GE Hitachi Nuclear Energy

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Non-Proprietary Information

Ontario Power Generation Inc.
Darlington New Nuclear Project
BWRX-300 Preliminary Safety Analysis Report:

Chapter 2
Site Characteristics

IMPORTANT NOTICE REGARDING CONTENTS OF THIS REPORT

Please Read Carefully

REVISION SUMMARY

Revision #	Section Modified	Revision Summary
0	All	Initial Release
1	Section 2.1.2 Section 2.2.3 Section 2.5.1 Section 2.6.4 Section 2.6.5 Section 2.6.8 Section 2.6.9 Section 2.7.1 Section 2.7.2 Section 2.7.3 Section 2.8.2 Section 2.11.4 Section 2.12.1 Section 2.12.5 Section 2.12.8	Incorporated corrections per customer acceptance review
2	All	Edited to improve readability, streamline the text, and ensure consistency across all sections of Chapter 2
	All	Several paragraphs are deleted for they became irrelevant, outdated, or obsolete due to the incorporation of recent (2022 and 2023) information generated in works involving DNNP site-specific investigations, analyses, and assessments.
	All Summary Tables	The tables at the beginning of each section are updated to reflect the edited and added contents of corresponding texts in that section.
	All Other Tables	Other tables are updated or replaced with inputs from new characteristics and parameters generated in the site-specific studies completed in 2022 and 2023.
	Al Figures	Updated or replaced to reflect the new information resulted from several 2022 and 2023 assessments, investigations, and analyses
	Acronym List	Updated to include added acronyms

Revision #	Section Modified	Revision Summary
	Section 2.0	Chapters 7, 19 and 20 added to the list of key chapters, and edits involving details are made to previously listed chapters
	Section 2.1.1	Paragraphs added on Site Topography regarding the different grade elevations at and around the Darlington Nuclear site
	Section 2.1.1	Edited to incorporate information in Reference 2.1-7
	Section 2.1.2	Edited to reflect current contents of Chapter 9B, and to incorporate the information in the 2022 Environmental Impact Assessment in Reference 2.1-4
	Section 2.1.2.1	Edited to incorporate information in the 2022 References 2.1-4, 2.1-5, and 2.1-6
	Section 2.1.2.3	A new bullet added to reflect information on the heavy haul routes described in Reference 2.1-4
	Section 2.1.2.4	Added bullets number 6 And 7 regarding not using the cooling towers and combing the primary and secondary heat transport systems
	Section 2.1.10	Added seven new References 2.1-4 to 2.1-9
	Section 2.2.2	Added a paragraph on the 2022 DNNP Hazard Analysis Methodology (Reference 2.2-10)
	Section 2.2.3.2	Edited to incorporate information in the 2022 assessments reported in Reference 2.2-11 and Reference 2.2-12
	Section 2.2.5.2	Edited to incorporate information in the 2022 PNGS re-assessment documented in Reference 2.2-13
	Section 2.2.11	Three references added: 2.2-13, 2.2-14 and 2.2-15
	Section 2.4.2	Paragraphs added to reflect information in the 2022 EIS in Reference 2.4-2
	Section 2.4.3	Two references added: the 2022 Reference 2.4-2 and the 2009 Reference 2.4-3
	Section 2.5.2.1	Edited and updated to incorporate information in the 2022 Flood Hazard Assessment documented in Reference 2.5-18
	Section 2.5.3 and associated subsections	Edited and updated to incorporate information in the 2022 Reference 2.5-18, Reference 2.5-19
	Section 2.5.3.1	Deleted DNGS information that became irrelevant

Revision #	Section Modified	Revision Summary
	Section 2.5.3.3	A new Table 2.5-2 is added
	Section 2.5.3.4	Deleted DNGS information that became irrelevant and edited to incorporate information in the 2022 Reference 2.5-18
	Section 2.5.4	Edited and updated to incorporate information in the 2022 Reference 2.5-18 and the 2023 Climate Change Impact Strategy documented in Reference 2.5-20
	Section 2.5.5 and associated subsections	Edited and updated to incorporate information in the 2022 References 2.5-18 and 2.5-21
	Section 2.5.6 and associated subsections	Edited and updated to incorporate information in the 2022 Reference 2.5-18
	Section 2.5.7	Added four new References: 2.5-18 and 2.5-21
	Section 2.6.2	Edited and updated to incorporate information in the 2022 Flood Hazard Assessment in Reference 2.6-17
	Section 2.6-4	Edited and updated to incorporate information in the 2022 Reference 2.6-17
	Section 2.6-5	Edited and updated to incorporate information in the 2022 Wind Gust Analysis in Reference 2.6-14
	Section 2.6-5	Added new Table 2.6-3 and Table 2.6-4
	Section 2.6.9	Edited and updated to incorporate information in the 2022 Winter PMP Validation in (Reference 2.6-15)
	Section 2.6.9	Added new Table 2.6-7
	Section 2.6.12	Edited to incorporate information in the 2023 Climate Change Impact Strategy in Reference 2.6-19
	Section 2.6.13	Added six new References: 2.6-14, 2.6-15, 2.6-16 and 2.5-18
	Section 2.7	The entire Section 2.7 is re-configured to incorporate new information documented in: 1. The 2023 DNNP Foundation Interface Analysis (FIA) Report (Reference 2.7-38). 2. The 2022 DNNP geotechnical investigations and test results, Phase-1 Power Block (Reference 2.7-39) 3. The 2023 offshore geotechnical investigations (Reference 2.7-40)

Revision #	Section Modified	Revision Summary
		4. The 2022 DNNP-specific Probabilistic Seismic Hazard Assessment (PSHA) (Reference 2.7-41) 5. The 2022 DNNP seismically-induced soil liquefaction assessment (Reference 2.7-42) Added referencing to the 2022 and 2023 completed DNNP/BWRX-300 investigations, analyses, and assessments.
	Section 2.7.1	Deleted irrelevant DNGS information and outdated information
	Section 2.7.2.4	Added information based on the 2023 offshore investigations (Reference 2.7-40), and deleted outdated information
	Section 2.7.3.1	Updated relevant figures, and added information based on the 2022 BWRX-300 Power Block geotechnical investigations (Reference 2.7-39)
	Section 2.7.3.2	Edited and added new information, including Table 2.7-1, Table 2.7-2, and Table 2.7-3, documented in the results and figures from the 2022 Power Block geotechnical investigations (Reference 2.7-39)
	Section 2.7.3.3	Deleted outdated information, made edits, and added new information, per in the results and figures in the 2023 FIA Report (Reference 2.7-38), and the 2022 Power Block geotechnical investigations (Reference 2.7-39)
	Section 2.7.4.1	Introduced the 2022 DNNP PSHA (Reference 2.7-41)
	Section 2.7.4.3	Added information and updated relevant figures based on information in the 2022 PSHA (Reference 2.7-41)
	Section 2.7.4.4	Added information and updated relevant figures based on the 2022 PSHA (Reference 2.7-41)
	Section 2.7.4.6	• This subsection is currently dedicated to present the results of the work performed in the 2022 PSHA report (Reference2.7-41) Outdated information deleted
	Section 2.7.4.7	• Added information under "Surface Faulting" based on findings reported in the 2022 geotechnical investigations (Reference 2.7-39) • Added information on potential liquefaction based on the results reported in the 2022 Soil Liquefaction Assessment report (Reference

Revision #	Section Modified	Revision Summary
		2.7-42) and the 2022 PSHA (Reference 2.7-41) Added new figures
	Section 2.7.4.8	• This subsection is discontinued Previous information in Subsection 4.7.4.8 pf Revision 1 was merged into other Subsections of Section 2.7
	Section 2.7.5	• Added referencing to the 2022 NK054-REP-01210-00175 Phase I Geotechnical Investigations (Reference 2.7-39) and the 2023 DNNP FIA report (Reference 2.7-38) • Focus is on providing DNNP and BWRX-300 characteristics and parameters Information on “Bounding Design” is deleted as such information is detailed in Chapter 3, Section 3.3.1.1
	Section 2.7.5.1	New information added and updates made based on the 2023 FIA (Reference 2.7-38) and the 2022 DNNP Power Block geotechnical investigations (Reference 2.7-39);); including: • 2.7.5.1.2 Bearing Capacity Evaluation for Proposed Foundations • 2.7.5.1.3 Earth Pressure 2.7.5.1.4 Time-Dependent Deformation for Proposed Foundations
	Section 2.7.5.2 and associated Subsections	Outdated information deleted, new information added, and updates made based on the 2023 FIA (Reference 2.7-38) and the 2022 DNNP Power Block geotechnical investigations (Reference 2.7-39); including: • 2.7.5.2.1 Subgrade Profiles Stratigraphy • 2.7.5.2.2 Equivalent Linearized Static Properties of Soil and Engineered Fill Materials • 2.7.5.2.3 Equivalent Linearized Static Properties of Rock • 2.7.5.2.4 Dynamic Subgrade Properties • 2.7.5.2.5 Seismic Design Parameters 2.7.5.2.6 Groundwater Level
	Section 2.7.5.3	New information added and updates made based on the 2022 DNNP Power Block geotechnical investigations (Reference 2.7-39)

Revision #	Section Modified	Revision Summary
	Previous Section 2.7.5.4	Information in Revision 1, Subsection 2.7.5.4 titled “Site Response Analysis” is deleted, since it is covered in Chapter 3, Subsection 3.3.1.1.2
	Previous Section 2.7.5.5	Information in Revision 1, Subsection 2.7.5.5 titled “Design Response Spectra for BWRX-300 at DNNP Site” is deleted and replaced with new information in Subsection 2.7.5.2.5.1 on Ground Motion Spectra
	Previous Section 2.7.5.6	Information in Revision 1, Subsection 2.7.5.6 on “Strain-Compatible Subgrade Profiles for BWXR-300 at DNNP Site” is deleted and replaced with new information in Subsection 2.7.5.2.5.2 on Strain-Compatible Soil properties
	Section 2.7.6	• Due to the reconfiguration of Section 2.7, several references in Revision 1 are deleted since they are not referenced anymore in Revision 2. The previous identifying numbers of such Revision 1 references were 2.7-20, -22, -23, -27, -28, -29, -33, -38, -39, -40, -42, -43, -44, -45, -46, -47 New references added, from the current Reference 2.7-31 to Reference 2.7-43, inclusive
	Section 2.8	Added Bullet number 6 for and edited the text based on the information in the 2022 DNNP EIS (Reference 2.8-10)
	Section 2.8.7	Added (Reference 2.8-10) regarding the 2022 DNNP EIS
	Section 2.9	Added a new bullet for and edited the text based on the information in the 2022 DNNP EIS (Reference 2.9-16)
	Section 2.9.3	Added (Reference 2.9-16) regarding the 2022 DNNP EIS
	Section 2.10	Introduced and added Table 2.10-1 titled Summary of DNNP Site Relevant Characteristics and Parameters
	Section 2.11.3	Introduced the work completed on FIA (Reference 2.11-19) and the Geotechnical investigations in (Reference 2.11-20)

ACRONYM LIST

Acronym	Explanation
3D	Three-Dimensional
AOO	Anticipated Operational Occurrence
BDBA	Beyond Design Basis Accident
BDBE	Beyond Design Basis Earthquake
BL-AOO	Baseline Abnormal Operational Occurrence
BWR	Boiling Water Reactor
BWRX-300	Boiling Water Reactor, 10^{th} Design – 300 MWe
CANDU	CANada Deuterium Uranium
CAV	Cumulative Absolute Velocity
CB	Control Building
CEUS	Central Eastern United States
CGD	Canadian Geodetic Datum
CNEP	Consolidated Nuclear Response Plan
CNSC	Canadian Nuclear Safety Commission
CWS	Circulating Water System
DBA	Design Basis Accident
DBE	Design Basis Earthquake
DEC	Design Extension Condition
D-in-D	Defence-in-Depth
DNGS	Darlington Nuclear Generating Station
DNNP	Darlington New Nuclear Project
DRL	Derived Release Limit
DSA	Deterministic Safety Analysis
DWMF	Darlington Waste Management Facility
EA	Environmental Assessment
EIS	Environmental Impact Statement
EME	Emergency Mitigating Equipment
EMP	Environmental Monitoring Program
EPRI	Electric Power Research Institute
ERA	Environmental Risk Assessment
FHA	Fire Hazards Assessment

Acronym	Explanation
FIA	Foundation Interface Analysis
FPC	Fuel Pool Cooling and Cleanup System
HCSC	Hazard-Consistent, Strain-Compatible
HU	Hydrostratigraphic Unit
HVAC	Heating, Ventilation, and Air Conditioning
IAEA	International Atomic Energy Agency
IC	Isolation Condenser
ICC	ICS Pool Cooling and Cleanup System
ICS	Isolation Condenser System
INPO	Institute of Nuclear Power Operations
LOCA	Loss-of-Coolant Accident
LOPP	Loss-of-Preferred Power
LTC	Licence to Construct
MCA	Main Condenser and Auxiliaries
MCR	Main Control Room
NHS	Normal Heat Sink
NSCA	Nuclear Safety and Control Act
OPG	Ontario Power Generation
PCW	Plant Cooling Water System
PEOC	Provincial Emergency Operations Centre
PIE	Postulated Initiating Event
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
PNERP	Provincial Nuclear Emergency Response Plan
PNGS	Pickering Nuclear Generating Station
POSAR	Pre-Operational Safety Analysis Report
PPE	Plant Parameter Envelope
PSA	Probabilistic Safety Assessment
PSHA	Probabilistic Seismic Hazard Assessment
RB	Reactor Building
RPV	Reactor Pressure Vessel
RWB	Radwaste Building

Acronym	Explanation
SA	Severe Accident
SAA	Severe Accident Analysis
SAM	Severe Accident Management
SAMG	Severe Accident Management Guideline
SCR	Secondary Control Room
SMR	Small Modular Reactor
SPT	Standard Penetration Test
SRA	Site Response Analysis
SSI	Soil-Structure Interaction
SSC	Structures, Systems, and Components
TB	Turbine Building
TLD	Thermoluminescent Dosimeter
UCS	Uniaxial Compression Stress
UHRS	Uniform Hazard Response Spectrum
USNRC	United States Nuclear Regulatory Commission
WPCP	Water Pollution Control Plant

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

2.0 SITE CHARACTERISTICS

Information in Chapter 2 details the site characteristics and their evaluation in support for the design, safety assessment and periodic safety review (Reference 2.0-4) of the Boiling Water Reactor, 10th Design – 300 MWe (BWRX-300) facility (also known as BWRX-300 facility). Over the planned design life (refer to Chapter 1, Table 1.5-1) of the BWRX-300 facility, the information in Chapter 2 will periodically be updated (Reference 2.0-4) to risk-inform the evaluation and implications of any such updates on safety.

Chapter 2 includes the following characteristics of Ontario Power Generation's (OPG) Darlington New Nuclear Project (DNNP) site and the surrounding region:

- Geography and Demography (Section 2.1)
- Evaluation of Site-specific Hazards (Section 2.2)
- Proximity of Industrial, Transportation and Other Facilities (Section 2.3)
- Plant Site Activities Influencing Plant Safety (Section 2.4)
- Hydrology (Section 2.5)
- Meteorology (Section 2.6)
- Geology, Seismology, and Geotechnical Engineering (Section 2.7)
- Potential Effects of Nuclear Power Plants in the Region (Section 2.8)
- Radiological Conditions due to External Sources (Section 2.9)
- Site-related Issues in Emergency Preparedness and Response, and Accident Management (Section 2.10)
- Monitoring of Site-related Parameters (Section 2.11)

Chapter 2 also includes Section 2.12 which describes OPG's disposition plans to finalize remaining DNNP site-specific characterization work including, for example, Foundation Interface Analysis (FIA), confirmatory site geological and seismic hazard investigations, and climate change effects on-site hydrological and meteorological parameters.

The following key chapters should be referred for additional information relevant to the material reported in Chapter 2:

1. Chapter 1: Introduction and General Considerations

   Information in Chapter 1, Sections 1.4 and 1.5 describes the DNNP site layout, as well as the BWRX-300 facility footprint, key parameters, and basic dimensions of key buildings in the Power Block.

2. Chapter 3: Safety Objectives and Design Rules for Structures, Systems, and Components

   Chapter 3, Section 3.3 includes information on the BWRX-300 design approach to prevent and mitigate the effect of external hazard on safety-classified structures, systems, and components (SSCs). Also, Chapter 3, Subsection 3.5.5.2 describes the design loads and load combinations on the deeply embedded Reactor Building (RB) structure.

3. Chapter 6: Engineered Safety Features

Information is provided in Chapter 6, Section 6.2 on the design of the Isolation Condenser System; and in Section 6.4 on the BWRX-300 control room habitability features including missile protection, radiation shielding, radiation monitoring, air filtration and ventilation systems, lighting, and fire protection.

4. Chapter 7: Instrumentation and Control

Measures for fire protection and qualification for electromagnetic compatibility are described in Chapter 7.

5. Chapter 9A: Auxiliary Systems

Chapter 9A presents information on the BWR-X-300 fuel storage and handling system in Subsection 9A1.2, Fuel Pool Cooling and Cleanup System (FPC) in Subsection 9A1.3, Plant Cooling Water System (PCW) in Subsection 9A.2.1, Normal Heat Sink (NHS) in Subsection 9A.2.5, Isolation Condenser System Pool Cooling and Cleanup System (ICC) in Subsection 9A.2.6, Heating, Ventilation, and Air Conditioning (HVAC) Systems in Section 9A.5, Fire Protection Systems, in Section 9A.6.

6. Chapter 9B: Civil Engineering Works and Structures

General design requirement information is provided in Chapter 9B, Section 9B.2 on the integrated RB, and Section 9B.3 on other structures including other buildings in the Power Block, the Pumphouse/Forebay as well as the intake and discharge tunnels.

7. Chapter 10: Steam and Power Conversion Systems

In Chapter 10, information related to equipment functions, design basis, operation, and maintenance is presented in Section 10.5 for the Main Condenser and Auxiliaries (MCA) system, and in Section 10.8 for the Circulating Water System (CWS).

8. Chapter 15: Safety Analysis

Chapter 15, Subsection 15.5.3 documents the Deterministic Safety Analysis (DSA) of bounding Baseline Abnormal Operational Occurrences (BL-AOOs), while 15.5.4 evaluates the bounding BWRX-300 Design Basis Accidents (DBAs) involving Loss-of-Coolant Accidents (LOCA) and non-LOCA. Also, Subsections 15.5.5 and 15.5.6 present analyses of Design Extension Conditions (DECs) with and without core damage, respectively. Furthermore, Subsection 15.6.1 described the general approach to the Probabilistic Safety Analysis (PSA) while Section 15.7 includes results of analyzed DSA and PSA bounding events. Finally, Appendix 15A demonstrates implementing Defence-in-Depth (D-in-D) provisions ensures protection against unacceptable radiation releases

9. Chapter 19: Emergency Preparedness and Response

The development of the DNNP nuclear emergency response plan is presented in Section 19.1, the emergency response facilities are described in Section 19.2, and the accident assessment techniques are detailed in Section 19.3.

10. Chapter 20: Environmental Aspects

Chapter 20 describes OPG’s Environmental Monitoring Program in Subsection 20.11.2, Effluent Monitoring Program in Subsection 20.11.3, and Groundwater Monitoring Program in Subsection 20.11.4.

11. BWRX-300 Security Annex

The prescribed information in the Security Annex documents the analysis of a large commercial aircraft crash.

Scope

Chapter 2 scope includes the establishment of site characteristics that comprise information such as:

1. The site location, the area under control of OPG, and the area surrounding the DNNP site including activities which impact BWRX-300 facility operation, population distribution and density (Section 2.1), and the locations and transport routes that present potential risk for the facility (Section 2.3).
2. The site-specific external hazard evaluation (Section 2.2) for events of natural and human-induced origin during the planned lifetime of the facility, and any process or activity at the site that affects the operation of the facility (Section 2.4).
3. The collection of DNNP site-specific baseline data such as hydrological (Section 2.5); meteorological (Section 2.6); as well as geological, seismological, geotechnical (Section 2.7) information.
4. The description of the site and the surrounding environment (Sections 2.8), and of external sources related to the dispersion of radioactive material in air, water, and soil (Section 2.9).
5. The feasibility of emergency preparedness as related to accessibility and transport of any pertinent equipment to the DNNP site and the BWRX-300 facility (Section 2.10).
6. The arrangements for monitoring site-related parameters (Section 2.11) throughout the lifetime of the facility.

Relevant Legislations and Regulations

The following provisions of the Nuclear Safety and Control Act (Reference 2.0-1), the General Nuclear Safety and Control Regulations (Reference 2.0-2) and the Class I Nuclear Facilities Regulations (Reference 2.0-3) are relevant to Chapter 2.

- Subsection 44(1) of the NSCA (Reference 2.0-1) states that “[t]he Commission may, with approval of the Governor in Council, make regulations.

  (e) Respecting the location, design, construction, installation, operation, maintenance, modification, decommissioning, abandonment and disposal of a nuclear facility or part of a nuclear facility.

  (o) Establishing requirements to be complied with by any person who possesses, uses, packages, transports, stores, or disposes of a nuclear substance or prescribed equipment or who locates, designs, constructs, installs, operates, maintains, modifies, decommissions, or abandons a nuclear facility or nuclear-powered vehicle.

- Section 3 of the Class I Nuclear Facilities Regulations (Reference 2.0-3) states that “[a]n application for a licence in respect of a Class I nuclear facility, other than a licence to abandon, shall contain the following information in addition to the information required by Section 3 of the General Nuclear Safety and Control Regulations (Reference 2.0-2):

  a. A description of the site of the activity to be licensed, including the location of any exclusion zone and any structures within that zone
  b. Plans showing the location, perimeter, areas, structures, and systems of the nuclear facility
  c. Proposed management system for the activity to be licensed, including measures to promote and support safety culture

d. Name, form, characteristics, and quantity of any hazardous substances that may be on the site while the activity to be licensed is carried on

e. Proposed worker health and safety policies and procedures

f. Proposed environmental protection policies and procedures

g. Proposed effluent and environmental monitoring programs

- Section 5 of the Class I Nuclear Facilities Regulations (Reference 2.0-3) states that: “[a]n application for a licence to construct a Class I nuclear facility shall contain the following information in addition to the information required by Section 3:

  a. Description of the proposed design of the nuclear facility, including the manner in which the physical and environmental characteristics of the site are considered in the design

  b. Description of the environmental baseline characteristics of the site and the surrounding area

  c. Effects on the environment and the health and safety of persons that may result from the construction, operation and decommissioning of the nuclear facility, and the measures that will be taken to prevent or mitigate those effects

  d. Proposed location of points of release, the proposed maximum quantities and concentrations, and the anticipated volume and flow rate of releases of nuclear substances and hazardous substances into the environment, including their physical, chemical, and radiological characteristics

References

2.0-1 Government of Canada, “Nuclear Safety and Control Act (S.C. 1997, c. 9).”

2.0-2 Government of Canada SOR/2000-202, “General Nuclear Safety and Control Regulations.”

2.0-3 Government of Canada SOR/2000-204, “Class I Nuclear Facilities Regulations.”

2.0-4 CNSC Regulatory Document REDGOC-2.3.3, “Operating Performance - Periodic Safety Reviews.”

2.1 Geography and Demography

Section 2.1 details the geographical and demographical baseline characteristics of the DNNP site and the surrounding regions. It contains the following information:

- Darlington Nuclear site context and surrounding land uses - Subsection 2.1.1
- BWRX-300 facility layout and the exclusion zone - Subsection 2.1.2
- Population distribution and density - Subsection 2.1.3
- Municipal services - Subsection 2.1.4
- Site access and transportation networks - Subsection 2.1.5
- Public transit – Subsection 2.1.6
- Active hiking and cycling trails - Subsection 2.1.7
- Parks spaces and waterbodies - Subsection 2.1.8
- Industrial facilities - Subsection 2.1.9

Table 2.1-1 lists key geographic and demographic characteristics and parameters within a 10-km survey area surrounding the Darlington Nuclear site.

Table 2.1-1: Site Layout, Geographic, and Demographic Characteristics and Parameters

Characteristic	Value/Description	
Land Size	Darlington Nuclear site	Approximately 4.9 km^2
	DNNP	Approximately 1.8 km^2
	DNGS	Approximately 3.1 km^2
Exclusion Zone	BWRX-300	350 m (radius) from the RB outside wall
	DNGS	914 m
Topography	• Current parking and storage areas east of the DWMF is at approximately 88 m (Canadian Geodetic Datum of 1928 (CGVD28), or simply CGD)) • Further east, the terrain rises to 102 m CGD close to the Darlington Creek watershed • Extreme berm of elevation from 100 to 110 characterize the north boundary of the southern portion of the site to the railway tracks The northern portion of the site is bounded the north by Energy Road and to the south by the Railway tracks • East of Holt Road, the terrain peaks at 120 m CGD and slopes down to the east to roughly 86 m CGD	
Grade Elevation	Plant (BWRX-300 Facility)	88 m CGD (Refer to Subsection 2.7.1)
Population Distribution and Density (2021), for the Municipality of Clarington	Courtice	28,545
	Bowmanville	47,176
	Orono	2,476
	Newcastle	11,933
	Total	90,130
Municipal Service within the 10-km Survey area	Fire Emergency Stations	6 (Excluding DNGS site fire station)
	Regional Police Station	One (plus one administrative police department)
	Hospitals	One (Lakeridge Health in Bowmanville)
Directly Adjacent Industrial Facilities	East	St. Marys Cement Group
	West	• Darlington Nuclear Energy Complex • CoPart, Vehicle Auction Facility • Covanta Durham York Energy Centre • Courtice Water Pollution Control Plant (WPCP) • East Penn, Batteries warehouse facility • Future Anaerobic Digester facility
Transportation network within 10 km	Highways	401, 407, 418
	Railways lines	• Canadian National, south of Highway 401 and bisects the site • Canadian Pacific, north of Highway 401
	Airports	Oshawa Executive Airport
	Naval Ports	Port of Oshawa East Pier

Characteristic	Value/Description	
	Private Dock	Private dock on St. Marys facility
Public Transit	Bus (902A King bus line)	One stop at Old Holt Road and King Street
	Transit-on-demand	Request pick up to nearest transit stop
	Rural-on-demand	Request pick up at current location
	88 GO Bus	Multiple stops along Bowmanville Avenue and King Street
	GO Transit's Lakeshore East Rail Service (planned for operation in 2026)	Courtice GO Station
		Bowmanville GO Station
Hiking and Cycling Trails	Darlington Waterfront Trail	Pedestrian and cyclists trail
Parks Spaces and Waterbodies (Note: A complete list is provided in Appendix C)	Provincial Parks	One – Darlington Provincial Park
	Recreational Facilities	Darlington Hydro Soccer Field and Bowmanville Baseball Fields
	Conservation Areas	Five in Bowmanville and two in Oshawa
	Beaches	Three – Two in Bowmanville and one in Oshawa
Industrial Facilities within 10 km	• Directly adjacent industrial facilities, refer to Subsection 2.1.1 • A complete list of industrial facilities falling within the surveyed area is found in Appendix A. • Pickering Nuclear Generating Station, about 25 km west of DNNP	

2.1.1 Darlington Nuclear Site Context and Surrounding Land Uses

Site Topography

The Darlington Nuclear site topography is briefly described in Subsection 2.7.1. The 2022 Flood Hazard Assessment NK054-REP-02730-00001 (Reference 2.1-9) provides in this Subsection 2.1.1 additional information on the site topography including key detailed terrain elevations, as briefly recapped in the following paragraph.

The Darlington Nuclear site is situated in an undulating to moderately rolling limestone till plain, although its natural contours have been extensively graded. The existing 4-unit Darlington Nuclear Generating Station (DNGS) is located at elevation of about 78 m CGD. This is the lowest elevation area of the southern portion of the Darlington Nuclear site. From this location, the site slopes upward to the northwest, north and east. To the east, the terrain steadily slopes upward along the Lake Ontario shoreline, forming a bluff. The DNNP site, currently a parking and storage area southeast of the Darlington Waste Management Facility (DWMF), is just north of shoreline bluff, at approximately 88 m CGD. Farther east, the terrain rises to elevation 102 m CGD at the boundary of the Darlington Creek watershed before sloping down to its main branch near the eastern boundary of the site. The north boundary of the southern portion of the Darlington Nuclear site is characterized by an extensive berm that ranges in elevation from 100 m CGD to 110 m CGD and separates the southern portion of the site from the transecting Canadian National Railway tracks. The northern portion of the site is bounded to the north by Energy Drive and to the south by the Canadian National Railway tracks. Between Crago Road and Park Road, there is a large ridge rising to 132 m CGD. Between Park Road and Holt Road, the terrain ranges from 98 m to 130 m CGD. East of Holt Road, the DNNP terrain peaks at 120 m CGD and slopes downward to the east to roughly 86 m CGD.

Area and Bounding Roads

The Darlington Nuclear site is approximately 4.9 km^2 in size and located within the Municipality of Clarington, Regional Municipality of Durham, Province of Ontario, Canada. OPG also owns and operates the eight-unit Pickering Nuclear Generating Station (PNGS) (refer to Subsection 2.2.5.2) within the City of Pickering which is located approximately 25 km to the west of the Darlington Nuclear site, as shown in Figure 2.1.1-1.

The Darlington Nuclear site encompasses both the DNGS and the DNNP lands as shown in Figure 2.1.1-2. The Darlington Nuclear site is bounded by Crago Road to the west, Energy Drive to the north, St. Marys Cement to the east and Lake Ontario to the south. The existing DNGS site is approximately 3.1 km^2 in size and is located west of Holt Road on the western portion of the Darlington Nuclear site, whereas the DNNP land of approximately 1.8 km^2 is located east of Holt Road. Figure 2.1.1-2 shows also the 914-meter DNGS exclusion zone, which partly overlaps the location where the BWRX-300 first unit is to be built in the southwestern corner of the DNNP site as shown in Chapter 1, Figure A1.1-2.

Industrial Facilities

The major industrial facilities in the vicinity of the Darlington Nuclear site, as shown in Figure 2.1.1-3, include:

1. St. Marys Cement Group which is located directly east of the DNNP site on Bowmanville Avenue, and is an active quarry for resources servicing the aggregate and concrete industry
2. The lands designated as Clarington Energy Business Park which is located directly west of the DNGS and includes:

   a. Covanta Durham York Energy Centre which manages household waste from the regions of Durham and York
   b. OPG's Darlington Energy Complex, an approximately 27,900 m^2 multi-use building that provides offices and services supporting the Darlington Refurbishment project
   c. CoPart, a vehicle auction and recycling facility
   d. East Penn, a warehousing facility for batteries
   e. Courtice Water Pollution Control Plant (WPCP), a wastewater treatment facility commissioned in late 2007, with an average day rated capacity of 68.2 million liters per day with a peak flow capacity of 180 million liters per day (Reference 2.1-7)
   f. Planned location for a project that is being evaluated involving an Anaerobic Digester facility (Reference 2.1-7) to treat raw sludge collected form Courtice WPCP
3. OWASCO RV, which is a recreational vehicle sale and service centre, located north of Highway 401

There are some industrial developments in the Courtice Employment Area located northwest of the Darlington Nuclear site, including warehousing and automobile dealerships. All of the industrial facilities falling within the surveyed area are listed in Appendix A.

Developmental Activities

OPG actively reviews planning applications in the Municipality of Clarington to monitor sensitive land use developments within 3 km of the DNGS and DNNP facilities. Additionally, OPG reviews planning applications within 10 km of the Darlington Nuclear site in the Municipality of Clarington and the City of Oshawa. These applications include official plan amendments, zoning by-law amendments, draft plans of subdivision and condominium, and other miscellaneous planning related documents.

OPG completes an annual development activity report detailing all proposed developments in the municipalities of Clarington and Oshawa within 10 km of the Darlington Nuclear site. In such a report, OPG reviews the:

a. Type and location of proposed application
b. Date on which the application was submitted
c. Details of the proposed application
d. Status of the application

Urban Communities and Rural Areas

The urban communities of Oshawa and Courtice are located northwest of the Darlington Nuclear site, while the urban community of Bowmanville is located to the northeast of the DNNP site. A rural area separating the Clarington urban areas of Courtice and Bowmanville is located immediately north of the DNNP site. The community of Newcastle is also located east of the DNNP site within the survey area; albeit only a portion is included in the survey area. For the purposes of Section 2.1 and Section 2.3, the geographic limits defined for the survey area are approximately 10 km from the site and include Taunton Road to the north, Simcoe Street to the west, an approximate border of Darlington Clarke Townline Road to the east, and Lake Ontario to the south (refer to Figure 2.1.1-4).

Land Use Assessment for Environmental Effects

The 10 km survey area is consistent with the Land Use Assessment Zone, which was the furthest distance that measurable effects on planned land use structure as well as impacts on sensitive land uses are identified in the proximity to the Darlington Nuclear site. The Land Use Assessment of Environmental Effects Technical Support Document completed in 2009 identified the Regional Study Area as being approximately 50 km from the Darlington Nuclear site as shown in Figure 2.1.1-4. The DNNP Land Use Environmental Assessment Follow-Up Monitoring Plan / Methodology Report was developed in 2022 NK054-CORR-00531-10635 (Reference 2.1-3) to fulfill the requirement of OPG Commitment D-P-12.7 in the 2021 NK054-REP-01210-00078 (Reference 2.1-2). As per the 2022 NK054-CORR-00531-10635 (Reference 2.1-3), OPG will continue to monitor planning development in land use in proximity to the DNNP site, and regularly consult with the Municipality of Clarington, City of Oshawa and the Regional Municipality of Durham on proposed land use changes. The effects on implementation of emergency plans will be investigated throughout the site preparation and construction phases.

2.1.2 BWRX-300 Facility Layout and Exclusion Zone

The layouts of the DNNP site and BWRX-300 Unit 1 as well as associated infrastructures are described in Chapter 1, Section 1.4, and Section 1.5 satisfy the regulatory requirements of Sections 4.5.4 and 4.5.5 of REGDOC-1.1.2 (Reference 2.1-1). The selected location, in the southwestern corner of the DNNP area, limits the amount of spoilage to remove and avoids encroachment on the Bank Swallow habitat. This location is also in proximity to DNGS ensuring effective connections to DNGS available infrastructure. The DNNP site also incorporates considerations that support a total of four BWRX-300 units, as conceptually shown in Figure 5 of the 2022 DNNP BWRX-300 Environmental Impact Statement (EIS) NK054-REP-07730-00055 (Reference 2.1-4).

The deployment of the BWRX-300 facility does not require expanding the DNGS switchyard. Rather, a new 230 kV switchyard is to be located East of the Extended Holt Rd and South of the Canadian National Railway tracks, adjacent to the BWRX-300 facility buildings, as shown in Chapter 1, Figure A1.1-2 and Figure A1.4-2 for one unit and conceptually shown in Figure 7 of the 2022 NK054-REP-07730-00055 (Reference 2.1-4) for four units.

Existing roads are being used to the maximum extent practicable and no new off-site roadways are required.

The Pumphouse/Forebay structure is positioned outside the northwestern corner of the protected area. As described in Chapter 9B, Subsection 9B.3.5.2, onshore vertical shafts are designed to facilitate the operation of up to four BWRX-300 units and the construction of the intake and discharge tunnels. The intake tunnel conveys cooling water from the lakebed intake structure to the onshore intake vertical shaft. The discharge tunnel conveys the discharge water from the onshore discharge vertical shaft to the discharge tunnel and diffusers. The discharge structure is located near the lakeshore and does not require lake infill.

2.1.2.1 Required Exclusion Zones

The exclusion zone is established at 350 m from the RB outside wall. For the BWRX-300 first unit, the exclusion zone partly overlaps the eastern portion of the DNGS site, as shown in Chapter 1, Figure A1.1-2. The exclusion zone of 350 m for the conceptual layout of four units shown in Figure 5 of the 2022 NK054-REP-07730-00055 (Reference 2.1-4) is within the DNNP eastern boundary with St. Mays Cement industrial facility.

The rationale for determining the exclusion zone is discussed in Section 8 of the 2022 NK054-REP-01210-00142 (Reference 2.1-5), and considers the security requirements, evacuation needs, land usage needs, and environmental conditions, in accordance with Section 6.5 of REGDOC-2.5.2 (Reference 2.1-8). Note the BWRX-300 Small Modular Reactor (SMR) is built within the DNNP site boundary with a smaller footprint of approximately 9,800 m^2, per the 2022 NK054-REP-01210-00142 (Reference 2.1-5), compared with the original application involving much larger nuclear power plants, per the 2010 NK054-REP-01200-10000 (Reference 2.1-6).

Chapter 15, Section 15.7 includes tabulated summaries listing the DSA results for bounding BWRX-300 AOO and DBA event sequences. Also, Chapter 15, Appendix 15A demonstrates implementation of the D-in-D provisions ensures protection against unacceptable radiation releases. Chapter 15, Section 15.7 thus concludes all BWRX-300 analyzed bounding AOOs, DBAs or DECs without core damage have met the dose acceptance criteria for the 350 m exclusion zone.

2.1.2.2 Security Requirements

The security requirements for the DNNP site and the BWRX-300 facility and how such security requirements are met are described in the Security Annex, which is an OPG Confidential Protected Security document.

2.1.2.3 Description of Site Layout

The high-level description of the DNNP site layout includes:

- The Power Block that encompasses several buildings and a plant services area (refer to Chapter 1, Figure A1.5-1)
- Locations of the site vehicle entrance (sally port) as well as roads to allow access of trucks and individuals to Power Block buildings, with the Protected Area Access Building located west of the sally port (refer to Chapter 1, Figure A1.4-1)
- Locations of the irradiated fuel dry storage (which is regulated under a separate licence), Pumphouse/Forebay, intake shaft and tunnel, discharge structure and tunnel, and switchyard and transmission lines (refer to Chapter 1, Figure A1.1-2)
- Heavy haul routes for the construction phase of Unit 1 as shown in Chapter 1, Figure A1.1-2, and for the construction phases of Units 2, 3, and 4, as shown in Figure 5 of the 2022 EIA (Reference 2.1-4).

2.1.2.4 Minimizing Environmental Impacts

Measures are included in the DNNP site layout and BWRX-300 design to minimize the impact on the surrounding region and the environment, per the 2022 NK054-REP-07730-00055 (Reference 2.1-4), for example:

1. The location and placement of the lakebed intake structure regarding the commitment for fish entrainment and impingement as well as the discharge diffusers to meet the commitment for effluent plume in the 2021 NK054-REP-01210-00078 (Reference 2.1-2)
2. Consideration of sensitive land features, such as shoreline bluffs and Bank Swallows, habitat to the extent practicable
3. A smaller BWRX-300 footprint which does not need any additional land area that could be obtained from lake infill
4. Designing into the site storm water management provisions for the construction and post construction phases

5. Minimizing the area of disturbance for permanent structures as well as the areas for spoils on the DNNP site by optimizing the BWRX-300 footprint
6. Cooling towers are not used for the BWRX-300 for either the normal or ultimate heat sinks, per Table 3 of the 2022 EIS NK054-REP-07730-00055 (Reference 2.1-4); thus, the adverse effects associated with cooling towers (e.g., effects on the visual landscape and socio-economic conditions) are not applicable
7. The primary and secondary heat transport systems are combined, and use is made of natural circulation and passive safety systems resulting in an optimized size of the facility and contributing to lowering the risk of normal and abnormal operating conditions

2.1.3 Population Distribution and Density

The Municipality of Clarington and the City of Oshawa have both experienced steady growth over the last ten years.

According to recently released Statistics Canada data, Clarington's population was 101,427 in 2021, which is an increase of 10.2% from that in 2016 when the population was recorded at 92,130. The rural area of Clarington had a population of 11,297 in 2021. The Municipality of Clarington Official Plan forecasts that Clarington will have a population of 140,340 by 2031, with 124,685 in its urban areas and 15,655 in its rural areas. The 2021 population data listed in Table 2.1-2 for the Municipality of Clarington is distributed amongst four urban areas including Courtice, Bowmanville, Orono, and Newcastle as shown in Figure 2.1.3-1.

Table 2.1-2: Population Data for the Municipality of Clarington for 2021

Urban Area	Population
Courtice	28,545
Bowmanville	47,176
Orono	2,476
Newcastle	11,933
Total	90,130

The population of the City of Oshawa was 149,607 in 2011 and grew to 159,458 in 2016, which was a 6.6% increase. The City of Oshawa's Official Plan provides population forecasts of 174, 695 in 2021, 184,460 in 2026 and 197,000 in 2031.

Refer to Subsection 2.8.4 for detailed 2016 population data that is broken into sectors by distance and direction for use in air dispersion modeling within a 30 km radius of the Darlington Nuclear site.

2.1.4 Municipal Services

Within the 10 km survey area, there are 17 education institutions available for students: 12 primary schools and five secondary schools. As well, there are six fire emergency stations (excluding OPG's on-site Darlington fire station) and one regional police station (plus one administrative police department). Additionally, there is one hospital - Lakeridge Health in Bowmanville.

2.1.5 Site Access and Transportation Networks

The Darlington Nuclear site can be accessed via two roads. Holt Road runs north to south and allows for direct access to the site. Energy Drive runs west to east and connects to Park Road for access to the site. Multiple parking lots are present on the site.

Within 10 km of the site, there are many arterial roads, minor arterial roads, highways, residential roads, and rural roads. These roads fall within the borders of the 10 km survey area defined in Subsection 2.1.1. A complete list of roads falling within the surveyed area can be found in Appendix B.

Transportation networks of significance are listed in the following:

1. Three 400-series highways are located within 10 km of the site - Highways 401, 407, and 418 (refer to Subsection 2.3.1(b) for supplementary information on Highway 401).
2. Two railway lines are located within 10 km of the site which converge and run adjacent to one another east of Lakeshore Road, Newcastle:
    a. The Canadian Pacific line runs west east, which is located just north of Highway 401, and is used for trains transporting cargo.
    b. The Canadian National line runs west east, which is located south of Highway 401 and used for trains transporting people and cargo, and part of which bisects the DNNP and DNGS sites (refer to Subsection 2.3.1 for further information, and Subsection 2.2.3.2(a) for hazards related to potential railway accidents).
3. Oshawa Executive Airport is located at the southeast corner of Taunton Road and Thornton Road North. The airport is located just outside the 10 km survey area (refer to Subsection 2.3.1(c) for additional information).
4. The Port of Oshawa East Pier (at the bottom of Simcoe Street South) is located west of the site and allows cargo ships to receive/deliver shipments.
5. St. Marys Cement has a private dock at its facility to the east of the DNNP site for the shipment of aggregate from its operations.

2.1.6 Public Transit

The closest regional transit stop to the site is located at Old Holt Road and King Street, approximately 5 km north of the site. The stop is part of the 902A King bus line offered by Durham Regional Transit and runs west east through the Durham Region. Additionally, the region introduced two types of on-demand transportation services in the Durham Transportation Master Plan (2017): transit on-demand and rural on-demand. Transit on-demand allows riders to request a ride with pickup located at their nearest transit stop, while rural on-demand allows riders to request a ride with pickup at their current location. The region also has a park and ride station within the survey area located at Courtice Road north of Highway 401.

The closest transit stop to the site is a GO Bus stop located at Bowmanville Avenue and Baseline Road. The stop is part of the 88 GO Bus Route that is running from Oshawa to Peterborough with multiple bus stops located north of the site along Bowmanville Avenue and King Street. Additionally, there are two proposed GO Transit stations within the survey area. GO Transit's Lakeshore East Rail Service will operate on the Canadian Pacific rail line north of Highway 401, which will include service to the two proposed stations: Courtice GO (Courtice Road north of Baseline Road) and Bowmanville GO (Bowmanville Avenue north of Aspen Spring Drive). Per correspondence with Durham Region staff, the Courtice and Bowmanville GO stations are projected to be operational in 2026. Furthermore, two secondary plans are currently being developed for the areas adjacent for each proposed GO station.

2.1.7 Active Hiking and Cycling Trails

As shown in Figure 2.1.8-1, the Darlington Waterfront Trail, part of the Great Lakes Waterfront Trail, is a multi-use path that forms part of the recently approved Durham Regional Cycling Plan. The trail is used by pedestrians and cyclists for transportation or recreational purposes, provides direct access to the Darlington Nuclear site and falls within OPG owned lands. Additionally, hiking trails are available near Lakeview Park in Oshawa, as the Larry Ladd Harbour Trail connects to Lakeview Beach. The Primary Cycling Network Durham currently provides over 400 km of cycling infrastructure in the region.

2.1.8 Park Spaces and Waterbodies

There is abundance of parks, greenspaces, conservation areas, and waterbodies located within the 10 km survey area, with multiple public recreational spaces directly adjacent to Darlington Nuclear site. As detailed in Subsection in 2.1.7, part of the Darlington Waterfront Trail runs through the Darlington Nuclear site. Directly adjacent to the west of the DNGS site is Alijco Beach, a beachfront which can be accessed by users for recreational purposes. Other park spaces and waterbodies are dispersed throughout the rest of the survey area, with places of significance listed below:

1. One provincial park falls within the survey area - Darlington Provincial Park.
2. The Darlington Hydro Soccer Fields facility (owned by OPG and licensed to the Municipality of Clarington) falls within the survey area, as does Bowmanville’s Baseball Fields Complex (located at Green Road just north of Highway 401).
3. Five conservation areas fall within the survey area: three are located in Bowmanville (Bowmanville Valley Conservation Area, Bowmanville Westside Conservation Area, Stephen Gulch’s Conservation Area) and two are located in Oshawa (Harmony Valley Conservation Area, Oshawa Valleylands Conservation Area).
4. Three beaches fall within the survey area: two are located in Bowmanville (Alijco Beach, Port Darlington Beach) and one is located in Oshawa (Lakeview Beach).

A complete list of park spaces and water bodies falling within the surveyed area can be found in Appendix C.

2.1.9 Industrial Facilities

The industrial facilities that are within the survey area of 10 km and directly adjacent to Darlington Nuclear site are discussed in Subsection 2.1.1.

Other industrial facilities are dispersed throughout the rest of the survey area, with most facilities located west of the site in Oshawa. A complete list of industrial facilities falling within the surveyed area is found in Appendix A.

While not located in the survey area, the PNGS is located approximately 25 km west of the Darlington Nuclear site (refer to Subsection 2.1.1 and Subsection 2.2.5.2).

2.1.10 References

2.1-1 CNSC Regulatory Document REGDOC-1.1.2, “Licence Application Guide: Licence to Construct a Reactor Facility.”

2.1-2 NK054-REP-01210-00078 R007, 2021, "Darlington New Nuclear Project Commitments Report," Ontario Power Generation.

2.1-3 NK054-CORR-00531-10635, 2022, "DNNP: Submission of Environmental Assessment Follow-Up Monitoring Plans / Methodology Reports and Request for Acceptance and Closure of Their Respective Commitments under D-P-12," Ontario Power Generation.

2.1-4 NK054-REP-07730-00055-R000, 2022, "Darlington New Nuclear Project Environmental Impact Statement Review Report for Small Modular Reactor BWRX-300," Ontario Power Generation.

2.1-5 NK054-REP-01210-00142-R000, 2022, "Darlington New Nuclear Project – Site Evaluation Update Summary Report," Ontario Power Generation.

2.1-6 NK054-REP-01200-10000 R005, 2010, "Use of Plant Parameters Envelope to Encompass the Reactor Designs being considered for the Darlington Site," Ontario Power Generation.

2.1-7 Durham Region, "Courtice Water Pollution Control Plant - 2021 Annual Performance Report."

2.1-8 CNSC Regulatory Document REGDOC-2.5.2, Version 1.0, "Design of Reactor Facilities: Nuclear Power Plants."

2.1-9 NK054-REP-02730-00001, 2022, "Flood Hazard Assessment," Ontario Power Generation.

Figure 2.1.1-1: Darlington Nuclear Site Proximity to Pickering Nuclear Generating Station

Figure 2.1.1-2: Darlington Nuclear Generation Station and Darlington New Nuclear Project Lands

Figure 2.1.1-3: Darling Nuclear Generating Station and – Darlington New Nuclear Project Proximity to Industry

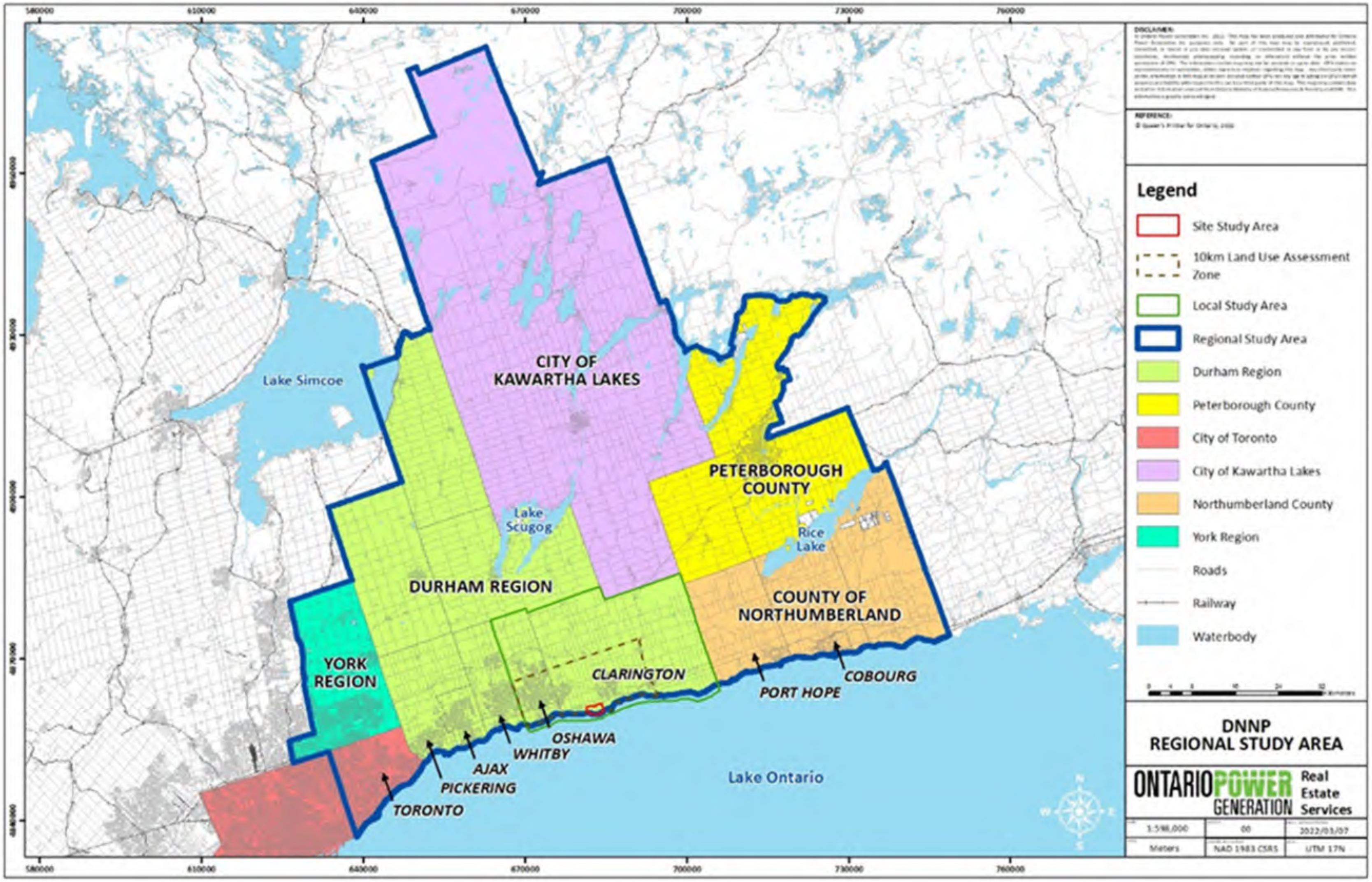

Figure 2.1.1-4: DNNP Regional Study Area

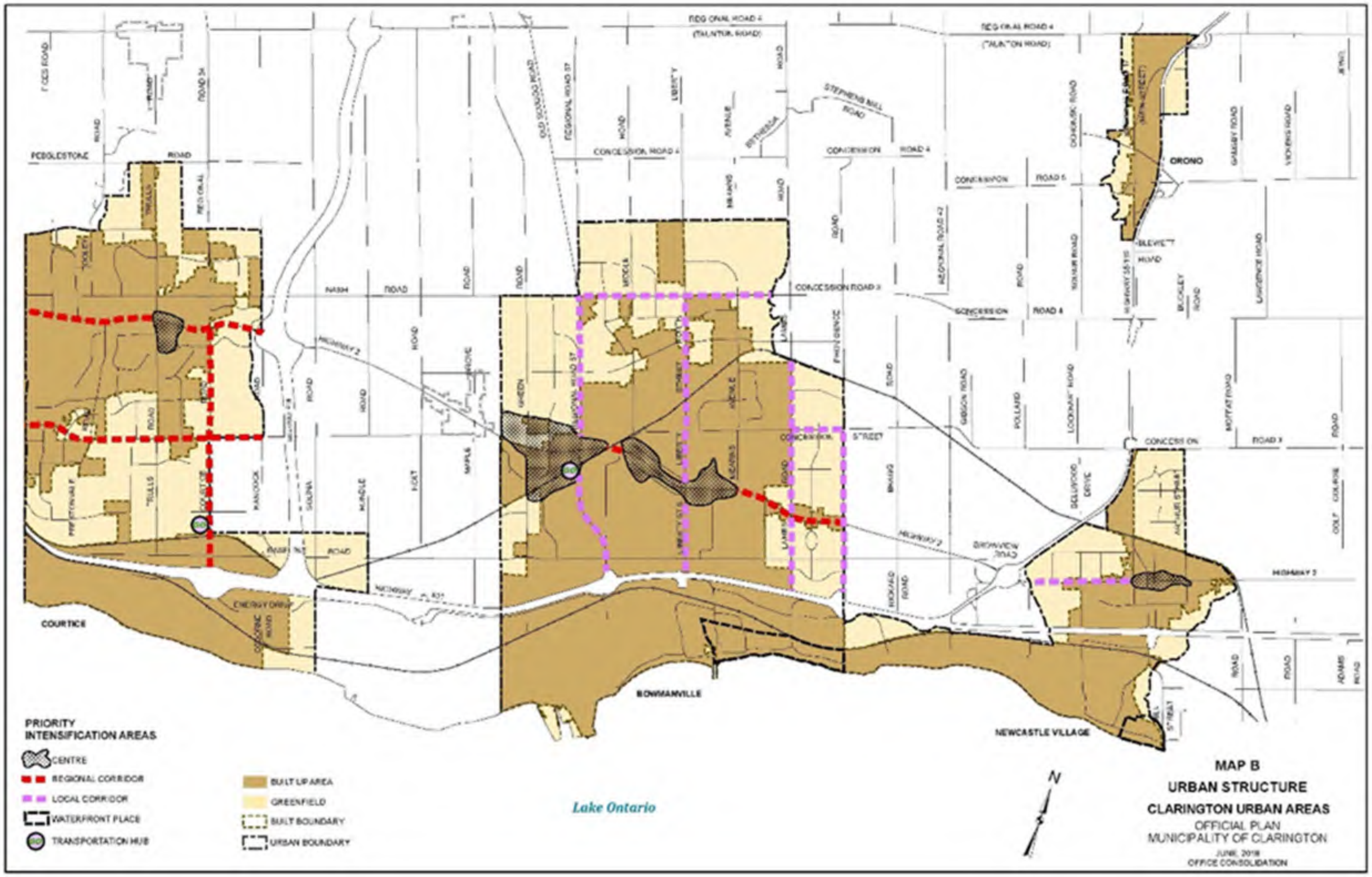

Figure 2.1.3-1: Clarington Urban Areas

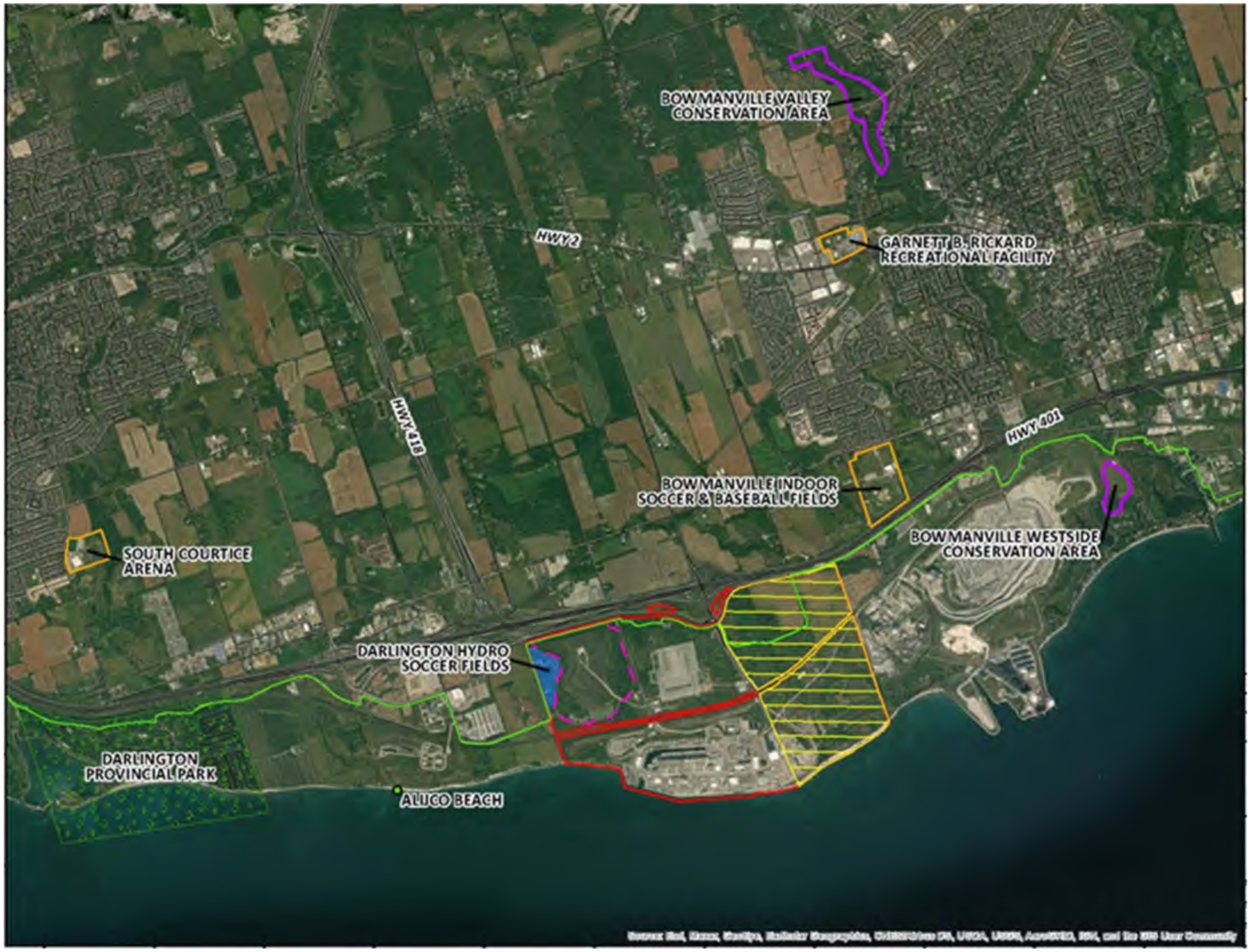

Figure 2.1.8-1: Darlington Nuclear Site – Active Darlington Waterfront Trail

2.2 Evaluation of Site-Specific Hazards

Section 2.2 characterizes and quantifies site-specific hazards that are used in the design of the BWRX-300 and builds upon the 2022 DNNP Hazard Analysis Methodology NK054-REP-01210-00144 (Reference 2.2-10). As the DNNP and DNGS share the Darlington Nuclear site (refer to Subsection 2.1.1), the DNGS 2019 Hazard Screening Analysis NK38-REP-03611-10043 (Reference 2.2-5) is used in support of Section 2.2 and to inform the DNNP hazard screening analysis. All such site characteristics are validated for the BWRX-300 Unit 1 design and its location on the DNNP site, as shown in Chapter 1, Figure A1.1-2.

2.2.1 Introduction

Section 2.2 includes the methodology used for and the results of the evaluation of site-specific external hazards associated with the DNNP site and the BWRX-300 facility. Such evaluation is derived from previous DNNP hazards assessment work completed in the 2009 NK054-REP-01210-00008 (Reference 2.2-1) and the 2009 NK054-REP-01210-00019 (Reference 2.2-2) as well as from a 2019 DNNP site preparation licence renewal activity report NK054-REP-01210-00108 (Reference 2.2-3). The evaluation addresses specific items relevant to DNNP site-specific external hazards, as identified in the 2020 OPG's application to renew the DNNP site preparation licence NK054-CORR-00531-10533 (Reference 2.2-4).

The methodology used to evaluate external hazards is described in Subsection 2.2.2.

The hazards identified for further evaluation are:

- Subsection 2.2.3: Transportation Accidents, Including Toxic Chemical or Gas Releases / Explosions Hazards
- Subsection 2.2.4: Stationary Non-nuclear Accidents Hazards
- Subsection 2.2.5: Stationary Nuclear Accidents Hazards
- Subsection 2.2.6: Industrial Hazards
- Subsection 2.2.7: Biological, Animal, and Frazil Ice Hazards
- Subsection 2.2.8: Ice Storm Hazard
- Subsection 2.2.9: Electromagnetic Inference Hazard
- Subsection 2.2.10: On-site Methane Hazard

A summary results and follow-up considerations of the hazards listed above are provided in Table 2.2-1.

Table 2.2-1: Screening and Validation of CNSC–Identified DNNP Site-Specific Hazards

2.2.2 External Hazards Evaluation Methodology			
Methodology	The methodology and criteria used in the 2019 DNGS NK38-REP-03611-10043 (Reference 2.2-5) Comparable methodology and criteria developed in the 2022 BWRX-300 DNNP NK054-REP-01210-00144 (Reference 2.2-10)		
Screening Criteria	Qualitative Criteria – QL-1 to QL-7 Quantitative criteria – QN-1 to QN-5		
2.2.3 Characterization of Hazards from Transportation Accidents, Including Toxic Chemicals or Gas Releases/Explosions			
2.2.3.1 Hazards from Air Transportation Accidents			
Small aircraft	Screened out	QL-1: Equal or lesser damage than similar design basis event	The small aircraft crash is screened out as the BWRX-300 is designed to withstand site-specific automobile tornado missiles, per Subsection 2.6.6.
Large military aircraft	Screened out	QL-3: Cannot occur at or close enough to the site to affect BWRX-300	Large bombers, large cargo planes, fuel tankers, or heavily armed jet fighters do not fly in the vicinity of the Bowmanville airspace
Large civil aircraft	Screened out	QN-5: Frequency of <1.0E-7/yr	NOTE: Malevolent large aircraft crash is analyzed in the Security Annex.
2.2.3.2 Characterization of Hazards from Rail Transportation Accidents			
Release of toxic gases	Screened in as DEC	Hazard frequency is estimated at 1.9E-06 occ./yr. Thus, this hazard is a Beyond Design Basis Accident (BDBA) DEC, as documented in NK054-REP-01210-00150 (Reference 2.2-11)	
Explosions	Screened in as DEC	Hazard frequency is estimated at 9.0E-07 acc./yr Thus, this hazard is a BDBA DEC, as documented in NK054-REP-01210-00149 (Reference 2.2-12)	
2.2.3.3 Characterization of Hazards from Road Transportation and Traffic Accidents			
Release of toxic or asphyxiant material	Screened out	QL3: Cannot occur on or close enough to the site to affect the plant	The location of the Darlington Nuclear site is about 1.0 km away from Highway 401.
2.2.3.4 Characterization of Marine Transportation			
Chemical Leak	Screened out	QL3: Cannot occur on or close enough to the site to affect the plant QL6: Does not cause an initiating event	Commercial shipping is approximately 27 km away for the DNNP. The consequence of a chemical leak from a tanker or a cargo ship, would be mostly an environmental hazard, and would not have an impact on safe operation of the station.
Release of toxic gases	Screened out	QL3: Cannot occur on or close enough to the site to affect the plant	The location of the DNNP is about 27 km away from the general tanker or cargo ship commercial routes in Lake Ontario.
Explosion	Screened out	QL3: Cannot occur on or close enough to the site to affect the plant	The location of the DNNP is about 27 km away from the general tanker or cargo ship commercial routes in Lake Ontario.

Physical Damage	Screened out	QL3: Cannot occur on or close enough to the site to affect the plant QL1: Bounded by the impact of damage caused by frazil ice described in Subsection 2.2.7.2	Hazards from accidents involving recreational boats or vessels pose no significant threat to the BWRX-300 safe operation, even if the accidents occur near the lake water intake structure. Also, a restricted zone is established around the BWRX-300 offshore structures.
2.2.4 Characterization of Stationary Non-Nuclear Accidents			
2.2.4 Fire – Natural Gas Pipelines	Screened out	QL6: Does not cause an initiating event or relevant safety function	There are no substantial pipelines carrying large quantities of natural gas, close enough to the site.
2.2.4.1 Release of toxic gases or chemical from commercial outlets in the area	Screened out	QL3: Cannot occur on or close enough to the site to affect the plant QL5: The event is slow to develop so there is sufficient time to eliminate the source of adequately respond	There are no industrial toxic gas or chemical storage tanks or pipelines carrying significant quantities of natural gas close enough to the site. Assumed St. Marys toxic release is not close enough to the site to affect the plant
2.2.4.2 Explosion – Shock Waves	Screened out	QL3: Cannot occur on or close enough to the site to affect the plant	Distances between DNNP and: • Cigas Propane tanks are about 3.6 km far from the DNNP site • St. Marys diesel fuel tanks is greater than 700 m from the Power Block of multi-unit layout (Reference 2.2-16).
2.2.4.2 Explosion - Missiles Hydrogen used for Tritium Removal Facility	Screened out	QL3: Large Missiles - Cannot occur on or close enough to the site to affect the plant QL4: Small Missiles - Bounded by design basis tornado in Subsection 2.6.6	The Tritium Removal Facility is located approximately 1.0 km west of the DNGS vacuum building.
2.2.5 Characterization of Stationary Nuclear Accidents Hazards			
2.2.5.1 Cameco's Port Hope Uranium Conversion Facility	Screened out	The facility is located on the north shore of Lake Ontario, approximately 40 km east of Darlington Nuclear site. The Cameco plant is a chemical processing facility with negligible radioactive releases.	
2.2.5.2 PNGS	Screened out	Any hazard from PNGS irradiated fuel still within an irradiated fuel bay or a dry storage facility is bounded by the much closer event from DNGS. Based on (Reference 2.2-5), PNGS radioactive release event is characterized as a slow developing event, allowing sufficient time for operators to take appropriate actions (if warranted), and can therefore be screened out.	
2.2.5.3 DNGS – Exclusion Zone	Screened in	The DNNP site is partly within the exclusion zone of DNGS.	
2.2.5.4 Characterization of Other Radiological Hazards from DNGS			
2.2.5.4.1 DNGS – Tritium Removal Facility – Tritium Release	Screened out	Evaluations in (Reference 2.2-1) and (Reference 2.2-5) determined that regulatory dose limits at the site boundary apply to all these nuclear events with negligible impact to DNNP.	

2.2.5.4.2 DNGS – Irradiated Wet Fuel Storage Facility	Screened out		
2.2.5.4.3 DNGS – Irradiated Dry Fuel Storage Facility	Screened out		
2.2.5.4.4 DNGS – Radioactive Waste Storage	Screened out		
2.2.6 Characterization Industrial Hazards (St. Marys)			
St. Marys Cement Plant – Uncontrolled blasts	Screened in	St. Marys Cement commits to carry out blasts with a maximum allowable horizontal, vertical, longitudinal, and radial velocities of less than 3 mm/s measured at the Darlington Nuclear site property boundary with St. Marys.	
2.2.7 Characterization of Biological, Animal and Frazil Ice Hazards			
2.2.7.1 Water-based Biological	Screened out	QL4: Bounded by the impact of damage caused by frazil ice described in Subsection 2.2.7.2	Hazards associated with blockage of intake cooling water resulting in the loss of heat sink
2.2.7.1 Airborne birds or insects	Screened out	QL-1: Equal or lesser damage than similar design basis event	This event is equivalent to outside air damper isolation during off-normal conditions
2.2.7.2 Frazil Ice	Screened in	Frazil ice is considered a potential hazard for causing water intake blockage to DNNP.	
2.2.8 Characterization of Ice Storm Hazard			
Ice Storm	Screened out	QL-1: Equal or lesser damage than similar design basis event	For the DNNP BWRX-300, the loss of the switchyard is part of the Loss-of-Preferred Power (LOPP), an Anticipated Operational Occurrence, which is the Pressure Increase Group and is designated as a BL-AOO event
2.2.9 Characterization of Electromagnetic Interference Hazard			
Electromagnetic Interference	Screened in	Since electromagnetic interference sources (e.g., high-voltage transmission lines and communication towers) are continuously present, the risk of electromagnetic interference at the site must be addressed in the design basis of the BWRX-300	
2.2.10 Characterization of On-site Methane Hazard			
During construction	Screened in	Methane gas is harmful to the health of humans and is combustible. Methane gas must be monitored during excavation, especially for the RB, since the methane is expected to dissipate quicker than what was observed in the boreholes due to the significantly larger air space.	
Post construction	Screened in	Methane in bedrock during operation is added as a hazard to be considered during design	

2.2.2 External Hazards Evaluation Methodology

The 2019 Hazards Screening Analysis reported in the 2019 NK38-REP-03611-10043 (Reference 2.2-5) provides a comprehensive assessment of the hazards associated with the DNGS site. Given that the DNNP site is within the Darlington Nuclear site (refer to Chapter 1, Figure A1.1-2) and in geographic proximity with the DNGS site, this analysis is deemed applicable to support and inform the evaluation of the external hazards listed in Subsection 2.2.1 for the DNNP site. In addition, since the DNGS external hazard screening methodology NK38-REP-03611-10043 (Reference 2.2-5) is aligned with the 2022 BWRX-300 DNNP Hazard Analysis Methodology NK054-REP-01210-00144 (Reference 2.2-10), the results of the 2019 DNGS analysis in NK38-REP-03611-10043 (Reference 2.2-5) are used to supplement and validate the DNNP site-specific external hazards evaluation reported in the 2022 DNNP NK054-REP-01210-00144 (Reference 2.2-10).

In the 2019 Site Preparation Licence Renewal Activity Report NK054-REP-01210-00108 (Reference 2.2-3), detailed DSA and PSA are performed during the BWRX-300 design phase. The DSA and PSA updates are performed in compliance with CNSC REGDOC-2.4.1 (Reference 2.2-14) and REGDOC-2.4.2 (Reference 2.2-15), respectively, and are tracked under the 2021 DNNP Commitment D-C-3 NK054-REP-01210-00078 (Reference 2.2-8). With respect to external hazards, DNNP Commitment D-C-3 also requires “the design of the new plant must demonstrate that it can mitigate the identified hazards to ensure that the required safety goals are met.”

The screening methodology and criteria used to assess hazards are described is found in Section 1.0 of the DNGS 2019 NK38-REP-03611-10043 (Reference 2.2-5). The screening technique involved a systematic approach starting with a qualitative assessment of the impacts of hazards on the safe operation of the station, followed by a quantitative screening of hazards not being screened out qualitatively. The methodology follows OPG’s PSA guides for screening of internal and external hazards.

The 2022 BWRX-300 DNNP Hazard Analysis Methodology NK054-REP-01210-00144 (Reference 2.2-10) builds on the 2019 Darlington screening technique NK38-REP-03611-10043 (Reference 2.2-5) and devises comparable criteria for the BWRX-300 facility. The developed qualitative and quantitative screening criteria are applicable to screening internal and external hazards, as listed in Appendix B of the 2022 NK054-REP-01210-00144 (Reference 2.2-10).

The following criteria are used for qualitative screening of hazards in the 2019 NK38-REP-03611-10043 (Reference 2.2-5):

- QL-1: The event is of equal or lesser damage potential than similar events for which the plant has been designed.
- QL-2: The event has a significantly lower reactor sources likelihood than another event that has been screened out, and yet the event could not result in worse consequences than the other event.
- QL-3: The event cannot occur at the site or close enough to the site to affect the plant.
- QL-4: The event is included in the definition of another event.
- QL-5: The event is slow in developing such that it can be demonstrated that there is sufficient time to eliminate the source of the threat or provide an adequate response.
- QL-6: The event does not cause an initiating event (including the need for a controlled shutdown) as well as safety system function losses needed for the event.
- QL-7: The consequences to the plant do not require the actuation of front-line systems.

NOTE: QL-1 to QL-5 apply to both the reactor and non-reactor sources. QL-6 and QL-7 apply only to reactor sources and not to the non-reactor sources.

The following criteria are used for quantitative screening in the 2019 NK38-REP-03611-10043 (Reference 2.2-5).

- QN-1: Severe Core Damage Frequency < 1.0E-6/yr. Applies only to reactor sources and not to non-reactor sources.
- QN-2: Design Basis Hazard Frequency, < 1.0E-5/yr and Conditional Core Damage Probability < 0.1. Applies to reactor sources only and not to non-reactor sources.
- QN-3: Severe Core Damage Frequency < 10-7/yr. Applies to the reactor sources only. An equivalent QN for non-reactor sources of Low Release Frequency (LRF) < 1.0E-7/yr is considered.
- QN-4: Design Basis Hazard Frequency, <1.0E-6/yr and Conditional Core Damage Probability <0.1. Applies to reactor sources only. An equivalent QN for non-reactor sources is considered as follows: Design Basis Hazard Frequency, < 1.0E-6/yr and conditional large release probability (CLRP) < 0.1.
- QN-5: Initiating Event or Hazard Frequency may be screened out if it can be shown that their frequency is < 1.0E-7/yr. Applies to both reactor and non-reactor sources.

The application of this methodology results in hazards being "screened out" or "screened in." "Screened out" implies that the hazard does not pose any safety concerns. "Screened in" implies further assessment is required to address the hazards. Hazards which are neither qualitatively nor quantitatively screened out, are addressed during detailed Probabilistic Safety Assessments (for example, seismic, high winds).

2.2.3 Characterization of Hazards from Transportation Accidents, Including Toxic Chemicals or Gas Releases/Explosions

Evaluations of hazards from transportation accidents are detailed as follows:

- By air - Subsection 2.2.3.1
- By train - Subsection 2.2.3.2
- By road - Subsection 2.2.3.3
- By marine – Subsection 2.2.3.4

Previous assessment results for DNNP hazards associated with transportation events are provided in the 2009 NK054-REP-01210-00008 (Reference 2.2-1) and the 2009 NK054-REP-01210-00019 (Reference 2.2-2). The evaluations presented in Subsection 2.2.3 address the specific issues identified by the CNSC in Subsections 4.6.1, 4.6.2 and 4.6.3 of the 2020 Renewal Application for DNNP Site Preparation Licence NK054-CORR-00531-10533 (Reference 2.2-4).

Aircraft crashes and ship accidents were evaluated for the DNNP site in Section 4.3 and 4.4 of the 2009 NK054-REP-01210-00008 (Reference 2.2-1). The evaluation did not consider the impact from toxic chemicals or gas releases/explosions specific to these accidents. However, the impact from toxic chemicals or gas releases/explosions from transportation accidents were implicitly assessed in Section 4.6 of the 2009 NK054-REP-01210-00008 (Reference 2.2-1).

Further, Section 4.6 of the 2009 NK054-REP-01210-00008 (Reference 2.2-1) evaluated the risks associated with hazardous fluids, including toxic clouds from the release of toxic gases, deflagrations (explosions) from the release of liquified petroleum gases and flammable pressure liquified gases. The evaluation determined toxic gas clouds reaching the DNNP site at high enough concentrations have the potential to impact the Main Control Room (MCR) and Secondary Control Room (SCR) habitability of the proposed plant (that is, the BWRX-300 nuclear facility). Refer to Chapter 6, Section 6.4 for further details on habitability of the MCR and SCR.

With respect to explosions, the evaluation in the 2009 NK054-REP-01210-00008 (Reference 2.2-1) identified potential damage to buildings from missiles resulting from Boiling Liquid Expanding Vapour Explosion (i.e., tanks containing liquified petroleum); when travelling at high velocity, these missiles can damage outdoor and indoor equipment. The evaluation determined that the overpressure effects due to explosion on the building must be mitigated. Mitigation may require the use of an appropriate physical barrier or the physical separation of important safety equipment/systems. The evaluation stated that requirements for this hazard is to be considered during the detailed design phase of the project (that is, BWRX-300). The 2019 DNGS Hazards Screening Analysis NK38-REP-03611-10043 (Reference 2.2-5) also assessed the release of toxic chemicals and gas/release explosions from transportation accidents. The data used for DNGS hazards analysis supplement the DNNP site-specific data that are employed in the design and safety analysis stage of the DNNP BWRX-300, as applicable.

For additional information specific to toxic gas and chemical hazards, refer to Subsection 2.2.3.2 for rail transportation accident hazards, Subsection 2.2.4.1 for release from stationary hazards, and Subsection 2.4.1 for on-site hazards.

2.2.3.1 Characterization of Hazards from Air Transportation Accidents

Two types of aircraft are examined: small and large (both civil and military).

1. The small aircraft crash is screened out qualitatively as not having an impact on the safe operation of the facility, based on the screening criterion QL1 that the event is of equal or lesser damage potential than similar events for which the plant is designed. Per Section 3.1 of the 2019 Darlington hazard screening analysis (Reference 2.2-5), small aircraft impact is bounded by tornado missiles. The small aircraft crash is therefore screened out as the BWRX-300 will be designed to withstand automobile tornadoes missiles (refer to Subsection 2.6.6).
2. Large aircraft (military) aviation accidents are not a concern for the Darlington Nuclear site, as there are no large bombers, large cargo planes or fuel tankers, or heavily armed jet fighters flying in the vicinity of the Bowmanville airspace, per the 2020 NK054-CORR-00531-10533 (Reference 2.2-4).
3. Large aircraft (civil) accidents are screened out under screening criterion QN5 (refer to Subsection 2.2.2) based on a hazard frequency of <1.0E-7/yr.

2.2.3.2 Characterization of Hazards from Rail Transportation Accidents

As described in Subsection 2.1.5, two railway lines run within the 10 km study area surrounding the Darlington Nuclear site. Of particular relevance is the Canadian National Railway line which bisects the Darlington Nuclear site and passes approximately 600 m north of the DNNP site. This railway line has potential hazards associated with assumed derailment accidents involving one or more cargo cars.

Rail transportation accidents are assessed in the 2019 DNGS Hazards Screening Analysis NK38-REP-03611-10043 (Reference 2.2-5), the 2022 DNNP Rail Transportation – Toxic Gas/Chemical Release Hazard Assessment NK054-REP-01210-00150 (Reference 2.2-11), and the 2022 DNNP Rail Transportation – Explosion Hazard Assessment NK054-REP-01210-00149 (Reference 2.2-12). The objective is to address hazards associated with train derailment and crash, including cold or hot toxic gas releases, as well as Vapour Cloud Explosions, Boiling Liquid Expanding Vapour Explosion, and other types of explosions.

The assessments considered the two rail lines running “east-west” directly north of Darlington Nuclear site. Of particular interest is the Canadian National Railway Toronto to Montreal main line which passes through the OPG DNGS and DNNP sites, as shown in Figure 2.1.1-2.

One of the hazards analyzed in the 2022 NK054-REP-01210-00150 (Reference 2.2-11) is the possibility of a large toxic gas/chemical release. A consequential harm from this hazard could be a toxic gas/chemical release that would be airborne toward the DNNP site with the capacity for widespread and distant impact. Another hazard is the potential of large explosion, analyzed in NK054-REP-01210-00149 (Reference 2.2-12), involving explosive commodities being transported by the railway line, occurring in the vicinity of DNNP BWRX-300 structures and components. The following toxic gas release and explosion scenarios are assessed in the 2019 NK38-REP-03611-10043 (Reference 2.2-5), the 2022 NK054-REP-01210-00150 (Reference 2.2-11), and the 2022 NK054-REP-01210---00149 (Reference 2.2-12), for applicability to DNNP:

1. Cold Toxic Gases Release: Release and dispersion of airborne toxic chemicals or asphyxiants toward the BWRX-300 HVAC intakes that could expose the station staff to toxic chemicals and result in challenging the habitability of work areas.
2. Hot Toxic Gas Release: Similar to cold toxic gas releases, if the train derailment accident involves fire, it could result in hot toxic gas releases. Combustible chemicals could result in releasing an intense heat, causing secondary combustion of other materials (e.g., insulations, containers and covers), and such releases usually involve other chemicals that can have a wide range of toxicities. Heavy hydrocarbons produce a significant amount of carbon dioxide, carbon monoxide and soot when they catch fire. Some chemicals may produce toxic byproducts while burning, such as hydrazine (combustion byproducts include nitrogen dioxide, which is highly toxic).
3. Hydrocarbon Explosions: Release of light hydrocarbons with high vapour pressures (flammable), when transported under high pressure (e.g., liquefied petroleum gas), can produce two types of explosions:
    a. Boiling Liquid Expanding Vapour Explosion: Boiling Liquid Expanding Vapour Explosions could generate missiles, fireballs, and blast waves. Missiles could travel hundreds of meters from the source. Blast waves from Boiling Liquid Expanding Vapour Explosions are normally localized.
    b. Vapour Cloud Explosion: With Vapour Cloud Explosions, vapour cloud ignition is delayed after the cloud has dispersed somewhat and mixed with air. Vapour Cloud Explosions produce blast waves that could damage buildings and equipment.
    c. Confined Explosions: A flammable fluid can produce a confined explosion if it becomes airborne, mixes with air, and is ignited in a confined space. This would produce a so-called Confined Explosion. Such an explosion could arise in a building, a room, or the vapour space of a storage tank. Blast waves from confined explosions are localized.

The hazard from the release of toxic gases resulting from Canadian National Railway assumed transportation accidents close to the DNNP site have an estimated frequency of 1.9E-06 occ./yr, per the 2022 NK054-REP-01210-00150 (Reference 2.2-11). Thus, it is screened out from design basis input since it is assessed as a Beyond Design Accident (BDBA) DEC, per REGDOC-2.4.1 (Reference 2.2-14).

Similarly, the explosion hazard from a Canadian National Railway derailment accident near the DNNP site has an estimated frequency of 9.0E-07 occ./yr, per the 2022 NK054-REP-01210-00149 (Reference 2.2-12). Consequently, it is screened out from design basis input based on the assessment that it is a BDBA DEC, per REGDOC-2.4.1 (Reference 2.2-14).

2.2.3.3 Characterization of Hazards from Road Transportation and Traffic Accidents

Road transportation and traffic accidents are assessed in 2019, and results for DNGS are reported in Subsection 3.2.3 of per the 2019 NK38-REP-03611-10043 (Reference 2.2-5). The assessment considered the location of the Darlington Nuclear site, also encompassing the DNNP site, which is about 1.0 km away from the Macdonald–Cartier Freeway (also known as Highway 401) and one of the busiest highways in Canada.

The event scenario considered involves two tractor trailers crash (or rollover), such that multiple containers are damaged, consequential toxic or asphyxiant materials are released into the atmosphere, and the wind (2 m/s) disperses the airborne chemicals toward the BWRX-300 HVAC systems intakes (refer to Chapter 9A, Section 9A.5 for information on BWRX-300 HVAC systems).

Highway 401 is about 1.0 km north of the DNNP site. The impact of two tractor trailer crash is therefore screened out based on distance. Explosion or release of toxic/asphyxiant materials from the colliding two tractor trailers depends on the size of insuring breaks and the consequential amount of material released (via leaking or 100% break), wind direction and speed, and the degree of dilution due to dispersion. This scenario is therefore screened out based on distance and low impact without performing confirmatory assessment.

2.2.3.4 Characterization Hazards from Marine Transportation

The cargo vessels move along shipping lanes which are designated by the Ministry of Transport, and the nearest approach is about 27 km from the Darlington Nuclear site, per Section 3.3 of the 2019 NK38-REP-03611-10043 (Reference 2.2-5). Therefore, scenarios involving tankers or cargo ships are, in general, screened out based on distance, per screening criterion [QL3]

The consequences of a chemical leak from a tanker or a cargo ship would be mostly an environmental hazard. Depending on the exact nature, severity, and progression time of the accident as well as the consequential amount of leaked material, lake current and degree of dilution, such scenarios would have negligible impact on the quality, or the quantity of the cooling water supplied to the BWRX-300. A tanker or cargo ship accident resulting in chemical leak is screened out based on screening criterion [QL6].

The hazard of an explosion onboard a cargo ship and subsequent release of toxic gases is screened out based on screening criterion [QL3], that is, the event cannot occur at the site or close enough to the site to affect the plant.

As described in the 2019 NK38-REP-03611-10043 (Reference 2.2-5), a large number of small or large recreational boats or vessels travel across Lake Ontario, Winter conditions limit this traffic to about 8 months of the year. Hazards from accidents involving such recreational boats or vessels pose no significant threat to the BWRX-300 safe operation, even if the accidents occur near the lake water intake structure. St. Marys Cement Company Limited owns a pier that is about 700 m to the east of the DNNP site. Bulk carriers may load cement or unload gypsum or coal at this dock. Also, a restricted zone is established around the BWRX-300 offshore structures. The consequence of such accidents is bounded by a frazil ice hazard, and therefore, associated hazards are screened out based on criterion [QL1]

2.2.4 Characterization of Stationary Non-Nuclear Accidents Hazards

The evaluation of hazards associated with stationary non-nuclear accidents is based on the results of the assessment reported in the 2019 NK38-REP-03611-10043 (Reference 2.2-5) for DNGS. Since DNNP is also located within the Darlington Nuclear site boundary, the results of the DNGS assessment are relevant to DNNP.

Event scenarios that can result in an accidental fire, explosion, or a release of hazardous material from stationary sources have been assessed in Section 3.5 of the 2019 NK38-REP-03611-10043 (Reference 2.2-5). The locations of the initiating mechanism for these sources are constrained to tank farms and forest fires.

The main stationary sources of external hazardous material near the Darlington Nuclear site are:

1. Regional Water Treatment Plants which generally have a large inventory of Chlorine for treatment of water.
2. Cigas Propane, which is located 3.6 km away from Darlington Nuclear site, where a large inventory of propane gas is stored.
3. St. Marys Cement plant located about 1.5 km east of the DNGS site and approximately 700 m from the DNNP site. The plant stores large inventories of a variety of hazardous chemicals on-site. The main toxic and hazardous materials are as follows (Reference 2.2-16):
    - Aqueous (19%) ammonia (NH_4OH) tank with capacity of up to 38 000 L
    - Diesel fuel storage tanks with capacity of up to 50 000 L used for heating and fueling mobile equipment.
4. The DNGS Tritium Removal Facility where chemicals and fuel stored could potentially pose hazards to DNNP BWRX-300 resulting from the release of toxic chemicals, hydrocarbon explosions (Boiling Liquid Expanding Vapour Explosions and Vapour Cloud Explosions), or confined explosions (refer to Subsection 2.2.5.4 for additional information on DNGS potential hazards).

Substantial pipelines carrying large quantities of natural gas do not run close enough to the Darlington Nuclear site. Therefore, the risk of fire due to pipelines ruptures poses a negligible incremental risk to the DNNP site and, thus, it was screened out based on screening criterion [QL-6] (Subsection 2.2.2).

