonal and surface water flow. Additionally, the Geology TSD does not predict a change in groundwater flow regimes; therefore, this potential interaction is not considered further.

The diets of eagle and mallard consist of aquatic species represented by the VECs selected in the Aquatic Environment TSD. There are residual adverse effects predicted for redbelly dace, creek chub, burrowing crayfish and variable leaf pondweed in the aquatic assessment. However, the residual adverse effects were determined to be of a low consequence, limited to the South Railway Ditch, and not significant. Therefore, the effects on terrestrial environment VECs would not be measurable, and is not considered further.

There are no expected indirect interactions with birds VECs as a result of changes in groundwater quality. Therefore, these are not considered further.

7.4.2 Identification and Assessment of Effects

Terrestrial environment VECs were screened for measurable change as a result of the DGR Project, as described above. The following measurable changes were identified:

- direct measurable change to eastern white cedar, red-eyed vireo and wild turkey as a result of vegetation removal during site preparation;

- indirect measurable change to all terrestrial species VECs as a result changes in air quality during the site preparation and construction, operations, and decommissioning phases;
- indirect measurable changes to common cattail, northern short-tailed shrew, muskrat, white-tailed deer, midland painted turtle, northern leopard frog, mallard, wild turkey and yellow warbler as a result of changes in surface water quantity and flow during the site preparation and construction, operations and decommissioning phases of the DGR Project;
- indirect measurable changes to all mammal, herpetofauna and bird species (excluding bald eagle) VECs as a result of changes in noise levels during all phases of the DGR Project; and
- indirect measurable changes to all mammal, herpetofauna and bird species VECs as a result of changes in light levels during all phases of the DGR Project.

No other measurable changes to the terrestrial environment were identified. These effects are assessed in the following sections.

7.4.2.1 Plant Species

Linkage Analysis

As part of the screening process, site preparation activities were determined to have a likely measurable change to the plant species and communities located within the DGR Project site (i.e., eastern white cedar, heal-all). Measurable indirect changes in air quality and surface water quantity and flow were identified as having a potential effect on plant species VECs.

Changes in these plant species VECs may interact with wildlife VECs that use the habitat.

Likely Effects

For plant species VECs, changes between baseline values and predicted values that result in local extirpation or large changes in population values are considered adverse and lead to recommendations for avoidance or mitigation of those effects.

As mentioned in Section 7.4.1.1, 8.9 ha (77% of the total 11.6 ha) of Mixed Forest and 21.7 ha (72% of the total 30.1 ha) of the Industrial Barren will be removed in the Project Area. Removal of the Industrial Barren areas will result in a measurable change to heal-all; however, growing conditions for plant species within this vegetation community are very limited. Therefore, an adverse direct effect on heal-all is not expected, and is not discussed further.

The removal of Mixed Forest areas will result in a measurable change to eastern white cedar. Eastern white cedar is a common and abundant species of tree both within the designated study areas of this project and on a provincial level. This species accounts for the dominant coniferous tree cover found in both upland forested areas and lowland swamps in the Local Study Area and Regional Study Area. The removal of forested habitat within the proposed DGR Project site will be limited to forested areas isolated from larger habitat units within the Site Study Area. Higher quality contiguous forested features and swamp communities will not be cleared as part of the proposed development. However, an adverse effect on eastern white cedar is identified as a result of removal of the Mixed Forest areas.

Changes in air quality were identified as resulting in an indirect measurable change to eastern white cedar, heal-all and common cattail. As shown in Table 7.4.2-1, the maximum 1-hour NO_2 concentration during site preparation and construction phase is 125% of the potential effects threshold of 400 µg/m³. The 1-hour NO_2 exceeds the criterion of 400 µg/m³ by 99.5 µg/m³ but it is noted that this will occur less than 1% of the time during site preparation and construction. Additionally, literature indicates that effects of NO_2 on plant species are a chronic (i.e., lower concentration, long-term exposure), rather than acute (high concentration, short-term exposure) phenomenon [395] and the annual concentration of NO_2 is far below the criterion of 100 µg/m³. The maximum 24-hour SPM concentration during site preparation and construction phase is 152% of the potential ecological effects threshold of 120 µg/m³. This criterion will be exceeded only 5.5% of the time during construction and site preparation and the annual SPM is far lower than the criteria. Based upon incidental observations from past construction on the Bruce nuclear site, vegetation and individual plant species have not been noticeably affected by the airborne dust and emissions generated during on-site construction activities. In addition, some plants, such as eastern white cedar, may be sensitive to fumigations of combustion engine exhaust (e.g., NO_2).

All other indicator compounds are within the thresholds during the site preparation and construction phase. Therefore, it is unlikely that there would be an adverse effect on the plant species populations in the Site Study Area during the site preparation and construction phase, and no further consideration is warranted.

All measurable changes during the operations phase fall within regulatory criteria; therefore, it is unlikely that there would be an adverse effect on plant species during the operations phase.

Table 7.4.2-1: Maximum Predicted Concentration at Ecological Receptors During the Site Preparation and Construction Phase

Indicator	Maximum Existing Concentrations (µg/m³)	Maximum Site Preparation and Construction Phase Concentrations (µg/m³)	Maximum Operations Phase Concentrations (µg/m³)	Criteria (µg/m³)
1-hour NO_2	81.6	499.5	184.0	400 [a]
24-hour NO_2	22.9	154.1	96.8	200 [a]
Annual NO_2	7.1	32.6	11.1	100 [a]
24-hour SO_2	40.5	40.6	40.5	150 [a]
Annual SO_2	5.7	5.8	5.8	30 [a]
24-hour SPM	63.3	182.5[d]	63.5	120 [a,b,c]

Table 7.4.2-1: Maximum Predicted Concentration at Ecological Receptors During the Site Preparation and Construction Phase (continued)

Indicator	Maximum Existing Concentrations (µg/m³)	Maximum Site Preparation and Construction Phase Concentrations (µg/m³)	Maximum Operations Phase Concentrations (µg/m³)	Criteria (µg/m³)
Annual SPM	25.0	46.5	25.1	70 [a]

Notes:
a National Ambient Air Quality Objectives
b O. Reg. 419 Schedule 3
c Exceeds the criteria less than 1% of the time
d Exceeds the SPM criteria less than 5.5% of the time
Source: Appendix J, Table J1.1.1-1 of the Atmospheric Environment TSD

A measurable change was predicted for common cattail resulting from changes to surface water quantity and flow. As described in Section 7.3.2.1, a decrease in flow of approximately 31% compared with existing conditions was predicted in the North Railway Ditch. As observed during field investigations, sections of this ditch are dry during low flow conditions. Therefore, this reduction is not expected to have any effect on common cattail since this emergent species requires only wetted substrate, and can often be found growing in areas where flows and water levels fluctuate. Therefore, no adverse effect is predicted.

The increase in flow to the drainage ditch at Interconnecting Road is predicted in the Surface Water and Hydrology TSD to be 114% of the existing flows during site preparation and construction, and 61% during operations. This increase in flow will coincide with storm events and spring runoff. These are the periodic flow conditions to which the common cattails within the drainage ditch would be adapted. Therefore, no adverse effect to common cattail in the drainage ditch is predicted.

Mitigation Measures

Suitable mitigation measures to minimize the loss of both species and habitat associated with the mixed forest clearing on the DGR Project site should include a combination of several methods. Opportunities to retain tree cover could be investigated where possible. Where retention is not possible, exclusionary fencing to prevent additional loss of specimens and habitat during construction is recommended surrounding the DGR Project site within the Project Area. Generally accepted Best Management Practices (BMPs) for construction would be used to minimize the transfer of soils from the DGR Project site area to natural features within the Project Area and Site Study Area. Rehabilitation after decommissioning of the DGR Project may include both active and passive naturalization of the Project Area to provide additional suitable habitat.

Residual Adverse Effects

As the mitigation measures will not sufficiently reduce or eliminate the effect of site preparation below the measurable change criterion, there is a residual adverse effect of the DGR Project on eastern white cedar. This is advanced for an assessment of significance in Section 7.4.3.

7.4.2.2 Wildlife Species

Mammal species, herpetofauna and bird species VECs are considered together for the assessment of the effects.

Linkage Analysis

The evaluation of the effects of the DGR Project on the wildlife species VECs used the changes in habitat availability and suitability, and changes in distribution of species to measure project effects.

Site preparation was identified as resulting in a direct measurable change to those VECs known to use mixed wood forest in the Project Area (i.e., red-eyed vireo, wild turkey). Changes in light levels and air quality were identified as causing an indirect effect on all of the wildlife species VECs that may be measurable. Changes in surface water quantity and flow were identified as having potential interactions with all wildlife VECs except red-eyed vireo and bald eagle. Changes in noise levels were identified as resulting in measurable changes to all wildlife VECs except the bald eagle.

Changes in the wildlife species VECs are not expected to have an interaction with any other VECs.

Likely Effects

Direct Effects

As mentioned in Section 7.4.2.1, 77% of the mixed forest within the Project Area and 11.4% of the total mixed forest area within the Site Study Area will be removed. This potential loss of habitat may affect red-eyed vireo and wild turkey as they are currently moving between habitat units within the Project Area and Site Study Area, with the large more contiguous habitat located on the uncleared portion of the Project Area and in the Site Study Area. The clearing of the mixed forest within the Project Area may result in the loss of individuals or breeding pairs of wild turkey and/or red-eyed vireo; however, it is more likely to result in the displacement of these species to other suitable habitat located within the Site Study Area. The loss of 11.4% of the mixed forest within the Site Study Area accounts for a portion of the suitable habitat for these species. Habitat preferences for these species include mixed, deciduous and coniferous forests, therefore a loss of 11.4% of the mixed forest within the Site Study Area accounts for 3% of all forests, a low portion of all available forest habitat units within the Site Study Area (i.e., <10%). This will not result in an adverse effect because it is not likely to result in local extirpation of measurable reductions in population status.

Indirect Effects of Changes in Air Quality

Changes in air quality at ecological receptors during site preparation and construction and operations phases are shown in Table 7.4.2-1, as compared to available criteria. Exceedances in 1-hour NO_2 and 24-hour SPM were identified during site preparation and construction phase and are expected to occur less than 1% and 5.5% of the time, respectively.

Animal toxicology studies suggest that peak concentrations contribute more to the toxicity of nitrogen dioxide than does duration, although duration is still important. The lowest observed adverse effects level to wildlife species for one to two hour periods is in the order of 940 µg/m³ [395]. Additionally, available data from animal toxicology experiments rarely indicate effects of acute exposure to NO_2 concentrations of less than 1,880 µg/m³ [396]. As the predicted peak 1-hour NO_2 concentration is below the lowest observed effects levels in animals, it is unlikely that there will be an adverse effect on wildlife species.

Suspended particulate matter is primarily a concern with deposition, and potential effects on vegetation. Since the majority of SPM will be too large to be inhaled, it is not expected to have an adverse effect on wildlife. Therefore, no adverse effects on wildlife species VECs are likely because of changes in air quality during site preparation and construction phase. As shown in Table 7.4.2-1, all measurable changes during the operations phase fall within regulatory criteria; therefore, it is unlikely that there would be an adverse effect on wildlife species during the operations phase.

Indirect Effects of Changes in Noise Levels

Potential adverse effects on wildlife VECs are possible because of measurable changes in noise levels at ecological receptors during the site preparation and construction phase of the DGR Project. The change in noise levels is summarized in Table 7.4.1-5. There are no provincial or federal guidelines for wildlife exposure to sound.

Habituation of wildlife to disturbance is believed to occur primarily when the disturbance is frequent, regular, and the result of identical stimulus types [397]. Therefore, it is reasonable to assume that even if species initially display an escape response to the increased disturbance that is predicted to occur in the vicinity of the DGR Project, they may habituate and resume current behaviours at the affected locations. Additionally, it is not likely that the loss of this habitat will affect local populations of VECs if disturbance proves sufficient to displace wildlife for extended periods (i.e., the complete duration of the DGR Project). If habituation does not occur and species exhibit an escape response on an on-going basis, they will most likely relocate to adjacent habitats in the Site Study Area.

The number of individuals using the built environment and adjacent areas that will be subjected to DGR Project-related increases in noise levels is limited when compared with the populations found elsewhere in the Site Study Area. It should be noted that most of the wildlife that currently range throughout the Bruce nuclear site are exposed to industrial activities including noise disturbances associated with the ongoing large-scale project for the refurbishment of units at the Bruce A generating station. Additionally, habitat exists in the Site and Local Study Areas that can accommodate displaced wildlife and are close enough to not likely require large energetic costs for animals to relocate. Therefore, changes in noise levels that may arise from the DGR Project are judged not likely to adversely affect the terrestrial environment wildlife species VECs.

Indirect Effects of Changes in Light Levels

Changes in light levels may affect all of the wildlife species VECs. Table 7.4.2-2 presents the predicted light trespass levels at the ecological receptor locations during the site preparation and construction phase, and the operations phase. The ecological receptor locations are the same as those shown in Figure 7.4.1-1.

Table 7.4.2-2: Results of Light Trespass Surveys

Location	Max Existing Level (mlx)	Max Predicted DGR Project-related Increase, During Site Preparation and Construction (mlx)	Max Predicted DGR Project-related Increase During Operations
ER1	16	0.05	4
ER2	1,424	0	59
ER3	1	1	67
ER4	22	15	340
ER5	21	4	1,241
ER6	1	1	0
ER7	82	14	227

Source: Appendix H, Table H7.2-1 of the Atmospheric Environment TSD

The results indicate modest changes to existing light levels at all ecological receptors during the site preparation and construction phase. During the operations phase, the results indicate modest changes to existing light levels at several of the ecological receptor locations. The only exceptions to this are receptors ER4, ER5 and ER7. Receptor ER4 is located in a small block of forest which will be retained as part of the proposed development within the Project Area. This location would be considered to have low levels of ambient brightness. The Commission Internationale de l'Eclairage (CIE) recommends that light trespass limits for this type of area should not exceed 1,000 mlx to maintain existing conditions [398]. The proposed increase of ambient light of 340 mlx should not result in an adverse effect to VEC species located within this habitat unit. Additionally, it is expected that the trees found in this location, which will not be affected by increases in ambient light levels, will act to shield the wildlife species at this location from some of the additional light. The potential for vegetation screening of light was not considered, as a conservative measure, in the prediction of light trespass.

Receptor ER5, which is located within an industrial barren area of the Project Area is predicted to have an increase of 1,241 mlx. This change exceeds the CIE recommended light trespass limit for areas with low ambient light; however, this area currently provides very limited habitat for VEC species. Additionally, this is the location within the Project Area that has been designated for the WRMA. Therefore, the proposed changes to light levels are not expected to have an adverse effect on VEC species.

Receptor ER7, which is located within a Cultural Barren area of the Project Area is predicted to have changes in ambient light levels of 227 mlx. This area currently provides limited habitat for tolerant species of plants and wildlife. The predicted change falls within guidelines provided for areas with low levels of ambient light. Additionally, this receptor is located at the top of a hill which would provide some shielding of light for VEC species using the habitat provided by the low ground vegetation in this area, potentially including northern short-tailed shrew.

Nighttime roosting could be interrupted by the lighting associated with the DGR Project. In addition to the above, the existing conditions within the Project Area and Site Study Area would indicate that wildlife species currently using these areas are habituated to lighting associated with human land uses. Additionally, the location of the DGR Project within the site is such that forest areas that currently provide darker nighttime roosting areas (e.g., the forest block south of Bruce B) will not be affected by lighting associated with the DGR Project. Accordingly, no adverse effect to habitat utilization opportunities, and in turn, bird species VECs populations are anticipated to occur as a result of changes in light levels. No further assessment is warranted.

Indirect Effects of Changes in Surface Water Quantity and Flow

As described in Section 7.3.2.1, measurable changes in flow are predicted as a result of redirecting drainage to MacPherson Bay. There was a predicted decrease in flow of approximately 31% in the North Railway Ditch just before the confluence with Stream C and an increase in flow to the drainage ditch, as summarized in Table 7.3.2-1. Muskrat and northern leopard frog should be able to tolerate changes in water levels. Habitat in the North Railway Ditch and drainage ditch, where flow is affected, is not suitable for mallard and midland painted turtle. Habitat occupied by wild turkey and yellow warbler will also not be affected by the changes in flow. Therefore, a measurable change in surface water quantity and flow is not expected to cause an adverse indirect effect on the wildlife species VECs and no further consideration is warranted.

Mitigation Measures

Although no adverse effects were identified, in order to protect nesting migratory birds, in accordance with the Migratory Birds Convention Act, the site preparation activities will avoid vegetation clearing during the breeding bird season (May 1 to July 31), wherever possible. If clearing cannot be scheduled outside the prime nesting season, a nest survey should be conducted to ensure there are no active nests in the trees to be felled.

Residual Adverse Effects

There are no residual adverse effects predicted for the wildlife species VECs.

7.4.2.3 Biodiversity

Within the Project Area and Site Study Area adverse effects to eastern white cedar have been identified within the Project Area, but not within the Site Study Area. This does not mean that there will be no loss of species or species habitat as part of the project; however, the effects are not considered to be measurable or to warrant mitigation measures. As the biodiversity directly correlates to increases in size of the study areas, it is expected that if there is no effect on the biodiversity within the Site Study Area, there will be no effect on the biodiversity of the Local or Regional Study Areas.

7.4.2.4 Summary of Assessment

Table 7.4.2-3 provides a summary of the assessment of the terrestrial environment VECs for the DGR Project. Diamonds (◆) on this matrix represent likely project-environment interactions resulting in a residual adverse effect on a VEC. These interactions are advanced to Section 7.4.3 for a consideration of significance. In this case, a residual adverse effect was identified for eastern white cedar.

Table 7.4.2-3: Summary of Effects Prediction and Assessment for Terrestrial Environment

Project Work and Activity	Eastern White Cedar	Heal-all	Common Cattail	Northern Short-tailed Shrew	Muskrat	White- Tailed Deer
Direct Effects						
Site Preparation	◆	•	•	•	•	•
Construction of Surface Facilities						
Excavation and Construction of Underground Facilities						
Above-ground Transfer of Waste				•	•	•
Underground Transfer of Waste						
Decommissioning of the DGR Project				•		
Abandonment of DGR Facility						
Presence of the DGR Project						
Waste Management						
Support and Monitoring of DGR Life Cycle						
Workers, Payroll and Purchasing				•	•	•
Indirect Effects						
Changes in Air Quality	■	■	■	■	■	■
Changes in Noise and/or Vibration Levels				■	■	■
Changes in Light Levels				■	■	■
Changes in Surface Water Quantity and Flow	•		■	■	■	■
Changes in Surface Water Quality	•		•	•	•	•
Changes in Soil Quality	•	•	•	•	•	•
Changes in Groundwater Quality						
Changes in Groundwater Flow	•					
Changes in Aquatic Environment VECs						

Notes:
The matrices are meant to indicate when the effect occurs and do not imply how long the effect will last.

• Potential project-environment interaction
■ Measurable change
◆ Residual adverse effect
Blank No potential interaction

Table 7.4.2-3: Summary of Effects Prediction and Assessment (continued)

Project Work and Activity	Midland Painted Turtle	Northern Leopard Frog	Mallard	Red-eyed Vireo	Wild Turkey	Yellow Warbler	Bald Eagle
Direct Effects							
Site Preparation	•	•	•	■	■	•	•
Construction of Surface Facilities			•	•	•	•	•
Excavation and Construction of Underground Facilities							
Above-ground Transfer of Waste	•	•	•		•		
Underground Transfer of Waste							
Decommissioning of the DGR Project							
Abandonment of DGR Facility							
Presence of the DGR Project							
Waste Management							
Support and Monitoring of DGR Life Cycle							
Workers, Payroll and Purchasing	•	•	•	•	•	•	•
Indirect Effects							
Changes in Air Quality	■	■	■	■	■	■	■
Changes in Noise and/or Vibration Levels	■	■	■	■	■	■	•
Changes in Light Levels	■	■	■	■	■	■	■
Changes in Surface Water Quantity and Flow	■	■	■		■	■	
Changes in Surface Water Quality	•	•	•	•	•	•	•
Changes in Soil Quality	•	•	•	•	•	•	•
Changes in Groundwater Quality							
Changes in Groundwater Flow					•		
Changes in Aquatic Environment VECs	•		•				•

Notes:
The matrices are meant to indicate when the effect occurs and do not imply how long the effect will last.

• Potential project-environment interaction
■ Measurable change
◆ Residual adverse effect
Blank No potential interaction

7.4.3 Significance of Residual Adverse Effects

As described in Section 7.4.2.1, one residual adverse effect of the DGR Project on the terrestrial environment was identified: loss of eastern white cedar in the Project Area during site preparation.

The criteria used for judging and describing the significance of the effect on eastern white cedar are shown in Table 7.1-1. Significance is rated using these criteria combined with the magnitude criteria applicable to eastern white cedar, shown in Table 7.4.3-1.

Table 7.4.3-1: Effects Levels for Assigning Magnitude for Eastern White Cedar

VEC	Magnitude Level Definition		
	Low	**Medium**	**High**
Eastern White Cedar	Loss of some trees at several locations leading to reduction in conifer woodlands by 5 to 10% or mixed woodlands by 10 to 25% in the Project Area compared with baseline	Loss of many trees at numerous locations associated with large-scale clearing of vegetation in the Project Area; reduction in conifer woodlands by >10% or mixed woodlands by >25% in the Project Area compared with baseline	Local population decrease of >25% in conifer woodlands or >40% of mixed woodlands attributed to loss of forest communities throughout the Site Study Area

The level of significance is assigned by using a decision tree model illustrated in Figure 7.4.3-1. Firstly, magnitude, geographic extent, timing and duration, frequency, and degree of irreversibility are combined to identify an environmental consequence. Then the social and/or ecological importance of the VEC being affected is considered to determine significance.

This decision tree is specific to the terrestrial environment and the effects level criteria defined in Tables 7.1-1 and 7.4.3-1. Some of the guiding principles are:

- all effects within a 5 to 10% decrease in the Project Area (i.e., low magnitude) would result in a low environmental consequence and would not be considered significant;
- generally, if the effect is immediately reversible (i.e., low irreversibility) it would result in a low environmental consequence and would not be considered significant; and
- effects with a high magnitude and extent and/or high irreversibility would result in a high environmental consequence and may be considered significant.

Table 7.4.3-2 summarizes the residual adverse effect expected as a result of the site clearing. As shown in Table 7.4.3-2, and based on the decision flow shown in Figure 7.4.3-1, the clearing of eastern white cedar was assessed as not significant because of the medium magnitude (>25% in the Project Area and <25% in the Site Study Area), low extent (limited to the Project Area), medium irreversibility (i.e., reversible with time) and low timing and duration.

Figure 7.4.3-1: Determination of Significance of Residual Adverse Effects for Terrestrial Environment VECs

Table 7.4.3-2: Summary of Residual Adverse Effects and Significance Levels for Terrestrial Environment

Residual Adverse Effect	Magnitude	Geographic Extent	Timing and Duration	Frequency	Degree of Irreversibility	Overall Assessment
Loss of eastern white cedar in the Project Area	**Medium** • Loss of greater than 25% of the Mixed Forest within the Project Area (77% loss) • Loss of less than 25% of the Mixed Forest within the Site Study Area (11% loss)	**Low** • Effect is limited to the Site Study Area	**Low** • Effect occurs during the site preparation and construction phase	**High** • The effect will persist continuously	**Medium** • Effect is reversible with time	**Not significant**

7.5 AQUATIC ENVIRONMENT

The aquatic environment is composed of nine VECs, as presented in Section 5.3. These have been grouped for discussion as:

- VECs in the South Railway Ditch;
- VECs in Stream C;
- VECs in Lake Huron and embayments; and
- VECs in other aquatic habitats (other ditches in the Project Area, the swamp in the southeast portion and the marsh located on the northern portion of the DGR Project site).

The results of the aquatic assessment are summarized in Section 7.5.2.6. The existing environmental features are described in more detail in Section 6.5 and the Aquatic Environment TSD.

7.5.1 Screening to Focus the Assessment

7.5.1.1 VECs in the South Railway Ditch

Direct Interactions and Measurable Changes

The surface buildings and infrastructure to be constructed for the DGR Project include the Waste Package Receiving Building, ancillary buildings, the main shaft, the ventilation shaft and the access road. The proposed locations for the buildings are removed from the aquatic features in the Project Area and, therefore, the construction of surface facilities will not directly interact with the VECs associated with the South Railway Ditch.

The abandoned rail bed crossing will affect a portion of the South Railway Ditch adjacent to the WWMF. Removal of some riparian vegetation and alteration of the banks of the South Railway Ditch will occur during the construction of the crossing. Therefore, this work and activity will have a direct interaction with the habitat within and adjacent to the South Railway Ditch and the associated VEC species (i.e., redbelly dace, creek chub, benthic invertebrates and variable leaf pondweed). Additionally, there is a potential interaction with burrowing crayfish habitat in the South Railway Ditch. These project-environment interactions are carried forward to the second screening.

The support and monitoring of the DGR life cycle work and activity includes activities to support the safe construction, operation and decommissioning of the DGR Project. Drainage ditch maintenance activities (e.g., cleaning out culverts) could potentially affect the VECs in the South Railway Ditch (redbelly dace, creek chub, burrowing crayfish, benthic invertebrates and variable leaf pondweed). Therefore, support and monitoring of the DGR life cycle is carried forward to the second screening.

Direct measurable changes to habitat in the South Railway Ditch are predicted and, in turn, measurable changes to redbelly dace, creek chub, burrowing crayfish, variable leaf pondweed and benthic invertebrates are predicted and are advanced for further consideration.

The following works and activities will not interact directly with VECs in the South Railway Ditch:

- site preparation;
- excavation and construction of underground facilities;
- above-ground transfer of waste;
- underground transfer of waste;
- decommissioning of the DGR Project;
- abandonment of the DGR facility;
- presence of the DGR Project;
- waste management; and
- workers, payroll and purchasing.

Indirect Interactions and Measurable Changes

Aquatic VECs may be affected by blasting activities during construction. The DFO Guidelines state that no explosive may be used that produces, or is likely to produce, a peak particle velocity greater than 13 mm/s in a spawning bed during egg incubation [399]. These guidelines apply to blasting in water; however, it can be assumed that they can be applied conservatively in this situation. The South Railway Ditch is the aquatic habitat nearest where blasting will occur and is located 150 m or more from both the ventilation shaft and the main shaft (main areas of blasting). The predicted maximum ground vibration during shaft sinking is predicted to be 8.4 mm/s. Therefore, no measurable change from blasting to the aquatic habitat and VEC species supported in the South Railway Ditch are predicted. Accordingly, no further consideration is warranted. Additional information on potential effects from blasting and vibrations on receptors is provided in Section 7.8.

Changes in surface water quality can affect VECs in the South Railway Ditch. Surface runoff and underground sump water from the DGR Project will be directed to the stormwater management pond. The stormwater pond will discharge via a controlled outlet into the existing drainage ditch network, which drains northwest under Interconnecting Road to MacPherson Bay. No changes in surface water quality in the South Railway Ditch are identified in the Hydrology and Surface Water Quality TSD. Therefore, there is no indirect effect resulting in measurable changes to aquatic environment VECs.

7.5.1.2 VECs in Stream C

Direct Interactions and Measurable Changes

There are no potential direct interactions identified with Stream C and its associated VECs as a result of the DGR Project. Accordingly, no measurable changes to VECs in Stream C are identified and no further consideration is warranted.

Indirect Interactions and Measurable Changes

Aquatic VECs may be affected by blasting activities during construction. Stream C is located 1.2 km or more from the ventilation and main shafts (main areas of blasting). Therefore, even with a charge of 20 kg, the setback distance between the blasting and the aquatic habitat within Stream C is far enough to protect aquatic life. Therefore, no measurable change to the aquatic habitat and VEC species supported in Stream C from blasting are predicted. Accordingly, no further consideration is warranted.

Site drainage that flows into the Stream C catchment will be diverted into the MacPherson Bay watershed during the site preparation and construction phase. This division will continue through the decommissioning phase. The purpose of this diversion is to avoid the discharge of potentially contaminated stormwater into the more sensitive coldwater habitat of the Stream C catchment and to ensure the treatment of all the drainage from the DGR Project in a stormwater management pond, prior to discharge to the drainage ditch to MacPherson Bay. The effects of the DGR Project on surface water quantity and flow are presented in Section 7.3.2.1. The change in flow to Stream C has the potential to interact with the VECs in Stream C (red belly dace, creek chub, spottail shiner and brook trout). As mentioned in Section 7.3.2.1, the predicted change in flow to Stream C (i.e., <1%) is not considered to be an adverse effect; therefore, the change in flow is not considered to result in a measurable change to the VECs in Stream C. Therefore, these indirect interactions are not considered further.

An indirect interaction is possible as a result of changes in surface water quality in Stream C, including increases in total suspended solids and nitrates as a result of atmospheric deposition, could affect VECs in this habitat. Increases in total suspended solids are predicted to be less than the method detection limit. Therefore, there are no likely measurable changes on aquatic VECs in Stream C.

7.5.1.3 VECs in Lake Huron and Embayments

Direct Interactions and Measurable Changes

As there are no project works or activities planned in these areas, there are no potential direct interactions predicted with the DGR Project on VECs within Lake Huron or embayments.

Indirect Interactions and Measurable Changes

Aquatic VECs may be affected by blasting activities during construction. MacPherson Bay is located at least 1 km from the ventilation and main shafts (main areas of blasting). Therefore, even with a charge of 20 kg, the setback distance between the blasting and the aquatic habitat within MacPherson Bay is far enough to protect aquatic life. Therefore, no measurable change to the aquatic habitat and VEC species supported in MacPherson Bay (and Lake Huron) from blasting are predicted. Accordingly, no further consideration is warranted.

Site drainage that is currently flowing into the Stream C watershed will be diverted into the MacPherson Bay watershed during the site preparation and construction phase and continue through the decommissioning phase. The extent of the DGR Project Area draining to

MacPherson Bay will increase causing a potential interaction with VECs (lake whitefish, spottail shiner, smallmouth bass and benthic invertebrates) that may use MacPherson Bay as a result of increased surface water flow. As described in Section 7.3.2.1, flow in the drainage ditch at Interconnecting Road is predicted to increase by 114% during construction and 61% during operations. This increase in flow is not likely to be measurable at the point of discharge to MacPherson Bay. Because of the nature of the habitat within MacPherson Bay (exposed to wind and wave action and therefore mixes readily with lake water) and its extent (approximately 40 ha), the increase in surface flows is not expected to result in a detectable alteration in the available aquatic habitat. Therefore, a measurable change to the VECs within MacPherson Bay is not likely, and no further consideration is warranted.

All developed areas within the Project Area will drain to MacPherson Bay potentially affecting surface water quality, which may cause an indirect interaction with some VECs (lake whitefish, spottail shiner, smallmouth bass and benthic invertebrates). Water from the stormwater management pond being discharged into MacPherson Bay (via the drainage ditch) will be tested and compared with predetermined criteria that will prevent water from being adversely affected (as described in Section 7.3.2.2). Provided that criteria are met, no indirect measurable changes to the VECs in MacPherson Bay are anticipated.

7.5.1.4 VECs in Other Aquatic Habitats

Direct Interactions and Measurable Changes

The proposed DGR Project site preparation activities occur within the north half of the Project Area and therefore, the swamp in the southeast portion and the marsh located on the northern portion of the site will be protected from this disturbance. Thus, no direct interaction is anticipated with these wetland areas and their associated VECs (burrowing crayfish and benthic invertebrates).

The roadside drainage ditches in the Project Area, the North Railway Ditch and the ditches along the abandoned rail spur, which serve as marginal or secondary aquatic habitat for burrowing crayfish and benthic invertebrates, could be affected during site preparation activities and the construction of surface facilities. These activities will likely occur within areas previously disturbed during site preparation; however, there remains a potential for interaction.

There will be removal of some riparian vegetation from the banks of the South Railway Ditch during the construction of the rail bed crossing. The construction of the crossing will disturb an area of approximately 100 m² in the South Railway Ditch. Burrowing crayfish were not found to be using the chimneys in this area when burrowing crayfish habitat use surveys were conducted, so the construction is not expected to result in crayfish mortality [400]. Nonetheless, crayfish have used this area at some point and constructing the crossing from the WWMF to the DGR represents a direct measurable change to habitat in the North and South Railway Ditches and a loss of burrowing crayfish habitat. Therefore, a measurable change to burrowing crayfish is advanced to Section 7.5.2.4.

Site preparation and construction of the surface facilities will result in the loss of benthic invertebrate habitat in the North Railway Ditch and along the abandoned rail spur in the western portion of the Project Area. This loss represents a small portion of the benthic invertebrate habitat available within the Project Area. It is likely that this change and would be bound by the measurable change identified for benthic invertebrates utilizing the South Railway Ditch.

The decommissioning of the DGR Project includes the removal of all surface facilities and the re-vegetation of the DGR Project site. The re-vegetated/re-naturalized site has the potential to interact with habitat for the burrowing crayfish in other aquatic habitats on-site, particularly in low lying areas that are utilized by burrowing crayfish under existing conditions.

The following works and activities will not interact directly with VECs in other aquatic habitats:

- excavation and construction of underground facilities;
- above-ground transfer of waste;
- underground transfer of waste;
- abandonment of the DGR facility;
- presence of the DGR Project;
- waste management;
- support and monitoring of DGR life cycle; and
- workers, payroll and purchasing.

Indirect Interactions and Measurable Changes

Burrowing crayfish rely on suitable soil and groundwater conditions, but they occur in open surface waters a few weeks each year for reproductive activities. The diversion of surface run-off from the North Railway Ditch has the potential to indirectly interact with burrowing crayfish. However, the North Railway Ditch is often dry and does not provide high quality or a large quantity of breeding habitat for crayfish. Therefore, a change in the quantity of surface water in marginal crayfish habitat is not expected to produce a measurable change in the burrowing crayfish population and is not considered further.

As burrowing crayfish spend the majority of their life stages in contact with the soil, a change in the soil could affect them. As described in the Geology TSD, no adverse effects are identified for soil quality. Similarly, no adverse effects were identified to sediments in the Hydrology and Surface Water Quality TSD. Therefore, no further consideration of this pathway is warranted.

Burrowing crayfish dig burrows to reach the groundwater table. Changes to the groundwater quality and level could indirectly interact with burrowing crayfish. Analysis completed in Section 7.2 indicates that the change in groundwater quality resulting from the DGR Project would not be measurable at any of the aquatic habitats in the Site Study Area. As a result a measurable change in groundwater quality at the burrowing crayfish habitats in the Site Study Area is not expected. No measurable change to the VECs is identified, and no further consideration is warranted.

Also, Section 7.2 (geology) indicates that the change in groundwater level caused by the excavation and construction of the underground facilities would not be measurable at any of the aquatic habitats in the Site Study Area. Therefore, no measurable changes to burrowing crayfish are identified through this pathway and no further consideration is warranted.

7.5.2 Identification and Assessment of Effects

Aquatic environment VECs were screened for measurable changes, as described above. The following measurable changes were identified:

- direct measurable change to burrowing crayfish resulting from loss of habitat within the North and South Railway Ditches during site preparation and construction of surface facilities and decommissioning; and
- direct measurable change to redbelly dace, creek chub, variable leaf pondweed and benthic invertebrates from loss of habitat in the South Railway Ditch because of the removal of riparian vegetation and road crossing construction during the construction of surface facilities.

7.5.2.1 VECs in the South Railway Ditch

Linkage Analysis

The evaluation of the effects of the DGR Project on VECs in the South Railway Ditch (redbelly dace, creek chub, variable leaf pondweed, burrowing crayfish, benthic invertebrates) uses changes in habitat to assess direct and indirect project effects.

The construction of the crossing over the abandoned rail bed (construction of surface facilities) was identified as resulting in direct measurable changes to the VECs in the South Railway Ditch during the site preparation and construction phase of the DGR Project. No indirect effects were advanced from the second screening.

In-design Mitigation

As described in Section 7.5.1.1, effects on the South Railway Ditch VECs that may result from the construction of the rail bed crossing will be minimized by incorporating appropriate design features (e.g., embedded culvert for fish passage), specific mitigation measures (e.g., management of surface water runoff) and best management practices (e.g., erosion and sediment control) both during and after construction. The construction of the abandoned rail bed crossing will be timed to comply with the DFO Operational Statement-Timing Windows [401]. This ensures that critical life history stages such as spawning activities are protected by restricting the conduct of works or undertakings in and around water at certain times of the year. The South Railway Ditch contains a warm water fish community and generally, the warm water timing window begins July 1 and ends March 31. However, the Saugeen Valley Conservation Authority has made a specific recommendation for this particular construction work of an 'in-water' timing window of July 1 to September 30 [402]. This recommendation is incorporated into the overall construction schedule.

Likely Effects

The crossing over the South Railway Ditch will cause a change in habitat in a localized area. The abandoned rail bed crossing consists of the placement of 20 m long culverts in-stream, which will affect approximately 100 m^2 of in-stream habitat. There will be an increase in channel shading in a localized area and elimination of the riparian vegetation for a 20 m section of the banks. Although culverts allow for fish passage, they restrict organic inputs from riparian vegetative sources and will not support much aquatic plant growth because of the low light conditions. Therefore, this will no longer be a productive reach of the South Railway Ditch. Consequently, the construction of the rail bed crossing across the South Railway Ditch will adversely affect the habitat of redbelly dace, creek chub, variable leaf pondweed, burrowing crayfish and benthic invertebrates in that there is a degradation of their non-critical habitat (does not contain spawning or rearing/nursery areas).

Additional Mitigation Measures

The application of standard measures to protect fish and fish habitat in the South Railway Ditch during the construction of the crossing is recommended. These mitigation measures include:

- Install effective sediment and erosion control measures before starting work to prevent silt/sediment laden runoff from directly entering the water in the South Railway Ditch. Inspect them regularly during the course of construction and make necessary repairs if damage occurs.
- Operate machinery on land and in a manner that minimizes disturbance to the banks of the South Railway Ditch. Machinery should arrive on-site in a clean condition, and should be maintained free of fluid leaks. Wash, refuel and service machinery and store fuel and other materials for the machinery away from the water to prevent any deleterious substance from entering the water. Keep an emergency spill kit on-site in case of fluid leaks or spills from machinery.
- Use measures to prevent deleterious substances such as new concrete (i.e., it is pre-cast, cured and dried before use near the watercourse), grout, paint and preservatives from entering the watercourse.
- Vegetate any disturbed areas by planting and seeding preferably with native trees, shrubs or grasses and cover such areas with mulch to prevent erosion and to help seeds germinate. If there is insufficient time remaining in the growing season, the disturbed area should be stabilized (e.g., cover exposed areas with erosion control blankets to keep the soil in place and prevent erosion) and vegetated the following spring.
- Isolate and dewater the section of the South Railway Ditch wherein the culvert will be placed. Prior to dewatering the work area, a fish salvage and relocation will be conducted so as to avoid harming any fish during construction.

Residual Adverse Effects

There is residual habitat loss in the South Railway Ditch for redbelly dace, creek chub, benthic invertebrates, burrowing crayfish and variable leaf pondweed as a result of the crossing over the abandoned rail bed within the Project Area. Therefore, these residual adverse effects are advanced for assessment of significance in Section 7.5.3.

7.5.2.2 VECs in Stream C

No measurable changes to VECs in Stream C were identified. Therefore, no further consideration is warranted.

7.5.2.3 VECs in Lake Huron and Embayments

No measurable changes to VECs in Lake Huron and the embayments were identified. Therefore, no further consideration is warranted.

7.5.2.4 VECs in Other Aquatic Habitats

Linkage Analysis

The evaluation of the effects of the DGR Project on VECs in other potential aquatic habitat areas in the Project Area (i.e., burrowing crayfish) used changes in habitat to identify likely direct and indirect project-related effects.

Site preparation activities and construction of the rail bed crossing are identified as resulting in a measurable change to the burrowing crayfish VEC. Decommissioning is also identified as resulting in a likely measurable change to the burrowing crayfish. No indirect effects were identified that could measurably affect burrowing crayfish.

In-design Mitigation

Burrowing crayfish species included as VECs require clay soils for the construction of chimneys, in which they can burrow down to the groundwater table to avoid dessication. Conditions appear to be suitable for burrowing crayfish in most of the moist, low-lying portions of the Project Area and Site Study Area. Therefore, although the design of the project successfully avoids most of the identified crayfish habitat in the Project Area, including protection of the marsh in the northeast portion of the Project Area, some burrowing crayfish could be disturbed. Since the majority of the existing burrowing crayfish habitat will be unchanged by the DGR Project, affected individuals may relocate to more favourable conditions.

Direct Effects

The construction of the crossing over the abandoned rail bed and other surface infrastructure will result in the loss of a small portion of burrowing crayfish habitat (approximately 100 m^2 along the North Railway Ditch), as well as other ditches and the abandoned railway spur in the western portion of the Project Area. This loss represents approximately 0.01% of the burrowing crayfish habitat available within the Project Area under existing conditions. Although chimneys are located in this area, crayfish were not captured in traps at these locations [400]. Because burrowing crayfish were not found to be using the chimneys in the DGR Project site during the field studies conducted in both 2006 and 2009, the construction is not expected to result in crayfish mortality.

Re-vegetation of the DGR Project site during decommissioning may have a beneficial effect on burrowing crayfish by potentially increasing available habitat. However, no credit has been assumed for this change, and it is not considered further.

Residual Adverse Effects

Since burrowing crayfish habitat will be lost as part of the site preparation and the construction of surface facilities works and activities, a residual adverse effect on this VEC is identified. This effect on burrowing crayfish is advanced for an evaluation of its significance in Section 7.5.3.

7.5.2.5 Biodiversity

Adverse effects on redbelly dace, creek chub, burrowing crayfish, benthic invertebrates and variable leaf pondweed have been identified within the Project Area, but do not extend into the Site Study Area. This does not mean that there will be no loss of species or species habitat as part of the project; however, the effects are not considered to be significant. As biodiversity directly correlates to increases in size of the study areas, it is expected that if there is no effect on the biodiversity within the Site Study Area, the DGR Project will not affect biodiversity in the Local or Regional Study Areas.

7.5.2.6 Summary of Assessment

Table 7.5.2-1 provides a summary of the assessment of the aquatic environment VECs for the DGR Project. Diamonds (◆) on this matrix represent likely project-environment interactions resulting in a residual adverse effect on a VEC. These interactions are advanced to Section 7.5.3 for an evaluation of significance. In this case, a residual adverse effect was identified for redbelly dace, creek chub, burrowing crayfish, benthic invertebrates and variable leaf pondweed.

Table 7.5.2-1: Summary of Effects Prediction and Assessment for Aquatic Environment

Project Work and Activity	Redbelly Dace	Creek Chub	Brook Trout	Burrowing Crayfish	Variable Leaf Pondweed
Direct Effects					
Site Preparation				◆	
Construction of Surface Facilities	◆	◆		◆	◆
Excavation and Construction of Underground Facilities					
Above-ground Transfer of Waste					
Underground Transfer of Waste					
Decommissioning of the DGR Project				■	
Abandonment of DGR Facility					
Presence of the DGR Project					
Waste Management					
Support and Monitoring of DGR Life Cycle	•	•		•	•
Workers, Payroll and Purchasing					
Indirect Effects					
Changes in Air Quality					
Changes in Vibrations	•	•	•		
Changes in Surface Water Quantity and Flow	•	•	•	•	
Changes in Surface Water Quality	•	•	•	•	•
Changes in Soil Quality				•	
Changes in Groundwater Quality				•	
Changes in Groundwater Flow				•	

Notes:
The matrices are meant to indicate when the effect occurs and do not imply how long the effect will last. The duration of the effect is assessed in Section 7.5.3.

• Potential project-environment interaction
■ Measurable change
◆ Residual adverse effect
Blank No potential interaction

Table 7.5.2-1: Summary of Effects Prediction and Assessment for Aquatic Environment (continued)

Project Work and Activity	Lake Whitefish	Spottail Shiner	Smallmouth Bass	Benthic Invertebrates
Direct Effects				
Site Preparation				■
Construction of Surface Facilities				◆
Excavation and Construction of Underground Facilities				
Above-ground Transfer of Waste				
Underground Transfer of Waste				
Decommissioning of the DGR Project				
Abandonment of DGR Facility				
Presence of the DGR Project				
Waste Management				
Support and Monitoring of DGR Life Cycle				•
Workers, Payroll and Purchasing				
Indirect Effects				
Changes in Air Quality				
Changes in Vibrations	•	•	•	
Changes in Surface Water Quantity and Flow	•	•	•	•
Changes in Surface Water Quality	•	•	•	•
Changes in Soil Quality				
Changes in Groundwater Quality				
Changes in Groundwater Flow				

Notes:
The matrices are meant to indicate when the effect occurs and do not imply how long the effect will last. The duration of the effect is assessed in Section 7.5.3.

• Potential project-environment interaction
■ Measurable change
◆ Residual adverse effect
Blank No potential interaction

7.5.3 Significance of Residual Adverse Effects

As described in Section 7.5.2, residual adverse effects resulting from the DGR Project were identified for burrowing crayfish, redbelly dace, creek chub, variable leaf pondweed and benthic invertebrates.

The criteria used for judging and describing the significance of effects are shown in Table 7.1-1. Significance is rated using these criteria combined with magnitude criteria applicable to aquatic environment VECs, shown in Table 7.5.3-1.

Table 7.5.3-1: Effects Levels for Assigning Magnitude for Aquatic Environment VECs

VEC	Magnitude Level Definition		
	Low	Medium	High
All Aquatic VECs	Non-critical habitat is removed or rendered non-usable	Critical habitat is removed or rendered non-usable, but comparable habitat is available elsewhere in the watercourse	Critical habitat is removed or rendered non-useable, and no comparable habitat is available elsewhere in the watercourse

The level of significance is assigned by using a decision tree model illustrated in Figure 7.5.3-1. First, magnitude, geographic extent, timing and duration, frequency, and degree of irreversibility are combined to identify an environmental consequence. Then the social and/or ecological importance of the VEC being affected is considered to determine significance. This decision tree is specific to the aquatic environment and the effects level criteria defined in Table 7.5.3-1. Some of the guiding principles are:

- effects associated with removal of non-critical habitat (i.e., low magnitude) would result in a low environmental consequence and are not considered significant;
- generally, if the effect is immediately reversible (i.e., low irreversibility) it would result in a low environmental consequence and is not considered significant; and
- effects with a high magnitude and extent and/or high irreversibility would result in a high environmental consequence and may be considered significant, taking social and/or ecological importance into consideration.

As shown in Table 7.5.3-2, and based on the decision flow diagram illustrated on Figure 7.5.3-1, the residual adverse effects were assessed as not significant because they involve removal/alteration of only non-critical habitat over a very limited portion of the Project Area (i.e., low magnitude). Furthermore, from an ecological and social perspective, the burrowing crayfish, fish and plant species affected are tolerant of a broad range of environmental conditions, are considered common in freshwater systems in Ontario, and would not be considered keystone species.

Figure 7.5.3-1: Determination of Significance of Residual Adverse Effects for Aquatic Environment VECs

Table 7.5.3-2: Summary of Residual Adverse Effects and Significance Levels for Aquatic Environment VECs

VEC	Magnitude	Geographic Extent	Timing and Duration	Frequency	Degree of Irreversibility	Overall Assessment
Burrowing Crayfish	**Low** • No critical habitat is removed • A portion (~0.01% of habitat in the Site Study Area) of non-critical habitat is removed	**Low** • The effect is limited to the Site Study Area	**Low** • The condition causing the effect occurs during the site preparation and construction phase	**High** • The habitat loss is continuous	**High** • Effect is not reversible (i.e., permanent)	**Not significant**
Redbelly Dace	**Low** • No critical habitat is removed • A portion (~1.6% of the length of the South Railway Ditch) of non-critical habitat is removed	**Low** • The effect is limited to the Site Study Area	**Low** • The condition causing the effect occurs during the site preparation and construction phase	**High** • The habitat loss is continuous	**High** • Effect is not reversible (i.e., permanent)	**Not significant**

Table 7.5.3-2: Summary of Residual Adverse Effects and Significance Levels for Aquatic Environment VECs (continued)

VEC	Magnitude	Geographic Extent	Timing and Duration	Frequency	Degree of Irreversibility	Overall Assessment
Creek Chub	**Low** • No critical habitat is removed • A portion (~1.6% of the length of the South Railway Ditch) of non-critical habitat is removed	**Low** • The effect is limited to the Site Study Area	**Low** • The condition causing the effect occurs during the site preparation and construction phase	**High** • The habitat loss is continuous	**High** • Effect is not reversible (i.e., permanent)	**Not significant**
Variable Leaf Pondweed	**Low** • No critical habitat is removed • A portion (~1.6% of the length of the South Railway Ditch) of non-critical habitat is removed	**Low** • The effect is limited to the Site Study Area	**Low** • The condition causing the effect occurs during the site preparation and construction phase	**High** • The habitat loss is continuous	**High** • Effect is not reversible (i.e., permanent)	**Not significant**

Table 7.5.3-2: Summary of Residual Adverse Effects and Significance Levels for Aquatic Environment VECs (continued)

VEC	Magnitude	Geographic Extent	Timing and Duration	Frequency	Degree of Irreversibility	Overall Assessment
Benthic Invertebrates	**Low** • No critical habitat is removed • A portion (~1.6% of the length of the South Railway Ditch) of non-critical habitat is removed	**Low** • The effect is limited to the Site Study Area	**Low** • The condition causing the effect occurs during the site preparation and construction phase	**High** • The habitat loss is continuous	**High** • Effect is not reversible (i.e., permanent)	**Not significant**

7.6 RADIOLOGICAL CONDITIONS

Twelve VECs, as presented in Section 5.3, comprise the radiation and radioactivity environment component. The results are summarized in Section 7.6.2.3. The existing environmental features are described in Section 6.6 and the Radiation and Radioactivity TSD.

7.6.1 Screening to Focus the Assessment

7.6.1.1 Humans

For this assessment, humans are indicated by Nuclear Energy Workers (NEWs), non-NEWs, members of the public including members of Aboriginal communities. In this section, the assessment of human exposure will be completed for each of these groups.

Direct Interactions and Measurable Changes

The following works and activities may interact with humans, as they all involve radiological materials:

- above-ground transfer of waste;
- underground transfer of waste;
- decommissioning of the DGR Project;
- waste management; and
- support and monitoring of DGR life cycle.

Any potential human exposure to radiation is considered measurable. Therefore, all of the above works and activities are forwarded for assessment in Section 7.6.2.1.

The following works and activities are not expected to directly interact with humans and are not considered in the assessment:

- site preparation;
- construction of surface facilities;
- excavation and construction of underground facilities;
- abandonment of the DGR facility;
- presence of the DGR Project; and
- workers, payroll and purchasing.

Indirect Interactions and Measurable Changes

The indirect exposures to humans resulting from the changes of radionuclide levels in all environmental media such as air, surface water, groundwater, and soil/sediment as the result of emission of radionuclides from the waste packages are judged to be measurable. Consumption of contaminated food is also considered to result in a measurable change in dose to humans. Therefore, a change in air quality, surface water, groundwater, food and soil quality is forwarded for assessment in Section 7.6.2.1.

Naturally occurring radioactive material (NORM), in particular radon, may be a cause for concern during the site preparation and construction, and operations phases. However, a recent study indicated that there is no significant radon hazard to the workers or general public during development and operation of the DGR resulting from the low concentration of uranium in the host rock, the rock properties and low concentration of radium in the waste [403]. For example, the maximum dose rate attributable to the exposure to radon gas, based on conservative assumptions outlined in the radon assessment document [403], is far less than the dose criteria for workers and members of the public. Therefore, further assessment of potential interactions related to radon gas exposure is not warranted.

7.6.1.2 Benthic Invertebrates

Burrowing crayfish, found in ditches and temporary wetlands in the Site Study Area and Project Area, are used as the indicator for the benthic invertebrates VEC.

Direct Interactions and Measurable Changes

There are no works or activities in which the DGR Project could provide direct exposure to benthic invertebrates. Therefore, no further consideration is warranted.

Indirect Interaction and Measurable Changes

It is unlikely that changes in radioactivity in air will indirectly interact with benthic invertebrates. Therefore, no further consideration is warranted.

The radionuclides released as a result of the DGR Project consist of tritium and carbon-14 [387], which could contaminate surface water, groundwater and soil/sediment. Accordingly, the concentrations of tritium and carbon-14 in surface water, groundwater and sediment could increase, which would result in an incremental dose to benthic invertebrates. This could result in a measurable change in doses to this VEC; therefore, these measurable changes are forwarded for assessment in Section 7.6.2.2.

7.6.1.3 Aquatic Vegetation and Benthic Fish

Variable leaf pondweed is used as an indicator for aquatic vegetation. Benthic fish spend most of their time at the bottom of waterbodies and watercourses. The benthic fishes selected as indicators for this study are lake whitefish, redbelly dace and creek chub.

Direct Interactions and Measurable Changes

There are no works or activities in which the DGR Project could provide direct exposure to aquatic vegetation and benthic fish. Therefore, no further consideration is warranted.

Indirect Interaction and Measurable Changes

No indirect interaction between groundwater and aquatic vegetation and benthic fish is expected and no further consideration is warranted.

Radiological changes in surface water and soil/sediment quality because of airborne or waterborne emissions during the operations and decommissioning phases of the DGR Project could indirectly interact with aquatic vegetation and benthic fish. Also, radiological changes in the food pathway could also interact with benthic fish. Tritium and carbon-14 concentrations may increase in the South Railway Ditch where some of these species live. This could result in a measurable change in doses to these species; therefore, these measurable changes are forwarded for assessment in Section 7.6.2.2.

It is unlikely that changes in air quality because of changes in radioactivity in air will indirectly interact with aquatic vegetation and benthic fish. Therefore, no further consideration is warranted.

7.6.1.4 Pelagic Fish

Pelagic fish include species that are free-swimming in the water column and do not frequently contact sediments. Smallmouth bass, spottail shiner and brook trout are used to represent pelagic fish in this study.

Direct Interactions and Measurable Changes

There are no works or activities in which the DGR Project could provide direct exposure to pelagic fish. As such, no further consideration is warranted.

Indirect Interactions and Measurable Changes

Pelagic fish spend their time in the water column of surface water bodies. Therefore, any potential changes to the concentration of radionuclides in air, groundwater or sediment will not affect pelagic fish.

Radiological changes in surface water and food because of airborne or waterborne emissions during the operations and decommissioning phases of the DGR Project could indirectly interact with pelagic fish. Tritium and carbon-14 concentrations may increase in the habitat where pelagic fish live. This could result in a measurable change in the dose received by pelagic fish; therefore, this measurable change is forwarded for assessment in Section 7.6.2.2.

7.6.1.5 Aquatic and Terrestrial Birds and Mammals

The double-crested cormorant and mallard are selected to represent birds that inhabit the shoreline of Lake Huron. Their feeding, diving and wading behaviours could maximize exposure to radionuclides and beta gamma emitters. The muskrat is selected as an aquatic mammalian species feeding on aquatic vegetation and that may be exposed to radionuclides in water and sediment.

The yellow warbler, red-eyed vireo, wild turkey and bald eagle are selected to represent terrestrial birds. The white-tailed deer, northern short-tailed shrew and red fox are selected to represent terrestrial mammals.

Direct Interactions and Measurable Changes

Radiological changes during the above-ground transfer of waste may interact with aquatic and terrestrial birds and aquatic and terrestrial mammals. However, no direct measurable exposure during all DGR Project works and activities is expected because the daily dose received by aquatic and terrestrial mammals and birds outside of the Waste Package Receiving Building (WPRB) is far lower than the criteria for these VECs. Therefore, no further consideration is warranted.

Indirect Interactions and Measurable Changes

Radiological changes in air, surface water, soil/sediment quality and food because of airborne and waterborne emissions during the operations and decommissioning phases of the DGR Project could indirectly interact with aquatic birds, aquatic mammals, terrestrial birds and terrestrial mammals. Tritium and carbon-14 concentrations may increase in the habitat where these species live. This could result in a measurable change in dose exposure to these VECs; therefore, these measurable changes are forwarded for assessment in Section 7.6.2.2.

It is unlikely that changes in groundwater quality would interact with aquatic birds, aquatic mammals, terrestrial birds and terrestrial mammals. Therefore, further consideration is warranted.

7.6.1.6 Terrestrial Invertebrates

The earthworm was selected as the indicator for determining potential effects of radionuclides released into the environment as a result of the DGR Project.

Direct Interactions and Measurable Changes

Radiological changes during the above-ground transfer of waste may interact with terrestrial invertebrates. However, no direct measurable exposure during all DGR Project works and activities is expected because the daily dose received by aquatic and terrestrial mammals and birds outside of the Waste Package Receiving Building (WPRB) is far lower than the criteria for this VEC. Therefore, no further consideration is warranted.

Indirect Interactions and Measurable Changes

Radiological changes in groundwater and soil quality because of airborne and waterborne emissions during the operations and decommissioning phases of the DGR Project could indirectly interact with terrestrial invertebrates. Tritium and carbon-14 concentrations may increase in the habitat where these species live. This could result in a measurable change in dose exposure to these species; therefore, these measurable changes are forwarded for assessment in Section 7.6.2.2.

7.6.1.7 Terrestrial Vegetation, Amphibians and Reptiles

The eastern white cedar, common cattail and heal-all are selected as indicators for determining potential effects on terrestrial vegetation. The northern leopard frog is selected to represent amphibians. It is known to be present on the Bruce nuclear site, exhibits high radiosensitivity, and utilizes both aquatic and terrestrial habitats during its life. The midland painted turtle is selected to represent reptiles that utilize both terrestrial and aquatic habitats. These VECs are presented in this section collectively as the DGR Project is expected to interact with them in a similar manner.

Direct Interactions and Measurable Changes

During the above-ground transfer of waste, terrestrial vegetation, amphibians and reptiles may be directly exposed to gamma radiation. However, no direct measurable exposure during all DGR Project works and activities is expected because the daily dose received by terrestrial vegetation, amphibians and reptiles outside of the Waste Package Receiving Building (WPRB) is far lower than the criteria for these VECs. As such, no further consideration is warranted.

Indirect Interactions and Measurable Changes

Radiological changes in air, surface water and soil/sediment quality because of airborne and waterborne emissions during the operations and decommissioning phases of the DGR Project could indirectly interact with terrestrial plants and amphibians and reptiles. Also, radiological changes in the food pathway can interact with amphibians and reptiles. Tritium and carbon-14 concentrations may increase in the habitat where these species live. This could result in a measurable change in dose exposure to these VECs; therefore, these measurable changes are forwarded for assessment in Section 7.6.2.2.

7.6.2 Identification and Assessment of Effects

Radiological conditions VECs were screened for measurable changes, as described above. The following measurable changes were identified:

- direct measurable change to humans associated with radiation exposures during the operations and decommissioning phases of the DGR Project;
- indirect measurable change to humans because of changes in concentrations of radionuclides in air, surface water, groundwater, food and soil during operations and decommissioning of the DGR Project;
- indirect measurable changes to benthic invertebrates because of changes in surface water, groundwater and soil/sediment quality during the operations and decommissioning phases;

- indirect measurable changes to aquatic vegetation and benthic fish because of changes in surface water and sediment quality during the operations and decommissioning phases (as well as an indirect measurable change to benthic fish as a result of changes in the food pathway);
- indirect measurable changes to pelagic fish as a result of changes in surface water quality and the food pathway during the operations and decommissioning phases;
- indirect measurable changes to aquatic birds, aquatic mammals, terrestrial birds and terrestrial mammals because of changes in air, surface water, soil/sediment quality and food sources during the operations and decommissioning phases;
- indirect measurable changes to terrestrial invertebrates because of changes in groundwater and soil quality during the operations and decommissioning phases; and
- indirect measurable changes to terrestrial vegetation, and amphibians and reptiles because of changes in air, surface water and soil/sediment quality during the operations and decommissioning phases (as well as an indirect measurable change to amphibians and reptiles as a result of changes in the food pathway).

For the purposes of this assessment, likely effects were considered adverse, or not, by comparison with regulatory limits for NEWs, non-NEWs and members of the public and screening dose criteria for non-human biota.

The CNSC has set the following regulatory limits on the annual dose to members of the public and to workers to ensure that the probability of occurrence of effects is acceptably low [404]:

- nuclear energy worker, including a pregnant nuclear energy worker: 50 mSv for one-year dosimetry period and 100 mSv for a five-year dosimetry period;
- pregnant nuclear energy worker: 4 mSv for the balance of the pregnancy; and
- a person who is not a nuclear energy worker (members of the public and non-NEWs): 1 mSv for one calendar year.

The regulatory limits established to protect members of the public also apply to Aboriginals, and will apply to the DGR Project.

The following screening dose criteria (Table 7.6.2-1) were used to assess the potential effect of the DGR Project on non-human biota. These benchmarks represent chronic dose rates that were observed not to produce any adverse effects upon populations of biota [405]. It is worth noting that daily dose rates, rather than annual ones, are used to prevent a scenario where the annual dose is received within a few days [405].

Table 7.6.2-1: Chronic Dose Rate Criteria

VEC	Dose Rate Criteria (mGy/d)
Benthic invertebrates	5.0
Aquatic vegetation	2.4
Pelagic fish	0.6
Benthic fish	0.6

Table 7.6.2-1: Chronic Dose Rate Criteria (continued)

VEC	Dose Rate Criteria (mGy/d)
Aquatic bird	1.0
Aquatic mammal	1.0
Terrestrial invertebrates	1.6
Terrestrial vegetation	1.6
Terrestrial bird	1.0
Terrestrial mammal	1.0
Amphibian and reptile	5.0

Source: [406]

The predictive modelling methods used for calculating doses for this assessment are described in the Radiation and Radioactivity TSD.

7.6.2.1 Humans

Exposure Pathway Analysis

The evaluation of the effects of the DGR Project used the dose to humans to assess direct and indirect project effects. The assessment considered three receptors, namely:

- NEWs;
- non-NEWs; and
- members of the public.

The above-ground transfer of waste, underground transfer of waste, waste management, support and monitoring of DGR life cycle and decommissioning activities were identified as resulting in measurable radiation exposures to humans during the operations and decommissioning phases of the DGR Project.

Radiological changes in air quality, surface water quality, groundwater quality, soil quality and food sources were identified as indirect pathways of radiation exposure to humans.

In-design Mitigation

To minimize the radiological effects on humans, mitigation measures have been developed during the design of the DGR and its supporting infrastructure. These in-design mitigation measures include the following features:

- shielding (e.g., appropriate design of waste container, WPRB design, underground emplacement rooms, installation of shielding and end and closure walls when appropriate);

- ventilation;
- sump and stormwater collection and management;
- emission control (airborne and waterborne);
- zoning to prevent spread of contamination in the DGR;
- fencing and security; and
- operating procedures and training.

These in-design mitigation measures are taken into account in the following assessment.

<u>*Dose to NEWs*</u>

External Radiation Dose

Direct radiation dose calculations were undertaken as described in the Radiation and Radioactivity TSD. The results showed that workers can be in most locations without exceeding OPG's occupational dose target (10 mSv/a) [387]. However, higher dose rate locations were identified where worker occupancy will be limited, for instance, near the face of an array of LLW or ILW packages in emplacement rooms [387]. Generally, workers would not need to spend much time in these locations, nor are most packages at these dose rate limits. However, it would be appropriate to monitor the radiation fields in these locations, and if necessary, limit the worker exposure, use shielded forklifts and/or use greater stand-off distances. This is considered further within the context of ALARA [407].

Inhalation and Immersion Dose

Air concentrations of tritium and carbon-14 in the DGR were estimated as described in the Radiation and Radioactivity TSD. All doses are much lower than OPG's occupational dose target of 10 mSv/a for workers.

<u>*Dose to non-NEWs On-site*</u>

The access and movement of non-NEWs (and thus the radiation doses) in the Site Study Area are controlled by OPG. Dose rate measurements at locations around the site where non-NEWs might be located ensure that the received doses do not exceed the non-NEW criterion value of 1 mSv/a. It is predicted that the dose rate will be less than 0.5 μSv/h at the perimeter of the DGR Project [387]. Furthermore, the radiation doses to non-NEWs from the normal operation of the project are expected to be negligible as they are not expected to be within the vicinity of any radiation source of concern related to the DGR Project.

<u>*Potential Dose to Members of the Public*</u>

Dose from Airborne and Waterborne Releases

The radiological effect on the public from airborne and waterborne releases from the DGR Project during normal operations was estimated using the methods described in the Radiation and Radioactivity TSD. The public dose estimates are very small and would be less than 1 μSv/a [387].

External Radiation Dose from Direct Radiation and Skyshine

The external dose was found to be negligible. The dose rate at the main guardhouse (nearest Bruce nuclear site boundary) is less than the dose target of 10 μSv/a [387].

Summary

In summary, the assessment of potential exposure to workers and members of the public resulting from the normal operation of the DGR concluded:

- With regard to worker (NEW) dose, inhalation, immersion and external radiation doses as a result of the DGR Project are all expected to be much lower than OPG's occupational dose target of 10 mSv/a for workers. The predicted project-related dose is also expected to be less than that received by existing NEWs at the Bruce nuclear site. However, some potentially higher dose rate locations were identified where worker occupancy may be limited. This should be considered further within the context of ALARA.
- For non-NEWs, the project-related external dose rate is well below the compliance dose limit of 0.5 μSv/h. For the members of the public, the external dose rate is less than the OPG site boundary dose target of 10 μSv/a.
- Project-related doses to members of the public due to airborne and waterborne emissions from the DGR are predicted to be well below the regulatory limit for members of the public of 1 mSv/a.

Therefore, although measurable changes to humans because of incremental doses to workers and members of the public are likely, they are not considered to be adverse and no further consideration is warranted.

7.6.2.2 Dose to Non-human Biota

Exposure Pathway Analysis

The evaluation of the effects of the DGR Project on the non-human biota VECs used the dose to non-human biota to assess direct and indirect project effects.

A direct interaction with non-human biota was identified during the above-ground transfer of waste; however, no DGR Project works and activities were identified as resulting in a direct measurable exposure to any non-human biota VECs site preparation and construction, operations, and decommissioning. Changes in a number of pathways were identified as indirect pathways resulting in measurable exposure to the non-human biota VECs.

In-design Mitigation

To minimize the radiological effects on non-human biota VECs, mitigation measures have been developed during the design of the DGR facilities. These in-design mitigation measures include the following features:

- repository is located a nominal 680 m below ground surface;
- shielding (e.g., appropriate design of waste container, WPRB design);
- emission control;
- zoning and monitoring to prevent spread of contamination in or around the DGR;
- sump and stormwater collection and management; and
- fencing.

These in-design mitigation measures are taken into account in the following assessment.

Non-human Biota Exposure to Radiation

Aquatic and terrestrial biota receive radiation doses from exposure to radioactivity in the atmosphere, surface water and from other media into which it transfers. Radiation doses to biota in the Regional, Site and Local Study Areas were calculated for the existing conditions, and then scaled for the operations scenario.

The effects of the DGR emissions would be an increment to the baseline concentrations around the site. It should also be noted that over 50% of the waste inventory intended for the DGR is already in storage at WWMF, and will increase to 70% by the time the operations phase begins. As wastes are transferred into the DGR, the corresponding emissions from the WWMF will decrease, so any increase in environmental concentrations as a result of the DGR Project will be balanced, in part, by the decrease in concentrations of emissions from the WWMF.

Since the DGR emissions will clearly be less than the current Bruce nuclear site emissions, a screening level estimate of the potential project effects can be provided by conservatively assuming the project causes an incremental increase in tritium and carbon-14 concentrations equal to the existing values.

Essentially, the dose rates to non-human biota during the operation of the DGR can be taken as a bounding case to be twice their existing value. Figure 7.6.2-1 presents the projected dose rate attributable to the operation of the DGR, compared with the dose rate criteria used in the assessment (see Table 7.6.2-1).

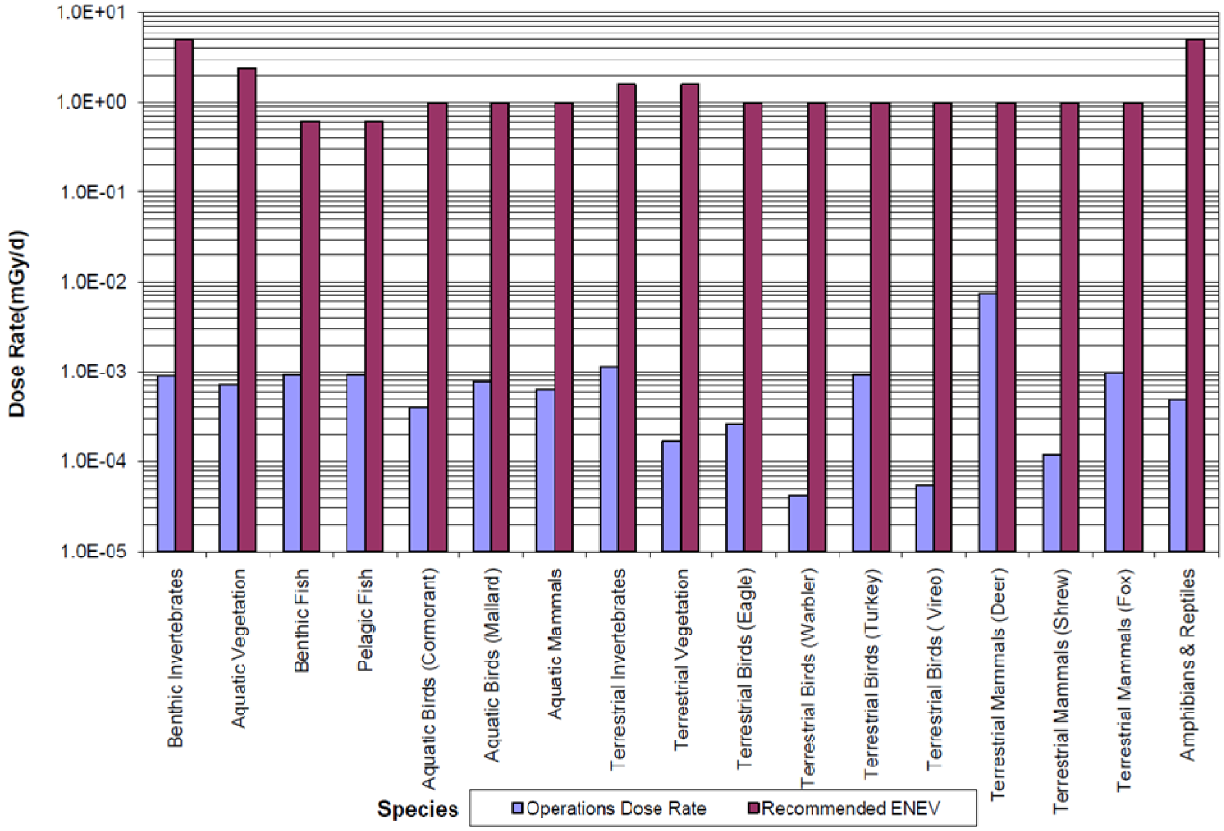


Figure 7.6.2-1: Dose Rates to Non-Human Biota during Operations Phase

As shown on Figure 7.6.2-1, the radioactivity releases to the terrestrial and aquatic environment from the DGR Project are not likely to have an adverse effect on non-human biota. Since there are no adverse effects, no additional mitigation measures are identified, and no further consideration is warranted.

7.6.2.3 Summary of Assessment

The results of the effects prediction and assessment are summarized in Table 7.6.2-2. No adverse effects on humans and non-human biota are identified as a result of the DGR Project from the radiation and radioactivity perspective.

7.6.3 Significance of Residual Adverse Effects

No residual adverse effects of the DGR Project were identified for radiation and radioactivity VECs. An evaluation of significance is not warranted since no adverse effects from project-related radiation exposures to humans and non-human biota are anticipated.

Table7.6.2-2: Summary of the Effects Prediction and Assessment for Radiation and Radioactivity

Project Work and Activity	Humans	Benthic Invertebrates	Aquatic Vegetation	Benthic Fish	Pelagic Fish	Aquatic Birds
Potential Effects from Direct Exposures						
Site Preparation						
Construction of Surface Facilities						
Excavation and Construction of Underground Facilities						
Above-ground Transfer of Waste	■					•
Underground Transfer of Waste	■					
Decommissioning of the DGR Project	■					
Abandonment of the DGR Facility						
Presence of the DGR Project						
Waste Management	■					
Support and Monitoring of DGR Life Cycle	■					
Workers, Payroll and Purchasing						
Potential Effects from Indirect Exposures						
Radiological Changes in Air Quality	■					■
Radiological Changes in Surface Water Quality	■	■	■	■	■	■
Radiological Changes in Soil/Sediment Quality	■	■	■	■		■
Radiological Changes in Groundwater Quality	■	■				
Changed Radionuclide Concentrations in Food	■			■	■	■

Notes:
The matrices are meant to indicate when the activity occurs and do not imply how long the effect will last.

• Potential project-environment interaction
■ Measurable change
Blank No potential interaction

Table7.6.2-2: Summary of the Effects Prediction and Assessment for Radiation and Radioactivity (continued)

Project Work and Activity	Aquatic Mammals	Terrestrial Vegetation	Terrestrial Birds	Terrestrial Mammals	Terrestrial Invertebrates	Amphibians and Reptiles
Potential Effects from Direct Exposures						
Site Preparation						
Construction of Surface Facilities						
Excavation and Construction of Underground Facilities						
Above-ground Transfer of Waste	•	•	•	•	•	•
Underground Transfer of Waste						
Decommissioning of the DGR Project						
Abandonment of the DGR Facility						
Presence of the DGR Project						
Waste Management						
Support and Monitoring of DGR Life Cycle						
Workers, Payroll and Purchasing						
Potential Effects from Indirect Exposures						
Radiological Changes in Air Quality	■	■	■	■		■
Radiological Changes in Surface Water Quality	■	■	■	■		■
Radiological Changes in Soil/Sediment Quality	■	■	■	■	■	■
Radiological Changes in Groundwater Quality					■	
Changed Radionuclide Concentrations in Food	■		■	■		■

Notes:
The matrices are meant to indicate when the activity occurs and do not imply how long the effect will last.

• Potential project-environment interaction
■ Measurable change
Blank No potential interaction

7.7 AIR QUALITY

This section considers one VEC: air quality. The results of the assessment of air quality are summarized in Section 7.7.2.6. The existing environmental features are described in Section 6.7 and the Atmospheric Environment TSD.

7.7.1 Screening to Focus the Assessment

7.7.1.1 Direct Interactions and Measurable Changes

The following works and activities may cause temporary increases in emissions of combustion products and dust causing a direct interaction with air quality:

- site preparation;
- construction of surface facilities;
- excavation and construction of underground facilities;
- above-ground transfer of waste;
- underground transfer of waste;
- decommissioning of the DGR Project;
- waste management;
- site support and monitoring; and
- workers, payroll and purchasing.

Although these components may not all occur at the same time, there are likely to be air emissions as a result of this work and activity. These DGR Project-related emissions are likely to result in a measurable change in air quality and are advanced for assessment in Section 7.7.2.

Activities during the abandonment of the DGR facility may include removal of access controls and installation of historic site markers. These activities are likely to be minor in nature and are not expected to interact with air quality and noise levels. Therefore, no further consideration is warranted.

Presence of the DGR Project represents the meaning people may attach to the existence of the DGR Project in their community and the influence its operations may have on their sense of health, safety and personal security. Therefore, there is no potential interaction with air quality and no further consideration is warranted.

7.7.1.2 Indirect Interactions

No potential indirect interactions for air quality are identified. There is no further consideration of the DGR Project to indirectly affect air quality.

7.7.2 Identification and Assessment of Effects

The air quality VEC was screened for measurable changes, as described above. Direct measurable changes are likely to result from all of the DGR Project works and activities except abandonment and presence of the DGR:

No other measurable changes, including no indirect measurable changes, to air quality were identified in the screening.

7.7.2.1 Linkage Analysis

Existing conditions for air quality were described using a combination of available monitoring data and dispersion modelling, as described in Section 6.7.5.

Direct measurable changes from the DGR Project on air quality were identified during each of the site preparation and construction, operations, and decommissioning phases of the project. Specifically, the direct effects were identified for the following works and activities.

- Site preparation (site preparation and construction phase) – the site preparation activities will result in the release of fugitive dust emissions associated with the construction activities, as well as the release of tailpipe emissions from on-site equipment.
- Construction of surface facilities (site preparation and construction phase) – construction of surface facilities will result in the release of fugitive dust emissions associated with the construction activities, as well as the release of tailpipe emissions from on-site equipment.
- Excavation and construction of underground facilities (site preparation and construction phase) – the excavation and construction of underground facilities will result in the release of fugitive dust from excavation and material handling activities, as well as tailpipe emissions from on-site equipment.
- Above-ground transfer of waste (operations phase) – the above-ground transfer of waste will result in the release of fugitive dust from road traffic, as well as tailpipe emissions from on-site equipment.
- Underground transfer of waste (operations phase) – the underground transfer of waste will result in the release of tailpipe emissions from on-site equipment.
- Decommissioning of the DGR (decommissioning phase) – the decommissioning of the DGR will result in the release of fugitive dust from on-site road traffic, as well as tailpipe emissions from on-site equipment.
- Waste management (all DGR Project phases) – waste management will result in the release of fugitive dust from on-site road traffic, as well as tailpipe emissions from on-site equipment.
- Site support (all DGR Project phases) – site support involves the operation of an emergency diesel generator that will result in combustion emissions.
- Workers, payroll and purchasing (all DGR Project phases) – the construction, operation and decommissioning of the DGR will require a workforce. The workers travelling to and from the Bruce nuclear site will result in the release of on-site fugitive road dust and tailpipe emissions from traffic. These emissions could affect air quality.

No potential indirect effects were identified for air quality. However, changes in air quality resulting from the DGR Project activities could have an indirect effect on soil quality (Section 7.2), hydrology and surface water quality VECs (Section 7.3), VECs in the terrestrial (Section 7.4) and aquatic (Section 7.5) environments, Aboriginal interests VECs (Section 7.9), socio-economic environment VECs (Section 7.10), and human health (Section 7.11).

7.7.2.2 In-design Mitigation

In determining the air emissions associated with the DGR Project works and activities, consideration was given to those mitigation measures that were considered to be integral to the design and implementation of the works and activities. These mitigation measures, which are considered to be typical and consistent with best practices, were incorporated into the emission estimates presented in Section 7.7.2.3, and therefore were incorporated in the effects predictions. The mitigation measures that were included in the air quality assessment of the DGR Project have been summarized in Table 7.7.2-1.

7.7.2.3 Likely Effects

For the air quality VEC, adverse effects are considered to be likely if the maximum concentrations of the air quality indicators resulting from the project are predicted to be higher than the maximum concentrations of the air quality indicators for the existing conditions. That is, any predicted increase in maximum concentrations relative to existing conditions is considered to be a likely adverse effect on the air quality VEC.

Site Preparation and Construction

The works and activities during the site preparation and construction phase will be staged over a period of approximately six years, and will not all occur at the same time. A review of the project details indicate that emissions would be greatest during the first stage of the site preparation and construction phase when site preparation, the construction of surface facilities and excavation of the shafts are occurring concurrently.

Dispersion modelling was used to predict the DGR Project-related effects on air quality. Modelling methods are described in detail in Appendix F of the Atmospheric Environment TSD. Table 7.7.2-2 lists the emissions of the bounding construction stage used as inputs to the dispersion modelling. These emissions include the site preparation, surface facility construction and shaft excavation activities, as well as those attributable to the site preparation and construction phase workers, payroll and purchasing and construction waste management works and activities. The dispersion modelling includes the effects of the combined site preparation and construction phase emissions, existing emissions (Table 6.7.5-7), and background air quality.

Table 7.7.2-1: Air Quality In-design Mitigation

Mitigation Measure	Mitigation Specifics	Works and Activities Affected	Compound Affected by Mitigation Measure	How Was the Mitigation Incorporated in the Assessment
Site Preparation and Construction Phase				
Watering of unpaved roadways, unpaved construction laydown areas, and unpaved construction work areas	Equipment will be available and maintained on-site to water roadways as required [a]	• Site preparation • Workers, payroll and purchasing	• SPM • PM_{10} • $PM_{2.5}$	• Considered integral to the DGR Project • Included in predictions
Maintain on-site vehicles and equipment	On-site vehicles and diesel equipment engines will meet Tier 2 emission standards and be maintained in good working order	• Site preparation • Excavation and construction of underground facilities	• NO_2 • CO • SO_2 • SPM • PM_{10} • $PM_{2.5}$	• Considered integral to the DGR Project • Included in predictions
Operations Phase				
Maintain on-site vehicles and equipment	On-site vehicles and diesel equipment engines will meet Tier 2 emission standards and be maintained in good working order	• Above-ground transfer of waste • Underground transfer of waste	• NO_2 • CO • SO_2 • SPM • PM_{10} • $PM_{2.5}$	• Considered integral to the DGR Project • Included in predictions

Note:
a The modelling assumed an effective 75% reduction of particulate matter emissions on a daily basis would be achieved.

