Canada's Nuclear Regulator

Protection of Groundwater at Nuclear Facilities in Canada

Discussion Paper DIS-12-01

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Preface

Discussion papers play an important role in the selection and development of the regulatory framework and regulatory program of the Canadian Nuclear Safety Commission (CNSC). They are used to solicit early public feedback on CNSC policies or approaches.

The use of discussion papers early in the regulatory process underlines the CNSC's commitment to a transparent consultation process. The CNSC analyzes and considers preliminary feedback when determining the type and nature of requirements and guidance to issue.

Discussion papers are made available for public comment for a specified period of time. At the end of the first comment period, CNSC staff review all public input, which is then posted for feedback on the CNSC Web site for a second round of consultation.

The CNSC considers all feedback received from this consultation process in determining its regulatory approach.

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Executive Summary

As Canada's nuclear regulator, the Canadian Nuclear Safety Commission (CNSC) has been charged by Parliament with regulating nuclear facilities and nuclear activities in Canada, in order to protect the health and safety of workers and the public and the environment, and to implement Canada's commitments to the peaceful uses of nuclear energy.

Groundwater is an important component of the environment and a valuable resource. For many Canadians, groundwater is their source of drinking water; for others, it is a source of water used in agriculture or industry.

One of the CNSC's objectives when regulating is to ensure a consistent approach to protecting health and safety, and the environment. While most licensees have some measures in place to protect groundwater from contamination by nuclear substances or hazardous substances used at nuclear facilities, there are differences and gaps in such programs. To establish greater consistency in groundwater protection practices, the CNSC is proposing to clarify and formalize its requirements related to groundwater protection. This will help ensure that all Class I nuclear facilities, uranium mines and mills, and nuclear waste management facilities have well-designed and robust programs for protecting and monitoring groundwater.

This discussion paper describes the CNSC's expectations with respect to the essential elements of groundwater protection programs. The CNSC is drawing upon existing guidance from industry standards, CNSC guidance documents and industry practices. In general, licensees would be expected to develop site descriptions so as to understand how unauthorized releases of nuclear substances or hazardous substances could contaminate groundwater and negatively impact the use of this valuable resource; to put in place measures to identify when contaminants may be entering groundwater; and to have identified practices to remediate contamination, should it occur.

The CNSC is seeking feedback on the proposed regulatory framework for groundwater protection described in this paper so that the CNSC can develop an informed Regulatory Document/Guidance Document to formalize its requirements related to groundwater protection. Comments on how and when these types of programs could be realistically implemented are also welcome.

1. Introduction

The Canadian Nuclear Safety Commission (CNSC) regulates the use of nuclear energy and materials to protect the health, safety and security of Canadians and the environment; and to implement Canada's international commitments on the peaceful use of nuclear energy.

Groundwater is an important component of the environment and a valuable resource. For many Canadians, groundwater is their source of drinking water; for others, it is a source of water used in agriculture or industry. As the awareness of the importance of all sources of water grows, groundwater protection is becoming an increasingly important component of environmental protection.

As with all of its regulatory programs, the CNSC is committed to ensuring its requirements related to environmental protection are clear, and to providing guidance on how to meet these requirements. To this end, the CNSC intends to clarify and formalize its requirements related to groundwater protection.

One of the CNSC's objectives when regulating is to ensure a consistent approach to protecting health and safety, the environment and nuclear safety. While most licensees have some measures in place to protect groundwater from contamination by nuclear substances or hazardous substances used at nuclear facilities, there are nonetheless differences and gaps in such programs. To establish greater consistency in groundwater protection practices, the CNSC is proposing to develop a regulatory document/guidance document (RD/GD) to clarify and formalize its requirements related to groundwater protection. This will help ensure that all Class I nuclear facilities, uranium mines and mills, and nuclear waste management facilities have well-designed and robust groundwater protection and monitoring programs.