2.2.4.1 Characterization of Toxic Chemicals Releases from Stationary Hazards

As described in the 2019 NK38-REP-03611-10043 (Reference 2.2-5), the event scenario assessed involves a local accident in one of the regional water treatment plants (for example, Courtice WPCP) or in the St. Marys Cement plant, resulting in the release of chlorine gas (Cl_2) or gas/aqueous ammonia (NH_3/NH_4OH), respectively. Combustion of NH_3 in the air could result in NO or NO_2, in the presence of appropriate catalysts. Nitrogen dioxide is toxic by inhalation, but it is easily detectable by smell at low concentrations. The combustion of ammonia in air is difficult in the absence of a catalyst, as the temperature of the flame is usually lower than the ignition temperature of the ammonia-air mixture.

The accident is assumed to include multiple containers. As such, the airborne toxic material, chlorine, or ammonia, released into the atmosphere could disperse toward the BWRX-300 HVAC intakes. Depending on the size and nature (i.e., severity and time frame) of the release, wind direction and wind speed, the concentration of toxic chemicals varies.

For the chlorine hazard, the nearest water treatment plant, the Courtice WPCP, is approximately 5 km west of the BWRX-300 HVAC intakes. Thus, this hazard is screened out under screening criterion [QL-3] (Subsection 2.2.2) as the event cannot occur at the site or close enough to the site to affect the plant.

With respect to the ammonia hazard associated with accidents at the St. Marys Cement plant which is located approximately 700 m east of DNNP site boundary (Reference 2.2-16) and considering the total low-level of inventory of ammonia at the St. Marys plant, the toxic release is screened out from further assessment under screening criterion [QL-1] (Subsection 2.2.2).

2.2.4.2 Characterization of Explosions from Stationary Sources

The event scenario involves the explosion of multiple propane tanks at the Cigas Propane storage facility, or the explosion of multiple diesel fuel tanks located at the St. Marys Cement plant as per Subsection 3.5.2 of the 2019 NK38-REP-03611-10043 (Reference 2.2-5). As multiple tanks are damaged, there are missiles potentially generated by the explosions, as well as shockwaves, which can damage SSCs several hundred meters away.

The screening distances for different types of explosions, per the 2019 NK38-REP-03611-10043 (Reference 2.2-5) are estimated at 1600 m for Boiling Liquid Expanding Vapour Explosion, 700 m for explosions equivalent to 61.5 Mg trinitrotoluene, and 460 m for Vapour Cloud Explosion. For the DNNP, considering the distances of the hazardous sites (3,600 m for Cigas Propane, and greater than 700 m for St. Marys Cement), both scenarios for Boiling Liquid Expanding Vapour Explosion due to propane tanks explosions at Cigas Propane, and explosions due to diesel fuel tanks at St. Marys Cement were screened out, based on distance screening criterion [QL3]. (NOTE: The St. Marys Cement does not store large quantities of pressurized light hydrocarbons (unlike that in Cigas Propane.)

An assessment of missiles generated from an explosion associated with hydrogen used in the Tritium Removal Facility was performed in 2019 for DNGS in NK38-REP-03611-10043 (Reference 2.2-5). The Tritium Removal Facility is located directly west of the DNGS vacuum building. The assessment determined that missiles generated by an explosion in the Tritium Removal Facility are bounded by missiles generated by a design basis tornado, for which DNGS is protected.

The DNNP facility is approximately 1.0 km away from the Tritium Removal Facility, and the DNGS and its vacuum building provide an obstruction between the Tritium Removal Facility and the DNNP BWRX-300 facility. As such, this hazard is screened out based on [QL-3] for large missiles since the event cannot occur on or close enough to the DNNP site to affect the BWRX-300 facility. Small missiles generated by an explosion at the Tritium Removal Facility can also be screened out for the DNNP BWRX-300 design, using screening criterion [QL-4], since such small missiles are bounded by the design basis tornado automobile missiles (refer to Subsection 2.6.6).

2.2.5 Characterization of Stationary Nuclear Accidents Hazards

Stationary nuclear accident sources within the vicinity of DNNP that pose potential hazards from nuclear accidents are:

1. Cameco’s Port Hope Uranium Conversion Facility – located about 40 km east of the Darlington Nuclear site where the DNNP is located
2. PNGS – located about 25 km west of the Darlington Nuclear site where the BWRX-300 is to be built
3. DNGS – located within one kilometer west of the BWRX-300 footprint

The Cameco facility and PNGS were assessed in the 2019 Hazard Screening Analysis NK38-REP-03611-10043 (Reference 2.2-5) performed for DNGS.

2.2.5.1 Evaluation of Cameco's Port Hope Uranium Conversion Facility Hazard

Cameco's Port Hope uranium conversion facility is a nuclear substance processing facility licensed to process uranium trioxide (UO_3) into both uranium dioxide (UO_2) and uranium hexafluoride (UF_6). Natural UO_2 is used to manufacture CANDU fuel for nuclear power reactors in Canada, while UF6 is exported to companies in other countries for enrichment and fabrication into fuel for international nuclear power reactors. The facility is located on the north shore of Lake Ontario, approximately 40 km east of Darlington Nuclear site. The Cameco plant is a chemical processing facility with negligible radioactive releases, and therefore it is not included in the screening analysis for DNGS. Based on the DNNP proximity to DNGS, the screening results for DNGS are directly applicable to DNNP and hence screened out from further evaluation both deterministically and probabilistically.

2.2.5.2 Characterization of Pickering Nuclear Generating Station Hazards

PNGS is located on the shores of Lake Ontario, approximately 25 km west of Darlington Nuclear site. The PNGS is an eight-unit station with six operating CANDU reactors with a total output of 3100 MWe, and two units in safe storage. OPG is conducting a re-assessment, per the 2022 P-CORR-00531-23042 (Reference 2.2-13), involving a comprehensive technical examination of the potential for refurbishing Units 5, 6, 7 and 8 of PNGS. The results including recommendations of such an assessment are to be reported in 2023.

As described in the 2019 NK38-REP-03611-10043 (Reference 2.2-5), the accidental release of radioactive materials at PNGS can be screened out for DNGS given it is a slow developing event, and there are mitigating features as well as enough time for operators to take proper actions. As the DNNP is farther from PNGS and similar mitigation measures, if warranted, are implemented, the radiological hazards associated with such events are also screened out for DNNP. Any hazard from PNGS used CANDU fuel still within an irradiated fuel bay or a dry storage facility is bounded by the much closer event from DNGS discussed in Subsection 2.2.5.4.2.

2.2.5.3 Characterization of Darlington Nuclear Generating Station Hazard

The BWRX-300 Unit 1 footprint resides partly within the DNGS exclusion zone (nominally 914 m), that is within DNGS controlled area, per Subsection 5.10 of the 2020 NK054-CORR-00531-10533 (Reference 2.2-4). The closeness of DNNP to DNGS means that in the event of a nuclear accident within DNGS the ability to maintain safe operation of DNNP can potentially be affected.

2.2.5.4 Characterization of Other Radiological Hazards from DNGS

Potential radiological hazards in the area that could affect the safe operation of the new nuclear plant were evaluated in Section 4.8 of the 2009 NK054-REP-01210-00008 (Reference 2.2-1). Nuclear events at the DNGS considered in this assessment were as follows:

- Tritium Removal Facility accidents leading to release of tritium
- In-plant fire near a storage area of active liquid waste
- Used irradiated fuel accident
- Design basis reactor accidents
- Beyond design basis reactor accidents which include severe accidents that have the potential for a significant off-site release of radioactive materials

The assessment determined these events do not pose a concern to equipment but would likely impact the operating staff of the proposed plant (that is, the BWRX-300 facility). Four specific events as listed below are discussed in more details:

- Tritium Removal Facility – Subsection 2.2.5.4.1
- Irradiated Fuel Storage Facility – Subsection 2.2.5.4.2
- Used Fuel Dry Storage – Subsection 2.2.5.4.3
- Radioactive Waste Storage -Subsection 2.2.5.4.4

In October 2021, DNGS Power Reactor Operating Licence PROL 13.02/2015 was amended to authorize unit 2 to produce molybdenum-99, an isotope used in the medical industry for diagnostics. The CNSC decision concludes that the licensed activities will have a negligible effect on severe core damage frequency and large release frequency (Reference 2.2-17). In the future, DNGS may pursue production of other isotopes and/or molybdenum-99 in other units.

2.2.5.4.1 Characterization of Tritium Removal Facility Hazard

The Tritium Removal Facility is located within the boundary of the DNGS site, to the west side of the DNGS vacuum building. Release of tritium from an accident at the Tritium Removal Facility was evaluated in Section 4.8 of the 2009 NK054-REP-01210-00008 (Reference 2.2-1). The assessment concluded that accidents leading to a tritium release do not pose concern to equipment but have the potential to impact operators. (Refer to Chapter 6, Subsections 6.4.1.1 and 6.4.1.2 for information on the BWRX-300 MCR and SCR habitability provisions, respectively.)

Helium-3 (He-3) is also extracted from tritium storage containers at the Tritium Removal Facility for medical and commercial uses. He-3 is a non-radioactive, inert, and non-toxic gas and therefore accidental release does not contribute any additional risk.

2.2.5.4.2 Characterization of Irradiated Fuel Storage Facilities Hazards

Following its useful life in the DNGS reactors, used CANDU fuel bundles are discharged from the fueling machine heads and initially stored underwater in modules in irradiated fuel bays at the West and East Fueling Facility Auxiliary Areas, located inside the DNGS protected area, adjacent to Unit 1 and Unit 4, respectively. Then the used fuel modules are transferred to and placed into seismic stacking frames inside the main irradiated fuel storage bays where the water in the bays removes heat produced by the decaying used fuel and provides shielding for workers. After a specified number of years, based on bays capacity and operational needs, the used fuel is transferred to an on-site irradiated fuel dry storage facility for short-term storage, and ultimately to an off-site long-term dry storage facility when it becomes available in the future. The hazards posed by both the irradiated fuel bays and the on-site irradiated fuel dry storage facility are analyzed in NK38-REP-03611-10043 (Reference 2.2-5).

Radiological releases from used fuel accidents were also evaluated in Section 4.8 of the 2009 NK054-REP-01210-00008 (Reference 2.2-1). It was determined that used fuel accidents posed no concern for DBAs.

Analysis of human-induced hazards and natural hazards for the DNGS irradiated fuel bays was performed and documented in Section 5 and Section 6, respectively of the 2019 NK38-REP-03611-10043 (Reference 2.2-5). All human-induced hazards analyzed have been screened out (Table 5-1 of the 2019 NK38-REP-03611-10043 (Reference 2.2-5)), which is applicable to DNNP as well. For natural hazards, Table 6-1 of the 2019 NK38-REP-03611-10043 (Reference 2.2-5) summarizes hazards which are not screened out. Irradiated fuel bay accident analysis is documented in Subsection 3.6.4 of the 2017 NK38-SR-03500-10002 (Reference 2.2-9).

2.2.5.4.3 Characterization of Used Fuel Dry Storage Hazard

Analysis of human-induced hazards and natural hazards for irradiated CANDU fuel dry storage facility was performed and documented in Section 7 and Section 8, respectively, of the 2019 NK38-REP-03611-10043 (Reference 2.2-5). All human-induced and natural hazards analyzed have been screened out as not having a safety impact on DNGS. The results are directly applicable to DNNP BWRX-300 and have been screened out, as per Table 5-1 of the 2019 NK38-REP-03611-10043 (Reference 2.2-5).

2.2.5.4.4 Characterization of Radioactive Waste Storage Hazard

The scenario analyzed in Section 4.8 of the 2009 NK054-REP-01210-00008 (Reference 2.2-1) for radioactive waste storage accidents is an in-plant fire near a storage area of active liquid waste. This event poses no concern for DBAs.

2.2.6 Characterization Industrial Hazards

The primary industrial hazard of concern is uncontrolled underground blasting associated with the St. Marys Cement plant.

This hazard was assessed in Section 3.6 of the 2019 DNGS Hazard Screening Assessment NK38-REP-03611-10043 (Reference 2.2-5). The results of the assessment indicated blasting at St. Marys quarry leads to shock waves in the ground travelling to the Darlington Nuclear site.

Vibration monitors on the Darlington Nuclear site at the St. Marys' property boundary are designed to record the amplitude and frequencies of such shock waves, originating from the St. Marys Cement plant. St. Marys Cement commits to not carry out blasts that may exceed the maximum allowable horizontal, vertical, longitudinal, and radial velocities of 3 mm/s measured at the Darlington Nuclear site property boundary with St. Marys.

This agreement was originally put in place to avoid turbine trips at DNGS. Since DNNP is in geographic proximity to DNGS and is closer to St. Marys Cement plant than DNGS, this hazard is applicable to the BWRX-300 facility.

The agreement noting 3 mm/s is between OPG and St. Marys and is therefore applicable to DNNP.

The maximum allowable horizontal, vertical, longitudinal, and radial velocities of 3 mm/s measured at OPG's Darlington Nuclear site property boundary is screened in and shall be considered in the design of the BWRX-300 facility.

2.2.7 Characterization of Biological, Animal, and Frazil Ice Hazards

Lake Ontario is the reservoir of cooling water for the DNNP BWRX-300 facility. Fouling of the intake structures and components from growth of biological species (e.g., algae, mussels, or clams) and the presence of animals (e.g., birds, fishes, or other wildlife) impede the availability of water for heat sink purposes. Also, the formation of frazil ice at the intake can restrict or block supply to the Circulating Water System (CWS) (refer to Subsection 2.5.2). Both potential hazards are evaluated in the following two subsections.

2.2.7.1 Characterization of Biological and Animal Hazard

<u>*Biological Hazards*</u>

A variety of sources of organisms or organic material that could contribute to biofouling associated with cooling water systems originate from the pathway represented by Lake Ontario, thus restricting or blocking water supply to the BWRX-300 facility.

The impact of biological and animal hazards on the safe operation of DNNP was considered and documented in the 2009 NK054-REP-01210-00019 (Reference 2.2-2), the 2020 NK054-CORR-00531-10533 (Reference 2.2-4), the 2009 NK054-REP-01210-00018 (Reference 2.2-7), and the 2021 NK054-REP-01210-00078 (Reference 2.2-8).

Section 2 of the 2009 NK054-REP-01210-00018 (Reference 2.2-7) assessed the hazards associated with blockage of cooling water intake. The primary species that can contribute to biofouling have been identified and assessed. Biofouling was identified as a potential hazard that can result in loss of cooling and fouling of cooling equipment, such as lines and heat exchangers.

Section 3.5 of the 2009 NK054-REP-01210-00008 (Reference 2.2-1) considered the adequacy of water supply affected by biofouling, where several species were assessed.

Further discussion on the prevention of biofouling for the cooling water intake is provided in Subsection 2.5.2.2.

Animal Hazards

Airborne animal hazards (e.g., birds or insects) have the ability to block the screens of the MCR air ventilation intakes. This event is equivalent to outside air damper isolation during off-normal conditions, as described in Chapter 9A, Subsection 9A.5.2.1.4. The airborne animal hazard is therefore screened out using screening criterion [QL6].

2.2.7.2 Characterization of Frazil Ice Hazard

Section 3.5 of the 2009 NK054-REP-01210-00008 (Reference 2.2-1) states frazil ice forms in turbulent, supercooled water (water temperatures of -0.01°C to -0.05°C). To generate these conditions, hydro-meteorological conditions must be such that there is sufficient heat loss from the water to cause water temperature to decrease to the freezing point. The physical parameters relevant to the formation of frazil ice include water temperature, air temperature, wind speed, and humidity.

In lakes, blockages of intakes are associated with open water, low temperatures, and clear nights. They also are often associated with strong winds, which increase the rate of heat loss at the water surface as well as potentially provide turbulence that can mix the supercooled water to the depth of the intake. The intake flow can also entrain the supercooled water if it is of sufficient velocity. The depth at which a lake intake will be free from the impacts of frazil ice is also dependent on other factors, such as lake bottom topography and intake structure dimensions.

Frazil ice is considered a potential hazard for causing water intake blockage to the BWRX-300 facility.

2.2.8 Characterization of Ice Storm Hazard

The impact of ice storms on the safe operation of the reactors at the Darlington Nuclear site was considered in the 2009 NK054-REP-01210-00008 (Reference 2.2-1) for DNNP and assessed in the 2019 NK38-REP-03611-10043 (Reference 2.2-5) for DNGS.

Section 3.2 of the 2009 NK054-REP-01210-00008 (Reference 2.2-1) considered ice storms as part of the freezing rain assessment under rare meteorological events. The major ice storm event on record for the Darlington Nuclear site occurred in January 1998, over a period of 5 days. During the storm event, 80 -100 mm of freezing rain affected areas from Kingston to Granby, Quebec. On average, Toronto Pearson Airport recorded 17.1 hours of freezing rain per year, 8.8 days per year; while Trenton airport reported 21.9 hours of freezing rain per year and 11.4 days per year, as per the 2021 NK054-REP-01210-00078 (Reference 2.2-8).

Freezing rain totals ranging from 50 mm to 75 mm have been reported on few occasions in southern Ontario; whereas 10 mm of freezing rain is to be expected occasionally and up to 20 mm of freezing rain is highly likely to occur over the time the site will be operational. Historically, freezing rain events with more than 50 mm have been observed in the same broad climatological region but are not frequent, with maximal amounts near 100 mm (refer to the 2009 NK054-REP-01210-00008 (Reference 2.2-1)).

The ice storm hazard for DNGS was assessed in the 2019 Darlington Hazards Screening Analysis NK38-REP-03611-10043 (Reference 2.2-5) and documented there in Subsection 4.5.5. The analysis reviewed OPG and CANDU Owners Group operating experience databases, as well as databases for other power plants. The review showed ice storms have not had an impact on the plants, but severe storms were seen to lead to losses of off-site power and switchyard failures in several cases. In 1998, Hydro Quebec experienced a loss of grid for several days due to an ice storm. During this ice storm, 40 mm of freezing rain was observed in Kingston, Ontario, and as much as 120 mm of freezing rain was observed in certain parts of Quebec.

For the DNNP BWRX-300, the LOPP event, an Anticipated Operational Occurrence (AOO), which is in the Pressure Increase Group and is designated as a BL-AOO event (refer to Chapter 15, Subsection 15.5.3.2.4).

2.2.9 Characterization of Electromagnetic Interference Hazard

Electromagnetic interference can affect the functionality of instrumentation and control equipment and can be initiated by both on-site sources, such as high-voltage switchgear and off-site sources such as communication networks. It has the potential of disrupting electrical components and instrumentation leading to potential impairment of critical plant control signals. This hazard was assessed in the 2009 NK054-REP-01210-00008 (Reference 2.2-1), the 2009 NK054-REP-01210-00019 (Reference 2.2-2), and the 2020 NK054-CORR-00531-10533 (Reference 2.2-4) for DNNP and in the 2019 NK38-REP-03611-10043 (Reference 2.2-5) for DNGS.

Section 2.1 of the 2009 NK054-REP-01210-00019 (Reference 2.2-2) identified this hazard for consideration in the design to provide the required shielding of critical components and “fail safe” wherever required.

Section 4.9 of the 2009 NK054-REP-01210-00008 (Reference 2.2-1) assessed external sources of electromagnetic interference including high-voltage transmission lines at DNGS and telecommunications towers. The assessment concluded that since electromagnetic interference sources are continuously present (including lightening induced electromagnetic interference), the risk of electromagnetic interference at the site must be addressed in the design basis of the new plant (currently, that is the BWRX-300 facility).

2.2.10 Characterization of On-site Methane Hazard

During initial site investigation, naturally occurring gas (methane) was found at/or near the bedrock/overburden interface in Boreholes DN-34, DN-41, DN-44, DN-48, DN53, DN-57, and DN-60 as described in Subsection 5.3.1 and Section 9.3 of the 2009 NK054-REP-01210-00011 Site Evaluation (Reference 2.2-6). Methane gas is harmful to the health of humans and is combustible. Methane is naturally produced at low-level from the bedrock by decaying vegetation from long ago.

Excavation near the bedrock/overburden interface will monitor for the methane gas and precautionary measures during construction will be taken per work documentation as required by the Canadian Centre for Occupational Health and Safety. For the RB excavation, the methane is expected to dissipate quicker than what was observed in the boreholes due to the significantly larger air space.

2.2.11 References

2.2-1 NK054-REP-01210-00008 R001, 2009, "Site Evaluation for OPG New Nuclear at Darlington - Nuclear Safety Considerations," Ontario Power Generation.

2.2-2 NK054-REP-01210-00019 R000, 2009, "Identification of Potential Design Implications Resulting from the Darlington Site Evaluation Project," Ontario Power Generation.

2.2-3 NK054-REP-01210-00108 R000, 2019, "Site Preparation Nuclear Safety Licence Renewal Activity Report," Ontario Power Generation.

2.2-4 NK054-CORR-00531-10533, 2020, "Application for Renewal of OPG's Darlington New Nuclear Project (DNNP) Nuclear Power Reactor Site Preparation Licence (PRSL)," Ontario Power Generation.

2.2-5 NK38-REP-03611-10043 R003, 2019, "Hazards Screening Analysis – Darlington," Ontario Power Generation.

2.2-6 NK054-REP-01210-00011 R001, 2009, "Site Evaluation of the OPG New Nuclear at Darlington - Part 6: Evaluation of Geotechnical Aspects," Ontario Power Generation.

2.2-7 NK054-REP-01210-00018 R001, 2009, "Site Evaluation of the OPG New Nuclear at Darlington - Additional Considerations," Ontario Power Generation.

2.2-8 NK054-REP-01210-00078 R007, 2021, "Darlington New Nuclear Project Commitments Report," Ontario Power Generation.

2.2-9 NK38-SR-03500-10002 R005. 2017, "Darlington Nuclear 1-4 Safety Report: Part 3 – Accident Analysis," Ontario Power Generation.

2.2-10 NK054-REP-01210-00144 R000, 2022, "(DNNP) Hazard Analysis Methodology," Ontario Power Generation.

2.2-11 NK054-REP-01210-00150 R000, 2022, "Darlington New Nuclear Project Rail Transportation – Toxic Gas/Chemical Release Hazard Assessment," Ontario Power Generation.

2.2-12 NK054-REP-01210-00149 00149 R000, 2022, "Darlington New Nuclear Project Rail Transportation – Explosion Hazard Assessment," Ontario Power Generation.

2.2-13 P-CORR-00531-23042, 2022 "Pickering NGS – Request to Extend Deadline Under PROL 48.01/2028 Licence Conditions 15.1 and 15.4 Related to the End of Commercial Operation", Ontario Power Generation.

2.2-14 CNSC Regulatory Document REDGOC-2.4.1, "Safety Analysis - Deterministic Safety Analysis."

2.2-15 CNSC Regulatory Document REGDOC-2.5.2, Version 1.0, "Design of Reactor Facilities: Nuclear Power Plants."

2.2-16 NK054-CORR-01210-1043237 R000, 2022, "St. Marys' Tank Location," Ontario Power Generation

2.2-17 CNSC DEC 21-H107, October 26, 2021, "Record of Decision – Application to amend Power Reactor Operating Licence PROL 13.02/2025 to Authorize Production of Molybdenum-99 at the Darlington Nuclear Generating Station."

2.3 Proximity of Industrial, Transportation and Other Facilities

Information in Section 2.3 describes potential hazards associated with transportation network, industrial facilities and the DNGS which are proximate to the DNNP site.

2.3.1 Transportation Network

There are multiple transportation networks within, adjacent to, and around the Darlington Nuclear site that present potential risks to the BWRX-300 facility operation.

a. Canadian National Railway

   The Canadian National Railway line bisects the Darlington Nuclear site and is primarily used to transport commuters (VIA Rail) with services from Toronto to Kingston, Montreal, and Ottawa. Significant number of passengers travel this route annually and tremendous cargo is transported annually on the line, including coal, forest products (e.g., lumber), chemicals, petroleum products (e.g., asphalt), automotive parts/products, and agricultural goods (e.g., fertilizer).

   Given the high frequency of both commuter and cargo traffic on this railway line, there is a potential risk of train derailment at the site. This risk is mitigated to some degree as the railway line is well buffered by berms on both sides of the railway corridor that would involve any possible derailment. In addition, VIA Rail announced in 2021 it was embarking the High Frequency Rail project that will divert a portion of the commuter rail to a separate line to relieve congestion on the current line and avoid congestion risks with cargo/freight shipments.

   Additional information on hazards related to rail transportation accidents is provided in Subsection 2.2.3.2.

b. Highway 401

   Highway 401, its official name Macdonald–Cartier Freeway, is a controlled-access 400-series highway stretching from Windsor in the west to the Ontario–Quebec border in the east. The highway runs along the north of the Darlington Nuclear site boundary as a six lane (three east-bound lanes and three west-bound lanes) highway.

   Information on transportation risk associated with the 401 highway is described in Subsection 2.2.3.3.

c. Oshawa Executive Airport

   The Oshawa Executive Airport, owned and managed by the City of Oshawa, is located northwest of the Darlington Nuclear site. It is located on an approximately 2.0 km^2 site with a modern terminal building and dual runways measuring approximately 1296 m and 809 m, respectively, to service different types of aircraft. The airport is required by the federal government to operate until 2047 but may close prior to 2047 (but not before 2033 at the earliest) if Pickering airport is opened. In 2018, total aircraft movement at the airport was over 78,000.

   Information on risk associated with air transportation is presented in Subsection 2.2.3.1.

2.3.2 Industrial Facilities

There are few industrial facilities in proximity to the east of the DNNP site and to the west of the DNGS site that could cause potential risks to the BWRX-300 operation. Details are presented on such facilities in Subsection 2.1.1, and on pertinent potential hazards in Subsection 2.2.4 and Subsection 2.2.6.

2.3.3 Darlington Nuclear Generating Station Site

There are numerous activities at the DNGS that may impact the operation of the BWRX-300. The following activities apply:

a. OPG uses arial photography drones, for inspection of the exterior of some of the DNGS buildings, as well as systems and components. The hazard of such drone crashing on the BWRX-300 buildings is bounded by the design basis automobile tornado missiles (refer to Subsection 2.6.6).

b. Chemicals and gases used at the 2019 DNGS NK38-REP-03611-10043 (Reference 2.3-1) are screened out on the basis:

    - That their impact is bound by the impact of similar chemicals on the BWRX-300 (refer to Section 2.4, Table 2.4-1)
    - Of distance from the DNNP site
    - Of the probability of occurrence of relevant accidents.

Refer to Subsection 2.2.5.3 and Subsection 2.2.5.4 for additional and detailed coverage of other hazards related to the operation of the DNGS, or activities being undertaken at the DNGS site.

2.3.4 References

2.3-1 NK38-REP-03611-10043 R003, 2019, “Hazard Screening Analysis - Darlington,” Ontario Power Generation.

2.4 Plant Site Activities Influencing Plant Safety

Section 2.4 includes two subsections:

- Subsection 2.4.1, which evaluates processes and activities at the DNNP site that, if incorrectly carried out, could affect or influence the safe operation of the BWRX-300 facility
- Subsection 2.4.2, which discusses measures for site and shoreline protection.

2.4.1 Site Hazards

Subsection 2.4.1 is limited to processes and activities at the DNNP site. Activities at DNGS or other off-site industrial locations are considered in Section 2.3. Subsection 2.4.1 information is focused on the following site-specific sources of hazards:

- Potentially explosive gases – Subsection 2.4.1.1
- Flammable vapour clouds – Subsection 2.4.1.2
- Toxic chemicals – Subsection 2.4.1.3
- Fire and smoke – Subsection 2.4.1.4

Table 2.4-1 provides a listing of gases and chemicals stored on the DNNP site.

Table 2.4-1: Summary of Gases and Chemicals Stored on DNNP Site

Chemical/Material (Formula/Trade/State)	Location (subject to change)	Quantity	Hazard Screening
Nitrogen	Gas Storage Area West of TB	Approximately 50 m^3 (Cryogenic Storage Tank)	Nitrogen is evaluated as potential asphyxiant concern for MCR and SCR habitability.
Hydrogen	Gas Storage Area West of TB	Each cylinder stores 356.1 standard cubic meters (SCM).	Hydrogen is a potential explosive and fire concern. Minimum separation distance between the cylinders and the BWRX-300 RB wall is determined based on explosive potential.
Diesel Fuel	Tank North of the Protected Area Access Building	Approximately 114 000 L Tank	Not a toxic or explosive hazard. Potential of fire hazard is addressed in Chapter 9A, Section 9A.6.
Turbine Oil	Tank North of the Protected Area Access Building	Approximately 20 000 L tank (volume of the tank does not impact MCR habitability)	Not a toxic or explosive hazard. Potential fire hazard is addressed in Chapter 9A, Section 9A.6.
Sodium Hypochlorite (7 to 15% Solution)	Adjacent to Pumphouse/Forebay, and Intake Shaft	Approximately 4000 L tank	Sodium hypochlorite is not considered a hazard due to being a liquid at 37.8 °C (100 °F) and normal atmospheric pressure. Sodium hypochlorite has a relatively low vapour pressure. Due to the relatively low vapour pressure, no significant unreported and prolonged release that could affect MCR habitability would be expected even in the event of a major spill.
Sodium Bisulphite (24 – 38% Solution)	Adjacent to Pumphouse/Forebay, and Intake Shaft	Approximately 11 400 L tank	Based on chemical safety data sheet sodium bisulphite is relatively stable. Sodium bisulphite is not considered a hazardous substance based on an absence of associated Immediately Dangerous to Life and Health exposure limits in National Institute of Occupational Safety and Health.
Captor Thiosulphate Dichlorination	Adjacent to Pumphouse/Forebay, and Intake Shaft	Approximately 11 400 L tank	Based on chemical safety data sheet captor thiosulphate is not a toxic hazardous substance.
Gasoline	Vehicle Maintenance Garage	Approximately 20 L containers	Gasoline is a potential explosion and fire concern. Small quantities do not pose a significant hazard.
Propylene Glycol	Within the P25, Chilled Water System, throughout the Power Block	39 000 L	Based on chemical safety data sheet propylene glycol is not a toxic hazardous substance for MCR habitability.

Chemical/Material (Formula/Trade/State)	Location (subject to change)	Quantity	Hazard Screening
Tetrafluoroethane (R-134a Refrigerant)	P25 Chillers on RadWaste Building Roof	Each Chiller contains a refrigerant charge of 250 kg	R134a is not a toxic hazard for MCR habitability. Release of the entire contents of the R-134a into the Control Building does not result in an oxygen-deficient environment in the MCR.
Noble Metal Solution	Reactor Building	Approximately 38 L of 1% noble metal solution is utilized over a 2-week time frame per year.	The noble metal solution is not considered a hazard to MCR habitability based on an absence of associated Immediately Dangerous to Life and Health exposure limits in National Institute of Occupational Safety and Health. A potential release will be relatively confined to the RB and not impact MCR habitability.
Depleted Zinc Oxide	Turbine Building (TB)	90 kg dissolution vessel (quantity does not impact MCR habitability)	Zinc oxide is not considered a hazard to MCR habitability based on an absence of associated Immediately Dangerous to Life and Health exposure limits in National Institute of Occupational Safety and Health. A potential release of zinc oxide dust will be relatively confined to the Turbine Building and not impact MCR habitability.

2.4.1.1 Potentially Explosive Gases

The nearest source of potentially explosive gases is the hydrogen gas storage cylinders for the Reactor Water Chemistry System. Table 2.4-1 lists the maximum quantity of hydrogen stored at this location. The hydrogen is stored in several cylinders.

The safe separation distance between the hydrogen storage area and nearest safety-related structure is determined using a methodology such as the approach in EPRI NP-5283-SR, Guidelines for Permanent BWR Hydrogen Water Chemistry Installations, September 1987 (Reference 2.4-1). In the 1987 EPRI NP-5283-SR (Reference 2.4-1) the required separation distance is determined for two different considerations. The first consideration is the required separation distance such that the safety-related structure is not adversely affected by the postulated hydrogen explosion. The second consideration is the required separation distance to air pathways into safety-related structures versus the internal diameter of leaking high-pressure piping. The results of the determination of required separation distance are considered in establishing the layouts for the DNNP site and BWRX-300 facility.

2.4.1.2 Flammable Vapour Clouds

There are no liquids stored on the DNNP site that can generate a significant quantity of flammable vapour.

2.4.1.3 Toxic Chemicals

Table 2.4-1 identifies the chemicals on the DNNP site that are considered in the evaluation of potential toxic chemical hazards. Table 2.4-1 identifies the chemical, the quantity, and how the chemical is dispositioned. Chemicals are initially evaluated based on relative location, quantity stored, toxicity, and properties such as vapour pressure. As shown in Table 2.4-1, from a toxic chemical perspective, the potential hazards at the DNNP site except for nitrogen are dispositioned as not being hazardous for control rooms habitability. The liquid nitrogen, however, cannot be screened out and requires a detailed evaluation.

The threat from nitrogen is displacement of oxygen. No specific acceptance criterion is provided for limiting concentrations, and nitrogen is not considered a toxicity hazard. Nitrogen impacts control room habitability if it displaces sufficient quantities of air to the extent that oxygen levels in the room decrease below a specified threshold. Chemicals are asphyxiating if they result in an oxygen-deficient atmosphere of less than 19.5% oxygen by volume, as defined by the Canadian Centre for Occupational Health and Safety.

As described in Chapter 6, Section 6.4, control room habitability is served by a combination of individual systems that collectively ensure that continued occupancy in the MCR or SCR is possible under Postulated Initiating Events (PIEs) for a minimum of 72 hours as required by REGDOC-2.5.2 (Reference 2.4-4).

Two different scenarios are considered: a tank burst and a tank leak. In the tank burst scenario, all the contents of the tank are instantaneously released. For the tank leak scenario, the nitrogen is leaked at a constant mass flow rate until the tank is empty over an assumed time. Inputs to the analyses include meteorological stability classification, wind speed, air temperature, and the assumed leak rate for the tank leak scenario. Several sensitivity cases are run to determine the limiting input values. For each location, the control room ventilation system is modeled in the analyses to credit the effects of intake and dilution within the control room atmosphere during the passage of the plume.

The limiting results from the analyses of the postulated nitrogen tank burst and leak scenarios are used to confirm that the placement of the tank relative to the MCR and SCR ventilation intakes is acceptable.

2.4.1.4 Fire and Smoke

On-site flammable and combustible liquid or gas storage facilities are designed in accordance with applicable fire codes, and plant safety is not jeopardized by fires or smoke in these areas. A detailed description of the fire protection system, as well as the Fire Hazard Assessment (FHA) methodology is presented in Chapter 9A, Section 9A.6.

2.4.2 Measures of Site Protection

As described in Subsection 2.7.1, the plant grade elevation at 88 m CGD is established using grading and engineered fill. Excavation is performed to depths to reach materials of specific properties suitable for buildings foundations. Materials removed during the excavation are reconditioned for use as backfill material if the material meets the required specifications or are disposed as spoils. Engineered fill material requirements are specified in Subsection 2.7.5.2.1.

The hydrology for the site and vicinity is described in Section 2.5. The site does not credit dams or dikes for flood protection. As described in Section 2.5 the topography and grading at the plant site are considered in the site flooding analyses to demonstrate the plant is adequately protected from precipitation events.

As described in the 2022 NK054-REP-07730-00055 DNNP Environmental Impact Statement [EIS] Review Report for BWRX-300 (Reference 2.4-2), the BWRX-300 deployment will not require lake infilling and, consequently, the associated adverse effects on site drainage and water quality will not occur. The BWRX-300 deployment will still require some shoreline protection works, but such works are expected to be smaller in scale resulting in smaller residual adverse effects on shoreline processes than those assessed in the 2009 EIS for no specific reactor technology NK054-REP-07730–00029 (Reference 2.4-3).

The construction of the first BWRX-300 would provide an opportunity to retain the Bank Swallow nesting habitat as the bluff would be remaining in place and as the impact of excavation and construction activities will be kept to a minimum, per the 2022 NK054-REP-07730-00055 (Reference 2.4-2). When the DNNP site is built out to include a total of four BWRX-300 reactors, additional shoreline protection is to be implemented to stabilize the shoreline as described in the 2022 NK054-REP-07730-00055 (Reference 2.4-2).

The specific extent and location of the shoreline protection works is determined in later phases of the project.

2.4.3 References

2.4-1 EPRI NP-5283-SR, “Guidelines for Permanent BWR Hydrogen Water Chemistry Installations,” 1987, Electric Power Research Institute.

2.4-2 NK054-REP-07730-00055, 2022, “Darlington New Nuclear Project Environmental Impact Statement Review Report For Small Modular Reactor BWRX-300,” Ontario Power Generation.

2.4-3 NK054-REP-07730–00029, 2009, “Environmental Impact Statement New Nuclear - Darlington Environmental Assessment,” Ontario Power Generation.

2.4-4 CNSC Regulatory Document REGDOC-2.5.2, Version 1.0, “Design of Reactor Facilities: Nuclear Power Plants.”

2.5 Hydrology

2.5.1 Introduction

Section 2.5 describes the hydrological conditions and their potential implications relevant to the DNNP site. Section 2.5 includes information on:

- The adequacy of the cooling water supply from Lake Ontario along with risks to the water supply (i.e., biofouling and frazil ice) - Subsection 2.5.2
- The potential flooding hazards, including the Probable Maximum Precipitation (PMP), Probable Maximum Flood (PMF), as well as flooding potential from runoffs, rivers, waves, storm surge and seiche, tsunami, and ice jamming - Subsection 2.5.3
- The potential impact of climate change - Subsection 2.5.4
- Assessment and monitoring of radionuclide dispersion in the groundwater – Subsection 2.5.5
- Assessment and monitoring of radionuclide dispersion in surface water – Subsection 2.5.6

Key hydrological characteristics and parameters described in Section 2.5 relevant to the DNNP site and the surrounding area are summarized and listed in Table 2.5-1. The list includes information on Lake Ontario adequacy as a water supply for use as a heat sink, maximum precipitation and flooding and associated probabilities, as well as surface and subsurface geotechnical properties relevant to transport of radionuclides.

Table 2.5-1: Hydrological Characteristics Summary of DNNP Site and Surrounding Area

<table>
<tr><td colspan="4">2.5.2 Description of Heat Removal Methods and Heat Sink</td></tr>
<tr><td>Normal Heat Removal / Normal Heat Sink</td><td colspan="3">The NHS is a once-through cooling water source from Lake Ontario to the CWS and the PCW</td></tr>
<tr><td>Ultimate Heat Removal / Ultimate Heat Sink</td><td colspan="3">The Isolation Condenser System consists of three high-pressure reactor isolation loops that passively remove heat from the reactor when the normal heat removal system is unavailable.</td></tr>
<tr><td colspan="4">2.5.2.1 Description of Lake Ontario Water Levels and Adequacy of Water Supply</td></tr>
<tr><td>Water Level</td><td colspan="3">Controlled by the International Joint Commission</td></tr>
<tr><td rowspan="6">Variability of Water Level (at the intake)</td><td>Lowest water level</td><td>73.71 m (statistical data at Cobourg Water Level Station) (Reference 2.5-18)</td><td>→ 73.71 m</td></tr>
<tr><td>Impact of seiche</td><td>0.75 m (reduction)</td><td>→ 72.96 m</td></tr>
<tr><td>Wave trough (1 s passage)</td><td>4.08 m (reduction)</td><td>→ 68.88 m</td></tr>
<tr><td>Spring tides</td><td>Less than 5 cm (hidden as part of normal fluctuation)</td><td>→ 68.88 m</td></tr>
<tr><td>Wave downwash</td><td>Close to the shoreline with no effect</td><td>→ 68.88 m</td></tr>
<tr><td>Tsunami</td><td>No risk expected</td><td>→ 68.88 m</td></tr>
<tr><td rowspan="3">Water Depth Available</td><td>Normal Conditions
73.71 – 62.50 m</td><td>11.21 m above the intake level of 62.50</td><td rowspan="3">Therefore, water supply is adequate under normal and extreme conditions</td></tr>
<tr><td>Impact of Seiche
72.96 – 62.50 m</td><td>10.46 m above the intake level of 62.50</td></tr>
<tr><td>Impact of Wave Trough (1s duration)
68.88 – 62.50 m</td><td>6.38 m above the intake level of 62.50 m</td></tr>
<tr><td colspan="4">2.5.2.2 Potential Impacts of Biofouling on Water Supply</td></tr>
<tr><td>Algae</td><td colspan="3">Algae have the potential to be entrained at cooling water and water supply system intakes, resulting in blockage or restriction issues.</td></tr>
<tr><td>Micro-biologicals</td><td colspan="3">Biological coatings or biofilms and particulate deposition on tube surfaces can cause lost flow capacity, extensive repairs and material replacement costs in heat exchangers, fire protection systems, storage vessels, intakes, and water distributions systems.</td></tr>
<tr><td>Macrophytes</td><td colspan="3">Macrophytes can contribute to macrofouling through sticks, leaves and other plant constituents from either terrestrial or aquatic sources that become a component of lake drift and debris material.</td></tr>
<tr><td>Mollusks</td><td colspan="3">Zebra and quagga mussels can clog water intake structures, such as screens, tunnels and pipes.</td></tr>
<tr><td>Fish</td><td colspan="3">Various life stages of fish can be taken into a cooling water system with the cooling water (entrainment), and consequently fish reach screens that protect the cooling water and other water systems (impingement). An excessive load of fish can cause blockage to the screening system and sump. In extreme events where screens become overloaded water supply can be reduced with associated reduction in power supply.</td></tr>
<tr><td colspan="4">2.5.2.3 Potential Impacts of Frazil Ice Accumulation on Water Supply</td></tr>
<tr><td>Frazil Ice Accumulation</td><td colspan="3">Accumulation of frazil ice on the intake trash rack, which can partially or completely block the trash rack and rapidly and unexpectedly shut down the intake facility</td></tr>
</table>

2.5.3 Description of Potential Sources of Flooding		
2.5.3.1 Flooding Due to PMF	PMP	420 mm 12-hour precipitation, equivalent to 420 mm of total rainfall, with 51% in the 6th hour with a return period of 1:1,000,000 year (Reference 2.5-19)
	Design Basis Flood	Conservative Rainfall: Standardized value of 12-hour PMP in Ontario of 420 mm, with zero infiltration (which greatly exceeds Hurricane Hazel in depth and intensity)
	PMF – Screened in	The event scenario involves a large volume of water runoff flooding the site (based on the application of PMP), while the drainage systems are blocked (due to debris or ice pellet), the soil nearby is saturated, and the lake water level is at 100-year high. Also, it is conservatively assumed that there is no time for implementing preventative measures or taking mitigating actions. The PMF sequence is expected to be worse than a lake level increase or heavy precipitation alone, and the event is not bounded by any other events. As such, flooding due to PMF could not be screened out based on screening criteria [QL1] through [QL5].
	Design Basis Flood Level	Using design basis flood (that is, PMP with zero infiltration), for modeling drainage for BWRX-300 Unit-1 or an assumed 4-unit layouts, Section 5.4.3 of Reference 2.5-18 resulted in flood water levels of up to 87.93 m CGD, considering realistic assumptions for stormwater infrastructure, including factors such as culverts sizing, conveyance, routing, and ponds.
2.5.3.2 Flooding Due to Runoffs	Natural or via Stormwater Management and infrastructure	• Five of nine catchments drain directly to Lake Ontario or to Darlington Creek watershed. • Remaining four catchments close to the BWRX-300 development area drain through a stormwater infrastructure directly to Lake Ontario and via engineered culverts stormwater infrastructure running to the southeast of DWMF to Lake Ontario (Reference 2.5-18). • Measures are proposed to mitigate the impact of PMP flooding due to runoff.
	Screened out, per [QL2]	PMF bounds flooding caused by runoffs.
2.5.3.3 Flooding Due to Rivers	Screened out, per [QL3]	The distance, infrastructure, and topography between the Tooley Creek watercourse and the DNNP site precludes Tooley Creek as the source of a flood hazard, There is not any history of severe flooding along Darlington Creek within the recorded history of the area. This is confirmed by the (2022) Flood Hazard Assessment (Reference 2.5-18) that modeled drainage of Darlington Creek watershed under 100-year recurrence PMP.
2.5.3.4 Flooding Due to Waves	Screened in (related to Shoreline Protection issue)	Wave height of 6.1 m and peak period of 9.2 s is recommended (Reference 2.5-18) Data and models suggest wave uprush between 3.5 to 11.3 m, and overlapping from 0.015 to 0.591 $m^3/s/m$. (Reference 2.5-2)
2.5.3.5 Flooding Due to Storm Surge and Seiche	Screened out	Models of most severe weather systems predicted a highest water level from storm surge or seiche of 0.75 m, per (Reference 2.5-2), and (Reference 2.5-18). The margins between the lake level and the top of the DNNP breakwater works are larger than 0.75 m.

2.5.3.6 Flooding Due to Tsunami	Screened out, per [QL3]	A tsunami in Lake Ontario is an improbable event for DNNP.
2.5.3.7 Flooding Due to Ponds, Dams or Dikes	Screened out, per [QL3]	There are no large permanent human-made water storage ponds, dams or dikes near the Darlington Nuclear site that can threaten the site.
2.5.3.8 Flooding Due to Ice Jamming	Screened out per [QL2] or [QL3]	Bounded by the detailed PMF analysis (Reference 2.5-4); or based on the conclusion of negligible ice forming in Lake Ontario near the DNNP region (Reference 2.5-18).
2.5.4 Potential Effects of Climate Change		
Effect on Temperature, Precipitation. Lake Water Level	Screened in	• Some models showed increase in the intensity (about 14%) and frequency (about 22%) of extreme precipitation in southern Ontario (Reference 2.5-2) • Maximum found historical lake water level is 75.6 m, which should be used as low estimate (Reference 2.5-13) • For additional information, refer to the 2022 "Flood Hazard Assessment NK054-02730-00001 (Reference 2.5-18) and the 2023 Darlington New Nuclear Project Strategy for Addressing Climate Change Impacts NK054-PLAN-07007-00001 (Reference 2.5-20)
2.5.5 Groundwater		
2.5.5.1 Groundwater Conditions	Described in detail in Subsection 2.7.3.2.4.	
Groundwater Flow System	Categorized into three hydrostratigraphic units: Shallow/Water Table; Interglacial Deposits; and Shallow Bedrock. In general, groundwater flows from north to south, and discharges toward Lake Ontario.	
Groundwater Level	Groundwater is anticipated to be present between elevation 80 to 85 m corresponding to depths of between 3 and 8 m below the plant grade at elevation 88 m.	
Monitoring	Environment Monitoring Program is employed along with the use of groundwater wells that are located in key areas of the Darlington Nuclear site, including protected areas, controlled areas, and site perimeter.	
2.5.6 Surface Water		
2.5.6.1 Surface Water Properties		
Water movement near the site is predominantly along the shore, occurring for 73% of the time (35% to the west and 38% to the east).		
Depth Averaged Speed – all directions		12.4 cm/s
Depth Averaged Speed – Easterly		14.1 cm/s
Depth Averaged Speed – Westerly		11.3 cm/s
Temperature		Lake-wide surface temperatures typically rage from freezing in winter to approximately 20 °C in summer.
Ice Conditions		Typically, are limited to the nearshore areas at the eastern end of the lake within the Kingston Basin.
2.5.6.2 Surface Water Monitoring		
Lake Current Monitoring		A real-time current profile measurement system to be used in the event of a radiological liquid emission.
Monitoring		Environment Monitoring Program is employed along with the Lake Current Monitoring system which a real-time current profile measurement system to be used in the event of a radiological liquid emission.

2.5.2 Description of Heat Removal Methods and Heat Sink

The NHS System that is described in Chapter 9A, Subsections 9A.2.5 provides cooling water source and heat rejection means to support the function of the Circulating Water System (CWS) (Chapter 10, Section 10.8) to supply cooling water to the MCA system (Chapter 10, Section 10.5), as well as to interface with the PCW (Chapter 9A, Subsection 9A.2.1). The NHS is a once-through cooling system using water from Lake Ontario. The water flows through the intake tunnel via the onshore intake vertical shaft to the Pumphouse/Forebay where the circulating water pumps deliver the cooling water to the MCA and PCW heat exchangers before returning the heated water back to the lake via the onshore discharge vehicle shaft through the discharge tunnel to the risers/diffusers.

The BWRX-300 Isolation Condenser System (ICS), described in Chapter 6, Section 6.2, consists of three independent trains, each containing a heat exchanger or Isolation Condenser (IC) that is submerged in a dedicated pool of water. The ICS provides the ultimate heat sink for protecting the reactor core for any off-normal event where the main condenser is not available, and the Reactor Pressure Vessel (RPV) is isolated.

The ICS Pool Cooling and Cleanup System (ICC) that is described in Chapter 9A, Subsection 9A.2.6 is designed to precondition and maintain the ICS pools in a state of readiness for postulated events that require reactor decay heat removal.

The FPC, as described in Chapter 9A, Subsection 9A1.3, has a primary function to provide continuous cooling of the water volume in the fuel pool to remove decay energy from irradiated fuel, and to provide replacement coolant inventory from a variety of sources, both to ensure irradiated fuel is kept cool and submerged under water throughout the life of the plant.

2.5.2.1 Description of Lake Ontario Water Levels and Adequacy of Water Supply

Lake Ontario is one of the main reservoirs of cooling water for the DNNP site. An assessment for the adequacy of water supply to DNNP was completed in the 2009 NK054-REP-01210-00018 (Reference 2.5-1) and validated in the 2022 Flood Hazard Assessment NK054-REP-02730-00001 (Reference 2.5-18), as described in the following paragraphs.

The water level in Lake Ontario is regulated by the International Joint Commission to reduce damages along the shores of the lake and the St. Lawrence River, per the 2022 Flood Hazard Assessment NK054-REP-02730-00001(Reference 2.5-18). The control of water levels by the International Joint Commission continues in the future and, though the plan for regulation may change, the fundamental function of eliminating extreme lake levels remains. However, the International Joint Commission acknowledges that it may become increasingly difficult to maintain levels within their currently defined operating band depending on the relevant impact of climate change in the future (refer to Subsection 2.5.4 which discusses the impact of climate change on Lake Ontario water levels). Careful consideration of the International Joint Commission study for management options, which included robust modeling of potential future levels under a range of stochastically generated hydrological and meteorological conditions, led to estimates greater than 100-year recurrence low water levels at 73 m as reported in Subsection 5.1.5 of the 2009 NK054-REP-01210-00012 (Reference 2.5-2). However, analysis of historical data at the Water Survey of Canada Cobourg Water Level Station shows a minimum water level of 73.71 m, as reported in the 2022 Flood Hazard Assessment, NK054-REP-02730-00001 (Reference 2.5-18).

Additional factors which influence the minimum water level at the intake were considered in the 2009 NK054-REP-01210-00018 (Reference 2.5-1) as follows:

1. A numerical model of the hydrodynamics of Lake Ontario was developed to assess the potential for generation of surge and seiche in response to extreme severe weather

systems tracking through the region. The maximum wave heights expected at the intake location will be depth limited. The lowest water level of 73.71 m, further lessened by 0.75 m due to seiche, yields an elevation of 72.96 m or a depth of 10.46 m at the intake of an elevation of 62.50 m.

2. Estimating wave breaking at about 0.78 times the water depth of 10.46 m yields maximum wave heights of about 8.08 m. An associated wave trough, taken as half the maximum wave height (that is 4.8 m), might reduce the depth to 6.38 m, though it is noted that the passage of large waves would be short-lived and on the order of 1s. (Note: The 8.16 m Maximum wave height is more conservative that the maximum wave height of 6.1 m recommended in Subsection 2.5.3.4.)
3. The largest spring tides in Lake Ontario are less than 5 cm in height and these minor variations are hidden by greater fluctuations in lake levels produced by wind and barometric pressure changes. Consequently, Lake Ontario is considered to be essentially non-tidal.
4. Wave downrush would occur within a relatively close distance to the shoreline and would have no effect on the water level near the intake.
5. The 2009 flood hazard assessment (Reference 2.5-2) concluded there is no risk of tsunamis so that there is no drawdown potential from that phenomenon that could affect nearshore lake levels. The 2022 Flood Hazard Assessment (Reference 2.5-18) also concluded the Darlington Nuclear site lies in a region with a low probability of tsunamis.

Consequently, even under the extreme scenario considered in the 2009 NK054-REP-01210-00018 (Reference 2.5-1) and the 2022 NK054-REP-02730-00001 Flood Hazard Assessment (Reference 2.5-18), a depth of more than 6 m remains over the intake at the lakebed elevation. Therefore, lake water supply is adequate for the DNNP cooling water intake.

Given the adequacy of the water supply from Lake Ontario, the potential for using groundwater sources in extraordinary situations is not considered.

Consideration for additional factors which might impact the availability of the cooling water supply were also assessed in the 2009 NK054-REP-01210-00018 (Reference 2.5-1), namely concerns related to biofouling and frazil ice conditions. These are discussed separately in the following two subsections.

Additional information on Lake Ontario's current, temperature, and ice conditions is provided in Subsection 2.5.4.2.

2.5.2.2 Potential Impacts of Biofouling on Water Supply

1. Algae: The Lake Ontario shoreline provides a favorable growth environment for Cladophora which are prominent nuisance filamentous algae that have the potential to affect the DNNP. Cladophora characteristically grows attached to hard surfaces within the littoral zone and where habitat conditions are optimal, thick mats of the algae can form across the lake substrates and become attached to infrastructure features. During mid-summer and fall, Cladophora senesces, the algae become detached from the substrate and drift in a suspended manner with waves and currents.

   The loose filaments as well as more substantial clumps of algae have the potential to be entrained at cooling water and water supply system intakes, resulting in blockage or restriction issues at the inlet as well as further blockage and organic material loading at the trash racks or travelling screen system.

2. Micro-biologicals: Biofilms consist of microorganisms immobilized at a substratum surface, typically embedded in an organic polymer matrix of bacterial origin. Such biofilms are ubiquitous in flowing aqueous environments, are not necessarily uniform in time and space, and may trap inorganic substances within the polymer matrix. Biofilms develop on virtually all surfaces immersed in natural aqueous environments, irrespective of whether the surface is biological (aquatic plants and animals) or abiological (stones, particles, metal, and concrete, etc.). Extensive bacterial growth, accompanied by excretion of copious amounts of extracellular polymers, thus leads to the formation of visible slimy layers (biofilms) on solid surfaces.

   Thin biological coatings or biofilms associated with microorganisms can reduce the efficiency of heat exchangers (forcing shutdowns or de-rating), enhance silt and particulate deposition on tube surfaces (causing fouling and pipe wall pitting), lost flow capacity, extensive repairs and material replacement costs in heat exchangers, fire protection systems, storage vessels, intakes, and water distributions systems.

3. Macrophytes: Both terrestrial and aquatic plants can contribute to floating and suspended plant material that becomes susceptible to entrainment at water intakes. A variety of rooted aquatic macrophytes are common to Lake Ontario. The existing DNGS forebay was shown to contain a community of Eurasian watermilfoil (Myriophyllum spicatum L.), the only rooted plant observed. The biomass of this material was estimated at 1.5 tons providing an indication of the potential availability of organic mass that can contribute to the load on the screening system. A future regional increase in aquatic plants and algae was concluded as being a reasonable expectation as the lake water clarity increases with the filtering effects of the exotic invader zebra and quagga mussel.

   Macrophytes can contribute to macrofouling through sticks, leaves and other plant constituents from either terrestrial or aquatic sources that become a component of lake drift and debris material. During the fall season when macrophytes typically senesce, the organic material of the plant stems and foliage have the potential to fragment and block travelling screens.

4. Mollusks: Lake Ontario contains confirmed populations of non-native invasive nuisance mussels including the zebra mussel, Dreissena polymorpha, and the quagga mussel, Dreissena rostriformis bugensis, inadvertently introduced to North America in the ballast water of oceangoing ships. More recent colonization has involved the quagga mussel, which has a preference for deeper, cooler water as compared to the zebra mussel and has now largely replaced the zebra mussel. Given the record of non-native introductions to Lake Ontario, additional nuisance mollusk species may appear in the future. The Asiatic clam Corbicula fluminea has been recorded in North America the longest of the three key invasive species arriving on the west coast in the 1920s and reaching the east coast by 1980s; however, it has not yet been reported as an issue in Lake Ontario.

   Dreissena species ability to rapidly colonize hard surfaces causes serious economic problems and potential reduced efficiency of water supply systems. These major biofouling organisms can clog water intake structures, such as pipes and screens, therefore reducing pumping capabilities for power and water treatment plants. Power plant features that may become fouled include crib structures, trash bars, screenhouses, steam condensers, heat exchangers, penstocks, service water systems and water level gauges.

5. Fish: Lake Ontario hosts a diverse population of both warm and cold-water fish species, many of which may utilize the project area either as local residents or seasonal migrants. During impingement investigations at DNGS operations from 1993 to 1995, fish encountered at the mitigative screen system and in sumps included at least 17 species. The predominant species were generally of a smaller body size which included alewife, shiner species and smelt, all representatives of the abundant forage fish-based community of the lake. Major community changes occurred with the introduction of non-native species through opening of waterways, intentional stocking, and unintentional introduction through ballast water of international shipping. This may have a bearing on future operational management systems at DNNP depending on the habits and productivity of a particular species.

   Various life stages of fish can be taken into a cooling water system with the cooling water (entrainment), and consequently fish reach screens that protect the cooling water and other water systems (impingement). An excessive load of fish can cause blockage to the screening system and sumps contributing to maintenance requirements. In extreme events where screens become overloaded water supply can be reduced with associated reduction in power supply.

NOTE: The 2009 report NK054-REP-01210-00018 (Reference 2.5-1) concludes that mitigation measures have been successfully applied at power generating facilities along the north shore of Lake Ontario to address the various forms of biofouling.

2.5.2.3 Potential Impacts of Frazil Ice Accumulation on Water Supply

As described in the 2009 NK054-REP-01210-00018 (Reference 2.5-1), operating water intakes in lakes and rivers in northern regions is complicated by the presence of ice. Controlling the generation and accumulation of frazil ice affects both navigation and power generation. The cooling water intake tunnel can accumulate frazil ice on the intake trash rack, which can partially or completely block the trash rack and rapidly and unexpectedly shut down the intake facility.

2.5.3 Description of Potential Sources of Flooding

Subsection 2.5.3 describes the assessment of potential flood hazards at the DNNP site. (Refer to Subsection 2.1.1 for information on the topography of the Darlington Nuclear and DNNP sites.)

The review of the flood hazard assessment performed in support of the 2020 DNNP Power Reactor Site Preparation Licence (Reference 2.5-3) against the 2019 codes and standards concluded there is no impact on the conclusion of the 2009 Flood Hazard Assessment NK054-REP-01210-00012 (Reference 2.5-2) as documented in the 2019 DNNP Site Preparation Licence Renewal activity report NK054-REP-01210-00108 (Reference 2.5-7).

Also, as stated in Subsection 4.5.3 of the 2020 NK054-CORR-00531-10533 (Reference 2.5-3), the results of the 2019 Darlington Hazard Screening Analysis NK054-REP-03611-10043 (Reference 2.5-4) apply to the DNNP site since the DNNP site is encompassed in the Darlington Nuclear site.

As described and assessed in the 2019 NK054-REP-03611-10043 (Reference 2.5-4), and in the 2022 NK054-REP-02730-00001 Flood Hazard Assessment (Reference 2.5-18), the DNNP flooding hazards are:

- Flooding due to PMF - Subsection 2.5.3.1
- Flooding due to Runoffs - Subsection 2.5.3.2
- Flooding due to Rivers - Subsection 2.5.3.3

- Flooding due to Waves - Subsection 2.5.3.4
- Flooding due to Seiche - Subsection 2.5.3.5
- Flooding due to Tsunami - Subsection 2.5.3.6
- Flooding Due to Ponds, Dams or Dikes - Subsection 2.5.3.7
- Flooding due to Ice Jamming - Subsection 2.5.3.8

These hazards are addressed in the following subsections.

2.5.3.1 Flooding Due to Probable Maximum Flood

As described in Section 5.4 of the 2009 NK054-REP-01210-00012 (Reference 2.5-2), the design storm event used to determine the flood hazard is the PMF event in the 2011 International Atomic Energy Agency (IAEA) SSG-18 (Reference 2.5-10). This is a specific hydrologic term that is defined in conjunction with the PMP, as per the following paragraphs.

The PMF is the flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in a particular drainage area. The PMP is defined as the greatest depth of precipitation for a given duration meteorologically possible for a given size storm area at a particular location at a particular time of year, with no allowance made for long-term climatic trends. It is a common practice that the PMF is the flood which is a direct result of the PMP. The PMP is applied to sub-basin delineations that account for variations in soil type, land use, size and shape of the watershed, and average watershed slope to generate PMF flows.

There are two considerations when determining the PMP for a given application, the site location, and the duration of the storm event. Based on the 2017 Lakes and Rivers Improvement Act Technical Guidelines (Reference 2.5-11), for watershed areas less than 1295 km^2, the PMP maximum precipitation duration of 6 or 12 hours is normally used as it produces the highest peak flood flow

Subsection 4.4.1 of the 2019 NK054-REP-03611-10043 (Reference 2.5-4) states that the Review Level Condition assumes no runoff in the worst hour of the 12-hour PMP; therefore, the flood depth is 51% of the total 12-hour PMP of 420 mm, which is approximately 214 mm, per Table 5.4-1 of the 2022 NK054-REP-02730-00001 (Reference 2.5-18). The PMF event scenario involves a large volume of water runoff flooding the site, while the sewer systems are blocked (due to debris or ice pellet), the soil nearby is saturated, and the lake level is at 100-year high. This PMF sequence is expected to be worse than a lake level increase or heavy precipitation alone, and the event is not bounded by any other events. Finally, it is conservatively assumed that there is no time for implementing preventative measures or taking mitigating actions. As such, flooding due to PMF could not be screened out based on screening criteria [QL1] through [QL5] (refer to Subsection 2.2.2 for descriptions of the screening criteria).

The PMF values which are commonly estimated using a combination of flood-inducing drivers such as snowmelt and rainfall can alternatively be estimated using an extreme rainfall outside the snow season that is higher than spring values. In Subsection 5.4.1 of the 2022 NK054-REP-02730-00001 (Reference 2.5-18), it is assumed that the summer PMP produces extreme floods (i.e., PMFs) at least comparable to the spring PMFs that consider snowmelt. This assumption was verified by comparing the precipitation values of spring (March-April) with summer-fall (May-November); so that a summer PMP can be deemed as the key driver of the PMF, per the 2022 NK054-REP-02730-00001 (Reference 2.5-18).

As described in Subsection 2.1.1 of the 2022 NK054-REP-02730-00002, PMP Validation (Reference 2.5-19), the PMP for watershed areas in the vicinity of and the DNNP site is a 12-hour precipitation equivalent to 420 mm of total rainfall, with 51% of the storm falling in the sixth hour, with a return period of 1:1,000,000. This value is on the conservative side considering the historical observed 24-hour point rainfall in the region is 212 mm (hurricane Hazel).

The design basis flood is the flood resulting from the PMP assuming zero infiltration in the drainage areas on site. In Subsection 5.4.1 of the 2022 Flood Hazard Assessment NK054-REP-01730-001 (Reference 2.5-18) design flood values in the DNNP site region are based on the 1:100-year return period storm or Hurricane Hazel, whichever is the greater. The 1:100-year return period storm was used to calibrate a Darlington Creek model, and as a comparison to the PMP results (refer to Table 2.5-2 under Subsection 2.5.3.3). For small watersheds such as Darlington Nuclear site, where no stream gauge is available, 1:100-year return period rainfall is assumed to produce a 1:100-year return period flood. Since the 420 mm, 12-hour duration PMP greatly exceeds Hurricane Hazel in depth and intensity, Hurricane Hazel was not used in this assessment. the 420 mm, 12-hour duration PMP was selected with zero infiltration as the current design basis storm for the DNNP, as shown in Table 2.5-2.

2.5.3.2 Flooding Due to Runoffs

Existing Pre-development Catchments and Flood Hazard

Section 3.2 of the 2022 NK054-REP-02730-00001 Flood Hazard Assessment (Reference 2.5-18) identified in Section 3.2 nine delineated catchments (A through I) for the pre-developed DNNP site, as shown in Figure 2.5.3.2-1. Information related to catchments A to I are provided in Table 3.2-1 of (Reference 2.5-18), such as area size, land use, soil/surface conditions and runoff. The runoff from Catchment A drains directly into Lake Ontario close to the DNGS forebay. The runoffs from Catchments B, C, D, and E in the north and east flow via the Canadian National Railway right-of-way ditch or through a wetland discharging into the Darlington Creek watershed. The runoffs from Catchments F, G, and H, which are former lay down areas in the DNNP site, flow through culverts southeast of the DWMF building and drain directly into Lake Ontario. The last runoff from Catchment I, a former lay down area, drains through various outlets into Lake Ontario. Potential existing on-site flood hazards include:

- Runoff from Catchments C and D overflowing the Canadian National Railway right-of-way ditch
- Capacity of designed stormwater infrastructure to convey potentially increased peak flows due to proposed DNNP site development.

Subsection 5.4.3 of the 2022 Flood Hazard Assessment (Reference 2.5-18) describes the flood hazard associated with a design basis flood involving PMP falling directly on the DNNP site, assuming 100% impervious land cover. The flood hazard due to direct precipitation is related to the ability of the site development to convey stormwater runoff through the site.

A nodal model (PCSWMM), per Subsection 5.4.3. of the 2022 Flood Hazard Assessment (Reference 2.5-18), of the nine catchments conveyance and retention as well as drainage structures was used to evaluate on-site flood hazards and to size conveyance and retention elements of stormwater for pre-development conditions.

The pre-development results indicate:

- None of Catchments A, B, E, G, and I pose a PMP flood risk on the DNNP site (refer to Table 5.4-11 of Reference 2.5-18)

- Catchments C and D showed significant overflow into the Canadian National Railway right-of-way ditches with no flooding (refer to Table 5.4-12 of Reference 2.5-18)
- While the stormwater infrastructure in Catchment F performs adequately under, for instance, the 1:100-year storm, significant PMP/PMF overflow occurred between its sub-catchments or into neighboring Catchment H, suggesting development is necessary to alter Catchment F and its drainage system (refer to Table 5.4-13 of Reference 2.5-18)
- The stormwater conveyance and retention capacity of Catchment H represents a significant potential overflow under the PMP, between its sub-catchments within the existing infrastructure (refer to Table 5.4-14 of Reference 2.5-18)

These results were carried forward to explore and compare with the post-development results.

Post-development of BWRX-300 Unit 1 Catchments and Flood Hazard

A large portion of the pre-development areas of Catchments F and H would be replaced by Catchment N, within which the BWRX-300 Unit 1 footprint would almost entirely be contained, as shown in Figure 2.5.3.2.2. The runoff from Catchment N flows through a series of culverts, roadside ditches, and a pond to a southern outlet into Lake Ontario. The proposed site layout of the BWRX-300 Unit-1 facility will therefore have significant impact on-site catchments and runoff flow directions. Though the upstream reaches of these catchments will still mostly be intact, most of the pre-development of Catchment F and roughly half of Catchment H will be covered by the footprint of the BWRX-300 facility Unit-1 (refer to Figure 3.2-1 in Reference 2.5-18). Conveyance and retention structure of such catchments would consequently require re-configuration.

The same nodal model PCSWMM) was used for post-development conditions including Catchment N. Culvert locations, diameters, conveyance (in m^3/s) and ditch depths were considered in the assessment. The post-development results for BWRX-300 Unit 1 indicate:

- Catchments A, B, C, D, E, G, and I do not represent a flood hazard for the DNNP site (refer to Subsection 5.4.3.4.1 in Reference 2.5-18)
- Under the PMP, there is significant flooding through the sub-catchments of Catchment F, and to Catchment G (refer to Table 5.4-16 in Reference 2.5-18)
- Current configuration of conveyance and retention structures in Catchment H will experience under the PMP significant flooding into its sub-catchments that may overtop into Catchment G (refer Table 5.4-17 in Reference 2.5-18)
- Catchment N system, comprising ditches, culverts, flood routes and storages, is sized to convey and retain adequately the PMP and is split into 12 sub-catchments described as follows:
  - Sub-catchment N_1 contains an administrative building and a parking lot and drains south through a culvert into N_10
  - Sub-catchment N_2 is a large laydown area, drains through ditch and outlets into N_12. In the model, all the flow within N_2 passes through a culvert adjacent to the Power Block, which is a conservative assumption to ensure N_2 runoff does not flood the Power Block area
  - Sub-catchments N_3 through N_7 contain the Power Block area, and each drain through a dedicated culvert into various downstream sub-catchments, with the culvert sizes chosen to ensure zero flooding of the Power Block area
  - Sub-catchment N_8 is a parking or laydown area draining through a culvert into N_12

- Sub-catchment N_9 is a parking or laydown area draining through a culvert in N_10
- Sub-catchment N_10 is a low area adjacent to the Power Block containing a storm water management pond that drains to the south through a culvert into N_12
- Sub-catchment N_11 is a low area immediately south of the Power Block accepting flow from N_5 and N_7 and conveying through a culvert to N_12
- Sub-catchment N_12 is a perimeter ditch, accepting flows from the remainder of Catchment N and conveying toward the Catchment H outlets to Lake Ontario

Post-development BWRX-300 Unit 1 Modeled Available Freeboard

The post-development peak flow and flooding results for Catchment N, shown in Table 5.4-18 of (Reference 2.5-18), indicate with “realistic” assumptions (i.e., the largest culvert in the system is 1 m in diameter) for sizing of conveyance and retention structures, the maximum flood level within the Catchment N system is 87.93 m CGD. This provides 0.07 m of freeboard below the 88 m CGD construction grade which is a flood hazard, but by increasing the conveyance and retention capacity of the system, this freeboard can be brought to a comfortable level.

Comparison of Pre- and Post-development of BWRX-300 Unit 1Results

Comparison of pre-developed and post-developed modelling results of BWRX-300 Unit 1 indicate (refer to Subsection 5.4.3.5 and Table 5.4-22 of Reference 2.5-18):

- There are no changes in Catchments A, B, C, D, E, G, and I.
- Maximum flood depth elevation changes between -0.02 m to +0.06 m in Catchment F since it is reconfigured from pre-development conditions.
- Maximum flood depth elevation changes between -0.23 m to +0.17 m occurred in Catchment H since it is also changed in post-development conditions, and it must convey and retain runoff from Catchment F and some runoff that may overtop into Catchment G.

Impact of Modeling of Four BWRX-300 Units

Additional modeling analysis showed with proper sizing and arrangement of additional conveyance and retention infrastructure in future site plans, the construction of additional three BWRX-300 units will not impact the functionality of the stormwater infrastructure protecting the first BWRX-300.

Proposed Flood Mitigation, Proofing, and Practice for DNNP

In Section 6 of the 2022 Flood Hazard Assessment (Reference 2.5-18), flood mitigation or flood proofing practices applicable to the DNNP as well as mitigation measures are proposed. Options for flood mitigations applicable to the DNNP site include:

- Constructing barriers to stop floodwater from entering the structure/site areas
- Constructing retention and detention ponds to slow and/or stop floodwaters entering the site area
- Wet Flood Proofing whereby floodwaters are allowed to enter the structure/site area, but ensuring that there is no or minimal damage to the building's structure/site and to its contents
- Emergency management/flood forecasting.

Summary of Flood Hazard for the DNNP Site

Table 6.2-2 in the 2022 Flood Hazard Assessment (Reference 2.5-18) summarizes the primary source of flood hazards for the DNNP site due to runoff. In essence, the flood hazards would be to backwatering and flooding of various sub-catchments causing overtopping of the receiving catchments or overloading the existing stormwater management infrastructure. Proposed mitigation includes measures such as:

- Increase the size of specific culverts draining into specific sub-catchments
- Increase the storage capacity of one or more stormwater management ponds
- Route runoff from specific catchments into other specific catchments
- Ensure progressing designs have sufficient conveyance and detention capacity and the stormwater infrastructure is adequate.

Per Subsection 5.4.1 of the 2022 Flood Hazard Assessment NK054-REP-01730-001 (Reference 2.5-18), the PMF, mentioned in Subsection 2.5.3.1, includes a design basis flood (involving a PMP and zero infiltration) concurrent with disabled sewer and drainage systems dure to, for example, debris. Therefore, the flooding due to runoff can be screened out based on screening criterion [QL2]. The PMF assessment is the bounding assessment that includes the impacts of potential runoffs.

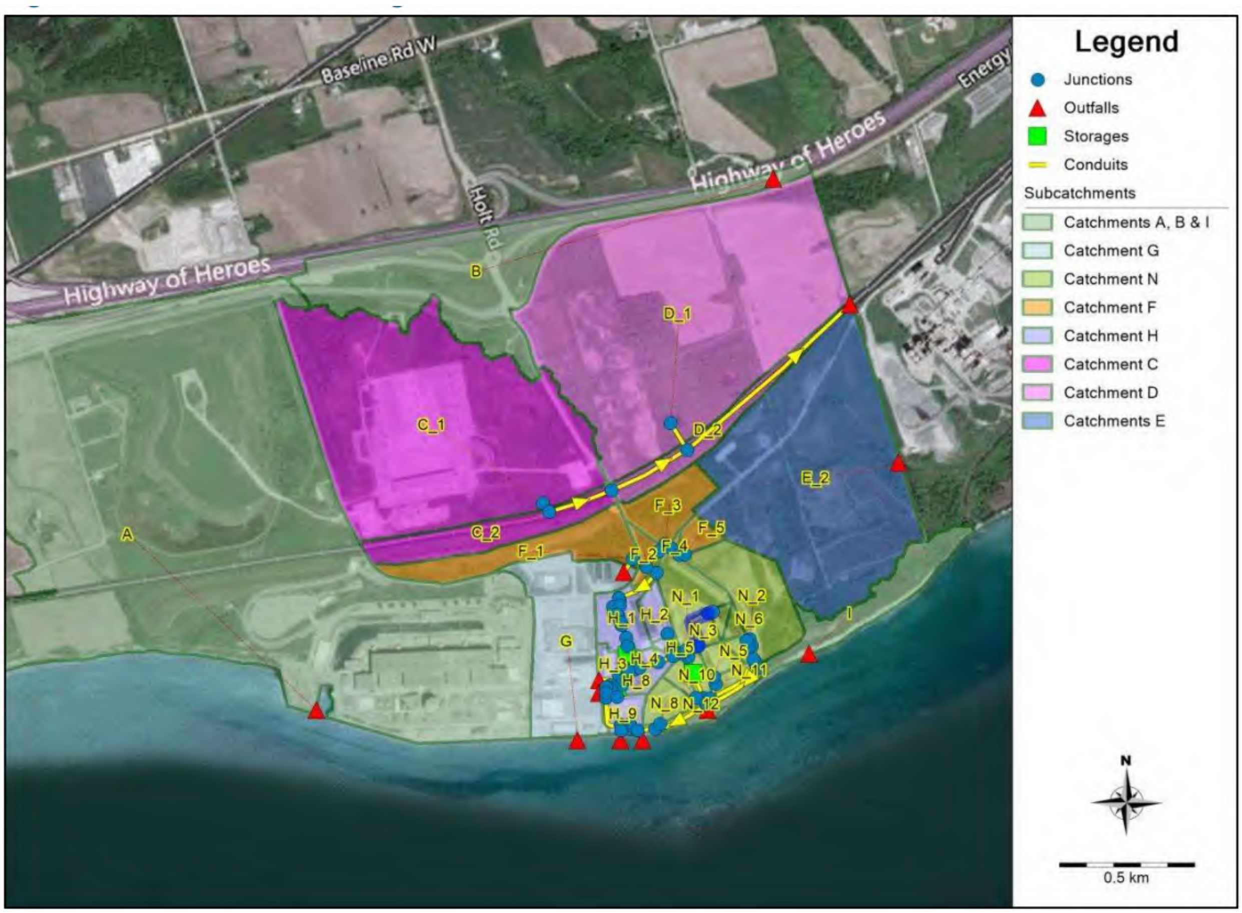

Figure 2.5.3.2-1 Pre-development Darlington Nuclear Site Drainage (Reference 2.5-18)

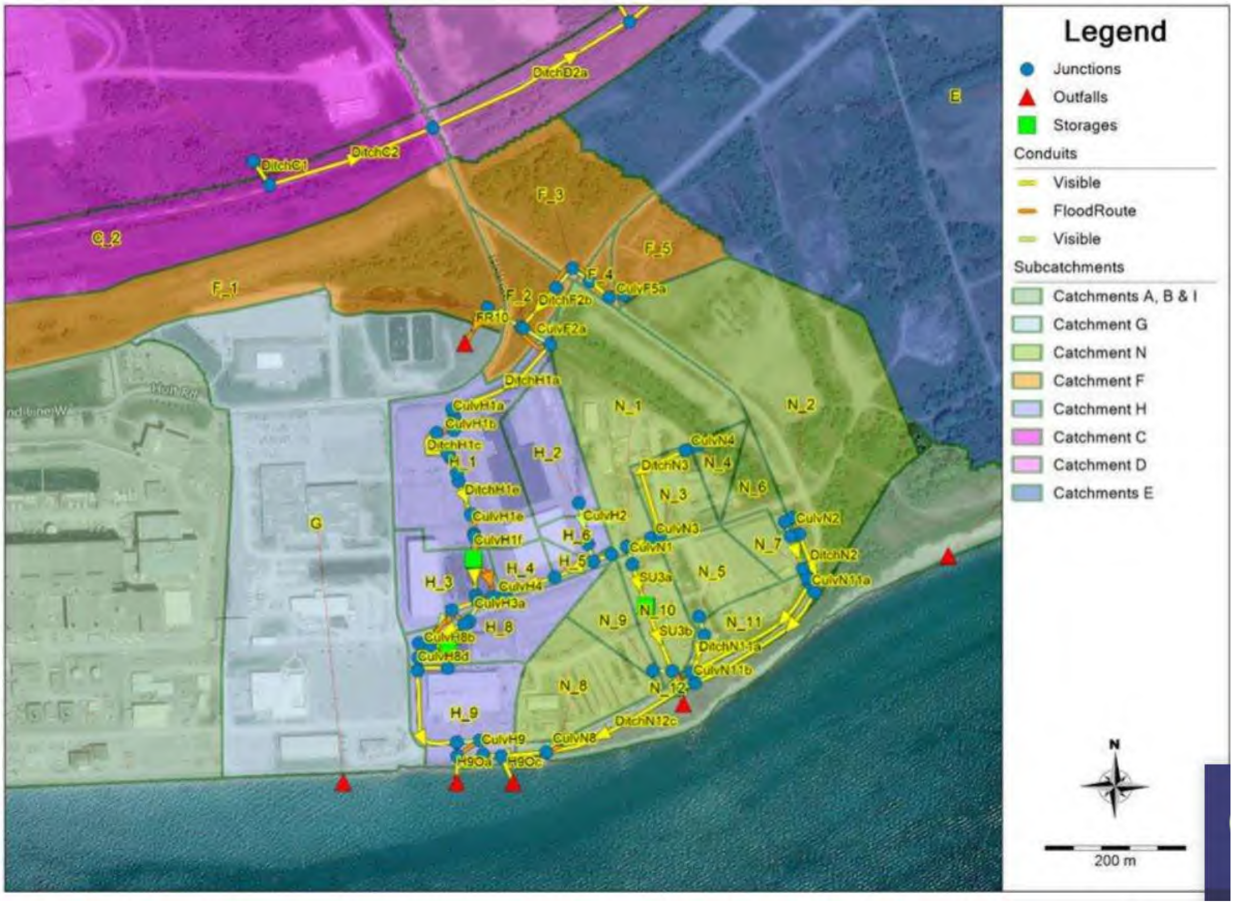

Figure 2.5.3.2-2 Post-development Darlington Nuclear Site Drainage (Reference 2.5-18)

2.5.3.3 Flooding Due to Rivers

Section 3.1 of the 2009 NK054-REP-01210-00012 (Reference 2.5-2) names two riverine systems within the local regional drainage basin: Tooley Creek and Darlington Creek.

The distance, infrastructure, and topography between the Tooley Creek watercourse and the proposed DNNP site precludes Tooley Creek as the source of a flood hazard.

Regarding Darlington Creek, the Central Lake Ontario Conservation Authority indicated there is not any history of severe flooding along Darlington Creek within the recorded history of the area. Figure 3.1-6 of the 2009 NK054-REP-01210-00012 (Reference 2.5-2) illustrates the current regulatory and 100-year recurrence floods inundation limits and shows that the inundation limits associated with these events do not represent a flood hazard to the DNNP site.

Subsection 5.4.2 in the 2022 Flood Hazard Assessment, NK054-REP-02730-00001 (Reference 2.5-18), describes comprehensive hydrologic and hydraulic models that are used to estimate drainage for the Darlington Creek watershed and its associated 14 sub-watersheds under 100-year recurrence PMP conditions, as replicated in Table 2.5-2. The models considered parameters such as length and slopes of the feeding reaches, time of concentration, storage coefficient, and future 100-year timeframe land use and development. The modelled Darlington Creek flood water elevations under PMP conditions in the future is estimated at 88.5 CGD at a stream gauge cross-section located just south of Highway 401. This is above the DNNP site construction grade of 88 CGD. However, to overtop into the DNNP site, flood waters would have to surpass the lowest elevation along the boundary separating the DNNP site from Darlington Creek, which is 95 CGD. Therefore, no external flood hazard to the DNNP site has been identified from Darlington Creek.

Thus, flooding due to the Tooley Creek and Darlington Creek is screened out for the DNNP site.

Table 2.5-2 Key Modelling and Assessment Parameters for Darlington Creek and On-site External Flood Hazards (Reference 2.5-18)

Parameter	Darlington Creek	On-site
Design Storm(s)	2.5-Hour 1:100-Year Storm (4 mm)	12-Hour PMP (420 mm)
	6-Hour PMP (405 mm)	
	12-Hour PMP (420 mm)	
Land Cover	Existing and Future Conditions	Zero infiltration
Threshold Water Level Constituting Flood Hazard	Above 95 m CGD	Above 88 m CGD

2.5.3.4 Flooding Due to Waves

The potential for flooding due to waves is discussed in Section 5.3 of the 2009 NK054-REP-01210-00012 (Reference 2.5-2):

1. Subsection 5.3.1 of the 2009 NK054-REP-01210-00012 (Reference 2.5-2) describes the data and models used to assess the flooding hazard by waves, including the Lake Ontario wind and wave hindcast developed by the Wave Information Studies of the Office, Chief of Engineers, U.S. Army Corps of Engineers. The Simulating Waves Nearshore model was used to propagate extreme wave conditions from a selected ‘offshore’ wave information studies node to the shoreline, using the SPLASH numerical model for calculations of wave uprush and wave overtopping on shoreline beaches and structures.

2. Subsection 5.3.2 of the 2009 NK054-REP-01210-00012 (Reference 2.5-2) describes the wave hindcast extreme analysis and determines that it is appropriate to use the wave information studies #192 100-year Hs of 4.7 m with peak wave period T_p of 9.7 s as input from the SW (225° N) to wave propagation/overtopping models.
3. Subsection 5.3.3 of the 2009 NK054-REP-01210-00012 (Reference 2.5-2) describes the wave propagation modeling for two water level scenarios and two site layout scenarios.
4. Subsection 5.3.4 of the 2009 NK054-REP-01210-00012 (Reference 2.5-2) describes the wave uprush and overtopping estimates.

Based on these scenarios, the wave uprush estimates range from 3.5 m to 11.3 m, and wave overtopping estimates range from 0.015 to 0.591 $m^3/s/m$.

In the 2022 Flood Hazard Assessment in NK054-REP-02730-00001 (Reference 2.5-18), the calculated wave heights extreme values were based on the latest hindcast data from two stations closest to the DNNP for the period from January 1979 to January 2020. Using a specific fitted method, wave heights were calculated for selected return periods of 10, 50 and 100 years. Based on the results, it was recommended to use an updated design wave of 6.1 m from the SW (225° N) with peak wave period T_p of 9.2 s to account for a more conservative estimate of the wave flooding potential at the DNNP site.

2.5.3.5 Flooding Due to Storm Surge and Seiche

Storm surges may cause seiches, because as a storm moves past the lake, the wind and pressure are no longer pushing the water, therefore the piled-up water moves toward the other end of the lake. The water sloshes from one end of the lake to the other few times until the water level is returned to normal. This sloshing back and forth is called a seiche. Seiches can be created due to other meteorological effects, seismic activities, or also tsunamis.

Section 5.2 of the 2009 NK054-REP-01210-00012 (Reference 2.5-2) describes the numerical hydrodynamic model of Lake Ontario which was developed to assess the potential for generation of storm surge and seiche response to extreme severe weather systems tracking through the region. The model was implemented on a bathymetric grid of Lake Ontario with a 2.7 km resolution.

The most severe types of weather systems in the region of Lake Ontario are:

1. Post Tropical Storms: A good example of a post tropical storm with very severe wind conditions for Lake Ontario was Hurricane Hazel (1954). A storm like Hazel would typically approach Lake Ontario from between the southeast and south. A Hazel-like post tropical storm with extremely severe characteristics could have sustained winds up to 100 km/h and a pressure drop as low as 95 kPa.
2. Alberta Clippers: They are compact fast moving winter storms with sustained winds up to about 80 km/h and a pressure drop of about 97 kPa. They would typically track from northwest to west-southwest.
3. Colorado Lows: They are less compact than the Alberta Clippers but have otherwise similar characteristics and would track from the southwest or south-southwest.
4. Gulf Lows: A good example of a very severe Gulf low is the Great Blizzard of 1978. The pressure dropped down to the extremely low value of 95.8 kPa. Characteristic severe sustained winds were up to about 100 km/h.

The parameters used to represent the four idealized storms listed above are shown in Table 5.2-1 of the 2009 NK054-REP-01210-00012 (Reference 2.5-2). The highest predicted water level at Darlington Nuclear site resulting from surge or seiche is about 0.75 m. This level can be produced either directly as a surge by a storm of Hazel-type tracking from the south over the western end of the lake, or indirectly after an Alberta Clipper from the west builds up a large surge at the eastern end of the lake resulting in a seiche of large amplitude. The 2022 Flood Hazard Assessment in NK054-REP-02730-00001 (Reference 2.5-18) also recommended 0.75 m as the highest water level produced by storm surge or seiche, in concurrence with the value predicted in the 2009 NK054-REP-01210-00012 (Reference 2.5-2).

Table 4.2 of the 2019 Darlington Hazard Screening Analysis NK054-REP-03611-1004 (Reference 2.5-4) shows the margin between the lake level and the top of the breakwater works at Darlington Nuclear site. As the margins are larger than the 0.75 m highest water level resulting from surge or seiche, the potential flood impacts are screened out.

2.5.3.6 Flooding Due to Tsunami

As described in Section 5.7 of the 2009 NK054-REP-01210-00012 (Reference 2.5-2), 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. An additional consideration is the potential for a tsunami to occur as a series of waves (rather than a single wave) with associated increased impact from cumulative damage or flooding effects.

Due to the geological stability of the Great Lakes region where the largest measured seismic activity results in only small earthquakes typically of magnitude 3 or 4, the 2009 flood hazard assessment NK054-REP-01210-00012 (Reference 2.5-2) concludes a tsunami in Lake Ontario is an improbable event for DNNP. This conclusion is confirmed in the 2022 Flood Hazard Assessment NK054-REP-02730-00001 (Reference 2.5-18).

2.5.3.7 Flooding Due to Ponds, Dams or Dikes

As noted in Subsection 4.4.7 of the 2019 NK054-REP-03611-10043 (Reference 2.5-4), there is no large permanent human-made water storage pond or dam near the Darlington Nuclear site that can threaten the site. Therefore, this potential flood mechanism is screened out. Per the 2020 NK054-CORR-00531-10533 (Reference 2.5-3), this conclusion is applicable to the DNNP site since it is encompassed by the Darlington Nuclear site. Subsection 5.5.1 of the 2022 NK054-REP-02730-00001 (Reference 2.5-18) also concluded no hazard assessment for the failure of human-made structures such as dams or dikes is required for the DNNP site

Any temporary ponds and body of water that could potentially be created during a severe storm (for example on the rail track, by the embankments, overflowing culverts) are addressed in the 2009 hydrological assessment NK054-REP-01210-00012 (Reference 2.5-2) and the 2022 Flood Hazard Assessment NK054-REP-02730-00001 (Reference 2.5-18) (refer to Subsection 2.5.3.2).