Table 7.7.2-2: Daily DGR Project Site Preparation and Construction Phase Emissions

Indicator Compound [a]	Daily Emission Rates (kg/d) [b]			
	Shafts	Vehicles [c]	Fugitive Dust [d]	Site Equipment
NO_X	31.91	5.25	—	206.31
SO_2	0.06	0.02	—	0.41
CO	27.19	12.09	—	129.28
SPM	1.72	0.19	197.87	7.47
PM_{10}	1.70	0.19	39.91	7.47
$PM_{2.5}$	1.68	0.18	22.97	7.47

Notes:
a Emissions of NO_X from the DGR Project include both the emissions of NO_2 (an indicator compound) and NO. A portion of the NO emissions will be converted to NO_2 in the atmosphere; therefore, the combined emissions of NO_2 and NO, collectively referred to as NO_X, are of concern.
b Adding the numbers in the rows above yielded the totals shown in the Stage 1 column of Table 8.2.3-1 of the Atmospheric Environment TSD.
c Includes tailpipe emissions from delivery vehicles and all of the OPG and DGR Project worker vehicles on-site.
d Includes all fugitive dust, including road dust, generated by on-site traffic.
— Not applicable

Table 7.7.2-3 provides a comparison of the site preparation and construction phase to the existing concentrations of indicator compounds. Those air quality indicator compounds for which adverse effects to air quality were predicted to occur are examined for possible application of mitigation measures in Section 7.7.2.2.

Table 7.7.2-3: Site Preparation and Construction Phase Adverse Effects to Air Quality in the Local Study Area

Indicator Compound	Maximum Existing Concentration (µg/m³) in Local Study Area	Maximum Site Preparation and Construction Phase Concentration (µg/m³) in Local Study Area	Increase Over Existing Concentration (µg/m³) in Local Study Area	Likely Adverse Effect?
1-hour NO_2	110.4	321.7	+211.3	**adverse effect**
24-hour NO_2	26.5	141.2	+114.7	**adverse effect**
Annual NO_2	6.8	18.5	+11.7	**adverse effect**
1-hour SO_2	318.9	318.9	0	no adverse effect
24-hour SO_2	51.3	51.3	0	no adverse effect
Annual SO_2	5.0	5.0	0	no adverse effect
1-hour CO	1,580.6	2,504.2	+923.6	**adverse effect**

Table 7.7.2-3: Site Preparation and Construction Phase Adverse Effects to Air Quality in the Local Study Area (continued)

Indicator Compound	Maximum Existing Concentration (µg/m³) in Local Study Area	Maximum Site Preparation and Construction Phase Concentration (µg/m³) in Local Study Area	Increase Over Existing Concentration (µg/m³) in Local Study Area	Likely Adverse Effect?
8-hour CO	1,201.8	1,595.7	+393.9	**adverse effect**
24-hour SPM	71.0	276.9	+205.9	**adverse effect**
Annual SPM	25.1	30.7	+5.6	**adverse effect**
24-hour PM_{10}	26.0	75.3	+49.3	**adverse effect**
24-hour $PM_{2.5}$	15.4	45.7	+30.3	**adverse effect**

Operations Phase

Table7.7.2-4 lists the emissions of the operations phase used as inputs to the dispersion modelling. The dispersion modelling includes effects of the combined operations phase emissions, existing emissions (Table 6.7.5-7) and background air quality.

Table 7.7.2-4: Daily DGR Project Operations Phase Emissions

Indicator Compound [a]	Daily Emission Rates (kg/d)				
	Vent Raise	Emergency Generator	Vehicles [b]	Fugitive Dust [c]	Site Equipment
NO_X	5.92	19.71	0.04	—	8.87
SO_2	0.01	0.02	0.00	—	0.02
CO	4.31	12.20	0.82	—	5.78
SPM	0.33	0.70	0.00	0.13	0.37
PM_{10}	0.33	0.70	0.00	0.02	0.37
$PM_{2.5}$	0.33	0.70	0.00	0.00	0.37

Notes:
a Emissions of NO_X from the DGR Project includes both the emissions of NO_2 (an indicator compound) and NO. A portion of the NO emissions will be converted to NO_2 in the atmosphere; therefore, the combined emissions of NO_2 and NO, collectively referred to as NO_X, are of concern.
b Includes tailpipe emissions from all of the OPG and DGR Project worker vehicles on-site.
c Includes all fugitive dust, including road dust, generated by on-site traffic.
— Not applicable

Table 7.7.2-5 provides a comparison of the operations phase to the existing concentrations of indicator compounds. Those air quality indicator compounds for which adverse effects to air quality were predicted to occur are examined for possible application of mitigation measures in Section 7.7.2.4.

Table 7.7.2-5: Operations Phase Adverse Effects to Air Quality in the Local Study Area

Indicator Compound	Maximum Existing Concentrations (µg/m³) in Local Study Area	Maximum Operations Phase Concentrations (µg/m³) in Local Study Area	Increase Over Existing Concentrations (µg/m³) in Local Study Area	Likely Adverse Effect?
1-hour NO_2	110.4	151.6	+41.2	**adverse effect**
24-hour NO_2	26.5	67.8	+41.3	**adverse effect**
Annual NO_2	6.8	7.6	+0.8	**adverse effect**
1-hour SO_2	318.9	318.9	0	no adverse effect
24-hour SO_2	51.3	51.3	0	no adverse effect
Annual SO_2	5.0	5.0	0	no adverse effect
1-hour CO	1,580.6	1,597.8	+17.2	**adverse effect**
8-hour CO	1,201.8	1,202.3	+0.5	**adverse effect**
24-hour SPM	71.0	71.5	+0.5	**adverse effect**
Annual SPM	25.1	25.1	0	no adverse effect
24-hour PM_{10}	26.0	26.9	+0.9	**adverse effect**
24-hour $PM_{2.5}$	15.4	15.9	+0.5	**adverse effect**

Decommissioning Phase

The emissions during the decommissioning phase are expected to be similar to, or less than those predicted for the site preparation and construction phase. Therefore, potential adverse effects are bounded by those predicted for the site preparation and construction phase, as presented in Table 7.7.2-3. The adverse effects identified for site preparation and construction phase are considered to be applicable to the decommissioning phase and are considered for possible mitigation measures.

7.7.2.4 Additional Mitigation Measures

As discussed in Section 7.7.2.2, in-design mitigation measures are considered to be integral to the design and implementation of the works and activities. No additional mitigation measures were considered in the assessment of changes in air quality as a result of the DGR Project.

7.7.2.5 Residual Adverse Effects

Table 7.7.2-6 provides a summary of the identified adverse effects of the DGR Project on air quality, along with an identification of whether residual adverse effects will remain after the implementation of mitigation measures. The residual adverse effects during decommissioning phase are expected to be similar to those identified for the site preparation and construction phase. As described above, no additional mitigation is considered. The significance of the residual adverse effects of the DGR Project on air quality is assessed in Section 7.7.3.

Table 7.7.2-6: Residual Adverse Effects on Air Quality

Adverse Effect	Mitigation Measures	Residual Adverse Effects
Site Preparation and Construction Phase		
1-hour NO_2	• Considered integral to the DGR Project (see Section 7.7.2.2) • Included in predictions	**Residual adverse effect**
24-hour NO_2		
Annual NO_2		
1-hour CO		
8-hour CO		
24-hour SPM		
Annual SPM		
24-hour PM_{10}		
24-hour $PM_{2.5}$		
Operations Phase		
1-hour NO_2	• Considered integral to the DGR Project (see Section 7.7.2.2) • Included in predictions	**Residual adverse effect**
24-hour NO_2		
Annual NO_2		
1-hour CO		
8-hour CO		
24-hour SPM		
24-hour PM_{10}		
24-hour $PM_{2.5}$		
Decommissioning Phase		
Assumed to be similar to the site preparation and construction phase	• Assumed to be similar to the site preparation and construction phase	**Residual adverse effect**

7.7.2.6 Summary of Assessment

Table 7.7.2-7 provides a summary of the assessed effects of the DGR Project on air quality. Diamonds (◆) on this matrix represent likely DGR Project-environment interactions resulting in a residual adverse effect on air quality. These interactions are advanced to Section 7.7.3 for determination of significance.

Table 7.7.2-7: Summary of Effects Prediction and Assessment

Project Work and Activity	Air Quality
Direct Effects	
Site Preparation	◆
Construction of Surface Buildings and Infrastructure	◆
Excavation and Construction of Underground Facilities	◆
Above-ground Transfer of Waste	◆
Underground Transfer of Waste	◆
Decommissioning of the DGR Project	◆
Abandonment of the DGR Facility	
Presence of the DGR Project	
Waste Management	◆
Support and Monitoring of DGR Life Cycle	◆
Workers, Payroll and Purchasing	◆
Indirect Effects	
Changes in Noise Levels	
Changes in Surface Water Quantity and Flow	
Changes in Surface Water Quality	
Changes in Soil Quality	
Changes in Groundwater Quality	
Changes in Groundwater Flow	

Notes:
The matrices are meant to indicate when the activity occurs and do not imply how long the effect will last.

◆ Residual adverse effect
Blank No potential interaction

7.7.3 Significance of Residual Adverse Effects

The criteria used for judging and describing the significance of effects are shown in Table 7.1-1. The magnitude criteria applicable to air quality are shown in Table 7.7.3-1.

Table 7.7.3-1: Effects Levels for Assigning Magnitude for Air Quality

Criteria	Magnitude Level Definition		
	Low [a]	Medium [b]	High [b]
1-hour NO_2 (µg/m³)	≤200	≤400	>400
24-hour NO_2 (µg/m³)	≤100	≤200	>200
Annual NO_2 (µg/m³)	≤50	≤100	>100
1-hour SO_2 (µg/m³)	≤450	≤900	>900
24-hour SO_2 (µg/m³)	≤150	≤300	>300
Annual SO_2 (µg/m³)	≤30	≤60	>60
1-hour CO (µg/m³)	≤17,500	≤35,000	>35,000
8-hour CO (µg/m³)	≤7,500	≤15,000	>15,000
24-hour SPM (µg/m³)	≤60	≤120	>120
Annual SPM (µg/m³)	≤35	≤70	>70
24-hour PM_{10} (µg/m³)	≤25	≤50[c]	>50[c]
24-hour $PM_{2.5}$ (µg/m³)	≤15	≤30[d]	>30[d]

Notes:
a The low threshold was set at 50% of the relevant criteria.
b National Ambient Air Quality Objectives [408].
c Ontario Ambient Air Quality Objectives [409].
d Canada-wide Standard [410].

The level of significance is assigned using a decision tree model, illustrated in Figure 7.7.3-1. The magnitude, geographic extent, timing and duration, frequency, and degree of irreversibility are combined to identify an environmental consequence. Then the social and/or ecological importance of the affected VEC is then considered to determine the overall significance of the effect.

This decision tree is specific to atmospheric environment, in this case air quality, and the effects level criteria defined in Tables 7.1-1 and 7.7.3-1. Some of the guiding principles are:

- All effects of low magnitude would result in a low environmental consequence and would not be considered significant. Low magnitudes are assigned for indicators where the maximum concentration is less than half of the relevant criteria. Since criteria are established to protect the environment and the health of people, effects less than half of those thresholds would be considered to have a low consequence.
- Effects that are limited to the Site Study Area (i.e., low extent) would result in a low environmental consequence and would not be considered significant. Ambient air quality and noise criteria are established to protect people beyond the site[19]. For this assessment, the site is defined by the limits of the Site Study Area.

[19] Airborne concentrations within the fenceline are not considered part of the environment from a permitting perspective, but are the subject of occupational health and safety concerns, which are addressed in Appendix C.

- Effects with a high magnitude that extend beyond the Site Study Area have the potential to be of a high consequence if the frequency is high or the effects of a high magnitude extend beyond the Local Study Area.

The residual adverse effect can be determined to be:

- not significant;
- may not be significant; or
- significant.

An effect that "may not be significant" is one that in the professional judgement of the specialists would not be significant; however, follow-up monitoring should be proposed to confirm significant adverse effects do not occur.

Residual adverse effects during the site preparation and construction, operations, and decommissioning phases were identified for the air quality VEC. Table 7.7.3-2 and Sections 7.7.3.1 to 7.7.3.3 below provide a summary of the assessment of significance for all identified residual adverse effects.

7.7.3.1 Site Preparation and Construction Phase

During the site preparation and construction phase, residual adverse effects on the air quality VEC were identified for eight individual indicators. Of these, four were predicted to have residual adverse effects that result in a low magnitude (see Table 7.7.3-1) and thus a low consequence. Therefore, air quality effects attributable to these indicators are considered not significant.

Two indicators (i.e., 1-hour and 24-hour NO_2) were classified as having a medium magnitude. While the maximum predictions for these indicators were below the relevant criteria, they were higher than 50% of the criteria. These indicators were determined to have a low consequence (see Figure 7.7.3-1), and thus considered not significant.

The remaining three individual indicators (i.e., 24-hour SPM, 24-hour PM_{10}, and 24-hour $PM_{2.5}$) were predicted to have residual adverse effects that result in a high magnitude (i.e., maximum predictions are greater than the respective criteria). All of the high magnitudes were restricted to the Local Study Area, in the immediate vicinity of the Bruce nuclear site, and have durations that are low (see Table 7.7.3-2). The frequencies for the indicators with high magnitudes are low (see Table 7.7.3-2). In fact, high magnitude predictions occurred on only nine days of the 5-years of dispersion modelling (i.e., <0.5% of the time). Therefore, these were assigned a moderate consequence and classified as may not be significant (see Figure 7.7.3-1). Significant impacts are not expected for these indicators during the site preparation and construction phase; however, monitoring would be required to determine the level of effects and effectiveness of the proposed mitigation (including the in-design mitigation).

7.7.3.2 Operations Phase

During the operations phase, residual adverse effects on the air quality VEC were identified for seven individual indicators. Five of these were predicted to have residual adverse effects that result in a low magnitude (see Table 7.7.3-1) and thus a low consequence (see Figure 7.7.3-1). Therefore, these residual adverse effects are considered not significant.

The remaining three individual indicators (i.e., 24-hour SPM, 24-hour PM_{10}, and 24-hour $PM_{2.5}$) were predicted to have residual adverse effects that result in a medium magnitude (i.e., maximum predictions are less than the respective criteria, but greater than half of the criteria). All of the medium magnitudes were restricted to the Local Study Area, in the immediate vicinity of the Bruce nuclear site. The duration is medium (see Table 7.7.3-2) and the frequency for the medium magnitude indicators range from low to medium (see Table 7.7.3-2). Therefore, these were assigned a low consequence and classified as not significant (see Figure 7.7.3-1).

7.7.3.3 Decommissioning Phase

The effects of the DGR Project on air quality during the decommissioning phase are considered to be similar to, or lower than those experienced during the site preparation and construction phase. Based on this, they are determined to be not significant, assuming a conservative approach to evaluation. Follow-up monitoring is described in Section 12.

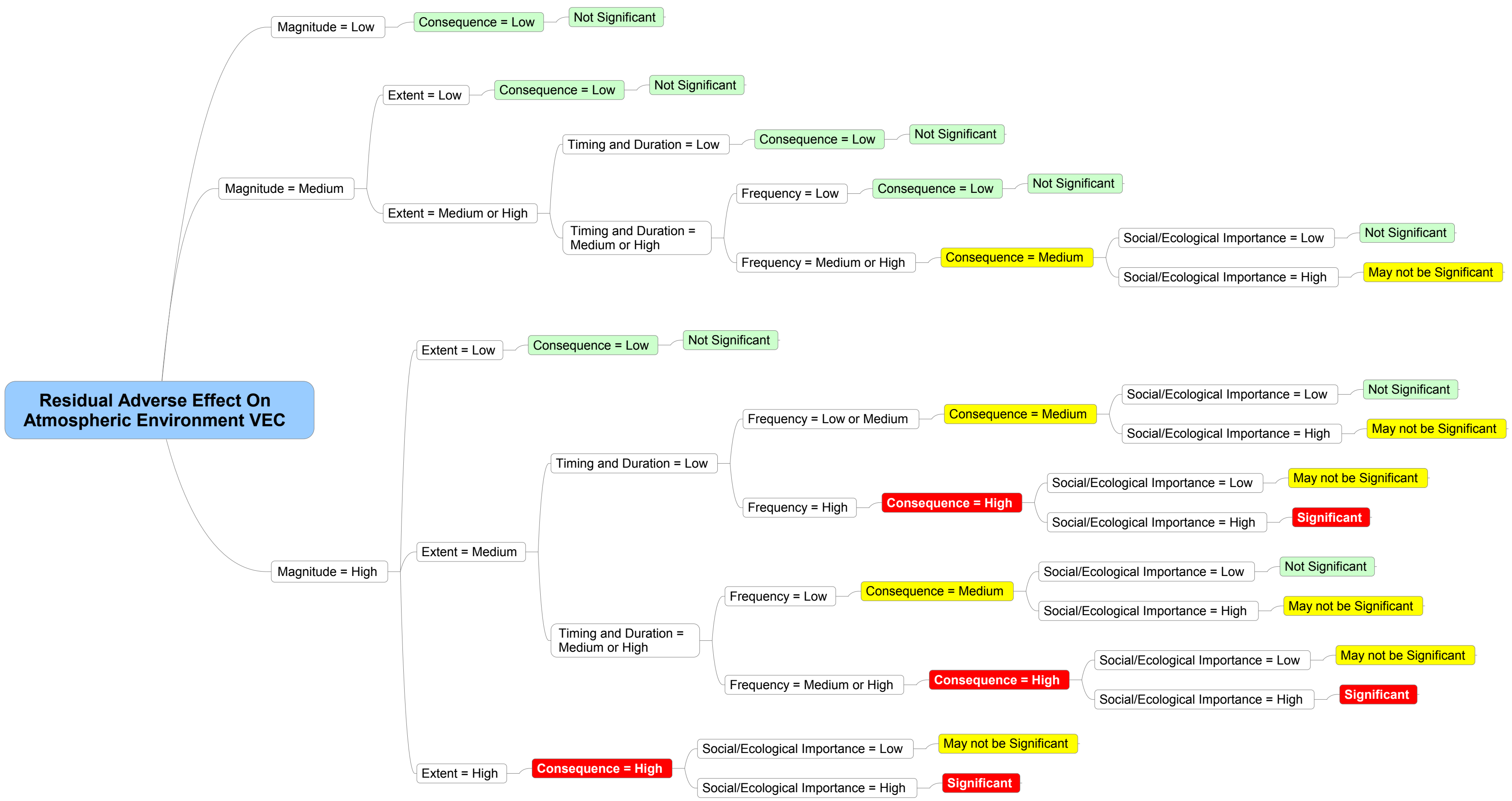


Figure 7.7.3-1: Determination of Significance of Residual Adverse Effects for Air Quality

Table 7.7.3-2: Summary of Residual Adverse Effects and Significance Levels for Air Quality

VEC	Magnitude	Geographic Extent	Timing and Duration[a]	Frequency	Degree of Irreversibility	Overall Assessment
Site Preparation and Construction Phase						
Air Quality	**High** • Predicted values for more than one indicator compound exceeds the relevant criteria	**Medium** • The effect extends to the Local Study Area	**Low** • Effect is evident during the site preparation and construction phase	**Low to Medium** • Conditions or phenomena causing the effect occur infrequently (i.e., <1%) or at regular, although infrequent intervals (i.e., <10%)	**Low** • Effect is readily (i.e., immediately) reversible	**May Not Be Significant** (See Section 7.7.3.1)
Operations Phase						
Air Quality	**Medium** • None of the predicted values exceed relevant criteria • Predicted values for more than one indicator exceed 50% of the relevant criteria	**Medium** • The effect extends to the Local Study Area	**Medium** • Effect is evident during the operations phase	**Medium** • Conditions or phenomena causing the effect occur at regular, although infrequent intervals (i.e., <10%)	**Low** • Effect is readily (i.e., immediately) reversible	**Not Significant** (See Section 7.7.3.2)

Table 7.7.3-2: Summary of Residual Adverse Effects and Significance Levels for Air Quality (continued)

VEC	Magnitude	Geographic Extent	Timing and Duration[a]	Frequency	Degree of Irreversibility	Overall Assessment
Decommissioning Phase						
Air Quality	**High** • Predicted values for more than one indicator compound exceeds the relevant criteria	**Medium** • The effect extends to the Local Study Area	**Low** • Effect is evident during the decommissioning phase	**Low** • Conditions or phenomena causing the effect occur infrequently (i.e., <1%)	**Low** • Effect is readily (i.e., immediately) reversible	**May Not Be Significant** (See Section 7.7.3.3)

Note:

a The duration in the above table is based on the magnitudes of the identified effects. For example, a high magnitude is predicted during the site preparation and construction phase. Therefore, the duration for this effect (i.e., the effect of a high magnitude) is low. In a similar manner, activities during the operations phase are predicted to have a medium magnitude on air quality. Because these occur during the operations phase, these effects (i.e., the effects of a medium magnitude) were assigned a medium duration.

7.8 NOISE AND VIBRATIONS

One VEC (i.e., noise levels) was identified for the assessment of noise and vibrations. A vibrations assessment is summarized in this section and presented in detail in Appendix I of the Atmospheric Environment TSD. The results of the noise assessment are summarized in Section 7.2.8.2. The existing noise levels are described in Section 6.8 and the Atmospheric Environment TSD.

7.8.1 Screening to Focus the Assessment

7.8.1.1 Direct Interactions and Measurable Changes

The following works activities may increase noise emissions causing a direct interaction with noise levels:

- site preparation;
- construction of surface facilities;
- excavation and construction of underground facilities;
- above-ground transfer of waste;
- decommissioning of the DGR Project;
- waste management;
- support and monitoring of DGR life cycle; and
- workers, payroll and purchasing.

Although these components may not all occur at the same time, there are likely to be noise emissions as a result of this work and activity. These DGR Project-related emissions are likely to have a measurable change in noise levels and are advanced for assessment in Section 7.8.2.

The abandonment activities may include removal of access controls and installation of historic markers. These activities are not likely to have a direct interaction with noise levels; therefore, no further consideration is warranted.

Presence of the DGR Project represents the meaning people may attach to the existence of the DGR Project in their community and the influence its operations may have on their sense of health, safety and personal security. Therefore, there is no potential interaction with noise levels and no further consideration is warranted.

7.8.1.2 Indirect Interactions

No potential indirect interactions for noise levels were identified.

7.8.2 Identification and Assessment of Effects

The noise levels VEC was screened for measurable changes, as described above. Direct measurable changes are likely to result from all of the DGR Project works and activities except abandonment and presence of the DGR.

No other measurable changes, including no indirect measurable changes, to noise levels were identified in the screening.

7.8.2.1 Linkage Analysis

Existing conditions for noise were described using a combination of monitoring and short duration measurements, as described in Section 6.8.

Measurable changes resulting from the project on noise levels were identified during each of the construction, operations, and decommissioning phases of the DGR Project. Specifically, the following direct measurable changes were identified:

- Site preparation (site preparation and construction phase) – the site preparation activities will result in the release of noise emissions associated with the construction activities.
- Construction of surface facilities (site preparation and construction phase) – the construction of the surface facilities involves the installation and operation of an emergency diesel generator that will result in increased noise emissions.
- Excavation and construction of underground facilities (site preparation and construction phase) – the excavation and construction of underground facilities will result in increased noise emissions from excavation and material handling activities.
- Above-ground transfer of waste (operations phase) – the above-ground transfer of waste will result in increased noise levels from waste transportation.
- Decommissioning of the DGR (decommissioning phase) – the decommissioning of the DGR will result in noise levels associated with road traffic and on-site equipment.
- Waste management (all DGR Project phases) – waste management will result in increased noise levels from road traffic, as well as noise emissions from on-site equipment.
- Site support (all DGR Project phases) – site support involves the operation of an emergency diesel generator that will result in noise emissions.
- Workers, payroll and purchasing (all DGR Project phases) – the construction, operation and decommissioning of the DGR will require a workforce. The workers traveling to and from the Bruce nuclear site will result in noise emissions from traffic.

No indirect effects were identified with respect to noise levels. However, changes in noise levels resulting from the DGR Project activities could have an indirect effect on VECs in the terrestrial (Section 7.4) and aquatic environments (Section 7.5), Aboriginal interests (Section 7.9), socio-economic environment (Section 7.10), and human health (Section 7.11).

7.8.2.2 In-design Mitigation

In determining the noise emissions associated with the DGR Project works and activities, consideration was given to those mitigation measures that were considered to be integral to the design and implementation of the works and activities. The noise mitigation measures that were included in the noise assessment have been summarized in Table 7.8.2-1.

7.8.2.3 Likely Effects on Noise Levels

As stated in the Atmospheric Environment TSD, the likely effects of the DGR Project on noise levels are evaluated with the aid of the CadnaA noise model, which uses the ISO 9613 [411] noise prediction formulations. Modelling methods are provided in Appendix G of the Atmospheric Environment TSD. For the noise levels VEC, adverse effects were considered to be likely if the predicted noise levels resulted in a change from existing conditions that would be perceptible to humans [412]. An adverse effect was considered to be likely if the predicted noise levels exceed the quietest existing hourly noise levels by more than 3 dB.

Site Preparation and Construction Phase

The levels of activities and associated noise emissions are not consistent throughout the site preparation and construction phase. In assessing the effects of the DGR Project on noise levels, the point when activity and noise emissions were projected to be at a maximum was selected as bounding the effects for this phase of the DGR Project.

Table 7.8.2-2 lists the overall sound power data of the bounding site preparation and construction phase emissions used as inputs to the noise prediction model. Although some of these pieces of equipment may be below grade during much of the phase, the assessment has conservatively assessed that they will be at or near the surface during the early stages of construction. The noise modelling presented later in this section includes the combined effects of the site preparation and construction phase emissions and existing noise levels.

Table 7.8.2-1: Noise Levels In-design Mitigation

Mitigation Measure	Mitigation Specifics	Works and Activities Affected	Property Affected by Mitigation Measure	How Was the Mitigation Incorporated in the Assessment
Site Preparation and Construction Phase				
Maintain on-site vehicles and equipment	On-site vehicles and equipment will be equipped with appropriate silencers and maintained in good working order	• Site preparation • Excavation and construction of underground facilities • Above-ground transfer of waste	• Equipment sound power levels	• Considered integral to the DGR Project • Included in predictions
Tight Footprint	Construction areas have been located close to the project footprint to limit vehicle travel routes	• Site preparation • Excavation and construction of underground facilities	• Equipment sound power levels	• Considered integral to the DGR Project • Included in predictions
Operations Phase				
Maintain on-site vehicles and equipment	On-site vehicles and equipment will be equipped with appropriate silencers and maintained in good working order	• Above-ground transfer of waste • Workers, payroll and purchasing	• Equipment sound power levels	• Considered integral to the DGR Project • Included in predictions
Maintain fresh air and return air raise fans	Fans maintained in good working order	• Above-ground transfer of waste	• Equipment sound power levels	• Considered integral to the DGR Project • Included in predictions

Table 7.8.2-2: Bounding Site Preparation and Construction Phase Noise Emissions

Source	Quantity	Overall Sound Power Level (dBA)
Articulated Trucks (Cat 730) Land Clearance	2	109
Articulated Trucks (Cat 730) Re-used Material Transfer	2	109
Articulated Trucks (Cat 730) Storm Water	2	109
Batch Plant Concrete Truck Blower	1	108
Batch Plant Hopper Blower	1	104
Batch Plant Truck Concrete Loading	4	109
Batch Plant Truck Rinsing	4	109
Bulldozer (Cat D9T WH) Land Clearance	1	115
Bulldozer (Cat D9T WH) Road Construction	1	115
Bulldozer (Cat D9T WH) Storm Water	1	115
Bulldozer (Cat D9T WH) Waste Rock Pile Construction	1	115
Cement Storage Hopper Blower	1	104
Concrete Truck	4	104
Compactors (Cat CS-683) Road Construction	1	109
Electrical Substation	1	91
Excavator (Cat 340D) Land Clearance	1	102
Excavator (Cat 340D) Storm Water	1	102
Explosives Carrier/loader	2	115
Feller Buncher (Cat 522) Land Clearance	1	114
Front End Loader (Cat 988H)	3	115
Front End Loader (Cat 988H) Waste Rock Pile	1	115
Heavy Vehicles – DGR Construction (Main Gate)	22	104
Jumbo Atlas Copco Boomer E3 C	2	119
Loader (Cat 988H) - batch plant	1	115
Motor Grader (CAT 140)	2	116
Pavers (Cat BG-240C) Road Construction	1	106
Shotcrete Transmixer	2	108
Sprayer	2	107

Table 7.8.2-2: Bounding Site Preparation and Construction Phase Noise Emissions (continued)

Source	Quantity	Overall Sound Power Level (dBA)
Vehicles - DGR Construction and Support Workers (Main Gate)	218	98

Table 7.8.2-3 provides a comparison of the predicted site preparation and construction phase noise levels along with the corresponding baseline results at the receptor locations in the Local Study Area (Figure 6.8.3-1). The application of possible mitigation measures is examined in Section 7.8.2.5.

Table 7.8.2-3: Site Preparation and Construction Phase Adverse Effects to Noise Levels in the Local Study Area

Receptor	Ambient Noise Levels During the Site Preparation and Construction Phase (dBA)	Baseline Noise Levels (dBA)	Project-related Change Relative to Baseline (dB)	Likely Adverse Effect?
R1 – Albert Road	38	36	+2	no adverse effect
R2 – Baie du Doré	42	37	+5	**adverse effect**
R3 – Inverhuron Provincial Park	37	35	+2	no adverse effect

Note: A change in noise levels >3 is considered an adverse effect.

Operations Phase

Table 7.8.2-4 lists the overall sound power levels for the bounding operations phase emissions used as inputs to the noise prediction model. The modelling presented later in this section includes the combined effects of the operations phase emissions and baseline.

Table 7.8.2-4: Operations Phase Emissions

Source	Quantity	Overall Sound Power Level (dBA) [a]
Air Compressor Plant	1	116
Diesel Generator (3,500 kW) Back-up [b]	1	118
Electrical Sub-Station	1	91
Exhaust Fans	2	117

Table 7.8.2-4: Operations Phase Emissions (continued)

Source	Quantity	Overall Sound Power Level (dBA) [a]
Flat-bed Transporter/Truck	1	105
Forklifts Large	1	99
Forklifts Small	1	99
Intake Fans	1	125
Headframe [c]	2	92
Hoist House [c]	1	92
Vehicles - DGR Employees (Main Gate)	25	75

Notes:
a Overall sound power source references provided in Appendix G.
b Diesel generator was conservatively assessed with a weather enclosure only.
c Sources of noise may include machinery, cabling, etc.

Table 7.8.2-5 provides a comparison of the predicted operations phase noise levels along with the corresponding baseline results. There are no adverse noise effects identified through the noise level indicator. Therefore, no further consideration is warranted for noise levels during the operations phase.

Table 7.8.2-5: Operations Phase Adverse Effects to Noise Levels in the Local Study Area

Receptor	Ambient Noise Levels During the Operations Phase (dBA)	Existing Noise Levels (dBA)	Project-related Change Relative to Baseline (dB)	Likely Adverse Effect?
R1 – Albert Road	38	36	+2	no adverse effect
R2 – Baie du Doré	40	37	+3	no adverse effect
R3 – Inverhuron Provincial Park	37	35	+2	no adverse effect

Note: A change in noise levels >3 is considered an adverse effect.

<u>*Decommissioning Phase*</u>

The emissions during the decommissioning phase are expected to be similar to the emissions from the site preparation and construction phase and therefore, the potential adverse effects are similar to those predicted for this phase, as presented in Table 7.8.2-3.

7.8.2.4 Summary of Vibrations Assessment

The vibrations assessment is detailed in Appendix I of the Atmospheric Environment TSD. The main shaft will be excavated to a diameter of 7.85 m and a nominal depth of 720 m. The ventilation shaft will be excavated to a diameter of 6.2 m and a nominal depth of 745 m. The underground repository would consist of a number of parallel rooms excavated at a nominal depth of 680 m below ground surface with each room measuring about 8.6 × 7.0 m in cross section.

Ground vibration guidelines or regulations typically established for blasting sites to prevent damage to adjacent facilities or structures generally range from 12.5 to 50 mm/s, depending on the dominant frequency of the ground vibration [413;414]. Exceeding these levels does not in itself imply that damage would or has occurred but only increases the potential that damage might occur.

Table 7.8.2-6 summarizes the predicted maximum ground and air vibration levels that could be experienced at each of the sensitive receptors identified in the Atmospheric Environment TSD (Appendix I), assuming maximum explosive weights of 112 and 150 kg per delay period during shaft sinking and underground development respectively.

Table 7.8.2-6: Predicted Maximum Ground and Air Vibration Levels

Receptor	Maximum Ground Vibration		Maximum Air Vibration	
	During Shaft Sinking (mm/s)	During Underground Development (mm/s)	During Shaft Sinking (dBL)	During Underground Development (dBL)
Hydro One substation	1.0	0.5	111	107
Bruce B transformers and switchyards	0.3	0.3	103	104
WWMF propane storage tanks	2.7	0.9	116	110
Bruce Power office building	0.5	0.5	107	107
Bruce nuclear site security entrance building (Main gate)	0.3	0.7	104	109
WWMF dry storage facility	2.7	0.9	116	110
Bruce A transformers and switchyards	0.5	0.5	108	107
CO_2 storage facility @ WWMF	4.3	0.9	119	110

Table 7.8.2-6: Predicted Maximum Ground and Air Vibration Levels (continued)

Receptor	Maximum Ground Vibration		Maximum Air Vibration	
	During Shaft Sinking (mm/s)	During Underground Development (mm/s)	During Shaft Sinking (dBL)	During Underground Development (dBL)
ER1, Baie du Doré Provincially Significant Wetland, northeast of Bruce nuclear site	<0.3	<0.3	96	97
ER2, beach north of Project Area	0.3	<0.3	103	103
ER3, forest southwest of Project Area	0.3	0.4	104	105
ER4, forest within Project Area	0.7	0.8	108	109
ER5, industrial barren within Project Area	4.3	0.9	119	110
ER6, forest northeast of Project Area	0.6	0.7	108	109
ER7, forest/meadow within Project Area	0.7	0.8	108	109
Shoreline of Lake Huron west of the Project Area	0.4	0.3	105	104
South Railway Ditch bisecting Project Area and Bruce nuclear site at closest point (150 m)[a]	8.4	0.9	123	110
R1, residence south of Bruce nuclear site	<0.3	<0.3	94	96
R2, residence on Baie du Doré north of Bruce nuclear site	<0.3	<0.3	96	97
R3, residence on shore of Lake Huron south of Bruce nuclear site	<0.3	<0.3	94	95

Note:
a Only applicable during spawning season and at identified spawning depressions

It should be recognized that these predicted peak ground vibration levels are based on empirical data and should be confirmed once blasting has commenced. No exceedances were predicted. For a receptor at 150 m away from the blast source, the maximum charge weight per delay would be 530 kg to maintain the 128 dBL air vibration limit. As the total weight of explosive for an entire development round would not exceed about 400 kg, the maximum explosive weight per delay period would not be expected to exceed about 150 kg. Therefore, no adverse vibration effects are predicted as a result of blasting activities during construction of underground facilities.

7.8.2.5 Additional Mitigation Measures

As discussed in Section 7.8.2.2, in-design mitigation measures considered to be integral to the design and implementation of the works and activities. No additional mitigation measures were considered in the assessment of changes in noise levels as a result of the DGR Project.

7.8.2.6 Residual Adverse Effects

Table 7.8.2-7 provides a summary of the identified adverse effects of the DGR Project on noise levels, along with an identification of whether residual adverse effects will remain after the implementation of mitigation measures. The significance of the residual adverse effects of the DGR Project on noise levels are assessed in Section 7.8.3.

Table 7.8.2-7: Residual Adverse Effects on Noise Levels

Adverse Effect	Mitigation Measures	Residual Adverse Effects
Site Preparation and Construction Phase		
Increase in L_{eq} by 5 dB at R2 – Baie du Doré	• Considered integral to the project • Included in predictions	**Residual adverse effect**
Decommissioning Phase		
Assumed to be the same, or less than the site preparation and construction phase	• Considered integral to the project • Included in predictions	**Residual adverse effect**

7.8.2.7 Summary of the Assessment

Table 7.8.2-8 provides a summary of the assessment of the noise levels VEC for the DGR Project. Diamonds (◆) on this matrix represent likely project-environment interactions resulting in a residual adverse effect on a VEC. These interactions are advanced to Section 7.8.3 for a consideration of significance.

Table 7.8.2.-8: Summary of Effects Prediction and Assessment for Noise Levels

Project Work and Activity	Noise Levels	Vibrations [a]
Direct Effects		
Site Preparation	◆	
Construction of Surface Facilities	◆	
Excavation and Construction of Underground Facilities	◆	■
Above-ground Transfer of Waste	■	
Underground Transfer of Waste	•	
Decommissioning of the DGR Project	◆	
Abandonment of the DGR Facility		
Presence of the DGR Project		
Waste Management	◆	
Support and Monitoring of DGR Life Cycle	◆	
Workers, Payroll and Purchasing	◆	
Indirect Effects		
Changes in Air Quality		
Changes in Surface Water Quantity and Flow		
Changes in Surface Water Quality		
Changes in Soil Quality		
Changes in Groundwater Quality		
Changes in Groundwater Flow		

Notes:
The matrices are meant to indicate when the activity occurs and do not imply how long the effect will last.
• Potential project-environment interaction
■ Measurable change
◆ Residual adverse effect
Blank No potential interaction
a Although not identified as a VEC, the results of the summarized vibrations analysis (Section 7.8.2.4) have been presented in the above table for consistency.

7.8.3 Significance of Residual Adverse Effects

The criteria used for judging and describing the significance of effects are shown in Table 7.1-1. Significance is rated using these criteria and the magnitude criteria applicable to noise levels, as shown in Table 7.8.3-1. These criteria are based on how humans respond to noise rather than established regulatory limits. Specifically, changes in noise levels for the quietest hour that would be hardly perceptible (i.e., less than or equal to 3 dB) are considered to be negligible (i.e., not adverse). A noticeable change in the quietest hour (i.e., greater than 3 dB, but less than or equal to 6 dB change) is classified as having a low magnitude. Readily noticeable changes in the L_{eq} for the quietest hour (i.e., greater than 6 dB, but less than or equal to 10 dB) are considered to be of medium magnitude. Disturbing changes in the noise levels for the quietest hour (i.e., greater than 10 dB) are classified as having a high magnitude.

Table 7.8.3-1: Effects Levels for Assigning Magnitude for Noise Levels

VEC	Low	Medium	High
Noise Levels	Change in L_{eq} >3 and ≤6 dB	Change in L_{eq} >6 and ≤10 dB	Change in L_{eq} >10 dB

The level of significance is assigned by using a decision tree model illustrated in Figure 7.8.3-1. Firstly, magnitude, geographic extent, timing and duration, frequency, and degree of irreversibility are combined to identify an environmental consequence. Then the social and/or ecological importance of the VEC being affected is considered to determine significance.

This decision tree is specific to noise levels and the effects level criteria defined in Tables 7.1-1 and 7.8.3-1. Some of the guiding principles are:

- All effects of low magnitude would result in a low environmental consequence and would not be considered significant.
- If the effect is limited to the Site Study Area (i.e., low extent) it would result in a low environmental consequence and would not be considered significant. Noise criteria are established to protect people beyond the fenceline of a site. The fenceline for the DGR Project corresponds to the limits of the Site Study Area.
- Effects with a high magnitude that extend beyond the Site Study Area have the potential to be of a high consequence if the frequency is high or the effects of a high magnitude extend beyond the Local Study Area.

Residual adverse effects during the site preparation and construction, and decommissioning phases were identified for the noise levels VEC. Table 7.8.3-2 and sections below provide a summary of the assessment of significance for all identified residual adverse effects.

7.8.3.1 Site Preparation and Construction Phase

During the site preparation and construction phase, emissions from the DGR Project were predicted to result in residual adverse effects for the noise levels VEC. These effects were classified to be of a low magnitude, medium extent, low duration and low irreversibility as seen in Table 7.8.3-2. The frequency is considered high; however, adverse effects will only be present approximately 24% of the time. Overall, this adverse effect was classified as a "low consequence", which is considered to be "not significant".

7.8.3.2 Operations Phase

During the operations phase, emissions from the DGR Project were predicted to result in no residual adverse effects for the noise levels VEC.

7.8.3.3 Decommissioning Phase

The effects of the DGR Project on noise levels during the decommissioning phase are considered to be similar to, or lower than those experienced during the site preparation and construction phase. Therefore, this effect is also not significant.

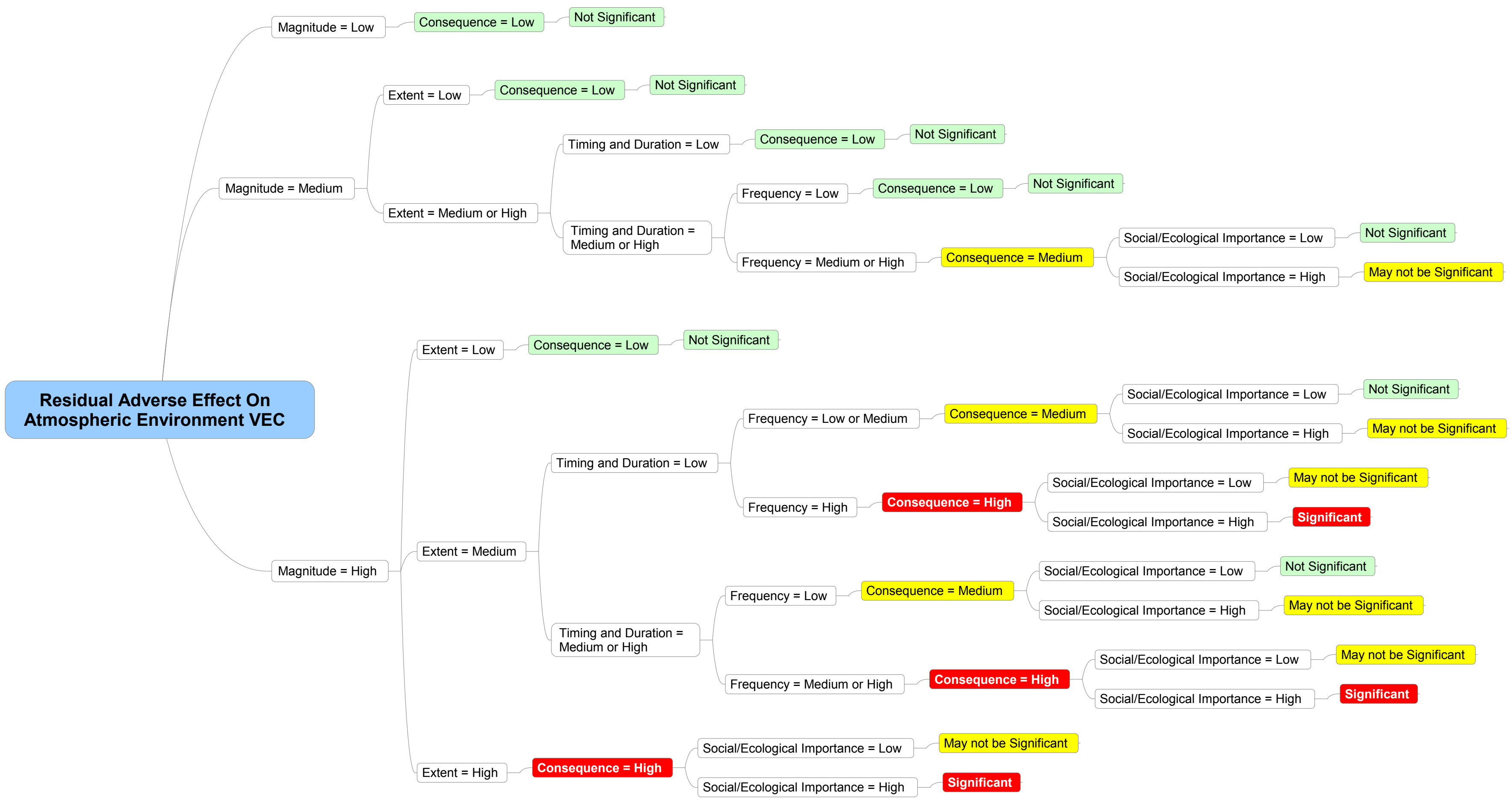


Figure 7.8.3-1: Determination of Significance of Residual Adverse Effects for Noise Levels

Table 7.8.3-2: Summary of Residual Adverse Effects and Significance Levels for Noise Levels

VEC	Magnitude	Geographic Extent	Timing and Duration	Frequency	Degree of Irreversibility	Overall Assessment
Site Preparation and Construction Phase						
Noise Levels	**Low** • A noise level indicator value exceeds the baseline values by 5 dB	**Medium** • The effect extends to the Local Study Area	**Low** • Effect is evident during the site preparation and construction phase	**High** • The noise effects are expected to occur on a daily basis	**Low** • Effect is readily (i.e., immediately) reversible	**Not Significant** (See Section 7.8.3.1)
Decommissioning Phase						
Noise Levels	**Low** • A noise level indicator value exceeds the baseline values by 5 dB	**Medium** • The effect extends to the Local Study Area	**Medium** • Effect is evident during the decommissionin g phase	**High** • The noise effects are expected to occur on a daily basis	**Low** • Effect is readily (i.e., immediately) reversible	**Not Significant** (See Section 7.8.3.3)

7.9 ABORIGINAL INTERESTS

Aboriginal interests comprises three VECs. Table 7.9-1 presents the VECs for Aboriginal interests and indicates how these VECs capture Aboriginal concerns identified through the EA (see Section 2 for a summary of Aboriginal engagement activities). The results of the Aboriginal traditional land use assessment are summarized in Section 7.9.2.4. The existing Aboriginal traditional land use is described in Section 6.9 and the Aboriginal Interests TSD.

Table 7.9-1: VECs Selected for Aboriginal Interests

VEC	Aboriginal Issues
Aboriginal Communities	• Economic benefits and or effects • Health of members of Aboriginal communities
Aboriginal Heritage Resources	• First Nation burial grounds on the Bruce nuclear site
Traditional Use of Land and Resources	• Fishing and harvesting rights • Land claims, traditional territory and long-term use of lands and waters • Environmental health • Cultural heritage and traditional knowledge

7.9.1 Screening to Focus the Assessment

7.9.1.1 Aboriginal Communities

Direct Interactions and Measurable Changes

The worker, payroll and purchasing activity throughout the site preparation and construction, operations and decommissioning phases will likely result in a measurable change to Aboriginal communities, should Aboriginal people take advantage of the opportunities generated by the DGR Project. Although the skills and expertise for mining and underground work are not likely to be available in the study areas or among many Aboriginal people, the DGR Project will generate direct, indirect and induced employment opportunities.

Expenditures on payroll will generate business activity through household spending. Purchasing of goods and services will generate business activity. Should Aboriginal people take advantage of the opportunities generated by the DGR Project, there is a likely measurable change to Aboriginal communities.

These measurable changes are considered further in the assessment in Section 7.9.2.1.

The following works and activities are not expected to directly interact with settlement areas associated with Aboriginal communities, as they are remote from the settlement areas:

- site preparation;

- construction of surface facilities;
- excavation and construction of underground facilities;
- above-ground transfer of waste;
- underground transfer of waste;
- decommissioning of the DGR Project;
- abandonment of the DGR facility;
- presence of the DGR Project;
- waste management; and
- support and monitoring of DGR life cycle.

Indirect Interactions and Measurable Changes

Changes in air quality during the site preparation and construction, operations and decommissioning phases have the potential to indirectly interact with Aboriginal communities because of nuisance-related effects. For the consideration of likely effects on Aboriginal communities resulting from changes in air quality, suspended particulate matter (SPM) (i.e., dust) was selected as the nuisance-related air quality parameter. Measurable changes in SPM are expected during the site preparation and construction, and operations phase. Changes in air quality during the decommissioning phase are expected to be similar to those predicted during the site preparation and construction phase. Therefore, measurable changes to Aboriginal communities are likely to occur as a result of project-related changes in air quality, and these interactions are advanced for assessment in Section 7.9.2.1.

Changes in noise levels during the site preparation and construction, operations and decommissioning phases have the potential to indirectly interact with Aboriginal communities because of nuisance-related effects. Measurable changes in noise levels during the site preparation and construction phase and operations phases of the DGR Project are expected. Changes in noise levels are associated with the decommissioning phase are expected to be similar to those during the site preparation and construction phase. Such measurable changes are likely to occur as a result of project-related changes in noise levels, and need to be considered further for Aboriginal communities. Therefore, these interactions are advanced for assessment in Section 7.9.2.1.

Changes in surface water quality have the potential to indirectly affect Aboriginal communities if they were to affect water supply at any point during the project life cycle. As described in Section 7.3.2.1, no measurable changes in surface water quality outside of the Site Study Area are expected during any phase of the DGR Project. Aboriginal communities do not obtain their water supply from the Site Study Area. Furthermore, since access to the Bruce nuclear site (i.e., the Site Study Area) is strictly controlled, Aboriginal community members are not likely to come into contact with surface water resources in the Site Study Area. No further consideration is warranted.

Changes in surface water quantity and flows throughout the project life could potentially interact with Aboriginal communities if they were to affect water supply. As described in Section 7.3.2.2, no measurable changes in surface water quantity and flow outside of the Site Study Area are expected during any phase of the DGR Project. Therefore, this interaction is not considered further.

Changes in groundwater quality during the various project phases have the potential to indirectly interact with the Aboriginal communities VEC if groundwater drinking water wells or irrigation wells are affected. As described in Section 7.2.2.2, no adverse effects on groundwater quality were identified. Therefore, measurable changes to Aboriginal communities are not likely through the groundwater quality pathway, and further evaluation is not warranted.

An indirect interaction with Aboriginal communities is possible if flow in groundwater drinking water wells or irrigation wells are affected. As described in Section 7.2.2.3, no measurable changes to groundwater flow are identified outside of the Site Study Area, and there are no down gradient Aboriginal communities or any other groundwater users. Therefore, the Aboriginal communities VEC is not likely to be measurably changed, and no further consideration of groundwater flow in relation to this VEC is warranted.

Changes in populations of aquatic and terrestrial species important to Aboriginal peoples may interact with the use of these resources for traditional purposes as a change in population could affect harvest. Such changes may occur during the site preparation and construction, operations, or decommissioning phases of the DGR Project. As discussed in Sections 7.4 and 7.5, no adverse effects were identified on terrestrial VEC and the aquatic environment VECs that might be harvested or otherwise used by Aboriginal peoples for traditional purposes. Measureable changes to the populations of aquatic and terrestrial species important to Aboriginal peoples' harvests will not be affected by the DGR Project; therefore, adverse effects on Aboriginal communities through economic means (e.g., changes to income and employment) are also considered to be unlikely. Therefore, there is no need to further evaluate potential effects from changes in aquatic and terrestrial VECs.

7.9.1.2 Aboriginal Heritage Resources

Direct Interactions and Measurable Changes

Site preparation, grading and land clearing activities have the potential to interact with Aboriginal heritage resources by uncovering or disturbing archaeological artifacts, particularly deeply buried artifacts in culturally-sensitive areas. Construction of surface facilities also has the potential to uncover and disturb archaeological sites/burials and artifacts, particularly deeply buried artifacts in culturally-sensitive areas. The Upper Mackenzie (BbHj-6) site, located inside the south entrance to the Bruce nuclear site on the north side of the South Access Road and the Dickie Lake/Jiibegmegoong (BbHj-12) site are located approximately one kilometre from the WWMF (see Figure 6.9.7-1) and are not likely to be directly affected by the DGR Project works and activities. Therefore, the DGR Project will not result in a direct measureable change to these Aboriginal heritage resources.

However, the Stage 2 archaeological assessment concluded that that the extreme southeastern corner of the Project Area overlaps with culturally-sensitive area B (CSA B) (see Figure 6.9.7.1). Because the site preparation, excavation and construction activities are to be limited to the DGR Project site and are therefore well removed from this portion of CSA B; it is unlikely that any archaeological remains or artifacts, including deeply buried artifacts, would be disturbed. Therefore, no further consideration is warranted.

The presence of the DGR Project is not related to land disturbance; however, its visibility may diminish the quality or value of activities undertaken at Aboriginal burial sites on the vicinity of the Bruce nuclear site during the site preparation and construction, operations and decommissioning phases. Therefore, a project-environment interaction is identified between this VEC and the presence of the DGR Project during all project phases, and is carried forward to Section 7.9.2.2.

The following works and activities are not expected to directly interact with Aboriginal heritage and resources, as they do not involve any land clearing activities:

- above-ground transfer of waste;
- underground transfer of waste;
- decommissioning of the DGR Project;
- abandonment of the DGR facility;
- waste management;
- support and monitoring of DGR life cycle; and
- workers, payroll and purchasing.

Indirect Interactions and Measurable Changes

Given the proximity of the Jiibegmegoong burial site to the Project Area and the likelihood for measurably increased dust and noise levels at this location, the quality and/or value of activities undertaken by Aboriginal peoples at this Aboriginal heritage resource could be diminished. The DGR Project is likely to result in increased dust and noise levels both on and off-site. These nuisance effects will strengthen the existing industrial character of the Bruce nuclear site, which will diminish the quality or value of activities undertaken by Aboriginal peoples at the burial site located approximately one kilometre from the DGR Project Area. Therefore, a measurable change to Aboriginal heritage resources is identified and forwarded for further assessment in Section 7.9.2.2.

A change in soil quality at an archaeological/burial site on the Bruce nuclear site may affect its long-term preservation and/or diminishing its quality and/or value to Aboriginal peoples when undertaking activities at the site, thereby indirectly affecting the Aboriginal heritage resources VEC. As discussed in Section 7.2.1.1, measurable changes to soil quality are possible within the Project Area over the abandonment and long-term performance phase. Any potential for this to occur exists within the DGR Project site well away from an archaeological/burial site or culturally sensitive areas. Therefore, there is no need to further evaluate potential effects on Aboriginal heritage resources from changes in soil quality.

7.9.1.3 Traditional Use of Land and Resources

Direct Interactions and Measurable Changes

The traditional Ojibway spiritual worldview is that the physical world, including the rock of the earth, is the first order of creation upon which the other orders of creation — the plant world, the animal world and the human world — depend upon for sustenance and existence. The presence of the DGR Project, which directly affects this first order of creation (i.e., the rock of the earth) may have special meaning to some Aboriginal peoples and therefore, may be seen by some Aboriginal people as incompatible with their world view, affecting how Aboriginal people value the plants and animals that they harvest for traditional purposes.

The Bruce nuclear site is an operating nuclear site on which traditional fishing, hunting, trapping and gathering activities are not undertaken. No adverse effects have been identified on the terrestrial environment VECs that might be harvested or otherwise used by Aboriginal peoples for traditional purposes (e.g., muskrat, white-tailed deer, wild turkey, mallard, bald eagle). Similarly, no adverse effects were identified on aquatic environment VECs that might be harvested or otherwise used by Aboriginal peoples for traditional purposes (i.e., brook trout, lake whitefish, spottail shiner, smallmouth bass). All plants and animals will continue to be exposed to radiation from a variety of natural and man-made sources, and the radiation doses they receive from the DGR Project are expected to be less than the levels at which there may be potential effects on populations. Therefore, there are no tangible reasons for Aboriginal people to change how they value the plants and animals that they harvest for traditional purposes.

The following works and activities are not expected to directly interact with Aboriginal traditional use of land and resources, because they have no direct mechanism to change the use of the land:

- site preparation;
- construction of surface facilities;
- excavation and construction of underground facilities;
- above-ground transfer of waste;
- underground transfer of waste;
- decommissioning of the DGR Project;
- abandonment of the DGR facility;
- waste management;
- support and monitoring of DGR life cycle; and
- workers, payroll and purchasing.

Indirect Interactions and Measurable Changes

Changes in noise levels during the site preparation and construction, operations and decommissioning phases are likely to be measurable. Should this change be of sufficient magnitude, it may result in noticeable disruption to terrestrial VECs at receptor locations in close proximity to the DGR Project and potentially a reduction in harvesting success in this area, should harvesting occur here. This would result in a measurable change in the traditional use of lands and resources and is advanced for further assessment in Section 7.9.2.3.

An area of 8.9 hectares (ha) of mixed woods forest will be removed from the DGR Project site during site preparation and construction. Although this represents a residual adverse effect on eastern white cedar, it will not adversely affect any terrestrial VEC species that use this habitat. Eastern white cedar is a common and abundant species of tree both within the study areas and within the Province. The removal of forested habitat within the Project Area will not affect larger habitat units in the Site Study Area or off-site. The trees will be removed from an area that is not accessible to Aboriginal people and the public due to the security requirements of an operating nuclear site. No adverse effects were identified on the other terrestrial environment VECs that might be harvested or otherwise used by Aboriginal peoples for traditional purposes (e.g., muskrat, white-tailed deer, wild turkey, mallard, bald eagle).

A portion of non-critical fish habitat will be removed in the Project Area during site preparation and construction. This represents a residual adverse effect on those VECs in the South Railway Ditch (i.e., burrowing crayfish, redbelly dace, creek chub, benthic invertebrates and variable leaf pondweed). This loss will be limited to within the Project Area in the location where the approximately 20 m wide crossing over the abandoned rail bed is constructed. No off-site effects on the aquatic environment are anticipated as a result of the project. No adverse effects were identified on the other aquatic environment VECs that might be harvested or otherwise used by Aboriginal peoples for traditional purposes (i.e., brook trout, lake whitefish, spottail shiner, smallmouth bass).

Furthermore, there is no indication that Aboriginal people rely on the Project or Site Study Area for the hunting, fishing or gathering of food. Harvesting and land use rights and access occur within the Regional Study Area. Therefore, there is no need to further evaluate potential effects on traditional use of lands and resources resulting from changes in aquatic and terrestrial VECs.

7.9.2 Identification and Assessment of Effects

Aboriginal interests VECs were screened for measurable changes, as described above. The following measurable changes were identified:

- direct measurable change to Aboriginal communities as a result of increased employment and income associated with workers, payroll and purchasing, work and activity;
- direct measurable change to Aboriginal heritage resources (burial site) as a result of the presence of the DGR Project during site preparation and construction, operations and decommissioning phases;
- indirect measurable changes to Aboriginal communities as a result of changes in air quality and changes in noise levels during site preparation and construction, operations and decommissioning phases;
- indirect measurable changes to Aboriginal heritage resources as a result of changes in air quality and changes in noise levels during site preparation and construction, operations and decommissioning phases; and
- indirect measurable changes to the traditional use of lands and resources VEC as a result of increased noise levels during site preparation and construction, operations and decommissioning phases.

7.9.2.1 Aboriginal Communities

Likely Effects

The economic modelling analysis, as described in Section 7.10.2 and the Socio-economic Environment TSD, indicates that the DGR Project would create new direct, indirect and induced employment opportunities both within and beyond the study areas. Project expenditures on payroll will generate business activity through household spending. Purchasing of goods and services will generate business activity.

Changes in Air Quality

For the purposes of this assessment, the effects of changes on air quality were evaluated based on the quantitative modelling completed as part of the Atmospheric Environment TSD (Appendix J of the TSD). In particular, SPM, as nuisance dust, was considered at receptors located at the burial grounds on the Bruce nuclear site, a residential dwelling on Albert Road, a cottage located across Baie du Doré from Bruce A and at an overnight campsite in Inverhuron Provincial Park. An increase in nuisance dust is only expected to be measurable during the site preparation and construction, and decommissioning phases of the project.

Adverse effects on Aboriginal communities resulting from changes in air quality are considered to occur when concentrations exceed both the baseline concentrations in air and the thresholds established to be protective of the receiving environment.

Since suspended particulate matter (SPM) is comprised of larger particles that are not readily inhaled, it is considered primarily to be a nuisance compound. The national Ambient Air Quality Objective for 24-hour SPM is 120 $\mu g/m^3$. A maximum existing SPM of 58.0 $\mu g/m^3$ is predicted for the Local Study Area. The maximum predicted SPM concentrations at the on-site burial ground during the site preparation and construction phase were determined to be 155.8 $\mu g/m^3$ and during the operations phase were determined to be 59.0 $\mu g/m^3$. These results are summarized in Table 7.9.2-1. Results for dust levels are not listed by nuisance receptor; therefore, the dust levels presented are the maximum receptor concentrations.

Table 7.9.2-1: Maximum Predicted Concentrations of SPM

Location	Indicator	Existing ($\mu g/m^3$)	Site Preparation and Construction Phase Concentration ($\mu g/m^3$)	Operations Phase Concentration ($\mu g/m^3$)	Criteria ($\mu g/m^3$)
Off-site Receptors	24-hour SPM	58.0	168.0	58.5	120
Burial Ground	24-hour SPM	58.7	155.8	59.0	120

Note:
Conditions during the decommissioning phase are expected to be similar to the conditions during the site preparation and construction phase
Source: Appendix J of the Atmospheric Environment TSD

Overall, these results indicate that increased dust levels are expected to be a nuisance during the site preparation and construction phase both on and in the immediate vicinity of the Bruce nuclear site, but no adverse effects will be experienced at any First Nation settlement area within the Regional Study Area. Therefore, no adverse effects on Aboriginal communities are anticipated.

Changes in Noise Levels

The existing off-site noise conditions are largely found to be reflective of a rural environment ranging between 35 and 37 dBA and are currently characterized by the sounds of nature. The noise levels predicted through the modelling exercise were compared to existing baseline conditions in the Local Study Area and the difference was compared to the qualitative criteria for assessing noise effects (Table 7.9.2-2).

Table 7.9.2-2: Existing and Predicted Noise Levels in the Local Study Area

Receptor	Existing Noise Levels (dBA)	Site Preparation and Construction Phase		Operations Phase	
		Predicted Ambient Noise Levels (dBA)	Predicted Change	Predicted Ambient Noise Levels (dBA)	Predicted Change
R1 – Albert Road	36	38	+2	38	+2
R2 – Baie du Doré	37	**42**	**+5**	40	+3
R3 – Inverhuron Provincial Park	35	37	+2	37	+2

Note:
Conditions during the decommissioning phase are expected to be similar to the conditions during the site preparation and construction phase
Source: Appendix J of the Atmospheric Environment TSD

Noise levels at receptors located at Albert Road (R1) and Inverhuron Provincial Park (R3) during all stages of the DGR Project increase by less than 3 dBA. During the site preparation and construction, and decommissioning phases of the project, noise levels at Baie du Doré (R2) are expected to increase by 5 dBA over baseline. Only those Aboriginal persons (i.e., off-reserve First Nation members and Métis persons) who might reside in the immediate vicinity of the Bruce nuclear site would be affected. Although it is not known with certainty if any off-reserve First Nation members or Métis persons currently reside in the immediate vicinity of the Bruce nuclear site, this is not considered to be likely because of the small off-site area affected. Therefore, no adverse effects on Aboriginal communities are anticipated, and no further consideration is warranted.

Mitigation Measures

Because no adverse effects on Aboriginal communities are anticipated as a result of the DGR Project, no additional mitigation is identified. In-design mitigation measures to reduce air quality and noise effects are specified in Sections 7.7.2.2 and 7.8.2.2, respectively.

Residual Adverse Effects

No residual adverse effects on Aboriginal communities are anticipated as a result of the DGR Project.

Positive Effects

The DGR Project will create new direct, indirect and induced employment opportunities. This effect is a positive influence on the economies of the Local and Regional Study Area municipalities and First Nation communities, contributing to employment during the site preparation and construction, operations and decommissioning phases.

7.9.2.2 Aboriginal Heritage Resources

Likely Effects

Although the existing Aboriginal burial site (Jiibegmegoong) at the Bruce nuclear site is already located within an existing industrialized site, the DGR Project will strengthen the industrial character of the Bruce nuclear site. Moreover, the main shaft headframe structure will likely be in the foreground of northerly views from the burial site. The visibility of the DGR structures may diminish the quality or value of activities undertaken by Aboriginal peoples at the burial site located approximately one kilometre from the DGR Project Area and 1.5 km from the tallest DGR building or structure (i.e., the main shaft headframe). This effect will occur during the site preparation and construction and operations phases. While all surface facilities will be removed during the decommissioning phase, the waste rock pile will remain in place. Therefore, an adverse effect on Aboriginal heritage resources is identified as a result of the presence of the DGR Project during all phases.

The DGR Project is likely to result in increased dust and noise levels both on and off-site. These nuisance effects will strengthen the existing industrial character of the Bruce nuclear site, which could diminish the quality or value of activities undertaken by Aboriginal peoples at the Jiibegmegoong burial site. This is because noise and dust from an industrial source are not considered compatible with the intended function of a burial ground, that is, a place where human remains of Aboriginal ancestors have likely been respectfully and ceremonially laid. Therefore, an adverse effect on Aboriginal heritage resources is identified.

Mitigation Measures

In-design mitigation measures to reduce air quality and noise effects are specified in the Atmospheric Environment TSD. In-design mitigation measures to reduce the visual effect of the DGR Project include a setback or buffer of 200 m from the Interconnecting Road to the long-term waste rock management area and other visual screening (e.g., berm and/or trees). As mentioned previously, the SON has requested access to the Bruce nuclear site to conduct either ceremonies or monitoring at the Jiibegmegoong burial ground. In 1998, the SON received approval to access the site for these activities. With the DGR Project, the SON will continue to have access to this burial site.

Residual Adverse Effects

The DGR Project is likely to diminish the quality or value of activities undertaken by Aboriginal peoples at the Jiibegmegoong burial site located at the Bruce nuclear site. This occurs as a result of changed aesthetics (i.e., presence of the DGR Project), temporarily increased noise and dust. This residual adverse effect is advanced for an assessment of significance in Section 7.9.3.

7.9.2.3 Traditional Use of Land and Resources

Likely Effects

Based on the results of the screening, no direct measurable changes to the traditional land use and resources VEC were considered likely. The only indirect measurable change was identified as a result of changes in noise levels. It was hypothesized that should a change in off-site noise levels be of sufficient magnitude, it may result in noticeable disruption to terrestrial VECs, in particular, those wildlife species harvested or important to Aboriginal people for traditional purposes. However, it was concluded in Section 6.4 that the minor changes in noise levels anticipated as a result of the DGR Project would not have an appreciable effect on wildlife, especially given that existing daytime noise levels vary by as much as 39 dB and night time noise levels vary as much as 21 dB. The number of individual fauna using the areas on and off-site affected by noise is limited when compared with the populations found elsewhere in the Site and Local Study Areas. Because traditional hunting is not permitted within the Bruce nuclear site boundary and because noise levels that may arise from the DGR Project are not likely to affect terrestrial environment wildlife species, no reduction in harvesting success of Aboriginal peoples is anticipated. Accordingly, no adverse effects on the traditional use of land and resources VEC are likely.

Mitigation Measures

No adverse effects on the traditional land use and resources VEC are expected from the DGR Project. Accordingly, no mitigation measures are warranted.

Residual Adverse Effects

No residual adverse effects on the traditional land use and resources VEC expected as a result of the DGR Project.

7.9.2.4 Summary of Assessment

Table 7.9.2-3 provides a summary of the assessment of the DGR Project for the Aboriginal Interests VECs. Diamonds (◆) on this matrix represent likely DGR Project-environment interactions resulting in a residual adverse effect on a VEC. These residual adverse effects are advanced to Section 7.9.3 for a consideration of significance.

Table 7.9.2-3: Summary of Effects Prediction and Assessment for Aboriginal Interests

Project Work and Activity	Aboriginal Communities	Aboriginal Heritage Resources	Traditional Use of Lands and Resources
Direct Effects			
Site Preparation		•	
Construction of Surface Facilities		•	
Excavation and Construction of Underground Facilities		•	
Above-ground Transfer of Waste			
Underground Transfer of Waste			
Decommissioning of the DGR Project			
Abandonment of the DGR Project			
Presence of the DGR Project		◆	•
Waste Management			
Support and Monitoring of DGR Life Cycle			
Workers, Payroll and Purchasing	+		
Indirect Effects			
Changes in Air Quality	■	◆	
Changes in Noise Levels	■	◆	■
Changes in Surface Water Quantity and Flow	•		
Changes in Surface Water Quality	•		
Changes in Soil Quality		•	
Changes in Groundwater Quality	•		
Changes in Groundwater Flow	•		
Changes in Aquatic and Terrestrial VECs			•

Notes:
The matrices are meant to indicate when the effect occurs and do not imply how long the effect will last.

• Potential project-environment interaction
■ Measurable change
◆ Residual adverse effect
Blank No potential interaction

7.9.3 Significance of Residual Adverse Effects

The criteria used for judging and describing the significance of effects are shown in Table 7.1-1. Significance is rated using magnitude criteria applicable to Aboriginal heritage resources, as shown in Table 7.9.3-1.

Table 7.9.3-1: Effects Levels for Assigning Magnitude for Aboriginal Heritage Resources

VEC	Magnitude Level Definition		
	Low	**Medium**	**High**
Aboriginal Heritage Resources	No physical disturbance occurs to any Aboriginal heritage resources A single identified Aboriginal heritage resource is affected through other direct means and/or indirect environmental change	No physical disturbance occurs to any Aboriginal heritage resources Multiple identified Aboriginal heritage resources are affected through other direct means and/or indirect environmental change	An Aboriginal heritage resource will be physically disturbed

The level of significance is assigned to residual adverse effects by using professional judgement to combine the magnitude, geographic extent, timing and duration, frequency, and degree of irreversibility. For example, a residual adverse effect would be considered to be significant if it has a high magnitude, high irreversibility and a high value to society or the environment.

One residual adverse effect of the DGR Project on Aboriginal interests VECs was identified:

- The DGR Project is likely to diminish the quality or value of activities undertaken by Aboriginal peoples at the Aboriginal burial site located at the Bruce nuclear site. This results from changed aesthetics, temporarily increased noise and dust.

The overall assessment of the residual adverse effect on Aboriginal heritage resources found that this effect is not likely to be significant primarily because the burial site is located on an existing industrial site, and may be affected by dust and noise infrequently (Table 7.9.3-2). It is considered unlikely that ceremonies would occur during these times. Moreover, apart from the visibility of the waste rock pile, adverse effects over the long term are not anticipated.

Table 7.9.3-2: Effects Magnitude Levels for Aboriginal Interests

Residual Adverse Effect	Magnitude	Geographic Extent	Timing and Duration	Frequency	Degree of Irreversibility	Overall Assessment
The DGR Project is likely to diminish the quality or value of ceremonial activities undertaken by Aboriginal peoples at the Aboriginal burial site located at the Bruce nuclear site (changed aesthetics, increased noise and dust)	**Low** • No physical disturbance occurs to the existing Aboriginal burial site at the Bruce nuclear site • It will be affected through other direct means (i.e., change in aesthetics) and/or indirect environmental change (i.e., dust and noise)	**Low** • Effect is limited to the Site Study Area (i.e., Bruce nuclear site)	**High** • Effect extends beyond any one phase	**Low** • Conditions or phenomena causing the effect occur at regular, although infrequent intervals and because the burial site is visited and used for ceremonial purposes infrequently	**Medium** • Effect is reversible with time	**Not Significant**

7.10 SOCIO-ECONOMIC ENVIRONMENT

Socio-economic environment VECs have been set up within the community assets framework, as discussed in Section 6.10 (see Figure 6.10-1) and are as follows:

- human assets:
    - population and demographics; and
    - other human assets.
- financial assets:
    - employment;
    - business activity;
    - tourism;
    - residential property values;
    - municipal finance and administration; and
    - other financial assets.
- physical assets:
    - housing;
    - municipal infrastructure and services; and
    - other physical assets.
- social assets:
    - Inverhuron Provincial Park; and
    - other social assets.

The results of the socio-economic environment assessment are summarized in Section 7.10.2.14. The existing environmental features are described in Section 6.10 and the Socio-economic Environment TSD.

7.10.1 Screening to Focus the Assessment

7.10.1.1 Human Assets

Direct Interactions and Measurable Changes

The following direct interactions are identified for population and demographics:

- presence of the DGR Project – influences on people's feelings of personal health, sense of safety or satisfaction with their community; and
- workers, payroll and purchasing – employment opportunities may attract workers and associated families.

The following direct interactions are identified for other human assets:

- site preparation – increased use of health and safety facilities and services due to typical workplace accidents;

- construction of surface facilities – increased use of health and safety facilities and services due to typical workplace accidents; presence of new buildings may require modifications to emergency response plans;
- excavation and construction of underground facilities – increased use of health and safety facilities and services due to typical workplace accidents; presence of underground facility may require modifications to emergency response plans to consider mine rescue operations;
- above-ground transfer of waste – increased use of health and safety facilities and services due to typical workplace accidents;
- underground transfer of waste – increased use of health and safety facilities and services; underground operations may require modifications to emergency response plant to consider new types of waste transfer;
- decommissioning of the DGR Project – increased use of health and safety facilities and services due to typical workplace accidents; underground operations may require modifications to emergency response plant to consider new types of waste transfer; and
- workers, payroll and purchasing – employment skills and labour requirements may change the availability of skills and labour supply; worker related population increases may affect educational, health and safety and social services.

Measurable population change associated with the DGR Project can be expected to occur across the Local and Regional Study Areas. Given the influence that a change in population has on other community assets and effects on many socio-economic VECs, the magnitude of the DGR Project associated population and its distribution across the Local and Regional Study Areas is quantified in Section 7.10.2. However, the number of in-movers associated with the DGR Project during the site preparation and construction phase is expected to be small in the context of the existing municipal populations and planned future growth, such that a measurable change in population demographics, including the overall age and gender of the population, family size or composition is not likely. Therefore, these demographic indicators are not considered further.

The DGR Project and the expected measurable change in associated population may place additional demands on external policing, fire-fighting, EMS services and hospital beds. Similarly, the expected measurable change in population associated with the DGR Project may result in increased school enrolment and demands on social services. These changes in demands on educational, health and safety, and social services are advanced for further assessment.

The worker requirements for the DGR Project are not expected to be large enough to measurably change the general availability of skills and labour in the Local or Regional Study Areas. However, because the skills and expertise necessary for excavating the shafts and underground work are not likely to be available in the Local or Regional Study Areas, there will be a need to find these skills and expertise from further afield. Therefore, the consideration of changes in existing skills and labour within the Local and Regional Study Areas are carried forward for further assessment.

Indirect Interactions and Measurable Changes

The following indirect interactions are identified for population and demographics:

- changes in radiation and radioactivity – may affect public attitudes towards their feelings of health, safety and/or satisfaction with their community.

The following indirect interactions are identified for other human assets:

- changes in air quality – diminished air quality at educational facilities may be disruptive to outdoor activities;
- changes in noise levels – increases in noise levels at educational facilities may be disruptive to indoor and outdoor activities; and
- changes in radiation and radioactivity – may affect public attitudes towards their feelings of health, safety and/or satisfaction with their community.

Measurable changes to air quality and noise levels are identified. These are advanced to evaluate whether there is an effect on human assets. Changes in radiation and radioactivity may also interact with population and demographics and other human assets. No measurable changes in radiation and radioactivity during the site preparation and construction phase are expected; therefore, this phase is not considered further. However, measurable changes are expected during the operations and decommissioning phases of the DGR Project.

Therefore, the identified indirect interactions considered to result in measurable changes are advanced for assessment in Section 7.10.2. No other indirect interactions were identified for human assets.

7.10.1.2 Financial Assets

Direct Interactions and Measurable Changes

The following direct interaction is identified for employment:

- workers, payroll and purchasing – direct and indirect employment may be generated by the DGR Project expenditures on payroll, goods and services; increased labour income may further induce employment.

The following direct interactions are identified for business activity:

- waste management – local business activity may be influenced by increased use of private licensed waste management facilities and waste haulers; and
- workers, payroll and purchasing – DGR Project related requirements for goods and services may generate business activity; increased population and labour income associated with the DGR Project may further generate business activity.

The following direct interactions are identified for tourism:

- presence of the DGR Project – potential to influence community character, thereby changing feelings of personal health and/or sense of safety, making visiting tourist features less attractive; and
- workers, payroll and purchasing – temporary workers may increase demand for accommodation typically available to tourists (e.g., hotels and motels).

The following direct interactions are identified for residential property values:

- presence of the DGR Project – potential to influence community character and/or lead to outmigration, thereby changing the demand for and value of residential properties; and
- workers, payroll and purchasing – increased workforce may increase demand for permanent housing, thereby influencing the local housing market and residential property values.

The following direct interactions are identified for municipal finance and administration:

- presence of the DGR Project – may generate municipal revenue through property taxes or other means as required by agreement with the host municipality and possibly with other communities;
- waste management – use of licensed municipal waste management facilities by the DGR Project may generate revenues from increased tipping fees; and
- workers, payroll and purchasing – increased population associated with the DGR Project may be an additional source of municipal revenue from property taxes.

The following direct interactions are identified for other financial assets:

- site preparation – requirements for non-renewable resources (i.e., aggregate, fuel);
- construction of surface facilities – requirements for non-renewable resources (i.e., aggregate, fuel);
- excavation and construction of underground facilities –requirements for non-renewable resources (i.e., fuel);
- above-ground transfer of waste – requirements for non-renewable resources (i.e., fuel);
- underground transfer of waste – requirements for non-renewable resources (i.e., fuel);
- decommissioning of the DGR Project – requirements for non-renewable resources (i.e., concrete, asphalt, sand, bentonite, fuel);
- workers, payroll and purchasing – DGR Project expenditures on worker payroll may increase labour income; increased population associated with the DGR Project may further increase labour income through indirect and induced means.

The DGR Project site preparation and construction phase is expected to generate measurable direct, indirect and induced employment opportunities.

DGR Project-related expenditures on payroll will directly change labour income of construction employees. The income generated by the DGR Project, through direct, indirect and induced employment will likely generate business activity through household spending. Goods and services purchasing for the DGR Project will also generate measurable business activity.

Off-site management of DGR Project non-hazardous non-radiological and small amounts of hazardous wastes at licensed facilities is required. Consumable material, such as rags and coveralls used in maintenance and clean-up operations, and solids generated by the underground sanitary facilities will be transported to appropriate licensed waste disposal facilities. Therefore, there is likely measurable change to business activity at private disposal facilities.

The DGR Project-related workforce and the presence of the DGR Project as a whole may result in a measurable change to the use and enjoyment of tourist features, considering the likelihood of measurable changes in public attitudes and behaviours attributable to the DGR Project.

The expected measurable change in the population associated with the DGR Project during the site preparation and construction phase could change the demand for housing, thereby influencing the housing market and residential property values.

Construction of new buildings and structures related to the DGR Project may require the payment of property taxes and building permit fees. Payment of development charges, taxes and/or other monetary payments would generate measurable revenue. Off-site management of DGR Project non-hazardous and non-radiological waste at licensed facilities is required. This may represent an additional, measurable source of revenue for a municipality through tipping fees.

A measurable change in non-renewable resource use, particularly aggregate and fuels, is likely during site preparation and construction. A measurable change resulting from DGR Project-related employment will generate labour income, which is likely to be measurable within the Local and Regional Study Areas.

Therefore, measurable changes were identified for all of the direct interactions. These measurable changes are assessed in Section 7.10.2.

Indirect Interactions and Measurable Changes

The following indirect interaction is identified for employment:

- changes in radiation and radioactivity – may affect public attitudes towards their feelings of health, safety and/or satisfaction with their community.

The following indirect interactions are identified for business activity:

- changes in air quality – diminished air quality may be disruptive to business operations with outdoor facilities or sensitive to increased dust levels;
- changes in noise levels – increased noise levels may be disruptive to business operations with outdoor facilities or sensitive to increased noise; and

- changes in radiation and radioactivity – an increase in exposure to radiation may affect public attitudes towards their feelings of health, safety and/or satisfaction with their community.

The following indirect interactions are identified for tourism:

- changes in air quality – diminished air quality may decrease the attractiveness of local parks and other attractions as tourist destinations, thereby affecting their use and enjoyment;
- changes in noise levels – increased noise levels may decrease the attractiveness of local parks and other attractions as tourist destinations, thereby affecting their use and enjoyment;
- changes in surface water quantity and flow – changes to surface water quantity and flow may affect local tourism operations through potential effects on their water supplies;
- changes in surface water quality – changes to surface water quality may affect local tourism operations through potential effects on their water supplies and/or potential effects on waters used for recreational purposes (e.g., swimming) by tourists;
- changes in groundwater quality – may affect local tourism operations through potential effects on their water supplies;
- changes in groundwater quantity and flow – may affect local tourism operations through potential effects on their water supplies;
- changes in the aquatic and terrestrial environment – changes to fish and terrestrial wildlife populations and their habitats may affect bird watching or nature viewing activities and fishing opportunities that may affect tourism (e.g., fishing charters); and
- changes to radiation and radioactivity – may affect public attitudes towards their feelings of health, safety and/or satisfaction with their community.

The following indirect interactions are identified for residential property values:

- changes in air quality – diminished air quality may decrease the value of residential properties;
- changes in noise levels – increased noise levels may decrease the value of residential properties;
- changes in surface water quantity and flow – may affect residential property values through potential effects on residential water supplies;
- changes in surface water quality – may affect residential property values through potential effects on residential water supplies;
- changes in groundwater quality – may affect residential property values through potential effects on residential water supplies;
- changes in groundwater flow – may affect residential property values through potential effects on residential water supplies; and
- changes to radiation and radioactivity – may affect public attitudes towards their feelings of health, safety and/or satisfaction with their community.

The following indirect interaction is identified for municipal finance:

- changes in radiation and radioactivity – may affect public attitudes towards their feelings of health, safety and/or satisfaction with their community.