Specifically, the CNSC proposes that licensees and applicants:

- implement controls to ensure that groundwater is protected as a resource
- conduct end-use analyses to set appropriate criteria for groundwater protection
- implement appropriate groundwater monitoring programs

2. Context

Groundwater is water that flows under the surface of the land, through soil, sand, gravel or layers of permeable rock. Groundwater also includes permafrost (frozen soil), immobile water in low-permeability bedrock, deep geothermal water and oil formation water. It is a valuable natural resource for all Canadians.

The CNSC conducted a review of its regulatory framework for the protection of groundwater and also made comparisons to other jurisdictions, including:

- Canada's provinces and territories
- The United States of America
- Australia
- Europe (France, Germany, UK)

The results of this review indicated that, while there are some variations, countries, provinces and territories require a level of protection of groundwater that is commensurate with its "use". Some regions may protect groundwater as a source of drinking water, or irrigation or simply as a pathway to the surface environment because the groundwater does not have a 'use' in the foreseeable future. Criteria are then developed that would ensure that the groundwater resource is protected based on its defined use.

It is the CNSC's position that a groundwater protection program (GPP) must be implemented in order to prevent releases of contaminants to groundwater and to ensure adequate measures are in place to contain, stop and remediate the effects of any accidental releases that do occur. To do this, a well-designed groundwater protection program should include:

- control measures to prevent the release of nuclear and/or hazardous substances to groundwater
- a monitoring system to provide data confirming that unauthorized releases are not occurring and, if unauthorized releases do occur, to signal when and where
- mitigation measures that would be taken in the event of an unauthorized release of any nuclear or hazardous substances

Most CNSC licensees have some type of groundwater monitoring program in place. Nonetheless, there are differences and gaps in these programs. The CNSC is therefore proposing to clarify and formalize its requirements related to groundwater protection. The proposals for a well-designed groundwater protection and monitoring program set out in this discussion paper consolidate and build on existing requirements and guidance included in:

- CNSC Regulatory Policy P-223, *Protection of the Environment*
- CNSC Regulatory Standard S-296, *Environmental Protection Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills*
- CNSC Regulatory Guide G-296, *Developing Environmental Protection Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills*

The CNSC has identified opportunities to improve the clarity of its regulatory framework as follows:

- establish goals or criteria for groundwater protection at nuclear facilities
- clarify expectations for the protection of groundwater
- clarify methods to control releases to groundwater in order to improve consistency across nuclear facilities (although the *Nuclear Safety and Control Act* and its regulations clearly state that measures to control releases must be proposed, methods vary among facilities, depending on the type of facility and its history)
- improve consistency relating to groundwater monitoring
- clarify expectations for the protection of groundwater

This discussion paper also seeks to clarify the actions that applicants and licensees should undertake to increase their understanding of groundwater at facilities. This, in turn, will inform the development of effective groundwater monitoring programs, provide improved information for the CNSC's review of program adequacy, and promote a consistent approach to such programs. These actions include:

- obtaining a thorough understanding of the current and potential uses of the groundwater around the site, as well as the ease by which a contaminant could migrate to the groundwater
- developing a model of the hydrology and hydrogeology of the site and its surrounding area to understand how groundwater migrates through the site
- establishing a site-specific monitoring program, which would be based on the level of risk associated with releases of contaminants into the groundwater

The CNSC recognizes that each site is unique and that groundwater protection programs would be developed based on site specific requirements.

3. Groundwater Protection Proposal

CNSC licensees are responsible for protecting groundwater by preventing, reducing or remediating contamination. Prevention is achieved by implementing measures to control releases of contaminants. The measures to be implemented at a specific site depend on the nature and potential uses of the groundwater at the site, the environmental characteristics of the ground at the site, and the characteristics of the potential contaminants at the facility.

In addition to measures to control potential releases, a facility would be required to have a groundwater monitoring program (GMP). If potentially harmful releases occur, the GMP would detect them early enough to contain and remediate any harmful effects.