2.5.3.8 Flooding Due to Ice Jamming

As described in Subsection 4.4.8 of the 2019 NK054-REP-03611-10043 (Reference 2.5-4), this event scenario is concerned with late winter conditions when large ice blocks, accumulated over winter, melt rapidly as the weather temperature rises above the freezing point.

The 2014 DNGS hydrological assessment NK38-REP-03611-10094 (Reference 2.5-12) examined the worst-case scenarios and concluded that a summer PMP, with storm drains blocked, would bound winter PMP with snow covering the ground and ice blocking the drains. The event consequences of ice jamming at the lakeshore, and rapid melting of the accumulated ice blocks may result in localized high water levels and flooding, but the consequences are not worse than the PMF assessed in the DNGS hydrological assessment.

Therefore, the hazard is screened out based on screening criterion [QL2], as both types of consequences (accumulation on the roof tops, and accumulation at the lakeshore) have consequences less severe than the events assessed in the 2014 DNGS hydrological assessment (Reference 2.5-12). This conclusion can be applicable to the DNNP site due to proximity to the DNGS site, per the 2020 NK054-CORR-00531-10533 (Reference 2.5-3).

The 2022 Flood Hazard Assessment in the 2022 NK054-REP-02730-00001 (Reference 2.5-18) states that in the DNNP site area, Lake Ontario freezing starts from the Bay of Quinte, east of the DNNP site. The ice then propagates eastward to the St. Lawrence River. As shown in Figure 5.6-2 of the 2022 Flood Hazard Assessment in the 2022 NK054-REP-02730-00001 (Reference 2.5-18), the ice coverage over Lake Ontario is about 17% by mid-February with an average of 10% coverage for the winter period. Ice breaking accelerates in early March. Thus, the DNNP site region of Lake Ontario is ice-free year-round, in an average year. This is mirrored in the fact that, on a weekly basis, between December 4 and May 14, the median ice concentrations near the DNNP site are 0%. Furthermore, Lake Ontario is the smallest Great Lake in terms of surface, but it is the second deepest and as such, has a large volume compared to its surface area, resulting in an exceptionally high heat storage capacity. Temperature changes occur at a much lower rate in Lake Ontario compared to the other Great Lakes.

Therefore, the 2022 Flood Hazard Assessment in the 2022 NK054-REP-02730-00001 (Reference 2.5-18) confirms that the flood hazard due to ice jamming is screened out based on the basis of screening criterion [QL3].

2.5.4 Potential Effects of Climate Change

The potential impacts of climate change are discussed and summarized in Subsections 7.2 of the 2022 NK054-REP-02730-00001 (Reference 2.5-18), where Subsections 7.2.1 and 2.7.2 address the effect of climate change on temperature and precipitation.

The total annual precipitations are forecast to slightly increase (+3% to 10%) in 2071-2100 compared to present-day conditions. However, precipitations are expected to remain stagnant during summer, hence resulting in higher percentage increases for other seasons (from +2% to 21%) depending on the emission scenario chosen. Considering that temperature is also forecast to significantly increase during winter, more liquid precipitations are to be expected as well.

Maximum daily precipitations are expected to vary from –4% to +25% depending on season and emission scenario. The seasonal trend follows a similar pattern as total precipitations with stagnant conditions during summer (-4% to 0% compared to present-day conditions) in contrast to spring and winter for example (from +10% to 25%).

Although maximum daily precipitations should not increase by much during fall and especially summer, these seasons remain the period when this extreme weather event will occur. While the projected increase in daily 1:100-year return period precipitation is up to 10.7% by 2100 in the high greenhouse gas emissions scenarios, the PMP evaluated is not anticipated to be exceeded due to climate change, and no additional flood hazard is identified on account of climate change.

Subsection 5.1.2.5 of the 2022 NK054-REP-02730-00001 (Reference 2.5-18) describes a 2014 plan that was adopted in 2017 to allow for control of extreme low or high water level conditions. Under the modelled conditions in the 2014 plan, the weekly mean water levels would never have exceeded 75.8 m. However, since the adoption of the new plan in 2017, water level exceeded the previous maximum on two occasions, in 2017 and 2019. Climate change was identified as the probable cause of these maximum water levels.

Subsection 7.2.5 of the 2022 NK054-REP-02730-00001 (Reference 2.5-18) discusses the impact of climate change on Lake Ontario water levels. Lake Ontario water levels are primarily controlled by variations in precipitation, runoff, and evaporation over the watershed. Climate change influences these parameters that control lake water level fluctuations. Climate change would contribute to increasing low and high extremes in Lake Ontario water levels. Anticipated increases in precipitation would contribute to high Lake Ontario water levels. The report recommends higher lake levels experienced recently in 2017 and 2019 should be considered as appropriate design lake levels for shoreline assessment and design bases.

According to the 2019 IAEA Site Evaluation for Nuclear Installations Safety Requirements for Flood Hazard (Reference 2.5-14), the reference water level upon which the computed surge or seiche is superimposed should be selected to have a sufficiently low probability of being exceeded. Usually the 100-year recurrence monthly average high water is adopted or, if the water level is controlled, the maximum controlled water level is used. However, the International Joint Commission Lake Ontario 2021 plan (Reference 2.5-13) allows deviations, so that no maximum level is set, and a stochastic approach is still necessary. In this case the controlled water level with a probability of exceedance of 1% is 75.6 m; however, the highest level during a century is about 76.6 m. In addition, measured water levels at Cobourg have exceeded 75.6 m for duration of about three months in 1973.

Therefore, 75.6 m may be a low estimate, and 76.6 m should be used, which is close to the maximum found in the historic data and greater than the 100-year recurrence level. This level assumes the International Joint Commission Lake Ontario continues with the current water level control plan.

The 2023 Darlington New Nuclear Project Strategy for Addressing Climate Change Impacts, NK054-PLAN-07007-00001 (Reference 2.5-20) is developed to address the potential impact of climate change on external hydrological and meteorological hazards. The strategy summarizes life cycle considerations including long-term monitoring (Subsection 2.11.9) and describes the plan to ensure the BWRX-300 facility is resilient to climate change as a potential external hazard.

The 2023 NK054-REP-07007-1049426 DNNP Hazard Bounding Analysis (Reference 2.5-22) presents a bounding analysis of climate change impacts and establishes probable extreme values for climate hazards where feasible. The 2022 NK054-REP-07007-1028871 DNNP Gradual Climate Change and Natural Hazard Identification (Reference 2.5-23) describes the process used in identifying a comprehensive list of natural external events for DNNP, which are screened for climate change impact for evaluation against the DNNP BWRX-300 design basis.

2.5.5 Groundwater

Relevant to the assessment of radioactive material transported through the groundwater system and potentially dispersed in the environment, the following subsections discuss the characterization of the hydrogeological subsurface properties as well as relevant monitoring programs.

The in-situ soil properties are derived based on existing subsurface investigations completed at the DNNP site and in the vicinity of the BWRX-300 SMR location, as described in Subsection 2.7.3.2.4.

2.5.5.1 Groundwater Conditions

The groundwater conditions are described in detail in Subsection 2.7.3.2.4. Groundwater flow maps are available in Section 2.7, Figures 2.7.3.2-3 to 2.7.3.2-9. In general, groundwater on the site flows from north to south, and discharges toward Lake Ontario, as confirmed in the 2022 DNNP Phase 1 Geotechnical Investigation Report NK054-REP-01210-00175 (Reference 2.5-21).

The predominant groundwater flow patterns reported in the 2022 geotechnical investigation NK054-REP-01210-00175 (Reference 2.5-21) remain unchanged from the historical interpretations of groundwater flow conditions documented in the 2009 NK054-REP-01210-00011 (Reference 2.5-15) and the 2009 NK054-REP-07730-00005 (Reference 2.5-16).

Relevant information is provided in Subsection 2.8.2.2 on the impact of hydrogeological conditions on the dispersion of radioactive material.

2.5.5.2 Groundwater Level

Based on the groundwater conditions at the DNNP site presented in Subsection 2.7.3.2.4 and Table 2.7-11, groundwater is anticipated to be present approximately between elevation 80 m to 86 m corresponding to depths between about 2 m and 8 m below the plant grade at elevation 88 m. (refer to Subsection 2.7.5.2.6)

2.5.5.3 Groundwater Monitoring

The OPG Environmental Monitoring Program (EMP) N-REP-03443-10027 (Reference 2.5-17) examines the chemical, radiological, and physical characteristics of the groundwater beneath the Darlington Nuclear site. The groundwater monitoring wells are located in key areas of the Darlington Nuclear site including the protected areas (near the RBs), controlled areas (farther away from the RBs but within the fence), and the Darlington Nuclear site perimeter. Wells on DNNP site are considered site perimeter wells (refer to the NK38-REP-10140-10032 (Reference 2.5-8)).

2.5.6 Surface Water

As related to the assessment of radioactive material transported through the surface water system and potentially dispersed in the environment, this subsection discusses the characterization of the surface water properties in Subsection 2.5.6.1, as well as the relevant monitoring programs in Subsection 2.5.6.2.

2.5.6.1 Surface Water Properties

The pertinent properties of the surface water (i.e., Lake Ontario) are described below:

1. <u>Lake-Wide Circulation</u>

   The Darlington Nuclear site is situated on the northern shore of Lake Ontario where the lake-wide circulation is generally eastward from the Niagara River to the discharge to the St. Lawrence River, per the 2021 D-REP-07701-00001 (Reference 2.5-9). Water movement near the site is predominantly along the shore, occurring for 73% of the time (35% to the west and 38% to the east), as described in the 2012 NK054-REP-01210-00016 (Reference 2.5-5). Onshore and offshore movement occurs about 15% of the time, as reported in the 2012 NK054-REP-01210-00016 (Reference 2.5-5). Table 2.7 in the 2021 D-REP-07701-00001 (Reference 2.5-9) shows the frequency of lake current flowing toward each direction and the maximum speed that occurred in each direction, per the 2021D-REP-07701-00001 (Reference 2.5-9). Table 2.5-3 shows the averaged lake current direction and speeds.

Table 2.5-3 Summary of Lake Ontario Depth Averaged current speed and direction (Reference 2.5-9)

Month	Direction	Depth Averaged Speed All Directions	Depth Averaged Speed Easterly	Depth Averaged Speed Westerly
	Degree from North	cm/s	cm/s	cm/s
January	142	17.5	20.6	12.4
February	145	16.2	18.9	13.1
March	159	13.5	15.5	12.7
April	165	11.8	12.7	12.3
May	181	9.4	12.0	7.8
June	177	9.5	10.5	9.7
July	183	13.3	16.0	11.4
August	193	10.9	12.2	11.1
September	196	9.9	10.3	10.9
October	170	11.8	13.0	11.9
November	159	11.5	13.2	9.8
December	169	12.9	14.4	12.5
Annual Average		12.4	14.1	11.3

2. Lake Water Temperature
   Lake Ontario is classified as a dimictic lake because it undergoes a complete cycle of isothermal and vertically stratified conditions every year. The thermal structure depends on the season because of large annual variation in surface heat fluxes. Lake-wide surface temperatures typically rage from freezing in winter to about 20 °C in summer, per the 2021 D-REP-07701-00001 (Reference 2.5-9). Statistical summary of ambient water temperatures near Darlington Nuclear site (from 1984 to 1996 and 2011 and 2012) is provided in Table 2-9 of the 2021 D-REP-07701-00001 (Reference 2.5-9).

3. Ice Conditions

   Ice formation in winter is typically limited to the nearshore areas at the eastern end of the lake within the Kingston Basin, per the 2021 D-REP-07701-00001 (Reference 2.5-9) and the 2022 NK054-REP-02730-00001 (Reference 2.5-18).

2.5.6.2 Surface Water Monitoring

As described in Subsection 3.2.2 of the 2019 NK38-OM-61100 (Reference 2.5-6), the Lake Current Monitoring system is a real-time current profile measurement system to be used in the event of a radiological liquid emission. Further details of the radiological baseline conditions of lake water at the Darlington Nuclear site are provided in Subsection 2.9.1.1.

The OPG EMP N-REP-03443-10027 (Reference 2.5-17) identifies the contaminants and physical stressors to be monitored in the environment surrounding the site. Locations considered to be outside the influence of site operations are also monitored to allow for a baseline comparison with background values. This includes monitoring and sampling of lake water, municipal drinking water, and other means of aquatic sampling. Further details on the EMP are provided in Chapter 20, Subsection 20.11.2.

2.5.7 References

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2.5-5 NK054-REP-01210-00016 R002, 2012, "Site Evaluation of the OPG New Nuclear at Darlington - Part 2: Dispersion of Radioactive Materials in Air and Water," Ontario Power Generation.

2.5-6 NK38-OM-61100 R013, 2019, "Environmental Monitoring – Air and Water," Ontario Power Generation.

2.5-7 NK054-REP-01210-00108 R000, 2019, "DNNP – Site Preparation Nuclear Safety Licence Renewal Activity Report," Ontario Power Generation.

2.5-8 NK38-REP-10140-10032 R000, "Darlington Nuclear Groundwater Monitoring Program Results," Ontario Power Generation.

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2.5-12 NK38-REP-03611-10094 R000, 2014, "Darlington Nuclear Generating Station Hydrological Assessment," Ontario Power Generation.

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2.5-16 NK054-REP-07730-00005 Rev. R000, 2009, "Geological and Hydrogeological Environment, Existing Environmental Conditions, Technical Support Document, New Nuclear – Darlington Environmental Assessment," Ontario Power Generation.

2.5-17 N-REP-03443-10027 R000, 2021, "Results of Environmental Monitoring Programs," Ontario Power Generation.

2.5-18 NK054-REP-02730-00001, 2022, "Flood Hazard Assessment," Ontario Power Generation.

2.5-19 NK054-REP-02730-00002, 2022, "PMP Validation," Ontario Power Generation.

2.5-20 NK054-PLAN-07007-00001, 2023, "Darlington New Nuclear Project Strategy for Addressing Climate Change Impacts," Ontario Power Generation.

2.2-22 NK054-REP-01210-00175 R000, 2022, "Phase I Geotechnical Investigation (Power Block) Darlington New Nuclear Project", Volume 2 of 2 "Geotechnical Interpretation of Design Parameters," Ontario Power Generation

2.5-22 NK054-REP-07007-1049426 R001, 2023 "Darlington New Nuclear Project – Hazard Bounding Analysis," Ontario Power Generation

2.5-23 NK054-REP-07007-1028871 R000, 2022 "Darlington New Nuclear Project – Gradual Climate Change and Natural Hazard Identification," Ontario Power Generation

2.6 Meteorology

2.6.1 Introduction

Section 2.6 describes the meteorological aspects relevant to the DNNP site based on the consideration of the local climatic effects. Details are included in Section 2.6 on the characterization of extreme values of meteorological events in relation to potential hazards to the BWRX-300 facility, as well as in relation to the transportation of radioactive materials and the dispersion of radionuclides with the potential to impact the DNNP site. The meteorological characteristics and conditions included in the following list are assessed in relation to the design and the evolution of extreme parameters over the lifetime of DNNP BWRX-300:

- Temperature (Subsection 2.6.2)
- Humidity (Subsection 2.6.3)
- Rainfall (Subsection 2.6.4)
- Wind Speed (Subsection 2.6.5)
- Tornadoes and Hurricanes (Subsection 2.6.6)
- Waterspouts (Subsection 2.6.7)
- Dust Storms and Sandstorms (Subsection 2.6.8)
- Snow Load and Ice Load, Freezing Rain, and Ice Storm (Subsection 2.6.9)
- Lightning (Subsection 2.6.10)
- Windborne Debris (Subsection 2.6.11)
- Climate Change (Subsection 2.6.12)

Key metrological characteristics and parameters relevant to the DNNP site and the surrounding area are listed in Table 2.6-1. The list includes characteristics such as temperature, humidity, precipitation, high wind, tornadoes, snowfalls, lightning, and climate change impact.

Table 2.6-1: Meteorological Characteristics Summary of DNNP Site and Surrounding Area

<table>
<tr><th>Characteristic</th><th colspan="3">Value/Description</th></tr>
<tr><td rowspan="8">2.6.2 Temperature</td><td>Highest ever recorded</td><td>Toronto
Bowmanville</td><td>36 °C
40.6 °C</td></tr>
<tr><td>Extreme minimum</td><td colspan="2">-40 °C, with annual degree-days below 18 °C of 4130 degree-days</td></tr>
<tr><td>Maximum</td><td>Dry bulb 37 °C</td><td>Wet bulb 23 °C</td></tr>
<tr><td>Design Basis Duration at low Temperature</td><td colspan="2"><table><tr><th>Temperature</th><th>Duration</th></tr><tr><td>-40 °C</td><td>1 h</td></tr><tr><td>-35 °C</td><td>5 h</td></tr><tr><td>-30 °C</td><td>10 h</td></tr><tr><td>-25 °C</td><td>20 h</td></tr><tr><td>-20 °C</td><td>70 h</td></tr><tr><td>-15 °C</td><td>150 h</td></tr></table></td></tr>
<tr><td>Safety Class 1 SSC Design Conditions</td><td>Highest 40 °C</td><td>Lowest -40 °C</td></tr>
<tr><td>Impact of extreme temperatures</td><td>Mist and white frost during winter</td><td>Heatwaves during summer</td></tr>
<tr><td>Impact of Climate Change by 2100</td><td colspan="2">Increase between 2 °C and 5 °C (References 2.6-3 and 2.6-4)
Recent analysis: increase by up to 7.2 °C (Reference 2.6-17)</td></tr>
<tr style="display:none"></tr>
<tr><td rowspan="4">2.6.3 Humidity</td><td>Lowest</td><td colspan="2">During winter and air is quite dry due to Arctic air from the north</td></tr>
<tr><td>Highest</td><td colspan="2">During summer and fall due to the air from the Gulf of Mexico.</td></tr>
<tr><td>Mean value</td><td colspan="2">65 to 80% throughout the year</td></tr>
<tr><td>Design Conditions</td><td colspan="2">No indication of extreme conditions that require design mitigation</td></tr>
<tr><td rowspan="9">2.6.4 Rainfall / Precipitation</td><td>Mean annual</td><td>Oshawa 877.9 mm</td><td>Toronto 800 mm</td></tr>
<tr><td>Maximum daily</td><td>Oshawa 88.6 mm</td><td>Toronto 79.3 mm</td></tr>
<tr><td>Average (DNGS PO-SAR)</td><td colspan="2">145 days/yr, with of 800 mm average, with 20% due to snowfall</td></tr>
<tr><td>Greatest per day</td><td colspan="2">In Oshawa, 144.8 mm</td></tr>
<tr><td>PMP (vicinity of DNNP)</td><td colspan="2">420 mm in 12-hours, with 51% in the 6^{th} hour, for a watershed area of < 1295 km^2</td></tr>
<tr><td>Severe flooding</td><td colspan="2">PMP conditions, combined with a 1 in 100-year recurrence lake level high, and storm surge</td></tr>
<tr><td>Extreme Daily</td><td colspan="2">Unlikely to exceed the PMP value in a 100-year recurrence for DNNP</td></tr>
<tr><td>For roof design</td><td colspan="2">16 mm in 5 min – 50-year, 5-minute storm
25 mm in 15 min - 50-year return, 15-Minute storm
47 mm in 60 min – 50-year return 1-hour storm
210 mm in 24 h – Regional storm (Hurricane Hazel)</td></tr>
<tr><td>Climate Change Impact by 2100</td><td colspan="2">Increase in heaviest precipitation intensity and frequency of 12% and 22%, respectively. Plausible increase in extreme precipitation amount over southern Ontario by 14% (7 mm) (Reference 2.6-3).</td></tr>
</table>

Table 2.6-1: Meteorological Characteristics Summary of DNNP Site and Surrounding Area

Characteristic	Value/Description	
		Recent analysis indicates total precipitation and maximum 24-hour re anticipated to increase by up to 25% (Reference 2.6-17). The 12-hour PMP of 420 mm remains bounding of this increase as the summer and fall projections (when PMP would occur) are lower, up to +10%, and the PMP value is conservative (Reference 2.6-18). Such predicted changes is to be considered in the design and monitored for long term as discussed in Subsection 2.11.9.
2.6.5 Wind and Wind Speed	Typical	The prevailing winds were from the north-westerly quarter (10.38% of the time) and from the west quarter (9.98% of the time) (Refer to Subsection 2.8.1.3)
	Average and Clam	Approximately 2.4 m/s (~8.6 km/h) and less than 2 m/s (~7.2 km/h), respectively at 10 m level (Refer to Subsection 2.8.1.3)
	Maximum	64 km/h at 10 m level and 80 km/h at 50 m level (for a 100-year return period)
	Wind 3-sec Gust	Extreme gusts – Occur mostly in the West, Southwest, and Northwest directions Speeds exceeding 120 km/h are rare Higher speeds of up to 174.4 km/h occurred in some instances
	Climate Change Impact by 2100	Wind speeds are expected to change due to climate change. Decline in average wind speed over the years in a warmer world
2.6.6 Tornadoes and Hurricanes	Maximum Pressure Drop	6.3 kPa
	Maximum Rotational Speed	257.4 km/h
	Maximum Transitional Speed	64.4 km/h
	Maximum Wind Speed	321.8 km/h (Upper limit - Enhanced Fujita scale 4 (EF-4) tornado)
	Radius of Maximum Rotational Speed	45.7 m
	Rate of Pressure Drop	2.5 kPa/s
	Design Basis – Tornado Missile Spectrum types	Schedule 40 pipe, Automobile 5 m x 2 m x 1.3 m, and Solid Steel Sphere (Refer to Table 2.6-6)
	Hurricanes, Cyclones, Tropical Storms, Tropical Depression	Very low probability of an actual hurricane directly impacting the DNNP site, and it describes the probable maximum tropical cyclone as unlikely to yield gusts of more than 100 km/h - lower than that of the design basis tornado. As such, wind hazard from a hurricane is not considered further.
2.6.7 Waterspouts	A tornado that forms over water that are rarely reported. Covered by the design basis tornado	
2.6.8 Dust and Sandstorms	Not identified as phenomena for southern Ontario, and as such are not identified as potential hazards for DNNP.	
	Average daily snowfall	3 cm to 5 cm from December to March

Table 2.6-1: Meteorological Characteristics Summary of DNNP Site and Surrounding Area

Characteristic	Value/Description	
2.6.9 Snow and Ice Load, Freezing Rain, and Ice Storm	Highest Daily snowpack	Mean value of 8.6 cm in January
	Darlington Nuclear site characteristic Value	2.2 kPa
	Combined snow load and winter PMP event	1.80 kPa for 50-year recurrence 1.71 kPa for 100-year recurrence, without Winter PMP
	Freezing Rain	Screened out due to low frequency
	Ice Storm	This issue is resolved as part of Pressure Increase Group (refer to Subsection 2.2.8).
2.6.10 Lightning	Frequency	2 to 3 cloud-to-ground flashes per year per square km, causing induced fires and electromagnetic compatibility. Screened out due to low hazard to the site.
2.6.11 Windborne Debris	Wind-propelled missiles are similar to tornado missiles which is assessed as part of the high wind PSA.	
2.6.12 Climate Change Impact	Impact of climate change is considered in the 2023 Darlington New Nuclear Project Strategy for Addressing Climate Change Impacts NK054-REP-07007-00001 (Reference 2.6-19) which summarizes life cycle considerations including long-term monitoring, described in Subsection 2.11.9	

2.6.2 Temperature

Since DNNP is in proximity to DNGS within the Darlington Nuclear Site, similar meteorological conditions are expected. The highest temperatures ever recorded at Bowmanville, and Toronto are 36 °C and 40.6 °C, respectively per Subsection 2.1.1 of the 2019 NK054-REP-01210-00108 (Reference 2.6-2). As shown in Table 2-1 of Part 2 of the 2018 NK38-SR-03500-10001 DNGS Safety Report (Reference 2.6-7), the extreme minimum temperature chosen for DNGS was -40°C, with annual degree-days below 18 °C of 4130 degree- days. Per Subsection B.8.4. Table 3 of the 2010 N-REP-01200-10000 (Reference 2.6-9), the Darlington Nuclear site characteristic value for maximum dry bulb temperature is 37°C, and the maximum wet bulb temperature is 23°C. The design basis durations at low temperature for DNGS site in the 2018 NK38-SR-03500-10001 (Reference 2.6-7), which are applicable to the DNNP site, are listed in Table 2.6-2.

Table 2.6-2: DNGS Design Basis Durations at Low Temperature Applicable to DNNP

Temperature	Duration
-40°C	1 h
-35°C	5 h
-30°C	10 h
-25°C	20 h
-20°C	70 h
-15°C	150 h

According to Subsection 4.5.1 of the 2012 NK054-REP-01210-00016 (Reference 2.6-6), Safety Class 1 (SC1) SSCs that are exposed to ambient environment conditions in DNGS are designed for extreme temperatures of -40 °C during the winter and +40 °C during the summer. The design temperature for the DNNP SSCs is -40 °C, while the design temperature of +40 °C is approximately the same as the highest recorded temperature of 40.6 °C as baseline data on extreme conditions. Although the HVAC system efficiency is generally reduced due to extreme high temperature conditions, the system is expected to provide sufficient cooling to maintain design limits for equipment rooms and to support control rooms habitability. This information is also relevant to DNNP SSCs which require the implementation of appropriate mitigating measures, as necessary.

Refer to Chapter 9A, Section 9A.5 for information on the functions, design bases, description, maintenance, performance, and safety evaluation of the BWRX-300 HVAC systems.

Furthermore, global climate models projected in 2009 an increase of the temperatures in southern Ontario of between 2 °C and 5 °C over the next century, due to rising greenhouse gas emissions, as indicated in Subsection 7.2.8 of the 2009 NK054-REP-01210-00012 (Reference 2.6-3). This information is in line with the contents in Subsection 4.1.2.2 of the 2009 NK054-REP-01210-00013 (Reference 2.6-4), which stated temperatures in the vicinity of DNNP site were expected to rise by 2 °C in 2040 and by as much as 5 °C in 2100 during winter and summer months. In the 2022 NK054-REP-02730-00001 Flood Hazard Assessment (Reference 2.6-17), Subsection 7.2.3 indicates temperatures at the DNNP site are anticipated to increase by up to 7.2 °C by 2100. Mitigation of these environmental changes is to be provided at DNNP. Subsection 2.11.9 describes the long-term monitoring of parameters susceptible to be impacted by climate change, as mentioned in the 2023 DNNP Strategy for Addressing Climate Change Impacts, NK054-PLAN-07007-00001 (Reference 2.5-20).

The extreme temperatures expected in the vicinity of DNNP site have the potential to result in mist and white frosts during winter, and heatwaves during summer, per Subsection 4.5.1 of the 2019 NK38-REP-03611-10043 (Reference 2.6-1). In the event of extremely high temperature conditions, an extended heatwave could lead to a high demand on the transmission lines, which could potentially cause a loss of grid condition.

Temperatures Normals at and near the Darlington Nuclear site are described in Subsection 2.8.1.1, as related to the meteorological impact on the dispersion on radioactive material.

2.6.3 Humidity

The 2009 Site Evaluation of Meteorological Events NK054-REP-01210-00013 (Reference 2.6-4) states the average relative humidity in the vicinity of DNNP is the lowest during winter, as the air is quite dry due to the Arctic air moving down from the north; the highest humidity values occur during summer and fall as the humid air from the Gulf of Mexico moves across southern Ontario.

Currently, humidity values are not recorded on-site by the meteorological tower as indicated in Subsection 2.2.1 of the 2012 NK054-REP-01210-00016 (Reference 2.6-6). However, this information is available from several Environment Canada stations such as Oshawa WPCP and Toronto Island. Based on the available data, the mean relative humidity ranges from 65 to 80% throughout the year, per Section 2.2 of the 2009 NK054-REP-01210-00008 (Reference 2.6-5). Section 3.11 of the 2009 NK054-REP-01210-00008 (Reference 2.6-5) also states the meteorological values evaluated with respect to humidity show no indications of extreme conditions requiring design mitigation. Based on Subsection 4.5.2 of the 2020 NK054-CORR-00531-10533 (Reference 2.6-8), no further evaluation is required on the impact of humidity, as the design of the BWX-300 facility is expected to fit within the Plant Parameter Envelope (PPE) values per commitment D-C-3 in the 2021 NK054-REP-01210-00078 DNNP Commitments Report (Reference 2.6-10).

2.6.4 Rainfall / Precipitation

The Bowmanville Mosert climate station is the closest to the Darlington Nuclear site. The Precipitation Normals (from 1981 to 2010) are described in Subsection 2.8.1.2, where the monthly averages and daily extremes (for precipitation (mm), rain (mm), and snow (cm)) are listed in Table 2.8-3.

The concept of PMP is defined in the 2009 NK054-REP-01210-00012 (Reference 2.6-3) as the greatest depth of precipitation possible for a given storm area at a particular location and time of the year (refer also to Subsection 2.5.3.1 for details on PMP and PMF definitions and values). According to Section 4.1 of the 2019 NK38-REP-03611-10043 (Reference 2.6-1), the PMP for watershed areas less than 1295 km^2 in the vicinity of DNNP site has been estimated as a 12-hour precipitation equivalent to 420 mm of total rainfall (with 51% in the 6th hour). Hence, based on the maximum daily precipitation predicted in Subsection 3.4.3 of the 2009 NK054-REP-01210-00013 (Reference 2.6-4) using data from the monitoring stations in Toronto Island and Oshawa (79.3 mm and 88.6 mm, respectively), it is unlikely for extreme daily precipitations to exceed the 420 mm PMP value in a 100-year period for DNGS. This conclusion, which is also applicable to DNNP given its proximity to DNGS, is confirmed in the 2022 DNNP Flood Hazard Assessment in NK054-REP-02730-00001 (Reference 2.6-17).

Precipitation, along with other meteorological factors such as wind direction and speed, influence dispersion and, in case of precipitation, especially deposition. Radioactive materials tend to flow toward low-pressure systems and rainfall often occurs around those systems. Having the PMP value for the DNGS site available for the DNNP PPE ensures that this (maximum probable) value is considered in the DNNP's dispersion (and deposition) models. Models/codes (such as ADDAM and PAVAN) would use the precipitation rate as input to wet deposition. Precipitation Normals at and near the Darlington Nuclear site are described in Subsection 2.8.1.2, as related to the meteorological impact on the dispersion on radioactive material.

According to Table 3-1 in the 2022 PMP Validation reported in NK054-REP-02730-00002 (Reference 2.6-18), the DNNP storm values to be considered as part of roof design are as follows:

- 210 mm in 24 h – Regional storm (Hurricane Hazel)
- 47 mm in 60 min – 50-year return 1-hour rainfall
- 25 mm in 15 min - 50-year return 15-Minute storm
- 16 mm in 5 min – 50-year 5-minute storm

In relation to the changes in precipitation over time, few studies have examined changes in precipitation over Canada. The 2009 site evaluation report on flood hazard assessment, NK054-REP-01210-00012 (Reference 2.6-3) provides references to a number of studies in Subsection 7.2.1. Based on the conclusions in this report, the heaviest precipitation events are becoming more frequent during the spring and summer, and less frequent during the winter. The information provided indicates a reported increase in extreme precipitation intensity and frequency of 12% and 22%, respectively. In addition, Subsection 7.2.8 of the 2009 NK054-REP-01210-00012 (Reference 2.6-3) states some models show a plausible increase in the amount of precipitation for the most extreme precipitation events over southern Ontario by 14% (7 mm). In the 2022 NK054-REP-02730-00001 DNNP Flood Hazard Assessment (Reference 2.6-17), Subsection 7.2.3 indicates the total precipitation and the maximum 24-hour for certain seasons to increase by up to 25% by 2100. The PMP event is not coincident with this increase and remains conservative considering anticipated coincident increases. Consequently, no additional flood hazard is considered for rainfall increase due to climate change, However, as discussed in Subsection 2.11.9, long-term monitoring of precipitation is included as part of the 2023 DNNP Strategy for Addressing Climate Change Impacts NK054-PLAN-07007-00001 (Reference 2.6-19).

2.6.5 Wind and Wind Speed

Wind data sets at a standard height of 10 m are collected from Darlington Nuclear site meteorological tower as well as from nearby monitoring stations. The Darlington Nuclear site average and calm wind speeds and wind direction data are presented in Subsection 2.8.1.3. The maximum wind speed at 10 m level and 50 m level at Darlington Nuclear site was estimated to be 64 km/h and 80 km/h, respectively, for a 100-year return period, per the 2009 NK054-REP-01210-00013 (Reference 2.6-4).

Wind gust analysis is performed in the 2022 NK0054-REP-02730-00003 (Reference 2.6-14) for the DNNP site. Although wind speed was collected at the DNGS for 12 years at 15-minutes intervals, 3-second wind gust data were not available. In the 2022 NK0054-REP-02730-00003 (Reference 2.6-14) high-quality Government of Canada publicly available 3-second wind gust data were used from four different stations located within 100 km form DNNP: the three airports in Toronto, Peterborough, and Trenton, as well as the Toronto City Centre. Wind roses were used to analyze the gust magnitude and frequency for each station in eight gust directions. Annual Maximum Series data were then extracted and statistically tested and analyzed. Based on the summary of the maximum and mean of gust Annual Maximum Series, extreme gusts were found to occur mostly in the West, Southwest, and Northwest directions.

To estimate the extreme design gust speeds for various return periods, the Extreme Value Type I model (kwon as Gumbel distribution model) was fitted to the extracted Annual Maximum Series values, as described in the 2022 NK0054-REP-02730-00003 Wind Gust Analysis (Reference 2.6-14). The extreme design gust speeds were then calculated for various return periods, particularly, for the design of reactor buildings based on ASCE7 IV risk category which corresponds to 3000-year return period. Other commonly used values corresponding 300-, 700-, and 1700-year return periods were also estimated. Finally, Inverse Distance Weighted interpolation technique was applied to transfer the estimated 3-second gust values from the four selected stations to the DNNP site; the results are listed in Table 2.6-3. Also, bounding envelop 3-second gust extreme values were computed for the DNNP site, as listed in Table 2.6-4. The envelop values are found to be on average 6% higher than the values estimated through interpolation for the DNNP site. Hence, for the design to be conservative, the 2022 NK0054-REP-02730-00003 Wind Gust Analysis (Reference 2.6-14) recommends using the envelop values.

Table 3-5 of the 2009 NK054-REP-01210-00008 (Reference 2.6-5) presents the historical data available for wind gusts in the nearby area to the Darlington Nuclear site. Similar to the methodology used in Subsection 3.4.2 of the 2009 NK054-REP-01210-00013 (Reference 2.6-4) and the 1990 N-REP-NGD-IR-61100-0002 (Reference 2.6-11), site-specific 3-second gust wind speeds of more than 120 km/h or more are rare. However, 3-second gust wind speeds have occurred in some instances with a maximum historical wind gust in the area of 154 km/h. This is consistent with Table 4-4 of the 2022 NK0054-REP-02730-00003 (Reference 2.6-14), as presented in Table 2.6-3, noting maximum speeds of up to 174.4 km/h occurred in some instances.

|The hazards associated with high winds were not addressed in the 2019 DNGS hazard screening analysis report NK38-REP-03611-10043 (Reference 2.6-1). However, there is a commitment in place by OPG to perform a high wind PSA as part of the Licence to Construct application, as indicated in Subsection 4.5.2 of the 2020 NK054-CORR-00531-10533 (Reference 2.6-8). The high wind PSA will consider the impact from wind pressure-loading effects and wind-propelled missile analysis from various categories of high wind, and their impact on severe core damage and large release analysis.

The review of literature and simulations from Environment Canada indicated in Subsection 7.2.8 of the 2009 NK054-REP-01210-00012 (Reference 2.6-3) points to expected changes in wind speed due to increased greenhouse gas emissions. The same subsection states the global average winds are expected to decrease in a warmer world due to the decrease in temperature differential between the equator and poles. In the 2022 NK054-REP-02730-00003, Wind Gust Analysis (Reference 2.6-14), it was reported that Lake Erie shores will experience a decrease in wind speeds of 5% by 2071-2100, while other areas in Ontario like James Bay and Georgian Bay will experience an increase in wind speeds ranging from 1.4% to 10%.

Table 2.6-3: Extreme 3-second Gust Speeds for the DNNP (Reference 2.6-14)

	Return Period (year)	Gust speed (km/h) for each direction							
		NE	E	SE	S	SW	W	NW	N
DNNP Site	3000	116.5	153.4	106.2	131.7	172.3	165.6	145.5	115.8
	1700	115.5	147.7	101.5	125.7	165.3	159.5	140.5	111.3
	1000	106.7	142.0	97.4	120.2	158.8	153.9	136.0	107.3
	700	103.8	138.9	94.6	116.7	154.6	150.3	132.9	104.5
	300	96.5	130.5	87.9	108.0	144.3	141.4	125.6	97.9
	200	93.0	126.0	84.7	103.6	139.6	137.2	122.0	94.6
	100	87.0	120.0	79.1	96.8	131.0	129.7	116.0	89.4
	50	81.0	113.0	73.6	89.7	122.5	122.5	110.0	83.9
	20	72.9	103.0	66.2	80.2	111.5	112.9	102.0	76.8
	10	66.7	96.3	60.6	72.8	102.5	105.2	95.8	71.3

Table 2.6-4: Extreme 3-second Gust Speeds Envelop Based on Four-station Data Around the DNNP (Reference 2.6-14)

	Return Period (year)	Gust speed (km/h) for each direction							
		NE	E	SE	S	SW	W	NW	N
DNNP Site	3000	123.3	153.4	121.4	135.2	174.4	170.7	145.5	143.1
	1700	118.1	147.7	116.0	129.0	167.6	164.6	140.5	137.7
	1000	113.0	142.0	111.0	123.0	161.4	159.0	136.0	133.0
	700	110.2	138.9	107.8	119.6	157.2	155.4	132.9	129.3
	300	102.6	130.5	100.0	110.6	147.3	146.6	125.6	121.3
	200	99.0	126.0	96.3	106.0	142.5	142.0	122.0	117.0
	100	92.8	120.0	89.8	99.0	134.4	135.0	116.0	111.0
	50	86.5	113.0	83.4	91.6	126.2	128.0	110.0	104.0
	20	78.2	103.0	74.8	81.7	115.2	118.0	102.0	95.6
	10	71.8	96.3	68.1	74.1	106.8	111.0	95.8	88.8

2.6.6 Tornadoes and Hurricanes

Tornadoes

As discussed in Section 3.2 of the 2009 NK054-REP-01210-00008 (Reference 2.6-5), tornadoes are characterized as a rare and non-negligible threat, and a study of a design basis tornado was conducted to estimate the probability of occurrence at the DNNP site. The results of this study are presented in Table 3-7 of the 2009 NK054-REP-01210-00008 (Reference 2.6-5).

The DNNP site characteristics associated with the design basis tornado are outlined in Table 3 of the 2010 N-REP-01200-10000 (Reference 2.6-9), summarized in the following, and listed in Table 2.6-5 and Table 2.6-6):

1. Maximum Pressure Drop – The design assumption for the decrease in ambient pressure from normal atmospheric pressure due to the passage of the tornado
2. Maximum Rotational Speed – The design assumption for the component of tornado wind speed due to the rotation within the tornado
3. Maximum Translational Speed – The design assumption for the component of tornado wind speed due to the movement of the tornado over the ground
4. Maximum Wind Speed – The design assumption for the sum of maximum rotational and maximum translational wind speed components
5. Radius of Maximum Rotational Speed – The design assumption for distance from the centre of the tornado at which the maximum rotational wind speed occurs
6. Rate of Pressure Drop – The assumed design rate at which the pressure drops due to the passage of the tornado
7. Tornado Missile Spectra – The design assumptions regarding missiles that could be ejected either horizontally or vertically from a tornado. The spectra identify mass, dimensions, and velocity of credible missiles

The DNNP site characteristics values in the 2010 N-REP-01200-10000 (Reference 2.6-9) are based on the U.S. NRC Regulatory Guide 1.76 Rev 1 (Reference 2.6-13), Region 2 design basis tornado values. The characteristics, and appropriate reasoning are summarized from the 2022 NK054-CORR-01210-1015770 Engineering Direction for DNNP Design Basis Tornado Values (Reference 2.6-12). The DNNP site is conservatively assumed to have the Site Characteristic Maximum Wind Speed Site Characteristic value of 321.8 km/h for maximum wind speed. This is supported by the following reasons:

- The Maximum Wind Speed of 321.8 km/h is the upper limit for an Enhanced Fujita scale 4 (EF-4) tornado.
- The Maximum Wind Speed of EF-4 is a conservative value for the Darington Nuclear site, as the Maximum Wind Speed value is not a measured value for the site.
- The assessment performed of the occurrence of tornadoes within an area of 100 000 km^2 of the Darlington Nuclear site during the past 50 to 60 years indicated two category Enhanced Fujita scale 4 (EF-4) tornadoes were observed within 180 km of the site during that period.
- A probability of approximately 0.01% per year was predicted corresponding to an EF-4 category of damage for the Darlington Nuclear site.
- The U.S. NRC RG-1.76 Rev1 (Reference 2.6-13) values for the two subregions adjacent to the Eastern Great Lakes and the northeastern boundary of Region 1 are 327 Km/h and

296 km/h, respectively. This further supports the use of 321.8 km/h as a bounding value for Darlington Nuclear site.

The missile spectrum in Table 2.6-6 is extracted from Table 2 of U.S. NRC RG-1.76 Rev1 (Reference 2.6-13), Region 2 values, which correspond to a maximum wind speed of 321.8 km/h.

Table 2.6-5: DNNP Site Characteristics for Design Basis Tornado (Reference 2.6-9)

Parameter	Value
Maximum Pressure Drop	6.3 kPa
Maximum Rotational Speed	257.4 km/h
Maximum Translational Speed	64.4 km/h
Maximum Wind Speed	321.8 km/h
Radius of Maximum Rotational Speed	45.7 km/h
Rate of pressure Drop	2.5 kPa/s

Table 2.6-6: DNNP Site Tornado Missiles Spectrum for Maximum Horizontal Speed (Reference 2.6-9)

Missile Type	Dimensions	Mass	Horizontal Velocity (V_{mh}^{max})	Vertical Velocity (0.67 of V_{mh}^{max})
Schedule 40 Pipe	0.168 m dia x 4.58 m long	130 kg	34 m/s	22.8 m/s
Automobile 5 m x 2 m x 1.3 m	5 m x 2 m x 1.3 m	1810 kg	34 m/s	22.8 m/s
Solid Steel Sphere	2.54 cm dia	0.0669 kg	7 m/s	4.7 m/s

Hurricanes

A tropical cyclone is a rapidly rotating storm system characterized by a low-pressure centre. Depending on the wind speed, it can be designated as hurricanes, tropical storms, or tropical depressions. Based on the information presented in Subsection 3.5.2 of the 2009 NK054-REP-01210-00013 (Reference 2.6-4), there is a very low probability of a hurricane directly impacting the DNNP site, and it describes the probable maximum tropical cyclone as unlikely to yield gusts of more than 100 km/h which is lower than that of the design basis tornado. As such, wind hazard from a hurricane is not considered further.

Additionally, the 2009 NK054-REP-01210-00013 (Reference 2.6-4) states that a tropical storm such as Hazel, which occurred in 1954, would be the worst-case scenario from systems of tropical origin. During this storm, Toronto Pearson reported over 150 mm of rain in 2 days with sustained winds of 92 km/h for 2 hours and multiple hours with winds of over 70 km/h, per Subsection 3.5.2 of the 2009 NK054-REP-01210-00013 (Reference 2.6-4). Precipitation caused from a tropical cyclone is covered in Subsection 2.5.3.5.

2.6.7 Waterspouts

A tornado forming over water is a waterspout. The Site Evaluation on Nuclear Safety Considerations in the 2009 NK054-REP-01210-00008 (Reference 2.6-5), Section 3.2, states tornadoes over water or waterspouts generally leave no trace and are rarely reported. Additionally, the report states it is less likely for tornadoes to form over water than over land.

However, the report assumes an equal distribution of tornadoes and waterspouts for a given area and calculates the probability of a tornado at DNNP site. It then concludes that with such a frequency, tornadoes can be characterized as a rare, but non-negligible threat and a study of a design basis tornado was required in order to estimate the probability of occurrences on-site. The DNNP site characteristics for design basis tornado is described in Subsection 2.6.6.

2.6.8 Dust Storms and Sandstorms

The assessment for the potential of dust storms or sandstorms was captured in the 2009 NK054-REP-01210-00013 (Reference 2.6-4) where Subsection 3.5.5 states a lack of evidence of these phenomena was identified from an extensive search through the available meteorological information relevant to southern Ontario. Hence, neither dust storms nor sandstorms were identified as potential hazards since the possibility of occurrence for these phenomena at the DNNP site is deemed to be highly unlikely.

2.6.9 Snow and Ice Load, Freezing Rain, and Ice Storm

Snow and Ice Load

The average daily snowfall recorded at the nearest monitoring station to the Darlington Nuclear site is between 3 cm and 5 cm from December to March, per Section 2.2 of the 2009 NK054-REP-01210-00008 (Reference 2.6-5). Similarly, the daily snowpack is typically recorded at the same location, and its highest point tends to occur in January, with a mean value of 8.6 cm.

Table 2.6-7 shows under Loading 1 the characteristic value of 2.2 kPa for snow and ice load for reactor designs considered for the DNNP site, per Subsection B.1.3, Table 3 of the 2012 N-REP-01200-10000 (Reference 2.6-9).

The 2019 DNGS hazard screening analysis report NK38-REP-03611-10043 (Reference 2.6-1) used the 1975 NBCC design criteria for the snowpack of 2.1 kPa (Loading 2 in Table 2.6-7).

For the DNNP, Subsection 4.5.2 of the 2020 NK054-CORR-00531-10533 (Reference 2.6-8) assumed that similar snowfall conditions to the ones experienced in DNGS are expected to occur at DNNP due to their proximity. In 2022, a study was performed in NK054-REP-02730-00004 Winter PMP Validation (Reference 2.6-15) where a 50-year recurrence snow fall depth and maximum one-day late winter rain load nearby Oshawa are used to calculate the roof loading. The resulting loading is 1.8 kPa, as shown in Table 2.6-7, Loading 3. Furthermore, Loading 4 of 1.71 kPa in Table 2.6-7 represents the calculated DNNP snow load based of an NBCC 100-year recurrence, following the recommendation of CSA N291:19 (Reference 2.6-16) and employing a 50- to 100-year conversion multiplying factor of 1/0.82, as described in the 2022 NK054-REP-02730-00004 Winter PMP Validation (Reference 2.6-15), noting CSA N291:19 (Reference 2.6-16) does not require adding WPMP. The DNNP estimated snow loads and winter PMP values listed in Table 2.6-7 for 50-year recurrence or 100-year recurrence with or without WPMP are equal or lower than the Darlington Nuclear site characteristic value (Loading 1) of 2.2 kPa listed in Subsection B.1.3, Table 3 of the 2012 N-REP-01200-10000 (Reference 2.6-9).

Table 2.6-7: Snow Loads and Winter PMP Values for DNGS and DNNP (Reference 2.6-15)

Loading ID	Nuclear Site	Values	Compliance Notes
1	Darlington Nuclear	**2.2 kPa**	Characteristic value for reactor designs considered for the site (2010 PPE - Reference 2.6-9)
2	DNGS	**Snow: 2.1 kPa**	Meets the 1975 NBCC requirements (2019 SNGS - Reference 2.6-1)
3	DNNP (50-year recurrence)	Snow: 1.4 kPa + WPMP: 0.4 kPa = **Total: 1.8 kPa**	Meets 2015 NBCC requirements for 50-year recurrence snowpack, plus 50-year recurrence winter PMP near Oshawa (2022 DNNP - Reference 2.6-15)
4	DNNP (100-year equivalent recurrence)	Snow: (1.4/0.82) **= Total 1.71 kPa**	Meets 2015 NBCC requirements and CSA N291:19 requirements using a multiplying ASCE/SEI 7-10 factor of 1/0.82 to calculate the 100-year recurrence snowpack (2022 DNNP - Reference 2.6-15), noting N291:19 does not require adding WPMP.

Freezing Rain

With respect to freezing rain, Subsection 4.5.2 of the 2020 NK054-CORR-00531-10533 (Reference 2.6-8) indicates this item was considered for assessment as part of the safety analysis for DNNP. The hazards associated with freezing rain were also screened out for DNNP due to low consequence, as indicated in the 2019 hazard screening analysis report NK38-REP-03611-10043 (Reference 2.6-1) and in the 2019 Site Preparation Nuclear Safety Licence Renewal Activity Report NK054-REP-01210-00108 (Reference 2.6-2).

Ice Storm

Ice storms present a potential hazard for the systems located outside the DNNP BWRX-300, as indicated in Subsection 4.5.2 of the 2020 NK054-CORR-00531-10533 (Reference 2.6-8). According to Subsection 4.5.5 of the 2019 NK38-REP-03611-10043 (Reference 2.6-1), a review of operating experiences indicates minor ice storms have not had an impact on other plants, but significant storms have caused losses of off-site power and switchyard failures. This event is described as an LOPP and is covered in Chapter 15, Subsection 15.5.3.2.4.

2.6.10 Lightning

The assessment of lightning strikes is provided in Subsection 3.5.3 of the 2009 NK054-REP-01210-00013 (Reference 2.6-4) in the context of frequency of occurrence, where Table 3.5.10 provides estimates of the cloud-to-ground flashes for Toronto and Trenton, while Figure 3.5.8 displays graphically the Average Annual Flash Density in southern Ontario. Based on the data evaluated, the vicinity of the DNNP site will likely experience a frequency of 2 to 3 cloud-to-ground flashes per year per square kilometer. The 2020 DNNP lightning data collected and evaluated per NK054-CORR-00531-10533 (Reference 2.6-8) confirmed lightning occurrences are frequent in southern Ontario.

Subsection 4.5.7 of the 2019 Hazard Screening Assessment NK38-REP-03611-10043 (Reference 2.6-1) for DNGS summarizes the potential consequences of lightning occurrences as induced fires and electromagnetic compatibility issues affecting the functionality of electrical systems. As shown in Table 4-3 of the 2019 NK38-REP-03611-10043 (Reference 2.6-1), the criterion assigned for lightning events is screening criterion QL-1 for DNGS, which is described as “an event of equal or lesser damage potential than similar events for which the plant has been designed.” This screening criterion is applicable to the DNNP site on the basis that adequate measures, such as fire barriers and qualification for electromagnetic compatibility, are incorporated in the BWRX-300 design, as described in Chapter 7, Section 7.1 and Section 7.3.

2.6.11 Windborne Debris

An analysis of windborne debris from various categories of high wind, also known as wind-propelled missiles, is assessed as part of the 2020 high wind PSA per NK054-CORR-00531-10533 (Reference 2.6-8). This assessment evaluated the impact of windborne debris on severe core damage and large release analysis. Tornado windborne missile hazard design basis is described in Table 2.6-6 in Subsection 2.6.6, Tornadoes and Hurricanes.

2.6.12 Climate Change Impact

As described in Subsection 2.5.4, the 2023 Darlington New Nuclear Project Strategy for Addressing Climate Change Impacts NK054-PLAN-07007-00001 (Reference 2.6-19) is developed with the objective of summarizing life cycle climate change considerations including relevant long-term monitoring that is described in Subsection 2.11.9.

2.6.13 References

2.6-1 NK38-REP-03611-10043 R003, 2019, “Hazards Screening Analysis – Darlington,” Ontario Power Generation.

2.6-2 NK054-REP-01210-00108 R000, 2019, “Site Preparation Nuclear Safety Licence Renewal Activity Report,” Ontario Power Generation.

2.6-3 NK054-REP-01210-00012 R001, 2009, “Site Evaluation of the OPG New Nuclear at Darlington - Part 5: Flood Hazard Assessment,” Ontario Power Generation.

2.6-4 NK054-REP-01210-00013 R001, 2009, “Site Evaluation of the OPG New Nuclear at Darlington - Part 4: Evaluation of Meteorological Events,” Ontario Power Generation.

2.6-5 NK054-REP-01210-00008 R001, 2009, “Site Evaluation for OPG New Nuclear at Darlington - Nuclear Safety Considerations,” Ontario Power Generation.

2.6-6 NK054-REP-01210-00016 R002, 2012, “Site Evaluation of the OPG New Nuclear at Darlington - Part 2: Dispersion of Radioactive Materials in Air and Water,” Ontario Power Generation.

2.6-7 NK38-SR-03500-10001 R005, 2018, “Darlington Safety Report, Part 1 and 2,” Ontario Power Generation.

2.6-8 NK054-CORR-00531-10533, 2020, “Application for Renewal of OPG's Darlington New Nuclear Project (DNNP) Nuclear Power Reactor Site Preparation Licence (PRSL),” Ontario Power Generation.

2.6-9 N-REP-01200-10000 R003, 2010, “Use of Plant Parameters Envelope to Encompass the Reactor Designs Being Considered for the Darlington Site,” Ontario Power Generation.

2.6-10 NK054-REP-01210-00078 R007, 2021, “Darlington New Nuclear Project Commitments Report,” Ontario Power Generation.

2.6-11 N-REP-NGD-IR-61100-0002, 1990, “NGD Meteorological Towers System Description and Operating Recommendations,” Ontario Power Generation.

2.6-12 NK054-CORR-01210-1015770 R00, 2022, “Engineering Direction for Darlington Nuclear Project Design Basis Tornado Values,” Ontario Power Generation.

2.6-13 U.S. NRC Regulatory Guide 1.76 Rev 1, Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants, July 2007.

2.6-14 NK054-REP-02730-00003, 2022, “Wind Gust Analysis,” Ontario Power Generation

2.6-15 NK054-REP-02730-00004, 2022, Winter PMP Validation,” Ontario Power Generation

2.6-16 CSA N291:19, “Requirements for Nuclear Safety-related Structures,” CSA Group.

2.6-17 NK054-REP-02730-00001, 2022, “Flood Hazard Assessment,” Ontario Power Generation.

2.6-18 NK054-REP-02730-00002, 2022, “PMP Validation,” Ontario Power Generation.

2.6-19 NK054-PLAN-07007-00001, 2023, “Darlington New Nuclear Project Strategy for Addressing Climate Change Impacts,” Ontario Power Generation.

2.7 Geology, Seismology and Geotechnical Engineering

Section 2.7 covers the following DNNP site-specific information:

- Site Location and Description - Subsection 2.7.1

  Subsection 2.7.1 presents a general description of the site and identifies the study areas considered for the characterization of the site geological and geotechnical conditions

- Geological Characteristics - Subsection 2.7.2

  Subsection 2.7.2 contains the geological characteristics of the site including descriptions of the site physiography, surficial and bedrock geology, and offshore bathymetric contours and lakebed geology

- Geotechnical Characteristics - Subsection 2.7.3

  Subsection 2.7.3 describes the geotechnical and geological data collected at the site, presents subsurface soil and rock profiles and groundwater conditions, and provides an assessment of potential geotechnical hazards on structures

- Seismology Characteristics - Subsection 2.7.4

  Subsection 2.7.4 summarizes the seismological characteristics of the site including descriptions of the regional geology and tectonic history, hazard models, regional seismicity and seismic sources, ground motion characterization, methodologies used for the PSHA, and geological hazards that could potentially affect the site and the plant design.

- Geotechnical and Seismological Requirements and DNNP Site Parameters - Subsection 2.7.5

  Subsection 2.7.5 presents geotechnical and seismological parameters for the DNNP site including evaluation of bearing capacity and settlement, static and dynamic properties of rock, soil and engineered fill materials, geotechnical variability and uncertainty, Site Response Analysis (SRA), and groundwater level

The presented summary of geological, seismological, and geotechnical characteristics of the DNNP site and the surrounding region are based on:

- Site-specific characteristics from DNNP documents including the PSHA and the geological mapping of subsurface soil layers and bedrock, as well as relevant Darlington Nuclear site data.
- Available information developed during the DNNP site selection and preparation stages

In 2022 and 2023, several DNNP site-specific investigations and studies are completed as follows:

1. NK054-REP-01210-00175 R001, 2022, “Phase I Geotechnical Investigation (Power Block) Darlington New Nuclear Project,” Volumes1 of 2 and 2 of 2 (Reference 2.7-39)
2. NK054-REP-10180-00001 R000, 2023 “Offshore Geotechnical Investigation,” (Reference 2.7-40)
3. NK054-REP-03500.8-00001 R000, 2022, “Darlington New Nuclear Project - Site-Specific Probabilistic Seismic Hazard Assessment”, (Reference 2.7-41)
4. NK054-REP-03500.8-00002 R000, 2022, “Darlington New Nuclear Project - Seismically-Induced Soil Liquefaction Assessment,” (Reference 2.7-42)

5. NK054-REP-03500.8-00003, 2023, “Darlington New Nuclear Project Foundation Interface Analysis (FIA) Report,” (Reference 2.7-38)

These investigations, assessments and analyses are used to validate and update DNNP-specific geological and geotechnical characteristics and parameters of subgrade materials, results of PSHA, potential of liquefaction underneath the BWRX-300 facility buildings, as well as Lake Ontario bathymetry and lakebed geology.

2.7.1 Site Location and Description

The Darlington Nuclear site, where the DNNP BWRX-300 facility is to be built, is located about 65 km east of the City of Toronto on the north shore of Lake Ontario in the Municipality of Clarington, Region of Durham in Ontario, Canada. The DNNP site is located to the east of the existing DNGS as shown in Chapter 1, Appendix A, Figure A1.1-2. The site is at latitude 43° 53’ north and longitude 78° 43' west, per the 2009 site geotechnical aspects evaluation NK054-REP-01210-00011 (Reference 2.7-1). (Refer to Section 2.1 for further information on the Darlington Nuclear site and the DNNP site description, layout, geography, and demography.)

The topography of the Darlington Nuclear site, shown in Figure 2.7.1-1, based on the Darlington Topographic Drawing NK054-DRAW-01210-00003 (Reference 2.7-26), indicates a gentle slope rising upward towards the east from an approximate elevation of 80 m to 88 m CGD, in a horizontal distance of about 400 m. Further east, the existing ground rises substantially to an elevation of about 100 m CGD near the east site boundary. The existing shoreline along the Darlington Nuclear site consists of a narrow beach with steep bluffs. Additional information about the Darlington Nuclear site topography is provided in Subsection 2.1.1.

The site is situated in an undulating to moderately rolling glacial till plain. However, the upper soils at the site are glaciolacustrine, indicating the site is in the Iroquois Plane. The previously irregular terrain was graded for the existing DNGS to an elevation of about 78 m CGD. For the DNNP, the terrain is planned to be graded to a grade elevation of 88 m CGD. The surface elevation for the DNNP site rises towards the north with a mean elevation of 100 m CGD just south of the Canadian National Railway tracks. To the north of the railway tracks, the ground is irregular ranging from 98 m to 106 m CGD. A higher ridge, starting from the shore just east of Raby Head, extends diagonally across the site in a northwesterly direction with levels of up to 15 m above the surrounding ground. Offshore from the site, the Lake Ontario bottom slopes away gradually reaching a depth of 6 m at about 425 m from shore and 14 m at approximately 1.2 km from shore. Offshore bathymetry is discussed in Subsection 2.7.2.4.

2.7.2 Geological Characteristics

Summaries based on the information in the 2009 DNNP Site Geotechnical Aspects Evaluation NK054-REP-01210-00011 (Reference 2.7-1), the 2013 DNNP Geotechnical Data Report NK054-REP-01210-00098 (Reference 2.7-29), the 2023 NK054-REP-10180-00001 Offshore Geophysical Investigation Report (Reference 2.7-40), and the 1989 DNGS Preoperational Summary Report No. 89575 (Reference 2.7-2) are presented in:

- Subsection 2.7.2.1 - Surficial Geology
- Subsection 2.7.2.2 - Site Physiography
- Subsection 2.7.2.3 - Bedrock Geology
- Subsection 2.7.2.4 - Offshore Bathymetric Contours / Lakebed Geology

These summaries furnish a framework within which the geological characteristics of the DNNP site and the surrounding region are described.

2.7.2.1 Surficial Geology

The regional surficial geology, for an area within an approximately 50 km radius from the DNNP site, is shown in Figure 2.7.2-1, as replicated from the 2009 NK054-REP-01210-00011 (Reference 2.7-1).

For the surficial geology, there are three general physiographic regions:

- The Oak Ridges Moraine on the north side of the regional study area
- The South Slope in the middle
- The Iroquois Plain, a wide belt along Lake Ontario in the south

The Oak Ridges Moraine Physiographic Region

The Oak Ridges Moraine is a significant geologic/hydrogeologic feature specific to southern Ontario. The moraine is a major source of groundwater recharge, and many creeks and rivers are derived from groundwater discharge from the moraine. It was formed by regional glaciation, the advance and recession of several ice sheets and the subsequent melting of the glaciers. The moraine marks the boundary between the Lake Simcoe ice lobe advancing from the north and the Lake Ontario ice lobe advancing from the south. It is a ridge of high land separating drainage northward to Lake Simcoe and southward to Lake Ontario.

The moraine consists of interbedded layers of glacial till, sand and gravel. The moraine has a distinctive hummocky terrain with knobs and kettles. The southern flank of the moraine is covered by the Halton Till, a silty to silt-clay till.

The South Slope Physiographic Region

The South Slope fills the area between the moraine and the Iroquois Plain. It consists of gentle to steep slopes but is more uniform compared to the irregular terrain of the moraine. It contains a number of drumlins which point to the southwest, indicating the general direction of glacier movement.

The Iroquois Plain Physiographic Region

The Iroquois Plain, an 8 to 12 km wide plain, lies between the former shoreline of Lake Iroquois and present-day Lake Ontario. Shoreline deposits and glaciolacustrine sediments are found in this area overlying the glacial tills. The shoreline deposits include sand and gravel bars and beach terraces as well as some deltas from former rivers and creeks flowing into Lake Iroquois. The lacustrine deposits, consisting of silts and clays overlying till are found further from the former shoreline. In the area of the site, the Iroquois Plain contains drumlins with a southeast orientation indicating the northwest glacial advance.

2.7.2.2 Site Physiography

The DNNP site is generally covered by upper and lower till deposits, per the 2009 NK054-REP-01210-00011 (Reference 2.7-1), as described in the following paragraphs.

The surface till in the DNNP area is similar to the Newmarket Till, a sandy silt to silt till. An earlier dense, to very dense, sandy silt to hard silty clay till overlies the bedrock. Bounded between the upper and lower tills are deposits of water-bearing sand or sand and gravel.

Earlier deposits of lacustrine varved silt and clay and stratified fine to medium sand overlie the upper till at lower elevations near the DNNP BWRX-300 location, as described in the 2013 NK054-REP-01210-00098 (Reference 2.7-29). These surficial lacustrine deposits consist of varved silt and clay and fine to medium sand of variable thickness, per the 2013 NK054-REP-01210-00098 (Reference 2.7-29).

Fill material of variable composition is present at the ground surface over portions of the DNNP site, as described in the 2013 NK054-REP-01210-00098 (Reference 2.7-29). The fill consists of a mixture of clay, silt, sand, and gravel.

Overburden thickness varies significantly from the north to the south. Overburden thickness in the Oak Ridges Moraine is approximately 200 m reducing in thickness towards the south with about 10 m of overburden at Lake Ontario.

2.7.2.3 Bedrock Geology

The bedrock is completely covered by Quaternary deposits and bedrock outcrops are found only in local quarries, as described in the 2009 NK054-REP-01210-00011 (Reference 2.7-1). The bedrock surface, from east to west, consists of the Simcoe Group overlain by the younger Blue Mountain (formerly the Whitby Formation) and Georgian Bay Formations. The Simcoe Group consists of the Gull River, Bobcaygeon, Verulam and Lindsay Formations (from deep to shallow). The dip of the bedrock formations is approximately 0.5 percent to the southwest.

The Blue Mountain Formation is a shale formation. The lower 2 m to 3 m includes what was formerly known as the Whitby Formation, a black, petroliferous calcareous shale which tends to weather grey on exposure. The shale is fissile and fossiliferous. The Lindsay Formation is a grey argillaceous limestone with a full formation thickness of approximately 67 m.

The Verulam, Bobcaygeon and Gull River Formations lie below the Lindsay Formation. They are shale and limestone formations. The Shadow Lake Formation, a sandstone and shale formation, lies unconformably on the Precambrian Basement, as explained in the 2009 NK054-REP-01210-00011 (Reference 2.7-1).

Based on the described bedrock geology, the bedrock at the site of the DNNP is mainly the Lindsay Formation overlying the Verulam and Bobcaygeon and Gull River Formations. The upper few meters of bedrock are shaley limestone and shale of the Blue Mountain Formation that overlies the Simcoe Group, as detailed in the 2013 NK054-REP-01210-00098 (Reference 2.7-29).

2.7.2.4 Offshore Bathymetric Contours / Lakebed Geology

The bathymetric contours of the lakebed along Lake Ontario shoreline of the Darlington Nuclear site are provided in the 2023 NK054-REP-10180-00001 Offshore Geophysical Investigation Report (Reference 2.7-40). This investigation was conducted to characterize the lakebed and sub-bottom materials and profile the depth to bedrock. The offshore geophysics methods used were:

- Seismic reflection
- Sub-bottom profiling
- Electrical resistivity tomography
- Multi-beam echosounder
- Side scan sonar
- Magnetometer

The most prominent feature of the lakebed topography reported in the 2023 NK054-REP-10180-00001 Offshore Geophysical Investigation Report (Reference 2.7-40) is a crescent shaped ridge and peninsula of shallower depths which wraps from the northeast to the west of the surveyed area. The shape of this ridge creates a deeper “bay” in the central west part of the surveyed area; to the southeast the lakebed drops off into deeper water, as shown in Figure 2.7.2-3 and Figure

2.7.2-4. The results are aligned with previous studies of the offshore bathymetry and lakebed surface geology, per the 1989 Report No. 89575 (Reference 2.7-2), as depicted in Figure 2.7.2-5 and Figure 2.7.2-6.

2.7.3 Geotechnical Characteristics

Subsection 2.7.3 includes the following information related to the geotechnical characteristics of the DNNP site:

- Subsection 2.7.3.1 describes available geotechnical and geological data collected for the DNNP site
- Subsection 2.7.3.2 presents subsurface stratigraphic soil and rock profiles and groundwater conditions at the DNNP site
- Subsection 2.7.3.3 provides an assessment of potential geotechnical hazards on the DNNP structures

2.7.3.1 Geotechnical Information Collected at the DNNP Site

Multiple geotechnical investigations have been completed for the DNNP site. The data compiled in the investigations described in this subsection are used in determining the static and dynamic subgrade properties of the DNNP site presented in Subsection 2.7.5.

2.7.3.1.1 CH2MHILL (2007, 2008) Study

The investigation was performed by CH2MHILL in late 2007 and early 2008 and included installing monitoring wells in 11 borings. The results of this study are presented in two reports, the 2009 DNNP Geotechnical Aspects Site Evaluation NK054-REP-01210-00011 (Reference 2.7-1) and the 2009 DNNP Geological and Hydrogeological Environment NK054-REP-07730-00005 (Reference 2.7-30). These boreholes covered an area larger than the boundary of the DNNP site. The locations of the monitoring wells and the corresponding borehole numbers (DN) within the area planned for the construction of the DNNP in the CH2MHILL study, are marked with red circles in Figure 2.7.3.1-1.

2.7.3.1.2 AMEC (2012) Study

Three vertical boreholes completed within the DNNP area by AMEC in the 2012 DNNP Geologic and Geophysical Evaluation NK054-REF-01210-0418696 (Reference 2.7-28) are used to obtain subsurface information to the depth of the Precambrian Basement rock. The results of this study are presented in the 2012 NK054-REF-01210-0418696 (Reference 2.7-28). The locations of these deep borings are shown in Figure 2.7.3.1-2. The boreholes included: AMC-01 to a depth of 231.6 m, AMC-02 to a depth of 239.6 m, and AMC-03alt to a depth of 239.6 m. This study provides detailed boring logs, downhole geophysical measurements including televiewer data, surface geophysical measurements, and laboratory testing results. The data compiled in this study was mainly used to characterize the bedrock units. The geotechnical data provided in this AMEC study for the soil units are limited.

2.7.3.1.3 EXP Service INC. (2013) Study

In the 2013 DNNP Geotechnical Data Report NK054-REP-01210-00098 (Reference 2.7-29), eight sampled boreholes were drilled at locations within the DNNP area as shown in Figure 2.7.3.1-3. The drilled boreholes were advanced to various depths between 34 m to 85 m below the surface. The geotechnical data include detailed stratigraphic information, results of in-situ Standard Penetration Tests (SPTs) with calibrated hammers, and data from laboratory testing of soil and rock samples. Subsurface cross-section diagrams developed as part of the EXP study are presented in Figure 2.7.3.1-4 and Figure 2.7.3.1-5.

2.7.3.1.4 WSP GOLDER (2022) Phase 1 Geotechnical Investigation Report

In the 2022 Geotechnical Investigations NK054-REP-01210-00175 (Reference 2.7-39), extensive drilling was conducted at locations within the DNNP area to determine engineering properties of soil and rock, with specific focus on the first BWRX-300 location as shown in Figure 2.7.3.1-6. The stratigraphic units identified for the DNNP site and corresponding description are listed in Table 2.7-1. The site investigation followed the guidelines of NEDO-33914-A (Reference 2.7-27), Section 3.1, to ensure an adequate characterization of the subsurface conditions that meet additional requirements specific to the BWRX-300 design as a deeply embedded Small Modular Reactor (SMR).

Sampling was conducted in conjunction with in-situ SPTs performed with calibrated automatic hammers and data from laboratory testing of soil and rock samples are outlined in Section 4 and Section 5 of the 2022 Phase-1 investigations report (Reference 2.7-39).

The methodology for the in-situ and laboratory test are outlined in Volume 1 – Factual Geotechnical Data Report of NK054-REP-01210-00175 (Reference 2.7-39). The types of tests conducted include:

- Soil chemical analysis for the following constituents:
  - Soil pH of soil for corrosion
  - Water-soluble sulfate
  - Chloride in water
  - Sulfate in water for concrete
- Soil resistivity analysis
- Vane shear tests (cohesive soils)
- Pressuremeter testing (soil), dilatomer testing (rock), piezocone soundings (soil), soil resistivity, packer testing (rock), over-coring stress testing (rock)
- Uniaxial Compression Stress (UCS) testing (rock)
- Triaxial compression stress testing (soil)
- Constant stress direct shear creep testing on rock joints
- Swell testing (rock)

2.7.3.2 Subsurface Stratigraphic Profile

2.7.3.2.1 Profiles for the DNNP Site (2022)

The stratigraphy for the DNNP site soil and bedrock units listed in Table 2.7-1 is developed based on the work performed in the 2022 Geotechnical Investigations NK054-REP-01210-00175 (Reference 2.7-39).

Details of the in-situ stratigraphic layers average and range of thicknesses are provided in Table 2.7-2 for the soil units and in Table 2.7-3 for the rock units. The interpreted soil and rock stratigraphy are presented in east-west oriented and north-south oriented cross-sections in Figure 2.7.3.2-1 and Figure 2.7.3.2-2, respectively. Further details for subsurface soil and bedrock profiles are described in the following paragraphs.

Unit 1 – Topsoil/Fill

The uppermost layer is topsoil and/or fill consisting of either poorly graded sand with gravel or sandy lean clay. Unit 1 was encountered at ground surface at all boreholes drilled for the 2022 Phase 1 Geotechnical Report NK054-REP-01210-00175 (Reference 2.7-39). This layer has an average thickness of 1.59 m ranging from 0.53 m in borehole 27 to 3.53 m in borehole 67.

Units 2a and 2b – Surficial Glaciolacustrine Deposits

Two glaciolacustrine deposits are found below the upper topsoil and fill. The upper deposits (Unit 2a) are encountered below the topsoil/fill layer. Unit 2a consists of silt, clay, fine to coarse sand and trace to some subrounded to subangular gravel. The lower deposits (Unit 2b) consist of silt with some clay, fine to coarse sand and subrounded to angular, fine to coarse gravel.

In some boreholes, Units 2a and 2b were observed to be interlayered. The combined thickness of Units 2a and 2b averages 1.74 m, and is ranging from zero in borehole 6, to 6.1 m in borehole 5.

Unit 3 - Upper Till

Deposits of silty sand with gravel to sandy lean clay with gravel are encountered below Units 2a and 2b. Unit 3 is described as a till layer generally consisting of a heterogeneous mixture of dense to very dense gravel, boulders, and cobbles in a matrix of silty sand. This deposit consists of silt, clay, fine to coarse sand and subrounded to subangular to angular, fine to coarse gravel. Unit 3 ranges in thickness from zero in borehole 4 to 13.49 m in borehole 17, with an average thickness of 7.35 m.

Units 4a and 4b – Intermediate Glaciolacustrine Deposits

Two distinct glaciolacustrine deposits are founded below Unit 3. The upper deposit, Unit 4a consists of silt, clay, fine to coarse sand and subrounded to angular, fine to coarse gravel. Boulders and cobbles are also present within Unit 4a. Below Unit 4a is Unit 4b which consists of silt, clay, fine to coarse sand and trace to some subrounded to angular gravel.

In some boreholes, Units 4a and 4b were observed to be interlayered. The combined thickness of units 4a and 4b averages 11.3 m, and ranges between zero in borehole 11SB to 17.7 m in borehole 27.

Unit 5 – Lower Till

Below the intermediate glaciolacustrine deposits (Units 4a and 4b), a deposit of very dense silt and sand to hard lean clay (Unit 5) is encountered. Unit 5 is described as a lower till layer generally consisting of a heterogeneous mixture of gravel, boulder, and cobbles in a matrix of silt sand and silty clay. This deposit consists of silt, clay, fine to coarse sand, and subrounded to angular, fine to coarse gravel. It has an average thickness of 3.57 m, ranging from zero in borehole 16 to 6.63 m in borehole 15.

Unit 6a – Blue Mountain Formation Bedrock

The top of the bedrock is at an average elevation of 64.20 CGD, ranging from 62.72 m CGD in borehole 6 to 65.80 m CGD in borehole 70.

Below Unit 5, is a moderately weathered to fresh, very thinly to medium bedded, fine grained, faintly porous, slightly to moderately reactive to hydrogen chloride, weak to strong shale with thin, limestone interbeds. Unit 6a has an average thickness of 2.98 m, ranging from 1.38 m in borehole 73 to 5.87 m in borehole 30.

Unit 6b – Lindsay Formation Bedrock

Below Unit 6a is a slightly weathered to fresh, very thinly to medium bedded, fine to medium grained, faintly porous, slightly to moderately reactive to hydrogen chloride, weak to medium strong to very strong limestone with shale interbeds, Unit 6b has an average thickness of 61.36 m, ranging from 60.61 m in borehole 16 to 61.93 m in borehole 65.

Unit 6c – Verulam Formation Bedrock

Below Unit 6b is a fresh very thinly to medium bedded, grey, fine to medium grained, faintly porous, moderately reactive to hydrogen chloride, medium strong to very strong limestone with shale interbeds. Full thickness of Unit 6c was not tested.

Table 2.7-1: Stratigraphic Units for the DNNP Site

Unit No.	Description
1	Topsoil / Fill
2a	Surficial Glaciolacustrine Deposits – Sandy Lean Clay to Lean Clay
2b	Surficial Glaciolacustrine Deposits – Silty Clayey Sand to Silty Sand/Sandy Silt
3	Upper Till
4a	Intermediate Glaciolacustrine Deposits – Silty Sand to Sandy Silt
4b	Intermediate Glaciolacustrine Deposits – Sandy Lean Clay to Lean Clay
5	Lower Till
6a	Blue Mountain Formation Bedrock
6b	Lindsay Formation Bedrock
6c	Verulam Formation Bedrock

Table 2.7-2: In-situ Soil Units Stratigraphy under the Power Block (Reference 2.7-39)

Layer	Layer Thickness (m)							
	Reactor Building[1]		Power Block[2]		BWRX-300 Protected Area[3]		BWRX-300 Study Area[4]	
	Average	Range	Average	Range	Average	Range	Average	Range
Unit 1	1.25	0.61 – 2.13	1.81	0.61 – 3.28	1.77	0.61 – 3.53	1.59	0.53 – 3.53
Unit 2a Unit 2b	1.73	0.61 – 3.81	2.32	0.00 – 6.09	2.35	0.00 – 6.09	1.74	0.00 – 6.10
Unit 3	6.24	1.07 – 8.87	6.01	0.00 – 9.06	6.26	0.00 – 13.47	7.35	0.00 – 13.49
Unit 4a, Unit 4b	9.32	0.00 – 14.48	9.78	0.00 – 14.32	9.07	0.00 – 14.54	11.30	0.00 – 17.70
Unit 5	2.29	1.36 – 2.98	3.78	1.36 – 6.63	3.25	0.86 – 6.63	3.57	0.00 – 6.63

Notes:
1. Includes borings BH 9, BH 10, BH 11, BH 11S, BH 11 SB, BH 12, BH 14 (Reference 2.7-39)
2. Includes borings BH 2, BH 4, BH 5, BH 9, BH 10, BH 11, BH 11S, BH 11SB, BH 12, BH 13, BH 14, BH 18, BH 19, BH 67, BH 68, BH 71, BH 73, BH 78 (Reference 2.7-39)
3. Includes borings BH 2, BH 4, BH 5, BH 6, BH 8, BH 7, BH 9, BH 10, BH 11, BH 11S, BH 11SB, BH 12, BH 13, BH 14, BH 15, BH 16, BH 17, BH 18, BH 19, BH 20, BH 66, BH 66S, BH 66SB, BH 67, BH 68, BH 71, BH 73, BH 77, BH 78 (Reference 2.7-39)
4. All boreholes considered in the study area in (Reference 2.7-39)

Table 2.7-3: Rock Units Stratigraphy (Reference 2.7-39)

	Layer Thickness or Depth (m)	
	Average	**Range**
Elevation Top of Bedrock	64.20 (CGD)	62.72 (BH 6) - 65.80 (BH 70)
Thickness Unit 6a - Blue Mountain Formation	2.98	1.38 (BH 73) - 5.87 (BH 30)
Thickness Unit 6b - Lindsay Formation	61.36	60.61 (BH 16) - 61.93 (BH 65)

Notes:
1. Full thickness of the Verulam Formation (Unit 6c) was not tested (Reference 2.7-39)
2. Lindsay formation thickness determined from small sample ~ (15%) of boreholes which extended fully through the formation (Reference 2.7-39)

2.7.3.2.2 Planned As-Built Soil Profile

Stratigraphic Units 1 and 2 are generally loose, have liquefaction potential (Subsection 2.7.4.7.6), and are not suitable for supporting the heavy foundations of the power block buildings. As a result, during site development, these soil layers will be excavated and replaced with compacted engineered fill.

Consequently, the as-built conditions at the site after construction of the BWRX-300 facility are anticipated to include compacted engineered fill from about elevation ranging between 80 m to 82 m CGD to the final grade at elevation 88 m CGD. The excavated soil from this site may be used as compacted engineered fill material if it meets the engineered fill gradation requirements outlined in the 2023 DNNP FIA Report NK054-REP-03500.8-00003 (Reference 2.7-38).

2.7.3.2.3 Bedrock Profile

The bedrock profile was developed based on readily available top-of-rock information from boreholes drilled for the geotechnical study in the 2022 NK054-REP-01210-00175 (Reference 2.7-39). Data between boreholes have been interpolated.

The top of the bedrock surface undulates relatively locally and slopes gently to the south from an elevation of 67 m CGD near the northern extent of the site to an elevation of 64 m CGD. This bedrock surface is consistent with the mapped sub-horizontal dip of the Paleozoic sequence observed within the vicinity of the project area.

Subsurface rock conditions may vary between and beyond the borehole/drillhole locations. The interpreted stratigraphy is therefore a simplification of the subsurface bedrock contacts. Variations in the stratigraphic boundaries between boreholes/drillholes will exist and are to be expected. Table 2.7-3 presents the top of bedrock elevation and bedrock thicknesses.

The BWRX-300 deeply embedded RB is anticipated to extend through the Blue Mountain Formation (Unit 6a) and be founded in the Lindsay Formation (Unit 6b) at 52.93 m CGD. The top of the Blue Mountain Formation near the BWRX-300 RB is anticipated to be at about 64 m CGD based on the depth to bedrock at BH 10, BH11 and BH 12 (refer to Figure 2.7.3.1-6), as explained in the 2022 Power Block geotechnical investigations NK054-REP-01210-00175 (Reference 2.7-39).

2.7.3.2.4 Groundwater Conditions

Based on the information provided in the 2022 DNNP Phase 1 Geotechnical Investigation Report NK054-REP-01210-00175 (Reference 2.7-39), the following three groundwater flow patterns are identified:

- The Unit 3 water table (shallow groundwater), shown in Figure 2.7.3.2-3
- Unit 4a groundwater flow in the integrated deposits, shown in Figure 2.7.3.2-4
- Unit 5 groundwater in the interglacial deposits located above the bedrock, shown in Figure 2.7.3.2-5
- Units 6a-6b groundwater in bedrock, shown in Figure 2.7.3.2-6

The groundwater flow interpretations in these figures (Figures 2.7.3.2-3 to 2.7.3.2-6) are based on a monitoring well-network with only a few months of monitoring data. The actual long-term interpretation may change. The contours are based on data from the new monitoring wells installed within the investigation area, which are limited in aerial extent, and have not been considered with contemporary groundwater elevation data from the pre-existing monitoring well-network at the site.

As shown on the figures, the groundwater flow direction in the upper and lower till (Units 3 and 5, respectively) is inferred to be toward the southwest and, in the intermediate glaciolacustrine deposits (Unit 4a) and shallow bedrock (Units 6a and 6b), to be toward the south-southeast.

Regional groundwater flow and flow at the DNNP site generally follows topography from higher elevations in the north towards the south, per the 2009 DNNP Geological and Hydrogeological Environment NK054-REP-07730-00005 (Reference 2.7-30). In general, this flow is driven by recharge from rainfall and snowmelt infiltration across the area and at higher elevations along the Oak Ridges Moraine north of the DNNP site with discharge, ultimately, to Lake Ontario to the south. The shallow groundwater system at the DNNP site deviates from this flow pattern near surface water conveyances and local recharge areas. Interpreted regional groundwater flow patterns documented in the 2009 report NK054-REP-01210-00011 (Reference 2.7-1) are shown in Figures 2.7.3.2-7, 2.7.3.2-8 and 2.7.3.2-9 for shallow water table, interglacial deposits, and shallow bedrock groundwater, respectively.

The hydro-stratigraphic units at the DNNP site follow the soil and geologic units. The upper till (Unit 3) forms an aquitard or confining layer at the site which restricts downward groundwater flow from the upper fill and glaciolacustrine materials. The interglacial deposits (Units 4a-4b) are the most significant hydrogeologic unit at the site since they extend across the site and to the recharge areas north of the site, as described in the 2009 NK054-REP-07730-00005 (Reference 2.7-30). There may be significant groundwater flow in the interglacial deposits due to the higher gradient and higher permeability of the materials. The lower till (Unit 5) beneath the interglacial deposits is also considered an aquitard with low permeability. Although flow in the upper till is downward due to under-draining by the interglacial deposits, there may be an upward component of flow through the lower till in some areas from the underlying upper bedrock aquifer, per the 2009 NK054-REP-07730-00005 (Reference 2.7-30).

The upper bedrock is likely fractured and weathered with higher secondary permeability and transmissivity compared to the intact bedrock. Flow in the upper bedrock is expected to be enhanced in areas where the lower till is absent, and the upper bedrock is in direct contact with the more permeable interglacial deposits. The lower bedrock at the DNNP site generally has low permeability and does transmit much groundwater. The groundwater conditions in the deeper bedrock formations below the Lindsay Formation have not been considered for study.

2.7.3.3 Evaluation of Geological Hazards on DNNP Structures

Subsection 2.7.3.3 provides an assessment of geological hazards that could impact the DNNP structures.

2.7.3.3.1 Karst Cavities

No evidence of significant karst cavities was encountered in the 2022 geotechnical boreholes (Reference 2.7-39). Some zones of lost core were encountered in the boreholes generally within 40 m of the ground surface and ranging from 5 cm to 66 cm in height, but no noticeable drop in the drilling rods was noted and therefore these are thought to be associated with zones of weathered and fragmented rock that had been washed out by the core drilling.

In addition, the previous geophysical reports associated with this site indicate the absence of anomalies in the rock that could indicate the presence of depressions or voids that may be indicative of large karst or faults. There is good seismic coverage with nine seismic refraction lines being executed at the site.

Review of the previous surface geophysical data as well as the numerous boreholes drilled in 2021 to 2022 for the power block, and the associated data (Reference 2.7-39) confirm the absence of karst features at this site.

2.7.3.3.2 Ground Frost

The conventional approach for protection of building foundations against frost action is to locate base of foundations and/or the base of grade beams (supported on deep foundation) at a depth at least equal to the depth of frost penetration. A minimum frost penetration depth of 1.3 m is therefore recommended, in accordance with OPSD 3090.101 (Foundation Frost Penetration Depths for Southern Ontario), as per the 2022 Geotechnical Investigation Report NK054-REP-01210-00175 (Reference 2.7-39). Partial or complete frost protection may also be achieved by using rigid polystyrene insulation.

Frost heaving may occur in fine grained soils where ice lenses occur when moisture is drawn to freezing horizons. Based on the existing site subsurface conditions, shallow silty fine sand and silt deposits below surficial granular fill are generally expected to be moderately to highly frost susceptible to heaving under freezing conditions. Therefore, adequate frost cover of 1.3 m depth is required for all foundations exposed to frost conditions.

2.7.3.3.3 Bearing Failure (Collapse)

The 2023 DNNP FIA Report NK054-REP-03500.8-00003 (Reference 2.7-38) evaluated the bearing capacities for the RB foundation and resulting bearing capacities for the Turbine Building (TB), Control Building (CB), Radwaste Building (RWB), and Reactor Auxiliary Bay foundations surrounding the deeply embedded RB using data reported in the 2022 geotechnical site investigations (Reference 2.7-39). The anticipated bearing pressure and bearing capacity for each building in the power block is summarized and discussed in Subsection 2.7.5.1.

2.7.3.3.4 Stability of Foundation

The 2023 DNNP FIA Report NK054-REP-03500.8-00003 (Reference 2.7-38) provides the anticipated maximum uniform and differential settlements of the RB, TB, CB, RWB, and Reactor Auxiliary Bay foundations. The anticipated bearing pressure and associated settlements are summarized and discussed in Subsection 2.7.5.1.

2.7.3.3.5 Stability Of Subgrade Surrounding the Reactor Building

A stability analysis was performed following the guidelines of NEDO-33914-A (Reference 2.7-27), Section 4.0, using the finite element software PLAXIS (Bentley) to perform advanced non-linear Soil-Structure Interaction (SSI) numerical modeling. In addition to the stability analysis, the potential for instability of the potentially unstable blocks or wedges surrounding the RB deep excavation were performed using UnWedge (RocScience), a 3D stability analysis and visualization program. The stability analysis is discussed further in Subsection 2.7.5.1 and all the analyses are detailed in the 2023 DNNP FIA Report NK054-REP-03500.8-00003 (Reference 2.7-38).