The following indirect interactions are identified for other financial assets:

- changes in air quality – diminished air quality may adversely affect crops and reduce yields;
- changes in noise levels – increased noise levels may adversely affect livestock;
- changes in surface water quantity and flow – changes to surface water quantity and flow may affect agricultural operations through potential effects on their water supplies
- changes in surface water quality – may affect agricultural operations through potential effects on their water supplies (e.g., water used for irrigation or food processing purposes);
- changes in groundwater quality – may affect agricultural operations through potential effects on their water supplies (e.g., water used for irrigation or food processing purposes);
- changes in groundwater flow – may affect agricultural operations through potential effects on their water supplies (e.g., water used for irrigation or food processing purposes);
- changes in the aquatic and terrestrial environment – changes to fish populations and their habitats may affect commercial fishing (i.e., a renewable resource use); and
- changes to radiation and radioactivity – may affect public attitudes towards their feelings of health, safety and/or satisfaction with their community.

Changes in air quality may indirectly interact with business activity, tourism, residential property values and other financial assets. As no sensitive businesses were identified, no measurable change to business activity through this indirect effect pathway is anticipated. The changes in air quality are expected to be of sufficient magnitude that they need to be considered further for their potential effect on tourism and residential property values.

Changes in noise levels may indirectly interact with business activity, tourism, residential property values and other financial assets. As no sensitive businesses were identified, no measurable change to business activity through this indirect effect pathway is anticipated. The changes in noise levels are expected to be of sufficient magnitude that they need to be considered further for their potential effect on tourism and residential property values.

As discussed in Section 7.3.1.1, the diversion of flow from the Stream C watershed to MacPherson Bay will cause a measurable change in stream flow in Stream C, the North Railway Ditch at Stream C, and the existing drainage ditch that conveys run-off from the DGR Project site to MacPherson Bay. However, these changes will be measurable only within the boundaries of the Site Study Area and therefore no measurable change to the financial assets VECs is anticipated. Therefore, no further consideration is required.

As described in Section 7.3.1.2, no measurable changes in surface water quality outside of the Site Study Area are expected as a result of the DGR Project. Therefore, this potential indirect change is not considered further for the financial assets VECs.

As described in Section 7.2.2, changes in groundwater quality and groundwater flow are not expected to result in adverse effects. Therefore, there is no need to further evaluate potential effects through the groundwater quality and groundwater flow pathways on financial assets VECs.

Changes in aquatic and terrestrial environments may indirectly interact with tourism and other financial assets VECs as a result of changes to wildlife viewing, hunting and fishing opportunities. However, the effects identified on the terrestrial environment VECs (Section 7.4.2) and aquatic environment VECs (Section 7.5.2) occur within the Project Area boundary, which is inaccessible to the public. Therefore, there will be no measurable change to the commercial fishery and tourism or recreational opportunities. Accordingly, no measurable changes to the financial assets VECs are anticipated and further evaluation is not warranted.

Changes in radiation and radioactivity may also interact with financial assets. No measurable changes in radiation and radioactivity during the site preparation and construction phase are expected; therefore, this phase is not considered further. However, measurable changes expected during the operations and decommissioning phases of the DGR Project are advanced for assessment.

7.10.1.3 Physical Assets

Direct Interactions and Measurable Changes

The following direct interactions are identified for housing:

- presence of the DGR Project – may affect the availability of housing because the project as a whole has the potential to lead to outmigration, thereby changing the demand for housing; and
- workers, payroll and purchasing – increased population associated with the DGR Project may increase demand for permanent housing.

The following direct interactions are identified for municipal infrastructure and services:

- waste management – the availability of municipal waste management facilities and sewage facilities may be affected through increased demand; and
- workers, payroll and purchasing – increased population associated with the DGR Project may increase demand for municipal infrastructure and services.

The following direct interactions are identified for other physical assets:

- site preparation – traffic associated with site preparation may affect transportation infrastructure function and safety;
- construction of surface facilities – receipt of construction materials by road transportation may affect transportation infrastructure function and safety;
- excavation and construction of underground facilities – receipt of construction materials by road transportation may affect transportation infrastructure function and safety;
- decommissioning of the DGR Project – receipt of construction materials by road transportation may affect transportation infrastructure function and safety;
- presence of the DGR Project – the visibility of DGR Project buildings and structures, its activities and operations may affect community character;
- waste management – the waste rock pile may be visible, thereby affecting community character; transport by road of some wastes to off-site licensed waste management facilities may affect transportation infrastructure function and safety; and
- workers, payroll and purchasing – DGR Project workers travelling to the Bruce nuclear site may affect transportation infrastructure function and safety.

Increased population related to the DGR workforce may result in a measurable increase in the demand for housing.

Increased population and employment may increase demand on municipal infrastructure services including transportation networks, waste management and water and sewer infrastructure. Management of domestic waste (non-hazardous non-radiological waste) off-site at municipal waste management facilities may also be required.

A measurable change to land use and community character may occur as a result of the visibility of the above-ground buildings and structures, including the WRMA. The DGR Project as a whole (considering the likelihood of measurable changes in public attitudes and behaviours attributable to the DGR Project) may results in a measurable change to land use and community character, through the potential attribution of a stigma.

Employee vehicles and DGR Project-related truck traffic, including the movement of goods onto the DGR Project site and removal of DGR Project-related materials for recycling or disposal are likely to have a measurable change on transportation infrastructure function and safety.

Therefore, all of the identified interactions with the physical assets VECs are expected to result in measurable changes and are forwarded for assessment in Section 7.10.2.

Indirect Interactions and Measurable Changes

The following indirect interaction is identified for housing:

- changes in radiation and radioactivity – may affect public attitudes towards their feelings of health, safety and/or satisfaction with their community.

The following indirect interactions are identified for municipal infrastructure and services:

- changes in surface water quantity and flow – may affect municipal infrastructure and services through a potential need for a change in sources of water;
- changes in surface water quality – may affect municipal infrastructure and services through a potential need for a change in sources of water and/or additional treatment;
- changes in groundwater quality – affect municipal infrastructure and services through a potential need for a change in sources of water and/or a need for additional treatment;
- changes in groundwater quantity and flow – may affect municipal infrastructure and services through a potential need for a change in sources of water and/or a need for additional treatment capacity; and
- changes to radiation and radioactivity – may affect public attitudes towards their feelings of health, safety and/or satisfaction with their community.

The following indirect interactions are identified for other physical assets:

- changes in air quality – diminished air quality may change community character;
- changes in noise levels – increased noise levels may affect community character;
- changes in surface water quantity and flow – community character may change as a result of a change in the community's source of water;
- changes in surface water quality – community character may change as a result of a change in the community's source of water;
- changes in groundwater quality – community character may change as a result of a change in the community's source of water; and
- changes in groundwater quantity and flow – community character may change as a result of a change in the community's source of water;
- changes in radiation and radioactivity – may affect public attitudes towards their feelings of health, safety and/or satisfaction with their community.

Changes in air quality may indirectly interact with other physical assets since changes in community character may occur with diminished air quality. The changes in air quality are expected to be of sufficient magnitude that they need to be considered further for their potential effect on other physical assets in Section 7.10.2.

Changes in noise levels may adversely affect community character resulting in an indirect interaction with other physical assets. The changes in noise levels are expected to be of sufficient magnitude that they need to be considered further for their potential effect on other physical assets in Section 7.10.2.

As discussed in Section 7.3.1.1, the diversion of flow from the Stream C watershed to MacPherson Bay will cause a measurable change in stream flow in Stream C, the North Railway Ditch at Stream C and the drainage ditch to MacPherson Bay. However, these effects will be contained within the Site Study Area and are not expected to result in an indirect measurable change to the physical assets VECs. Therefore, no further consideration is required.

As described in Section 7.3.1.2, no measurable changes in surface water quality outside of the Site Study Area are expected during any phase of the DGR Project. Therefore, this potential indirect change is not considered further for the physical assets VECs.

As described in Section 7.2.2, changes in groundwater quality and groundwater flow (transport) are not expected to be measurable outside of the Site Study Area. Therefore, there is no need to further evaluate effects from changes in groundwater quality and groundwater flow on physical assets VECs.

Changes in radiation and radioactively may also interact with physical assets VECs. No measurable changes in radiation and radioactivity during the site preparation and construction phase are expected; therefore, this phase is not considered further. However, measurable changes are expected during the operations and decommissioning phases of the DGR Project, and are advanced for assessment.

7.10.1.4 Social Assets

Direct Interactions and Measurable Changes

The following direct interactions are identified for Inverhuron Provincial Park:

- presence of the DGR Project – may affect people's use and enjoyment of the park due to the visibility of buildings and structures and changes in tourist's and day users' feelings of personal health and sense of safety; and
- workers, payroll and purchasing – temporary workers may increase demand for overnight accommodations at Inverhuron Provincial Park, typically available to tourists; increased population associated with the DGR Project may also affect the use of the park.

The following direct interactions are identified for other social assets:

- site preparation – disturbance of cultural and heritage resources may occur, if present;
- decommissioning of the DGR Project – potential for additional ground disturbing activities (e.g., grading) to disrupt cultural heritage resources;
- presence of the DGR Project –may affect the use and enjoyment of other Provincial parks, conservation areas and/or areas used for recreational purposes due to the visibility of buildings and structures and changes in people's feelings of personal health and/or sense of safety; people's use and enjoyment of private property may be affected in similar ways; and community cohesion may be affected because the project as a whole may lead to out-migration; and
- workers, payroll and purchasing – temporary workers may increase demand for overnight accommodations at other Provincial parks, typically available to tourists; increased population associated with the DGR Project may affect the use of other community and recreational facilities and programs. Changes in population and demographics may affect community cohesion.

The DGR Project-related workforce and presence of the DGR Project as a whole may result in a measurable change to the use and enjoyment of Inverhuron Provincial Park, community and recreational features, and community cohesion. The disruption to cultural heritage resource potentially encountered in the Project Area is also considered to be measurable, should this occur.

Therefore, all of the identified interactions with social assets VECs are expected to result in measurable changes and are forwarded for assessment in Section 7.10.2.

Indirect Interactions and Measurable Changes

The following indirect interactions are identified for Inverhuron Provincial Park:

- changes in air quality – diminished air quality may decrease the attractiveness of Inverhuron Provincial Park as a tourist or day use destination, thereby affecting its use and enjoyment;
- changes in noise levels – increased noise levels may decrease the attractiveness of Inverhuron Provincial Park as a tourist or day use destination, thereby affecting its use and enjoyment;
- changes in surface water quantity and flow – changes to surface water quantity and flow may affect the use and enjoyment of Inverhuron Provincial Park through potential effects on their water supply;
- changes in surface water quality – changes to surface water quality may affect the use and enjoyment of Inverhuron Provincial Park by tourists and day users through potential effects on their water supplies and/or potential effects on waters used for recreational purposes (e.g., swimming);
- changes in aquatic and terrestrial environment – changes to fish and terrestrial wildlife populations and their habitats may affect bird watching, nature viewing and fishing opportunities that may affect people's use and enjoyment of Inverhuron Provincial Park; and
- changes in radiation and radioactivity – may affect public attitudes towards their feelings of health, safety and/or satisfaction with their community.

The following indirect interactions are identified for other social assets:

- changes in air quality – diminished air quality may decrease the attractiveness of community and recreational features, and private property, thereby affecting their use and enjoyment;
- changes in noise levels – increased noise level may decrease the attractiveness of community and recreational features, and private property, thereby affecting their use and enjoyment;
- changes in surface water quantity and flow – changes to surface water quantity and flow may affect the use and enjoyment of community and recreational features, and private property, through potential effects on their water supplies;
- changes in surface water quality – changes to surface water quality may affect the use and enjoyment of community and recreational features, and private property, through potential effects on their water supplies;

- changes in groundwater quality – changes to groundwater quality may affect the use and enjoyment of community and recreational features, and private property, through potential effects on their water supplies;
- changes in groundwater quantity and flow – changes to groundwater quantity and flow may affect the use and enjoyment of community and recreational features, and private property, through potential effects on their water supplies;
- changes in aquatic and terrestrial environment – changes to fish and terrestrial wildlife populations and their habitats may affect bird watching, nature viewing and fishing opportunities that may affect people's use and enjoyment of community and recreational features (e.g., parks, conservation areas , beaches, trails, fishing and boating activities); and
- changes in radiation and radioactivity – may affect public attitudes towards their feelings of health, safety and/or satisfaction with their community.

The changes in air quality and noise levels are expected to be of sufficient magnitude that they need to be considered further for their potential effect on Inverhuron Provincial Park and other social assets.

As discussed in Section 7.3.1.1, the diversion of flow from the Stream C watershed to MacPherson Bay will cause a measurable change in stream flow in Stream C, the North Railway Ditch at Stream C and the drainage ditch. However, these effects will be contained within the Site Study Area and are not expected to result in an indirect measurable change on the social assets VECs. Therefore, no further consideration is required.

As described in Section 7.3.1.2, no measurable changes in surface water quality outside of the Site Study Area are expected during any phase of the DGR Project. Therefore, this potential indirect change is not considered further for the social assets VECs.

As described in Section 7.2.2, changes in groundwater quality and groundwater flow are not expected to result in adverse effects, and no further consideration of these pathways is warranted.

Changes in radiation and radioactively may also interact with social assets VECs. No measurable changes in radiation and radioactivity during the site preparation and construction phase are expected; therefore, this phase is not considered further. However, measurable changes are expected during the operations and decommissioning phases of the DGR Project, and are advanced for assessment in Section 7.10.2.

7.10.2 Identification and Assessment of Effects

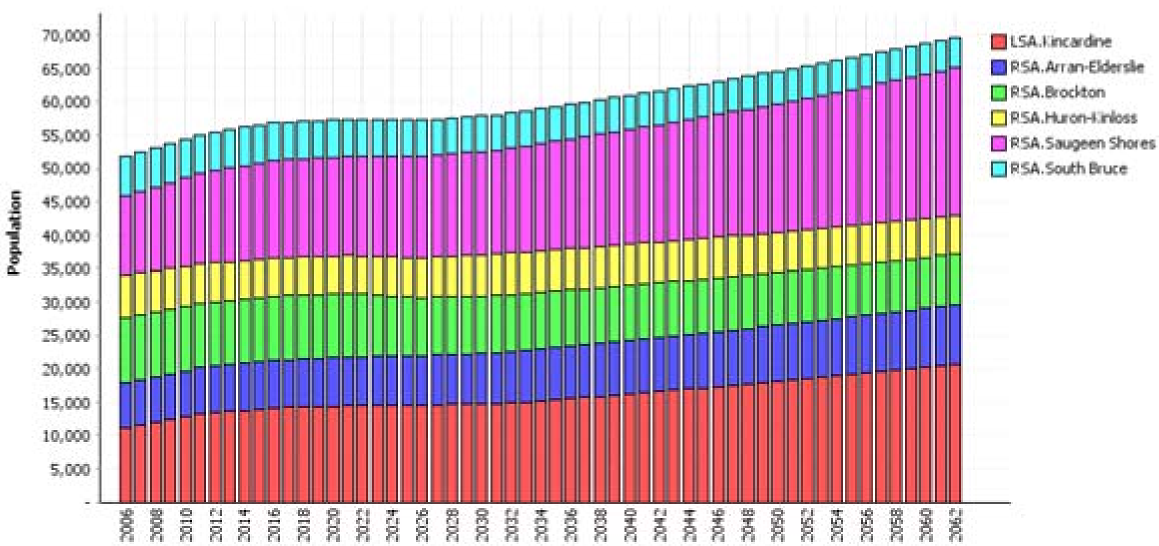
Socio-economic environment VECs were screened for measurable changes, as described in Section 7.10.1. Measurable changes to all of the VECs through direct and indirect interactions were identified. The assessment of effects is summarized for each in VEC in the following sections.

Likely effects are assessed using a variety of analytical methods and data sources, including the analysis of effects on natural assets, economic modelling and results of stakeholder interviews, past experience and case studies, and professional judgement.

7.10.2.1 Population and Demographics

Likely Effects

The following discussion provides the baseline projections for population by study area municipalities from 2006 through to the assumed end of the DGR Project decommissioning in 2062 (Figure 7.10.2-1).

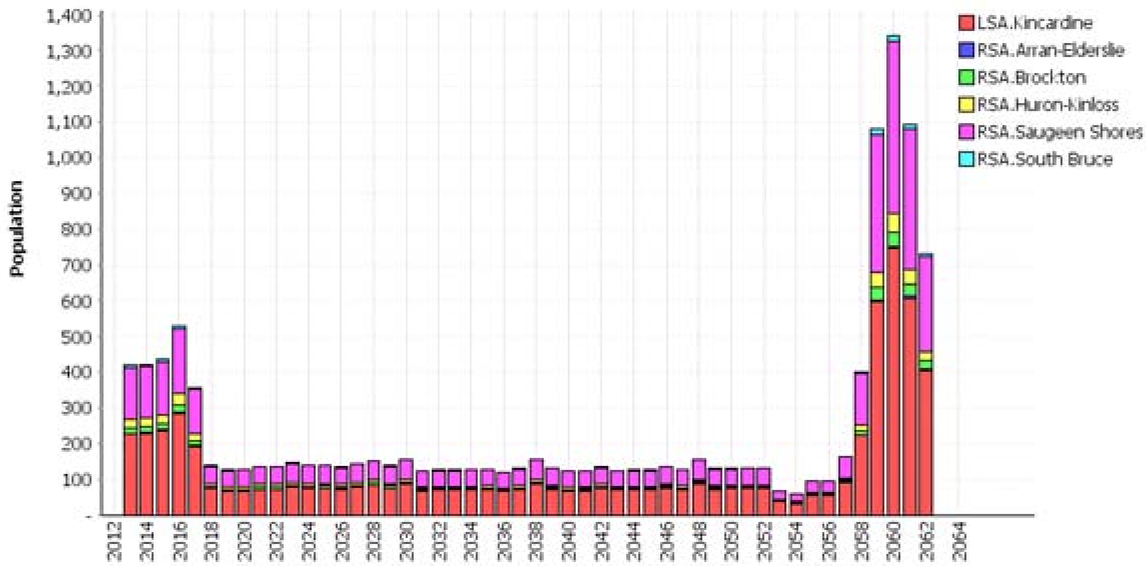


Note: RSA = Regional Study Area, LSA = Local Study Area
Source: Appendix E of Socio-economic Environment TSD

Figure 7.10.2-1: Population Projections by Municipality – without DGR Project (2006 to 2062)

The baseline population projections show the combined study area population increasing from roughly 52,000 in 2006 to almost 70,000 people by 2062. Kincardine and Saugeen Shores will grow proportionately faster over the forecast period. In 2006 these communities accounted for 44% of the Local/Regional Study Area population; by 2062 they are projected to account for almost 58%.

Figure 7.10.2-2 summarizes the population (i.e., the number of people) associated with the DGR Project in the context of municipal population projections during each phase of the DGR Project. The population associated with the DGR Project represents the number of people who are anticipated to reside within the municipality and are associated with the project through its direct, indirect and induced employment. These estimates are the result of economic modelling completed as part of this socio-economic assessment and derived from an assumed employment to population ratio.



Note: RSA = Regional Study Area, LSA = Local Study Area
Source: Appendix E of Socio-economic Environment TSD

Figure 7.10.2-2: DGR Project Associated Population Distribution (2013 to 2062)

In the context of these projections, the effects of the DGR Project on population are likely to be noticeable. The DGR Project is forecast to create 650 jobs in the Local and Regional Study Area during peak construction, 128 jobs per year on average during operations and 548 jobs per year on average during decommissioning. Overall the DGR Project's effect on population in the Local and Regional Study Areas is relatively small but apparent (approximately 5% of the total projected population in the Local and Regional Study Areas in the peak year of 2060). It is anticipated that the largest associated population will be in the decommissioning phase, rather than the site preparation and construction phase. This is because many more residents from the Local and Regional Study Areas are likely to fill decommissioning phase jobs than during the site preparation and construction phase.

Experience with other projects, particularly those involving radiation or radioactivity and/or wastes, indicates that population levels may be affected if residents choose to leave their community as a direct result of the undertaking, and if growth is not sufficient to offset this loss. Sociological research indicates that individuals or groups tend to conduct a mental "cost-benefit" analysis of what they are satisfied or dissatisfied with in their communities and that there is a tendency to tolerate certain conditions until a threshold is reached. At such a time, individuals or groups may become more motivated to leave and find a new location with more positive and satisfying features.

Public attitude research conducted for this study indicates that individuals who experience a change in their feelings of personal health, sense of personal safety or a change in their satisfaction with community may choose to voluntarily leave their communities.

With respect to people's feelings of personal health and sense of safety, PAR results indicate that 9% of Local Study Area residents and 10% of Regional Study Area residents reported that they might experience reduced feelings of personal health and sense of safety as a result of the DGR Project. Up to 3% across both study areas believe that their attitudes regarding their personal well-being would decrease "a great deal" as a result of the DGR Project.

With respect to people's overall satisfaction with community, 7% of Local Study Area and 7% of Regional Study Area residents reported that they might experience reduced feelings of satisfaction with living in their community as a result of the DGR Project. Up to 3% across both study areas believe that their satisfaction with community would decrease "a great deal" as a result of the DGR Project.

These people (i.e., up to approximately 3%) are considered to be most sensitive to the proposed DGR Project and its anticipated effects. Therefore, they are considered the most likely to fundamentally change their attitudes such that they actually might consider moving from their community (i.e., strongest behaviour intention to move). However, when asked directly whether the DGR Project might affect their commitment to living in the community, even fewer residents indicated that their commitment to living in the community would decrease as a result of the DGR Project. Only 5% of Local Study Area residents and 6% of Regional Study Area residents indicated that their commitment to living in their community would decrease. Only 1% of Local Study Area residents and 3% of Regional Study Area residents indicated that their commitment would go down a 'great deal'. Conversely, between 1% (Local Study Area) and 4% (Regional Study Area) indicated the opposite, namely that their level of satisfaction with living in their community might increase as a result of the DGR Project.

These results indicate that there will be some people who will be motivated to move because of the new or unfamiliar nature of the nuclear operations and/or the long-term waste management aspects of the DGR Project or because of the changes that occur within their communities. It is expected that only those who are already "not at all satisfied" with their community, have rated their feelings of health and sense of personal safety as "very poor", and are highly mobile (e.g., those in a favourable housing, financial or employment position) may consider moving.

Given the relatively high levels of satisfaction present in the Local and Regional Study Areas, and the small likelihood of major changes in levels of satisfaction with community, people's feelings of personal health and sense of personal safety, it is projected that, at most, 3% of total population in the Local and Regional Study Areas might consider moving. This value falls within the typical percentage of "movers" that can be expected within the Local or Regional Study Area in a given year (i.e., 4%), and are also well below the anticipated growth in the populations in the study areas over the DGR Project lifetime.

Considering that people do not always act on their intentions, actual out-migration of existing residents because of the DGR Project is likely to be minimal. In the event that some individuals leave as a result of the DGR Project, they will likely be replaced by others who may be more tolerant of local conditions or have fewer issues regarding the Bruce nuclear site, the WWMF or the DGR Project and its environmental or socio-economic effects. Therefore, out-migration, should it occur, will not be noticeable to the vast majority of residents.

Finally, in the absence of malfunctions or accidents at the Bruce nuclear site or the DGR and the associated publicity that would occur, the number of people considering leaving their communities as a result of the DGR Project is expected to decrease over time.

Recommended Mitigation or Effects Management

OPG will share information with local and regional land use planners and economic development officials regarding the timing and magnitude of meaningful changes in its on-site labour requirements for each phase of the DGR Project. Because no adverse effects on population and demographics are anticipated as a result of the DGR Project, no additional mitigation is identified or warranted.

Residual Adverse Effects

No residual adverse effects on population are anticipated as a result of the DGR Project.

Beneficial Effects

The beneficial effect of the DGR Project on population is increased population associated with, or directly dependent on DGR Project-related employment. The increase in population associated with DGR employment will support the achievement of municipal planning objectives regarding population growth, maintaining the stability of Local and Regional Study Area municipalities. This beneficial effect will likely be experienced in Kincardine and by all Regional Study Area municipalities, with the greatest beneficial effect in Kincardine.

7.10.2.2 Other Human Assets

The other human assets considered include effects on:

- skills and labour supply;
- education;
- health and safety facilities and services; and
- social services.

Likely Effects

Skills and Labour Supply

Planned construction techniques for the DGR Project will require standard engineering trades, management and support as well as specialized labour. These requirements include a geological characterization team that includes a rock mechanics engineer and geologist who will be involved in construction design and inspection activities. Based on information provided in

Section 6.10, specialized skills associated with geology or mining-like construction works are not likely to be available in the Local and Regional Study Areas.

While some mining occurs nearby in the Town of Goderich, the labour force associated with primary industry across the Local and Regional Study Areas is largely in the agricultural sector. Therefore, it is anticipated that the construction workforce will largely be sourced from outside the Local and Regional Study Area. This expectation seems justified as the skills and expertise, particularly when it comes to underground work, do not likely to exist in the Local or Regional Study Areas since mining is not a major industrial activity. Nevertheless, the DGR Project can benefit from the specialized skills and knowledge that exists because of the mining activity in the Goderich area. Similarly, the indirect employees who would build the machinery and supply the construction materials for the site preparation and construction phase are also not likely to reside in the Local or Regional Study Areas as the manufacturing sector is not dominant here and the study area municipalities do not have an extensive nuclear service industry. The relatively small number of DGR Project-related jobs associated with the construction phase that would be sourced locally is not expected to noticeably affect local skills and labour availability. It is not likely that any economic sector would be adversely affected by the DGR Project skills and labour requirements.

This scenario changes to some extent during the operations phase, as the jobs are longer term and because there will likely be some employment transfer between the WWMF and the DGR. Some nuclear-related expertise will also be available from other employers with operations at the Bruce nuclear site. It is therefore anticipated that most of the individuals to be employed, both directly and indirectly as a result of the DGR Project, will be from the Local and/or Regional Study Areas. The indirect jobs associated with operations are much less specialized than those associated with construction and are likely to be sourced and/or could be trained locally. The jobs induced by the DGR Project are also likely to be sourced from the local workforce. From experience with other projects of a similar type, there is a greater tendency during operations to use local firms to supply goods and services to the project for most routine purchases. Overall, it is not likely that any economic sector would be adversely affected by the DGR Project skills and labour requirements.

During decommissioning, there is a substantial increase in employment relative to the operations phase. As with the operations phase, it is expected that this employment will be predominately sourced from the Local and Regional Study Areas, where the skills required for construction-type activities and transportation are likely to be available. Nevertheless, given the size of the DGR Project skills and labour requirements for decommissioning relative to the existing labour pool, it is not likely that any economic sector would be adversely affected by the DGR Project skills and labour requirements.

Education

The Regional Study Area municipalities are serviced by two school boards. A small increase in enrolment of students in elementary and secondary schools is anticipated during all phases because of increased DGR Project-related population.

The economic modelling provided a forecast of the number of additional students expected as a result of the DGR Project. During the site preparation and construction phase, the DGR Project could be associated with up to 150 students in Kincardine and Saugeen Shores. It is not likely that all of these students would be new ones, as much of the labour force for the site preparation and construction phase would be comprised of workers relocating to the area for a relatively short period of time and are not likely to be permanent in-movers. During the operations phase, the corresponding figure is about 31 students. These students are most likely to be associated with permanent residents or in-movers. During the decommissioning phase, the associated enrolment in Kincardine and Saugeen Shores is predicted to be approximately 130 students, on average. While a peak of approximately 270 students may be associated with the decommissioning phase, it is not likely that all of these students would be new ones, as much of the labour force for the decommissioning phase would be sourced from the Local and Regional Study Areas, rather than being in-movers.

Based on information from stakeholder interviews, the schools in Kincardine have capacity to receive approximately 350 more students and the schools in Saugeen Shores have capacity to receive approximately 700 more students. The projected additional student numbers associated with the DGR are only a small fraction of the excess capacity that currently exists in area school board facilities.

Changes in noise or dust levels as a result of the DGR Project were considered due to their potential to disrupt activities at schools. However, changes in noise and dust are not likely to be noticeable at schools nearest to the DGR Project site (i.e., Kincardine Township Tiverton Public School and Kincardine District Secondary School), which are located 15 and 16 km, respectively, from the DGR Project site boundary. There are no schools in close proximity to the site where nuisance effects are most likely. No schools are located directly on any major transportation routes in the vicinity of the DGR Project site and therefore, they are not likely to experience traffic-related disruption. Therefore, it is highly unlikely that the DGR Project will disrupt activities conducted at individual schools (e.g., indoor classes or outdoor activities, use of school facilities by other community members or staff) through indirect nuisance effects.

Overall, no adverse effects on individual schools or School Boards are anticipated in the Local or Regional Study Areas as a direct result of the DGR Project.

Finally, interviews with stakeholders from local area schools also mentioned increased educational opportunities for their students as a result of the DGR Project. As a leading new technology for the long-term management of nuclear waste in Canada, the DGR Project will be the first of its kind in North America, and will provide unique learning opportunities for students in the Local and Regional Study Areas, as well as Ontarians and out-of-Province visitors.

Health and Safety Facilities and Services

Malfunctions and accidents could occur that would require an emergency response (as described in Section 8). Trained and qualified mine rescue teams (primary and back-up rescue teams) will be provided as required by applicable mining regulations. A primary mine rescue team will be available to assist with the evacuation of workers from the DGR to the surface. Backup rescue team(s) will be available through mutual assistance agreements with nearby facilities.

In the event that workers get trapped by a rock fall or other extraordinary event, facility management will co-ordinate the response and utilize the mine rescue teams to assess the situation and recommend a recovery strategy depending on the circumstances. Radiological contaminant release will be responded to with a pre-developed plan for rescue of personnel and clean up.

In some cases, local health and safety service providers may be called upon to assist in an emergency at the DGR. Therefore, specialized training and preparation for the unlikely event of an emergency may be required for staff at existing health and safety facilities and services.

While the Bruce nuclear site has its own fire services department (see Section 6.10), Bruce Power and OPG will work co-operatively with Emergency Management Ontario and other local emergency responders to assist in the development and testing of emergency plans throughout the life of the DGR Project. Local fire departments may require additional orientation and training of their staff regarding the presence of new above-ground and below-ground facilities and equipment. Some may require specialized training and resources to respond to emergencies, especially below-ground emergencies, which are likely to be new and unfamiliar to emergency response staff, should they be called upon to assist. Based on stakeholder interviews, Local and Regional Study Area fire departments confirmed that they would require additional information and training and that this issue is of primary concern to them.

Other demands on municipal health and safety services may result from the DGR-associated population in the Local and Regional Study Areas. The health and safety services investigated for this assessment include health care, EMS, fire and police protection. As was seen from the population effects analysis (Section 7.10.2.1), the effect of the DGR Project is estimated to be small and the demand on health and safety facilities is barely measurable. It is expected that demand will not be noticeable in terms of levels of service provided to community members.

Interviews conducted with stakeholder representatives from Local and Regional Study Area health and safety service providers support this conclusion. They did not anticipate an adverse effect on their operations or the levels of service they provide community members as a result of the DGR Project. For example, the main concerns of hospital officials were with the aging population in the area. While they did anticipate some increased demand in services because of the DGR Project, the project-related workers would largely be young families that would not put an increased strain on resources required to care for the aging population in the area.

Similarly, stakeholder representatives from local area police services did not anticipate an adverse effect on their operations or the levels of service they provide community members as a result of the DGR Project. Some concern was expressed as a result of a potential increase in traffic-related incidents, though these were not considered substantial enough to affect their operations or levels of service.

Social Services

The population associated with the DGR Project (see Section 7.10.2.1) is anticipated to be extremely minor in the context of current and foreseeable population levels. In addition, no change in the demographic characteristics of the population is anticipated as a result of the

DGR Project. On the other hand, increased employment and business opportunities along with increased labour income may contribute towards reducing the demand for various social services offered throughout the study areas. Therefore, no adverse effects on demands on social services are anticipated as a result of the DGR Project.

Recommended Mitigation or Effects Management

OPG will share information with local and regional land use planners and economic development officials as well as local and regional health and safety service providers regarding the timing and magnitude of meaningful changes to its on-site labour and skills requirements for each phase of the DGR Project. OPG will ensure that an emergency and fire response plan is prepared and implemented for the DGR Project including plans for mine rescue and training opportunities for each phase of the DGR Project.

Residual Adverse Effects

No residual adverse effects on labour supply, education, health and safety facilities, and social services are anticipated as a result of the DGR Project.

Beneficial Effects (Education)

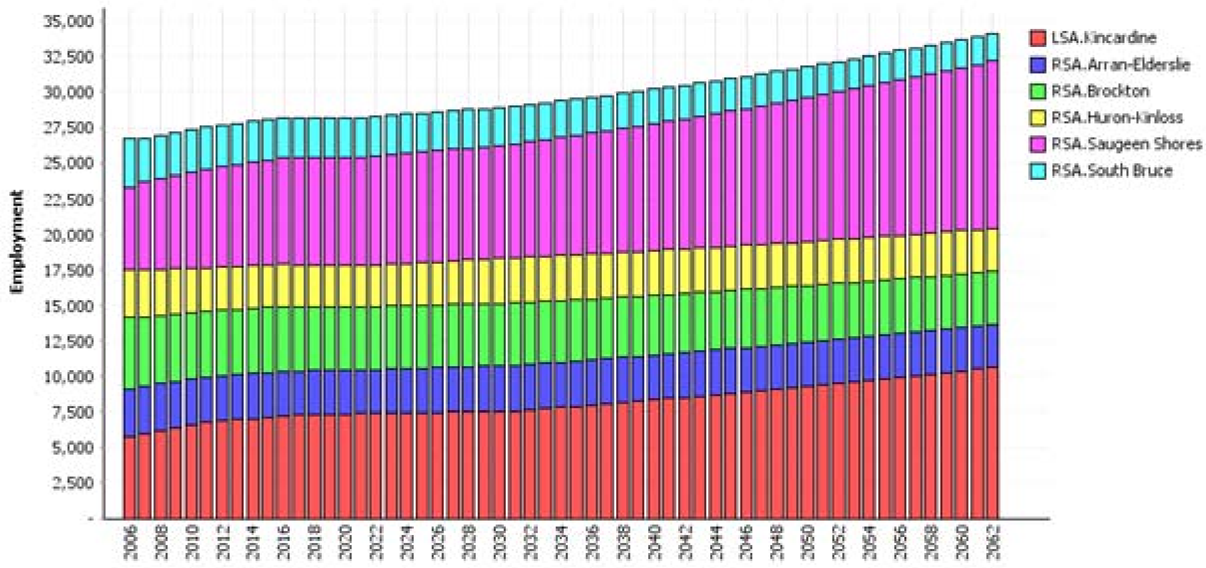
The beneficial effect of the DGR Project is increased educational opportunities for students.

7.10.2.3 Employment

Likely Effects

The importance of employment to the well-being of Local and Regional Study Areas' communities is clearly evident from the research undertaken as part of this socio-economic assessment [415].

As described in the socio-economic existing conditions, the municipalities in the Local and Regional Study Areas have experienced modest employment growth over the past several years. To provide a context within which the effects of the DGR Project on employment may be felt, projections for employment growth without the DGR Project over the timeframe of the project are provided in Figure 7.10.2-3. For the purposes of this assessment, employment from 2006 to 2062 has been estimated based on the 2006 population to employment ratio and projected population over the forecast period.



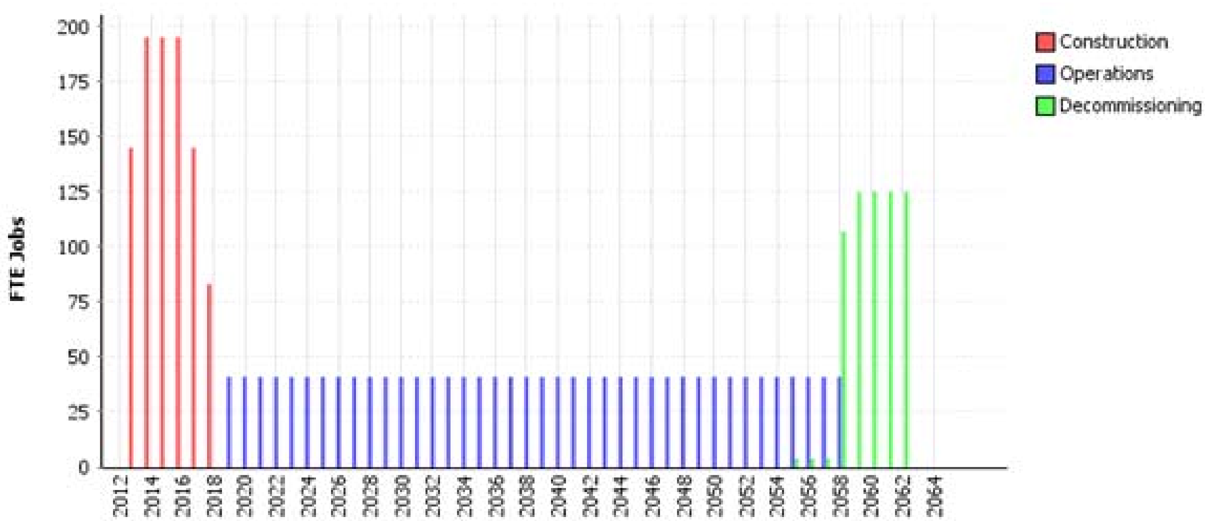
Note: RSA = Regional Study Area, LSA = Local Study Area
Source: Appendix E of Socio-economic Environment TSD

Figure 7.10.2-3: Employment Projections by Municipality – without DGR Project (2006 to 2062)

The following three types of employment are predicted to result from the DGR Project, and may affect the employment VEC:

- **On-site employment** refers to the on-site workforce, that is OPG and NWMO personnel at the DGR Project site and construction workers employed at the DGR Project site.
- **Indirect employment** refers to jobs created in the economy to support the industry sectors represented by the direct jobs. These are typically upstream suppliers of goods and services to the direct industries.
- **Induced employment** refers to the induced or "spin-off" jobs as the result of income spending by DGR Project-associated employees from the direct and indirect industry sectors. Income spending exclusive of income tax typically reflects household spending for a wide variety of commercial goods and services to meet the day to day needs of the household.

Figure 7.10.2-4 shows the anticipated workforce profile for the DGR Project over the forecast period. For the purposes of this assessment, DGR Project-related hiring and spending for the site preparation and construction phase is assumed to begin in 2013 and conclude in 2018. The required on-site labour force during this period ranges from about 80 to 200 workers. The operations phase is assumed to begin in 2017 and runs through to 2058. During this phase of the DGR Project the average on-site employment compliment will be approximately 40. Hiring and spending related to the decommissioning phase runs from 2055 to 2062 and requires an on-site workforce compliment ranging from four to a peak of approximately 125. While these specific timeframes were used for modelling purposes, the actual start or completion of each phase will depend upon licensing approval from the CNSC and/or other applicable regulatory bodies.

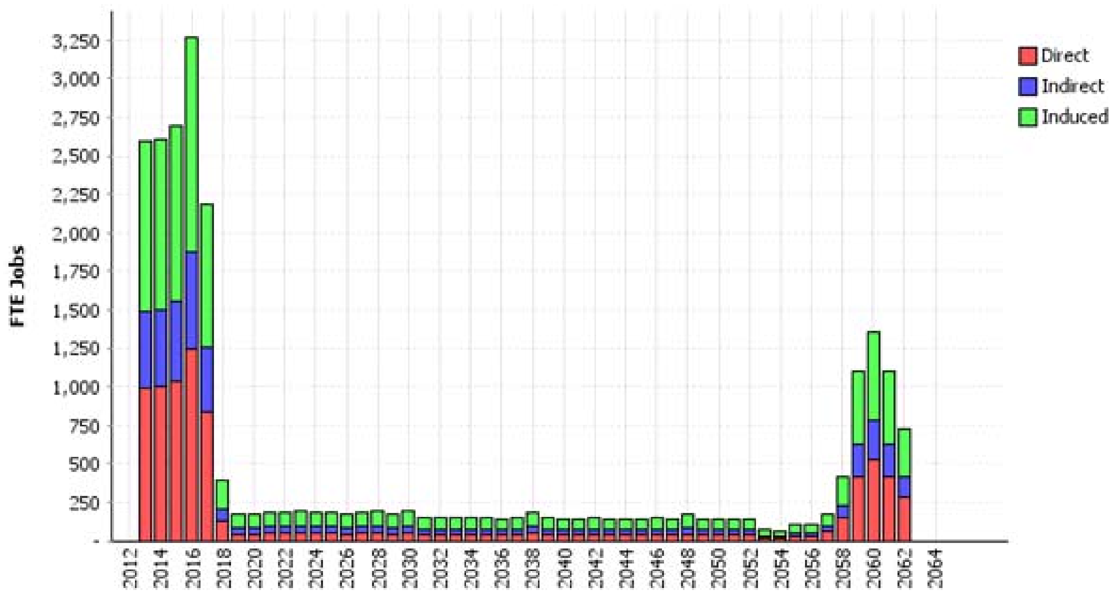


Source: Appendix E of Socio-economic Environment TSD

Figure 7.10.2-4: DGR Project On-site Jobs (2013 to 2062)

The DGR Project will be one of several facilities at the Bruce nuclear site. The proposed labour force associated with the DGR, through the site preparation and construction, operations and decommissioning phases, represents a small fraction of the of the overall labour force at the Bruce nuclear site over the projection period.

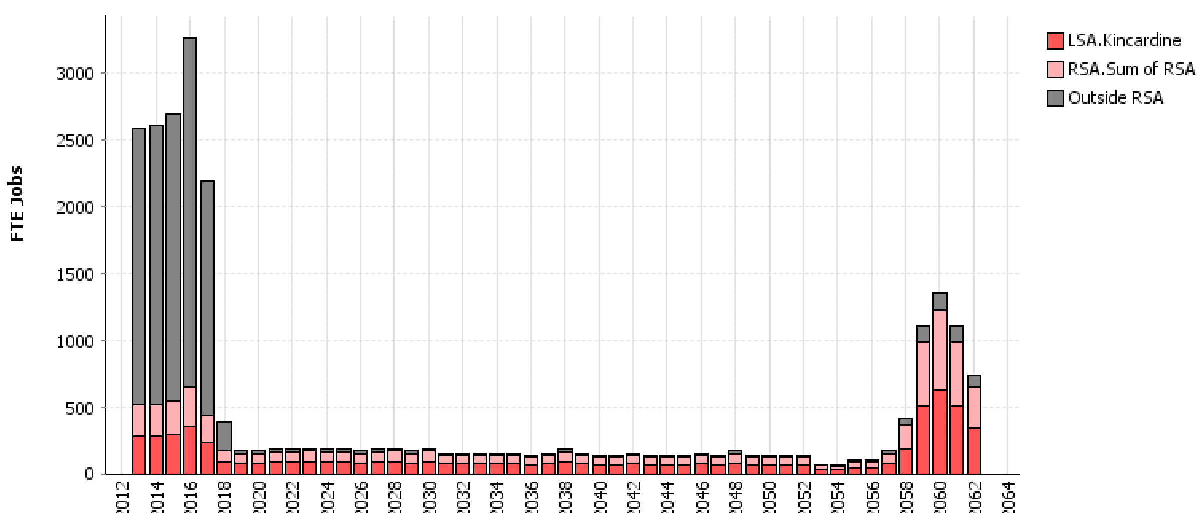
Figure 7.10.2-5 illustrates the DGR Project-related employment across the site preparation and construction, operations and decommissioning phases. Of the total 24,330 person years associated with the DGR Project, 6,522 person years (27%) are anticipated within the Local Study Area and 5,849 (24%) are anticipated in the Regional Study Area. The balance of DGR Project-related employment (49%) will likely occur outside the study areas.



Source: Appendix E of Socio-economic Environment TSD

Figure 7.10.2-5: Total DGR Project Employment – Direct, Indirect and Induced (2013 to 2062)

Not all employment opportunities created as a result of the DGR will be filled by employees who reside in the Local Study Area. A substantial number will be distributed across the Regional Study Area, other parts of the Province and in some cases beyond. Figure 7.10.2-6 depicts the estimated distribution of jobs to Kincardine, the Regional Study Area and outside the Regional Study Area.



Note: RSA = Regional Study Area, LSA = Local Study Area
Source: Appendix E of Socio-economic Environment TSD

Figure 7.10.2-6: Total Employment Distribution – Kincardine, Regional Study Area, Outside Regional Study Area (2013 to 2062)

In summary, the economic modelling indicates that the DGR Project will create new direct, indirect and induced employment opportunities in the Local and Regional Study Areas and beyond that will contribute to overall community well-being. As anticipated by the PAR respondents, a positive local employment effect is likely; however, this effect is relatively modest in the context of the Bruce nuclear site employment and within the context of employment levels within the municipalities over the life of the DGR Project. The number of jobs created and their distribution over time does not suggest that the municipalities in the study areas would experience any "boom" or "bust" effects as a result of the DGR Project as previously experienced in relation to other nuclear projects at the Bruce nuclear site.

The presence of the DGR is also seen by some in the community as an indication of the continued presence of nuclear-related activity and employment opportunities at the Bruce nuclear site. This expectation may contribute to positive attitudes toward future well-being of the community.

Recommended Mitigation or Effects Management

Because no adverse effects on employment are anticipated as a result of the DGR Project, no additional mitigation is identified.

Residual Adverse Effects

No residual adverse effects on employment are anticipated as a result of the DGR Project.

Beneficial Effects

The DGR Project will create new direct, indirect and induced employment opportunities. This effect is a beneficial influence on the economies of the municipalities in the Local and Regional Study Areas and overall community well-being during the site preparation and construction, operations, and decommissioning phases.

7.10.2.4 Business Activity

Likely Effects

The economic modelling of likely effects of the DGR provides insights into the effects of the DGR Project in the Local and Regional Study Area economies. As described previously, not all jobs created as a result of the DGR will reside in the Local Study Area. A substantial number will be distributed to the Regional Study Area, other parts of the Province and in some cases beyond Ontario. In addition, the supply of goods and services directly to the DGR Project can be expected to contribute to business activity in the Local and Regional Study Areas. In particular, aggregate required during the site preparation and construction phase and during the decommissioning phase will likely be sourced from off-site aggregate operations providing additional business opportunities for Regional Study Area suppliers. Similarly, transportation of various goods to the DGR Project site and the removal of conventional, non-hazardous wastes and small quantities of hazardous wastes will provide business opportunities for the waste management and transportation sectors.

Indirect effects on business activity may also occur as a result of other environmental changes. As with any major industrial construction project or activity, nuisance and traffic-related effects have the potential to be disruptive to business activities should they be of sufficient magnitude over baseline conditions, particularly at sensitive business locations (i.e., commercial operations with an outdoor component, businesses typically relying on transient or drive-by customers). It is not expected that any commercial business in the Local or Regional Study Area will experience nuisance or traffic-related disruption because of the DGR Project for the following reasons:

- the atmospheric environment assessment (Section 7.7) concludes that nuisance dust effects are not likely to be widespread in the Local Study Area, but rather restricted to a small portion of the Local Study Area in close proximity to the Bruce nuclear site;
- based on-site reconnaissance visits, there are no sensitive businesses located in the vicinity of Baie du Doré area where a potential nuisance noise effect may be experienced; and
- traffic associated with the DGR Project can be accommodated within the current transportation infrastructure.

Recommended Mitigation or Effects Management

Because no adverse effects on business activity are anticipated as a result of the DGR Project, no additional mitigation is identified. To enhance the potential for positive effects on local and regional business activity, the DGR Project non-salary expenditures will be sourced locally wherever practical and in accordance with relevant supply chain policies, procedures, and standards for competitive purchasing.

Residual Adverse Effects

No residual adverse effects on business activity are anticipated as a result of the DGR Project.

Beneficial Effects

As noted above, a beneficial effect on business activity is anticipated during all DGR Project phases which can be enhanced through policies to utilize local business services wherever practical and in accordance with OPG supply chain policies, procedures, and standards for competitive purchasing.

7.10.2.5 Tourism

Likely Effects

Tourism is an important and thriving component of the Local and Regional Study Areas. The study areas are home to many tourist attractions and tourist accommodations both large and small. Seasonal cottages and a vibrant array of local community events also serve to attract a growing number of visitors from outside the area.

During the site preparation and construction phase, it is assumed that some construction workers, particularly those that are transient, may compete with tourists for temporary accommodation in the vicinity of the Bruce nuclear site. This assumption is based on experience from other major construction projects, including the recent refurbishment of Bruce A reactors. This competition may result in some tourists deciding to search for alternative accommodations elsewhere in the Local and Regional Study Area. If this effect is of sufficient magnitude, some tourists may choose to "stop coming" or will choose to "look elsewhere" for accommodations and tourist activities. As such, some tourist businesses, including souvenir and gift shops, pick-your-own farm operations, Bed & Breakfasts and other temporary accommodation providers, whose operations are largely dependent on visiting tourists (including day-trippers) for the majority of their revenues would be the most vulnerable to adverse effects on their business activity.

With regard to the DGR Project, the site preparation and construction phase will require an on-site workforce of up to 200 skilled and unskilled workers for approximately six years and a smaller contingent during the decommissioning phase. Given the small size of the labour force associated with the site preparation and construction phase and the decommissioning phase for the DGR Project, some competition for temporary accommodation is anticipated but is not expected to be of sufficient magnitude to affect the tourism accommodation industry over the long term. Interviews with tourism accommodation providers across the Regional and Local Study Areas indicate that most operators attribute some of their business to the presence of the Bruce nuclear site, its employees or activities and some indicated that up to 70% of their business can be attributed to Bruce Power employees. The increased number of workers on-site because of the DGR Project and increased number of corporate clients using local hotels and motels during the off-season is likely to help maintain the economic viability of these businesses but is not expected to be of sufficient magnitude to generate substantial re-investment into these facilities by their owners, nor encourage the improvement of the tourist accommodation stock over the long term.

Notwithstanding the positive effects on temporary accommodation providers, should tourists and other visitors to the Provincial parks, Local Study Area hotels, motels and campgrounds "stop coming" or be "diverted elsewhere" as a result of increased competition, it is not likely that the overall tourism industry would suffer. This possible loss of visitation would not likely translate directly into a loss in revenues at all tourism establishments, because DGR Project workers would act as a substitute source of revenue to some extent. For example, the additional construction workforce associated with the DGR Project may choose to visit downtown Kincardine and Port Elgin merchants and purchase goods and services year round, as tourists would do during peak season.

Results of air quality and noise studies indicate that the DGR Project is not likely to result in noticeable increased dust or noise levels at Inverhuron Provincial Park or MacGregor Point Provincial Park, or any other key tourist attraction areas. Surface water studies also indicate that the DGR Project is not likely to measurably change the water quality at Local or Regional Study Area beaches and nearshore areas used by tourists and day users for outdoor leisure activities such as swimming, fishing and boating. Therefore, the DGR Project will not result in environmental effects to the Provincial parks, affect their accessibility nor require park operators to modify their facilities or programs.

Apart from the potential effects of dust, noise and traffic, it was hypothesized that adverse effects on the use and enjoyment of the Provincial parks and the tourism industry in general within the Local and Regional Study Areas may occur, if the DGR Project results in an adverse effect on community character (i.e., physical asset), particularly if a stigma is attributed to the Local Study Area and tourists take steps to avoid the area, and its tourism-related products and services.

The DGR Project is not likely to result in any direct adverse effects on community character, but rather represents a strengthening of an existing industrial presence at the Bruce nuclear site. However, this is not expected to adversely affect the attractiveness of the Local or Regional Study Area to tourists for the following reasons:

- no noticeable increases in dust or noise levels at the two Provincial parks, downtown Kincardine or Port Elgin are anticipated during the DGR Project phases;
- the DGR Project is not likely to noticeably change environmental conditions at the beaches and nearshore areas used by tourists and day users;
- increased traffic is not anticipated to be noticeable at the entrance to Inverhuron Provincial Park or on Highway 21, which are regularly used by tourists;
- the DGR Project is not expected to result in a substantial change in the visual character of the Local Study Area, nor block view of the lake from the Provincial parks or the Bruce Power Visitors' Centre;
- based on the results of the Inverhuron and MacGregor Point Provincial Park Survey, the DGR Project is not likely to affect the things or special features that affect the use and enjoyment of the Provincial parks by tourists (i.e., beaches, park amenities and atmosphere, surrounding environment and recreational opportunities); and
- the DGR Project will be visible from Lake Huron, but its above-ground facilities will not be dominant as compared to the existing buildings and structures at the Bruce nuclear site.

Finally, notwithstanding the link between Inverhuron Provincial Park and the Bruce nuclear site in terms of their proximity, there are no strong indications that a "stigma" already exists. The results of interviews conducted as part of this socio-economic assessment across the Local and Regional Study Areas support the conclusion that the Regional and Local Study Areas have not been stigmatized by the ongoing presence of the Bruce nuclear site or the WWMF. Surveys of tourists at Provincial parks and conservation areas also support this conclusion. Of the 119 users surveyed at these areas, 104 said that the existing Bruce nuclear site has not affected their use and enjoyment of those areas. Of those same users, 108 said that the existing WWMF has not affected their use and enjoyment of those areas. Therefore, no adverse effects on Provincial parks or the tourism industry as a whole are expected during the DGR Project.

Recommended Mitigation or Effects Management

Because no adverse effects on tourism are anticipated as a result of the DGR Project, no additional mitigation is identified.

Residual Adverse Effects

No residual adverse effects on tourism are anticipated as a result of the DGR Project.

7.10.2.6 Residential Property Values

Likely Effects

Stakeholder interviews for the DGR Project occasionally identified the potential for property value effects when asked what effects the project may have on the image of the community (two of 76 respondents).

Decreased property values and increased marketing time (i.e., time between listing and sale) typically result from noticeable increases in nuisance effects such as noise, dust, and traffic associated with a project. In the case of the DGR Project, the following conclusions were reached regarding nuisance effects:

- no nuisance effects because of dust;
- no nuisance effects because of noise at R1 (a residential dwelling on Albert Road) and R3 (Inverhuron Provincial Park);
- a moderately perceptible increase in noise with a low nuisance effect at R2 (Baie du Doré); and
- modest increased traffic levels on local roads in the vicinity of the DGR Project site during the site preparation and construction phase and decommissioning phase are anticipated; however, the DGR Project will not be the cause of unacceptable levels of service along the local transportation network within the Local Study Area.

The DGR Project will be located at the Bruce nuclear site, which represents an existing industrial and nuclear presence in the Local Study Area and its visibility from areas in close proximity to the site is not likely to be a major determinant of residential property values. Although no contamination is expected to result from the DGR Project, property values could be affected should operation of the DGR result in contamination beyond the site boundaries. In any case, the 2004 DGR Hosting Agreement between OPG and the Municipality of Kincardine provides a property value protection plan to compensate property owners for any such losses, subject to meeting specified conditions [416].

Therefore, it is concluded that while there may be some nuisance effects associated with the project, these are localized to a small portion of the Local Study Area in close proximity to the Bruce nuclear site and are not anticipated to result in property value changes in that area.

Recommended Mitigation or Effects Management

Taking into account the availability of a property value protection plan, no adverse effects on property values are anticipated as a result of the DGR Project and no additional mitigation is identified.

Residual Adverse Effects

No residual adverse effects to residential property values are identified.

7.10.2.7 Municipal Finance and Administration

Likely Effects

The DGR Project could affect municipal finance in the Local and Regional Study Area municipalities in two key ways, namely by changing municipal revenues or expenditures. Firstly, municipalities gain the vast majority of their revenues from property taxes. In the case of the DGR Project, an increase in municipal revenue as a result of changes in area housing or commercial/industrial development is expected to occur. Increased property tax and other revenues for land development may be attributable to the DGR Project. A much greater change in municipal revenues may also result from land improvements at the Bruce nuclear site associated with the DGR Project. The land improvements will generate building permit fees and development charges which will be paid by OPG. No upgrades or improvement to municipal infrastructure associated with the DGR Project are identified as necessary.

In 2009, OPG contributed approximately $5 million to the Municipality of Kincardine and Bruce County through property tax payments. These payments will be reassessed to take into account the new DGR buildings and structures. Any change in property tax is subject to final DGR Project design and confirmation by the Municipal Property Assessment Corporation (MPAC).

Increased municipal expenditures are possible due to increased service demands from new residents and businesses on municipally-provided services such as water, sewage and waste management. Overall, however, the population and business-related development is anticipated to be relatively small; therefore, it is not expected to generate a meaningful net (revenue less expenditure) effect on municipal finance. Moreover, service capacity remains for these services as the municipalities continue to plan for anticipated population growth regardless of the DGR Project.

Because of the small magnitude of DGR Project-related changes to municipal revenues and expenditures, it is not necessary to quantify these effects. Furthermore, in October 2004, the DGR Hosting Agreement between OPG and the Municipality of Kincardine was accepted by the two parties. This agreement established one-time cash payments and annual payments to Kincardine and the specified adjacent municipalities (Saugeen Shores, Huron Kinloss, Arran-Elderslie and Brockton) based on completion of activity and approval milestones throughout the construction and operation of the DGR Project. This Agreement also clarified the payments to be made regarding applicable property tax and building permits that would otherwise be payable to the Municipality of Kincardine [416].

Recommended Mitigation or Effects Management

Because no adverse effects on municipal finance and administration are anticipated as a result of the DGR Project, no mitigation is identified.

Residual Adverse Effects

No residual adverse effects are identified on municipal finance and administration.

Beneficial Effects

The DGR Project will likely result in increased municipal revenue through various monetary payments to the host municipalities as calculated in consultation with the Municipality of Kincardine, Bruce County and MPAC.

7.10.2.8 Other Financial Assets

The other financial assets considered in this assessment include:

- income;
- renewable and non-renewable resources use;
- agriculture; and
- economic development services.

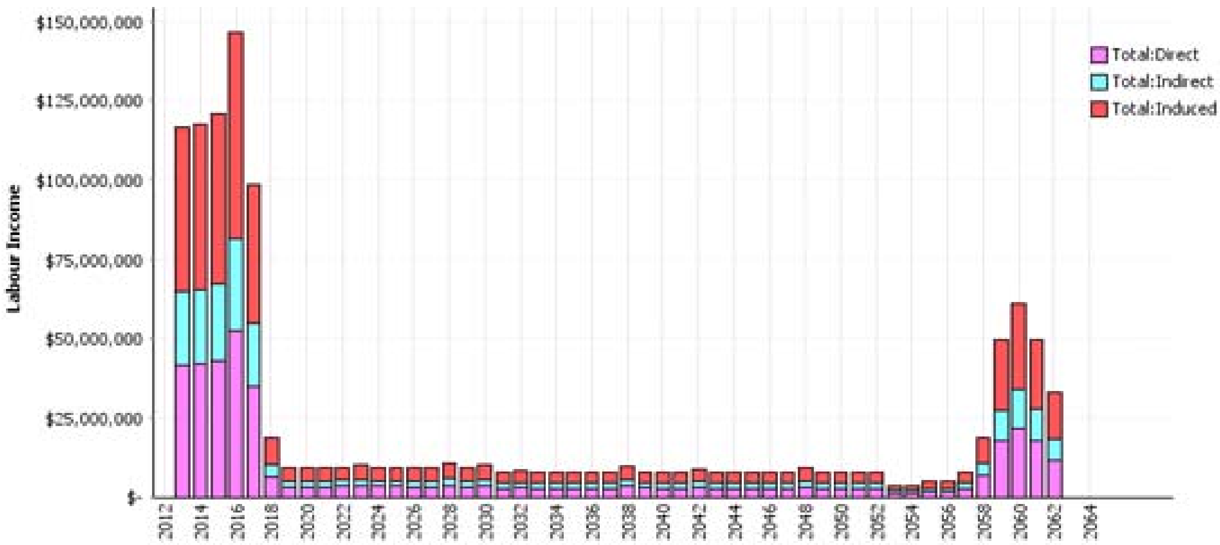
Likely Effects

Income

To assess the effects of the DGR Project on income, three types of income are estimated:

- **Direct Income** is the initial value created by the DGR Project through direct project spending on labour, goods and services.
- **Indirect Income** is the subsequent value added in the economy through the economic sectors that support the direct work being completed on the DGR Project. This value comes from increases in economic activity from upstream suppliers of goods and services to the direct industries.
- **Induced Income** is the increase in value created in the economy through growth in goods and services to meet the demands of additional labour income spending directly and indirectly related to the DGR Project.

Figure 7.10.2-7 shows the anticipated direct, indirect and induced income creation by the DGR facility over its lifetime. For the purposes of this assessment, the DGR Project-related hiring and spending for the site preparation and construction phase is assumed to begin in 2013 and conclude in 2018. The annual income added to the economy ranges from $11.4M to $146.8M during this phase. Hiring and spending related to the operations phase begins in 2017 and runs through to 2058. Annual average income creation during this period is in the order of $7.6M. Hiring in and spending related to the decommissioning phase is assumed to run from 2055 to 2062 and annual average income creation associated with this phase is in the order of $27.4M. While these specific timeframes were used for modelling purposes, the actual start or completion of each phase will depend upon licensing approval from the CNSC and/or other applicable regulatory bodies.



Source: Appendix E of Socio-economic Environment TSD

Figure 7.10.2-7: Total DGR Project Income – Direct, Indirect and Induced (2013 to 2062)

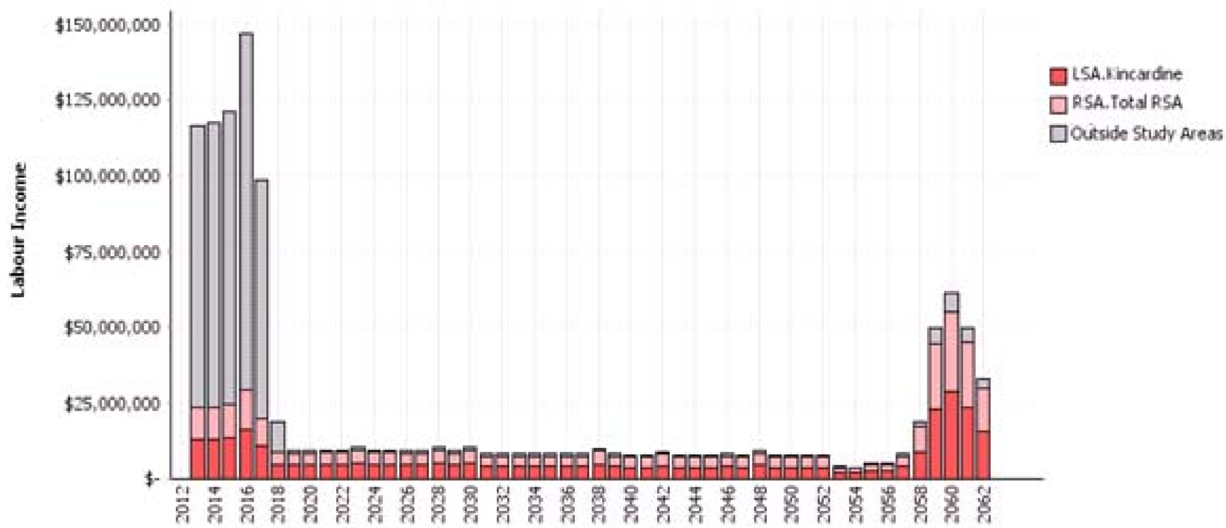
The estimated direct, indirect and induced income associated with the DGR Project over its life from construction to the end of decommissioning are summarized in Table 7.10.2-1.

Table 7.10.2-1: Direct, Indirect and Induced Income Associated with the DGR Project

Type	Income
Direct	$408,728,000
Indirect	$229,475,000
Induced	$510,562,000
Total	**$1,148,765,000**

Source: Appendix E of the Socio-economic Environment TSD

Not all of the income created as a result of the DGR Project will be generated in the Local Study Area. These income distributions are depicted in Figure 7.10.2-8.



Note: RSA = Regional Study Area, LSA = Local Study Area
Source: Appendix E of Socio-economic Environment TSD

Figure 7.10.2-8: Bruce Nuclear Site Income Distributions (2013 to 2062)

The DGR Project income, including direct, indirect and induced income, within the Local and Regional Study Areas municipalities is summarized in Table 7.10.2-2.

Table 7.10.2-2: Summary of DGR Income Distribution in Study Areas

Area		Income (GDP)
Local Study Area	Kincardine	$316,710,459
Regional Study Area	Arran-Elderslie	$4,786,505
	Brockton	$24,286,103
	Huron-Kinloss	$38,303,683
	Saugeen Shores	$211,897,733
	South Bruce	$9,567,157
Total Local and Regional Study Area		$288,841,181
Outside Regional Study Area		$543,213,581
Total		**$1,148,765,221**

Source: Appendix E of Socio-economic Environment TSD

In summary, this analysis indicates that the DGR Project would create direct, indirect and induced labour income in the Local and Regional Study Areas.

Renewable and Non-Renewable Resource Use

The renewable resource considered in this analysis is commercial fishing. The commercial fishery in Lake Huron in the vicinity of the Bruce nuclear site is an active and valuable activity managed in partnership by area First Nations. As described in Section 6.9.8, the Saugeen Ojibway Nation (SON) has exclusive rights to the commercial fishery in the vicinity of the Bruce nuclear site through a commercial fishing agreement in place with the Ontario Ministry of Natural Recourses. The likely effects of the DGR Project on this resource and its contribution to community well-being are therefore discussed in Section 7.9 and the Aboriginal Interests TSD. There is also a recreational (i.e., sport fishery) in Lake Huron. There are no measurable changes identified to the aquatic environment VECs that would be of particular interest to recreational anglers; therefore, no adverse effects on the sport fishery are anticipated.

The greatest potential for non-renewable resource use is associated with the DGR Project's use of aggregate and fuels. Most of the aggregate required during the site preparation and construction phase and the decommissioning phase will likely be sourced from off-site aggregate operations. Aggregate production across the Province, including production within the Local and Regional Study Areas, is sufficient to supply the DGR Project and is not likely to cause a shortage for other community uses. The DGR Project assumes that any waste rock excavated from the DGR facility and not required for the DGR Project itself will remain on-site, thereby eliminating the potential for increased supply to affect local markets and production.

Fuels for on-site vehicle and equipment operation are required from site preparation through decommissioning of the DGR Project. One of the main sources of fuel consumption will be the heating of intake air in winter for DGR ventilation. Because this will be achieved using electric heaters, fuel consumption will be minimized. The annual requirement of fuel for DGR Project vehicles and equipment is not expected to be of such magnitude to affect fuel supply in any community or the Province as a whole.

Agriculture

No measurable direct or indirect changes in agricultural activity attributable to the DGR Project are anticipated. For the purposes of this socio-economic assessment, only traffic-related effects have the potential to be disruptive to agricultural activities, since increased traffic may disrupt the movement of slow-moving farm vehicles.

Most farmers use public roads for the movement of farm vehicles from property to property, or use these roads to transport their produce to market. This is the case for roads in the vicinity of the Bruce nuclear site that will experience increased traffic volumes as a result of the DGR Project. Therefore, DGR Project-related traffic can be expected to disrupt the movement of slow moving farm vehicles such as tractors, combines, cultivators, spreaders.

Economic Development Services

The DGR Project will contribute to increased local and regional economic development throughout each of its phases. The local and regional economies will be stimulated by the increased population and skills base, more employment opportunities and greater income, and the increased business activity generated by the DGR Project. Each of these positive effects is anticipated to improve the attractiveness of the Local and Regional Study Areas to potential investors, particularly those in the nuclear service industry.

Overall, the DGR Project is considered to be compatible with, and supportive of, local and regional economic development initiatives. The development of a centre of energy excellence, as envisaged in the DGR Hosting Agreement, provides an opportunity to enhance existing initiatives aimed at economic diversification. However, it is not anticipated that existing economic development plans would need to be modified or otherwise reconsidered as a result of the DGR Project.

Recommended Mitigation or Effects Management

Mitigation measures may be warranted to minimize disruption to the movement of slow moving farm vehicles and other users of local roads in the vicinity of the Bruce nuclear site during site preparation and construction. To this end, farmers in the Local Study Area along the transportation route should be informed if and when oversize or slow-moving project-related vehicles will be on local or municipal area roads during the planting or harvesting season.

Residual Adverse Effects

No residual adverse effects on income, renewable and non-renewable resources use, agriculture and economic development services are anticipated as a result of the DGR Project.

Beneficial Effects

The DGR Project would create an appreciable amount of direct, indirect and induced income in the Local and Regional Study Areas.

7.10.2.9 Housing

Likely Effects

The combined Local and Regional Study Areas housing stock is forecast to rise from 21,000 units to almost 33,000 units between 2006 and 2062. Similar to the population and employment, the dominant housing stock concentrations are in Kincardine and Saugeen Shores.

In the context of the Local and Regional Study Area communities, the effect of the DGR Project effect on the availability of housing is quite small. The DGR Project represents 1% or less of each municipality's housing stock, with the exception of Kincardine and Saugeen Shores. During site preparation and construction the DGR Project's association with projected housing stock is 3.4% in Kincardine and 2.1% in Saugeen Shores. During decommissioning the DGR Project's association with projected housing stock is 2.8% in Kincardine and 1.7% in Saugeen Shores. Further, it is expected that many of the DGR Project-associated households, particularly during the operations and decommissioning phases, will be occupied by long-term residents of the communities. Therefore, it is not expected that the DGR Project will have a substantial effect on housing availability in the Local and Regional Study Areas.

There will not be substantially increased demand for housing that could not be reasonable absorbed by the municipal housing stock or planned additions to it. In this context, the DGR Project is considered to be a very small contributor to the anticipated housing growth in these municipalities during the study period.

Recommended Mitigation or Effects Management

Because no adverse effects on housing are anticipated as a result of the DGR, no mitigation is identified.

Residual Adverse Effects

No residual adverse effects on housing are anticipated as a result of the DGR.

7.10.2.10 Municipal Infrastructure and Services

Likely Effects

Potable water is required primarily for underground workers' use and also as a supply to the washrooms and refuge chambers. Potable water will be supplied from Bruce Power's on-site water treatment plant for surface facilities. This service will not result in any direct demands on, or modification to, the municipal water supply system.

All human effluent from surface washrooms will be collected and pumped to the existing sewage treatment system at the Bruce nuclear site. The DGR Project will not result in any direct demands on, or modification to, the municipal sewage system.

Municipalities will not experience substantial direct increased demands on their solid non-hazardous waste management facilities as a result of the DGR Project. This is because it is expected that the current practice of managing all Bruce non-hazardous solid waste on-site (i.e., through reuse, recycling and the on-site landfill) will continue. Should off-site disposal of some wastes be required, it is anticipated that licensed private facilities would be utilized rather than municipal landfills.

Recommended Mitigation or Effects Management

Because no adverse effects on municipal infrastructure and services are anticipated as a result of the DGR, no mitigation is identified.

Residual Adverse Effects

No residual adverse effects on municipal infrastructure and services are anticipated as a result of the DGR Project.

7.10.2.11 Other Physical Assets

Other Physical Assets considered in this assessment include:

- land use;
- transportation infrastructure; and
- community character.

Likely Effects

Land Use

As is the case with all activity at the Bruce nuclear site, no Site Plan Applications or Building Permits are required for site development; the Municipality of Kincardine has no review or approval roles in this regard.

The DGR Project is a nuclear facility located on a licensed nuclear site. Accordingly, the DGR Project is not expected to change the Bruce nuclear site land use or its compatibility with adjacent land uses.

The DGR Project's effect on population in both the Local and Regional Study Areas during project life is small. Therefore, no noticeable induced residential development and/or associated changes in land use in the Local and Regional Study Areas are anticipated.

The visual analysis for the DGR Project [417] provides a conservative estimate of the general distribution of visible areas. The analysis concludes that the DGR will be a barely visible object on the horizon; the site buildings and features will be visible from some areas but will often be screened from view. Many of the visualizations illustrated in the analysis are from observation points that are 5 to 7 km from the Bruce nuclear site and the buildings and structures associated with the DGR Project appear as very small portions of the viewscape. From places where the DGR Project's buildings and structures are likely to be visible, they are surrounded by existing buildings with similar industrial character. The existing old steam stack will remain as the tallest structure on the Bruce nuclear site. The presence of existing wind turbines and hydro towers in the local and regional study area landscapes further influences the industrial nature of these viewsheds. Therefore, the visual presence of the DGR Project will not be drastically different to what viewers are accustomed to. Overall, it is determined that the DGR Project will have a minor visual effect that is not likely to influence existing or planned land uses.

Transportation Infrastructure

The information contained in this section is drawn from the Traffic Impact Study [393]. Overall, the DGR Project on its own does not result in a need for any improvements to the road network over the forecast period as some improvements were already warranted under existing conditions, without the DGR Project. However, should the improvements required to alleviate existing congestion be undertaken, the addition of the DGR Project site traffic would not result in any unacceptable levels of service nor a need for any additional improvements to the road network.

Community Character

In general, the DGR Project could affect the character of the community if it fundamentally changes key assets of the community, particularly those assets that are valued by its residents for their positive influence on community character or attributes a negative "stigma", potentially associated with nuclear waste. Based on the results of PAR undertaken as part of this socio-economic assessment, residents in the Local Study Area value Lake Huron, the waterfront and the lighthouse, the nature and scenery, the agricultural presence, and the close-knit feel and friendly people in the community.

Nuisance effects are not likely to have an effect on the environment such that community character would be affected. For example, dust levels are not expected to be a nuisance outside of the Bruce nuclear site. Noise levels are also expected to be hardly perceptible at two of the three noise receptors identified for the socio-economic assessment and only noticeable at one of these three noise receptors (i.e., at Baie du Doré). Overall, these results indicate that increased noise levels are not expected to have a nuisance effect at most off-site locations and so will not have an indirect effect on community character.

The DGR Project is not expected to affect Lake Huron, the beachfront, or the lighthouse, nor is it expected to have an overall effect on the natural landscape and its visual aesthetic. Agriculture is not expected to be affected by the DGR Project, which is also an attribute that contributes to community character. Community cohesion is also not likely to be negatively affected by the DGR Project because of the slight increases in population and stable demographic character of the communities.

Community character may also be adversely affected if the assets that are seen to be negative influences on community character become more pronounced as a result of the DGR Project. In the Local Study Area, the most frequently mentioned negative influences on community character include: the presence of windmills and political issues. These factors are not expected to change a result of the DGR Project.

It was also hypothesized that the DGR Project might adversely affect the character of the community if a stigma is generated because of the DGR Project. Stigma refers to the negative images attached to a neighbourhood, community, other geographic area and its residents or to local products and services.

In the stakeholder interviews and the tourist and day user surveys, respondents were asked to describe how, if at all the DGR Project might affect their image of Kincardine and the surrounding municipalities. The results indicate that most of the stakeholders interviewed feel that the DGR Project will not change the image of Kincardine and its surrounding municipalities, or that it will change the image in a positive way (41 out of 72 responses). Approximately 28 of 72 respondents felt that while the image may change in a negative way, this change would likely be attributed to a pre-existing bias against the nuclear industry or because of people being uninformed of the project details.

With regard to the Bruce nuclear site and its influence on community character, less than 1% of Local Study Area and 2% of Regional Study Area respondents from the public attitude research considered the Bruce nuclear site as a negative influence, while a slightly larger proportion (5% of Local Study Area and 13% of Regional Study Area) of respondents considered the Bruce nuclear site as a positive influence on community character. Therefore, further development at the Bruce nuclear site, related to its already existing industrial presence, is not expected to affect community character.

The overall rural and small town feel of the communities are not likely to be affected by the DGR Project. This is attributed to the relatively small workforce and associated increase in population expected as a result of the DGR Project. Existing housing stock, municipal infrastructure and health and safety facilities and services are all expected to be able to absorb the small increase in population with no adverse effects on the existing environment.

The effects of the DGR Project on the character of the neighbourhoods nearest the Bruce nuclear site are not likely to be noticeable. The effect of the DGR Project on local traffic and transportation is minimal. The DGR Project is placed in the context of existing land uses in the Local Study Area and is considered to be compatible with the existing community character.

The DGR Project does, however, introduce a new type of facility to the Local and Regional Study Area, which is unique in North America at the time of writing. Therefore, there remains some potential for this new facility to be a source of stigma, as it is relatively unknown and unfamiliar to the residents of the Local and Regional Study Areas. However, there are no strong indications that the DGR Project would result in a stigma.

Overall, although a small number of tourists and day users and stakeholders stated that their image of Kincardine might change as a result of the DGR Project, the indirect effects of the project are not likely to change the physical aspects of the community that define its community character. However, widespread changes in the attitudes among tourists are not expected and overall, the community character is not expected to change as a result of the DGR Project.

Recommended Mitigation or Effects Management

In terms of mitigation or effects management for transportation infrastructure, additional mitigation is warranted to minimize congestion at intersections nearest the Bruce nuclear site. In collaboration with relevant stakeholders, OPG will develop and implement a traffic management plan for the site preparation and construction phase that will serve to minimize DGR Project related peak hour volumes. Specific measures may include: staggering of shifts, encouraging ride sharing and the use of shuttle buses, and off-peak timing of shipments of materials and wastes on and off the DGR Project site.

No other adverse effects on other physical assets are anticipated as a result of the DGR Project; therefore, no additional mitigation is identified.

Residual Adverse Effects

No residual adverse effects on the other physical assets VECs are expected as a result of the DGR Project.

7.10.2.12 Inverhuron Provincial Park

Likely Effects

For the purposes of this socio-economic assessment, nuisance effects have the potential to be disruptive to activities and operations conducted at Inverhuron Provincial Park. An interview with the park superintendent revealed some concerns regarding the DGR Project and its effects on Inverhuron Provincial Park. These included a concern over potential nuisance effects because of construction and the potential for an accident at the DGR. However, it is not expected that any community or recreational facilities in the park will experience nuisance disruption for the following reasons:

- no adverse effects for dust levels across the Local Study Area during all phases of the DGR Project are predicted; and
- small, barely perceptible changes in noise levels (i.e., up to 2 dBA) are predicted at Inverhuron Provincial Park.

Although the DGR Project will add some volumes of traffic to the road network it is expected that these effects will be very small.

Other adverse effects on Inverhuron Provincial Park may occur indirectly, because of changes in demand as a result of increased project-associated population, as a result of adverse effects on community character or if a stigma is attributed to the Local Study Area and people subsequently decide to avoid Inverhuron Provincial Park.

Since the increased population associated with the DGR Project is expected to be relatively small and will not impose a noticeable increase in demand on housing stock, municipal infrastructure or health and safety facilities and services, it is also expected that the small population increase will not change the overall demand for the recreational opportunities provided by Inverhuron Provincial Park.

Stakeholder concerns regarding the potential for an accident at the DGR are normal concerns associated with any major nuclear project. However, this potential will not likely result in the attribution of a stigma as demonstrated in the detailed discussion on community character (see Section 7.10.2.11). There is no strong evidence for the presence of an existing stigma associated with the existing WWMF, and there are no strong indications that the DGR Project would result in the attribution of a stigma in the future. Therefore it is not expected that the DGR Project will have any effect on Inverhuron Provincial Park as a result of stigma.

The results of the public attitude research [415] indicate that the vast majority of people (i.e., more than 86% in the Local Study Area and 75% in the Regional Study Area) do not anticipate any changes to their use of community and recreational facilities or other areas in the vicinity of the Bruce nuclear site. However, a smaller number of respondents anticipated their use and enjoyment might decrease "a great deal" (3% in the Local Study Area and 5% in the Regional Study Area) or increase (1% in the Local Study Area and 2% in the Regional Study Area).

More specifically, Inverhuron Provincial Park users were asked about the potential for the DGR to affect their use and enjoyment of the park, conservation areas and trails along the waterfront near the Bruce nuclear site. As a group, the users of the park are described as tourists and day users. These tourists and day users were asked if and how they might change their recreational behaviour at the park because of the presence of the DGR.

Of the 13 respondents that said they would do something differently at Inverhuron Provincial Park, six indicated that they would consider no longer visiting the park, while seven indicated that they would keep a close watch on safety and would only return to the park if there were no negative effects on health or the environment.

Notwithstanding these results, Inverhuron Provincial Park will remain an important local feature that will continue to be accessible and provide benefits to community residents, tourists and other visitors. In the context of the general population growth anticipated across the Regional and Local Study Area, Inverhuron Provincial Park will likely continue to be attractive and utilized extensively by an increasing number of users. The DGR Project will not result in direct environmental effects to the park, affect accessibility nor require any modifications to accommodate the DGR Project. Any users who might choose to frequent Inverhuron Provincial Park less or stop coming outright are likely to be replaced by others who are more tolerant of local conditions or have fewer issues with the DGR Project. Overall, widespread measurable changes to people's use and enjoyment of Inverhuron Provincial Park attributable to the DGR Project are not anticipated and therefore, no adverse effects on visitation to the park are anticipated.

Recommended Mitigation or Effects Management

While no adverse effects on Inverhuron Provincial Park are anticipated as a result of the DGR Project, OPG will continue to keep its neighbours and the broader public informed concerning DGR Project activities at the Bruce nuclear site.

Residual Adverse Effects

No residual adverse effects to Inverhuron Provincial Park as a result of the DGR Project are anticipated.

7.10.2.13 Other Social Assets

Other Social Assets considered in this assessment include:

- cultural and heritage resources;
- community recreational facilities and programs;
- use and enjoyment of private property; and
- community cohesion.

Likely Effects

Cultural and Heritage Resources

As described in Section 7.9.2.2, a Stage 2 Archaeology Assessment has been conducted for the Bruce nuclear site [418]. The assessment concluded that only the extreme southeastern corner of the Project Area overlaps with culturally-sensitive area B (CSA B), which contains the Bonnett (BbHj-32) cultural heritage feature (i.e., a band of low-relief cobble piles that represent a section of a collapsed snake rail fence along the Lot 21/Lot 22 line). The remaining culturally sensitive areas (A, C and D) are located well away from the Project Area and will not be subject to any project works or activities. The Stage 2 archaeological assessment also concluded that the remainder of the Bruce nuclear site, including the DGR Project site is considered to be cleared of further archaeological concern.

