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AMS Through the Lens of the Nuclear Regulator – A Retrospective and Prospective Look at the Regulatory Applications of AMS

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About the CNSC

- The CNSC is the federal regulator of the Canadian nuclear industry
- It is an independent, quasi-judicial tribunal and court of record, supported by scientific, technical and professional staff
- The CNSC's mandate is to:
  - protect the **health, safety and security** of **people and the environment**
  - implement Canada's **international agreements** on the peaceful use of nuclear energy
  - disseminate **objective** scientific, technical and regulatory information to the public

CNSC Regulatory Framework and Philosophy

- The *Nuclear Safety and Control Act* is the enabling legislation
- The Commission makes regulations through a transparent process
- Regulatory requirements are continually updated based on a systematic and transparent process
  - reflected in a comprehensive 10-year plan
  - aligned with IAEA safety standards
  - adoption of national and international standards into the CNSC's regulatory framework

Regulatory philosophy is risk informed and science based

Facilities the CNSC Regulates

- The CNSC regulates the entirety of the nuclear fuel cycle in Canada – **cradle to grave**

  - uranium mines and mills
  - uranium fuel fabrication and processing
  - nuclear power plants
  - nuclear substance processing
  - industrial and medical applications
  - nuclear research and educational activities
  - transportation of nuclear substances
  - nuclear security and safeguards
  - import and export controls
  - **waste management facilities**

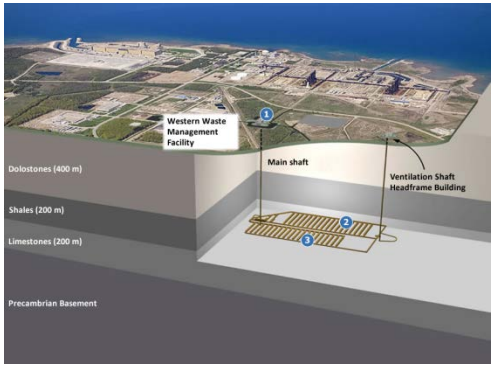
Future Regulatory Challenges

- Many projects are new in the Canadian regulatory context and require ongoing regulatory oversight throughout their lifecycles

- These facilities will be new to Canada and will have a variety of unique characteristics and requirements:
  - new types of waste
  - need for a long-term safety case – 1 Ma
  - demonstrate isolation and containment
  - rigorous performance assessment

- These include:
  - CNL's Near Surface Disposal Facility
  - entombment of NPD reactor
  - decommissioning of Whiteshell
  - OPG's DGR for L/ILW
  - APM DGR for used nuclear fuel

Design picture of proposed near surface disposal facility, which will be located at the current site of Chalk River Laboratories, Ontario - Picture courtesy of CNL



Conceptual design of OPG's Deep Geologic Repository for L/ILW.

How can AMS be used?

Previous Regulatory Applications of AMS

- Applications primarily oriented towards regulatory research and site characterization
  - waste characterization
  - site characterization – sites and natural analogues
  - environmental monitoring

Iodine-129 constraints on residence times of deep marine brines in the Canadian Shield

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Partitioning of ^{127}I and ^{129}I in an unconfined glaciofluvial aquifer on the Canadian shield

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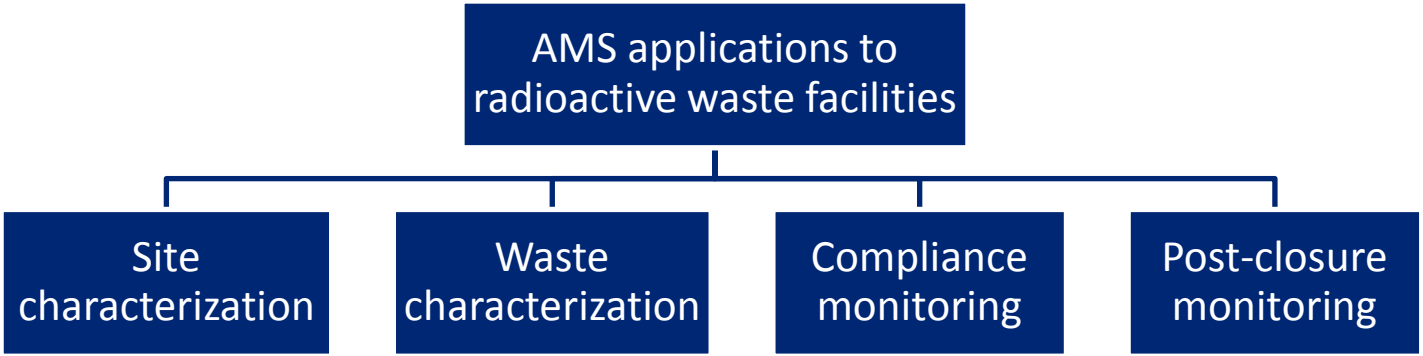
Technical Report