The following are important elements of a groundwater protection program:

- control of potential releases of contaminants
- assessment of groundwater end-use and vulnerability
- site characterization
- release source characterization
- groundwater monitoring program
- investigation and remediation of unauthorized releases of contaminants

The adequacy and level of detail required for each element would depend on the nature and size of a facility, how nuclear and hazardous substances are used, produced or stored at the facility, the hydrology, the geology and hydrogeology of the site, and the end-use and vulnerability of groundwater in the region. Each facility should be judged individually.

3.1 Controlling releases

A fundamental principle of environmental protection is pollution prevention. This principle applies to the prevention or minimization of releases of contaminants to groundwater. Controls should be in place to prevent the release of contaminants to groundwater before addressing how to reverse or compensate for the release once it occurs. The CNSC proposes that this principle be incorporated into the design as well as the operation of a nuclear facility.

A licensee should therefore implement adequate and reasonable measures to control the potential releases of contaminants to groundwater. The adequacy of such measures should ensure that the risk of contamination is as low as reasonably achievable (ALARA). This is consistent with the pollution prevention principle detailed in:

- *Canadian Environmental Protection Act*, 1999 (CEPA 1999)
- CAN/CSA-ISO 14004:04 - *Environmental Management Systems - General Guidelines*

- CNSC S-296, *Environmental Protection Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills*
- G-296, *Developing Environmental Protection Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills*

Groundwater protection should ensure that the use of groundwater as a resource is not affected. This requires knowledge of the potential use of the groundwater and of the water quality required by these end-uses, as well as of site characteristics that may affect the migration of groundwater and/or potential contaminants.

3.2 Assessing end-use and vulnerability

An analysis of current and potential uses – combined with an assessment of the relative vulnerability of groundwater in the region of the facility to contamination – provide the basis for selecting the level of groundwater protection required. This analysis should be provided to the CNSC when an environmental assessment is conducted or an assessment in support of licensing activities is performed.

End-use assessment
End-use of the groundwater can be determined by consulting with municipal, provincial/territorial or federal authorities. Groundwater that is identified by municipal, provincial or territorial authorities as a current or potential source of drinking water must be protected, in order to ensure that its quality remains within drinking water quality standards. Similarly, groundwater designated for other uses, such as irrigation, must meet applicable quality standards or objectives.

On the other hand, provincial authorities may confirm there is no current or future use for groundwater along the potential pathway of nuclear substances and hazardous substances. In this case, the water quality criteria should ensure the protection of the aquatic and/or terrestrial environment.

The following are some issues that may be considered when making an assessment:

- current and potential users of the groundwater resource
- impact of potential change in groundwater quality on the intended uses
- impact of intended uses on groundwater quality
- volume and location of withdrawals from a groundwater supply system, for use by a nuclear facility
- potential changes in groundwater flow paths and aquifer hydraulic characteristics that may result from operation of the nuclear facility
- biological communities that can be affected by the quality of groundwater that discharges to surface waters and wetlands

Vulnerability assessment
The vulnerability of groundwater to contamination is primarily a function of the nature of the geologic materials, any overlying saturated materials and the overlying unsaturated zone. A groundwater vulnerability assessment would take into account scientific information about these characteristics for the area where the groundwater is vulnerable to contamination from the activities of the licensed facility.

3.3 Site characterization

Site characterization is necessary to understand the vulnerability of groundwater to releases and to inform the design of the groundwater monitoring networks. The primary objectives of this site characterization would be to obtain sufficient information for an understanding of:

- how the facility, including facility-specific structures, processes, substances, and waste sources, may influence the environment
- the geologic and hyrdrogeologic factors that control the migration of actual or potential releases to the environment
- the risk of actual or potential releases

The scope of site characterization information required and the appropriateness of investigation techniques would vary according to a site's specific attributes. For example, sites in complex geologic settings will require more hydrogeologic data than sites in less complex settings, in order to understand how groundwater migrates through the sites. Likewise, investigatory techniques that may be appropriate in one geologic setting or for one contaminant type may be inappropriate in another setting or for a different contaminant type.