Because the site preparation, construction and decommissioning activities are to be limited to the DGR Project Site and are therefore well removed from the Bonnett cultural heritage feature and the overlapping portion of CSA B it is unlikely that the Bonnett cultural heritage feature will be directly affected. Nor is it likely that any unknown Euro-Canadian cultural heritage features, including deeply buried ones would be disturbed.

Community Recreational Facilities and Programs

Nuisance effects have the potential to be disruptive to activities and operations conducted at community and recreational facilities located near the Bruce nuclear site, should they be of sufficient magnitude over baseline conditions, particularly at those facilities with outdoor components such as MacGregor Point Provincial Park and Brucedale Conservation area (for a detailed discussion of likely effects to Inverhuron Provincial Park see Section 7.10.2.12). However, it is not expected that any community or recreational facilities will experience nuisance disruption for the following reasons:

- No adverse effects for dust levels across the Local Study Area during any phase of the DGR Project are predicted.
- Small, barely perceptible changes in noise levels (i.e., up to 2 dBA) are predicted at Inverhuron Provincial Park. No other outdoor recreational facilities are expected to experience a change to noise levels.

Although the DGR Project will add some volumes of traffic to the road network it is expected that effects will be very small and will not cause a change in existing levels of service. In addition, there are no community or recreational facilities present along the main transportation routes to and from the Bruce nuclear site.

Other adverse effects on community and recreational features within the Local and Regional Study Areas may occur indirectly:

- because of changes in demand as a result of increased DGR Project associated population; and

- as a result of adverse effects on community character, particularly if a stigma is attributed to the Local Study Area and people take steps to avoid community and recreational facilities in the vicinity of the Bruce nuclear site.

Since the increased population associated with the DGR Project is expected to be relatively small and will not impose any increased demands on housing stock, municipal infrastructure or health and safety facilities and services, it is also expected that the small population increase will not change the overall demand for recreational facilities in the Local or Regional Study Area.

As discussed in Section 7.10.2.12, the results of the public attitude research [415] indicate that a large majority of people (i.e., more than 86% in the Local Study Area and 75% in the Regional Study Area) do not anticipate any changes to their use of community and recreational facilities or other areas in the vicinity of the Bruce nuclear site.

In addition, users at MacGregor Point Provincial Park and the Brucedale Conservation Area were asked about the potential for the DGR to affect their visitation to these areas. As a group, the users of these areas are described as tourists and day users. These tourists and day users were asked how they might change their recreational behaviour at the park and conservation area because of the presence of the DGR.

Twelve respondents that said they would do something differently at the Provincial Park or conservation area. Responses, by recreational area included:

- **MacGregor Point Provincial Park:** Of the nine respondents who indicated that they would change their behaviour, the majority indicated that they would no longer visit MacGregor Point Provincial Park. More specifically:
  - six stated that they may not come back;
  - one stated that they would more closely monitor safety at the park;
  - one stated that they would still come to the park but that it may affect other aspects of visitation; and
  - one made no comment.
- **Brucedale Conservation Area:** Of the three respondents who indicated that they would change their behaviour, comments were made that the construction would make them stop and think before visiting the conservation area but none indicated that they would stop visiting. More specifically:
  - two stated that they would still come to the park but that it may affect other aspects of visitation; and
  - one made no comment.

Overall, 57 out of 69 respondents stated that they would not do anything differently at those recreational areas because of the presence of the DGR. Of those that replied that the DGR Project would affect their behaviour or visitation to these areas, some of the respondents simply stated that they would try to stay more informed of site activities while others stated that the DGR Project would deter them from visiting the area in the future.

Residents in the Local and Regional Study Areas feel that their recreational behaviours would not change as a result of the DGR Project. Of those that said their behaviours would change as a result of the DGR, the greatest change was anticipated by Regional Study Area residents (6%) that anticipated their use and enjoyment of the beaches along the waterfront near the Bruce nuclear site would decrease 'somewhat'.

Notwithstanding these public attitude research results and results from the park and conservation area users, the community and recreational features nearest the Bruce nuclear site will remain important local features that will continue to be accessible and provide benefits to community residents, tourists and other visitors. In the context of the general population growth anticipated across the Regional and Local Study Areas, these off-site features will likely continue to be attractive and utilized extensively by an increasing number of users. The DGR Project will not result in direct environmental effects to these features, affect their accessibility nor require any modifications to accommodate the DGR Project. Any users who might choose to frequent these places less or stop coming outright are likely to be replaced by others who are more tolerant of local conditions or have fewer issues with the DGR Project. Overall, widespread adverse changes to people's use and enjoyment of community and recreational features across the Local Study Area attributable to the DGR Project are not anticipated.

No measurable changes are anticipated in the demand for community recreational facilities as the population change associated with DGR will be relatively minor.

Use and Enjoyment of Private Property

Effect of major industrial projects on people's use and enjoyment of private property (i.e., people's homes) is a typical public concern. For the purposes of this socio-economic assessment, the focus is placed on the Local Study Area, reflecting the more direct relationship between the presence of the Bruce nuclear site and the Local Study Area and where nuisance and traffic effects are most likely to be the greatest. No adverse nuisance effects are expected because of dust. However, some nuisance effects can be expected for some residences in the Local Study Area, particularly those residents in the Baie du Doré area (R2), who can expect a low level of nuisance (+5 dBA) because of noise associated with the DGR Project. All other noise receptors were found to have minimal to no noise effects. These residents (near Baie du Doré) may experience some nuisance effects, which may indirectly affect their use and enjoyment of private property, though these effects are not expected to be widespread.

Secondly, the DGR Project might adversely affect people's use and enjoyment of private property if it fundamentally changes those features of the community or neighbourhood that are valued for their positive influence on use and enjoyment of property or prevents or constrains people from using their private property in the manner they choose

Based on the results of public attitude research undertaken as part of this socio-economic assessment [415] residents in the Local Study Area most value Lake Huron, the waterfront and the lighthouse, the nature and scenery, the agriculture and farmland as well as the cohesiveness of their community. These aspects of the community are not likely to be affected by the DGR Project directly or indirectly. Similarly, based on the results of the site neighbour survey and from observation and professional judgement, residents in the immediate vicinity of the Bruce nuclear site use their property for a variety of purposes, the most popular of which are gardening, swimming, relaxing outside, and general outdoor recreational activities. The ability of residents to undertake these activities is not likely to be directly or indirectly affected by the DGR Project.

With regard to the influence of increased growth and development on people's use and enjoyment of private property, the increased population associated with the DGR Project is expected to be relatively small and effects on housing stock are not expected. Therefore, people are not likely to consider the DGR Project as an influence on their use and enjoyment of property.

Finally, the DGR Project might adversely affect people's use and enjoyment of private property if it adversely affects community character or if a "stigma" is generated because of the DGR Project. Adverse changes in community character or the attribution of a stigma would likely make the area less desirable as a place to live, potentially adversely affecting people's enjoyment of their property. There is no strong evidence for the presence of an existing stigma associated with the existing WWMF and there are no strong indications that the DGR Project would result in the attribution of a stigma in the future.

The visual analysis concluded that the DGR Project will be a barely visible object on the horizon and will have a minor visual impact. The existing old steam plant stack will remain as the tallest structure on-site. The DGR Project's surface buildings and structures will be visible from some off-site areas but will often be screened from view. From places where the surface buildings and structures will be visible, they are surrounded by other existing buildings and structures with similar industrial character. The presence of the existing wind turbines and hydro towers in the landscape further influences the industrial nature of these viewsheds. Therefore, the visual impact of the DGR Project's surface buildings and structures will not be drastically different to what viewers are already accustomed to seeing and the DGR Project's visual effect is not expected to indirectly affect people's use and enjoyment of private property.

These conclusions are supported by public attitude research results. Residents in the Local and Regional Study Areas were asked, through the public attitude research, if they anticipated the DGR Project might affect their use and enjoyment of their private property. These results indicate that the vast majority of respondents (96% in the Local Study Area and 91% in the Regional Study Area) anticipate that the DGR Project will not affect the use and enjoyment of their private property.

Finally, all of the four residential site neighbours surveyed stated that they do not anticipate doing anything differently at their property as a result of the DGR Project.

Overall, widespread widespread changes to people's use and enjoyment of private property attributable to the DGR Project are not anticipated. However, increases in off-site noise levels during the site preparation and construction phase and during the decommissioning phase will be approximately 5 dBA, which is noticeable. The change may reduce the enjoyment of private property in the Baie du Doré area, in close proximity to the Bruce nuclear site.

Community Cohesion

Similar to the consideration of effects on the use and enjoyment of property, consideration of effects on community cohesion are focused on the Local Study Area, reflecting the more direct relationship between the presence of the Bruce nuclear site and the Local Study Area.

The DGR Project would be considered a negative influence on the cohesiveness of a community if it fundamentally changes those aspects of the community that are considered to positively influence community cohesion. Based on the results of public attitude research undertaken as part of this socio-economic assessment [415], residents in the Local Study Area consider the fact that the area has a small town community with friendly people as positive influences on community cohesion. Cohesion in the Local Study Area is also influenced by the social and community events in their communities and the fact that the community works together.

The DGR Project is not likely to become a divisive issue among Local Study Area residents. It is not anticipated that the overall small town feel of the Local Study Area will be indirectly adversely affected by the DGR Project. Population increases associated with the DGR Project are expected to be relatively small and traffic levels associated with the DGR Project are expected to be very small. The demand for rental and permanent housing across the Local Study Area is not expected to be substantial and is not expected to indirectly contribute to adverse effects on community cohesion.

The DGR Project would also be considered a negative influence on community cohesion should people change those behaviours that support community cohesion as a result of the DGR Project. For example, community cohesion might be adversely affected if service clubs or other organizations and individuals are unable to make use of facilities that are currently used for socializing or other community-based activities. Based on feedback from stakeholders, including operators of community and recreational facilities, the DGR Project and associated workforce is not expected to have an adverse effect on recreational opportunities in the area that support cohesiveness.

Finally, the DGR Project would be a negative influence on community cohesion should people choose to move from their neighbourhoods or community. Although some people might consider moving from their community because of the DGR Project, out-migration of residents is not anticipated to be widespread nor of such magnitude that it would adversely affect the cohesiveness of the community as a whole. None of the four residential site neighbours interviewed stated that they would move as a result of the DGR Project.

In the long-term, the DGR Project is likely to be a positive influence on community cohesion. In 2009, OPG was a large private employer in the Local and Regional Study Areas with 183 employees, and Bruce Power was the largest private employer with 4,000 employees. Continued development at the Bruce nuclear site will, therefore, strengthen the presence of this site and nuclear industry employees in the community.

Most importantly, the DGR Project will provide OPG with opportunities to continue its presence as an economic driver and corporate citizen in the Local Study Area. It is likely that more people, community groups and organizations will have opportunities to connect or partner with OPG. For example, OPG is and will continue to be an employer that promotes community cohesion through its Corporate Citizenship Program and the community initiatives of its employees. OPG encourages its employees to contribute individually through volunteering, coaching of amateur sports, participating in local service groups and fundraising for local charities. A workforce related to constructing, operating and eventually decommissioning the DGR will likely translate into continued charitable donations by employees and opportunities for volunteerism. OPG encourages employee charitable donations through a program called the OPG Charity Trust. Furthermore, OPG, the Power Workers' Union and the Society of Energy Professionals have all developed many partnerships with local and regional community service organizations, schools and others to deliver specific initiatives aimed at improving the well-being of community members. As demonstrated by the results of the Community Leader Survey, OPG is a recognized and well-respected member of the community. Through the ongoing delivery of such programs and activities and the opportunities for their expansion, OPG and its partners will continue to foster socially meaningful interactions within the community, thereby strengthening its positive influence on community cohesion. This will benefit not only those who directly engage in these programs and activities, but also all residents living in the Local and Regional Study Areas.

Overall, each individual, neighbourhood or community will experience changes in cohesion in their own way, depending upon the strength of the positive and negative influences encountered. The positive influences on community cohesion are more likely to be noticeable than the negative ones. On a community wide basis, adverse effects attributable to the DGR Project are not considered likely.

Recommended Mitigation or Effects Management

Cultural and Heritage Resources

In the unlikely event that site preparation, construction or decommissioning activities encounter artifacts that could be associated with a cultural or heritage resource, the activities will be curtailed until further assessment (i.e., a Stage 3 and/or 4 archaeological assessment) can be undertaken to protect the resource from further disturbance and conserve its cultural heritage value.

Community Recreational Facilities and Programs

While no adverse effects on community recreational facilities and programs are identified, OPG will continue to keep its neighbours and the broader public informed concerning its activities at the Bruce nuclear site as appropriate to each phase of the DGR Project and will continue to make contributions to the community through its Corporate Citizenship Program.

Use and Enjoyment of Private Property and Community Cohesion

Mitigation measures to help control noise levels associated with the DGR Project are described in Section 7.8.2.3. OPG will continue to keep its neighbours and the broader public informed concerning its activities at the Bruce nuclear site as appropriate to each phase of the DGR Project and will continue to make contributions to the community through its Corporate Citizenship Program. OPG will also continue to work with various stakeholders to deliver its community, recreational and educational initiatives.

Residual Adverse Effects

The residual adverse effect of the DGR Project on the Other Social Assets VEC relates to increases in off-site noise levels during site preparation and construction phase, and during the decommissioning phase will be approximately 5 dBA, which is a noticeable level of change. This change may reduce the enjoyment of private property in the Baie du Doré area, in close proximity to the Bruce nuclear site.

7.10.2.14 Summary of Assessment

The summary of the assessment is presented in Table 7.10.2-3.

Residual Adverse Effects

The single residual adverse effect of the DGR Project on the socio-economic environment is anticipated as a result of the change in noise levels in the Baie du Doré area north of the Bruce nuclear site, which could reduce enjoyment of private property in that location. It is estimated that increases in noise levels during site preparation and construction will be approximately 5 dBa, which is a noticeable level of change. This level can also be expected during the decommissioning phase of the DGR. This reduction in use and enjoyment of personal property in the localized area affected; is reflected in the socio-economic VEC Other Social Assets. This effect is forwarded for assessment of significance in Section 7.10.3.

Beneficial Effects

Although beneficial effects are identified they are not forwarded for assessment of significance. The anticipated beneficial effects on the socio-economic VECs as a result of the DGR Project are as follows:

- Population and Demographics: Increased population associated with DGR Project-related employment. This positive effect will likely be experienced in all Regional Study Area municipalities, with the greatest benefit anticipated in Kincardine.
- Other Human Assets (Education): Increased educational opportunities for students and others interested in nuclear technology through the presence of the DGR Project and the establishment of a centre of energy excellence.
- Employment: The DGR Project will create new direct, indirect and induced employment opportunities.
- Business Activity: A positive effect on business activity is anticipated during all project phases, which can be enhanced through policies to utilize local business services wherever practical and appropriate.
- Municipal Finance and Administration: The DGR Project will result in increased municipal revenue because of payments of property taxes and other payments. The DGR Project will also contribute to municipal revenues through positive economic and population growth.
- Other Financial Assets (Income): The DGR Project will increase labour income through direct, indirect and induced employment in the Local and Regional Study Areas.

Table 7.10.2-3: Summary of Effects Prediction and Assessment for Socio-economic Environment

Project Work and Activity	Population and Demographics	Other Human Assets	Employment	Business Activity
Direct Effects				
Site Preparation		■		
Construction of Surface Facilities		■		
Excavation and Construction of Underground Facilities		■		
Above-ground Transfer of Waste		■		
Underground Transfer of Waste		■		
Decommissioning of the DGR Project		■		
Abandonment of DGR Facility				
Presence of the DGR Project	■			
Waste Management				■
Support and Monitoring of DGR Life Cycle				
Workers, Payroll and Purchasing	+	■	+	+
Indirect Effects				
Changes in Air Quality		■		•
Changes in Noise Levels		■		•
Changes in Surface Water Quantity and Flow				
Changes in Surface Water Quality				
Changes in Soil Quality				
Changes in Groundwater Quality				
Changes in Groundwater Flow				
Changes in Aquatic and Terrestrial Environment				
Changes in Radiation and Radioactivity	■	■	■	■

Notes:
The matrices are meant to indicate when the activity occurs and do not imply how long the effect will last.
Blank No potential interaction

- • Potential project-environment interaction
- ■ Measurable change
- ◆ Residual adverse effect
- \+ Beneficial effect

Table 7.10.2-3: Summary of Effects Prediction and Assessment for Socio-economic Environment (continued)

Project Work and Activity	Tourism	Residential Property Values	Municipal Finance and Administration	Other Financial Assets
Direct Effects				
Site Preparation				■
Construction of Surface Facilities				■
Excavation and Construction of Underground Facilities				■
Above-ground Transfer of Waste				■
Underground Transfer of Waste				■
Decommissioning of the DGR Project				■
Abandonment of DGR Facility*				
Presence of the DGR Project	■	■	+	
Waste Management			■	
Support and Monitoring of DGR Life Cycle				
Workers, Payroll and Purchasing	■	■	+	+
Indirect Effects				
Changes in Air Quality	■	■		•
Changes in Noise Levels	■	■		•
Changes in Surface Water Quantity and Flow	•	•		•
Changes in Surface Water Quality	•	•		•
Changes in Soil Quality				
Changes in Groundwater Quality	•	•		•
Changes in Groundwater Flow	•	•		•
Changes in Aquatic and Terrestrial Environment	•			•
Changes in Radiation and Radioactivity	■	■	■	■

Notes:
The matrices are meant to indicate when the activity occurs and do not imply how long the effect will last.
Blank No potential interaction

- • Potential project-environment interaction
- ■ Measurable change
- ◆ Residual adverse effect
- \+ Beneficial effect

Table 7.10.2-3: Summary of Effects Prediction and Assessment for Socio-economic Environment (continued)

Project Work and Activity	Housing	Municipal Infrastructure and Services	Other Physical Assets	Inverhuron Provincial Park	Other Social Assets
Direct Effects					
Site Preparation			■		■
Construction of Surface Facilities			■		
Excavation and Construction of Underground Facilities			■		
Above-ground Transfer of Waste					
Underground Transfer of Waste					
Decommissioning of the DGR Project			■		■
Abandonment of DGR Facility					
Presence of the DGR Project	■		■	■	■
Waste Management		■	■		
Support and Monitoring of DGR Life Cycle					
Workers, Payroll and Purchasing	■	■	■	■	■
Indirect Effects					
Changes in Air Quality			■	■	■
Changes in Noise Levels			■	■	◆
Changes in Surface Water Quantity and Flow		•	•	•	•
Changes in Surface Water Quality		•	•	•	•
Changes in Soil Quality					
Changes in Groundwater Quality		•	•		•
Changes in Groundwater Flow		•	•		•
Changes in Aquatic and Terrestrial Environment				•	•
Changes in Radiation and Radioactivity	■	■	■	■	■

Notes:
The matrices are meant to indicate when the activity occurs and do not imply how long the effect will last.
Blank No potential interaction

• Potential project-environment interaction
■ Measurable change
◆ Residual adverse effect
\+ Beneficial effect

7.10.3 Significance of Residual Adverse Effects

The criteria used for judging and describing the significance of effects are shown in Table 7.1-1, combined with the magnitude criteria applicable to the socio-economic environment, shown in Table 7.10.3-1.

Table 7.10.3-1: Effects Magnitude Levels for the Socio-economic Environment

VEC	Magnitude Level Definition		
	Low	**Medium**	**High**
Other Social Assets	Effect on a community asset is evident only when compared to existing conditions and there is not likely to be a change in the community asset's contribution to overall community well-being	Effect on a community asset is evident only when compared to existing conditions, and there is likely to be a measurable change in the community asset's contribution to overall community well-being but a measurable change in overall community well-being is not likely	Effect on a community asset is clearly evident and the effect will result in a measurable change in overall community well-being

The level of significance is assigned to residual adverse effects by using professional judgement to combine the magnitude, geographic extent, timing and duration, frequency, degree of irreversibility and social/ecological context. For example, a residual adverse effect would be considered to be significant if it has a high magnitude, high irreversibility and a high value to society or the environment.

One residual adverse effect of the DGR Project on the Other Social Assets VECs was identified:

- Increases in noise levels during site preparation and construction will be approximately 5 dBa, which is a noticeable level of change. This level can also be expected during the decommissioning phase of the DGR Project. This change may reduce use and enjoyment of private property in the Baie du Doré area, in close proximity to the Bruce nuclear site.

The overall assessment of the residual adverse effect on the use and enjoyment of private property during site preparation and construction, and decommissioning, found that this effect is not significant (Table 7.10.3-2).

Table 7.10.3-2: Summary of Residual Adverse Effects and Significance Levels for the Socio-economic Environment

Residual Adverse Effect	Magnitude	Geographic Extent	Timing and Duration	Frequency	Degree of Irreversibility	Overall Assessment
Effects of increased noise levels on the enjoyment of private property (Other Social Assets VEC)	**Low** • There is not likely to be a measurable change in the community asset • There is no change to the overall community well-being	**Low** • Effect is limited to a small portion of the Local Study Area	**Low** • Effect occurs during the site preparation and construction phase and the decommissioning phase	**Medium** • The effect occurs at regular, although infrequent intervals	**Medium** • Effect is reversible with time	**Not significant**

7.11 HUMAN HEALTH

The following VECs have been selected for the assessment of human health:

- overall health of local residents;
- overall health of members of Aboriginal communities;
- overall health of seasonal users; and
- health of workers.

Effects on the overall health VECs are predicted by considering potential effects of the DGR Project on each of the determinants (physical environment, socio-economic, cultural and emotional). Therefore, predictions for each of the determinants are presented first, followed by the VECs. Consistent with accepted EA practice, quantitative and qualitative methods, including professional expertise and judgement, are used to predict and describe the DGR Project-specific effects to allow for a detailed assessment.

The existing environmental features are described in Section 6.11 and the Appendix C of this EIS.

7.11.1 Effects on the Determinants

7.11.1.1 Physical Environmental Determinants

Changes in Air Quality

The effects of changes in air quality on human health were evaluated based on quantitative exposure modelling at six receptor locations, discussed in Section 6.11. Human health exposures were calculated using modelled concentrations determined by air dispersion modelling (air modelling methods are described in the Atmospheric Environment TSD).

The incremental lifetime cancer risk (ILCR) was calculated using dispersion model predictions from the Atmospheric Environment TSD and Human Health Risk Assessment (HHRA) methods presented in Appendix C. The resulting ILCR values are well below the target risk value of one in a million for all of the receptor groups.

In addition, the hazard quotient (HQ) values were calculated for both the site preparation and construction, and operations phases using dispersion modelling results from the Atmospheric Environment TSD and HHRA methods presented in Appendix C. Only one of the target compounds (acrolein) had an HQ value in excess of the desired target (i.e., 1.0) for the local resident and member of the Aboriginal community. All of the remaining target compounds had HQ values that were considerably lower than the relevant targets of either 1.0 for volatile and inert compounds, or 0.2 for semi-volatile compounds and metals, at identified receptor locations.

Acrolein exposures are driven by existing concentrations (see Section 6.11). During the site preparation and construction phase, HQ values increased for all three of the local resident receptors and one of the Aboriginal community receptors (AR5, as shown in Figure 6.11.4-1). None of the HQ values change during the operations phase.

Changes in Noise Levels

The effects of changes in noise levels on human health were evaluated based on quantitative modelling (described in Appendix J of the Atmospheric Environment TSD) and prediction of noise estimates at three receptor locations (shown on Figure 6.11.4-1):

- NR1 – located on Albert Road adjacent to Inverhuron Provincial Park;
- NR2 – located across Baie du Doré from Bruce A; and
- NR3 – located within Inverhuron Park at an existing camp site.

The percentage of the exposed population that could be "highly annoyed" by increased noise levels caused by the DGR Project is calculated as the %HA. Table 7.11.1-1 presents the %HA for the site preparation and construction, and operations phase relative to existing conditions. As shown, all project-related changes are less than 6.5% (i.e., no adverse effects).

Table 7.11.1-1: Noise Level Predictions at Human Health Receptors (%HA)

Receptor	Ambient %HA	Existing %HA	Project-related Change Relative to Existing (%)	%HA Threshold [a]	Likely Adverse Effect?
Site Preparation and Construction Phase					
NR1 – Albert Road	1.6	1.5	0.1	6.5	no adverse effect
NR2 – Baie du Doré	2.6	2.1	0.5	6.5	no adverse effect
NR3 – Inverhuron Provincial Park	2.2	2.1	0.1	6.5	no adverse effect
Operations Phase					
NR1 – Albert Road	6.0	1.5	4.5	6.5	no adverse effect
NR2 – Baie du Doré	8.3	2.1	6.2	6.5	no adverse effect
NR3 – Inverhuron Provincial Park	7.7	2.1	5.6	6.5	no adverse effect

Note:
a The %HA threshold is applied to the project-related change relative to existing conditions

Health Canada also recommends a consideration of impulse noises using the specific impact (HCII), or impulse noise indicator. Table 7.11.1-2 summarizes the predicted HCII levels from the DGR Project. As shown the predicted HCII levels are all expected to be less than 75 dBA (i.e., no adverse effects).

Table 7.11.1-2: Noise Level Predictions at Human Health Receptors (HCII)

Receptor	Ambient HCII (dBA)	Existing HCII (dBA)	HCII Threshold (dBA)	Likely Adverse Effect?
Site Preparation and Construction Phase				
NR1 – Albert Road	48	47	75	no adverse effect
NR2 – Baie du Doré	51	50	75	no adverse effect
NR3 – Inverhuron Provincial Park	50	50	75	no adverse effect
Operations Phase				
NR1 – Albert Road	58	47	75	no adverse effect
NR2 – Baie du Doré	61	50	75	no adverse effect
NR3 – Inverhuron Provincial Park	60	50	75	no adverse effect

Noise levels during the decommissioning and abandonment and long-term performance phases will be equal or less than those during the site preparation and construction phase. Therefore, adverse effects to human health from changes in noise levels are not likely during any of the phases of the DGR Project.

Changes in Surface Water Quality, Soil Quality and Groundwater Quality

There are no likely adverse effects identified on surface water quality, soil quality or groundwater quality. Accordingly, further consideration of these interactions with human health is not warranted.

Changes in Human Exposures to Radiation

As described in Section 7.6, there are no likely adverse effects from the DGR Project on human exposure to radiation. The total dose to the public is well below the 1 mSv/a regulatory limit and below the OPG dose target of 0.01 mSv/a set for the facility. The dose to the public will further decrease after the above ground radioactive waste inventories are disposed of in the emplacement rooms, which will then be progressively closed during operations and when the DGR is ultimately sealed. Therefore, adverse effects to human health from exposure to radiation are not likely.

Country Foods

The calculated HQs/ILCRs discussed above are totals from all pathways (i.e., they consider ingestion of chemicals emitted by the DGR Project via home-grown vegetables). The ingestion rates considered in calculations are provided in Appendix C. Exposure from consumption of fish and wild game is not included because changes in concentrations target compounds in fish and game from the DGR Project would not be measurable (as discussed in the Aquatic Environment and Terrestrial Environment TSDs).

7.11.1.2 Socio-economic Determinants

As discussed in Appendix C, Section C3.3, no residual adverse effects on socio-economic determinants are anticipated as a result of the DGR Project. Various positive effects were identified as a result of increased income, employment, education opportunities and improved well-being in the community (Section 7.10.2).

7.11.1.3 Cultural Determinants

The DGR Project has the potential to disrupt cultural activities conducted at community facilities near the Bruce nuclear site. However, as discussed in the socio-economic assessment (Section 7.10.2.13), it is not expected that any cultural site will experience nuisance disruption. As described in Section 7.9, although Aboriginal culturally sensitive areas are identified in the Site Study Area, the DGR Project is not expected to affect any of these sites.

There are no residual adverse effects to health attributed to changes in access to cultural sites as result of the DGR Project. No residual adverse effects to cultural determinants of Aboriginal health were identified as a result of the DGR Project.

7.11.1.4 Emotional Determinants

Emotional determinants may be affected by changes in community cohesion. Based on the results of public attitude research (Section 7.10.2.13), residents in the Local Study Area consider the fact that the area has a small town community with friendly people as positive influences on community cohesion. The DGR Project is not likely to become a divisive issue among Local Study Area residents. No residual adverse effects to human health are identified as a result of changes to emotional determinants as a result of the DGR Project.

7.11.2 Effects on Overall Health for Local Residents

7.11.2.1 Likely Effects

The overall health of local residents is determined by combining the physical environment, socio-economic factors, cultural factors and emotional determinants for local resident receptors in the Local Study Area. As discussed in the preceding sections, a potential adverse effect (i.e., a non-trivial change from existing conditions) to the health of a local resident is identified because of potential exposure to acrolein in air as a result of the DGR Project during the site preparation and construction phase. No adverse effects are identified for local residents for cultural, socio-economic and emotional health determinants. Conservatively, it has been assumed that the adverse effect for this one determinant warrants the identification of an adverse effect on overall health for local residents.

7.11.2.2 Mitigation Measures

As described above, the predicted air quality concentrations include a number of in-design mitigation measures considered integral to the project design (see Section 7.7.2). No additional mitigation measures are feasible.

7.11.2.3 Residual Adverse Effects

A residual adverse effect to the overall health of the local resident attributed to potential exposure to acrolein in air is identified during the site preparation and construction phase of the DGR Project. This residual adverse effect is advanced for an evaluation of significance.

7.11.3 Effects on Overall Health for Members of Aboriginal Communities

7.11.3.1 Likely Effects

The overall health of the member of an Aboriginal community is determined by combining the physical environment, socio-economic factors, cultural factors and emotional determinants for member of Aboriginal community receptors. As discussed in the preceding sections, a potential adverse effect (i.e., a non-trivial change from existing conditions) to the health of the members of the Aboriginal communities because of potential exposure to acrolein in air is identified as a result of the DGR Project during site preparation and construction phase. No adverse effects are identified for Aboriginal residents for cultural, socio-economic and emotional health determinants. Conservatively, it has been assumed that the adverse effect for this one determinant warrants the identification of an adverse effect on overall health for a member of the Aboriginal community.

7.11.3.2 Mitigation Measures

As described above, the predicted air quality concentrations include a number of in-design mitigation measures considered integral to the project design (see Section 7.7.2.2). No additional mitigation measures are feasible.

7.11.3.3 Residual Adverse Effects

A residual adverse effect to the overall health of members of Aboriginal communities as a result of changes in air quality (i.e., acrolein concentrations) is identified during the site preparation and construction phase. The residual adverse effect is advanced for an evaluation of significance.

7.11.4 Effects on Overall Health for Seasonal Users

7.11.4.1 Likely Effects

The overall health of the seasonal users is evaluated by changes in the physical environment, socio-economic, cultural and emotional determinants of health. As discussed in the preceding sections, no adverse effects for any of the determinants are likely at the seasonal user receptors. Therefore, no adverse effects are likely on overall health of seasonal users.

7.11.4.2 Mitigation Measures

No adverse effects on the overall health of seasonal users are anticipated as a result of the DGR Project. Accordingly, no mitigation measure is identified.

7.11.4.3 Residual Adverse Effects

No residual adverse effects to the overall health of seasonal users are likely as a result of the DGR Project.

7.11.5 Effects on Health of Workers

7.11.5.1 Likely Effects

The health of workers is evaluated by the magnitude of radiological exposures and the potential health and safety consequence(s) caused by exposure to non-radiological hazards. An adverse effect on overall health is considered likely if, in the case of radiological exposures, the dose exceeds the occupational exposure dose target or in the case of non-radiological hazards, the effect (or potential consequence) has a potential adverse health outcome.

As discussed in Section 7.6, the radiation doses to workers from the normal operation of the DGR Project are expected to be much lower than OPG's occupational dose target of 10 mSv/a for workers [387].

The assessment on non-radiological hazards was conducted systematically using a Screening Process Hazard Analysis method combined with a Job Hazard Analysis approach [419]. Hazards were identified based on the activities that would normally be expected for the various phases of the DGR Project. Possible outcomes that may result from potential hazards are recorded on worksheets and may include personal injury, death, property damage, or loss of critical safety function for example. These outcomes provide a basis for establishing priorities related to mitigation and control measures and recommendations; they assist in determining the safety significance of the hazards associated with certain activities. The health of workers is evaluated by the potential health and safety consequence(s) caused by exposure to non-radiological hazards.

7.11.5.2 Mitigation Measures

Section 7.6 and Radiation and Radioactivity TSD, describes the mitigation measures that have been developed during the design of the DGR Project and its associated infrastructure (e.g., the WPRB), to minimize the radiological effects on workers. Hazardous activities or conditions on the DGR Project site have potential consequences and potential outcomes that can adversely affect human health. For each hazardous activity or condition, control/mitigation measures are recommended, as shown in Appendix C (Tables C3.9.1-1 and C3.9.1-2).

7.11.5.3 Residual Adverse Effects

The assessment, as described in Appendix C, Section C3.9, identified no residual adverse effects to the health of workers as a result of the DGR Project. The controls and mitigation measures are expected provide adequate control to protect the health of workers.

7.11.6 Significance of Residual Adverse Effects

The criteria used for judging and describing the significance of effects are shown in Table 7.1-1. The magnitude criteria applicable to the residual adverse effects identified are shown in Table 7.11.6-1.

Table 7.11.6-1: Effects Levels for Assigning Magnitude for Human Health VECs

VEC	Measure	Effects Level Definition		
		Low	Medium	High
Overall Health VECs	HQ (non-carcinogenic compounds – single exposure pathway)	>1 and ≤10	>10 and ≤20	>20

The level of significance is assigned to residual adverse effects by using professional judgement to combine the magnitude, geographic extent, timing and duration, frequency, and degree of irreversibility. For example, a residual adverse effect would be considered to be significant if it has a high magnitude, high irreversibility and a high value to society or the environment.

Residual adverse effects on the overall health of local residents and member of Aboriginal communities VECs were identified as a result of changes in air quality (i.e., acrolein concentrations). Residual adverse effects are discussed with reference to the overall health of receptors. The potential exposure to acrolein is not significant for these VECs. The summary of assessment of significance for human health VECs is provided in Table 7.11.6-2.

Table 7.11.6-2: Summary of Residual Adverse Effects and Significance Levels for Human Health

Residual Adverse Effect	Magnitude	Geographic Extent	Timing and Duration	Frequency	Degree of Irreversibility	Overall Assessment
Effect of acrolein exposure on overall health of local residents	**Low** • HQ >1 and <10 at receptor locations	**Medium** • Effect is limited to the Local Study Area	**Low** • Effect occurs during site preparation and construction phase	**Medium** • Conditions or phenomena causing the effect occur at regular, although infrequent intervals (i.e., several times per month).	**Low** • Effect is readily (i.e., immediately) reversible when the exposure ceases	**Not significant**
Effect of acrolein exposure on overall health of members of Aboriginal communities	**Low** • HQ >1 and <10 at receptor locations	**Medium** • Effect is limited to the Local Study Area	**Low** • Effect occurs during site preparation and construction phase	**Low** • Conditions or phenomena causing the effect occur at infrequent intervals (i.e., once per year).	**Low** • Effect is readily (i.e., immediately) reversible when the exposure ceases	**Not significant**

7.12 ECOLOGICAL FEATURES

The following ecological feature VECs are identified for the assessment of combined effects resulting from the DGR Project:

- Lake Huron;
- Stream C;
- South Railway Ditch; and
- wetland within the Project Area.

The sections below summarize the assessment of effects on each of the ecological feature VECs. The following steps are followed for the assessment of ecological feature VECs:

- indicator VECs for the ecological feature VEC are identified;
- indicator VECs are screened and passed on for further assessment of combined effects if a residual adverse effect was identified for the indicator VEC;
- the combined effect on the ecological feature is assessed using the adverse effects identified for indicator VECs; and
- if a residual adverse effect is identified for the ecological feature VEC, mitigation measures are proposed and the effect is assessed further to determine significance.

The assessment of ecological feature VECs considers both the non-radiological and radiological effects.

7.12.1 Lake Huron

7.12.1.1 Identification of Indicator VECs

Within Lake Huron, near the Bruce nuclear site there are two main habitats, the nearshore and offshore. The nearshore habitat consists mainly of rocky areas, which are exposed to the wind and wave action of the Lake Huron shoreline (e.g., MacPherson Bay), and sheltered bays such as the Baie du Doré, which provides a more constant environment, protected from wave and current action. Baie du Doré is recognized as a Provincially Significant Wetland. Offshore habitat consists of the deep, cool, open waters of Lake Huron.

The following terrestrial species VECs can be found using the shoreline habitat of Lake Huron:

- mallard;
- bald eagle;
- midland painted turtle; and
- northern leopard frog.

The following aquatic species VECs can be found in the nearshore and offshore Lake Huron habitats:

- smallmouth bass;

- spottail shiner;
- lake whitefish; and
- benthic invertebrates.

Municipal, commercial and recreational uses of Lake Huron in the vicinity of the Bruce nuclear site include drinking water intakes, disposal of treated municipal waste water, parks, Aboriginal reserve lands, commercial and recreation fishing, recreational boating, and swimming. Many communities along the shoreline obtain their drinking water from Lake Huron. Closest to the Bruce nuclear site, the towns of Southampton and Kincardine have municipal water supply plants that obtain water from Lake Huron. The Lake Huron water quality is assessed through consideration of the surface water quality VEC, overburden groundwater quality VEC and shallow bedrock groundwater quality VEC.

The effects to recreational uses of Lake Huron are considered through the tourism VEC. The Saugeen Ojibway Nation operates a commercial whitefish fishery on Lake Huron. The potential effect to the commercial whitefish fishery on Lake Huron is considered through the traditional use of land and resources VEC.

Radiological effects on Lake Huron are considered through exposures to humans (members of the public), benthic invertebrates, aquatic vegetation, benthic fish, pelagic fish, aquatic birds and aquatic mammals.

7.12.1.2 Screening to Focus the Assessment

Figure 7.12.1-1 illustrates the Lake Huron indicator VECs, as identified above, and provides cross-references to where each indicator VEC is individually assessed. The figure also shows whether the indicator VECs were assessed to have a measurable change or residual adverse effect as a result of the DGR Project, as summarized below.

Although measurable changes resulting from changes in air quality, noise levels, light levels and surface water quantity and flow were identified for mallard, midland painted turtle and northern leopard frog, no residual adverse effects were identified for these VECs (see Section 7.4.2). Measurable changes resulting from changes in air quality and light levels were also identified for bald eagle, but were assessed to result in no residual adverse effects (see Section 7.4.2). Therefore, terrestrial species VECs identified for Lake Huron are not forwarded for assessment.

No measurable changes or residual adverse effects were identified for any of the Lake Huron aquatic species indicator VECs. Therefore, the aquatic species indicator VECs are not considered further in the assessment.

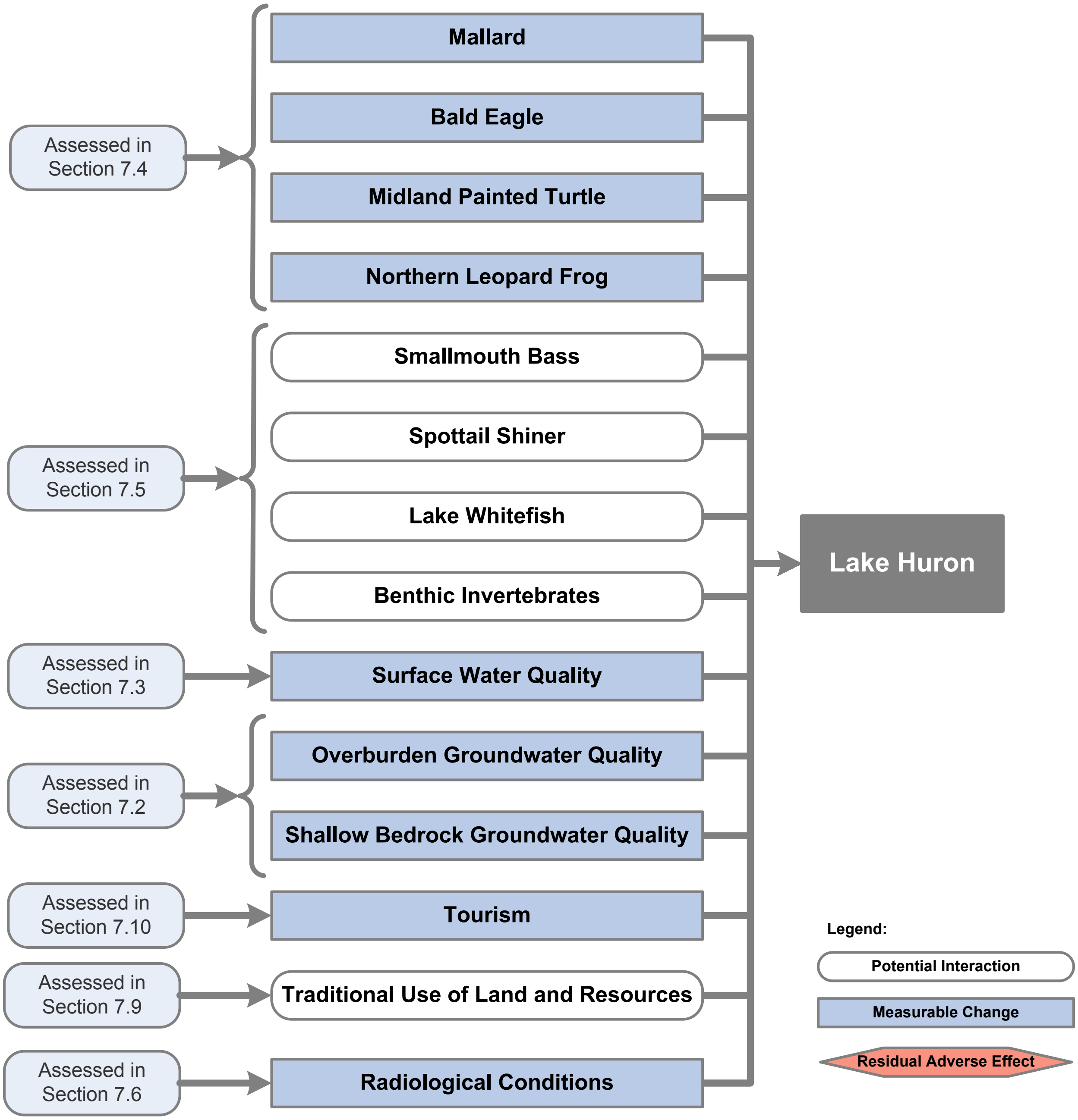


Figure 7.12.1-1: Components and Interactions for Lake Huron VEC

Measurable changes were identified to surface water quality, overburden groundwater quality, shallow bedrock groundwater quality and tourism, but did not result in residual adverse effects. Although a residual adverse effect on benthic invertebrates was identified in Section 7.5.2, the residual adverse effect is limited to the population in the Project Area. Therefore, only a potential interaction is identified for the benthic invertebrate population that inhabits Lake Huron. The assessment of surface water quality considers surface water quality on-site and to Lake

Huron, the eventual receiving body of the site discharge. Since no residual adverse effects were identified to surface water quality on-site, no effects are expected for Lake Huron (Section 7.3.2.2). The measurable changes in overburden groundwater quality and shallow bedrock groundwater quality are not expected to result in adverse effects (Section 7.2.2). The groundwater quality at recharge points in Lake Huron is therefore not expected to be affected as a result of the DGR Project during site preparation and construction, operations or decommissioning phases. Therefore, these indicator VECs are not forwarded for assessment of combined effects on Lake Huron.

No residual adverse effects were identified for the traditional use of land and resources VEC (Section 7.9.2.3). No adverse effects were identified in relation to the Aboriginal rights in Lake Huron. Therefore, these VECs are not forwarded for assessment of combined effects on Lake Huron.

Measurable changes were identified for radiation exposures to humans (members of the public), benthic invertebrates, aquatic vegetation, benthic fish, pelagic fish, aquatic birds and aquatic mammals. No residual adverse effects were identified for any of the exposures (Section 7.6.2). Therefore, the radiation exposures are not forwarded for further assessment of combined effects on Lake Huron.

7.12.1.3 Assessment of Effects

The screening identified no residual adverse effects associated with any of the indicator VECs. Therefore, no combined effects are expected for the Lake Huron VEC.

7.12.2 Stream C

7.12.2.1 Identification of Indicator VECs

Stream C is located to the east, outside of the DGR Project site (as shown on Figure 6.5.3-1). It is a former tributary of the Little Sauble River that was diverted to Baie du Doré during the initial development of the Bruce nuclear site in the 1960s. It is the largest stream entering Baie du Doré. Stream C is designated by Fisheries and Oceans Canada (DFO) as coldwater fish habitat. The following aquatic species VECs can be found in the Stream C:

- redbelly dace;
- brook trout;
- creek chub;
- spottail shiner; and
- benthic invertebrates.

The following terrestrial species VECs can be found in the Stream C:

- common cattail;
- midland painted turtle; and
- northern leopard frog.

As a waterbody on-site, changes in the surface water quality VEC and surface water quantity and flow VEC are also considered an important part of Stream C.

Radiological effects to Stream C are considered through exposures to terrestrial vegetation, aquatic mammals, amphibians and reptiles, aquatic vegetation, benthic fish and benthic invertebrates.

7.12.2.2 Screening to Focus the Assessment

Figure 7.12.2-1 illustrates Stream C indicator VECs, as identified above, and provides cross-references to where each indicator VEC is assessed. The figure also shows whether the indicator VECs were individually assessed to have a measurable change or residual adverse effect as a result of the DGR Project, as summarized below.

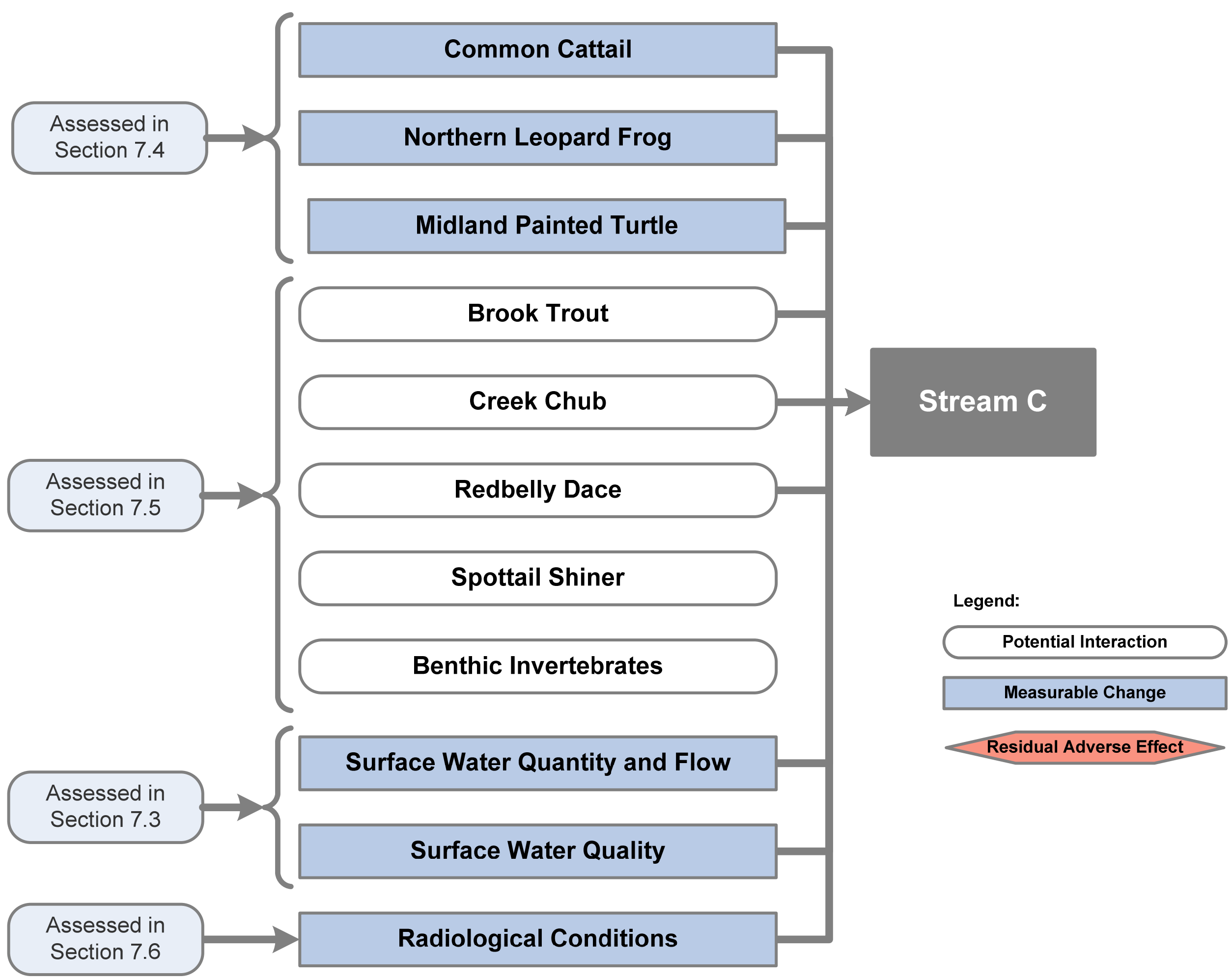


Figure 7.12.2-1: Components and Interactions for the Stream C VEC

Residual adverse effects were identified for creek chub, redbelly dace and benthic invertebrates. However, these effects were only identified for the VECs in the South Railway Ditch. These VECs were not affected in Stream C. No measurable change or adverse effects have been identified for brook trout and spottail shiner (Section 7.5.2). Therefore, no adverse effects are identified for the aquatic species VECs in Stream C.

Although measurable changes resulting from changes in air quality, noise levels, light levels and surface water quantity and flow were identified for the midland painted turtle and northern leopard frog, no residual adverse effects were identified for these VECs. Measurable changes resulting from changes in air quality and surface water quantity and flow were also identified for common cattail, but were assessed to result in no residual adverse effects (Section 7.4.2). Therefore, terrestrial species VECs identified for Stream C are not forwarded for assessment.

A measurable change was identified for surface water quantity and flow in the Stream C as a result of the diversion of runoff from a small area of the DGR Project site. However, the assessment did not identify a residual adverse effect for surface water quantity and flow in Stream C (Section 7.3.2.1, Table 7.3.2-1). Therefore, surface water quantity and flow is not advanced for assessment of combined effects on the Stream C.

There are no direct releases from the DGR Project to Stream C or the tributaries that feed it. However, measurable changes in surface water quality were identified due to the deposition of airborne compounds on Stream C and its catchment area. Although measurable changes were identified for surface water quality, no residual adverse effects were identified (Section 7.3.2.2). Therefore, the surface water quality VEC is not advanced for assessment.

Measurable changes were identified for radiation exposures to terrestrial vegetation, aquatic mammals, amphibians and reptiles, aquatic vegetation, benthic fish and benthic invertebrates. No residual adverse effects were identified for any of the exposures (Section 7.6.2). Therefore, the radiation exposures are not forwarded for assessment of combined effects on the Stream C.

7.12.2.3 Assessment of Effects

The screening identified no residual adverse effects associated with any of the indicator VECs. Furthermore, the drainage diversion from Stream C was done to avoid the discharge of potentially contaminated stormwater into the more sensitive coldwater habitat of the Stream C watershed and to ensure the treatment of all the drainage from the DGR Project in a stormwater management pond, prior to discharge to ditches that lead to MacPherson Bay. No releases from the site will be directed to the North Railway Ditch or the Stream C watershed. Therefore, no combined effects are expected for the Stream C VEC.

7.12.3 South Railway Ditch

7.12.3.1 Identification of Indicator VECs

Drainage in the Project Area is carried through a ditch to Lake Huron via MacPherson Bay; however, a portion of the Project Area currently drains to Baie du Doré via the Railway Ditch on the north side of the abandoned rail bed (North Railway Ditch) and Stream C (as shown on

Figure 6.5.3-1). There is another railway ditch on the south side of the old rail bed (South Railway Ditch) that is situated within the Project Area but drains the WWMF site. Both ditched channels along the abandoned rail bed traverse the Project Area from west to east, carrying drainage in an easterly direction, parallel to the abandoned rail bed and are referred to separately as the North Railway Ditch and the South Railway Ditch.

The assessment in this section focuses on the South Railway Ditch, since it is designated as fish habitat and previous studies by the Saugeen Valley Conservation Authority did not classify the North Railway Ditch as fish habitat [420]. The South Railway Ditch appears to be intermittent (certain sections are choked with cattail and do not contain water) with enough water contained in remnant pools during low flow periods to maintain fish habitat. It also provides suitable habitat for burrowing crayfish. The following aquatic species VECs can be found in the South Railway Ditch:

- redbelly dace;
- creek chub;
- burrowing crayfish;
- benthic invertebrates; and
- variable leaf pondweed.

The following terrestrial VECs can be found in the South Railway Ditch:

- common cattail;
- muskrat;
- midland painted turtle; and
- northern leopard frog.

As a waterbody on-site, changes in the surface water quality VEC and surface water quantity and flow VEC are also considered an important part of the South Railway Ditch.

Radiological effects to South Railway Ditch are considered through exposures to terrestrial vegetation, aquatic mammals, amphibians and reptiles, aquatic vegetation, benthic fish and benthic invertebrates.

7.12.3.2 Screening to Focus the Assessment

Figure 7.12.3-1 illustrates South Railway Ditch indicator VECs, as identified above, and provides cross-references to where each indicator VEC is assessed. The figure also shows whether the indicator VECs were individually assessed to have a measurable change or residual adverse effect as a result of the DGR Project, as summarized below.

Residual adverse effects were identified for redbelly dace, creek chub, burrowing crayfish, benthic invertebrates and variable leaf pondweed (Section 7.5.2). Therefore, these aquatic species VECs are advanced for further assessment of combined effects on the South Railway Ditch.

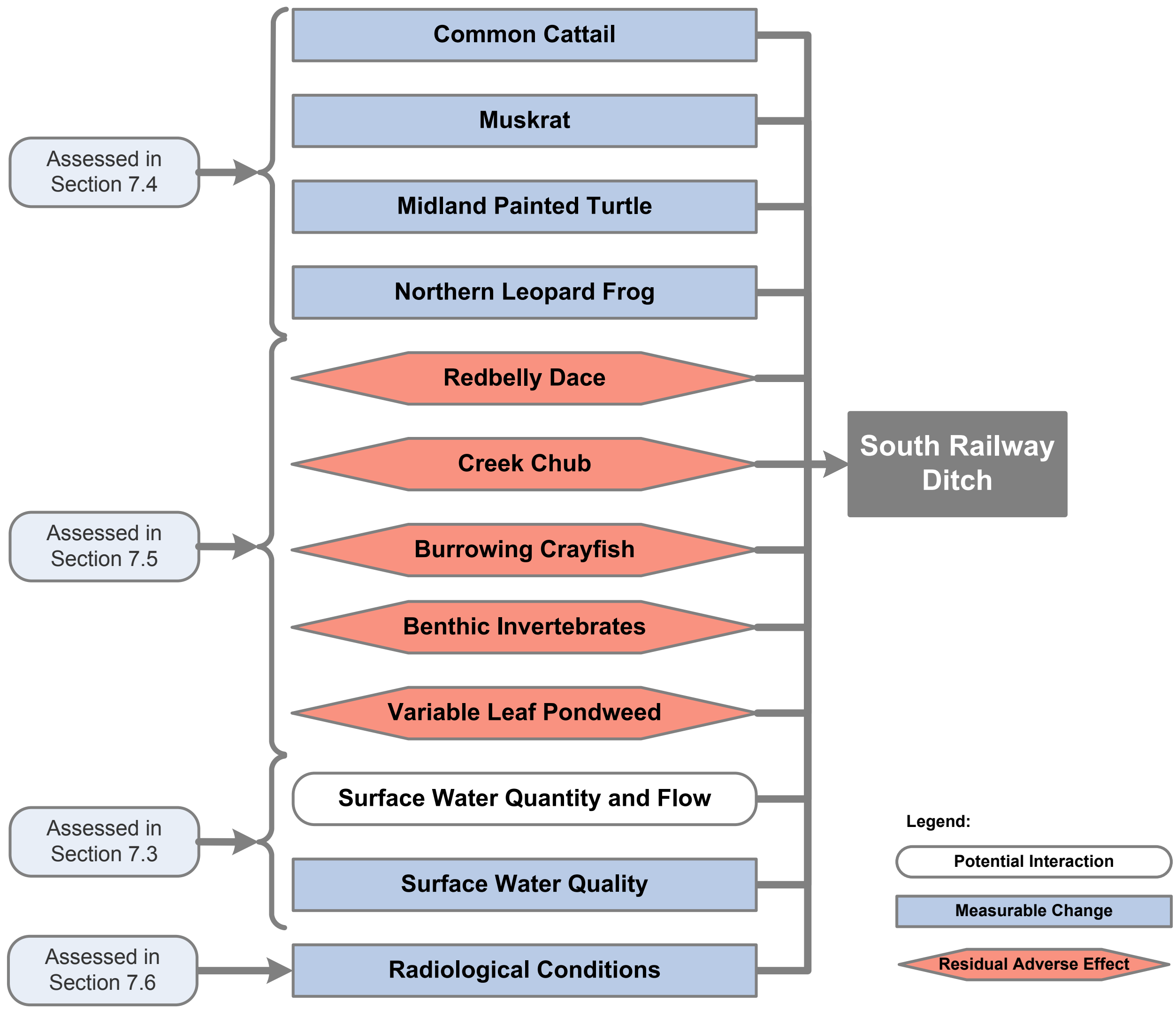


Figure 7.12.3-1: Components and Interactions for Railway Ditch VEC

Although measurable changes resulting from changes in air quality, noise levels, light levels and surface water quantity and flow were identified for muskrat, midland painted turtle and northern leopard frog, no residual adverse effects were identified for these VECs. Measurable changes resulting from changes in air quality and surface water quantity and flow were also identified for common cattail, but were assessed to result in no residual adverse effects (Section 7.4.2). Therefore, terrestrial species VECs identified for South Railway Ditch are not forwarded for assessment.

A residual adverse effect was identified for surface water quantity and flow in the North Railway Ditch (Section 7.3.2.1), but no changes in flow were identified for the South Railway Ditch. Therefore, surface water quantity and flow is not advanced for further assessment of combined effects on the South Railway Ditch.

Although measurable changes were identified for surface water quality, no residual adverse effects were identified (Section 7.3.2.2). In addition, there are no surface water discharges to the South Railway Ditch. Therefore, the surface water quality VEC is not advanced for further consideration.

Measurable changes were identified for radiation exposures to terrestrial vegetation, aquatic mammals, amphibians and reptiles, aquatic vegetation, benthic fish and benthic invertebrates. No residual adverse effects were identified for any of the exposures (Section 7.6.2). Therefore, the radiation exposures are not forwarded for assessment of combined effects on the South Railway Ditch.

7.12.3.3 Assessment of Effects

Residual adverse effects were identified for aquatic species VECs found in the South Railway Ditch. These VECs were assessed for combined effects on the South Railway Ditch VEC.

The construction of the abandoned rail bed crossing and the surface facilities will result in the loss of a small portion of burrowing crayfish habitat (approximately 20 m along the South Railway Ditch). This loss represents a small proportion of the burrowing crayfish habitat available within the Project Area. The site preparation and construction activities for the crossing will also result in the habitat loss in the South Railway Ditch for redbelly dace, creek chub and variable leaf pondweed. These changes in the habitat are in a localized area and limited to the 20 m section of the South Railway Ditch.

The construction of the crossing over the Railway Ditch is not likely to change the overall character of the ditch (i.e., it is compatible with surrounding land uses) and there is other suitable habitat available in the South Railway Ditch for the aquatic species that may be displaced. Therefore, no combined effects are identified for the South Railway Ditch as a result of the DGR Project.

7.12.4 Wetland within the Project Area

7.12.4.1 Identification of Indicator VECs

There are two wetland features within the Project Area. One of the communities is a seasonal swamp, covers approximately 3.1 ha and is located in the southeast portion of the Project Area. The other wetland community is a marsh, approximately 0.9 ha in size and is located in the northeast portion of the Project Area. These are shown on Figure 6.5.3-1. The seasonal swamp in the southeast portion of the Project Area is not expected to interact with the DGR Project. Therefore, this assessment focuses on the marsh in the northeast portion of the Project Area. Burrowing crayfish and benthic invertebrates (aquatic environment VECs) were observed in the marsh within the Project Area.

The following terrestrial species can be found in the marsh within the Project Area:

- eastern white cedar;
- common cattail;

- muskrat;
- midland painted turtle;
- northern leopard frog;
- mallard; and
- yellow warbler.

The water quality in the marsh is assessed through consideration of the overburden groundwater quality VEC and shallow bedrock groundwater quality VEC.

Radiological effects to marsh within the Project Area are considered through exposures to terrestrial vegetation, terrestrial birds, aquatic mammals, amphibians and reptiles, benthic fish and benthic invertebrates.

7.12.4.2 Screening to Focus the Assessment

Figure 7.12.4-1 illustrates the marsh within the Project Area indicator VECs, as identified above, and provides cross-references to where each indicator VEC is assessed. The figure also shows whether the indicator VECs were individually assessed to have a measurable change or residual adverse effect as a result of the DGR Project, as summarized below.

As the project avoids disturbance of marsh areas of the site, no measurable changes to the habitat of the burrowing crayfish and benthic invertebrates in the marsh are predicted from the DGR Project (Section 7.5.1). Therefore, burrowing crayfish and benthic invertebrates VECs are not forwarded for the assessment.

Although measurable changes were identified for common cattail, muskrat, midland painted turtle, northern leopard frog, mallard and yellow warbler, no residual adverse effects were identified for these VECs. Although a residual adverse effect was identified for eastern white cedar, the eastern white cedar within the marsh is not expected to be affected by the project as the marsh areas of the site will be avoided (Section 7.4.2). No vegetation in the marsh area will be cleared as a result of the project. Therefore, the terrestrial species VECs are not forwarded for the assessment.

The measurable changes in overburden groundwater quality and shallow bedrock groundwater quality are not expected to result in residual adverse effects (Section 7.2.2). Therefore, the groundwater quality at recharge points in the marsh is not expected to be affected as a result of the DGR Project during site preparation and construction, operations or decommissioning phases.

Measurable changes were identified for radiation exposures to terrestrial vegetation, terrestrial birds, aquatic mammals, amphibians and reptiles, benthic fish and benthic invertebrates (Section 7.6.2). No residual adverse effects were identified for any of the exposures. Therefore, the radiation exposures are not forwarded for assessment of combined effects on the wetland within the Project Area.

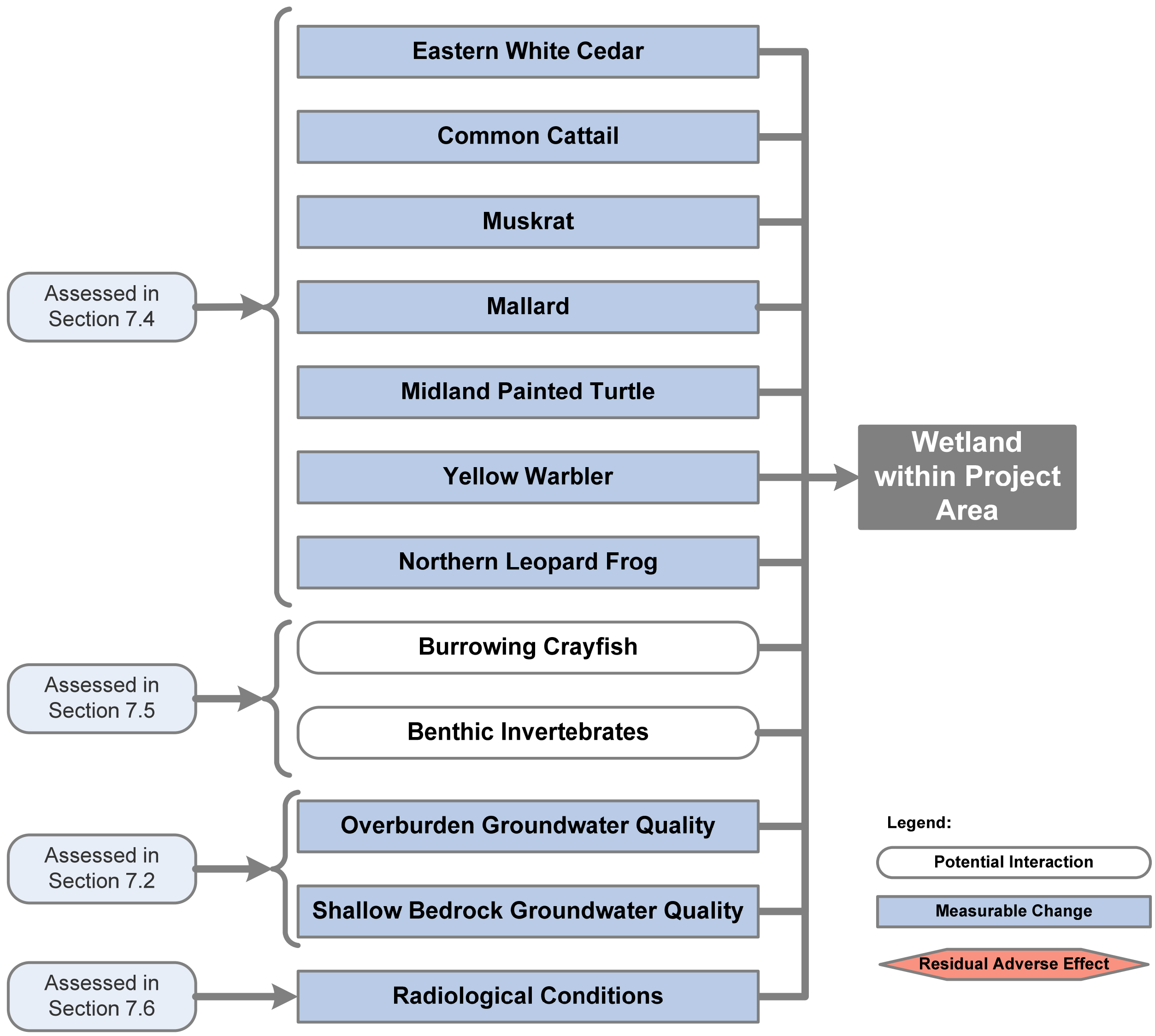


Figure 7.12.4-1: Components and Interactions for the Wetland within the Project Area VEC

7.12.4.3 Assessment of Effects

The screening identified no residual adverse effects associated with any of the indicator VECs. Therefore, no combined effects are expected for the wetland within the Project Area VEC.

7.13 EFFECTS OF THE ENVIRONMENT ON THE PROJECT

The EA must include a consideration of how the environment could adversely affect the DGR Project. This assessment was accomplished using the steps in Figure 7.13-1.

The following natural hazards have been identified to have a potential to affect the DGR Project:

- **seismic events**, described further in the Geology TSD, Geosynthesis [421] and Preliminary Safety Report [387];
- **coastal flooding**, described further in the Preliminary Safety Report [387] and probable maximum flood assessment [422];
- **surface flooding**, described further in the Preliminary Safety Report [387] and probable maximum flood assessment [422];
- **thunderstorms**, described further in the Atmospheric Environment TSD and the Preliminary Safety Report [387];
- **lightning**, described further in the Atmospheric Environment TSD and the Preliminary Safety Report [387];
- **hail storms**, described further in the Atmospheric Environment TSD and the Preliminary Safety Report [387];
- **tornadoes**, described further in the Atmospheric Environment TSD and the Preliminary Safety Report [387]; and
- **ice storms**, described further in the Atmospheric Environment TSD and the Preliminary Safety Report [387].

These hazards are described in further detail below and are assessed for their potential to affect DGR Project.

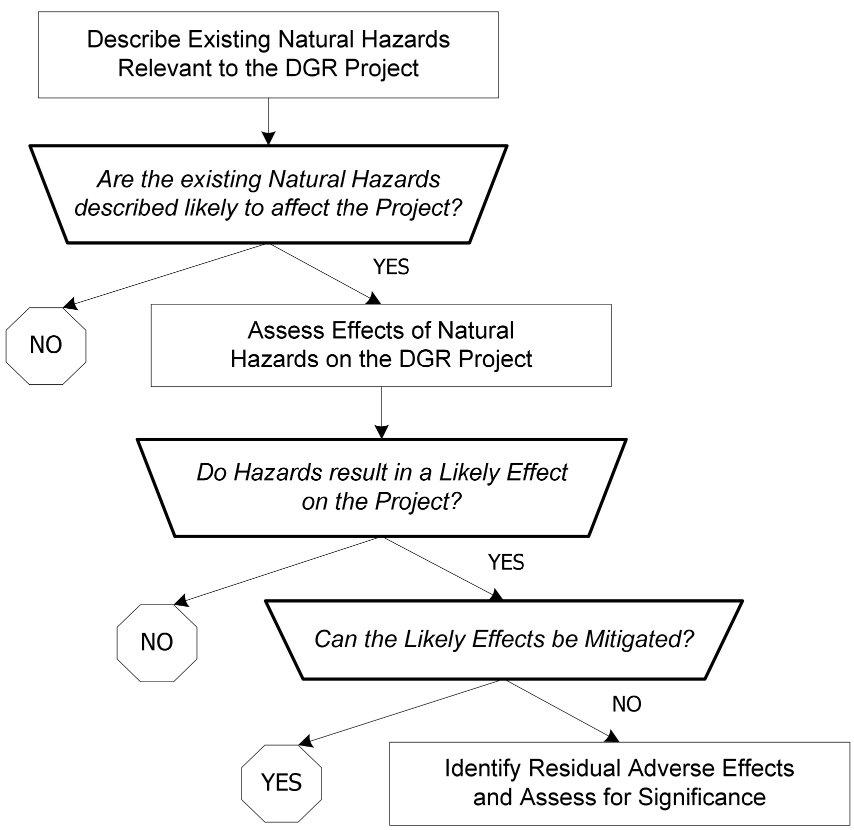


Figure 7.13-1: Method to Assess Effects of the Environment on the DGR Project

7.13.1 Seismic Events

The DGR is located at the Bruce nuclear site, which is within the tectonically stable interior of the North American continent and characterized by low rates of seismicity, as described in Section 6.2.10 and in the Geology TSD. For example, the historic seismicity record over 180 years shows recorded events have magnitudes that do not exceed M5 on the Richter scale [423].

All above-ground structures (access building, ventilation shaft headframe building and HVAC and mechanical building) and underground facilities (office, tunnel, emplacement room) will be constructed in accordance with the seismic requirements of the latest edition of the National Building Code at the time of the construction. Potential effects from seismicity are also addressed in the postclosure safety assessment and summarized in Section 9. In summary, it is unlikely that seismic activity could have an adverse effect on the DGR Project.

7.13.2 Coastal Flooding

The assessment for potential coastal flooding considered maximum lake water level, storm surge, seiche, wind wave and wave uprush that could affect the DGR operational area inland of the Lake Huron shoreline. Further information is provided in the Maximum Flood Hazard Assessment [422].

The 500-year maximum instantaneous Lake Huron water level is predicted to be 178.6 m IGLD [422]. In 80 years of record the maximum observed water-level was approximately 177.8 m IGLD in 1986. The planned elevation of the operation areas of the DGR Project site is expected to be approximately 186 masl. Thus the freeboard above static lake levels for extreme events is at least 7 m and the risk of coastal flooding of the DGR Project site as a result of high lake levels is extremely small.

The predicted maximum storm surge (of 1.3 m) resulting from a passing severe Alberta Clipper storm would likely last for time scales of minutes to one or several hours and would not affect the DGR Project site [422]. The wave flooding model (seiche and wind wave) showed significant wave height amounts of up to 6 m within 100 m from the shoreline. This translated into some 'wetting' of the northern tip of the DGR Project Area; however, maximum wave flooding would not affect the operational area of the DGR to the southwest with regards to the hydrology and surface water quality.

Maximum estimated elevation of wave uprushes is 180.5 m IGLD [422]. However, because of the location of the DGR facility approximately 1 km from the shoreline, the likelihood that the DGR Project Area will experience the wave run-ups is extremely low. Any water that would overtop existing near-shore perimeter works would temporarily collect on these works then eventually drain back to the lake.

Tsunamis are long period gravity waves generated by seismic disturbances of the sea bottom or shore, or landslides resulting in a sudden displacement of the water surface with the resulting wave energy spreading outwards across the ocean or lake at high speed. Tsunami occurrences in Canada are rare, with the Pacific coast at greatest risk due to the high occurrence of earthquake and landslide activity. No probable or definite tsunamis have been recorded for Lake Huron [422].

7.13.3 Surface Flooding

The assessment for potential surface flooding considered the maximum riverine flood hazard assessment and the assessment of flood hazard due to direct rainfall. Further information can be found in the Preliminary Safety Report [387].

In terms of the assessment of the maximum riverine flood hazard, two conclusions were derived for probable maximum flood (PMF) and probable maximum precipitation (PMP).

- The computed Little Sauble River PMF floodplain does not extend into the DGR Project site. Further, transfer of flood water from the Little Sauble River to Stream C during a PMP/PMF event is not anticipated given the topography that separates the watercourses.
- The computed Stream C PMF floodplain does not extend in to the DGR Project site. The spill area identified on the upstream side of the North Access Road flowing in the direction of Interconnecting Road is not anticipated to represent a flood risk to the DGR Project site as the spill elevation (approximately 181.3 m) at the spill discharge location is well below currently planned elevations of the operational areas of the DGR Project site (i.e., 186 m).

As a result, the riverine flood potential resulting from a PMP/PMF event will not impact the DGR Project site given currently planned elevations of the DGR operational areas and existing topography.

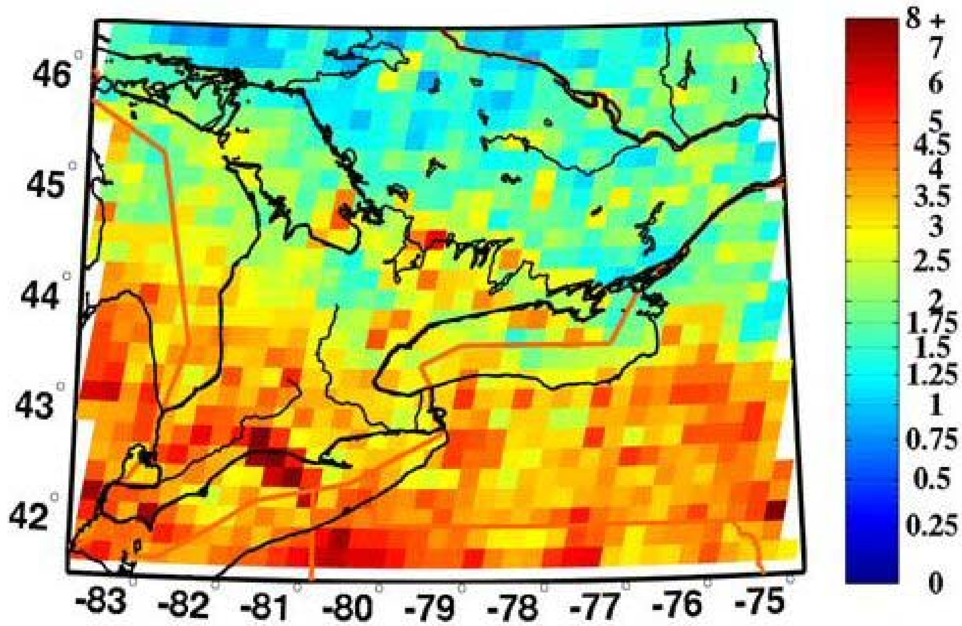
A PMP event occurring across the DGR Project site has the potential to generate flood levels in excess of the DGR Project site preliminary design elevation of 186 m. This flood risk is mitigated through engineered features.

7.13.4 Thunderstorms

Thunderstorms can damage external structures through high winds, heavy rain and lightning. The frequency of thunderstorm occurrence at the Bruce nuclear site is expected to be similar to that at Wiarton Airport, the location of the nearest meteorological station that records thunderstorms. For the period 1961 to 1990, Wiarton Airport averaged 28 thunderstorms per year [424]. However, the DGR Project will be designed to the National Building Code and the DGR Project shaft collar is designed to be above the PMF and PMP event (see Section 7.13.3). In addition, the majority of the project structures are located well below ground and would not be directly affected by severe weather events. Therefore, any thunderstorms that may occur in the vicinity of the DGR Project are not likely to affect the structural integrity of the main facilities and no further assessment is warranted. The effects of power failures that may result from thunderstorms are addressed in Section 8 (Malfunctions, Accidents and Malevolent Acts).

7.13.5 Lightning

As illustrated in Figure 7.13.5-1, extreme south-western Ontario shows a large area of lightning activity (3.0 to 5.0 flashes per square kilometre). A second maximum is located along a line from the southern tip of Georgian Bay to southeast of Barrie, also 2.5 to 4.5) flashes per square kilometre. The two highland areas in southern Ontario, Algonquin Park and the Dundalk Highlands experience lightning much less frequently than the low land areas surrounding them. The Bruce nuclear site had an average of 2.0 to 3.0 flashes per square kilometre for the period 1999 to 2008.



Source: [425]

Figure 7.13.5-1: Lightning Climatology 1998-2002 Southern Ontario (flashes per square kilometre)

The headframe, which is the tallest DGR Project structure will be designed with lightning protection, using technology that is will advanced in the mining industry. This technology is well advanced in the mining industry. The majority of the remaining project structures are located well below ground and would not be directly affected by severe weather events. Therefore, any lightning strikes that may occur in the vicinity of the DGR Project are not likely to affect the structural integrity of the main facilities and no further assessment is warranted. The effects of power failures and fires that could result from lightning storms are considered in Section 8 and the Malfunctions, Accidents and Malevolent Acts TSD.

7.13.6 Hail Storms

Hailstorms, associated exclusively with severe thunderstorms, are a warm season phenomena and typically occur between May and September. Hailstorms can damage external structures through high winds and the impact of falling hail. Currently, statistics on the frequency and prevalence of hail storms is not available. However, the OPG reports that there have been no occurrences of hail damage to the WWMF structures over the last 30 years.

The DGR Project is designed to the National Building Code to withstand severe weather events. In addition, the majority of the project structures are located well below ground and would not be directly affected by hail storm events. Therefore, any hail storms that may occur in the vicinity of the DGR Project are not likely to affect the structural integrity of the main facilities and no further assessment is warranted.

7.13.7 Tornadoes

Tornadoes have a random distribution and are extremely localized and only a few near-tornadoes or tornadoes are reported in southern Ontario each year and are not as intense or damaging as tornadoes in the United States south and west of the Great Lakes [426]. In the Regional Study Area, one to two tornadoes per 10,000 km^2 can be expected annually [426]. The majority of the DGR Project structures are located well below ground and would not be directly affected by tornado events. The headframes and surface structures are designed to the National Building Code and are designed for a 100-year design life. Therefore, any tornadoes that may occur in the vicinity of the DGR Project are not likely to affect the structural integrity of the main facilities and no further assessment is warranted. The effects of tornadoes on the integrity of the hoist have been considered in Section 8 (malfunctions, accidents and malevolent acts).

7.13.8 Ice Storms

Ice storms can damage light structures such as power transmission lines through the weight of accumulated ice. For the period of 1961 to 1990 freezing precipitation occurred nine days per year on average at Wiarton Airport [424]. In January 1998, a severe ice storm occurred in eastern Ontario and Quebec. This ice storm caused significant damage to transmission lines and sub-transmission systems. However, it did not damage any generating stations, because these have greater structural integrity for reasons other than resisting ice and wind loading [427].

Since the majority of the project structures are located well below ground they would not be directly affected by ice storm events. In addition, the physical hoist mechanisms are fully enclosed within the headframe structure. In the event of an ice storm, there is the potential for a loss of power that would affect the DGR facilities, including the hoist. However, the DGR Project has included emergency backup power systems that would engage in the eventuality of a power loss. Therefore, any ice storms that may occur in the vicinity of the DGR Project are not likely to affect the structural integrity of the main facilities and no further assessment is warranted. The effects of power failures are considered in Section 8 (malfunctions, accidents and malevolent acts).

7.13.9 Summary of Likely Effects of the Environment on the Project

The preceding assessment considered the effects of the environment on the DGR Project. The assessment found that the identified effects of the environment on the DGR Project are not likely to result in residual adverse effects.

7.14 EFFECTS OF CLIMATE CHANGE ON THE PROJECT

The following sections consider climate change by considering the following:

- How will the future environment affect the DGR Project?
- How will the DGR Project affect the future environment?
- How will the DGR Project affect climate change (e.g., contribution to climate change by the emission of greenhouse gases)?

Establishing how the climate may change over the life of the DGR Project is an initial requirement for addressing the first two considerations.

7.14.1 Description of Predicted Changes in Climate

Climate represents the long-term expected values for parameters such as temperature, precipitation and winds. The climate of an area is described using normals, which are averages calculated over a 30 year period (the latest accepted normals period is from 1971 to 2000) [428]. It is now widely accepted that climate is changing; therefore, consideration of these changes needs to be incorporated in the EA of the DGR Project. Traditionally, scientists looked to past weather records to provide guidance for predicting future conditions. Historic climate trends for the DGR Project are determined using the temperature archives observed at Wiarton Airport over the period from 1971 through 2000. While past trends have traditionally been used to provide guidance to the future, reliance is shifting to global climate models, which incorporate accepted understandings of climate mechanisms and standardized scenarios reflecting potential human development in the future.