Title: ***Radioisotopes in DGR Groundwater and Porewater***

Key AMS Applications



- Safety case development
  - AMS will be used primarily by implementers in support of safety case development
- Contributes to emergency preparedness and response
  - AMS can trace accidentally released isotopes, such as those released by a leak or in a nuclear emergency
- Radionuclide monitoring tool
  - AMS has the ability to analyze small sample sizes in a wide variety of environmental matrices
- Regulatory research
  - AMS is a useful tool for a wide variety of geoscience applications related to DGRs and tracing nuclear emission

Site Characterization

- Extensive site characterization of waste facilities is a critical aspect of the safety case
  - the site's ability to isolate and contain the waste, preferably with passive barriers, is key
- Baseline characterization of key parameters during the environmental assessment phase is also critical to the identification of effects during operations – both in surface environment and deep environment
- Key data for the safety case of a site includes information on:
  - groundwater age and provenance
  - erosion rates and depths
  - *in situ* radionuclide production
  - radionuclide transport, etc.
  - hydrothermal fluid dates and movement – fracture infill minerals
- Radionuclides of interest include ^{14}C, ^{129}I, ^{36}Cl, ^{99}Tc, ^{81}Kr, ^{10}Be and ^{26}Al

Radioactive Waste Characterization

- Radioactive waste – particularly intermediate-level waste (ILW) and high-level waste (HLW) – often contains long-lived, hard-to-analyze isotopes
- These isotopes:
  - often constitute the largest dose contributors over the site lifespan and post-closure
  - often impose limitations on the performance assessment, making an understanding of the source term a critical aspect of the safety case

- The waste source term must be adequately characterized to enable accurate performance assessments, waste acceptance criteria development and support for the safety case

- These key radionuclides include ^{3}H, ^{14}C, ^{36}Cl, ^{135}Cs, ^{129}I, ^{99}Tc, ^{236}U, ^{93}Zr and $^{240,241,242}Pu$

Compliance Monitoring

- Environmental monitoring of radioactive waste sites is a requirement of a CNSC licence
- It is the licensee's responsibility to perform environmental compliance monitoring
- The CNSC also conducts environmental monitoring as part of its Independent Environmental Monitoring Program
  - both the environment and food items are sampled
- If key radionuclides in waste require AMS analysis for characterization, compliance monitoring could target these radioisotopes to ensure the environment is protected

A CNSC staff member collects a water sample as part of the IEMP

Post-Closure Monitoring

- Post-closure monitoring is required at all CNSC-licensed waste facilities
- Not the same as compliance monitoring, as post-closure monitoring begins after the facility has been decommissioned and continues over a long period of time
- Samples a variety of environmental media; sampling is informed by the safety case and performance assessment
- Monitoring programs should incorporate radioisotopes identified as important in the waste characterization and performance assessment (e.g., ^{129}I, ^{36}Cl)




Advances in AMS Technology

- Advances in AMS technology have a myriad of regulatory applications

- Specifically, technological advances will aid regulatory applications:
  - isobar separation (e.g., ^{36}Cl)
  - positive ion AMS
  - gas and laser ion sources
  - new sample preparation methods and matrices
  - background reduction, both on machine and with sample preparation

- Will allow for the analysis of new isotopes in waste and environmental reservoirs

The 3 MV AMS system installed at the Advanced Research Complex (ARC) University of Ottawa

Emergency Preparedness and Response

- Licensees are required to work continually to maintain and enhance their nuclear emergency management programs
- The CNSC also maintains a nuclear emergency management program, which could benefit from the availability of AMS
- Gas and laser ion sources could provide the ability to rapidly analyze samples for radionuclides released in an emergency situation
- In terms of emergency response, the ability to analyze small sample sizes in air, soil and water allows for rapid detection of releases to the environment
- Key isotopes of interest (relevant to AMS) include: ^{90}Sr, ^{129}I, ^{3}H, ^{14}C and $^{240,241,242,244}Pu$

Regulatory Research

- Ongoing and future regulatory research will continue to focus on the themes discussed
- Tracing of global nuclear emissions remains of interest to the CNSC
- AMS research in nuclear forensics and safeguards is also the purview of the CNSC

Conclusions

- Valuable role to play in providing services to nuclear regulators; its role will only increase in the future
- Applies to a wide variety of waste facilities, from surface to deep geological repositories
- Applications encompass facility lifecycles, from waste and site characterization and compliance monitoring, to long-term, post-closure monitoring
- Benefits can be realized through emergency preparedness, tracing of accidental releases and AMS technology developments

Questions?

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