Canada's Deep Geological Repository for Used Nuclear Fuel - Geoscientific Site Evaluation Process – 13117

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ABSTRACT

The Nuclear Waste Management Organization (NWMO) is responsible for implementing Adaptive Phased Management (APM), the approach selected by the Government of Canada for long-term management of used nuclear fuel generated by Canadian nuclear reactors. The ultimate objective of APM is the centralized containment and isolation of Canada's used nuclear fuel in a Deep Geological Repository in a suitable rock formation at a depth of approximately 500 meters (m) (1,640 feet [ft]).

In May 2010, the NWMO published a nine-step site selection process that serves as the road map to decision-making on the location for the deep geological repository. The safety and appropriateness of any potential site will be assessed against a number of factors, both technical and social in nature. The selected site will be one that can be demonstrated to be able to safely contain and isolate used nuclear fuel, protecting humans and the environment over the very long term. The geoscientific suitability of potential candidate sites will be assessed in a stepwise manner following a progressive and thorough site evaluation process that addresses a series of geoscientific factors revolving around five safety functions. The geoscientific site evaluation process includes: Initial Screenings; Preliminary Assessments; and Detailed Site Evaluations.

As of November 2012, 22 communities have entered the site selection process (three in northern Saskatchewan and 18 in northwestern and southwestern Ontario).

INTRODUCTION

The Nuclear Waste Management Organization (NWMO) is responsible for implementing Adaptive Phased Management, the approach selected by the Government of Canada for long-term management of used nuclear fuel generated by Canadian nuclear reactors. The ultimate objective of Adaptive Phased Management is the centralized containment and isolation of Canada's used nuclear fuel in a Deep Geological Repository in a suitable crystalline or sedimentary rock formation at a depth of approximately 500 m (1,640 ft).

The repository will consist of access and service shafts and a series of tunnels leading to placement rooms where used fuel will be placed and sealed in competent rock using a multi-barrier system which includes long-lived specially designed containers, clay-based sealing materials and the rock itself. The used fuel will be monitored throughout all phases of implementation and will also remain retrievable for an extended period of time. In May 2010, the NWMO published the nine step site selection process that serves as the road map to decision-making on the location for the deep geological repository [1]. The safety and appropriateness of any potential site will be assessed against a number of factors, both technical and social in nature. The suitability of candidate areas will be assessed in a stepwise manner over a period of many years.

The increasingly detailed progression of geoscientific evaluations will include:

- ***Initial Screenings*** on request of potentially interested communities, against a list of initial screening criteria to identify obvious conditions that would preclude an area from further consideration (Step 2);
- ***Preliminary Assessment*** (feasibility studies in the form of desktop and preliminary field investigations) for communities interested in continuing in the NWMO site selection process, to assess whether a candidate area contains general siting areas that are potentially suitable for hosting a deep geological repository (Step 3); and
- ***Detailed multi-year Site Characterizations at one or more sites*** selected by NWMO, to confirm suitability and identify a preferred site based on detailed site evaluation factors (Step 4).

The geoscientific suitability of potential sites will be evaluated using a number of geoscientific site evaluation factors, organized under five safety functions that a site would need to ultimately satisfy in order to be considered suitable [1]:

1. ***Safe containment and isolation of used nuclear fuel.*** Are the characteristics of the rock at the site appropriate to ensuring the long-term containment and isolation of used nuclear fuel from humans, the environment and surface disturbances?
2. ***Long-term resilience to future geological processes and climate change.*** Is the rock formation at the site geologically stable and likely to remain stable over the very long-term in a manner that will ensure the repository will not be substantially affected by natural disturbances and events such as earthquakes and climate change?
3. ***Safe construction, operation and closure of the repository.*** Are conditions at the site suitable for the safe construction, operation and closure of the repository?
4. ***Isolation of used fuel from future human activities.*** Is human intrusion at the site unlikely, for instance, through future exploration or mining?
5. ***Amenable to site characterization and data interpretation activities.*** Can the geologic conditions at the site be practically studied and described on dimensions that are important for demonstrating long-term safety?

GEOSCIENTIFIC SITE EVALUATION PROCESS

Initial Screenings

The initial screening evaluates the potential suitability of the community against five initial screening criteria, using readily available information. The purpose of this step is to assess whether there are any obvious conditions that would exclude a community from the site selection process. This step is completed within about three months.