Tables 7.14.1-1 and 7.14.1-2 provide a summary of the past and future trends for temperature and precipitation, respectively. The tables describe how climate in the region has been changing, as well as how it is projected to change over the life of the DGR Project through to the end of the decommissioning phase. These data will be used to evaluate how climate change may affect the conclusions reached regarding the assessment of the effects of the DGR Project on the selected VECs. The Atmospheric Environment TSD (specifically Appendix D) provides further details on the predicted changes in climate.

7.14.2 Assessment of Effects of the Future Environment on the DGR Project

7.14.2.1 Assessment Methods

Changes to the climate are predicted to occur over the lifetime of the DGR Project; therefore, it is also necessary to assess how the predicted future environment may affect the DGR Project. The method used to assess these changes is shown in Figure 7.14.2-1.

Once the future environment is established, the evaluation of changed and/or additional natural hazards on the DGR Project is conducted in a similar fashion to the assessment of effects of the current environment on the DGR Project (Section 7.13). The assessment addresses only predicted hazards that are different from or in addition to those considered in the assessment of existing natural hazards. The EA predictions of potential future hazards as a result of a changing climate relies upon both qualitative and quantitative evaluations based on available data and technical experience, with consideration for the design and contingency measures incorporated into the DGR Project to mitigate likely effects. Identified residual adverse effects are assessed for their significance.

Table 7.14.1-1: Historic and Future Temperature Trends

Criteria	1971-2000 Normals (°C)	1971-2000 Trend (°C/decade)	2011 – 2040 Forecast (°C/decade)			2041 – 2070 Forecast (°C/decade)			2071 – 2100 Forecast (°C/decade)		
			Low	Average	High	Low	Average	High	Low	Average	High
Annual	6.1	+0.31	+0.00	+0.41	+1.05	+0.15	+0.34	+0.66	+0.20	+0.33	+0.51
Spring	4.5	+0.50	+0.00	+0.45	+1.09	+0.14	+0.35	+0.69	+0.19	+0.34	+0.54
Summer	17.4	+0.26	+0.00	+0.43	+1.10	+0.15	+0.34	+0.69	+0.21	+0.34	+0.52
Fall	8.3	+0.05	+0.00	+0.36	+1.02	+0.12	+0.30	+0.63	+0.19	+0.32	+0.49
Winter	-5.7	+0.68	+0.00	+0.40	+0.99	+0.16	+0.33	+0.63	+0.21	+0.33	+0.50

Note:
The low and high data correspond to the forecasts for the scenario with the smallest and largest respective changes in temperature for each forecast horizon. The average represents the arithmetic average of the available forecasts. Refer to Appendix D of the Atmospheric Environment TSD for the derivation of climate data

Table 7.14.1-2: Historic and Future Precipitation Trends

Season	1971-2000 Normals (mm)	1971-2000 Trend (mm/decade)	2011 – 2040 Forecast (%/decade)			2041 – 2070 Forecast (%/decade)			2071 – 2100 Forecast (%/decade)		
			Low	Average	High	Low	Average	High	Low	Average	High
Annual	1,041.3	+0.13%	+0.00%	+1.44%	+3.57%	+0.36%	+1.11%	+2.09%	+1.39%	+1.30%	+2.25%
Spring	216.8	+3.23%	+0.00%	+2.59%	+5.39%	+0.62%	+1.51%	+2.72%	+1.88%	+2.24%	+4.05%
Summer	230.8	-0.51%	+0.00%	-1.65%	-3.40%	-0.95%	-1.13%	-0.42%	-0.68%	-0.85%	-0.61%
Fall	310.9	+4.41%	+0.00%	+2.09%	+4.35%	+2.28%	+1.67%	+2.75%	+2.11%	+1.65%	+1.85%
Winter	282.8	-4.65%	+0.00%	+2.39%	+7.30%	-0.27%	+1.82%	+3.08%	+2.05%	+1.92%	+3.32%

Note:
The low and high data correspond to the forecasts for the scenario with the smallest and largest respective changes in temperature for each forecast horizon. The average represents the arithmetic average of the available forecasts. Refer to Appendix D of the Atmospheric Environment TSD for the derivation of climate data

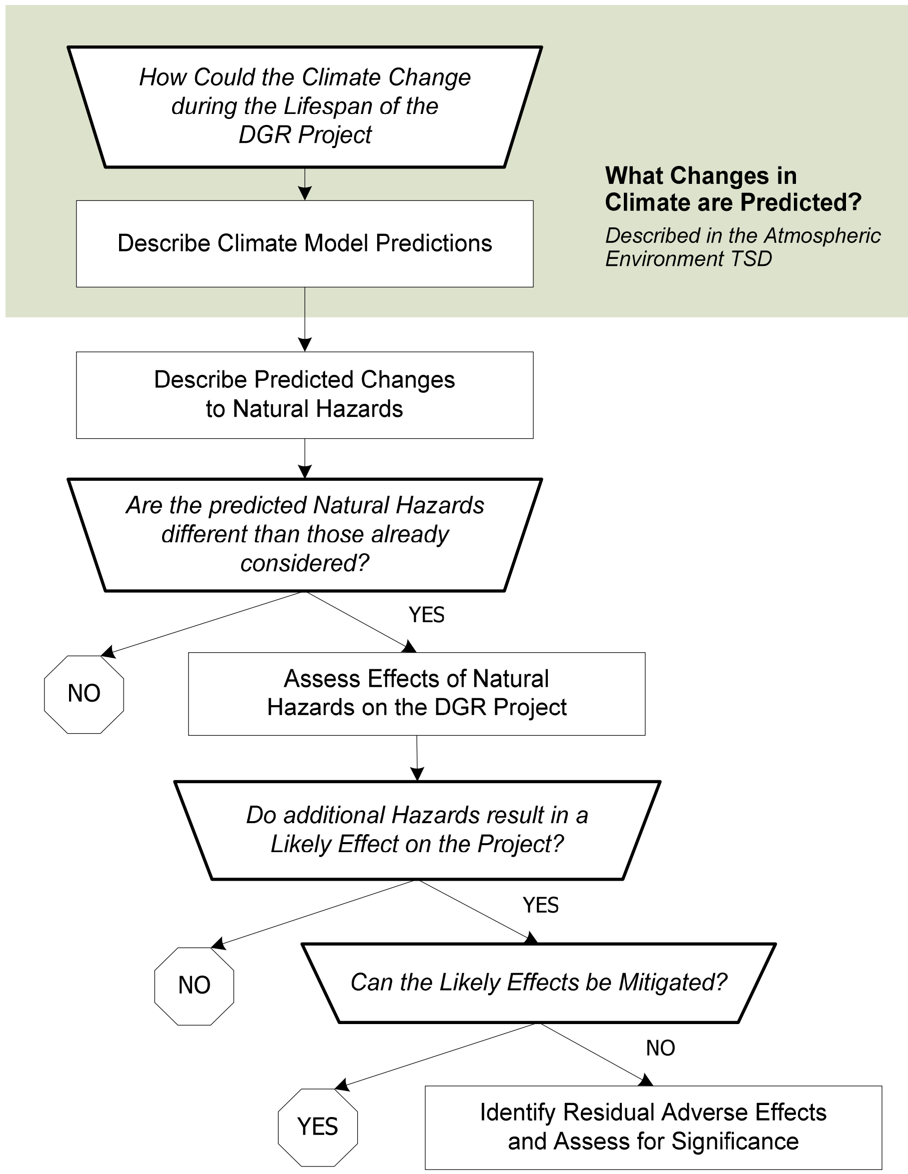


Figure 7.14.2-1: Method to Assess Effects of the Future Environment on the DGR Project

It should be noted that this assessment of climate change generally focuses on changes that could occur during the site preparation and construction, operations, and decommissioning phases of the DGR Project. Epochal shifts in climate (e.g., glaciation) have been incorporated in the assessment of the long-term safety of the DGR Project described in Section 9, and are also discussed in the context of the geology VECs.

7.14.2.2 Seismic Events

As described above in Section 7.13.1, the seismicity of the existing environment in the vicinity of the Regional Study Area, Local Study Area, Site Study Area and Project Area could potentially affect the DGR Project.

The seismicity of a region is the function of subsurface tectonic processes and forces which originate within the crust and underlying mantle of the Earth. There is no expectation that potential climate change within the timeframe of the project will affect the seismicity of the Regional Study Area, Local Study Area, Site Study Area or Project Area in any way. No changes to the occurrence or risk of seismic events are likely as a result of climate change. Accordingly, no effects of climate change on seismicity are identified.

7.14.2.3 Flooding

As discussed in Sections 7.13.2 and 7.13.3, the probability of flooding (from the lake) is low for the DGR Project because of its elevation and distance from the lake and potential surface flooding (from Stream C) will be mitigated with proper engineering design. During the site preparation and construction phase and operations phase, an increase in the flood potential attributed to climate change is unlikely. In terms of coastal flooding the potential is, in fact, likely to be reduced in the future according to studies reported in the literature that predict Lake Huron levels to drop by between -0.73 to -0.98 m relative to the baseline case (1961 to 1990) for the 2041 to 2070 forecast period (see Appendix D of the Atmospheric Environment TSD). With respect to on land flooding, predicted increased precipitation in all but the summer season for the three forecast periods shown in Table 7.14.1-2, suggest an increased possibility of flooding associated with spring snowmelt/rainfall runoff events affecting both Stream C and the DGR Project site stormwater management system. If these trends are realized, it stands to reason that increased precipitation through the winter months (December to February) would result in greater snowpack depths, which combined with higher soil moisture conditions in the fall and higher precipitation in the spring months (March to May) would produce more severe spring runoff events in the future. However, these potential impacts can be mitigated with proper engineering design.

In the longer term, there may also be an increased potential for flooding attributed to possible increases in the frequency and intensity of precipitation (see Appendix D of the Atmospheric Environment TSD). However, when the DGR is decommissioned, the shafts will be sealed and flooding will no longer have an effect.

7.14.2.4 Severe Weather

The effects of the environment on the DGR Project associated with severe weather events include effects from thunderstorms, lightning, hail storms, tornadoes and ice storms. Despite the greater number of severe weather events recorded since 1970 as described in Section 7.13 these events have not affected the operation of the facilities at the Bruce nuclear site. The facilities have incorporated a consideration of the potential effects of extreme weather in their design and have been constructed to withstand the effects of such events. Therefore, increases in the frequency of severe weather events that could potentially be related to climate change should have no more effect on the DGR Project than past severe weather events. Accordingly, no further consideration is warranted.

7.14.3 Assessment of the Future Effects of Climate Change on VECs

7.14.3.1 Assessment Methods

Climate change may result in an environment that is different from the current environment as less severe winters or increased precipitation might alter the habitat or behaviour of VECs. Climate-related changes to VECs may result in changed or additional effects of the DGR Project compared with those predicted on the current environment. The method used to assess these changes is shown in Figure 7.14.3-1.

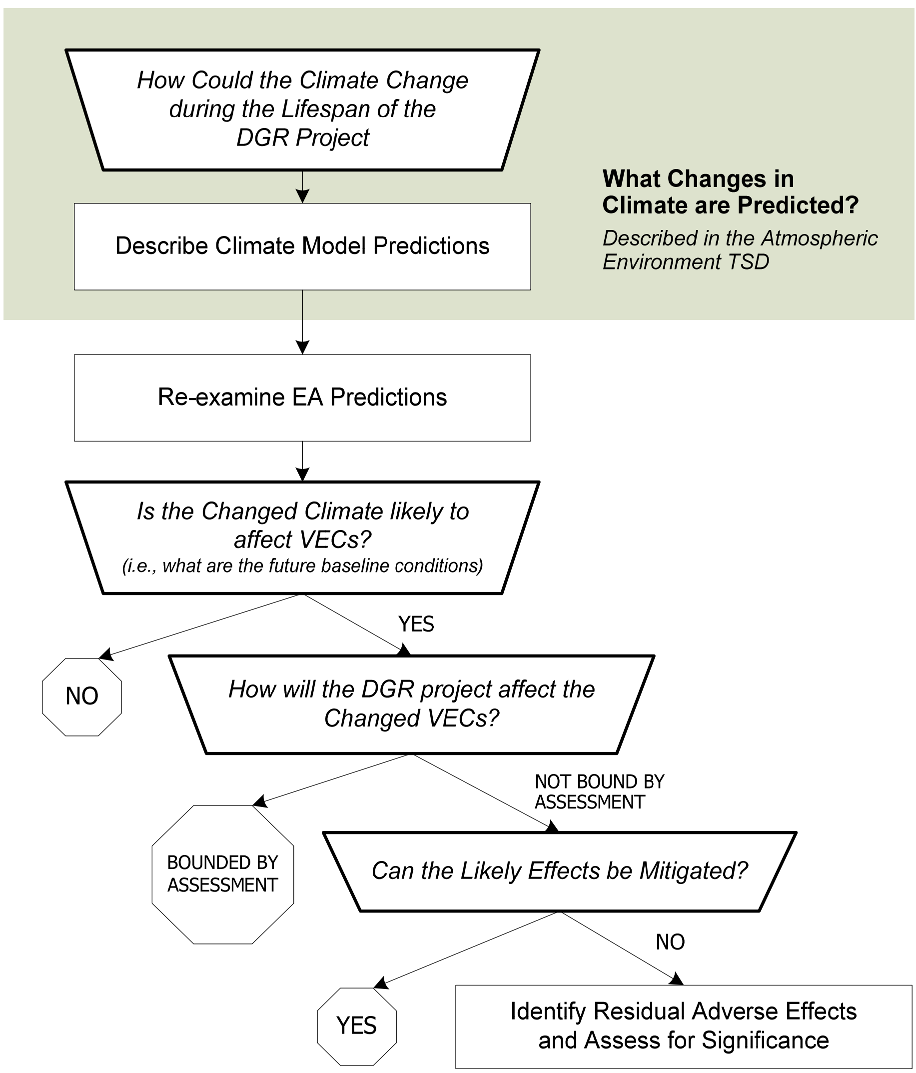


Figure 7.14.3-1: Method to Assess Effects of the DGR Project on the Future Environment

The assessment of the effects of the DGR Project on VECs in a changed future environment begins with re-examining the EA predictions for the current environment by identifying whether or not the VECs might be altered as a result of climate change. The effects of the DGR Project on the altered VECs are then assessed to determine whether they are bounded by the predictions made for the effects assessment for the current environment. All additional or different effects are fully assessed, using a similar method to that followed for assessing effects of the DGR Project on the current environment. Effects that cannot be fully mitigated will result in residual adverse effects, which are assessed for their significance.

7.14.3.2 Geology

The potential effects of changing climate on the assessment of effects to geology are best indicated through the predicted changes to the groundwater transport VECs. Increases in seasonal temperatures may result in increased evaporation of precipitation, potentially reducing groundwater recharge. Conversely, increases in seasonal precipitation may result in potential increases in available groundwater recharge. For the years 2011 to 2100 – spring, fall, and winter modelling scenarios, both temperature and precipitation are predicted to increase over the life of the project. The potentially adverse effects to recharge because of increased temperature may be largely offset by the increases in precipitation predicted in the modelling.

Table 7.14.3-1 summarizes the potential effects of climate change on the geology VECs. The table also describes whether these changes could affect the conclusions of the assessments in Section 7.2.

Table 7.14.3-1: Potential Effects of Climate Change on Geology VECs

VEC	Potential Interaction of Climate Change with VEC	Likely Effect	Changes to EA Conclusion?
Soil Quality	Changes to soil quality as a result of changes in soil moisture	Changes in climate could affect the soil moisture, and ultimately the quality of the soil	None
Overburden Groundwater Quality	Changes to groundwater quality as a result of changes in the recharge regime	Changes in climate could affect the surface water availability, affecting groundwater recharge and flow, and potentially groundwater quality	None
Overburden Groundwater Transport	Changes to solute transport (recharge) regime	Changes in climate have the potential to affect the surface water availability, which could alter groundwater recharge	None

Table 7.14.3-1: Potential Effects of Climate Change on Geology VECs (continued)

VEC	Potential Interaction of Climate Change with VEC	Likely Effect	Changes to EA Conclusion?
Shallow Bedrock Groundwater Quality	Changes to groundwater quality as a result of changes in the recharge regime	Changes in climate are not considered to have an effect on the transport characteristics between shallow bedrock formations	None
Shallow Bedrock Groundwater and Solute Transport	Changes to groundwater flow (recharge) regime	Changes in climate are not considered to have an effect on the transport characteristics between shallow bedrock formations	None
Intermediate Bedrock Water Quality	Changes to groundwater flow (recharge) regime	Changes in climate are not considered to have an effect on the transport characteristics between intermediate bedrock formations	None
Intermediate Bedrock Solute Transport	Changes to groundwater flow (recharge) regime	Changes in climate are not considered to have an effect on the transport characteristics between intermediate bedrock formations	None
Deep Bedrock Water Quality	Changes to groundwater flow (recharge) regime	Changes in climate are not considered to have an effect on the deep bedrock porewaters	None
Deep Bedrock Solute Transport	Changes to groundwater flow (recharge) regime	Changes in climate are not considered to have an effect on the deep bedrock porewaters	None

Although considered beyond the range of the climate change requirements set out in the EIS Guidelines, the geology assessment also considers shifts in climate over geologic time. This assessment includes consideration of future glacial and interglacial events. Glacial/interglacial cycling will have an impact on the hydrological conditions in the overburden and shallow bedrock groundwater zones. It is very unlikely that previous glaciations had any significant impact on groundwater flow in the intermediate and deep bedrock groundwater zones. Notable responses to glaciation include; permafrost formation (which only extends tens of metres in depth), short-lived meltwater events (which may intrude into the shallow bedrock groundwater zone and have geochemical consequences) and the formation of a major proglacial lake over the site during ice-sheet retreat [386].

The future ice-sheet that is postulated will cause significant changes in the surficial physical environment and the shallow groundwater zone, in terms of permafrost, hydraulic pressures and flow rates, as well as the penetration of glacial recharge waters. Gradients within the permeable formations of the intermediate groundwater zone – Guelph, Salina A0 upper carbonate – may vary in direction and magnitude as the ice sheets advance and retreat. However, the impacts of glacial cycles on the deep groundwater zone are expected to be primarily changes in the stress and hydraulic pressure regime resulting from ice-sheet loading and unloading. This is supported by evidence from the site itself, where the deep groundwaters do not show signs of impact from past glaciations, nor are there signs of faulting or fracturing due to glaciation stresses. This is also supported by modelling of the behaviour of the groundwater and geomechanical environment around the repository, and modelling of the mechanical behaviour of the shaft seals, presented in the Geosynthesis [421]. The overall rock will remain intact, and contaminant transport remains diffusion-dominated, as in previous glacial cycles.

Geochemical studies conducted as part of the geosynthesis program revealed that there was little likelihood that water from previous glaciations reached the intermediate or deep bedrock formations. Bromine and chlorine profiles show very little change versus depth below the top of the Ordovician formations, suggesting that meteoric water has had no influence on the composition of the ancient brines at depth. Paleohydrogeologic simulations for a glaciation scenario indicate that basal meltwaters would not penetrate below the Salina Formation. Simulations further indicate that while ice-loading will influence hydraulic head distributions and gradients, solute transport processes within the Ordovician sediments hosting and enclosing the proposed DGR will remain diffusion dominant [429].

There was no evidence found during the deep geological site investigations of meltwater from previous glaciations penetrating the deep and intermediate bedrock groundwater zones, because of their low permeability and the relatively high permeability of the shallow bedrock groundwater zone.

Geomechanical modelling of the DGR opening in the Cobourg Formation considered several perturbation scenarios, including seismic shaking and glacial loading. The results of the work demonstrated that the maximum damage zone around the room openings was about 7.5 m under the long-term strength degaradation case, and a maximum horizontal fracture propagation of 16 m under the gas generation scenario. None of the scenarios modelled created potential pathways to the biosphere.

In summary, the effects of future glaciation events on the DGR Project are not considered adverse.

7.14.3.3 Hydrology and Surface Water Quality

Change in air temperature (i.e., affecting evapotranspiration rates and precipitation) could potentially change the flow in area streams and the amount of runoff from the DGR Project. An increase in annual precipitation as predicted in Table 7.14.1-2 would increase the potential amount of runoff from the DGR Project. An increase in air temperature as predicted in Table 7.14.1-1 would increase the rate of evaporation, thus reducing runoff, primarily in the summer months and diminishing the effect of increased precipitation on an annual basis. From Table 7.14.1-2, the projected future increase in annual precipitation for the highest forecast scenario over the time period from 2011 to 2100 is shown in Table 7.14.3-2. Also shown is the estimated change in runoff attributable to the increased precipitation, based on a conservative runoff coefficient of 0.5 and ignoring the potential reduction in runoff due to increase temperatures and evapotranspiration rates.

Table 7.14.3-2: Projected Increase in Annual Precipitation and Runoff

Time Period	Annual Precipitation Increase (%/decade)	Annual Precipitation Increase for Time Period (%)	Estimated Change in Runoff (%)
2011 to 2040	3.57	10.71	5.36
2041 to 2070	2.09	6.27	3.14
2071 to 2100	2.25	6.75	3.38
Total Period	—	23.73	11.88

From Table 7.14.3-2, the estimated maximum change in streamflow (runoff) is approximately 12% (by the end of the century) based on the most conservative climate change forecast, a conservative runoff coefficient and ignoring the effects of increased temperatures. Since this potential change is <15% (i.e., less than the adopted criteria for reliable flow measurement), adverse effects on Stream C or the DGR Project site drainage ditches are not anticipated (see Section 7.3).

Changes in surface water quality could result from the effects of climate change, for example, increased volumes of runoff could potentially increase turbidity levels or decrease the overall concentration of contaminants in the runoff through dilution. However, since the change in runoff is not expected to be measurable, no adverse changes to water quality are expected.

Table 7.14.3-3 summarizes the potential effects of climate change on hydrology and surface water quality VECs, and describes whether these changes could affect the conclusions of the assessments presented for assessment of direct effects in Section 7.3.

Table 7.14.3-3: Effects of Climate Change on Hydrology and Surface Water Quality VECs

VEC	Potential Interaction of Climate Change with VEC	Likely Effect	Change to EA Conclusion?
Surface Water Quantity and Flow	Changes in temperatures and precipitation have the potential to affect streamflows (runoff)	Increases in runoff resulting from increased precipitation are partially mitigated by increased evaporation resulting from increased air temperature Maximum estimated changes in flow are within the accuracy limits of standard flow measurement equipment and are predicted to be non-adverse (i.e., changes would be <15%) through to year 2011	None
Surface Water Quality	Changes in temperature and precipitation could change the streamflows (runoff), which could indirectly affect water quality	Changes in water quality would only result from changes in runoff Since no measurable change in runoff is predicted, no measurable changes in water quality are expected	None

7.14.3.4 Terrestrial Environment

Climate change may affect terrestrial environment VECs by shifting the composition of plant communities to species that are better adapted to warmer and wetter conditions, which would, in turn, shift the location of available habitat for wildlife communities. However, the response of any single species to possible climate change cannot be reasonably predicted because of the complexity of the response to environmental parameters. Species distributions are based upon both intrinsic and extrinsic factors, most of which have a broad range of acceptable conditions. In addition, ecological inertia will likely ensure that, except in the event of catastrophic change, there will be a substantial lag between the change in physical environmental parameters and any change in the composition of plant communities. As a result, the predicted climatic changes (Tables 7.14.1-1 and 7.14.1-2) will not be sufficiently substantial during the DGR Project lifecycle to affect the health of vegetation and wildlife considered in the assessment.

Table 7.14.3-4 summarizes the potential changes in the terrestrial environment that could result from climate change, and describes whether these changes could affect the conclusions of the assessment.

Table 7.14.3-4: Effects of Climate Change on Terrestrial Environment VECs

VECs	Potential Interaction of Climate Change with VEC	Likely Effect	Change to EA Conclusion?
Eastern White Cedar	Increasing precipitation and increasing temperatures could alter the ecology, resulting in a positive or negative effect on individual VECs, species distributions and abundance	Shifts in climate will gradually alter the ecosystem of an area to be similar to the ecosystems experienced today in those areas that have climates similar to the climate expected in the future	None
Heal-all			
Common Cattail			
Northern Short-tailed Shrew			
Muskrat			
White-tailed Deer			
Red-eyed Vireo			
Wild Turkey			
Yellow Warbler			
Mallard			
Bald Eagle			
Midland Painted Turtle			
Northern Leopard Frog			

7.14.3.5 Aquatic Environment

Changes in surface water quality could result from the effects of climate change, for example, increased volumes of runoff could decrease the overall concentration of contaminants in the runoff. Since the change in runoff is not expected to be measurable, no measurable changes to water quality are expected.

Table 7.14.3-5 summarizes the consideration of effects of the DGR Project taking into account the potential effects of climate change on aquatic environment VECs, and describes whether these changes could affect the conclusions of the assessments presented for assessment of direct and indirect effects in Section 7.5.2.

Table 7.14.3-5: Effects of Climate Change on Aquatic Environment VECs

VECs	Potential Effects of Climate Change on VEC	Rationale	Change to EA Conclusion?
Redbelly Dace Creek Chub Brook Trout Variable Leaf Pondweed Benthic Invertebrates	Change to frequency and magnitude of precipitation events	Increases in runoff resulting from increased precipitation are offset by increased evaporation resulting from increased air temperature	None
Burrowing Crayfish	Change to frequency and magnitude of precipitation events result in changes to surface and groundwater recharge	Increased surface water and groundwater flow associated with extreme weather events could lead to flood conditions in crayfish burrows	None
Lake Whitefish Spottail Shiner Smallmouth Bass Benthic Invertebrates	Increased flow associated with extreme weather events could lead to changes in surface water quality entering Lake Huron from the tributaries	Potential effects of increasing levels of suspended sediments entering the lake	None

7.14.3.6 Radiation and Radioactivity

It is expected that the climate change discussed in Section 7.14.1 (small changes in temperature and precipitation) will not change atmospheric dispersion by any significant amount. Therefore, it is considered unlikely that climate change will alter any of the potential adverse effects of the DGR Project on the radiation and radioactivity VECs, as described in Section 7.6.2. Therefore, no additional effects have been passed on for consideration as a result of climate change.

7.14.3.7 Air Quality

The future climate forecast using Global Climate Models (GCMs) (Tables 7.14.1-1 and 7.14.1-2) suggest that the climate in the vicinity of the DGR Project will get warmer and be wetter than historically observed in the region. Generally, the rates at which temperatures are increasing (°C per decade) are similar to the rates of warming observed over the period of 1971 to 2000.

Changes in temperature and precipitation can affect air quality in a number of ways. First, changes in precipitation and soil moisture content can result in reduced or increased emissions of dust. A review of the Global Climate Change Models (GCM) forecast suggests that precipitation will increase at a greater rate relative to the past, while temperatures will increase at a similar rate. This suggests that the soil would have greater moisture and emissions of fugitive dust would be lower. However, the greatest increase in precipitation is forecast during the winter months. During the summer months, precipitation is forecast to decrease suggesting that soil moisture will be lower and fugitive dust emissions higher. This is consistent with the findings of Warren, et al [430].

While this could suggest a potential increase in the dust emissions from the DGR Project; however, equipment will be available and maintained on-site to water roadways as required. Therefore, any potential increase in dust emissions will be mitigated. The climate during the site preparation and construction phase is expected to be similar to today's climate. In addition, most of the dust emissions are expected during the site preparation and construction phase.

Changes in temperature and precipitation can also affect how emissions from the DGR Project are dispersed in the atmosphere. First, plumes from stacks will not rise as far during warm conditions as the plume rise is a function of the difference between the exhaust and ambient temperatures. However, there are no large stacks associated with the DGR Project. Therefore, there would be no measurable effect on the air quality VEC as a result of increases in temperature.

Increased precipitation could indicate an increase in the number of hours when clouds are present. During sunny conditions, dispersion is at its greatest and would be decreased with increased cloud cover. However, Kharin, et al [431] suggests that increases in precipitation will be experienced as increased intensities rather than an increasing number of hours of precipitation. Therefore, there should be no measurable effect on the air quality VEC as a result of increased precipitation.

Table 7.14.3-6 summarizes the potential effects of climate change on atmospheric environment VECs, and describes whether these changes could affect the conclusions presented for assessment of direct effects in Section 7.7.2.

Table 7.14.3-6: Effects of Climate Change on Air Quality

VEC	Potential Interaction of Climate Change with VEC	Likely Effect	Change to EA Conclusion?
Air Quality	Changes in temperature and precipitation can result in decreased soil moisture Decreased soil moisture could result in higher dust emissions	Most dust emissions will occur during site preparation and construction Equipment will be available and maintained on-site to water roadways as required; therefore, any change in emissions will be mitigated	None
	Increased temperatures could result in decreased plume rise and associated dispersion; degradation in air quality would not measurable	There are no large stacks associated with the DGR Project	None

Table 7.14.3-6: Effects of Climate Change on Air Quality (continued)

VEC	Potential Interaction of Climate Change with VEC	Likely Effect	Change to EA Conclusion?
Air Quality (continued)	Increased precipitation could result in more cloud cover Increased cloud cover could result in decreased dispersion	Increased precipitation is associated with increased intensity rather than increased duration There should be no measurable increase in the number of hours of cloud cover	None

7.14.3.8 Noise Levels and Vibrations

Changing climate is not projected to affect noise levels and vibrations.

7.14.3.9 Socio-Economic Environment

No potential interactions between the DGR Project and the future effects of climate change with respect to the socio-economic environment are likely. No further consideration of this factor is required.

7.14.3.10 Aboriginal Interests

Changes in temperature and precipitation may have an indirect effect on Aboriginal interests VECs. Table 7.14.3-7 summarizes the potential effects of climate change on Aboriginal interests VECs, and describes whether these changes could affect the conclusions of the assessments presented for assessment of effects in Section 7.9.2.

Table 7.14.3-7: Effects of Climate Change on Aboriginal Interests VECs

VEC	Potential Interaction of Climate Change with VEC	Likely Effect	Change to EA Conclusion?
Aboriginal Communities	Changes in temperatures and precipitation have the potential to affect community services (e.g., water supply)	No measurable changes in surface water quality, groundwater quality or surface water quantity and flow VECs are identified in the other TSDs as a result of climate change; therefore, no measurable change to Aboriginal communities is anticipated	None

Table 7.14.3-7: Effects of Climate Change on Aboriginal Interests VECs (continued)

VEC	Potential Interaction of Climate Change with VEC	Likely Effect	Change to EA Conclusion?
Aboriginal Heritage Resources	There are no mechanisms for changes in climate to interact with Aboriginal heritage resources	No measurable change to Aboriginal heritage resources likely	None
Traditional Use of Land and Resources	Changes in temperature and precipitation have the potential to affect aquatic and terrestrial VECs used for fishing, hunting, trapping and gathering	No measurable changes in aquatic or terrestrial VECs were identified as a result of climate change in other TSDs; therefore, no measurable change in traditional use of land and resources is anticipated	None

7.14.3.11 Human Health

Changes in temperature and precipitation may have an indirect effect on human health VECs. Table 7.14.3-8 summarizes the potential effects of climate change on human health VECs, and describes whether these changes could affect the conclusions of the assessments presented for assessment of effects in Section 7.11.

Table 7.14.3-8: Effects of Climate Change on Human Health VECs

VEC	Potential Interaction of Climate Change with VEC	Likely Effect	Change to EA Conclusion?
Overall Health of Local Residents/ Members of Aboriginal Communities/ Seasonal Users	No potential interactions between the DGR Project and future effects of climate change are predicted for overall health	The effects to human health would not be measurable	None
Health of Workers	No potential interactions between the DGR Project and future effects of climate change are predicted for health of workers	The effects to health of workers would not be measurable	None

7.14.4 Assessment of Effects of the DGR Project on Climate Change

7.14.4.1 Assessment Methods

The DGR Project may also contribute to how the climate is changing (e.g., through changes in the levels of greenhouse gas emissions). The assessment will quantify the direct and indirect changes as a result of the DGR Project on the atmospheric environment and climate change and put them into context on a sector, provincial and national basis.

7.14.4.2 Greenhouse Gas Considerations

Although the DGR Project will have low levels of greenhouse gas (GHG) emissions during the Operations Phase, the activities required to construct and support the operations of the DGR Project will result in direct (i.e., emitted from combustion sources) and indirect (i.e., emissions associated with changes in land use such as vegetation removal and leaf litter) greenhouse gas emissions. This section describes and quantifies the direct and indirect GHG emissions associated with the site preparation and construction phase and operations phase of the DGR Project, and helps put those emissions into perspective on a sector, provincial and national basis. Direct GHG emissions during the decommissioning phase would be similar to those during the site preparation and construction phase, assuming no change in the vehicle technology would be available for the decommissioning of the DGR Project.

Table 7.14.4-1 compares the direct and indirect GHG emission from the site preparation and construction phase of the DGR Project to the Ontario power sector, Ontario provincial total and Canadian national GHG emissions for 2005 [432]. A further breakdown of the direct and indirect GHG emissions can be found in the Atmospheric Environment TSD. The total GHG emissions from the site preparation and construction of the DGR Project are insignificant in comparison to these totals.

Table 7.14.4-1: Site Preparation and Construction Phase GHG Emissions in Context

Source		Annual GHG Emissions (kt CO_2e/a)	Project as a Relative Percentage
Project	Direct[a]	22.22	—
	Indirect[b]	0.18	
	Total	22.40	
Ontario Power Sector[c]		34,176	0.066%
Ontario Provincial Total[c]		201,000	0.011%
Canadian National Total[c]		747,000	0.0030%

Notes:
a The direct GHG emissions correspond to the site preparation and construction phase Stage 5 emissions listed in Table 10.4.2-3 in the Atmospheric Environment TSD.
b The indirect GHG emissions listed in Table 10.5.1-2 in the Atmospheric Environment TSD.
c Emissions represent the reported values for 2005 [432].

Table 7.14.4-2 compares the direct and indirect GHG emission from the operations phase of the DGR Project to the Ontario power sector, Ontario provincial total and Canadian national GHG emissions for 2005 [432]. The total GHG emissions from the operation of the DGR Project are insignificant in comparison to these totals.

Table 7.14.4-2: Operations Phase GHG Emissions in Context

Source		Annual GHG Emissions (kt CO_2e/a)	Project as a Relative Percentage
Project	Direct[a]	2.05	—
	Indirect[b]	0.18	
	Total	2.23	
Ontario Power Sector[c]		34,176	0.0065%
Ontario Provincial Total[c]		201,000	0.0011%
Canadian National Total[c]		747,000	0.00030%

Notes:
a The direct GHG emissions correspond to the operations phase emissions listed in Table 10.5.1-1 in the Atmospheric Environment TSD.
b The indirect GHG emissions listed in Table 10.4.2-4 in the Atmospheric Environment TSD.
c Emissions represent the reported values for 2005 [432].

7.14.4.3 Effects of DGR Project GHG Emissions on Climate

A review of literature from the IPCC confirms that the majority of scientists feel that there is compelling evidence to link observed and forecasted changes in climate to the release of man-made greenhouse gas emissions. However, the Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment (FPTCCCEA) indicates in its guidance document for practitioners [433] that "…unlike most project-related environmental effects, the contribution of an individual project to climate change cannot be measured." To illustrate this, the GHG emissions associated with the project are compared to the GHG emissions associated with the forecasted changes in climate expected over the project life. Table 7.14.4-3 compares the global and DGR Project-related emissions, and can be seen to reasonably support the conclusion that the GHG emissions from the DGR Project will not have a measurable effect on climate. Therefore, the effect of the project on climate would be insignificant.

Table 7.14.4-3: Comparison of Project and Global GHG Emissions and Potential Effects to Climate Change

Parameter	SRES Scenario A1B	SRES Scenario A2	SRES Scenario B1	Project
Change in GHG emissions relative to the 2000 global baseline [a]	+59.7%	+109.3%	+18.6%	+0.00013%
Change in annual temperature for the 2041 to 2070 horizon [b]	+1.65 °C	+1.60 °C	+0.75 °C	Cannot be measured [c]
Change in annual precipitation for the 2041 to 2070 horizon [b]	+5.65%	+4.25%	+1.80%	Cannot be measured [d]

Notes:
a The global baseline emissions for 2000 were listed by the IPCC as 16,927 Mt CO_2e/a [434].
b Changes were calculated as the difference between the baseline and scenario forecasts for the 2041 to 2070 time horizon.
c On the basis of proportionality, the GHG emissions from the DGR Project could represent an increase of less than 0.00001 °C in the annual temperature. Such a change would not be measurable.
d On the basis of proportionality, the GHG emissions from the DGR Project could represent an increase of less than 0.000013% in the annual precipitation. Such a change would not be measurable.

7.15 APPLICATION OF A PRECAUTIONARY APPROACH IN THE ASSESSMENT

This section provides a summary of how the Precautionary Principle has been taken into account in the assessment of DGR Project.

Throughout the EA, the DGR Project has been conservatively considered in a thorough and traceable manner. For example, at each of the screening stages, potential project-related effects are advanced if they cannot be systematically removed from consideration through application of rigorous, sound and credible scientific evidence. In addition, with the exception of malfunctions, accidents and malevolent acts, all identified residual adverse effects are assumed to occur (i.e., probability of occurrence is assumed to be 1), and are assessed for significance.

The assessment of geology uses the conservative (i.e., worst-case for considering a deep geologic repository) range of physical parameters that have been measured and/or estimated for the geologic materials and hydrogeologic regime within and underlying the Project Area and vicinity.

The hydrology and surface water quality estimates the change in flow for Stream C by assuming that the runoff coefficients for the entire watershed and the diverted areas are identical. The runoff coefficient for the diverted areas is likely lower than the greater watershed. As a result, the contribution from the diverted area would be smaller and the corresponding reduction in flow is expected to be lower. In addition, criteria established for the protection of natural watercourses have been applied equally to man-made drainage features.

Baseline data collection for the characterization of the terrestrial environment was scoped to both assess the habitat potential within the terrestrial environment, and the number of individual species using these habitats and the population or community associations of the VECs. Losses of individual specimens and specific habitat elements have been considered throughout the screening process for the project, so as to accurately assess any effects that the project may have on the natural heritage features and functions of the study areas.

Aquatic species depend on the conditions within their aquatic environments albeit they have different tolerances to changes in those conditions. For the sake of the aquatic assessment, conservatism is built in using a bounding assessment approach, grouping the VECs by habitat and using the assumption that effects are likely to occur to all VECs in a particular habitat. In addition, any loss of habitat, regardless of size is considered to be adverse.

For radiation and radioactivity, air quality and noise level, conservatism is built into the assessment using a bounding assessment approach. The calculation of doses to humans and non-human biota in this study involved postulating scenarios leading to the highest possible doses, and then comparison with the most stringent regulatory and literature dose criteria for the assessment of consequences. The assessment of the potential effects of the DGR Project on air quality considers conservative emission rates during the site preparation and construction phase. Specifically, all of the equipment and activities identified during a particular year were assumed to be operating at their maximum rate concurrently. In addition, traffic associated with the construction workforce was assumed to be at its maximum level throughout the site preparation and construction phase.

For the assessment of Aboriginal interests, the VECs defined for this assessment considered a broad range of Aboriginal interests identified from multiple sources rather than relying solely on DGR specific communications. As such, the Aboriginal interests identified reflect not only those articulated at present, but also those articulated by Aboriginal people in the past. Additionally, Aboriginal communities have been defined as consisting of those individuals who are officially recognized by SON or Métis Nation of Ontario or the Historic Saugeen Métis Council, rather than limiting the definition to the political or jurisdictional boundaries of First Nation reserve lands.

The socio-economic assessment made predictions and used assumptions in the economic modelling based on broad Statistics Canada data from the Ontario economy and municipal projections. They assume current service ratios. The evaluation of potential socio-economic effects is rooted in changes to the existing environment within the community assets framework and not solely on compliance with regulatory standards.

7.16 APPLICATION OF TRADITIONAL KNOWLEDGE IN THE ASSESSMENT

Where available, specific traditional knowledge was used to complete the EA, and is incorporated into the EIS through the characterization of the existing environment and assessment of effects. Issues of importance to Aboriginal communities were identified as part of the Aboriginal Interests TSD through examination of available information pertaining to general ecological, socio-economic and cultural heritage interests for Ojibway and Métis peoples in Ontario. This examination identified a range of interests raised by Aboriginal communities that can be used to focus the current EA relative to potential effects on residents of the Aboriginal communities in the study areas. This examination included:

- interests raised by Aboriginal communities with regards to previous studies;
- interests raised by Aboriginal communities in the context of dialogue for the DGR Project; and
- insight into traditional knowledge, and interests of general importance to local Aboriginal communities.

This section highlights where Aboriginal traditional knowledge and traditional ecological knowledge were available, and have influenced the assessment.

7.16.1 Hydrology and Surface Water Quality

The local Aboriginal communities have historically identified a number of issues relating to the Bruce nuclear site, which would apply to the DGR Project. Those issues that relate to hydrology and surface water quality include:

- traditional lands, waters, and resources, a fundamental part of Aboriginal culture, identity and economy, and essential to the sustainability of the Aboriginal communities;
- treaty rights in the waters surrounding the Bruce Peninsula, including fishing rights and lake bed;
- long-term use of lands and waters, including use of traditional territory for hunting, gathering and fishing;
- the traditional fisheries of Lake Huron and Georgian Bay and their importance to the cultural and economic health of the First Nation communities;
- Lake Huron water quality; and
- effects of future lake water levels and climate change.

The description of the existing hydrology and surface water quality includes discussion of water quality in Lake Huron and other streams and ditches in the Site Study Area (Section 6.3.4). The effects of climate change are considered in Section 7.14. The effects of DGR Project on fish communities are addressed in Aquatic Environment TSD, which takes into account changes in surface water quality and surface water quantity and flow identified in this TSD. In addition, the overall effects of DGR Project on Lake Huron are considered in Section 7.12.1.

Lake Huron water quality is known to be important to the Aboriginal communities and was considered in the effects assessment through the selection of VECs. No other Aboriginal input was available relative to the hydrology and surface water quality for use in the assessment.

7.16.2 Terrestrial Environment

As described in the Aboriginal Interests TSD, concerns with regards to the terrestrial environment historically raised by local Aboriginal communities include:

- concerns regarding treaty rights, traditional land use and harvesting activities, and way of life;
- concerns about increased pressures on traditional heritage sites in the Municipality of Kincardine and Ontario Parks adjacent to the Bruce nuclear site;
- the long-term use of lands and waters, including use of traditional territory for hunting, gathering and fishing, and claims and settlements; and
- maintaining their culture, including traditional hunting, traditional gathering, traditional fishing, and claims of rights to access lands and interests in areas of traditional settlements.

The description of the existing terrestrial environment includes a characterization of species identified to be of cultural importance and a description of the adjacent parks. In addition, Aboriginal observers were present during a number of field study events.

Some of the VECs chosen (e.g., bald eagle, eastern white cedar) are known to historically have importance to Aboriginal communities and were considered explicitly in the effects assessment. No other Aboriginal input was available relative to the terrestrial environment.

7.16.3 Aquatic Environment

As described in the Aquatic Environment TSD, concerns with regards to aquatic environment historically raised by local Aboriginal communities include:

- traditional lands, waters, and resources, a fundamental part of Aboriginal culture, identity and economy, and essential to the sustainability of the Aboriginal communities;
- treaty rights in the waters surrounding the Bruce Peninsula, including fishing rights and lake bed;
- long-term use of lands and waters, including use of traditional territory for hunting, gathering and fishing;
- the importance to the cultural and economic health of the Aboriginal communities of the traditional fisheries of Lake Huron and Georgian Bay, particularly lake whitefish harvest; and
- level of contaminants in fish.

The description of the existing aquatic environment includes discussion of fish communities in Lake Huron and other streams and ditches in the Site Study Area. In addition, the overall effects of DGR Project on Lake Huron are considered in Section 7.12.1. Aboriginal observers were present during the detailed habitat survey of Stream C.

Some of the VECs chosen (e.g., lake whitefish) are known to historically have importance to Aboriginal communities and were considered explicitly in the effects assessment. No other Aboriginal input was available relative to the aquatic environment.

7.16.4 Radiation and Radioactivity

Concerns with regards to radiation and radioactivity historically raised by local Aboriginal communities include:

- radiological impacts on health, animals and plants;
- potential health and safety implications for the natural environment, and future generations resulting from the potential for damage to traditional lands and Aboriginal way of life;
- level of contaminants in fish;
- effects on the food web and on all parts of the environment; and
- safety of Aboriginal communities.

The description of the existing radiation and radioactivity environment includes a presentation of the existing doses to both humans and non-human biota. In addition, available information on Aboriginal dietary surveys in relation to the local fishery have been included.

7.16.5 Air Quality and Noise Levels

No specific Aboriginal traditional knowledge was available to help in characterizing the existing atmospheric environment conditions. During past assessments, Aboriginal concerns have been raised regarding the effects of changes in air quality on their health, as described more fully in the Aboriginal Interests TSD. Results from the Atmospheric Environment TSD have been used as inputs to the human health assessment prepared in this EIS. The effects of the DGR Project on air quality and noise levels are assessed at the edge of the Bruce nuclear site, which is the closest point of exposure for both Aboriginal and non-Aboriginal people. The aesthetic and nuisance effects associated with changes in air quality and noise levels caused by the DGR Project were evaluated as part of assessment of Aboriginal interests assessment (Section 7.9). Finally, the potential effects of changes in air quality and noise levels on the health of Aboriginal people are presented in Section 7.11.

7.16.6 Human Health

As described in the Aboriginal Interests TSD, concerns with regards to human health historically raised by local Aboriginal communities include:

- radiological impacts on health, animals and plants;
- potential health and safety implications for the natural environment, and future generations as a result of the potential for damage to traditional lands and Aboriginal way of life;
- level of contaminants in fish and effects on the food web and on all parts of the environment; and
- safety of Aboriginal communities.

With respect to the human health, Aboriginal traditional knowledge and traditional ecological knowledge has been built into the assessment, where available. The predictions of effects on human health included those to the member of Aboriginal community. The changes in air quality were modelled for the on-site burial ground and for the Aboriginal communities.

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8. MALFUNCTIONS, ACCIDENTS AND MALEVOLENT ACTS

The EA includes a description of malfunctions, accidents and malevolent acts associated with the DGR Project. Assessment methods are discussed first, followed by an identification of initiating events (Section 8.1), the assessment of radiological accidents (Section 8.2), non-radiological accidents, including worker safety (Section 8.3), and malevolent acts (Section 8.4). Further details can be found in the Malfunctions, Accidents and Malevolent Acts TSD.

The methods used for identifying the bounding accident scenarios were specific to the type of accident (i.e., non-radiological vs. radiological) and when the accident could occur (i.e., during site preparation, construction, operations or decommissioning vs. following abandonment). These are described within each section.

8.1 INITIATING EVENTS

Malfunctions and accidents could be initiated by a variety of events[20]. Initiating events could result in an accident that releases solely radiological, both radiological and conventional, or solely conventional contaminants. These initiating events are categorized into three groups:

- operations initiating events: power failure (grid and emergency power supply), mechanical/equipment failure (such as truck, forklift, crane, ventilation fan, hoisting system), stacked package fall due to corrosion, cage fall, utility pipe failure, and human error;
- geotechnical initiating events: major earthquake, and local rock fall within emplacement room; and
- external initiating events: severe weather conditions, flood, forest fire affecting the DGR Project, aircraft crash, and meteor impact.

Table 8.1-1 summarizes the initiating events considered for the DGR Project and their potential frequency of occurring at the DGR Project. Frequency is grouped into three classes:

- Possible Events: annual frequency $>10^{-2}$;
- Unlikely Events: annual frequency between 10^{-2} and 10^{-7}; and
- Non-credible Events: an annual frequency of $\leq 10^{-7}$.

Accident scenarios with an annual frequency of 10^{-6} or less are generally considered to be not credible. However, to accommodate the uncertainty in frequency estimates in this range, hazardous events with a frequency of 10^{-7} or less were considered non-credible. The risk from such accident scenarios was deemed to be acceptable, and they were screened out from further consideration. Therefore, the following initiating events are deemed non-credible and are not considered further in this report:

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20 The equivalent initiating event for abandonment and long-term performance phases are those features, events and processes (FEPs) discussed in Section 8.2.2 and in the Malfunctions, Accidents and Malevolent Acts TSD.

- criticality;
- explosion;
- tornado;
- external fire affecting the DGR Project;
- aircraft crash[21]; and
- meteor impact.

Table 8.1-1: Summary of the Initiating Events Considered

Type	Initiating Events	Frequency [a]
Operations Initiating Events	Mechanical/equipment failure	Possible
	Human error causing: • LLW package drop/hit • ILW package drop/hit [b] • Indoor fire • Inadequate package shielding	 Possible Unlikely Unlikely Unlikely
	Major vehicle accident	Unlikely
	Container failure	Unlikely
	Power failure (both grid and backup)	Unlikely
	Cage fall	Unlikely
	Criticality	Non-credible
	Explosion	Non-credible
Geotechnical Initiating Events	Major earthquake	Unlikely
	Rock fall/rock burst	Unlikely
External Initiating Events	Severe weather conditions: • Severe rainfall • Severe snow/ice • Severe wind • Lightning strike • Tornado	 Unlikely Unlikely Unlikely Unlikely (Headframe) Non-credible (Waste Package) Non-credible
	Flooding (above ground)	Unlikely
	Flooding (underground)	Unlikely

21 The potential consequences of a deliberate aircraft crash (i.e., a malevolent act) are considered in Section 8.4.

Table 8.1-1: Summary of the Initiating Events Considered (continued)

Type	Initiating Events	Frequency [a]
External Initiating Events (continued)	External fire	Non-credible
	Aircraft crash	Non-credible
	Meteor impact	Non-credible

Notes:
a Possible events were assessed to have an annual frequency of $>10^{-2}$ of occurring at the DGR; Unlikely events have an annual frequency of between 10^{-2} and 10^{-7}; Non-credible events have an annual frequency $\leq 10^{-7}$.
b Less likely than LLW package due to the smaller number of ILW packages handled at DGR.
Source: [435]

8.2 RADIOLOGICAL MALFUNCTIONS AND ACCIDENTS

Radiological accidents are defined as those that could result in the acute release of radioactivity to the environment and potentially affect the environment. Radiological accidents can also result in the release of non-radiological compounds. For continuity, the assessment of effects from radiological accidents considers both the radiological and non-radiological releases. The method applied to the assessment of site preparation, construction, operations and decommissioning (see Section 8.2.1) was different from that used to assess the abandonment and long-term performance phase (see Section 8.2.2).

8.2.1 Site Preparation and Construction, Operations, and Decommissioning Phase

During the site preparation and construction, operations, and decommissioning phases, the assessment follows the steps described below:

1. **Identification of credible initiating events:** A list of operations, geotechnical and external initiating events is identified (see Section 8.1). Credible initiating events are then defined for these phases based on the annual frequency estimated.
2. **Identification and screening of credible accidents:** The potential malfunctions and accidents that could occur as a result of credible initiating events are identified. A list of bounding accident scenarios is then developed for further assessment.
3. **Assessment:** For those bounding malfunctions and accidents, assessment is carried out to determine the significance of adverse effects on the environment, taking into account the DGR Project design, safety procedures and plans and past industry experience and records. Mitigation measures are identified to control or minimize the adverse effects on the environment, feasibility and economic factors being taken into account.

8.2.1.1 Radiological Dose Criteria

Dose Limits for Humans

The radiological doses from radionuclide releases and direct radiation must not exceed 50 mSv for DGR Project workers and 1 mSv for members of the public (at the Bruce nuclear site boundary) to meet the CNSC regulatory dose limits. In this report, comparison with these criteria is used to assess the effects of the DGR Project on humans during malfunctions and accidents.

Dose Criteria for Non-human Biota

The following dose criteria (Table 8.2.1-1) are used to assess the effects of the project on non-human biota during malfunctions and accidents.

Table 8.2.1-1: Dose Criteria

VEC	Dose Rate Criteria (Gy)
Benthic Invertebrates	1.8
Aquatic Vegetation	0.9
Pelagic Fish	0.2
Benthic Fish	0.2
Aquatic Birds	0.4
Aquatic Mammals	0.4
Terrestrial Invertebrates	0.6
Terrestrial Vegetation	0.6
Terrestrial Birds	0.4
Terrestrial Mammals	0.4
Amphibians and Reptiles	1.8

Source: [436]

8.2.1.2 Non-radiological Exposure Criteria

The L&ILW contain a variety of non-radiological species or chemicals. Table 8.2.1-2 presents the non-radiological species that could potentially be released during radiological accidents in quantities sufficient to cause effects to health of workers and members of the public.

The potential effect of the non-radiological species or chemicals shown in Table 8.2.1-2 is assessed against the values of Immediately Dangerous to Life and Health (IDLH), provided by the U.S. National Institute for Occupational Safety and Health (NIOSH) and the U.S. DOE Protective Action Criteria (PAC), which are applicable for workers and members of the public, respectively and have been accepted by the CNSC for application to this project [437]. The values of IDLH and PAC are also presented in Table 8.2.1-2. The effects of these substances on non-human biota are assessed against the Canadian Environmental Quality Guidelines.

Table 8.2.1-2: Exposure Criteria for Short-term Inhalation of Non-radiological Species

Non-Radiological Species in Waste	Workers	Public
	IDLH (μg/m³)	PAC Criteria (μg/m³)
Antimony	50,000	500
Arsenic	5,000	300
Asbestos	N/D	50
Barium	50,000	1,220
Beryllium	4,000	3.5
Cadmium	9,000	30
Chromium	25,000	25[i]
Cobalt	20,000	60
Copper	100,000	220
Lead	100,000 [a]	150
Manganese	500,000 [b]	3,000
Mercury	10,000 [c]	250 [j]
Nickel	10,000 [d]	600
Selenium	1,000	600
Strontium	N/D	125,000
Uranium	10,000 [e]	600 [f]
Zinc	500,000 [g]	3,000
Zirconium	25,000	10,000
Dioxin/Furan [h]	N/D	1.5

Notes:
a as lead monoxide
b as manganese tetroxide
c as mercurous oxide
d as nickel (II) oxide
e as uranium (soluble) and uranium (insoluble)
f as U, UO_2, U_3O_3
g as zinc oxide
h as 2,3,7,8-tetrachlorodibenzo-p-dioxin
i based on 20% CrO_3 (CrVI); PAC values are 1,000 as Cr; 10,000 as Cr_2O_3(CrIII); 5 as CrO_3 (CrVI)
j as mercury vapour; Hg_2O is not stable
PAC values adopted are PAC 1. PAC-1 criteria based on lowest of element or oxide form; expressed in terms of element content. IDLH and PAC values from [435].
N/D Criteria for workers have not been developed by NIOSH

8.2.1.3 Potential Effects

Site Preparation and Construction Phase

The site preparation and construction phase includes initial preparation of the site for future construction activities, construction of surface facilities, and excavation and construction of underground facilities. All these activities will take place in the DGR Project site and there is no L&ILW involved during this phase. Therefore, the occurrence of radiological accidents during this phase has been screened out.

Operations Phase

The operations phase includes the receipt of waste from the WWMF, and emplacement of the transferred waste into the DGR. Chapter 7 of the Preliminary Safety Report [435] documents the process followed to identify credible accident scenarios, taking into account the potential accident scenarios involving an initiating event, and potential consequences. Combinations of events were also considered, but most combinations were found to be not credible, unless they have a common cause. The resulting credible accident scenarios can be categorized into the following accident types:

- Fire: External fires (e.g., diesel fires) may cause the contents of some waste packages to ignite and burn, mainly LLW and unshielded ILW packages. Shielded ILW packages are unlikely to ignite, but the heat from an external fire can cause release of steam and volatile species (e.g., carbon-14; tritium).
- Container Breach (Low Energy): Low-height or low-speed impacts resulting in some loss of containment. Waste packages are not crushed. This category includes low-speed transfer vehicle accidents, and drops from heights less than four metres.
- Container Breach (High Energy): Drops or impacts that result in significant package failure. This category includes drops from heights greater than four metres, cage fall, and roof collapse.
- Ventilation System Failure: Loss of ventilation underground due to loss of power.
- Inadequate Shielding: Inadvertent exposure of workers to high dose rate conditions. This category includes waste packages that do not meet the DGR Project WAC for dose rate, and have not been identified as such.

The wastes are grouped into categories in terms of characteristics, and representative waste types are selected from each category for this assessment as follows in order to quantitatively assess the potential consequences of the identified accident scenarios:

- ash LLW (spillable, not combustible, contains chemical hazard elements);
- combustible LLW (combustible);
- non-processible/other LLW (not readily spillable or combustible, largest volume of waste);
- resin/filter ILW (spillable, potentially combustible); and
- retube ILW (not spillable, not combustible, activated metal).

Although retube waste packages are robust and designed not to fail under accident conditions, including drop from stacking height, they are considered in high energy breaches due to cage falls underground [435].

As L&ILW will be handled during the operations phase, radiological malfunctions and accidents may occur. They could be initiated by any of a variety of events as discussed in Section 8.1. The identification of the radiological accident scenarios considered for the operations phase is detailed in Chapter 7 of the Preliminary Safety Report [435].

Based on the qualitative estimation of the magnitude of the consequences of credible radiological accidents, those accident scenarios with the highest potential inventory at risk are identified as the bounding accidents [435]. The bounding accident scenarios developed for above-ground and underground accidents can be found in Chapter 7 of the Preliminary Safety Report [435].

Members of the Public

The predicted radiological dose, over a 1-hour exposure period, to a member of the public at the nearest Bruce nuclear site boundary for any accident scenario is much less than the 1 mSv limit. Although unlikely that a member of the public would be exposed at the Bruce Site boundary for more than one hour, longer exposures would not exceed the criteria. In addition, non-radiological species released during any accident scenario are less than the PAC 1 criteria for the public [435].

Workers

The predicted radiological doses to workers over a 5-minute exposure time for any accident scenario are much less than the 50 mSv limit. In addition, in the case of a ventilation system failure, workers exposed to tritium and carbon-14 would be subjected to air concentrations much less than the Derived Air Concentrations (DACs)[22]. Concentrations of non-radiological species released during any accident scenario are less than the IDLH criteria for workers [435].

Non-Human Biota

Detailed calculation results of dose to non-human biota for the bounding scenario are summarized in Table 8.2.1-3. As shown in Table 8.2.1-3, dose to non-human biota resulting from the bounding scenarios will be below the applicable criteria.

The effects of non-radiological contaminants on non-human biota are also assessed. The estimated concentrations of non-radiological contaminants released from the worst scenarios identified in Chapter 7 of the Preliminary Safety Report [435] are summarized in Table 8.2.1-4. These values are contaminant concentrations in soil resulting from the deposition of chemical species from the contaminated plume. It can be seen that the concentrations of non-

[22] The concentration of a given radionuclide in air which, if breathed by the reference man for a working year of 2,000 hours under conditions of light work (inhalation rate 1.2 m^3 of air per hour), results in Annual Limit on Intake.

radiological contaminants in soil are considerably below the criteria. Therefore non-human biota will not be affected.

It should also be noted that in the unlikely event of a radiological accident involving the DGR Project, unplanned releases will be controlled. The consequences of an accidental release are limited because only a small number of packages and a small quantity of L&ILW are handled at any time. Also, the design includes measures to control accidental release. Therefore, the concentrations of radionuclides in environmental media would be greatly reduced. Accidents would be cleaned up as soon as possible. Thus, the effect would be localized and for a short period of time. Accordingly, only individual flora and fauna in the immediate vicinity would be affected. The overall populations of non-human biota would remain unaffected, in particular those populations spanning Bruce County.

In summary, the assessment of potential exposure to humans (workers and members of the public) and non-human biota resulting from the malfunctions and accidents related to the operations phase of the DGR Project concludes:

- major DGR Project accidents are unlikely to occur;
- credible DGR Project accidents do not exceed radiological dose criteria for workers or members of the public;
- credible DGR Project accidents do not exceed the relevant non-radiological species criteria for workers or members of the public;
- credible DGR Project accidents do not exceed radiological dose criteria for non-human biota; and
- credible DGR Project accidents do not exceed the relevant non-radiological species criteria for non-human biota; and in all cases, the safety criteria are met by large margins.

Table 8.2.1-3: Dose to Non-human Biota for Bounding Accident – Operations Phase

VEC	Indicator	Dose (Gy)	Dose Rate Criteria (Gy)	Dose (% of Dose Limit)
Benthic Invertebrates	Burrowing crayfish	1.9×10^{-3}	1.8	0.1
Aquatic Vegetation	Variable leaf pondweed	2.2×10^{-3}	0.9	0.3
Benthic Fish	Lake whitefish	2.2×10^{-3}	0.2	1.0
	Redbelly dace			
	Creek chub			
Pelagic Fish	Spottail shiner	2.2×10^{-3}	0.2	1.0
	Smallmouth bass			
	Brook trout			

Table 8.2.1-3: Dose to Non-human Biota for Bounding Accident – Operations Phase (continued)

VEC	Indicator	Dose (Gy)	Dose Rate Criteria (Gy)	Dose (% of Dose Limit)
Aquatic Birds	Double-crested cormorant	2.9×10^{-3}	0.4	0.8
	Mallard	4.3×10^{-3}	0.4	1.2
Aquatic Mammals	Muskrat	8.2×10^{-3}	0.4	2.2
Terrestrial Invertebrates	Earthworm	6.3×10^{-5}	0.6	0.01
Terrestrial Vegetation	Eastern white cedar	5.6×10^{-2}	0.6	9.6
	Common cattail			
	Heal-all			
Terrestrial Birds	Bald eagle	2.7×10^{-2}	0.4	7.5
	Yellow warbler	6.3×10^{-4}		0.2
	Wild turkey	9.2×10^{-2}		25.1
	Red-eyed vireo	8.1×10^{-4}		0.2
Terrestrial Mammals	White-tailed deer	1.7×10^{-1}	0.4	46.2
	Northern short-tailed shrew	4.6×10^{-6}	0.4	0.001
	Red fox	2.1×10^{-1}	0.4	57.2
Amphibians & Reptiles	Midland painted turtle	2.0×10^{-3}	1.8	0.1
	Northern leopard frog			

Table 8.2.1-4: Estimated Non-radiological Contaminants in Soil – Operations Phase

Non-radiological contaminants [a]	Concentration in air ($\mu g/m^3$) [b]	Deposition velocity (m/s) [c]	Concentration in soil (μg/g) [d]	Criteria-soil (μg/g)
Chromium	12.5	1.56×10^{-2}	1.68×10^{-2}	67
Nickel	12	1.56×10^{-2}	1.62×10^{-2}	37

Notes:
a The contaminants with the highest ratio of air concentration to criterion are listed
b The concentration in air is derived based on the Preliminary Safety Report [435]
c The deposition velocity is taken from CSA N288.1-08 [438]
d It is based on an assumption of 24- hour deposition

8.2.1.4 Decommissioning Phase

Decommissioning of the DGR Project includes all activities required to close and seal the repository and remove the above-ground infrastructure. This includes dismantling the equipment, sealing the repository shafts and decontaminating and demolishing the surface facilities. Credible radiological malfunctions and accidents could occur during the decommissioning of the DGR Project. However, the L&ILW wastes of concern have been emplaced in the underground facilities and are isolated from the environment. It is considered that radiological malfunctions and accidents during decommissioning are bounded by those identified for the operations phase. Therefore, no further assessment of the radiological malfunctions and accidents for DGR Project decommissioning is warranted. Mitigation strategies and emergency procedures for operations will remain in place during decommissioning in case of the occurrence of potential accidents.

8.2.2 Abandonment and Long-term Performance Phase

The long-term performance assessment (Section 9) considers the normal (or expected) evolution of the site and facility with time based on reasonable extrapolations of present-day site features and receptors' lifestyles (i.e., the Normal Evolution Scenario), and including its expected degradation (loss of barrier functions) with time. In accordance with Regulatory guidance [439], additional scenarios are considered to examine the impacts of unlikely disruptive events that could lead to possible penetration of barriers and abnormal degradation and loss of containment (Disruptive Scenarios). As such, the Disruptive Scenarios consider unlikely "what if" cases that are designed to test the robustness of the DGR system to scenarios that result in the breaching or extreme degradation of geosphere and/or engineered barriers. The uncertainties associated with the future evolution of the DGR system are assessed in part through these scenarios, and in part through sensitivity cases considered within each scenario.

As there will be no physical works and activities during the abandonment and long-term performance phase, there is no potential for non-radiological accidents. Disruptive events that bypass the natural and engineered baseline could result in the release of radiological or non-radiological compounds. For continuity, the assessment of effects from the disruptive events considers both the radiological and non-radiological releases.

During the abandonment and long-term performance phase, the assessment considers the following steps:

1. **Identification of disruptive events:** Disruptive events considered for this phase are identified in the postclosure safety assessment [435;440].
2. **Screening of disruptive events:** Through a systematic study of potential external features, events and processes (FEPs) that could drive the evolution of the repository system, the postclosure safety assessment [435;440] identified four disruptive scenarios, which consider events that could lead to possible penetration of barriers and abnormal degradation and loss of containment. These disruptive scenarios are unlikely or "what if" cases that test the robustness of the DGR Project.
3. **Assessment of representative disruptive events:** The disruptive events were then assessed to investigate the effects on humans and non-human biota (Section 8.2.2.3).

The basis of the assessment of the representative events, including the assumptions and models for the calculation of doses to humans and the effects on non-human biota, can be found in Chapter 8 of the Preliminary Safety Report [435].

8.2.2.1 Radiological Dose Criteria

Dose Limits for Humans

In this report, comparison with the dose criterion of 1 mSv/a is used for radiological exposure of humans under credible disruptive scenarios during the abandonment and long term performance phase [435]. If calculated doses exceed 1.0 mSv/a, the acceptability of results from that scenario is examined on a case-by-case basis, taking into account the likelihood and nature of the exposure, uncertainty in the assessment, and conservatism in the dose criterion.

Dose Criteria for Non-human Biota

The screening-level acceptance criteria, expressed as No-Effect Concentrations (NECs), are used as radiological criteria for non-human biota for this phase. The criteria, listed in Table 8.2.2-1, have been accepted by the CNSC for postclosure safety assessment purposes.

Table 8.2.2-1: No-Effects Concentrations for Non-human Biota

Radionuclide	Media			
	Water (Bq/L)	Soil (Bq/kg)	Sediment (Bq/kg)	Groundwater (Bq/L)
Carbon-14	0.24	350	280,000	1,600,000
Chlorine-36	3.1	5	41,000	300,000
Zirconium-93	1.8	280,000	5,000,000	5,900,000
Niobium-94	0.016	130	26,000	36,000
Technetium-99	0.8	60	3,000,000	810,000
Iodine-129	3.2	19,000	1,200,000	900,000
Radium-226	0.00059	280	930	590
Neptunium-237	0.058	50	1,100	580
Uranium-238	0.023	49	66,000	560
Lead-210	5.0	3,700	6,300	180,000
Polonium-210	0.007	30	110,000	540

8.2.2.2 Non-radiological Exposure Criteria

The non-radiological exposure criteria, which have been reviewed and accepted by the CNSC [437;441], are consistent with the recommendations of the CNSC Regulatory Guide G-320 [439]. The benchmark concentrations are taken from federal and provincial environmental objectives and guidelines, in particular the Environmental Quality Guidelines published by the Canadian Council of Ministers of the Environment (CCME). These criteria, presented in Table 8.2.2-2, apply to humans and terrestrial and aquatic biota. These are based on the most conservative guideline concentration for surface water, groundwater, soil and sediment from CCME and Ministry of the Environment (MOE) guidelines [442;443;444]. For some element of potential interest, no criteria are available from CCME or MOE. In these cases, the exposure is evaluated based on surface water criteria from other sources [445].

Table 8.2.2-2: Environmental Quality Standards for Non-radioactive Contaminants

Species	Groundwater (µg/L)	Soil (µg/g)	Surface Water (µg/L)	Sediment (µg/g)
Silver	0.3	0.5	0.1	0.5
Arsenic	13	11	5	6
Boron	1,700	36	200	—
Barium	610	210	—	—
Beryllium	0.5	2.5	11	—
Bromine	—	—	1,700	—
Cadmium	0.5	1	0.017	0.6
Chlorobenzene	0.01	0.01	0.0065	0.02
Chlorophenol	0.2	0.1	0.2	—
Cobalt	3.8	19	0.9	50
Chromium	11	67	1	26
Copper	5	62	1	16
Dioxins/Furans	1.5×10^{-5}	7×10^{-6}	0.3	—
Gadolinium	—	—	7.1	—
Hafnium	—	—	4	—
Mercury	0.1	0.16	0.004	0.2
Iodine	—	—	100	—
Lithium	—	—	2,500	—
Manganese	—	—	200	—
Molybdenum	23	2	40	—
Niobium	—	—	600	—

Table 8.2.2-2: Environmental Quality Standards for Non-radioactive Contaminants (continued)

Species	Groundwater (µg/L)	Soil (µg/g)	Surface Water (µg/L)	Sediment (µg/g)
Nickel	14	37	25	16
PAH	0.1	0.05	0.0008	0.22
Lead	1.9	45	1	31
PCB	0.2	0.3	0.001	0.07
Antimony	1.5	1	20	—
Scandium	—	—	1.8	—
Selenium	5	1.2	1	—
Tin	—	—	73	—
Strontium	—	—	1,500	—
Tellurium	—	—	20	—
Thallium	0.5	1.0	0.3	—
Uranium	8.9	1.9	5	—
Vanadium	3.9	86	6	—
Tungsten	—	—	30	—
Zinc	160	290	20	120
Zirconium	—	—	4	—

Note:
— No values available
Source: [435]

8.2.2.3 Potential Effects

The evaluation of credible disruptive events during the abandonment and long-term performance phase are assessed fully in the Postclosure Safety Assessment [440], and summarized in Table 8.2.2-3.

Table 8.2.2-3: Disruptive Scenarios during the Abandonment and Long-term Performance Phase

Disruptive Scenarios	Brief Description
Human Intrusion	Inadvertent intrusion through the geosphere into the DGR Project by an exploration borehole at some time after control of the site is no longer effective. In this "what if" case, contaminants are assumed to be released and humans could be exposed via three pathways: • direct release to the surface of gas and slurry prior to sealing of the borehole; • retrieval and examination of core contaminated with waste; and • the long-term release of contaminated water from the repository into permeable geosphere horizons via the exploration borehole. These releases could result in the exposure of the drill crew or people who might occupy the DGR Project site subsequent to the intrusion event.
Severe Shaft Seal Failure	The shafts represent a potentially important pathway for contaminant release, and therefore the project design includes specific measures to provide a good shaft seal, taking into account the characteristics of the DGR Project system. This "what if" scenario represents very poor performance of the shaft seals and repository/shaft excavation damaged zone (EDZs).
Poorly Sealed Borehole	Several site investigation/monitoring boreholes have been sunk in the vicinity of the DGR Project down to and beyond the depth of the DGR Project during site characterization. This scenario considers the consequences of one of the boreholes not being properly sealed. The poorly sealed borehole provides an enhanced permeability connection between the level of the repository, the overlying groundwater zones and the biosphere, thereby bypassing some of the natural geological barriers to contaminant migration from the DGR Project.
Vertical Fault	There is strong geological, hydrogeological, and geochemical evidence that transmissive vertical faults/fracture zones do not exist within the footprint or near the vicinity of the DGR. Despite this evidence, the Vertical Fault Scenario considers "what if" there was a transmissive vertical fault, either undetected or representing the displacement of an existing structural discontinuity, in close proximity to the repository. The fault extends from the Precambrian basement to the permeable Guelph formation, thereby bypassing part of the natural barrier to contaminant migration from the DGR.

Source: [435]

Further details on the assumptions and model used to predict these scenarios are provided in Section 9.

Humans

The likelihood of the disruptive events that could initiate the Disruptive Scenarios identified in Table 8.2.2-3 is expected to be very low. In actuality, the likelihood of the scenarios that could occur is even lower since the Disruptive Scenarios assessed herein make additional conservative assumptions [435]. The key results for different scenarios are as described:

- For the Human Intrusion Scenario, if a borehole is drilled into the repository and gases and material from the repository are not appropriately contained, the calculated doses could be about 1 mSv for the drill crew and for a future person farming on the contaminated site. The likelihood of drilling into the repository in any given year is very low due to the lack of mineral resources and the repository's small footprint and depth, and high contaminant releases are unlikely when following standard deep drilling practices. Thus the peak risk of serious health effects is low, and much less than the reference health risk value of 10^{-5}/a.
- For the Severe Shaft Seal Failure Scenario, the maximum calculated doses are about 1 mSv/a, based on immediate failure of 500 m of low-permeability shaft seals (to 10^{-9} m/s hydraulic conductivity), reduced sorption in the shafts, increased degradation of shaft EDZs, and assuming a family is farming directly on top of the shafts (including a house located on the main shaft). The scenario is very unlikely. Therefore the risk from the severe shaft seal failure scenario is low.
- Calculated peak annual doses for the Poorly Sealed Borehole Scenario and the Vertical Fault Scenario are about several orders of magnitude less than the dose criterion.
- Additional cases were evaluated to determine what it would take to have a disruptive scenario with larger impacts. For the Human Intrusion Scenario, the borehole would have to be extended down to the Cambrian and then poorly sealed, so that there was water flowing up the borehole, through the repository and to the surface. For the Severe Shaft Seal Failure Scenario, the entire shaft would need to degrade by 4 to 5 orders of magnitude below design basis to a hydraulic conductivity of 10^{-7} m/s, about equivalent to fine silt and sand. In these cases, the peak doses to someone living on top of the repository site could be tens of milliSieverts.
- The primary risk in the disruptive scenarios is from release of carbon-14 containing gas from the repository. The potential impacts therefore decrease to well below the dose criterion after about 60,000 years due to carbon-14 decay. Since glaciation at the DGR site is not likely to occur prior to then, there is little risk from glaciation affecting these maximum peak doses from disruptive scenarios.
- Finally, it is noted that the impacts of the disruptive scenarios are local. Even if the entire carbon-14 inventory were released as gas within a one year period, then dose impacts for people living around the Bruce nuclear site would be around or below the public dose criterion.

Non-human Biota

For post-closure Disruptive Scenarios, the potential effects on non-human biota are low. Most contaminants (i.e., all non-radiological elements and most radionuclides) are likely to remain well below their respective screening criteria [435]. There could be local exceedance of screening criteria for some radioactive species relating to the Human Intrusion Scenario and the Severe Shaft Failure Scenario. In particular, carbon-14 and niobium-94 would locally exceed soil criteria by a factor of 20 if the drilling debris from the repository were to be dumped on the surface at the DGR Project site in the event the Human Intrusion Scenario were to occur. Carbon-14 would locally exceed the surface water screening criterion by a factor of 1.4 if the event of the Severe Shaft Failure Scenario occurs. Since these exceedances are local, the screening criteria are conservative, and the scenarios are very unlikely, the risk to non-human biota is determined to be low.

8.2.3 Mitigation, Contingency Plans and Emergency Procedures

The effects on human and non-human biota from potential accidents at the DGR Project were found to be generally small. The effect can be minimized or controlled through implementation of the following mitigation measures:

- minimization of combustible materials and ignition sources, especially near waste packages;
- use of overpacking and shielding on higher activity packages;
- limited number of packages handled in any transfer;
- limited equipment speeds;
- fire detection and suppression equipment, such as automatic fire suppression systems on diesel transfer equipment;
- appropriate follow-up measures corresponding to the results of contamination and dose rate monitoring;
- access to refuge stations and safety equipment;
- appropriate worker training and operating procedures; and
- emergency communication systems.

These measures have already been considered within the design and can be further emphasized during detailed design and later during operation. Contingency plans will also be in place, and emergency response, including mine rescue, will be available to protect the workers.

8.3 NON-RADIOLOGICAL MALFUNCTIONS AND ACCIDENTS

Non-radiological accidents refer to those that involve only non-radiological substances and hence do not have the potential to release radiological substances or have any radiological effects on the environment or human beings. These include things such as the spill of chemicals, lubricants and oils, fires, and explosions.

The assessment of non-radiological accidents follows the steps described below:

1. **Identification of credible initiating events:** Credible accidents are identified based on literature review and analysis of past and current practices in the mining and nuclear industries [435;446]. It is conservatively assumed in this report that all conventional accidents that could occur as a result of credible initiating events (see Section 8.1) are credible.
2. **Screening of Credible Non-radiological accidents:** Consequences of effects of non-radiological accidents are considered separately for members of the public, workers and the environment. Therefore, the credible non-radiological accidents were screened taking into account the different receptor groups.
3. **Assessment of Non-radiological accidents:** The bounding non-radiological accidents are then assessed in the context of each of the environmental components, members of

the public and workers to determine their likelihood to result in adverse effects on the various VECs. The likelihood of an adverse effect occurring was determined by taking into account control and mitigation measures available.

8.3.1 Screening of Conventional Malfunctions and Accidents

8.3.1.1 Environment (including Non-human Biota)

Each credible malfunction and accident identified in Table 8.3.1-1 was reviewed to determine if it has the potential to interact with the environment. Those accidents associated primarily with worker hazards (i.e., occupational safety) are considered in Section 8.3.2.4.

Table 8.3.1-1: Screening of Conventional Accidents on the Environment

Malfunctions and Accidents	Phase	Screening
Fire	• Site preparation and construction phase • Operations phase • Decommissioning phase	An above-ground fire was considered in Section 8.2. This evaluation considered non-radiological effects in addition to radiological effects. No adverse effects were identified, and effects would be limited to the Bruce nuclear site. Given the range of compounds associated with the fire considered in Section 8.2, this would likely bound the effects of a fire of brush or construction materials. No further consideration is required in this section.
Explosion/ detonation	• Site preparation and construction phase	An on-site explosion may occur during the site preparation and construction phase. Effects would likely be restricted to the Bruce nuclear site. However, this scenario is advanced for further consideration.
Electrical accidents	• Site preparation and construction phase • Operations phase • Decommissioning phase	An electrical accident could occur within the DGR Project site and may lead to a fire. A fire is considered separately in this table. Potential effects of an electrical accident on workers (e.g., electrical shock) are considered in Section 8.3.2.4. Therefore, no further consideration required in this section regarding potential effects on the environment.

Table 8.3.1-1: Screening of Conventional Accidents on the Environment (continued)

Malfunctions and Accidents	Phase	Screening
Spill of fuel, chemicals, lubricants or oils	• Site preparation and construction phase • Operations phase • Decommissioning phase	A spill of fuel, chemicals, lubricants or oils could occur on the DGR Project site. This accident is advanced for further consideration.
Vehicle accident	• Site preparation and construction phase • Operations phase • Decommissioning phase	An on-site vehicle accident could result in a fire, spill or explosion. These possible outcomes of a vehicle accident are considered separately in this table. Potential effects of a vehicle accident on workers are considered in Section 8.3.2.4. Therefore, no further consideration of a vehicle accident is required.

8.3.1.2 Members of the Public

Similar to the screening of effects on the environment described above, each credible malfunction and accident identified was also screened to determine if it could reasonably be expected to result in an adverse consequence to members of the public that would warrant further analysis. Only accidents with potential off-site consequences could affect members of the public, and only a fire or a spill could potentially have off-site effects. As described in Table 8.3.1-1, a fire was considered in Section 8.2 and found to have no adverse effects on- or off-site. Therefore, the scenario advanced for assessment is a spill of fuel, chemicals, lubricants or oils during the site preparation and construction, operations, and decommissioning phases.

8.3.1.3 Workers

Occupational hazards to workers resulting from malfunctions and accidents are described in the Preliminary Conventional Safety Assessment [446]. The assessment was conducted systematically using a screening process hazard analysis method combined with a job hazard analysis approach [446]. Although the hazard assessment considered both occupational safety and accidents, only the latter are discussed in this TSD. Occupational safety is discussed in Appendix C. The hazards and corresponding potential consequences during the decommissioning phase are considered to be similar to those identified for the site preparation and construction phase.

8.3.2 Potential Effects

8.3.2.1 Spill of Fuel, Chemicals, Lubricants or Oils

As noted in Table 8.3.1-1, malfunctions and accidents scenarios involving a spill could include a vehicle accident, failure of on-site storage equipment (i.e., a storage tank) or operational errors. For the purpose of the assessment, the likely maximum volume of a spill is assumed to be approximately 4,500 L diesel fuel, 200 L of a chemical or 100 L of a lubricant or oil. The consequences of a spill would be the same, regardless of the project phase they occur in, therefore, the discussion below applies to each of the site preparation and construction, operations, and decommissioning phases.

Atmospheric Environment

In the event of a spill, equipment used to respond to the spill would result in tailpipe, dust and noise emissions that may interact with air quality and noise. However, emissions associated with the support and response equipment are similar to those identified for the existing operations at the WWMF, and are therefore not expected to result in measurable increases to air or noise emissions. Fuel represents the largest potential spill volume. Spilled fuel also has the potential to volatilize; however, the majority of fuel used is diesel, which is less likely to volatilize than gasoline. Therefore, the effects of such a spill are likely to be very localized and not measurable. Chemical spills would also be of a small volume (i.e., 200 L) and would represent a localized on-site issue even if they volatilize. Accordingly, no likely measurable changes to either air quality or noise are predicted to result from spills during the DGR Project and no further consideration is warranted.