2.7.3.3.6 Transitional Ground Heave and Settlement

As part of site grading and development, there will be unloading and transitional ground heave resulting from excavation of the upper soft-to-loose soil layers of Units 1 and 2 at the site. Additionally, some of the heave will be offset by settlement, which will occur on completion of backfilling. Depending on the net change in the overall effective stress profile, net ground heave is expected to occur due to reduction in the finished ground level compared to existing levels.

During the process of unloading and re-loading, stratigraphic Units 3, 4 and 5 are expected to react quickly to the changes in the ground stresses with minimal lag. Hence, long-term consolidation or heave is not expected to occur. Rather only transitional elastic rebound, and compression are expected to occur, as documented in the 2023 DNNP FIA Report NK054-REP-03500.8-00003 (Reference 2.7-38).

It is anticipated that there will be about 10 mm of heave from offloading due to excavation and some nominal heave/settlement after the completion of fill placement. There may be some ongoing creep settlement from the fill placement; however, ground movements will be small and the impact on structures founded on or in the overburden soils will be insignificant, as described in the 2023 DNNP FIA Report NK054-REP-03500.8-00003 (Reference 2.7-38).

2.7.3.3.7 Stability of Natural Slopes

The structures located within the power block are level at finished grade and over 100 m away from the shoreline. The structures are expected to be founded on or in either engineered fill, very dense native Unit 3 soil or deeply embedded in strong to very strong bedrock. Therefore, slope instability will not be threat to these power block structures. However, the natural shoreline is prone to erosion, especially the steep bluffs to the east of the power block area. Erosion of the shoreline has the potential to pose a hazard eventually, through gradual reduction of the ground pressure, if allowed to progress over long periods. This is discussed in the 2022 NK054-REP-03500.8-00002 Darlington New Nuclear Project - Seismically-Induced Soil Liquefaction Assessment (Reference: 2.7-42). Prevention of erosion is to be achieved through the establishment of engineered shoreline protection. The steep bluffs as a slope do not pose a hazard to the first BWRX-300 unit planned, and design of subsequent units will mitigate the hazard as required.

2.7.3.3.8 Stability of Cut and Fill Slopes

The existing ground to the east of the existing DNGS will be excavated to form a large level area for the DNNP and its associated structures. For preliminary design purposes, cut slopes into the competent interglacial/till deposits will be at a general inclination of 1V:3H (18.4°). The excavated soils will be partially stored at the north-east part of the site. The fill slopes will be designed to ensure stability.

2.7.3.3.9 Stability of Dikes and Dams

No dams are currently present or planned for the DNNP. No dikes are currently present or planned on DNNP, and lake infilling is no longer planned for the project.

2.7.4 Seismology Characteristics

Subsection 2.7.4 summarizes findings of past seismic hazard investigations as well as of the 2022 site-specific PSHA (Reference 2.7-41) that were performed for the DNNP and DNGS site.

Subsection 2.7.4 includes:

- Subsection 2.7.4.1 - provides background seismological information and data collected since 1997
- Subsection 2.7.4.2 - describes the regional geological structure and tectonic history of the Darlington Nuclear site
- Subsection 2.7.4.3 - presents information on the seismicity of the region surrounding the site and the development of earthquake catalogue
- Subsection 2.7.4.4 - describes the seismic hazard model containing regional and local sources
- Subsection 2.7.4.5 - describes aspects related to ground motion characterization
- Subsection 2.7.4.6 - discusses the PSHA methodology and the results for the DNNP site
- Subsection 2.7.4.7 - describes protentional geological and seismological aspects at the DNNP site

2.7.4.1 Background and Data Collection

In 2009, the Darlington Nuclear site was evaluated for suitability for the DNNP. A PSHA was performed, per the 2009 NK054-REP-01210-00014 (Reference 2.7-4) in accordance with:

- CNSC Regulatory Document RD-346 Site Evaluation for New Nuclear Power Plants (Reference 2.7-5), which is superseded by CNSC's REGDOC 1.1.1 Site Evaluation and Site Preparation for New Reactor Facilities (Reference 2.7-6)
- IAEA NS-R-3 (Reference 2.7-7), which is superseded by SSR-1 (Reference 2.7-8)

The 2009 PSHA (Reference 2.7-4) details assembly of the geological, geophysical, and seismological data collection for the region, near region and vicinity of the DNNP site. The approach adopted utilized the 1997 study (Reference 2.7-3) as a starting point. The database assembled for that study was updated, and the effects of the updates of regulatory requirements in CNSC RD-346 (Reference 2.7-5) and IAEA NS-R-3 (Reference 2.7-7) were evaluated, and changes were incorporated. The 2009 PSHA was thereafter revised three times: in 2011 in NK38-REP-03611-10041 R000 (Reference 2.7-9), in compliance with CSA Standard N289.2 (Reference 2.7-31); in 2019 in NK38-REP-03611-10041 R002 (Reference 2.7-10), and in 2021 in NK38-REP-03611-10041 R003 (Reference 2.7-11), with minor changes to address CNSC comments not previously incorporated. The PSHA updates in both the 2019 NK38-REP-03611-10041 R002 (Reference 2.7-10) and the 2021 NK38-REP-03611-10041 R003 (Reference 2.7-11) include:

- Updates to the Earthquake Catalogue
- Updates to the Maximum Magnitude Assessment
- Updates to Earthquake Occurrence Rates

- Application of the Next Generation Attenuation -East Ground Motion Model

In 2022, a DNNP site-specific PSHA (Reference 2.7-41) was conducted in accordance with the requirements of CNSC REGDOC 2.5.2 and CSA N289 series, as well as with the BWRX-300 SMR specific design requirements listed in NEDO 33914-A (Reference 2.7-27). In addition, the 2022 PSHA study (Reference 2.7-41) used the 2001 NUREG/CR-6728 (Reference 2.7-20) to develop site-specific ground motions considering local site conditions.

2.7.4.2 Regional Geological Structure and Tectonic History

2.7.4.2.1 Regional Geological Structure Stratigraphy

The Darlington Nuclear site lies within the western Lake Ontario region in the tectonically stable interior of the North American continent, which is characterized by low rates of historical seismicity, as described in the 1994 EPRI TR-102261-V1 (Reference 2.7-12). The region is underlain by middle Proterozoic (about 900 to 1600 million years ago) Grenville basement rock and overlying Paleozoic (about 250 to 570 million years ago) shallow-water sedimentary strata.

The Grenville Province formed in response to several phases of compression and metamorphism. The “Grenville Front” and “Grenville Front Tectonic zone”, shown in Figure 2.7.4.2-1, is the contact between the Grenville Province to the east and the continental Eastern Granite-Rhyolite provinces to the west. Rocks of the Central Gneiss Belt are between the “Grenville Front Tectonic Zone” and the Central Metasedimentary Belt Boundary Zone. The Central Metasedimentary Belt Boundary Zone underlies the western end of Lake Ontario, and the Central Metasedimentary Belt underlies the rest of Lake Ontario and the site study region. The Central Metasedimentary Belt is an intensely faulted and folded zone formed less than 1,300 million years ago. The southeastern portion of the Central Metasedimentary Belt consists of slightly younger rock. The Grenville orogeny (mountain-building episode) is widely attributed to a continental collision; however, deformation occurred in several episodes of extension and compression.

The Grenville Province’s crustal structure is characterized by north-northeast-striking, relatively shallow east-southeast-dipping ductile thrust faults that developed at mid- to lower-crustal depths during the middle Proterozoic Grenville orogeny. Prominent north-northeast-trending geophysical anomalies associated with exposed Grenville structures extend southward beyond the Canadian Shield and beneath the unconformable lower Paleozoic cover rocks. Regional geologic maps (e.g., Ontario Geological Survey, 1991) indicate that the overlying Paleozoic rocks are, with few exceptions, relatively flat-lying and laterally continuous, indicating that no large-scale, major faulting has occurred in the region since they were deposited.

The notable exception to the lack of regional-scale faulting in southern Ontario and Quebec occurs within the St. Lawrence rift system, as described in the 1966 Canadian Journal of Earth Sciences, Volume 3, No. 5 (Reference 2.7-13), which is a remnant of the late Proterozoic/early Paleozoic Iapetan passive margin, as described in the 1996 published article of R.L. Wheeler (Reference 2.7-14). The St. Lawrence rift system comprises abundant large-scale normal faults displacing lower Paleozoic strata and underlying Grenville basement on the order of many hundreds of meters along the Ottawa, Champlain, St. Lawrence, and Saguenay River valleys (Reference 2.7-13). These extensional faults generally cut discordantly across Grenville-aged structures instead of reactivating them. Mesoscopic-scale faulting of the lower Paleozoic strata, with fault displacements ranging from less than a meter to several tens of meters, has been recognized locally throughout much of the Lake Ontario region outside of the St. Lawrence rift system. The St. Lawrence rift system is associated with zones of elevated and persistent seismicity, per Slemmons, D.B., et al. in 1991 (Reference 2.7-15).

Worldwide, the seismic potential of a stable continental region varies according to the degree of crustal extension that it experienced in the geologic past, and to a lesser extent, the age of the crust, per the 1994 EPRI TR-102261-V1 (Reference 2.7-12). Three types of crust are identified in eastern North America, per the 1994 EPRI TR-102261-V1 (Reference 2.7-12):

- Unrifted - the craton and the Appalachian fold belt
- Failed intracontinental rifts—the Ottawa and Saguenay aulacogens and the Reelfoot rift complex
- Rifted passive continental margin—the Atlantic passive margin produced by the present opening of the Atlantic Ocean in the late Mesozoic, and a relic passive margin produced by Iapetan rifting in the late Proterozoic/early Paleozoic

The north-northeast-trending faults along the Champlain and St. Lawrence River valleys, once attributed to a two-sided, failed intracontinental rift, are now recognized as part of the southeast-facing Iapetan margin, per R. L. Wheeler, in 1996 (Reference 2.7-14). The present-day Atlantic passive margin comprises transitional crust (continental-oceanic) and the extended and faulted inboard continental shelf.

Evidence of Iapetan rifting of the craton adjacent to the northern Appalachians is recorded within the St. Lawrence rift system (Reference 2.7-13) in the form of rift-related extensional structures, sediments, and magmatic/volcanic products that developed along the ancient continental margin. The rift structures include zones of echelon faults parallel to the ancient margin, possible fracture zones transverse to the ancient margin, and two well-defined aulacogens (failed rifts)—the Ottawa and Saguenay grabens.

The Appalachian orogen lies approximately 400 km east of the Darlington Nuclear site. Northern Appalachian orogenic events occurred from Ordovician to Permian time and consisted of several distinct tectonic episodes. As discussed in the 2022 DNNP PSHA NK054-REP-03500.8-00001 (Reference 2.7-41), the key structural elements that mark the boundaries of the various crustal provinces (e.g., the western limit of Mesozoic extensional structures) are used to define regional seismic source zones that are characterized by similar crustal properties (for an example of one boundary interpretation, refer to Figure 2.7.4.2-2).

2.7.4.2.2 Neotectonics Setting

The geologically most recent evidence for major tectonic activity in the region is Alleghanian (late Permian) thrust faults formed in the Appalachian foreland basin and late Triassic to late Jurassic normal faults along the Atlantic margin related to continental rifting and the subsequent opening of the Atlantic Ocean, per the 2009 NK054-REP-01210-00014 DNNP PSHA (Reference 2.7-4). However, historical seismicity along the St. Lawrence rift system, in the Charleston, South Carolina, area, and in other concentrated zones; local geologic evidence of Cenozoic reactivation of faults; evidence of seismically-induced liquefaction in susceptible sands and silts; and geologic and geodetic data indicative of regional and local crustal deformation suggest continuing neotectonic activity, albeit at much lower rates than during the last episode of major tectonic deformation.

Slemmons, D.B., et al. in 1991 (Reference 2.7-15) have reported that most large historical and instrumental earthquakes in eastern Canada have occurred near Paleozoic or younger rift zones. This is similar to stable continental region earthquakes worldwide, as described in the 1994 EPRI TR-102261-V1 (Reference 2.7-12). The early Paleozoic St. Lawrence rift system, which is delineated by a persistent pattern of seismicity, is the postulated source of numerous large, historical earthquakes in southeastern Canada, per Slemmons, D.B., et al. in 1991 (Reference 2.7-15). Seismicity along this rift system appears to be concentrated in a number of well-defined clusters, including the Ottawa River, Charlevoix, and lower St. Lawrence River seismic zones, which are all separated by relatively aseismic regions.

Equivocal evidence for neotectonism, per Thomas, R.L., et al. in 1993 (Reference 2.7-16), has been found in the Lake Ontario region, and there are difficulties in distinguishing between deformation related to glacial processes and that related to deep-seated tectonic processes.

East-northeast/west-southwest-trending lakebed features in the Rochester basin of Lake Ontario and the Hamilton-Presqu'ile fault zone, along with some of the features observed in western Lake Ontario, have been proposed by Thomas, R.L., et al. in 1993 (Reference 2.7-16), as neotectonic evidence for the southwest continuation of the St. Lawrence rift system through Lakes Ontario and Erie.

The postulated northwestern boundary of the late Proterozoic/early Paleozoic Iapetan rifted margin tectonic province lies approximately 80 km east of the site, per Wheeler, R.L. in 1995 (Reference 2.7-17). There also is deep seismic evidence suggesting that the western boundary of the Iapetan margin may lie farther to the west, along the Central Metasedimentary Belt Boundary Zone of the Grenville province as described by Milkereit, B., et al. in 1992 (Reference 2.7-18). These alternative boundaries are considered in defining regional seismic source zones (for an example of one boundary interpretation, refer to Figure 2.7.4.2-2).

The rate of historical seismic activity in the Grenville Province west of the Iapetan rifted margin is low and appears typical of stable cratonic crust, per the 1994 EPRI TR-102261-V1 (Reference 2.7-12). In general, seismic activity and the geologic conditions most associated with earthquake activity in the stable continental region of Central and Eastern North America increase towards the east, away from the Precambrian central craton and towards the rifted passive continental margin.

2.7.4.3 Seismicity

Characterization of the seismicity of the region surrounding the DNNP site forms an essential part of the assessment of the seismic hazard. The primary means of characterization of seismicity is the use of the earthquake catalogue to assess earthquake occurrence rates and maximum magnitudes for earthquake sources.

In the Darlington Nuclear site PSHA studies, presented in the 2019 NK38-REP-03611-10041 R002 (Reference 2.7-10) and the 2021 NK38-REP-03611-10041 R003 (Reference 2.7-11), the 2012 NUREG-2115 (Reference 2.7-21) earthquake catalogue was updated to include independent earthquakes from the end of 2008 through 20 May 2019. The earthquake catalogue was again updated in the 2022 NK054-REP-03500.8-00001 DNNP PSHA (Reference 2.7-41) to extend the duration of the catalogue to the end of December 2021 using the:

1. National Earthquake Database of Canada
2. U.S. Geological Survey earthquake catalogue
3. Weston Observatory earthquake catalogue

The 2012 NUREG-2115 (Reference 2.7-21) contains data collected through mid-2009. Expected moment magnitudes were determined for the added earthquakes as described in 2022 PSHA NK054-REP-03500.8-00001 (Reference 2.7-41).

Figure 2.7.4.3-1 depicts the spatial distribution of earthquakes in the updated de-clustered catalogue exclusively in the time window between 2008 and December 31, 2021, as described in the 2022 DNNP PSHA NK054-REP-03500.8-00001 (Reference-2.7-41).

The maximum magnitude (M_{max}) distributions for the distributed seismicity sources (seismicity source zones) were obtained using the project earthquake catalogue and the methodology developed in NUREG-2115 (Reference 2.7-21). The project earthquake catalogue was also used to obtain updated earthquake recurrence assessments for the seismic sources

2.7.4.4 Seismic Source Characterization

The seismic source zonation model used in the 2022 DNNP PSHA NK54-REP-03500.8-00001 (Reference 2.7-41) is that presented in the 2021 Darlington PSHA NK38-REP-03611-10041 R003 (Reference 2.7-11) with the exception of updates to the 2020 Geological Survey of Canada historical seismicity zonation (H model) based on Adams, et al. (Reference 2.7-19). The seismic source characterization model comprises regions of distributed seismicity and local sources representing identified geological/geophysical features. An overview of the information in the 2022 DNNP PSHA (Reference 2.7-41) with respect to the regional and local seismic sources is summarized in the following paragraphs.

2.7.4.4.1 Regional Source Zones

Three alternative approaches to regional seismic zonation are used to represent the sources of distributed seismicity throughout the study region. Figure 2.7.4.4-1 presents the logic tree structure used in the 2022 DNNP PSHA (Reference 2.7-41) as well as previous PSHA studies in the Darlington Nuclear site area, representing the epistemic uncertainty in regional seismic source zonation. The three alternative approaches are used to define the source zonation for distributed seismicity sources as follows:

1. The favored approach (weight 0.8) was to define source zones on the basis of seismotectonic evaluations. Epistemic uncertainty in defining the boundaries between these seismotectonic sources led to the set of alternative zonations.
2. An alternative approach (weight 0.1) was to use the historical seismicity zonation developed by the Geological Survey of Canada as part of the Canadian National Earthquakes Hazards Program (Adams, J., et al., 2019) (Reference 2.7-19) These regional Seismicity Zones are shown in Figure 2.7.4.4-2.
3. The third alternative was to use a zoneless model (weight of 0.1) in which seismicity parameters were defined for individual cells comprising 1 degree longitude by 1 degree latitude within the study region shown in Figure 2.7.4.4-3.

2.7.4.4.2 Local Source Zones

There are six potential local seismic source zones that are defined based on their identified geological/geophysical features, per the 2022 DNNP PSHA NK054-REP-03500.8-00001 (Reference 2.7-41). These six source zones are: Clarendon-Linden Fault System, Georgian Bay Linear Zone, Hamilton-Presqu'ile Fault, Mississauga Magnetic Domain, Niagara-Pickering Linear Zone, and Wilson-Port Hope Magnetic Lineament. These sources act as potential concentrators of seismic activity and are critically assessed for their seismogenic potential. The locations of these sources have been extracted from the 2022 DNNP PSHA (Reference 2.7-41) and are depicted in Figure 2.7.4.4-4.

2.7.4.5 Ground Motion Characterization

Ground motion models are needed to calculate the effects at the site of earthquakes occurring in the characterized seismic sources. Two aspects are considered as follows:

1. Estimation of the amplitude of ground motions as a function of earthquake size and the source-to-site distance that is provided by ground motion models
2. Assessment of the effect of the local site conditions on the generic hard rock ground motions by results of site response analyses performed in a manner that achieves hazard-consistent ground motions at the site surface

In active tectonic environments, ground motion models are often developed from the analysis of recorded strong motion data. The seismic hazard was computed using the Pacific Earthquake Engineering Research Center model documented in the 2018 PEER Report No. 2018/08 by Goulet, C., et al. (Reference 2.7-22), The model is the most comprehensive ground motion model available for Central and Eastern United States (CEUS) Seismic Source Characterization.

2.7.4.6 PSHA Results for the DNNP Site

The 2022 PSHA study in NK054-REP-03500.8-00001 (Reference 2.7-41) presents the seismic hazard characterization for the deeply embedded BWRX-300 RB at the DNNP site. The study meets the requirements and follows the guidance of CNSC REGDOC-2.5.2 (Reference 2.7-32), CSA N289 Series (Reference 2.7-31, 2.7-32, and 2.7-33), and the Licensing Topical Report NEDO-33914-A (Reference 2.7-27).

The PSHA presented in the 1994 EPRI TR-102261-V1 (Reference 2.7-12) and the 2021 Darlington Risk Assessment (Reference 2.7-11), developed Uniform Hazard Response Spectra (UHRS) for rock outcropping motions at the anticipated level of the foundation of the DNGS plant at the top of the Paleozoic bedrock strata. The DNGS foundation level is not at the same elevation as the foundation of the BWRX-300 deeply embedded RB.

The seismic hazard model used in the 2022 DNNP PSHA (Reference 2.7-41) is based on the seismic hazard model employed in the 2021 Darlington Nuclear site PSHA (Reference 2.7-11) and is updated using new data and information. Differences between the two seismic hazard models, overall, are minor and include:

- Recalculated earthquake recurrence parameters, such as rates, maximum magnitude (M_{max}), and spatial distributions, using the updated earthquake catalogue
- Slight increase in the probability that the Wilson-Port Hope local source is associated with small magnitude earthquake, resulting from additional earthquakes being recorded in the region (this produces a minor increase in the overall probability of activity for this source)
- The source zone geometry for zonation based on historical seismicity is updated to be consistent with the 6th Generation of seismic hazard maps of Canada, H2 model for source zonation, per Adams, J., et al. (Reference 2.7-19).

The approach to site-specific hazard differs between the 2022 DNNP PSHA NK054-REP-03500.8-00001 (Reference 2.7-41) and the 2021 Darlington site PSHA NK38-REP-03611-10041 (Reference 2.7-11). In the 2021 Darlington site PSHA (Reference 2.7-11) site-specific hazard results were obtained solely for the reactor basemat elevation for the existing DNGS using the two options for application of the EPRI 2006 Cumulative Absolute Velocity (CAV) model specified in USNRC (2012a) (Reference 2.7-35):

- Option 1 specified computing the hazard integrating from a minimum magnitude of M 5 (M 4 was used) but only applying the CAV filter to the contributions from magnitudes less than M 5.5
- Option 2 specified computing the hazard integrating from a minimum magnitude of M 5 without applying the CAV filter. Deterministic site amplification functions from reference rock were computed using a site profile truncated at the reactor foundation elevation.

Epistemic uncertainty in site amplification scaling reference rock motions to foundation level motions was incorporated into the CAV calculations but aleatory variability in amplification was not included. Vertical motions were obtained by applying mean V/H ratios to the horizontal UHRS.

2.7.4.6.1 Site Response Analysis

Site-specific hazard in the 2022 DNNP PSHA (Reference 2.7-41) is computed only using USNRC (2012a) (Reference 2.7-35) Option 2, integration of hazard from M 5 without applying the EPRI (2006) (Reference 2.7-36) CAV filter. Site amplification was computed using NUREG/CR-6728 Approach 3, per McGuire et al., in 2001 (Reference 2.7-20). This approach develops the SRA in which probabilistic site amplification functions defining both median amplification and aleatory variability in amplification were convolved with the reference rock hazard to produce site-specific hazard at the target elevations. Epistemic uncertainty in site amplification was modeled.

The site response model was extended to finish grade to represent anticipated as-built site conditions with reactor basemat elevation for the planned BWRX-300 is located approximately 12 m below the top of rock at the DNNP site while the reactor foundation levels at the existing DNGS site are at or near top of rock. Minimum epistemic uncertainty in site amplification was applied in both studies, with the updated value used for the DNNP study being 50 percent larger than the value used in the 2021 NK38-REP-03611-10041 (Reference 2.7-11). Seismic hazard results for vertical motions were computed by convolving probabilistic V/H ratios with the horizontal hazard rather than applying mean V/H ratios.

Per guidance of NEDO 33914-A (Reference 2.7-27), Section 5.2.2, the site-specific hazard is defined for the following three horizons at:

- The RB foundation bottom elevation 52.93 m CGD
- The soil/rock interface elevation 64 m CGD
- The finished grade elevation 88 m CGD

There are only slight differences between the reference rock and site-specific hazard curves at the RB base and soil/rock interface as presented in the 2022 DNNP PSHA report (Reference 2.7-41). The horizontal mean hazard curves were interpolated to obtain UHRS for an Annual Frequency of Exceedance (AFE) of 1E-2, 1E-3, 1E-4, 1E-5, 1E-6, and 1E-7 for the RB base, soil / rock interface, and finished grade elevations, respectively. The results of the UHRS curves at the horizontal and vertical of the three targeted horizons are provided in Figure 2.7.4.6-1 through Figure 2.7.4.6-8.

Seismic hazard results were produced in the 2022 DNNP PSHA report NK054-REP-03500.8-00001 (Reference 2.7-41) for Design Basis Earthquake (DBE) seismic inputs to design and Beyond Design Basis Earthquake (BDBE) seismic inputs for the evaluations of the Design Extension Conditions (DEC) as per REGDOC-2.5.2 (Reference 2.7-32) and to the Checking Level Earthquake as per CSA N289.1:18 (Reference 2.7-33). Section 9.2 of NK054-REP-03500.8-00001 (Reference 2.7-41) describes the development of DBE and BDBE ground motion response spectra. Figure 2.7.4.6-9 through Figure 2.7.4.6-11 compare the DBE and BDBE horizontal ground motion spectra with the corresponding UHRS with 1E-4 and 1E-5 AFE for the three elevations mentioned above.

Subsection 2.7.5.3.5.1 presents the DBE and BDBE response spectra that define the amplitude and frequency content of the DBE and BDBE ground motion. The DBE horizontal ground motion spectra meet the minimum earthquake requirement by enveloping the CSA N289.3 minimum spectrum as shown in Figure 2.7.4.6-12 and Figure 2.7.4.6-13.

Subsection 2.7.5.2.5.2 presents the hazard-consistent, strain-compatible dynamic soil properties used as input for the seismic response analysis and design of BWRX-300 RB that were also developed for both the DBE and BDBE levels of motion using the results of the site response analyses.

Augmentations were applied to the DBE and BDBE RB base motions, as described in Section 9.4 of NK054-REP-03500.8-00001 (Reference 2.7-41), to produce foundation input response spectra which meet the requirements of the 2010 USNRC DC/COL ISG-017 (Reference 2.7-37) for hazard consistency of foundation input response spectra for SSI analyses following guidance of NEDO 33914-A, Section 5.3.4.1. Finally, sets of recorded ground motions were recommended for use as seed motion in developing time histories for seismic analyses.

Table 2.7-4 identifies the figures which present UHRS based on the mean hazard results, reproduced from the 2022 PSHA NK054-REP-03500-.8-00001 (Reference 2.7-41).

Table 2.7-4: Figures Presenting UHRS Based on Mean Hazard Results.

Elevation (m CGD)	Orientation	Figure
52.93	Horizontal	2.7.4.6-1
52.93	Vertical	2.7.4.6-2
64	Horizontal	2.7.4.6-3
64	Vertical	2.7.4.6-4
88	Horizontal	2.7.4.6-5
88	Vertical	2.7.4.6-6
Reference Rock	Horizontal	2.7.4.6-7
Reference Rock	Vertical	2.7.4.6-8
52.93	Horizontal DBE and BDBE	2.7.6.4-9
64	Horizontal DBE and BDBE	2.7.6.4-10
88	Horizontal DBE and BEBE	2.7.6.4-11

2.7.4.7 Potential Seismically Related Hazards

Several geological hazards and seismicity-related phenomena that could potentially affect the suitability of the DNNP site and the plant design are evaluated.

2.7.4.7.1 Volcanism

A methodology for initial investigation of volcanism suggests evaluating within a 150 km radius of the site, per the 2009 DNNP Flood Hazard Assessment NK054-REP-01210-00012 (Reference 2.7-23). The methodology states that if there is no evidence of Cenozoic era (i.e., within the last 65 million years), volcanic rocks or volcanism in the region, no further investigations are required. Geological Map 1860a from Natural Resources Canada in the 2009 DNNP NK054-REP-01210-00012 (Reference 2.7-23) does not identify Cenozoic era formations within 150 km of the site. Hence, volcanism at the DNNP site is considered an improbable hazard with no associated seismic activity.

2.7.4.7.2 Tsunami

Tsunamis are long period gravity waves generated in oceans or lakes by seismic disturbances or landslides resulting in a sudden displacement of the water surface. The resulting wave energy spreads across the ocean or lake at high speed. Tsunami occurrences in Canada are rare, with the Pacific Coast at greatest risk due to the higher occurrence rate of earthquake and landslide activity. The magnitude 7.2 Grand Banks earthquake of 1929 produced tsunami effects on the Burin Peninsula of Newfoundland. The Great Lakes are on the edge of the Canadian Shield, a geologically stable, mid-continental region where the rate of occurrence of earthquakes is about one tenth of that at tectonic plate boundaries.

The Lake Ontario shorelines are not generally susceptible to shore slope failure or landslide. Review of U.S. National Geophysical Data Center Lake Ontario bathymetry gave no evidence of submarine landslides or other surface disturbance in the post-glacial period, per the 2009 NK054-REP-01210-00012 (Reference 2.7-23). Around the perimeter of Lake Ontario, “Quaternary sediments are relatively thin or absent, and bedrock exposures are common, possibly reflecting the effects of sub-glacial erosion and subsequent abrasion by lacustrine waves and currents.”

The Natural Hazards Database at the U.S. National Geophysical Data Center reports one 1755 “tsunami run-up event” in Lake Ontario, though this appears to have been a seiche-like event. The event, for a location about 50 km northwest of Rochester, N.Y. is coded as “an event that only caused a seiche or disturbance in an inland river”, source “unknown.” “In Lake Ontario the water repeatedly rose in an unusual way to the height of about 1.5 m, no shock is mentioned. Exact latitude and longitude are unknown.”

In the absence of tsunami reports in Lake Ontario and the lack of shoreline or lakebed evidence of tsunami initiators, tsunamis are considered improbable events with no associated flood hazard potential at the site.

2.7.4.7.3 Seiches

Storm surge and seiche effects in Lake Ontario resulting for various scenario storms were considered in the 2009 NK054-REP-01210-00012 (Reference 2.7-23). The maximum storm-induced surge and seiche at the Darlington shore is 0.75 m. The 1755 event where 1.5 m high seiche-like oscillations in Lake Ontario were reported may not have been seismically-induced as no shock is mentioned. A review of historical earthquake records in the 2009 DNNP PSHA NK054-REP-01210-00014 DNNP PSHA (Reference 2.7-4) identified an event on January 9th, 1847, in Grafton Harbour where with “Lake Ontario calm under a north wind, suddenly the lake level descended, exposing the lakebed for upwards of about 107 m". In moments it recoiled, rushing towards the shore in one unbroken wave about 1.2 m above normal. This wave accompanied by a heavy noise crashed over the wharf and washed inland about 91 m. This happened about 8 or 9 times, each with “diminishing force.” The editor of the Cobourg Star reminded his readers that something similar had occurred in Cobourg and Port Hope in 1845. An apparently related report described “some commotion” at Rice Lake about 19 km north of Grafton Harbour, during which the 0.46 m of ice on Rice Lake began “to undulate”. Eventually the ice burst with “a noise like thunder” and chunks in the center of the lake were tossed into a pile about 3.1 m high. These reports do not mention ground shaking, although noise is mentioned.

Based on the historical evidence, seiche events have occurred in Lake Ontario; therefore, shoreline protection at DNNP is considered in the design as discussed in Subsection 2.4.2.

2.7.4.7.4 Dams and Landslides

There are no human-made water retaining structures within the Darlington Creek watershed or other site vicinity watersheds, as described in the 2009 Flood Hazard Assessment NK054-REP-01210-00012 (Reference 2.7-23). Hence, there are no flooding hazards associated with seismically-induced failure of human-made water retaining structures. Additionally, the flooding threat due to seismically-induced landslide at the site is minimal, per the 2009 NK054-REP-01210-00012 (Reference 2.7-23). These conclusions are validated in Section 5.6 of the 2022 DNNP Site Evaluation Update Summary Report NK054-REP-01210-00142 (Reference 2.7-43).

2.7.4.7.5 Surface Faulting

At present, there is no known evidence of larger, pre-historic earthquakes that have resulted in surface fault rupture because such earthquakes have not occurred, or the evidence for surface rupture or coseismal damage is not preserved, or the studies needed to identify past large earthquakes is insufficient to recognize these events.

Given the relatively stable geological setting of the region surrounding the Darlington site, the recency of the post-glacial landscape that might preserve past large earthquake effects, it is expected that evidence for large earthquakes if they have occurred, would be difficult to identify. The 2022 Geotechnical Investigation Report NK054-REP-01210-00175 (Reference 2.7-39) confirms the absence of historical evidence for surface rupture within the Darlington site, including any absence of faults within the boreholes as logged.

The onshore and offshore boreholes and mapping of the DNGS excavations did not indicate offsets in the stratigraphic units, shear zones, or deep depressions in the bedrock surface, hence no near surface faulting has occurred in the bedrock at the site, as described in the 1981 DNGS Geotechnical Mapping of Bedrock Excavation NK38-02004P (Reference 2.7-24). There is no evidence of post-glacial fault-related scarps in the overburden or of solution-weathered cavities in the bedrock, as reported in the 1977 DNGS Geology and Seismicity - Hydro Geotechnical Engineering Dept. Report 77110 (Reference 2.7-25).

The stratigraphic continuity of the upper Paleozoic bedrock in the site vicinity conformed to the regional dip of about 5 m/km to the south. Minor changes in thickness and position of marker units were evident, but the differences were well within the limits of variation expected for sedimentary rock formations in southern Ontario. No vertical dislocation or displacement was evident in the upper Paleozoic bedrock formations, indicating that faulting has not propagated through the sedimentary rock strata from the Precambrian basement rock.

Mapping of marker units in the DNGS intake and discharge tunnels that extend over 1 km south of the site showed continuity consistent with the regional dip. Jointing in the rock is tight and water ingress is insignificant.

Regional geologic maps, e.g., Ontario Geological Survey, 1991, indicate that the Paleozoic rocks are, with few exceptions, relatively flat-lying and laterally continuous, indicating that no large-scale, major faulting has occurred in the region since they were deposited.

The 2022 DNNP Geotechnical Investigation NK054-REP-01210-00175 (Reference 2.7-39) reaffirmed the conclusions from the 2009 investigations and it is concluded that there is no evidence of surface faulting in the overburden or bedrock at the site or site vicinity.

2.7.4.7.6 Liquefaction Potential of Foundations

The RB foundation is to be founded on sound limestone bedrock. Foundations of other structures are to be founded on dense to very dense till deposits, and/or engineered fill. As such, the liquefaction potential of foundations will be low.

The 2022 DNNP Liquefaction Assessment Report NK054-REP-03500.8-00002 (Reference 2.7-42) assessed seismically-induced liquefaction hazards of foundation soils for the DNNP to support the Licence to Construct (LTC) application. The assessment considered the latest seismic hazard values reported in the 2022 DNNP PSHA NK054-REP-03500.8-00001 DNNP PSHA (Reference 2.7-41). The detailed liquefaction assessment of foundation soils was performed for the structures No. 1 to No. 6, namely, (1) RB, (2) TB, (3) RWB, (4) CB, (5) Reactor Auxiliary Bay, and (6) Independent Spent Fuel Storage Installation (ISFSI), as labelled in Figure 2.7.4.7-1 and Figure 2.7.4.7-2. In addition, for the potential Emergency Mitigating Equipment (EME) Access Routes at the site, all boreholes within the project boundary were evaluated for liquefaction potential.

The following conclusions were derived from the results of the liquefaction assessment (Reference 2.7-42).

- For the DBE event, foundation soil liquefaction is not expected for the structures within the power block including the RB, TB, RWB, CB, and Reactor Auxiliary Bay, based on available soil data and the plan for the power block area to be over-excavated approximately to elevation 81 m CGD and then backfilled to plant grade elevation of 88 m CGD. For the foundation soil below the structures No.2 to No.5, the estimated seismically-induced settlement is typically less than 5 mm with a maximum of 8 mm, and the seismically-induced lateral displacement is expected to be up to 28 mm under DBE event
- For the DBE event, soil in the vicinity of the ISFSI structure (Structure No. 6) is expected to experience liquefaction, particularly in the surficial glaciolacustrine deposit (Unit 2 from the expected finished grade at elevation 88 m down to about 5 m depth). The estimated seismically-induced settlement is up to 154 mm and the lateral spreading displacement is up to 1.67 m.
- For the BDBE event, foundation soil liquefaction is not expected for the following structures:
  - RB (Structure No. 1), founded directly on bedrock
  - TB (Structure No. 2)
  - RWB (Structure No. 3)
- For the BDBE event, liquefaction potential exists at only one data point (isolated and limited extent of zones) for foundation soils in the vicinity of the following structures:
  - CB (Structure No. 4) - The liquefaction data point is at about elevation 69.1 m CGD, about 18.9 m depth from the finished grade.
  - Reactor Auxiliary Bay (Structure No. 5) - The liquefaction data point is at about elevation 69.9 m CGD, about 18.1 m depth from the finished grade.
- For the BDBE event, the foundation soil of the structures No.2 and No.5 in the power block area is calculated to have typically less than 17 mm and up to 27 mm of seismically-induced settlement, and the displacement due to lateral spreading that is calculated to be typically less than about 0.05 m and up to about 0.09 m displacement, as per the detailed liquefaction assessment of the available geotechnical data.
- For the BDBE event, significant liquefaction and seismically-induced deformation is expected in the vicinity of the proposed location for the ISFSI structure (Structure No.6).
- For the EME access routes, liquefaction susceptibility and screening assessment was performed considering all boreholes (forty-eight in total) at the site except for those within the power block area. Figure 2.7.4.7-1 and Figure 2.7.4.7-2 show the locations of the boreholes which are susceptible to liquefaction for the DBE and BDBE events respectively.

In Section 7.2 of the 2022 DNNP Geotechnical Investigation Report (Reference 2.7-39), it is indicated the upper clayey, sandy, and silty deposits (i.e., Units 2a and 2b) are potentially liquefiable during the 10,000-year design earthquake event. However, approximately 8 m of soil will be removed from beneath the power block and replaced by engineered fill. Excavating the aforementioned soil units by the specified 8 m will mitigate the potential for liquefaction. It is therefore concluded that the soil under the power block is considered non-liquefiable under the 10,000-year design earthquake for the RB, TB, RWB, CB, and the Reactor Auxiliary Bay.

2.7.5 Geotechnical and Seismological Parameters

Subsection 2.7.5 describes the site-specific information used for developing the geotechnical and seismological parameters for the in-situ site conditions prior to construction of and the anticipated as-built conditions after the construction of the BWRX-300 facility. The in-situ conditions are characterized based on the information described in Subsection 2.7.3, including the results reported in the 2022 NK054-REP-01210-00175 Phase I Geotechnical Investigation Report (Reference 2.7-39) and the 2023 DNNP FIA Report NK054-REP-03500.8-00003 (Reference 2.7-38).

Subsection 2.7.5 is divided into the following subsections:

- Subsection 2.7.5.1: Assessment of As-Built Conditions at the DNNP Site, including a description of the over-excavation and fill replacement, evaluation of bearing capacity and time-dependent deformation for the proposed foundations, and evaluation of the anticipated earth pressure on structures.
- Subsection 2.7.5.2: Geotechnical and Seismological Site Properties, including subgrade stratigraphic profiles, static and dynamic properties of rock and soil; and groundwater level
- Subsection 2.7.5.3: Geotechnical Variability and Uncertainty, including potential sampling bias, inherent variability of samples and possible measurements errors consideration, including the main source of epistemic and aleatory uncertainties

2.7.5.1 Assessment of As-Built Conditions at DNNP Site

The site geotechnical investigations, presented in Subsection 2.7.3, are used to characterize the stratigraphy of subsurface materials at the area of the DNNP site where the first BWRX-300 unit is to be constructed. The data collected from the 2022 geophysical investigations NK054-REP-01210-00175 (Reference 2.7-39) provide comprehensive understanding of the subsurface soil and the deep bedrock conditions at the site.

The DNNP site subsurface soil and rock profiles are presented in Subsection 2.7.3.2. The DNNP site consists of approximately 25 m of soil deposits overlaying bedrock. Both the soil and bedrock materials are characterized as flat laying to slightly dipping toward the south. The top and surficial soil deposits may not have the required capacity to support the near surface mounted foundations of the BWRX-300 RWB, TB, CB and Reactor Auxiliary Bay (refer to Chapter 1, Figure A1.1-2, Figure A1.4-1 and Figure A1.5-1 for site and BWRX-300 Unit 1 layouts). Bearing capacity and settlement confirmatory calculations were performed, as part of the 2022 geotechnical work NK054-REP-01210-00175 (Reference 2.7-39) and the 2023 DNNP FIA Report NK054-REP-03500.8-00003 (Reference 2.7-38), considering approximate dimensions, bearing pressure demands and stratigraphy of the soil materials under the RWB, TB, and CB and the Reactor Auxiliary Bay foundations.

The results of the geotechnical investigations that are reported in the 2012 NK054-REF-01210-0418696 (Reference 2.7-28), the 2013 NK054-REP-01210-00098 (Reference 2.7-29), and the 2022 geotechnical investigations and tests (Reference 2.7-39) do not indicate the presence of rock cavities, voids, large open fractures, significant eroded zones, shear zones, or joint configurations that would have a potential for causing rock instability and thus jeopardizing the integrity or the safety functions of the deeply embedded BWRX-300 RB.

2.7.5.1.1 Over-excavation and Fill Replacement

The range of SPT blow count numbers (as low as 6) and laboratory tests results indicate that the topsoil and fill materials may contain organic clays and be soft or very loose sands, which is not suitable for supporting the near surface mounted foundations of RWB, TB, CB, and Reactor

Auxiliary Bay. As described in Subsection 2.7.3.1, beneath the topsoil and fill materials, two layers of surficial lacustrine soil materials that differ in clay content and plasticity were identified:

- The layer at the top (Unit 2a) consists of sandy lean clay to lean clay soil with soft to very stiff consistency
- The layer below (Unit 2b) consists of cohesionless silty gravel to silty sand materials, with compactness varying from very loose to very dense

The SPT blow counts taken for the two surficial lacustrine soil layers (Units 2a and 2b) show low values indicating that these materials may not be suitable for supporting the RWB, TB, CB, and Reactor Auxiliary Bay foundations and may liquefy during a DBE level event. The results of field and laboratory tests performed for the upper till (unit 3), intermediate glaciolacustrine (Units 4a and 4b), and lower till (Unit 5) indicate dense and stiff materials surrounding the deeply embedded RB that have no potential for liquefaction during a DBE event and are suitable for supporting the foundations of the RWB, TB, CB, and other power block structures.

As a result, site preparation for construction of the BWRX-300 SMR is anticipated to include excavation at the power block area of the weaker surficial soils to an elevation between 80 m and 82 m CGD. The excavated surface soils will be replaced with engineered fill to bring the site grade back to elevation 88 m CGD. The dense upper till, intermediate glaciolacustrine and lower till soils below elevations 80 m to 82 m CGD would remain in place. The BWRX-300 RB would then be constructed in a vertical right cylinder shaft excavation that extends to a depth of about 35.2 m or elevation 52.8 m CGD. At this depth, the bottom of deeply embedded BWRX-300 RB is anticipated to extend through the compacted or engineered fill and in-situ soils and into the underlying bedrock.

The RWB, TB, CB, and other power block structures surrounding the deeply embedded RB are anticipated to be supported by shallow foundations on the engineered fill.

Information detailed in the 2021 licensing topical report on BWRX 300 Advanced Civil Construction and Design Approach, NEDO-33914-A (Reference 2.7-27) describes the approach to be used for monitoring the effects of excavation and construction on the properties of subsurface materials; specifically in its Subsection 3.4 Field Instrumentation Plan, and Section 4.0 Foundation Interface Analysis.

2.7.5.1.2 Bearing Capacity Evaluation for Proposed Foundations

2.7.5.1.2.1 Shallow Foundation

As documented in the 2023 DNNP FIA Report NK054-REP-03500.8-00003 (Reference 2.7-38), based on engineering assessment, conventional spread and strip footings located in the power block area which are founded on engineered fill can be designed using ultimate bearing capacities (q_u):

- 1.0 m wide with depths of 1.3 to 2.5 m: 1857 to 3642 kPa
- 2.0 m wide with depths of 1.3 to 2.5 m: 1854 to 3493 kPa
- 3.0 m wide with depths of 1.3 to 2.5 m: 1834 to 3509 kPa
- 4.0 m wide with depths of 1.3 to 2.5 m: 1854 to 3422 kPa
- 5.0 m wide with depths of 1.3 to 2.5 m: 1891 to 3393 kPa

Raft foundations can be used for heavily loaded structures where conventional spread or strip footings are not adequate to support. Raft foundation founded on engineered fill can be designed for the following ultimate bearing capacities (q_u):

- 68 x 70 m TB raft foundation with depths of 1.3 to 2.5 m: 5672 to 6917 kPa
- 30 x 48 m RWB raft foundation with depths of 1.3 to 2.5 m: 3986 to 4978 kPa
- A factor of safety of 3.0 is recommended to be used for the service limit state, and a resistance factor of 0.5 is recommended to calculate the ultimate limit state

2.7.5.1.2.2 Reactor Building Deeply Embedded Foundation

The proposed elevation for the RB foundation is at elevation of approximately 53 m CGD, corresponding to a depth of about 35 m below grade. At this elevation/depth, the Lindsay Formation has Rock Quality Designation values ranging from 90% to 100% and discontinuity spacing is considered to be 1 m to 3 m, per the 2022 Power Block geotechnical investigations (Reference 2.7-39).

Considering a mean UCS of 75 MPa and 48 MPa (Reference 2.7-39), the allowable bearing capacity (qa) for the RB is 7.5 MPa and 4.8 MPa, respectively.

For a conservative bearing capacity estimate, using a minimum UCS of 48 MPa and bearing capacity factor (Ksp) of 0.1, an allowable bearing capacity of 4.8 MPa will be used for the Reactor Building foundation design.

2.7.5.1.2.3 Pile Foundation

Pile foundations may also be considered for other heavily loaded power block structures. These structures may be supported on drilled caissons founded on competent undisturbed very dense/hard glacial till (with minimum 1 m embedment) or bedrock (with 1 m embedment recommended) with the over-excavation and backfill for soil deposits above elevation 80 m to 82 m CGD. End-Bearing Caissons founded on native undisturbed lower till deposit (Unit 5) at about 20 m depth can be designed for a factored geotechnical compression resistance 1100 kN. Alternatively, end-bearing caissons advanced to about 25 m depth, at least 1.0 m socket into bedrock (Unit 6a – Blue Mountain Formation), can be designed using a factored geotechnical compression resistance of 620 kN. The ultimate end-bearing resistance in bedrock is estimated to be approximately 20 MPa and a resistance factor of 0.4 is used to calculate the factored geotechnical compression resistance. These will form predominantly end-bearing foundations and therefore larger diameters (minimum 0.76 m in diameter) are recommended. Relatively undisturbed (clean) caisson bases should be ensured prior to concrete placement to minimize any potential settlement under maximum applied loads. The end-bearing caissons with at least 1 m embedment below weathered and/or fractured bedrock is estimated and presented in the 2023 DNNP FIA Report NK054-REP-03500.8-00003 (Reference 2.7-38).

Uplift forces of cast-in place concrete caissons will be resisted by the weight of the foundation and friction along its embedment surface area. Estimation of uplift resistance of 1.0 m diameter caissons are presented in the 2023 DNNP FIA Report NK054-REP-03500.8-00003 (Reference 2.7-38).

2.7.5.1.3 Earth Pressure

The anticipated earth pressure considering the in-situ stress, ground conditions, soil shoring system, RB stiffness, and loads from surrounding buildings along the depth of the RB has been conservatively evaluated based on results of non-linear FIA, as presented in the 2023 DNNP FIA Report NK054-REP-03500.8-00003 (Reference 2.7-38) and is displayed in Figure 2.7.5.1.3-1.

The horizontal pressure was found higher in bedrock compared to the soil. This is due to the higher in-situ stress locked in the bedrock as a result of past tectonic activities. The earth pressure at the interface of the RB wall in the bedrock presented in Figure 2.7.5.1.3-1 represents a bounding post-construction stage scenario that assumes no stress release occurs in the bedrock during excavation so all the in-situ stresses locked in the rock would be fully transferred to the RB wall. Reinforcement in the bedrock is to be incorporated in updates to the 2023 DNNP FIA Report NK054-REP-03500.8-00003 (Reference 2.7-38) that estimates stress release in the bedrock at the end of the excavation once the rock reinforcement is designed. A field instrumentation plan is to be implemented, per guidance in Section 3.4 of NEDO-33914-A (Reference 2.7-27), to monitor the deformations of the rock during the excavation. These measurements will be used to calibrate the FIA model.

2.7.5.1.4 Time-Dependent Deformation for Proposed Foundations

2.7.5.1.4.1 Elastic Settlement Method

The elastic settlement is presented in the 2023 DNNP FIA Report NK054-REP-03500.8-00003 (Reference 2.7-38) and summarized in Table 2.7-5

Table 2.7-5 Deformation for Proposed Foundations (Reference 2.7-38)

Building Structures	Structural Bearing Pressure, Upper Bound (kPa)	Proposed Foundation (Width, Depth) (m)	Estimated Elastic Settlement (mm)
Control Building	28.7	Spread footing (3, 1.3)	1
Turbine Building	270 150 80	Raft Foundation (68X70, 1.3)	41 23 12
RAD Waste Building	162 162	Spread Footing (3, 1.3) Raft Foundation (48X30, 1.3)	5 16
Reactor Auxiliary Bay	36.8	Spread Footing (3, 1.3)	1

The expected settlement of raft foundation was analysed for the non-uniform structural load as documented in the 2023 DNNP FIA Report NK054-REP-03500.8-00003 (Reference 2.7-38).

2.7.5.1.4.2 Consolidation Settlement Method

As detailed in the 2023 DNNP FIA Report NK054-REP-03500.8-00003 (Reference 2.7-38), it is anticipated that much of the consolidation settlement occurs in the lean clay deposit (Unit 4b). Given the Over-Consolidation-Ratio for Unit 4b is between 1.8 and 2.2, the lean clay deposit is over consolidated. Since the final effective pressure caused by the structural pressure is estimated to be lower than the pre-consolidation pressure in the deposit, the consolidation settlement is therefore estimated using the reconsolidation index (Cr). Annual secondary (creep) consolidation settlement is negligible.

The estimated consolidation settlement of different building structures is summarized in Table 2.7-6.

Table 2.7-6 Consolidation Settlement Method (Reference 2.7-38)

Building Structures	Structural Bearing Pressure, Upper Bound (kPa)	Proposed Foundation (Width, Depth) (m)	Estimated Consolidated Settlement (mm)
Control Building	28.7	Spread Footing (3, 1.3)	5
Turbine Building	270 150 80	Raft Foundation (68X70, 1.3)	51 31 17
RAD Waste Building	162 162	Spread Footing (3, 1.3) Raft Foundation (48X30, 1.3)	9 45
Reactor Auxiliary Bay	162	Spread Footing (3, 1.3)	2

The expected settlement of raft foundation was analysed for the non-uniform structural load. The maximum total settlement (elastic and consolidated settlement) of the TB is approximately 92 mm, and the differential settlement is approximately 61 mm.

The settlement of raft foundations is also dependent on the rigidity of the foundation, homogeneity of the subgrade material and the construction method. Following the guidance of Section 4.0 of NEDO-33914-A (Reference 2.7-27), a 3-D non-linear FIA is to be performed to develop settlement contours of the raft foundations at a later design stage.

2.7.5.2 Geotechnical and Seismological Site Design Parameters

Subsection 2.7.5.2 presents the geotechnical and seismological properties for the seismic and structural analysis, and design, including:

- Subgrade profiles – Subsection
- Equivalent linearized static properties of soil and engineered fill materials – Subsection 2.7.5.2.2
- Equivalent linearized static properties of rock – Subsection 2.7.5.2.3
- Dynamic subgrade properties – Subsection 2.7.5.2.4
- Seismic Design Parameters – Subsection 2.7.5.2.5
- Groundwater Level – Subsection 2.7.5.2.6

2.7.5.2.1 Subgrade Profiles Stratigraphy

The design analyses of the deeply embedded BWRX-300 RB consider subgrade profiles to account for the variations of the soil and rock properties with depth at the DNNP site. The soil profiles represent "as-built" conditions at the DNNP site after construction of the BWRX-300 facility, where the engineered fill replaces the excavated top in-situ upper lacustrine or fill units. The stratigraphy of the as-built subgrade profiles consists of:

- Engineered fill that is for the upper 6 m to 8 m from elevation 80 m to 82 m CGD, as required to the final grade at elevation 88 m CGD.
- In-situ soils consisting of upper till (Unit 3), intermediate glaciolacustrine soils (Units 4a and 4b), and the lower till unit (Unit 5).
- Rock units including Blue Mountain (Unit 6a), Lindsay (Unit 6b), Verulam (Unit 6c), Bobcaygeon, Gull River, Shadow Lake and Genesis formations.

The engineered fill will comprise either commercial crusher run, or pit run granular fill or select excavated material meeting the requirements of engineered fill described under "Planned As-Built Soil Profile" in Subsection 2.7.3.2. Placement of the fill will be controlled based on in-situ testing and monitoring by the geotechnical engineer as described in the 2023 DNNP FIA Report NK054-REP-03500.8-00003 (Reference 2.7-38).

The BWRX-300 RB vertical cylindrical shaft deep excavation is to be extended through the Blue Mountain Formation (Unit 6a) and founded in the Lindsay Formation (Unit 6b). The Gneiss formation – the deepest investigated unit - is taken as the hard rock basement with shear wave velocities that are greater than or equal to 3000 m/s, per the 2012 Field Work – Geology and Geological Evaluation NK054-REF-01210-0418696 (Reference 2.7-28).

The pre-excavation in-situ site stratigraphy for soil layers are presented in Table 2.7-2. The adopted in-situ soil layer thicknesses are based on the 2022 Geotechnical Investigation Report NK054-REP-01210-00175 (Reference 2.7-39).

The stratigraphy of the rock units at the DNNP site including rock formations and thicknesses are presented in Table 2.7-3. The bedrock stratigraphy is based on the discussion presented in Subsection 2.7.3.2. The elevation of top of upper rock unit, the Blue Mountain (Whitby) Formation, considered as "top of rock" is expected to be about 64.2 m CGD with a variability of ±2 m. The variation in the thickness layer of ±3 m is based on the results of the 2022 DNNP Geotechnical Investigation reported in NK054-REP-01210-00175 (Reference 2.7-39).

2.7.5.2.2 Equivalent Linearized Static Properties of Soil and Engineered Fill Materials

Upper Bound and Lower Bound equivalent linearized properties representing the pressure of the soil and rock materials under long-term (static) loads are established based on measurements obtained from the different field and laboratory tests executed during the 2022 geotechnical investigation NK054-REP-012010-00175 (Reference 2.7-39). Upper and lower values are directly from the measured values. Further statistical analysis is completed to account for uncertainty as required during detailed design.

The static Elastic Modulus E_{st} values for soil materials are obtained from the results of field and laboratory tests. Initial Tangent Elastic Modulus values for the soil materials are established by Triaxial Compression Testing and Pressuremeter Testing, respectively. Initial Tangent Elastic Modulus is interpreted from consolidated anisotropic drained triaxial testing of reconstituted specimen. This is representative of in-situ conditions where the specimen is consolidated to approximate in-situ vertical effective stress.

Poisson's ratio ν_{st} values are determined by compression and shear wave velocities measured during triaxial compression testing. Effective friction angle and Coefficient Lateral Earth Pressure at Rest is determined by Triaxial Compression Testing and Pressuremeter Testing during the 2022 geotechnical investigation NK054-REP-01210-000175 (Reference-2.7-39).

A summary of linearized static properties for engineered fill and in-situ soil layers in the as-built profiles are provided in the Table 2.7-7.

2.7.5.2.3 Equivalent Linearized Static Properties of Rock

The 2022 geotechnical investigation NK054-REP-01210-00175 (Reference 2.7-39) studied the linearized static properties of rock on the DNNP site, with focus around the BWRX-300 power block area. The linearized E_{st} and ν_{st} values of the rock masses are evaluated from UCS testing and triaxial compression testing. The intact rock modulus was measured through UCS testing of intact rock samples. The intact rock modulus was then adjusted to evaluate the rock mass deformation modulus by two different methods:

- Evaluation of the Geologic Strength Index (two separate ways) and further calculation
- Directly measured through pressuremeter testing.

Total or bulk unit weight was measured during the uniaxial and triaxial compressive strength testing. Table 2.7-8 presents a summary of linearized static properties for the rock layers.

Table 2.7-7: As-Built Linearized Static Properties for Soil Layers (Reference 2.7-39)

Stratigraphic Unit	Layer Thickness (m)	Total Unit Weight (kN/m³)	Effective Friction Angle (degrees)		Elastic (Young's) Modulus (MPa)		Estimated Coefficient of Lateral Earth Pressure at rest	
		Ave.	Ave.	Range	Lower	Upper	Ave.	Range
Unit 2a	0.00 - 5.72	21.5	32[(a)]	25 – 37[(a)]	13	49	0.61[(a)] - 0.67[(b)]	0.41 – 0.95[(a)] 0.65-0.68 [(b)]
Unit 2b		non-plastic	34[(b)]	29 – 41[(b)]	32	80	0.73 [(b)]	0.49 – 0.91 [(b)]
Unit 3	<1.00 - 13.1	24.3	37[(a)] 41 [(b)]	36 – 38[(a)] 31 - 48[(b)]	31	613	0.69[(b)]	0.53 – 1.02 [(b)]
Unit 4a	0.00 - 17.7	22.1	40 [(a)] 39[(b)]	39 – 41[(a)] 35 - 45 [(b)]	52	600	0.57[(b)]	0.42 – 0.73 [(b)]
Unit 4b		22.2	30[(a)] 34[(b)]	30 [(a)] 29 – 42[(b)]	136	413	0.83[(a)]0.53[(b)]	0.43 – 1.15[(a)] 0.34 - 0.70 [(b)]
Unit 5	0.00 – 6.4	23.7	35[(a)] 31[(b)]	32-38[(a)] 26 – 36[(b)]	110	330	0.58[(a)] 0.49[(b)]	0.39 – 0.74([a)] 0.39-0.58[(b)]

(a) From Triaxial Compression Testing
(b) From Pressuremeter Testing

Table 2.7-8: Summary of Linearized Static Rock Properties (Reference 2.7-39)

Stratigraphic Unit	Average Bulk Density (kgN/m^3)	Mean Intact Modulus (GPa)	Rock Mass Deformation Modulus (GPa)		Poisson's Ratio
			GSI	Pressuremeter Tests	
Unit 6a - Blue Mountain Shale / Shale+Limestone / Limestone	2641	26.6	17.9	5.91	0.32/0.28/0.00
Unit 6b – Lindsay Formation Shale / Shale+Limestone / Limestone	2681	43.4	38.7	9.75	0.00/0.22/0.36
Unit 6c – Verulam Formation Shale / Shale+Limestone / Limestone	2679	25.0	22.3	12.29	0.21/0.29/0.25

2.7.5.2.4 Dynamic Subgrade Properties

The measured values for dynamic properties of rock are presented in Table 2.7-9a and Table 2.7-9b. The measured small-strain in-situ soil dynamic properties are listed in Table 2.7-10a and Table 2.7-10b. The compression wave velocities, shear wave velocities for the soil and bedrock rock units are obtained from the measurements during the 2022 geotechnical investigation NK054-REP-01210-00175 (Reference 2.7-39). Poisson's Ratio, Young's Modulus, Shear Modulus and Bulk Modulus are presented as calculated in the 2022 Geotechnical Investigation Report NK054-REP-01210-00175 (Reference 2.7-39).

Table 2.7-9a: Rock Dynamic Properties (Reference 2.7-39)

Stratigraphic Unit	Total Unit Weight (kN/m^3)	Shear Wave Velocity (m/s)		Compression Wave Velocity (m/s)		Poisson's Ratio	
		Average	Range	Average	Range	Average	Range
Unit 6a – Blue Mountain Formation	26.4	2405	1841 - 2953	4283	3073 - 5935	0.26	0.20 - 0.38
Unit 6b -Lindsay Formation	26.6	2640	1934 - 3024	4792	3202 - 5773	0.28	0.27 - 0.30
Unit 6c – Verulam Formation	26.6	2559	2128 - 2801	4570	3772 - 5443	0.27	0.26 - 0.28

Table 2.7-9b: Rock Dynamic Properties (Reference 2.7-39)

Stratigraphic Unit	Dynamic Shear Modulus (MPa)		Dynamic Young's Modulus (MPa)		Dynamic Bulk Modulus (MPa)	
	Average	Range	Average	Range	Average	Range
Unit 6a – Blue Mountain (Whitby) Formation	15320	12772 - 18186	38674	34068 - 45959	0.26	0.20 - 0.38
Unit 6b – Lindsay Formation	18696	17099 - 19458	47931	43539 - 49978	0.28	0.27 - 0.30
Unit 6c – Verulam Formation	17544	16534 - 18041	44614	42363 - 45762	0.27	0.26 - 0.28

Table 2.7-10a: In-situ Soil Dynamic Properties (Reference 2.7-39)

Stratigraphic Unit	Total Unit Weight (kN/m^3)	Shear Wave Velocity (m/s)		Compression Wave Velocity (m/s)		Poisson's Ratio	
		Average	Range	Average	Range	Average	Range
Unit 2a – Surficial Glaciolacustrine Deposits – Sandy Lean Clay to Lean Clay	21.5	304	215 - 451	1087	560 - 2200	0.43	0.15 - 0.48
Unit 2b – Surficial Glaciolacustrine Deposits – Silty Clayey Sand to Silty Sand/Sandy Silt	0.00	351	255 - 483	1769	800 - 2200	0.48	0.45 - 0.49
Unit 3 – Upper Till	24.3	489	240 - 705	1845	700 - 2400	0.46	0.42 - 0.48
Unit 4a – Intermediate Glaciolacustrine Deposits – Silty Sand to Sandy Silt	22.1	659	362 - 1078	2107	1600 - 2400	0.44	0.30 - 0.48
Unit 4b – Intermediate Glaciolacustrine Deposits – Sandy Lean Clay to Lean Clay	22.2	656	440-994	2118	1800-2400	0.44	0.37-0.47
Unit 5 (Lower Till)	23.7	875	683-1344	2470	2000-3400	0.42	0.24-0.47

Table 2.7-10b: In-situ Soil Dynamic Properties (Reference 2.7-39)

Stratigraphic Unit	Dynamic Shear Modulus (MPa)		Dynamic Young's Modulus (MPa)		Dynamic Bulk Modulus (MPa)	
	Average	Range	Average	Range	Average	Range
Unit 2a – Surficial Glaciolacustrine Deposits – Sandy Lean Clay to Lean Clay	198	94-415	550	277-950	2374	446 - 6271
Unit 2b – Surficial Glaciolacustrine Deposits – Silty Clayey Sand to Silty Sand/Sandy Silt	298	181-450	879	525-1331	7304	1658 - 10750
Unit 3 – Upper Till	577	265 - 878	1678	783 - 2489	7340	4066 - 10472
Unit 4a – Intermediate Glaciolacustrine Deposits – Silty Sand to Sandy Silt	1025	454 - 2607	2915	1338 - 6752	8636	5497 - 10914
Unit 4b – Intermediate Glaciolacustrine Deposits – Sandy Lean Clay to Lean Clay	947	432 - 1808	2719	1272 - 4941	8386	6038 - 10869
Unit 5 (Lower Till)	1848	1133 - 3670	5217	3273 - 10435	12180	5093 - 22215

2.7.5.2.5 Seismic Design Parameters

Two sets of seismic design parameters were developed based on the results of the site response analyses described in Subsection 2.7.4.6.1 for DBE seismic design and BDBE DEC seismic evaluations:

- Ground motion spectra defining the amplitude and frequency content of the DBE and BDBE ground motion at the DNNP site
- Hazard-Consistent, Strain-Compatible (HCSC) profiles defining the variation with depth of the dynamic properties of DNNP subgrade materials compatible to the strains generated by DBE and BDBE levels

2.7.5.2.5.1 Ground Motion Spectra

Per guidance of NEDO 33914-A, Section 5.2.2, three sets of response spectra are developed, as described in Section 9.2 of the 2022 DNNP PHSA NK054-REP-03500.8-00001 (Reference 2.7-41), defining the amplitude and frequency content of the DNNP site-specific DBE and BDBE ground motion:

1. Foundation Input Response Spectra at RB foundation bottom elevation of 52.93 m CGD presented in Figure 2.7.5.2.5-1
2. Performance Based Intermediate Response Spectra at the soil / rock interface elevation 64 m CGD, located 24 m below planned finished grade presented in Figure 2.7.5.2.5-2
3. Performance Based Surface Response Spectra at the finished grade elevation of 88 m CGD presented in Figure 2.7.5.2.5-3

2.7.5.2.5.2 Strain-Compatible Soil Properties

Profiles of HCSC dynamic subgrade properties, needed for the SSI analyses, are developed based on the results from the site response analyses described in Section 2.7.4.6. The profiles defining the variation with depth of subgrade shear wave velocities compatible to the DBE and BDBE strain levels are presented in Figure 2.7.5.2.5-4. The profiles of subgrade compression wave velocities for the DBE and BDBE strain levels are presented in Figure 2.7.5.2.5-5. Figure 2.7.5.2.5-6 presents the subgrade damping profiles representing the dissipation of energy in the subgrade materials for the DBE and BDBE levels. The presented HCSC dynamic subgrade properties are per Section 9.3 (Table 9-40 through Table 9-45) of the 2022 DNNP PSHA NK054-REP-03500.8-00001 (Reference 2.7-41).

2.7.5.2.6 Groundwater Level

The groundwater elevations are listed in Table 3-7 in Volume 2 of 2 of the 2022 Phase 1 Geotechnical Investigation - DNNP (Reference 2.7-39), and is replicated, in part, in Table 2.7-11, which provides samples of groundwater elevation and hydraulic vertical gradient at BH12 area which is located on the western side of the RB perimeter, as shown in Figure 2.7.3.1-6.

Table 2.7-11 Samples of Groundwater Elevation and vertical Hydraulic Gradients, BH12 Area (Reference 2.7-39, Table 3-7)

Date	Groundwater Elevation (m)				Vertical Gradient (m/m)		
	Unit 3[1]	Unit 4a[2]	Unit 5[3]	Unit 6[4]	Unit 3 to 4a (down)	Unit 4a to 5 (Down)	Unit 5 to 6 (Down)
	BH12-1	BH12-2	BH12-3	BH14			
29NOV21	85.47	83.89	79.47	77.09	-0.25	-0.71	-0.28
05JAN22	85.72	84.03	82.47	78.56	-0.27	-0.25	-0.46
07FEB22	85.24	83.66	79.18	78.41	-0.25	-0.72	-0.09
17FEB22	85.46	83.81	79.29	78.52	-0.26	-0.73	-0.09

1. Upper Till
2. Surficial Glaciolacustrine Deposits
3. Lower Till
4. Bedrock

Based on the groundwater information at the DNNP site presented in Subsection 2.7.3.2 and Table 2.7-11, an upper bound groundwater level at elevation of 85.74 m CGD (or approximately 86 m CGD) corresponding to a depth of 2.26 m (or approximately 2 m) below the plant grade at elevation 88 m CGD is to be used for design.

2.7.5.3 Geotechnical Variability and Uncertainty

Geotechnical variability and uncertainty are considered in detail in the 2022 Geotechnical Investigation NK054-REP-01210-00175 (Reference 2.7-39).

When sampling the soil and rock there can be sampling bias that is introduced in the sample selection process. In general, DNNP project samples were selected based on predetermined testing requirements for each borehole and samples were selected from a variety of depths within each borehole. In some cases, such as the shale from the Blue Mountain Formation, it is not possible to test the weaker rock as intact samples of this material cannot properly be prepared for testing (typically breaking apart along weaker bedding planes). In these cases, sensitivity analysis and engineering judgement are required during design to account for the fact that the range in the data may not capture the minimum values.

When in-situ and laboratory methods are used to measure soil and rock attributes, the inherent variability along with measurement error typically led to data scatter. Measurement error may result from equipment errors and procedural or operator errors. Measurement error is minimized through equipment calibration, standardized procedures, laboratory accreditation, etc.

In-situ and laboratory methods are also subject to statistical uncertainty, which may be reduced by increasing the sampling frequency. Further, certain in-situ and laboratory measurements are transformed for design purposes through empirical or other correlation methods.

Geotechnical variability and uncertainty are addressed using a two-pronged approach:

- Reduction in uncertainty through the use of reliable, calibrated equipment, precision in measurement and testing procedures and sufficient quantity of sampling/testing.

- Consideration of total variability associated with each geotechnical property/parameter, including evaluation of statistical parameters and identification of sources of uncertainty particular to each property/parameter.

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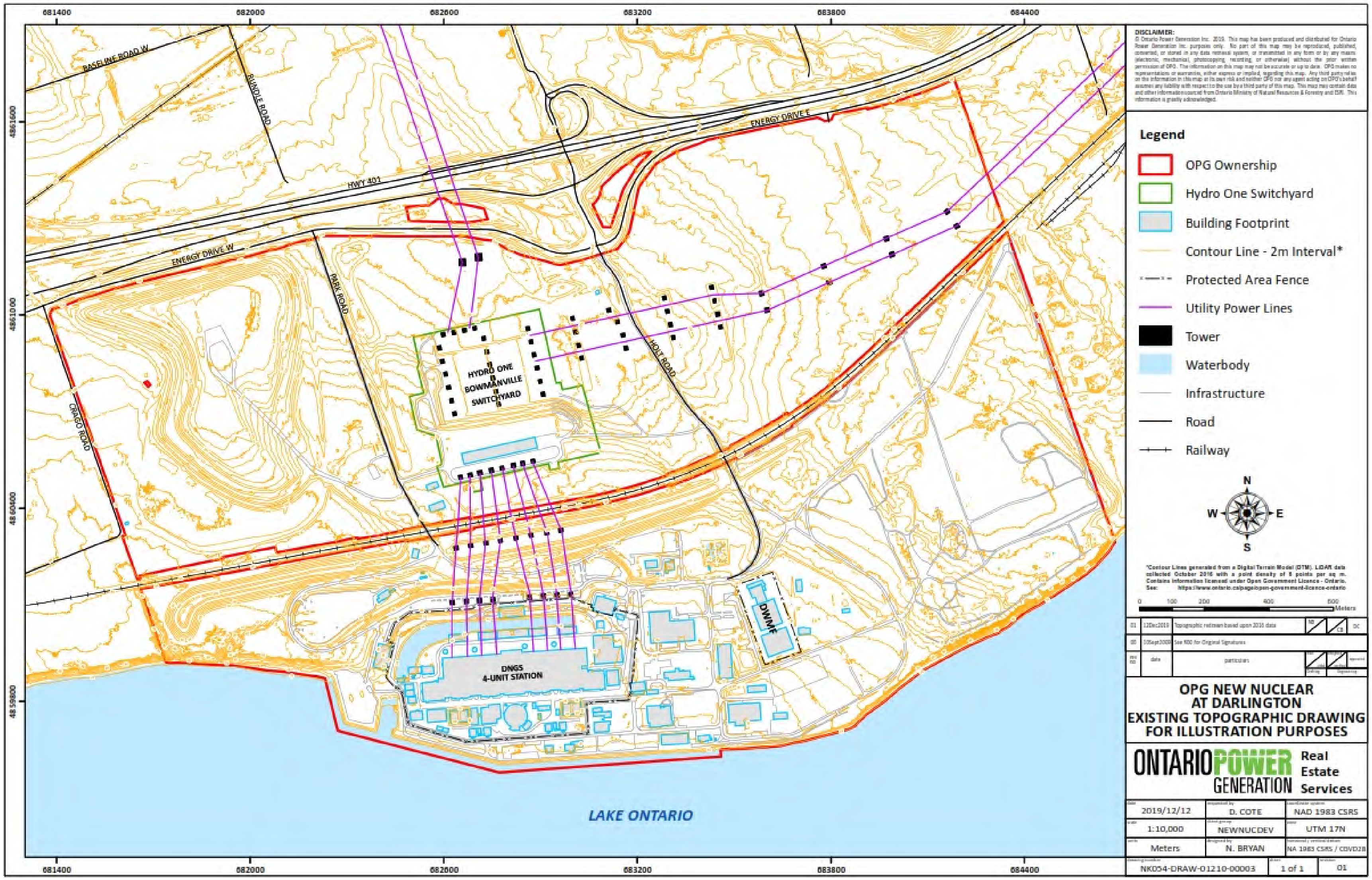


Figure 2.7.1-1: Existing Topographic Contours of DNNP Site (Reference 2.7-26)

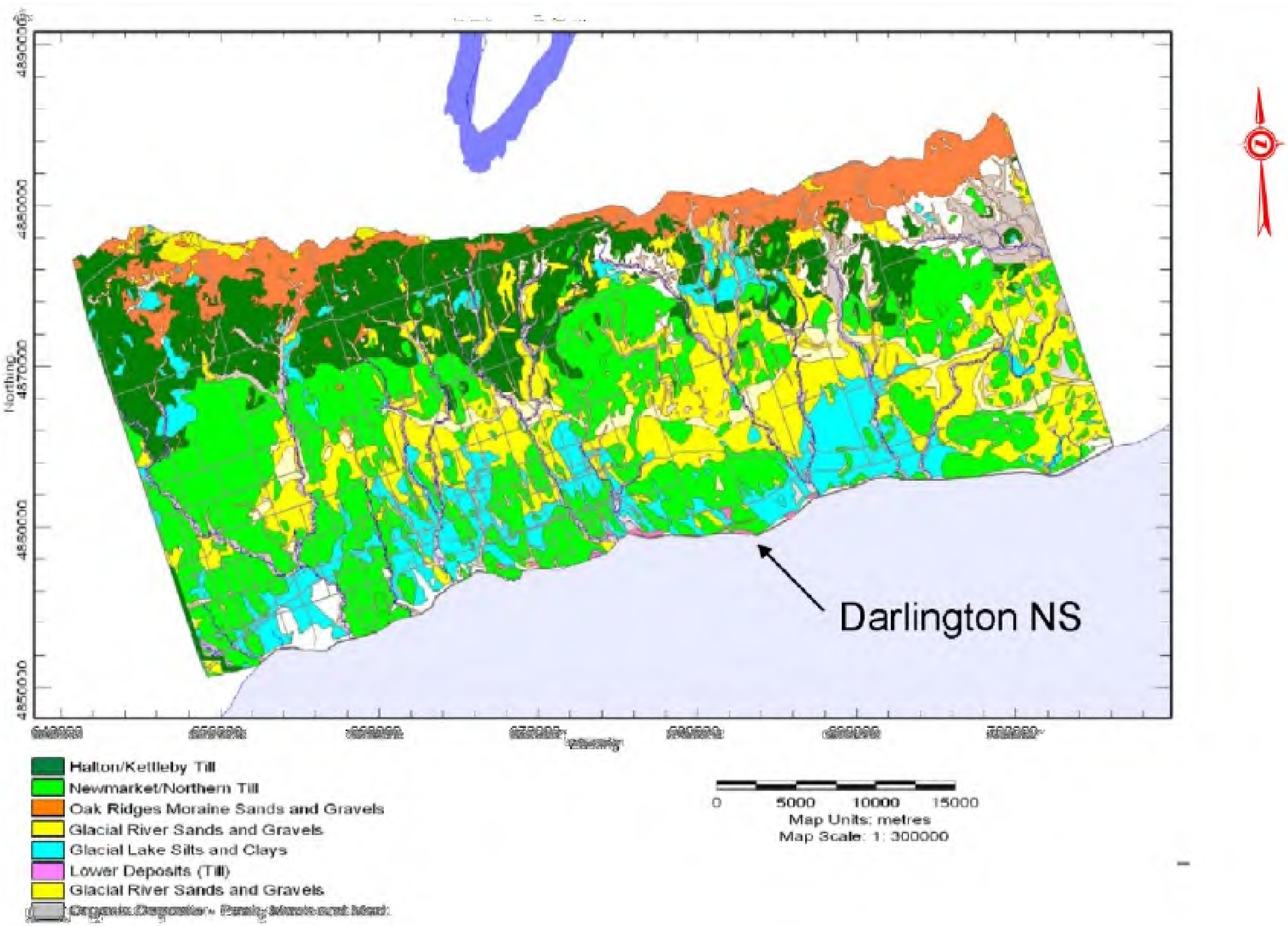


Figure 2.7.2-1: Darlington Nuclear Site - Regional Surficial Geology (Reference 2.7-1)

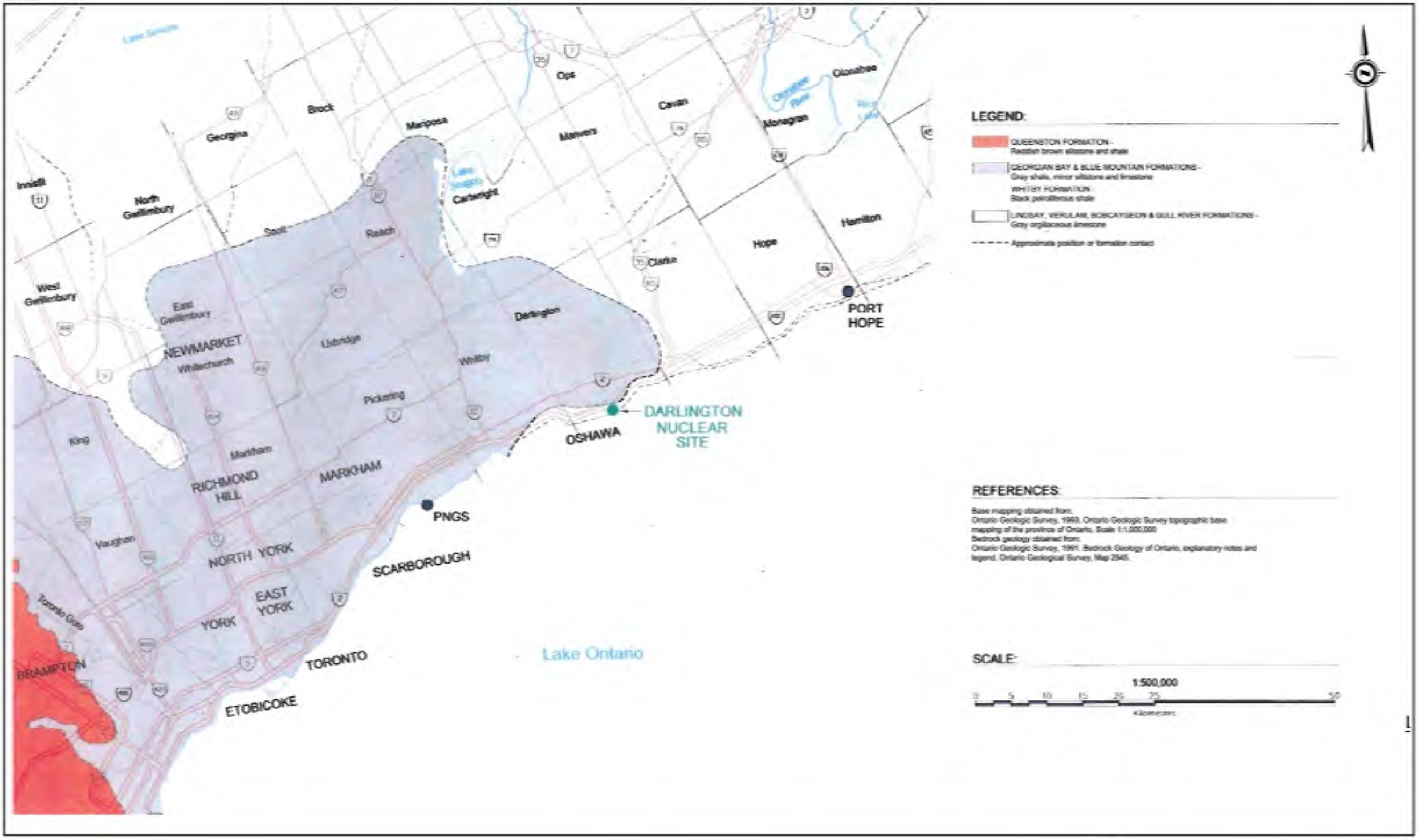


Figure 2.7.2-2: Darlington Nuclear Site - Regional Bedrock Geology (Reference 2.7-1)

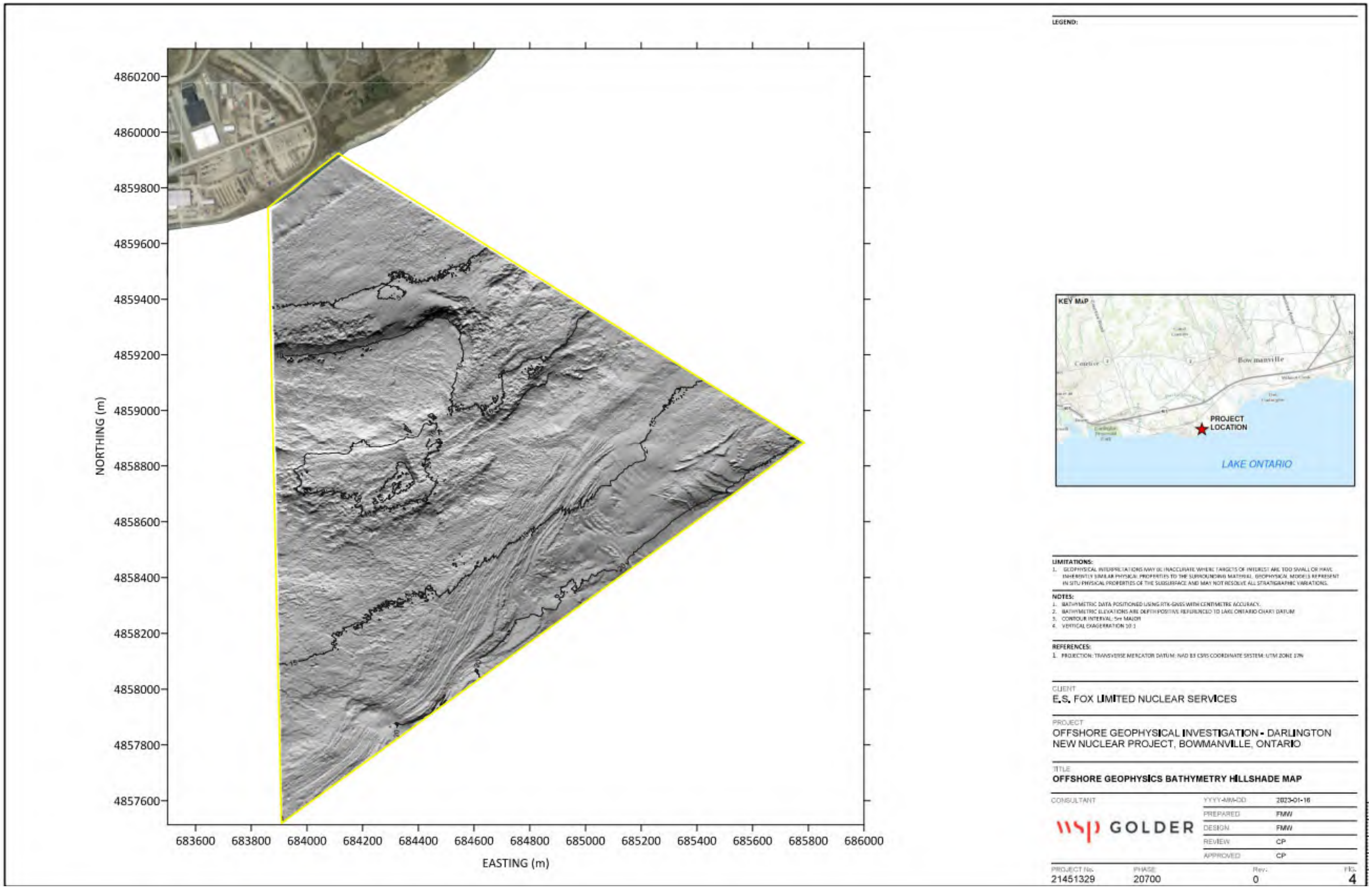


Figure 2.7.2-3: Offshore Geophysics Bathymetry Hillshade Map (Reference 2.7-40)

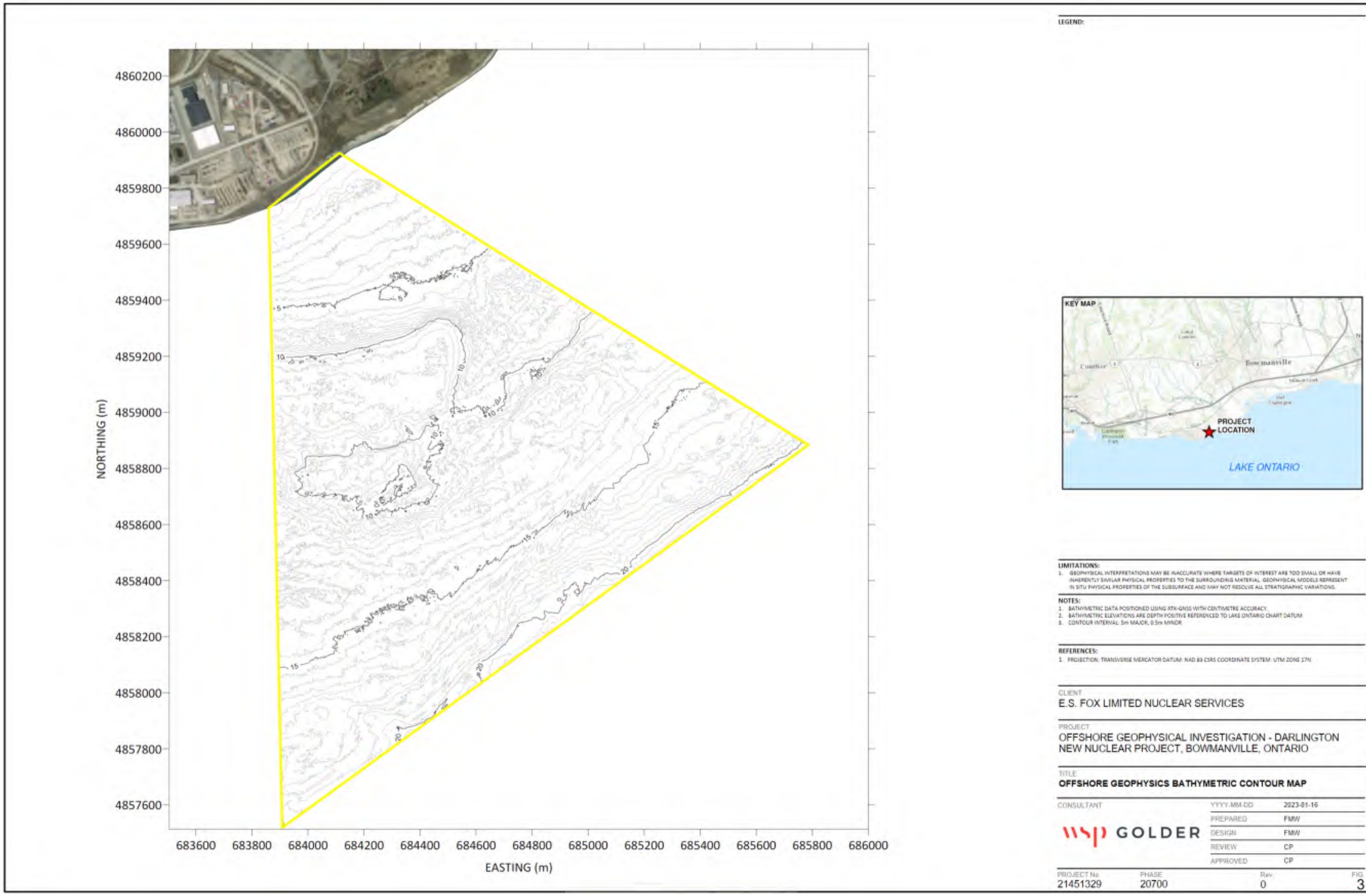


Figure 2.7.2-4: Offshore Geophysical Bathymetric Contour Map (Reference 2.7-40)

