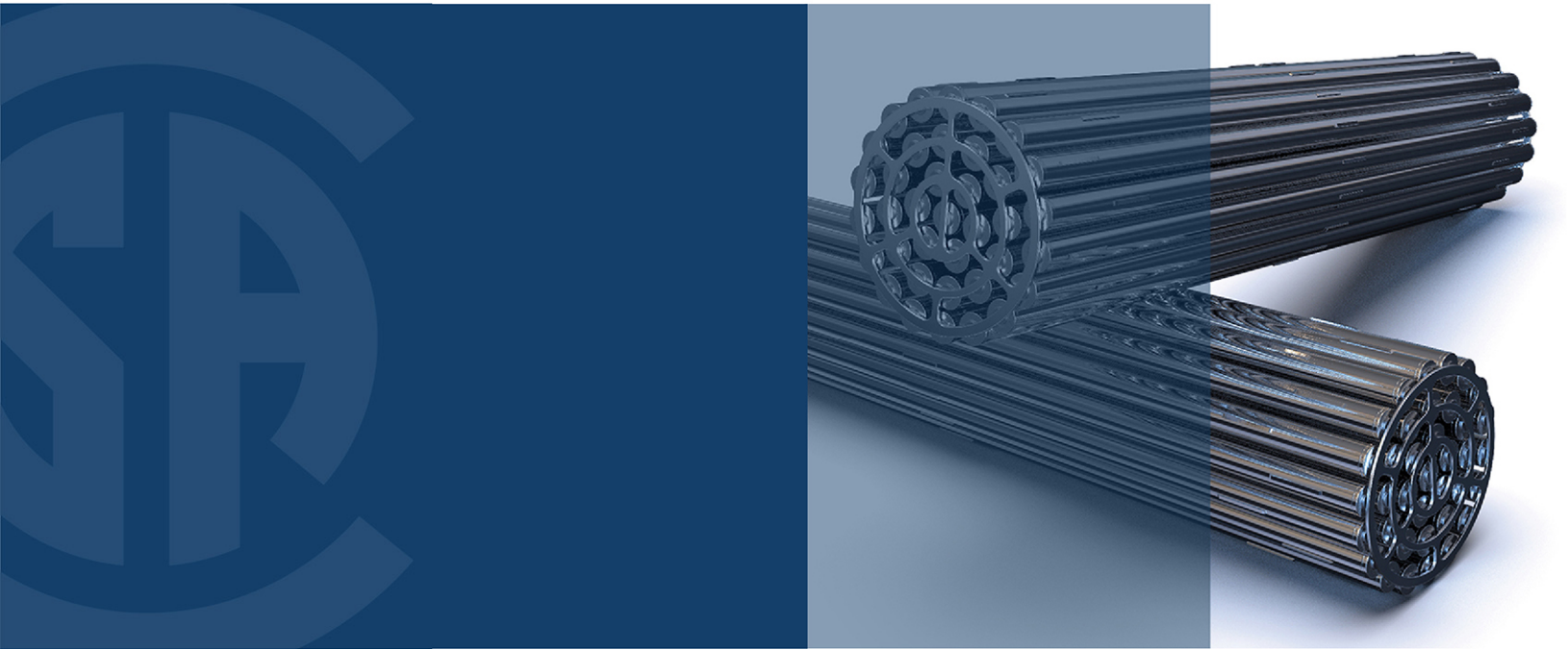


Deep geological disposal of radioactive waste and irradiated fuel



Legal Notice for Standards

Canadian Standards Association (operating as “CSA Group”) develops standards through a consensus standards development process approved by the Standards Council of Canada. This process brings together volunteers representing varied viewpoints and interests to achieve consensus and develop a standard. Although CSA Group administers the process and establishes rules to promote fairness in achieving consensus, it does not independently test, evaluate, or verify the content of standards.

Disclaimer and exclusion of liability

This document is provided without any representations, warranties, or conditions of any kind, express or implied, including, without limitation, implied warranties or conditions concerning this document’s fitness for a particular purpose or use, its merchantability, or its non-infringement of any third party’s intellectual property rights. CSA Group does not warrant the accuracy, completeness, or currency of any of the information published in this document. CSA Group makes no representations or warranties regarding this document’s compliance with any applicable statute, rule, or regulation.