Hydrology and Surface Water Quality

It is assumed these spills would occur in the boundaries of the DGR Project site and thus would be remote from any water bodies (e.g., Stream C, Lake Huron) with the exception of the site drainage and North and South Railway Ditches. A spill could potentially occur during the construction of the crossing from the WWMF to the DGR, which could potentially affect the water quality in the North or South Railway Ditches. The likelihood of a fuel spill occurring in the immediate vicinity of the North and South Railway Ditches is very low as fuel storage areas are not located near these ditches. During operations, a spill could potentially occur during the on-site transfer of wastes from the WWMF to the Waste Package Receiving Building, and could potentially affect the water quality in the North and South Railway Ditch if the spill occurred while crossing the abandoned rail bed. A spill to one of the on-site ditches would be collected and directed via the stormwater management system to the stormwater management pond where it can be held until it is treated or determined to be suitable for discharge.

As described in Section 6.3, there was no observed flow in the North and South Railway Ditches during 2007 and 2009 field programs (i.e., it is typically stagnant and/or dry); therefore, a spill would likely be contained to the immediate environment and would not reach Lake Huron or Stream C.

To mitigate the effects of spills, appropriately equipped and trained on-site spills response teams will be available at all times as part of emergency response programs. For example, a spill of diesel fuel would be mitigated by quickly assessing the situation for any immediate health and safety risks to the spills response team, on-site workers and the public by controlling the source of the spill and notifying appropriate regulatory agencies, by deploying containment booms to surround and contain the spill and, finally, by implementing an effective cleanup plan that would likely involve the use of specialized equipment to pump the diesel fuel into secure containers. These measures would contain a spill within the Project Area.

Therefore, taking into account the above, it is unlikely that there would be adverse effects on surface water quality.

Geology

Releases of fuel, chemicals, lubricants and oils can affect soil quality and groundwater quality through the introduction of contaminants into the sub-surface, including direct pathways to subsurface soils and/or bedrock groundwater (e.g., because of excavations, trenches).

Measurable changes to soil quality and/or groundwater quality can occur over the short-term to long-term as a result of a release of contaminants in an accident or malfunction. However, through the use of best management practices inherent in the DGR Project, through operating in compliance with current Ontario regulations, and through the implementation of protocols for the transportation, handling, storage and process systems (which are already in place at the Bruce nuclear site), it is expected that conventional spills can be mitigated such that any adverse effects to soil and groundwater quality are unlikely.

The majority of spills would be recognized and responded to immediately because of the inherent nature of construction activities (i.e., the malfunction/accident occurs while workers are present), and, therefore the likelihood of an accident or malfunction creating a persistent adverse effect to soil quality and/or groundwater quality is considered to be minimal. During operations, there will be an even lower likelihood of a spill affecting soil and groundwater quality as many of the surface facility areas will all be paved and there will be limited opportunity for interaction with the subsurface. Therefore, taking into account the above discussion, it is unlikely that there would be adverse effects on geology.

Aquatic Environment

Accidental spills could affect the aquatic environment. Construction equipment is not expected to be near the North or South Railway Ditch, Stream C, wetland communities or Lake Huron for the majority of the DGR Project. However, equipment will be used in proximity to the railway ditches during construction of the crossing of the abandoned rail bed. The occurrence of a spill on or in the vicinity of the crossing is expected to be unlikely. Additionally, any spills would be responded to quickly and no adverse effects on surface water quality are likely. Therefore, it is unlikely that there will be an adverse effect on the aquatic environment VECs if a spill occurs.

Terrestrial Environment

Conventional malfunctions and accidents could affect plants or wildlife if they come in contact with the spilled contaminant. This could lead to changes in the health of individual plants and wildlife through toxic effects if chemicals are absorbed, inhaled or ingested.

Measures for spill containment, spill emergency response and environmental protection will be in place before any potentially hazardous materials are brought on-site. Additionally, the spill would be confined to within the DGR Project site as discussed in the previous sections. Vegetation will have been cleared in the very early stages of the site preparation and construction phase and animals will likely avoid the area once construction activities commence due to lack of habitat and the presence of workers. Therefore, there is no likely adverse effect on the terrestrial environment VECs as a result of a spill. As noted above, no adverse effects on other environmental components have been identified; therefore there are no pathways through which indirect effects on the terrestrial environment VECs could occur.

Socio-economic Environment

There is no likely direct interaction with the socio-economic environment VECs as a result of a spill. As noted above, no adverse effects on other environmental components have been identified that would cause an indirect effect on the socio-economic environment VECs.

Aboriginal Interests

There is no likely direct interaction with Aboriginal Interests VECs as a result of a spill. As noted above, no adverse effects on other environmental components have been identified that would cause an indirect effect on Aboriginal Interests VECs.

8.3.2.2 Explosion

In the event of an explosion, there would be a localized release of emissions that may interact with air quality and noise. However, these emissions would be similar to those predicted as part of normal blasting during construction. Emissions associated with the support and response equipment are similar to those identified for the existing operations at the WWMF, and are therefore not expected to result in measurable increases to air or noise emissions. No off-site effects are anticipated on air quality.

There are no likely interactions with hydrology, surface water, soil or groundwater quality. An explosion would not likely directly affect aquatic and terrestrial biota unless they were in the immediate vicinity of the accident, although some nearby individuals could be startled by the sudden loud noise associated with an explosion. The DGR Project site will be fenced and the site cleared very early in the project schedule, therefore, it is unlikely that there will be animals in the immediate area. In addition, an explosion associated with blasting is likely to be located below ground surface, away from the receiving environment.

An explosion on the Bruce nuclear site may have an effect on people's feelings of well-being and sense of safety and security. However, an explosion associated with the DGR Project would be limited to the DGR Project site, and will not result in the release of radioactivity. Therefore, an explosion would not likely result in a measurable change in people's feelings.

Therefore, no adverse effects on the environment are likely as a result of an explosion. Effects on workers are considered in Section 8.3.2.4.

8.3.2.3 Members of the Public

As described in Section 8.3.1.2, the only scenario with potential off-site effects advanced for discussion is a spill during the site preparation and construction, operations or decommissioning phases. As described in Section 8.3.2.1, no likely adverse effects are identified on air, surface water or groundwater quality. Only vegetation within the immediate vicinity of the spill could be contaminated, but the public cannot access the Bruce nuclear site so there is no potential that the public could come into direct contact with any potentially contaminated vegetation.

Therefore, a spill at the DGR Project site will not have an adverse effect on members of the public.

8.3.2.4 Effects on Workers

The assessment of hazards to workers was conducted systematically using a screening process hazard analysis method combined with a job hazard analysis approach [446]. The assessment of hazards forms the basis for establishing priorities related to mitigation measures and recommendations for the DGR Project, and assists in determining the safety significance of the hazards associated with certain activities.

The non-radiological hazards to workers resulting in personal injury or death identified for the DGR Project are listed in Table 5.3.3-1 of the Malfunctions, Accidents and Malevolent Acts TSD and are summarized as follows:

- explosive atmosphere;
- fire (i.e., brush fire, construction material fire, equipment fire);
- oxygen deficiency, accumulation of hazardous aerosols and hazardous atmosphere;
- dropped load from cranes and shaft hoisting, crane failure and uncontrolled load on the crane impacting equipment or personnel;
- shaft damage and hoist failure;
- electric shock, worker burns, cuts, bruises, scrapes, slips, trips and falls;
- damaged communications cables, water lines;
- crush or amputation injury;
- rock falling from roof or walls (rock burst);
- falling from scaffold, ladder or elevated platform;
- structural collapse;
- falling material from scaffold or elevated platform;
- drowning as a result of shaft flooding;
- traffic accident, heavy equipment collision and vehicle hitting personnel;
- caving/trench wall collapse;

- toppling of unstable staking pile;
- collapse or rolling of staked pipes;
- exposure to noxious fumes, dust and gasses, and blasting dust and fumes;
- unexpected detonation, exposure to blast concussion and flying debris; and
- exposure to welding flash, toxic or designated substance.

Mitigation and control measures will be implemented as part of the DGR Project. The mitigation and control measures identified for non-radiological hazards to workers are as follows:

- slow rates of gas generation expected, ventilation, and end walls reduce levels of contaminants in air;
- confined space entry program;
- monitoring;
- critical lift procedure and lift planning;
- qualified workers, work permits, worker awareness, personal protective equipment and operator training;
- hoisting logbooks/records;
- planned/preventative equipment maintenance;
- equipment design installation and operation to meet established crane and hoisting safety permits;
- safe work code practice;
- live electrical line work procedures;
- lock-out/tag-out procedure;
- emergency response capability;
- access to refuge stations, multiple exits and safety equipment;
- emergency communication systems;
- fire detection and suppression equipment;
- fuel dispensing procedure, good housekeeping and hot work permit;
- ground disturbance permits; pre-excavation ground survey;
- shaft sinking safe work practices;
- ground control standards, loose rock scaling work instruction, inspection protocol;
- machine guarding, spotters for mobile equipment, barricading off of work areas and controlled access;
- flash back arrestors; and
- WHMIS.

The effects from the malfunctions and accidents scenarios originating from identified hazards can be minimized through implementing these measures as part of the DGR Project. Provided that the mitigation and control measures are used, it is anticipated that there will be no unacceptable risks to workers resulting from the DGR Project.

8.3.3 Preventive Measures, Contingency Plans and Emergency Procedures

Based on the assessment, it is concluded that residual adverse effects of all malfunctions and accidents identified will be unlikely. However, in case of the occurrence of accidents such as fire or spills, NWMO (site preparation and construction) and OPG (operations) will establish preventive measures, contingency plans and emergency procedures to prevent incidents and minimize the effects of a fire or spill. OPG's Nuclear Waste Management Program requires that activities involving the handling, processing, transportation and storage of radioactive materials be performed in a manner that protects the workers, the public and the environment, and ensures compliance with applicable regulatory and licence basis requirements [447].

OPG has a number of environmental programs and emergency response procedures for the operation of the WWMF established and implemented under OPG Environmental Management System in accordance with the requirements of ISO 14001, OHSAS 18001, and industry best practices [448;449;450;451;452]. OPG will have programs in place for the DGR Project similar to those at the WWMF and that comply with the above standards and practices, as well as applicable Canadian standards, such as CSA Z16000-08 *Emergency Management and Business Continuity Programs* and CSA Z-731-03 *Emergency Preparedness and Response* [453;454].

In particular, the control and safe handling of hazardous materials are covered under various aspects of OPG's Nuclear Waste Management Division (NWMD) Environment Health and Safety Program [449] and OPG's Environmental Policy [455]. The handling of hazardous materials must meet provincial legislation, particularly the Occupational Health and Safety Act and the Environmental Protection Act for non-radiological hazards. Material Safety Data Sheets on all hazardous materials used on the DGR Project site will be available as required by the Workplace Hazardous Materials Information System (WHMIS). Spills management and response for the WWMF [456], or equivalent, will be extended to the DGR Project.

8.3.3.1 Fire Protection and Emergency Response

The Bruce nuclear site is served by its own internal Emergency Response Team, medical aid and fire prevention and response capabilities provided by Bruce Power. In addition, a comprehensive on- and off-site emergency response plan is in place. Response teams have been trained and are equipped to respond to potential emergencies such as personal injury, fire or non-routine releases of radioactivity. The municipal fire department, the Regional Medical Officer of Health and Kincardine's health and safety service providers work co-operatively with OPG and Bruce Power to ensure that additional support and response capability is in place.

Trained and qualified mine rescue teams will be provided as required by the mining Regulations. If necessary, the mine rescue team will evacuate workers after a fresh air passage can be guaranteed to the surface. Back up will be provided by nearby mine rescue teams through mutual assistance agreements.

8.3.3.2 Spills Response

To mitigate the effect of spills, appropriately equipped and trained on-site spills response teams will be available at all times as part of emergency response procedures, as described in the EA Follow-up Monitoring Program. The malfunctions and accidents prevention follow-up monitoring program consists of a checklist of good industry management practice that will be verified in the field (see DGR EA Follow-up Monitoring Program for more information).

The environmental management plan will include the site spills and release response plan. During the operations phase, environmental policies, programs and procedures will be implemented consistent with the requirements of OPG's existing Environmental Policy (OPG-POL-0021 [455]) and Spills Management Policy (OPG-POL-0020) [457]. Spills management and response will be consistent with those outlined in the NWMD's Western Spill Management Procedure [456]. Decommissioning is planned many years in the future; however, it is assumed an environmental management plan, including policies and procedures to address potential spills will be in place. Further, an EA will be required prior to receipt of a decommissioning licence.

8.4 MALEVOLENT ACTS

Malevolent acts are defined as those events where the initiating event for a malfunction or accident was an intentional attempt to cause damage to the facility. There are four broad categories of potential malevolent acts: threats of violence, sabotage, theft and attack. Threats and theft are not considered in this assessment.

Malevolent acts are assessed using methods different from those used for conventional malfunctions and accidents. As malevolent acts cannot necessarily be bounded by specified event scenarios, a high level, qualitative assessment of these events is provided in this document.

The DGR Project is entirely contained within the Bruce nuclear site and will continue to be well protected by the Bruce nuclear site security forces from the start of site preparation and construction through to decommissioning of the facility.

Security measures at the Bruce nuclear site, within which the DGR Project is located, include:

- facility fences and controlled access to both the Bruce nuclear site and the DGR Project site;
- emergency response and preparedness planning; and
- security screening for all personnel working at the DGR Project facility consistent with the standard requirement for workers within the Bruce nuclear site.

Potential malevolent acts are considered for each DGR Project phase: site preparation and construction; operations; decommissioning; and abandonment and long-term performance.

8.4.1 Potential Effects

8.4.1.1 Site Preparation and Construction Phase

Radiological Effects

The site preparation and construction phase includes initial preparation of the site for future construction activities, construction of surface facilities, and excavation and construction of underground facilities. Since there will be no radioactive waste on-site during this phase, malevolent acts with potential radiological effects can be screened out.

Non-radiological Effects

The site preparation and construction phase of the DGR Project will present a range of conventional (non-radiological) work-place hazards similar to those presented by comparable large construction and mining projects.

Sabotage may precipitate malfunctions and accidents considered within the conventional safety assessment [446], in which case the consequences are bounded by that assessment. Section 8.3.2.4 summarizes potential effects on the health of workers because of potential malfunctions and accidents.

All attack scenarios have the potential to produce significant consequences. Public consequences would be bounded by the accident scenarios considered within the assessment of non-radiological accidents (Section 8.3), possibly by the estimated consequences of a large fire at the facility. For workers positioned at the periphery of an attack, consequences may be bounded by the accidents considered within the safety assessment. In the immediate vicinity of an attack, worker fatalities are possible.

8.4.1.2 Operations Phase

Radiological Effects

The operations phase includes the receipt of radioactive waste from the WWMF and emplacement of radioactive waste in the DGR. In general, DGR Project waste package integrity and worker safety do not depend on power, ventilation or control systems (or can tolerate extended outages). This helps to reduce the vulnerability of the project to sabotage. In addition, the DGR Project is within a fenced and monitored area within the overall Bruce nuclear site fence. It will be well protected by Bruce nuclear site security. Scenarios are postulated in the Malfunctions, Accidents and Malevolent Acts TSD.

Transfer of ILW from the WWMF to the DGR Project, including any staging at surface prior to emplacement, may present a vulnerability to malevolent acts. This risk can be mitigated through procedures, such as controlling the total amount of radioactivity in transit or queued for emplacement, and use of indoor staging areas to make it more difficult to estimate the total amount of material in queue. As the wastes are emplaced underground, they become protected from attack by several hundred metres of rock.

Non-radiological Effects

The access to underground is through either the main shaft, which is centrally located and monitored, or the ventilation shaft. There will be multiple mechanisms available for communicating with underground staff. There will also be two exits and several refuge locations. These measures will minimize the risk of malevolent acts having an effect on personnel.

Explosives would not be on-site during operations. Some of the conventional work place hazards present during construction will persist into the operations phase as documented in Section 8.3.2.4. The potential non-radiological consequences of malevolent acts will remain largely unchanged. Bounding consequences of malevolent acts during construction of the DGR Project will continue to be bounding during operations.

8.4.1.3 Decommissioning Phase

Radiological Effects

While reduced project activities will limit opportunities for malevolent acts and reduce the potential consequences, less worker presence could increase the potential for malevolent acts to occur. However, all radioactive wastes would have been emplaced in the repository and isolated from the environment by several hundred meters of rock. Therefore, the potential radiological effects of a malevolent act during decommissioning are considered bounded by those of the operations phase.

Non-radiological Effects

Opportunities for sabotage and attack during decommissioning will be limited and consequences are considered to be bounded by those of the operations phase.

8.4.1.4 Abandonment and Long-term Performance Phase

Over the long term, deep geologic disposal of L&ILW provides the best possible security against malevolent acts. Placing the waste a nominal 680 m below the surface presents significant impediments to any attempt to retrieve or otherwise disturb the emplaced materials.

8.4.2 Consequences of Malevolent Acts

The Preliminary Safety Report [435] considers the consequences of container breach, cage fall, and fires. Therefore, the consequences of many credible malevolent acts are already represented or bounded within the scenarios described in Section 8.2 and 8.3, the Malfunctions, Accidents and Malevolent Acts TSD, and in the Preliminary Safety Report [435].

8.4.2.1 Consequences to Non-human Biota

The malevolent acts considered in this assessment have the potential to affect non-human biota that use the Bruce nuclear site. This includes individual members of populations of terrestrial and aquatic biota identified in this EA as VECs. Since the greatest effect of a malevolent act would be limited to the near vicinity of the DGR and because small quantities of radioactive material are stored at surface at the DGR, the overall populations of terrestrial and aquatic biota would remain unaffected in the event a malevolent act against the DGR Project is carried out. In particular, those species with populations spanning Bruce County would be unaffected.

8.4.2.2 Consequences to Members of the Public

The public consequences of container breach, cage fall and fires, including exposure to radionuclides and non-radioactive species, have been shown to be small in the Preliminary Safety Report [435].

Less credible acts, such as use of explosives also result in a radiological dose to the public well below the acute accidental dose criterion of 1 mSv.

8.4.2.3 Consequences to Workers

The effect of extreme malevolent acts can include worker fatalities, depending on their proximity to the location of the attack. Nonetheless, the effect of more credible malevolent acts would be bounded by malfunctions and accidents caused by unintentional human activity, resulting in relatively low consequences for workers. These bounding scenarios are discussed in the Preliminary Safety Report [435].

8.4.3 Comparison of Effects of Malevolent Acts with Malfunctions and Accidents

In general, the radiological consequences of credible malevolent acts are expected to be similar to those of malfunctions and accidents. Scenarios including detonation of explosives have the potential to produce public consequences exceeding those of the bounding accident scenarios, but public consequences remain significantly below the acute accidental dose criterion of 1 mSv.

Extreme malevolent acts, such as use of explosives, could cause worker fatalities in the vicinity. The effects of more credible malevolent acts (e.g., deliberately crashing a transfer vehicle) would be bounded by the effects of accident scenarios.

The potential non-radiological consequences of malevolent acts are expected to be similar to those of non-radiological malfunctions and accidents, particularly in terms of affecting the public.

While individual members of resident populations of non-human biota could be affected by malevolent acts, overall populations are expected to remain unaffected. This is true for both radiological and non-radiological consequences.

9. LONG-TERM SAFETY OF THE DGR

This section provides a summary of the effects of the DGR Project during the long-term (postclosure) phase. Because there are no physical works and activities occurring during this phase, the assessment addresses only the radiological and non-radiological safety after the repository is closed. Details of the assessment methodology and results are given in the Preliminary Safety Report [458].

9.1 DEMONSTRATING THE LONG-TERM SAFETY OF THE DGR

The postclosure safety of the repository is quantitatively assessed through considering a range of potential future scenarios. These scenarios include the expected evolution of the DGR system with time, and the potential impacts of low-probability events leading to degradation and loss of containment. Potential effects are considered for both humans and the environment.

The safety assessment has been undertaken using the following approach:

1. the assessment context is defined, documenting the high-level assumptions and the constraints, notably regulatory requirements and assessment timeframe;
2. the system is described, including the features relevant to postclosure safety;
3. a range of potential future scenarios is systematically identified;
4. conceptual and mathematical models are developed for these scenarios; and
5. the scenarios are analyzed and the results are assessed regarding the performance of the system, and its overall robustness.

Key components of the postclosure safety assessment context are summarised in Table 9.1-1.

Table 9.1-1: Components of the Postclosure Safety Assessment

Component	Description
Regulatory Requirements and Guidance	• Nuclear Safety and Control Act and associated regulations • Canadian Nuclear Safety Commission regulatory guidance document G-320 "Assessing the Long Term Safety of Radioactive Waste Management" [459] • Canadian Environmental Assessment Agency and Canadian Nuclear Safety Commission Guidelines for the preparation of the EIS for the DGR
Endpoints	• Radiation dose to humans • Environmental concentrations of radionuclides and non-radioactive species
Criteria	Numerical criteria have been approved by the CNSC for the following [458]: • radiation dose limits to prevent impact on humans • no-effect concentration limits of radionuclides in environment to prevent impact on non-human biota • concentration limits for non-radioactive elements in various environmental media to prevent impact on humans and the environment

Table 9.1-1: Components of the Postclosure Safety Assessment (continued)

Component	Description
Timeframe	• 1 million year baseline • Encompasses the period over which the maximum impacts are expected to occur

9.2 SELECTION OF ASSESSMENT SCENARIOS

The potential effects from the repository are assessed by considering a range of future scenarios. A scenario is a postulated, or assumed, set of future conditions or events.

The scenarios are identified in a systematic manner based on considering potential features, events and processes (FEPs) that could drive the evolution of the repository system. These FEPs are often (but not exclusively) external events and processes like glaciation that provide the system with boundary conditions and/or with factors that might cause change in the system.

The set of possible FEPs was based on an international list prepared by the Nuclear Energy Agency (NEA) [460]. These FEPs were then analyzed to define their likely status over the next 1 million years at the DGR Project site (i.e., whether the FEP is likely to affect the normal evolution of the site or repository). Potential unlikely or alternative states for these FEPs were then considered in order to identify additional scenarios. The analysis of the FEPs and the derivation of the scenarios is documented in the postclosure safety assessment.

Consistent with G-320 [459] and the EIS Guidelines, the resulting scenarios are classified into those that consider the expected evolution of the DGR system with time (i.e., the Normal Evolution Scenario) and those that examine the potential effects of low-probability events leading to degradation and loss of containment (i.e., Disruptive Scenarios or "what if" scenarios).

The Normal Evolution Scenario describes the expected long-term evolution of the repository and site following closure. It includes a reasonable extrapolation of present-day site features and receptor lifestyles, and includes degradation of the waste disposal system as it ages. The Disruptive Scenarios are unlikely or "what if" cases that test the robustness of the DGR system. The uncertainties associated with the future evolution of the DGR system are assessed in part through these scenarios, and in part through sensitivity cases considered within each scenario.

A brief description of each scenario is given below. A detailed description of each scenario is provided in the Preliminary Safety Report, and in the supporting technical reports.

9.2.1 Normal Evolution Scenario

After closure, the wastes and waste packages will corrode. The atmosphere in the repository will become anaerobic because of the consumption of oxygen through corrosion. Subsequent corrosion of the waste packages will then proceed by slower anaerobic processes. These anaerobic processes will generate gases — especially H_2 from the corrosion of metal, and CO_2 and CH_4 from the microbial degradation of organic wastes.

Water will also initially seep into the repository from the surrounding rock. This will occur slowly as a result of the low permeability of the rock. Some of this water is consumed by the anaerobic corrosion processes. Also, gases produced by the corrosion reactions will build up, and the resulting gas pressure will inhibit water inflow, which in turn will limit the gas generating corrosion processes. The net effect is that the repository is likely to remain largely unsaturated, with methane as the dominant gas.

The region around the DGR site is tectonically stable. Large earthquakes are very unlikely in general. Furthermore, the host rock around the repository has good mechanical quality, and the rooms are designed for maximum stability. However, in the long term, it is expected that rockfall will occur from the roof and walls, as a result of the degradation of the engineered rock support and eventually seismic and glacial stresses. This process will continue intermittently, until the collapsed rock fills the available space and is able to support the roof.

Most of the waste packages are not designed to be long-lived. As they corrode or are damaged by rockfall, the wastes are exposed and the radioactivity can be released. Carbon-14 and tritium, important radionuclides at closure, can be released as gas. Other radionuclides will primarily be released into the water, as the repository resaturates. Almost all of these contaminants will be contained within or near the repository by the host rock and shaft seals. The host rock has very low permeability, as demonstrated through tests conducted as part of the site characterization program. The shafts will be sealed primarily with a durable, low-permeable bentonite (clay)/sand mixture that will swell and self-seal, as described in Section 4.11.4.

The radioactivity will decay, with most of the tritium (H-3) decayed within 100 years, and most of the carbon-14 (C-14) within 60,000 years. Some slow migration of some dissolved or gaseous contaminants will occur via the geosphere and the sealed shafts. People living on or near the site could be exposed to these contaminants. In the safety assessment, it is assumed that a family is living and farming on top of the repository.

Beyond about 60,000 years, the climate could cool and glaciation could reoccur. There were nine major glacial cycles in the past one million years, and the key factors that caused these cycles are still present. Although global warming may delay the onset of the next glacial cycle, it is prudent to assume that they will resume in the long term.

An ice sheet would have major effects on the surface and shallow groundwater system. However, the primary effect of glaciation on the deep groundwater zone around the repository is expected to be transient changes in the rock stress and hydraulic pressures during ice sheet loading and unloading. This is supported by modelling and by evidence from the site, where the deep groundwaters do not show signs of effects from past glaciations, nor are there signs of faulting or fracturing attributed to glaciation stresses. The host rock will remain intact, and contaminants transport will remain diffusion dominated, as it did during previous glacial cycles.

At very long times, the radioactivity will decay to less than the natural radioactivity of the overlying rock. The repository itself will primarily consist of limestone rock, iron corrosion products and other minerals and salts, methane gas, and brine.

9.2.2 Disruptive ("What if") Scenarios

9.2.2.1 Human Intrusion

This scenario considers the same evolution of the DGR system as for the Normal Evolution Scenario with the exception that inadvertent human intrusion is assumed to occur directly into the repository via an exploration borehole at some time in the future. Contaminants are released and humans are exposed via two pathways: direct release to the surface; and release to the shallow groundwater. The direct release to the surface can occur as contaminated gas, slurry, or solid (core samples); release into the shallow groundwater occurs as contaminated groundwater.

9.2.2.2 Severe Shaft Seal Failure

This scenario considers the same evolution of the DGR system and the same exposure pathways and groups as the Normal Evolution Scenario with the exception that the performance of the sealed shaft is assumed to be very poor.

9.2.2.3 Poorly Sealed Borehole

This scenario considers the consequences of one of the deep site investigation boreholes in the vicinity of the DGR not being properly sealed. The borehole provides an enhanced permeability connection between the level of the repository, the shallow groundwater zones and the surface environment.

9.2.2.4 Vertical Fault

There is strong evidence from site characterization that there are no deep transmissive vertical faults close to the DGR. The excavation of the repository is expected to further verify this. Nevertheless, this scenario considers "what if" there was a vertical fault in the vicinity of the repository. Two locations are considered, one just outside the well-characterized DGR Project Area at about 500 m distant, and one within the DGR Project Area at 100 m.

9.2.2.5 Other Scenarios

Other potential disruptive scenarios were considered, but ruled out on various grounds as described in the Postclosure Safety Assessment [461]. For example, no volcanic activity is anticipated in the area over the next one million years, and the probability of being hit by a large meteor capable of damaging the repository is remote. Seismic activity is possible, and likely earthquakes are included in the Normal Evolution Scenario, where their main effect is rockfall within the repository. Large earthquakes are unlikely, and their main effects on the repository are bounded by the Severe Shaft Seal Failure and Vertical Fault Scenarios, so there is no need to consider an additional earthquake scenario. Repository gas pressures are expected to be significantly less than the lithostatic pressure of about 17 MPa and the regional horizontal stress of 20 to 30 MPa. Therefore, they do not cause fracturing of the rock and this scenario is not evaluated. Glaciation could affect the site; it is considered within the Normal Evolution Scenario.

9.3 MATHEMATICAL MODELS

The safety assessment uses a range of mathematical (computer) models. The site models are based on the understanding of the site, its past history, and its likely evolution as described in the Geosynthesis [462], which is based on four years of site characterization.

The three main models used for the analysis are as follows [458]:

- Assessment-level (system) models are implemented in AMBER 5.3, which is a compartment-model code that represents package degradation, contaminant transport through repository, geosphere and the surface environment, and the associated impacts such as dose.
- Detailed groundwater flow and transport calculations are implemented in the 3-D finite-element/finite-difference code FRAC3DVS-OPG, the same code as used for DGR regional geosynthesis modelling.
- Detailed gas generation and transport calculations are implemented in T2GGM, a code that couples the Gas Generation Model (GGM) and TOUGH2. GGM is a project-specific code that models the generation of gas within the DGR attributed to corrosion and microbial degradation of the metals and organics present. TOUGH2 models the subsequent two-phase transport of gas through the repository and geosphere.

The postclosure safety assessment models include the important features, processes and events. The assessment approach has been reviewed by an international peer review team, and by checking of interim results by independent contractors. The models have been implemented based on industry-standard codes, with modifications made under strict quality assurance programs and the computer codes tested by various methods including internal cross-checking between different codes.

A list of the codes and their main verification tests is given in Table 9.3-1. The codes are described in the Postclosure Safety Assessment [461] and references therein.

Table 9.3-1: Summary of Key Mathematical Model Tests

Model	Tests
AMBER – solute transport and dose impact code	• Uses the industry-standard AMBER base code, with custom DGR repository model • Implements the CSA N288.1 standard for calculating biosphere dose impacts [463] • Verified through independent review of the input case files • Cross-check with FRAC3DVS for solute transport
FRAC3DVS – 3D groundwater flow and contaminant transport	• Commercial code • Safety assessment site-scale model compared with Geosynthesis regional scale model • Verified through independent review of the input case files • Cross-check with T2GGM for steady state groundwater flow and hydraulic heads at the DGR Project site • Cross-check with detailed and less detailed 3D FRAC3DVS models • Cross-check with simple calculation for base case contaminant transport
T2GGM – 3D gas generation and two-phase transport code	• Industry-standard TOUGH2 for two-phase transport combined with custom GGM gas generation model • GGM tested by verification test suite, including various mass balance tests • Cross-check with FRAC3DVS for steady groundwater flow and hydraulic heads at the DGR Project site • Cross-check 2D and 3D T2GGM with different levels of detail • Cross-check with simple calculations for gas pressure and gas flow rate

The data used in the models have been taken from OPG waste characterization, DGR preliminary design, and DGR site characterization information. These have been complemented with data from the published and peer-reviewed literature for other parameters. The specific data used for the postclosure safety assessment is documented and justified in the reference data report [464], including source of information, assumptions built into the data, and range and confidence estimates for the parameters.

9.4 ASSESSMENT RESULTS AND COMPARISON WITH ACCEPTANCE CRITERIA

9.4.1 Normal Evolution Scenario Results

The Normal Evolution Scenario Reference Case draws on the results of the site investigations and geosynthesis, and represents the site in the most detail. It includes the measured over-pressure in the Cambrian sandstone below the DGR, and the measured under-pressures and partial gas saturations in the Ordovician formations within which the DGR is located. Analyses included evaluation of water inflow from rock and shaft, gas generation and build up within the repository, corrosion and rockfall processes that would degrade waste packages, groundwater and gas flow through repository, host rock and shaft seals, and impacts on people living above and around the repository. Variant calculation cases are also assessed to explore uncertainties associated with the Normal Evolution Scenario.

The key results for these cases are as follows:

- The full resaturation of the repository with water is gradual, taking more than 1 million years, due to the low permeability of the host rock and gas generation in the repository. The majority of the water seeps into the repository from the surrounding host rock rather than the shafts.
- Contaminants are contained within the repository and host rock, thereby limiting their release into the surface environment and their subsequent impacts. Reference Case calculations estimate that less than 0.1% of the initial waste activity is released into the geosphere around the repository, and much less is released into the shafts.
- Gases are contained within the repository and geosphere. The gas pressure is anticipated to equilibrate at 7 to 9 MPa (i.e., around the 7.4 MPa equilibrium hydrostatic pressure at the repository level), and well below the lithostatic pressure of about 17 MPa at the repository level. The gas will be primarily methane in the long term.
- The geosphere and shaft attenuate the release of contaminants, providing time for radioactive decay to decrease the radioactivity in the repository.
- The maximum calculated dose is more than five orders of magnitude below the 0.3 mSv/a public dose criterion (Figure 9.4.1-1).
- These results apply to a hypothetical family assumed to be living on the site in the future, and obtaining all of its food from the area. The potential dose would decrease rapidly with distance from the site. For example the calculated dose to a "downstream" group exposed via consumption of lake fish and water from Lake Huron are more than three orders of magnitude lower than the dose to the family living on the site.

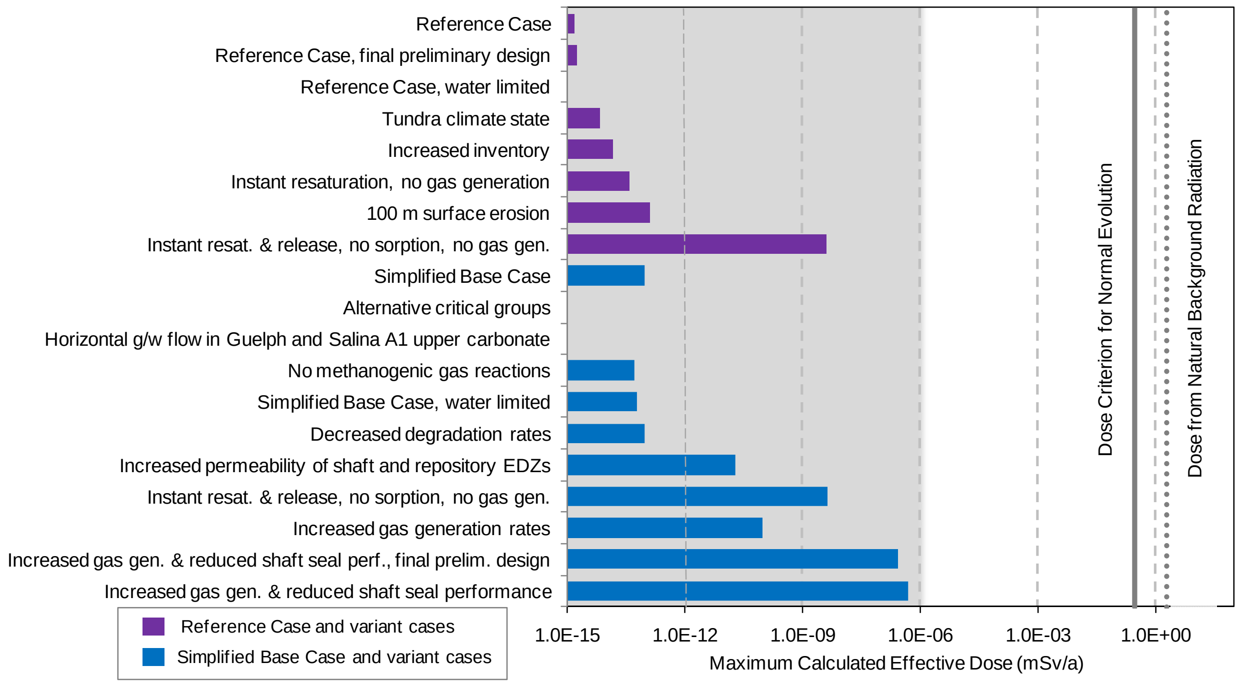

Figure 9.4.1-1: Normal Evolution Scenario: Maximum Calculated Doses for all Calculation Cases

9.4.2 Disruptive Scenarios Results

A tiered approach is adopted for disruptive scenarios, recognizing the speculative nature of some scenarios. First, a dose criterion of 1 mSv/a is used for radiological exposure of humans under credible scenarios. Second, if calculated doses exceed 1 mSv/a for a scenario, the acceptability of results from that scenario is examined on a case-by-case basis taking into account the likelihood and nature of the exposure, conservatism and uncertainty in the assessment, and conservatism in the dose criterion. Where feasible, they are compared to a reference health risk of 10^{-5}/a.

Consistent with the Normal Evolution Scenario, a reference calculation is undertaken for each Disruptive Scenario. To avoid ambiguity with the Normal Evolution Scenario Reference Case, the reference calculation for each Disruptive Scenario is termed the Base Case calculation. In addition to each Base Case calculation, some variant calculations were also undertaken.

The key results for these cases are summarized below.

- For the Human Intrusion Scenario, if a borehole is drilled into the repository and gases and material from the repository are not appropriately contained, the calculated doses could be about 1 mSv for the drill crew and for a future person farming on the contaminated site. The likelihood of drilling into the repository in any given year is very low due to the lack of mineral resources and the repository's small footprint and depth, and high contaminant releases are unlikely when following standard deep drilling practices. Thus the peak risk of serious health effects is low and much less than the reference health risk value of 10^{-5}/a.

- For the Severe Shaft Seal Failure Scenario, the maximum calculated doses are about 1 mSv/a, based on immediate failure of 500 m low-permeability shaft seals (to 10^{-9} m/s hydraulic conductivity), reduced sorption in the shafts, increased degradation of shaft and repository EDZs, and assuming a family is farming directly on top of the shafts (including a house on the main shaft). The scenario is very unlikely. Therefore the risk from the severe shaft seal failure scenario is low.
- Calculated peak annual doses for the Poorly Sealed Borehole Scenario and for the Vertical Fault Scenario are several orders of magnitude less than the dose criterion.
- Additional cases were evaluated to determine what it would take to have a disruptive scenario with larger impacts. For the Human Intrusion Scenario, the borehole would have to be extended down to the Cambrian and then poorly sealed, so that there was water flowing up the borehole, through the repository and into the shallow groundwater system. For the Severe Shaft Seal Failure Scenario, the entire shaft would need to degrade by four to five orders of magnitude beyond design basis to a hydraulic conductivity of 10^{-7} m/s, about equivalent to fine silt and sand. In these cases, the peak doses to someone living on top of the repository site could be tens of milliSieverts.
- The primary risk in disruptive scenarios is release of C-14 containing gas from the repository. The potential impacts therefore decrease to well below the dose criterion after about 60,000 years due to C-14 decay. Since glaciation at the DGR site is not likely to occur prior to then, there is little risk from glaciation affecting the maximum peak doses from Disruptive Scenarios.
- Finally, it is noted that the impacts of the disruptive scenarios are local. The total content of C-14 in the repository on closure is approximately equal to the site annual Derived Release Limit for air release of C-14 as CO_2. So even if the entire C-14 inventory were released as gas within a one year period, then dose impacts for people living around the Bruce nuclear site would be around or below the public dose criterion.

Key Radionuclides

- Most radionuclides are retained within the repository or geosphere.
- H-3, although a significant contributor to the waste radioactivity at closure, is fully retained within the repository and host rock, where it decays.
- For scenarios that could result in releases of contaminants to the surface environment within about 60,000 years of closure, C-14 (mostly from ILW moderator resins) is the key radionuclide, together with Nb-94 (mostly from ILW pressure tubes) for human intrusion.
- For releases that occur at later times, Cl-36 (mostly from ILW pressure tubes), and I-129 (mostly from ILW PHT resins) become more important due to their longer half-life and their mobility.
- Nb-94 and Zr-93 are mostly retained within the shaft and geosphere and so are not significant contributors to the calculated doses for groundwater releases.

9.4.3 Impacts on Non-human Biota and Non-radiological Impacts

Calculations have been undertaken to assess the impact of radionuclides on non-human biota and the impact of non-radioactive chemical contaminants on humans and the environment. The key results are as follows:

- For the Normal Evolution Scenario, concentrations of radionuclides and of non-radioactive contaminants in surface media are well below the relevant environmental protection criteria.
- For Disruptive Scenarios, impacts are also low. All non-radiological elements and most radionuclides have calculated concentrations that are well below their screening concentration criteria for the base cases.
- There are some local exceedances of screening criteria for the Human Intrusion Scenario and the Severe Shaft Seal Failure Scenario. In particular, C-14 and Nb-94 would locally exceed soil criteria by a factor of 20 if the drilling debris from the repository were to be dumped on the surface at the site in the Human Intrusion Scenario. And the C-14 would locally exceed the surface water screening criteria by a factor of 1.4 in the shaft seal failure scenario.
- Since these exceedances are local, the screening criteria are conservative and the scenarios are very unlikely, the risk to biota from these scenarios is low.

9.4.4 Implications on Design

The results indicate that there is no benefit to be gained from backfilling the repository due to the significant containment already provided by the host geology and the shaft seals. Backfilling results in a higher gas pressure within the repository after closure.

The calculations have emphasized the importance of the shaft seals in limiting contaminant fluxes in groundwater and gas from the repository. The damaged zone in the rock around the concrete monolith at the shaft base is a key pathway to the shafts.

Some contaminants that do migrate up the shafts as gas or dissolved species can be laterally diverted into the higher permeability Silurian units (Guelph and Salina A1 upper carbonate). The low-permeability shaft seals in the Silurian are effective in directing contaminant transport into these features.

9.4.5 Traditional Use of Land and Resources

The potential effects under the Normal Evolution Scenario were also evaluated for families living a few kilometres along the Lake Huron shore and consuming a high fish diet, consistent with historic practices in the area. The peak dose was found to be very small, less than about 0.1% of the dose to a family living and farming on the repository site.

There are no indications that the repository would have any effect on traditional use of the land and surrounding waters.

9.4.6 Uncertainties

The long timescales under consideration mean that there are uncertainties about the way in which the system will evolve. These uncertainties have been treated in the current assessment through: the assessment of range of scenarios, models and data; the adoption of conservative scenarios, models and data; and the adoption of a stylized approach for the representation of future human actions and biosphere evolution. The key uncertainties in terms of their importance to potential impacts are as follows:

- **Gas pressure and repository saturation** are important in determining the release of radioactivity into repository water, and the potential for C-14 release through gas in the first 60,000 years. Therefore, the processes that control these parameters are important. They were approached in this safety assessment through use of a range of calculation cases to test the importance of uncertainties in those contributing processes.
- **Shaft seal and EDZ properties** and their evolution with time. Variant calculation cases for the Normal Evolution Scenario and the Severe Shaft Seal Failure Scenario calculations emphasize the importance of the shaft seals, particularly in the first 60,000 years following closure.
- **Glaciation effects.** Although geological evidence at the site indicates that the deep geosphere has not been affected by past glaciation events and that the deep groundwater system has remained stagnant, glaciation is expected to have a major effect on the surface and near-surface environment and it is not entirely predictable. It should, however, be noted that ice-sheet coverage of the site is likely to occur only after 60,000 to 100,000 years, at which point the primary remaining hazard will be long-lived radionuclides in groundwater rather than C-14. Calculations have shown that the deep groundwaters are stable and transport is diffusion-dominated, so dissolved radionuclides will be contained in the deep geosphere with large safety margins.
- **Chemical reactions**. Under the highly saline conditions of the deep geosphere at the DGR site, several aspects of the chemistry are uncertain due to the limited database. In particular, this includes the sorption of contaminants on seal materials and host rocks, as well as mineral precipitation/dissolution reactions. Generally conservative values have been adopted in this assessment.

The geosphere is clearly key to the DGR safety. In general, the attributes of the geosphere are sufficiently well known to support the safety assessment [458]. However, some aspects are still uncertain, such as the cause of the over/under-pressures. These geosphere uncertainties have been considered in this assessment through a range of scenarios, calculation cases and conservative parameter values. Although further resolution of these uncertainties is desirable to increase confidence, they have not been found to be important to the conclusions of this assessment.

The Geoscientific Verification Plan outlines plans to initiate tests of important processes and materials under in situ conditions, for example, EDZ measurements. Also, the shaft seal design will not be finalized until the decommissioning application several decades from now and will take advantage of knowledge gained over the intervening period. While these tests plus further modelling work will improve confidence in the assessment, the results presented here show that the DGR meets the postclosure safety criteria, that it provides isolation and containment of wastes, and that the system safety is robust (i.e., the system will maintain its integrity and reliability under a range of conditions). The uncertainties should be interpreted in the context of the low calculated impacts, for example calculated doses for all Normal Evolution Scenario variant cases are all more than five orders of magnitude below the dose criterion.

9.5 ADDITIONAL ARGUMENTS FOR THE SAFETY CASE

In addition to the quantitative safety assessment results summarized above, the ability of the DGR site to provide long-term isolation and containment is supported in part by qualitative arguments based on measurements and characteristics of the site itself, especially the following:

- The DGR is isolated from the biosphere:
  - The repository is placed at a depth of approximately 680 m, about 1 km distant from lake shore at surface and approximately 400 m below the lake bottom in the vicinity of the Bruce nuclear site. Water 200 m below ground surface is too salty to drink, with total dissolved solids (TDS) reaching 200 to 400 g/L, more than 10 times the salinity of seawater.
- Multiple geological barriers:
  - The DGR repository horizon is under- and overlain by multiple low permeability bedrock formations (with measured permeabilities $<10^{-17}$ m^2).
  - There is over 200 m of low permeability shale directly overlying the host Cobourg Formation and 150 m of low permeability carbonates below. These bedrock formations have been in place since the Silurian (416 to 444 million years ago) or Ordovician ages (444 to 488 million years ago) and extend laterally for hundreds of kilometres from the site.
  - Measured under- and over-pressure hydraulic heads, particularly within the Ordovician sediments at the repository depth, indicate that extremely low permeabilities extend well beyond the repository location and have persisted for long times.
- Stable deep diffusion-dominant groundwater system:
  - Within the Michigan Basin, the regional hydrogeochemistry reveals that pore waters within the intermediate and deep groundwater domains have resided in the sediments since at least the Mesozoic era.
  - Stable isotope data from the brines indicate enrichment of $\delta^{18}O$. This enrichment is indicative of water-rock interaction and long residence time, which supports the interpretation of a marine origin for the brines.
  - Ordovician hydrothermal dolomite reservoirs elsewhere in southern Ontario contain natural gas and oil. Most reservoirs had a discovery pressure gradient at or near the normal hydrostatic pressure gradient of 9.79 kPa/m which supports the idea that these type of rock formations are capable of maintaining reservoir pressures for periods of time on the order of 65 to 300 million years.
- Hydrogeological and chemical conditions limit contaminant mobility at repository depth:
  - Stable natural tracers indicate very slow movement at repository depth over geologic time periods.

9.6 CONCLUSIONS

Consistent with the guidelines for the preparation of the EIS for the DGR and the regulatory guide for assessing the long-term safety of radioactive waste management (G-320 [459]), the postclosure safety assessment has evaluated the DGR's ability to perform in a manner that will protect human health and the environment from the emplaced waste for an expected evolution scenario, as well as a number of disruptive ("what if") scenarios.

The assessment calculations for the Normal Evolution Scenario indicate that the DGR system provides effective containment of the emplaced contaminants. Most radionuclides decay within the repository or the deep geosphere (Figure 9.6-1). The amount of contaminants reaching the surface is very small, such that the maximum calculated impacts for the Normal Evolution Scenario are much less than the public dose criterion of 0.3 mSv/a for all calculation cases. In addition, potential impacts of radionuclides on biota and non-radioactive contaminants on humans and non-human biota are well below the relevant criteria. The isolation afforded by the location and design of the DGR limits the likelihood of disruptive events potentially able to bypass the natural barriers to a small number of situations with very low probability. Even if these events were to occur, the analysis shows that the contamination in the waste would continue to be contained effectively by the DGR system such that risk criterion is met.

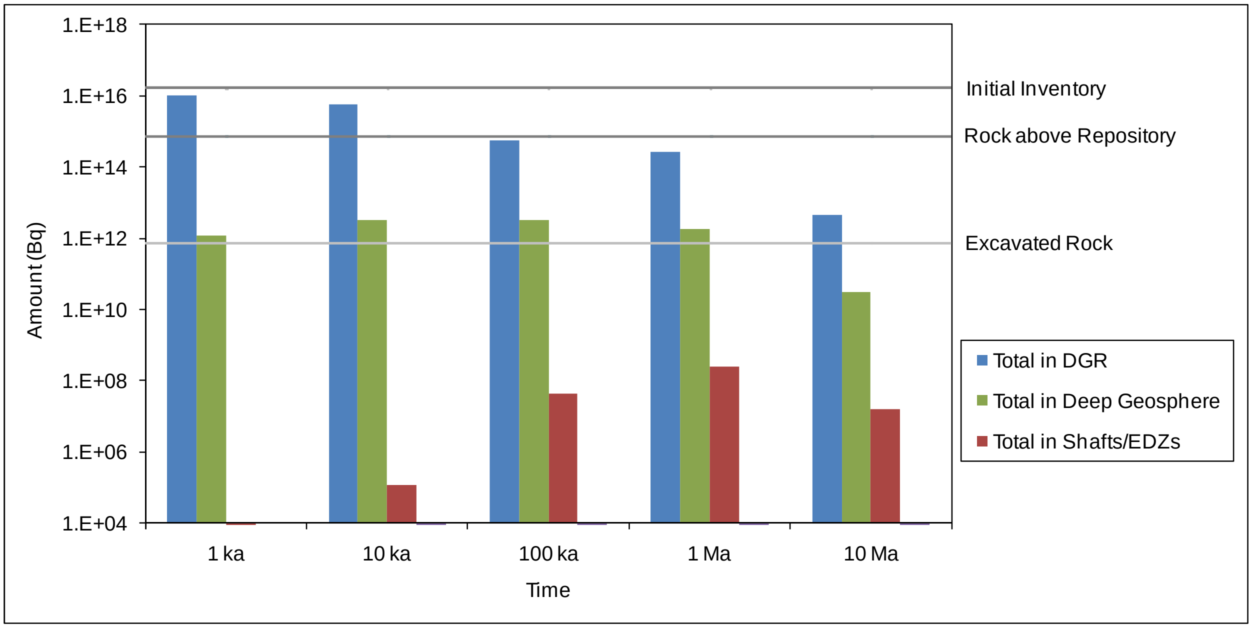

Figure 9.6-1: Distribution of Activity in System at Different Times for the Normal Evolution Scenario's Reference Case

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10. CUMULATIVE EFFECTS

The EIS Guidelines require the consideration of cumulative environmental effects in relation to the DGR Project. Cumulative effects are the combination of the incremental effects caused by the DGR Project with the effects caused by other projects or activities on-site as well as off-site, including past, present and reasonably foreseeable projects.

10.1 OVERVIEW

The method for assessment of cumulative effects is consistent with the EIS Guidelines and the Canadian Environmental Assessment Agency's Cumulative Effects Assessment Practitioners Guide [465]. The steps for the assessment of cumulative effects are detailed further in Section 10.2. The cumulative effects assessment builds on the results of the direct effects assessment completed in Section 7 and considers all of the incremental effects of the DGR Project that were assessed to have a likely residual adverse effect or beneficial effect on a VEC.

Other projects that have the potential to act cumulatively with the DGR Project are then identified in three categories.

- Past and existing projects and activities. Although these activities occurred in the past, the effects from these projects may continue into the future. The effects from the past and existing projects and activities that have occurred in the past or are currently occurring are captured under the existing conditions (Section 6).
- Certain/planned projects and activities. These include projects that have been approved, but yet to start construction and/or operations. This category can also include projects that are well advanced in the planning process, but have not yet been approved.
- Reasonably foreseeable projects and activities. These are projects that have started in the approval process and are on the path to obtaining approval. This category would also include smaller routine activities that one can say, with a fair degree of certainty, will need to occur (e.g., routine building and infrastructure upgrades). In the case of the DGR Project, the EIS Guidelines require that emplacement of decommissioning waste at the Bruce nuclear site be included in the assessment of cumulative effects even though it is not a project that is planned or a project for which the schedule is in the reasonably foreseeable future.

Using professional judgement, the projects are then screened to focus the assessment of cumulative effects on those projects whose effects overlap in type of effect, time and space with those residual adverse effects of the DGR Project. The cumulative effects assessment is conducted at a more general level of detail than in previous sections of the EIS since the projects are more remote in time and space. Consistent with EA practice, the cumulative effects assessment applies to activities during normal operations only.

10.2 CUMULATIVE EFFECTS ASSESSMENT METHOD

The EIS Guidelines require that the effects of the DGR Project be considered with those of other projects and activities that have been, or will be carried out, and for which the effects are expected to overlap with those of the DGR Project (i.e., overlap in time and geographic area).

The effects of the DGR Project may overlap with other projects' effects, even though the activities causing them do not. Projects with additive effects are also considered in the cumulative effects assessment (e.g., dose). These effects are referred to as cumulative effects.

The overall method for assessment of adverse cumulative effects is shown in Figure 10.2-1. Any measurable (i.e., non-trivial) beneficial effects of the DGR Project would be considered in similar manner. This method is consistent with the guidance provided in the Canadian Environmental Assessment Agency's Cumulative Effects Assessment Practitioners Guide [465] and the Operational Policy Statement to Addressing Cumulative Environmental Effects under CEAA [466].

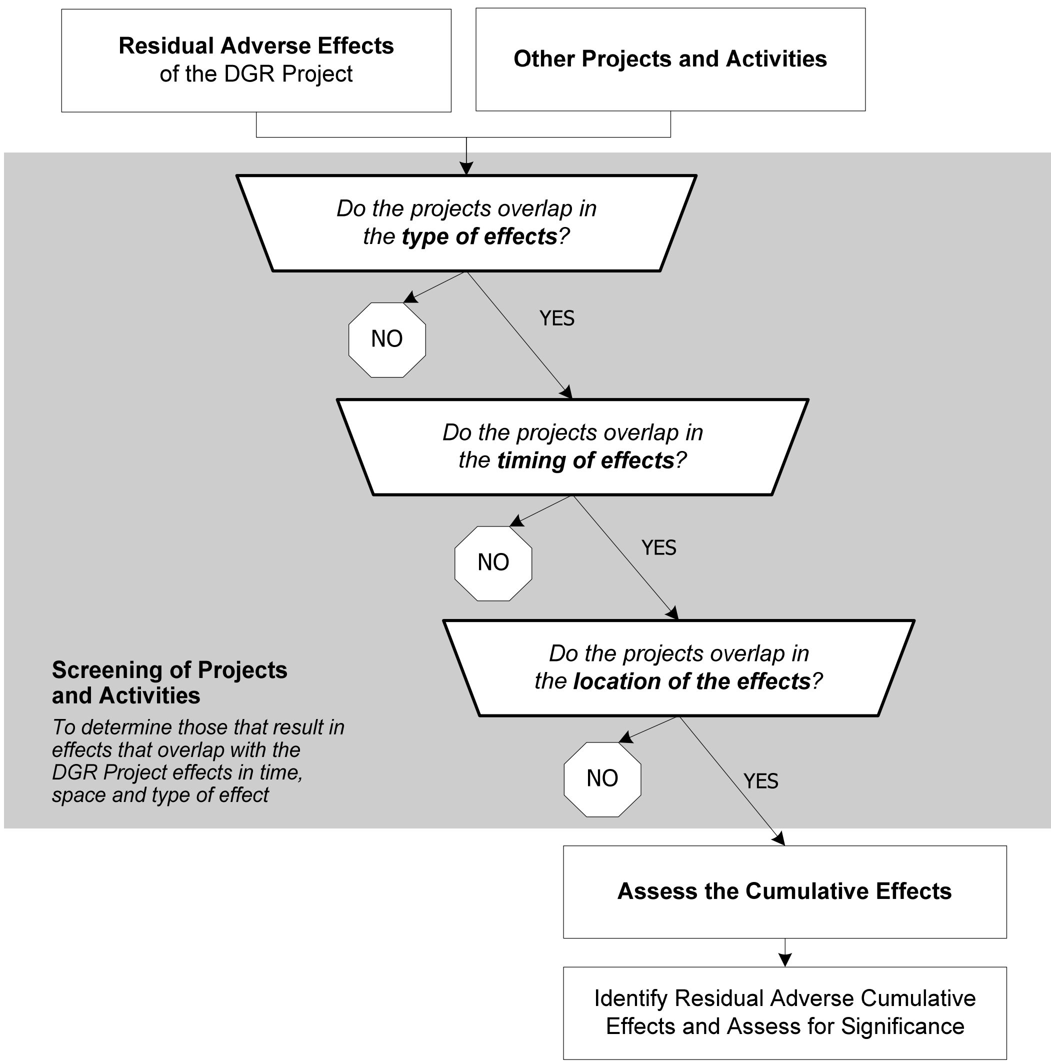


Figure 10.2-1: Cumulative Effects Assessment Method

10.3 RESIDUAL ADVERSE AND BENEFICIAL EFFECTS OF THE DGR PROJECT

The cumulative effects assessment builds on the results of the assessment of the effects of the DGR Project that were considered to have a residual adverse or beneficial effect on VECs. Table 10.3-1 summarizes the residual adverse effects and the relevant VECs. The beneficial effects and relevant VECs are summarized in Table 10.3-2. Although no residual adverse effects were identified, radiation and radioactivity is also included in Table 10.3-1 for consideration of additive effects. Malfunctions and accidents are not considered in the cumulative effects assessment. The possibility of malfunctions and accidents are considered too "rare" to be assessed together with those caused by normal operational activities.

Table 10.3-1: Summary of Residual Adverse Effects of the DGR Project

Environmental Component	VEC	Residual Adverse Effect
Hydrology and Surface Water Quality	Surface Water Quantity and Flow	31% reduction in surface water quantity and flow in the North Railway Ditch upstream of Stream C resulting from reduction in drainage area from the construction of the stormwater management system.
		114% increase during the site preparation and construction phase and 61% increase during the operation phase in surface quantity and flow in the drainage ditch at Interconnecting Road resulting from operation of the stormwater management system, redirected drainage area flows, dewatering of the shaft excavation during construction and the shaft sump pumping during operations.
Terrestrial Environment	Eastern White Cedar	Loss of eastern white cedar in the Project Area during site preparation and continuing through DGR Project life.
Aquatic Environment	Burrowing Crayfish	A portion of burrowing crayfish habitat in the South and North Railway Ditches, as well as other ditches and the abandoned rail spur in the western portion of the Project Area, is removed during site preparation and construction.
	Redbelly Dace	A portion of non-critical habitat is removed in the South Railway Ditch during construction of the rail bed crossing.
	Creek Chub	
	Variable Leaf Pondweed	
	Benthic Invertebrates	
Air Quality	Air Quality	Increase in concentrations of air quality indicators during site preparation and construction, operations and decommissioning phases.
Noise Levels	Noise Levels	Increase in noise levels during site preparation and construction, and decommissioning phases.

Table 10.3-1: Summary of Residual Adverse Effects of the DGR Project (continued)

Environmental Component	VEC	Residual Adverse Effect
Socio-economic Environment	Other Social Assets	Change in noise levels in the Baie du Doré area resulting in reduced enjoyment and use of personal property in this localized area during site preparation and construction, and decommissioning phases.
Human Health	Overall Health for Local Resident	Effect to the overall health for local resident and member of Aboriginal communities resulting from exposure to acrolein in air during the site preparation and construction phase.
	Overall Health for Member of Aboriginal Community	
Aboriginal Interests	Aboriginal Heritage Resources	Diminishment of quality or value of activities at the on-site burial site from changed aesthetics and temporary dust and noise.
Radiation and Radioactivity	Human Exposure to Radiation	Radiological emissions as a result of the DGR Project.[a]
	Radiation Dose to Non-human Biota	

Note:
a Unlike the assessment of other environmental components completed in Section 7, the radioactivity assessment considered the incremental effects of the DGR Project only for comparison with regulatory standards. Therefore, although no residual adverse effect on radiation and radioactivity VECs was identified in Section 7; it has been included here to allow consideration of additive effects.

Table 10.3-2: Summary of Beneficial Effects of the DGR Project

Environmental Component	VEC	Beneficial Effect
Socio-economic Environment	Population and Demographics	Increased population associated with DGR Project related employment will occur in all Regional Study Area municipalities, with the greatest benefit anticipated in Kincardine.
	Other Human Assets	Increased educational opportunities for local students and others with an interest in nuclear technology.
	Employment	The DGR Project will create new direct, indirect and induced employment opportunities.
	Business Activity	A positive effect on business activity is anticipated during all DGR Project phases, which can be enhanced through policies to utilize local business services wherever practical and appropriate.

Table 10.3-2: Summary of Beneficial Effects of the DGR Project (continued)

Environmental Component	VEC	Beneficial Effect
Socio-economic Environment (continued)	Municipal Finance and Administration	The DGR Project may result in increased municipal revenue because of increases in property taxes and other revenues; as well as through one-time and annual payments agreed to in the 2004 Hosting Agreement.
	Other Financial Assets	The DGR Project will increase the direct, indirect and induced labour income in the Local and Regional Study Areas.

Although a number of beneficial effects were identified for the DGR Project, these effects were assessed in the Socio-economic Environment TSD to be of a low magnitude and are not expected to contribute to cumulative effects. The beneficial effects are not considered further in the assessment of cumulative effects.

10.4 DESCRIPTION OF OTHER PROJECTS AND ACTIVITIES

Projects that have the potential to act cumulatively with the DGR Project are identified in this section. The identification of these additional projects and activities is based on information contained in Sections 6 and 7 that describe existing environmental conditions across the Site, Local and Regional Study Areas for each environmental component, and considers the effects of past and existing projects and activities.

Additional projects and activities were identified through a review of EA Study Reports for several other completed and ongoing and planned projects, and comments received as part of the public participation program. The list has been reviewed to ensure a comparable listing of all past, present and future projects to other EAs completed for the Bruce nuclear site.

Past projects or activities may also represent ongoing disturbances to the VECs identified in Table 10.3-1, and as such will have become part of the existing conditions. The description provided in Section 6 represents a cumulative description of the effects of all past and existing projects on the VECs. Therefore, the assessment of effects in Section 7 represents the cumulative effects of the DGR Project and all past and existing projects.

In addition, the Canadian Environmental Assessment Agency's Operational Policy Statement [466] indicates that the cumulative effects assessment should consider other 'certain' and 'reasonably foreseeable' projects. Because there may be an extensive list of future projects of varying sizes it is necessary to provide focus on the other projects to be considered in the cumulative effects assessment. To this end, other certain or reasonably foreseeable projects and activities were considered in the cumulative effects assessment if they were likely to involve or represent cumulative effects, including the following:

- a major change in an existing or ongoing project or activity;
- an activity that occurs on or immediately adjacent to the Site Study Area;

- an additional source of radioactive emissions to the air, land or water that may contribute to radioactive doses to humans and non-human biota;
- an additional source of non-radioactive chemical emissions to the air, land or water similar to those of DGR Project;
- activities that could affect surface water or groundwater flows; and
- activities adding additional vehicular traffic onto local roads.

Although effects of the DGR Project are assessed over a very long time frame (i.e., millions of years), the list of projects includes those that are expected to occur within the reasonably foreseeable future (i.e., until decommissioning of the DGR in approximately 50 years).

Table 10.4-1 lists each of the projects and activities considered in the cumulative effects assessment and provides a description of the project and the likely types of effect and the relationship to the criteria noted above. To be consistent with the Practitioner's Guide and EIS Guidelines, these other projects or activities are grouped into three major categories:

- past and existing projects and activities;
- certain/planned projects and activities; and
- reasonably foreseeable projects and activities.

Figure 10.4-1 identifies the general location of each of the projects and activities described in Tables 10.4-1 to 10.4-3. Figure 10.4-2 summarizes the general timelines for each of the described projects.

10.4.1 Bruce Nuclear Site Development

The 932 ha Bruce nuclear site has been undergoing development on a continuous basis since the initial clearing of land in 1960 for the building of the Douglas Point nuclear generating station. The Bruce nuclear site, with the exception of certain OPG-retained lands and lands used by Hydro One, was leased to Bruce Power by OPG in May 2001. The DGR Project site, as well as the WWMF, is located on a part of OPG-retained lands (see Figure 1.1.1-2).

Within the Bruce nuclear site boundaries, existing land uses consist of activities, structures and transportation access required to operate and support Bruce A and B, Douglas Point nuclear generating station, and OPG's various waste operations. Construction began on Douglas Point nuclear generating station, the first nuclear generating station built at the Bruce nuclear site, in 1960, with the first unit coming into service in 1968. It ceased operations in 1984. Construction of Bruce A (Units 1 to 4) began in 1969 and was completed in the late 1970s. It began operation in 1977. In the late 1990s the station was placed in layup status with the units taken out of service between 1995 and 1998. Construction of Bruce B units (Units 5 to 8) began in 1976 and the station's four reactors began operation between 1984 and 1987. In 2001, OPG leased the Bruce nuclear reactors to Bruce Power who restarted Bruce A Units 3 & 4 in 2003 and 2004 and is currently undertaking the refurbishment of Units 1 & 2.

Another former large facility on-site, the Bruce Heavy Water Plant (BHWP), produced its first heavy water in 1973, with a second plant coming into production in 1981. The heavy water plants ceased production in 1988. In 2005, the heavy water towers were demolished and the site is being decommissioned.

With the start-up of Douglas Point nuclear generating station, a small radioactive waste storage site, Radioactive Waste Operations Site 1, was established. With the expansion of the nuclear power program in Ontario during the 1970s, more storage space was required, land was reserved and a second larger storage site, Radioactive Waste Operations Site 2, was established in 1974. Additional storage structures and processing systems have been added over the years. In 2001, the name was changed from Radioactive Waste Operations Site 2 to the WWMF.

Table 10.4-1: Past and Existing Project Descriptions

Map Number	Project/Activity Name	Project/Activity Description	Type of Effect
1	Bruce A (Operation and Refurbishment) (Bruce Power)	Bruce A is a four unit nuclear generating station located on the northwest portion of the Bruce nuclear site. The station is leased from OPG by Bruce Power, which currently operates Bruce A Units 3 and 4 while refurbishing Units 1 and 2. Each unit has a capacity to produce 750 megawatts of electricity. Bruce A Unit 2 was taken out of service in August 1995, and Unit 1 followed in May 1997. The restart of the two units will provide another 1,500 MW of electricity. The refurbishment of Bruce A spans the period from 2006 to 2013, with units expected to operate until approximately 2037.	• Water temperature and circulation • Dose • Impingement/ entrainment • Traffic • Air quality • Noise • Visual • Community services • Labour/housing
2	Bruce B (Operation) (Bruce Power)	Bruce B is a four unit nuclear generating station located on the southwest portion of the Bruce nuclear site. The station is leased from OPG by Bruce Power, which currently operates all four units each of which is licensed to produce 840 MW of electricity. The first Bruce B unit was started in 1984, and the station is expected to continue operations until 2024 without any refurbishment activities.	• Water temperature and circulation • Dose • Air quality • Noise • Impingement/ entrainment • Traffic • Visual • Community services • Labour/housing
3	Western Waste Management Facility (WWMF) (Operation) (OPG)	The WWMF is located in the central portion of the Bruce nuclear site, immediately north of the Central Services Road, and is owned and operated by OPG. It provides processing and storage facilities for L&ILW (i.e., non-fuel) produced at OPG-owned nuclear generating stations. The WWMF is described in detail in Section 3.1.	• Dose • Air quality • Labour • Groundwater quality

Table 10.4-1: Past and Existing Project Descriptions (continued)

Map Number	Project/Activity Name	Project/Activity Description	Type of Effect
4	Western Used Fuel Dry Storage Facility (WUFDSF) (OPG)	The WUFDSF is located at the WWMF and manages used fuel from the Bruce nuclear generating facilities. It comprises facilities to seal dry storage containers as well as two storage buildings. The facility began operating in 2002.	• Dose • Air quality • Labour • Groundwater quality
5	Centre of Site Facilities (Bruce Power)	The centre of site facilities include all of the facilities required to support the operation of the Bruce nuclear site. • The Central Maintenance and Laundry Facility (CMLF), which is a 14,400 m² building located in the central portion of the Bruce nuclear site immediately south of the Central Services Road. The CMLF is operated by Bruce Power. It comprises maintenance areas and laboratories that handle work involving both radioactive and non-radioactive materials. Various fabrication and welding activities take place at the facility, as well as equipment maintenance and refurbishing. The facility also handles instrumentation calibration and repair, laundering of radioactive protective clothing and waste bag monitoring. It is anticipated that the CMLF will operate well into the future to support operating nuclear plants, both on and off the Bruce nuclear site. • The Sewage Processing Plant treats all sewage generated at the Bruce nuclear site and discharges treated effluent through the Douglas Point outfall. • Fire Training Facility, which is used for fire and emergency response training. • Bruce Steam Plant. • The Bruce Power Support Centre, which has more than 1,100 employees. • Two licensed PCB storage facilities. One is located at Bruce A in a caged enclosure in the Chemical Waste facility on the east side of Unit 1 and one facility is located at Bruce B. • Other facilities include: parking lots, helicopter landing pad, the Learning Centre and storage facilities.	• Dose • Air quality • Water quality • Groundwater contamination • Traffic

Table 10.4-1: Past and Existing Project Descriptions (continued)

Map Number	Project/Activity Name	Project/Activity Description	Type of Effect
6	Bruce Eco-Industrial Park	The Bruce Eco-Industrial Park is a 325 ha serviced industrial park located immediately southeast of the Bruce nuclear site. The Bruce Eco-Industrial Park was established in 1986 with the intent to develop an industrial ecopark where waste and by-products of one industry could become the feedstock for a neighbouring industry. Currently, there is one company that operates in the Bruce Eco-Industrial Park, a dehydration plant. Bruce Technology Skills Training Centre is also located at the park.	• Traffic • Air quality
7	Douglas Point Nuclear Generating Station (Decommissioning)	The Douglas Point Nuclear Generating Station was put into service in 1968 and was permanently shut down in 1984. The station is located north of, and adjacent to, the Bruce B station, and is maintained by Atomic Energy of Canada Limited. The Douglas Point Nuclear Reactor is currently in safe storage with surveillance mode pending final decommissioning scheduled to occur several decades in the future. The decommissioning and disposal of all resultant radioactive materials is planned to be complete in approximately 50 to 100 years. Used fuel is currently stored in a specially constructed on-site dry fuel storage facility containing 47 dry storage containers. All major radioactive, or radioactively contaminated components not shipped to other facilities licensed to receive them were consolidated on-site near the reactor building.	• Dose
8	On-site Landfill	The on-site conventional landfill is located within an abandoned gravel pit on 1.5 ha of land in the southeast corner of the Bruce nuclear site. It is operated by OPG and is primarily used for the disposal of commercial, non-radioactive solid industrial and domestic wastes that are generated at the various on-site facilities (e.g., metal, wood, paper, construction debris). The site has been used for waste disposal since the mid 1970's. Until 1987 the adjacent area to the southeast of the landfill was used for the disposal of waste from the construction of the two generating stations. In 1996, the on-site conventional waste landfill was expanded. As of 2008, it was reported that the on-site landfill is nearing capacity and could be full in as little as three years [467].	• Groundwater quality

Table 10.4-1: Past and Existing Project Descriptions (continued)

Map Number	Project/Activity Name	Project/Activity Description	Type of Effect
9	Ripley Wind Farm	Ripley Wind Power Project is a wind energy facility being developed by Suncor Energy Products Inc. and Acciona Wind Energy Canada Inc. over approximately 3,600 ha of lands optioned for wind power development within the Townships of Huron-Kinloss near the Town of Ripley, in southwestern Bruce County. The wind power project is a 76 MW wind farm utilizing 38 wind turbines. Each turbine has a rated capacity of 2 MW. The wind farm has been operational since December 2007. The service life of the wind farm is expected to be 20 years (i.e., until 2027).	• Noise • Visual • Wildlife (birds and bats)
10	Huron Wind Farm	The Huron Wind Farm is owned and operated by Bruce Power and consists of a group of five 1.8 MW wind turbines on a 40 ha lot adjacent to the Bruce Power Visitors' Centre in the Municipality of Kincardine (there is also an OPG turbine on this lot). The wind farm has a total capacity of 9 MW or enough energy to supply electricity to 3,000 homes. The Huron Wind Farm has been operating since December 2002. The service life of the wind farm is expected to be 20 years (i.e., until 2022).	• Noise • Visual • Wildlife (birds and bats)
11	Enbridge Wind Farm	The Enbridge Ontario Wind Farm is a 181.5 MW wind farm developed by Enbridge Ontario Wind Power L.P. over 5,600 ha of farmland optioned for wind power development north of Kincardine, Ontario along the shore of Lake Huron. The project is developed under two separate Renewable Energy Supply II contracts; Enbridge Ontario Wind Farm Project A and Project B (formerly known as Leader Wind Power). The overall project utilizes a total of 110 Vestas V82 wind turbines. Each turbine has a rated capacity of 1.65 MW. A 44 kV connection system which includes both underground cable and overhead power line connects the turbines. The wind farm has been fully operational since February 2009 with expected service life of 20 years.	• Noise • Visual • Wildlife (birds and bats)

Table 10.4-1: Past and Existing Project Descriptions (continued)

Map Number	Project/Activity Name	Project/Activity Description	Type of Effect
12	Water Supply Plants (WSPs)	The communities of Kincardine, Port Elgin and Southampton are supplied by two Water Supply Plants (WSPs) which obtain their water from Lake Huron. The Kincardine WSP is located 17 km southwest of the Bruce B station and serves a population between 8,500 and 11,500 persons as well as Inverhuron Provincial Park. The Southampton WTP is located 20 km northeast of Bruce A. The plant has a rated capacity of 6,300 to 9,500 m^3/day and serves a population of approximately 5,300 in Southampton and 6,800 in Port Elgin. It also provides water to the Chippewas of Saugeen First Nation and McGregor Point Provincial Park.	• Water use/water circulation • Impingement/ entrainment
13	Water Pollution Control Plants (WPCPs)	The Municipality of Kincardine operates one Sewage Treatment Plant. The plant serves a population of approximately 9,582 and handles an average flow of 5,910 m^3/day. Final effluent disinfection is provided by chlorine. The Port Elgin WPCP handles an average daily flow of 2,120 to 2,786 m^3/day. Final effluent disinfection is provided by chlorine. The Southampton WPCP handles an average flow of 1,425 to 1,734 m^3/day. Final effluent disinfection is provided by ultraviolet irradiation. In addition to these municipal WPCPs, the Bruce Eco-Industrial Park has its own facility that has an average design flow of 2,200 m^3/s with flow aerated lagoons. The Bruce Eco-Industrial Park WPCP services the centre and Tiverton, is operated for Bruce Power by the Ontario Clean Water Agency and the plant discharges its treated effluent via the Bruce B discharge channel.	• Water quality and circulation
14	Commercial Fisheries	The MNR reports annually on the major commercial fish species in Lake Huron. The principal commercial fishery species that they track for Lake Huron's Quota Management Area 4-4 include: channel catfish, chub, lake herring, lake sturgeon, lake trout, lake whitefish, northern pike, walleye, yellow perch, chinook salmon, common carp, Micropterus sp., smallmouth bass and white sucker. The total quota (including lake trout and lake whitefish allowance) issued on commercial fishing licenses and other commercial allocations in Area 4-4 amounted to 508,105 kg in 2008. Harvest of all fish species under quota control was 242,291 kg.	• Aquatic Biota

Table 10.4-1: Past and Existing Project Descriptions (continued)

Map Number	Project/Activity Name	Project/Activity Description	Type of Effect
15	Aboriginal Fisheries	The Chippewas of Nawash Unceded First Nation consider the traditional fishery a vital part of their cultural heritage and of their values and attitudes that inform their spirituality. Additionally, between 50 and 60 members of the Chippewas of Nawash Unceded First Nation are employed in fishing and related activities. The Saugeen Ojibway Nations have an agreement to manage the commercial fishery in Lake Huron.	• Aquatic Biota
16	Heavy Water Plant Decommissioning	The Bruce Heavy Water Plant, which began operating in the early 1970s, ceased production in 1997 and has since been dismantled. OPG is in the final stages of decommissioning the plant under a licence from the CNSC, which monitors these activities. Decommissioning activities are expected to be completed before 2014 [468].	• Groundwater quality • Air quality
17	Hydro One Switchyard Operations and Maintenance	Bruce A and Bruce B have their own switchyards located immediately adjacent to the generation station buildings. The switchyards are dedicated to Bruce A and Bruce B and are owned and operated by Hydro One. These switchyards are used to transfer electricity generated at the stations to Hydro One transformer stations in Owen Sound, London, Hanover and further to transmission facilities which comprise the Ontario-wide hydro-electric grid. Hydro One also operates a service centre adjacent to the Bruce A switchyard.	• Noise

Table 10.4-1: Past and Existing Project Descriptions (continued)

Map Number	Project/Activity Name	Project/Activity Description	Type of Effect
18	Inverhuron Provincial Park	Inverhuron Provincial Park is located immediately south of the Bruce nuclear site. It is operated by Ontario Parks and has been in operation since 1959. As a result of the construction of the heavy water plant in 1973 the park began to operate as a day use facility only. At that time, the owner of the Bruce nuclear site, Ontario Hydro, signed a 999 year lease with the Ontario Ministry of Natural Resources. As a condition of the operating licence for Bruce B, a 914 m radius exclusion zone exists at the northwest corner of the park. For the purposes of public safety, a fence and gate exists as a means to prevent public access into this area. In 1998 following shut down of the Bruce Heavy Water Plant, the park's management plan was amended to allow expanded public access, extended hours of operation, four season operation, and the reintroduction of overnight camping. Ontario Parks is in the process of redeveloping campgrounds at Inverhuron Provincial Park and recently re-opened for overnight use with 125 camping sites available as of July 2005. Plans call for 250 camping sites, a recreation centre, comfort stations, an amphitheatre, trails and improvements to the existing boat launch [469].	• Traffic
19	Bruce to Milton Transmission Line	The Ontario Power Authority (OPA) recommended Hydro One obtain the approvals required to build a new transmission line to deliver power from renewable and existing nuclear sources in the Bruce area to Ontario's electricity consumers. Hydro One received EA approval in 2009 to build a new 180 km double-circuit 500,000 volt (500 kV) transmission line from the Bruce nuclear site to Hydro One's Milton Switching Station in Milton. The project construction began in May 2010 and the project is scheduled to be in-service in December 2012.	• Habitat loss • Noise and air quality (construction) • Residential and community nuisance

Table 10.4-2: Certain/Planned Project Descriptions

Map Number	Project/Activity Name	Project/Activity Description	Type of Effect
20	Bruce A Decommissioning and Safe Storage	Decommissioning will span a period of 40 years and will include a 30-year safe storage period to allow radioactivity to decay to levels that make dismantling operations safer.	• Dose • Traffic • Air quality • Noise • Visual • Community services • Labour/housing
21	Bruce B Decommissioning and Safe Storage	Decommissioning will span a period of 40 years and will include a 30-year safe storage period to allow radioactivity to decay to levels that make dismantling operations safer.	• Dose • Traffic • Air quality • Noise • Visual • Community services • Labour/housing
22	RWOS1 Safe Storage	RWOS1 is located in the south central area of the Bruce nuclear site. RWOS1 was established to manage the low and intermediate level wastes from the Douglas Point Nuclear Generating Station and the Pickering Nuclear Generating Station. It was operated from 1967 to 1976, at which time it was placed into care-taking mode. The RWOS1 site is owned and operated by OPG. A program was undertaken in 1997 to remove the waste stored at RWOS1 and consolidate it with the waste stored at the WWMF, also operated by OPG on the Bruce nuclear site. Waste from four of the six RWOS1 trenches has been transferred to the WWMF. The 23 tile holes have been removed to the WWMF, and monitoring is underway. RWOS1 is now in caretaker mode with no active operations [470]. It is anticipated that the RWOS1 site will be remediated over the next several years.	• Dose • Groundwater

Table 10.4-2: Certain/Planned Project Descriptions (continued)

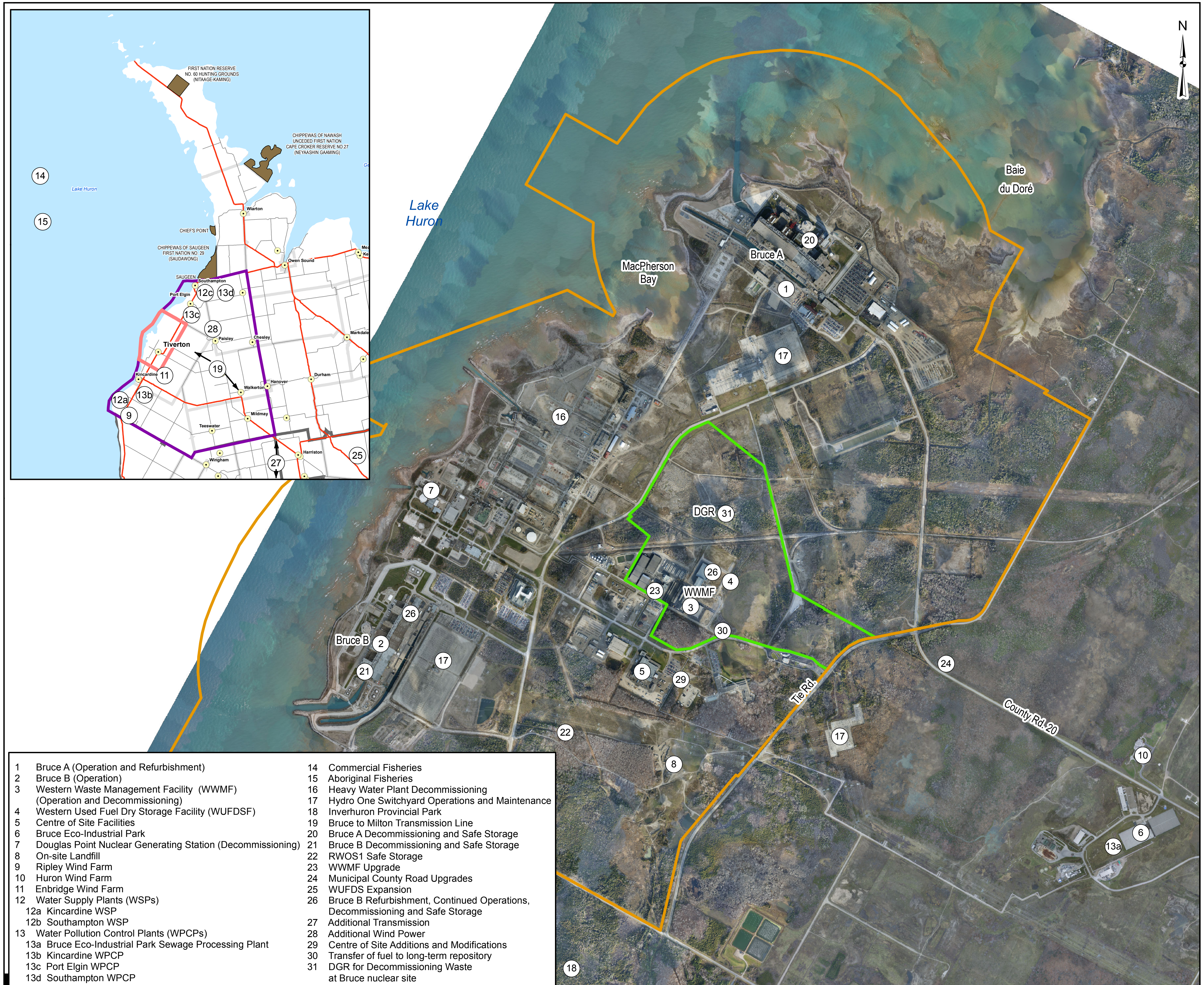
Map Number	Project/Activity Name	Project/Activity Description	Type of Effect
23	WWMF Upgrades	OPG proposed to expand its waste management capacity at the WWMF to handle waste generated by refurbishment waste from Ontario's nuclear power plants. The Refurbishment Waste Storage (RWS) Project was approved by the CNSC in 2006 for the support of continued operation of the nuclear power plants in Ontario. Construction of the initial storage structures will be undertaken on an "as required" basis, to meet the refurbishment schedules of Ontario nuclear generating stations. The construction and operation of this project's additional storage structures will be accommodated entirely within the existing licensed WWMF. OPG has safely operated this facility since 1974 under an operating licence issued by the CNSC. For planning purposes, six Steam Generator Storage Buildings (SGSBs) and six Retube Components Storage Buildings (RCSBs) have been included in the RWS Project. As part of the project OPG proposed the construction of two new low-level storage buildings (LLSBs) at the WWMF. LLSBs 10 and 11 will be for the storage of LLW produced at nuclear power plants across Ontario, and other facilities owned by OPG.	• Air quality • Noise • Aquatic Habitat (South Railway Ditch) • Dose
24	Municipal County Road Upgrades	Road upgrades are likely to occur in the vicinity of Bruce nuclear site at the discretion of County of Bruce administration.	• Habitat loss (terrestrial and aquatic) • Noise and air quality (construction) • Traffic
25	WUFDSF Expansion	The OPG WWMF currently has used fuel dry storage for approximately 744,000 fuel bundles in 1,940 dry storage containers. A total of approximately 1,430,000 used fuel bundles are expected to be produced by Bruce A and B stations over their design life. In preparation for this expected waste, OPG obtained CNSC approval to construct two additional dry storage buildings at the site as required. One of these buildings is currently under construction. To facilitate construction, there may be a rail bed crossing over the abandoned rail bed constructed.	• Dose • Noise and air quality (construction) • Aquatic Habitat (South Railway Ditch

Table 10.4-3: Reasonably Foreseeable Project Descriptions

Map Number	Project/Activity Name	Project/Activity Description	Type of Effect
26	Bruce B Refurbishment, Continued Operations, Decommissioning and Safe Storage	If Bruce Power decides to proceed with the refurbishment of Bruce B, this will form an alternative timing of the Bruce B activities and will supersede those identified under numbers 2 and 20. Bruce Power analysis has identified steam generators and pressure tubes as source of the primary limits on station life. Bruce Power may decide to replace the pressure tubes and refurbish the facility to extend its operating life. It is currently assumed that, if Bruce Power decides to proceed with the refurbishment of Bruce B, that such work would take place between 2018 and 2023 and could extend the operating life of the facility to approximately 2050. Bruce B refurbishment would require CNSC approval before implementation. Decommissioning will span a period of 40 years and will include a 30-year safe storage period to allow radioactivity to decay to levels that make dismantling operations safer.	• Water temperature and circulation • Dose • Impingement/ entrainment • Traffic • Noise and air quality (construction) • Visual • Community services • Labour/housing
27	Additional Transmission	As power production grows in Bruce County, additional transmission lines will be necessary to deliver electricity to customers in other regions of Ontario. Additional transmission options identified are Bruce to Longwood and Bruce to Essa corridors. No construction activities are currently planned.	• Habitat loss • Noise and air quality (construction) • Residential and community nuisance
28	Additional Wind Power	According to Wind Resource Atlas [471], developed by MNR, the shores of Lake Huron in Bruce County have some of highest wind potentials in the province. Hence, additional wind power developments in the area are very likely. There are a number of wind power projects in the Regional Study Area currently undergoing feasibility studies under the Renewable Energy Approvals process.	• Noise • Visual • Wildlife (birds and bats)
29	Centre of Site Additions and Modifications	During the anticipated life of the Bruce nuclear site various upgrades to buildings and facilities are likely. This may include new office space, structural upgrades to existing facilities and expansion of current centre of site services (e.g., WPCP, WTP, and landfill).	• Noise and air quality (construction) • Habitat loss

Table 10.4-3: Reasonably Foreseeable Project Descriptions (continued)

Map Number	Project/Activity Name	Project/Activity Description	Type of Effect
30	Transfer of Fuel to Long-term Repository	The used fuel that is currently stored in interim storage at the Western Used Fuel Dry Storage Facility will, at some point in the future, be relocated to a suitable long-term storage site. The Adaptive Phased Management Project is the mandate of the NWMO. The NWMO has initiated a process to seek an informed, willing host community for all of Canada's nuclear waste. The transfer of fuel is not expected until 2035 or later. The DGR Project is not the planned repository for used fuel.	• Dose • Air quality (from transportation)
31	DGR for Decommissioning Waste at Bruce Nuclear Site	The decommissioning waste from OPG-owned or operated reactors will, at some point in the future, be relocated to a suitable long-term management site. The long-term management of decommissioning waste is not expected to start before 2050. Although no site has been identified, the DGR Hosting Agreement includes provision for decommissioning waste to be placed in the DGR Project and the EIS Guidelines stipulate that consideration of placing decommissioning waste in the DGR be included in the cumulative effects assessment. The assessment is based on emplacement of decommissioning waste in an extension of the DGR (approximately doubling the underground capacity). The extension could be accommodated within the DGR Project site (i.e., no additional site clearance would be required). Management of decommissioning waste at the DGR would require a separate EA process.	• Noise and air quality (construction) • Dose • Surface water quality • Traffic • Visual • Community services • Labour



1	Bruce A (Operation and Refurbishment)	14	Commercial Fisheries
2	Bruce B (Operation)	15	Aboriginal Fisheries
3	Western Waste Management Facility (WWMF) (Operation and Decommissioning)	16	Heavy Water Plant Decommissioning
4	Western Used Fuel Dry Storage Facility (WUFDSF)	17	Hydro One Switchyard Operations and Maintenance
5	Centre of Site Facilities	18	Inverhuron Provincial Park
6	Bruce Eco-Industrial Park	19	Bruce to Milton Transmission Line
7	Douglas Point Nuclear Generating Station (Decommissioning)	20	Bruce A Decommissioning and Safe Storage
8	On-site Landfill	21	Bruce B Decommissioning and Safe Storage
9	Ripley Wind Farm	22	RWOS1 Safe Storage
10	Huron Wind Farm	23	WWMF Upgrade
11	Enbridge Wind Farm	24	Municipal County Road Upgrades
12	Water Supply Plants (WSPs)	25	WUFDS Expansion
12a	Kincardine WSP	26	Bruce B Refurbishment, Continued Operations, Decommissioning and Safe Storage
12b	Southampton WSP	27	Additional Transmission
13	Water Pollution Control Plants (WPCPs)	28	Additional Wind Power
13a	Bruce Eco-Industrial Park Sewage Processing Plant	29	Centre of Site Additions and Modifications
13b	Kincardine WPCP	30	Transfer of fuel to long-term repository
13c	Port Elgin WPCP	31	DGR for Decommissioning Waste at Bruce nuclear site
13d	Southampton WPCP		

LEGEND

- Site Study Area [1]
- Project Area (OPG-retained lands that encompass the DGR Project)

NOTE

1. Site Study Area is defined by EIS Guidelines as: "includes the facilities, buildings and infrastructure at the Bruce nuclear site, including the existing licensed exclusion zone for the site on land and within Lake Huron, and particularly the property where the Deep Geologic Repository is proposed.