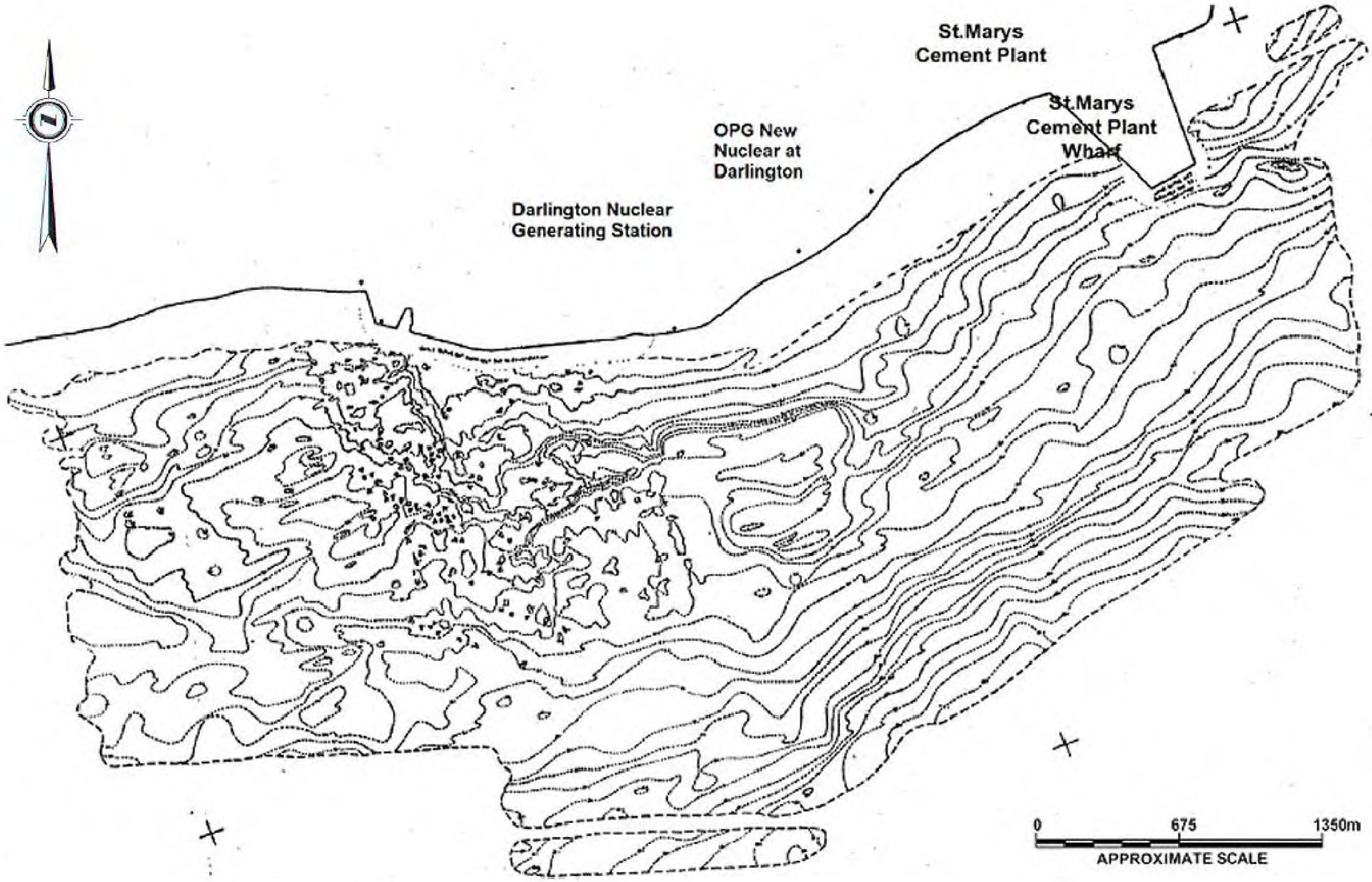


Figure 2.7.2-5: Lakebed Bathymetric Contours along DNNP Site's Shoreline (Reference 2.7-2)

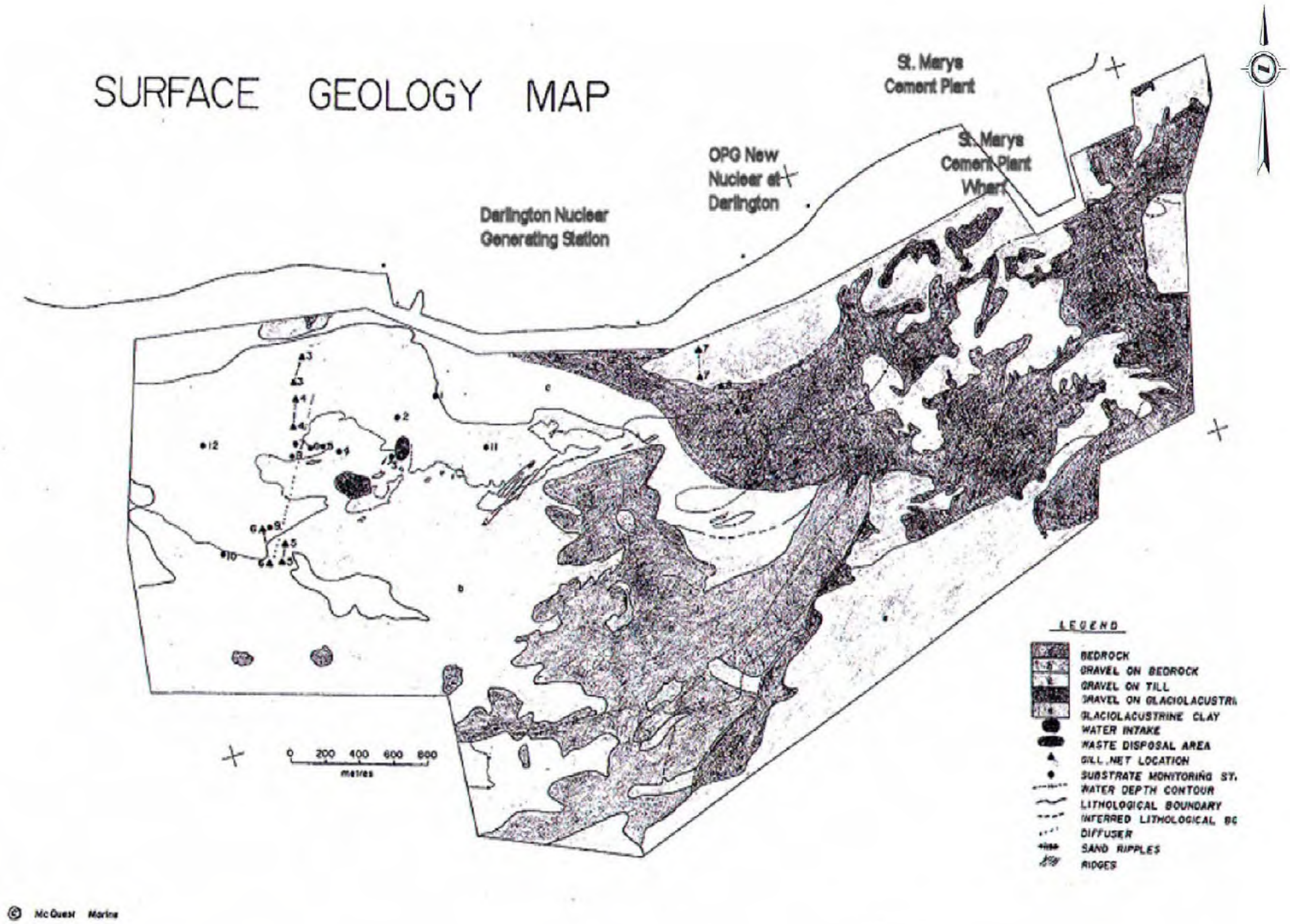


Figure 2.7.2-6: Lakebed Surface Geology Map along DNNP Site's Shoreline (Reference 2.7-2)

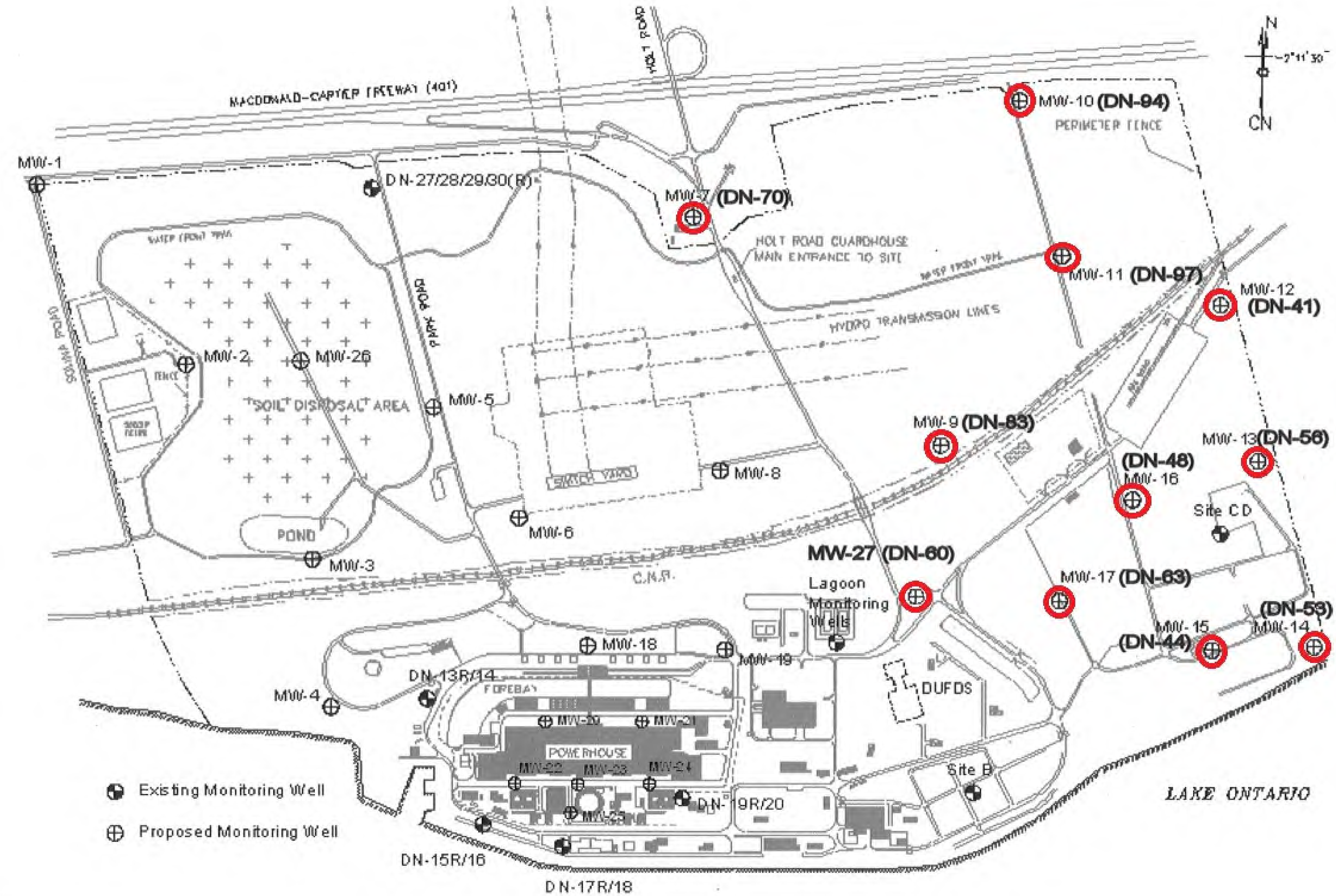


Figure 2.7.3.1-1: Locations of CH2MHILL (2009) Monitoring Wells/Boreholes (Reference 2.7-1)

Figure 2.7.3.1-2: Locations of AMEC (2012) Boreholes (Reference 2.7-35)

Figure 2.7.3.1-3: Locations of EXP (2013) Boreholes (Reference 2.7-36)

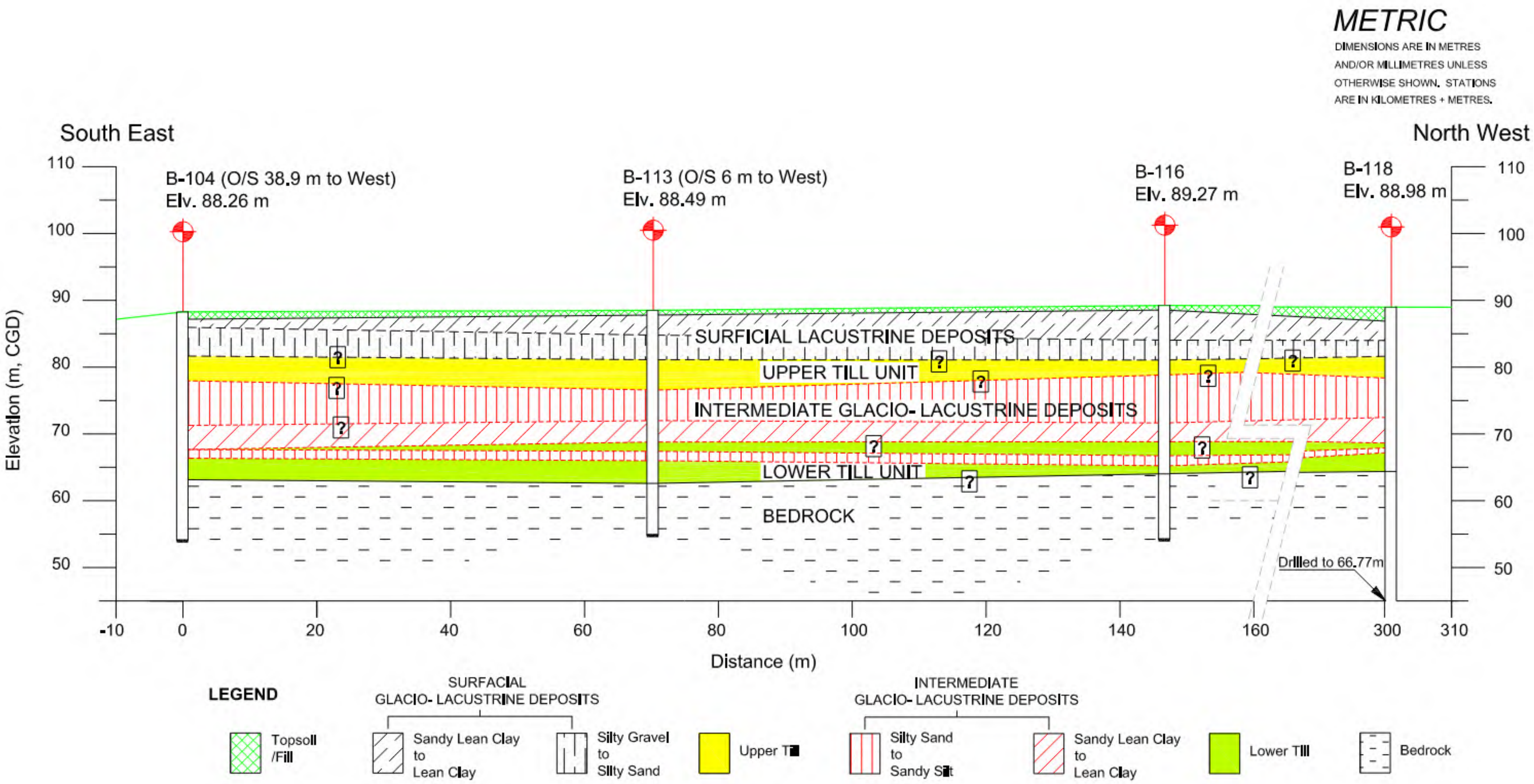


Figure 2.7.3.1-4: Stratigraphic Profile near BWRX-300 Location (Reference 2.7-36)

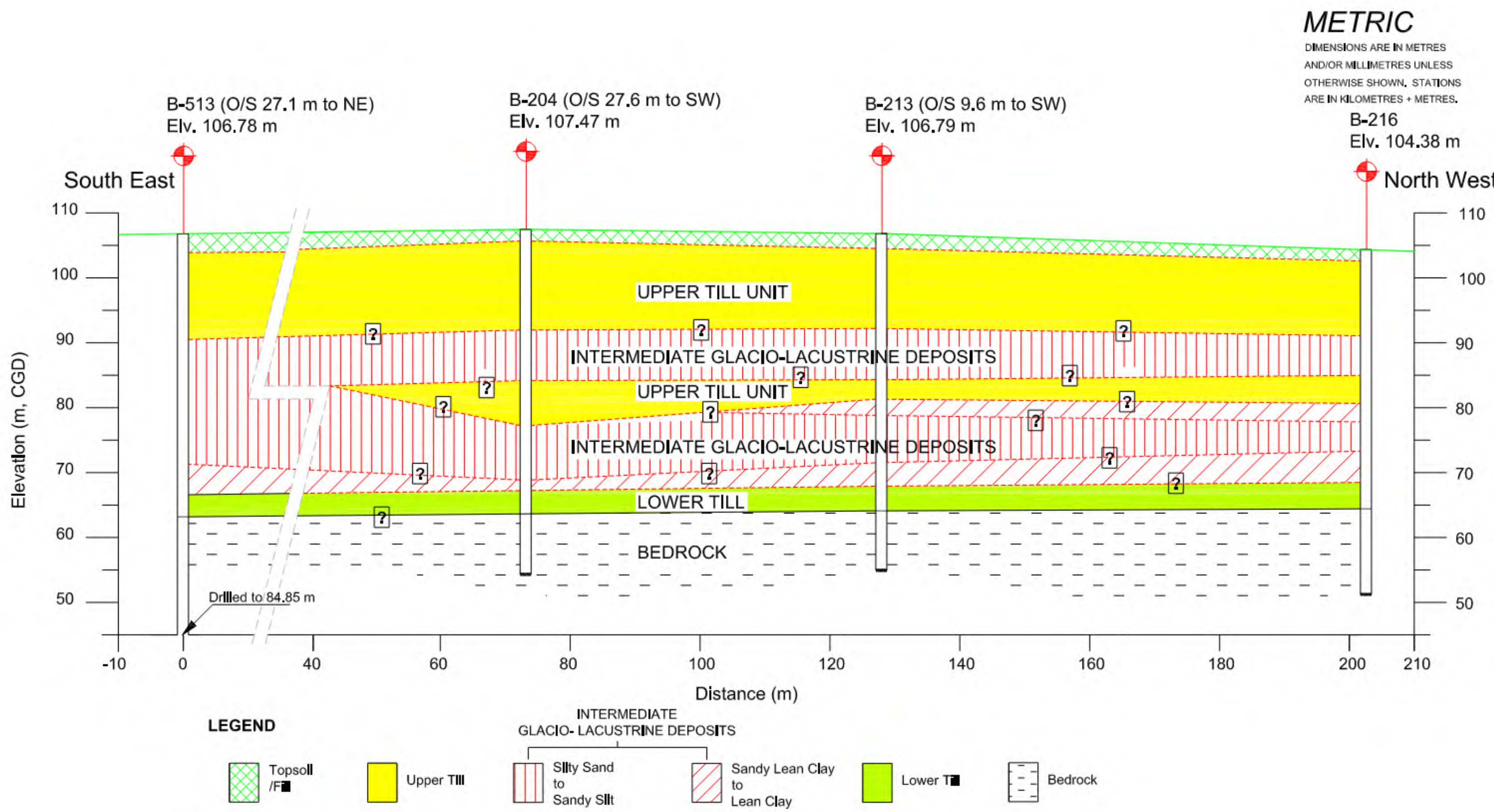


Figure 2.7.3.1-5: Stratigraphic Profile near Topographic Ridge East of the BWRX-300 Location (Reference 2.7-36)

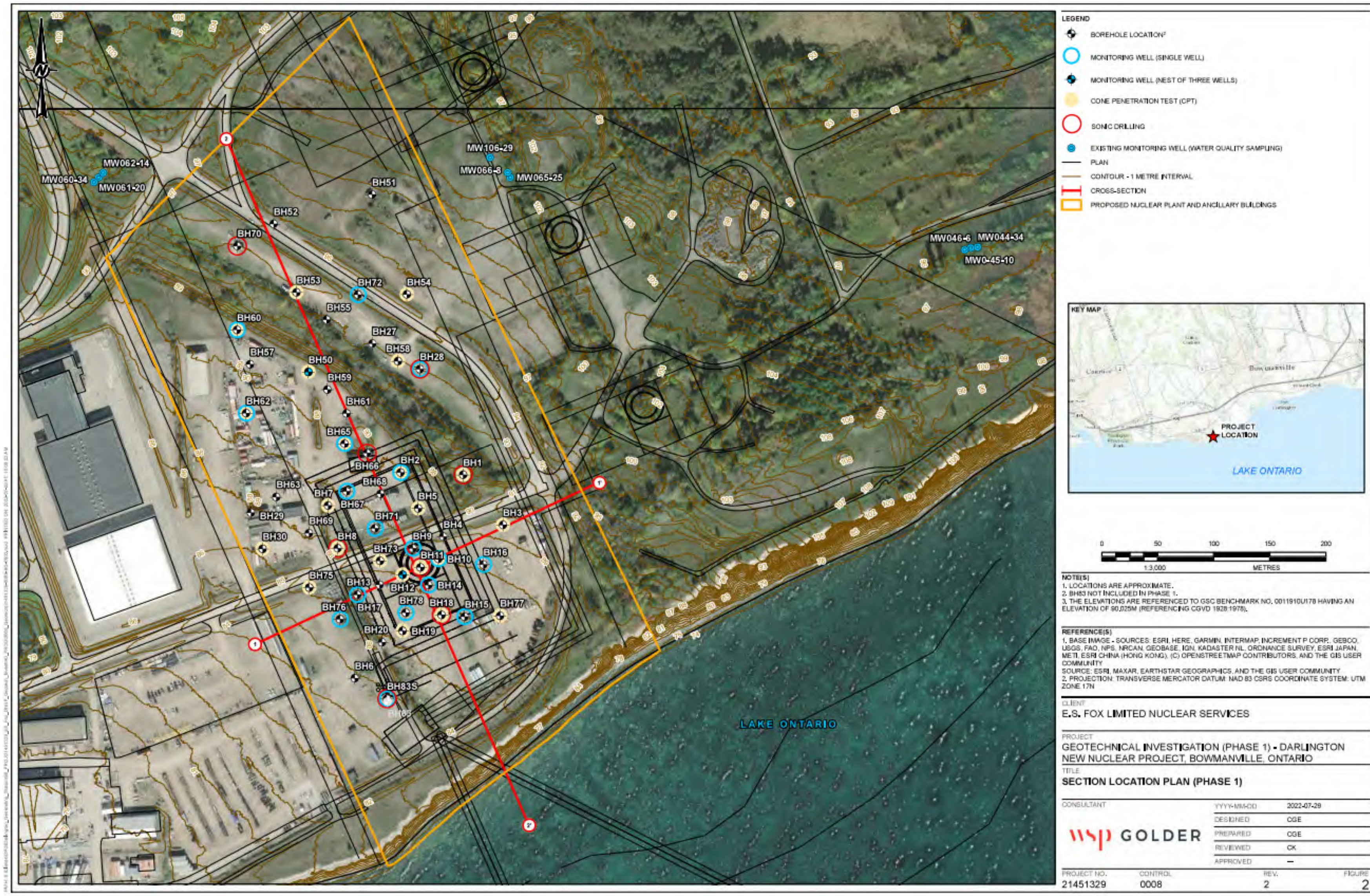


Figure 2.7.3.1-6: Boreholes Sections (1-1’ and 2-2’) Locations Plan (Phase 1) (Reference 2.7-39)

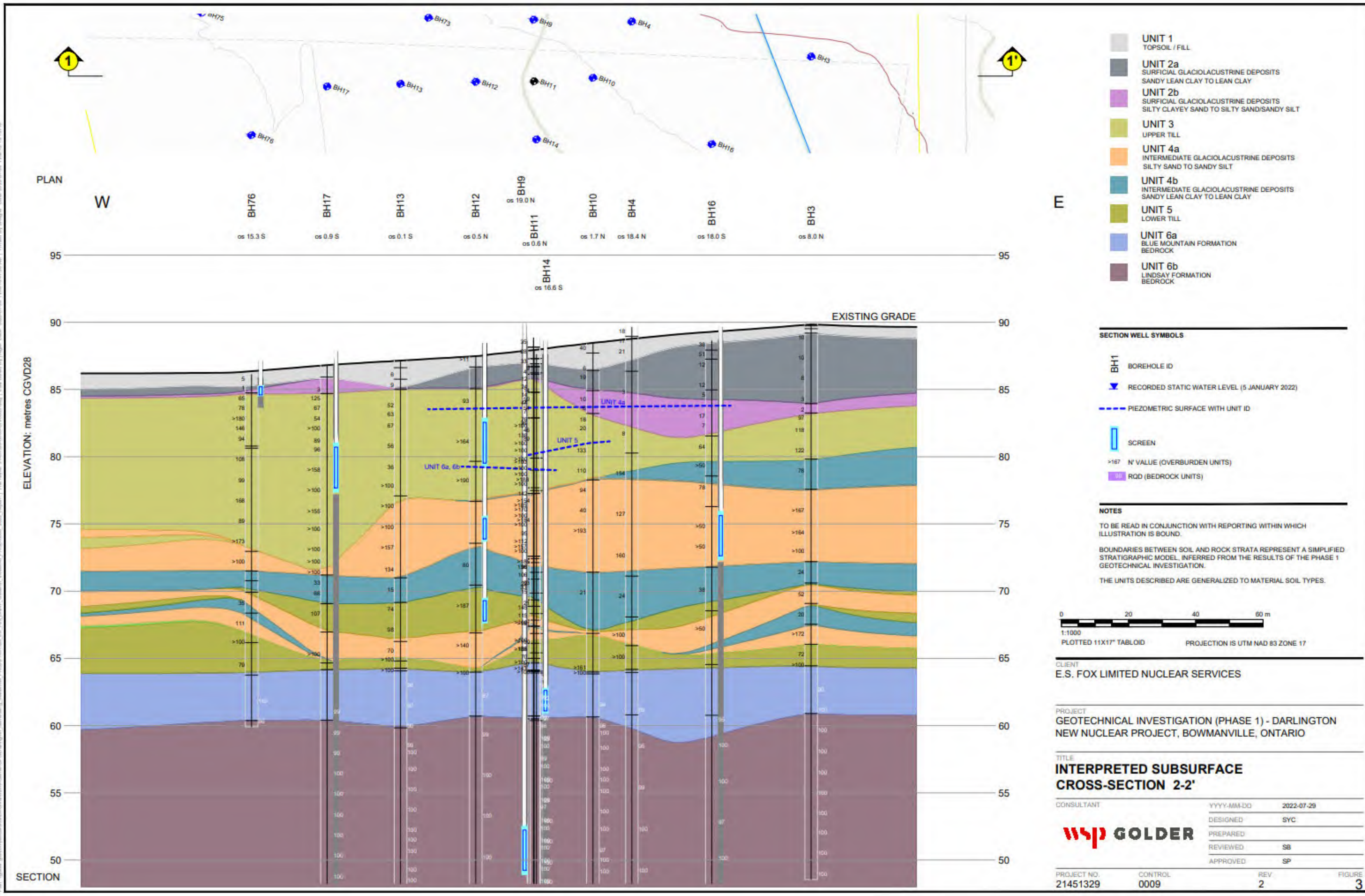


Figure 2.7.3.2-1: Subsurface Stratigraphic Profile at Cross-Section 1-1 (Reference 2.7-39)

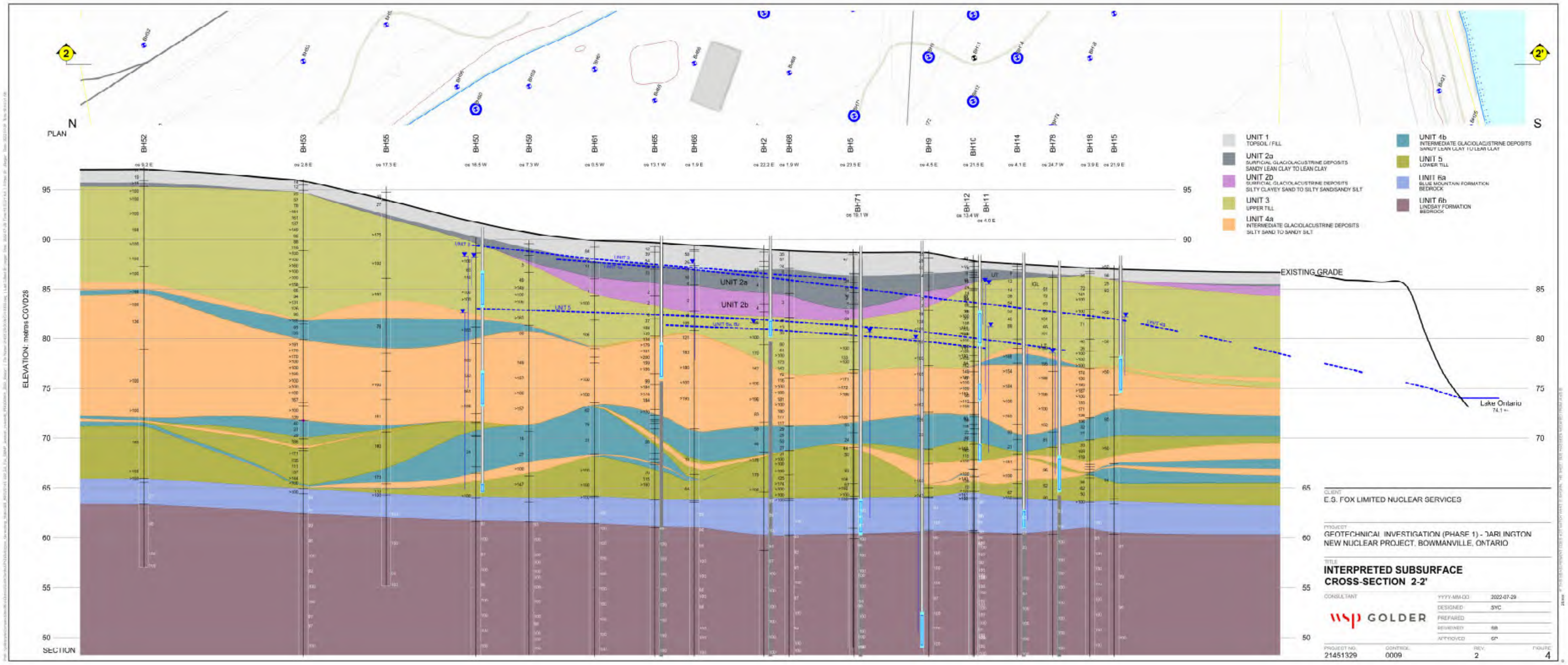


Figure 2.7.3.2-2: Subsurface Stratigraphic Profile at Cross-Section 2-2 (Reference 2.7-39)

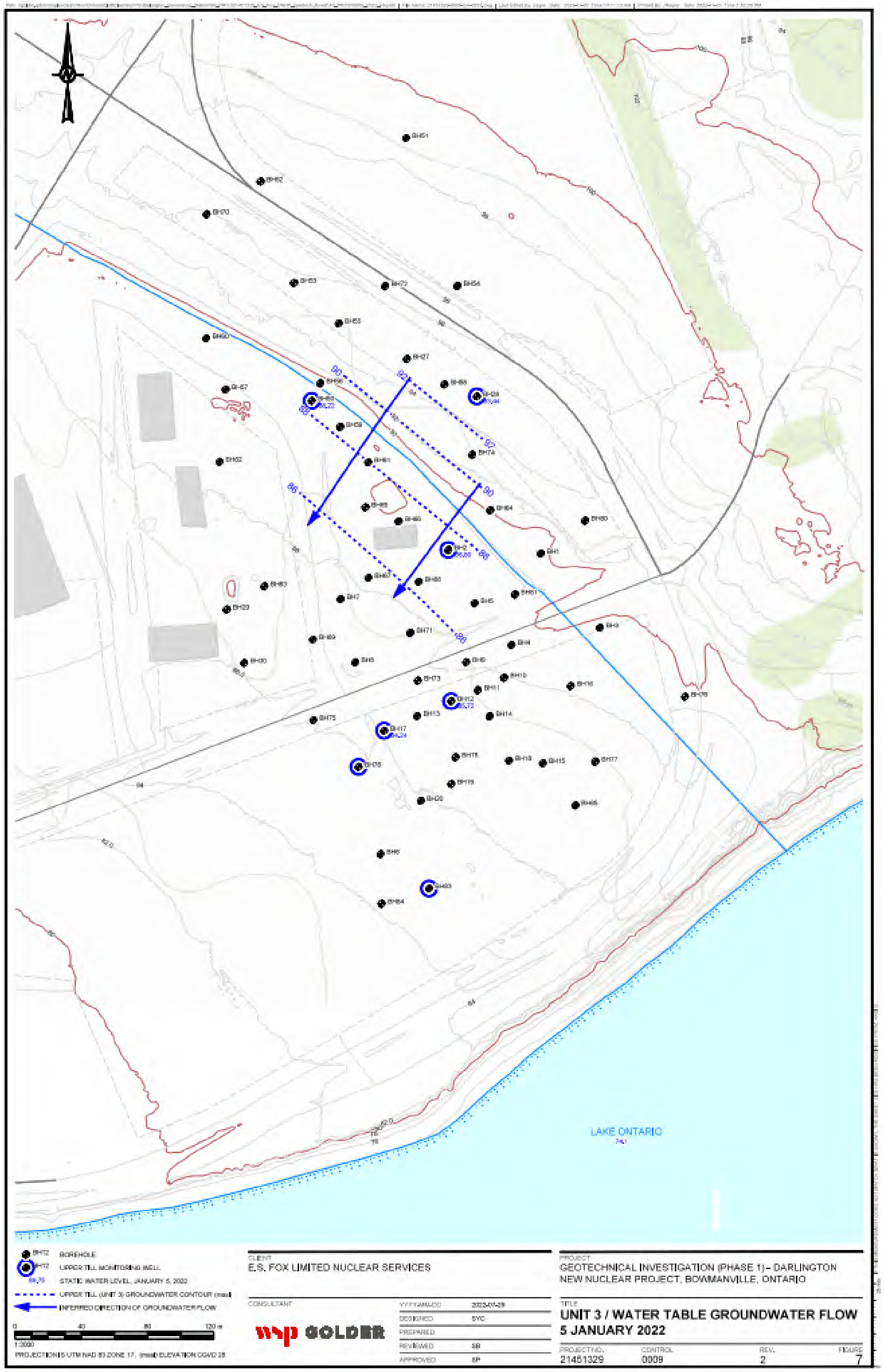


Figure 2.7.3.2-3: Unit 3 Groundwater Levels – Shallow/Water Table (Reference 2.7-39)

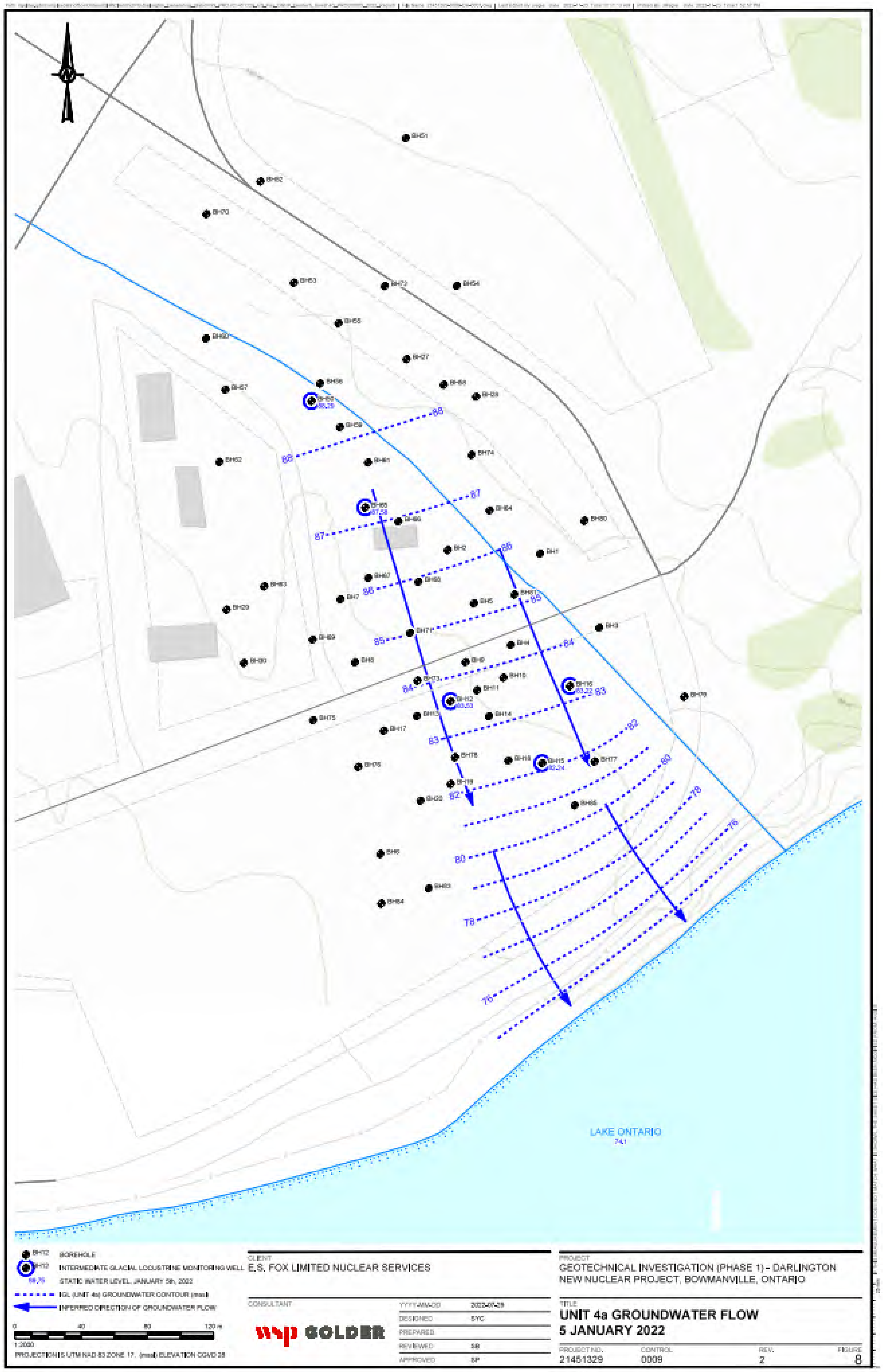


Figure 2.7.3.2-4: Unit 4a Groundwater Flow – Interglacial Deposits (Reference 2.7-39)

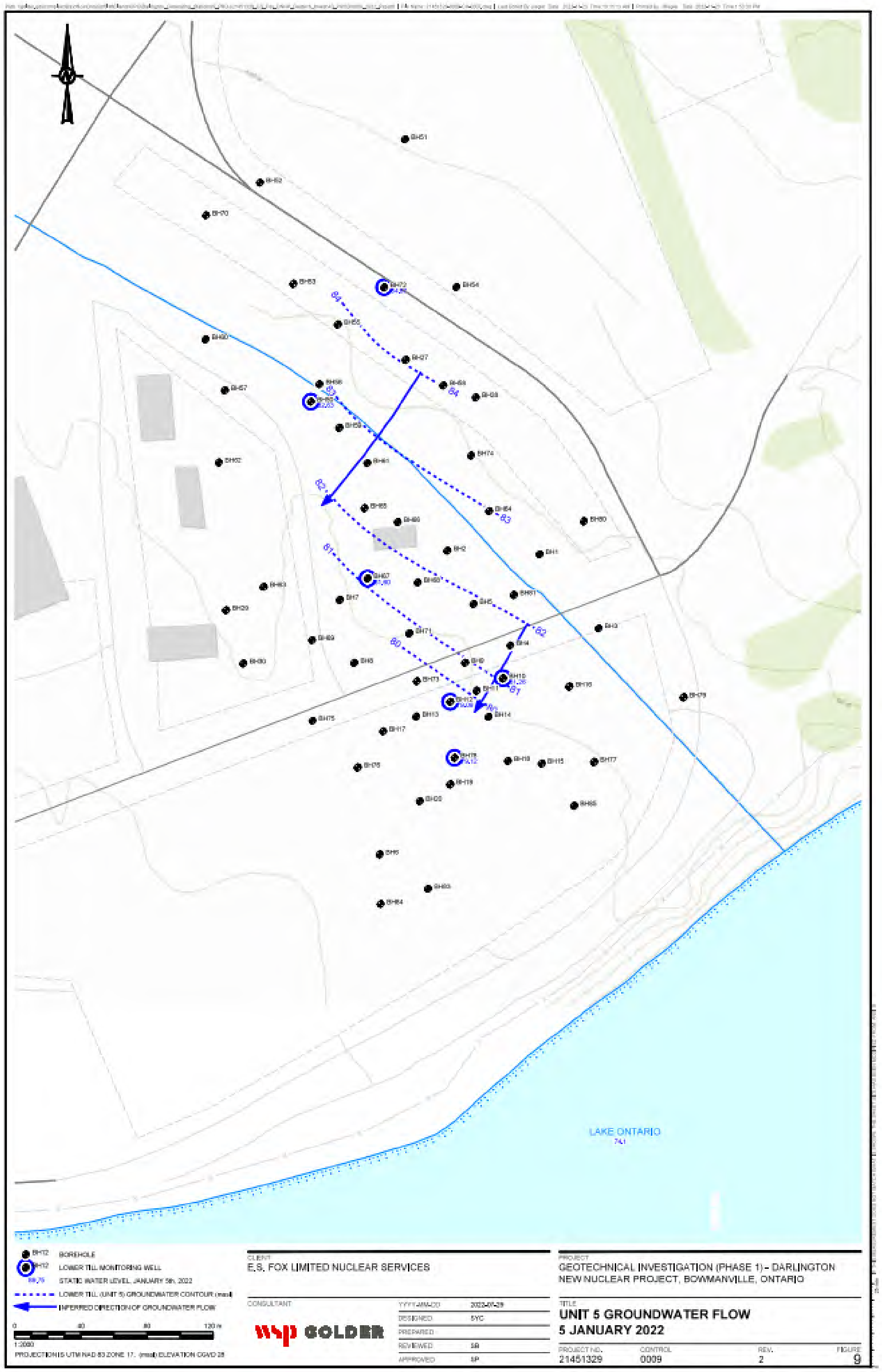


Figure 2.7.3.2-5: Unit 5 Groundwater Flow – Shallow Bedrock (Reference 2.7-39)

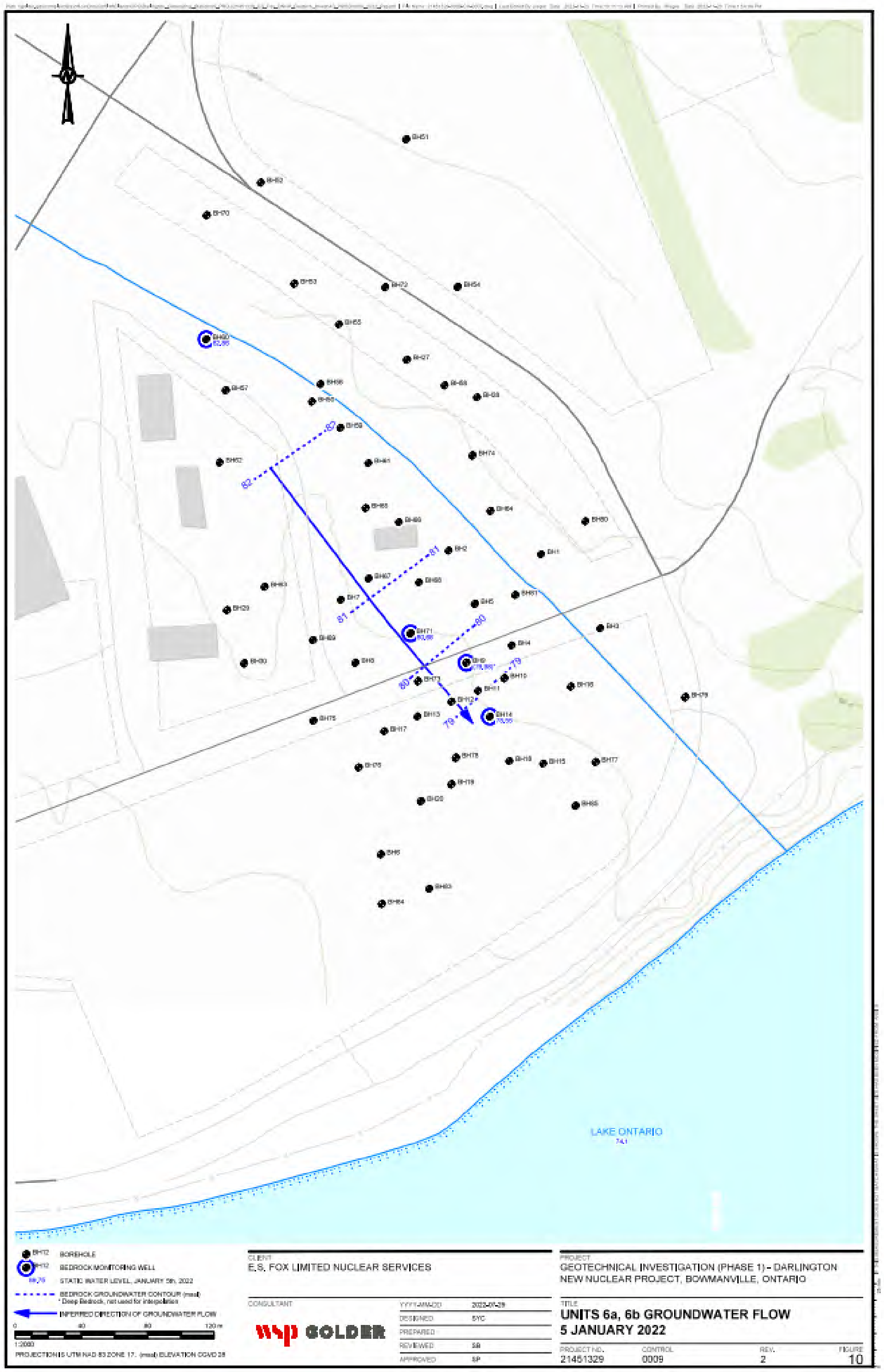


Figure 2.7.3.2-6: Units 6a - 6b Groundwater Flow – Shallow Bedrock (Reference 2.7-39)

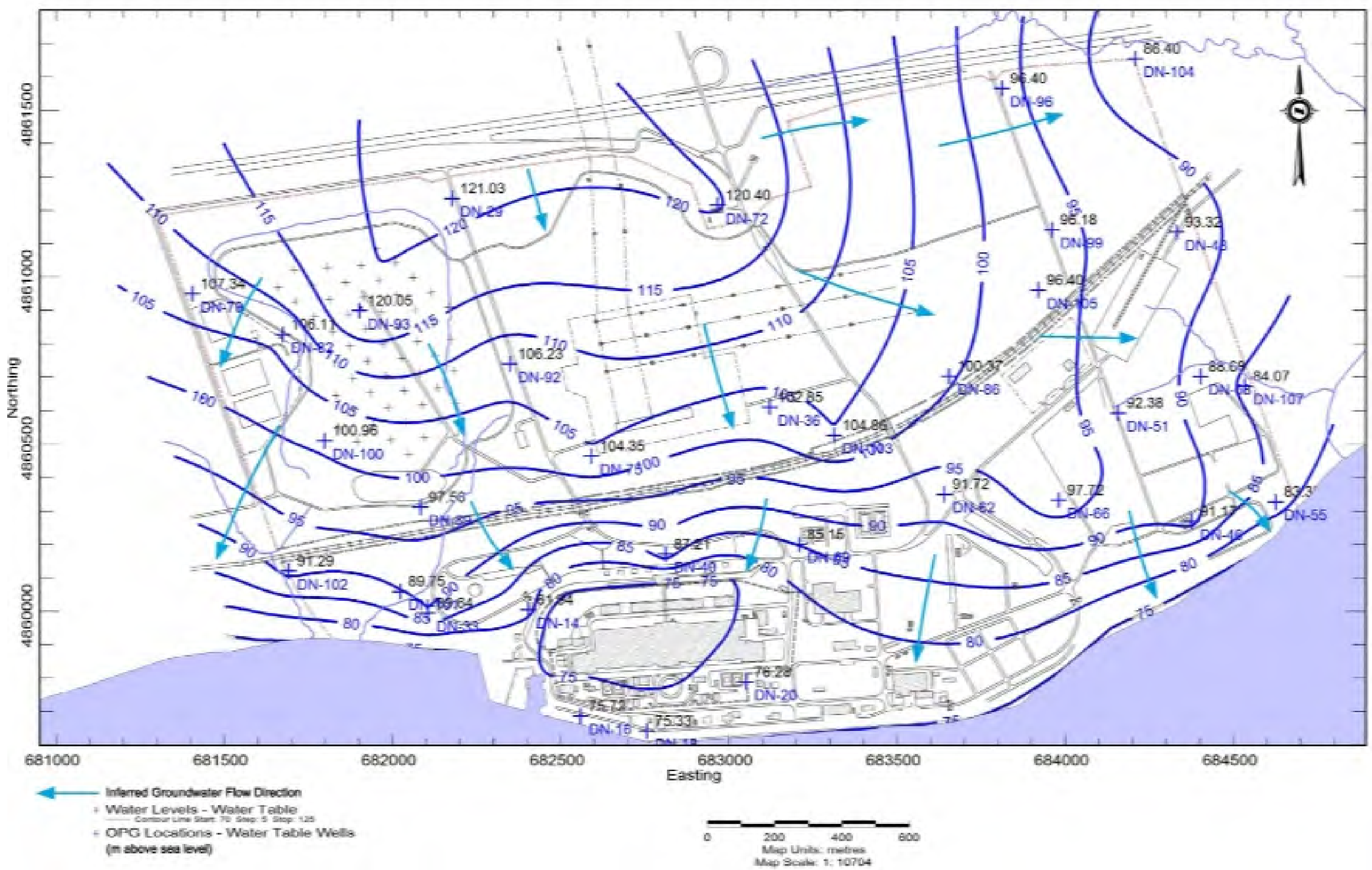


Figure 2.7.3.2-7: Regional Groundwater Levels – Shallow/Water Table (Reference 2.7-1)

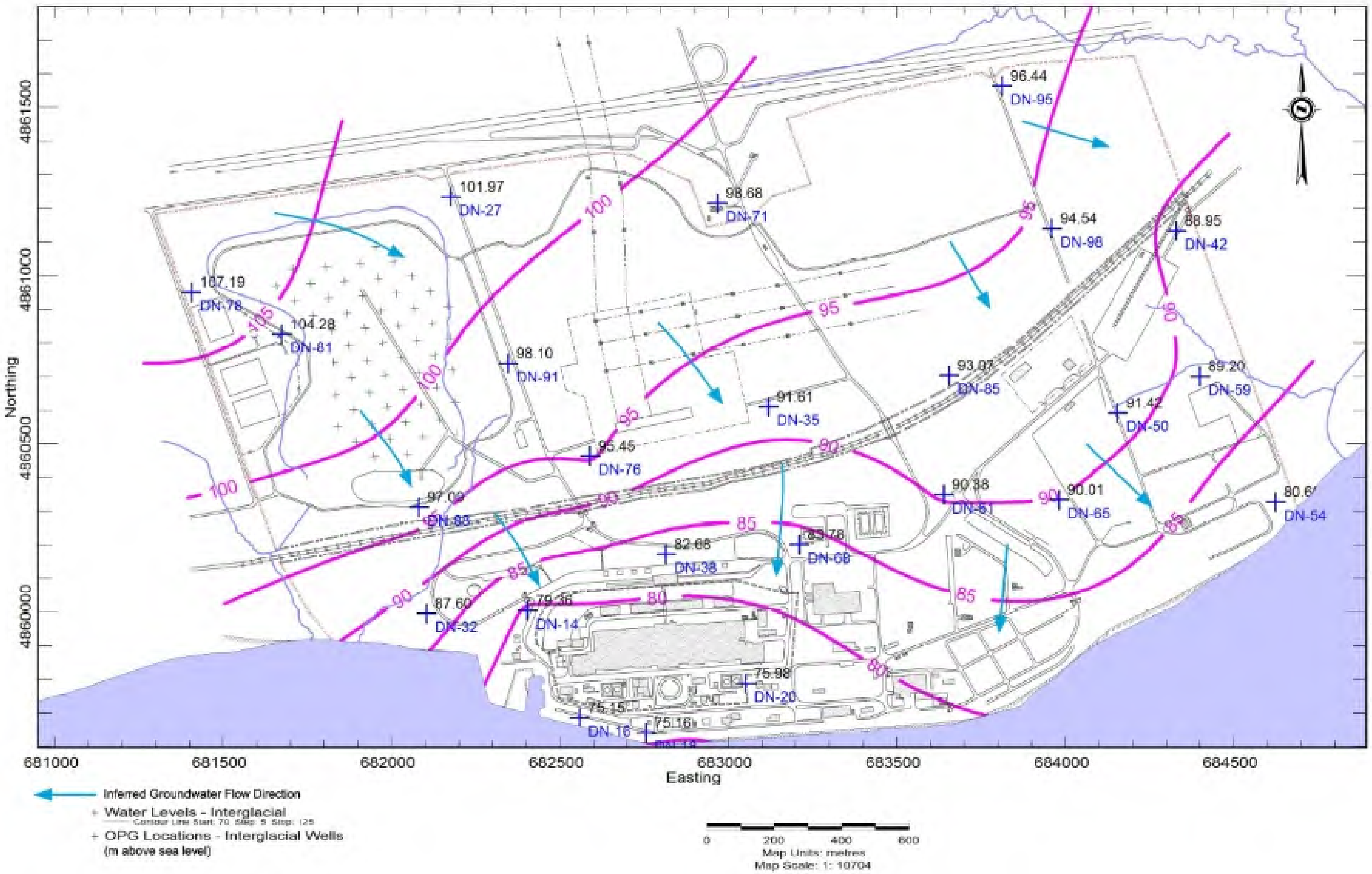


Figure 2.7.3.2-8: Regional Groundwater Flow – Interglacial Deposits (Reference 2.7-1)

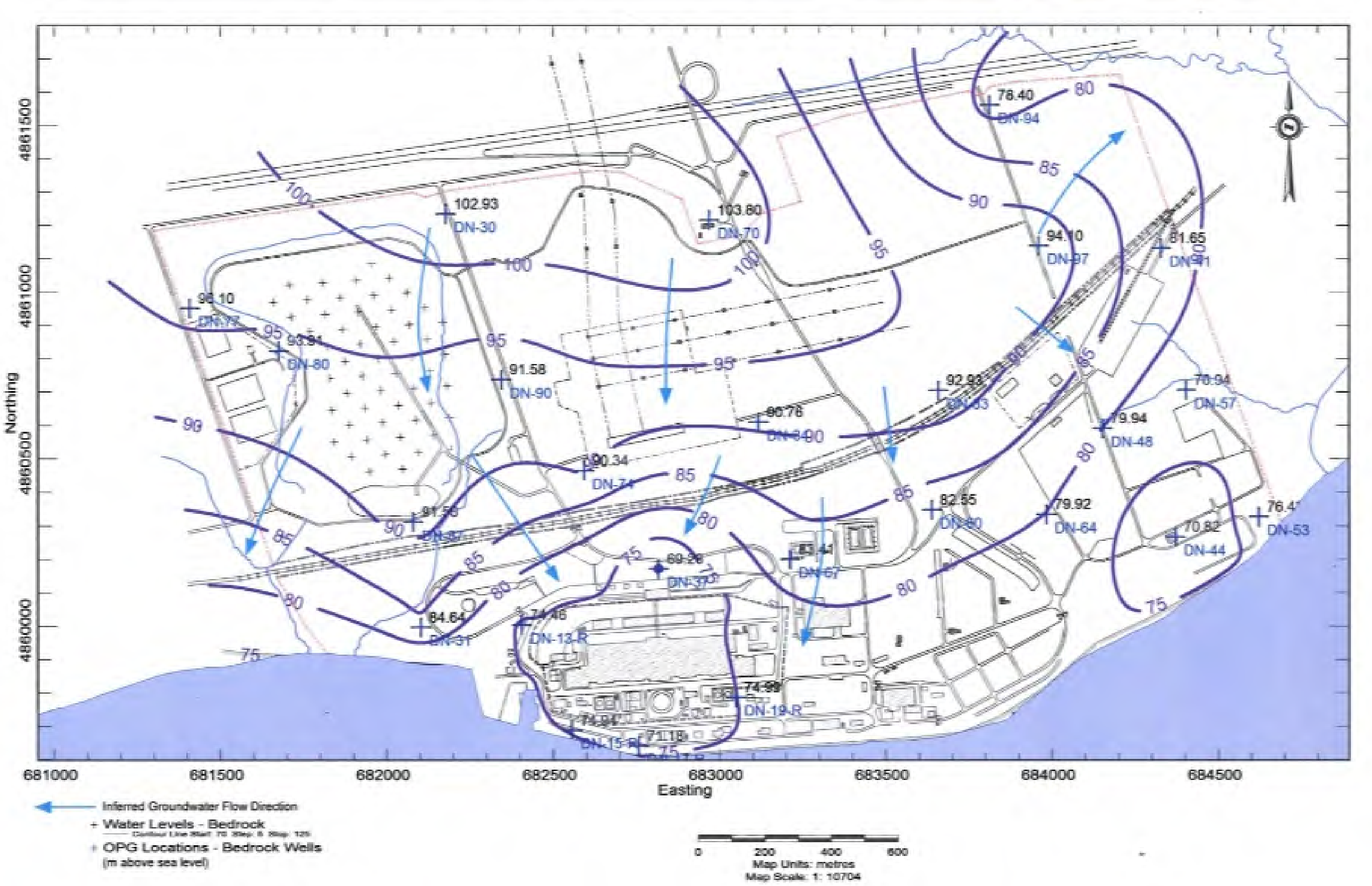


Figure 2.7.3.2-9: Regional Groundwater Flow – Shallow Bedrock (Reference 2.7-1)

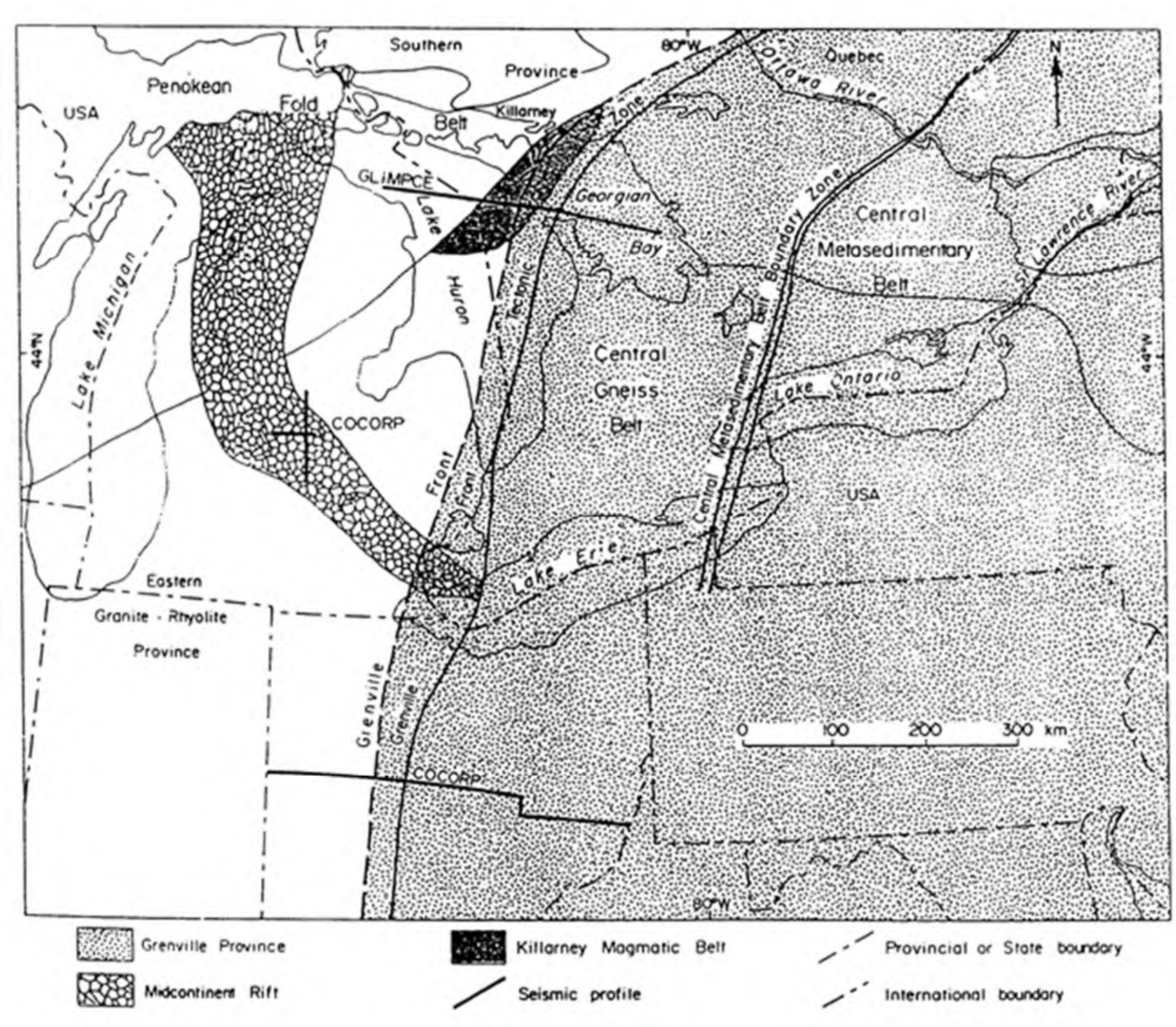
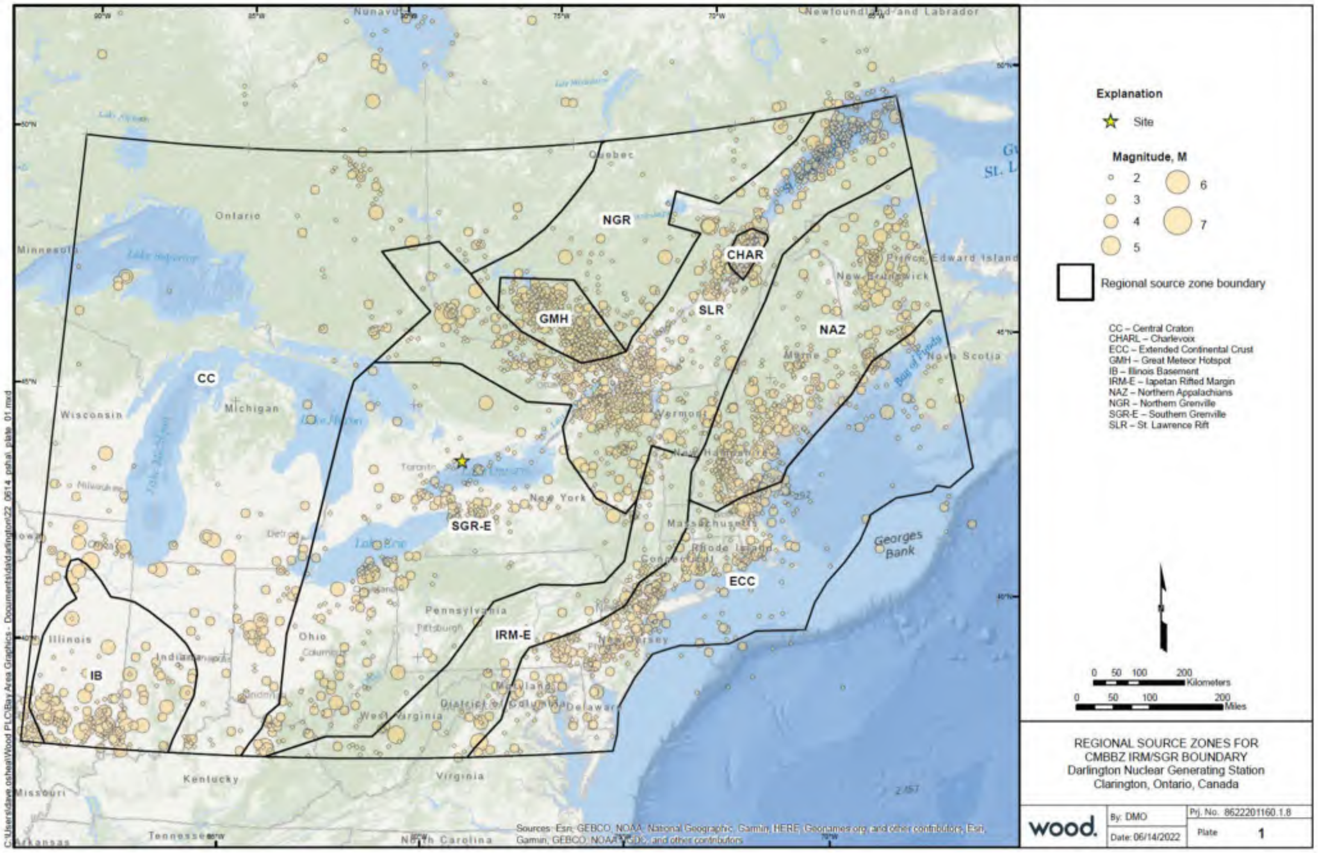


Figure 2.7.4.2-1: Principal Subdivisions of Precambrian Rocks in the Great Lakes Region (Reference 2.7-5)



Abbreviations:

CC – Central Craton
CHAR – Charlevoix
ECC – Extended Continental Crust
GMH – Great Meteor Hotspot
IB – Illinois Basement
IRM-E – Iapetan Rifted Margin
NAZ – Northern Appalachians
NGR – Northern Grenville
SGR-E – Southern Grenville
SLR – St. Lawrence Rift

Figure 2.7.4.2-2: Regional Source Zones for IRM/SGR Boundary Eastern Boundary (Reference 2.7-41)

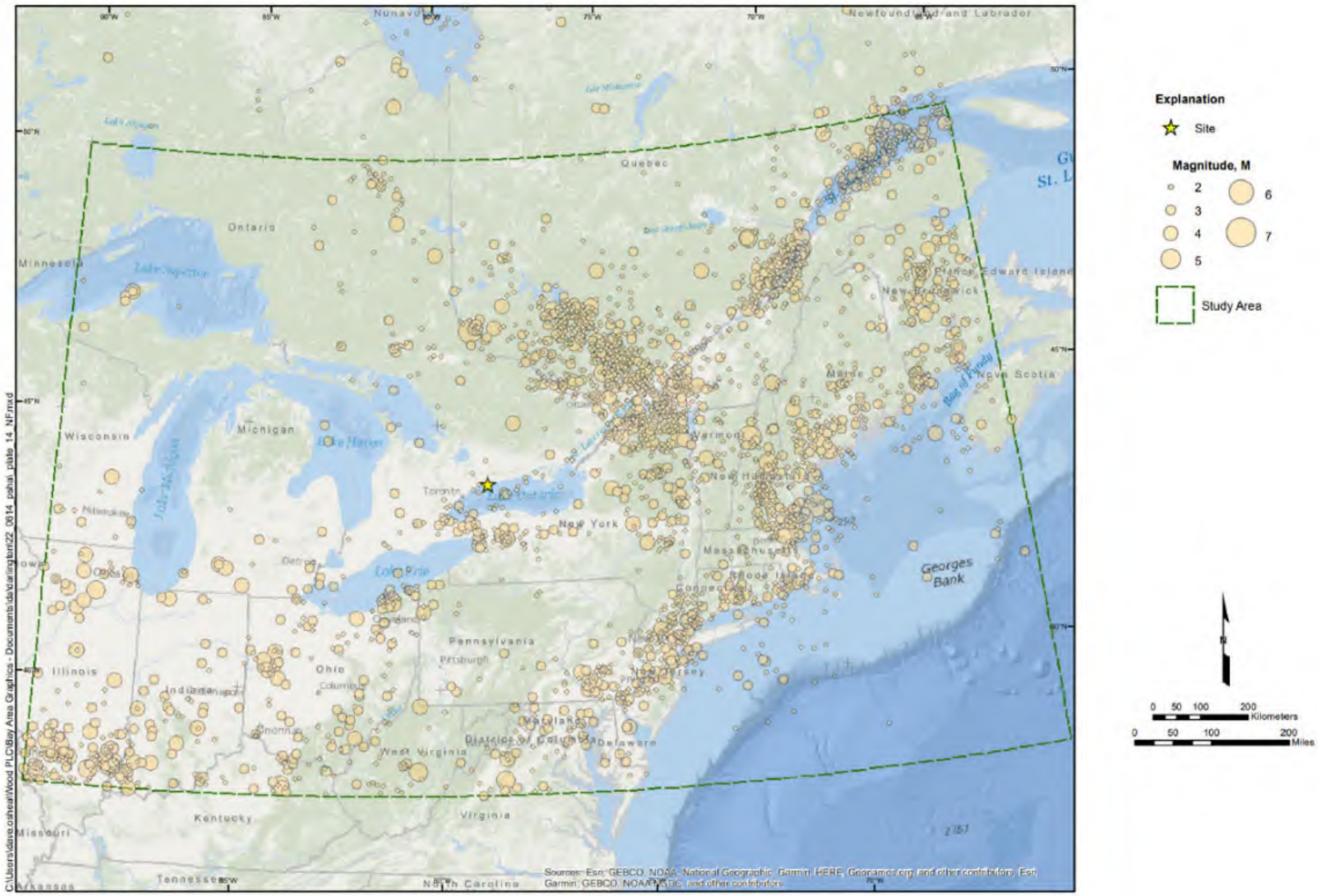


Figure 2.7.4.3-1: Map of Independent Earthquakes in the Updated Earthquake Catalogue for the Study Region (Reference 2.7-41)

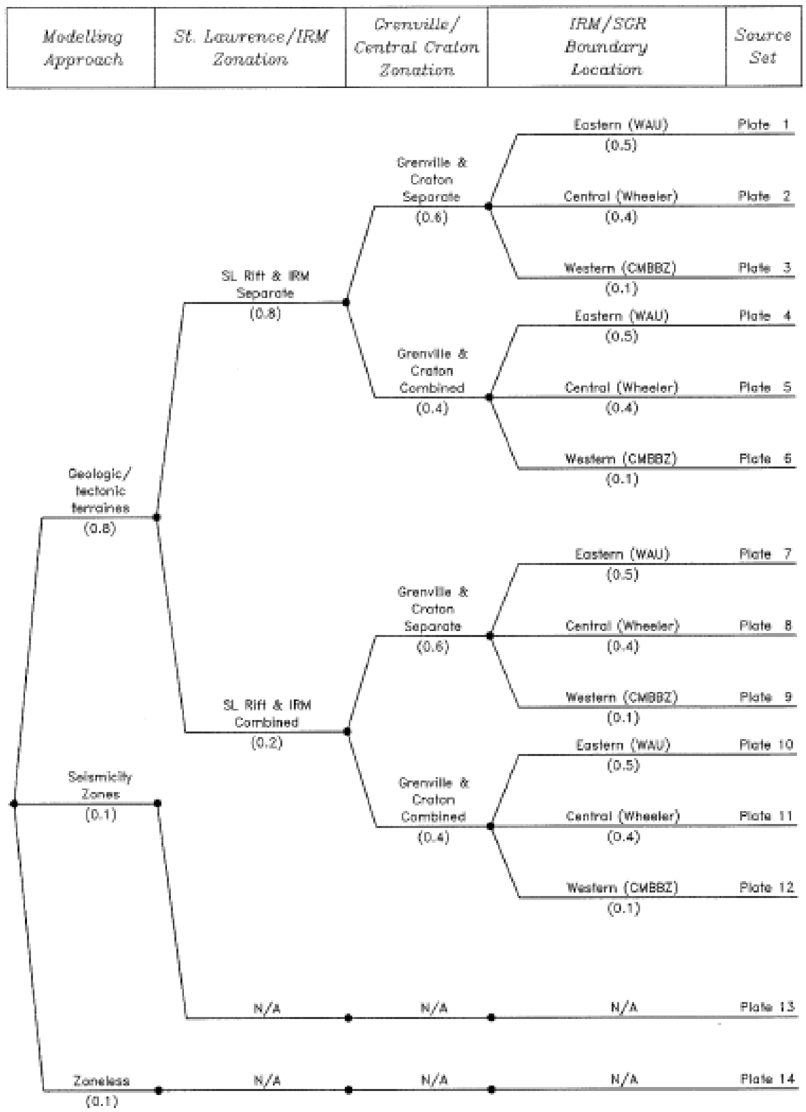


Figure 2.7.4.4-1: Logic Tree for Distributed Seismicity Sources (Reference 2.7- 42)

Abbreviations:

ADR – North Adirondacks
AOBH — Atlantic Offshore Background
AOH — Anna Ohio
BSL — Bas Saint Laurent
CHA — Champlaine
CHV — Charlevoix
COC — Cochrane
GAT — Gatineau
MNT — Montreal
NAN — Northern Appalachians
NAT — Niagara Attica Trend
SLE — South Shore Lake Erie
OBGH — Ontario Background
TAD — Tadoussac
PEM — Pembroke
TIM — Timiskaming
PMQ — Passamaquoddy Bay
TRR — Trois-Rivieres
SAG — Saguenay
SEB — Southeast Canada Background

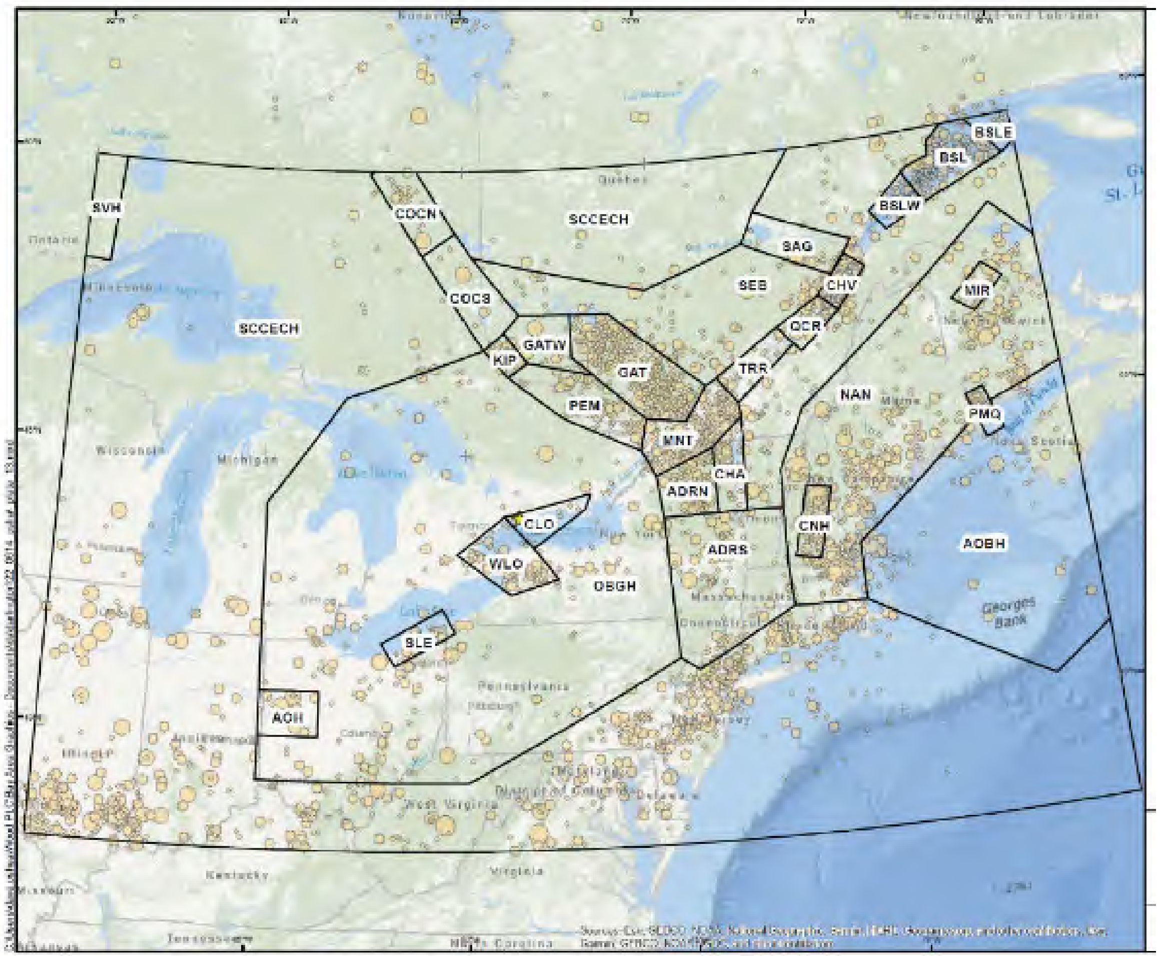


Figure 2.7.4.4-2: Regional Seismicity Source Zones from the Geological Survey of Canada's Sixth Generation H Model (Plate 13 in Reference 2.7-41)

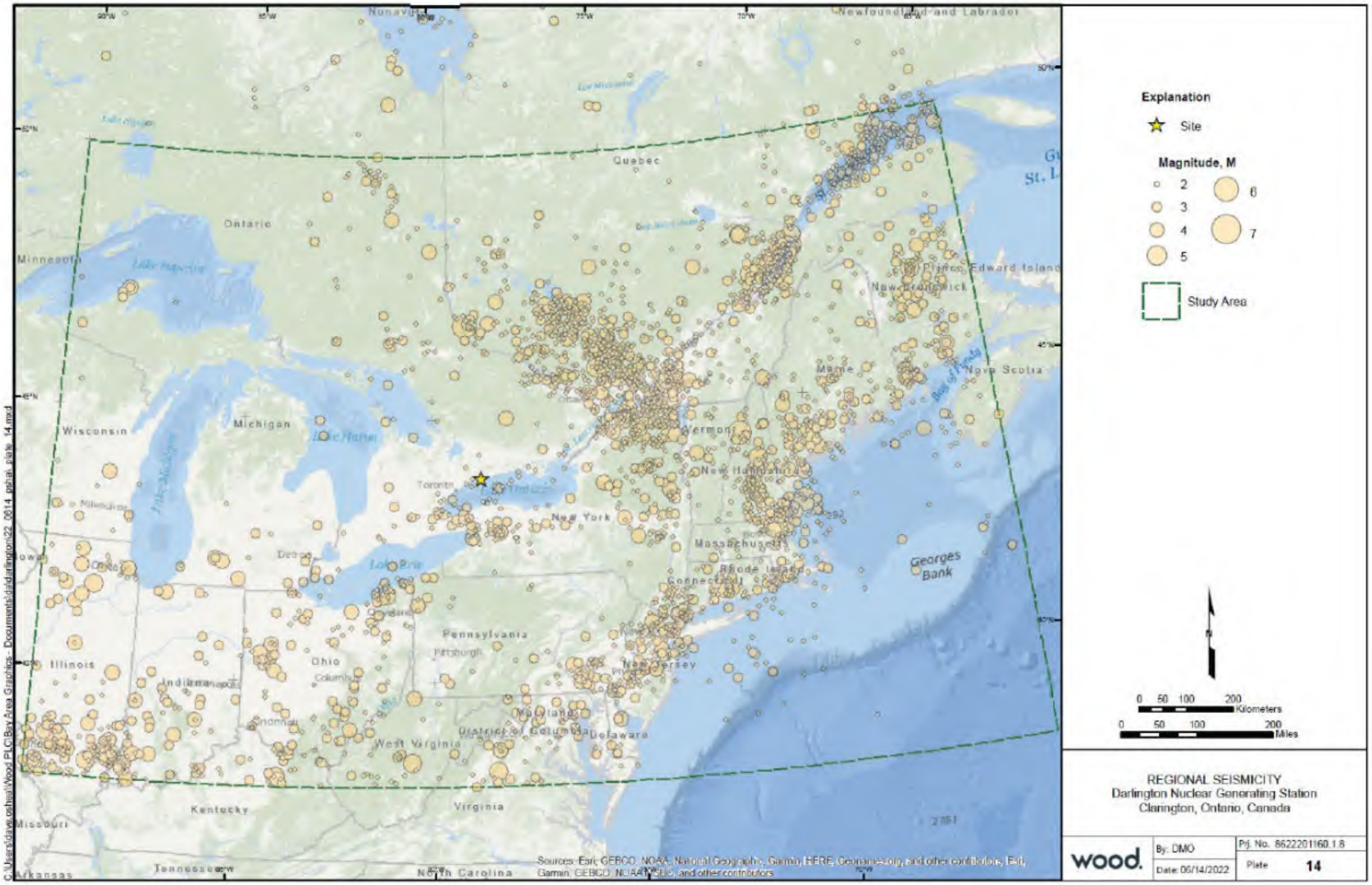
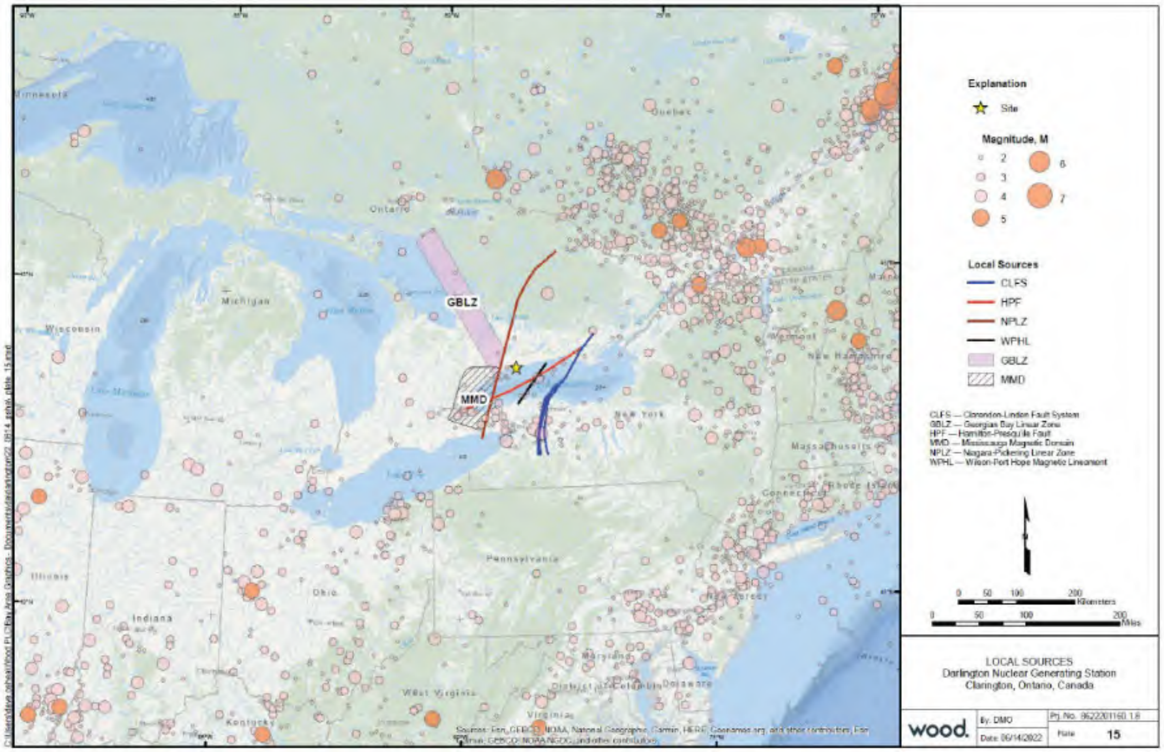


Figure 2.7.4.4-3: Regional Seismicity for Zoneless Model (Plate 14 in Reference 2.7-41)



<u>Abbreviations</u>:

CLFS — Clarendon-Linden Fault System
GBLZ — Georgian Bay Linear Zone
HPF — Hamilton-Presqu'ile Fault
MMD — Mississauga Magnetic Domain
NPLZ — Niagara-Pickering Linear Zone
WPHL — Wilson-Port Hope Magnetic Lineament

Figure 2.7.4.4-4: Local Source Zones (Plate 15 in Reference 2.7-41)

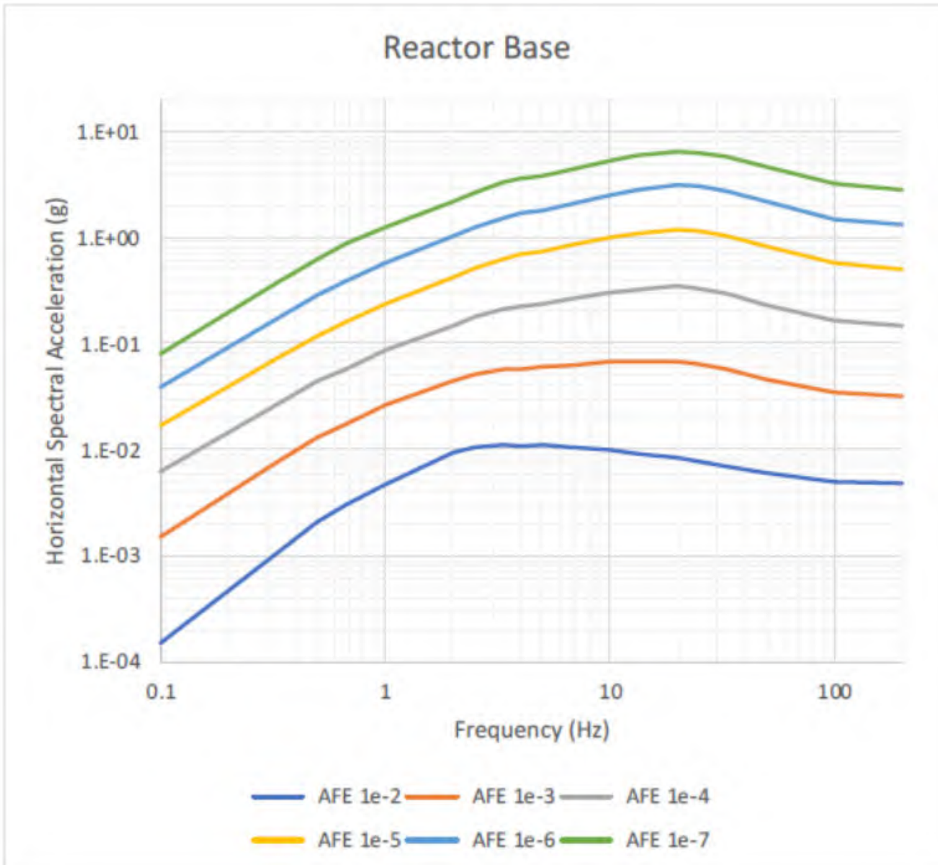


Figure 2.7.4.6-1: Horizontal UHRS at Elevation 52.93 m Based on Mean Hazard (Reference 2.7-41)