Initial screening criteria [1] require that:

1. The site must have enough available land of sufficient size to accommodate the surface and underground facilities.
2. This available land must be outside of protected areas, heritage sites, provincial parks and national parks.
3. This available land must not contain known groundwater resources at the repository depth, so that the repository site is unlikely to be disturbed by future generations.
4. This available land must not contain economically exploitable natural resources as known today, so that the repository site is unlikely to be disturbed by future generations.
5. This available land must not be located in areas with known geological and hydrogeological characteristics that would prevent the site from being safe, considering the safety factors outlined in the NWMO site selection document [1].

It is not the intent of the initial screening study to conduct a detailed analysis of all available information, but rather to identify any obvious conditions that would exclude a community from the site selection process. For cases where readily available information is limited and where assessment of some of the criteria is not possible at the screening stage, the area would be advanced to the preliminary assessment stage for more detailed evaluation provided the community remains interested in continuing to participate in the siting process.

The initial screening commences with an analysis of readily available information in order to develop an overall understanding of the geoscientific and other relevant characteristics of the site. The initial screening criteria are then applied in a systematic manner based on the understanding of the proposed area. The tasks involved include:

- Reviewing the regional and local physical geography, geology, seismicity, structural geology and Quaternary geology (surface geology);
- Reviewing the hydrogeology, including, regional groundwater flow, deep and shallow aquifers and hydrogeochemistry;
- Reviewing the economic geology, including petroleum resources, and metallic and non-metallic mineral resources;
- Applying the screening criteria; and
- Summarizing the findings with regards to the five screening criteria.

Preliminary Assessments

The overall preliminary assessment of potential suitability is a multicomponent study integrating both technical and community well-being assessments as illustrated below (Figure 1). The five components of the preliminary assessment address geoscientific suitability, engineering, transportation, environment and safety, as well as social, economic and cultural considerations.