IN NO EVENT SHALL CSA GROUP, ITS VOLUNTEERS, MEMBERS, SUBSIDIARIES, OR AFFILIATED COMPANIES, OR THEIR EMPLOYEES, DIRECTORS, OR OFFICERS, BE LIABLE FOR ANY DIRECT, INDIRECT, OR INCIDENTAL DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES, HOWSOEVER CAUSED, INCLUDING BUT NOT LIMITED TO SPECIAL OR CONSEQUENTIAL DAMAGES, LOST REVENUE, BUSINESS INTERRUPTION, LOST OR DAMAGED DATA, OR ANY OTHER COMMERCIAL OR ECONOMIC LOSS, WHETHER BASED IN CONTRACT, TORT (INCLUDING NEGLIGENCE), OR ANY OTHER THEORY OF LIABILITY, ARISING OUT OF OR RESULTING FROM ACCESS TO OR POSSESSION OR USE OF THIS DOCUMENT, EVEN IF CSA GROUP HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES.

In publishing and making this document available, CSA Group is not undertaking to render professional or other services for or on behalf of any person or entity or to perform any duty owed by any person or entity to another person or entity. The information in this document is directed to those who have the appropriate degree of experience to use and apply its contents, and CSA Group accepts no responsibility whatsoever arising in any way from any and all use of or reliance on the information contained in this document.

CSA Group is a private not-for-profit company that publishes voluntary standards and related documents. CSA Group has no power, nor does it undertake, to enforce compliance with the contents of the standards or other documents it publishes.

Intellectual property rights and ownership

As between CSA Group and the users of this document (whether it be in printed or electronic form), CSA Group is the owner, or the authorized licensee, of all works contained herein that are protected by copyright, all trade-marks (except as otherwise noted to the contrary), and all inventions and trade secrets that may be contained in this document, whether or not such inventions and trade secrets are protected by patents and applications for patents. Without limitation, the unauthorized use, modification, copying, or disclosure of this document may violate laws that protect CSA Group’s and/or others’ intellectual property and may give rise to a right in CSA Group and/or others to seek legal redress for such use, modification, copying, or disclosure. To the extent permitted by licence or by law, CSA Group reserves all intellectual property rights in this document.

Patent rights

Attention is drawn to the possibility that some of the elements of this standard may be the subject of patent rights. CSA Group shall not be held responsible for identifying any or all such patent rights. Users of this standard are expressly advised that determination of the validity of any such patent rights is entirely their own responsibility.

Authorized use of this document

This document is being provided by CSA Group for informational and non-commercial use only. The user of this document is authorized to do only the following:

If this document is in electronic form:

- load this document onto a computer for the sole purpose of reviewing it;
- search and browse this document; and
- print this document if it is in PDF format.

Limited copies of this document in print or paper form may be distributed only to persons who are authorized by CSA Group to have such copies, and only if this Legal Notice appears on each such copy.

In addition, users may not and may not permit others to

- alter this document in any way or remove this Legal Notice from the attached standard;
- sell this document without authorization from CSA Group; or
- make an electronic copy of this document.

If you do not agree with any of the terms and conditions contained in this Legal Notice, you may not load or use this document or make any copies of the contents hereof, and if you do make such copies, you are required to destroy them immediately. Use of this document constitutes your acceptance of the terms and conditions of this Legal Notice.



Standards Update Service

CSA N292.7:22

March 2022

Title: *Deep geological disposal of radioactive waste and irradiated fuel*

To register for e-mail notification about any updates to this publication

- go to www.csagroup.org/store/
- click on **Product Updates**

The **List ID** that you will need to register for updates to this publication is **2429486**.

If you require assistance, please e-mail techsupport@csagroup.org or call 416-747-2233.

Visit CSA Group's policy on privacy at www.csagroup.org/legal to find out how we protect your personal information.

CSA N292.7:22

***Deep geological disposal of
radioactive waste and irradiated
fuel***



®A trademark of the Canadian Standards Association, operating as “CSA Group”

*Published in March 2022 by CSA Group
A not-for-profit private sector organization
178 Rexdale Boulevard, Toronto, Ontario, Canada M9W 1R3*

*To purchase standards and related publications, visit our Online Store at www.csagroup.org/store/
or call toll-free 1-800-463-6727 or 416-747-4044.*

*ICS 13.030.30
ISBN 978-1-4883-3820-5*

*© 2022 Canadian Standards Association
All rights reserved. No part of this publication may be reproduced in any form whatsoever
without the prior permission of the publisher.*