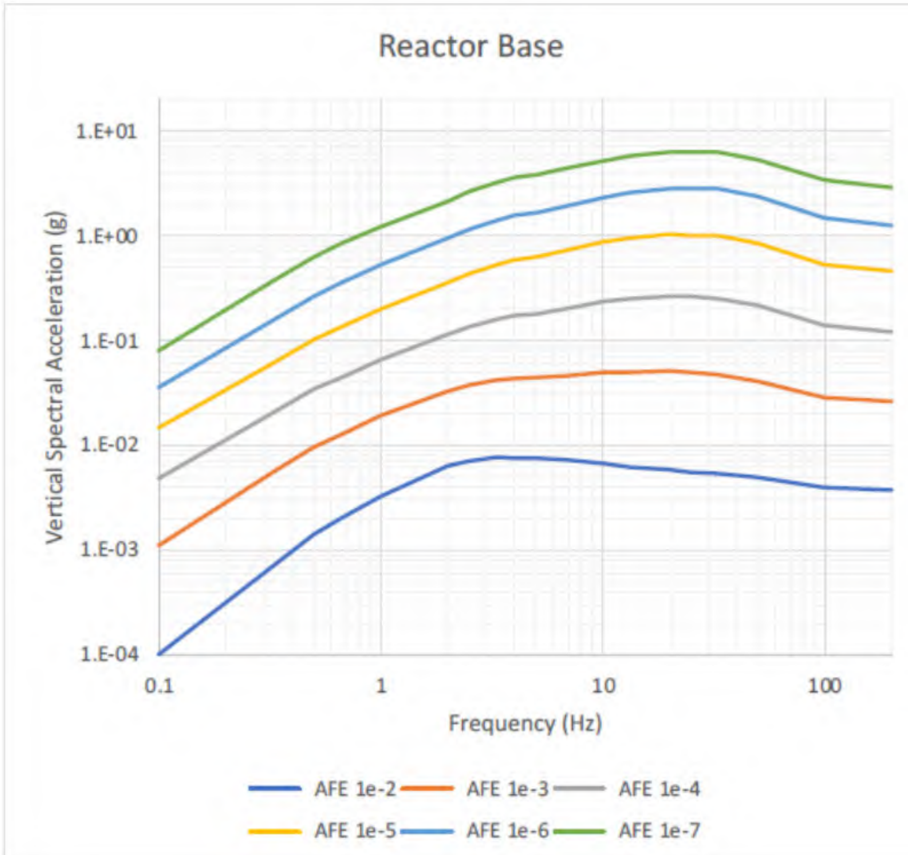


Figure 2.7.4.6-2: Vertical UHRS at Elevation 52.93 m Based on Mean Hazard (Reference 2.7-41)

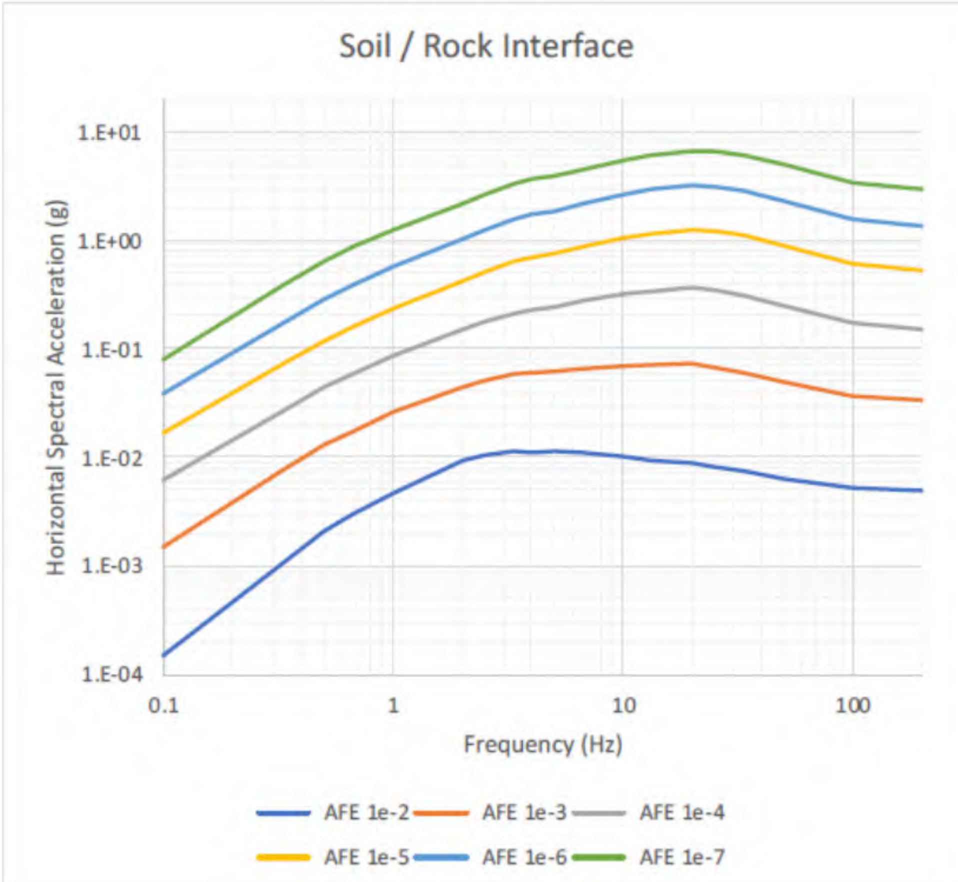


Figure 2.7.4.6-3: Horizontal UHRS at Elevation 64 m Based on Mean Hazard (Reference 2.7-41)

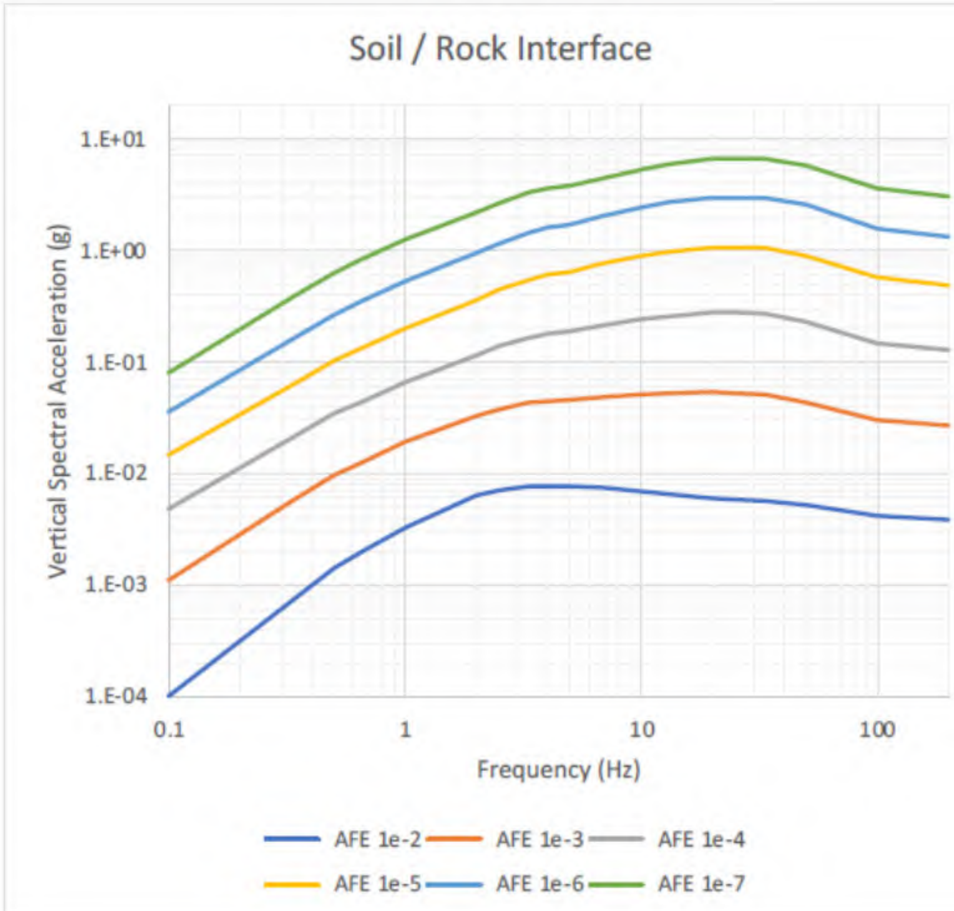


Figure 2.7.4.6-4: Vertical UHRS at Elevation 64 m Based on Mean Hazard (Reference 2.7-41)

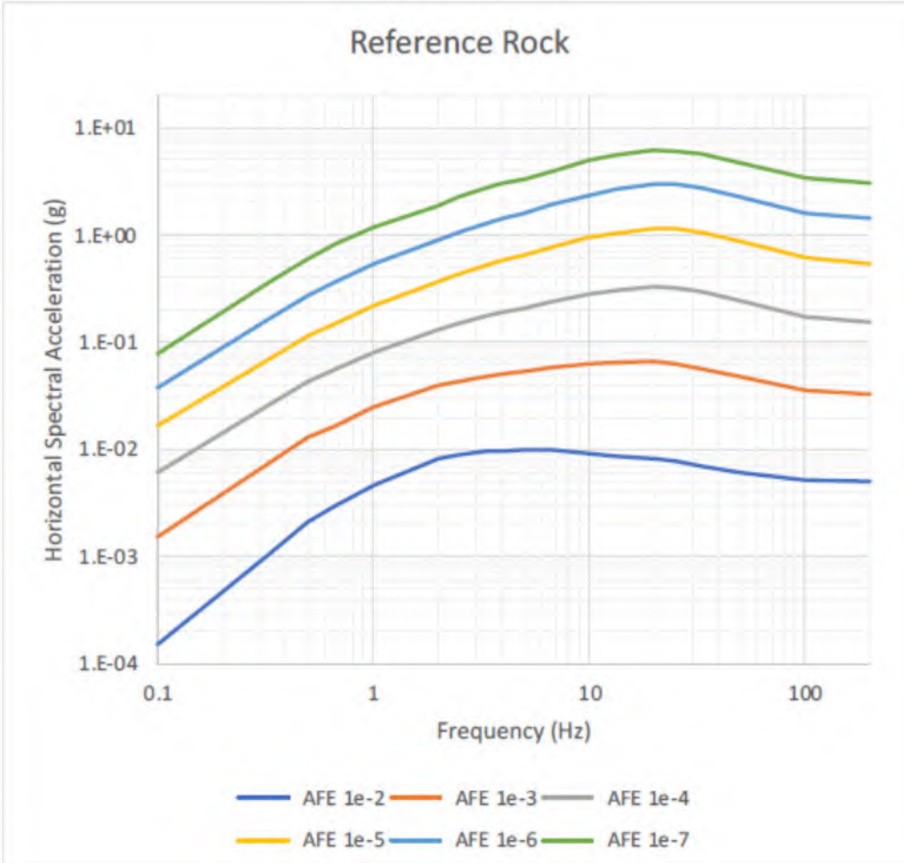


Figure 2.7.4.6-5: Horizontal UHRS for Finished Grade at Elevation 88 m Based on Mean Hazard (Reference 2.7-41)

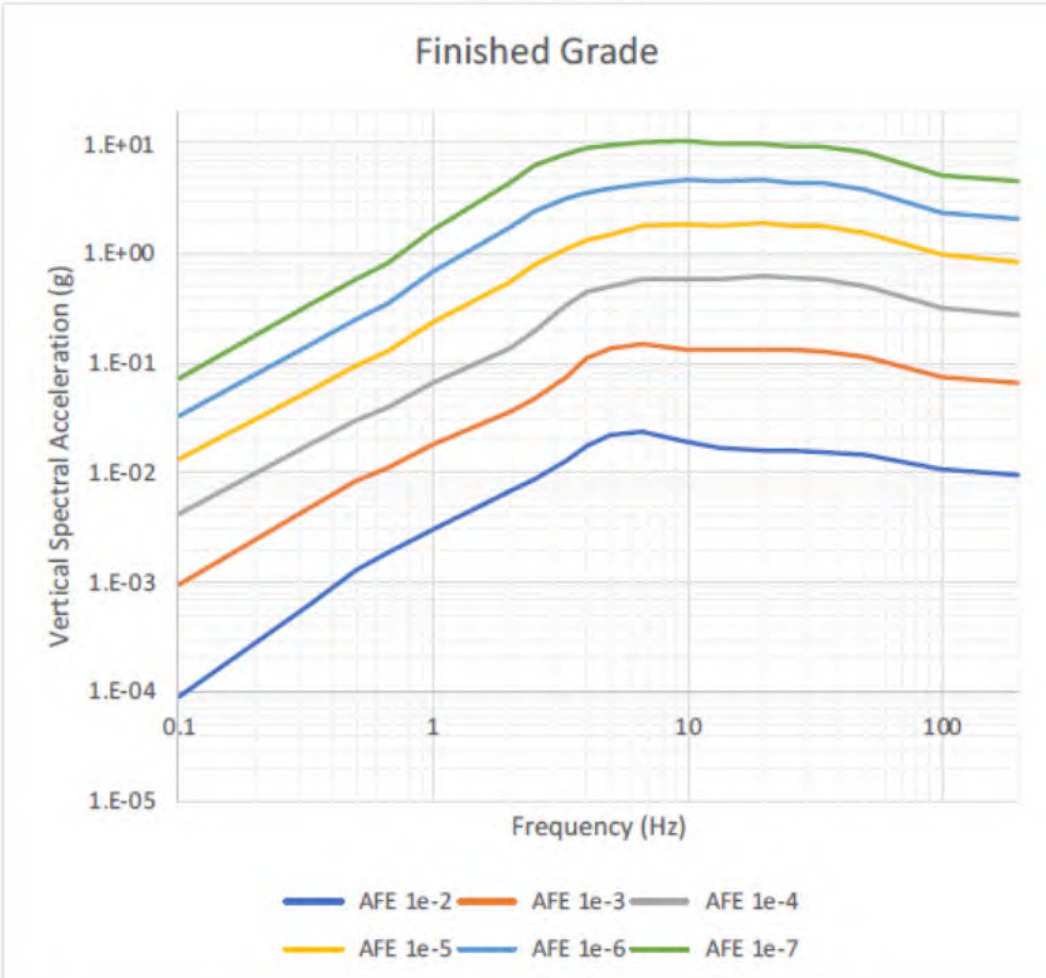


Figure 2.7.4.6-6: Vertical UHRS for Finished Grade at Elevation 88 m Based on Mean Hazard (Reference 2.7-41)

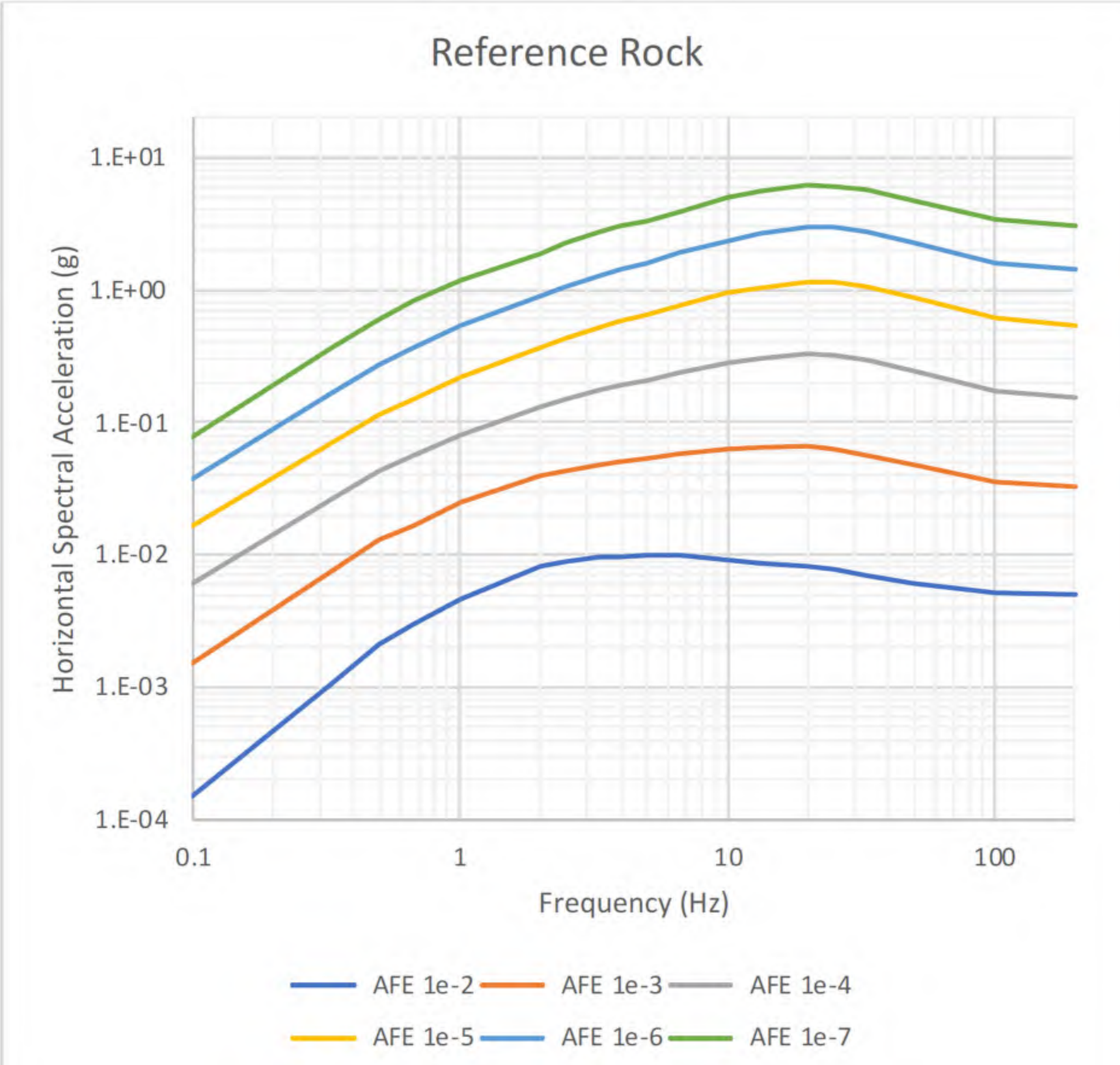


Figure 2.7.4.6-7: Horizontal UHRS for Reference Rock Based on Mean Hazard (Reference 2.7-41)

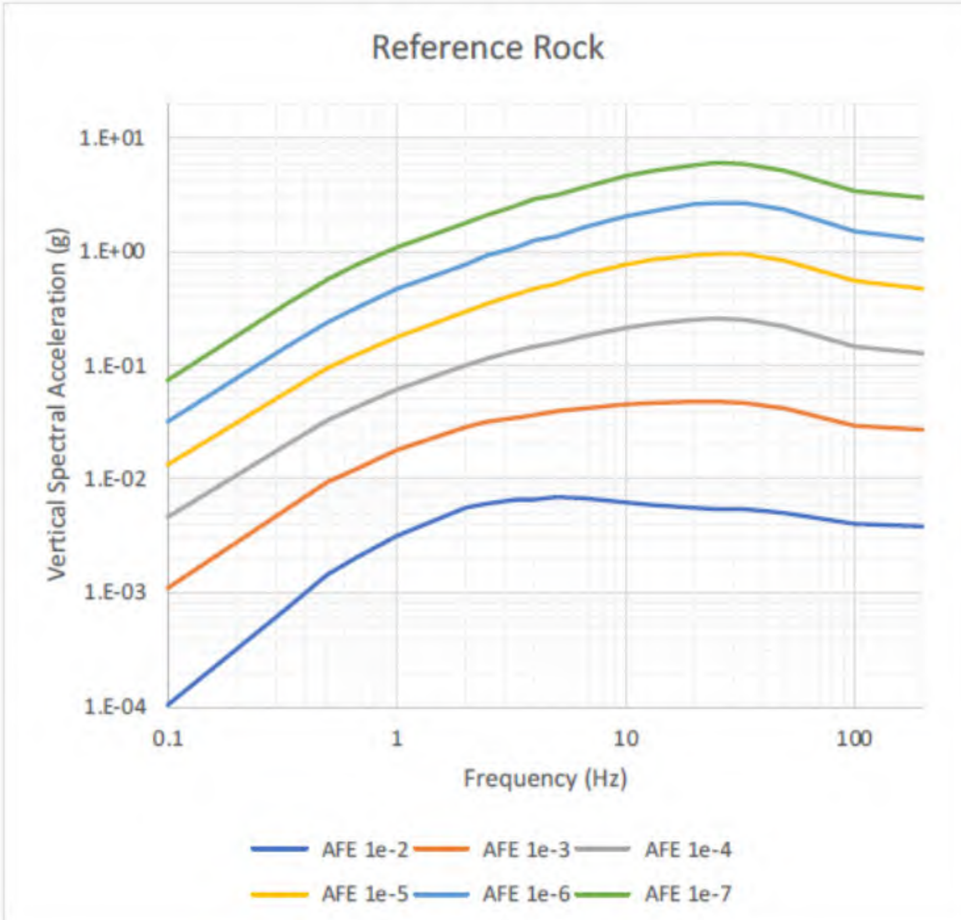


Figure 2.7.4.6-8: Vertical UHRS for Reference Rock Basedon Mean Hazard (Reference 2.7-41)

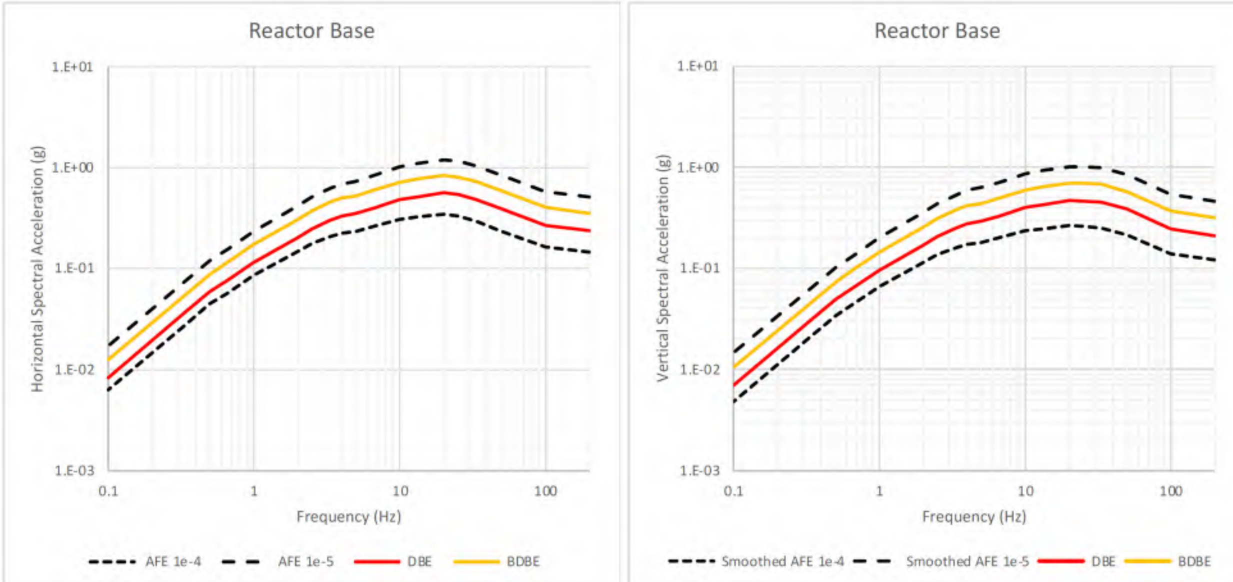


Figure 2.7.4.6-9: Initial Horizontal DBE and BDBE Spectra for Reactor Base (Elevation 52.93 m) (Reference 2.7-41)

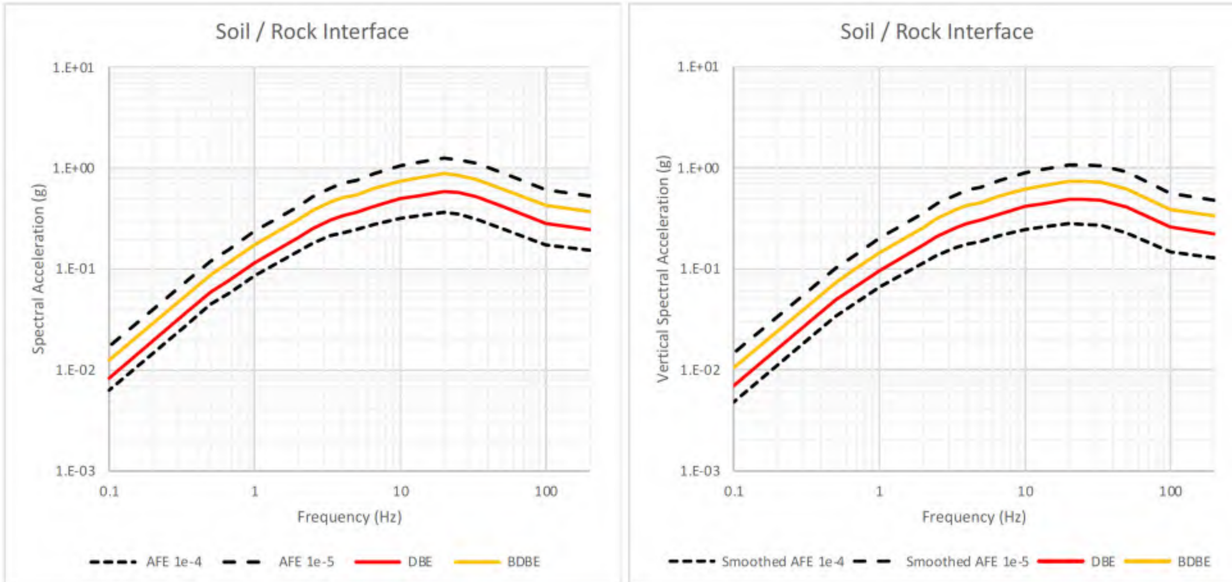


Figure 2.7.4.6-10: Initial Horizontal DBE and BDBE Spectra for Soil-Rock Interface (Elevation 64 m) (Reference 2.7-41)

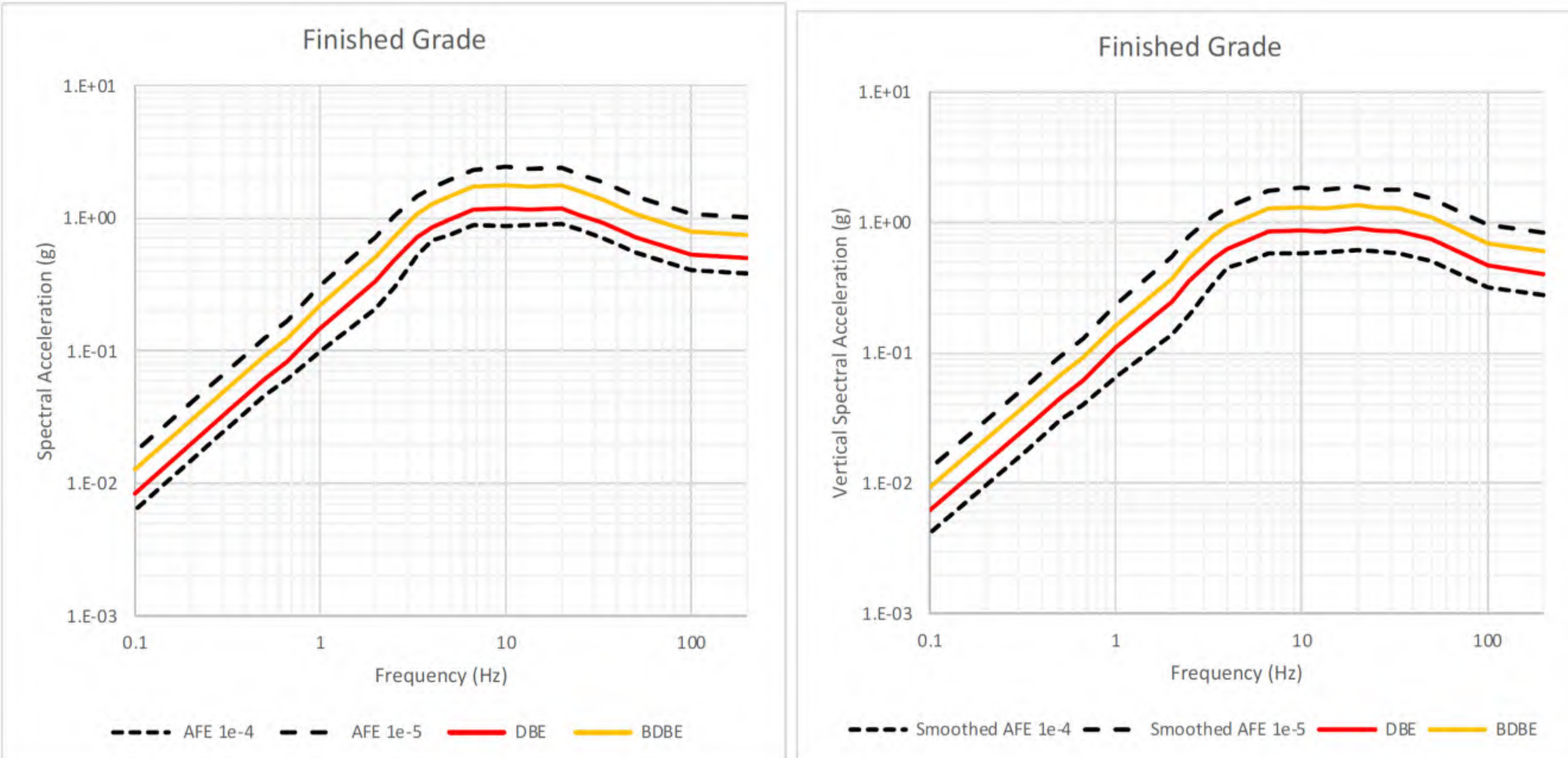


Figure 2.7.4.6-11: Initial Horizontal DBE and BDBE Spectra for Finished Grade (Elevation 88 m) (Reference 2.7-41)

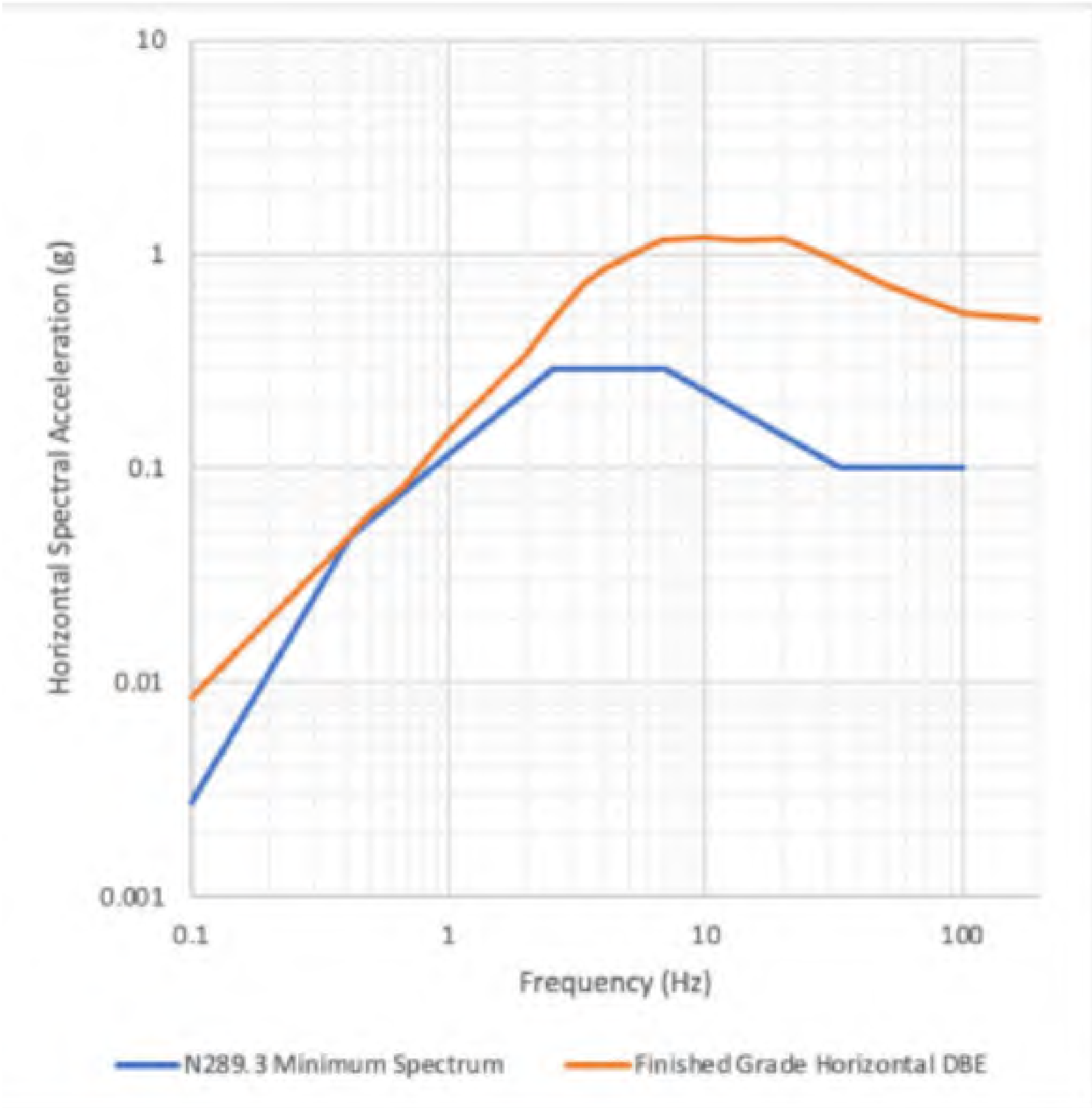


Figure 2.7.4.6-12: Comparison of Finished Grade Horizontal DBE with CSA N289.3 Minimum Spectrum (Reference 2.7-41)

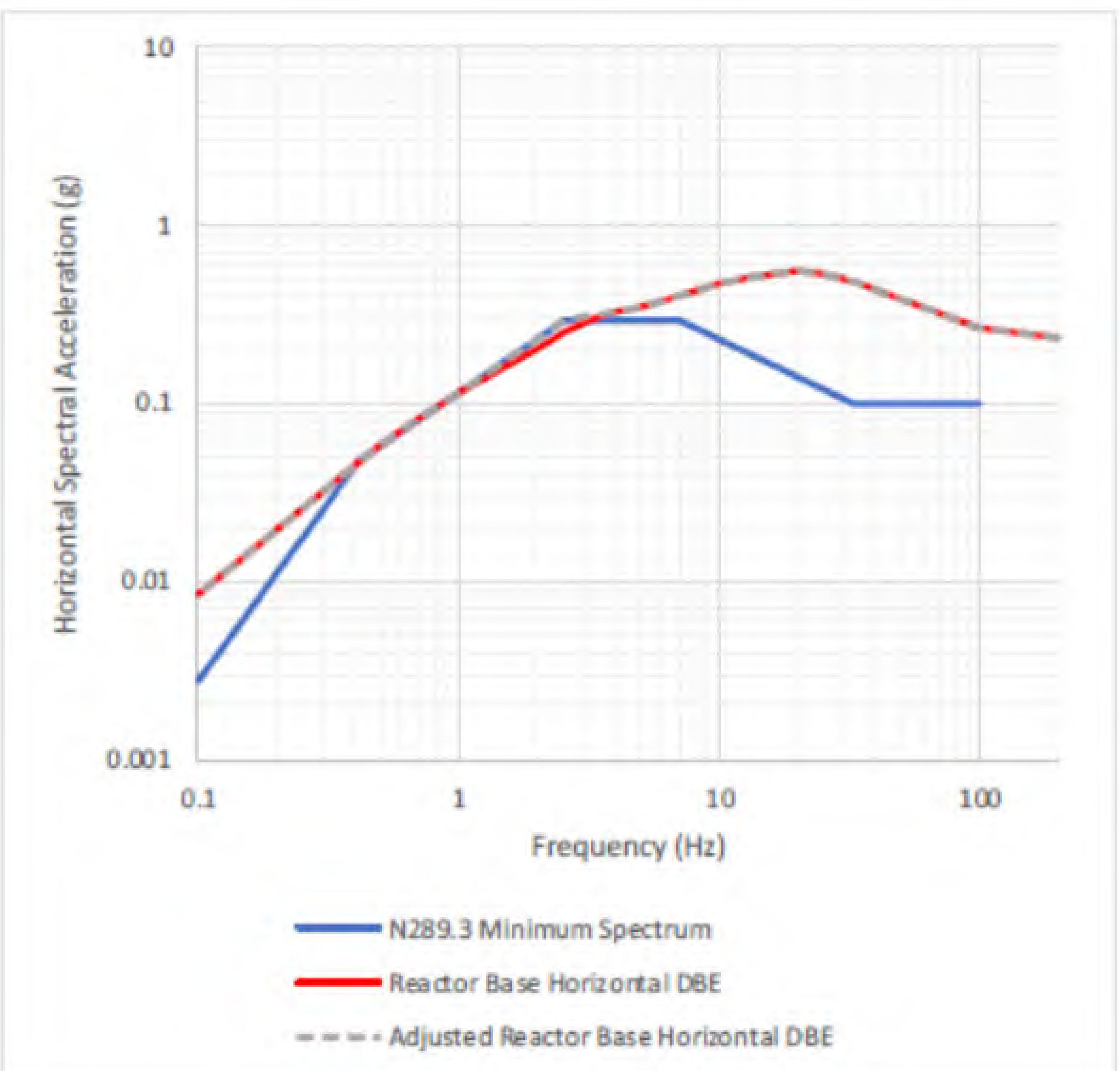


Figure 2.7.4.6-13: Comparison of Reactor Building Base Horizontal DBE with CSA N289.3 Minimum Spectrum (Reference 2.7-41)

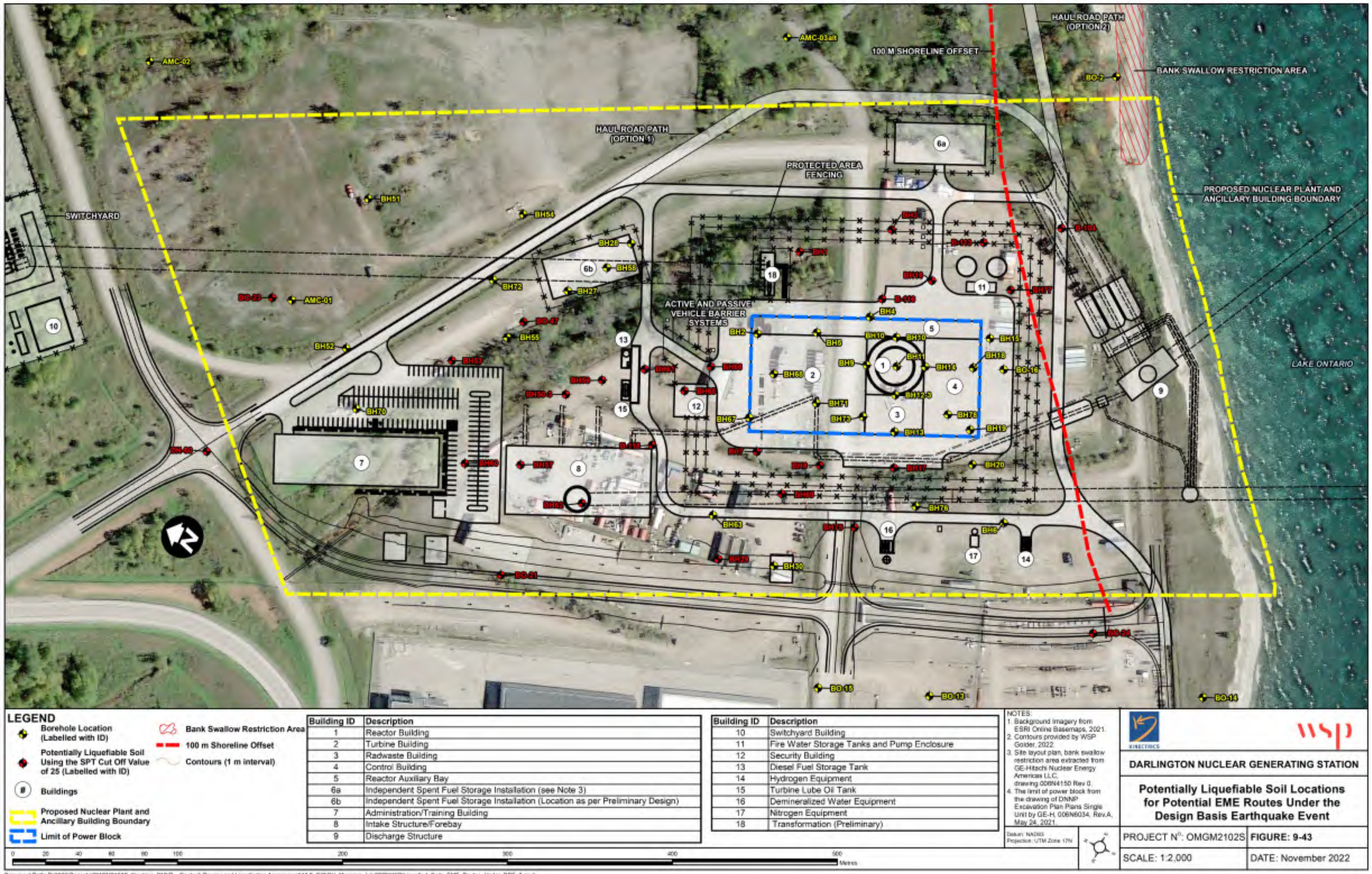
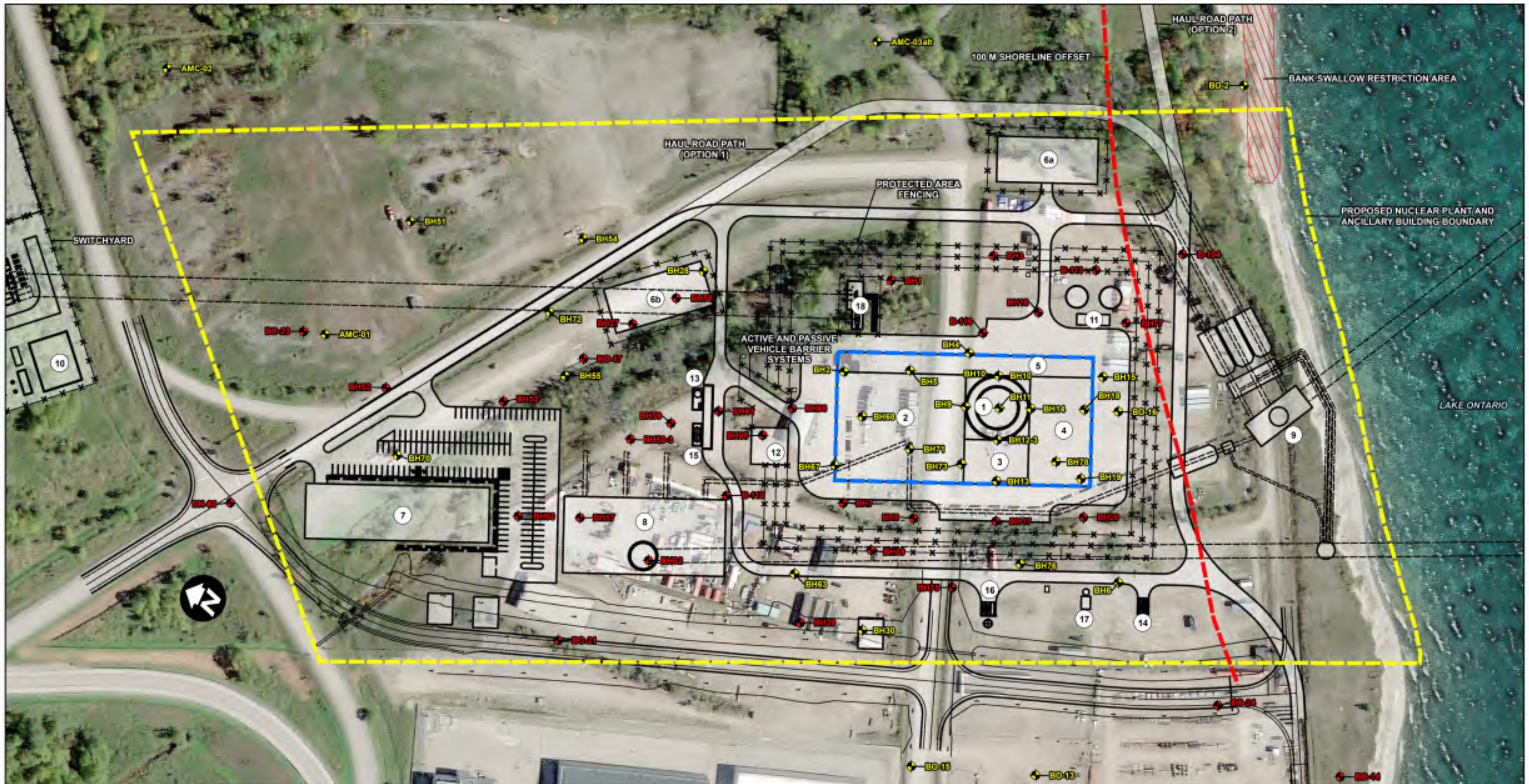


Figure 2.7.4.7-1: Locations of Boreholes Potentially to Liquefaction Under the DBE Event (Reference 2.7-42)



LEGEND

- Borehole Location (Labelled with ID)
- Potentially Liquefiable Soil Using the SPT Cut Off Value of 30 (Labelled with ID)
- Buildings
- Proposed Nuclear Plant and Ancillary Building Boundary
- Limit of Power Block
- Bank Swallow Restriction Area
- 100 m Shoreline Offset
- Contours (1 m interval)

Building ID	Description
1	Reactor Building
2	Turbine Building
3	Radwaste Building
4	Control Building
5	Reactor Auxiliary Bay
6a	Independent Spent Fuel Storage Installation (see Note 3)
6b	Independent Spent Fuel Storage Installation (Location as per Preliminary Design)
7	Administration/Training Building
8	Intake Structure/Forebay
9	Discharge Structure

Building ID	Description
10	Switchyard Building
11	Fire Water Storage Tanks and Pump Enclosure
12	Security Building
13	Diesel Fuel Storage Tank
14	Hydrogen Equipment
15	Turbine Lube Oil Tank
16	Demineralized Water Equipment
17	Nitrogen Equipment
18	Transformation (Preliminary)

NOTES:
1. Background Imagery from ESRI Online Basemaps, 2021.
2. Contours provided by WSP Golder, 2022.
3. Site layout plan, bank swallow restriction area extracted from GE-Hitachi Nuclear Energy Americas LLC, drawing 008N4150 Rev 0.
4. The limit of power block from the drawing of DNNP Excavation Plan Plans Single Unit by GE-H, 006N6034, Rev A, May 24, 2021.

Datum: NAD83
Projection: UTM Zone 17N

0 20 40 60 80 100 200 300 400 500 Metres

KINECTRICS WSP

DARLINGTON NUCLEAR GENERATING STATION

Potentially Liquefiable Soil Locations for Potential EME Routes Under the Beyond Design Basis Earthquake Event

PROJECT N°: OMGM2102S | FIGURE: 9-44
SCALE: 1:2,000 | DATE: November 2022

Figure 2.7.4.7-2: Locations of Boreholes Potentially to Liquefaction Under the BDBE Event (Reference 2.7-42)

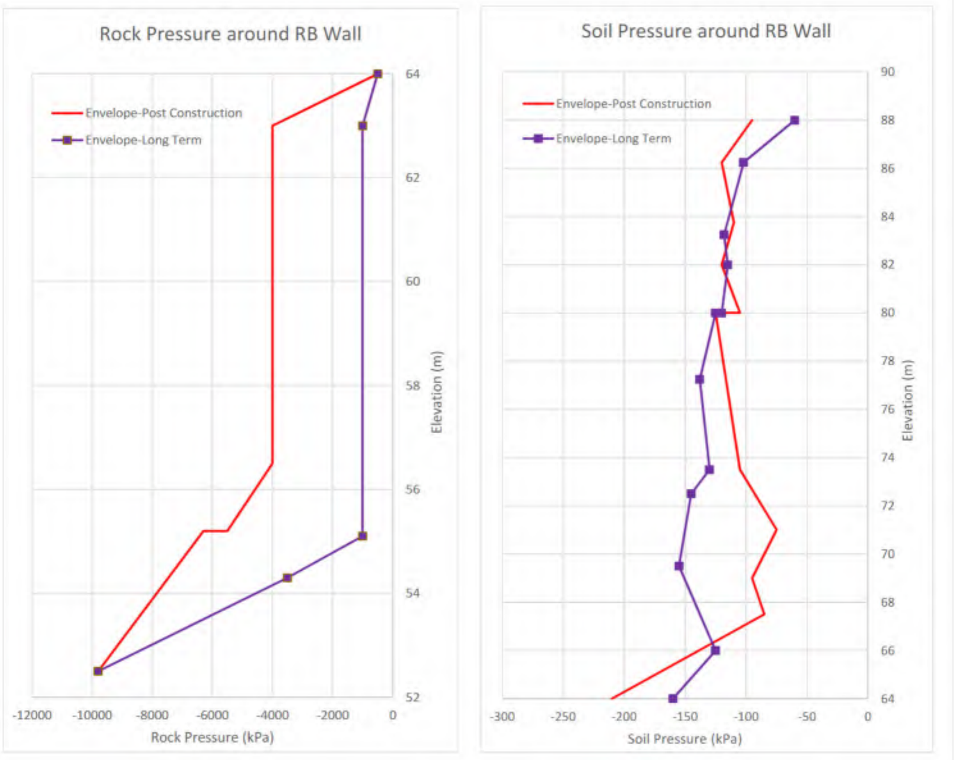


Figure 2.7.5.1.3-1: Rock and Soil Pressures Around RB Wall (Reference 2.7-38)

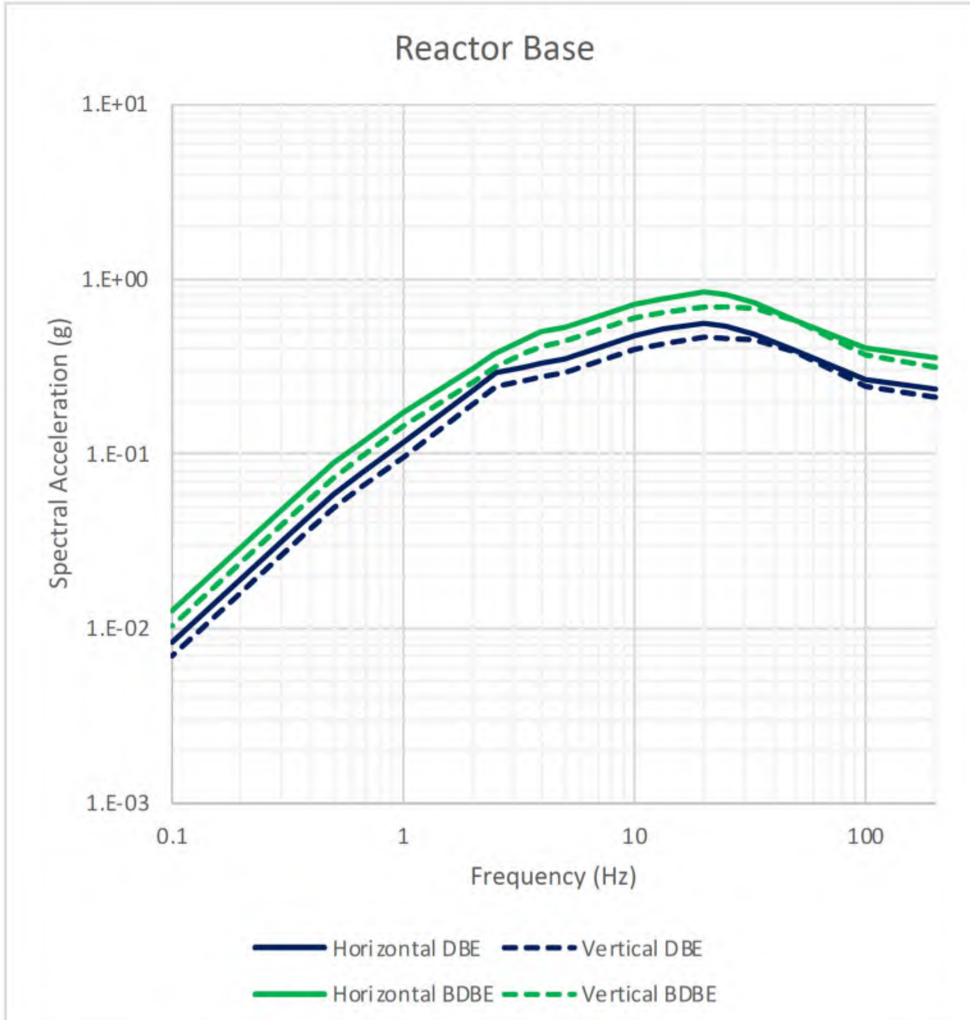


Figure 2.7.5.2.5-1: DBE and BDBE Foundation Input Response Spectra for Reactor Base (Elevation 52.93 m) (Reference 2.7-41)

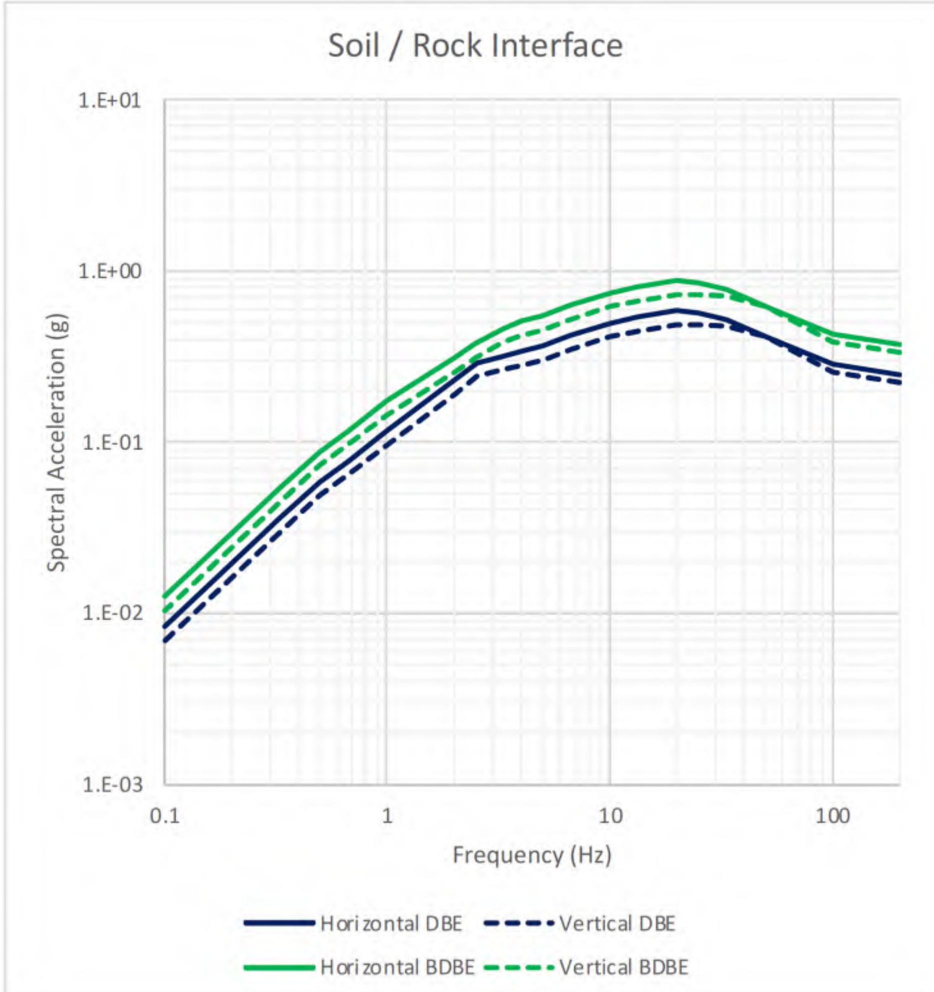


Figure 2.7.5.2.5-2: DBE and BDBE Performance Based Intermediate Response Spectra for Soil/Rock Interface (Elevation 64 m) (Reference 2.7-41)

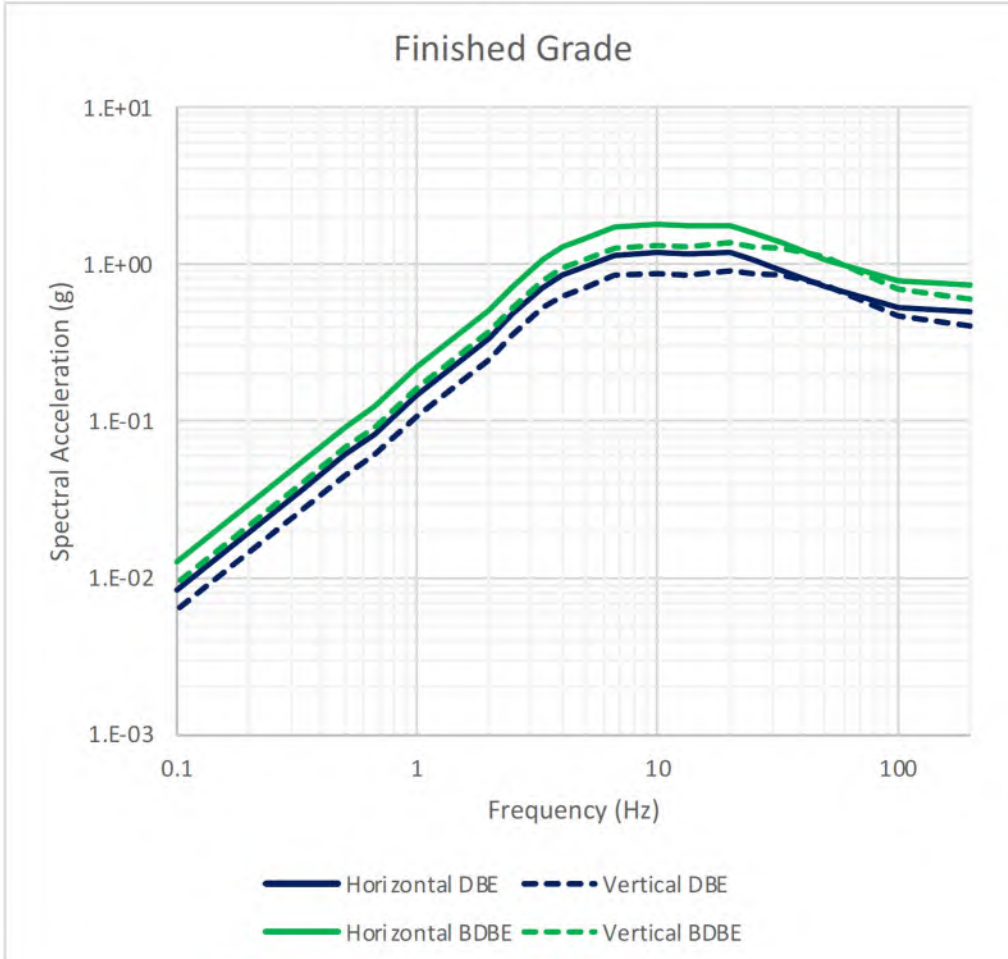


Figure 2.7.5.2.5-3: DBE and BDBE Performance Based Surface Response Spectra for Finished Grade (Elevation 88 m) (Reference 2.7-41)

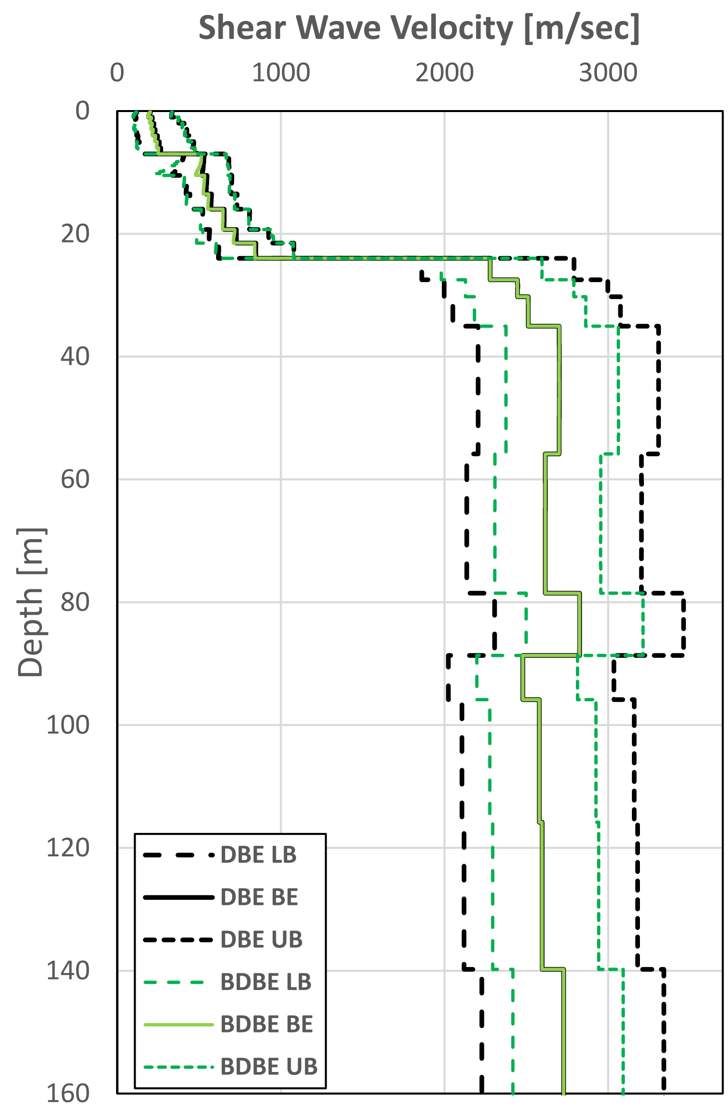


Figure 2.7.5.2.5-4: Subgrade Profiles of DBE and BDBE HCSC Shear Wave Velocities (Reference 2.7-41)

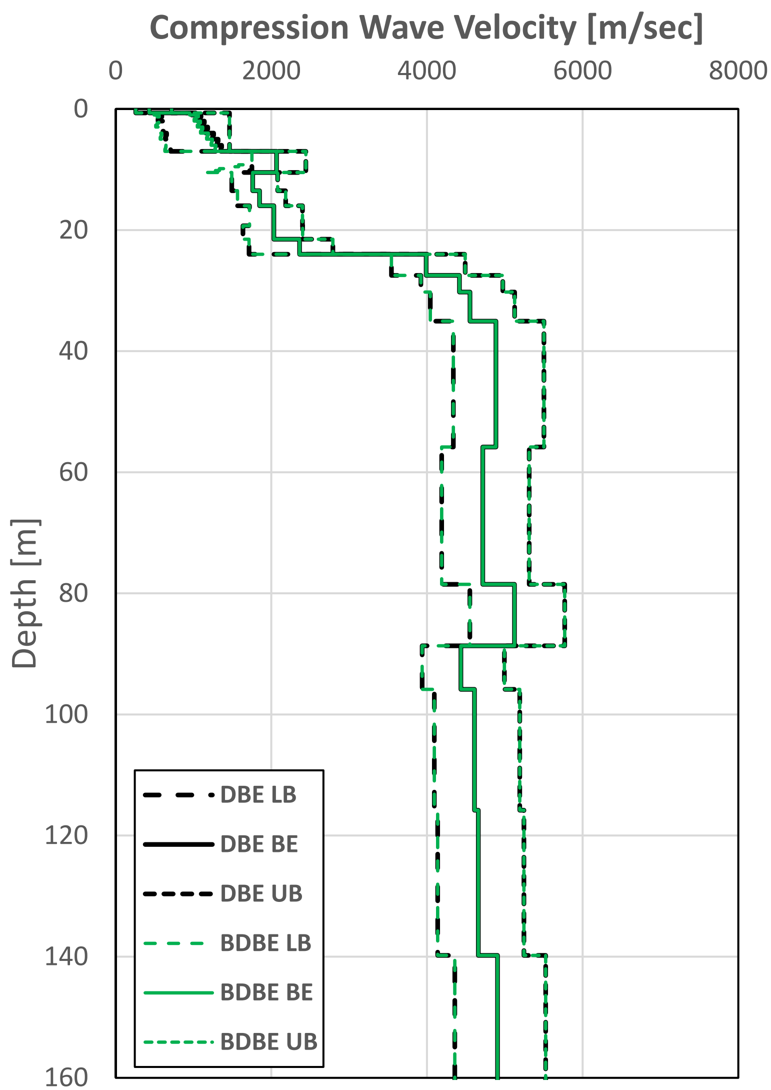


Figure 2.7.5.2.5-5: Subgrade Profiles of DBE and BDBE HCSC Compression Wave Velocities (Reference 2.7-41)

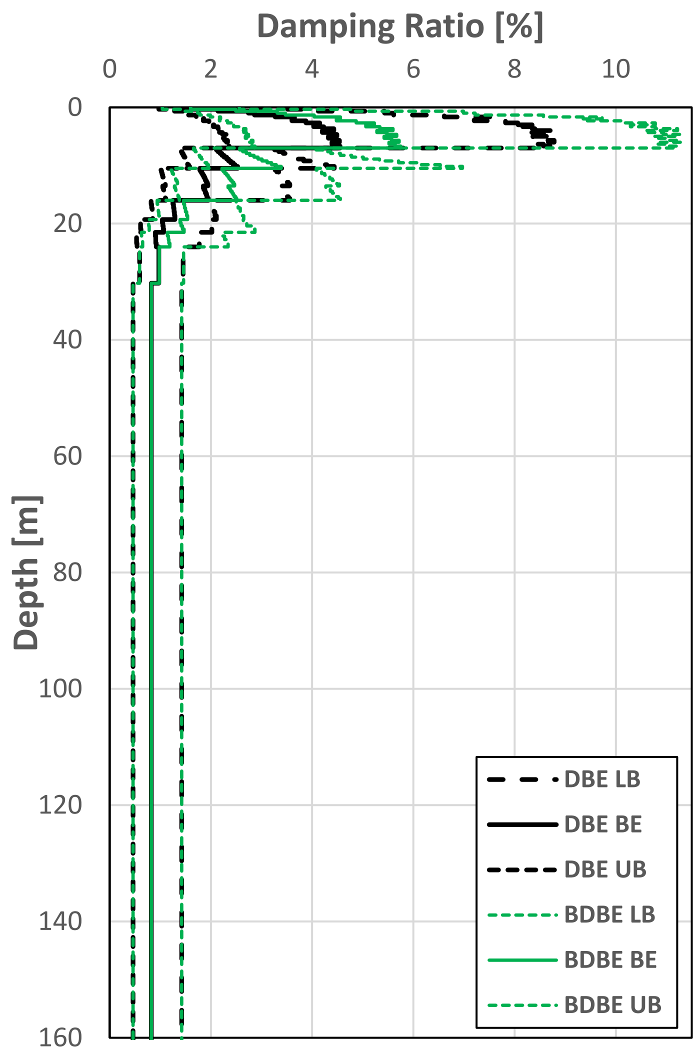


Figure 2.7.5.2.5-6: Subgrade Profiles of DBE and BDBE HCSC Damping Ratios (Reference 2.7-41)

2.8 Site Characteristics Impact on Dispersion of Radioactive Material

The dispersion of radioactive material in water, air, and soil is affected by natural and physical characteristics of the site and the surrounding environment, including meteorology and climate, hydrological and hydrogeological parameters, as well as land cover and use (e.g., vegetation and structures). Population and receptors also influence the potential effects of dispersion of radioactive material. The baseline conditions for these characteristics are established in the:

1. Darlington New Nuclear Project (DNNP) Environmental Impact Statement (EIS), completed in 2009 in NK054-REP-07730-00029 (Reference 2.8-1)
2. Updates to the baseline conditions since the EA was conducted, as discussed in detail in documentation including the 2020 Environmental Risk Assessment (ERA) for the Darlington Nuclear Site, D-REP-07701-00001 (Reference 2.8-2)
3. Yearly Environmental Monitoring Program (EMP) reports, per N-REP-03443-10027 (Reference 2.8-3)
4. DNNP – Site Preparation Licence Renewal Activity Report – Environment, completed in 2020 in NK054-REP-01210-00110 (Reference 2.8-4)
5. Darlington New Nuclear Project Supporting Environment Studies – Environment, completed in 2020, NK054-REP-01210-0001 (Reference 2.8-5)
6. Darlington New Nuclear Project Environmental Impact Statement (EIS) Review Report For Small Modular Reactor BWRX-300, completed in October 2022, per NK054-REP-07730-00055 (Reference 2.8-10)

The 2020 DNNP Site Preparation Licence Renewal Activity Report NK054-REP-01210-00110 (Reference 2.8-4) concluded the baseline conditions have not changed since the DNNP EA that was conducted in 2009 NK054-REP-07730-00029 (Reference 2.8.1) – a conclusion that is confirmed in the 2022 EIS Review Report NK054-REP-07730-00055 (Reference 2.8-10).

The impact of baseline characteristics of the DNNP site and surrounding environment on dispersion of radioactive material are summarized as follows:

- Impact of meteorology and climate, including Temperature Normals, Precipitation Normals, and Wind Speed and Direction – Subsection 2.8.1
- Impact of hydrology and hydrogeology – Subsection 2.8.2
- Impact of land cover and use – Subsection 2.8.3
- Impact of population, including numbers, locations, ages, and critical groups – Subsection 2.8.4
- Impact of accident scenarios and dispersion models – Subsection 2.8.5
- Impact of biological data – Subsection 2.8.6

Table 2.8-1 lists key characteristics and parameters within the Survey Areas of 10 km and 30 km of the Darlington Nuclear site that encompasses both the Darlington Nuclear Generating Station (DNGS) and DNNP sites.

Table 2.8-1: DNNP and Darlington Nuclear Sites Characteristics and Parameters

Characteristic	Value/Description		
2.8.1 Meteorology and Climate			
2.8.1 Climate	Humid with four distinct seasons, uniform precipitation year-round, delayed spring and autumn, moderate temperatures in winter and summer		
2.8.1.1 Temperature Normals	Local Oshawa/Bowmanville Meteorological Stations) Mean Highest	July 4-y monthly average	21.5 °C
	Local (Oshawa/Bowmanville Meteorological Stations) Mean Lowest	January 4-y monthly average	-4.1 °C
	Regional (Toronto Meteorological Station) Mean Highest	July 4-y monthly average	21.5 °C
	Regional (Toronto Meteorological Station) Mean Lowest	January 4-y monthly average	-4.1 °C
	Mean Daily Maximum	August 2016	23.0 °C
	Mean Daily Minimum	January 2019	-6.4 °C
2.8.1.2 Precipitation Normals	Average annual	866 mm (of which <11% snowfall)	
	Total monthly average	From 50.5 mm in February to 98.7 mm in September	
2.8.1.3 Wind Speed and Direction	Predominant (Average wind frequency at 10m height)	ENE (wind from WSW)	
	Average Speed	2.4 m/s (Calm winds of <2 m/s were reported 37% of time)	

Direction Wind Blowing From	Darlington Nuclear Wind Frequency (%)
N	7.22
NNE	3.09
NE	3.65
ENE	8.48
E	8.25
ESE	4.60
SE	3.43
SSE	2.25
S	2.33
SSW	2.35
SW	6.65
WSW	9.18
W	9.98
WNW	8.34
NW	9.82
NNW	10.38
Total	100

Table 2.8-1: DNNP and Darlington Nuclear Sites Characteristics and Parameters

<table>
<tr><th>Characteristic</th><th colspan="2">Value/Description</th></tr>
<tr><td colspan="3">2.8.2 Impact of Hydrology and Hydrogeology</td></tr>
<tr><td rowspan="4">2.8.2.1
Impact of Hydrology</td><td>Lake current</td><td>Easterly – near shore
Speed in all direction 9 to 18 cm/s</td></tr>
<tr><td>Lake water temperature</td><td>Surface – Freezing to 20 °C
Ambient (Winter) – 0.5 °C in January to 7.7°C in November</td></tr>
<tr><td>Surface Drainage</td><td>South of railway – slopes toward Lake Ontario
Northeast of railway – slopes toward the east</td></tr>
<tr><td>Stormwater</td><td>Collected in natural channels or swales and constructed outfalls and conveyed to the lake; or ponds</td></tr>
<tr><td rowspan="3">2.8.2.2
Existing Hydrogeological Conditions</td><td>Groundwater aquifers</td><td>South of railway – north to south
Northeast of railway – toward the east
Flows are impacted by subsurface structures of BWRX-300 facility.</td></tr>
<tr><td>Urban areas water supply</td><td>Municipal water supply for Lake Ontario</td></tr>
<tr><td>Rural areas water supply</td><td>Surface water intake (lakes) or ground water wells</td></tr>
<tr><td colspan="3">2.8.3 Impact of Land Cover and Use</td></tr>
<tr><td>Terrain Type – Water</td><td colspan="2">Lake Ontario – South of the site from the E to the WSW sectors</td></tr>
<tr><td>Terrain Type – Ploughed land</td><td colspan="2">Within 3 km – Open grassland, farmland, residential homes, parking lots, and industrial land with low-elevation or low-density buildings to the north of the site from the W to the ENE sectors</td></tr>
<tr><td>Cities</td><td colspan="2">All are farther than 3 km: W and WNW – Oshawa, Whitby, NW – Courtice, and NE – Bowmanville</td></tr>
<tr><td>Rural Areas</td><td colspan="2">With tall trees, North of the site – NW to NNE, and ENE sectors</td></tr>
<tr><td>Ecological Features</td><td colspan="2">Meadow (24%), thicket (14%), woodland (5%), and swamp (5%)</td></tr>
<tr><td rowspan="4">Vegetation communities</td><td>Bluff communities</td><td>West and east – cover <1% of the Darlington Nuclear site, shrubs with 10% tree cover</td></tr>
<tr><td>Beach communities</td><td>Cover <1% of the Darlington Nuclear site, exposed to the lake with patchy vegetation cover</td></tr>
<tr><td>Forested areas</td><td>Cover about 3% of the Darlington Nuclear site, with 60% tree cover with variable substrate types and conditions</td></tr>
<tr><td>Cultural communities (resulting from cultural or anthropogenic disturbances)</td><td>Cover much of the site, include meadows (24%), thickets (14%), woodlands (5%)</td></tr>
</table>

Table 2.8-1: DNNP and Darlington Nuclear Sites Characteristics and Parameters

Characteristic	Value/Description	
	March areas and swamps	3.7% and 5.4%, respectively of the Darlington Nuclear site
Land use in Durham Region and Clarington Municipality	Variety of landscape and lakeshore communities of small rural towns, as well as villages, hamlets, and farm holdings in the northern portion	
	Residential, industrial, and commercial areas	Generally located in Courtice (6.4 km NW of the site), and Bowmanville (4 km NE of the site)
	Agriculture	Predominant land use in Clarington
2.8.4 Impact of Population (Based on Site-specific Survey (2018) and Pathway Analyses (2016))		
Numbers (2016 census)	Within 30 km	- Approximately 500,000 within 30 km radius (88% WSW to NNW, 12% E to NE, and 0.0% [Lake Ontario] SW to E of the site) - 90% of population reside in urban areas
	Within 10 km	Approximately 100,000 residents
	0 to 2.0 km	Only 20 residents
By age (2016 census)	Durham Region	Children (aged under 15) (18%), Young persons (aged 15-29) (19%), Adults (aged 30-64) (49%), Older adults (aged 65+) (14)
By Gender (2018 survey)	Ontario	Largest age group is 20 to 24 for males; 55 to 59 for females
	Durham Region	Largest age group is 50 to 59 for males; 50 to 54 for females
Public Dose Assessment	Critical Groups (site-specific surveys) (NOTE: Annual site-specific survey reports dose for the top three critical groups, as well as specifically for the dairy farm potential critical group)	1. Rural Residents 2. Oshawa/Courtice Residents 3. Bowmanville Residents 4. Local Farms 5. Local Dairy Farms 6. West-East Beach Residents 7. Darlington Provincial Park Campers 8. Sport Fisher 9. Industrial/Commercial Workers
	Site-specific survey (2018) and pathway analyses (2016)	Done about every 5 years Within each critical group, 3 age classes are used – 0-5 years (Infant), 5 to 15 years (child), 16 to 70 years (adult) Group and age classes with highest dose are reported as the site dose for the given year
2.8.5 Impact of Accident Scenarios and Dispersion Models		

Table 2.8-1: DNNP and Darlington Nuclear Sites Characteristics and Parameters

Characteristic	Value/Description
Refer to Chapter 15, Section 15.5.for DBAs and DECs with and without core melt; as well as events related to irradiated fuel pool and fuel handling	
2.8.6 Impact of Biological Data The baseline terrestrial flora, fauna, and food chain data as well as baseline aquatic biota and food chain data were updated in 2020 in NK054-CORR-00531-10533 (Reference 2.8-9) and did not change the conclusion of the 2009 EIS of NK054-REP-07730-00029 (Reference 2.8.1) as evidenced in the 2022 EIS documented in NK054-REP-07730-00055 (Reference 2.8-10)	

2.8.1 Impact of Meteorology and Climate

Meteorological characteristics are relevant to the dispersion of material in water, air, and soil as they directly impact the characteristics of the plume, including distance, direction, deposition, and ground concentrations. Relevant meteorological characteristics include temperature, precipitation as well as wind speed and direction.

The Darlington Nuclear site is in Southern Ontario on the north shore of Lake Ontario (refer to Subsection 2.1.1 for additional information). The Darlington Nuclear site displays a humid continental climate with four distinct seasons. In general, Southern Ontario climate is highly modified by the influence of the Great Lakes which results in uniform precipitation amounts year-round, delayed spring and autumn, and moderated temperatures in winter and summer, as described in D-REP-07701-00001 (Reference 2.8-2).

Refer to Section 2.6 for additional DNNP site information relevant to local and regional meteorological characteristics, hazards from meteorological events, and extreme values of meteorological parameters.

2.8.1.1 Temperature Normals

The most recent Canadian Climate Normals available span the 1981-2010 period. The meteorological stations at Oshawa and Bowmanville represent the local climate conditions at the Darlington Nuclear site, while the meteorological station at Toronto’s Pearson Airport represents the regional conditions. The highest mean temperatures, both regionally and locally, occurred in July, and the lowest mean temperatures occurred in January, as shown in Table 2.8-2. Similar to the local and regional conditions, the highest (21.5 °C) and the lowest (-4.1 °C) 4-year average monthly temperatures at the Darlington Nuclear site occurred in July and January, respectively. The mean daily maximum temperature (23.0 °C) was recorded in August 2016, and the mean daily minimum temperature (-6.4 °C) was recorded in January 2019, as reported in D-REP-07701-00001 (Reference 2.8-2).

Table 2.8-2: Temperature Normals Near the Darlington Nuclear Site (Reference 2.8-2)

Month	Daily Mean (°C)				Mean Daily Maximum (°C)				Mean Daily Minimum (°C)			
	Regional Study Area	Local Study Area		Site Study Area	Regional Study Area	Local Study Area		Site Study Area	Regional Study Area	Local Study Area		Site Study Area
	TOR[1]	OSH[2]	BOW[3]	DN[4]	TOR[1]	OSH[2]	BOW[3]	DN[4]	TOR[1]	OSH[2]	BOW[3]	DN[4]
January	-5.5	-4.8	-5.6	-4.1	-1.5	-1.1	-1.4	-1.5	-9.4	-8.5	-9.9	-6.4
February	-4.5	-3.6	-4.4	-2	-0.4	0.1	0	-0.5	-8.7	-7.3	-8.8	-4.1
March	0.1	0.4	-0.2	-0.1	4.6	4.2	4.3	2	-4.5	-3.5	-4.6	-1.1
April	7.1	6.6	6.4	5.4	12.2	10.8	11.3	8.3	1.9	2.5	1.5	3.2
May	13.1	12.3	12.4	12.6	18.8	16.9	18	13.8	7.4	7.7	6.8	11.6
June	18.6	17.6	17.5	17.8	24.2	22.3	23.1	18.3	13	12.9	11.8	17.4
July	21.5	20.6	20	21.5	27.1	25.1	25.8	22.1	15.8	15.9	14.3	20.7
August	20.6	20	19.2	21.3	26	24.3	24.8	23	15.1	15.6	13.5	19.5
September	16.2	15.9	15	18	21.6	20.2	20.4	18.8	10.8	11.7	9.5	16.8
October	9.5	9.5	8.7	11.2	14.3	13.3	13.7	13.2	4.6	5.6	3.6	9.1
November	3.7	4.2	3.4	3.3	7.6	7.4	7.2	6.3	-0.2	1	-0.4	1.1
December	-2.2	-1.2	-2.2	-1.7	1.4	2.1	1.6	-0.1	-5.8	-4.4	-6	-5.2
Year	8.2	8.1	7.5	8.6	13	12.1	12.4	10.3	3.3	4.1	2.6	6.9

1. Toronto Lester B. Pearson International Airport, 1981-2010 Climate Normals
2. Oshawa Water Pollution Control Plant (WPCP), 1981-2010 Climate Normals
3. Bowmanville Mostert Station, 1981-2010 Climate Normals
4. Darlington Nuclear, 2016-2019 (2017 data from Darlington Nuclear site on-site meteorological tower, while 2016, 2018, 2019 data from Pickering Nuclear on-site meteorological tower).

2.8.1.2 Precipitation Normals

The Bowmanville climate station is the closest to the Darlington Nuclear site. The 1981-2010 climate normal precipitation data, listed in Table 2.8-3, from the Bowmanville Mostert Station are used to characterize precipitation patterns for the Darlington Nuclear site. During this period the Bowmanville station reported an average annual precipitation of approximately 866 mm; with snowfall representing less than 11% of the total precipitation measured. Total monthly precipitation averages range from approximately 50.5 mm in February to approximately 98.7 mm in September, per D-REP-07701-00001 (Reference 2.8-2).

Table 2.8-3: Precipitation at Bowmanville Mostert Station (1981-2010)

Month	Monthly Averages			Daily Extremes		
	Precipitation (mm)	Rain (mm)	Snow (cm)	Precipitation (mm)	Rain (mm)	Snow (cm)
January	63.1	32.2	31	46.2	46.2	29
February	50.5	32.8	17.7	42.2	42.2	19.4
March	55	41	14.1	47.6	47.6	20.8
April	70.6	68	2.6	43.4	43.4	10.2
May	75.9	75.9	0	36.4	36.4	0
June	83.8	83.8	0	50.6	50.6	0
July	63.2	63.2	0	51.1	51.1	0
August	78.1	78.1	0	81.2	81.2	0
September	98.7	98.7	0	84	84	0
October	70.8	70.6	0.1	48.6	48.6	12.2
November	88.6	83.1	5.6	71.4	71.4	15.5
December	68.1	46.1	22	41.1	41.1	24
Annual Total	866.4	773.5	93.1	-	-	-

2.8.1.3 Wind Speed and Direction

As discussed in the annual EMP report N-REP-03443-10027 (Reference 2.8-3), the wind speed, direction, and frequency are measured continuously at meteorological towers at the Darlington Nuclear site. As shown in Table 2.8-4 for the year 2021, the landward sector at the Darlington Nuclear site the wind predominantly blew toward was the ENE sector (wind from WSW), based on the average annual wind frequencies at a 10 m height. Over all sectors, the wind predominantly blew from the north and west sectors. The dominant wind direction was NNW (10.38% of the time), followed by W (9.98% of the time) and NW (9.82% of the time).

Table 2.8-4: Darlington Nuclear – 2021 Annual Average Wind Frequency by Direction (at 10 m height)

Direction Wind Blowing From	Darlington Nuclear Wind Frequency (%)
N	7.22
NNE	3.09
NE	3.65
ENE	8.48
E	8.25
ESE	4.60
SE	3.43
SSE	2.25
S	2.33
SSW	2.35
SW	6.65
WSW	**9.18**
W	9.98
WNW	8.34
NW	9.82
NNW	10.38
Total	100

Notes:

(1) Shaded fields indicate landward wind sectors.

(2) Bolded values indicate landward wind sectors with the highest wind frequency.

As reported in the 2020 ERA for the Darlington Nuclear site D-REP-07701-00001 (Reference 2.8-2), wind speeds were measured from 2013-2019 at the Darlington Nuclear on-site meteorological towers at a height of 10 m. The average wind speed was approximately 2.4 m/s. Calm winds of less than 2 m/s were reported approximately 37% of the time. The prevailing winds for these years were measured to be from the north-west sector – the north direction (9.6% of the time) followed by the west direction (8.9% of the time). The wind rose for the 2013-2019 data is provided in Figure 2-8 of D-REP-07701-00001 (Reference 2.8-2).

2.8.2 Impact of Hydrology and Hydrogeology

Hydrological and hydrogeological characteristics are relevant to the dispersion of material in water. These characteristics influence the flow and concentration of radioactive and conventional contaminants, as well as impact the populations that are affected. Relevant characteristics include aquifer type, groundwater flow, stormwater runoff, municipal water supply sources, lake currents and temperature, and major lake water intake and discharge structures.

Refer to Section 2.5 for further information on the implication of hydrological and hydrogeological conditions, including abnormal phenomena at the DNNP site on the design and safe operation of the BWRX-300 facility.

2.8.2.1 Impact of Hydrology

There is very little current net flow along the northern shore of Lake Ontario. However, the current in the nearshore region is overall easterly and is influenced by brief patterns of strong winds exerting stress at the water surface. Lake current speeds for all directions for the 2012-2016 period typically ranged from about 9 to 18 cm/s and were typically slower during spring and early summer, (May through June) than during late summer, fall and winter (August through April), as described in the 2020 ERA D-REP-07701-00001 (Reference 2.8-2).

Lake-wide surface temperatures typically range from freezing in the winter to approximately 20 °C in the summer. Ice formation in the winter is typically limited to the nearshore areas at the eastern end of the lake within the Kingston Basin. Average ambient water temperatures in the winter have varied from 0.5 °C in January to 7.7 °C in November. The water temperatures recorded from December 2011 to March 2012 and from December 2011 to April 2012 in the Darlington Nuclear study area had an average temperature of 3.8 °C and 4.4 °C, respectively, per the 2020 ERA D-REP-07701-00001 (Reference 2.8-2).

The intake pumphouse/forebay of the BWRX-300 facility provides the transition of water flowing from the intake tunnel up to the Circulating Water System pumps (refer to Subsection 2.5.2) via an onshore vertical shaft The intake offshore tunnel transitions into a porous veneer intake. Similarly, the submerged discharge tunnel connects to a discharge shaft that is located near the shoreline bluff, to convey returned heated water to the diffusers. Refer to Chapter 9B, Subsection 9B.3.5, for design information on the BWXR-300 pumphouse/forebay, intake and discharge shafts and tunnels, lakebed intake structure and discharge diffusers.

The surface drainage at the Darlington Nuclear site is divided by the Canadian National Railway line which runs east to west across the site (refer to Section 2.1, and Figure 2.1.1.2). The area south of the railway tracks generally slopes toward Lake Ontario while the area north of the railway tracks and east of Holt Road slopes toward the east. In the developed parts of Darlington Nuclear site including the DNGS areas, stormwater is collected in natural channels/swales and constructed outfalls and conveyed to Lake Ontario. Currently, a stormwater pond is located to the south of the Engineering Support Services Building and another pond is associated with the Darlington Waste Management Facility (DWMF). Another stormwater pond is located north of the lagoons which collect runoff from adjacent parking lots and from the railroad tracks (refer to the 2020 ERA D-REP-07701-00001 (Reference 2.8-2)). These features could change as the DNNP site is further developed, and the BWRX-300 design progresses.

To support the Site Preparation Licence renewal application in 2020, OPG obtained hydrological data, surface water data, and sediment quality data in the site, as well as in the local, and regional study areas, as provided in the 2009 DNNP EIS NK054-REP-07730-00029 (Reference 2.8-1).

The 2022 EIS in NK054-REP-07730-00055 (Reference 2.8-10) reports that the BWRX-300 deployment will have no residual adverse effects on site drainage and identified minor changes in DNNP flows and the number of days per year that an area of land is wet can be mitigated using best industry practices.

2.8.2.2 Existing Hydrogeological Conditions

The information on existing groundwater conditions discussed in the 2020 ERA D-REP-07701-00001 (Reference 2.8-2) and the 2009 DNNP Supporting Environment Studies NK054-REP-01210-0001 (Reference 2.8-5) is detailed in Subsection 2.5.5.