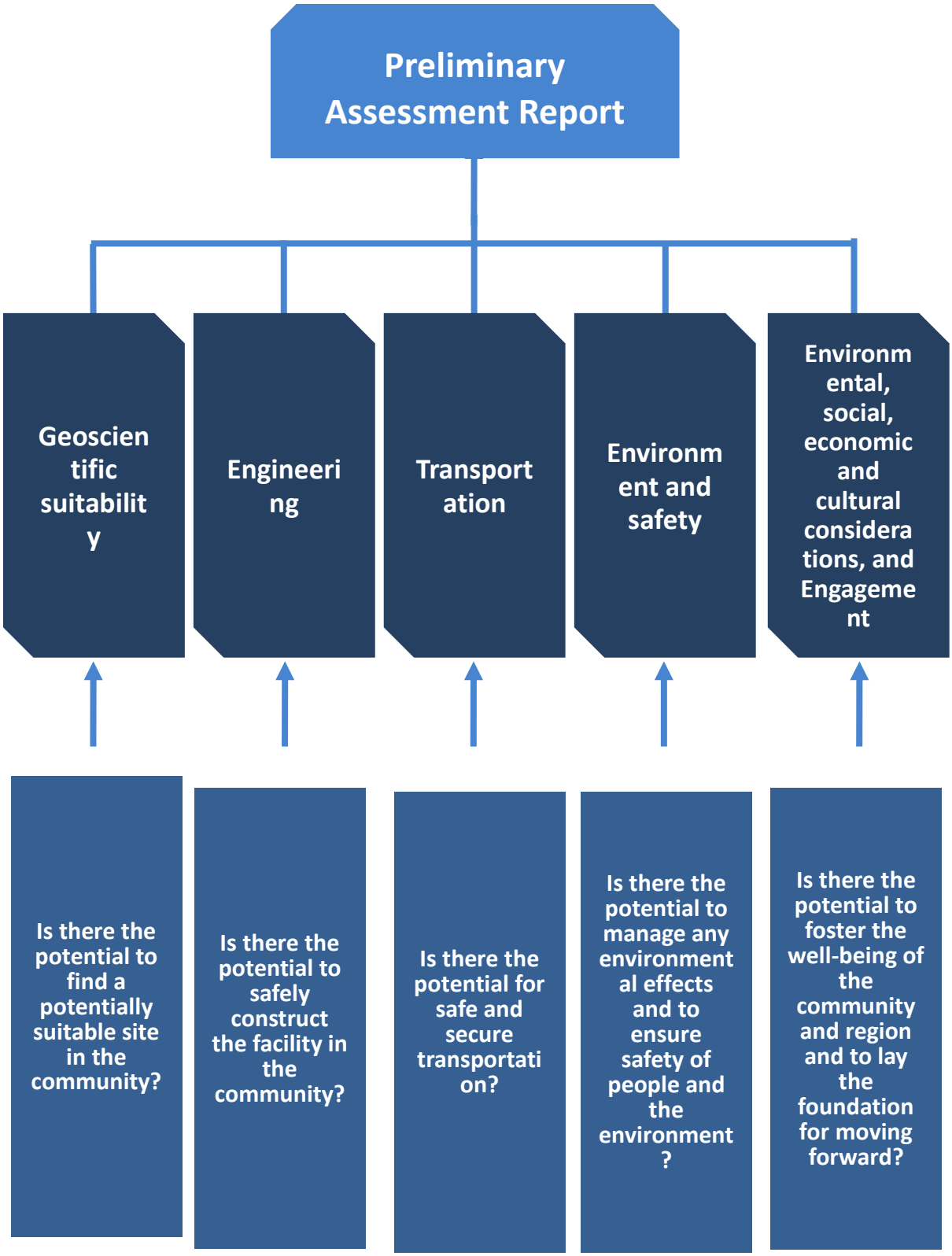

Fig. 1. Components of the preliminary assessments.

The objective of the geoscientific component is to assess whether a candidate area contains general siting areas that are potentially suitable for safely hosting an assessment deep geological repository for used nuclear fuel. The preliminary assessment builds on the findings of the initial screening, and involves two phases:

- ***Phase 1 - Desktop Study.*** For all communities electing to be the focus of a preliminary assessment. It will primarily involve desktop studies using available geoscientific information, which may be supplemented with optional, limited non-intrusive field reconnaissance for confirmation purposes.
- ***Phase 2 - Preliminary Field Investigations.*** For a subset of communities selected by the NWMO, to further assess potential suitability of general siting areas identified in each candidate area. This phase will involve a site investigation that includes geophysical surveys, detailed geological mapping and the drilling of a limited number of boreholes, and is expected to last approximately two years.

The subset of communities considered in Phase 2 of the preliminary assessment will be selected based on the findings of the overall desktop preliminary assessment considering both technical and community well-being factors discussed above.

Phase 1 - Desktop Study

The objective of the Phase 1 desktop geoscientific preliminary assessment is to assess whether it is possible to identify general siting areas within a candidate area that are potentially suitable for hosting a deep geological repository based on the geoscientific evaluation factors outlined in the NWMO site selection process [1]. The general siting areas must be large enough to accommodate the repository surface facilities and the underground repository footprint. It is expected that the surface facilities will require a dedicated surface area of about 600 m (1,969 ft) by 550 m (1,805 ft) for the main buildings and about 100 m (328 ft) by 100 m (328 ft) for the ventilation exhaust shaft. The repository is expected to be constructed at a depth of about 500 m (1,640 ft) below ground surface.

The actual repository depth and underground footprint at any particular site would depend on a number of factors, including the characteristics of the rock at the preferred site, the final design of the repository and the inventory of used nuclear fuel to be managed. For the purpose of the preliminary assessment, it is assumed that repository would require a footprint in the order of 2 kilometers (km) (1.24 miles [mi]) by 3 km (1.86 mi). Therefore, identified general siting areas would need to have an area of 2 km (1.24 mi) by 3 km (1.86 mi) or more.

It is important to note that at the desktop stage of the preliminary assessment, the intent is not to identify specific repository sites, but rather to assess whether it is possible to identify general siting areas within the candidate area that have the potential to satisfy the safety functions defined in the site selection process document [1]. The location and extent of the siting areas would be refined during the second phase of the preliminary assessment through more detailed assessments and field evaluations, if the community is selected by NWMO and continues to be interested in continuing with the site selection process.