Contents

Technical Committee on Radioactive Waste Management	6
Subcommittee on Disposal of Radioactive Waste and Irradiated Fuel	8
Preface	10
1 Scope	11
1.1 Lifecycle activities	11
1.2 Informative annexes	11
1.3 Exclusions	11
1.4 CSA N292.0	12
1.5 Users	12
1.6 Mandatory language	12
2 Reference publications	12
3 Definitions and abbreviations	15
3.1 Definitions	15
3.2 Abbreviations	20
4 General requirements	20
4.1 Application of other CSA standards	20
4.2 Disposal facility lifecycle	20
4.2.1 Lifecycle activities	21
4.2.2 Iterative approach	21
4.2.3 Parallel activities	21
4.3 General safety considerations	22
4.3.1 Safety objective	22
4.3.2 Safety strategy	22
4.3.3 Limitation of hazardous substances	22
4.3.4 Conventional health and safety measures	22
4.3.5 Consideration of parallel activities	22
4.3.6 Operating procedures	22
4.3.7 Operational limits and conditions	22
4.3.8 Impact of changes	22
4.4 Graded approach	23
4.5 Waste characteristics	23
4.5.1 Inventories for disposal	23
4.5.2 Waste acceptance criteria	23
4.5.3 Secondary waste streams	23
4.6 Foreign material management	24
4.6.1 Foreign material management program	24
4.6.2 Limitation and mitigation of foreign materials	24
4.7 Maintenance, periodic testing, and inspection	24
4.7.1 Maintenance, periodic testing, and inspection programs	24
4.7.2 Impact on pre- and post-closure safety	24

4.8	Aging management	24
4.9	Records management	25
4.9.1	Records management program	25
4.9.2	Waste records	25
4.9.3	Preservation of records	25
4.10	Accountability of the operating organization	25
4.11	Safeguards	25
4.11.1	Safeguards arrangements	25
4.11.2	Consideration of safety impact	25
4.12	Research and development	26
4.13	Retrievability	26
4.13.1	Consideration of retrieval prior to closure	26
4.13.2	Impact on post-closure safety	26
5	Indigenous and public engagement	26
5.1	Engagement programs	26
5.2	Commencement of engagement activities	26
5.3	Duration of engagement activities	27
5.4	Inclusivity	27
5.5	Communication channels	27
6	Site evaluation	27
6.1	Scope of site evaluation	27
6.1.1	Lifecycle activities associated with site evaluation	27
6.1.2	Safety and security aspects in site evaluation	27
6.2	Establishing and maintaining a safety basis	27
6.2.1	Scope of establishing and maintaining a safety basis	27
6.2.2	Preparation for subsequent site evaluation activities	28
6.2.3	Site characterization	28
6.2.4	Ongoing site evaluation by analytical assessment	33
6.2.5	Site evaluation documentation	36
6.3	Establishing and maintaining a security basis	39
6.3.1	Nuclear security principles	39
6.3.2	Security-related physical protection objectives	39
6.3.3	Physical dimensions of the facility and its surroundings	39
6.3.4	Security threat assessment	39
6.3.5	Security documentation	40
7	Design	40
7.1	Depth of the deep geological disposal facility	40
7.1.1	Justification of selected depth	40
7.1.2	Main considerations for selection of depth	40
7.2	Location of the deep geological disposal facility	40
7.2.1	Geologically suitable rock	40
7.2.2	Absence of economically exploitable natural resources	40
7.3	Design for pre-closure safety	41
7.3.1	Achieving the safety objective during the pre-closure period	41
7.3.2	Pre-closure main safety functions	41
7.3.3	Pre-closure SSCs	41