Inside the protected area at DNGS, groundwater flow is further influenced by anthropogenic subsurface features such as foundations, drain systems and sumps, and the vacuum building.

For the protected area at the DNNP, the Power Block footprint is smaller than the DNGS footprint. Also, the Reactor Building (RB) is embedded in the soil and extends to bedrock, impacting connection between groundwater flows at the north and south of the structure, per the 2020 ERA D-REP-07701-00001 (Reference 2.8-2). Such anthropogenic DNNP structures would influence the hydrostratigraphic layers and the neighboring groundwater flows. (Refer to Chapter 1, Subsection 1.5.2, and Table 1.5.2 for dimensions of the RB and other buildings in the Power Block).

Recharge of precipitation is expected to be low at the Darlington Nuclear site in areas where till is encountered at surface. Within these areas most precipitation runs off to surface water ditches or yard drainage features, as described in the 2020 ERA D-REP-07701-00001 (Reference 2.8-2). (Refer to Subsection 2.5.3 for additional information on potential sources of flooding).

Since the Site Preparation Licence renewal application in 2020 included in NK054-CORR-00531-10533 (Reference 2.8-9), OPG examined groundwater flow characteristics at the Darlington Nuclear site as part of annual groundwater monitoring (refer to Subsection 2.5.5.3). Furthermore, additional geotechnical investigations are completed for the DNNP's onshore Power Block area, with the results documented in the 2022 NK054-REP-10180-00001 DNNP Geotechnical and Seismic Hazard Investigation Plan – Phase 1 (Reference 2.8-11).

Groundwater on the Darlington Nuclear site is not used as drinking water and is not considered to be potable.

Annual groundwater quality monitoring (described in Subsection 2.5.5.3) is carried out across the site study area. Recent monitoring results, such as the levels of tritium, Volatile Organic Components, Benzene, Toluene, Ethylbenzene and Xylene, Petroleum Hydrocarbons, sodium, chloride, and metals in groundwater, are used to establish the groundwater quality baseline. Based on the annual groundwater monitoring results for the period of 2019 to 2021, groundwater quality remains consistent with that documented in the licence to prepare site application, per the 2020 Site Preparation Licence Renewal Activity Report NK054-REP-01210-00110 (Reference 2.8-4). The tritium concentrations at the sampled perimeter groundwater locations remained low in 2021. This is aligned with a trend observed indicating the tritium levels over time have remained nearly steady or decreased, which indicates stable or improved environmental performance. The groundwater quality results were compared to the Ministry of Environment, Conservation and Parks' Provincial Water Quality Objectives, based on the assumption that groundwater pumped during construction or in the long term will be discharged to the natural environment. Some groundwater samples exhibited elevated concentrations of total metals, dissolved metals, phenols, and toluene above the selected Provincial Water Quality Objectives. Several samples exhibited pH outside the acceptable Provincial Water Quality Objectives range of 6.5 to 8.5. However, given that the water is not used for drinking and is not considered potable, the conclusions of the original Site Evaluation, reported in the 2020 renewal of licence to prepare site application NK054-REP-01210-00110 (Reference 2.8-4), are valid.

Urban areas such as Bowmanville to the east and Courtice to the west of the Darlington Nuclear site rely on municipal water supply from a Lake-Ontario-based source. The more rural areas of Durham are supplied by individual water supply systems from either surface water intakes (lakes) or ground water wells. There are rural and farm residents in rural areas in all landward wind sectors around the site at distances of about 2 km to 5 km. Residents in these areas obtain at least a portion of their water supply from wells, and use it for drinking, bathing, and irrigation. However, there are no potable groundwater supply wells within or downgradient of potential source areas on-site. As water on the Darlington Nuclear site is not used for human consumption, the only on-site pathway for human exposure to groundwater would be from ingestion of water from Lake Ontario after dilution of the groundwater in the lake. Off-site drinking water wells are influenced by atmospheric tritium, but this makes a negligible contribution to dose. Concentrations of potential chemical stressors in off-site drinking water wells are not influenced by the Darlington Nuclear site, refer to the 2020 ERA D-REP-07701-00001 (Reference 2.8-2).

2.8.3 Impact of Land Cover and Use

Land cover and use characteristics are relevant to the dispersion of material in water, air and soil as these characteristics define the terrain cover and impact deposition. Relevant characteristics include terrain type, vegetation type, vegetation height, building height, and locations.

The terrain cover surrounding the Darlington Nuclear site is broadly characterized for air dispersion modelling (refer to Subsection 2.8-5) in the Derived Release Limits and Environmental Action Levels for DNGS NK38-REP-03482-10001 (Reference 2.8-6). The major terrain types are as follows:

- Water: Lake Ontario to the south of the site from the E to the WSW sectors
- Ploughed Land: At the site boundary to a distance of 3 km, open grassland, farmland, residential homes, parking lots, and industrial land with low-elevation or low-density buildings to the north of the site from the W to the ENE sectors

At distances further than 3 km from the site boundary, inspection of aerial photographs shows cities with larger buildings, including Oshawa and Whitby to the W and WNW of the site, and Bowmanville to the NE of the site. Rural areas with tall trees, including Ganaraska Forest, are located north of the site from the NW to the NNE sectors and ENE sectors.

The dominant ecological feature of the Darlington Nuclear site is meadow (24%), followed by thicket (14%), woodland (5%), and swamp (5%). In general, the Darlington Nuclear site has four main areas, per NK054-REP-01210-0001 (Reference 2.8-5):

1. In the northwest there are sports fields, a large settling pond (Coot's Pond), and Bobolink Hill comprised of cultural meadow and cultural thicket
2. In the northeast there are agricultural fields, cultural thicket, and deciduous forest as well as three constructed wetland ponds (Treefrog, Dragonfly and Polliwog ponds)
3. In the southeast there are mostly cultural meadows
4. In the south centre and southeast is the DNGS

There are various terrain types and vegetation communities on or immediately surrounding the Darlington Nuclear site, including bluffs, beach, forest, cultural woodland, cultural meadow, cultural thickets, marshland, swamp, and urban areas. The dominant vegetation cover surrounding the Darlington Nuclear site relates to agricultural use, including row crops and pastureland, as detailed in D-REP-07701-00001 (Reference 2.8-2).

Bluff communities are present west and east of the Darlington Nuclear site and cover a very small portion (<1%) of the Darlington Nuclear site. Bluff communities are characterized by variable vegetation cover that can range from patchy and barren to herbaceous cover. Generally, bluffs have no more than 10% tree cover because of erosion which results in steep, sometimes near vertical faces that are more than 2 meters in height. The bluff community on the west side of the Darlington Nuclear site is dominated by shrubs, mostly willows with Red-Osier Dogwood and Nannyberry. The bluff community on the east side of the Darlington Nuclear site is characterized by open or sparsely vegetated land due to ongoing erosional disturbance. The most abundant vegetation on these bluffs is Colt's Foot, refer to D-REP-07701-00001 (Reference 2.8-2).

The beach community covers a very small fraction (<1%) of the Darlington Nuclear site and much of the area is relatively exposed to the lake. The beach community is characterized by patchy vegetation cover that varies from sparse cover to areas with treed cover equal to or less than 60%, as described in D-REP-07701-00001 (Reference 2.8-2).

Forested areas cover about 0.16 km^2 (about 3%) at the Darlington Nuclear site. The forest community is characterized by a high level of tree cover (more than 60%) as well as variable substrate types and conditions and is classified as a coniferous, deciduous, or mixed forest type, as detailed in D-REP-07701-00001 (Reference 2.8-2).

Much of the Darlington Nuclear site vegetation communities are characterized as cultural communities such as cultural meadows, thickets, and woodlands (including plantations) that generally resulted from or are maintained by cultural or anthropogenic disturbances. Cultural woodlands, meadows, and thickets arise following anthropogenic disturbance. Cultural woodlands cover approximately 5% of the Darlington Nuclear site. They are characterized by a relatively open canopy (less than 60% cover). Cultural meadows cover approximately 24% of the Darlington Nuclear site. There are many types of cultural thickets that cover approximately 14% of the Darlington Nuclear site. They are formed during early successional stages following anthropogenic disturbance. Shrubs generally comprise the bulk of the vegetation cover and include a high proportion of non-native species, refer to D-REP-07701-00001 (Reference 2.8-2) for additional information.

Marsh areas cover over approximately 0.2 km^2 on the Darlington Nuclear site, or 3.7% of the total area. Swamp areas are the most dominant of the Wetland Community Classes at the Darlington Nuclear site, covering approximately 0.25 km^2, or 5.4% of the total Darlington Nuclear site. Swamps are characterized by the presence of wetland trees and shrubs and a low proportion of tree and shrub cover, as reported in D-REP-07701-00001 (Reference 2.8-2).

Durham Region is characterized by a variety of landscapes and communities including major lakeshore urban communities in the southern portion, and small rural towns, villages, hamlets and farm holdings in the northern portion of the region. Urban land uses are generally parallel the shoreline of Lake Ontario in the communities of Pickering, Ajax, Whitby, Oshawa and Clarington, while rural land uses are found in the communities of Brock, Scugog and Uxbridge in the northern portion of the region, all are described in D-REP-07701-00001 (Reference 2.8-2).

Urban land uses in the Municipality of Clarington, including residential, commercial, and industrial, are generally located in Courtice, located approximately 6.4 km northwest of the Darlington Nuclear site, and Bowmanville, located approximately 4 km northeast of the site. Agriculture is a predominant land use in the Municipality of Clarington and is less predominant in the City of Oshawa west of the site, per D-REP-07701-00001 (Reference 2.8-2). (Refer to Subsection 2.1.1 for recent and forecast land use data for the Municipality of Clarington and the City of Oshawa.)

2.8.4 Impact of Population

Population characteristics are relevant to the determination of the potential effects of the dispersion of material in water, air, and soil as the dispersion of radioactive and conventional contaminants affects the population surrounding the Darling Nuclear site. Relevant characteristics include population numbers, locations, ages, and critical groups.

The census data for the region used in the most recent Review of the Darlington Nuclear Site-Specific Survey, reported in NK38-REP-03443-10004 (Reference 2.8-7), are for 2016.

A population of approximately 500,000 resides within a 30 km radius of the Darlington Nuclear site, based on 2016 census data shown in Table 2.8-5. The bulk of this population (approximately 88% or 478,634 individuals) resides west of the Darlington Nuclear site, in the west-south-west to north-north-west sectors, while approximately 12% (64,575 individuals) reside east of the Darlington Nuclear site in the north to east north-east sectors. Areas south and east of the Darlington Nuclear site (south-west to east) are occupied by Lake Ontario. Only 20 residents reside within a 0 to 2 km radius of the centre of Darlington Nuclear site and approximately 99,953 individuals reside within 10 km of the Darlington Nuclear site, as documented in D-REP-07701-00001 (Reference 2.8-2).

The majority of residents in the Durham Region live in urban areas. Over 90% of the population in Pickering, Ajax, Oshawa, and Whitby resides in urban areas, whereas, the townships of Brock, Scugog and Uxbridge represent the greatest percentage of the rural population in Durham. Urban/rural population trends for Durham indicate this trend will continue into 2031, per D-REP-07701-00001 (Reference 2.8-2).

Children under the age of 15 comprised 18.0% of Durham's population in 2016, while young persons (aged 15-29), adults (aged 30-64) and older adults (aged 65+) comprised 19.2%, 49.4% and 14.4%, respectively. Ontario Population Estimates for 2018 indicate the 20 to 24 age group is the largest age group for males and 55 to 59 for females in Ontario, while in Durham Region the largest age group was 50 to 59 for males and 50 to 54 for females, refer to D-REP-07701-00001 (Reference 2.8-2).

In public dose assessments, "critical groups" are used to estimate the mean realistic impacts of emissions on the most affected individuals. The site-specific surveys identify the potential critical groups for Darlington Nuclear site. Approximately every five years the site-specific surveys and pathway analyses are reviewed to ensure the public dose accurately represents the public living near Darlington Nuclear site. Site-specific surveys were most recently reviewed in 2018 and pathway analyses were last updated in 2016. The EMP design reviews were conducted in 2018, and minor changes are implemented in 2019 which primarily affect which potential critical groups are used for reporting purposes, as documented in N-REP-03443-10027 (Reference 2.8-3).

An individual with the average characteristics of the critical group is known as the "Representative Person" as described in CSA N288.1-14 (Reference 2.8-8). Dose estimates are calculated for a number of potential critical groups for Darlington Nuclear site, and for three age classes within each potential critical group. The three age classes are 0-5 years (infant), 6-15 years (child), and 16-70 years (adult). The dose estimates to these three age groups are sufficient to characterize doses to the public. For practical implementation in dose calculations, the dose coefficients, and characteristics for a one-year-old infant, a 10-year-old child, and an adult are used to represent the three age classes. The group and age class with the highest dose is reported as the site public dose for the given in year, as described in N-REP-03443-10027 (Reference 2.8-3). (Refer to Subsection 2.9.1.2 for information on radiological dose to the public).

Nine potential critical groups are identified for the Darlington Nuclear site. The list of potential critical groups around Darlington Nuclear site includes the following, per NK38-REP-03443-10004 (Reference 2.8-7):

1. Rural Residents
2. Oshawa/Courtice Residents
3. Bowmanville Residents
4. Local Farms
5. Local Dairy Farms
6. West-East Beach Residents
7. Darlington Provincial Park Campers
8. Sport Fisher
9. Industrial/Commercial Workers

The annual public dose is calculated for specific three potential critical groups only, which have yielded the highest dose estimates in recent years. These are the Farms, the West/East Beach Residents, and the Rural Residents, as described in N-REP-03443-10027 (Reference 2.8-3). Additionally, the annual public dose is also calculated for the local dairy farm potential critical group as the dairy farm group is exposed to the most media types and pathways.

Table 2.8-5: Population Distribution Surrounding Darlington Nuclear Site Based on 2016 Census Data (Reference 2.8-2)

Direction	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
0-2 km	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
2-4 km	10	3,516	0	0	0	0	0	0	0	0	0	0	0	10	69	50	3,655
4-6 km	1,612	6,803	5,037	315	0	0	0	0	0	0	0	0	0	1,611	1,646	589	17,613
6-8 km	569	14,691	5,809	314	0	0	0	0	0	0	0	0	5	13,936	10,172	247	45,743
8-10 km	751	1,507	196	1,217	0	0	0	0	0	0	0	0	7,389	15,749	5,729	384	32,922
10-12 km	897	221	462	5,004	0	0	0	0	0	0	0	0	15,568	29,781	7,768	251	59,952
12-14 km	390	129	398	3,375	0	0	0	0	0	0	0	0	7,115	27,662	15,599	412	55,080
14-16 km	436	734	943	875	0	0	0	0	0	0	0	0	9,013	21,052	7,294	214	40,561
16-22 km	850	873	691	1,287	0	0	0	0	0	0	0	732	50,773	60,986	4,655	1,394	122,241
22-30 km	1,224	1,562	981	876	0	0	0	0	0	0	0	7,998	141,667	6,853	2,705	1,556	165,422
Total	6,759	30,036	14,517	13,263	0	0	0	0	0	0	0	8,730	231,530	177,640	55,637	5,097	543,209

2.8.5 Impact of Accident Scenarios and Dispersion Models

Accident scenarios and associated dispersion models are described in Chapter 15, Section 15.5, for Design Basis Accidents (DBAs), Design Extension Conditions (DECs) with and without core melt, as well as for irradiated fuel pool and fuel handling events for BWRX-300 site-specific application.

2.8.6 Impact of Biological Data

The biological characteristics of the site were documented in the 2009 DNNP EIS, NK054-REP-07730-00029 (Reference 2.8-1), to support the original application of the Site Preparation Licence. The report includes both baseline of terrestrial flora, fauna and food chain data, as well as baseline aquatic biota and habitat, and food chain data. The biological characterization underwent a baseline update for the 2020 Site Preparation Licence renewal, which is provided in NK054-CORR-00531-10533 (Reference 2.8-9). The 2020 updated baseline conditions will not change the conclusion with respect to residual adverse effects of the on the environment nor the conclusions of the original Site Evaluation. The same conclusion is confirmed the recent 2022 EIS documented in NK054-REP-07730-00055 (Reference 2.8-10).

2.8.7 References

2.8-1 NK054-REP-07730-00029 R000, 2009, "Environmental Impact Statement New Nuclear – Darlington Environmental Assessment," Ontario Power Generation.

2.8-2 D-REP-07701-00001 R001, 2020 "Environmental Risk Assessment for the Darlington Nuclear Site," Ontario Power Generation.

2.8-3 N-REP-03443-10027 R000, "Results of Environmental Monitoring Programs," Ontario Power Generation.

2.8-4 NK054-REP-01210-00110 R001, 2020, "DNNP – Site Preparation Licence Renewal Activity Report – Environment," Ontario Power Generation.

2.8-5 NK054-REP-01210-0001 R000, 2020, "Darlington New Nuclear Project Supporting Environment Studies – Environment," Ontario Power Generation.

2.8-6 NK38-REP-03482-10001 R002, "Derived Release Limits and Environmental Action Levels for Darlington Nuclear Generating Station," Ontario Power Generation.

2.8-7 NK38-REP-03443-10004 R001, 2021, "Review of the Darlington Nuclear Site-Specific Survey," Ontario Power Generation.

2.8-8 CSA N288.1-14, "Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities," CSA Group.

2.8-9 NK054-CORR-00531-10533, 2020, "Application for Renewal of OPG's Darlington New Nuclear Project (DNNP) Nuclear Power Reactor Site Preparation License (PRSL)," Ontario Power Generation.

2.8-10 NK054-REP-07730-00055 R000, 2022, "Darlington New Nuclear Project Environmental Impact Statement Review Report For Small Modular Reactor BWRX-300," Ontario Power Generation.

2.8-11 NK054-REP-10180-00001 R000, (GOLDER 2022), "Phase I Geotechnical Investigation (Power Block) Darlington New Nuclear Project", Volume 2 of 2 "Geotechnical Interpretation of Design Parameters," Ontario Power Generation.

2.9 Radiological Conditions Due to External Sources

Section 2.9 details information on:

- Radiological Conditions in the Environment – Subsection 2.9.1, including
  - Radiological Baseline Conditions – Subsection 2.9.1.1
  - Radiological Dose to Public Due to Activities on DNGS Site – Subsection 2.9.1.2
- Radiation Monitoring Systems – Subsection 2.9.2, including
  - Environmental Monitoring Program – Subsection 2.9.2.1
  - TLD Monitoring – Subsection 2.9.2.2
  - Gamma Monitoring – Subsection 2.9.2.3
  - Effluent Monitoring – Subsection 2.9.2.4

Table 2.9-1 lists key characteristics and parameters for the radiological conditions due to sources external to the DNNP site.

Table 2.9-1: DNNP Site Radiological Conditions in 2021

Characteristic	Value/Description		
2.9.1 Radiological Conditions in the Environment			
Sources of Baseline radiation and Radioactivity		• Natural background • Nuclear testing, nuclear facilities • DNGS, Tritium Removal Facility, DWMF	
Radiological Emissions		Small fraction of the Derived Release Limit (DRL) • 2016 to 2019 <0.01 – 0.41% of the DRLs • In 2021 <0.01 – 0.53% of the DRLs	
2.9.1.1 Radiological Baseline Conditions			
NOTE: The unit Bq/kg-C means becquerels per each kilogram of Carbon			
Air Samples – Concentrations	tritium	Range: 0.2 to 1.8 Bq/m^3	Average: 0.87 Bq/m^3
	C-14	Range: 206 to 248 Bq/kg-C	Average: 230 Bq/kg-C
	Ar-41, Xe-133, Xe-135, and Ir-192	Estimated to be below detection	
Terrestrial Samples – Concentration	Average tritium	In fruits In vegetables In milk In animal feed	17.8 Bq/L 17.5 Bq/L 4.3 Bq/L 8.6 Bq/L
	Average C-14	In fruits In vegetables In milk In animal feed	230 Bq/kg-C 248 Bq/kg-C 229 Bq/kg-C 236 Bq/kg-C
	Soil Sampling in 2017 (every 5 years)	• Cs-137, background values (from 1.7 to 9.0 Bq/kg) are present as results of historic weapon testing and around DNGS (5.1 to 7.2 Bq/kg)	

Table 2.9-1: DNNP Site Radiological Conditions in 2021

Characteristic	Value/Description	
		• Co-60 and Cs-134, due to emission from DNGS and other nuclear sites, neither detected.
Aquatic Samples – Concentration	tritium	• All nearby water Supply plants – Average is below provincial standard of 7,000 Bq/L • Bowmanville, Newcastle, and Oshawa water supply plants, range from 4.6 to 6.6 Bq/L • Well Water – Average 12.0 Bq/L • Lake Water – Average 9.6 Bq/L • Fish – Average <3.4 Bq/L
	C-14	• Fish – Average 243 Bq/kg-C
	C-137	• Fish – Average 0.2 Bq/kg • Sand Beach – (< 0.1) to 0.2 Bq/kg
	Co-60 and Cs-124	• Fish – Not detected • Sand Beach – Not detected
	Gross beta activities	All nearby water Supply plants – Average 1 Bq/L, which is below Health Canada Guideline for drinking water
NOTES: 1. In 2021 ground water monitoring program, tritium concentrations at the sampled Darlington Nuclear site perimeter groundwater locations remained low. 2. In general, tritium trends over time show levels have remained nearly steady or decreased, indicating stable or improved environmental performance 3. Where unexpected tritium concentrations are identified, investigations are completed to determine the root cause and to implement corrective measures. 4. Ongoing results confirm that tritium in groundwater is mainly localized within the station protected area and the site perimeter tritium concentrations remain low		
2.9.1.2 Radiological Dose to the Public		
Public dose for the Darlington Nuclear site was 0.6 μSv/year (represented by the adult farm resident critical group); which is • <0.1% of the regulatory limit of 1,000 μSv/year for a member of the public • <0.1% of the background radiation around Darlington Nuclear site		
2.9.2 Radiation Monitoring Systems		
2.9.2.1 Environmental Monitoring Program		
2.9.2.1.1 Atmospheric Sampling	tritium	Active samplers at six site boundary locations. Samples are collected and analysed monthly
	C-14	Monitored at four boundary locations and analysed each quarter
	Noble gases	8 detectors that monitor gamma radiation dose rate continuously

Table 2.9-1: DNNP Site Radiological Conditions in 2021

Characteristic	Value/Description	
2.9.2.1.2 Aquatic Sampling	Drinking water	Samples taken every 8-12-hour shift. Weakly composites are analysed weekly for tritium and monthly for gross beta activates
	Well water	Collected from four wells and analysed monthly for tritium
	Lake water	Sampled from two beaches and analysed monthly for tritium
	Fish	At DNGS – Muscle-tissue eight replicated target fish species are collected for tritium, C-14, Co-60, Cs-134, Cs-137, and Potassium-40 (K-40) measurements
	Sand	Samples collected from three beaches and analysed annually using gamma spectrometry to detect Cs-137
	Groundwater	81 monitoring locations are sampled each year for tritium.
2.9.2.1.3 Terrestrial Sampling (tested for tritium and C-14)	Fruits and Vegetables	Sampled three times from each of five locations representing the growing season
	Milk	Samples collected monthly from three dairy farms around the site
	Animal feed	Samples collected form four dairy farms with two replicates per visit. Dry feed and wet feed are collected separately
	Eggs	Sampled quarterly with three samples replicated per visit. Poultry samples collected annually with eight samples replicated per visit
2.9.2.2 Thermoluminescent Dosimeter (TLD) Monitoring		
Located around the site and off-site. TLD cards are analysed annually when they are changed. They are located around the DWMF fence line		
2.9.2.3 Gamma Monitoring System		
The automated fixed monitors provide real-time gamma dose rate measurements		
2.9.2.4 Effluent Monitoring Program		
Establishes surveillance and monitoring of effluents, refer to Chapter 20, Subsection 20.11.3.		

2.9.1 Radiological Conditions in the Environment

To characterize the potential effects of the BWRX-300 operation on the surrounding environment, the baseline conditions must first be identified, described and delineated. Baseline radiation and radioactivity in the area of the DNNP site includes:

- Natural background
- Background from anthropogenic sources (fallout from nuclear testing and releases from other nuclear sites)
- Releases from activities on the Darlington Nuclear site, including operation of the existing DNGS, Tritium Removal Facility, and DWMF

Radiological emissions from the Darlington Nuclear site, including the DWMF, represented a small fraction of the DRLs. The four-year period 2016 – 2019 emissions ranged from 0.01 to

0.41% of the DRLs, as reported in the 2020 ERA for the Darlington Nuclear site D-REP-07701-00001 (Reference 2.9-1). The 2021 emissions were from 0.01 to 0.53% of the DRLs, as noted in the annual report on the results of the EMP N-REP-03443-10027 (Reference 2.9-2).

The radiological baseline conditions were established in the 2009 DNNP Environmental Impact Statement (EIS) – DNNP Environmental Assessment (EA) NK054-REP-07730-00029 (Reference 2.9-3). Updates to the radiological baseline conditions since the 2009 EIS-EA was conducted are discussed in detail in documentation including:

- The annual EMP report N-REP-03443-10027 (Reference 2.9-2)
- The 2020 ERA for the Darlington Nuclear site D-REP-07701-00001 (Reference 2.9-1)
- The 2020 DNNP – Site Preparation Licence Renewal Activity Report – Environment NK054-REP-01210-00110 (Reference 2.9-4)
- The 2020 DNNP Supporting Environment Studies – Environment NK054-REP-01210-0001 (Reference 2.9-5)
- The 2022 DNNP EIS NK054-REP-07730-00055 (Reference 2.9-16)

The 2020 Site Preparation Licence Renewal Activity Report NK054-REP-01210-00110 (Reference 2.9-4) concludes the radiological baseline conditions have not changed since the 2009 EIS-EA, per NK054-REP-07730-00029 (Reference 2.9-3). The same conclusion is reached in the 2022 DNNP EIS NK054-REP-07730-00055 (Reference 2.9-16). Details of these conditions are summarized in the following Subsections 2.9.1.1 and 2.9.1.2.

2.9.1.1 Radiological Baseline Conditions

The radiological baseline conditions in the area surrounding the Darlington Nuclear site are discussed in detail in the annual EMP report N-REP-03443-10027 (Reference 2.9-2), which demonstrates that all levels of radionuclides monitored around the Darlington Nuclear site remained stable since 2009 NK054-REP-07730-00029 (Reference 2.9-3). A Mann-Kendall trend analysis at the 95% confidence level did not indicate any statistically significant trends over the past 10 years for tritium in any medium sampled. For C-14, a Mann-Kendall trend analysis at the 95% confidence level over the past 10 years of data either indicated a statistically significant downward trend (C-14 in air at the Darlington Nuclear site boundary, C-14 in milk at dairy farms) or did not indicate any statistically significant trends (C-14 in fruit and vegetables, and C-14 in fish). A similar analysis was not conducted for noble gas parameters, as measurements taken at the Darlington Nuclear site boundary had average dose rates that were typically below detection limits.

Summaries are presented in the following paragraphs of the results of the annual results of the EMP report N-REP-03443-10027 (Reference 2.9-2), where sampling locations are available – as shown Figure 2.9-1.

Air Samples

Samples of air are collected to monitor the environment around the Darlington Nuclear site.

1. The 2021 tritium in air annual average concentrations measured at Darlington Nuclear site boundary locations ranged from 0.2 to 1.8 Bq/m^3, with an average concentration of 0.87 Bq/m^3. The 2021 annual average C-14 in air concentrations measured at Darlington Nuclear site boundary locations ranged from 206 to 248 Bq/kg-C, with an average concentration of 230 Bq/kg-C.

2. The annual boundary average noble gas dose rate is estimated from the monthly data from each detector. The Darlington Nuclear site boundary average dose rates for Ar-41, Xe-133, Xe-135, and Ir-192 are typically below the detection limits.

Terrestrial Samples

Terrestrial baseline sampling is done in fruits and vegetables, milk, animal feed, eggs and poultry, and soil around the Darlington Nuclear site.

Fruits and Vegetables

Fruits and vegetables, the 2021 average concentration for tritium near the Darlington Nuclear site was 17.8 Bq/L in fruits and 17.5 Bq/L in vegetables. The 2021 average concentration of C-14 was 230 Bq/kg-C in fruits and 248 Bq/kg-C in vegetables. A Mann-Kendall trend analysis of average fruit and vegetable activity at the 95% confidence level did not indicate any statistically significant trend over the past 10 years for tritiated water tritium and C-14.

Milk

The 2021 average concentration of tritium was 4.3 Bq/L based on three dairy farms around the Darlington Nuclear site. The 2021 average concentration of C-14 in milk from dairy farm locations in the vicinity of the Darlington Nuclear site was 229 Bq/kg-C. A Mann-Kendall trend analysis of average milk activity at the 95% confidence level did not indicate any statistically significant trend over the past 10 years for tritium and C-14.

Animal Feed

The average tritium concentration was 8.6 Bq/L for wet feed (forage). No dry feed samples were available in 2021. The average C-14 concentration in animal feed was 236 Bq/kg-C for wet feed (forage). No trend analysis was performed on animal feed since, beginning in 2013, wet feed and dry feed have been sampled separately, resulting in changes to sampling frequency and replicates.

Eggs and Poultry

The concentration of tritium in eggs was 4.4 Bq/L and tritium in poultry was 10.3 Bq/L. Concentration of C-14 in eggs was 230 Bq/kg-C and in poultry was 229 Bq/kg-C. No trend analysis was performed as less than 10 years of data have been collected from sampling locations thus far.

Soil

Soil is sampled every five years to identify possible radionuclide accumulation over time. The last soil sampling took place in 2017. Background values of Cs-137 are present in the soil as a result of historic weapons testing fallout. Co-60 and Cs-134, if detected, would be a result of emissions from the DNGS or other nuclear stations. In 2017, Cs-137 concentrations in background soil samples taken at provincial background locations ranged from 1.7 to 9.0 Bq/kg. All measured Cs-137 concentrations at locations around the Darlington Nuclear site in 2017 were within the range of values seen at the background locations, ranging from 5.1 to 7.2 Bq/kg. There is no indication of a buildup of activity in soil. Neither Cs-134 nor Co-60 were detected in any soil samples in 2017. Therefore, the Cs-137 measured in these soil samples is from historic weapons testing fallout and not from OPG Operations, as documented in the annual EMP report N-REP-03443-10017 (Reference 2.9-6).

Aquatic Samples

Aquatic baseline sampling is done at nearby water supply plants, in well water, lake water, fish, and beach sand. As a result of the location of the Darlington Nuclear site, there are no depositional sediment locations near enough that are appropriate for sampling due to the high wave energy environment.

Water Supply Plants

The impact of tritium emissions from OPG stations on the nearby water supply plants varies depending upon their distance from the station, lake current direction, location and depth of the water supply plant intake pipe as well as general dispersion conditions. Annual average tritium levels at all nearby water supply plants are well below the Ontario Drinking Water Quality Standard of 7,000 Bq/L. Annual average tritium concentrations measured at the Bowmanville, Newcastle, and Oshawa water supply plants in 2021 ranged from 4.6 to 6.6 Bq/L. Mann-Kendall trend analysis at the 95% confidence level does not indicate any statistically significant trend for tritium at any water supply plant near Darlington Nuclear site. Annual average gross beta activity levels at water supply plants were 0.11 Bq/L. This is well below the gross beta activity screening level of 1 Bq/L, which is a drinking water level recommended by Health Canada in the Guidelines for Canadian Drinking Water Quality: Guideline Technical Document.

Well Water

The 2021 annual average tritium concentration observed in well water samples collected from the Darlington Nuclear site area was 12.0 Bq/L. Based on the past 10 years of data, a Mann-Kendall trend analysis at the 95% confidence level does not indicate any statistically significant trend for tritium in well water.

Lake Water

The 2021 annual average tritium concentration observed in lake water samples collected from two beaches near the Darlington Nuclear site was 9.6 Bq/L. Based on the past 10 years of data, a Mann-Kendall trend analysis at the 95% confidence level indicates no statistically significant trend for Darlington Nuclear site tritium in lake water.

Fish

The 2021 tritium levels in the Darlington Nuclear site diffuser fish samples averaged <3.4 Bq/L, while the annual average C-14 level in same samples was 243 Bq/kg-C. Based on the past 10 years of data, a Mann-Kendall trend analysis at the 95% confidence level does not indicate any statistically significant trend for tritium or C-14 in Darlington Nuclear site fish. Cs-134 and Co-60, which are indicative of reactor operation, were not detected in any fish samples at Darlington Nuclear site in 2021. This is similar to past years. The average Cs-137 value for fish was 0.2 Bq/kg. The presence of Cs-137 in fish is primarily due to nuclear weapons testing and not reactor operation.

Beach Sand

The average concentration of Cs-137 measured at beaches near the Darlington Nuclear site ranged from below detection (< 0.1) to 0.2 Bq/kg in 2021. Similar to previous years, there was no Co-60 or Cs-134 detected in any of the samples.

Groundwater

In 2021, Darlington Nuclear site completed its annual groundwater monitoring program to evaluate groundwater quality and flow across the site and to detect any emergent issues. Tritium concentrations at the sampled perimeter groundwater locations remained low. In general, tritium trends over time show that levels have remained nearly steady or decreased, indicating stable or improved environmental performance. There have been isolated cases within the DNGS protected area where tritium concentrations have shown increases, as reported in REP-07701-00001 (Reference 2.9-1). Where unexpected tritium concentrations are identified, investigations are completed to determine the root cause and to implement corrective measures. Ongoing results confirm that tritium in groundwater is mainly localized within the station protected area and the site perimeter tritium concentrations remain low.

2.9.1.2 Radiological Dose to the Public Due to Activities on DNGS Site

The radiological public dose resulting from the operation of existing facilities on the Darlington Nuclear site is calculated annually and the results are published and made available to the public in the annual report summarizing the results of the EMP, per N-REP-03443-10027 (Reference 2.9-2). The dose calculations consider all significant pathways of exposure. Such calculations use the environmental pathway and dosimetric models and parameters that are provided in CSA N288.1-14 (Reference 2.9-7). The data used in the calculations consist of measurements of radionuclides released from the facility in environmental media obtained from the results of the yearly EMP report and consider background contributions where such data are available. For pathways or radionuclides where measured environmental data are not available, the dose is modelled from measured radionuclide emissions data reported in N-REP-03443-10027 (Reference 2.9-2).

Site public dose remains a small fraction of both the annual regulatory dose limit and annual natural background radiation in the area. The results of the annual EMP report N-REP-03443-10027 (Reference 2.9-2) conclude that the 2021 public dose for the Darlington Nuclear site was 0.6 μSv/year (represented by the adult farm resident critical group). The Darlington Nuclear site dose is <0.1% of the regulatory limit of 1,000 μSv/year for a member of the public, and <0.1% of the background radiation around Darlington Nuclear site. As can be seen in the 2016-2021 EMP reports, the 2016 to 2021 public dose estimates for the critical groups are at most approximately 0.08% of the regulatory public dose limit of 1,000 μSv/year, and at most approximately 0.06% of the dose from background radiation (1.4 mSv/year) in the vicinity of Darlington Nuclear site.

The public dose is also reported in the Darlington Nuclear site ERA, which is routinely updated in accordance with REGDOC-3.1.1 (Reference 2.9-8). A CSA N288.6-12 (Reference 2.9-9) compliant ERA was produced for the Darlington Nuclear site in 2020 D-REP-07701-00001 (Reference 2.9-1) and included a human health risk assessment and ecological risk assessment for both radiological and non-radiological parameters and physical stressors. The ERA concluded that the Darlington Nuclear site is operating in a manner that is protective of human and ecological receptors residing in the surrounding area. No discernable health effects are anticipated due to the exposure of potential critical groups to the radiological effluent from the Darlington Nuclear site. Demonstration that the critical groups are protected implies that other receptor groups near the Darlington Nuclear site are also protected.

2.9.2 Radiation Monitoring Systems

OPG's radiation monitoring systems, which are currently used for DNGS, comprise on-site, site boundary, and off-site monitoring systems. Detailed information about environmental sampling locations, sampling frequency, the number of samples taken, the media sampled, the sampling method, and the radionuclides monitored can be found in CSA N288.4 on Environmental Monitoring Programs at Nuclear Facilities and Uranium Mines and Mills (Reference 2.9-10). Summaries of four specific aspects of the radiation monitoring systems are presented as follow:

1. Environmental monitoring systems, including the environmental off-site and site boundary monitoring as well as samples taking and analysis – Subsection 2.9.2.1
2. The off-site and site boundary TLD sites – Subsection 2.9.2.2
3. The Automated Near Boundary Gamma Monitoring System, located around the Darlington Nuclear site boundary – Subsection 2.9.2.3
4. The site Effluent Monitoring Program – Subsection 2.9.2.4

2.9.2.1 Environmental Monitoring Program

The environmental monitoring systems and sampling programs detailed in the annual EMP report N-REP-03443-10027 (Reference 2.9-2) include off-site and site boundary monitoring and are summarized here. Samples taken are analysed at certified laboratories or laboratories with documented comprehensive quality assurance and quality control programs, in accordance with clause 8.3.2 of CSA N288.4 (Reference 2.9-10). The Canadian Association for Laboratory Accreditation certified OPG Health Physics Laboratory, and external contractors, perform the sample collection and analysis for Darlington Nuclear site and provincial EMPs, as per N-PROC-OP-0025 R012 (Reference 2.9-11). Sampling locations are shown in Figure C1 in Appendix C of N-REP-03443-10027 (Reference 2.9-2), which is replicated in Figure 2.9-1.

2.9.2.1.1 Atmospheric Sampling

Concentrations in air are sampled to monitor the environment around the Darlington Nuclear site. Tritium, C-14, and noble gases are measured and reported in N-REP-03443-10027 (Reference 2.9-2).

1. The active tritium in air sampler collects water vapor by passing air continuously at a steady rate through two molecular sieve canisters in series. The active samplers are located at six site boundary EMP monitoring locations around the Darlington Nuclear site. These samples are collected and analysed monthly.
2. C-14 in air is sampled using passive sampling technology. The passive C-14 sampler works by absorption of CO_2 in air into soda lime pellets exposed for a period of an annual quarter. Samples are analysed after each quarter. C-14 in air is monitored at four boundary locations for the Darlington Nuclear site.
3. External gamma radiation doses from noble gases and Ir-192 are measured using sodium iodide (NaI) spectrometers set up around the Darlington Nuclear site. There are a total of eight detectors around the Darlington Nuclear site that monitor the dose rate continuously.

2.9.2.1.2 Aquatic Sampling

Samples of drinking water sources (municipal and well water), lake water, beach sand and fish are collected to monitor the aquatic environment around the Darlington Nuclear site. Tritium, gross beta, C-14, and gamma activity are measured and reported in N-REP-03443-10027 (Reference 2.9-2).

1. Samples of drinking water are taken during each 8-12-hour shift at water supply plants that supply water to Durham Region the Bowmanville water supply plant, the Newcastle water supply plant, and the Oshawa water supply plant. Weekly composites of these samples are analysed for tritium, and monthly composites are analysed for gross beta activity.
2. Monthly well water samples are collected from four wells around the Darlington Nuclear site area. Samples are analysed monthly for tritium.

3. Lake water for recreational use is sampled from two beaches in the vicinity of the Darlington Nuclear site on a monthly basis and analysed for tritium. It is used to assess the water immersion dose exposure pathway from swimming in lake water.
4. At the Darlington Nuclear site, fish sampling takes place over the cooling water discharge diffuser. The target fish species to be collected at Darlington Nuclear site and at background locations is White Sucker, with Brown Bullhead as the backup species. Eight replicate fish samples are collected and analysed at each location. A sample consists of the fish muscle tissue only, and excludes the head, skin, fins, and as many bones as possible. Tritium, C-14, Co-60, Cs-134, Cs-137, and Potassium-40 (K-40) measurements are performed on each fish sample.
5. Sand from three beaches around the Darlington Nuclear site is collected annually to represent a potential pathway for external dose. Eight replicates are collected per sampling location. Gamma spectrometry is performed on these samples. Beach sand samples were collected at a background location to determine the Cs-137 concentrations in sand due to atmospheric weapons test fallout.
6. Groundwater monitoring occurs of each year, with 81 groundwater monitoring locations at Darlington Nuclear site sampled in 2021 for tritium, the key parameter of concern, refer to NK38-REP-10140-10031 (Reference 2.9-12). Annual water level measurements are also conducted.

2.9.2.1.3 Terrestrial Sampling

Samples of soil, fruits, vegetables, animal feed, milk, eggs, and poultry are collected to support the public dose calculation for the Darlington Nuclear site. Terrestrial biotas receive exposure from both airborne and waterborne emissions. Tritium and C-14 are measured, per N-REP-03443-10027 (Reference 2.9-2).

1. Fruits and vegetables are sampled three times from each location for a representation of the entire growing season. Each sample is analysed for C-14 and tritium. A total of five locations for fruit and vegetable were sampled around the Darlington Nuclear site.
2. Milk sampling is used to estimate the portion of dose received from milk ingestion for the dairy farm potential critical group. Milk samples are collected on a monthly basis from dairy farms around the Darlington Nuclear site and analysed for tritium and C-14. Samples are collected from three dairy farms around the Darlington Nuclear site.
3. Locally grown animal feed is collected from four dairy farms around the Darlington Nuclear site, twice a year, with two replicates collected per visit. Since 2013, dry feed (grains, hay, etc.) and wet feed (forage) are collected separately. Animal feed is analysed for tritium and C-14.
4. Eggs are sampled on a quarterly basis and three sample replicates are collected per visit. Poultry is collected annually with eight sample replicates collected per visit. Both eggs and poultry are analysed for tritium and C-14. One farm location around the Darlington Nuclear site is sampled for eggs.

2.9.2.2 Thermoluminescent Dosimeter Monitoring

TLDs are located around the Darlington Nuclear site perimeter as well as at off-site locations. The TLDs contain field cards that passively monitor the airborne dose over the course of a year. Cards are read and analysed annually when they are changed. The net readings for the four elements from the field card readings are input to an algorithm that converts the readings into air kerma (short for Kinetic Energy Released per unit mass of Air, which is a measure of energy in joules (J) deposited in a unit mass (kg) of air; thus, in J/kg), ambient dose equivalent and directional dose equivalent, as described in N-PROG-RA-0001 (Reference 2.9-13).

Also, TLDs are located around the DWMF fence line. The DWMF perimeter dose rates are measured and reported quarterly.

2.9.2.3 Gamma Monitoring System

The Automated Near Boundary Gamma Monitoring System, located around the Darlington Nuclear site boundary, is a fixed radiological detection and monitoring system designed to provide real-time gamma dose rate measurements, as reported in N-PROG-RA-0001 (Reference 2.9-13). Refer to Chapter 19, Section 19.3 for additional relevant information.

2.9.2.4 Effluent Monitoring Program

The Darlington Nuclear Site Effluent Monitoring Program is governed by OPG's N-STD-OP-0031 Monitoring of Nuclear and Hazardous Substances in Effluents (Reference 2.9-14). This standard establishes minimum requirements to establish an appropriate surveillance and monitoring program for nuclear and hazardous substances in airborne and waterborne effluents from operating OPG Nuclear facilities, including the DNGS, in accordance with CSA N288.5-11 (Reference 2.9-15). The effluent monitoring program is further discussed in Chapter 20, Subsection 20.11.3.

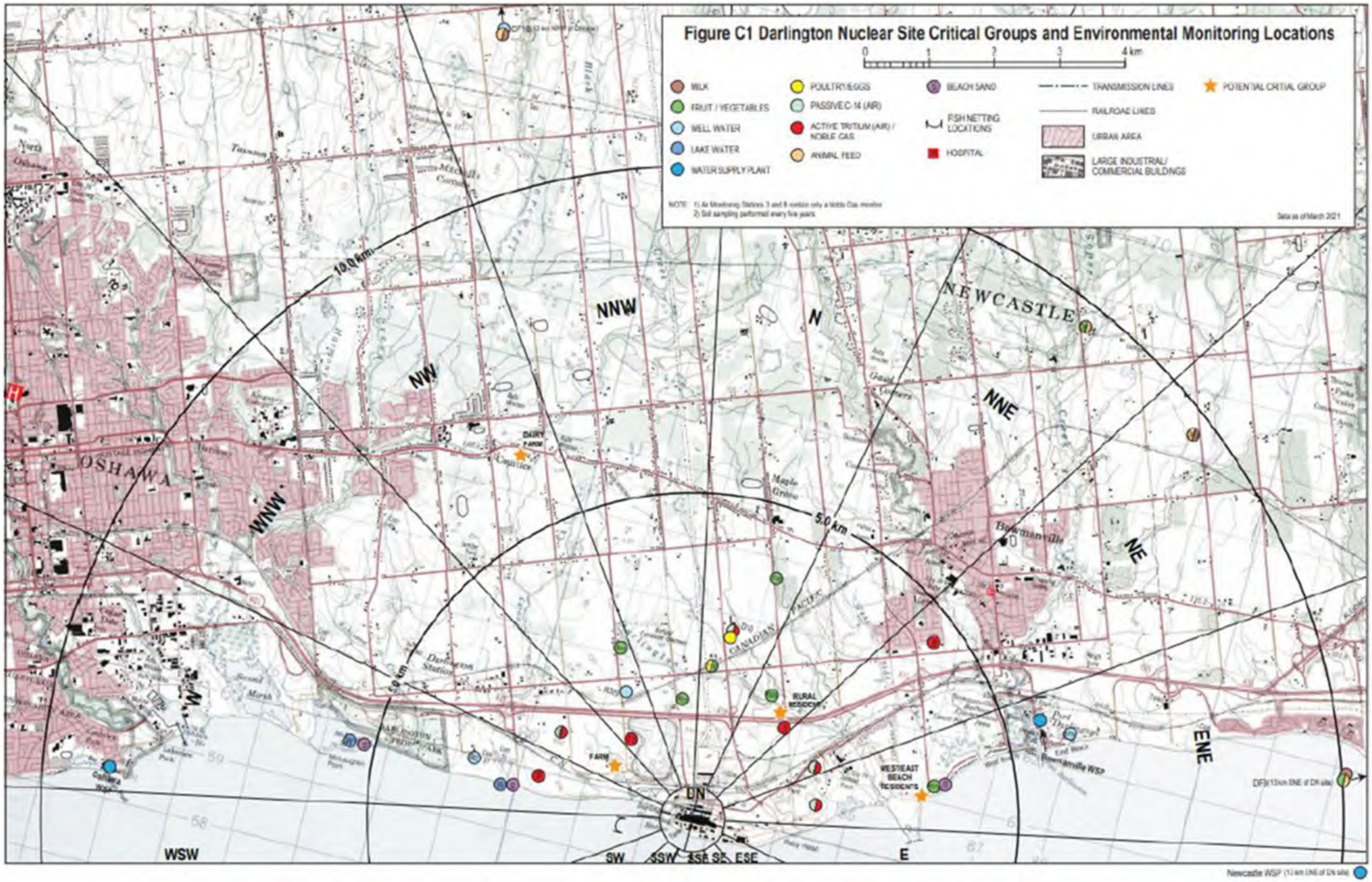


Figure 2.9-1: Darlington Nuclear Site Critical Groups and Environmental Monitoring Locations (Reference 2.9-2)

2.9.3 References

2.9-1 D-REP-07701-00001 R001, 2020, "Environmental Risk Assessment for the Darlington Nuclear Site," Ontario Power Generation.

2.9-2 N-REP-03443-10027 R000, "Results of Environmental Monitoring Programs," Ontario Power Generation.

2.9-3 NK054-REP-07730-00029 R000, 2009, "Environmental Impact Statement New Nuclear – Darlington Environmental Assessment," Ontario Power Generation.

2.9-4 NK054-REP-01210-00110 R001, 2020, "DNNP – Site Preparation Licence Renewal Activity Report – Environment," Ontario Power Generation.

2.9-5 NK054-REP-01210-0001 R000, 2020, "Darlington New Nuclear Project Supporting Environment Studies – Environment," Ontario Power Generation.

2.9-6 N-REP-03443-10017 R000, "Results of Environmental Monitoring Programs," Ontario Power Generation.

2.9-7 CSA N288.1-14 "Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities," CSA Group.

2.9-8 CNSC Regulatory Document REGDOC-3.1.1, "Reporting Requirements for Nuclear Power Plants."

2.9-9 CSA N288.6-12, "Environmental Risk Assessments At Class I Nuclear Facilities And Uranium Mines And Mills," CSA Group.

2.9-10 CSA N288.4, "Environmental Monitoring Programs At Nuclear Facilities And Uranium Mines And Mills," CSA Group.

2.9-11 N-PROC-OP-0025 R012, "Management of the Environmental Monitoring Programs," Ontario Power Generation.

2.9-12 NK38-REP-10140-10031 R001, 2021, "Darlington Nuclear Groundwater Monitoring Program Results," Ontario Power Generation.

2.9-13 N-PROG-RA-0001 R019, "Consolidated Nuclear Emergency Plan," Ontario Power Generation.

2.9-14 N-STD-OP-0031 R009, "Monitoring of Nuclear and Hazardous Substances in Effluents," Ontario Power Generation.

2.9-15 CSA N288.5-11, "Effluent Monitoring Programs At Class I Nuclear Facilities And Uranium Mines And Mills," CSA Group.

2.9-16 NK054-REP-07730-00055 R000 2022, "Darlington New Nuclear Project Environmental Impact Statement Review Report For Small Modular Reactor BWRX-300," Ontario Power Generation.

2.10 Site-Related Issues in Emergency Preparedness and Response and Accident Management

The information presented in Section 2.10 includes:

- General Consideration – Subsection 2.10.1
- Feasibility of Emergency Preparedness and Response – Subsection 2.10.2
- Evacuation Time Estimates and Route – Subsection 2.10.3
- Support Networks in the Vicinity of the Site – Subsection 2.10.4
- Administrative Measures with External Organizations – Subsection 2.10.5

In Table 2.10-1, a summary description is included of site-related emergency preparedness and response feasibility, relevant evacuation time estimates; supporting agencies and services; communication systems; provincial and on-site plans; and other nuclear organization.

Table 2.10-1: Summary of DNNP Site Relevant Characteristics and Parameters

Characteristic	Value/Description		
2.10.2 Feasibility of Emergency Preparedness and Response			
Accessibility	• Studies considered number of personnel on site, regional population change, infrastructure updates, geography, and weather patterns. • Main entrance: Holt Road South via Energy Drive, or Highway 401, or Park Road via Highway 401 to Energy Road.		
DNNP Traffic Management Plan	Developed to guide site transportation demands during various phases of project, including construction		
BWRX-300 Design	• Incorporates reliable and passive safety functions with redundancy and diversity that satisfy safety goal requirements • Informed by DSA and Probabilistic Safety Assessment (PSA) results to develop optimized accident management strategies and measures.		
2.10.3 Evacuation Time Estimates and Route			
Estimates	• Provides off-site emergency planners with projections on how long it may take for various emergency planning sectors and the Detailed Planning Zone (DPZ) to evacuate. • Considered various scenarios as time of day, day of week, road restrictions, special event assemblies and weather conditions.		
Routes	• On-site process and travel route for site evacuations are documented in site-specific instructions, including DNNP site during various phases of the project. • Measures to evacuate publicly accessible areas on the Darlington Nuclear site.		
Infrastructure	Impacted local businesses and transportation networks		
2.10.4 Support Networks in the Vicinity of the Site			
Agencies, Businesses, Services, Plans	• Ambulances and Hospital • Municipal services • Potassium Iodide Program	• Police force • Alerting systems • PNERP • Consolidated Nuclear Emergency Plan (CNEP)	• On-site and off-site communication systems • Information to media

Table 2.10-1: Summary of DNNP Site Relevant Characteristics and Parameters

Characteristic	Value/Description
Off-site Alerting System	Managed by Durham Region and the Province of Ontario
Designated and Host Municipalities	• Administered the Potassium Iodide Program • Provide centres for Emergency Workers, Evacuation, and Reception (with personnel and resources support provided form OPG)
2.10.5 Administrative Measures with External Organizations	
The Province of Ontario, Provincial Nuclear Emergency Response Plan (PNERP)	• Provides the off-site planning basis for nuclear emergencies with the goal of ensuring public safety in the event of a nuclear emergency • Establishes the principles, concepts, organization, responsibilities, policy, functions, and interrelationships which govern all off-site nuclear emergency planning, preparation, and response in Ontario
Other Nuclear Partners	• Nuclear partners in Canada are expected to respond, if necessary • CANada Deuterium Uranium (CANDU) Owners Group for support and technical assistance • Institute of Nuclear Power Operations (INPO) for necessary support from the industry

2.10.1 General Consideration

In accordance with Subsection 4.10.2 of REGDOC-1.1.2 (Reference 2.10-17), OPG, as the licensee for the BWRX-300 facility, has established an effective DNNP Nuclear Emergency Preparedness Plan NK054-PLAN-01210-00002 (Reference 2.10-1) which is governed by OPG CNEP N-PROG-RA-0001 (Reference 2.10-2). These two plans cover aspects such as:

- Feasibility of emergency preparedness and response
- Local infrastructure for evacuation adequacy
- Availability of support networks in the vicinity of the site
- Availability of transport, communication and infrastructure external to site
- Need for administrative measures
- Roles of response organization other than OPG

Elaboration on these aspects and associated detailed information are included in the following Subsections 2.10.2 to 2.10.5.

2.10.2 Feasibility of Emergency Preparedness and Response

The BWRX-300 facility accessibility for OPG personnel, contractors, and response crews, as well as for the transport of any equipment necessary in an emergency, is critical for the purposes of emergency preparedness and response at the DNNP site. Such accessibility is considered by OPG in the design of the BWRX-300 facility for the construction, commissioning, operation, and decommissioning phases. In this regard, events at both the DNNP site and the existing DNGS site are considered since an event at one site may affect personnel and the emergency response at the other site. Emergency response is, therefore, considered for the entire Darlington Nuclear site. Protocols throughout the project phases are included in the DNNP Nuclear Emergency Preparedness Plan NK054-PLAN-01210-00002 (Reference 2.10-1).

To ensure accessibility for both off-site emergency responders and on-site personnel to and from the DNNP site, OPG conducted studies that considered estimated number of all personnel in the Darlington Nuclear site, regional population changes, infrastructure updates, geography, and weather patterns. The results of these studies are formalized into plans and reports to assist with emergency planning; primarily in, DNGS Development of Evacuation Time Estimates, per NK38-REP-03490-10133 (Reference 2.10-3), Summary Report: Site Evaluation Studies for Nuclear Installations at Darlington External Human Induced Events NK054-REP-01210-00010 (Reference 2.10-4), Darlington New Nuclear Project Traffic Management Plan NK054-PLAN-08965.4-00001 (Reference 2.10-5) and Updated Traffic Management Plan NK054-REP-07730-0969014 (Reference 2.10-20). In addition, detailed analysis of the DNNP site accessibility is noted in Site Evaluation for OPG New Nuclear at Darlington – Nuclear Safety Considerations NK054-REP-01210-00008 (Reference 2.10-6).

The main entrance to the DNNP site is per the existing entrance to the entire Darlington Nuclear site via Holt Road South in Bowmanville, Ontario. Holt Road South is accessible via Energy Drive eastbound on Highway 401 and has a direct off-exit of Highway 401 westbound. An alternate access point from westbound Highway 401 to Energy Drive is Park Road. Park Road traverses the western part of the Darlington Nuclear site, crossing 2nd Line, which then connects to Holt Road. Energy Drive west of Park Road is named Megawatt Drive. Additional detailed information on transportation networks on the Darlington Nuclear site and in the surrounding area is provided in Subsection 2.1.5.

For the purpose of Subsection 2.10.2, a generic site map displaying the Darlington Nuclear site in relation to major roadways is shown in Figure 2.10.2-1, where the area allotted to DNNP is shaded in yellow east of the DNGS area, and the DNGS exclusion zone of 914 m is shown, per D-PLAN-00120-0001 (Reference 2.10-7).

The DNNP Traffic Management Plan (Reference 2.10-5) was initiated by OPG to guide, in a safe manner, site transportation demands during various phases of the BWRX-300 facility including construction. This Traffic Management Plan assesses the impact of traffic within the vicinity of the DNNP site, in the area noted in Figure 2.10.2-2.

Chapter 15, Subsection 15.6.1 states that the specific objectives of the PSA and severe accident analysis (SAA) are to demonstrate that the BWRX-300 facility is designed with features that incorporate highly reliable and available passive safety functions with significant redundancy and diversity to comply with the safety goal requirements in REGDOC-2.5.2 (Reference 2.10-9).

Further, as described in Chapter 15, Subsection 15.1.5, DECs are identified to aid in designing and implementing safety features (complementary design features) to mitigate the consequences of DECs. The Severe Accident Management (SAM) program is informed by the insights of the Deterministic Safety Analysis (DSA) and results of the PSA for the development, implementation, training and optimization of accident management strategies and measures, as identified in Chapter 15 Subsection 15.6.1.

Additionally, Chapter 13, Subsection 13.4.3 discusses the programmatic approach to develop emergency operating procedures and severe accident management guidelines (SAMG) in accordance with REGDOC-2.3.2 (Reference 2.10-21).

2.10.3 Evacuation Time Estimates and Route

OPG made available to off-site planning authorities a revised Darlington Site Evacuation Time Estimate, per NK38-REP-03490-10133 (Reference 2.10.3) using the 2016 National Census Data with per decade population projections out to 2088, as well as current and forecasted infrastructure.

The estimate provides off-site emergency planners with projections on how long it may take for current emergency planning sectors and the DPZ to evacuate if required. Variables such as time of day, day of week, road restrictions, special event assemblies and weather were assessed as to how those factors may impact the evacuation duration. In the first quarter of 2023, OPG will issue an updated Darlington Site Evacuation Time Estimate based on the 2021 national census data and will subsequently be shared with stakeholders.

On-site, the process and travel route for site evacuations are described in D-INS-0349-10030 (Reference 2.10-10). The current revision of such OPG's instructions considers the DNNP site during various phases of the project. The main exit routes are via:

1. Park Road to Energy Drive to Highway 401 westbound
2. Old Holt Road, continuing onto Holt Road northbound of Highway 401 east and westbound

During an evacuation from the Darlington Nuclear site, Energy Drive will be closed, as necessary, by local police between Park Road to Holt Road to control traffic volume and delays. Additionally, procedures exist for OPG to evacuate publicly accessible areas on the Darlington Nuclear site, per INS-03490-10015 (Reference 2.10-11), including the Darlington Waterfront Trail and the Hydro Soccer Fields (refer to Subsections 2.1.7 and 2.1.8).

Local infrastructure within the vicinity of the DNNP site is described in Section 2.3, which includes local businesses, and transportation networks that are impacted by an emergency on-site in their current and future expanded state.

2.10.4 Support Networks in the Vicinity of the Site

Collaboration of OPG with local government agencies and businesses is essential to the DNNP emergency response capabilities. Shared roads, emergency services, communication networks, and transportation networks are utilized to assist with site response, evacuation, and relocation services, as required.

During construction, prior to turnover to Operations, the fire protection controls and response are primarily the responsibility of the prime contractor or constructor, per CSA N293-12 (Reference 2.10-18). Once handover to Operations occurs, OPG's own fire protection program, with its necessary updates for the BWRX-300 facility, will be in place and be compliant with CSA N293S1:21 (Reference 2.10-19).

Arrangements also exist for local ambulance service and hospital support for casualties from the Darlington Nuclear site. Toronto Hospital Corporation, Western Division, has been provincially designated and funded as the radiation trauma centre for Ontario. This includes the capability to deal with contaminated casualties, trauma, and acute radiation syndrome. Lakeridge Health—Bowmanville Hospital is the primary local hospital designated to receive contaminated casualties from DNGS. DNNP is expected to be included in this agreement, encompassed under the Darlington Nuclear site. Agreements are also in place to provide support to the site from the local police force in the event of an on-site security event (Reference 2.10-2). Subsection 2.1.4 and Subsection 2.1.6 provide, respectively, additional details on Municipal Services local to the area as well as on public transit.

To communicate with off-site emergency responders during an event, OPG currently uses Durham NEXGEN P-25 Radio system – part of the Durham Emergency Communication. As the DNNP progresses, and prior to Operations, these systems will be assessed for future use.

As noted in Chapter 9A, Subsection 9A.9.1.3, the off-site communication system is designed to satisfy emergency plan requirements for accident conditions, including notification of personnel and implementation of evacuation procedures. This capability includes communications support to both on-site and off-site emergency response facilities; at least one on-site and one off-site communications system, each with a backup power source. The on-site communications involve immediate notification process and secondary communication methods to alert all on-site personnel in all vital areas during the full spectrum of accident or incident conditions under maximum potential noise levels. This capability also includes communications support for firefighting, including support of alternative and dedicated shutdown capabilities.

As noted in Subsection 2.10.2, the SAMG is informed by the insights of the DSA and results of the PSA for the development, implementation, training and optimization of accident management strategies and measures. This includes review of the existing Beyond Design Basis Accident telecommunications equipment designated for DNGS, which also are considered for DNNP and rely on external infrastructure to function.

Durham Region and the Province of Ontario manage alerting systems to let the public know when a nuclear emergency occurs. Durham Region's public alerting system includes loud sirens, located within the Automatic Action Zone of the Darlington Nuclear site and an automated landline telephone calling system. The automated telephone system sends a recorded message to landline phones in the DPZ area around the nuclear station. The Province of Ontario manages the Alert Ready system. These alerts broadcast through television, radio, and cellphones. The off-site public alerting systems are currently applicable to DNGS but expected to be utilized for DNNP. Prior to fuel-in commissioning, this will be identified as part of the revised PNERP (Reference 2.10-12).

The DNGS station has an established Potassium Iodide Program, which satisfies the requirements of the PNERP (Reference 2.10-12) and REGDOC-2.10.1 (Reference 2.10-13), both are encompassed by the CNEP (Reference 2.10-2). The program is supported by designated municipalities to ensure continued availability of Potassium Iodide to residents of the DPZ and Ingestion Planning Zone, and information is available to the general public, including on-line, as per N-GUID-03491-10011 (Reference 2.10-14). Similar to the public alerting systems, this program is currently applicable to DNGS, but expected to be utilized for DNNP. Prior to fuel-in commissioning, this will be identified as part of the revised PNERP.

The PNERP (reference 2.10-12) outlines the requirements for designated municipalities and host municipalities to include provisions for Emergency Worker Centres, Evacuation Centres, and Reception Centres in the unlikely event of an evacuation, as noted in D-INS-0349-10030 (Reference 2.10-10). OPG supports these Off-site Centres by providing personnel and resources for personal monitoring and decontamination. The current facilities applicable to the DNGS are listed in Appendix C3.4 of CNEP (Reference 2.10-12). It is to be determined whether such facilities are required for DNNP which, if so, will be reflected in a future revision of the PNERP. Additionally, OPG has two Mobile Monitoring and Decontamination Units that are poised and ready for deployment when designated by the Provincial Emergency Operations Centre (PEOC). OPG deploys on-site and off-site radiation survey teams to the area, if required.

The Joint (Emergency) Information Centres intending to disseminate Information to the media are also set up between OPG, the Province of Ontario, and local municipalities. Refer to the CNEP (Reference 2.10-2). OPG's Nuclear Crisis Communication Standard (Reference 2.10-15) provides corporate direction for assisting with site emergencies. This standard outlines how information is passed between the incident station, emergency response facilities, Corporate Media Desk, and the public domain.

There are no known issues at this time that would hinder the implementation of DNNP emergency response actions. OPG is currently working with the Province of Ontario to develop timelines for PNERP revisions to incorporate a separate implementing plan for the DNNP site or as part of the DNGS site implementing plan.

Descriptions of the development of the DNNP emergency response plan, and the emergency response facilities are detailed in Chapter 19, Sections 19.1 and 19.2, respectively.

2.10.5 Administrative Measures with External Organizations

In the Province of Ontario, Canada, the PNERP (Reference 2.10-12) provides the off-site planning basis for nuclear emergencies with the goal of ensuring public safety in the event of a nuclear emergency. The PNERP Master Plan (Reference 2.10.12) establishes the principles, concepts, organization, responsibilities, policy, functions, and interrelationships which govern all off-site nuclear emergency planning, preparation, and response in Ontario. Each nuclear facility identified in the PNERP has its own implementing plan which is site-specific in nature and deals with local characteristics, planning and operational particulars. OPG has a memorandum of understanding in place with the Province of Ontario to revise the PNERP prior to fuel-in commissioning to include DNNP and issue a revised Darlington implementing plan or a separate implementing plan for DNNP (Reference 2.10-1).

OPG continues to collaborate with the Province of Ontario and other external organizations responsible for off-site nuclear emergency planning to ensure the implementation of their respective emergency plans and related protective actions accommodate the lifecycle of BWRX-300 facility built on the DNNP site.

Other nuclear partners within Canada are requested to respond where necessary, for any assistance in a nuclear event at DNGS and DNNP, as per the existing mutual aid response memoranda of understanding.

OPG also has arrangements for support and technical assistance with the CANDU Owners Group members and INPO, a consortium of nuclear utilities, to obtain any necessary support available from the industry during an emergency. INPO operates a 24-hour emergency assistance line and an Emergency Response Centre in Atlanta, Georgia, USA, to provide support to member utilities.

Further information on external administrative assistance is provided in the Emergency Planning and Preparedness Technical Support Document: New Nuclear – Darlington Environmental Assessment NK054-REP-07730-00021 (Reference 2.10-8), and the DNNP Nuclear Emergency Preparedness Plan NK054-PLAN-01210-00002 (Reference 2.10-1).

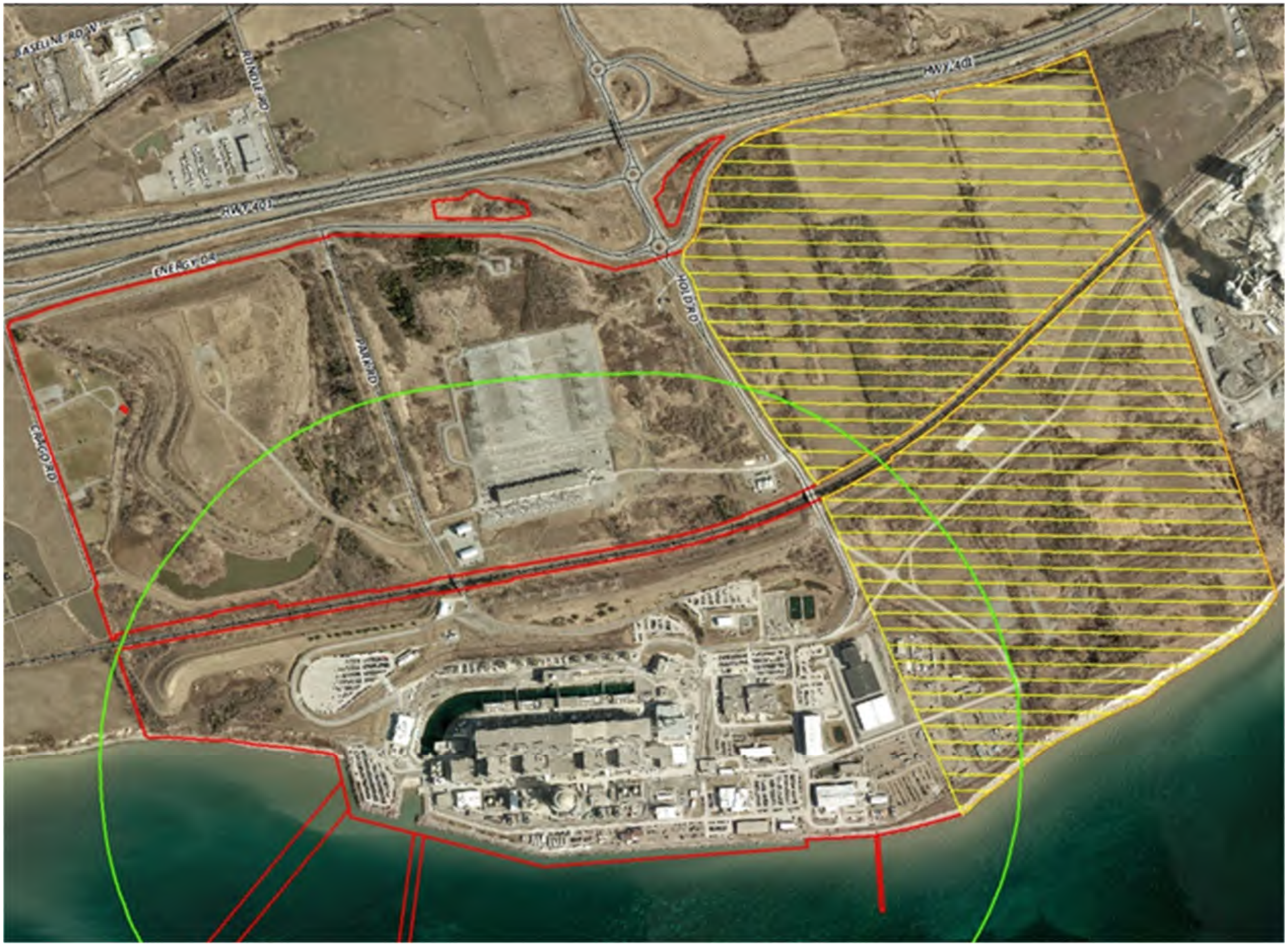


Figure 2.10.2-1: Darlington Nuclear Site Showing DNGS and DNNP Areas

Figure 2.10.2-2: Area of Consideration for Traffic Management Plan

2.10.6 References

2.10-1 NK054-PLAN-01210-00002, “DNNP Nuclear Emergency Preparedness Plan,” Ontario Power Generation.

2.10-2 N-PROG-RA-0001, “Consolidated Nuclear Emergency Plan,” Ontario Power Generation.

2.10-3 NK38-REP-03490-10133, “Darlington NGS Development of Evacuation Time Estimates,” Ontario Power Generation.

2.10-4 NK054-REP-01210-00010, “Summary Report: Site Evaluation Studies for Nuclear Installations at Darlington External Human Induced Events,” Ontario Power Generation.

2.10-5 NK054-PLAN-08965.4-00001, “Darlington New Nuclear Project Traffic Management Plan (TMP),” Ontario Power Generation.

2.10-6 NK054-REP-01210-00008, “Site Evacuation for OPG new Nuclear at Darlington – New Nuclear Safety Considerations,” Ontario Power Generation.

2.10-7 D-PLAN-00120-0001, “Darlington Nuclear Generating Station Campus Plan,” Ontario Power Generation.

2.10-8 NK054-REP-07730-00021, “Emergency Planning and Preparedness Technical Support Document: New Nuclear – Darlington Environmental Assessment,” Ontario Power Generation.

2.10-9 CNSC Regulatory Document REGDOC-2.5.2, “Design of Reactor Facilities; Nuclear Power Plants.”

2.10-10 D-INS-03490-10030, “Evacuation Relocation,” Ontario Power Generation.

2.10-11 D-INS-03490-10015, “Security First Line Manager,” Ontario Power Generation.

2.10-12 Ontario Provincial Nuclear Emergency Response Plan (PNERP) – Master Plan, 2017.

2.10-13 CNSC Regulatory Document REGDOC-2.10.1, “Nuclear Emergency Preparedness and Response.”

2.10-14 N-GUID-03491-10011, “Potassium Iodide (KI) Pill Administration Guide,” Ontario Power Generation.

2.10-15 N-STD-AS-0010, “Nuclear Crisis Communication Standard,” Ontario Power Generation.

2.10-16 OPG-PROC-0028, “Crisis Management and Communications Centre Procedure,” Ontario Power Generation.

2.10-17 CNSC Regulatory Document REGDOC-1.1.2, Licence Application Guide: Licence to Construct a Reactor Facility.”

2.10-18 CSA N293-12, “Fire Protection for Nuclear Power Plants,” CSA Group.

2.10-19 CSA N293S1:21, “Supplement No. 1 to N293-12, Fire protection for nuclear power plants (application to small modular reactors),” CSA Group.

2.10-20 NK054-REP-07730-0969014, “Updated Darlington New Nuclear Project Traffic Management Plan (TMP),” Ontario Power Generation.

2.10-21 CNSC Regulatory Document REGDOC-2.3.2, “Operating Performance – Accident Management.”

2.11 Monitoring of Site-Related Parameters

Section 2.11 provides a description of the strategy for monitoring site-related parameters relevant to the DNNP site, with emphasis on the site parameters that need to be monitored for the hazards identified in Section 2.2 which affect the DNNP through the lifecycle of the BWRX-300 facility. The information in Section 2.11 satisfies the requirements of Subsection 4.5.2 of REGDOC-1.1.2 (Reference 2.11-15) and the guidance of Subsection 7.4.2 of REGDOC-2.5.2 (Reference 2.11-16).

The information in Section 2.11 covers:

- Volcanic Phenomena Monitoring – Subsection 2.11.1
- Surface Faulting Monitoring – Subsection 2.11.2
- Seismic and Geotechnical Monitoring – Subsection 2.11.3
- Meteorological Monitoring – Subsection 2.11.4
- Hydrological monitoring – Subsection 2.11.5
- Radiation Monitoring – Subsection 2.11.6
- Environmental Monitoring – Subsection 2.11.7
- Biological Organisms and Human Induced Hazards Monitoring – Subsection 2.11.8
- Long Term Monitoring Program – Subsection 2.11.9

Table 2.11-1 summarizes key DNNP characteristics and the approach for monitoring key site parameters.

Table 2.11-1: DNNP Site Characteristics and Parameters Monitoring Approach

Characteristic	Monitoring Approach
2.11.1 Volcanoes Monitoring	Hazard Screened out – No site-specific parameter to be monitored
2.11.2 Surface Faulting Monitoring	Hazard Screened out – No site-specific parameter to be monitored. Any changes will be evaluated within the long-term monitoring program.
2.11.3 Seismic and Geotechnical Monitoring	• Southern Ontario Seismic Network stations on Darlington Nuclear site • Current site-specific information is used during construction, with monitoring of excavation and blasting effects. • The Foundation Interface Analysis (FIA) work in (Reference 2.11.19) is fed by the site-specific parameters reported in (Reference 2.11-20) and will be updated by monitored specific geotechnical and seismic parameters during operation. • In-service monitoring approach of and instrumentation for BWRX-300 structures include testing and surveillance programs for below-grade structures and foundations over their design lives Field instrumentation system with recordings is benchmarked against design estimates of settlement and vertical and horizontal movement around the deeply embedded RB and the foundations of the Control Building (CB), TB, and RWB

Table 2.11-1: DNNP Site Characteristics and Parameters Monitoring Approach

<table>
<tr><th>Characteristic</th><th colspan="2">Monitoring Approach</th></tr>
<tr><td>2.11.4 Meteorological Monitoring</td><td colspan="2">• On-site meteorological tower
Environment Canada maintained stations, and notification on severe weather conditions</td></tr>
<tr><td>2.11.5 Hydrological Monitoring</td><td colspan="2">• Precipitation, groundwater flow and groundwater hydrology
• Lake Ontario water levels
Lake current real-time monitoring system</td></tr>
<tr><td>2.11.6 Radiation Monitoring (refer to Section 2.9)</td><td colspan="2">• Environmental off-site and site boundary monitoring and sampling
• Off-site and site boundary TLD sites
• Automated Gamma monitoring system
Effluent Monitoring Program</td></tr>
<tr><td>2.11.7 Environmental Monitoring</td><td colspan="2">Environmental Monitoring Program, detailed I Chapter 20, Subsection 20.11.2</td></tr>
<tr><td rowspan="5">2.11.8 Biological Organisms and Human Induced Hazards Monitoring</td><td>Waterborne, and Airborne Hazards and Biological Organisms</td><td>Monitored and controlled in a manner to enable the continued safe operation of the BWRX-300</td></tr>
<tr><td>Human Induced Hazards—General</td><td>Screened out based on Design Mitigation – No Site-specific parameter to be monitored</td></tr>
<tr><td>Air Transportation activities</td><td>Hazard Screened out – No site-specific parameter to be monitored</td></tr>
<tr><td>Chemical Explosions</td><td>Screened out based on Design Mitigation – No Site-specific parameter to be monitored</td></tr>
<tr><td>Activities at nearby industrial and other facilities</td><td>St. Marys Cement plant seismic monitoring station</td></tr>
<tr><td>2.11.9 Long Term Monitoring Program</td><td colspan="2">To be determined potential impacts of climate changes on BWRX-300 operation via long-term monitoring, review, and updates</td></tr>
</table>

2.11.1 Volcanic Phenomena Monitoring

There are no volcanic structures or active volcanoes in the vicinity of the DNNP site. Therefore, the volcanic hazard is not a potential hazard to the DNNP site, and no site-specific parameter to be monitored for this hazard as it is screened out, as per the 2020 DNNP application to renew the Site Preparation Licence NK054-CORR-00531-10533 (Reference 2.11-2).

2.11.2 Surface Faulting Monitoring

There are no active surface faults or tectonic plates in the vicinity of the DNNP site. Therefore, there is no site-specific parameter to be monitored for surface faulting hazard at the DNNP site as this is screened out, as described in the 2020 NK054-CORR-00531-10533 (Reference 2.11-2). Any changes in this hazard are to be evaluated as part of the long-term monitoring program.

2.11.3 Seismic and Geotechnical Monitoring

Site-related parameters are monitored to account for effects from seismic or geotechnical hazards, including earthquakes. Characterization of the seismicity of the region surrounding the site, using the Southern Ontario Seismic Network stations on Darlington Nuclear site, forms an essential part of the assessment of the seismic hazard.

Considering the proximity of the DNNP and DNGS sites, the updated hazard curve characterizing the seismic conditions for DNGS in the 2021 Darlington Risk Assessment NK38-REP-03611-10041 (Reference 2.11-1) is deemed applicable to the DNNP site and, thus, is to be utilized during the design and construction stages of the BWRX-300 facility.

The DNNP site-specific geotechnical considerations are discussed in Section 9.3 of the 2009 DNNP Site Evaluation of geotechnical aspects NK054-REP-01210-00011 (Reference 2.11-3). During the construction of the BWRX-300 facility, the effects of any excavation or blasting is to be monitored for their impact on the existing DNGS Power Blocks.

All permanent cut/fill slopes within the areas for DNNP site are to be instrumented and monitored regularly during and after completion of construction and during operation of the BWRX-300 facility (Reference 2.11-3). The information in NEDO-33914-A (Reference 2.11-4) identifies the BWRX-300 advanced civil construction and design approach.

The activities during construction and commissioning are to be monitored to identify the surfaces of civil structures that are exposed to soil, backfill or engineered fill, rock, and groundwater. The monitoring results are evaluated to determine susceptibility of the civil structures surfaces material to deterioration, and the ability to perform the intended design function under the anticipated conditions. An FIA is described in Section 4 of NEDO-33914-A (Reference 2.11-4), The FIA is further advanced specifically for the DNNP BWRX-300 in the 2023 NK054-REP-03500.8-00003 DNNP FIA report (Reference 2.11-19) by running analytical models which employed site-specific parameters that are reported in the 2022 geotechnical investigation and laboratory tests (Reference 2.11-20). The 2023 DNNP FIA report (Reference 2.11-19) analysed the subsurface soil and rock interface with the structures of the Power Block buildings including the deeply embedded RB, and new loads arising during the operational life of the BWRX-300, such as loads from ground motions, pressures, and from potential subsurface deformations that originate from subgrade instabilities and potential liquefaction (Reference 2.11-22). (Additional information on FIA as related to the DNNP and BWRX-300 is provided in Subsection 2.7.3.2, Subsection 2.7.3.3, and Subsection 2.7.5.1).

The in-service monitoring approach, presented in Section 3.3 of NEDO-33914-A (Reference 2.11-4) for the BWRX-300 also covers post-construction testing and in-service surveillance programs for below-grade structural members and foundation. Some of such activities include periodic examination of inaccessible areas, monitoring of groundwater chemistry, and monitoring of settlements and differential displacements. The purpose of the in-service monitoring programs is to monitor the condition of BWRX-300 structures over their design lives to ensure the credited safety functions as well as the overall structural integrity are maintained. The overall integrity of all civil structures, regardless of safety classification, is critical for plant personnel to safely maintain plant facilities during service and through decommissioning.

Additionally, DNNP will have a field instrumentation system related to the BWRX-300 deeply embedded RB. As described in NEDO-33914-A (Reference 2.11-4), field instrumentation that is beyond the current regulatory guidelines, is deployed to monitor the magnitude and distribution of pore pressure and amount of deformation during excavation, construction, loading and continuing through the BWRX-300 plant operation. The instrumentation provides recordings that are frequently benchmarked against design estimates. Short-term and long-term settlement monitoring plans are developed that can detect both vertical and horizontal movements in and around the structures, as well as differential distortion across the foundation footprint and differential settlements between the foundations of the CB, Turbine Building (TB), RWB and RB.

Free field and in-service seismic instrumentation are further discussed in Chapter 3, Subsection 3.3.1.5 as follows:

- Location and description of instrumentation – Subsection 3.3.1.5.1
- Design and installation – Subsection 3.3.1.5.2
- Maintenance and testing – Subsection 3.3.1.5.3
- Arrangement for control room operator notification – Subsection 3.3.1.5.4
- Comparison of measured and predicted responses – Subsection 3.3.1.5.5

2.11.4 Meteorological Monitoring

With respect to meteorological factors, data such as temperature, wind speed, and wind direction are required for monitoring the direction of dispersion of any potential containment release from the DNNP site to the surrounding environment. The meteorological data are used to calculate DRLs and dose to the public through off-site radiological environmental monitoring. In the event of an accidental release off-site, the meteorological factors provide data to support the CNEP N-PROG-RA-0001 (Reference 2.11-9).

The meteorological tower at the Darlington Nuclear site described in the 2009 NK054-REP-01210-00013 (Reference 2.11-5) is located just north of the site, just southeast of the intersection of Highway 401 and Holt Road (main access to the site). The tower has no significant obstructions from nearby buildings. Meteorological data available from the site consist of wind speed and direction at two heights (10 m and 50 m) and temperature at one height (10 m). Humidity, air pressure, and precipitation are currently not logged on-site by the meteorological tower. However, the information is readily available from Environment Canada stations as listed in Section 2.2.1 of the 2012 NK054-REP-01210-00016 (Reference 2.11-6). The data collected from the Darlington Nuclear site, per NK054-REP-01210-00013 (Reference 2.11-5) are used and adapted for to the DNNP site characteristics and the BWRX-300 design. The development of a DNNP on-site meteorological program progresses, tracked by CNSC commitment D-C-8, Meteorological Monitoring Station.

Additionally, notifications from Environment Canada for existing OPG facilities are received on severe weather which allow OPG to enter the severe weather emergency preparedness procedure N-PROC-RA-0095 (Reference 2.11-18).

2.11.5 Hydrological Monitoring

The assessment of the potential flood hazards at DNNP is described in the 2022 NK054-REP-02730-00001, Flood Hazard Assessment (Reference 2.1-21)

The BWRX-300 does include precipitation as a site-related parameter for monitoring and is assessed against the flooding hazard as part of the safety analysis as the detailed design progresses, as described in the 2020 Application to renew DNNP Site Preparation Licence NK054-CORR-00531-10533 (Reference 2.11-2). As noted in Subsection 2.11.4, precipitation is monitored through local Environment Canada weather stations.

Groundwater flow and groundwater hydrology were assessed as a part of the 2020 NK054-CORR-00531-10533 (Reference 2.11-2), and conditions monitoring with respect to hydrology, boreholes and wells were fitted with equipment for sampling and level monitoring purposes. Sections 3.5 and 3.6 of Volume 2 of the 2022 DNNP Geotechnical Investigation (Power Block) NK054-REP-01210-00175 (Reference 2.11-21) updated the information and database on groundwater flow and hydrostratigraphic units. Annual groundwater monitoring has occurred across the DNNP site study area since the original 2009 Site Evaluation NK054-REP-01210-

00011 (Reference 2.11.3). Additional information is presented on groundwater conditions, flow, and hydro-stratigraphy in Subsection 2.5.5 and Subsection 2.7.3.2.4, Further information on the groundwater monitoring program is provided in Chapter 20, Subsection 20.11.4.

Levels in Lake Ontario are monitored by various organizations, including the Canadian Hydrographic Service, National Oceanic and Atmospheric Administration and Environment Canada as described in Section 8.2 of the 2009 NK054-REP-01210-00012 (Reference 2.11-13). The water level of Lake Ontario is controlled by the International Joint Committee–- a joint group between Canada and the USA. Additional information is presented in Subsection 2.5.2.1 on how Lake Ontario water level is monitored and regulated.

The current in Lake Ontario is also monitored using the Lake Current Monitoring System as described in the 2019 NK38-OM-61100 (Reference 2.11-10) which resides in the lake approximately 1.6 km offshore of the Bowmanville Water Supply Plant, east of Darlington Nuclear site. The Lake Current Monitoring System real-time current profile measurement system is used in the event of a radiological liquid emission from Operations that takes place on the DNNP site. The Lake Current Monitoring System consists of an Acoustic Doppler Current Profiler and a Remote System Manager base station. The data acquired from Lake Current Monitoring System is also applicable to the DNNP given it is part of the Darlington Nuclear site.

2.11.6 Radiation Monitoring

Radiation Monitoring is comprised of on-site, site boundary, and off-site monitoring systems and programs. Information on radiation monitoring is available in the following subsections:

1. The environmental off-site and site boundary monitoring systems and sampling programs (Environmental Monitoring Program) – Subsection 2.9.2.1
2. The TLDs that are located around the Darlington Nuclear site perimeter as well as at off-site locations – Subsection 2.9.2.2
3. The Automated Near Boundary Gamma Monitoring System, located around the Darlington Nuclear site boundary – Subsection 2.9.2.3
4. Site Effluent Monitoring Program – Subsection 2.9.2.4

2.11.7 Environmental Monitoring

The Darlington Nuclear Environmental Monitoring Program identifies the contaminants and physical stressors to be monitored and conducts monitoring in the environment surrounding the site, The Environmental Monitoring Program is discussed in detail in Chapter 20, Subsection 20.11.2.

2.11.8 Biological Organisms and Human Induced Hazards Monitoring

2.11.8.1 Biological Organisms

Biological hazards specific to the DNNP site are similar to those of the 2019 DNGS NK38-REP-03611-10043 (Reference 2.11-7), given the two sites proximity.

Examples of such hazards are waterborne (e.g., fish, algae, zebra-mussel, or biofouling), large animals (e.g., herds of deer) or flying birds/insects (e.g., flocks of geese). These biological hazards are monitored and controlled in a manner enabling the safe operation of the plant.

Biofouling control typically involves appropriate biomonitoring and application of appropriate biocides/antimicrobials specific to the circuits and sensitivity of the system components. The control of the biofilms is a standard operational procedure at facilities supplied by water from Lake Ontario, and accordingly this form of biofouling is manageable for the BWRX-300 using available technology, as described in the 2009 DNNP Site Evaluation on nuclear safety considerations NK054-REP-01210-00008 (Reference 2.11-8).

Additional information on the impact of biological and animal hazards on the safe operation of BWRX-300 facility is provided in Subsection 2.2.7.1 , and on potential biofouling hazard and its impact on cooling lake water supply is presented in Subsection 2.5.2.2.

2.11.8.2 Human Induced Hazards

With respect to non-malevolent human induced hazards, all events were screened out, per the 2019 Hazards Screening Analysis NK38-REP-03611-10043 R003 (Reference 2.11-7) from the need to perform a PSA. As discussed in the following subsections, human induced hazards are screened out qualitatively or quantitatively based on the design and robustness of the BWRX-300 facility. No specific parameters are to be monitored for external human induced hazards.

2.11.8.2.1 Air Transportation Activities

As discussed in Subsection 2.2.3.1, hazards from air transportation accidents are screened out. No site-specific parameter is expected to be monitored for aircraft/flight impacts for the DNNP site. Refer to Subsection 2.2.3.1 for additional information.