REFERENCE

Base Data Provided by 4DM, November 2007.
Imagery and Topo Collected and Processed by Terrapoint Canada Inc., Acquisition Date: Nov. 12, 14, and 15, 2006, Ground Resolution: 0.25m,
Datum: NAD 83 Projection: UTM Zone 17N

0 125 250 500 750 1,000
Metres

PROJECT
DGR PROJECT
EVIRONMENTAL IMPACT STATEMENT

TITLE
GENERAL LOCATION OF OTHER PROJECTS AND ACTIVITIES CONSIDERED IN THE CUMULATIVE EFFECTS ASSESSMENT

Golder Associates
Mississauga, Ontario

PROJECT NO. 6-1112-037			SCALE: AS SHOWN	R000
DESIGN	ASB	03 Aug. 2006	**FIGURE 10.4-1**	
GIS	BC	28 Jun. 2010		
CHECK	KC	28 Jun. 2010		
REVIEW	MAR	28 Jun. 2010		

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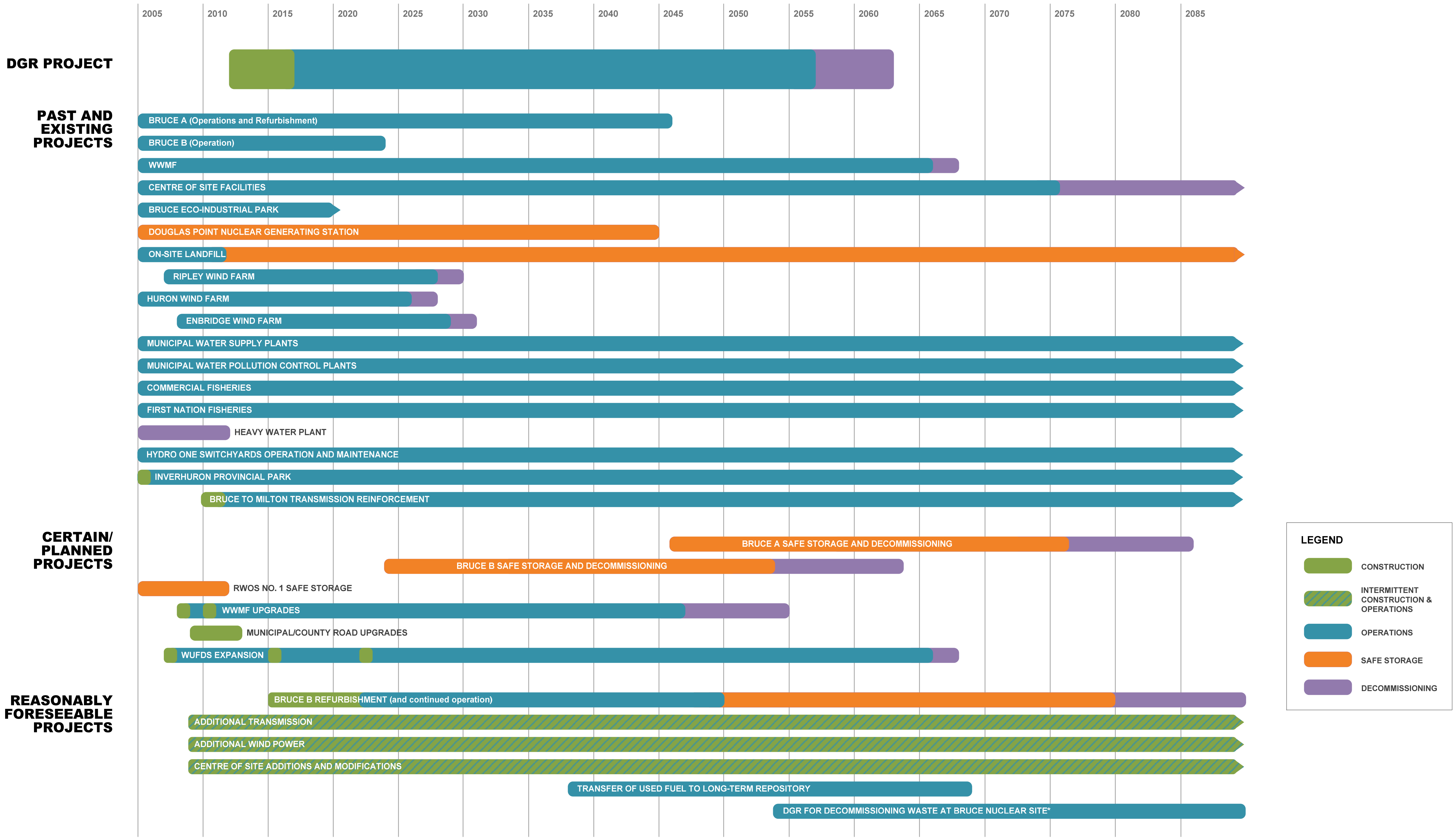

Note: * Not a planned activity; included to meet EIS Guideline requirements

Figure 10.4-2: Cumulative Effects Assessment Timeline

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10.5 SCREENING OF PROJECTS

Other projects or activities can act cumulatively with the DGR Project if they result in the same type of environmental effect, occur at the same time or affect the same geographic location (space). This section examines potential cumulative effects of other projects and activities to determine whether their effects overlap in type of effect (Section 10.5.1), time (Section 10.5.2), and space (Section 10.5.3) with the residual adverse effects of the DGR Project to determine the potential for cumulative effects (Section 10.6). The result of the screening is summarized in Table 10.5.4-1.

10.5.1 Identification of Projects with Similar Effects

10.5.1.1 Surface Water Quantity and Flow

Likely residual adverse effects of the DGR Project on surface water quantity and flow were identified for all phases of the DGR Project. Specifically, there is expected to be a decrease in flow in the North Railway Ditch and increase of flow in drainage ditch. Other projects that may cause changes in surface water flow will overlap in the type of effect with the DGR Project. Based on the information in Tables 10.4-1 to 10.4-3, the following other projects and activities are advanced for further assessment based on effects on surface water quantity and flow:

- Bruce A (operation and refurbishment);
- Bruce B (operation);
- water supply plants;
- water pollution control plants; and
- Bruce B refurbishment, continued operations, decommissioning and safe storage.

10.5.1.2 Terrestrial Environment

A residual adverse effect of the DGR Project on eastern white cedar was identified as a result of site clearing. Other projects that may cause changes to terrestrial plants will overlap in type of effect with the DGR Project. Based on the information in Tables 10.4-1 to 10.4-3, the following other projects and activities are advanced for further assessment based on effects on terrestrial plants:

- Bruce to Milton transmission line;
- municipal county road upgrades;
- additional transmissions; and
- centre of site additions and modifications.

10.5.1.3 Aquatic Environment

Residual adverse effects of the DGR Project on aquatic species in the South Railway Ditch (burrowing crayfish, redbelly dace, creek chub and variable leaf pondweed) were identified as a result of construction of a new rail bed crossing. Other projects that may cause changes to aquatic biota will overlap in type of effect with the DGR Project. Based on the information in

Tables 10.4-1 to 10.4-3, the following other project and activities are advanced for further assessment based on effects on aquatic biota:

- Bruce A (operations and refurbishment);
- Bruce B (operations);
- water supply plants;
- water pollution control plants;
- commercial fisheries;
- Aboriginal fisheries;
- Bruce to Milton Transmission Line;
- WWMF upgrades;
- municipal county road upgrades;
- WUFDS expansion;
- Bruce B refurbishment, continued operations, decommissioning and safe storage;
- additional transmissions; and
- centre of site additions and modifications.

10.5.1.4 Air Quality

Likely residual adverse effects of the DGR Project on air quality were identified during the site preparation, construction, operations and decommissioning phases. Specifically, there is expected to be an increase in emissions of combustion products (i.e., NO_2 and CO) and particulate matter (i.e., SPM, PM_{10} and $PM_{2.5}$). Other projects that may cause an increase in combustion products or particulate matter will overlap in the type of effect with the DGR Project. Based on the information in Tables 10.4-1 to 10.4-3, the following other projects and activities are advanced for further assessment based on effects on air quality:

- Bruce A (operations and refurbishment);
- Bruce B (operations);
- WWMF;
- WUFDSF;
- centre of site facilities;
- Bruce Eco-Industrial Park;
- Heavy Water Plant decommissioning;
- Bruce to Milton transmission line;
- Bruce A decommissioning and safe storage;
- Bruce B decommissioning and safe storage;
- WWMF upgrades;
- municipal/county road upgrades;
- WUFDSF expansion;
- Bruce B refurbishment, continued operations, decommissioning and safe storage;
- additional transmission;
- centre of site additions and modifications; and
- DGR for decommissioning waste at Bruce nuclear site.

10.5.1.5 Noise Levels

Likely residual adverse effects of the DGR Project on noise levels were identified during the site preparation and construction, and decommissioning phases. Other projects that may cause an increase in noise will overlap in the type of effect with the DGR Project. Based on the information in Tables 10.4-1 to 10.4-3, the following projects and activities are advanced for further assessment based on noise levels:

- Bruce A (operation and refurbishment);
- Bruce B (operation);
- Ripley Wind Farm;
- Huron Wind Farm;
- Enbridge Wind Farm;
- Hydro One switchyard operations and maintenance;
- Bruce to Milton transmission line;
- Bruce A decommissioning and safe storage;
- Bruce B decommissioning and safe storage;
- WWMF upgrades;
- Municipal/County road upgrades;
- WUFDSF expansion;
- Bruce B refurbishment, continued operations, decommissioning and safe storage;
- additional transmission;
- additional wind power;
- centre of site additions and modifications; and
- DGR for decommissioning waste at Bruce nuclear site.

10.5.1.6 Socio-economic Environment

A residual adverse effect was identified for socio-economic environment as a result of changes in noise levels. Therefore, potential cumulative effects associated with this residual adverse effect are considered through assessment of noise levels (Section 10.5.1.5).

10.5.1.7 Human Health

Residual adverse effects were identified for human health were as a result of changes in air quality. Therefore, potential cumulative effects associated with these residual adverse effects are considered through assessment of air quality (Section 10.5.1.4).

10.5.1.8 Radiation and Radioactivity

A measurable dose from the DGR Project was identified during the operations phase. Other projects may also release radioactivity dose and create an additive effect. Based on the information in Tables 10.4-1 to 10.4-3, the following projects and activities are advanced for further assessment based on radiation and radioactivity:

- Bruce A (operation and refurbishment);

- Bruce B (operation);
- WWMF operation and decommissioning;
- WUFDSF operation;
- centre of site facilities;
- Douglas Point Nuclear Generating Station decommissioning;
- Heavy Water Plant decommissioning;
- Bruce A decommissioning and safe storage;
- Bruce B decommissioning and safe storage;
- RWOS1 safe storage;
- WWMF upgrades;
- WUFDSF expansion;
- Bruce B refurbishment, continued operations, decommissioning and safe storage;
- centre of site additions and modifications;
- transfer of used fuel to long-term repository; and
- DGR for decommissioning waste at Bruce nuclear site.

10.5.2 Identification of Effects that Overlap in Time

It is necessary to determine if the projects and activities that overlap in type of effect (Section 10.5.1) could also act cumulatively with the DGR Project in time. Figure 10.4-2 shows the general timeframes for the other projects and activities being considered. The DGR Project consists of four phases:

- site preparation and construction phase;
- operations phase;
- decommissioning phase; and
- abandonment and long-term performance phase.

For the purposes of the cumulative effects assessment, it is necessary to assign a time frame to these phases. Therefore, it has been assumed that the site preparation and construction phase will start in 2013 and last for approximately six years. The operations phase will then commence and continue for forty years, followed by a six year decommissioning phase. Uncertainty with this schedule is most likely to relate to the site preparation and construction phase starting later than 2013, or continuing for a period of more than six years. In evaluating effects that may overlap in time, this assessment considers that there could be uncertainty associated with the timing and duration of this phase. Therefore, projects that are consecutive, or nearly consecutive in time are also considered to overlap, and are considered further.

Abandonment immediately follows decommissioning but extends for a long time. Prior to initiating decommissioning activities another EA would be required to assess the potential effects of the activities associated with decommissioning.

10.5.2.1 Surface Water Quantity and Flow

Changes in surface water quantity and flow are expected to occur during all phases of the DGR Project. All of the other projects with similar effects occur during at least one phase of the DGR

Project. Therefore, they all overlap in type of effect and time and are advanced for further assessment.

10.5.2.2 Terrestrial Environment

The effect on eastern white cedar is expected to occur during site preparation and construction phase as a result of site clearing. However, the effect is expected to last throughout the operations phase of the DGR Project. All of the other projects with similar effects occur during at least one of those phases of the DGR Project. Therefore, all of the projects overlap in time and are advanced for further assessment.

10.5.2.3 Aquatic Environment

Changes in the South Railway Ditch habitat are expected to occur during the site preparation and construction and last through the operations phases of the DGR Project. All of the other projects with similar effects occur during at least one of these phases of the DGR Project. Therefore, they all overlap in type of effect and time and are advanced for further assessment.

10.5.2.4 Air Quality

Changes in air quality are expected to occur during all phases of the DGR Project. Air quality effects from the heavy water plant decommissioning, WWMF upgrades, county road upgrades and the Bruce to Milton transmission line are only anticipated during construction or decommissioning activities. These activities all occur prior to the start of the DGR Project for these four particular projects. Therefore, the effects from these four projects do not overlap in time and are not considered further.

The remainder of the projects or activities that overlap in type of effect also overlap in time and are advanced for further assessment.

10.5.2.5 Noise Levels

Changes in noise levels are expected to occur during the site preparation and construction and decommissioning phases of the DGR Project. Noise level effects from the WWMF upgrades, county road upgrades and the Bruce to Milton transmission line are only anticipated during construction or decommissioning activities. These activities all occur prior to the start of the DGR Project for these three particular projects. Therefore, the effects from these three projects do not overlap in time and are not considered further.

The remainder of the projects or activities that overlap in type of effect also overlap in time and are advanced for further assessment.

10.5.2.6 Radiation and Radioactivity

As radiological effects are considered additive, all projects are assumed to overlap in time and are advanced for further assessment.

10.5.3 Identification of Effects that Overlap Spatially

It is necessary to determine whether those effects that overlap in type of effect and time could also act cumulatively with the effects of the DGR Project within the same geographic area (space). Spatial effects are considered within the context of the Regional, Local and Site Study Areas and Project Area (described in Section 5.1). Figure 10.4-1 shows the general location of all other projects and activities. Completion of this screening step provides a short list of other projects and activities with effects that have the potential to act cumulatively with the residual adverse effects of the DGR Project.

10.5.3.1 Surface Water Quantity and Flow

The reduction in surface water flow attributable the DGR Project is expected be limited to the North Railway Ditch within the Project Area (i.e., within the OPG-retained lands in the centre of the Bruce nuclear site). The increase in surface water quantity and flow caused by the DGR Project is expected to be limited to the drainage ditch within the Site Study Area. None of the projects and activities that overlap in effect and time, are expected to have potential changes in surface water flows within the Project Area and Site Study Area (specifically the North Railway Ditch and drainage ditch). Therefore, potential cumulative effects on surface water quantity and flow are not considered further.

10.5.3.2 Terrestrial Environment

The residual adverse effect for eastern white cedar as a result of site clearing for the DGR Project is expected to be limited to the Project Area. All of the projects identified to have potential to result in habitat loss would occur outside of the Project Area. The centre of site additions and modifications may have potential to result in habitat loss in the Site Study Area. All other projects are expected to occur outside of the Site Study Area and therefore do not overlap spatially with the DGR Project residual adverse effects for eastern white cedar. Therefore, potential cumulative effects on eastern white cedar are advanced further for the centre of site additions and modifications only. This interaction is advanced for an assessment of cumulative effects in Section 10.6. None of the other projects are advanced for assessment.

10.5.3.3 Aquatic Environment

The residual adverse effect of the loss of habitat in South Railway Ditch resulting from the construction of the rail bed crossing for the DGR Project is expected to be limited to the Project Area. Of those projects and activities that potentially result in effects that overlap in effect and time, only the WWMF upgrades and WUFDSF expansion are also expected to have potential loss of habitat effects to the South Railway Ditch.

This interaction is advanced for an assessment of cumulative effects in Section 10.6. None of the other projects are expected to have effects on the South Railway Ditch.

10.5.3.4 Air Quality

The degradation of air quality resulting from the DGR Project is expected to extend to the Local Study Area defined for the air quality assessment (Section 6.7.1). Of those projects and activities that potentially result in effects that overlap in effect and time, the following are also expected to have air quality effects that occur in the Local Study Area:

- Bruce A (operation and refurbishment);
- Bruce B (operation);
- WWMF;
- WUFDSF;
- centre of site facilities;
- Bruce Eco-Industrial Park;
- Bruce A decommissioning and safe storage;
- Bruce B decommissioning and safe storage;
- WUFDSF expansion;
- Bruce B refurbishment, continued operations, decommissioning and safe storage;
- centre of site additions and modifications; and
- DGR for decommissioning waste at Bruce nuclear site.

These interactions are advanced for an assessment of cumulative effects in Section 10.6.

10.5.3.5 Noise Levels

The increase in noise levels resulting from the DGR Project is expected to extend to the Local Study Area (Section 6.8.1). Of those projects and activities that may result in effects that overlap in effect and time, the following are also expected to have noise level effects that occur in the Local Study Area:

- Bruce A (operation and refurbishment);
- Bruce B (operation)
- Huron Wind Farm;
- Hydro One switchyard operations and maintenance;
- Bruce A decommissioning and safe storage;
- Bruce B decommissioning and safe storage;
- WUFDSF expansion;
- Bruce B refurbishment, continued operations, decommissioning and safe storage;
- centre of site additions and modifications; and
- DGR for decommissioning waste at Bruce nuclear site.

These interactions are advanced for an assessment of cumulative effects in Section 10.6.

10.5.3.6 Radiation and Radioactivity

All of the other projects are located on the Bruce nuclear site; therefore, they are expected to overlap in space and are advanced for an assessment of cumulative effects in Section 10.6.

10.5.4 Summary of Effects that Overlap in Type of Effect, Time and Space

Table 10.5.4-1 summarizes all of the other projects and activities likely to overlap with a residual adverse effect of the DGR Project. Residual adverse effects from the assessment (Section 7) are identified with diamonds (◆) in the table. Projects and activities that were identified as only overlapping in type of effect are marked with a single star (★) in the table, while those projects that overlap in type of effect and time have two stars (★★). Projects that occur consecutively were also assumed to overlap in time. Those projects that overlap in time, space and type of effect are identified with three stars (★★★) and are advanced for further assessment in Section 10.6.

Table 10.5.4-1: Summary of Effects that Overlap in Type of Effect, Time and Space

Projects	**VEC Affected**					
	Surface Water Quantity and Flow	**Terrestrial Environment**	**Aquatic Environment**	**Air Quality**	**Noise Levels**	**Radiation and Radioactivity**
DGR Project	◆	◆	◆	◆	◆	
Past and Existing Projects						
1. Bruce A (operations and refurbishment)	★★		★★	★★★	★★★	★★★
2. Bruce B (operations)	★★		★★	★★★	★★★	★★★
3. WWMF (operations and decommissioning)				★★★		★★★
4. WUFDSF (operations and decommissioning)				★★★		★★★
5. Centre of Site Facilities				★★★		★★★
6. Bruce Eco-Industrial Park				★★★		
7. Douglas Point Nuclear Generating Station (decommissioning)						★★★
8. On-site Landfill						
9. Ripley Wind Farm					★★	
10. Huron Wind Farm					★★★	
11. Enbridge Wind Farm					★★	
12. Water Supply Plants	★★		★★			
13. Water Pollution Control Plants	★★		★★			
14. Commercial Fisheries			★★			

Table 10.5.4-1: Summary of Effects that Overlap in Type of Effect, Time and Space (continued)

Projects	VEC Affected					
	Surface Water Quantity and Flow	Terrestrial Environment	Aquatic Environment	Air Quality	Noise Levels	Radiation and Radioactivity
15. First Nation Fisheries			★★			
16. Heavy Water Plant Decommissioning				★		★★★
17. Hydro One Switchyard Operations and Maintenance					★★★	
18. Inverhuron Provincial Park						
19. Bruce to Milton Transmission Line		★★	★★	★	★	
Certain/Planned Projects						
20. Bruce A Decommissioning and Safe Storage				★★★	★★★	★★★
21. Bruce B Decommissioning and Safe Storage				★★★	★★★	★★★
22. RWOS1 Safe Storage						★★★
23. WWMF Upgrades			★★★	★	★	★★★
24. Municipal/County Road Upgrades		★★	★★	★	★	
25. WUFDSF Expansion			★★★	★★★	★★★	★★★
Reasonably Foreseeable Projects						
26. Bruce B Refurbishment, Continued Operations, Decommissioning and Safe Storage	★★		★★	★★★	★★★	★★★

Table 10.5.4-1: Summary of Effects that Overlap in Type of Effect, Time and Space (continued)

Projects	VEC Affected					
	Surface Water Quantity and Flow	Terrestrial Environment	Aquatic Environment	Air Quality	Noise Levels	Radiation and Radioactivity
27. Additional Transmission		★★	★★	★★	★★	
28. Additional Wind Power					★★	
29. Centre of Site Additions and Modifications		★★★	★★	★★★	★★★	★★★
30. Transfer of Fuel to Long-term Repository						★★★
31. DGR for Decommissioning Waste at Bruce Nuclear Site				★★★	★★★	★★★

Notes:
Blank Project effects do not overlap with DGR Project effects in type of effect
◆ Residual adverse effect identified for the DGR Project
★ Project effects overlap with the DGR Project effects in type
★★ Project effects overlap with the DGR Project effects in type and time (projects that are consecutive in time are also considered to overlap)
★★★ Project effects overlap with the DGR Project effects in type, time and space

10.6 ASSESSMENT OF CUMULATIVE EFFECTS

10.6.1 Surface Water Quantity and Flow

There were no other projects that may result in effects that overlap with the DGR Project effects in type, time and space. Therefore, there are no cumulative effects on surface water quantity and flow.

10.6.2 Terrestrial Environment

The residual adverse effect on eastern white cedar resulting from site clearing for the DGR Project was identified to interact with centre of site additions and modifications in type of effect, time and space. Additions to the centre of site facilities may result in additional land clearing. Forest areas (Figure 6.4.3-1) are located adjacent to the south of the centre of site facilities (Figure 1.1.1-3). It is likely that these projects would require relatively small areas of land clearing. The habitat loss as a result of these projects is expected to be small and is unlikely to result in adverse cumulative effects on eastern white cedar. Extension of the DGR to accommodate decommissioning wastes would not require any additional land clearing.

10.6.3 Aquatic Environment

Residual adverse effects were identified for aquatic species in the South Railway Ditch (redbelly dace, creek chub, variable leaf pondweed, benthic invertebrates) and burrowing crayfish in North and South Railway Ditch as a result of construction of the rail bed crossing for the DGR Project. WWMF upgrades have been identified to potentially interact with these aquatic species in the railway ditches. The activities associated with the WWMF upgrades are not expected to result in any additional direct habitat loss in the South Railway Ditch. In addition, if the DGR is constructed that would limit the requirement for new buildings at the WWMF. However, an additional rail bed crossing over the South Railway Ditch may be constructed as part of the WUFDSF expansion. This may represent an additional 20 m disturbance to aquatic habitat. However, the cumulative disturbance (40 m) is still very small relative to the total length (approximately 1,250 m), and it would remain a low magnitude effect. Furthermore, it is expected that the WUFDSF rail bed crossing will incorporate all of the same construction mitigation measures (see Section 7.5.2.1). Therefore, the WWMF upgrades and WUFDSF expansion are not likely to result in cumulative effects on the redbelly dace, creek chub, variable leaf pondweed, burrowing crayfish and benthic invertebrates.

10.6.4 Air Quality

Likely residual adverse effects on air quality from DGR Project-related emissions during the site preparation and construction, operations, and decommissioning phases were identified as a result of emissions of particulate matter and combustion products (see Section 7.7.2). Based on the screening of cumulative effects, five existing projects, three certain/planned projects and three reasonably foreseeable projects may act cumulatively with the DGR Project.

The likely environmental effects for the DGR Project-environment interactions involving air quality were evaluated with the use of modelling methods. Inputs to this model included the emissions sources on-site, including those emissions associated with the operation of four reactor units at Bruce A and four units at Bruce B. Therefore, the assessment of effects of air quality presented in Section 7.7.2 includes the cumulative effects of the operation of Bruce A, Bruce B, the WWMF and the centre of site facilities. Operations at the Bruce Eco-Industrial Park are expected to continue through the construction and operations of the DGR Project. Emissions to air may occur as a result of operations of the industries in the Bruce Eco-Industrial Park, and/or vehicle emissions are likely captured in the background air quality that was added to the model predictions. Accordingly, these emissions are not likely to result in measurable cumulative effects to air quality beyond those already captured in Section 7.7.2.

Construction activities for the WUFDSF expansion may occur during both the site preparation and construction, and operations phases of the DGR Project. The EA completed for the WUFDSF expansion indicates that that dust and particulates are likely to be produced by this project; however, both are predicted to be very low and well below the MOE criteria [472]. Additionally, construction activities for the expansion are only expected to be of a very short duration (less than a year per campaign). Therefore, these emissions are not likely to result in measurable cumulative effects to air quality.

The decommissioning activities for Bruce A and Bruce B may overlap in time with the operations and decommissioning phases of the DGR Project. The emissions associated with these activities are expected to be similar to those associated with the refurbishment. As no cumulative effects to air quality are expected for the refurbishment activities (Bruce A), these emissions are not considered further.

Construction activities for the refurbishment of Bruce B may overlap in time with the site preparation and construction phase for the DGR Project. The refurbishment of Bruce B was considered in the New Fuel Project for Bruce B EA [473]. No residual adverse effects associated with particulates or combustion products were identified in this assessment. Therefore, these emissions are not considered further.

Centre of site additions and modifications could occur at any time during the DGR Project. These would likely involve site clearing, building construction and/or demolition and associated emissions of particulates and combustion products. These projects are likely to be much smaller in scale than the DGR Project and would likely occur for a shorter duration. Best management practices required for all construction activities would minimize particulate emissions. Therefore, no measurable cumulative effect is likely from these emissions in the Local Study Area.

Long-term management of decommissioning wastes is considered to occur at some time in the future. This would require additional construction and emplacement activities. Effects from this would be assumed to be similar to those identified for the site preparation and construction phase of the DGR Project. However, these effects would occur after the site preparation and construction phase of the DGR Project, and would likely be after completion of the operations phase and installation of the closure walls in the current DGR layout. Therefore, the air quality effects from the construction of emplacement rooms for decommissioning wastes would not overlap with the air quality effects of the DGR Project. Thus, no measurable cumulative effects are likely from these emissions.

10.6.5 Noise Levels

Likely residual adverse effects on noise levels from DGR Project-related emissions during the site preparation and construction, and decommissioning phases were identified. An increase in noise levels of 5 dBA over baseline was identified at the Baie du Doré receptor location. No adverse effects were identified at any other locations. Based on the screening of cumulative effects, four other existing projects, two other certain/planned projects and two other reasonably foreseeable projects may act cumulatively with the DGR Project.

The likely environmental effects for the DGR Project-environment interactions involving noise levels were evaluated with the use of modelling methods. Inputs to this model included the current noise levels on-site and at the receptor locations. Therefore, the assessment of effects of noise levels presented in Section 7.8.2 includes the cumulative effects of the existing operations of Bruce A and Bruce B, the Huron Wind Farm and Hydro One switchyards. Accordingly, these existing and ongoing emissions are not likely to result in additional cumulative effects to noise levels beyond those described in Section 7.8.

Bruce A and B decommissioning activities may overlap with the decommissioning phase of the DGR Project. The noise levels during the decommissioning of Bruce A and B is expected to be similar to those during refurbishment. As no cumulative effects to noise levels are expected for the refurbishment activities (Bruce A), these emissions are not considered further.

Construction activities for the refurbishment of Bruce B may overlap in time with the site preparation and construction phase for the DGR Project. The refurbishment of Bruce B was considered in the New Fuel Project for Bruce B EA [473]. No residual adverse effects associated with noise levels were identified in this assessment. Therefore, these emissions are not considered further.

Centre of site additions and modifications could occur at any time during the DGR Project. These would likely involve site clearing, building construction and/or demolition and associated noise emissions. These projects are likely to be much smaller in scale than the DGR Project and would likely occur for a shorter duration. Best management practices required for all construction activities would minimize noise levels. Therefore, no cumulative effect is likely from these emissions at the points of reception evaluated.

Long-term management of decommissioning wastes in the DGR is considered as a potential project to occur at some time in the future. This would require additional construction and emplacement activities. However, it is unlikely that construction would occur concurrent with the operation of the DGR Project. Therefore, no cumulative effect is likely from these emissions.

10.6.6 Radiation and Radioactivity

No residual adverse effects on radiation and radioactivity were identified for the DGR Project. However, they may have an additive effect with radiological effects from other projects. Based on the screening of cumulative effects, seven existing projects, five certain/planned projects and four reasonably foreseeable projects may act cumulatively with the DGR Project. As described in Section 7.6, the public dose estimates for the DGR Project are very small and would be less than 1 µSv/a [474]. All predicted doses to non-human biota are less than 0.8% of the regulatory standard.

As described in Section 6.6.10, the existing dose to the public is monitored as part of Bruce Power's Radiological Environmental Monitoring Program. The total existing dose from the Bruce nuclear site is approximately 4 µSv/a (2009 data). This would include the existing operation of Bruce A, Bruce B, the WWMF, the WUFDSF, centre of site facilities, Douglas Point, and RWOS1.

The decommissioning of Bruce A and Bruce B may also result in an additive dose. However, if these facilities are being decommissioned, they will no longer be contributing a dose from operations. Therefore, a change in dose is not expected to be measurable. The WWMF upgrades and WUFDSF expansion will increase the capacity of these facilities, and likely the dose from operations. As described in Section 6.6.4, the WWMF currently contributes less than 0.1% of the releases from the Bruce nuclear site. Therefore, a change in dose is not likely to be measurable.

The dose from the refurbishment of Bruce B would likely be similar to that experienced currently during the refurbishment of Bruce A. The radiological emissions from centre of site upgrades would not likely result in a measurable dose compared to the other emissions on-site. Therefore, these two projects are not considered further.

At some time in the future, used fuel and decommissioning wastes will be transferred to a long-term repository. The DGR is not for the long-term management of used fuel; therefore, the repository will be located off-site. Any dose will be solely from the transport of used fuel, and as the used fuel is transferred off-site, will result in a net reduction of dose. The Hosting Agreement does, however, include a provision for the long-term management of decommissioning wastes. If this is the case, the operational doses are expected to be similar to those of the DGR for operating waste. There would be no additive effect because panels in the DGR for operating waste would be closed. It would increase the radiological releases during the abandonment and long-term performance phase of the DGR. However, even if they were to double, doses would still be small (i.e., <2 µSv/a), and would be well below regulatory limits. Therefore, no further consideration is required.

10.7 SIGNIFICANCE OF CUMULATIVE EFFECTS

Any residual adverse cumulative effects must be assessed for significance. The methods used to determine significance are described in Section 7.1. No residual adverse cumulative effects of the DGR Project were identified. Therefore, the assessment of the significance of the residual adverse cumulative effects is not required. Follow-up monitoring is proposed to confirm adverse effects do not occur and that in-design mitigation measures are effective, as described in Section 13.

10.8 SUMMARY OF CUMULATIVE EFFECTS ASSESSMENT

Table 10.7-1 summarizes the assessment of cumulative effects of the DGR Project in combination with other past, existing, planned or reasonably foreseeable projects considered in this EIS. No adverse cumulative effects were identified.

Table 10.7-1: Summary of Likely Adverse Cumulative Effects

VEC Affected	Cumulative Effect Considered	Conclusion of Cumulative Effects Assessment
Surface Water Quantity and Flow	Decrease in flow in the North Railway Ditch and increase in flow in the drainage ditch	No likely adverse cumulative effects
Terrestrial Environment	Clearing of eastern white cedar in the Project Area during site preparation	No likely adverse cumulative effects
Aquatic Environment	Loss of redbelly dace, creek chub and variable leaf pondweed habitat in South Railway Ditch and loss of burrowing crayfish habitat in North and South Railway Ditch	No likely adverse cumulative effects
Air Quality	Increase in particulates and combustion products	No likely adverse cumulative effects
Noise Levels	Increase in noise levels at the Baie du Doré	No likely adverse cumulative effects
Radiation and Radioactivity	Additive effects of radiological emissions from other projects	No likely adverse cumulative effects

11. CAPACITY OF RENEWABLE RESOURCES

This section describes the effect of DGR Project-related environmental effects on the capacity of renewable resources to meet the needs of the present and those of the future. One goal of the assessment is to determine whether renewable resources would be affected by the DGR Project to the point where they are not sustainable. Sustainability is defined in a manner consistent with the United Nations' definition of sustainable development as "economic development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

Potential DGR Project-environment interactions identified in the screening matrices were reviewed to determine the likelihood of interactions between the DGR Project and resource sustainability. For context, non-renewable resources are also discussed.

11.1 SURFACE WATER RESOURCES

Surface water is considered a renewable resource. Both surface water quality and surface water quantity and flow can be considered distinct aspects of this resource. All underground water from the DGR Project and surface runoff (up to the design storm event) will be captured in the stormwater management pond. The water will be tested and compared against predetermined criteria to confirm whether applicable limits are met (Appendix D in the Hydrology and Surface Water Quality TSD). In the event that water quality does not meet criteria, treatment will be applied. As described in Section 7.3.2.2, provided that the certificate of approval criteria are met, there are no likely residual adverse effects on surface water quality.

A 31% reduction in flow in the North Railway Ditch at Stream C as a result of the single diversion of drainage area was identified for surface water quantity and flow in Section 7.3.2.1. The assessment also identified a residual adverse effect in surface water quantity and flow as a result of an increase in flow in the drainage ditch at Interconnecting Road (Section 7.3.2.1). However, for the purpose of this assessment, the likely residual adverse effects of the DGR Project on the environment were not considered to have the potential to adversely affect the sustainability of associated resources (i.e., local and regional water resources).

As described in Section 7.13, no residual adverse effects are likely on Lake Huron. The increases in flow described above will not be measurable in Lake Huron, and no adverse effects are identified for surface water quality, or the use and enjoyment of the lake for recreation.

11.2 GEOLOGY AND GROUNDWATER RESOURCES

11.2.1 Groundwater

Groundwater in the overburden and shallow bedrock is considered a renewable resource. Both the overburden and shallow bedrock groundwater quality, and groundwater transport may be considered as distinct components of the renewable resource. No likely adverse effects were identified for overburden and shallow bedrock groundwater quality, and overburden and shallow bedrock groundwater transport (Section 7.2.2). The duration of dewatering is short in relation to the life of the DGR Project and the zone of influence attributed to dewatering activities during the site preparation and construction phase is expected to be small. Additionally, no utilization is made of potable groundwater sources within the Site Study Area. Therefore, there are no likely adverse effects on the sustainability of the renewable groundwater resource as a result of the DGR Project.

11.2.2 Aggregate Resources

Aggregate resources (i.e., sand and gravel, quarried rock) are considered a non-renewable resource. An assessment of Quaternary and Paleozoic geology and aggregate resources indicates that the DGR Project site is located within the Huron Fringe and Huron Slope physiographic regions, consisting of Quaternary sediments, mainly till, overlying the Paleozoic basement (Section 6.2.6). There are no primary sand and gravel deposits identified within 20 km of the DGR Project site.

Many of the Paleozoic rocks identified at the Bruce nuclear site have been exploited elsewhere in Ontario for their aggregate potential, for landscaping rock, and for brick manufacture. Generally, for these industries to be economic, the rock source must be close to surface (less than 8 mBGS), and be of mineable thickness. Therefore, most of the rock aggregate is extracted in quarries along the Niagara escarpment or areas of shallow overburden in Bruce County. The DGR Project site is considered to have a low potential for aggregate resource extraction.

The DGR Project will consume some concrete aggregate resources during construction; however, the quantity is a small portion of locally available aggregate. Therefore, there are not likely to be any adverse effects to the non-renewable resources in the Local and/or Regional Study Areas as a result of the DGR Project.

Aggregate resources will also be created on the site through the excavation and blasting activities during the site preparation and construction phases of the DGR Project. However, there are currently no plans for releasing the waste rock excavated during the construction of the DGR Project into the local aggregate market.

11.2.3 Petroleum Resources

A petroleum geology assessment based on a review of existing literature indicated that there is a very low probability of identifying economic oil and/or gas resources in the vicinity of the DGR site. At present, there is no petroleum/gas production within 40 km of the Project Area. In addition, the DGR boreholes confirmed the results of the Texaco #6 exploration well, located some 3 km east of the Project Area, that there are no significant oil or gas shows in the Palaeozoic sequence at the Bruce nuclear site. Therefore, there are no likely adverse effects on the non-renewable petroleum resources as a result of the DGR Project.

Fuels for on-site vehicle and equipment operation are required through all phases of the DGR Project. The consumption of fuels for the DGR Project is not expected to deplete the existing supply. Heating of intake air in winter for DGR ventilation will be achieved using electric heating. Therefore, there will be no requirements for non-renewable resources for heating purposes.

11.2.4 Soil Quality

The soil quality VEC may be considered a renewable aspect of the non-renewable soil aggregate resource, in that soil quality impacted as a result of human activities can be "renewed" (i.e., remediated) and returned to its baseline environmental quality. No adverse effects on soil quality are likely. Therefore, it was concluded that the DGR Project will not create residual adverse effects on the soil quality VEC. Accordingly, soil quality-project interactions are not expected to affect the non-renewable soil resource.

11.3 AQUATIC RESOURCES

The aquatic resources are considered in terms of fisheries and fish habitat. A residual adverse effect was identified for redbelly dace, creek chub, variable leaf pondweed, burrowing crayfish and benthic invertebrates (Section 7.5.2). However, any effects are restricted to the Project Area. Therefore, it is not expected to affect the Lake Huron fisheries, or aquatic resources. Therefore, there is no likely effect on the sustainability of these resources.

11.4 TERRESTRIAL RESOURCES

A residual adverse effect was identified in Section 7.4.2.1 on eastern white cedar as a result of land clearing activities during site preparation and construction. However, there is no intention of managing the cedar forest in the Project Area as a harvestable resource to produce lumber. Therefore, the removal of the mixed forest will not have an effect on renewable resources.

The optimum habitat for white-tailed deer is a mixture of open areas and young forest with suitable cover, which is well-represented in the Site Study Area. White-tailed deer may also feed on cedar during the winter months. While 8.9 ha of mixed woods forest will be removed during site preparation, this is a small area which represents only 11.4% of this type of habitat available for sheltering and foraging within the Site Study Area. Therefore, white-tailed deer are not likely to relocate.

11.5 SOCIO-ECONOMIC RESOURCES

Likely effects were predicted, described and their significance assessed (if necessary) by considering renewable resource use as one component within the Other Financial Assets VEC (see Section 7.10). No adverse effects were identified.

11.6 ABORIGINAL RESOURCES

Non-renewable resource use associated with the DGR Project related to Aboriginal interests is expected to include use of aggregate and fuels. The availability of aggregate may be of interest to Aboriginal communities as a resource for their own use and/or a business opportunity.

Aggregate required during the site preparation and construction phase will most likely be sourced from off-site aggregate operations. The DGR Project assumes that any waste rock not used for the DGR Project will remain on-site, thereby eliminating the potential for increased supply to affect local markets and production.

The renewable resources considered in this analysis are those fish species (e.g., lake whitefish) that are harvested by Aboriginal people for commercial purposes. As described in Section 11.3, no adverse effect is expected on fish populations. Therefore, no adverse effects on commercial fisheries are expected.

12. FOLLOW-UP PROGRAM

12.1 PURPOSE OF THE FOLLOW-UP PROGRAM

The DGR Project EIS Guidelines (see Appendix A) stipulate that the need for, and the requirements of, any follow-up program for the DGR Project be identified. A follow-up program may be required to verify that the environmental and cumulative effects of the DGR Project are consistent with predictions reported in the EIS. It can also be used to verify that mitigation measures are effective once implemented and determine whether there is a need for additional mitigation measures. A preliminary follow-up program plan is provided below. The follow-up program is designed to be appropriate to the scale of the DGR Project and the effects identified through the EA process.

Follow-up monitoring programs are generally required to:

- verify the key predictions of the EA studies; or
- confirm the effectiveness of mitigation measures, and in doing so, determine if alternative mitigation strategies are required.

The CNSC and Canadian Environmental Assessment Agency will provide the regulatory oversight to ensure that OPG has implemented all appropriate mitigation measures and that the follow-up monitoring is designed and carried out. The CNSC compliance program can be used as the mechanism for ensuring the final design and implementation of the follow-up program and reporting of the follow-up program results.

12.2 INITIAL SCOPE OF THE FOLLOW-UP PROGRAM

An environmental monitoring framework was developed in accordance with CSA N288.4-10, CNSC S-296 and CNSC G-320 [475;476;477]. It is documented in the DGR EA Follow-up Monitoring Program [478]. The objective of the environmental monitoring framework is to ensure that the predictions made in the EA are confirmed, anticipated licensing and legislative requirements are adhered to and best management practice is employed, while minimizing the duplication and overlap of monitoring activities and reporting. The monitoring program encompasses four groups of monitoring activities:

- EA follow-up monitoring;
- Environmental Management Plan (EMP) monitoring;
- radiological regulatory monitoring; and
- conventional regulatory monitoring (e.g., provincial and federal requirements, permits and approvals).

In addition to the four groups of monitoring activities, some baseline monitoring will be conducted prior to and during construction in order to acquire information and data to which future monitoring results can be compared.

A description of each of the four groups of monitoring activities within the framework is provided in Section 1 of the DGR EA Follow-up Monitoring Program [478]. The monitoring activities for each of the four programs, as well as the baseline monitoring activities are described in Sections 2 to 11 of the DGR EA Follow-up Monitoring Program [478]. Contingency Procedures are described in Section 13 of the DGR EA Follow-up Monitoring Program as a means of assessing unforeseen effects or for correcting exceedances, as required.

The DGR EA Follow-up Monitoring Program [478] focuses on the EA follow-up monitoring activities; however, because of the interconnected nature of the environmental monitoring framework, the components of the three other programs are also discussed, where appropriate, to provide a complete picture of the environmental monitoring for the DGR Project as a whole. Though there may be some overlap with another monitoring program, the EA follow-up monitoring program is intended to capture elements that would otherwise not be required (either by licensing or legislation), but satisfy the requirement to confirm an effect (or lack-of), a prediction, an assumption used in assessing the effects, or the effectiveness of a mitigation measure identified in the EIS.

All EA follow-up monitoring activities are designed to satisfy a specific statement in the EIS and are expected to be discontinued when the requirement has been satisfied or at the end of a predetermined duration. In some cases, a particular monitoring activity may continue as a best management practice under the EMP, but the reporting requirement as part of the EA follow-up will be discontinued. Results of the activities identified in the EA follow-up monitoring program will be provided to the CNSC and CEAA in an annual EA-follow-up monitoring report, as described in Section 15 of the DGR EA Follow-up Monitoring Program [478]. Reporting approaches for the other three components of the environmental monitoring framework are also discussed in Section 15 of the DGR EA Follow-up Monitoring Program.

The monitoring program will be reviewed and updated as necessary. For example, because the detailed project design has not been finalized, some of the activities may become irrelevant or redundant, and additional items may be required as the project progresses. Input received from regulators will also be incorporated into the applicable monitoring programs which will be updated accordingly.

Table 12.2-1 provides an initial scope of the follow-up program. The recommendations identify the general timeframe for follow-up and monitoring (site preparation and construction, operations and/or decommissioning phase). The DGR EA Follow-up Monitoring Program [478] has been submitted along with the EIS.

Table 12.2-1: Recommended Follow-up Monitoring

VEC	Project Phase	Program Objective	Suggested Frequency and Location of Monitoring
Geology			
Soil quality; overburden groundwater quality	• Site preparation and construction • Operations • Decommissioning	• Identify and monitor effects of any soil contamination to ensure compliance with regulatory standards (i.e., MOE Table 3 SCS [479]) or baseline conditions • If non-compliant, determine additional mitigation required to be compliant, as required under Ontario Environmental Protection Act	• As needed and where needed in response to malfunction or accident
Overburden groundwater transport	• Site preparation and construction • Operations	• Confirm EA predictions of no measurable change in groundwater levels beyond the Site Study Area • Anticipated ZOI benchmark to be established during the pumping test for Permit to Take Water Application (regulatory requirement – Ontario Water Resources Act)	• Dependent on results of pumping test program – to be established prior to excavation and site preparation and construction phase of the project
Shallow bedrock groundwater and solute transport; intermediate bedrock water quality and solute transport; deep bedrock water quality and solute transport	• Site preparation and construction • Operations • Decommissioning	• Confirm predictions of Geosynthesis program	• To be established in conjunction with CNSC

Table 12.2-1: Recommended Follow-up Monitoring (continued)

VEC	Project Phase	Program Objective	Suggested Frequency and Location of Monitoring
Hydrology and Surface Water Quality			
Surface water quality	• Site preparation and construction • Operations (1 year) [a]	• Confirm site discharge meets certificate of approval discharge criteria	• Project Area discharge point (Interconnecting Road) – quarterly, when flowing
		• Confirm effectiveness of water treatment	• Project Area discharge point (Interconnecting Road) – quarterly, when flowing
Terrestrial Environment			
Eastern white cedar	• Site preparation and construction	• Monitoring of plant species communities and wildlife habitat use adjacent to the areas which have been cleared following the site preparation and construction phase	• One time after construction of surface facilities
Aquatic Environment			
VECs in the South Railway Ditch (redbelly dace, creek chub, variable leaf pondweed, burrowing crayfish, benthic invertebrates)	• Site preparation and construction • Operations	• Monitor re-growth of riparian vegetation following removal, note deficiencies in bank stability (i.e., erosion and slumping)	• Annually for three years following construction of abandoned rail bed crossing • Time period: during the growing season-summer • Location: disturbed areas; at abandoned rail bed crossing
		• Vibration monitoring	• As described in Appendix I of the Atmospheric Environment TSD

Table 12.2-1: Recommended Follow-up Monitoring (continued)

VEC	Project Phase	Program Objective	Suggested Frequency and Location of Monitoring
VECs in MacPherson Bay (spottail shiner, benthic invertebrates, lake whitefish, smallmouth bass)	• Site preparation and construction	• Monitor stability and re-vegetation of new ditches	• One time after construction of drainage ditches and stormwater management pond • Time period: during the growing season-summer
Burrowing crayfish	• Site preparation and construction	• Monitor the on-site marsh for confirmation that excavation of underground facilities does not dewater marsh habitat utilized by burrowing crayfish	• Incorporate the results of shallow groundwater level monitoring taking place in the Project Area on a monthly basis during excavation of the underground facilities • Compare the groundwater levels with a water level gauge located in the marsh to determine if there is any effect on water levels • Location: shallow groundwater monitoring well (to be installed in 2011) closest to the marsh located in the Project Area as discussed in the DGR EA Follow-up Monitoring Program [478]. • Annual monitoring of the Project Area for three years to observe and document burrowing crayfish activity (visual observations of chimneys)

Table 12.2-1: Recommended Follow-up Monitoring (continued)

VEC	Project Phase	Program Objective	Suggested Frequency and Location of Monitoring
Radiation and Radioactivity			
Radiological analysis of air	• Site preparation and construction • Operations • Decommissioning	• Confirm effectiveness of mitigation; confirm no residual adverse effects	• Throughout site preparation and construction, and operations phases in the Project Area
External (fenceline) radiation monitoring	• Site preparation and construction • Operations • Decommissioning	• Confirm effectiveness of mitigation; confirm no residual adverse effects	• Throughout site preparation and construction, and operations phases in the Project Area
Radiological analysis of groundwater	• Site preparation and construction • Operations • Decommissioning	• Confirm no residual adverse effects	• Throughout site preparation and construction, and operations phases in the Project Area
Radiological analysis of surface water	• Site preparation and construction • Operations • Decommissioning	• Confirm no residual adverse effects	• Throughout site preparation and construction, and operations phases in the Project Area
Dose to workers	• Operations • Decommissioning	• Confirm effectiveness of mitigation; confirm no residual adverse effects	• Throughout operations phase in the Project Area

Table 12.2-1: Recommended Follow-up Monitoring (continued)

VEC	Project Phase	Program Objective	Suggested Frequency and Location of Monitoring
Atmospheric Environment			
Air quality	• Site preparation and construction	• To verify that the PM_{10} and $PM_{2.5}$ emission rates used in the assessment were reasonable, but conservative • To verify the predicted concentrations of PM_{10} and $PM_{2.5}$ • To verify that the mitigation measures considered integral to the DGR Project are being incorporated as planned, and are effective	• Continuous during the site preparation and construction phase with a re-evaluation at the end of each year • The monitoring equipment (diatomaceous continuous analyzer) to be set up in a secure location near the Main Entrance to the Bruce nuclear site; between the construction activities and the property boundary
		• To verify that the NO_X emission rates used in the assessment were reasonable, but conservative • To verify the predicted concentrations of NO_X and NO_2 • To verify that the mitigation measures considered integral to the DGR Project are being incorporated as planned, and are effective	• Continuous during the site preparation and construction phase with a re-evaluation at the end of each year • The monitoring equipment to be set up in a secure location near the Main Entrance to the Bruce nuclear site between the construction activities and the property boundary • The monitoring (continuous NO_X analyzers) for NO_X and NO_2 to be co-located with the PM_{10} and $PM_{2.5}$ analyzer

Table 12.2-1: Recommended Follow-up Monitoring (continued)

VEC	Project Phase	Program Objective	Suggested Frequency and Location of Monitoring
Noise levels	• Site preparation and construction	• To confirm that the construction noise predictions presented in the assessment were reasonable, but conservative • To verify that the mitigation measures considered integral to the DGR Project are being incorporated as planned, and are effective	• Integrating sound level meter • Noise monitoring campaign of sufficient duration to confirm construction noise predictions presented in the assessment – this campaign would include continuous noise readings taken at each of R1, R2 and R3 for a period of at least 48 hours
Socio-economic Environment			
Public attitude research (PAR)	• Site preparation and construction • Operations • Decommissioning	• Provide results which can be compared to 2009 PAR	• During the peak year of employment during the site preparation and construction phase • Subsequent to any accidents or malfunctions of the DGR or associated operations resulting in a release of radioactive contamination to the environment • Public attitude research during operations to be considered in conjunction with ongoing WWMF public attitude research

Note:
a Monitoring of the discharge will continue through operations under the conventional regulatory monitoring program, as described in the DGR EA Follow-up Monitoring Program.

12.3 PERMITTING REQUIREMENTS

The follow-up program described above will be required as part of the CNSC licence. In addition, it is expected that the DGR Project will be subject to a number of permitting requirements. The permits include, but may not be limited to those listed below.

- Ontario Ministry of the Environment Certificate of Approval (Air and Noise) – Section 9 of the Ontario Environmental Protection Act, requires that equipment, structures or processes that may discharge a contaminant, as defined by the Act, to the atmosphere must be approved before construction, alteration, extension or replacement of the equipment. Specifically, O. Reg. 419/05 [480] considers the emissions from selected stationary sources. Ontario exempts emission sources associated with construction activities from evaluation [481]. Regardless of compliance with Section 9, every facility is also required to meet the air quality standards, as stated in O. Reg. 419/05 [480].
- Under Section 53 of the Ontario Water Resources Act, a Certificate of Approval – Industrial Sewage Works would be required for the construction and operation of the stormwater management system.
- Permit to Take Water – may be required for dewatering the shafts during the site preparation and construction phase of the DGR Project depending on the effectiveness of ground treatment to limit groundwater inflows in the top 200 m of bedrock. This may also be required during the operations phase, depending on volume of water inflows, although the shafts are expected to be well-sealed.
- SVCA permit under O. Reg. 169/06 [482] (Development, Interference with Wetlands, and Alterations to Shorelines and Watercourses Regulation) may be required for construction of the crossing of the South Railway Ditch. Although OPG is not subject to this Regulation, it has been their past practice to proceed through the SCVA permitting process. If fish salvage is required prior to the construction of the crossing over the abandoned rail bed, a Fish Collection Permit will be obtained from the OMNR.

Additional federal acts and regulations related to the terrestrial environment that do not require an authorization, but will be considered and adhered to, include the following:

- Species at Risk Act (SARA);
- Fish and Wildlife Conservation Act*;* and
- Migratory Birds Convention Act.

In addition to the federal and provincial project requirements, the DGR Project may require a Tree Cutting Permit from Bruce County to ensure compliance with applicable tree cutting by-laws.

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13. ASSESSMENT SUMMARY AND CONCLUSIONS

The EIS describes the DGR Project, the existing environmental conditions on the Bruce nuclear site, and assesses the likely effects of the DGR Project on the environment. The EIS also includes an assessment of likely cumulative effects of the DGR Project in combination with other past, present or reasonably foreseeable projects, as required. It describes the effects for normal conditions and as a result of malfunctions, accidents and malevolent acts. The EIS also describes and assesses the likely effects of the environment on the DGR Project, climate change, and renewable and non-renewable resources.

The significance of the likely environmental effects of the DGR Project has been assessed in Section 7. Table 13-1 summarizes residual adverse effects, mitigation measures, significance of residual adverse effects and the follow-up program. Residual adverse effects — that is to say non-trivial changes from existing conditions — were identified for air quality, noise levels, surface water quantity and flow, eastern white cedar, burrowing crayfish, VECs in the South Railway Ditch, an Aboriginal heritage resource, the use and enjoyment of property, and overall human health. Based on the evaluation, each of the residual adverse effects was assessed to be not significant.

The DGR is expected to safely contain the L&ILW and isolate them from humans and non-human biota, including during the abandonment and long-term performance phase. The amount of contaminants reaching the surface is very small, and would occur far into the future. The isolation afforded by the location and design of the DGR also limits the likelihood of disruptive events having the potential to bypass the natural barriers to a small number of situations with very low probability of occurring.

No residual adverse effects were identified during the assessment of the effects of the environment on the DGR Project and of the DGR Project on climate change. The assessment also considered the effect of DGR Project-related environmental effects on the capacity of renewable resources to meet the needs of the present and those of the future. The assessment determined that sustainable use of renewable resources would not be affected by the DGR Project.

It is OPG's conclusion that with the identified mitigation measures, the implementation of the DGR Project is not likely to result in any significant adverse impacts on the environment.

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Table 13-1: Summary of Likely Effects, Mitigation Measures, Residual Adverse Effects, Significance and Follow-up

Valued Ecosystem Component	Likely Environmental Effect	Phase Likely Environmental Effect Occurs In	Mitigation Measures		Residual Adverse Effects	Significance	Follow-up Monitoring	Possible Mitigation Failure, Risk and Consequence[a]
			In-design Mitigation Measures (incorporated into project design)	Additional Mitigation Measures (identified through the EA process)				
Geology								
Soil Quality	• No likely adverse effects are identified	—	• Native soils underlying the stormwater retention pond, which have a low permeability	• None identified	• No residual adverse effects are identified	—	• Identify and monitor effects of any contamination as a result of a malfunction or accident (i.e., spill) to ensure compliance during site preparation and construction, and operations phases	• Overburden different than expected • Low risk of failure as overburden has been thoroughly characterized • Low consequence as WRMA runoff quality expected to be only marginally greater than criteria
Overburden Groundwater Quality			• None identified					—
Overburden Groundwater Transport			• None identified				• Confirm EA predictions of no measurable change in groundwater levels beyond the Site Study Area	—
Shallow Bedrock Groundwater Quality			• None identified				• Confirm predictions of Geosynthesis program	—
Shallow Bedrock Groundwater and Solute Transport			• Ground treatment in the upper 170 m of the two shafts to reduce or eliminate inflows of water and the zone of influence				• None identified	• Ground treatment doesn't effectively manage flows • Low risk of failure as ground treatment will be tested prior to excavation • Low consequence – may cause delay in construction, but can be responded to prior to adverse effects in the environment
Intermediate Bedrock Water Quality			• The geological/ hydrogeological setting underneath the Bruce nuclear site provides excellent isolation and containment of the repository wastes				• Confirm predictions of Geosynthesis program	• Bedrock geology different than expected • Low risk of failure as bedrock has been thoroughly characterized • Low – consequences of failure scenarios assessed as part of safety case (see Section 9)
Intermediate Bedrock Solute Transport								
Deep Bedrock Water Quality								
Deep Bedrock Solute Transport								

Table 13-1: Summary of Likely Effects, Mitigation Measures, Residual Adverse Effects, Significance and Follow-up (continued)

Valued Ecosystem Component	Likely Environmental Effect	Phase Likely Environmental Effect Occurs In	Mitigation Measures: In-design Mitigation Measures (incorporated into project design)	Mitigation Measures: Additional Mitigation Measures (identified through the EA process)	Residual Adverse Effects	Significance	Follow-up Monitoring	Possible Mitigation Failure, Risk and Consequence[a]
Hydrology and Surface Water Quality								
Surface Water Quantity and Flow	• Measurable changes in flows (>±15%) to the North Railway Ditch and the drainage ditch at point of discharge from the DGR Project site	Site preparation and construction, operations, and decommissioning	• The shaft liner is designed with the objective to operate as a dry facility, with little to no seepage through the shaft lining, and therefore less water to manage in the stormwater management system	• None identified	• Reduction in surface water quantity and flow in the North Railway Ditch upstream of Stream C (31%) • Increase in surface water quantity and flow in the drainage ditch at Interconnecting Road (61 to 114%)	Not significant	• None proposed	• Larger flows released to stormwater management pond • Low – the shaft liner will need to limit flows for construction; shaft sumps are able to handle larger flows • Low – although flows into the pond may increase, changes would not likely be measurable out of the pond under most circumstances
Surface Water Quality	• No likely adverse effects are identified	—	• No runoff from the DGR Project site will be directed to the South Railway Ditch or Stream C • All stormwater runoff from the DGR Project site and the WRMA will be collected in drainage ditches that flow into a stormwater management pond	• Water sampling and testing is proposed to confirm that all water released from the DGR Project site via the stormwater management pond has concentration levels below certificate of approval discharge criteria • Flow from the SWMP can be stopped if criteria are not met	• No residual adverse effects are identified	—	• Monitoring at the Project Area discharge point (Interconnecting Road) quarterly during site preparation and construction phase, and for one year during the operations phase to confirm site discharge meets regulatory requirements and water treatment is effective	• Water may be released to the drainage ditch that doesn't meet discharge criteria • Low – there will be procedures in place to meet permitting requirements • Low – the quality of runoff from the WRMA is only slightly higher than guidelines; additionally, unplanned releases would most likely occur during a storm event when there is more dilution
Terrestrial Environment								
Eastern White Cedar	• The removal (77% of 11.5 ha in the Project Area) of Mixed Forest areas	Site preparation and construction	• None identified	• Opportunities to retain tree cover could be investigated where possible • Best Management Practices • Rehabilitation after decommissioning	• There is a residual adverse effect as a result of land clearing activities	Not significant	• Monitoring of plant species communities and wildlife habitat use adjacent to areas which have been cleared during site preparation and construction	• No credit has been taken in the assessment for mitigation, therefore, no additional risk or consequence of mitigation failure

Table 13-1: Summary of Likely Effects, Mitigation Measures, Residual Adverse Effects, Significance and Follow-up (continued)

Valued Ecosystem Component	Likely Environmental Effect	Phase Likely Environmental Effect Occurs In	Mitigation Measures		Residual Adverse Effects	Significance	Follow-up Monitoring	Possible Mitigation Failure, Risk and Consequence[a]
			In-design Mitigation Measures (incorporated into project design)	Additional Mitigation Measures (identified through the EA process)				
Terrestrial Environment (continued)								
Other Plant VECs (Heal-all, Common Cattail) Mammal VECs (muskrat, white-tailed deer, northern short-tailed shrew) Amphibian and Reptile VECs (midland painted turtle, northern leopard frog)	• No likely adverse effects identified	—	• None identified	• None identified	• No residual adverse effects identified	—	• Monitoring of plant species and communities and wildlife habitat use in adjacent areas to those that are cleared during the site preparation and construction phase	—
Bird VECs (mallard, red-eyed vireo, wild turkey, yellow warbler, bald eagle)	• No likely adverse effects identified	—	• None identified	• Avoid vegetation clearing during the breeding bird season	• No residual adverse effects identified	—	• Monitoring of wildlife habitat use in adjacent areas to those that are cleared during the site preparation and construction phase	• No credit has been taken in the assessment for mitigation, therefore, no additional risk or consequence of mitigation failure
Aquatic Environment								
Variable-Leaf Pondweed Redbelly Dace Creek Chub Benthic Invertebrates	• Construction of the crossing over the abandoned rail bed will affect aquatic habitat in the South Railway Ditch	Site preparation and construction	• Appropriate design features (e.g., embedded culvert for fish passage), specific mitigation measures (e.g., management of surface water runoff) and best management practices (e.g. erosion and sediment control) • Timing of the construction of the abandoned rail bed crossing will take place according to the DFO Operational Statement-Timing Windows	• Install effective sediment and erosion control measures • Operate and maintain machinery on land and in a manner that minimizes disturbance • Re-vegetate any disturbed areas • Isolate and dewater the section of the South Railway Ditch wherein the culvert will be placed	• There is a residual habitat loss in the South Railway Ditch	Not significant	• Monitoring annually for three years following site preparation and construction for re-growth of riparian vegetation and deficiencies in bank stability	• Construction practices done to prevent impacts to fish habitat or fish in the South Railway Ditch are not completed • Low – there will be procedures in place to meet SVCA requirements • Low – the ditch is a man-made channel to which the VECs have become adapted, and provides marginal habitat; suitable habitat elsewhere

Table 13-1: Summary of Likely Effects, Mitigation Measures, Residual Adverse Effects, Significance and Follow-up (continued)

Valued Ecosystem Component	Likely Environmental Effect	Phase Likely Environmental Effect Occurs In	Mitigation Measures		Residual Adverse Effects	Significance	Follow-up Monitoring	Possible Mitigation Failure, Risk and Consequence[a]
			In-design Mitigation Measures (incorporated into project design)	Additional Mitigation Measures (identified through the EA process)				
Aquatic Environment (continued)								
Burrowing Crayfish	• Construction of surface facilities will result in an adverse effect on habitat used by burrowing crayfish	Site preparation and construction	• DGR Project design avoided the marsh in the northeast portion of the Project Area where there is known crayfish habitat	• None identified	• There is a loss of habitat used by burrowing crayfish within the Project Area	Not significant	• Compare groundwater levels in closest monitoring well with water level gauge located in the marsh to determine if there are any effects for three years following site preparation and construction	• No credit has been taken in the assessment for mitigation, therefore, no additional risk or consequence of mitigation failure
Lake Whitefish	• No likely adverse effects identified	—	• None identified	• None identified	• No residual adverse effects are identified	—	• One time monitoring after construction of drainage ditches and stormwater management pond for bank stability and re-vegetation of new ditches	—
Smallmouth Bass								
Brook Trout								
Spottail Shiner								
Radiation and Radioactivity								
Invertebrates	• No likely adverse effects identified	—	• Repository is located a nominal 680 m below ground surface • Shielding (e.g., appropriate design of waste container, WPRB design) • Emission control • Zoning and monitoring to prevent spread of contamination in or around the DGR • Sump and stormwater collection and management • Fencing	• None identified	• No residual adverse effects are identified	—	• Radiological analysis of air during site preparation and construction, operations, and decommissioning • External radiation monitoring, radiological analysis of groundwater and surface water program during the site preparation and construction, operations, and decommissioning phases • Monitoring of the dose to workers to determine exposure to radiation and radioactivity • Location and frequencies will be as specified in the licence requirements	• Exposures greater than those identified in the assessment • Low – there will be procedures and protocols in place to meet licence requirements • Low – accident scenarios (e.g., loss of shielding) assessed as part of the safety case (see Section 8)
Aquatic Vegetation								
Benthic Fish								
Pelagic Fish								
Aquatic Birds								
Aquatic Mammals								
Terrestrial Plants								
Terrestrial Birds								
Terrestrial Mammals								
Amphibians and Reptiles								
Human Exposure to Radiation	• No likely adverse effects identified	—	• Mitigation noted above for non-human biota • Emission control (airborne and waterborne) • Operating procedures and training	• None identified	• No residual adverse effects are identified			

Table 13-1: Summary of Likely Effects, Mitigation Measures, Residual Adverse Effects, Significance and Follow-up (continued)

Valued Ecosystem Component	Likely Environmental Effect	Phase Likely Environmental Effect Occurs In	Mitigation Measures: In-design Mitigation Measures (incorporated into project design)	Mitigation Measures: Additional Mitigation Measures (identified through the EA process)	Residual Adverse Effects	Significance	Follow-up Monitoring	Possible Mitigation Failure, Risk and Consequence[a]
Atmospheric Environment								
Air Quality	• Increases in concentrations of NO_2, CO, SPM, PM_{10} and $PM_{2.5}$	Site preparation and construction, and decommissioning	• The use of best management practices, including watering of unpaved roadways, unpaved construction laydown areas, and unpaved construction work areas • Maintain on-site vehicles and equipment	• None identified	• There is a residual adverse effect from increases in concentrations of NO_2, CO, SPM, PM_{10} and $PM_{2.5}$	May not be significant	• Continuous monitoring during the site preparation and construction for PM_{10}, $PM_{2.5}$, NO_2 and NO_X	• Higher emissions than considered in the assessment • Low – there will be construction and operations procedures in place to maintain equipment • Low – would likely only increase particulate emissions, which would cause a localized nuisance effect
	• Increases in concentrations of NO_2, CO, SPM, PM_{10} and $PM_{2.5}$	Operations	• Maintain on-site vehicles and equipment	• None identified	• There is a residual adverse effect from increases in concentrations of NO_2, CO, SPM, PM_{10} and $PM_{2.5}$	Not significant	• None proposed	• Same as for the site preparation and construction phase
Noise Levels	• A likely adverse increase in noise levels at R2 (Baie du Doré)	Site preparation and construction, decommissioning	• Maintain on-site vehicles and equipment • Maintain a compact DGR Project site • Maintain fresh air and return air raise fans	• None identified	• There is a residual adverse effect on noise levels at R2 (Baie du Doré)	Not significant	• Continuous noise monitoring campaign during site preparation and construction phase of sufficient duration to confirm predictions in the assessment	• Higher emissions than considered in the assessment • Low – there will be construction and operations procedures in place as part of the permit requirements (Ontario Ministry of the Environment Certificate of Approval (Air and Noise) – Section 9 of the *Ontario Environmental Protection Act)* • Low – would likely only cause a localized change that could be addressed readily

Table 13-1: Summary of Likely Effects, Mitigation Measures, Residual Adverse Effects, Significance and Follow-up (continued)

Valued Ecosystem Component	Likely Environmental Effect	Phase Likely Environmental Effect Occurs In	Mitigation Measures: In-design Mitigation Measures (incorporated into project design)	Mitigation Measures: Additional Mitigation Measures (identified through the EA process)	Residual Adverse Effects	Significance	Follow-up Monitoring	Possible Mitigation Failure, Risk and Consequence[a]
Atmospheric Environment (continued)								
Vibrations	• No likely adverse effects identified	—	• Reduce explosive weights during spawning season, if necessary	• None identified	• None identified	—	• Monitor initial series of blasts at varying distances to characterize specific ground vibration attenuation rates • Monitoring of blasting in the vicinity of closest receptors • Communications program to keep neighbours informed	• Higher vibration rates than recommended in spawning habitat • Low – spawning window can generally be avoided • Low – no confirmed spawning habitat in the South Railway Ditch
Aboriginal Interests								
Aboriginal Communities	• Beneficial effect as a result of direct, indirect and induced employment opportunities	Site preparation and construction, operations, decommissioning	• None identified	• None identified	• Beneficial effect identified	—	• None proposed	—
Aboriginal Heritage Resources	• Diminished quality or value of ceremonial activities undertaken by Aboriginal peoples at the Aboriginal burial site located on the Bruce nuclear site (changed aesthetics, temporarily increased noise and dust)	Site preparation and construction, operations, and decommissioning	• The use of best management practices, including watering of unpaved roadways, unpaved construction laydown areas, and unpaved construction work areas • Maintain on-site vehicles and equipment	• A setback or buffer of 200 m from the Interconnecting Road to the long-term waste rock management area and other visual screening (e.g., berm and/or trees)	• A residual adverse effect on the quality or value of ceremonial activities undertaken by Aboriginal peoples at the Aboriginal burial site located at the Bruce nuclear site	Not significant	• Continuous monitoring during the site preparation and construction for PM_{10}, $PM_{2.5}$, NO_2 and NO_X as described for air quality	• Higher emissions than considered in the assessment • Low – there will be construction and operations procedures in place to maintain equipment • Low – would likely only increase particulate emissions, which would cause a localized nuisance effect
Traditional Use of Lands and Resources	• No likely adverse effects identified	—	• None identified	• None identified	• No residual adverse effects identified	—	• None proposed	—

Table 13-1: Summary of Likely Effects, Mitigation Measures, Residual Adverse Effects, Significance and Follow-up (continued)

Valued Ecosystem Component	Likely Environmental Effect	Phase Likely Environmental Effect Occurs In	Mitigation Measures		Residual Adverse Effects	Significance	Follow-up Monitoring	Possible Mitigation Failure, Risk and Consequence[a]
			In-design Mitigation Measures (incorporated into project design)	Additional Mitigation Measures (identified through the EA process)				
Socio-economic Environment								
Human Assets	• A beneficial effect as a result of increased population associated with DGR Project related employment • Increased educational opportunities for local students and others with an interest in nuclear technology	Site preparation and construction, operations, decommissioning	• None identified	• An emergency and fire response plan is prepared and implemented for the DGR Project, including plans for mine rescue • Share information with local and regional land use planners and economic development officials regarding the timing and magnitude of its on-site labour force	• Beneficial effects identified	—	• Continue to monitor public attitudes toward the DGR Project	• No credit has been taken in the assessment for mitigation, therefore, no additional risk or consequence of mitigation failure
Physical Assets	• Increase in congestion at some intersections near the Bruce nuclear site • A very small contributor to the anticipated positive housing growth over the DGR Project life	Site preparation and construction, operations, decommissioning	• None identified	• Develop and implement a traffic management plan that will serve to minimize DGR Project related peak hour volumes (e.g., staggering of shifts, encouraging ride sharing and the use of shuttle buses, and off-peak timing of shipments of materials and wastes on and off the DGR Project site)	• Beneficial effects identified	—	• None proposed	• No credit has been taken in the assessment for mitigation, therefore, no additional risk or consequence of mitigation failure

Table 13-1: Summary of Likely Effects, Mitigation Measures, Residual Adverse Effects, Significance and Follow-up (continued)

Valued Ecosystem Component	Likely Environmental Effect	Phase Likely Environmental Effect Occurs In	Mitigation Measures: In-design Mitigation Measures (incorporated into project design)	Mitigation Measures: Additional Mitigation Measures (identified through the EA process)	Residual Adverse Effects	Significance	Follow-up Monitoring	Possible Mitigation Failure, Risk and Consequence[a]
Socio-economic Environment (continued)								
Social Assets	• No likely adverse effects are identified	—	• None identified	• Keep neighbours and the broader public informed concerning DGR Project activities at the Bruce nuclear site and continue to make contributions to the community through its Corporate Citizenship Program • Continue to work with various stakeholders to deliver its community, recreational and educational initiatives • In the event that artifacts that could be associated with a cultural or heritage resource are encountered, the activities will be curtailed until further assessment can be undertaken to protect the resource from further disturbance and conserve its cultural heritage value	• Beneficial effects identified	—	• Continue to monitor public attitudes toward the DGR Project	• No credit has been taken in the assessment for mitigation, therefore, no additional risk or consequence of mitigation failure

Table 13-1: Summary of Likely Effects, Mitigation Measures, Residual Adverse Effects, Significance and Follow-up (continued)

Valued Ecosystem Component	Likely Environmental Effect	Phase Likely Environmental Effect Occurs In	Mitigation Measures: In-design Mitigation Measures (incorporated into project design)	Mitigation Measures: Additional Mitigation Measures (identified through the EA process)	Residual Adverse Effects	Significance	Follow-up Monitoring	Possible Mitigation Failure, Risk and Consequence[a]
Socio-economic Environment (continued)								
Financial Assets	• A beneficial effect as a result of new direct, indirect and induced employment opportunities • A positive effect on business activity is anticipated • A beneficial effect as a result of increased municipal revenue • A beneficial effect as a result of a substantial amount of direct, indirect and induced income in the Local and Regional Study Areas • DGR Project-related traffic can be expected to disrupt the movement of slow moving farm vehicles	Site preparation and construction, operations, decommissioning	• None identified	• Non-salary expenditures will be sourced locally wherever practical and in accordance with relevant supply chain policies, procedures and standards for competitive purchasing • Share information with local and regional economic development officials (i.e., the timing and magnitude of meaningful changes to its on-site labour requirements) • Farmers in the Local Study Area along the transportation route should be informed if and when oversize or slow-moving project-related vehicles will be on local or municipal area roads during the planting or harvesting season	• Beneficial effects identified	—	• Continue to monitor public attitudes toward the DGR Project	• No credit has been taken in the assessment for mitigation, therefore, no additional risk or consequence of mitigation failure
Natural Assets	• There is a likely adverse effect of noise levels on residents at the Baie du Doré	Site preparation and construction, decommissioning	• Maintain on-site vehicles and equipment • Maintain a compact DGR Project site • Maintain fresh air and return air raise fans	• None identified	• Residual adverse effect on noise levels at the Baie du Doré	Not significant		• Higher emissions than considered in the assessment • Low – there will be construction and operations procedures in place • Low – would likely only cause a localized change that could be addressed readily

Table 13-1: Summary of Likely Effects, Mitigation Measures, Residual Adverse Effects, Significance and Follow-up (continued)

Valued Ecosystem Component	Likely Environmental Effect	Phase Likely Environmental Effect Occurs In	Mitigation Measures		Residual Adverse Effects	Significance	Follow-up Monitoring	Possible Mitigation Failure, Risk and Consequence[a]
			In-design Mitigation Measures (incorporated into project design)	Additional Mitigation Measures (identified through the EA process)				
Human Health								
Overall Health of Local Residents	• Exposure to acrolein concentrations in air	Site preparation and construction	• The use of best management practices, including watering of unpaved roadways, unpaved construction laydown areas, and unpaved construction work areas • Maintain on-site vehicles and equipment	• None identified	• Exposure to acrolein concentrations in air	Not significant	• None proposed	• Higher emissions than considered in the assessment • Low – there will be construction and operations procedures in place to maintain equipment • Low – would likely only increase particulate emissions, which would cause a localized nuisance effect
Overall Health of Members of Aboriginal Communities	• Exposure to acrolein concentrations in air	Site preparation and construction	• The use of best management practices, including watering of unpaved roadways, unpaved construction laydown areas, and unpaved construction work areas • Maintain on-site vehicles and equipment	• None identified	• Exposure to acrolein concentrations in air	Not significant		• Higher emissions than considered in the assessment • Low – there will be construction and operations procedures in place to maintain equipment • Low – would likely only increase particulate emissions, which would cause a localized nuisance effect
Overall Health of Seasonal Users	• No likely adverse effects identified	—	• None identified	• None identified	• No residual adverse effects identified	—		—
Health of Workers	• No likely adverse effects identified	—	• None identified	• None identified	• No residual adverse effects identified	—		—
Ecological Features								
Lake Huron	• No likely adverse effects identified	—	• None identified	• None identified	• No residual adverse effects identified	—	• None proposed	—
Stream C								
South Railway Ditch								
Wetland within the Project Area								

Note:
a In this column, the first bullet describes the possible mitigation failure, the risk or likelihood of that failure occurring, and the potential consequence to the VECs if the failure did occur.