A site characterization study may involve the following steps:

- initial information review
- development of a site model
- gathering of additional data

Initial information review
Compilation and review of all available site information serves two purposes: providing data for formulation of a model of hydrogeology and contaminant transport and establishing a basis for designing field investigations.

Development of a site model
A hydrological and hydrogeologic model of the site is an important tool in understanding the site's characteristics. The first step in developing a model is to incorporate existing data. Where important data are not available, fieldwork and other scientific data collection methodologies may need to be undertaken to fill the gaps. The end result would be a model of the site that incorporates all essential features of the hydrological and hydrogeologic system in relation to the nuclear facility.

Gathering additional data
Additional data may be required to characterize the site. This data would be identified after a survey of existing data and identification of any gaps that would be required to fully characterize the site.

3.4 Characterizing sources of releases

The nature of past, current and potential releases should be characterized. This process would typically involve identifying existing and potential sources of releases to groundwater and contaminants of potential concern (COPCs).

Identifying sources of releases
All potential releases of contaminants to groundwater, including both radionuclides and non-radionuclide substances, should be identified. Potential sources of releases include tanks, drains, sumps, surface impoundments, used fuel bays, waste storage areas, septic systems, container storage areas, pipelines and discharge locations, and other areas where radionuclide and/or hazardous substances or wastes are handled or stored.

Characterizing contaminants of potential concern
Understanding the type of contaminants that might be released to the environment and where they could enter the environment, is essential when designing a groundwater monitoring program (GMP). The characteristics of COPCs may be described in terms of their physical and chemical properties, inventory, and spatial distribution, including past, current and projected rates of releases.

3.5 Implementing a groundwater monitoring program

A GMP is an integrated program for obtaining and evaluating information on the physical, chemical, and biological characteristics of groundwater and their changes over time. The CNSC proposes that a licensee develop and implement a GMP at any nuclear facility that has, or could have, an adverse impact on the groundwater environment. Such a program may require groundwater monitoring wells, the number of which would depend on the site's geological complexity.

A GMP may also be used to verify the hydrogeology of the site, including groundwater flow patterns, rates, and temporal trends.

The concept and details of the proposed GMP would be primarily based on CSA Standard N288.4, with particular reference to sections 4.1, 4.2, 5, 8, and 9.

3.6 Investigating and remediating unauthorized releases

Upon discovery of an unauthorized or uncontrolled release (such as a spill or leak), or when historic contamination has been identified at a nuclear facility, immediate action would be expected to be taken to stop or control the leak and manage the spilled material in order to contain the spread of contamination.

The licensee should conduct an environmental investigation. The major objective of an environmental investigation is to collect information on the nature, source(s), distribution and extent of contamination, and to understand the pathways that transported the contaminant, potential receptors, and exposure routes. This information is then used to assess risks to human health and the environment and make decisions about future actions, such as remediation or monitoring. Remediation of the site by the licensee would be expected, if necessary.

4. CNSC Implementation and Evaluation

The CNSC would use information about how licensees and applicants achieve GPP objectives during the following:

- environmental assessments
- reviews of new licence applications
- requests for licence renewals
- at any time where the need is identified (for example, response to an unplanned release which would require a re-assessment of risk of groundwater contamination at an existing site or facility)

This approach is based on science that is currently available. The CNSC is committed to ensuring that its regulatory framework is clear and modern. It will continue to maintain up-to-date regulatory information about groundwater protection that considers an evolving scientific understanding and policy framework of groundwater protection practices.

5. Feedback and Questions

In this discussion paper, the CNSC has proposed measures to protect groundwater from contamination by nuclear substances or hazardous substances that may be released from nuclear facilities. It is proposed that these measures be incorporated into a RD/GD. Specifically, the CNSC is proposing that licensees and applicants:

- implement controls to ensure that groundwater is protected as a resource
- conduct end-use analyses to set the appropriate criteria for groundwater protection
- implement appropriate groundwater monitoring programs

The CNSC is seeking feedback on any aspect of these proposals to ensure that groundwater quality is not compromised due to licensed activities. This could include actions that have been found to be effective, so that others may benefit. Comments on how and when such a program could be realistically implemented are also welcome.