7.3.4	Classification of SSCs	42
7.3.5	Consideration of operational limits and conditions	43
7.3.6	Service loading and conditions	43
7.3.7	Design rules and limits	43
7.3.8	Specific design requirements	44
7.3.9	Inspection and maintenance considerations	45
7.3.10	Design for closure	45
7.4	Design for post-closure safety	45
7.4.1	Achieving the safety objective during the post-closure period	45
7.4.2	Effect of time	46
7.4.3	Post-closure safety functions	47
7.4.4	Barrier system design	48
7.4.5	Design of underground structures	52
7.4.6	Barrier design with degradation	53
7.4.7	Design optimization	53
7.5	Design verification	53
7.5.1	Verification plan for natural barriers	53
7.5.2	Verification plan for engineered barriers	54
7.5.3	Verification for other SSCs	54
8	Monitoring and surveillance	54
8.1	Monitoring and surveillance program	54
8.1.1	Features of the monitoring and surveillance program	54
8.1.2	Design of the monitoring and surveillance program	54
8.1.3	Confirmation of conditions	54
8.2	Pre-closure monitoring	55
8.2.1	Baseline establishment	55
8.2.2	Monitoring during site preparation, construction, and commissioning	55
8.2.3	Monitoring during operation and closure	55
8.2.4	Remediation of seals showing degradation	55
8.3	Post-closure monitoring	55
8.3.1	Post-closure monitoring plans	56
8.3.2	Features of post-closure monitoring plans	56
8.4	Surveillance	56
8.4.1	Site-specific surveillance program	56
8.4.2	Duration of surveillance activities	56
8.4.3	Level of surveillance	56
8.4.4	Impact on functionality of safety features	56
9	Safety assessment	56
9.1	Safety assessment components	57
9.2	Safety assessment periods	57
9.2.1	Consistency with lifecycle time frames	57
9.2.2	Separate assessments	57
9.3	Pre-closure safety assessment	57
9.3.1	Normal operation safety analysis	57
9.3.2	Accident scenario safety analysis	57
9.3.3	Criticality safety analysis	58
9.3.4	Uncertainties	59

9.4	Post-closure safety assessment	59
9.4.1	Components of assessment	59
9.4.2	Scope of assessment	59
9.4.3	Purposes of assessment	60
9.4.4	Comprehensiveness of scenarios	60
9.4.5	Application of models to scenarios	60
9.4.6	Impact of the failure of one barrier on other barriers	60
9.4.7	Active control measures	60
9.4.8	Acceptance criteria	60
9.4.9	Criticality safety analysis	61
9.4.10	Uncertainties	61
9.5	Periodic review of safety assessments	62
9.5.1	Frequency of safety assessment reviews	62
9.5.2	Considerations for periodic review frequency	62
10	Site preparation	62
10.1	Consideration of pre-closure safety	63
10.2	Impacts on host environment	63
10.3	Impacts on design and consideration of post-closure safety	63
10.4	Flexibility in engineering techniques	63
10.5	Facilitation of continued advancement of technical aspects	63
11	Construction	63
11.1	Alignment with design and preservation of safety functions	63
11.2	Construction program	63
11.2.1	Scope of construction program	63
11.2.2	Barrier verification plan	63
11.2.3	Ground control program	64
11.3	Consideration of pre-closure safety	64
11.4	Minimizing construction impacts	64
11.4.1	Consideration of post-closure safety	64
11.4.2	Extent of excavation damage zone	64
11.5	Flexibility in engineering techniques	64
11.6	Facilitation of continued advancement of technical aspects	64
11.7	Duration of construction activities	64
12	Commissioning	64
12.1	Commissioning program	64
12.2	Scope of commissioning program	64
12.3	Duration of commissioning activities	64
12.4	Consideration of post-closure safety	65
12.5	Commissioning test results	65
13	Operation	65
13.1	WAC compliance	65
13.2	Waste transfer and tracking	65
13.2.1	Access point	65
13.2.2	Transfer systems	65
13.2.3	Radioactive waste tracking	65

14 Closure 66

- 14.1 Facility closure 66
 - 14.1.1 Commencement of closure activities 66
 - 14.1.2 Specification of end state 66
 - 14.1.3 Closure activities 66
 - 14.1.4 Consideration of post-closure safety 66
- 14.2 Partial closure 67
- 14.3 Closure plans 67
 - 14.3.1 Preliminary closure plan 67
 - 14.3.2 Detailed closure plan 67
 - 14.3.3 Periodic review of closure plans 67

15 Institutional controls 68

- 15.1 Active institutional controls 68
- 15.2 Passive institutional controls 68
- 15.3 Duration of institutional control periods 68
- 15.4 Planning and implementation of institutional control arrangements 68

Annex A (informative) — Licensing stages of a deep geological disposal facility 69