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Section 13

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15. LIST OF ACRONYMS, UNITS AND TERMS

15.1 ACRONYMS

Table 15.1-1: Acronyms

Acronym	Descriptive Term
AAQC	Ambient Air Quality Criteria
ACNS	Advisory Committee on Nuclear Safety
ACRP	Canadian Advisory Committee on Radiological Protection
AECB	Atomic Energy Control Board
AECL	Atomic Energy of Canada Limited
AFN	Assembly of First Nations
AGM	Annual General Meeting
AIR	All Injury Rate
AL	Alvar
ALARA	As Low As Reasonable Achievable
ALW	Active Liquid Waste
ANFO	Ammonium Nitrate/Fuel Oil
ANSI	Area of Natural and Scientific Interest
APM	Adaptive Phased Management
ASR	Accident Severity Rate
ATHEL	Alternative Tile Hole Equivalent Liner
ATV	Acoustic Televiewer
BB	Beach
BCFDC	Bruce Community Futures Development Corporation
BCOA	Bunker C Oil ASTs and Oil Delivery System
BDSB	Bluewater District School Board
BGCDSB	Bluewater Grey Catholic School Board
BHWP	Bruce Heavy Water Plant
BMI	Body Mass Index
BMP	Best Management Practices
BNPD	Bruce Nuclear Power Development
BNSG	Former Bruce Nuclear Standby Generator

Table 15.1-1: Acronyms (continued)

Acronym	Descriptive Term
BTEX	Benzene, Toluene, Ethylbenzene and Xylene
BUFDS	Bruce Used Fuel Dry Storage
BUFDSF	Bruce Used Fuel Dry Storage Facility
BUFDSP	Bruce Used Fuel Dry Storage Project
CAD	Canadian
CANDU	Canadian Deuterium Uranium (trademark of AECL)
CAO	Chief Administrative Officer
CAP-C	Community Action Program for Children
CB	Cultural Beach
CCME	Canadian Council of Ministers of the Environment
CCP	Corporate Citizenship Program
CCR	Canadian Cancer Registry
CEAA	Canadian Environmental Assessment Act
CEAR	Canadian Environmental Assessment Registry
CIE	Commission Internationale de l'Eclairage
CIHI	Canadian Institute for Health Information
CL	Former Construction Landfill
CMLF	Central Maintenance and Laundry Facility
CNSC	Canadian Nuclear Safety Commission
CNS	Canadian Nuclear Society
CO	Carbon Monoxide
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CPS	Counts Per Second
CSA	Canadian Standards Association
CSA	Culturally Sensitive Area
CUG	Cultural Grassland
CUM	Cultural Meadow
CUT	Cultural Thicket
DAC	Derived Air Concentration
DMIN	Drum Bin

Table 15.1-1: Acronyms (continued)

Acronym	Descriptive Term
DEA	Diethylamine
DEER	Discover Energized Environmental Resources
DFAIT	Department of Foreign Affairs and International Trade
DFO	Fisheries and Oceans Canada
DGR	Deep Geologic Repository
DGSM	Descriptive Geosphere Site Model
DOE	Department of Energy
DPNGS	Douglas Point Nuclear Generating Station
DRL	Derived Release Limit
DS	Distribution Station
EA	Environmental Assessment
EDTA	Ethylenediaminetetraacetic acid
EDZ	Excavation Damage Zone
EF	End Fittings
EIS	Environmental Impact Statement
ELC	Ecological Land Classification
EMP	Environmental Management Plan
EMS	Environmental Management System
ENEV	Estimated No Effect Value
EPC	Engineering, Procurement and Contracting Company
EPH	Extractable Petroleum Hydrocarbons
EPRI	Electric Power Research Institute
ERT	Emergency Response Team
ESA	Environmental Site Assessment
ETH	Encapsulated Tile Holes
FEAC	Federal Environmental Assessment Coordinator
FEPs	Features, Events and Processes
FN	First Nation
FO	Forest
FPTCCCEA	Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment

Table 15.1-1: Acronyms (continued)

Acronym	Descriptive Term
FTF	Fire Training Facility
GBHS	Grey Bruce Health Services
GCM	Global Climate Models
GDP	Gross Domestic Product
GED	General Education Development
GFTZ	Grenville Front Tectonic Zone
GGM	Gas Generation Model
GHG	Greenhouse gas
GIS	Geographic Information System
GMWL	Global Meteoric Water Line
GUSCO	Guideline for Use at Contaminated Sites in Ontario
HCII	Impact/Impulse Noise Indicator
HDPE	High Density Polyethylene
HDZ	Highly Damaged Zone
HHRA	Human Health Risk Assessment
HQ	Hazard Quotient
HS	Hydrostratigraphic
HSM	Historic Saugeen Métis
HSMC	Historic Saugeen Métis Community
HTO	Tritiated water
HU	Health Unit
HVAC	Heating, Ventilation and Air Conditioning
IAC	Impact Advisory Committee
IB	Industrial Barren
IBA	Important Bird Area
IBP	International Biological Program
IC	In-Ground Container
ICRP	International Committee on Radiological Protection
IDLH	Immediately Dangerous to Life and Health
IDRA	Inverhuron District Ratepayers Association

Table 15.1-1: Acronyms (continued)

Acronym	Descriptive Term
IGLD	International Great Lakes Datum
IJC	International Joint Commission
ILCR	Incremental Lifetime Cancer Risk
ILW	Intermediate Level Waste
INAC	Indian and Northern Affair Canada
IND	Industrial Land
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
IWTS	Integrated Waste Tracking System
IX	Ion Exchange
JRP	Joint Review Panel
K	Bulk Hydraulic Conductivity
L&ILW	Low and Intermediate Level Waste
L_{eq}	Whole Day Equivalent Noise Level
LHD	Load Haul Dump
LHIN	Local Health Integration Network
LL	Low Level
LLSB	Low Level Storage Building
LLW	Low level waste
MA	Marsh
MAC	Maximum Acceptable Concentration
MDEA	Methyldiethylamine
MDL	Method Detection Limits
MLE	Mean Life Expectancy
MMAH	Ministry of Municipal Affairs and Housing
MNO	Métis Nation of Ontario
MNR	Ministry of Natural Resources
MOE	Ministry of the Environment
MOH	Medical Officer of Health
MOU	Memorandum of Understanding

Table 15.1-1: Acronyms (continued)

Acronym	Descriptive Term
MP	Member of Parliament
MPAC	Municipal Property Assessment Corporation
MPP	Provincial Member of Parliament
MRPH	Maximum Reasonable Potential for Harm
MSC	Meteorological Services of Canada
NAR	Not At Risk
NARS	Natural Area of Regional Significance
NCRP	National Council on Radiation Protection
NE-BC	Natural Evolution Base Case
NEA	Nuclear Energy Agency
NEC	No Effect Concentration
NE-UG-BC	Updated Geosphere Natural Evolution Base Case
NEW	Nuclear Energy Worker
NHF	Natural Hydraulic Fracture
NGO	Non-governmental Organization
NHIC	Natural Heritage Information Centre
NIOSH	National Institute of Occupational Safety and Health
NO_x	Nitrogen Oxides
NORM	Naturally Occurring Radioactive Material
NPRI	National Pollutant Release Inventory
NRCan	Natural Resources Canada
NSCA	Nuclear Safety and Control Act
NWMD	Nuclear Waste Management Division
NWMO	Nuclear Waste Management Organization
O_3	Ozone
OA	Open Water
OBT	Organically Bound Tritium
OD	Outer Diameter
ODWAC	Ontario Drinking Water Advisory Council
ODWQS	Ontario Drinking Water Quality Standards

Table 15.1-1: Acronyms (continued)

Acronym	Descriptive Term
OGSR	Ontario Oil, Gas and Salt Resources
OHN	Ontario Hydro Nuclear
OHSA	Ontario Occupational Health and Safety Act
OHSAS	Occupational Health and Safety Assessment Series
OL	Outer Length
OMNR	Ontario Ministry of Natural Resources
OMR	Ontario Mining Regulations
OPA	Ontario Power Authority
OPG	Ontario Power Generation Inc.
OPP	Ontario Provincial Police
OSART	Operational Safety Review Team
PAC	Protective Action Criteria
PAH	Polycyclic Aromatic Hydrocarbons
PAR	Public Attitude Research
PCB	Polychlorinated Biphenyls
PCN	Project Change Notice
PHC	Petroleum Hydrocarbons
PHT	Primary Heat Transport
PHU	Public Health Unit
$PM_{2.5}$	Particulate Matter with aerodynamic diameters of 2.5 μm or less
PM_{10}	Particulate Matter with aerodynamic diameters of 10 μm or less
PMF	Probable Maximum Flood
PMP	Maximum Probable Precipitation
PPE	Personal Protective Equipment
PPH	Purgeable Petroleum Hydrocarbons
PRC	Petroleum Resources Centre
PSW	Provincially Significant Wetland
PWQO	Provincial Water Quality Objectives
PWU	Power Workers Union
RA	Responsible Authority

Table 15.1-1: Acronyms (continued)

Acronym	Descriptive Term
RCSB	Retube Components Storage Building
REMP	Radiological Environmental Monitoring Program
RLSS	Resin Liner
RQD	Rock Quality Designation
RWC-EF	Retube Waste Container-Endfitting
RWOS	Radioactive Waste Operation Site
RWS	Refurbishment Waste Storage
SAR	Species At Risk
SARA	Species At Risk Act
SAT	System Approach to Training
SBGHC	South Bruce Grey Health Centre
SCS	Site Conditions Standards
SGSB	Steam Generator Storage Building
SON	Saugeen Ojibway Nation
SPC	Shield Plug Container
SPM	Suspended Particulate Matter
SSTF	Spent Solvent Treatment Facility
SVCA	Saugeen Valley Conservation Authority
SW	Swamp
TDI	Tolerable Daily Intake
TDS	Total Dissolved Solids
TEK	Traditional Ecological Knowledge
TFWT	Tissue Free Water Tritium
T-H-E	Tile-Hole Equivalent
TLD	Thermoluminescent Dosimeter
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
TRU	TransUranics
TSD	Technical Support Document
TSS	Total suspended Solids

Table 15.1-1: Acronyms (continued)

Acronym	Descriptive Term
UCS	Uniaxial Compressive Strength
VEC	Valued Ecosystem Component
VOC	Volatile Organic Compound
WAC	Waste Acceptance Criteria
WANO	World Association on Nuclear Operations
WCTF	Waste Chemical Transfer Facility
WHMIS	Workplace Hazardous Materials Information System
WHO	World Health Organization
WiN	Women in Nuclear
WIPP	Waste Isolation Pilot Plant
WPCP	Water Pollution Control Plant
WPRB	Waste Package Receiving Building
WRMA	Waste Rock Management Area
WSIB	Workplace Safety and Insurance Board
WSP	Waste Supply Plant
WTP	Water Treatment Plant
WUFDSF	Western Used Fuel Dry Storage Facility
WWMF	Western Waste Management Facility
ZOI	Zone of Influence

15.2 UNITS

Table 15.2-1: Units

Symbol	Units
Bq	Becquerels
Bq/cm^2	Becquerels per Square Centimetre
Bq/kg	Becquerels per Kilogram
Bq/kg-C	Becquerels per Kilogram Carbon
Bq/L	Becquerels per Litre
Bq/m^2	Becquerels per square metre
Bq/m^3	Becquerels per Cubic Metre
$Bq\text{-}MeV/m^3$	Becquerels MegaElectron Volt per Cubic Metre
°C	Degrees Celsius
cm	Centimetre
cm^2	Square Centimetre
cm/a	Centimetre per Year
cm/s^2	Centimetres per Square Second
dB_{lin}	Un-weighted Decibels
dB	Decibels
dBA	A-Weighted Decibels
D_e	Diffusion Coefficient
g	Gram
µg/g	Microgram per gram
g/L	Grams per Litre
$\mu g/m^3$	Microgram per Cubic Metre
h/a	Hour per Year
ha	Hectares
%HA	Percent Highly Annoyed
in/a	Inches per Year
kg	Kilograms
kg/a	Kilogram per Year
kg/d	Kilogram per Day
kg/m^3	Kilogram per Cubic Metre

Table 15.2-1: Units (continued)

Symbol	Units
km	Kilometres
km^2	Square Kilometres
Kg/d	Kilograms per Day
Kt CO_2^e/a	Kilotonnes of Carbon Dioxide per Year
kV	Kilovolt
kW	Kilowatt
L	Litre
L/a	Litre per Year
L/day	Litre per Day
L/min	Litre per Minute
L/s	Litres per Second
m	Metres
µm	Micrometre
m/s	Metres per Second
m^2	Square Metres (area)
m^2/s	Square Metres per Second
m^3	Cubic Metres (volume)
m^3/a	Cubic Metres per Year
m^3/day	Cubic Metres per Day
mlx	Millilux
m^3/s	Cubic Metres per Second
Ma	Million Years
mAGS	Metres above ground surface
mASL	Metres above sea level
mBGS	Metres below ground surface
µg/L	Micrograms per Litre
µg/m^3	Microgram per Cubic Metre
mg/L	Milligrams per Litre
mGy/d	MilliGray per Day, unit of dose
nGy/h	NanoGray per Hour

Table 15.2-1: Units (continued)

Symbol	Units
µGy/h	MicroGray per Hour
mm	Millimetres
mm/s	Millimetres per Second
MW	Megawatt
MPa(g)	MegaPascals (gauge)
mSv	MilliSievert
mSv/a	MilliSievert per year
mSv/h	MilliSievert/h
Mt CO_2^e/a	Megatonnes of Carbon Dioxide per Year
nN	Nutti Magnitude
µSv	MicroSievert
µSv/a	MicroSievert per year
µSv/h	MicroSievert per hour
person-mSv/a	Person- MilliSievert
person-Sv	Person-Sievert
ρ	Density
pH	A measure of the acidity or alkalinity of a solution. The pH scale spans 0 to 14, with 0 representing a strongly acidic solution, 7 representing a neutral solution, and 14 representing a strongly basic (alkaline) solution.
ppb	Parts per Billion
ppm	Parts per Million
W/m^3	Watts per Cubic Metre
%	Percent
"	Inch
σ_v	Minimum Vertical Stress
σ_h	Minimum Horizontal Stress
σ_H	Maximum Horizontal Stress

15.3 GLOSSARY

Aboriginal traditional knowledge – Knowledge that is held by, and unique to, Aboriginal peoples. Aboriginal traditional knowledge is a body of knowledge built up by a group of people through generations of living in close contact with nature. It is cumulative and dynamic and builds upon the historic experiences of a people and adapts to social, economic, environmental, spiritual and political change.

Action level – A specific dose of radiation or other parameter that, if reached, may indicate a loss of control of part of a facility's radiation protection program, and triggers a requirement for specific action to be taken.

Adaptive Management – A combination of management, research, and monitoring that allows credible information to be gained and management activities to be modified by experience.

Advection – A process by which dissolved or suspended substances (natural constituents, artificial tracers, contaminants), are transported by the bulk motion of a fluid medium (water, air).

Aerobic – Commonly used to describe the presence of air (oxygen), the term aerobic is often used interchangeably with the term *oxic*. However, aerobic can also be used more generally to describe environments in which one or more redox couples control the redox potential (Eh) at relatively positive values.

Aeromagnetic Survey – A magnetic survey measuring the earth's magnetic field, made with an airborne magnetometer.

Aftershock – An earthquake that follows a larger earthquake (main shock) and originates at or near the focus of the larger earthquake. Generally, major earthquakes are followed by many aftershocks, which decrease in frequency and magnitude with time. Such a series of aftershocks may last for many days for small earthquakes or many months for large ones.

Algonquin Arch – A northeast trending crystalline basement doming (high) that separates the *Michigan Basin* from the *Appalachian Basin*.

Anaerobic – Commonly used to describe the absence of air (oxygen), the term anaerobic is often used interchangeably with the term *anoxic*. However, anaerobic can also be used more generally to describe environments in which one or more redox couples control the redox potential (Eh) at relatively negative values.

Analogue (Geosphere) – An investigation or quantitative analysis of the natural evolution of a repository site that conveys an understanding of long-term geologic and hydrogeologic stability relevant to demonstrating concepts of long-term waste isolation and containment.

Anhydrite – A mineral consisting of anhydrous calcium sulphate: $CaSO_4$. It represents gypsum without its water of crystallization, and it alters readily to gypsum, from which it differs in crystal form and in being harder and slightly less soluble. Anhydrite usually occurs in white or slightly colored, granular to compact masses, forming large beds or seams in sedimentary rocks or associated with gypsum or halite in evaporites.

Anion exclusion – The process by which transport of anions (negatively-charged species in solution) is confined to only part of the available pore space in a rock due to repulsion by negative charges on the surface of clay minerals.

Anisotropy – The condition of having properties that vary with direction at a given point location (e.g., a glacial till or clay, in which the hydraulic conductivities could be orders of magnitude different in the x, y, and z directions). See also *isotropy.*

Anoxic – Often used interchangeably with the term *anaerobic*, anoxic strictly means the absence of oxygen.

Appalachian Basin – An elongated *sedimentary basin* on the North American continent, with a maximum depth of 12 km. In southern Ontario, sedimentary rocks of both the Appalachian Basin and *Michigan Basin* overlie the Precambrian crystalline basement, with a maximum thickness of approximately 1.5 km.

Aquiclude – A medium with very low values of hydraulic conductivity (permeability) which, although it may be saturated with groundwater, is almost impermeable with respect to groundwater flow. Such geologic media will act as boundaries to aquifers and may form confining strata.

Aquifer – A geological formation or structure that is sufficiently porous and permeable to store, transmit, and yield significant or economic quantities of groundwater to wells and springs. A confined aquifer is bound by low permeability formations such that it is under pressure. An unconfined aquifer is one whose upper groundwater surface (water table) is at atmospheric pressure.

Aquifer, Fractured Bedrock – An aquifer composed of rock, but where most water flows through fractures or solution openings instead of pore spaces in the rock mass.

Aquitard – A confining bed and/or formation composed of rock or sediment that retards but does not prevent the flow of water to or from an adjacent aquifer. It does not readily yield water to wells or springs, but stores groundwater.

Archipelago – A chain or cluster of islands that are formed tectonically.

Argillaceous – Pertaining to, largely composed of, or containing clay-size particles (< 4 microns) or clay minerals.

Argillaceous Limestone – A limestone containing an appreciable amount (but < 50 percent) of clay.

Arkose – A feldspar-rich (*feldspathic*) sandstone, commonly coarse-grained and pink/reddish in color. Typically, quartz is the dominant mineral phase, and feldspars comprise ≥ 25%.

Artesian aquifer – A body of rock or sediment containing groundwater that is under greater than hydrostatic pressure; that is, a confined aquifer. When an artesian aquifer is penetrated by a well, the water level will rise above the top of the aquifer. If the water level in the well exceeds the elevation of the ground surface, it is referred to as a flowing artesian well.

Asthenosphere – The layer of the Earth below the *lithosphere* (continental plates), which is weak and plastic, in which isostatic adjustments and plate movements take place and magmas may be generated.

Backfill – An engineered material formulated and placed to fill the excavated openings in a repository as part of sealing and closure. See also *Grout.*

Barrier Reef – A long, narrow coral reef roughly parallel to the shore and separated from it by a lagoon of considerable depth and width.

Basement (rock) – **T**he crust of the Earth (Precambrian igneous and metamorphic complex) underlying the sedimentary deposits.

Bathymetry – The measurement of water depth at various locations within a body of water. Bathymetry maps enable estimates of the topography and elevation of ground surface within areas covered by bodies of water.

Bedding – The natural arrangement of sedimentary rocks into layers of varying thickness and character.

Biosphere – The physical media (atmosphere, soil, surface waters and associated sediments) and the living organisms (including humans) that interact with them.

Borehole Breakout – The spalling at the edge of a borehole as a result of the concentration of the maximum horizontal stress. The stress concentration is so large that induced differential stress causes shear fractures within the rock next to the borehole wall. Spalling releases the fractured rock to create a deformation or elongation of the borehole wall in the direction of the least horizontal stress.

Bound Water – The sum of internally bound and externally bound water. See also *Internally Bound Water* and *Externally Bound Water.*

Bounding Assessment – An assessment designed to provide limiting estimates, based on simplification of the processes being simulated or the use of data limits (such as maximum possible precipitation, or thermodynamic solubility limits).

Brackish Water – Water with a salinity between freshwater and seawater (i.e., water that contains between 1 and 10 g/L total dissolved solids. See also *Brine* and *Saline Water*.

Breccia – A coarse-grained clastic rock, composed of angular or broken rock fragments, and held together by a mineral cement or fine-grained matrix.

Brine – Water with a salinity greater than 100 g/L total dissolved solids. See also *Brackish Water* and *Saline Water*.

Bruce Megablock – A regional subdivision of Southern Ontario based upon characteristics of an interpreted fracture framework, developed by Sanford (1985). It extends from the top of the *Algonquin Arch* to Georgian Bay to the north.

Bruce nuclear site – The 932 hectare (9.32 km^2) parcel of land located within the administrative boundaries of the Municipality of Kincardine in Bruce County. Two operating nuclear stations are located on the site. The site is owned by OPG but has been leased to Bruce Power since May 2001. However, parts of the site, including land on which WWMF is located, have been retained by OPG. See also *OPG-retained lands*.

Bruce Power – The licensed operator of the Bruce A and Bruce B nuclear generating stations.

Calcareous – Term referring to a rock, mud, or cement is mostly or partly composed of calcium carbonate (typically >50%).

Cambrian – The earliest period of the Paleozoic era extending from 543 to 490 million years ago; also, refers to rocks formed, or sediments laid down, during this period (e.g., Cambrian sandstones).

Canadian Nuclear Safety Commission (CNSC) – The Canadian federal agency responsible for regulating nuclear facilities and materials, including management of all radioactive waste in Canada.

Canadian Shield – A large plateau that occupies most of eastern and central Canada and consists of exposed Precambrian basement rocks in a stable craton. It is surrounded by younger sedimentary rocks.

CANDECON Waste – CANDECON is a chemical decontamination process for nuclear heat transport systems. Wastes produced from this process are contaminated resins and filters, which contain high levels of chelating agents such as EDTA.

Capacity Factor - A dimensionless factor that accounts for retention of a solute by sorption onto the surfaces of a porous medium. The *capacity factor* α is defined by the *solute-accessible porosity* ϕ_s, the porous medium dry bulk density ρ and the porous medium distribution coefficient K_d for the specific solute as follows: $\alpha = \phi_s + \rho K_d$

Cap rock – Refers to the thick sequence of Ordovician shales that act as a barrier to fluid movement and overlie the DGR host rock.

Capillary Pressure – The difference in pressure across two immiscible fluid phases jointly occupying the interstices of a rock.

Cenozoic – The time span covering from 65 million years to present.

Chatham Sag – A narrow topographic low within the Precambrian crystalline basement surface that separates the Algonquin and Findlay Arches; located in the vicinity of Lake St. Clair in southwestern Ontario.

Clastic – Refers to rock or sediment that is composed primarily of broken fragments derived from pre-existing rocks or minerals, which have been transported some distance from their place of origin and accumulated.

Closure – The administrative and technical actions directed at a repository at the end of its operating lifetime. For example covering the waste (for a near surface repository), backfilling and/or sealing of rooms, tunnels and/or shafts (for a geological repository), and termination or completion of activities in any associated structures.

Colloids – Small particles suspended in groundwater. The particles are typically 1 to 1,000 nanometres in size.

Compactible Waste – Wastes which can be processed by medium force compaction, such as light metal objects, insulation materials, hoses, cables, metal fillings and turnings, with a contact dose rate less than 2 mSv/h (200 mrem/h).

Conceptual Model – A set of qualitative and/or quantitative assumptions used to describe a system or subsystem for a given purpose. At a minimum, these assumptions concern the geometry and dimensionality of the system, temporal and spatial boundary conditions, and the nature of the relevant physical and chemical processes. The assumptions should be consistent with one another and with existing information within the context of the given purpose.

Conformity – The mutual and undisturbed relationship between adjacent sedimentary strata that have been deposited in orderly sequence, with little or no evidence of time lapses.

Connate Water – Water which is entrapped in the pores at the time of sediment deposition. Term is used to describe rock porewater with long residence times, i.e., water that has been out of contact with the atmosphere for an appreciable part of a geologic period.

Containment (Safety Case) – Limiting the release of hazardous materials to the biosphere.

Controlled Area – A defined area in which specific protection measures and safety provisions are or could be required for controlling normal exposures or preventing the spread of contamination during normal working conditions, and preventing or limiting the extent of potential exposures.

Constrictivity – A geometric factor that accounts for the effects of constricted pathways or channels along a diffusive solute transport path within a porous medium. Note that constrictivity cannot be measured directly and is typically combined with *tortuosity* to yield the *tortuosity factor*.

Core Disking – Rock core recovered from vertical wells in argillaceous rocks may split into thin disks, parallel to the near horizontal bedding, due to their fissile nature. At the DGR, this does not appear to be related to relief of in-situ stress. See also *Fissility (rock).*

Crack Damage Stress – Marks the onset of unstable crack growth of a brittle rock sample under loading which could be interpreted as the upper bound of the short-term in situ rock strength. Beyond this stress, the coalescence of propagating cracks in the sample will occur.

Crack Initiation Stress – Represents the threshold marking the onset of stable crack growth in brittle rock under loading, which is the lower bound for the in situ rock strength, and is identifiable as the point where the lateral strain curve of a test rock sample departs from linearity (or the initiation of acoustic emission response of the sample to loading).

Craton – A large portion of a continental plate that has remained relatively tectonically stable since the Precambrian era.

Critical Group – A group of members of the public which is reasonably homogeneous with respect to its exposure for a given contamination source and given exposure pathway, and is typical of individuals receiving the highest health impacts by the given exposure pathway from the source. See also *Exposure Group*.

Darcy Flux – Refers to the observation derived from Darcy's Law that the flux of fluid through a unit area of permeable media is directly proportional to the hydraulic gradient.

Decommissioning – Those actions taken, in the interest of health, safety, security and protection of the environment, to retire a licensed activity/facility permanently from service and render it to a predetermined end-state condition.

Deep Geologic Repository (or DGR, or Repository) – The underground portion of the deep geologic repository facility for low- and intermediate-level waste. Initially, the repository includes the access-ways (shafts, ramps and/or tunnels), underground service areas and installations, and emplacement rooms. In the postclosure phase it also includes the engineered barrier systems. The repository includes the waste emplaced within the rooms and excludes the excavation damage zone.

Deep Geologic Repository Facility (or DGR Facility, or Repository Facility) – The deep geologic repository for low- and intermediate-level waste, and the various surface and underground support facilities. The support facilities include equipment, materials and infrastructure for receiving, inspecting and handling waste packages, for transferring waste packages from the surface to the repository horizon, for handling the waste packages in the repository, for emplacing waste packages, for excavating the repository (during operations), for constructing room shield walls, and for material storage. The repository facility excludes the waste emplaced within the rooms and any zones of damaged rock around underground openings.

Deep Geologic Repository System (or DGR System, or Repository System) – The deep geologic repository facility for low and intermediate-level waste, its geological setting, and the surrounding surface environment. The system includes the wastes, and the engineered and natural barriers that provide isolation and containment of the waste.

Deep Geologic Repository Project Site (or DGR Project site) – The portion of the Project Area that will be affected by the site preparation and construction of the surface facilities (i.e., the surface footprint).

Deformation – A general term for the process of folding, faulting, shearing, or fabric development of the rocks as a result of Earth stresses; or the change in geometry of a body of rock as a consequence of stress(es).

Descriptive Geosphere Site Model – A description of the present day 3-dimensional physical and chemical characteristics of a specific site as they relate to implementation of the Deep Geologic Repository concept. The model is based on the integration of multi-disciplinary geoscientific data that, in part, relies on multiple lines of evidence to constrain uncertainty and/or non-uniqueness in interpretation. See also *Geosynthesis.*

Design Basis – Identifies specific functions to be performed by a system, structure, equipment, component or software; and the specific values or range of values chosen for controlling parameters as reference bounds for the design.

Design Constraint – A mandatory requirement to be fulfilled by the repository design. For example, must be located on OPG-retained land, must be constructed in suitable Ordovician limestone. See also *Design Limit, Functional Requirement* and *Performance Requirement.*

Design Life – The period during which a structure, system or component will perform while still meeting original design specifications, including routine maintenance but without major repair or refurbishment.

Design Limit – A limit beyond which an element or combination of repository elements is not expected to function properly. Design limits should have either "maximum" or "minimum" in the description. See also *Design Constraint, Functional Requirement* and *Performance Requirement.*

Detritus – Loose fragments or grains that have been worn away (eroded) from a rock(s) and are transported from their place of origin and accumulate elsewhere (i.e. clay is composed of numerous detrital grains that have been eroded from the primary (host) rock(s) and have been transported via mechanical forces (wind, water), resulting in the accumulation and formation of a cohesive sedimentary rock mass elsewhere).

Deuterium – Refers to 'heavy hydrogen', ^2H, the stable isotope of hydrogen that has an atomic mass of two, as opposed to the common isotope of hydrogen, ^1H, which has an atomic mass of one.

Devonian – The fourth period of the Paleozoic Era extending from 417 to 354 million years ago; also refers to rocks formed, or sediments laid down, during this period (eg., Devonian shales).

Diffusion – The process by which both ionic and molecular species dissolved in water move from areas of higher concentration to areas of lower concentration. Movement is random and is proportional to the gradient of concentration. The process tends to distribute the particles more uniformly. See also *Advection* and *Dispersion*.

Diffusion Coefficient – The diffusion coefficient *D* is the constant of proportionality relating the solute flux J_i to the solute concentration gradient in a given co-ordinate direction $\partial C/\partial x_i$ as described by Fick's First Law: $J_i = -D \; \partial C/\partial x_i$

Apparent Diffusion Coefficient (D_a) – The diffusion coefficient for a specific solute in a porous medium that accounts for the 3-dimensional geometry of the pore space, as well as the sorption behaviour of the solute. It is related to the *effective diffusion coefficient* D_e and the porous medium *capacity factor* α as follows: $D_a = D_e / \alpha$

Effective Diffusion Coefficient (D_e) – The diffusion coefficient for a specific solute in a porous medium that accounts for the 3-dimensional geometry of the pore space, including tortuosity, constrictivity and diffusion-accessible porosity. It is the product of the *diffusion-accessible porosity* ϕ_{diff}, the *tortuosity factor* τ_f, and the *free-water diffusion coefficient* D_0 as follows: $D_e = \phi_{diff} \cdot \tau_f \cdot D_0$

Free-Water Diffusion Coefficient (D_0) – The diffusion coefficient for a specific solute in bulk aqueous solution (no porous media) at 25 °C.

Pore-Water Diffusion Coefficient (D_p) – The diffusion coefficient for a specific solute in porous medium that accounts for the 3-dimensional geometry of the pore space, including its tortuosity and constrictivity. It is the product of the *tortuosity factor* τ_f and the *free-water diffusion coefficient* D_0 as follows: $D_p = \tau_f \cdot D_0$

Digital Elevation model (DEM) – A representation of the topography of the land surface in a digital format (also digital terrain model). Data files consist of elevation data related to rectangular grid coordinates.

Dip – The maximum angle that a geological structural surface (bedding plane, fault, etc.) makes with the horizontal; measured in the vertical plane, perpendicular to the strike of the structure.

Direct Effect – A direct effect occurs when the VEC is affected by a change that results from a work and activity.

Discontinuity – Any interruption in sedimentation (*unconformity*), for whatever cause or length of time. Typically, discontinuities represent time periods of non-deposition or erosion. May also refer to any naturally occurring fracture (break) in logging rock core samples.

Dispersion – A small scale, spreading and mixing process resulting from dissolved substances traveling at different velocities along and between flow paths through a porous or fractured medium. The spreading of the dissolved substance in the direction of bulk flow is known as longitudinal dispersion. Spreading in directions perpendicular to bulk flow is known as transverse dispersion.

Disposal – The emplacement of waste in an appropriate facility without the intention of retrieval.

Dolostone – A sedimentary rock of which more than 50 percent by weight consists of the mineral dolomite (magnesium carbonate). Dolostone is generally thought to form when magnesium ions replace some of the calcium ions in limestone by the process of dolomitization. Migrating fluids along some faults and fractures may locally dolomitize limestone, the resulting rock being more porous may become a host for oil and gas deposits.

Dose – A measure of the energy deposited by radiation in a tissue. Also referred to as absorbed dose, committed equivalent dose, committed effective dose, effective dose, equivalent dose or organ dose, depending on the context.

Drilling Fluid – A fluid used to lubricate and cool the drill bit, to carry cuttings from the bottom, and to maintain a hydrostatic pressure in the borehole offsetting pressures of fluids that may exist in the formation. For the DGR, water from Lake Huron was employed to drill the upper rock sequence above the Salina Formation (where fresh groundwater is encountered) and a brine-based fluid was used to drill the Salina and underlying formations (where saline groundwaters are present).

Drill Fluid Tracers – Any substance that is used in a drill fluid to trace the presence of the fluid and distinguish it from the natural groundwater. It is used to determine the amount of well development required before sufficient drill fluid has been removed from the system. Naturally occurring tritium from lake water and fluorescence dye were used as tracers at the DGR.

DRL (**Derived Release Limit**) **-** The limit at which release of a radionuclide occurring from a nuclear station or a facility will not result in dose to individual members of the public exceeding the dose limits set by the CNSC.

Drumlin – A low, smoothly rounded, elongate oval hill, mound, or ridge, of compact glacial till or drift, built under the margin of glacial ice and shaped by fluid flow beneath the glacier. The long axis of a drumlin is oriented parallel to the direction of ice movement.

Dyke – A planar injection of magmatic or sedimentary material that cuts across the pre-existing fabric of a rock. Dykes can be formed by the filling of a crack/fissure from above, below, or laterally by forcible injection, or intrusion, under abnormal pressures.

Earthquake – A shaking or trembling of the earth resulting from subterranean movement usually along faults.

Effective Stress – The average normal force per unit area transmitted directly from particle to particle in a soil or rock mass. It is the stress that is effective in mobilizing internal friction. In a saturated soil in equilibrium, the effective stress is the difference between the *total stress* and the neutral stress of the water in the voids (pore water pressure). It attains a maximum value at complete consolidation and before shear failure. See also *Total Stress*.

Elastic Modulus – A measurement of material stiffness. The modulus represents the ratio of the stress applied to a body to the strain that results in the body in response to the stress. All moduli of elasticity determined in DGR testing are tangent Young's moduli, which are computed based on the stress-strain curve at a fixed stress level of 40% of the peak strength of the material.

Emplaced Volume (Waste) – The external volume of the *waste package* for emplacement in the DGR, which includes the waste, storage container, overpack, and/or shield.

Emplacement Room – A portion of the underground repository into which waste packages are permanently placed. Rooms are bounded by the host rock for floor, ceiling and walls on most sides, and by a wall or access tunnel on one side.

Engineered Barrier – A physical obstruction that has been constructed to prevent or delay water seepage and/or radionuclide migration and/or migration of other materials between components in the repository, or between the repository and the surface environment.

Environ – Refers to the surrounding area or surrounding environment.

Environmental Isotopes – Naturally occurring stable and radioactive *isotopes* of elements found in the environment. The principal elements of hydrogeological, geological and biological systems are hydrogen, oxygen, carbon, nitrogen and sulphur. Less abundant elements include helium, argon and krypton. Environmental isotopes permit quantitative determinations of the origin, age and flow paths of groundwaters on a regional scale.

Epicenter – The point on the Earth's surface that is directly above the focus of an earthquake.

Equivalent Sound Level (Leq) – Average weighted sound level over a specified period of time.

Era – Used to denote a long period or division of geologic time, during which the respective rocks were formed (i.e. *Paleozoic* Era, *Mesozoic* Era).

Eustasy/Eustatic – Refers to sea-level changes which occur on a global scale. Eustasy results from either a change in the volume of seawater, or a change in the size of the ocean basin that contains the water. Causes of eustatic sea level change include glaciations and deglaciation, tectonic activity, and continental drift.

Excavation Damaged Zone (EDZ) – The region of rock around repository openings that has been physically or chemically affected as a result of the excavation process, with significant changes in flow and transport properties (i.e., permeability of the rock increased by at least one order of magnitude). See also *Highly Damaged Zone* and *Excavation Disturbed Zone*.

Excavation Disturbed Zone (EdZ) – The region of rock surrounding the EDZ with possible stress or flow changes as a result of the excavation, but without significant changes in flow and transport properties (i.e. permeabilities with the rock materially unchanged). See also *Highly Damaged Zone* and *Excavation Damaged Zone*.

Exposure Group – A group of members of the public which is reasonably homogeneous with respect to its exposure for a given radiation source and given exposure pathway and receives a dose (radioactive contaminants) or intake (non-radioactive contaminants) by the given exposure pathway from the source. See also *Critical Group*.

Exposure Pathway – A route by which contaminants can reach humans or biota and cause exposure. An exposure pathway may be very simple, for example external exposure from airborne contaminants, or involve a more complex chain, for example internal exposure from drinking milk from cows that ate grass contaminated with deposited contaminants.

Extended Monitoring – Monitoring during the time period following completion of waste emplacement activities and prior to closure of the repository (see also *Postclosure Monitoring*). The results from extended monitoring would be used in the decision-making processes related to decommissioning and closure of the repository.

Externally Bound Water, External Layer Water – Water in close proximity (few molecular diameters) of surface areas of mineral grains or clay particles in a porous medium, influenced by electrostatic interactions with surfaces or with cations near negatively charged surfaces of clay minerals. See also *Bound Water*, *Internally Bound Water.*

Extraction Ratio – The ratio of the excavated area of the repository (at the level of emplacement rooms) to the total area occupied by the repository.

Facies Change – A lateral or vertical variation in the lithologic or paleontologic characteristics of contemporaneous sedimentary deposits. It is caused by, or reflects, a change in the depositional environment.

Fault – A discrete surface or zone of discrete surfaces separating two rock masses across which one mass has slid past the other. Any faults in the DGR region would most likely be vertical/sub-vertical with probable vertical displacements propagating from the Precambrian surface into the overlying sedimentary rocks.

Feldspars – A group of abundant rock-forming minerals, generally rich in potassium, sodium, calcium, barium, rubidium, and strontium, as well as silicon and aluminum. Feldspars constitute approximately 60% of the Earth's crust.

Feldspathic – Term to describe a rock or mineral aggregate containing feldspar.

FEPs (Features, Events and Processes) – FEPs are all relevant factors that describe the current state and possible future evolution of a system. They are used as input for scenario development and subsequent consequence analysis regarding health, safety and environment.

Filter Waste – Depending on each specific station system, filter waste may consist of disposable vessels along with the exhausted filter cartridges contained therein, or filter cartridges from systems employing permanent vessels.

Fissility (Rock) – The property possessed by some rocks of splitting easily into thin layers along closely spaced, roughly planar, and approximately parallel surfaces, such as bedding planes in shale.

Focal Depth – The depth at which an earthquake originates (the focal depth can be measured with respect to mean sea level, or with respect to the average ground surface elevation for all seismic stations that record a given seismic event).

Fracture - A general term for any surface within a material across which there is no cohesion, including cracks, joints, faults, and bedding partings.

Free Pore Water – Water in a porous medium not or only weakly influenced by mineral surfaces and cations on these surfaces. See also *Pore Water*.

FSR (Final Safety Report). See *Safety Report.*

Functional Requirements – These specify what has to be done but not how it should be accomplished. A function can be described by an action verb and a measurable noun, for example, a function of the repository is to "contain waste". See also *Performance Requirements*.

Geophysics – The study of the earth by quantitative physical methods, especially by seismic reflection and refraction, gravity, magnetic, electrical, electromagnetic, and radioactivity methods.

Geosphere – The rock around the repository, and extending up to the biosphere. It can consist of both an unsaturated zone (which is above the groundwater table) and the saturated zone (which is below the groundwater table).

Geosynthesis – The assembly of all the geologically-based evidence relevant to the repository safety case; the integration of multi-disciplinary geoscientific data relevant to the development of a descriptive conceptual geosphere model; explanation of a site-specific descriptive conceptual geosphere model within a systematic and structured framework. See also *Descriptive Geosphere Site Model*.

GIS – Geographic Information System, a computer system designed to allow users to collect, manage and analyze large volumes of spatially referenced information and associated attribute data.

Glacial Perturbations – Changes in geological, hydrological or geochemical systems as a result of glacial processes that include glacial isostacy, permafrost and ice sheet history.

Glaciation – The formation, movement, and recession of glaciers or ice sheets.

Graben – An elongate geological depression bounded on both sides by high-angle normal faults that dip toward one another.

Grenville Front Tectonic Zone (GFTZ) – That part of the Central Gneiss Belt (a subdivision of the Precambrian Grenville Province) that lies within 20-30 km of the Grenville Front boundary fault, consists of deformed and metamorphosed rocks, and is characterized by northeasterly trending shear zones (several kilometers wide) and foliation.

Grenville Orogeny – A major plutonic, metamorphic, and deformational event during the Precambrian era, 800 to 1,000 million years ago, which affected a broad province along the southeastern border of the Canadian Shield. The Grenville orogeny is thought to be the consequence of a Himalayan-type continental collision during the assembly of a supercontinent (Rodinia).

Groundwater (or Ground water) – In general, water contained in geologic formations below the Earth's surface. In the context of the DGR, the term is specifically applied to water that is relatively unconstrained by low permeability media and therefore free to flow under the influence of hydraulic gradients. This includes water within the connected pore space between mineral grains in unconsolidated sediment or in a fractured or porous rock matrix, as well as water in permeable, connected structures in the subsurface. See also *Porewater.*

Grout – A fluid mixture of cementitious materials, aggregates, additives and/or clay and water that will flow without segregation of the constituents into small spaces, and will form a low-permeability fill material to resist groundwater flow. In the DGR context, grouting applies to filling of fractures within the rock, or pore spaces within waste containers. See also *Backfill*.

High Pressure Permeameter – Equipment for measuring permeability using high fluid pressures. Provides measurements of the pressure and volume of unidirectional liquid flow through sample cores of rock.

Highly Damaged Zone (HDZ) – The zone of rock around an excavation where macro-scale fracturing or spalling may occur, thereby inducing changes in flow and transport through the interconnected fracture system (i.e. permeabilities within the rock increased by at least 2 orders of magnitude). See also *Excavation Damaged Zone* and *Excavation Disturbed Zone*.

Holocene – The later of two epochs comprising the Quaternary Period covering the time span between 11.5 thousand years ago and the present. See also *Pleistocene*.

Homogenous – A property of a parameter or system whose values are unchanged over space.

Horst – An elongate, topographically positive, geological block that is bounded on both sides by normal faults that dip away from one another.

Human Intrusion – Human actions that modify the performance of engineered and/or natural barriers leading to the creation of a route by which humans (potentially both the intruder(s) and public) could be exposed to radionuclides derived from the repository.

Huron Slope – An area of approximately 1500 km^2, located on the eastern shore of Lake Huron between Point Clark and Grand Bend. The area near the shoreline consists of high clay till bluffs (primarily St. Joseph Till), which slope westward.

Hydraulic Conductivity – The capacity of a rock to transmit a fluid. It is expressed as the volume of water at a given kinematic viscosity that will move in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow.

Hydraulic Gradient – The rate of change of pressure (pressure head) per unit of distance. Typical hydraulic gradients in natural groundwater flow systems are on the order of 0.01 to 0.001.

Hydraulic Head – Fluid mechanical energy per unit weight of fluid, which correlates to the elevation that water will rise in a well.

Elevation Head – Head caused by gravity (the elevation of the water relative to a datum elevation).

Pressure Head – Head caused by the pressure (energy) of the fluid at a given elevation.

Environmental Head – The sum of the elevation head and the pressure head calculated using the average density of the water over the entire vertical water column. This is used for calculating vertical hydraulic gradients.

Freshwater Head – The sum of the elevation head and the pressure head calculated using the density of fresh water (1000 kg m^{-3}). This is used for calculating horizontal hydraulic gradients.

Hydrogeology – The science that deals with subsurface waters and related aspects of surface waters. Hydrogeology is the study of the law governing 1) the movement of groundwater, 2) mechanical, chemical, and thermal interaction of groundwater and the porous medium, and 3) the transport of energy and chemical constituents by flow of groundwater.

Iapetus Ocean – The ocean that existed east of North America before Europe and Africa collided with North America during the Carboniferous and Permian periods (320-250 million years ago).

IC-18 – An in-ground storage structure used for intermediate level waste, primarily ion exchange resins, with a capacity of 18 m^3. See *In-Ground Storage*.

Incinerable Waste – Radioactive waste materials generally consisting of paper, plastic, wood, cardboard etc. which can be incinerated. The contact dose rate of such waste is less than 0.6 mSv/h (60 mrem/hr).

Indirect Effect – An indirect effect occurs when the VEC is affected by a change in another VEC.

In-Ground Storage – Storage of waste in in-ground containers (ICs); generally used for intermediate level waste. All ICs with the exception of those used for heat exchangers (HXs) consist of steel liners fixed with concrete inside boreholes in the ground. IC-HXs use limestone gravel for the backfill.

In-Service Date – The date on which the facility is put into service or made available for operation.

In-Situ Stress – The natural or virgin state of stress in a rock mass that was derived from a pervasive force field imposed by geological perturbations such as tectonic activity.

Institutional Control – Control of a deep geologic repository by an authority or institution designated under the laws of a country or state. This control may be active (monitoring, surveillance, remedial work) or passive (land use control).

Interlayer Water – Water in interlayers of expandable clays (smectites). Except for strongly expanded smectites, all interlayer water is *internally bound water*.

Intermediate-Level Waste (ILW) – Radioactive non-fuel waste, containing significant quantities of long-lived radionuclides (generally refers to half-lives greater than 30 years).

Internally Bound Water, Internal Layer Water – Water in close proximity (few molecular diameters) of internal surfaces (e.g., the surface areas of water accessible interlayers of expandable clay minerals); influenced by electrostatic interactions with internal surfaces or with cations near internal surfaces. See also *Bound Water*, *Externally Bound Water.*

Interstice – An opening or space (pore) in a rock or soil.

Intracratonic Basin – A basin formed in the interior region of a continental *craton* (away from plate boundaries) due to subsidence of some part of the craton.

Intraplate – A feature, event or process (i.e. earthquake, fault) located far from any tectonic plate boundary and therefore considered unrelated to subduction or sea-floor spreading.

Ion – An atom or molecule that has an unbalanced charge (i.e. the number of protons is not equal to the number of electrons). A cation is an ion with a net positive charge (e.g. Ca^{2+}, Na^+) and an anion is an ion with a net negative charge (e.g. Cl^-, SO_4^{2-}).

Irradiated Core Components – Radioactive waste such as flux detectors and liquid zone control rods resulting from the routine replacement of core components during the operation of nuclear reactors.

Island Arc – A type of archipelago formed as one oceanic tectonic plate slides beneath another and produces magma at depth below the over-riding plate. Island arcs are formed by volcanic activity associated with oceanic plate subduction at convergent plate margins and are also known as volcanic arcs.

Isolation (Safety Case) – Making human encounter with the waste unlikely.

Isostacy – The condition of equilibrium, comparable to floating, of the units of the *lithosphere* above the *asthenosphere*. Crustal loading (ice, water, and/or sediment) leads to isostatic depression, and removal of load (i.e. melting of glacial ice) leads to uplift (sometimes referred to as isostatic rebound).

Isotope – An isotope is one of two or more species of the same element that have the same number of protons in the nucleus but a different number of neutrons, which results in small variations in the atomic mass (e.g., oxygen has 8 protons, but the atomic masses of naturally occurring oxygen isotopes range between ^{16}O, ^{17}O and ^{18}O). See also *radioisotope.*

Isotropy – The condition of having properties that are uniform in all directions at a given point location; the property of interest does not depend on directionality (e.g., uniform sand, in which hydraulic conductivities are the same in the x, y, and z directions). See also *anisotropy.*

IX Resin – Ion-exchange resin used to maintain the water quality in station process systems (e.g., moderator and Primary Heat Transport heavy water systems, and light water auxiliary systems such as the Active Liquid Waste Treatment System).

Joint – A planar fracture, crack, or parting in a rock, without shear displacement. Often occurs with parallel joints to form part of a joint set.

Karst – A type of topography that is formed in limestone, gypsum or other rocks, primarily by dissolution, and that is characterized by sinkholes, caves and underground drainage. The most common type of karst is associated with the dissolution of limestone by meteoric waters when the carbonate rocks are exposed to the atmosphere at the Earth's surface, forming an unconfined aquifer. This most commonly occurs when shallow-marine limestones have become exposed due to a fall in sea-level. Karst can also be formed in coastal settings where fresh and marine waters mix, or as a result of limestone dissolution by sulphuric acid during deep burial of sediments.

Kimberlite – A mantle-derived *ultramafic* igneous rock containing at least 35% olivine, does not contain leucite, and contains one or more of the following: monticellite, carbonate, serpentine, diopside, or phlogopite.

Kriging – A technique of interpolation based on a combination of known data points. Kriging is often used to interpolate geoscientific information between boreholes.

L&ILW – Low- and Intermediate-Level radioactive Waste.

Licensing Basis – The *Licensing Basis* for a regulated facility or activity is a set of requirements and documents comprising: (i) the regulatory requirements set out in the applicable laws and regulations; (ii) the conditions and safety and control measures described in the facility's or activity's licence and the documents directly referenced in that licence; and (iii) the safety and control measures described in the licence application and the documents needed to support that licence application.

Licensing Pre-requisites – The requirements to obtain a licence for a new facility or a licence renewal for an existing facility formally discussed and agreed with the CNSC and documented prior to applying for the licence.

Licensing Submission – A document, or set of documents, submitted to the CNSC in support of a new licence application or an application for licence renewal or amendment.

LIDAR (Laser Imaging Detection and Ranging) – A technology similar to radar technology that accurately determines distance to an object or surface using laser pulses.

Limestone – A sedimentary rock composed of the mineral calcite (calcium carbonate). Where it contains appreciable magnesium carbonate it is called dolomitic limestone. The primary source of this calcite is usually the shells of marine organisms. See also *Dolostone*.

Lineament – An extensive linear geologic or topographic surface feature. Some examples are straight stream courses, fault lines, and straight escarpments.

Lithofacies – A lateral, mappable, subdivision of a stratigraphic unit, distinguished from adjacent subdivisions on the basis of lithology (mineralogy, petrography, paleontology – appearance, composition, and texture).

Lithology – Describes the physical character of a rock, including color, grain size, and mineralogy.

Lithosphere – The outer, relatively rigid layer of the Earth that responds to the emplacement of a load by flexural bending. The lithosphere consists of the entire crust, plus the uppermost mantle. The lithosphere has been divided into about 20 plates. According to the theory of plate tectonics, motion and interaction of lithosphere plates is responsible for most geologic activity.

Low Level Storage Building (LLSB) - Refers to a series of buildings at OPG's Western Waste Management Facility for the interim storage of low-level waste.

Low-Level Waste (LLW) – Radioactive waste in which the concentration or quantity of radionuclides is above the clearance levels established by the regulatory body (CNSC), and which contains primarily short-lived radionuclides (half-lives shorter than or equal to 30-years).

Mafic – General term for igneous rocks composed primarily of ferromagnesian (iron- and magnesium-rich), dark-colored, minerals.

Marker (bed) – An easily recognized stratigraphic feature having characteristics distinctive enough for it to serve as a reference point or datum, and that is traceable over long distances, especially in the subsurface (i.e. unconformities, salt beds, etc.).

mASL – Metres above sea level.

mBGS – Metres below ground surface.

Mesozoic – An era of geologic time covering the time span from 248 to 65 million years ago, that lies above the *Paleozoic* and below the *Cenozoic*. This is the era when dinosaurs roamed on earth.

Meteoric Recharge – Surface water that has recently been a part of the atmospheric portion of the hydrologic cycle, which has infiltrated into the sub-surface.

Methanogenesis – The generation of methane (CH_4) as a result of biogenic (microbial) activity.

Michigan Basin – A nearly-circular intracratonic *sedimentary basin* with a diameter of between 500 and 600 km, centered in Michigan, with a maximum depth of over 4 km. In southern Ontario, sedimentary rocks from edges of both the Michigan Basin and the *Appalachian Basin* are present. The maximum thickness of the sedimentary rocks in southern Ontario is approximately 1.5 km.

Microseismicity – Very low level seismic activity, generally considered to be seismic events of M3 or less. The three borehole seismographs installed in 2007 in the vicinity of the *Bruce nuclear site* are capable of measuring microseismic events of less than M1.

Mississippi Valley-type (MVT) deposit – A strata-bound hydrothermal deposit of lead and/or zinc minerals in carbonate rocks, together with associated minerals fluorite and barite. These deposits characteristically have relatively simple mineralogy, occur as veins and replacement bodies, are at moderate to shallow depths, show little post-ore deformation, are marginal to sedimentary basins, and are without an obvious source of mineralization.

Moderately Fractured Rock – A fractured rock domain in which groundwater flow and transport occurs through an interconnected fracture network. Fracture frequencies are typically in the range of one to five fractures per metre and effective rock mass permeability is typically 10^{-15} m^2.

Moment Magnitude Scale (MMS, or M_w) – The scale used by seismologists to characterize the size of an earthquake based on the amount of energy released. The scale is logarithmic, with each increase of 1 representing a 10-fold increase in energy.

Moraine – A glacially formed accumulation of unconsolidated glacial debris (soil, rock). Moraines are deposited as sheets or piles of debris directly from the ice of the glacier on/in which the debris is carried. Various types of moraines exist and their classification is based on where they were deposited with respect to the front of the glacier.

Mylonitic Texture – A characteristic of mylonites that is produced by intense microbrecciation and shearing, giving the appearance of a 'flowing/flow' texture.

Near- field Rock – The rock adjacent to the repository that may have experienced changes in flow, mechanical, chemical or microbial characteristics as a consequence of the excavation, operation, decommissioning and closure of the repository. See also *Highly Damaged Zone, Excavation Damaged Zone* and *Excavation Disturbed Zone*.

Neo- – Prefix used when referring to something 'new' or 'recent'.

Net Volume (Waste) – The internal volume of the container in which waste is stored.

NWMD – Nuclear Waste Management Division of Ontario Power Generation Inc.

Non-Processible Waste – Wastes that are neither incinerable nor compactible, such as heavy gauge metal objects, glass, concrete, tools, heavy slings and cables. Maximum dose rate is 10 mSv/h (1 rem/hr) at 30 cm for storage in LLSBs. Higher dose rate wastes are stored in shielded structures, notably trenches or ICs.

OPG-retained Land – The parcels of land on the Bruce nuclear site for which control has been retained by OPG. This includes the WWMF, certain landfills, and the Heavy Water Plant Lands.

Ordovician – The second period of the *Paleozoic* Era extending from 443 to 490 million years ago; also refers to rocks formed, or sediments laid down, during this period (eg., Ordovician carbonates).

Orogeny – A period of mountain building that lasts for several to tens of millions of years.

Orthophoto – A digital air photo that is like a map, with a uniform scale, after the effects of tilt and relief are removed.

Osmosis – The movement of water across a semi-permeable membrane in order to reduce the difference in solution concentration. Water moves from a volume of low solute concentration to a volume of high solute concentration - essentially diluting the fluid of high solute concentration by the addition of water, and concentrating the fluid of low solute concentration by the removal of water.

Outcrop – An exposure of bedrock at the surface of the Earth. Specifically, an outcrop is the part of a geologic (rock) formation or structure that appears at or above the surface of the surrounding land.

Overcoring – Rock coring directly over an existing smaller diameter borehole to relieve the in situ stresses present in the smaller borehole. Used to measure the magnitude and direction of in situ stresses.

Overpack – An enclosure used to provide physical and/or radiological protection or convenience in handling of a waste package, or to combine two or more waste packages.

Oxic – Often used interchangeably with the term *aerobic*, oxic strictly means the presence of oxygen.

Packstone – A sedimentary carbonate rock in which the granular material is arranged in a self-supporting frame-work, but also contains calcareous mud.

Paleo- – Prefix used when referring to something 'ancient' or 'old' (e.g. *Paleozoic* refers to 'ancient/old life'), or which involved ancient conditions (e.g. paleoclimate).

Paleohydrogeology – The hydrogeologic study (physical/chemical) of the evolution of a site or flow domain based on knowledge of its current state and external perturbations that have acted upon it in geologic time.

Paleozoic – The time span covering approximately from 540 to 250 million years ago.

Pangaea – The supercontinent that existed during the Paleozoic and Mesozoic eras (about 300 to 200 million years ago), before the component continents were separated into their current configuration by fragmentation and continental drift.

Passive Margin – A continental boundary formed by rifting and continental rupture, without plate-boundary collisional tectonism.

Performance Requirements – The quantifiable measures of adequate performance of the deep geologic repository system. Each performance requirement should include both a measurable item or parameter and the value of that item or parameter that would identify satisfactory performance of that aspect of the deep geologic repository. See also *Functional Requirement, Design Limit* and *Design Constraint*.

Periglacial – The conditions, processes and landforms associated with non-glacial cold climate conditions. Periglacial environments are those where frost action or permafrost processes dominate.

Permafrost – Ground that has been below 0°C for at least 2 years. It is not necessarily frozen because the freezing point of any included water may be depressed by pressure or salinity, or moisture may not be present. A continuous layer of permafrost is found where the annual mean temperature is below about -5°C.

Permeability – The ease with which a porous medium can transmit water or other fluids. The intrinsic permeability [m^2] of medium is independent of the type of fluid present.

Petrophysics – The study of the physical and chemical properties of rocks, which relates to the distribution of the pore system and the contained water and hydrocarbons.

Phanerozoic – Includes the *Paleozoic*, *Mesozoic*, and *Cenozoic* eras, and represents the time-frame from 540 million years ago to present.

Pinnacle Reef – A small reef patch, consisting of coral growing sharply upwards (with slopes ranging from 45° to nearly vertical). In southern Ontario, ancient, fossilized pinnacle reefs occur in the Guelph Formation and can become oil and gas traps when they are capped by anhydrite or shale.

Pleistocene – The earlier of two epochs comprising the Quaternary Period covering the time span from 1.8 million years to 11.5 thousand years before present. See also *Holocene*.

Poisson's Ratio – The ratio of the lateral strain (perpendicular to the applied load) to the axial strain (in the direction of the applied load) in a body that has been stressed longitudinally within its elastic limit.

POLARIS – (Portable Observatories for Lithospheric Analysis and Research Investigating Seismicity) is a university-government-industry research collaboration to study earthquakes and associated ground motion in Canada.

Porewater (or Pore water) – Water within the connected pore space between mineral grains in low-permeability sediments or rocks in which flow under the influence of hydraulic gradients is inhibited. In contrast with groundwater, which flows into or can be sampled from boreholes over time scales of days to months, laboratory techniques are generally required to extract porewaters from the sediment or rock matrix. See also *Groundwater, Free Pore Water*.

Pop-ups – Are low elongated anticlinal ridges formed in response to high horizontal in situ stresses usually in horizontally bedded sedimentary rocks. They are considered as surficial deformation features, affecting only the first few meters of the bedrock surface. Some authors include quarry floor buckles as pop-ups.

Porosity – **Physical Porosity** – The volume of pores per total volume of sample. Pores are defined as everything which is not solid. Interlayer water of clays is considered as part of the pore space.

Diffusion (Accessible) Porosity – The volume of pores, per total volume, accessible for a given solute. Typically determined from diffusion experiments. Solute specific.

Transport Porosity (also Effective porosity) – The proportion of the *physical porosity* of a rock or soil in which transport of fluids (e.g., gases, water) occurs.

Water Loss Porosity – The volume of pores per total volume of sample, derived from water extraction at 105°C (additional specification if extracted e.g., under vacuum). In argillaceous rocks, water loss porosity at 105°C is usually somewhat smaller than the *physical porosity*, because the bound water is only partially released at this temperature.

Postclosure Monitoring – Monitoring during the time period following closure of the repository. See also *Extended Monitoring*.

Postclosure Phase – The period of time following closure of the deep geologic repository.

Potentiometric surface – An imaginary surface that represents the total hydraulic head in an aquifer. It represents the height above a datum plane at which the water level stands in tightly cased wells that penetrate the aquifer.

Precambrian – All geologic time before the beginning of the Paleozoic Era, preceding 543 million years ago; also refers to rocks formed, or sediments laid down, during this period (eg., Precambrian gneiss).

Precautionary Approach – The precautionary approach is ultimately guided by judgement, based on values and is intended to address uncertainties in the assessment. This approach is consistent with Principle 15 of the 1992 Rio Declaration on Environment and Development. Principle 15 of 1992 Rio Declaration on Environment and Development and the Canadian government's framework for applying precaution in decision-making processes.

Preclosure Phase – The period of time that includes all activities from siting through to decommissioning and closure of all components of the deep geologic repository.

Preliminary Design – A design product that is sufficiently developed so that management can determine the merit of completing the design based on financial, safety and regulatory criteria.

PSR – Preliminary Safety Report. See *Safety Report.*

Quadricell – An above-ground storage structure used for intermediate level waste, primarily ion exchange resins.

Quaternary – The upper time period of the *Cenozoic* era, extending from 1.8 million years ago and continuing into the present. It contains two epochs: the *Pleistocene* and the *Holocene*.

Radioactive Waste – Any material (liquid, gaseous or solid) that contains a radioactive "nuclear substance" as defined in Section 2 of Nuclear Safety and Control Act, and which the owner has declared to be waste. In addition to containing nuclear substances, radioactive waste may also contain non-radioactive "hazardous substances", as defined in Section 1 of the CNSC's General Nuclear Safety and Control Regulations.

Radioisotope – A radioactive *isotope*. See also *radionuclide.*

Radionuclide – A radionuclide is an atom with an unstable nucleus which can undergo radioactive decay by the emission of gamma ray(s) and/or subatomic particles. The resulting emission(s) is defined as radiation. See also *radioisotope.*

Ramp – An inclined excavated passageway that connects the surface with an underground workplace or connects one underground workplace to another at a different elevation. Also called inclines or declines.

Receptor – Any person or environmental entity that is exposed to radiation, or a hazardous substance, or both. A receptor is usually an organism or a population, but it could also be an abiotic entity such as surface water or sediment. See also *Exposure Group*.

Redox – A shorthand notation used to describe chemical reduction-oxidation reactions. Such reactions involve a change in the oxidation state of the atoms or molecules involved.

Retrieval – 1) The accessing and removal of waste containers from storage facilities for the purpose of transferring to another facility (e.g. a repository).
2) The accessing and removal of waste containers from either closed emplacement rooms (i.e., prior to decommissioning and closure of the repository), or from a sealed deep geologic repository (i.e., after the decommissioning and closure of the underground excavations).

Retrievability – The ability to remove waste packages from where they have been emplaced. Conditions may necessitate the use of different equipment and procedures from those used during emplacement of waste packages.

Retubing Waste – Radioactive waste produced from the fuel channel replacement (retubing) program i.e., pressure tubes, calandria tubes, calandria tube inserts, end fittings, yokes and studs.

Risk – A multi-attribute quantity expressing hazard, danger or chance of harmful or injurious consequences associated with actual or potential exposures. It relates to quantities such as the probability that specific deleterious consequences may arise and the magnitude and character of such consequences.

Rock Mass – An assemblage of blocks or layers of rock material bounded by discontinuities in which groundwater may be present.

Rock Mass Rating (RMR) – A rating system for rock masses based on five parameters: 1) strength of intact rock material, 2) *Rock Quality Designation* (RQD), 3) rock discontinuity spacing, 4) rock discontinuity condition, and 5) groundwater condition. It is also adjusted for rock discontinuity orientation with respect to a tunnel or cut-slope geometry. RMR values range from 0 – 100 and indicate very poor rock ($RMR \leq 20$), poor rock ($20 \leq RMR \leq 40$), fair rock ($40 \leq RMR \leq 60$), good rock($60 \leq RMR \leq 80$), and very good rock ($80 \leq RMR \leq 100$).

Rock Quality Designation (RQD) – The cumulative length of drilled core pieces longer than 100 mm in a run, divided by the total length of the run, expressed as a percentage. Mechanical breaks caused by the drilling process or extracting the core from the core barrel are ignored, but lost or missing core is included in the total core-run length.

Risk Quotient (RQ) – The risk quotient compares predicted exposures to radioactive or hazardous substances to the concentrations of these substances that would have to be exceeded to result in an effect. A RQ greater than one indicates that the contaminant is of concern and requires further investigation.

Safety Analysis – A calculation performed, with or without the assistance of computer software, to address a specific safety issue or as part of a safety assessment.

Safety Assessment (SA) – The process of systematically analyzing the hazards associated with the facility, and the ability of the site and design to provide the safety functions and meet technical requirements.

Safety Case – An integration of arguments and evidence that describe, quantify and substantiate the safety, and the level of confidence in the safety, of the geological disposal facility.

Safety Functions – The functions that the DGR must perform to ensure that the safety objective is achieved. These functions are *Isolation* and *Containment.*

Safety Indicator – A quantity used in safety assessments as a measure of the impact of a source, or of the performance of protection and safety provisions.

Safety Objective – The safety objective of the DGR is to prevent unreasonable risk to the health and safety of the public and the workers, and the environment.

Safety Report – A key licensing document which provides an overview of the facility design and operations, summarizes the integrated results of individual safety assessments, and demonstrates that a facility can be constructed, operated, or continue to be operated, without undue risk to health and safety of the workers and the public, and the environment.

Preliminary Safety Report (PSR) is the Safety Report submitted to CNSC in support of an application for a Site Preparation/Construction Licence.

Final Safety Report (FSR) is the Safety Report submitted to CNSC in support of an application for a Licence to Operate.

Saline Water – Water with a salinity between 10 to 100 g/L total dissolved solids. See also *Brackish Water* and *Brine*.

Sandstone – A medium-grained *clastic* sedimentary rock composed of abundant sand size particles with or without a fine-grained matrix (clay or silt) and cemented (commonly silica, iron oxide or calcium carbonate), the consolidated equivalent of sand. May be deposited by water or wind.

Saturated – A state of being completely wet, or in which the rock mass has absorbed and is retaining the greatest possible amount of fluid and can hold no more.

Scenarios – A postulated or assumed set of conditions or events. They are most commonly used in analysis or assessment to represent possible future conditions or events to be modelled, such as the possible future evolution of a repository and its surroundings.

Sealing System – A low-permeability system, typically comprising clay and/or cementitious materials, placed to fill and seal rooms, tunnels, shafts and/or boreholes when they are no longer needed, in order to inhibit groundwater movement and contaminant transport.

Sedimentary Basin – A low area in the earth's crust in which sediments have accumulated over geologic time and subsequently transformed into sedimentary rock, such as the *Michigan Basin* or the *Appalachian Basin*.

Sedimentary Rock – A layered rock made of compacted and cemented sediments such as fragments of other rocks, minerals and/or organic remains (fossils), or precipitated out of solution. *Limestone*, *dolostone*, *shale* and *sandstone* are examples.

Seismicity – The frequency or magnitude of earthquake activity in a given area. See also *microseismicity*.

Seismic Reflection – A surface geophysical method recording seismic waves reflected from geologic strata, giving an estimate of their depth and thickness.

Seismograph – An instrument that detects, magnifies, and records vibrations of the Earth, either earthquake or those generated for applied seismology purposes. Also called a seismometer.

Sensitivity Analysis – A quantitative examination of how the behaviour of a simulated system (e.g., a computer model) varies with change, usually in the values of its parameters.

Shaft – A vertical or near-vertical excavated passageway that connects the surface with an underground workplace or connects two or more underground workplaces at different elevations.

Shale – A fine-grained detrital sedimentary rock, formed by the compaction and cementation of clay, silt, or mud. It may have a fine laminated structure which gives it a fissility along which the rock splits readily.

Shear Strength - The capacity to resist deformation resulting from stresses that cause contiguous parts of a body to slide relatively to each other in a direction parallel to their plane of contact.

Silurian – The third period of the *Paleozoic* Era extending from 443 to 417 million years ago, also refers to rocks formed, or sediments laid down, during this period (eg., Silurian evaporites).

Slickenside – Term to denote lineated fault surfaces, which also may consist of grooves and/or fibrous minerals. The general definition refers to a rock surface that has been scratched or polished by the effects of friction during structural changes. The term can also refer to changes in the appearance of swelling clays that have been subject to large changes in water content, and to diagenetic features formed as a result of differential compaction of layered sediments.

Solute – A substance that is dissolved in another (e.g. dissolving salt in water: salt is the solute, water is the solvent, and the result is a saline solution).

Sonic Velocity – Acoustic velocity, related to the propagation of acoustic waves in air or water, or P-waves in the solid Earth.

Specific storage – The volume of water that a rock mass (or aquifer) releases, per unit volume of rock mass, per unit decline in pressure head, while remaining fully saturated. Essentially, the volume of water that a confined unit (or aquifer) will release due to a given change in pressure head.

Stakeholder – Any person or organization that has an interest in a particular aspect of the project.

Stored Volume (Waste) (also As-stored waste volume) – The external volume of the storage container in which the waste is currently stored. This volume does not include overpacks or concrete shields which may be required for repository emplacement. See also *Net Volume* and *Emplaced Volume*.

Straddle Packers – A straddle packer is a system of two packers separated by a fixed length into which fluid is injected, after packer inflation, to test the hydraulic properties of the bedrock in a borehole.

Strain – To alter the relations between the parts of a structure or shape by applying an external force.

Stratigraphy – The study of the age relation of rock strata, including the original succession (order of emplacement), form, distribution, composition, fossil content, geophysical and geochemical properties, and the environment of origin and geologic history, of a rock mass. The science primarily involves the description of rock bodies, and their organization into distinctive, mappable units based on their properties and features.

Strength – The ability to withstand differential stress, expressed in the units of stress. See also *stress*.

Stress – In a solid, the force per unit area, acting on any surface within it.

Strike – The direction or trend taken by a structural surface as it intersects the horizontal; measured with respect to the horizontal plane.

Strike-slip Fault – A geologic fault on which movement of the respective fault blocks is parallel to the strike of the fault.

Stylolite – A surface or contact, usually in carbonate rocks, marked by an irregular and interlocking penetration of the two sides: the columns, teeth, and pits on one side, fit into their counterparts on the other side. Stylolites resemble a suture, or 'seam', in the rock, and the 'seams' are usually parallel to bedding surfaces and consist of insoluble rock constituents (clay, iron oxides).

Subduction – The process by which collision of the earth's crustal plates results in one plate's being drawn down or overridden by another, localized along the juncture (subduction zone) of two plates.

Subsurface characterization – All activities carried out in the shafts, tunnels and rooms of the repository and via deep boreholes in the vicinity of the repository for the purpose of gathering geoscience data for the development of a repository design and the associated safety case. Examples of characterization activities are mapping and testing of rock formations during underground excavation, monitoring of groundwater pressures and chemistry via boreholes and within the repository, and in situ testing to measure rock properties.

Surfaces (minerals) – **Internal Surface -** Surface areas of water accessible interlayers of (expandable) clay minerals (smectites) mass of solids. **External Surfaces -** Surface areas of mineral grains or clay particles of a porous medium per mass of solids. **Total Surfaces** – The sum of external and internal surface areas.

Technical Computing Software – Software used by technical specialists for design, analysis or simulation of engineered systems. Examples include finite element stress analysis software, waste site safety analysis software, radiation shielding software, and waste inventory database software.

Tectonic – Said of or pertaining to the forces involved in, or the resulting structures or features of, *tectonics.* **Neotectonic** is tectonic activity that had occurred since the last *glaciation*, in the last 12,000 years.

Tectonics – A branch of geology dealing with a broad architecture of the outer part of the earth, that is, the regional assembling of structural or deformational features, a study of their mutual relations, origin, and historical evolution.

Tensile Strength - The capacity of a material to resist a normal stress that tends to pull apart the material on the opposite sides of the plane on which it acts.

Thermal Maturity – A measure of the state of a rock in terms of hydrocarbon generation. The sedimentary rock type, physical environment, and temperature of the environment will determine thermal maturity. Rocks that have been exposed to high temperatures, resulting in a different distribution of the various compounds (e.g. the alteration of organic molecules and petroleum to hydrocarbons - oil and/or gas) are defined as mature, and the extent of such alteration determines the level of maturity.

Time-Dependent Deformation – Deformation that occurs slowly and continuously through time leading to gradual *strain* failure of a rock mass. Synonymous with creep and swelling. An example is the gradual inward convergence of the walls of underground openings in response to *stress*.

Tortuosity (τ) – A geometric factor that accounts for the effective transport path length for solute transport within a porous medium (L_e) compared to the shortest straight-line transport path length (L) between two points, as follows: $\tau = (L_e / L)^2$. Note that $\tau \geq 1$.

Tortuosity Factor (τ_f) – An empirical factor that combines the *tortuosity* τ and the *constrictivity* δ to describe the geometric properties of the porous medium that influence diffusive transport. It is defined as $\tau_f = \delta / \tau$. Note that $\tau_f \leq 1$.

Total Stress – Also known as the applied stress. Defined as the sum of the *effective stress* plus the pore water pressure. See also *Effective Stress*.

Traditional ecological knowledge – Traditional ecological knowledge is a subset of Aboriginal traditional knowledge. Traditional ecological knowledge refers specifically to all types of knowledge about the environment derived from the experience and traditions of a particular group of people. There are four traditional ecological knowledge categories: knowledge about the environment; knowledge about the use of the environment; values about the environment; and the foundation of the knowledge system.

Transfer Fault – A strike-slip fault that links two segments of a rift that are offset relative to one another.

Transmissivity – The product of *hydraulic conductivity* and aquifer thickness; a measure of a volume of water to move through an aquifer. Transmissivity is a measure of the subsurface's ability to transmit groundwater through its entire saturated thickness and affects the potential yield of wells.

Ultramafic – Term to describe an igneous rock composed of > 90% *mafic* minerals.

Uncertainty Analysis – An analysis of the amount of variation in the results of assessments or analyses due to incomplete knowledge about the current and future states of a system.

Unconformity – An erosion surface separating two rock masses or strata of different ages, indicating that sediment deposition was not continuous. An unconformity refers to any substantial break in the geologic record, where a rock unit is overlain by another that is not the next in the stratigraphic succession.

Underground Service Areas – Any excavations within the deep geologic repository that provide the space for the infrastructure to characterize, demonstrate, construct, operate, monitor and decommission a deep geologic repository. Service areas include all excavations in a deep geologic repository that are not classified as tunnels, shafts, ramps, emplacement rooms or boreholes.

Uniaxial Compressive Strength - Represents the capacity of a material to withstand applied mechanical compressive forces; also is that value of uniaxial compressive stress reached when the material fails completely. The strength is usually expressed in units of stress.

Validation (Model) – The process of building confidence that a model adequately represents a real system for a specific purpose.

Valued Ecosystem Component (VEC) – VECs are features of the environment selected to be a focus of the environmental assessment because of their ecological, social, or economic value, and their potential vulnerability to the effects of the DGR Project.

Verification (Model) – The process of determining whether a computer model correctly implements the intended conceptual or mathematical model.

Wackestone – A mud-supported sedimentary rock containing >10% granular material.

Waste Acceptance Criteria (WAC) – Formal criteria which define the qualities of waste packages (including the waste) that are accepted for emplacement in the repository.

Waste Arisings – The amount of waste produced at the stations, prior to any *waste conditioning*.

Waste Characterization – Activities to define the physical, chemical and radiological characteristics of the radioactive waste.

Waste Conditioning – Those operations that produce a waste package suitable for handling, transport, storage and/or disposal. Conditioning may include the conversion of the waste to a solid waste form, enclosure of the waste in containers, and, if necessary, providing an overpack.

Waste Package – The waste material, the container, and any external barriers (e.g. shielding material), as prepared in accordance with requirements for handling, transfer and emplacement in the repository. It is a discrete unit that can be individually identified and handled at the repository facility. See also *Waste Packaging*.

Waste Packaging – The container and any external barriers (e.g., *overpack*, shielding material), used for handling, transfer and disposal of the waste. It does not include the waste itself. See also *Waste Package*.

Water Content – Also known as volumetric water content. Identical to *water loss porosity* for a fully saturated rock sample.

Water Loss Porosity – Refers to the ratio of the water-filled pore volume in a rock sample with respect to the total volume of the rock sample, and is typically measured during the heating and drying of the sample.

Water table (groundwater table) – The top water surface of an unconfined aquifer at atmospheric pressure.

Westbay Casing – A multi-level modular groundwater monitoring, sampling and testing system, consisting of multiple inflatable packers, valved ports, blank pipe segments and couplings to seal and provide access to multiple monitoring zones in one borehole. Monitoring, sampling and testing are carried out with the use of several available types of wireline operated probes.

Wetting phase – The preference of a solid to contact one liquid or gas, known as the wetting phase, rather than another. The wetting phase will tend to spread on the solid surface and a porous solid will tend to imbibe the wetting phase, in both cases displacing the non-wetting phase. Rocks can be water-wet, oil-wet or intermediate-wet. The intermediate state between water-wet and oil-wet can be caused by a mixed-wet system, in which some surfaces or grains are water-wet and others are oil-wet, or a neutral-wet system, in which the surfaces are not strongly wet by either water or oil. Both water and oil wet most materials in preference to gas, but gas can wet sulphur, graphite and coal.

WPRB (Waste Package Receiving Building) – The building at the DGR surface where waste packages arrive for transfer underground.

Wrench Fault – A regional scale *strike-slip fault*. Typically, the term wrench fault implies that the strike-slip movement resulted in the formation of a complex band of subsidiary faults and folds.

Waste Volume Reduction Building (WVRB) – The building at WWMF containing waste volume reduction equipment.

Western Waste Management Facility (WWMF) – The centralized processing and storage facility on the Bruce nuclear site for OPG's L&ILW and for the dry storage of used fuel from Bruce nuclear generating stations.

16. KEY SUBJECT INDEX

Table 16-1: Key Subject Index

Table 16-1: Key Subject Index (continued)