Please send any comments or feedback to:
consultation@cnsc-ccsn.gc.ca

Glossary

as low as reasonably achievable (ALARA):
An optimization tool in radiation protection used to keep individual, workplace and public dose limits As Low As Reasonably Achievable (ALARA), social and economic factors being taken into account. ALARA is not a dose limit; it is a practice that aims to keep dose levels as far as possible below regulatory limits.

assessment:
The process and the result of systematically evaluating the hazards associated with sources and practices, and associated protection and safety measures, aimed at quantifying performance measures for comparison with criteria. Assessment should be distinguished from analysis. Assessment is aimed at providing information that forms the basis of a decision of whether something is satisfactory. Various kinds of analysis may be used as tools in doing this. Hence an assessment may include a number of analyses.

Canadian Nuclear Safety Commission (CNSC):
"CNSC" refers to the staff, while "Commission" refers to the quasi-judicial tribunal, as described on the CNSC's public Web site at nuclearsafety.gc.ca

control:
Environmental management procedures or engineering techniques that reduce the release of hazardous and radiological substances to the environment.

contaminants of potential concern (COPCs):
Any constituents that warrant monitoring that are present at a site and that may be released to the air or water.

Canadian Standards Association (CSA):
A not-for-profit standard-setting body that brings together the regulator, industry and stakeholders to produce Canadian industry standards that may be used by the regulator or industry.

environment:
The components of the Earth, including:

(a) air, land and water
(b) all layers of the atmosphere
(c) all organic and inorganic matter and living organisms
(d) the interacting natural systems that include components referred to in (a), (b) and (c)

groundwater:
Water that flows under the land surface or through soil, sand, gravel, or layers of permeable rock. Groundwater also includes permafrost (frozen soil), immobile water in low-permeability bedrock, deep geothermal water, and oil formation water.

groundwater monitoring program (GMP):
An integrated program for obtaining and evaluating information on the physical, chemical, and biological characteristics of groundwater and their changes with time.

hazardous substance:
A substance, other than a nuclear substance, that is used or produced in the course of carrying on a licensed activity and that may pose a risk to the environment or the health and safety of persons.

nuclear facility:
According to the *Nuclear Safety and Control Act* [1], any of the following facilities:

> "(*a*) a nuclear fission or fusion reactor or subcritical nuclear assembly,
>
> (*b*) a particle accelerator,
>
> (*c*) a uranium or thorium mine or mill,
>
> (*d*) a plant for the processing, reprocessing or separation of an isotope of uranium, thorium or plutonium,
>
> (*e*) a plant for the manufacture of a product from uranium, thorium or plutonium,
>
> (*f*) a plant for the processing or use, in a quantity greater than 10^{15} Bq per calendar year, of nuclear substances other than uranium, thorium or plutonium,
>
> (*g*) a facility for the disposal of a nuclear substance generated at another nuclear facility,
>
> (*h*) a vehicle that is equipped with a nuclear reactor, and
>
> (*i*) any other facility that is prescribed for the development, production or use of nuclear energy or the production, possession or use of a nuclear substance, prescribed equipment or prescribed information,
>
> and includes, where applicable, the land on which the facility is located, a building that forms part of, or equipment used in conjunction with, the facility and any system for the management, storage or disposal of a nuclear substance."

pollution prevention:
The use of processes, practices, materials, products, substances or energy that avoid or minimize the creation of pollutants and waste and reduce the overall risk to the environment or human health as well as groundwater resources.

release:
The discharge of substances to the environment.

vulnerability:
The sensitivity of a groundwater system to human and/or natural water quality impacts.

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