Annex B (informative) — Complementary content about the IA process 73

Technical Committee on Radioactive Waste Management

K. Gillin	Vysus Group, Sundbyberg, Sweden <i>Category: Service Industry</i>	<i>Chair</i>
S. Suryanarayan	Kinectrics Inc., Toronto, Ontario, Canada <i>Category: Service Industry</i>	<i>Vice-Chair</i>
T. Abraham	SNC-Lavalin Nuclear Inc., Mississauga, Ontario, Canada <i>Category: Service Industry</i>	
P. Burton	Canadian Nuclear Safety Commission (CNSC), Ottawa, Ontario, Canada <i>Category: Government and/or Regulatory Authority</i>	
C. Campbell	New Brunswick Power (NB Power), Lepreau, New Brunswick, Canada <i>Category: Owner/Operator/Producer</i>	
M. W. Chapman	Canadian Nuclear Laboratories Limited (CNL), Chalk River, Ontario, Canada <i>Category: Owner/Operator/Producer</i>	
P. A. D'Aubin	Nordion Inc., Ottawa, Ontario, Canada <i>Category: Service Industry</i>	
N. C. Garisto	ARCADIS Canada Inc., Richmond Hill, Ontario, Canada <i>Category: Supplier/Fabricator/Contractor</i>	
B. M. Ikeda	Ontario Tech University, Oshawa, Ontario, Canada <i>Category: General Interest</i>	
J. Mecke	Natural Resources Canada (NRCan), Ottawa, Ontario, Canada	<i>Non-voting</i>

D. Mekonen	Bruce Power, Tiverton, Ontario, Canada <i>Category: Owner/Operator/Producer</i>	
A. Murchison	Nuclear Waste Management Organization (NWMO), Toronto, Ontario, Canada	<i>Non-voting</i>
N. Persaud	Kinectrics Inc., Toronto, Ontario, Canada	<i>Non-voting</i>
R. Prokopowicz	Kinectrics Inc., Toronto, Ontario, Canada	<i>Non-voting</i>
F. Rodrigues	Ontario Power Generation (OPG), Pickering, Ontario, Canada <i>Category: Owner/Operator/Producer</i>	
T. P. Smith	Cameco Corporation Fuel Services Division, Port Hope, Ontario, Canada <i>Category: Supplier/Fabricator/Contractor</i>	
J. D. Swann	Department of National Defence, Ottawa, Ontario, Canada	<i>Non-voting</i>
F. Tourneur	University Health Network, Toronto, Ontario, Canada <i>Category: General Interest</i>	
P. W. Yuen	Natural Resources Canada (NRCan), Ottawa, Ontario, Canada <i>Category: Government and/or Regulatory Authority</i>	
X. Zhang	Nuclear Waste Management Organization (NWMO), Toronto, Ontario, Canada <i>Category: Supplier/Fabricator/Contractor</i>	
D. Mendolia	CSA Group, Toronto, Ontario, Canada	<i>Project Manager</i>

This edition of CSA N292.7 is dedicated to the memory of Michael Stephens.

Subcommittee on Disposal of Radioactive Waste and Irradiated Fuel

J. Keto	Kinectrics Inc., Kincardine, Ontario, Canada	<i>Co-Chair</i>
V. Khotylev	Canadian Nuclear Safety Commission (CNSC), Ottawa, Ontario, Canada	<i>Co-Chair</i>
W. Basiouny	Candu Energy Inc., Member of the SNC-Lavalin Group, Mississauga, Ontario, Canada	
J. Brown	Canadian Nuclear Safety Commission (CNSC), Ottawa, Ontario, Canada	
N. C. Garisto	ARCADIS Canada Inc., Richmond Hill, Ontario, Canada	
K. Gillin	Vysus Group, Sundbyberg, Sweden	
R. Harrison	Bruce Power, Tiverton, Ontario, Canada	
B. M. Ikeda	Ontario Tech University, Oshawa, Ontario, Canada	
L. Jones	Canadian Nuclear Laboratories Limited (CNL), Chalk River, Ontario, Canada	
L. Lang	Nuclear Waste Management Organization (NWMO), Toronto, Ontario, Canada	
J. Matilainen	Ontario Power Generation (OPG), Pickering, Ontario, Canada	
J. Mecke	Natural Resources Canada (NRCan), Ottawa, Ontario, Canada	

J. A. Percival	Geological Survey of Canada (Natural Resources Canada), Ottawa, Ontario, Canada	
J. Smith	Canadian Nuclear Safety Commission (CNSC), Ottawa, Ontario, Canada	
S. Suryanarayan	Kinectrics Inc., Toronto, Ontario, Canada	
X. Zhang	Nuclear Waste Management Organization (NWMO), Toronto, Ontario, Canada	
D. Mendolia	CSA Group, Toronto, Ontario, Canada	<i>Project Manager</i>

Preface

This is the first edition of CSA N292.7, *Deep geological disposal of radioactive waste and irradiated fuel*. This Standard is part of the CSA N292 series of Standards on radioactive waste management.

This Standard works in concert with CSA N292.0, *General principles for the management of radioactive waste and irradiated fuel*, which specifies common requirements for the management of radioactive waste and irradiated fuel.