The Phase 1 Desktop Geoscientific Preliminary Assessment included the following review and interpretation activities:

- Detailed review of available geoscientific information related to geology, structural geology, natural resources, hydrogeology, overburden deposits, etc.;
- Interpretation of available geophysical surveys (magnetic, electromagnetic, gravity, radiometric);
- Lineament studies using available satellite imagery, topography and geophysical surveys to provide information on the significance (location, orientation, length, etc.) of interpreted structural bedrock features;
- Terrain analysis studies to help assess overburden type and distribution, bedrock exposures, accessibility constraints, watershed and subwatershed boundaries, groundwater discharge and recharge zones, and locations where neotectonic features may potentially be preserved;
- The identification of potentially suitable siting areas based on the systematic application of geoscientific evaluation factors, understanding of the bedrock geology and structural history of the Ignace area, and the lineament investigation findings; and
- Preliminary non-intrusive field reconnaissance activities (if deemed necessary).

Phase 2 - Preliminary Field Investigations

The objective of the preliminary field investigation program is to collect site-specific field information to further assess and increase confidence in potential suitability of siting areas that have been identified during the Phase 1 desktop geoscientific preliminary assessment. The specific nature and extent of the investigations would be driven by factors such as the geologic setting (e.g. sedimentary versus crystalline rock); the nature, extent and quality of available information; the level of confidence in the understanding of key geoscientific site evaluation factors; and practical considerations, such as land access and ownership. The various field activities will be conducted in a step-wise manner in order to optimize cost and leverage field investigation results.

The program is likely to include the following sequence of activities:

- High resolution airborne geophysical surveys over identified potentially suitable siting areas to improve the identification and delineation of structural features, lithological contacts and overburden characteristics. Some of the surveys will cover the entire candidate area;
- Detailed geological mapping to “ground truth” Phase 1 lineament results, local bedrock geology and overburden cover, as well as geophysical phase 2 results; and
- Drilling a limited number of vertical and/or inclined cored boreholes to repository depth or greater, including core logging, borehole geophysical logging and potentially hydraulic and geochemical testing. The location of the drill sites in each community will be informed by the results of the geophysical surveys and detailed geological mapping.

Detailed Site Evaluations

Detailed Site Evaluations will be conducted at one or more selected sites to confirm suitability. This step would include detailed site investigations involving geophysical surveys, characterization of the existing environment, drilling and sampling of boreholes, field and laboratory testing and monitoring activities. This step is expected to last more than five years.

STATUS OF SITE EVALUATIONS

As of November 2012, twenty one (21) communities are currently engaged in the site selection process. Three communities are located in northern Saskatchewan and 18 are located in northwestern and southwestern Ontario (Figure 2).

Fifteen of the communities shown on Figure 2 are located within crystalline rocks of the Canadian Shield. Potentially suitable rock formations identified in the initial screenings include granite, granodiorite, tonalite, quartz diorite, gneiss and migmatites. Six communities are located within Paleozoic sedimentary rocks of Southern Ontario. Potentially suitable host formations identified in the initial screenings include the Upper Ordovician shale and limestone units that comprise the geology of southwestern Ontario at typical repository depths.

On September 30, 2012 the NWMO suspended expressions of interest for new communities wishing to engage in the site selection process for Canada's Used Nuclear Fuel Repository. As of November, 2012, initial screenings have been completed for twenty communities. Except for one, the results of the all initial screenings did not identify any obvious conditions that would exclude the communities from further consideration in the site selection process. The findings of all completed initial screening are available on the NWMO Siting Process website [2]. The review of readily available information and the application of the five initial screening criteria for the community of Red Rock, Ontario (adjacent to Nipigon on Figure 2) showed that the community is unlikely to contain geological formations that would be potentially suitable for hosting a deep geological repository. Initial Screenings are ongoing for 2 communities.

Nine communities have recently expressed interest in continuing with the site selection process, and requested that a preliminary assessment be conducted to further assess their suitability. Other communities are still assessing their interest in continuing with the site selection process.

Fig. 2. Communities in the NWMO site selection process as of November 2012.

REFERENCES

1. NWMO, 2010. Moving forward together: Process for selecting a site for Canada's deep geological repository for used nuclear fuel.
2. NWMO, 2012. NWMO Siting Process Website. http://www.nwmo.ca/sitingprocess_whatsnew