2.11.8.2.2 Chemical Explosions

The DNNP site has various shipping lanes, which carry bulk marine shipments and the Canadian National Railway which runs within the exclusion zone of the site. The probability of accidents posing significant threat to the site is low, per the 2019 NK38-REP-03611-10043 (Reference 2.11-7). Transport vehicles carrying toxic and hazardous materials (mainly gaseous) pose a threat to worker safety which is recognized in the Site Evaluation. No site-specific parameter is expected to be monitored for chemical explosions for impacts on the DNNP site. For additional information on hazards resulting from transportation accidents refer to Subsections 2.2.3.2, 2.2.3.3, and 2.2.3.4, and from stationary non-nuclear accident refer to Subsection 2.2.4.

2.11.8.2.3 Activities at Nearby Industrial and Other Facilities

The St. Marys Cement plant is located on the east side of DNNP site, about 700 meters from the proposed BWRX-300 location. This cement plant performs blasting at the quarry that leads to shock waves in the ground that could travel up to the BWRX-300 structures. Such shock waves are monitored using vibration monitors at a seismic monitoring station on the St. Marys property boundary. The St. Marys Cement plant is also committed to comply with the agreement established with OPG, which states that the cement plant should not carry out blasts that may exceed the maximum allowable horizontal, vertical, longitudinal, and radial velocities of 3 mm/s, peer the 2019 NK38-REP-03611-10043 (Reference 2.11-7). As part of the DNGS seismic hazard curve provided in the 2021 NK38-REP-03611-10041 (Reference 2.11-1) to be used also for the DNNP site, underground shock wave effects are to be addressed through the PSA. Refer to Subsection 2.2.6 for additional information.

2.11.9 Long Term Monitoring Program

The work conducted in the 2023 report on Climate Change Impact NK054-PLAN-07007-00001 (Reference 2.11-20) confirmed the low impact of climate change stipulated in Subsection 2.5.4. Such work included climate modelling and reviewed published articles to evaluate the anticipated impact of climate change on the DNNP site and surrounding area.

Long term monitoring (periodic review/update) of applicable site-specific hazards is an inherent feature of the PSA process. As per REGDOC-2.4.2 (Reference 2.11-14), the PSA models for nuclear stations are updated every 5 years, or sooner if the facility undergoes major changes and are managed by the 2021 Preparation, Maintenance and Application of Probabilistic Safety

Assessment N-STD-RA-033 (Reference 2.11-11). As part of this process, site-related parameters that feed into the hazard screening are revisited for new modelling methods or for any changes in the site parameters. The screening criteria for the PSA are updated every 5 years as per the 2018 OPG's Probabilistic Safety Assessment Guide N-GUID-03611-10001 (Reference 2.11-12). For cases in which data are regularly monitored at the site (e.g., wind speed or other meteorological data), and cases for which data are collected from external sources (e.g., air traffic in the vicinity of the site), the new data are assessed as part of the hazard screening for the DNGS site. A similar long-term approach is applied for the DNNP site to assess all site-related parameters for any changes.

Long term monitoring of climate change data is to be performed in accordance with REGDOC-1.1.1 (Reference 2.11-17) which requires the Site Evaluation and Site Characterization be revisited at each licensing phase to confirm it remains valid with changing environmental conditions. REGDOC-1.1.2 (Reference 2.11-15) reinforces this requirement for the Licence to Construct application and requires site characteristics be confirmed for the construction phase. REGDOC-2.5.2 (Reference 2.11-16) also requires the design of a nuclear power plant to consider all site characteristics that may affect the safety of the plant and monitoring of site-related parameters be in place throughout the lifecycle of the plant. Hazards that are applicable to the DNNP site and affected by climate change are to be monitored. Parameters associated with these climate change hazards (e.g., meteorological, lake temperature) are to be obtained from a variety of sources, including but not limited to, site-located instrumentation and local weather data. The frequency at which a climate change hazard is to be measured and analysed will depend on the nature of the hazard and its impact on the DNNP facility (e.g., nuclear safety impact, commercial impact). Climate change hazards will undergo risk assessment and where suitable will be subject to risk treatment (e.g., adaptive action or a risk monitoring plan). Where a risk monitoring plan is in place the trigger point for an adaptive action will be specified with consideration for the duration required to implement the action. The 2023 NK054-PLAN-07007-00001 Darlington New Nuclear Project Strategy for Addressing Climate Change Impacts (Reference 2.11-20) provides additional information on lifecycle considerations including long term monitoring.

2.11.10 References

2.11-1 NK38-REP-03611-10041 R003, 2021, "Update of the OPG Darlington Site Probabilistic Seismic Hazard Assessment for the Darlington Risk Assessment (DARA)," Ontario Power Generation.

2.11-2 NK054-CORR-00531-10533, 2020, "Application for Renewal of OP''s Darlington New Nuclear Project (DNNP) Nuclear Power Reactor Site Preparation License (PRSL)," Ontario Power Generation.

2.11-3 NK054-REP-01210-00011 R001, 2009, "Site Evaluation of the OPG New Nuclear at Darlington–- Part 6: Evaluation of Geotechnical Aspects," Ontario Power Generation.

2.11-4 NEDO-33914-A, Revision 2, 2022,""BWRX-300 Advanced Civil Construction and Design Approach"" GE-Hitachi Nuclear Energy Americas, LLC.

2.11-5 NK054-REP-01210-00013 R001,2009, "Site Evaluation of the OPG New Nuclear at Darlington–- Part 4: Evaluation of Meteorological Events," Ontario Power Generation.

2.11-6 NK054-REP-01210-00016 R002, 2012. "Site Evaluation of the OPG New Nuclear at Darlington–- Part 2: Dispersion of Radioactive Materials in Air and Water," Ontario Power Generation.

2.11-7 NK38-REP-03611-10043 R003, 2019, “Hazards Screening Analysis – Darlington,” Ontario Power Generation.

2.11-8 NK054-REP-01210-00008 R001, 2009, “Site Evaluation of the OPG New Nuclear at Darlington – Nuclear Safety Considerations,” Ontario Power Generation.

2.11-9 N-PROG-RA-0001 R019, “Consolidated Nuclear Emergency Plan,” Ontario Power Generation.

2.11-10 NK38-OM-61100 R013, 2019, “Environmental Monitoring – Air and Water,” Ontario Power Generation.

2.11-11 N-STD-RA-033 R006, 2021, “Preparation, Maintenance and Application of Probabilistic Safety Assessment,” Ontario Power Generation.

2.11-12 N-GUID-03611-10001 Volume 8, 2018, “OPG Probabilistic Safety Assessment (PSA) Guide – External Hazard Screening,” Ontario Power Generation.

2.11-13 NK054-REP-01210-00012 R001, 2009, “Site Evaluation of the OPG New Nuclear at Darlington–- Part 5: Flood Hazard Assessment,” Ontario Power Generation.

2.11-14 CNSC Regulatory Document REGDOC-2.4.2, “Safety Analysis Probabilistic Safety Assessment (PSA) for Reactor Facilities.”

2.11-15 CNSC Regulatory Document REGDOC-1.1.2, “Licence Application Guide: Licence to Construct a Reactor Facility.”

2.11-16 CNSC Regulatory Document REGDOC-2.5.2, “Design of Reactor Facilities: Nuclear Power Plants.”

2.11-17 CNSC Regulatory Document REGDOC-1.1.1, “Licence Application Guide: Site Evaluation and Site Preparation for New Reactor Facilities.”

2.11-18 N-PROC-RA-0095, “Severe Weather Emergency Preparedness,” Ontario Power Generation.

2.11-19 NK054-REP-03500.8-00003, 2023, “Darlington New Nuclear Project Foundation Interface Analysis (FIA) Report,” Ontario Power Generation

2.11-20 NK054-PLAN-07007-00001, 2023, “Darlington New Nuclear Project Strategy for Addressing Climate Change Impacts,” Ontario Power Generation

2.11-21 NK054-REP-01210-00175 R000, 2022, “Phase I Geotechnical Investigation (Power Block) Darlington New Nuclear Project”, Volume 2 of 2 “Geotechnical Interpretation of Design Parameters,” Ontario Power Generation.

2.11-22 NK054-REP-03500.8-00002 R000, 2022, “Darlington New Nuclear Project–- Seismically-Induced Soil Liquefaction Assessment,” Ontario Power Generation

2.12 Ongoing Work Plans

2.12.1 Introduction

Section 2.12 details information on plans to complete ongoing DNNP specific works involving geotechnical investigations, laboratory tests, analyses, and assessments to validate and update existing DNNP parameters or generate new site-specific characterizations and parameters to supplement and update existing database. Each disposition plan provides:

- Background information on the ongoing work
- The schedule and workflow by which the ongoing work is to be completed
- Risks associated with the ongoing work
- Chapter 2 sections impacted by the ongoing work
- Progress of work, including deliverables

Details of each work is provided as follows:

Subsection 2.12.2 – Foundation Interface Analysis (FIA)

Subsection 2.12.3–- Site Geotechnical and Seismic Hazard Investigation Plan, which includes

- Geotechnical investigations (Power Block) and laboratory tests
- Offshore geotechnical investigation
- Site-specific Probabilistic Seismic Hazard Assessment (PSHA)
- Seismically-induced liquefaction assessment

Subsection 2.12.4–- Flood Hazard Assessment

Subsection 2.12.5 – Climate Change Impact

Subsection 2.12.6 – 3-second Wind Gust Validation

Subsection 2.12.7- Winter PMP Validation

Subsection 2.12.8 – PMP Validation

The results of each completed work are incorporated into the impacted sections in Chapter 2 A summary description of each work along with the deliverables are provided in Table 2.12-1.

Table 2.12-1: DNNP Projects Closure Plans and Associated Updates

Sub-section	Disposition Plan/Status	Description/Deliverables
2.12.2	Foundation Interface Analysis (FIA) Status: Complete	The FIA results will support the evaluation of the construction plan, the stability of the excavation, ground improvements and the design of excavation support systems. Also, the results of ground pressure demands on the below-grade exterior walls of the RB will be used to validate ground pressure design loads. The FIA will be performed with three dimensional models representing the site conditions at all project stages, including design, construction, and operation. Specific tasks are as follows: • Evaluation of the subgrade materials and the materials surrounding the deeply embedded BRWX-300 RB • Confirmation that the Radwaste Building, Turbine Building, and CB foundations are to be supported by the engineered fill, intermediate glaciolacustrine, and lower till soils • Confirmation of the stability of sand and rock excavation for the stability of the deeply embedded RB shaft evaluation for excavation and construction The resulting report will discuss: 1. Effects of excavation, dewatering (based on hydrogeology report) and construction on subgrade material properties 2. Evaluations of potential for unstable rock mass or unstable blocks and wedges including the joints and sizes of the potential blocks or wedges 3. Results of the FIA of the site characterization, excavation, construction, loading, operation stages 4. Inputs and results of sensitivity FIA or additional stability analysis Deliverables: 1. NK054-REP-03500.8-00003, 2023, “Darlington New Nuclear Project Foundation Interaction Analysis (FIA) Report,” Ontario Power Generation

Table 2.12-1: DNNP Projects Closure Plans and Associated Updates

Sub-section	Disposition Plan/Status	Description/Deliverables
2.12.3	Site Geotechnical and Seismic Hazard Investigation Plan Status: Complete	The main deliverables of OPG's Site Geotechnical and Seismic Hazard Investigation are as follows: 1. Perform Geophysical Survey and Mapping of Subsurface Strata 2. Detailed Site Investigation and Geotechnical Lab Tests 3. Excavation and Stockpile / Earth Removal 4. Geological Hazard Scenarios 5. Liquefaction Potential Assessment 6. DNNP Probabilistic Seismic Hazard Analysis 7. DNNP Specific Seismic Hazard The results of this work will be used for the confirmation of BWRX-300 bounding parameters Deliverables: 1. (NK054-REP-01210-00175) Golder Associates Ltd. (Golder), 2022, Phase I Geotechnical Investigation (Power Block) Darlington New Nuclear Project, Revision 2, Volumes 1 and 2, July 29 2. (NK054-REP-10180-00001) Golder Associates Ltd. (Golder), 2023, Offshore Geotechnical Investigation Darlington New Nuclear Project, Revision 0. 3. (NK054-REP-03500.8-00001) Kinectrics Inc., K-620423/RP/0001 R01, "Darlington New Nuclear Project–-Site-Specific Probabilistic Seismic Hazard Assessment," 2022 4. (NK054-REP-03500.8-00002) Kinectrics Inc., K-620423/RP/0002 R00, "Darlington New Nuclear Project–-Seismically-Induced Soil Liquefaction Assessment," 2022

Table 2.12-1: DNNP Projects Closure Plans and Associated Updates

Sub-section	Disposition Plan/Status	Description/Deliverables
2.12.4	Flood Hazard Assessment <u>Status</u>: Complete	This Hydrological Analysis is expected to follow a similar format to the original flood assessment covering: • Identification of Flooding Hazards • Description of DNNP Site Layout • Assessment of Flooding Hazards • Flood Protection • Modification of the Flood Hazard over time • Monitoring and Warning for Plant Protection • Conclusions and Recommendations The results of this work are used for the confirmation of BWRX-300 bounding parameters <u>Deliverables</u>: 1. NK054-REP-02730-00001 R000, 2022, “Flood Hazard Assessment”, Ontario Power Generation (SNC Lavalin ID 690633-0000-4HER-001 R01).

Table 2.12-1: DNNP Projects Closure Plans and Associated Updates

Sub-section	Disposition Plan/Status	Description/Deliverables
2.12.5	Climate Change Impact Status: "CNSC Deliverable1: DNNP Strategy for Addressing Climate Change Impacts." Complete	Conditions from climate change which impact flooding have been incorporated into Chapter 2 based on the 2022 NK054-REP-02730-00001 "Flood Hazard Assessment" (Reference 2.12-4). OPG has issued the 2023 NK054-PLAN-07007-00001 R000 "Darlington New Nuclear Project Strategy for Addressing Climate Change Impacts" (Reference 2.12-5). This strategy has two primary phases: Climate Change Risk Assessment and Climate Change Risk Treatment. Following work will be performed on an as-required basis to integrate climate change assessments into the current nuclear safety framework. This will include lifecycle considerations such as long-term monitoring and periodic reassessment of hazards associated with climate change DNNP commitment D-C-7 in accordance with the strategy outlined in NK054-PLAN-07007-00001 (Reference 2.12-5). D-C-7 will be completed prior to start of construction as per NK054-REP-01210-00078 (Reference 2.12-2). Deliverables: 1. (NK054-PLAN-07007-00001 R000), 2023, "Darlington New Nuclear Project Strategy for Addressing Climate Change Impacts", Ontario Power Generation 2. NK054-REP-07007-1049426 R001, 2023, "Darlington New Nuclear Project – Hazard Bounding Analysis," Ontario Power Generation 3. NK054-REP-07007-1028871 R000, 2022, "Darlington New Nuclear Project–- Gradual Climate Change and Natural Hazard Identification," Ontario Power Generation
2.12.6	3-second Wind Gust Calculation Status: Complete	While maximum wind speed is an instantaneous wind speed, the 3-second gust value is a sustained wind speed. Maximum wind speed is shown in Subsection 2.6.5. Key two aspects of this work are: • Calculation of the site characteristic for 3-second wind gust speed is in progress • Value will confirm BWRX-300 bounding approach Deliverables: 1. NK054-REP-02730-00003 R000, 2022, "Wind Gust Analysis", Ontario Power Generation (SNC Lavalin ID 690633-0000-4HER-003 R01)

Table 2.12-1: DNNP Projects Closure Plans and Associated Updates

Sub-section	Disposition Plan/Status	Description/Deliverables
2.12.7	Winter PMP Validation Status: Complete	Work started to finalize appropriate consideration for snow load with a Winter Probable Maximum Precipitation (PMP) event. DNNP considers this a review level condition. Finalization of the coincident snow load and winter PMP is complete. Deliverables: 1. NK054-REP-02730-00004 R000, 2022, “Winter PMP Validation”, Ontario Power Generation (SNC Lavalin ID 690633-0000-4HER-004 R01)
2.12.8	PMP Validation Status: Complete	Confirmation of rainfall and PMP Deliverables: 1. NK054-REP-02730-00002 R000, 2022, “PMP Validation”, Ontario Power Generation (SNC Lavalin ID 690633-0000-4HER-002 R01)

2.12.2 Foundation Interface Analysis

2.12.2.1 Background

OPG has undertaken a site-specific, non-linear FIA, to ensure the stability of structures, supporting media, soil, and rock per NUREG-800 SRP 2.5.4 guidance. The FIA results support the evaluation of the construction plan, the stability of the excavation, ground improvements and the design of excavation support systems. Also, the results of ground pressure demands on the below-grade exterior walls of the RB are used to validate ground pressure design loads. The FIA is performed with three dimensional models representing the site conditions at all project stages, including design, construction, and operation.

The schematic workplan for the FIA modelling is shown in Figure 2.12.2-1.

All relevant available reports describing ground conditions and structural details are reviewed including but not limited to: Geotechnical Investigation Factual and Interpretation Reports, NEDO 33914 Licensing Topical Report [1], and relevant nuclear standards/guidelines. The factual data are summarized and classified for each geological unit and the input parameters required for FIA numerical modelling are calculated or extracted from the laboratory and in-situ test results. The structural information such as the shoring design, construction staging, and the structure details are reviewed and summarized in our FIA interaction modelling activity.

All relevant available reports describing ground conditions and structural details are reviewed, including but not limited to:

- Geotechnical Investigation Factual and Interpretation Reports, NEDO 33914 Licensing Topical Report (Reference 2.12-1)
- Relevant nuclear standards/guidelines.

This information is used to develop the Finite Element Analysis method and 3D framework in Plaxis 3D, allowing full FIA interaction modelling.

The Technical Report is prepared based on the FIA modelling, includes the results of the FIA of the deeply embedded BWRX-300 RB and the surrounding Power Block foundations at the DNNP site. The report discusses:

1. Effects of excavation, dewatering (based on hydrogeology report) and construction on subgrade material properties
2. Evaluations of potential for unstable rock mass or unstable blocks and wedges including the joints and sizes of the potential blocks or wedges
3. Results of the FIA of the site characterization, excavation, construction, loading, operation stages
4. Inputs and results of sensitivity FIA or additional stability analysis

2.12.2.2 Project Schedule and Logic

The report concludes the results of the FIA for the deeply embedded BWRX-300 RB and the surrounding Power Block foundations at the DNNP site. The schematic workplan for the FIA modelling is shown in Figure 2.12.2-1.

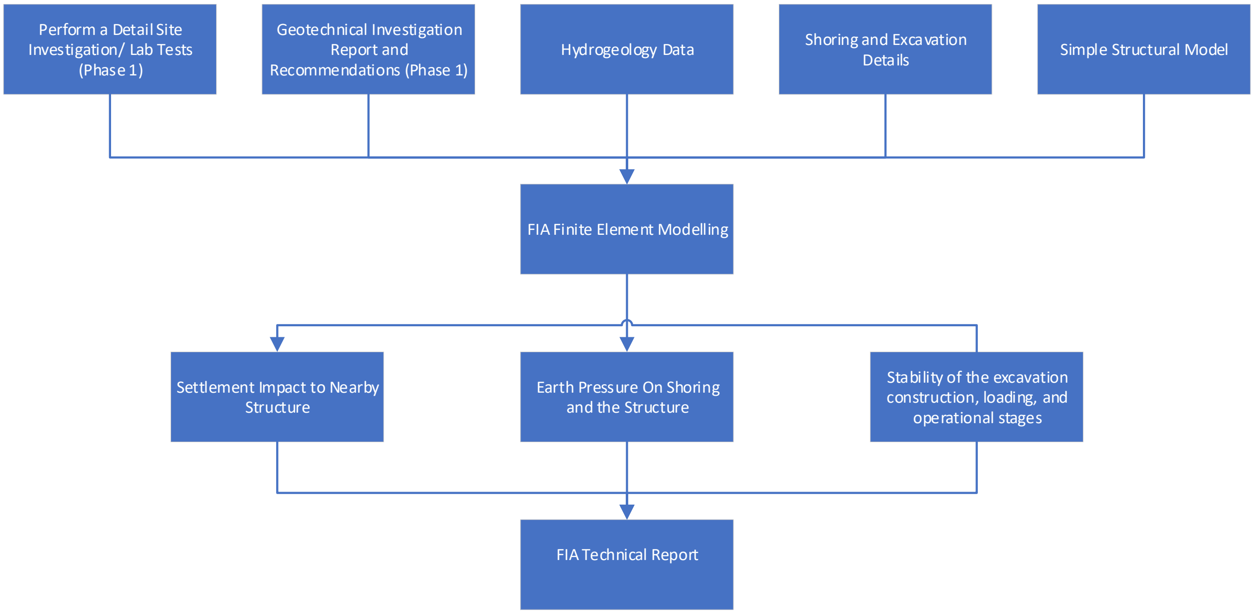


Figure 2.12.2-1: FIA Modelling Workflow and Deliverables

2.12.2.3 Risks

Project timeline is dependent on DNNP confirmatory geotechnical investigation results (Laboratory Test Results and In-Site Test Results) (refer to Subsection 2.12.3). Any delays to the geotechnical investigation may cause a delay to the FIA final deliverable (Technical Report)

2.12.2.4 Impacted Chapter 2 Sections

Section 2.7 – Geology, Seismology, and Geotechnical Engineering.

2.12.2.5 Progress of Work

1. Review completed of recent reports by Golder Associates Ltd. (refer to Subsection 2.12.3) that includes site-specific results of geotechnical investigations and laboratory tests
2. Information received on shoring and excavation details from AECON
3. A simple structural model is tested and verified
4. FIA Finite Element modelling is developed
5. Technical memoranda developed, circulated for review and comments, on the following topics:
    a. Bearing Capacity Evaluations of the BWRX-300 RB and the Surrounding Power Block Foundations at the DNNP Site
    b. Settlement Evaluations of the BWRX-300 RB and the Surrounding Power Block Foundations at the DNNP Site
    c. Excavation and Construction Stages of the BWRX-300 RB Shaft
    d. FIA Numerical Modelling
6. Additional key parameters are sought and confirmed for use as input to the FIA model

7. Final report is complete

Work is complete and closed. The results are incorporated in Section 2.7.

Deliverables:

The following report was submitted by the outsourced contactor, and was reviewed and accepted by to OPG:

1. NK054-REP-03500.8-00003, 2023, "Darlington New Nuclear Project Foundation Interface Analysis (FIA) Report," Ontario Power Generation

2.12.3 Site Geotechnical and Seismic Hazard Investigation Plan

2.12.3.1 Background

Geotechnical Program

OPG has undertaken a detailed site geotechnical program which provides information on the soil physical, mechanical, and dynamic properties of overburden and rock material. The program assesses whether there are karstic features in the local bedrock at the site. The program is linked to the existing CNSC commitment D-P-9 Site Geotechnical and Seismic Hazard Investigation (Reference 2.12-2). The schematic workplan for OPG's Geotechnical Program is shown in Figure 2.12.3-1.

The geotechnical and seismic hazard investigation program, undertaken by OPG, has primary goals to gather sufficient geological data for the proposed DNNP site, identify potential geotechnical and seismic related hazards, and perform the necessary safety evaluations, analyses, and assessments. Investigation methods used included compilation, review and evaluation of existing/historical documents, detailed geophysical and geotechnical site exploration, and extensive in-situ and laboratory testing. Each of these methods are applicable to all stages of the Site Evaluation process, but to varying extents. The main deliverables of OPG's Site Geotechnical and Seismic Hazard Investigation are as follows:

- Perform Geophysical Survey and Mapping of Subsurface Strata
- Detailed Site Investigation and Geotechnical Lab Tests
- Excavation and Stockpile / Earth Removal
- Geological Hazard Scenarios
- Liquefaction Potential Assessment
- DNNP Probabilistic Seismic Hazard Analysis
- DNNP Specific Seismic Hazard

The results of the OPG's Geotechnical and Seismic Hazard Investigation feed into Section 2.7 Geology, Seismology, and Geotechnical Engineering.

2.12.3.2 Project Schedule and Logic

OPG's Geotechnical Program for Phase 1 is demonstrated in the Project Logic of Figure 2.12.3-1. DNNP's Geotechnical and Seismic Investigations are linked to the existing DNNP CNSC commitment D-P-9 Site Geotechnical and Seismic Hazards Investigations (Reference 13-3).

2.12.3.3 Risks

Delays in completing this program may impact completing OPG work on FIA discussed in Subsection 2.12.2.

2.12.3.4 Impacted Chapter 2 Sections

Subsection 2.7.3 Geotechnical Characteristics

2.12.3.5 Progress of Work

1. Completed geophysical investigation and mapping of subsurface strata
2. Completed detailed site investigation and laboratory tests
3. Drafted report on the geophysical investigation and laboratory tests as well as recommendations
4. Excavation and earth removal studies continue
5. Site-specific characteristics and site response analysis is progressing
6. DNNP PSHA is progressing
7. Liquefaction potential is being assessed and is progressing

Work is complete and closed. The results are incorporated in Section 2.7.

Deliverables

The reports were submitted by the outsourced contactor, and were reviewed and accepted by OPG:

1. NK054-REP-01210-00175 R01, (Golder 2022) "Phase I Geotechnical Investigation (Power Block) Darlington New Nuclear Project," Volumes 1 and 2, Ontario Power Generation.
2. (NK054-REP-10180-00001) Golder Associates Ltd. (Golder), 2023, Offshore Geotechnical Investigation Darlington New Nuclear Project, Revision 0.
3. NK054-REP-03500.8-00001 R00, 2022, Kinectrics Inc., K-620423/RP/0001 R01, "Darlington New Nuclear Project–- Site-Specific Probabilistic Seismic Hazard Assessment," Ontario Power Generation.
4. (NK054-REP-03500.8-00002) Kinectrics Inc., K-620423/RP/0002 R00, "Darlington New Nuclear Project–- Seismically-Induced Soil Liquefaction Assessment," 2022

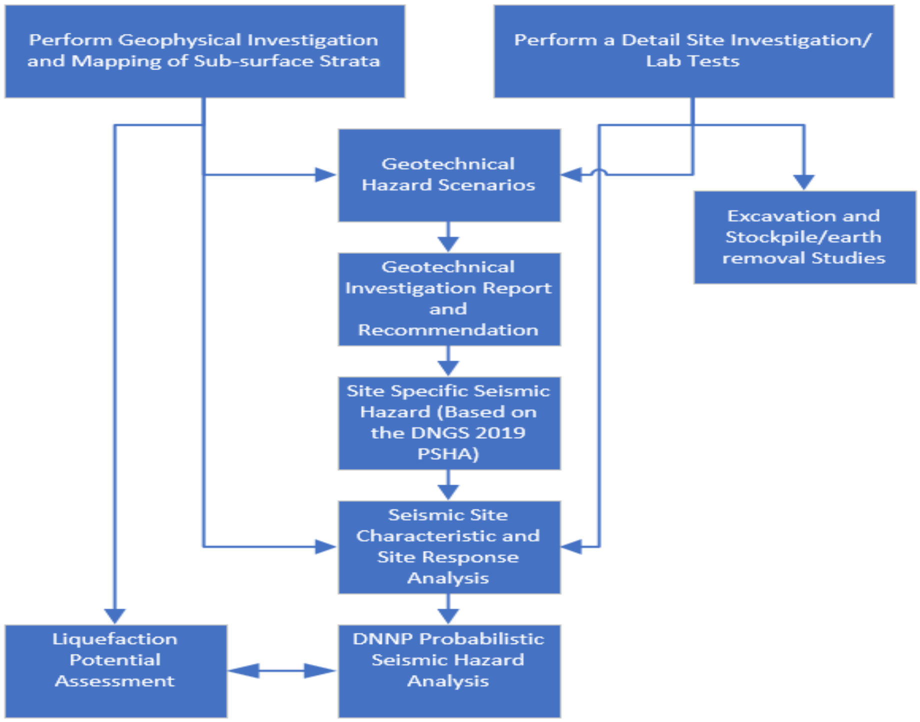


Figure 2.12.3-1: Workflow for the Geotechnical Program

2.12.4 Flood Hazard Assessment

2.12.4.1 Background

A Flood Hazard Assessment is required for Section 2.5 Hydrology.

A previous DNNP Flood Hazard Assessment was completed (Reference 2.12-4) as part of the original Site Evaluation in 2009 included in the EIS and Licence to Prepare Site process, which reflects a site build for up to 4800 mWe of either an EPR, AP-1000, ACR or EC-6 reactor type.

The construction of a 300 mWe BWRX-300 Small Modular Reactor at the DNNP site, led to different site layout, plant grade, and topography to that previously evaluated in Reference 2.12.4. This requires an update to the Flood Hazard Assessment.

OPG has contracted an outsource to complete the Hydrological Analysis which followed a similar format to the original flood assessment covering:

- Review of existing work and data
- Completion of a gap analysis to determine if additional modelling and analysis is required
- Completion of required modelling and analysis
- Organization of information, identification of flood hazards and mitigations, meeting the requirements outlined in REG-DOC1.1.1and IAEA Nos. NS-R-3, SSG-18, and other regulatory documents

- Identification of Flooding Hazards
- Description of DNNP Site Layout
- Assessment of Flooding Hazards
- Flood Protection
- Modification of the Flood Hazard over time
- Monitoring and Warning for Plant Protection
- Conclusions and Recommendations

2.12.4.2 Project Schedule and Logic

The following deliverables close this ongoing work:

- Draft Flood Hazard Assessment report
- Final Flood Hazard Assessment report

2.12.4.3 Risks

None.

2.12.4.4 Impacted Chapter 2 Sections

Section 2.5 Hydrology.

2.12.4.5 Progress of Work

1. Work is completed and a final report is delivered and accepted by OPG
2. OPG issued, in December 2022, the report as NK054-REP-02730-00001, “Flood Hazard Assessment,” Ontario Power Generation.
3. The report has the following contents
    1. Introduction
    2. General Site Description and Characteristics
    3. Existing Site Conditions – Potential Flood Hazards
    4. Post-Development Site Layout
    5. Assessment of Flood Hazards
    6. Mitigation Measures
    7. Modification of the Flood Hazard with Time
    8. Monitoring and Warning for Plant Protection
    9. Conclusions and Recommendations
    10. References

Work is complete and the results are incorporated in impacted sections of Chapter 2

Deliverables:

1. NK054-REP-02730-00001 R000, 2022, “Flood Hazard Assessment”, Ontario Power Generation (SNC Lavalin ID 690633-0000-4HER-001 R01).

2.12.5 Climate Change Impact

2.12.5.1 Background

The potential effects of climate change on external natural hazards such as flooding and temperature as well as life cycle considerations including long-term monitoring programs (refer to Subsection 2.5.4, Subsection 2.6.4, Subsection 2.6.12, and Subsection 2.11.9) are linked to the existing commitment D-C-7, Contingency Plan for Flooding and Other Extreme Weather Hazards (Reference 2.12-2). To address this commitment, OPG has developed NK054-PLAN-07007-00001 Darlington New Nuclear Project Strategy for Addressing Climate Change Impacts (Reference 2.12-5), which describes the plan for fulfilling the requirements of commitment D-C-7, and consequently ensuring the DNNP facility is resilient to climate change hazards. Additional information on long term monitoring of climate change hazards is provided in Section 2.11.9.

The DNNP Strategy for addressing Climate Change Impact consists of the following three phases:

1. Phase 1 – Climate Change Risk Assessment

   The purpose of this phase is to perform a climate change risk assessment for the DNNP facility to identify climate change hazards, bounding values/ranges, and vulnerable structures, systems, and components. There are two main activities in this phase, the Hazards Identification and Bounding Analysis. Hazard Identification will identify climate change related hazards that can affect DNNP site (e.g., hydrological, meteorological, etc.). Bounding Analysis report will then determine bounding values/ranges for the hazards that pose nuclear safety, commercial, or operational impacts. The values from the bounding analysis will feed into the Plant Envelope Assessment to determine which systems may be vulnerable to climate change hazards.

2. Phase 2 – Climate Change Risk Treatment

   The phase analyses the design margins of vulnerable structures, systems and components and develops risk treatments as required. These risk treatments can include adaptation of the design or implementation of risk monitoring plans. The completion of Phase 2 will provide the necessary information that will comply with addressing the effects of climate change on-site.

3. Phase 3 – As Required Work

   Work will be performed on an as required basis to integrate climate change assessments into the current nuclear safety framework.

The results of this work are used to confirm low impact of climate change. Where structures, systems, and components are potentially vulnerable to climate change hazards, appropriate risk treatments are developed to ensure climate change resilience is implemented within the design.

To ensure alignment with the regulator, OPG will submit three deliverables to the CNSC. The first being the 2023 NK054-PLAN-07007-00001 Darlington New Nuclear Project Strategy for Addressing Climate Change Impacts (Reference 2.12-5) which provides the CNSC a description of the proposed methodology for the close-out of commitment D-C-7. The second deliverable will be a summary report of Phase 1, which outlines the results from the Hazard Identification, Bounding Analysis, and Plant Envelope Assessment. The Phase 1 report will be submitted to the CNSC to progress closure of D-C-7. Lastly, the third deliverable will be a summary report of Phase 2, which will summarize the risk assessment of vulnerable structures, systems, and components and their risk treatment plans. The Phase 2 report will be submitted to the CNSC for closure of DNNP commitment D-C-7. CNSC feedback will be obtained on strategy and deliverables for D-C-7 prior to licence to the start of construction.

2.12.5.2 Project Logic

Phase 1 Climate Change Risk Assessment and Phase 2 Risk Treatment for Vulnerable Systems are to be completed in 2023. This work will be tracked according to the 2023 NK054-PLAN-07007-00001 Darlington New Nuclear Project Strategy for Addressing Climate Change Impacts to align with the closing of existing commitment D-C-7 prior to the start of construction.

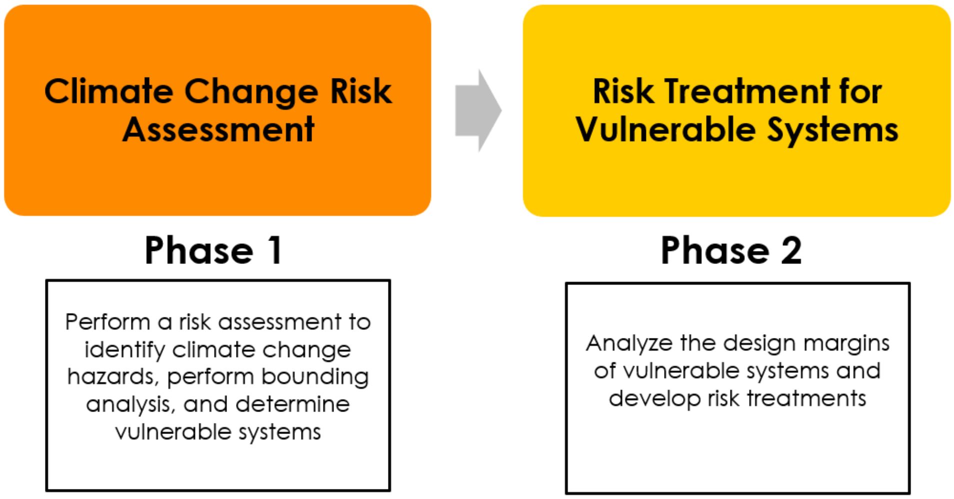


Figure 2.12.5-1: Risk Roadmap for OPG Strategy on Addressing Climate Change Impacts

2.12.5.3 Risks

None.

2.12.5.4 Impacted Chapter 2 Sections

Subsection 2.6.2 Temperature

Subsection 2.6.4 Rainfall

Subsection 2.11.9 Long Term Monitoring Program

2.12.5.5 Progress of Work

OPG issued, in January 2023, the plan as NK054-PLAN-07007-0001, “Darlington New Nuclear Project Strategy for Addressing Climate Change Impacts,” Ontario Power Generation

The plan has the following contents

1. Introduction
2. Objective
3. Regulatory and Governance Drivers
4. Strategy Overview
5. Lifecycle Considerations
6. Strategy Partners
7. Definitions and Acronyms
8. References

Work is complete and results are incorporated in Subsection 2.5.4, Subsection 2.6.4, Subsection 2.6.12, and Subsection 2.11.9

Phase 1 and 2 of the 2023 NK054-PLAN-07007-0001 Darlington New Nuclear Project Strategy for Addressing Climate Change Impacts are to be completed and tracked to the existing commitment D-C-7.

Deliverables:

1. (NK054-PLAN-07007-00001 R000), 2023, “Darlington New Nuclear Project Strategy for Addressing Climate Change Impacts”, Ontario Power Generation.
2. NK054-REP-07007-1049426 R001, 2023, “Darlington New Nuclear Project – Hazard Bounding Analysis,” Ontario Power Generation
3. NK054-REP-07007-1028871 R000, 2022, “Darlington New Nuclear Project–- Gradual Climate Change and Natural Hazard Identification,” Ontario Power Generation

2.12.6 3-Second Wind Gust Speed

2.12.6.1 Background

Chapter 2, Subsection 2.6.5 requires description of the site characteristic for 3-second wind gust speed. While maximum wind speed is an instantaneous wind speed, the 3-second gust value is a sustained wind speed. Maximum wind speed is shown in Subsection 2.6.5.

Calculation of the site characteristic for 3-second gust wind is in progress and will be added in a future revision.

2.12.6.2 Project Logic

Completion of calculations is undergoing and will be updated in the subsequent revision of PSAR Chapter 2.

2.12.6.3 Assumptions

None.

2.12.6.4 Risks

None.

2.12.6.5 Impacted Chapter 2 Sections

Subsection 2.6.5 – Wind Speed

2.12.6.6 Progress of Work

1. Work is completed and a final report is delivered and accepted by OPG
2. OPG issued, in December 2022, the report as NK054-REP-02730-00003, “Wind Gust Analysis,” Ontario Power Generation.
3. The report has the following contents
    1. Introduction
    2. Study Site and Data
    3. Wind Rose Diagram
    4. Frequency Analysis

5. Conclusions
6. References

Work is complete and results are incorporated in impacted sections Chapter 2

Deliverables:

1. NK054-REP-02730-00003 R000, 2022, "Wind Gust Analysis", Ontario Power Generation (SNC Lavalin ID 690633-0000-4HER-003 R01)

2.12.7 Snow Load and Coincident Winter Probable Maximum Precipitation

2.12.7.1 Background

Work is ongoing to finalize appropriate consideration for snow load with a Winter PMP event. DNNP considers this a review level condition.

2.12.7.2 Project Logic

Completion of calculations is undergoing and will be updated in a subsequent revision of PSAR Chapter 2.

Winter PMP Validation - The requirements of N291 for safety related structures other than containment for 100 years snow loading is not mentioned nor the guidance in it to extrapolate the National Building Code of Canada (NBCC) 50-years value if the 100-years site snow values are not available. N291 mention this for the snow component, however, it is silent about associated rain.

For safety related structures, 100 years snow with 100 years associated rain would be required for the design.

It is recommended that OPG follow the General-Electric Hitachi recommendation in the Design Input Request for Non-Seismic External Hazards at DNNP Site document to determine the following site-specific parameters:

- 100-year return period ground snowpack
- Historical maximum snowpack, including the month of occurrence • 100-year return period ground snowfall
- Historical maximum ground snowfall
- 48-hour Winter PMP over a 25.9-square-kilometer (10-square-mile) area at this location during those months with the historically highest snowpacks.

The depth, area, and duration curves of the probable maximum storm event equivalent to the Winter PMP should be identified. (OPG, 2017)

The anticipated resulting roof loading will be situated in the range of 3.0-4.5 kPa.

2.12.7.3 Risks

None.

2.12.7.4 Impacted Chapter 2 Sections

Subsection 2.6.9 – Snow and Ice Load

2.12.7.5 Progress of Work

1. Work is completed and a final report is delivered and accepted by OPG

2. OPG issued, in December 2022, the report as NK054-REP-02730-00004, “Winter PMP Validation,” Ontario Power Generation.
3. The report has the following contents
    1. Introduction
    2. Existing Values
    3. Winter PMP Usage
    4. Conclusions
    5. References

Work is complete and results are incorporated in impacted sections Chapter 2

Deliverables:

1. NK054-REP-02730-00004 R000, 2022, “Winter PMP Validation”, Ontario Power Generation (SNC Lavalin ID 690633-0000-4HER-004 R01)

2.12.8 Confirmation of Probable Maximum Precipitation

2.12.8.1 Background

Subsection 2.6.4 describes the rainfall and PMP for the Darlington Nuclear site (which includes the DNNP site). Also, Subsection 2.12.4 describes an ongoing work to update the PMP and Probable Maximum Flood for the DNNP site for BWRX-300 unit 1, with potential three additional units.

This information is being supplemented by PMP Validation work being added to Subsection 2.12.4. The supplementary work is to satisfy the requirements of N291 of 100 years return period for safety related structures (similar to wind and snow), and to ensure information in: the recommendation of 21 mm for storm H (in Table 3-1 of the contractor’s preliminary report) meets the NBCC as a minimum (as NBCC value for 15 min is 23mm).

2.12.8.2 Project Schedule and Logic

Confirmation work is ongoing. Subsection 2.6.4 is expected to be updated, as required, in the subsequent revision of the PSAR Chapter 2.

2.12.8.3 Assumptions

None

2.12.8.4 Risks

None

2.12.8.5 Impacted Chapter 2 Sections

Subsection 2.6.4 – Rainfall

2.12.8.6 Progress of Work

1. Work is completed and a final report is delivered and accepted by OPG
2. OPG issued, in December 2022, the report as NK054-REP-02730-00002, “PMP Validation,” Ontario Power Generation.
3. The report has the following contents
    1. Introduction

2. Storms
    a. PMP Validation
    b. Plant Parameter Envelop Storms
    c. National Building Code of Canada Storms
3. Conclusions
4. References

Work is complete and results are incorporated in impacted sections Chapter 2

Deliverables:

1. NK054-REP-02730-00002 R000, 2022, "PMP Validation", Ontario Power Generation (SNC Lavalin ID 690633-0000-4HER-002 R01)

2.12.9 References

2.12-1 NEDO-33914-A, Revision 2, 2022, "BWRX-300 Advanced Civil Construction and Design Approach," GE-Hitachi Nuclear Energy Americas, LLC.

2.12-2 NK054-REP-01210-00078 R007, "Darlington New Nuclear Project Commitments Report," Ontario Power Generation.

2.12-3 NK054-PLAN-01210-00033, Site Geotechnical and Seismic Hazard Investigation Plan," Ontario Power Generation.

2.12-4 NK054-REP-01210-00012-R01, "Site Evaluation of the OPG New Nuclear at Darlington - Part 5: Flood Hazard Assessment," Ontario Power Generation.

2.12-5 NK054-PLAN-07007-00001 R000, 2023, "Darlington New Nuclear Project Strategy for Addressing Climate Change Impacts", Ontario Power Generation.

2.13 Appendices

Appendix A List of Industrial Facilities within the Survey Area

Appendix B List of Roads within the Survey Area

Appendix C List of Park Spaces and Water Bodies within the Survey Area

APPENDIX A – List of Industrial Facilities within the Survey Area

Company Name	Location
McAshpalt Industries Ltd. - Oshawa Facility	Bottom of Farewell Street
Gerdau Metals Recycling - Oshawa	Waterloo Crt
TMT Salvage & Metal Recyclers	SE Corner - Nelson St & Waterloo Crt
D. Crupi & Sons Ltd.	NE Corner - Nelson St & Wellington Ave E.
Allmix Concrete Oshawa	NE Corner - Farewell St & Harbour Rd.
Coco Paving Plant	SE Corner - Wilson Rd N & Taunton Rd
Covanta Durham York	Courtice Rd. & Megawatt Dr
Courtice Water Pollution Control Plant (WPCP)	Osbourne Rd.
Miller Compost	Baseline Rd & Hancock Rd.
Hydro One Bowmanville SS	Toward bottom of Holt Rd.
St. Marys Cement Group	Bottom of Bowmanville Ave.
CBM Aggregates	Waverley Rd.
Port Darlington WPCP	E Shore Dr.
Bowmanville Water Supply Plant	E Beach Rd.

APPENDIX B – List of Roads within the Survey Area

Name of Road / Highway / Station	Direction	Road Type
Highway 401	W-E	Hwy
Highway 418	N-S	Hwy
Highway 407	W-E	Hwy
Baseline Road W	W-E	Arterial
Courtice Road	N-S	Arterial
2nd Line W	Internal	Minor Arterial
Park Rd	N-S	Minor Arterial
Energy Dr	W-E	Arterial
Symons Rd	N-S	Minor Arterial
Crago Rd	N-S	Minor Arterial
Megawatt Dr	W-E	Minor Arterial
Osbourne Rd	N-S	Minor Arterial
Darlington Park Rd	W-E	Minor Arterial
Down Rd	N-S	Minor Arterial
Holt Rd	N-S	Arterial
Martin Rd S	N-S	Minor Arterial
Colonel Sam Dr	W-E	Minor Arterial
Cedar Crest Beach Rd	W-E	Minor Arterial
Cove Rd	W-E	Minor Arterial
W Beach Rd	N-S	Minor Arterial
Main St	W-E	Minor Arterial
E Beach Rd	W-E	Minor Arterial
Port Darlington Rd	N-S	Minor Arterial
Lake Rd	W-E	Minor Arterial
S Service Rd	N-S	Minor Arterial
Lookout Dr	W-E	Minor Arterial
Bennett Rd	N-S	Arterial
Wilmot Creek Dr	N-S	Minor Arterial
Heatherlea Dr		Residential
Hinkley Tr		Residential
Cliff Dr		Residential
Fir Dr		Residential
Niagara Tr		Residential
Wilmot Tr	W-E	Minor Arterial
Little Brook Rd		Residential
Bluffs Rd		Residential
Heritage Ln		Residential
The Cove Rd		Residential
Steelhead Ln		Residential
Fairway Dr		Residential
Service Rd	W-E	Minor Arterial
Bloor St E	W-E	Arterial
Farewell St	N-S	Minor Arterial
Veterans Rd	W-E	Minor Arterial
Wilson Rd S	N-S	Minor Arterial
Raleigh Ave	W-E	Minor Arterial

Name of Road / Highway / Station	Direction	Road Type
Wentworth St W	W-E	Arterial
Marwood Dr	W-E	Minor Arterial
Harbour Rd	W-E	Arterial
Drake St	N-S	Minor Arterial
Holland St	N-S	Minor Arterial
Simcoe St S	N-S	Arterial
Nelson St	N-S	Minor Arterial
Ritson Rd S	N-S	Arterial
Dnipro Blvd	W-E	Minor Arterial
Conant St	W-E	Residential
Sylvia St		Residential
Myers St		Residential
Sharon Ave		Residential
Trafalgar Ave		Residential
Waterloo St / Crt		Residential
Tilbury St		Residential
Wellington Ave E		Residential
Kawartha Ave	W-E	Minor Arterial
Southlawn Ave	W-E	Minor Arterial
Cloverdale St	N-S	Minor Arterial
Grassmere Crt		Residential
Ravine Rd	N-S	Minor Arterial
Sandra St W/E		Residential
Wolfe St	W-E	Minor Arterial
Daniel St		Residential
Douglas St	N-S	Minor Arterial

Name of Road / Highway / Station	Direction	Road Type
4th Ave	W-E	Minor Arterial
Annis St	W-E	Minor Arterial
Rowena St	N-S	Minor Arterial
Gifford St		Residential
Phillips St		Residential
Merritt St		Residential
Knights Rd		Residential
Cedar St		Residential
Erie St		Residential
Whiting Ave	N-S	Minor Arterial
Robson St		Residential
Frank St		Residential
Valley Dr	W-E	Minor Arterial
Wecker Dr	W-E	Minor Arterial
Outlet Dr		Residential
Birchcliffe Ave	N-S	Minor Arterial
Kluane Ave	N-S	Minor Arterial
Rondeau Crt		Residential
Madawaska Ave		Residential
Sauble St		Residential
Quetico Ave / Crt		Residential
Georgian Crt		Residential
Fundy St / Crt		Residential
Phillip Murray Ave		Residential
Chaleur Ave		Residential
Sharbot St		Residential
Minden St		Residential
Scugog Ave		Residential

Name of Road / Highway / Station	Direction	Road Type
Jasper Ave		Residential
Banff Ave		Residential
Geneva Ave		Residential
Thomas St	W-E	Minor Arterial
Tamarack Crt		Residential
Erie St		Residential
Grandview Dr	W-E	Minor Arterial
Downview Cres	W-E	Minor Arterial
Endna Crt		Residential
Welsey Dr	N-S	Minor Arterial
Down Cres		Residential
Norman Cres		Residential
Southdown Dr	N-S	Minor Arterial
Southdale Ave	W-E	Minor Arterial
Southgate Dr	N-S	Minor Arterial
Southridge St	N-S	Minor Arterial
Southport Dr		Residential
Townline Rd S	N-S	Minor Arterial
Gord Vinson Ave	W-E	Minor Arterial
Kilgannon Ave		Residential
Pickard Gate		Residential
Cornish Dr	N-S	Minor Arterial
Staples Ave		Residential
Bingham Gate		Residential
Dudley Crt		Residential
Cousins St		Residential

Name of Road / Highway / Station	Direction	Road Type
Fenning Dr	N-S	Minor Arterial
Stainton St		Residential
Roy Nichols Dr		Residential
Southfield Ave		Residential
Aylesworth Ave		Residential
Montague Ave		Residential
Frank Wheeler Ave		Residential
Eastfield Cres		Residential
Rosswell Dr		Residential
Dewell Cres		Residential
Bathgate Cres		Residential
Kersey Cres		Residential
Prestonvale Rd	N-S	Arterial
Trulls Rd	N-S	Arterial
Cigas Rd	W-E	Minor Arterial
Hancock Rd	N-S	Arterial
McKnight Rd		Residential
Courtice Crt		Residential
Solina Rd	N-S	Arterial
Rundle Rd	N-S	Arterial
Maple Grove Rd	N-S	Arterial
Boswell Dr	N-S	Minor Arterial
Ivory Crt		Residential
Shady Lane Cres		Residential
Bonathan Cres		Residential
Connors Crt		Residential
Rustwood St		Residential
Weldick Cres		Residential
Padfield Dr		Residential
Hammond St		Residential

Name of Road / Highway / Station	Direction	Road Type
Oxley Crt		Residential
Collier Ln		Residential
Dystra Ln		Residential
Sidney Ln		Residential
Connell Ln		Residential
Farmstead Dr		Residential
Autumn harvest Rd		Residential
McBride Ave		Residential
Buxton Ln		Residential
Buttonshaw St	N-S	Minor Arterial
Woolacott Ln		Residential
McPhail Ave		Residential
Shackleton St		Residential
Kimble Ave		Residential
Remmington St	W-E	Minor Arterial
Butson Cres		Residential
Green Rd	N-S	Arterial
Clarington Blvd	N-S	Minor Arterial
Prince William Blvd	W-E	Minor Arterial
Pethick St	N-S	Minor Arterial
Aspen Springs Dr	W-E	Minor Arterial
Baxter St	N-S	Minor Arterial
West Side Dr		Residential
Landerville Ln		Residential
Fry Cres		Residential
Vail Meadows Cres		Residential
Glen Ray Crt		Residential

Name of Road / Highway / Station	Direction	Road Type
Hartwell Ave		Residential
Candler Crt		Residential
Prestonway Dr		Residential
Bonnycastle Dr		Residential
Luttrell St		Residential
Higgon St		Residential
Brodie Crt		Residential
Martin Rd	N-S	Minor Arterial
Bagnell Cres		Residential
Abernethy Cres		Residential
Penfound Dr		Residential
Alonna St		Residential
Clancy Ln		Residential
Bottrell St		Residential
Squires Gt		Residential
Roser Cres		Residential
Walbridge Crt		Residential
Woolner Ln		Residential
Dodds Sq		Residential
Millburn Dr		Residential
Bannister St		Residential
Spicer Sq	W-E	Minor Arterial
Bowmanville Ave	N-S	Arterial
Kings Hill Ln		Residential
McCrimmon Cres		Residential
Wrenn Blvd		Residential
Rhonda Blvd	N-S	Minor Arterial
Chapel St		Residential
Roenigk Dr	W-E	Minor Arterial

Name of Road / Highway / Station	Direction	Road Type
Waverley Rd	N-S	Minor Arterial
Strike Ave		Residential
Little Ave		Residential
Cole Ave		Residential
Trewin Ln		Residential
Lawrence Gt / Cres	N-S	Minor Arterial
Hetherington Dr		Residential
Holgate Cres		Residential
Doreen Cres		Residential
Quinn Dr		Residential
The Bridle Path		Residential
Park Ln Circ		Residential
Hillier St		Residential
Rosalynne Ave		Residential
Spry Ave		Residential
Carruthers Dr		Residential
Loscombe Dr		Residential
John Scott Ave		Residential
Lockhart Gt		Residential
Sandringham Dr	W-E	Minor Arterial
Short Cres		Residential
Avondale Dr	N-S	Minor Arterial
Caleche Ave		Residential
Richard Gay Ave		Residential
Stagemaster Cres		Residential
Fieldcrest Ave	N-S	Minor Arterial
Pingle Dr		Residential
Farmington Dr		Residential
Stonefield St		Residential

Name of Road / Highway / Station	Direction	Road Type
Wilkins Cres		Residential
Brownstone Cres		Residential
Hearthstone Cres		Residential
Weaver St		Residential
Phair Ave		Residential
Stirling Ave		Residential
Kennedy Dr		Residential
Faircomb Cres		Residential
McMann Cres		Residential
Strahallan Dr	W-E	Minor Arterial
Bushford St		Residential
Buyson Cres		Residential
Poolton Cres		Residential
Stuart Rd		Residential
Stephen Ave		Residential
Lyndale Cres		Residential
Claret Rd		Residential
Windham Cres		Residential
Parklawn Dr		Residential
Hillhurst Cres		Residential
Inglis Ave		Residential
Yorkville Dr	W-E	Minor Arterial
Granville Dr	N-S	Minor Arterial
Glenabbey Dr	W-E	Minor Arterial
Beechnut Cres		Residential
Rex Tooley Ln		Residential
Oke Rd		Residential
John Walter Cres		Residential
William Ingles Dr		Residential
Wade Sq		Residential

Name of Road / Highway / Station	Direction	Road Type
Adair St		Residential
Katerson Ln		Residential
Meadowglade Rd	W-E	Minor Arterial
Worden Dr		Residential
Hayman St		Residential
Cameron Ferguson St		Residential
Arnold Johnston St		Residential
Old Kingston Rd	W-E	Minor Arterial
Osgoode Gt		Residential
Robert Adams Dr	N-S	Minor Arterial
Renwick Rd		Residential
White Cliffe Dr		Residential
Halstead Rd		Residential
Hathaway Dr		Residential
Decoe Crt		Residential
Mulholland Crt		Residential
Worthington Dr		Residential
Sagewood Ave		Residential
Thornbury St		Residential
Saddlebrook Crt		Residential
Glen Eagles Dr		Residential
Pears Crt		Residential
Sheenan Crt		Residential
Hampstead Gt		Residential
Cale Ave		Residential
McRoberts Cres		Residential
Ferris Sq		Residential
Huntington Cres		Residential
Shuttleworth Dr		Residential

Name of Road / Highway / Station	Direction	Road Type
Partner Dr		Residential
Beckett Cres		Residential
Auburn Ln		Residential
Hemmingway Dr		Residential
Bruntsfield St		Residential
Newport Ave		Residential
Pebble Beach Dr		Residential
Pinedale Cres		Residential
Summerlea Crt		Residential
Turnberry Cres		Residential
Darlington Blvd	N-S	Minor Arterial
Foxhunt Tr		Residential
Empire Cres		Residential
Kingsview Crt		Residential
Edinborough Ln		Residential
Kingswood Dr		Residential
Kingsway Gt		Residential
Barron Crt		Residential
Olive Ave	W-E	Arterial
Birkdale Crt		Residential
Sunnybrae Cres		Residential
Cherrydown Dr	W-E	Minor Arterial
Pinehurst Ave		Residential
Sunningdale Ave		Residential
Capilano Cres		Residential
Annandale St		Residential
Augusta Crt		Residential
Glenridge Crt		Residential
Labrador Dr		Residential
McClure Crt		Residential
Athabasca St	N-S	Minor Arterial

Name of Road / Highway / Station	Direction	Road Type
Sutton Ave		Residential
Maclaren St		Residential
Erinlea Ave		Residential
Wakefield Cres		Residential
Eastlawn St	N-S	Minor Arterial
Merivale Crt		Residential
Carling Ave		Residential
Winter Ave		Residential
Mackenzie Ave		Residential
Kingsmere Ave		Residential
Belvedere Ave		Residential
Lisgar Ave		Residential
Thorncliffe St		Residential
Ridgecrest Ave		Residential
Gatineau St		Residential
Eton St		Residential
Windermere St		Residential
Cumberland Crt		Residential
Ellesmere Crt		Residential
Springdale Crt		Residential
Keewatin St S	N-S	Minor Arterial
Oriole Crt		Residential
Applegrove Ave		Residential
Oriole St		Residential
Melrose St		Residential
Basswood Ave / Crt		Residential
Viewmount St		Residential
Palm Crt		Residential
Hawthorne Crt		Residential
Lorindale Dr	N-S	Minor Arterial

Name of Road / Highway / Station	Direction	Road Type
Ivy Crt		Residential
Martindale St		Residential
Oakdale Dr		Residential
Queensdale Ave		Residential
Walnut Crt		Residential
Carnation Crt		Residential
Capri Crt		Residential
Florell Dr	N-S	Minor Arterial
Harcourt Dr		Residential
Dianne Dr	N-S	Minor Arterial
Karen Crt		Residential
Brenda Crt		Residential
Susan Crt		Residential
Denise Dr		Residential
Ronlea Ave		Residential
Carolyn Ave		Residential
Cherryhill St		Residential
St Andrews St		Residential
Augusta Ave		Residential
Palace St	W-E	Minor Arterial
Brunswick St / Crt		Residential
Riverside Dr N/S	N-S	Minor Arterial
Hoskin Ave		Residential
Taylor Ave	W-E	Minor Arterial
Poplar St / Crt		Residential
Linden St / Crt		Residential
Elmridge St		Residential
Wicklow Dr		Residential
Chesterton Ave		Residential

Name of Road / Highway / Station	Direction	Road Type
Browning St		Residential
Shelley Ave		Residential
Tennyson Ave / Crt		Residential
Milton St		Residential
Emerson Ave / Crt		Residential
Coleridge St		Residential
Whitman Cres		Residential
Dean Ave	W-E	Minor Arterial
Addison Cres		Residential
Carman Crt		Residential
Shakespeare Ave	W-E	Minor Arterial
Byron Crt		Residential
Keates Ave		Residential
Chaucer Ave		Residential
Macaulay St		Residential
Loring St		Residential
Austen Crt		Residential
Guelph St	N-S	Minor Arterial
Baldwin St	N-S	Minor Arterial
Windsor St	N-S	Minor Arterial
Crerar Ave	W-E	Minor Arterial
Gliddon Ave	W-E	Minor Arterial
Devon Ave		Residential
Athol St E	W-E	Minor Arterial
Highland Ave	N-S	Minor Arterial

Name of Road / Highway / Station	Direction	Road Type
Cadillac Ave N / S	N-S	Minor Arterial
Lasalle Ave	N-S	Minor Arterial
Central Park Blvd N/S	N-S	Minor Arterial
Arthur St	W-E	Minor Arterial
Bruce St	W-E	Minor Arterial
Oshawa Blvd N/S	N-S	Minor Arterial
Rowe St		Residential
Eulalie Ave	W-E	Minor Arterial
Festhubert Ave		Residential
Courcellette Ave		Residential
Vimy Ave		Residential
Verdun Rd		Residential
St Eloi Ave		Residential
Chadburn Crt		Residential
Mitchell Ave	W-E	Minor Arterial
Viola St		Residential
Kitchener Ave		Residential
Monsah Ave		Residential
Currie Ave		Residential
Montgomery St		Residential
Christine Cres		Residential
Nevis Ave		Residential
Normandy St		Residential
Lomond St		Residential
Dieppe Ave / Crt		Residential
Sterling Ave		Residential
Hillcrest Dr		Residential
Dunkirk Ave		Residential

Name of Road / Highway / Station	Direction	Road Type
Sedan Cres		Residential
Brest Crt		Residential
Drew St	N-S	Minor Arterial
Huron St	N-S	Minor Arterial
Charles St	N-S	Minor Arterial
Court St		Residential
Mary St N / S	N-S	Arterial
Albert St	N	Minor Arterial
Celina St	S	Minor Arterial
John St W / E	W-E	Minor Arterial
Emma St	W-E	Minor Arterial
Hogarth St		Residential
Wilkinson Ave		Residential
Elm St	W-E	Minor Arterial
Maple St		Residential
Banting Ave	W-E	Minor Arterial
Barrie Ave	W-E	Minor Arterial
McKim St		Residential
Summer St		Residential
Stacey Ave	W-E	Minor Arterial
Tylor Cres		Residential
George St		Residential
Edward Ave		Residential
Graburn Ave		Residential
Beatty Ave		Residential
McNaughton Ave		Residential

Name of Road / Highway / Station	Direction	Road Type
Etna Ave		Residential
Toronto Ave		Residential
Jackson Ave		Residential
Howard St	N-S	Minor Arterial
First Ave	W-E	Minor Arterial
Lviv Blvd		Residential
Third Ave		Residential
Front St	N-S	Minor Arterial
Elena Ave		Residential
Albany St		Residential
Fisher St		Residential
Ray St	N-S	Minor Arterial
Ontario St	N-S	Minor Arterial
Richmond St E	W-E	Minor Arterial
Colborne St E	E	Minor Arterial
Brock St E	W	Minor Arterial
Elgin St E	W-E	Minor Arterial
Dearborn Ave		Residential
Kendal Ave		Residential
Carriage Works Dr	N-S	Minor Arterial
William St E	W-E	Minor Arterial
Divison St	N-S	Minor Arterial
Agnes St		Residential
kenneth Ave	N-S	Minor Arterial

Name of Road / Highway / Station	Direction	Road Type
Roxborough Ave	N-S	Minor Arterial
Patricia Ave		Residential
Delroy Crt		Residential
Westminister Ave		Residential
Beverly St		Residential
Luke St		Residential
Oakes Ave		Residential
Lasalle Crt		Residential
Rogers St		Residential
Dover St		Residential
Digby Ave		Residential
Surrey Dr		Residential
Coventry Crt		Residential
Landsdowne Dr		Residential
Sussex St		Residential
Claymore Cres		Residential
Cambridge Ave		Residential
Regent Dr	W-E	Minor Arterial
Eastglen Dr		Residential
Easthaven St		Residential
Florian Crt		Residential
Eastgrove Ave		Residential
Eastdale Ave		Residential
Eastbourne Ave		Residential
Ascot Crt		Residential
Arden Dr / Crt		Residential
Acadia Dr		Residential
Eastmount St		Residential
Parklane Ave		Residential
Woodlane Crt		Residential
Baker Crt		Residential

Name of Road / Highway / Station	Direction	Road Type
Beaufort Ave / Crt		Residential
Southwood St		Residential
Conifer St		Residential
Cherry St		Residential
Holly Crt		Residential
Cleta Crt		Residential
Briar Crt		Residential
Laurel Crt		Residential
Heather Crt		Residential
Newbury Ave		Residential
Grandview St N	N-S	Minor Arterial
Cardinal Crt		Residential
Bluefinch Crt		Residential
Blue Heron Dr		Residential
Killdeer Dr		Residential
Bluejay Cres		Residential
Norwood Crt		Residential
Fleetwood Dr		Residential
Eldorado Ave		Residential
Belair Cres		Residential
Kingsway College Dr		Residential
Rockcliffe St		Residential
Maracle Rd		Residential
Violet Hall Rd		Residential
Clarence Biesenthal Dr		Residential
Leland Rd		Residential
Wilbert Bresett Rd		Residential
Wagar Crt		Residential
Shankel Rd		Residential
Bradenton Path		Residential

Name of Road / Highway / Station	Direction	Road Type
Apollo St		Residential
Malibu St		Residential
Wood St		Residential
Rolson St		Residential
Haig St		Residential
French St		Residential
Jarvis St	N-S	Minor Arterial
Kingsdale Ave / dr		Residential
Leslie Ave		Residential
Aberdeen St		Residential
Masson St	N-S	Minor Arterial
Leslie St		Residential
Rosedale Ave	W-E	Minor Arterial
Grove Ave		Residential
Sutherland Ave		Residential
Connaught St		Residential
Hillcroft St	W-E	Minor Arterial
Adeline Ave		Residential
Trick Ave		Residential
Pearson St		Residential
Greta St	W-E	Minor Arterial
Grierson St		Residential
Minto St / Crt		Residential
Hillsdale Ave		Residential
Laracor Ln		Residential
Jasmine Cres		Residential
Lilac Crt		Residential
Tulip Crt		Residential

Name of Road / Highway / Station	Direction	Road Type
Darcy St	W-E	Minor Arterial
Juniper St / Crt		Residential
Violet Crt		Residential
Verbana Crt		Residential
Wildflower Crt		Residential
Marigold Ave / Crt		Residential
Robert St	W-E	Minor Arterial
Gardenia Crt		Residential
Orchid Crt		Residential
Lavender Crt		Residential
Marica Ave		Residential
Caledon Crt		Residential
Spirea Crt		Residential
Sycamore Cres		Residential
Iris Crt		Residential
Trillium Crt		Residential
Beatrice St E	W-E	Minor Arterial
Lobelia Crt		Residential
Nonquon Rd		Residential
Pentland St		Residential
Lauder Rd		Residential
Maplewood Dr		Residential
Orange Cres		Residential
Juliana Dr		Residential
Bernhard Cres		Residential
Amstel Cres		Residential
Marken Cres		Residential
Arnhem Dr		Residential
Holcan Ave		Residential
Fernwood Ave		Residential
Rembrandt Crt		Residential

Name of Road / Highway / Station	Direction	Road Type
Crestwood Dr		Residential
Everson Crt		Residential
Oakwood Ave		Residential
Brentwood Ave		Residential
Edgewood Ave		Residential
Beechwood St		Residential
Pinewood St		Residential
Dogwood Ave		Residential
Harwood Dr		Residential
Humewood Ave		Residential
Wychwood St		Residential
New Gate Ave		Residential
Clifton Dr		Residential
Rodney Crt		Residential
Lexington St		Residential
Exeter St	N-S	Minor Arterial
Mayfair Ave		Residential
Terrace Dr	N-S	Minor Arterial
Canonberry Crt		Residential
Ashley Crt		Residential
Hackney Crt		Residential
Carnaby Crt		Residential
William Booth Cres		Residential
Lambeth Crt		Residential
Charrington Ave		Residential
Whitehall Crt		Residential
Downing Crt		Residential
Tiffany Circ		Residential
Paddington Cres		Residential
Old Brampton Crt		Residential
Chelsea Crt		Residential

Name of Road / Highway / Station	Direction	Road Type
Old Pye Crt		Residential
Torrington Crt		Residential
Trowbridge Crt		Residential
Highgate Ave		Residential
Burnley Crt		Residential
Cardigan Crt		Residential
Compton Cres		Residential
Kensington Cres		Residential
Trowbridge Dr		Residential
Dover St		Residential
Brighton Crt		Residential
Aspen Crt		Residential
Gothic Crt / Dr		Residential
Greenbriar Dr		Residential
Grange Crt		Residential
Camelot Crt / Dr		Residential
Chancery Crt		Residential
Gaylord Dr		Residential
Merlin Crt		Residential
Percival Crt		Residential
Cavendish Crt		Residential
Lancelot Cres		Residential
Gentry Cres		Residential
Glebe Ave		Residential
Galahad Dr		Residential
Gladfern St		Residential
Pascoe Crt		Residential
Avery Crt		Residential
Deauville Crt		Residential
Attersley Dr		Residential
Bayla Crt		Residential
Foxrun Crt		Residential
Cricklewood Dr		Residential

Name of Road / Highway / Station	Direction	Road Type
Cobblehill Dr		Residential
Courville Crt		Residential
Bennett Cres		Residential
Mountjoy Crt		Residential
Hayes Ave		Residential
Lavis St / Crt		Residential
Storie Ave		Residential
Dyer Crt		Residential
Crowells St / Crt		Residential
Meadowhill Crt		Residential
Trailridge Cres		Residential
Cresthill Crt		Residential
Strawberry Crt		Residential
Pepperbush Crt		Residential
Elderberry Dr		Residential
Idylwood Crt		Residential
Greenlane Dr / Crt		Residential
Pondtail Crt		Residential
Beaconhill Crt		Residential
Snowberry St / Crt		Residential
Wolfberry Crt		Residential
Buttonbush Crt		Residential
Keswick Crt		Residential
Greystone Crt		Residential
Brasswinds Tr		Residential
Songbird Dr		Residential
Cascade Dr		Residential
Summerwood Hgts		Residential
Silverfox Crt		Residential
Grand Ridge Ave		Residential
Taggart Cres		Residential

Name of Road / Highway / Station	Direction	Road Type
Langley Circ / Gt		Residential
Walter Ave		Residential
Blackthorn St		Residential
Nina Crt		Residential
Cranberry St		Residential
Pinetree Crt		Residential
Thimbleberry Circ		Residential
Palmtree Cres		Residential
Lemans Ave		Residential
Safari Dr		Residential
Century St		Residential
Skylark Ave		Residential
Laguna St		Residential
Corsica Ave		Residential
Astra Ave		Residential
Le Sabre St		Residential
Andover Crt / Dr		Residential
Vega St		Residential
Nova St		Residential
Kilmaurs Ave / Crt		Residential
Dartmoor St		Residential
Hartgrove Ln		Residential
Aldershot Dr		Residential
Faywood Cres		Residential
Margate Dr		Residential
Nottingham Cres		Residential
Langford St		Residential
Shaftsbury St		Residential
Oldman Rd		Residential
Cotsworld Crt		Residential
Dickers Dr		Residential
Traddles Ave		Residential
Wickham St		Residential

Name of Road / Highway / Station	Direction	Road Type
Micawber St		Residential
Peggotry Circ		Residential
Copperfield Dr		Residential
Steerforth St		Residential
Coyston Crt / Dr		Residential
Beneford Rd		Residential
Jim Brewster Circ		Residential
Drinkle Cres		Residential
Wadebridge Cres		Residential
Autumnwood Tr		Residential
Kettering Dr		Residential
Krawchuk Cres		Residential
Oxbow Cres		Residential
Aldsworth Cres		Residential
Cronk Crt		Residential
Hanmore St / Crt		Residential
Baynes Ave		Residential
Maddock Dr / Crt		Residential
Corbetts Rd		Residential
Grandlea Crt		Residential
Ripley Cres		Residential
Kingsley Crt		Residential
Lindsay Blvd		Residential
Sproule Cres		Residential
Stone Cottage Cres		Residential
Royal Orchard Dr		Residential
Ridge Valley Dr		Residential
Sandcliff Dr		Residential
Rathburn St		Residential
Trail Valley Dr		Residential
Pondview Crt		Residential

Name of Road / Highway / Station	Direction	Road Type
Edward Bolton Cres		Residential
Tall Pine Crt		Residential
Glenbourne Dr / St / Crt		Residential
Glaspell Cres		Residential
Gyatt Cres		Residential
Whitelaw Ave		Residential
Stire St		Residential
Meath dr		Residential
Magnolia Ave		Residential
Ashgrove Cres		Residential
Liveoak St		Residential
Ridgemount Blvd		Residential
Macinally Crt		Residential
Benson St		Residential
Mountview Dr / Crt		Residential
Highbrooke Crt		Residential
Summitview Cres		Residential
Forest Hill Crt		Residential
Springbank Dr		Residential
Westridge Dr / Crt		Residential
Roseheath St		Residential
Hinterland Crt		Residential
Swiss Hgts		Residential
Matterhorn St		Residential
Oberland Dr		Residential
Interlake Dr		Residential
William Tell Dr		Residential
Briarwood Dr		Residential
Pinecrest Rd		Residential
Bridle Crt		Residential
Varcoe Rd		Residential

Name of Road / Highway / Station	Direction	Road Type
Dale Park Dr		Residential
Dalepark Dr		Residential
Cherry Blossom Cres		Residential
Briar Hill Gate		Residential
Valleycrest Dr		Residential
Centrefield Dr		Residential
Belleview Crt		Residential
Windsor Valley Pl / Gt		Residential
Black Creek Tr		Residential
Carriage Ln		Residential
Barrington Pl		Residential
Nash Rd	W-E	Minor Arterial
Lawson Rd		Residential
Wabbokish Crt		Residential
Sheco Crt		Residential
Cloverfield St		Residential
Washburn Park		Residential
Spyfield Tr		Residential
Tooley Rd	N-S	Minor Arterial
Rowland Crt		Residential
McLellan Dr		Residential
Oban Crt		Residential
Alderbrook Dr		Residential
Goldpine Ave		Residential
Abbeywood Cres		Residential
Mossgrove Crt		Residential
Devondale St		Residential
George Reynolds Dr		Residential
Mull Cres		Residential

Name of Road / Highway / Station	Direction	Road Type
Birchfield Dr		Residential
Centrefield Dr		Residential
Homefield Sq		Residential
Oakfield Gt		Residential
Hartsfield Dr		Residential
Old Varcoe Rd		Residential
Mahaffy Pl		Residential
Springfield Ln		Residential
McLean Rd		Residential
Longwood Crt		Residential
Broadlands Cres		Residential
Firwood Ave		Residential
Kintyre St		Residential
Dunkin Ave		Residential
Arran Crt		Residential
Leith Crt		Residential
Jura Crt		Residential
Islay Crt		Residential
Mallory St		Residential
Daiseyfield Ave		Residential
Page Pl		Residential
Adelaide Ave		Residential
Niddery St		Residential
Vetzal Crt		Residential
Vivian Dr		Residential
Timberlane Crt		Residential
Sherry Ln		Residential
Prince Rupert Dr		Residential
Lord Duncan Crt		Residential
Firner St		Residential
Fices Rd		Residential
Richfield Sq		Residential
Westmore St		Residential

Name of Road / Highway / Station	Direction	Road Type
Lynwood Ave		Residential
Glenview Rd		Residential
Fourth Ave		Residential
Jane Ave		Residential
Sleeman Sq		Residential
Cecil Found Cres		Residential
Pidduck St		Residential
Meredith Crt		Residential
Skinner Crt		Residential
Pebblestone Rd	W-E	Minor Arterial
Tyler St		Residential
Leith Crt		Residential
Bradley Blvd		Residential
Progress Dr		Residential
Fewster St		Residential
Jolliffe St		Residential
Living Crt		Residential
Moyse Dr		Residential
Moulton Crt		Residential
Simnick Cres		Residential
Harry Gay Dr		Residential
Duval St		Residential
Tabb St		Residential
Elmer Adams Dr		Residential
Holyrod Dr		Residential
Arthur Trewin St		Residential
Gordon Cowling St		Residential
Brookhill Blvd		Residential
Meachin gt		Residential

Name of Road / Highway / Station	Direction	Road Type
Hovey Ln		Residential
Ted Miller Cres		Residential
Daigle Ln		Residential
Purdy Pl		Residential
Quick Tr		Residential
Murray Tabb St		Residential
Harvey Jones Ave		Residential
Summersford Dr		Residential
Gough Ln		Residential
Carl Raby St		Residential
Forsey Ln		Residential
Ross Wright Ave		Residential
Kilpatrick Crt		Residential
Stevens Rd	W-E	Minor Arterial
Uptown Ave		Residential
Old Scugog Rd	N-S	Minor Arterial
Buttery Crt		Residential
Maryleah Crt		Residential
Taunus Crt		Residential
Glenelge Crt		Residential
Craig Crt		Residential
Munday Crt		Residential
Wellington St		Residential
Sturrock Ave		Residential
Rehder Ave		Residential
Edsall Ave		Residential
Frederick Ave		Residential
Luvmere Crt		Residential
Linden Ln		Residential
Barbara St		Residential

Name of Road / Highway / Station	Direction	Road Type
Jackman Rd		Residential
Don Morris Crt		Residential
Mill Ln		Residential
West Scugog Ln		Residential
Terry Cres		Residential
Willoughby Pl		Residential
Kaukonen Crt		Residential
Crockett Pl		Residential
N Scugog Crt		Residential
Westover Dr		Residential
Piper Cres		Residential
Hockley Ave		Residential
Nicks St		Residential
Childs Crt		Residential
Bons Ave		Residential
Lunney Cres		Residential
Goddall Cres		Residential
Dan Sheehan Ln		Residential
Edwin Carr St	N-S	Minor Arterial
Kenneth Cole Dr		Residential
Carey Ln		Residential
Richard Davies Cres		Residential
Robb Ln		Residential
Sidney Rundle Ave		Residential
Northglen Blvd	W-E	Minor Arterial
Loana Ln		Residential
Jerome Way		Residential
Moses Cres		Residential
Crombie St		Residential

Name of Road / Highway / Station	Direction	Road Type
John Matthew Cres		Residential
Jack Roach St		Residential
Ray Richards St		Residential
Fred Jackman Ave		Residential
William Fair Dr		Residential
Bruce Cameron Dr		Residential
Arthur McLaughlin St		Residential
Henry Smith Ave		Residential
Temperance St	N-S	Minor Arterial
Silver St		Residential
Brown St		Residential
Church St	W-E	Minor Arterial
Horsey St		Residential
Beech Ave		Residential
Lowe St		Residential
Liberty Pl		Residential
Carlisie Ave		Residential
Centre St		Residential
Grants Ln		Residential
Alexander Blvd		Residential
Lovers Ln		Residential
Concession St W / E	W-E	Minor Arterial
O'Dell St		Residential
Prospect St	N-S	Minor Arterial
High St		Residential
Burk Crt		Residential
Borland Crt		Residential
Saunders Crt		Residential

Name of Road / Highway / Station	Direction	Road Type
Lorraine Crt		Residential
Prout Dr		Residential
Lambs Ln		Residential
Elgin St E		Residential
First St		Residential
2nd St		Residential
3rd St		Residential
Bernard St		Residential
Summerfield Crt		Residential
Sunset Rd		Residential
Vanstone Crt		Residential
Sunicrest Crt		Residential
Veterans Ave		Residential
4th St		Residential
Hilltop Dr		Residential
Shoreview Dr / Crt		Residential
Meadowview Blvd		Residential
Aldcroft Cres		Residential
Clayton Cres		Residential
Argent St		Residential
Longworth Ave	W-E	Minor Arterial
Daley Ave		Residential
Hogan cres		Residential
Markham Tr		Residential
Streathern Way		Residential
Ken Bromley Lane		Residential
Somerscales Dr		Residential
Laurelwood St		Residential
Willey Dr		Residential
Birmingham Ave		Residential
Goodwin Ave		Residential

Name of Road / Highway / Station	Direction	Road Type
Honeyman Dr		Residential
Darryl Caswell Way		Residential
Allworth Cres		Residential
Allison St		Residential
Lander Cres		Residential
Colville Ave		Residential
Wyse Gt		Residential
Gimblett St		Residential
Courtney St		Residential
Brough Crt		Residential
McCorkell St		Residential
Jennings Dr		Residential
Keeler Cres		Residential
David Baker Crt		Residential
Bavin St		Residential
Higbee Ln		Residential
Ambereen Pl		Residential
Concession Road 3	W-E	Minor Arterial
Northglen Blvd	N-S	Minor Arterial
John Stalker Dr		Residential
Harry Lee Cres		Residential
Higham Pl		Residential
Rebecca Crt		Residential
Pamela Crt		Residential
Avi Crt		Residential
Sydel Crt		Residential
Gary Crt		Residential
Middle Rd	N-S	Minor Arterial
Concession Road 4	W-E	Minor Arterial

Name of Road / Highway / Station	Direction	Road Type
Liberty St N	N-S	Arterial
Scugog St	N-S	Arterial
Soper Crt		Residential
Hobbs Dr		Residential
Duke St		Residential
Wharf St		Residential
Simpson Ave		Residential
Mearns Crt		Residential
Caristrap St		Residential
Lambs Rd	N-S	Minor Arterial
Haines St	N-S	Minor Arterial
Parkway Ave / Cres		Residential
Flett St		Residential
Southway Dr		Residential
Nelson St		Residential
Morgandale Cres		Residential
Deerpark Cres		Residential
Jane St		Residential
Wilde Crt		Residential
Hailey Crt		Residential
Ashdale Cres		Residential
Prince St		Residential
Frank St		Residential
Queen St	W-E	Minor Arterial
Mearns Ave	N-S	Minor Arterial
Lambert St		Residential
Church St		Residential
Kingscourt Rd		Residential
Galbraith Crt		Residential

Name of Road / Highway / Station	Direction	Road Type
Climie Crt		Residential
Royal Pines Crt		Residential
Orchard Park Dr		Residential
Peachtree Cres		Residential
Strathmanor Dr		Residential
Merryfield Crt		Residential
Trudeau Dr		Residential
Marchwood Cres		Residential
Orr Cres		Residential
Hendy Gt		Residential
Dadson Dr		Residential
Squire Fletcher Dr		Residential
McFeeters Cres		Residential
Clinton Crt		Residential
Soper Creek Dr		Residential
Downham Dr		Residential
Souch Crt		Residential
Barley Mill Cres		Residential
Farncomb Cres		Residential
Herriman St		Residential
Mann St		Residential
Tucker Rd		Residential
Baker Crt		Residential
Apple Blossom Blvd		Residential
Glanville Cres		Residential
Tilley Rd		Residential
Bradshaw St		Residential
Maconnachie Pl		Residential
Kershaw St		Residential
Chance Crt		Residential
Edgerton Dr		Residential

Name of Road / Highway / Station	Direction	Road Type
Swindells St		Residential
Flaxman Ave		Residential
Forrester Dr		Residential
Redfern Cres		Residential
Elephant Hill Dr		Residential
Ireland St		Residential
Lyle Dr		Residential
Brent Cres		Residential
Scottsdale Dr		Residential
Assunta Ln		Residential
Courvier Cres		Residential
Quackenbush St		Residential
William Cowles Dr		Residential
Barlow Crt		Residential
Brooking St		Residential
Stephens Gulch Dr		Residential
Eldad Dr		Residential
Rickaby St		Residential
Dart Crt		Residential
Guildwood Dr		Residential
Lownie Crt		Residential
Budd Ln		Residential
Sprucewood Cres		Residential
Hutton Pl		Residential
Madden Pl		Residential
Cotton St		Residential
Taft Pl		Residential
Crough St		Residential
Hanna Dr		Residential
Laprade Sq		Residential
Lobb Crt		Residential

Name of Road / Highway / Station	Direction	Road Type
Fenwick Ave		Residential
Freeland Ave		Residential
Hanning Crt		Residential
Elford Dr		Residential
Pomeroy St		Residential
Bates Crt		Residential
Jollow Dr		Residential
Maxwell Crt		Residential
Hooper Sq		Residential
Champine Sq		Residential
Bethesda Rd	N-S	Minor Arterial
Stephen Mills Rd		Residential
Darlington Clarke Townline Rd	N-S	Minor Arterial
Bennett Rd	N-S	Minor Arterial
Baseline Rd E	W-E	Minor Arterial
Rickard Rd	N-S	Minor Arterial
Providence Rd	N-S	Minor Arterial
Bragg Rd	N-S	Minor Arterial
Taunton Rd	W-E	Arterial
Highway 2	W-E	Arterial
Cobbledick Rd	N-S	Minor Arterial
Lovekin Rd	W-E	Minor Arterial
Browview Rd	W-E	Minor Arterial
Gibson Rd		Residential
Pollard Rd	N-S	Minor Arterial

Name of Road / Highway / Station	Direction	Road Type
Concession Road 5	W-E	Minor Arterial
Hwy 115	N-S	Arterial
Canadian Pacific Railway North of Hwy 401	W-E	Rail
Canadian Pacific Railway South of Hwy 401	W-E	Rail
Oshawa Executive Airport		Airport
Port of Oshawa East Pier		Pier

APPENDIX C – List of Park Spaces and Water Bodies within the Survey Area

Park Spaces and Water Bodies	Location
Lakeview Park / Beach	Oshawa
Southmead Park	Oshawa
Lake Ontario	Multiple municipalities
Oshawa Creek	Oshawa
Cordova Park	Oshawa
Chopin Park	Oshawa
Eastview Park	Oshawa
Woodview Park	Oshawa
Connaught Park	Oshawa
Centennial Park	Oshawa
Central Park	Oshawa
Northway Court Park	Oshawa
North Oshawa Park	Oshawa
Hyde Park	Oshawa
Bathe Park	Oshawa
Conant Park	Oshawa
Kingside Park	Oshawa
Knights of Columbus Park	Oshawa
Eastbourne Park	Oshawa
Galahad Park	Oshawa
Attersley Park	Oshawa
Swiss Height Park	Oshawa
Iroquois Shoreline Park	Oshawa
Ridge valley Park	Oshawa
Corbett's Park	Oshawa
Harmony Valley Conservation Area	Oshawa
Easton Park	Oshawa
Baker Park	Oshawa

Park Spaces and Water Bodies	Location
Martindale Park	Oshawa
Harmony Village Park	Oshawa
Florell Park	Oshawa
Grandview North / South Park	Oshawa
Second Marsh Wildlife Area	Oshawa
McLaughlin Bay	Oshawa
McLaughlin Bay Wildlife reserve	Oshawa
Rosswell Park	Courtice
Terry Fox Park	Oshawa
"Oshawa Valleylands Conservation Area"	Oshawa
MacKenzie Park	Oshawa
Margate Park	Oshawa
Kettering Park	Oshawa
Pinecrest Park	Oshawa
Glenbourne Park	Oshawa
South Courtice Dog Park	Courtice
Gatehouse Parkette	Courtice
Glenabbey Park	Courtice
Courtice Duck Pond	Courtice
Tooley's Mill Park	Courtice
Courtice West Park	Courtice
Highland Park	Courtice
Penfound Park	Courtice
Bathgate Park	Courtice
Darlington Provincial Park	Bowmanville
Stuart Park	Courtice
Zion Park	Clarington
Avondale Park	Courtice
Alijco Beach	Courtice

Park Spaces and Water Bodies	Location
W & D Courtice Memorial Park	Courtice
Moyse Parkette	Courtice
Darlington Hydro Soccer Fields	Clarington
Darlington Waterfront Trail	Clarington
Burk Pioneer Cemetery	Clarington
Harvey Jones Park	Bowmanville
Green Park	Bowmanville
Baxter Park	Bowmanville
Baseline Park	Bowmanville
West Side Park	Bowmanville
Landerville Parkette	Bowmanville
Northglen park	Bowmanville
Douglas Kemp Parkette	Bowmanville
Bons Park	Bowmanville
"Bowmanville Valley Conservation Area"	Bowmanville
Rotary Park	Bowmanville
Bowmanville Creek Barrier Dam	Bowmanville
Waverley Park	Bowmanville
"Bowmanville Westside Conservation Area"	Bowmanville
Bowmanville Harbour	Bowmanville
Port Darlington West / East Beach	Bowmanville
Lions Parkette	Bowmanville
Nelson Parkette	Bowmanville
Argent Park	Bowmanville
Barlow Court Parkette	Bowmanville
Elephant Hill Park	Bowmanville

Park Spaces and Water Bodies	Location
Bowmanville Cemetery	Bowmanville
"Bowmanville Soper Creek Playground"	Bowmanville
Guildwood Park	Bowmanville
Stephen Gulch's Conservation Area	Bowmanville
Samuel Wilmont Natural Area	Newcastle
Mearns Park	Bowmanville
Soper Creek Trail	Bowmanville