The CSA N-series Standards provide an interlinked set of requirements for the management of nuclear facilities and activities. CSA N286 provides overall direction to management to develop and implement sound management practices and controls, while the other CSA Group nuclear Standards provide technical requirements and guidance that support the management system. This Standard works in harmony with CSA N286 and does not duplicate the generic requirements of CSA N286; however, it might provide more specific direction for those requirements.

This Standard draws on the experience both in Canada and internationally in developing deep geological disposal facilities and reflects current best practices.

Users of this Standard are reminded that the design, manufacture, construction, commissioning, operation, and decommissioning of nuclear facilities in Canada are subject to the provisions of the *Nuclear Safety and Control Act* and its supporting Regulations.

This Standard was prepared by the Subcommittee on Disposal of Radioactive Waste and Irradiated Fuel, under the jurisdiction of the Technical Committee on Radioactive Waste Management and the Strategic Steering Committee on Nuclear Standards, and has been formally approved by the Technical Committee.

Notes:

- 1) *Use of the singular does not exclude the plural (and vice versa) when the sense allows.*
- 2) *Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.*
- 3) *This Standard was developed by consensus, which is defined by CSA Policy governing standardization — Code of good practice for standardization as “substantial agreement. Consensus implies much more than a simple majority, but not necessarily unanimity”. It is consistent with this definition that a member may be included in the Technical Committee list and yet not be in full agreement with all clauses of this Standard.*
- 4) *To submit a request for interpretation of this Standard, please send the following information to inquiries@csagroup.org and include “Request for interpretation” in the subject line:*
 - a) *define the problem, making reference to the specific clause, and, where appropriate, include an illustrative sketch;*
 - b) *provide an explanation of circumstances surrounding the actual field condition; and*
 - c) *where possible, phrase the request in such a way that a specific “yes” or “no” answer will address the issue.*

Committee interpretations are processed in accordance with the CSA Directives and guidelines governing standardization and are available on the Current Standards Activities page at standardsactivities.csa.ca.

- 5) *This Standard is subject to review within five years from the date of publication. Suggestions for its improvement will be referred to the appropriate committee. To submit a proposal for change, please send the following information to inquiries@csagroup.org and include “Proposal for change” in the subject line:*
 - a) *Standard designation (number);*
 - b) *relevant clause, table, and/or figure number;*
 - c) *wording of the proposed change; and*
 - d) *rationale for the change.*

CSA N292.7:22

Deep geological disposal of radioactive waste and irradiated fuel

1 Scope

1.1 Lifecycle activities

This Standard specifies the requirements for the following activities that occur during the lifecycle of a deep geological disposal facility for radioactive waste and irradiated fuel:

- a) Indigenous and public engagement (see Clause [5](#));
- b) site evaluation (see Clause [6](#));
- c) design (see Clause [7](#));
- d) monitoring and surveillance (see Clause [8](#));
- e) safety assessment (see Clause [9](#));
- f) site preparation (see Clause [10](#));
- g) construction (see Clause [11](#));
- h) commissioning (see Clause [12](#));
- i) operation (see Clause [13](#));
- j) closure (see Clause [14](#)); and
- k) institutional controls (see Clause [15](#)).

Notes:

- 1) *Within this Standard, a deep geological disposal facility is also referred to as a “disposal facility”.*
- 2) *Within this Standard, both the terms “waste” and “radioactive waste” are used to refer to “radioactive waste and irradiated fuel”.*
- 3) *Surface facilities or structures that interface with the underground portion of a disposal facility and fulfil an underground function are included in the scope of this Standard (e.g., a shaft headframe).*

1.2 Informative annexes

This Standard includes informative annexes to clarify

- a) the stages associated with licensing of a deep geological disposal facility in Canada, and the lifecycle activities that are typically performed during each stage (see Annex [A](#)); and
- b) the complementary content about the impact assessment (IA) process (see Annex [B](#)).

Notes:

- 1) *The term “stages” could also be referred to as “phases”.*
- 2) *Each licensing stage represents the dominant activity occurring at a point in time. For example, during the operation stage, the dominant activity is operation, but this stage could also include construction, commissioning, and closure activities.*

1.3 Exclusions

This Standard excludes

- a) requirements for the siting of a deep geological disposal facility, apart from siting-related aspects during the lifecycle activities of Indigenous and public engagement, site evaluation, design, and safety assessment;
- b) disposal facility types other than deep geological disposal facilities, such as near surface disposal facilities and deep boreholes; and